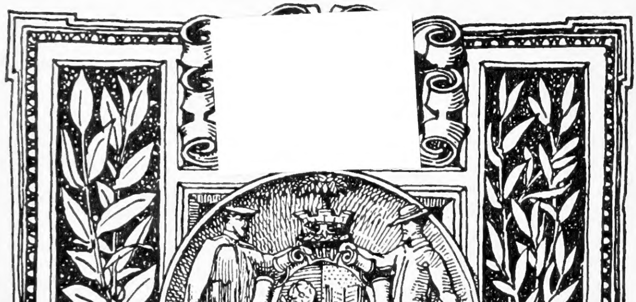
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TRANSACTIONS

OF THE

ILLINOIS STATE ACADEMY

OF

SCIENCE

VOLUME I

1908

SPRINGFIELD
Schnepp & Barnes, Printers

TRANSACTIONS

OF THE

Illinois State Academy of Science

ORGANIZATION MEETING
SPRINGFIELD, DEC. 7, 1907

FIRST REGULAR MEETING
DECATUR, FEB. 22, 1908

VOLUME I

1908

EDITED BY PUBLICATION COMMITTEE

vol 1-3

OFFICERS

President, T. C. Chamberlin, University of Chicago, Chicago, Ill.

Vice-President, Henry Crew, Northwestern University, Evanston, Ill.

Secretary, A. R. Crook, State Museum Natural History, Springfield, Ill.

Treasurer, J. C. Hessler, James Millikin University, Decatur, Ill.

The Council—President, Past President, Vice-President, Chairman of each Section, Secretary, Treasurer.

Publication Committee—President, Secretary, H. Foster Bain.

Membership Committee—S. A. Forbes, T. W. Galloway, J. P. Macnusson, C. H. Smith, B. B. James.

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TRANSACTIONS

ORGANIZATION MEETING

SENATE CHAMBER, SPRINGFIELD, DEC. 7, 1907.

MINUTES.

MORNING SESSION.

The meeting was called to order by A. R. Crook, Curator State Museum, at 10 A. M.

Upon nomination by H. Foster Bain, U. S. Grant, Northwestern University, was elected temporary chairman.

After a few words of introduction, the chairman presented to the assembly, Secretary of State James A. Rose, who, in the absence of the Governor, welcomed the company to the State Capital, and spoke concerning the desirability of effecting an organization of scientific men along lines similar to those already followed by men of many professions and callings in the State.

T. C. Chamberlin, University of Chicago, gave the opening address, on "The Advantages of a State Academy of Science," and S. A. Forbes, State Entomologist, gave an address on the "History of the former State Natural History Societies of Illinois."

On motion of S. W. Williston, University of Chicago, A. R. Crook was elected temporary secretary, and it was voted that the Chair appoint a committee of three on organization. This committee was to add six others to its number, and these nine were directed to draw up a constitution and nominate officers.

The Chair appointed S. W. Williston, University of Chicago, W. A. Noyes, University of Illinois, C. B. Atwell, Northwestern University; and this committee added T. C. Chamberlin, University of Chicago, S. A. Forbes, University of Illinois, A. R. Crook, State Museum, F. L. Charles, Northern Illinois State Normal, H. V. Neal, Knox College, and B. B. James, Millikin University.

While the committee were at work, a general discussion concerning the plan and aims of the organization was participated in by various speakers.

C. E. M. Fischer, College of Physicians and Surgeons, called attention to the desirability of affiliating with various existing organizations.

T. W. Galloway, Millikin University, suggested that the committee on organization report early.

C. W. Andrews, John Crerar Library, suggested that the committee make possible the admission of libraries and other institutions to membership in the organization, and expressed the interest which such institutions as the one with which he was connected would feel in the movement.

T. J. Bryan, Illinois State Food Commission, spoke in behalf of the interests of the men who are not engaged in teaching but are interested in technical work.

Q. I. Simpson, of Palmer, spoke from the standpoint of one occupied with practical application of scientific principles in stock breeding and thought that the academy would be of great advantage to men of science engaged in application rather than investigation.

T. J. Burrill, University of Illinois, suggested that the singular rather than the plural of *science* be used in the naming of the academy, and that a definite home and one place of meeting would add to its effectiveness.

Edward Bartow, University of Illinois, said that the organization would not only promote general interest in science, but would increase each member's enthusiasm for his own work.

Albert Carver, Springfield High School, enumerated some advantages to be gained by holding meetings of the academy in Springfield.

Isabel S. Smith, Illinois College, hoped that the academy would lend its influence towards saving the forests and especially the remnants of the pine forests in the State.

R. H. McKee, Lake Forest University, mentioned the desirability of small fees being charged by the new organization, and that the place of meetings should alternate between different parts of the State.

F. D. Haddock, Superintendent Public Schools, Champaign, said that while a superintendent should give all lines of work equal consideration, he wished to express his great interest in science and the work of the academy.

C. G. Hopkins, University of Illinois, thought that the academy would be of service both to pure and applied science.

Henry Crew, Northwestern University, cautioned against too minute division of the academy into sections. He thought the departments might well be grouped so that there would be but two sections—such as that of natural and physical science or of pure and applied science.

E. J. Townsend, University of Illinois, thought that the sections should not be too small. The meetings should be held at different places, meeting in alternate years in the State Capitol.

W. S. Bayley, University of Illinois, thought that the dues should be as low as possible and the sections given a place of minor importance, since it was desirable for the academy to extend its influence broadly rather than minutely. One of the great advantages would be the opportunity which it would furnish for specialists to gain interesting facts outside of their own lines. He suggested that the secretary should be in Springfield in order to keep in touch with legislation.

Miss Stella M. Hague, Rockford College, expressed her interest and that of Rockford College in the organization.

W. F. M. Goss, University of Illinois, advocated caution in dividing the academy into sections, and the importance of keeping in mind the larger interests.

H. A. Gleason, University of Illinois, called attention to the inspiration and help which the academy might afford younger men.

F. C. Gates, Chicago, thought that the high schools should be in touch with the academy.

W. E. Loomis, Springfield, spoke in the interest of astronomy.

A. W. French, Springfield, expressed the hope that the academy would do much towards advancing scientific spirit and knowledge.

The meeting then adjourned till 2 P. M.

Afternoon Session.

2:15 P. M.

Meeting called to order at 2:15 P. M. by the president pro tempore.

Upon motion of S. W. Williston, chairman of the committee on constitution, the draft of the proposed constitution was presented. It was read by the secretary of the committee, F. L.

Charles, and upon motion of H. F. Bain, it was considered section by section.

After revision and discussion the constitution and by-laws as given below were adopted.

It was voted that the first annual dues should apply for the year 1908.

S. W. Williston presented the report of the committee on nominations. It was voted that the secretary cast the ballot for the following officers, and they were declared elected:

President, T. C. Chamberlin, University of Chicago.

Vice-President, Henry Crew, Northwestern University.

Secretary, A. R. Crook, State Museum.

Treasurer, J. C. Hessler, James Millikin University.

Third member of Publication Committee,

H. F. Bain, State Geological Survey.

Committee on Membership:

S. A. Forbes, State Entomologist.

T. W. Galloway, James Millikin University.

J. P. Magnusson, Augustana College.

C. H. Smith, Hyde Park High School.

B. B. James, James Millikin University.

President pro tempore Grant then introduced the President-elect.

In the absence of the Treasurer, B. B. James, of James Millikin University, was appointed Treasurer pro tempore.

A symposium upon the "Outlook for Young Men in Various Sciences" was participated in by W J McGee, J. G. Coulter, Wm. A. Noyes, H. F. Bain, Henry Crew and H. V. Neal.

The membership committee was authorized to accept as charter members those persons who had previously expressed their desire to be enrolled as such, but were unable to be present at the meeting. The committee acted upon the names submitted.

Upon motion of W. E. Loomis it was voted that 500 copies of the proceedings of the organization meeting be printed and that one copy be furnishel to each member of the Society.

The meeting then adjourned till 8 P. M.

Evening Session.

In the evening, to an audience of about six hundred, Dr. W J McGee gave his lecture on "Greater Steps in Human Progress."

His address combined in a rare degree such facts as would attract men of the highest scientific attainments and at the same time the more popular audience also. It might be expected that such a title, "Greater Steps in Human Progress," would imply consideration of the remarkable manufacturing and commercial advances which have characterized the last century. His plan, however, was to note various habits and discoveries of men which indicate evolution from a low physical and mental equipment to the full expansion of man's faculties. Primitive men were unable to open the hand so as to bring the thumb in the same plane with the fingers. This was shown by the aboriginal Philippine tribes which Dr. McGee assembled at the St. Louis Exposition.

Primitive man is characterized by movements of the hand and arm *toward* the body, whereas his more highly developed descendants directs these movements *from* the body. It is the Anglo-Saxon who has shown this development in the highest degree, and while in other respects prize-fighting is indicative of the lower traits, in this one fact, namely, that the motions of the arm in a well-directed blow are from the body of the fighter, the prize-fighter's profession indicates high physical development—a real step in progress.

The savage grasps a knife with the blade held towards the body. Civilized man holds the blade from the body. The mistress wishing to judge the mental alertness of a prospective maid servant should hand her a plate and towel, noting the motion of the hand as the maid wipes the plate. If the motion of the right hand is clock-wise the maid should be considered a promising subject.

At some length Dr. McGee illustrated the fact that the development of "knife sense" is one of the greatest steps in human progress. Primitive men used a rounded stone and had no conception of the value of a sharp edge.

Another one of the great steps, and indeed the chief one, is in the use of fire. Man alone of all created things employs fire. It required long ages for men to learn the use of fire, and this discovery has made possible the great development of the human race, socially, commercially and intellectually.

Finally, the faculty of invention is one which has contributed most forcibly and characterized most materially the development of the human race.

The address was a masterly presentation of unique and original material.

The interest which was displayed throughout the meeting, argues well for a successful and useful career for the society.

A. R. Crook,
Secretary.

CONSTITUTION AND BY-LAWS

ILLINOIS STATE ACADEMY OF SCIENCE.

CONSTITUTION.

ARTICLE I. NAME.

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

ARTICLE II. OBJECTS.

The objects of the Academy shall be the promotion of scientific research, the diffusion of scientific knowledge and scientific spirit, and the unification of the scientific interests of the State.

ARTICLE III. MEMBERS.

The membership of the Academy shall consist of *Active Members*, *Non-resident Members*, *Corresponding Members*, *Life Members*, and *Honorary Members*.

Active Members shall be persons who are interested in scientific work and are residents of the State of Illinois. Each active member shall pay an initiation fee of one dollar and an annual assessment of one dollar.

Non-resident Members shall be persons who have been members of the Academy but have removed from the State. Their duties and privileges shall be the same as those of active members except that they may not hold office.

Corresponding Members shall be such persons actively engaged in scientific research as shall be chosen by the Academy, their duties and privileges to be the same as those of active members, except that they may not hold office and shall be free from all dues.

Life Members shall be active or non-resident members who have paid fees to the amount of twenty dollars. They shall be free from further annual dues.

Honorary Members shall be persons who have rendered distinguished service to science and who are not residents of the State of Illinois. The number shall not exceed twenty at one time. They shall be free from all dues.

For election to any class of membership the candidate's name must be proposed by two members, be approved by a majority of the committee on membership, and receive the assent of three fourths of the members voting.

All workers in science present at the organization meeting who sign the constitution, upon payment of their initiation fee and their annual dues for 1908 become charter members.

Article IV. Officers.

The officers of the Academy shall consist of a President, a Vice-President, a Chairman of each section that may be organized, a Secretary, and a Treasurer. These officers shall be chosen by ballot on recommendation of a nominating committee, at an annual meeting, and shall hold office for one year or until their successors qualify.

They shall perform the duties usually pertaining to their respective offices.

It shall be one of the duties of the president to prepare an address which shall be delivered before the Academy at the annual meeting at which his term of office expires.

The secretary shall have charge of all the books, collections, and material property belonging to the Academy.

Article V. Council.

The Council shall consist of the President, Vice-President, Chairman of each section, Secretary, Treasurer, and the president for the preceding year. To the Council shall be entrusted the management of the affairs of the Academy during the intervals between regular meetings.

Article VI. Standing Committees.

The Standing Committees of the Academy shall be a Committee on Publication and a Committee on Membership.

The Committee on Publication shall consist of the President, the Secretary, and a third member chosen annually by the Academy.

The Committee on Membership shall consist of five members chosen annually by the Academy.

Article VII. Meetings.

The regular meetings of the Academy shall be held at such time and place as the Council may designate. Special meetings may be called by the Council and shall be called upon written request of twenty members.

Article VIII. Publication.

The regular publications of the Academy shall include the transactions of the Academy and such papers as are deemed suitable by the Committee on Publication.

All members shall receive gratis the current issues of the Academy.

Article IX. Affiliation.

The Academy may enter into such relations of affiliation with other organizations of appropriate character as may be recommended by the Council and be ordered by a three-fourths vote of the members present at any regular meeting.

Article X. Amendments.

This constitution may be amended by a three-fourths vote of the members present at an annual meeting, provided that notice of the desired change has been sent by the Secretary to all members at least twenty days before such meeting.

BY-LAWS.

I. The following shall be the regular order of business:

1. Call to order.
2. Reports of officers.
3. Reports of standing committees.
4. Election of members.
5. Reports of special committees.
6. Appointment of special committees.
7. Unfinished business.
8. New business.
9. Election of officers.
10. Program.
11. Adjournment.

II. No meeting of the Academy shall be held without thirty days' previous notice being sent by the Secretary to all members.

III. Fifteen members shall constitute a quorum of the Academy. A majority of the Council shall constitute a quorum of the Council.

IV. No bill against the Academy shall be paid without an order signed by the President and Secretary.

V. Members who shall allow their dues to remain unpaid for three years, having been annually notified of their arrearage by the Treasurer, shall have their names stricken from the roll.

VI. The Secretary shall have charge of the distribution, sale, and exchange of the published Transactions of the Academy, under such restrictions as may be imposed by the Council.

VII. The presiding officer shall at each annual meeting appoint a committee of three who shall examine and report in writing upon the account of the Treasurer.

VIII. No paper shall be entitled to a place on the program unless the manuscript or an abstract of the same shall have been previously delivered to the Secretary.

IX. These by-laws may be suspended by a three-fourths vote of the members present at any regular meeting.

ADDRESSES

THE ADVANTAGES OF A STATE ACADEMY OF SCIENCE.

T. C. Chamberlin.

The opening address, by Professor Chamberlin, on *The Advantages of a State Academy of Science,* was given in the extemporaneous form, and the following outline very imperfectly represents what was said.

Professor Chamberlin introduced his address by conveying the felicitations of the Chicago Academy of Sciences, and sketched some of the salient features of its history of a little more than fifty years as a means of giving concrete illustration to some of the problems which the new academy must face. Special attention was directed to the radical change in the nature and relations of scientific activity since the oldest academies of the interior were established. In the pioneer days, an almost virgin field was open to naturalists, and enthusiasts in this field constituted the largest factor in the membership of its academies of science during their early stages of development. The results of these pioneer workers were much more fully within the appreciation of all their colleagues and of the intelligent public than are the products of the more highly specialized investigations of today. So widely has research deployed in the last fifty years, and so far has it reached into the more recondite phases of each field, that there is now far less community of interest and of intelligent appreciation, even among scientific workers themselves. This fundamental change brings new problems of organization and of adjustment. In like manner, the function of an academy as an avenue of publication has assumed a new aspect. Fifty years ago, an appropriate means of publication was one of the greatest needs which the academies supplied to the pioneer workers, for, aside from these academies, the available opportunities of giving publicity and permanence to scientific results were few and unsatisfactory. As the regional element was dominant in the results of the early naturalists, it was fitting that there should be a local means of publication. Today, however, the results of research are, in general, more serviceable to scientific workers if they are gathered into the special journals devoted to the several departments of science. While the function of publishing the results of regional investigations still remains, and may well continue to be subserved by the regional academies of science, and while certain adaptations of other results may serve an important regional purpose, the question whether an academy should endeavor to be the avenue of miscellaneous publication to the same extent as in the early days is one of the problems that invite the serious consideration of a new academy.

Attention was also directed to the problems presented by the geographic distribution of the centers of scientific activity within the State and by the not altogether felicitious relations of these centers to the capital of Illinois.

The advantages of a state academy to those who are just entering upon scientific careers, to amateurs dissociated from institutions of research, to trained workers in relative isolation, and to workers in scientific centers, were specifically set forth. The values to be derived from opportunities of reading papers before fellow workers, of submitting results to discussion, of participating in the discussion of others' results, of extending scientific acquaintance, of co-operation, of mutual stimulus to endeavor, of personal education by contact with other workers, were dwelt upon in detail. The value of the academy as a means of disseminating the spirit, the method, and the love of science among the people of the State was especially emphasized. The function of advising relative to legislation on scientific matters was urged as highly important.

The address closed with an earnest advocacy of the value of the spirit and method of science to the state and nation as an essential element in the solution of its great social, political, and ethical problems. The habit of conscientious search for the precise truth and the systematic control and guidance of opinion and action in accordance with the canons of scientific procedure were urged as means of supreme value in the elevation and purification of the common thought and feeling of our people. More than anything else, are the intellectual and moral methods of science a protection against current evils and a guarantee of safety in the future.

HISTORY OF THE FORMER STATE NATURAL HISTORY SOCIETIES OF ILLINOIS.

S. A. Forbes.

The history of scientific organization is a part, merely, of the history of scientific progress, and that is a part of the history of the progress of civilization, and especially of education; and the subject which I am to present is no exception to this rule. It is difficult to omit from even a brief abstract of the history of the Illinois natural history societies all reference to the character and status of the general movements of which they were scarcely more than by-products, and still to leave in the account enough significance to make it worthy of presentation here. Under these circumstances I shall be governed by the reflection that we are today looking forward and not back —that we are preparing for the future and not studying the past—and that we are hence practically interested in what has come and gone only as it may help us to bring a new thing into being in a way to secure its permanent continuance and its normal growth. There have been two state natural history societies in Illinois, one founded in 1858, and the other in 1879. The first was the result of a proposal by an entomologist, Dr. Cyrus Thomas, afterwards State Entomologist of Illinois, made at a meeting of the State Teachers' Association at Bloomington in 1857. The second sprang up as a sequel to the sessions of a summer school of natural science held at the State Normal School, at Normal, and had for its first president, the state geologist, A. H. Worthen, and for its first secretary, the present writer, then in charge of the museum of the old society in the State Normal building.

The first society was chartered by the state legislature in 1861; held its tenth and last annual meeting in 1868; published, in 1861, Volume I., series 1, of its *Transactions* (in Volume IV. of the *Transactions* of the State Agricultural Society, and again, in a second edition, in 1862, as a separate pamphlet, a rare copy of which I hold in my hand); formed a museum of natural history which was housed in the building of the State Normal School, at Normal; and held two final business meetings in Bloomington, May 26 and June 22, 1871, for the transfer of its museum to the State in accordance with a provision of law passed by the general assembly of that year. This museum, held by the State Board of Education "for the use and benefit of the State," was gradually transformed, in due time, into the present State Laboratory of Natural History. A part of its original material is now in the possession of that institution at Urbana, a part of it belongs to the State Normal School at Normal, and the remainder is in the State Museum of Natural History, founded here in 1879, and now in charge of Professor Crook as its curator.

The officers of the society mainly responsible for its establishment and growth were its corresponding secretary, later called its general commissioner, and the curator of its museum. The former was its field agent and general manager, and the latter was the custodian of its collections. Its first corresponding secretary was C. D. Wilbur, who served in that capacity until 1864. Its curator was for several years Dr. J. A. Sewall, instructor in chemistry in the State Normal School, at Normal, and afterwards president of the Colorado State University. Its second general commissioner, and afterwards the second curator of its museum, was Major J. W. Powell, who was in its service in the latter capacity when he made those remarkable western explorations, and especially that most remarkable expedition down the Colorado River of the West, which gave him world-wide fame and did much to make him later the United States Geologist. The third actual curator, serving, however, nominally as Major Powell's deputy, was Dr. George W. Vasey, afterwards for many years botanist to the United States Department of Agriculture, at Washington; and the last to serve in this capacity was the present writer, appointed by the State Board of Education in 1872, after the State had acquired the museum, and continued as director of the State Laboratory of Natural History after the change of name and function finally made in 1879.

This society came into existence at a time so different from our own that we can derive little from its experience by way of either warning or instruction. Its period was that of the first active exploration and discovery of the scientific contents and economic resources of our territory, and of the first general impulse to the scientific education of the people; and the society was formed as an agency for a natural history survey of the State in the old sense of an accumulation of museum specimens and a descriptive record of its zoology, botany and paleontology—meteorology and physical geography being nominally included, also, within the scope of the society. In 1858 the State Geological Survey was just getting on its feet, with Mr. Worthen appointed that year as its director. The normal school at Normal was the only state educational institution in Illinois, and that has been organized only one year. The state university was not founded until nine years thereafter, at which time, also, the state entomologist's office was first established.

Very few of the men engaged in the work of this old society had anything approximating what we would now call a scientific education, and few of them were what we would now call professional scientists or teachers of science, and yet they were evidently the pick of the State in scientific ability, enthusiasm and activity. Among its more efficient members, besides Powell, Vasey, Worthen and Thomas, already mentioned, were Benjamin D. Walsh, the first state entomologist; M. S. Bebb, well known for his work on the willows of the United States; Dr. Oliver Everett, of Dixon; James Shaw, of Mt. Carroll, and Dr. Henry M. Bannister, the last two assistants on the Geological Survey; Dr. J. W. Velie, a life-long ornithologist, still living in Michigan; and Dr. Frederick Brendel, of Peoria, author of many botanical papers, and also still with us, one of the very few survivors of the early membership. I must not omit, even in this briefest mention, the name of Professor J. B. Turner, of Jacksonville, first president of the society, famous in the history of the state universities because of his leadership in the pioneer movement for an industrial education of college grade; nor Dr. Edmund Andrews, of Chicago, who became one of the leading surgeons of that city; nor Newton Bateman, state superintendent of public instruction, who lent to the society the prestige of his great name—a most potent educational influence in that day.

You will wish, I am sure, to know something of the subjects in which the more prominent members were interested, and on which they wrote their papers for the society programs, and I will mention a few of them, taken at random. By Dr. Brendel: "Forests and Forest Trees of Illinois," "The Trees and Shrubs of Illinois," "The Oaks of Illinois," "Meteorology in connection with Botanical Investigations," "Additions to Robert Kennicott's Flora of Illinois." By Dr. Everett: "The Geology of a Section of the Rock River Valley." By A. M.

Gow, of Dixon: "Natural History in Schools." By R. H. Holder, of Bloomingon: "A Catalogue of the Birds of Illinois." By James Shaw: "The Great Tornado of 1860." By Dr. Thomas; "Insects of Illinois, with Catalogue of Coleoptera," "Mammals of Illinois." These latter papers, it scarcely need be said, were extremely slight sketches of their subjects. By Dr. Vasey: "Additions to the Flora of Illinois," "The Pernicious Weeds of Illinois," "The Range of Arborescent Vegetation." By Mr. Walsh: "Insects Injurious to Vegetation in Illinois," "The Army-worm and its Insect Foes," "Insect Life in its Relation to Agriculture." By Mr. Wilber: "The Mastodon giganteus, its Remains in Illinois." Most of these papers were published in the Transactions of the State Agricultural Society, some of them also in the *Prairie Farmer*, of Chicago, those being virtually the only avenues of publication open to students of science in Illinois in that day.

The society operated through an elaborate organization of special committees of its members, one for each division of the natural history of the State, each committee composed, of course, of unpaid volunteers, who were made responsible for the accumulation and preparation of material for their several departments of the museum, and for contributions on their respective divisions of its natural history. This survey work was extremely irregular in amount and unequal in value, and its results were never organized by the society into a working collection. The curator was an instructor in the normal school, and seems to have received no pay from the society; but the general commissioner was supposed to give his entire time to its service. His salary was evidently uncertain in amount, and dependent largely on his success in securing entrance fees from new members. Financial complications arose—disputes as to ownership of property, difficulties in the payment of debts incurred, refusals to turn over to the treasurer the funds claimed by the society—and these, with other confusing and discouraging conditions, led to the withdrawal by members of gifts and deposits of specimens and a falling off in the active membership. The society finally collapsed, chiefly because of its financial disabilities. Since it could neither pay adequately its general commissioner or its curator, nor organize its collections or publish its papers from its own resources, it turned to the State for aid, and found itself ultimately obliged to accept the condition that its property should be transferred to the State, and that its curator should be appointed by a state board, as the price of continued appropriations,—which, by the way, were largely drawn upon to outfit and maintain the Powell expeditions to the far west.

There is no doubt that this short-lived society brought a body of influential public opinion to the aid of state scientific and educational enterprises appearing during its existence, and that it did much to stimulate a general interest in scientific knowledge and research, and thus to hasten the introduction of the sciences into the public schools—influences which did not cease when its own organic life was ended. It also afforded to Powell the standing-ground from which he leaped into fame as an explorer and won his way to a scientific career of the first importance, and it left in its museum nuclear collections which were later made useful in a revival and firm establishment of the original enterprise of the society, modified to suit more modern ideals, by the State Laboratory of Natural History. This first state society thus gave indirect origin to the state laboratory, with which the state entomologist's office became practically identified in 1883, much as the first geological survey of the state gave origin to our present state museum. If our new academy do no more, proportionately to its period and its environment, within the next ten years, it will amply justify our proceedings today.

By 1879, after an interval of eleven years from the actual dissolution of the old society, a virtually new situation had arisen in science, and especially in scientific education. Under the influence of Darwin and Agassiz and Huxley a transforming wave of progress was sweeping through college and school—a wave whose strong upward swing was a joy to those fortunate enough to ride on its crest, but which smothered miserably many an unfortunate whose feet were mired in marsh mud. This wave reached central Illinois in the early seventies with the effect to bring about, in 1875, a summer school of natural history at the State Normal School—only two years, it will be noticed, after the first session of the Agassiz school at Penikese. Wilder, of Cornell, and W. S. Barnard, just back from Europe with a doctor's degree, were members of its teaching staff, together with Burrill, of the State University, Thomas, the state entomologist, and the present writer, who was also director of the school. Besides an abundance of living plants and animals of our own environment, we had great boxes and barrels of marine material in large variety, some of it received alive, secured by a most active collector engaged for the purpose, who scoured the New England coast for us from Portland to Buzzard's Bay. This school was a notable success, except that the Illinois instructors all worked for nothing and paid their own expenses, but the Centennial Exposition of 1876 deranged plans for its immediate continuance. In 1878, however, a second equally successful session was held, at the close of which its students spontaneously organized themselves into a natural history society, and appointed a committee of correspondence to extend its membership and enlarge its scope. As a consequence of the numerous and unanimously favorable responses to the letters following, a conference was held at the office of the state geologist in Springfield, December 12, 1878, and the secretary of this conference was instructed to call a convention at Chicago for the organization of a state natural history society.

Some forty persons responded to the call, and organized at the Palmer House, January 16, 1879, and letters were read from fourteen others who wished to join the proposed society. The first officers were A. H. Worthen, of Springfield, President; T. J. Burrill, of Urbana, and H. M. Bannister, of Chicago, Vice-Presidents; Homer N. Hibbard, of Chicago, Treasurer; S. A. Forbes, Secretary; and Selim H. Peabody, of Champaign, and Cyrus Thomas, of Carbondale, additional members of the executive committee. By the close of the year sixty-six members had paid their initiation fee of three dollars each.

This was the period of the return to nature in the study of science, and annual field meetings were provided for. The first of these was held at Ottawa, July 10, 1879. Dividing into three sections—geological, botanical and zoological—under the leadership of Worthen, Burrill and Forbes, respectively, the society took to the woods in the beautiful, prolific and historically interesting valley extending along the Illinois River eighteen miles from Ottawa to Peru, and with Starved Rock, Deer Park, Buffalo Rock and the site of the famous Indian village at Utica within or near its boundaries.

Annual program meetings followed at Bloomington, Springfield, Urbana, Springfield, Peoria and Jacsonville; and field meetings at Lake George, Indiana, near Chicago, where a Chicago sportsmen's club placed their club house, premises and equipment at our disposal; at Fountain Bluff and Grand Tower, on the Mississippi, in southern Illinois;; at Warsaw, in Hancock county, the home of Mr. Worthen; and at Peoria, where the Peoria Scientific Association joined us in a steamer trip up the Illinois River for aquatic work. These field meetings were well attended, as a rule, and were much enjoyed, although it must be confessed that they were perhaps more agreeable than permanently profitable to us. The annual meetings also were interesting to the participants, and did something, no doubt, to stimulate the workers among us, and something also to interest and instruct the communities in which they were held. Their average character may be well enough illustrated by the program of the Urbana meeting in 1882.

The first session was devoted to an address on "Primitive Religion in America," by Mr. McAdams, of Jerseyville, which was substantially an account of the religion of the Mound Builders as inferred from idols and other implements of a religious character which had been collected by the speaker. During the next session, Dr. Edwin Evans, of Streator, read a paper on "The Rock System of the Northwest," based mainly on the records of borings for artesian wells, and illustrated by maps and colored diagrams. This was followed by a paper on "Recent Microscopy," by Professor Burrill, of the university, giving a historical account of the development of the miscroscope and a description of its most recent improvements and performances; and this by a paper on "Prehistoric Remains in Southeastern Missouri," by F. S. Earle, of Cobden—essentially a classification and general description of mounds studied on a trip made for the Smithsonian Institution. A lecture on "The Fossil Tracks of the Connecticut Valley," by Don Carlos Taft, professor of geology in the university; a paper on "The Army-worm in 1881," by F. M. Webster, of Waterman; and one on "The Organs of the Sixth Sense of Blind Fishes," by S. A. Forbes, completed the program of the first day, which was followed by an evening reception to the society by the faculty and students of the university, and a microscope display given jointly by the university and the society.

The program of the following day contained a paper on "Sciences in the Public Schools," by C. W. Rolfe, of the university; one by Mr. McAdams on "The Great Cahokia Mound of Madison County," of which the writer has just completed a survey; one by Professor Burrill on "Some Vegetable Poisons," and one by Mr. Forbes on "The First Food of the Whitefish." Professor N. C. Ricker, of the university, read a paper on "The 'Blue Process' of Copying by Photography," just coming into use for the duplication of papers and drawings; James E. Armstrong, of Champaign, gave an account of the life history of a jellyfish studied by him at Beaufort, N. C.; Dr. Evans gave a paper on "The Subterranean Waters of the Northwest"—a discussion of the origin of the artesian waters of northern Illinois and southern Wisconsin; Mr. A. B. Seymour, botanist to the State Laboratory of Natural History, read a paper on "Field Work on Parasitic Fungi;" Mr. Cyrus W. Butler, also a state laboratory assistant, gave some zoological notes from the field-book of a naturalist; J. E. Armstrong presented an abstract of the papers read at a recent meeting of the University Natural History Society; and Professor Rolfe read brief papers on "Experiments with Germinating Seeds," and on "The Rings of Wood as indicating the Growth of Trees."

In 1880 the question of an enlargement of the field of the society to include the physical and mathematical sciences came up for discussion, and was decided negatively, on the ground that the interests represented by physicists, chemists and mathematicians were so separate from those of the naturalists that a common society was not desirable—a conclusion perhaps warranted in view of the kind of naturalists that most of us were.

In 1882, when the treasurer reported a balance of $150 in his hands and $122 more due from members in annual fees, the question of a publication of papers and proceedings was brought forward in the secretary's report and referred to a committee; but no steps were taken to that end on the ground that it was not desirable to multiply centers of publication unnecessarily, and that there was no lack of opportunity to publish really valuable papers in established periodicals.

Following upon these conclusions, and possibly in part because of them, the paid-up membership of the society began to decline. Indeed, of the sixty-six persons who completed their membership during the first year, thirty-nine did not continue their payments thereafter, and at the end of the second year the actual paid-up membership was fifty-two. The following year it was fifty-four, then fifty-two, then forty-three, and finally, in 1884, it fell to twenty-seven. The executive committe took these facts to indicate that there was at the time no sufficiently general and urgent desire for the permanent maintenance of a society of this description to warrant its continuance, and after the Jacksonville meeting of 1885, which passed without a formal election of officers, it was not called together again.

And now I hardly need say that, after the lapse of twenty-two years of amazing progress in science and in scientific education, an entirely new situation again exists in Illinois—one so radically different from that of the early eighties that the conclusions then reached have no very important bearing on our problem of today. There are more college specialists here today from one department of one institution than there were in our whole membership in 1879. Indeed that list is not so long that I cannot give it to you now, to emphasize the contrast. It consisted of J. D. Conley, of Carlinville; T. J. Burrill, of Urbana; S. H. Peabody, of Champaign; Rev. Francis X. Shulak, of St. Ignatius College, and E. S. Bastin, of the old University of Chicago—five men, one of whom, Dr. Bastin, did not meet with us again. Lindahl, of Rock Island, and Marcy, of the Northwestern, joined us in 1880, and Robertson, of Carlinville, in 1882, and a few additional members of the faculty of the State University paid us the compliment of an initiation fee when we held our meeting at Urbana, but went no farther with us. If there was any professional or active worker in biology or geology at any other Illinois college at the time, we never made his acquaintance nor he ours. Of the state scientific officials there were only Worthen, Thomas and Forbes. Thomas left the state in 1883, but the other two stayed with the society to the end.

It should be remembered, in this connection, that this was a time when college men, as a rule, worked like dray-horses and were paid like oxen, and the sacrifice of time and means necessary to prepare adequately for the annual and seminnual meetings of the society, and then to attend them, was more than they could, or ought to, make, except for some really important end.

It will be seen that, under these conditions, our membership would now be largely classed as amateurs. The active members of the last two years were chiefly collectors of specimens, and species-students of the old school—a few still-glowing brands from the enthusiasms of the exploration period, with scarcely a spark to testify to the coming illumination, in the midst of which it is our present privilege to live. And so the society passed, leaving no permanent material product of its work, except private collections and such papers of its members as were published here and there, as each individual thought best.

Does this account seem discouraging to our present undertaking? I do not think that it ought to, but quite the contrary. If, under such conditions, with so little material, and—as a reasonable modesty perhaps requires that I should add—under such general management, it was possible then for us to organize a state natural history society and to keep it actively at work for seven years, we ought now, I think, with all our present comparatively immense advantages, to found a state academy of science which shall live and thrive at least for seventy years, and, for all that I can see, for seventy times seven—by which time we shall all have been long relieved from all our responsibilities, and the labors and the honors of scientific enterprise will have been handed on to our remote successors.

SYMPOSIUM

ON THE LOOKOUT FOR YOUNG MEN IN VARIOUS SCIENCES.

ANTHROPOLOGY.

W J McGee.

In considering the promise of anthropology as a field for work by younger men, it should be remembered that the field is a particularly broad one. Other sciences find their object-matter and their opportunity in some special class of phenomena; anthropology deals with *man,* not only in general but also as a science-maker. Partly for this reason, the research is particularly attractive and especially stimulating and broadening; and other things equal the grasp of the specialist in this science ought to be—and generally is—large and strong.

Unfortunately the opportunities either for student or worker are less in anthropology than in some other branches of science. Thus far the subject is not well recognized in college curricula, while the pressure for development in other departments tends to retard its introduction. Just now, too, state, federal, and related institutions are concentrating activity along other lines, so that anthropology may be said to be temporarily in eclipse; and although this condition can not long persist, it is a present discouragement. The chief opportunities are those presented by museums. Of course both naturalists and educators are aware that we are in the midst of an era of museum development, and that public museums especially are multiplying in number and extent far beyond all precedent—indeed the museum is the correlative both of object teaching in primary education and of scientific and technical training in advanced institutions, and thus meets a growing demand. Now it is noteworthy that the departments of anthropology in the museums of the country are particularly attractive both to casual visitors and to investigators, and that they are growing on the average more rapidly than other departments; which means that in museum corps the opportunities for anthropologic students average well. Of the branches of general anthropology, archeology is most attractive in museums, partly because of the wide-spread intuitive interest in human relics which draws visitors and contributors, and partly by reason of the abundance of material; next follows ethnology, with its preparations and other exhibits illustrating the types of mankind and the artifacts and customs by which peoples are defined and classified. There is a current tendency toward the differentiation of museums in two primary classes, viz., museums or art, including painting, sculpture, and other esthetic productions of mankind; and museums of nature and industry, comprising objects of natural history and all those objects and products of mankind not primarily esthetic in character. While both classes of museums afford opportunities for the would-be worker in anthropology, the latter is especially promising—for the industrial development of the world is of never ending and always increasing interest, and the human artifacts are susceptible of arrangement in series serving to satisfy the instinctive desire to understand sequential development, and hence meeting a large demand.

In one respect the field of anthropology is perhaps more enticing than that of any other science. In geology, for example, the great problems seem to have been worked out in such manner as to leave no function for a Hall or a Hilgard, a Lyell or a LeConte, a Playfair or a Powell; and it may be questioned whether biology affords proper scope for a Linne or a Darwin; for while the necessities and the opportunities are continually arising, they are connected rather with sub-problems than with the primary problems of the pioneers. Not so of anthropology. This science presents today primary problems in classification, in correlation, in tracing serial development and relation, in throwing light on the most fundamental questions of human life; and for the ambitious student, desirous of enlarging the field of human knowledge, these opportunities can not fail of attraction.

OPPORTUNITIES IN BOTANY.

John G. Coulter.

Some of us have been assured by those who have had to do with the program that the sharers in this symposium are not to feel themselves fettered by the specific limitations of their assigned topics. Hence my liberty in asking first, why we should be concerned at all in any special effort to increase interest in science work as a profession. General interest in science is another matter. as a profession. General interest in science is another matter. The aim of this symposium, however, appears to be to point out why a choice of their life work from the various branches of science is a desirable choice for young men to make.

It may be reasonably inferred, if only from the remarks made this morning in the discussion upon what shall be the dues of this organization (so happily placed at one dollar), that we have nothing very great in the way of financial compensation to offer. For that very reason, if we are good economists, should we not be the last to encourage more strenuous competition for the apparently limited number of real competences which exist for the sustenance of life workers in science? Yet we are most cheerfully engaged in doing that very thing. Though there may be far from enough to go around in generous portions, let us by all means have more in at the feast. There may be compensation in the extra-prandial proceedings.

An editorial in a recent science periodical estimates that fewer than five thousand persons in the United States are professionally engaged in science investigation or in the teaching of science up to the research point. Of these it reckons that fewer than one thousand should be counted real contributors. What are one thousand among eighty millions? We must accept the fact that several European nations excel us in this respect.

It comes to mind that our inferiority herein may be due as much to absence in the minds of the educated public of the aims and actual work in science progress as to anything else. Herein is, perhaps, the best reason for such a symposium and for such an organization as has just been perfected. These words of Matthew Arnold seem appropriate:

"The great men of culture are those who have had a passion for diffusing, for making prevail, for carrying from one end of society to the other, the best knowledge, the best ideas of their time; who have labored to divest knowledge of all that was harsh, uncouth, difficult, abstract, professional, exclusive; to humanize it, to make it efficient outside the clique of the cultivated and learned."

The point is, then, that our real science workers are both too few and too remote from the general public. They work very largely in another world than the one of common conception. From the world of common knowledge they must, perhaps always, remain aloof. But may not the real value of their work be at least adequately conceived?

In Europe the magazines and even the shop windows furnish evidence of the popular interest in science progress. Wherever the forward movement is most active you catch a quick reflection of it in the popular press. There the public is said to be really much concerned of late with what is sometimes called the "passing of Darwinism." What does the American public know or seriously care about Darwinism being on its death-bed?"

Here our editors shun the rather dry and obscure authorities in favor of picturesquely worded and sensation-charged celebrities; and, reciprocally, the authorities shun the editors.

Yet are we not ready to admit that the modern aspect of "national progress" depends very largely upon the number of properly qualified persons who are engaged in science research, and, perhaps as much, upon the extent to which the general public follows their advance?

Does not the fault for this large American gap between science workers and the general public lie much with the scientists who have held aloof; who have rarely taken it as part of their task properly to popularize the problems on which they are at work; who have let misrepresentation go almost unchecked; who have done much to form a sort of aristocracy of their own kind?

But, wherever the fault lies, we must lessen the gap. The constitution we have just adopted explicitly commits us to this. Unless there develops more popular interest in the great truth search, in this and its many other aspects; unless there develops more feeling of personal responsibility in finding out for one's own self, and less of being easily satisfied with the first plausible explanation, then the national peril for lack of "clean truth" to which Dr. Chamberlin made reference this morning is surely not very difficult to perceive; a reference which, by the way, has some responsibility for this digression from my topic.

Specifically, of the opportunities in botany, we can say that the demand for trained botanists continues to exceed the supply. Such demand is, of course, especially for young men ready to begin their service at compensation less than the theoretical value of the service rendered. Further, it is almost exclusively a demand for men to whom the service means at least as much as the compensation. But, as such, it is unquestionably a vigorous and growing demand.

The most extensive employer of young botanists in America is the United States government, and we are very reliably informed that the various bureaus of the Department of Agriculture are in positive need of more men adequately trained in plant morphology and physiology than they can find. Such training is usually sufficiently well attained in two or, at most, three years of graduate study.

It is becoming increasingly difficult to differentiate between botanists pure and simple and special students of agriculture. Yet we are loath to lose good men through a mere juggling of terms, as botanist into agrcnomist or something like, even though the latter cashes in better. So, among present-day opportunities in botany should not be overlooked the one of being botanist in fact only, with sedulous advoidance of a name which suggests nothing of the large cash values upon which this section of the profession, under its many aliases, may justly pride itself.

For teachers of botany the market is still brisk, though the upward tendency is not perhaps so marked as in other lines of demand. Doctors of philosophy in botany are commanding beginning salaries in teaching positions which average about fifty per cent. more than those offered eight years ago. There are in the main, of course, positions of collegiate or equivalent rank. It is for teachers of lesser training that the demand has shown a barely perceptible falling off. But this is more than offset by the increasing demand for teachers of agriculture for the rural high schools. What botany in some quarters is threatened with losing as a high school subject, agriculture has already more than gained. Since the question has become very largely one of teaching much the same subject in a more efficient way, we may expect that botany, in this respect, will be a graceful loser.

In the Philippines a "practical" botanist is wanted in every province, of which there are more than thirty, to take in charge the immensely important educational side of the problem, especially from the standpoint of the agricultural possibilities. No stereotyped problem here, nor meager compensation therewith!

The opportunities for amateur work in connection with the academy should, perhaps, receive a word of comment. Apart from its large educational function, I take it that the contributory work of the academy will confine itself, in the main, within state boundaries. With such limitation, and assuming the co-operation of a considerable and favorably distributed number of persons, an ecologically annotated geographic catalogue is perhaps the first task which suggests itself. Such work for such an organization has the peculiar virtue of simplicity in its individual parts, absolute necessity for extensve co-operation, and the very large value of the final symposium. The humblest sharer in the work may be thoroughly satisfied that his part is quite as important as almost any other part.

Of intensive area work in ecology, Cowles's work on the dunes and Gleason's quite recent study of sand-flat areas of the Illinois river forcefully suggest the considerable number of similar, yet untouched and equally attractive, problems within the state.

The native prairie plants, made historic by their striking floral aspects alone, remain undisturbed in but few and restricted areas. The salvation of a strip of native prairie large enough to reveal the original ecological factors may be already impracticable, but the academy may well have in mind the establishment of a state garden of the native plants.

Fresh acres in garden and field will be given each year to the new experiments in plant breeding, and here, too, the amateur may well lend a hand, though our agronomical friends may question whether such a suggestion is pertinent among points for amateur *botanists*.

In closing, I beg to submit a definite suggestion for which I must again seek excuse in that incontestable statement of our president this morning, that in lack of clean truth there lies national peril.

Nowhere in our educational literature is the absence of clean truth more conspicuous than in the nature-study books which are in common use in the graded schools. Nowhere has the unauthorized word had wider play or more credulous following. Untrained teachers have had nature study thrust upon them and have turned with avidity toward whatever seemed to offer help. Composites of sentiment and inaccuracy have been liberally supplied as "supplementary reading."

The suggestion is that there be issued in the name and under the direct auspices of the academy a series of leaflets upon science topics suitable for use as material in nature study and geography. Such topics should be treated especially from the standpoint of the state in so far as they lend themselves suitably to such treatment. Such leaflets should be available to the public schools at low cost. An educational editor, perhaps a member of the standing committee upon publication, might have in charge the apportionment of topics to members willing to cooperate, and ample discretion in editing to suit the educational needs in view should be allowed such an editor.

In objection, the point may be raised that in its very infancy the academy would be rash to venture to finance such a scheme. It may be confidently stated, however, that funds sufficient for such purpose would be at the disposal of the academy in case such proposal meets its good will.

A similar service has been and continues to be rendered by the Cornell Nature Study and Agricultural Leaflets.

OPENINGS FOR CHEMISTS

W. A. Noyes.

Eighteen years ago, as I was sitting in a cafe in Munich one evening, talking to a young Englishman, he said to me, "England has the present but America has the future." He meant, of course, that while England at that time stood in the forefront of progress, industrially as well as politically, the conditions were such in America, both in our command of natural resources and in the character of our people, as to make it practically certain that the lead in both respects must go to America in a not far-distant future.

In the years which have passed since that time, this prophecy has been going on toward a rapid fulfillment. As an illustration, we may take the manufacture of iron. At that time more iron was manufactured in England than in any country in the world, but within a few years afterwards the production in America exceeded that in England, and it is now very much greater here than there.

In this increased industrial activity in America, chemists have played and are playing a very important part. In this very industry of the manufacture of iron and steel, twenty-five years ago very few chemists were employed in this country, but today chemists are required not only in the large establishments where steel is produced, but in foundries and factories of all kinds where large amounts of iron are used.

What has happened in the iron industry has happened also in a great variety of other industries. To speak of the different lines in which chemists are today employed would be almost to give a list of the important industries of the country. There is in these and in chemical work in general a rapidly increasing diversity. During the past year the American Chemical Society has established an abstract *Journal* which intends to give an account of all new work in chemistry which is published in the world. The abstracts in this journal are classified in thirty divisions, and this illustrates the great variety of industries and directions in which chemists are interested.

The amount of knowledge which has been accumulated in chemical science is so great that I feel safe in saying that the detailed knowledge in this science is greater in amount than the whole mass of scientific knowledge in all sciences fifty years ago. I do not, of course, mean that the value of this chemical knowledge is greater than the value of the scientific knowledge fifty years ago, but merely that its amount is greater, and I say this for the purpose of emphasizing the diversity of interests among chemists.

It is estimated that there are about eight thousand chemists employed in the United States at the present time. One of the previous speakers has referred to an estimate that there are only five thousand scientific men in the United States. While I do not suppose that all of the eight thousand chemists can be properly classed as scientific men in the sense in which the term was used by the former speaker, I am inclined to think that this number indicates that there are many more scientific men in the United States than would correspond to that estimate. The increase in the number of chemists during the past twenty-five years has been very largely occasioned by the employment of chemists in the industries. A quarter of a century ago, nearly all of the chemists in the United States were engaged in teaching, while today the majority are undoubtedly working in industrial lines.

But it is not merely in the industries that the number of chemists has greatly increased during this period. Thirty years ago very few educational institutions could have been found which had more than three or four chemists on their staff. In the institution with which I am connected, the staff includes more than thirty chemists who are engaged in teaching or research, and I do not think that the institution is unusual in this regard.

Very large numbers of chemists have also been required in recent years by agricultural experiment stations and by government bureaus. Since the enactment of the pure-food law especially, the demand for chemists to fill positions in connection with the bureau of chemistry has largely exceeded the supply of suitable men, and during the past summer many of those who have been called upon to answer inquiries for chemists to fill positions have been compelled to reply that they had no suitable candidate to recommend.

OUTLOOK FOR YOUNG MEN IN GEOLOGY

H. Foster Bain.

Probably our academy can do no one thing more useful than to encourage the young men and women of talent who are looking forward to a career in science. By this is not meant a deliberate effort to divert men and women from other work to ours, but rather the holding out of a helping hand to those whose inclinations are toward a scientific career, but who hesitate for fear that there is either no work or no place for them.

It is well known that men of science receive relatively poor financial returns for their work. Capable and industrious workers make a good living, but rarely are able to accumulate wealth. This is true of geologists as of others, and I for one am by no means sure that a change in this regard would bring to our profession any larger number of men of the highest talent and devotion. Be that as it may, the best which can be now offered to the hesitating young man is a good living while he does his work. The opportunities for making his way are found in three lines of activity: (*a*) teaching, (*b*) survey work and (*c*) industrial positions.

Geology is seldom taught in high schools and secondary schools, though there is a strong and increasing demand for teachers in physiography. This affords an excellent opening for beginners. In the colleges, universities and mining schools, geology is taught as frequently as the other sciences, and there are, accordingly, as many positions open.

The largest number of professional geologists in this country are connected for a whole or a part of their time with official surveys or bureaus. The greatest of these is the U. S. Geological Survey, which in the season just closed maintained ninety-three geological field parties. These each included from one to three geologists or aids. In addition many of the topographic and other field parties were engaged upon work so closely related to geology as to afford suitable opportunity for service on the part of beginners at least. In the forest service and in other branches of government work still other men are employed. Thirty-one of the states now have state geologists or equivalent officers, and sustain more or less geological work. This work varies greatly in character from refined paleontologic investigations to the registering of mining prospectuses and bureau-of-information work. In some cases only a few hundred dollars are appropriated for the summer field-work, perhaps, of the professor of geology at the university, and in others several thousand dollars are given annually and ten or a dozen field parties maintained. State survey work, where available, offers peculiar advantages to the beginner, since on account of the small force there is less specialization.

In mining and industrial work geologists are finding an increasing number of opportunities. Many railways, mining companies, development companies, etc., now employ one or more geologists. This indicates a welcome change of attitude in the public recognition of our work, but for the time being it cripples survey work by drawing away many of the best men. These positions are eagerly sought and pay relatively well, but usually offer only restricted opportunities for research work and often prohibitive conditions as regards publication. It is to be hoped that in time these restrictions will largely disappear.

Granted, then, that properly equipped and willing workers may rest assured of positions being open to them, the vital question remains as to the work to be done. To some extent, in geology, pioneer conditions have passed. In our portion of the world geologic mapping on some scale has very generally been done. In much of Canada, in Alaska, in parts of Mexico and in most of South America pioneer conditions, as regards geology, still prevail. Very little of either Africa or Asia has been carefully studied so that as regards systematic work alone the bulk of our task is still before us. If also we measure the work from the point of view of development of ideas, the task is even more attractive. Geology has heretofore been mainly in the qualitative state. Its workers have been busy developing the processes involved and have had only the crudest means of elimination when it was necessary to test one hypothesis against another. As Van Hise has pointed out, we have now at least entered into the quantitative stage, and this means nothing less than the reduction to an orderly basis of the accumulated observations of all the years past. As we accomplish this we shall change our science from an inexact one of hypothesis to an exact one of law; and we shall then stand on an equal basis as regards certainty with our associates of the physical and mathematical sciences. This is certainly a field large enough and important enough to attract the best energies of any man or woman. If our academy shall help to put the right man in touch with his problem and the means of solving it, we shall quickly justify its existence.

OUTLOOK FOR YOUNG MEN IN PHYSICS

HENRY CREW.

Mr. Chairman and Gentlemen: Sudden and unexpected as this call is, I feel bound by the courteous manner in which the invitation is extended, to respond.

The opportunities offered by the science of physics may for convenience, at least, be grouped under the four following heads:

(1) *Research.*—To him who finds his "manifest destiny" in investigation, the recent discoveries of physical science have vastly multiplied the opportunities for new discoveries. To illustrate: when Hertz in the autumn of 1888 showed us how to produce electric waves, a tremendous field was opened to research. The various properties of waves of different lengths, under different conditions all had to be studied. Every year some new domain of this kind is made ready for occupation by the earnest and serious student.

(2) *Applied Physics.*—For him who has that practical turn of mind which characterized Franklin and has yet preserved an interest in pure science (which also characterized Franklin) there is always a rare opportunity. In the autumn of 1831 Faraday not only discovered the induction of electric currents, but also actually made an electric motor and an electric generator about the same time. But it was not until the late sixties that the dynamo became a commercial success. This delay is typical of the mental hysteresis which generally separates discoveries in physical science from their industrial applications.

It was seven years after Hertz's discovery of electric waves that Marconi showed them to have commercial value; and it has taken practically twenty years to employ them for trans-atlantic messages. In these intervening periods lie great opportunities for the alert "practical mind."

(3) *Engineering.*—Nearly all the great engineering concerns of America are looking for more men than they can now find of the broadly trained type—men who are acquainted, *at first hand,* with the general principles of physical science. A man may know every machine in the shop of an engineering firm and yet not know how to design a new mechanism to meet a new want or a new circumstance. What is demanded today is, therefore, not so much an acquaintance with present-day practise as a thorough mastery of the fundamental principles of engineering—and these are mainly the principles of physics.

4) *Teaching.*—The high salaries which engineering concerns are offering to men well trained in physical science and to men of executive ability have had the effect to leave vacant many excellent teaching positions in physics. The door is wide open for him who enjoys this line of work and who is willing to leave behind all hope of opulence.

OUTLOOK FOR YOUNG MEN IN ZOOLOGY

H. V. NEAL.

In the ten minutes allotted, I shall attempt to answer six questions of special interest to those who are planning to enter zoology as a profession. Through the kindness of Professors Mark, Minot, Comstock, Sedgwick, Reighard, Lillie, Conklin, Ward and Jennings, who have generously responded to my appeal for information, I am in a position to state the outlook for young men somewhat from the standpoint of their experience. As far as possible, the answers to the questions relating to the topic assigned me will be given in the words of the above-named zoologists.

1. *How do the chances for getting good positions compare with those of a decade ago?*

All of the zoologists who have expressed an opinion on this question agree that the chances are much better than they were a decade ago. Professor Comstock writes: "I should say that they are much better. It is only fair to emphasize, however, that the man who takes up work along these lines purely as a financial venture, apart from other considerations, will be disappointed. And I should say also that a large part of the demand for entomologists in recent years has been due largely to the great increase of this kind of work in the Department of Agriculture at Washington. Many men have found places with Dr. Howard or have taken places vacated by others who have gone to Dr. Howard. If the government support of this kind of work were to cease it would make a great difference in the chances for getting good positions."

Dr. Mark writes: "Have been surprised that the demand has increased so rapidly. This has been more noticeable in the field of comparative anatomy than in other lines during the past five or ten years."

According to Dr. Minot, "There is great difficulty in getting any men for positions in anatomical and zoological laboratories, and I believe that for a few years the opportunities will be unusually good. But for heaven's sake, do not encourage any mediocrities to go into science. If you can, have them Oslerized at sixteen."

Dr. Conklin thinks that the chances of a young man's going at once from his graduation to the headship of a department are probably not so great now "as they were a decade ago."

Dr. Jennings says that "it is difficult to get the men needed for positions in zoology, and this is true all along the line from assistantships up to full professorships."

2. *Is is ever necessary for a man with a doctor's degree to rest on his oars for a year because no desirable college or university position is open to him?*

The reply of Dr. Lillie is typical of the answers given to this question: "In the course of a good many years several of our doctors of philosophy have accepted positions in high schools and normal schools; in such cases it has usually been a matter of preference with them. So far as I know, there has never been a case of one of our doctors of philosophy being obliged to go without a position for even a year."

According to Dr. Jennings, "many excellent positions have gone to men without the doctorate."

3. *Does the number of desirable positions equal the number of candidates?*

Dean Ward writes that "there have been more desirable positions in zoology which have come to my attention in the last five years than I could have filled times over if every one of my advanced students had been ready to consider such opportunities. We have not been able to furnish enough teachers to supply the college demand, nor enough collectors and workers for museum and government positions. The expansion in connection with college teaching, the demand for more men in old institutions and for new men in those recently founded has exceeded the supply."

Dr. Reighard writes that in his department "the number of applications for candidates to fill positions in biology and zoology has for some years fallen far short of the supply. I have had about ten applications for the present year and have been able to fill *none* of them with men directly from my laboratory. Two were, however, filled with men who have recently been here. These were applications for *men* and for positions above secondary-school grade."

4. *Has the number of men entering zoology as a profession increased or decreased?*

"There certainly has been no increase in proportion to demand," says Dr. Jennings. Dr. Reighard, however, writes that "the number of students in advanced classes with the definite purpose of preparing to teach in institutions above secondary-school rank, is *less*.'

5. *Are any new fields opening up for zoological students?*

According to Dr. Sedgwick "The demand for men in physiolgy and sanitary biology is particularly brisk, especially in the latter subject. For several years it has been impossible to meet the demands for young men properly equipped to fill positions in sanitary or industrial biology."

Dr. Reighard writes that "to a certain extent new fields are opening up: (*a*) I have had two applications within a month for men to fill positions in experimental research work, particularly breeding experiments, in agricultural colleges, under the Adams act. (*b*) There is a slowly increasing demand for men to undertake museum work. We have difficulty in keeping good museum men here. (*c*) Some of the older educational institutions are reorganizing their zoological departments and expanding them. (*d*) The normal schools are seeking men (and women) with the newer, ecological training, capable of organizing work along 'nature study' lines. I have had a couple of calls of this sort within a few months."

According to Dr. Jennings, "Some new fields are opening for zoological students. The various research institutions recently established take a number. The Adams act recently enacted by Congress promises to call a number into the service of state experiment stations, and has begun to do so already. I should judge that many more educational institutions require competent men in this line, or a greater number of them, than was the case a few years ago. On the whole, I should say that the prospects are excellent in zoology at present, particularly for the investigator."

6. *Is the demand for zoologists likely to continue as great as at present?*

There seems to be good reason to believe that the conditions which have kept up the demand for the past decade will continue in the next. Even financial depression such as that of the present time does not seem to diminish the number of students in higher institutions of learning. The policy of the General Education Board and of the Carnegie foundation will tend not only to open up new positions for younger men, but also to make college and university positions more attractive.

From such considerations, we need not hesitate to encourage the exceptional man whose tastes lead him in that direction to enter zoology as a profession, with the well-grounded hope of attaining such a position as his talents deserve.

TRANSACTIONS

FIRST REGULAR MEETING.

JAMES MILLIKIN UNIVERSITY, DECATUR, FEB. 22, 1908.

MINUTES.

MORNING SESSION.

The meting was called to order by President Chamberlin, at 10 A. M., 96 persons being present. The minutes of the organization meting of December 7, 1907, were read and approved.

The Treasurer made announcements concerning payment of dues, and plans for the present meeting.

Prof. Forbes reported for committee on membership, list of names recomended for election and an additional list of names of persons whose nomination for membership had not been seconded. The persons properly nominated and recommended, were voted in.

The following papers were read:

Biotic Zones and Districts of Illinois.—Charles A. Harts.

A Case of Phosphorescence as a Mating Adaptation.—T. W. Galloway.

Some Problems connected with the Coals of Illinois.—S. W. Parr.

The Desirability of a Systematic Ecological Survey from the Standpoint of Plant and Animal Associations.—H. C. Cowles.

A State Ecological Survey.—E. N. Transeau.

A Virgin Prairie in Illinois.—H. A. Gleason.

Occurrence of Oil and Gas in Eastern Illinois.—H. Foster Bain.

Illinois Trees.—T. J. Burrill.

Plant Pathology in its Relation to other Sciences.—Ernest J. Reynolds.

President Chamberlin spoke on the desirability and a method of affiliating with other scientific societies in the State; gave an account of the discussion at the meeting of the Council which was called by the President, December 30, in Chicago; and invited those interested in considering plans to meet at 1:45, before the opening of the afternoon session.

Prof. Forbes stated that as the result of many years' labor a great mass of ecological material had been collected by the State Natural History Survey, named and labeled, and was at the disposal of students. He spoke of his gratification at the increasing enthusiasm for the work.

A. R. Crook expressed the hope that the Academy would aid the State Museum of Natural History in securing materials to illustrate both the mineral resources of every section of the State and the relation of animals and plants in various portions of the State to each other and to their environment.

C. C. Adams suggestd that definite work be taken up in order that a report could be made on some locality.

The meeting was then adjourned till 2 P. M.

Afternoon Session.

At 2:25 P. M. the Academy was called to order by President Chamberlin.

The following papers were presented:

Relation of the State Academy to the Natural History Survey of the Chicago Academy of Sciences.—Frank C. Baker.

Farm Water Supplies.—Edward Bartow.

President Chamberlin made an announcement concerning the publication of the transactions, requesting all who were taking part in the program to send copies or abstracts of their papers to the secretary, inasmuch as it is desirable to have a record of these papers to show the subject matter considered and the condition of science in the State at the present time. He expressed the hope that means for publication would be provided by the state legislature, as was customary in other states.

The chairman of the committee on membership presented an additional list of names and they were voted in.

It was voted upon motion of H. F. Bain that the chairman appoint a committee of five on the collection of drill records.

On motion of S. A. Forbes, the following resolution was adopted:

Resolved, That scientific organizations which enter into relations of affiliations with the Academy may each nominate one of its members to be a member of the Academy Council, who shall have the right to vote on questions specifically relating to matters covered by the terms of their affiliation, but not on other business.

On motion of H. F. Bain, it was voted to invite appropriate organizations to select some member of their company to represent them on the Academy Council while an ecological survey of the State is being made.

A symposium on "The Atmosphere," was participated in by T. C. Chamberlin, Albert P. Carman, H. C. Cowles, John M. Coulter, Wm. A. Noyes, Chas. E. M. Fischer, H. Foster Bain.

The meeting was then adjourned.

As the guests of W. F. Barnes, M. D., the members of the Academy were conveyed to the Decatur Country Club and entertained at a dinner which served to celebrate George Washington's birthday and the first meeting of the State Academy of Science in a most pleasing manner.

Evening Session.

At 8 P. M., A. A. Michelson lectured on "Recent Advances in Spectroscopy."

A. R. Crook,
Secretary.

ABSTRACTS OF PAPERS.

BIOTIC ZONES AND DISTRICTS IN ILLINOIS.

CHARLES A. HART.

Temperature as a universal factor causes differences in the biota according to latitude, modified to some extent by elevation above sea-level, thus permitting the delimiting of life zones. In the United States the three principal zones in current acceptation are all represented in Illinois. Zones are limited according to distribution of characteristic species, and many species of each zone range into the borders of those adjacent to it. The ranging of Lower Austral and Transition species a considerable distance into Illinois should not be used as an argument for extending the boundaries of these zones over Illinois to such a distance as to unduly narrow the intervening Upper Austral zone, as some investigators have done in adjacent states.

Within the Upper Austral zone in Illinois, variations of soil, vegetal covering, and climatic conditions are definitely enough marked to permit the division of this area into a number of biotic districts; and these, together with the adjoining zones, give the following series from north to south:

1. Transition zone. Small area at northeast, including a large part of the Chicago area.

2. Northeastern sand area. About south end of Lake Michigan and headwaters of Kankakee River in Illinois.

3. Western and northwestern sand areas. In Illinois and Mississippi river valleys, exterior to Wisconsin morainic border.

4. Northern Prairie. Greater part of northern and central Illinois, as far south as latitude of Wisconsin morainic border in eastern Illinois.

5. Southern Prairie. From the Northern Prairie to the Ozark ridge. The life approaches that of the sand regions.

6. The Ozark Ridge and River Valley area. Life of southern type, and of rough, rocky forested ground, extending up the larger river valleys.

7. Lower Austral zone. Area south of main Ozark ridge.

"A CASE OF PHOSPHORESCENCE AS A MATING ADAPTATION."

T. W. Galloway.

There appears periodically in certain waters of the Bermudas, an annelid in which the phosphorescence is clearly a direct mating adaptation.

The worms are never seen except at mating time. They appear at dusk, quite regularly for three to five days, at intervals of approximately a month.

The female swims at the surface and is intermittently phosphorescent as the eggs are extruded. The males, which are deeper in the water, are at once attracted, and copulation takes place with wonderful uniformity and certainty. The males are somewhat phosphorescent, but, so far as can be observed, this serves no end in the mating.

If males are not attracted at the first display it is repeated, at short intervals, for three or four times.

In nature, the worm is not phosphorescent after the mating, apparently. In confinement, a dull phosphorescence may be produced by disturbance for an hour or more.

This phenomenon makes it possible to study the embryology of the species with exactness.

SOME PROBLEMS CONNECTED WITH THE COALS OF ILLINOIS.

S. W. Parr.

I. Weathering of Coal.

Summary of results:

(*a*) Submerged coal does not lose appreciably in heat value.

(*b*) Outdoor exposure results in a loss of heating value varying from 2 to 10 per cent.

(*c*) Dry storage has not advantage over storage in the open except with high sulphur coals, where the disintegrating effect of sulphur in the process of oxidation facilitates the escape of hydrocarbons or the oxidation of the same.

(*d*) In most cases the losses in storage appear to be practically complete at the end of five months. From the seventh to the ninth month, the loss is inappreciable.

(*e*) The results obtained in small samples are to be considered as an index of the changes affecting large masses in kind rather than in degree, but since the losses here shown are not beyond what seems to conform in a general way to the experience of users of coal from large storage heaps, it may not be without value as an indication of weathering effects in actual practice.

Further studies are to be continued, having reference to actual storage conditions.

II. Deterioration of Coal.

Summary of results:

(*a*) An exudation of combustible gases from coal occurs from the time of breaking out of the sample from the vein.

(*b*) An absorption of oxygen accompanies the exudation of hydrocarbons.

(*c*) Samples of coal in most carefully sealed containers are subject to deterioration.

(*d*) The process of deterioration is probably due to oxidation of hydrogen or hydrocarbons by means of the absorbed oxygen. It may also be due to a simple loss of combustible gases and the replacement of the same by non-combustible gases such as oxygen.

(*e*) The rapidity or extent of this deterioration varies with different coals but is probably most active during the first two or three weeks from the taking of the sample, and does not seem to reach a normal state till after a few months have elapsed. Further data on this point especially are necessary.

It is interesting, also, to bring together the averages of the results in the three tables for further comparison. There is thus afforded further evidence suggesting the fact of deterioration.

THE DESIRABILITY OF AN ECOLOGICAL SURVEY OF ILLINOIS BASED ON PLANT ASSOCIATION.

H. C. Cowles.

The oft-repeated words "vanishing data" have no more apt use than in connection with our native plant associations. The state should be systematically surveyed by botanists and zoologists, and maps should be made, showing the distribution of the associations. Where topographic maps have been published, and especially where geologic folios exist, this work should be much more easily accomplished than elsewhere. A start has been made at this work in Chicago, but much co-operation is necessary for success. The Academy might well take up such work as this officially.

A STATE ECOLOGICAL SURVEY.

Edgar N. Transeau.

The fact that the native fauna and flora of Illinois are rapidly disappearing, makes imperative a survey of the state which shall serve not only as a record of the past and present conditions, but which shall throw light upon certain fundamental biological problems.

Illinois by virtue of its geographic position offers exceptional opportunities for the investigation of the factors involved in the development of the prairie and the forest; the study of the post-glacial migration of both plants and animals; the determination of the methods of competition between biotic associations belonging to four great centers of distribution; the relation of great tension lines to the origin of species.

The fundamental plan of such a survey should be geographic and involve the entire state. Its methods should be ecological and involve the study of both plants and animals from the point of view of the habitat. Taxonomic work should be subordinated to the investigation of biological problems. The bearing of such work upon agriculure, horticulture and forestry is well known. It is the one method of working up the biological resources of a state which will give results valuable alike to theoretical and applied science.

Such a survey carried out under competent direction will provide a fund of information for natural history students throughout the state; will be of assistance to every teacher of botany, zoology and geography; will aid in the solution of many biological problems; will advance our knowledge of the natural resources of Illinois; will aid in their conservation; and will suggest the proper methods for their development.

A VIRGIN PRAIRIE IN ILLINOIS.

H. A. GLEASON.

Twenty miles northeast of Champaign is a five-acre strip of untouched prairie lying along a small stream. It contains a large number of the rare species of prairie plants, notably *Cypripedium candidum* and *Lilium umbellatum*. It is highly important that the strip should be preserved, and negotiations to that effect are already under way.

OCCURRENCE OF OIL AND GAS IN EASTERN ILLINOIS.

H. Foster Bain.

The year just closed was a very prosperous one in the petroleum fields of Illinois. The area was extended rapidly to the southeast, many gaps were filled in, new and lower sands were tapped, additional pipe-lines were laid, a new refinery was built and the output was phenomenal.

At the close of 1906 the number of producing wells was estimated at 4,185, and 532 dry holes were known to have been drilled. The total number of producing wells January 1, 1908, may be estimated at 9,772, with 1,260 dry holes. At this rate 88 per cent. of the holes put down have proved productive despite the fact that the outlines of the field are at many points yet to be determined.

The first oil was shipped from this field in June, 1905, and the shipment for that year, all of which went out in tank cars, amount to 156,502 barrels. In 1906 a pipe-line was extended into the territory, and the shipments as reported by the Ohio Oil Co., were 4,385,470 barrels.

There are now collecting mains extending from north to south throughout the field and four 8-in. lines (or an equivalent) from Martinsville, the central pumping plant, eastward across Indiana. A new line has recently been put in service running westward to a large refinery built this year near Alton, Illinois, by the Standard Oil Co.

The pipe-line runs for 1907, given through the courtesy of the Ohio Oil Company, were as follows:

PIPE-LINE RUNS FROM ILLINOIS, 1907.

January	752,670	barrels
February	918,620	barrels
March	1,494,598	barrels
April	1,823,024	barrels
May	2,094,194	barrels
June	1,830,633	barrels
July	2,376,281	barrels
August	2,398,895	barrels
September	2,560,592	barrels
October	2,818,952	barrels
November	2,464,980	barrels
December	2,201,265	barrels
Total	23,734,704	barrels

To these figures must be added something for the fuel oil shipped by cars from Duncanville, the oil used by the local refinery at Robinson, and the tank-car shipments of the Sun, Cornplanter and other independent companies, amounting to something over 800,000 barrels. The recorded production for the year is 24,540,024 barrels, and probably the actual production ran a little over this. The oil, in the main, grades 32 degrees or better, and sold at the standard price of 68 cents per barrel. Only a limited amount was lower and sold at 60 cents. Of the year's production, 12,610,618 barrels are stored in the field by the Ohio Oil Company and a large amount is in producers' tanks.

OCCURRENCE.

The oil occurs in a number of isolated pools which, however, are being brought closer together by drilling. It is not improbable that they will eventually be found to overlap. To the north they are higher stratigraphically, and also shallower in depth. The Westfield pool is in the upper coal-measures. Most of the oil in Crawford county seems to come from the lower coal-measures, well down toward the base. In Lawrence county there are three sands, the main production being from the Buchanan sand at 1,300 ft. This probably represents the Mansfield sandstone of the Indiana geologists, an approximate equivalent of the Pottsville strata of the East. The Kirkwood sand at 1,600 feet is in the Chester. Farther south in the Princeton, Indiana, the Chester group is also productive.

In general the year's work resulted in extending the field to the south and in connecting up intervening territory. Wild-catting was active in other parts of the state, but so far without much result. Some gas has been found near Medora, and one or two oil wells have been brought in at Sparta, but as yet too little has been done to test thoroughly any considerable portion of the field.

ILLINOIS TREES.

T. J. Burrill.

Illinois was originally a prairie country, but there were also large bodies of woodland. The northern and southern quarters were better wooded than was the central half of the area, tho the latter had many groves and belts of timber. The trees were of numerous species and often were finely developed specimens. The largest were on the rich lands bordering the streams, notably upon the "bottoms" of the Mississippi, Ohio and Wabash rivers.

A very large proportion of the forests have been cut off, until today there is supposed to be but 18 per cent. of the whole area which can be classed as woodland. On the other hand, multitudes of trees have been planted and in many instances have grown into great size. There is far less "timber" existing now than formerly, tho there may be as many living trees as there were before the white man began his sway.

Only eight species of coniferous trees are native to our area, none of which existed in comparatively large numbers, and some of which were closely restricted in distribution. The broad-leaved kinds are represented by eighty-two native species which may be called timber trees. Besides these, at least seven kinds which reach the size of large trees have been introduced and are now self-perpetuating. Numerous other kinds have been planted and have proved to be well adapted to the prevailing conditions.

The time has fully arrived for effective action by individuals, by societies, and by the State looking toward the preservation and better utilization of our natural forests and for the extension and improvement of woodlands. The local conditions and general needs should be exhaustively studied in order that the best provision for the future may be made. Illinois has comparatively small forest areas, but has needs for forest supplies and influences enormously large. These can in part be self furnished. It is surely time that the work should begin.

PLANT PATHOLOGY IN ITS RELATIONS TO OTHER SCIENCES.

E. S. Reynolds.

In pursuance of the thought that science is a unit and not merely an aggregation of separate sciences, the relations of various sciences to plant pathology are to be considered. This science is defined as the study of the diseased conditions of plants, and its importance, as indicated by the large losses to the farmer caused by plant diseases, can not be overestimated.

The relations existing between pathology and botany are very close: In morphology we must study the natural and diseased forms and structure of plants, as well as the morphology of the attacking parasites; in physiology the normal and abnormal functions of host and of parasites must be investigated; from bacteriology many methods have been adapted to pathological study, and, as many diseases are caused by bacteria, the paths of the pathologist and of the bacteriologist cross; many diseases attack our woody plants and greatly endanger our forestries, thus bringing forestry and pathology into intimate relations.

When we turn to the other sciences, zoology attracts our attention, for insects and other animals either cause or carry many diseases. The diseased conditions in plants may cause disease in those animals which feed upon them. Between chemistry and pathology some intimate relations exist. The manufacture and use of fungicides, and the contributions of chemistry to our knowledge of the normal and abnormal plant products make evident these relations. The problems in plant pathology which relate to physics as well are even more subtle, for in these we must study such questions as involve the process of osmosis in plants, the ascent of water in trees, etc., and the influence of parasitic growth upon these processes.

THE RELATION OF THE STATE ACADEMY OF SCIENCE TO THE NATURAL HISTORY SURVEY OF THE CHICAGO ACADEMY OF SCIENCES.

F. C. Baker.

The relation of the State Academy of Science to various existing institutions is a matter for serious consideration, because the question is at once raised, "Can the State Academy perform any work which can not be equally as well done by some society already established?"

In addition to the social advantages offered by the State Academy it would seem that its most important work will be its relation to the various institutions as a central governing body, so far as the scientific work connected directly with the State of Illinois is concerned.

Provision should be made for a complete biological survey of the state, of such an exhaustive character as to leave no part of the area unknown. Much of the past work has been scattered over widely separated areas and has not been properly coordinated. The state should be divided into distinct areas, which should be thoroughly explored and the results co-ordinated with other similar areas. The method used by the Natural History Survey of the Chicago Academy of Sciences could be adopted with equal benefit in a general survey of the state. This survey covers Cook and Du Page counties and a part of Will county, embracing an area of about 2,500 square miles. Each lake, pond, creek and river has been thoroughly surveyed by a number of collectors and students, and the results have been turned over to the Academy and have resulted in the publication of six bulletins, and it may be safely said that there is no equal part of the state as well known, so far as the work has been published.

It is believed that the entire state should be surveyed in a similar manner. Should the State Academy seriously consider a biological survey, the relation of the Natural History Survey of the Chicago Academy of Sciences to this survey would be that of general supervision of the work in northeastern Illinois. It would seem that the various institutions scattered over the state should have general charge of the work in their immediate vicinity, which would later be co-ordinated by the State Academy. The State Academy might also, with great benefit to the scientific workers of the state, act as a central bureau of information, providing information relative to the most reliable sources for help on any given topic, and the Chicago Academy of Sciences would naturally offer aid in the departments of Mollusca and ornithology. By this means the State Academy would become the recognized center around which the scientific activities of the various workers would crystallize.

In conclusion the speaker wishes to place before the State Academy for its consideration the subject of a biological survey of a size and nature commensurate with the extent and importance of the great state of Illinois.

FARM WATER SUPPLY.

Edward Bartow.

Of the well waters sent to the State Water Survey during 1907, 60 per cent were condemned. Of the waters from wells less than twenty-five feet deep, 85 per cent. were condemned. Well water is usually sent to the Water Survey because of suspected contamination. Therefore, believing that these well could not represent the normal well waters in the state, series of samples were collected from farms in five widely separated sections, namely, at Elgin, Kankakee, Champaign, Centralia, and Cairo. At Elgin deep rock wells predominate, and are in excellent condition. At Kankakee shallow rock wells predominate, and are in good condition. At Champaign, drift wells 160 feet deep are in the majority, and are in good condition. At Centralia, the shallow dug wells predominate and are poor. At Cairo, the samples were taken from cisterns, driven wells, and from one artesian well. The wells are in good condition.

Conclusions drawn from the examinations made, indicate that driven, drilled or bored wells can be obtained in many parts of the state, and are preferable. Where dug wells are necessary, as at Centralia, better precautions must be taken to prevent surface contamination.

SYMPOSIUM ON THE ATMOSPHERE

Opening Address by T. C. Chamberlin.

In opening the symposium Mr. Chamberlin dwelt chiefly on recent deductions relative to the distribution of atmospheric molecules outside of the recognized atmosphere and occupying in an attenuated way the remainder of the sphere of control of the earth. The basis of these deductions lies, in the main, in the accepted principles of the kinetic theory of gases, but the application of these principles is modified by sources of molecular agitation springing from radio-activity and electric dissociation. In the lower horizons of the familiar collisional atmosphere the molecules are held to move to and fro encountering one another some billions of times per second. They therefore pursue essentially straight paths at equal rates between encounters, because the interval is too short to permit gravity to curve their paths. But as we ascend to the upper regions of the collisional atmosphere the distances between encounters increase until at length the free paths are sufficiently long to be curved by gravity. At still greater heights curved paths come to dominate, and the spacing becomes so open that occasional molecules, rebounding outwardly from collisions, do not encounter any other molecules in their paths. In these cases the molecules go outward until the attraction of the earth stays their progress and starts a return movement toward the collisional atmosphere, which increases in velocity until an encounter takes place. The principle remains the same whether the outshooting particle is directed normally or obliquely. In either case the molecule pursues theoretically an elliptical path. It is obvious that the more attenuated the atmosphere the more prevalent these escapes outward, followed by elliptical flights, must become. Gravity is the only barrier on the outer side and must ultimately take the place of collisions altogether in turning the molecules backward toward the earth. It is therefore inferred as a logical necessity that the outer face of the collisional atmosphere takes on this phase of action fully. Dr. Stone long since appropriately styled this phase of action, "fountain-like."

Logical analysis can not, however, stop here. The extent of the elliptical flight of any molecule is measured by the velocity it derived from the last encounter matched against the gravity of the earth. If the gravity overcomes the inertia of the molecule before it reaches the limit of the earth's control, it returns to the collisional atmosphere; if not, it passes beyond the sphere of the earth's control into that of the sun, and is lost, temporarily at least, to the atmosphere of the earth. Now under the Boltzmann-Maxwell law of distribution of velocities, some molecules must acquire velocities greater than the gravity of the earth can control. In addition to the velocities derived from the collisional atmosphere through the law of distribution, there are special agencies of agitation which give to some molecules of the external atmosphere exceptionally high velocities, and hence cause them to make excursions into the outer fields of the earth's control or pass entirely beyond it. Among these agencies are the impacts of meteorites, the ionizing action of ultra-violet light, the probable bombardment of the outer atmosphere by both electrons and alpha particles from the sun, the probable infall of molecules from the sun's atmosphere, the strokes of particles driven by light pressure, etc.

There does not, therefore, seem to be any bound which can be set as the outer limit of the earth's atmosphere of this class, except the limit of the earth's control. This limit of control on a line between the earth and the sun is, accordng to Moulton, 620,000 miles from the earth's center, and in the opposite direction, 930,000. These are the minimum and maximum radii of the spheroidal space within which the earth exercises greater differential attraction on molecules than the sun. This then may be taken as the strictest limitation of the earth's atmosphere.

Between the collisional atmosphere and this outer limit, the molecules in shooting out and returning are liable to collide with one another, and the rebounds from such encounters are liable to be in any direction. It therefore follows as a necessary consequence that if such a collision takes place when the velocities are of the higher order, and if the rebounds are more or less tangential to the earth's surface, one or both of the colliding molecules may pass into orbits about the earth, having such form that they will not encounter the collisional atmosphere. Inspection shows that of the molecules that have fallen back toward the earth a distance greater than its radius and which encounter molecules going outwards with like velocities, a notable percentage will pass into orbits instead of returning to the earth. This leads to the conception of an atmosphere formed of molecules that behave as satellites of the earth and are divorced, for the time being, from the collisional system and from the fountain-like system. It is important to observe further that this divorce lasts as long as the revolutional molecule escapes further encounter, and so, if we assume that the number of these is small, we at the same time impliedly assume that they have an excellent chance of remaining for long periods. This implies that the accumulation of such molecules may go on for correspondingly long periods if the accumulation is not rapid. Hence, although the accessions be few in any brief period the final accumulation may be relatively great. When it is considered that the outer field within the earth's control which might be traversed by such orbital molecules is 20,000,000 times as great as that which is occupied by the collisional atmosphere, it will be seen that the total mass of orbital molecules might be considerable though the density remained very small.

It will be observed that we have assigned to this large outer field of the earth's control, two sets of moving molecules: the fountain-like system of outshooting-returning molecules, and the orbital system. The molecules of these two systems cut one another roughly at right angles, and collision between them is a necessary consequence. The logic of the case seems to drive us to the conclusion that the collisions between the outshooting and infalling molecules of the fountain-like system, among themselves, will divert into the orbital system molecules until such numbers accumulate in orbital courses that as many of these latter are thrown out of their orbits by collisions with one another or with the outshooting-infalling molecules as are thrown into the system by the latter. In other words, we seem forced to recognize a self-imposed limit which marks a state of equilibrium between the systems, after which as many orbital molecules, roundly, will be thrown back into the collisional system, or outside the control of the earth, as are thrown into the orbital system. Similar relations of equilibrium will be established mutually between all of the three systems.

We have thus far ignored the rotation of the earth. As the atmosphere is carried with the earth the molecules in the outer part of the equatorial atmosphere are moving from west to east at a rate, roundly, of 1,000 miles per hour faster than the molecules at the poles. It follows from this that, of the molecules that are shot out from the equatorial belt, those directed eastward have the advantage of a rotational speed of 1,000 miles per hour, while those inclined to the westward have an equal disadvantage, a total difference of 2,000 miles per hour. Under these conditions molecules shot eastward will more largely pass into orbits than those shot against the rotation of the earth. It is therefore inferred that the orbital molecules of the equatorial tract moving in harmony with the earth's rotation will preponderate over those moving in the opposite direction, and that there will be a larger number of these than of any other class of orbital molecules. This view is strengthened by the fact that the influences agitating the molecules in the equatorial tract are more intense than those in higher latitudes. The earth is therefore conceived to be surrounded by a belt of molecular satellites revolving in the same direction as itself and having orbits at various distances from it out to the limit of control.

What may be the quantitative value of these rare supplemenary atmospheres is not here estimated. It is difficult to determine from present data. There are suggestions that these atmospheres have some appreciable value, in the great heights at which meteorites become incandescent from atmospheric impact and friction, and in the still greater heights to which the aurora extends. Its streamers are held to be incandescent molecules whose light springs from their ionization. Trigonometrical measurements give them heights reaching to 600 and even 1,000 km.

The profound function which the atmosphere plays in both the organic and physical kingdom of the earth are thought to be sufficient justification for tracing out its factors to any degree of refinement and for using logical deductions where direct observation is impracticable.

Discussion.

A. P. Carman spoke of the kinetic theory of gases and the mathematical assumptions made when we go beyond the very simple applications of that theory. The discussion of the escape of gas molecules from the earth's atmosphere involves assumptions of the rate of fall of temperature with height in the atmosphere. Extended experimental data on that subject are limited to a few stations, and then to a height of only two or three miles. The theory also calls for a change in the composition of the atmosphere as we go onward. The diagrams of Henrich and of Ferrel based on the dynamical theory of gases show that at comparatively small heights the percentage of the lighter gases of the atmosphere should increase measurably; and yet an observation at nine miles is on record, which shows no difference in the percentage of composition of the air at that height from the earth's surface. This can of course be explained as due to the mixture of the different atmospheric layers by currents; but it leaves us without confirmatory experiments. The rate of escape of the lighter gases from the earth's atmosphere, even according to mathematical physicists who allow that it can take place at all, is very small. Much data are therefore needed before we can speak with any great confidence of what takes place at the outer layers of the earth's atmosphere.

John M. Coulter said:

In considering the adjustment of plants to the present atmosphere, it is interesting to remember that there are plants existing, notably among the bacteria, which can live without free oxygen, which can manufacture carbohydrate food without chlorophyll or light, which can use free nitrogen, and which are remarkably resistant to external conditions that destroy other plants. This is suggestive of the possibilities of plant life under conditions that would forbid all existing vegetation. It is an open question whether the plants referred to are survivors of an earlier vegetation under different atmospheric conditions, or have developed these remarkable habits under existing conditions. At all events, they teach us that the atmospheric conditions which would permit plant life are not necessarily those that obtain now.

In reply to a question, W. A. Noyes spoke of the recent demonstration by Cady and McFarland, of Kansas University, that helium is a practically universal constituent of natural gas and hence must be present in the atmosphere; also of the fact that the presence of helium in natural gas indicates a wide distribution of radium, and has an important bearing, especially in connection with the experiments of Strutt, upon the question of the source of heat in the interior of the earth.

In reply to another question, he also spoke of the two directions in which there is, at present, some prospect of rendering the nitrogen of the air available for use as a fertilizer and in other directions, namely, in the manufacture of calcium cyanamide and in the manufacture of nitrates by oxidizing the nitrogen of the air in an electric arc.

C. E. M. Fischer: The maintainance of a pure atmosphere is an economic question of great importance, affecting as it does the health and life of the community.

Chemistry teaches us of what a pure atmosphere consists, and also informs us of the various inanimate impurities which are contained therein at various times and places. Biology tells us of the various plant and animal spores with which the atmosphere is laden.

Medical science owes it as a duty to the community to make use of the facts taught by chemistry and biology to bring about a pure state of the atmosphere by insisting that the same shall not be contaminated more than is unavoidable by dust of various kinds or noxious or poisonous gases and vapors originating in processes of manufacture, or by the careless introduction of disease germs therein.

The harm done by inanimate impurities consists not only of the diseases which they produce of themselves, but also of the lowering of body resistance with a consequent greater susceptibility to other diseases.

An individual whose lungs are continually being filled with the carbon particles of smoke, with particles of chalk dust, marble dust or the dust of metals, whose lungs and bronchi are continually being irritated by vapors of putrefaction, fumes from a laboratory, etc., whose blood is continually absorbing the gases of incomplete combustion, has very poor opportunity to become the oldest inhabitant. The germs of tuberculosis and pneumonia, to say nothing of the rest of the microbe family, mark him as an easy victim.

One of the most important of the animate impurities is the *Bacillus tuberculosis*. Rigidly *enforced* anti-spitting laws which will prevent the consumptive from depositing his daily contribution of 7,200,000,000 tuberle germs upon the sidewalk, later to be tdried and carried by the atmosphere thru a radius of many miles, will do much to decrease the yearly death rate from this disease, which in Illinois alone carried off over 7,000 inhabitants in 1907, and more than 150,000 in the whole United States.

Rigid quarantine of such diseases as scarlet fever and smallpox must also be here considered. That the atmosphere is important in their distribution is demonstrated by the fact that new cases often arise in the direction towards which the wind was blowing from improperly quarantined infected premises.

However, the province of the physician does not stop here. After seeing that a pure atmosphere is provided, he must see that the individual is able to make the fullest use thereof. No one realizes this more than the physician who has much practice among children.

It is a lamentable fact that many children, otherwise well cared for, are allowed to suffer from lack of sufficient air because of some nasal or pharyngeal defect whereby free respiration is interfered with. The importance of correcting such common defects as enlarged tonsils, adenoid growth, deformities and growths within the nose is a matter all too little appreciated by the laity, and countless children are left to suffer the effects of neglect of these conditions, never attaining their full mental or physical development in consequence thereof.

ADDRESS

RECENT ADVANCES IN SPECTROSCOPY.*

A. A. MICHELSON.

The fame of Newton rests chiefly on his epoch-making discovery of the laws of gravitational astronomy—by means of which the positions of the moons, the planets, and the comets, and other members of our solar system can be calculated and verified with the utmost precision, and in many cases such calculation and verification may be extended to systems of suns and planets outside our own.

But in no less degree are we indebted to this monumental genius for that equally important branch of astrophysics—in which the spectroscope plays so fundamental a role—by means of which we are enabled to discover the physical and chemical constitution of the heavenly bodies, as well as their positions and motions. As the number and intricacy of the wonderful systems of stellar worlds which the telescope can reveal increase with its power, so also do the evidences of the innermost molecular structure of matter increase with the power of the spectroscope. If Newton's fundamental experiment of separating the colors of sunlight had been made under conditions so slightly different from those in his actual experiment that in the present stage of experimental science they would at once suggest themselves to the veriest tyro, the science of spectroscopy would have been founded.

*Nobel Lecture, delivered by A. A. Michelson before the Royal Academy of Science at Stockholm, Dec. 12, 1907, and awarded the Nobel Prize.

So simple a matter as the narrowing of the aperture through which the sunlight streamed before it fell upon the prism which separates it into its constituent colors, would have sufficed to show that the spectrum was crossed by dark lines, named, after their discoverer, the Fraunhofer lines of the solar spectrum. These may be readily enough observed, with no other appliances than a slit in a shutter which is observed through an ordinary prism of glass. Fraunhofer increased the power of the combination enormously by observing with a telescope, and this simple combination, omitting minor details, constitutes that wonder of modern science, the spectroscope. As the power of a telescope is measured by the closeness of double stars which it can "resolve," so that of the spectroscope may be estimated by the closeness of the spectral lines which it can separate. In order to form an idea of the advance in the power of spectroscopes let us for a moment consider the map of the solar spectrum. (Fig. 1) * * (For Fig. 1 see colored plate in a good text-book of physics or an encyclopedia. Ed.)

The portion which is visible to the unaided eye extends from the Fraunhofer line A to H; but by photography it may be traced far into the ultra-violet region and by bolometric measurements it is found to extend enormously farther in the region beyond the red. In the yellow we observe a dark line, mark D, which coincides in position with the bright light emitted by sodium—as when salt is placed in an alcohol flame. It may be readily shown by a prism of very moderate power that this line is double, and as the power of the instrument increases, the distance apart, or separation, of this doublet furnishes a very convenient measure of its separating or revolving power. Of course this separation may be effected by simple magnification, but this would in itself be of no service, as the "lines" themselves would be broadened by the magnification in the same proportion. It can be shown that the effective resolving power depends on the material of the prism, which must be as highly dispersive as possible, and on the size, or number, of the prisms employed; and by increasing these it has been found possible to "resolve" double lines thirty or forty times as near together as are the sodium lines. It will be convenient to take the measure of the resolving power when just sufficient to separate the sodium lines as 1,000. Then the limit of resolving power of prism spectroscopes may be said not much to exceed 40,000.*

This value of resolving power is found in practice to obtain under average conditions. Theoretically there is no limit save that imposed by the optical conditions to be fulfilled—and especially by the difficulty in obtaining large masses of the refracting material of sufficient homogeneity and high dispersive power. It is very likely that this limit has not yet been reached.

Meanwhile another device for analysing light into its component parts has been found by Fraunhofer †, which at present has practically superseded the prism; namely, the diffraction grating. Fraunhofer's original grating consisted of a number of fine equidistant wires, but he afterwards made them by ruling fine lines on a glass plate covered with gold-leaf and removing the alternate strips. They are now made by ruling upon a glass or a metal surface fine equidistant lines with a diamond point.

The separation of light into its elements by a grating depends on its action on the constituent light-waves.

*Lord Rayleigh has obtained results from prism of carbon disulphide which promises a much higher resolving power.

†1821.

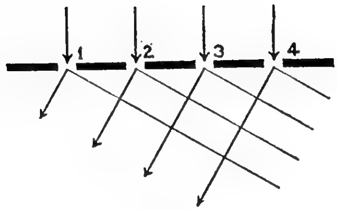

Fig. 2.

Let Fig. 2 represent a highly magnified cross-section of a diffraction grating with plane waves of light falling upon it normally, as indicated by the arrows. The wave motion will pass through the apertures, and will continue as a series of plane waves; and if brought to a focus by a telescope will produce an image of the slit source just as if no grating were present (save that it is fainter, and some of the light is cut off by the opaque portions). This image may be considered as produced by the concurrence of all the elementary waves from the separate apertures meeting in the same phase of vibration, thus re-inforcing each other. But this may also be true in an oblique direction, as shown in the figure, if the retardation of the successive waves is just one whole wave length (or any whole number), as is illustrated in Fig. 3,

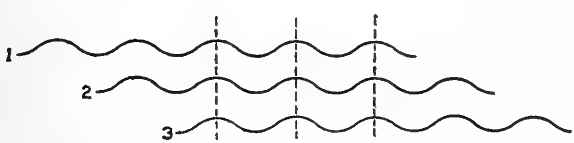

Fig. 3.

where the successive waves from apertures 1, 2, 3, are shown to re-inforce each other just as if they all belonged to a single wave- train. In this direction therefore there will also be an image of the slit source; and this direction is determined by the relation

$$\sin \Theta = \frac{ml}{s}$$

where l is the length of the light-wave of this particular color; s, the distance between the apertures (the grating space); and m, the number of waves in the common retardation (1, 2, 3, etc.) But even if the light thus diffracted be absolutely homogeneous (that is, consist of an infinite wave-train of constant wave-length) it does not follow that the light is diffracted in the given direction; there will be some light in directions differing slightly from this—growing less until the extreme difference of path is, say, n+l waves (instead of n), when it is nil.

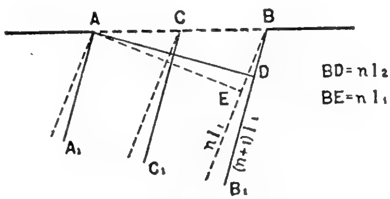

Fig. 4.

In fact, if we divide the pencil having this new direction into two equal parts, AC and CB, the ray AA, will be n+½ waves in advance of CC, and the two will be in opposite phases of vibration and will therefore neutralize each other. The same will be true of each pair of rays taken in the same manner over the whole grating space, and the result is total darkness for this direction. Let us suppose we are examining the double sodium line. The difference between the components is about one-thousandth of the wave length. With a grating of n lines there will be total darkness in a direction corresponding to a retardation of $(n+1)l_1$. Let this direction correspond to the brightest part of the image for the second sodium line l_2, so that $(n+1)l_1=nl_2$, or $l_2-l_1=\frac{l_1}{n}$. Under these conditions the two images are just "resolved." But $\frac{l_2-l_1}{l_1}=\frac{1}{1000}$ for sodium lines, whence n=1000. That is a grating of 1000 lines will "resolve" the sodium lines in the spectrum, or R=1000. In the second (where the common retardation is two waves lengths) the resolving power is twice as great, or $2n$, and in the *mth* spectrum, xm times as great. The resolving power is therefore the product of the number of lines in the grating by the order of the spectrum, that is, R=*mn*

In order, therefore, to obtain high resolving power the grating must have a large number of rulings, and if possible a high order of spectrum should be used. The rulings need not be exceedingly close together, but it is found practically sufficient if there are from 500 to 1000 lines per millimeter. The earlier gratings were relatively small and contained only a few thousand lines. The best of these were ruled by Nobert, (1851). A very great advance was made by Rutherford, of New York, who, in 1868, ruled gratings two inches long, on speculum metal and containing about 20,000 lines. These gratings exceeded in resolving power the best prism-trains in use at the time. The next advance was made by Rowland, of the Johns Hopkins University, who succeeded in ruling gratings six inches long (by two to three inches stroke) having about one hundred thousand lines, and capable (theoretically, at least) of resolving in the first spectrum, double lines whose distance apart was only one one-hundredth as great as that of the sodium lines. Practically this is about the limit of the power of the best Rowland grating which I have examined.

The difference between the theoretical and the actual performance is due to want of absolute uniformity in the grating space. This is due to the enormous difficulty in constructing a screw which shall be practically perfect throughout its whole length—a difficulty which increases very rapidly as the length of the screw increases, and it has been supposed that the limit of accuracy was reached in these gratings.

The great and rapidly increasing importance of spectrum analysis, especially in determining the distribution of light in so-called spectral lines under normal conditions, in the resolution of complicated systems of lines, and in the investigation of the effects of temperature, of pressure, and especially of a magnetic field, justified the undertaking of much larger gratings than these. As an example of progress made in this direction, I have the honor of exhibiting a grating having a ruled surface nine inches long by four and one-half inches stroke (220mm× 110mm.) This has one hundred and ten thousand lines and is nearly perfect in the second order, so that its resolving power is theoretically 220,000, and is very nearly realized in actual experiments.

It will be observed that the effect produced at the focus of the telescope depends on the concurrence or opposition—in general on the *interference*—of the elementary trains of light-waves. We are again indebted to the genius of Newton for the first observation of such interference; and a comparatively slight modification of the celebrated experiment of "Newton's rings" leads to a third method of spectrum analysis which, if more indirect and less convenient than the methods just described, is far more powerful. If two plane surfaces (say the inner surfaces of two glass plates) are adjusted very accurately to parallelism, and sodium light fall on the combination at nearly normal incidence, the light reflected from the two surfaces will interfere, showing a series of concentric rings alternately bright and dark, according to the relative retardation of the two reflected light-beams.

If this retardation change (by slowly increasing the distance between the surfaces(, the center of the ring system goes through alternations of light and darkness, the number of these alternations corresponding exactly to the number of light-waves in twice the increase in distance. Hence the measurement of the length of the waves of any monochromatic light may be obtained by counting the number of such alternations in a given distance. Such measurements of wave lengths constitutes one of the most important objects of spectroscopic research.

Another object accomplished by such measurement is the establishment of a natural standard of length in place of the arbitrary standard at present in use—the meter. Originally it was intended this should be the ten-millionth part of an earth-quadrant, but it was found that the results of measurements differed so much that this definition was abandoned. The proposition to make the ultimate standard the length of a pendulum which vibrates seconds at Paris met with a similar fate.

Shortly after the excellent gratings made by Rutherford appeared, it was proposed (by Dr. B. A. Gould) to make the length of a wave of sodium light the ultimate standard; but this idea was never carried out. It can be shown also that it is not susceptible of the requisite degree of accuracy, and in fact a number of measurements made with a Rowland grating have been shown to be in error by about one part in thirty thousand. But modern conditions require a much higher degree of accuracy. In fact, it is doubtful if any natural standard could replace the arbitrary standard meter, unless it can be shown that it admits of realization in the shape of a material standard which can not be distinguished from the original.

One of the most serious difficulties encountered in the attempt to carry into practice the method of counting the alternations of light and darkness in the interference method, is the defect in homogeneity of the light employed. This causes indistinctness of the interference rings when the distance is greater than a few centimeters. The light emitted by various kinds of gases and metallic vapors, when made luminous by the electric discharge, differs enormously in this respect. A systematic search showed that among some forty, or more, radiations nearly all were defective, some being represented by a spectrum of broad hazy "lines," others being double, triple, or even more highly complex. But the red light emitted by luminous vapor of metallic cadmium was found to be almost ideally adapted for the purpose. Accordingly this was employed; and the results of three independent measurements, made by different observers and at different times, of the number of light-waves of red cadmium light in the standard meter are as follows:

I. 1553392.4.
II. 1553393.2.
III. 1553393.4.

It will be seen that the differences are less than half a millionth part, and this is about the limit of accuracy of the comparative measurements of the material standards. Within the last year a similar determination has been carried out by Perot and Fabry, with a result not to be distinguished from the above. It follows that we now have a natural standard of length—the length of a light-wave of incandescent cadmium vapor—by means of which a material standard can be realized, whose length can not be distinguished from the actual standard meter,—so that if, through accident or in time, the actual standard meter should alter, or if it were lost or destroyed, it could be replaced so accurately that the difference could not be observed.

In the search for a radiation sufficiently homogeneous for the purpose of a standard, it became evident that the interference method might be made to yield information concerning the distribution of light in an approximately homogeneous source when such observations would be entirely beyond the power of the best spectroscopes. To illustrate, suppose this source to be again the double radiation from sodium vapor. As the wave lengths of these two radiations differ by about one part in a thousand, then at a difference of path of five hundred waves (about 0.36 mm.) the bright fringes of one wave-train would cover the dark fringes of the other, so that if the two radiations were of equal intensity all traces of interference would vanish. At twice this distance they would reappear, and so on indefinitely, if the separate radiations were absolutely homogeneous. As this is not the case, however, there would be a gradual falling off in the clearness or visibility of the bands. Inversely, if such changes are observed in actual experiment, we infer that we are dealing with a double source. Further, from the distance between the maxima of distinctions, we may determine (and with extraordinary accuracy) the ratio of wave lengths of the components; from the ratio of maxima to minima we may infer the ratio of their intensities; and, finally, the gradual falling off when the distance becomes large gives accurate information of the "width" of the corresponding spectral lines.

In this way it was found that the red line of hydrogen is a double with components about one-fortieth of the distance apart of the sodium lines. Thallium has a brilliant green radiation which is also double, the distance being one-sixtieth that of the sodium lines. Mercury shows a brilliant green line, which is highly complex, but whose chief component is a doublet, whose separation is only one seven-hundredth of that of sodium. The interference fringes are still visible when the difference of path is of the order of five hundred millimetrs, corrsponding to over a million light-waves;; and the corresponding width of spectral line would be less than a thousandth part of that which separates the sodium lines.

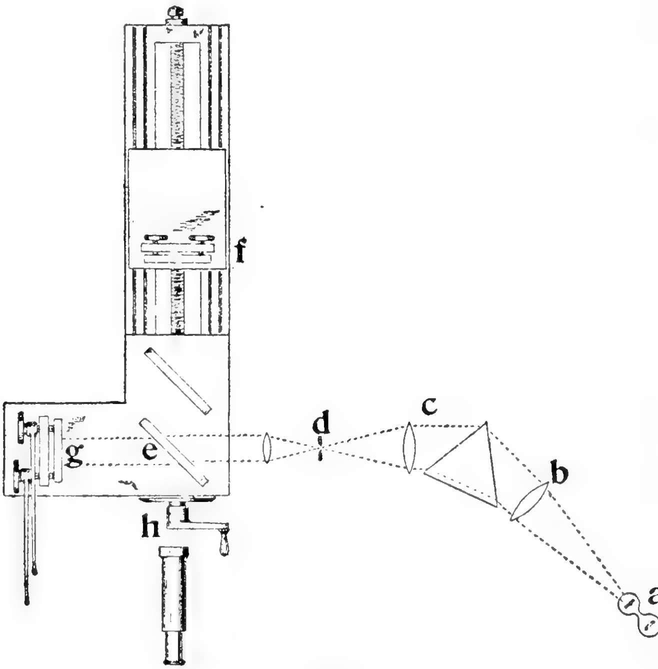

Fig 5.

Figure 5 illustrates the arrangement of the apparatus as it is actually used. An ordinary prism spectroscope gives a preliminary analysis of the light from the source. This is necessary because the spectra of most substances consist of numerous lines. For example, the spectrum of mercury contains two yellow lines, a very brilliant green line, and a less brilliant violet line, so that if we pass all the light together into the interferometer, we have a combination of all four. It is usually better to separate the various radiations before they enter the interferometer.

Accordingly, the light from the vacuum tube at *a* passes through an ordinary spectroscope *bc,* and the light from only one of the lines in the spectrum thus formed is allowed to pass through the slit *d* into the interferometer.

As explained above, the light divides at the plate *e,* part going to the mirror *f,* which is movable, and part passing through, to the mirror *g.* The first ray returns on the path *feh.* The second returns to *e,* is reflected, and passes into the telescope *h.*

The resolving power of the interferometer is measured by the number of light-waves in the difference of path of the two interfering pencils, and as this is unlimited, the interferometer furnishes the most powerful means for investigating the structure of spectral lines or groups. Its use is, however, somewhat handicapped by the fact that the examination of a single group of lines may require a considerable number of observations which take some time and during which it may be difficult to prevent changes in the light source. Nevertheless it was found possible by its means to investigate the wonderful discovery of Zeeman—of the effect of a magnetic field on the character of the radiation from a source subjected to its influence—and the results thus obtained have been confirmed by methods subsequently devised.

One of these is the application of the echelon. This is in effect a diffraction grating in which high resolving power is obtained by using a very high order of spectrum into which practically all the light is concentrated. The number of elements may be quite moderate—since the resolving power is the product of the two. The order of the spectrum is the number of wave lengths in the retardation at each step. This retardation (which must be very accurately constant) is secured by allowing the incident light to fall upon a pile of glass plates optically plane parallel and of the same thickness—each one a little wider than the preceding as in Fig. 6.

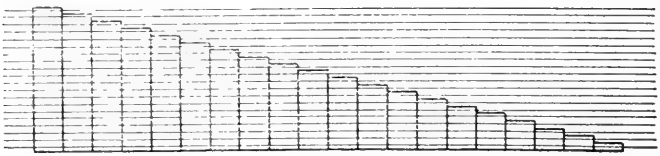

Fig. 6.

Thus, if the pile has forty plates, each one centimeter thick, the retardation will be about ten thousand light-waves; and the revolving power would be forty times this, or four hundred thousand—which is about four times as great as that of a six-inch diffraction grating of the usual form. The number of elements might be increased till the absorption of the glass brought a limit. A difficulty, which appears long before this limit is reached, is due to the loss of light by repeated reflections between the many surfaces. This has been very ingeniously overcome by Mr. Twyman, of the firm of Hilger & Company, by pressing the plates tigether to actual contact, when the reflection vanishes. It is likely that the echelon under these conditions may be used by reflection instead of transmission (the plates being silvered for the purpose) with the advantage of quadrupling the resolving power for the same number of plates and eliminating the absorption.

An illustration of the efficiency of the echelon spectroscope is furnished by the following photographs of the spectrum of green radiations from mercury vapor. The first of the figures shows the spectrum of the second order of a diffraction grating whose ruled surface is nine inches by four and a half—the largest in existence. The second is by an echelon of thirty plates, each an inch and a fourth think (30 mm). The corresponding lines are similarly lettered in the three figures. The scale is in Aongstrom unites. It will be noted in the last of the three figures that the width of the fainter companion is about one one-hundredth of an A. U. The limit of resolution of the instrument is about half as much, or its resolving power is over a million. (Figs. 7, 8, 9, Plates I and II.)†

It will be observed that the echelon spectra are repeated, thus, a_1 and a_2 are two successive spectra of the same line. This is true of any grating spectrum, and the difficulties which arise from the overlapping of the successive orders of spectrum may be overcome by separating these by a prism whose refracting edges are perpendicular to the lines of the grating. The same is true of the echelon spectrum—save that the order of the overlapping spectra is so high that a prism is hardly adequate, and recourse must be had to a grating with its plane of diffraction perpendicular to that of the echelon.

With this arrangement it is possible to photograph a large part of the spectrum at once.*

A photograph of the iron spectrum may be taken so that it may be noted that this combination of grating and echelon makes it possible to observe absorption spectra as well as bright line spectra.

A photograph of the solar spectrum may be so taken as to show that the spectral "lines" are generally too broad to justify the use of so great a resolving power.

Finally it may be pointed out that this combination gives us the means of comparing the wave lengths of spectral lines with a degree of accuracy far superior to that of the grating.

†For these illustrations see Michelson's paper as originally published.

*If the preliminary analysis has been made before the light entered the slit of echelon spectroscope, it would be possible to examine but one—at most a few—lines at a time.

COUNCIL MEETING

OF

STATE ACADEMY OF SCIENCE.

AUDITORIUM ANNEX.

CHICAGO, ILL., FRIDAY, MAY 8, 2:30 P. M.

On motion of Prof. Crew the following committee upon the ecological survey of the State of Illinois was appointed: S. A. Forbes, Chairman; F. C. Baker, H. C. Cowles, H. A. Gleason, F. T. L. Hankinson.

It was voted to publish an 8vo volume of "Transactions" which should include the transactions of the meeting of organization and of the first regular meeting, the constitution, and the list of members.

It was voted to hold the next meeting of the Academy at Springfield, February 20, 1909, at which meeting the program shall consist of a business meeting and reading of papers in the morning, a symposium on the scientific activities of the State—their history, methods and purpose—in the afternoon, and an address by the retiring president in the evening.

The Council then adjourned.

A. R. CROOK, *Secretary.*

MEMBERS

*Abbott, G. A., M. A., 945 Marquette Building, Chicago, Ill. (Ornithology.)

*Adams, C. C., Ph.D., University of Chicago, Chicago, Ill. (Zoology.)

Akeley, C. E., Field Museum, Chicago. (Taxidermy.)

*Andrews, Clement W., M. A., The John Crerar Library, Chicago. (Librarian.)

*Atwell, Chas. B., Ph.M., Northwestern University, Evanston, Ill. (Botany.)

*Atwood, W. W., Ph.D., University of Chicago, Chicago, Ill. (Geology.)

*Bachman, F., University of Illinois, 705 High St., Urbana, Ill. (Chemistry.)

*Bain, H. F., Ph.D., State Geological Survey, Urbana, Ill. (Geology.)

*Bain, Walter G., M. D., State Board of Health, 229 East Capitol Ave., Springfield, Ill. (Bacteriology.)

Baird, Grace J., B. A., 608 S. Mathews Ave., Urbana, Ill. (Biology.)

Baird, L. P., B. A., Atwood, Piatt Co., Ill. (Eugenics.)

Baker, Frank C., Chicago Academy of Sciences, Chicago, Ill. (Mollusca.)

*Balke, Clarence W., Ph.D., University of Illinois, 809 W. Hubbard Ave., Urbana, Ill. (Chemistry.)

Barber, E. H., Field Museum, Chicago, Ill.

Barker, Perry, University of Illinois, Urbana, Ill.

Barnes, Chas. Reid, Ph. D., University of Chicago, Chicago.

*Barnes, Frank G., D.D., President Illinois Wesleyan University, Bloomington, Ill. (Ethnology.)

*Barnes, H. O., High School, 1220 S. 5th St., Springfield, Ill. (Mathematics.)

Charter Members.

Barnes, R. Magoon, LL. B., Lacon, Ill. (Ornithology.)
Barnes, W. F., M. D., Decatur, Ill.
Barrett, J. T., University of Illinois, Urbana, Ill.
Barrows, H. H., University of Chicago, Chicago, Ill.
*Bartow, Edward, Ph.D., University of Illinois, Urbana, Ill. (Chemistry.)
Barwell, J. W., Waukegan, Ill. (Anthropology.)
Basquin, O. H., Ph.D., Northwestern University, Evanston, Ill. (Physics.)
*Bayley, W. S., Ph.D., University of Illinois, Urbana, Ill. (Mineralogy.)
Bement, A., M. E., Fisher Building, Chicago, Ill. (Engineering.)
*Bennett, A. N., B. S., Assistant State Analyst, 1601 Manhattan Building, Chicago, Ill. (Chemistry.)
Berry, Daniel, M. D., Carmi, Ill. (Medicine.)
Berry, Rufus L., 511 N. S. Square, Springfield, Ill.
*Betten, Cornelius, Ph.D., Lake Forest College, Lake Forest, Ill. (Biology.)
*Birdsall, L. I., University of Illinois, State Water Survey, Urbana, Ill.
*Bjorkland, A., High School, Lincoln, Ill.
Bleininger, A. V., University of Illinois, Urbana, Ill.
Bloom, Miss M. E., 310 W. College Ave., Jacksonville, Ill.
Boerner, Wunibald R., Ravinia, Lake Co., Ill. (Biology.)
*Bretnall, G. H., M. A., Monmouth College, Monmouth, Ill. (Botany.)
Browning, Jas. H., Taylorville, Ill.
*Bryan, . J., Ph.D., Illinois State Food Commission, 1601 Manhattan Building, Chicago, Ill. (Chemistry.)
*Burchard, Ernest F., B. S., U. S. Geological Survey, Washington, D. C. (Economic Geology.)
*Burrill, T. J., LL.D., University of Illinois, Urbana, Ill. (Botany.)
Cable, Wickliffe I., Oak Park, Ill.
Caldwell, O. W,. Ph. D., University of Chicago, Chicago, Ill. (Botany.)

*Carman, Albert P., Ph.D., University of Illinois, Urbana, Ill. (Physics.)
*Carpenter, Chas. K., D.D., Aurora, Ill. (Ornithology.)
Carr, J. H., Morris, Ill.
Carus, Paul, Ph.D., P. O. Drawer "F," Chicago, Ill. (Philosophy.)
*Carver, Albert, B. S., Springfield High School, 120 W. Allen St., Springfield, Illinois. (Physics.)
*Chamberlin, T. C., LL.D., University of Chicago, Chicago, Ill. (Geology.)
*Charles, Fred L., M. S., Northern Illinois State Normal, DeKalb, Ill. (Botany.)
*Clawson, A. B., B. A., Lake Forest, Ill. (Biology.)
Cohn, M. L., 218 LaSalle St., Chicago, Ill. (Mining.)
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TRANSACTIONS

OF THE

ILLINOIS STATE ACADEMY

OF

SCIENCE

VOLUME II

1909

SPRINGFIELD
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TRANSACTIONS

OF THE

Illinois State Academy of Science

SECOND ANNUAL MEETING

SPRINGFIELD, ILL., FEB. 20, 1909

VOLUME II

1909

EDITED BY PUBLICATION COMMITTEE

Price, Paper Binding, 75c; Cloth Binding, $1.00

OFFICERS FOR THE YEAR 1909-10

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TRANSACTIONS

SECOND ANNUAL MEETING.

OLD SUPREME COURT ROOM, STATE HOUSE, SPRINGFIELD.
FEBRUARY 20, 1909.

MINUTES.

MORNING SESSION.

The Academy was called to order by Vice-President Henry Crew at 10 A. M.

The minutes of the last meeting were read by Secretary Crook. After Professor Forbes had added the name of J. E. Ackert to the list of members elected at the last meeting, the minutes were approved.

Professor Hessler presented the Treasurer's report, which was laid upon the Chairman's table until an auditing committee could be appointed to examine and report on it.

The Secretary called attention to the desirability of the members sending in their correct addresses, degrees, and the subjects in which they were interested, in order that the Academy records be as complete as possible.

Professor Forbes then presented the report of the Membership Committee, which was approved, and the Secretary was instructed to cast the ballot of the Academy for those nominated by the committee. For the Committee on an Ecological Survey, Professor Forbes reported progress as follows:

"One of the first tasks of an ecological survey is the recognition and description of the plant and animal associations represented. This may be reached by the detailed study and mapping of limited districts chosen from various parts of the state and representative of much larger areas. The results of this detailed work will give by comparison a general idea of the structure of the associations throughout the state. It may be supplemented by a more general study of the entire state, showing the distribution of such association groups as forest and prairie, sand regions, cypress swamps, etc. Both lines of work lead to the production of an ecological map of the state, showing the distribution of all the associations represented. Survey work of this nature will give appreciable results in a comparatively short time, will indicate the general nature of the survey, will serve as a pattern to amateurs, will open a large field for the use of teachers, and will be a foundation for subsequent investigation. Work on other phases of ecology, such as the correlation of associations with environmental factors or their interrelations with each other, will necessarily accompany the cartographic work to some extent.

Members of the committee reported the following field work under way:

F. C. Baker, ecological study and mapping of a limited area at Shermerville, with especial reference to Mollusca.

H. C. Cowles, mapping the plant associations of portions of the South Chicago area.

H. A. Gleason, a study of the vegetation of inland sand deposits.

T. L. Hankinson, the breeding habits of fish near Charleston, correlated with environmental conditions.

V. E. Shelford, ponds in the dune region at the head of Lake Michigan.

E. N. Transeau, plant associations in the vicinity of Charleston; studies of evaporation.

After a discussion of the need of state aid for the survey, it was formally recommended by the committee that, 'instead of a separate organization, the Academy cooperate with the State Laboratory of Natural History in securing funds and in carrying out the work of the proposed ecological survey. The State Laboratory has been engaged in this work for years, and is now willing to aid in the survey and to bring together in a comprehensive plan the ecological results of the work of both institutions and individuals.

The committee especially wishes to bring into its membership all persons prepared and disposed to do active work on the ecology of any part of the state."

On motion of Professor Grant the report was approved and the Committee was continued for another year.

The Chairman then appointed the following committees:

Committee on nominations—W. F. M. Goss, F. L. Charles, S. W. Parr and T. W. Galloway.

Committee to audit the Treasurer's report—F. R. Watson, H. O. Barnes, R. O. Graham and T. W. Galloway.

The Secretary then stated that a committee was to have been appointed last year to collect drill records, and suggested that it be appointed at this time or a little later in the day.

"As a member of the Geological Survey to whom this work will be of special value," said Mr. DeWolf, "I would like to suggest the name of Professor J. A. Udden for appointment on the committee, as a great deal of the work is now in his hands."

President Crew suggested, that as the committee was an important one, and required some consideration, the matter go over until later in the day. This was agreed to.

Under the head of new business, Professor Bartow said: "The time has arrived when there is a possibility of having sectional meetings, such as a chemistry and physics section and a geological section, for the purpose of reading papers."

Professor Hessler replied: "The question came before the Council last year and it was considered inadvisable at that time. The attendance at the different sections would be small and, therefore, I think for the present at least that it is undesirable for the Academy to be divided into sections or to try to hold more than a one-day session."

Professor Goss then moved "That it is the sense of the Academy that we should not resolve our meetings into sectional meetings at this time." The motion was carried.

At the conclusion of the business meeting Professor Isabel Smith presented a paper on "Illinois Trees."

In leading the discussion on this paper, Professor Forbes said:

"I think the reason the pioneers settled along the streams was because of the shelter, and because most of the earliest settlers came from forest countries. We see, in reading the records of the first explorers, that there was a general prejudice against the prairies, as being bare and lonesome, and practically worthless for agriculture."

Dr. Crook—"I might say that at the last session a law was passed by the State Legislature designating the 'native oak' as the symbolic tree of this State. If the law-makers had consulted with some one like Miss Smith they might have found out that there are sixteen varieties of native oaks in this State—another illustration of the fact that our laws would often be better if they were framed by men who availed themselves of the knowledge of experts."

The following papers were then presented without any discussion:

"Some Botanical Features of Illinois Sand Dunes"—H. A. Gleason.

"Preliminary Report of Observations Upon a Robin's Nest"—F. L. Charles.

"Cliff Flora of Jo Daviess County"—H. S. Pepoon. (Read by title only.)

"The Clay Seams of No. 5 Coal Bed in Springfield Quadrangle"—T. E. Savage.

At the conclusion of this paper the meeting adjourned until 2 P. M.

Afternoon Session.

The Academy was called to order at 2:15 P. M. by Prof. Crew.

Before proceeding to the presentation of papers, Mr. Forbes made a report from the Membership Committee on additional names proposed for membership. These names were voted on.

The list of those elected at both morning and afternoon sessions follows:

Abbott, J. F., Washington University, St. Louis.
Bagg, R. M., Jr., University of Illinois, Urbana.
Blatchley, R. S., Geological Survey, Urbana.
Brewer, J. M., Lebanon.
Coghill, W. H., Northwestern University, Evanston.
Coulter, S. M., 3883 Juniata Street, St. Louis.
Davis, N. S., M.D., 291 Huron Street, Chicago.
Egan, Dr. James A., Secretary State Board of Health, Springfield.
Ekblaw, W. E., University of Illinois, Urbana.
Eycleshymer, A. C., St. Louis University, St. Louis.
Ferguson, J. J., St. Anne.
Gale, H. G., University of Chicago, Chicago.
Glasgow, H., University of Illinois, Urbana.
Glasgow, R. D., University of Illinois, Urbana.
Grindley, H. S., University of Illinois, Urbana.
Hammond, H. S., University of Iowa, Iowa City, Ia.
Head, W. R., Hyde Park.
Howe, P. E., University of Illinois, Urbana.
Kirk, Howard S., Rockford.
Kuh, Dr. Sydney, Chicago.
Latham, B. A., Rogers Park.
Lyons, E. P., St. Louis University, St. Louis.
Mansfield, G. R., Northwestern University, Evanston.
Mohr, Louis, Chicago.
Packard, W. H., Bradley Institute, Peoria.
Payne, Edward W., State National Bank, Springfield.
Pinckney, F. L., University of Illinois, Champaign.
Ratcliff, H. H., Taylorville.
Rice, William F., McHenry.
Ricker, N. C., University of Illinois, Urbana.
Roberts, H. L., Cape Girardeau, Mo.
Sawyer, M. Louise, Elgin High School, Elgin.
Smith, Frank, University of Illinois, Urbana.
Snyder, Dr. John F., Virginia.
Stevenson, A. H., Principal Lincoln School, Chicago.
Stine, J. C., Superintendent, Virden.
Trelease, William, LL.D., Missouri Botanical Gardens, St. Louis.
Turner, C. H., Sumner High School, St. Louis.
Watson, F. R., University of Illinois, Urbana.
Webster, G. W., M. D., Chicago.
Widman, Otto, St. Louis.
Williams, R. Y., State Geological Survey, Urbana.

The following papers were then presented:

"Hardness of Illinois Municipal Water Supplies"—Edward Bartow.

"Electrolytic Separation of Metals by Graded Electromotive Forces"—Albert Carver.

At the conclusion of this paper Prof. Crew called for reports from committees.

Professor Watson, for the auditing committee, stated that the Treasurer's report was found to be correct. Thereupon the Treasurer's report as presented at the morning session was adopted unanimously.

In making the report for the Committee on Nominations, Professor Goss said:

"Before formally presenting the report of the committee I wish to say that the committee considered some matters rather informally, one of which at least, should be mentioned. In the meeting of the committee, expressions of appreciation were frequent for the work and services of the present Vice-President and Chairman, and it was the desire and purpose of the committee to recognize that work. I make this statement because his name does not appear in the list of names presented by the committee, and the reason his name does not appear, is due to the extreme modesty of the Chairman himself, and his positive statement that he would not accept nomination as President."

Your committee nominates the following officers for the coming year:

For President—S. A. Forbes.

For Vice-President—John M. Coulter.

For Secretary—A. R. Crook.

For Treasurer—J. C. Hessler.

For the third member of the publication committee, which consists of the President and Secretary and one member elected, the third member—H. F. Bain.

For the Membership Committee—T. W. Galloway, Chairman; F. L. Charles, U. S. Grant, T. L. Hankinson and S. W. Williston.

The report is signed by all the members of the committee.

Professor Goss moved the acceptance of the report of the committee and that the Secretary be authorized to cast the ballot of the Academy for the officers mentioned in the report. The Chairman cast the ballot and the report was adopted unanimously.

The chair then announced the following Committee on Deep Drillings:

J. A. Udden, of Augustana College; U. S. Grant, of Northwestern University, and Frank DeWolf, of the State Geological Survey.

The following papers were then presented in a symposium on "The Scientific Activities of the State; their History, Methods and Purpose."

"State Laboratory of Natural History and State Entomologist's Office"—S. A. Forbes.

"State Water Survey"—Edward Bartow.

"State Highway Commission"—A. N. Johnson.

"State Geological Survey"—Frank W. DeWolf.

"State Museum of Natural History"—A. R. Crook.

No discussion followed the symposium.

Mr. Adams moved that the Chairman of the Academy appoint a committee of five as a legislative committee to consider legislation that the Academy would care to support, and that this committee take an active part in the accomplishment of any legislation that the Academy may desire.

Mr. Bartow—"It occurs to me that the Academy might well ask for support from the legislature for an appropriation which would enable it to carry on more work. I notice a number of state associations are receiving appropriations. We would not want an appropriation for salaries, but one for publication, etc.,—not more than $500 to $5,000."

Mr. Crook—"I think it would be very wise, at this time, for the Academy to take definite action. You possibly know that a bill has been introduced in both Houses of the Legislature, to erect a building for museum, historical library, and such general educational purposes as are represented by the office of the Superintendent of Public Instruction. If we could take some definite action with regard to this bill I think it would have a wholesome effect."

Mr. Forbes—"According to my experience and observation, mere resolutions by bodies of this description do not have very much effect at the critical time—the time when propositions and requests are being rubbed against each other to see which is the hardest, which has the strongest support of a kind the Legislature and the Appropriations Committees must take into account. It seems to me the most important thing to do is to interest our individual members of the legislature at home in our proposition."

Mr. Galloway—"I move you that this body now express itself, both for itself and for the benefit of those other selves that may be constrained to listen to us, to the effect that we are in sympathy with the passage of this bill which has been presented for this institution in Springfield."

Mr. Andrews—"Would it not be better if this motion should be referred to a committee to report to this convention the wording of a resolution with definite presentation of argument?"

The motion to appoint a committee was put and carried.

Mr. Gleason then moved to appoint a committee to secure funds from the legislature for the publication of the transactions of this Academy.

In talking to the motion, Mr. Johnson said: "I heard a discussion the other day as to the wrong and right of making these special appropriations to particular societies. For instance, why should the Bee Keepers' or Poultry Association of only a few people spend the peoples' money? There is no way of having any one responsible for that expenditure. I should take it, inasmuch as this is a scientific body, that it would be unwise for us to ask for unscientific legislation. In other words, if we want to publish a publication let us look after it ourselves."

Discussing the matter further, Mr. Crook said: "Steps have been taken in this direction. The Academy is not asking for special legislation. It proposes a service to every one in the State. The results of the work of the Academy should be available to every citizen. If the Academy publishes its own proceedings the edition will be small. If the State does so the results may be widely distributed. This is right in line with what the National Government is doing. The National Academy of Sciences has recently been requested by the government to consider and report on the methods and expense of the scientific work being carried on by the government. I believe if this motion is carried it will simply incite us to action."

Motion was put and carried unanimously.

The Secretary suggested that the Academy require that all papers be in the hands of the Secretary two weeks in advance of the meeting. Mr. Watson suggested that the time it would take to present the paper also be noted in order that an estimate might be made of the length of the program. No definite action was taken, however, on this subject.

Mr. Andrews called attention to one point in the remarks made by Professor Forbes on the Brown-tail Moth.

"I never knew until two years ago," he said, "what this was or meant; but in taking a trip or walk through the moth-infested district of Massachusetts, one runs a risk of serious personal trouble and inconvenience, as serious as the ivy poisoning that we get here, and I am sure that we would have applauded even more heartily if we had known of the personal inconvenience from which we have perhaps been saved."

Chairman Crew then announced the following committee to take charge of whatever legislative agitation the Academy thought wise:

Forbes, Coulter, Crook and Hessler.

Professor Goss then extended an invitation to the Academy, in the name of the portion of the membership from Urbana, to hold the next meeting at Urbana, and asked the Executive Committee to give the invitation due consideration.

Adjournment was then taken until 6 o'clock P. M., when a banquet was given by the Chamber of Commerce at the Y. M. C. A. Building.

REPORT OF THE LEGISLATIVE COMMITTEE CONCERNING THE STATE NATURAL HISTORY MUSEUM.

WHEREAS, The Illinois State Museum of Natural History in its more than fifty years of existence has become the repository of many thousand valuable scientific objects, and

WHEREAS, The present housing of these objects is inadequate, unsightly and dangerous, since they are crowded, exposed to dust, and in danger of fire, and

WHEREAS, The museum should preserve and exhibit materials showing the work of many State scientific departments, such as the Geological Survey, Soil Survey, Water Survey, Laboratory of Natural History, Highway Commission, etc., and should preserve the records of vanishing animals and plants and exhibit the oils, coals, clays, cements, fluxes, abrasives, metals and other minerals of the State which, though abundant, are absolutely limited and capable of exhaustion, and

WHEREAS, The museum thus makes a forcible and concrete appeal for the conservation of our natural resources, and is an institution of great importance, both from an educational and a practical point of view; be it

Resolved, By the Illinois State Academy of Science that an institution of such scientific and commercial importance should be adequately cared for by the State and that commodious quarters should be provided for it as soon as practicable in a new building in Springfield; and be it further

Resolved, That the Illinois State Academy of Science hereby expresses its earnest wish that the present State Legislature should take steps to provide such a building for the museum, either alone or with other appropriate State Departments.

STEPHEN A. FORBES,
A. R. CROOK,
J. C. HESSLER,
Signed for the Committee.

March 1st, 1909.

PAPERS.

NATIVE TREES OF MORGAN COUNTY.

Isabel S. Smith.

My real paper is a list of the native trees of Morgan county, which I shall be glad to give to any interested in local dendrology. My purpose in appearing before you is to call attention to it. Little can be said about the trees which would be new to an audience of this character.

Morgan county embraces quite a range of prairie conditions —the northwestern corner of it is bordered by the Illinois River. Here we find a sandy soil which gives in spots dune conditions, as may be seen from the growth of the *Opuntia* and *Viola pedata* there. Near Chapin large sandstone rocks crop out, while most of the county has a rich clay and humus soil. There is consequently a large variety of trees. The timber is along the watercourses, Mauvaiseterre Creek and Indian Creek being the chief streams, aside from the river.

As may be seen by the maps of the government survey of 1819, the forest extended along the streams, stretching out from them on each side a distance of from two to three miles. The timber has been largely cut off, the patches that remain not being more than one-eighth of a mile deep as a rule. Settlers usually made their homes along the streams. It was well for them to be near the streams for stock, and it was really easier to clear the forest and remove the roots of the trees than to get rid of the tough knotweed which lay just underneath the prairie soil, its rhizomes being often several inches in diameter. Magnificent trees were cut down by these early settlers and fashioned into their rude homes and farm buildings. I have accurate authority for the statement that a *Quercus macrocarpa* which was cut down was six feet in diameter and that eleven hundred and forty-two rings were counted in the sawed stump. Such were the trees of Morgan county's primeval forest. The forest of to-day is second growth timber and very inferior to the forests the white man found. Because of our fertile soil, trees in Illinois grow much faster than in New England and are consequently less compact and shorter lived.

The important timber trees of Illinois were the black walnut, the oaks, the hard maple and the red cedar. The black walnuts were almost exterminated. Some of the old houses have black walnut framework that would be worth much to-day, were it not for the nail holes. For interior finishing butternut was often used.

The red cedar (*Juniperus Virginiana*) was at one time abundant and a fine large tree. To-day we find only low, straggling bushes. This is the only native gymnosperm. The Virginia cherry-tree (*Prunus serotina* Ehrhart) was very abundant. It was largely used by the settlers for the making of furniture. It has practically disappeared. It resembles mahogany, having the brownish red tinge that we enjoy in old pieces of cherry furniture.

To-day little lumber is cut in the county, most of that being oak. Considerable hickory is cut for firewood. The pecan has become a valuable nut tree.

Cornus florida has almost disappeared, though it was very abundant fifty years ago in places.

In conclusion I would wish to express my thanks to Mr. John C. Andeas, of Manchester, for much assistance in securing facts for this paper.

NATIVE TREES OF MORGAN COUNTY

Pinaceæ—
- Juniperus Virginiana L. Red Cedar.

Salicaceæ—
- Populus tremuloides Michx. American Aspen.
- Populus balsamifera L. Tacamahac.
- Populus deltoides Marsh. Cottonwood. Necklace Poplar.
- Salix nigra Marsh. Black Willow.
- Salix lucida Muhl. Shining Willow.
- Salix humilis Marsh. Prairie Willow.
- Salix petiolaris J. S. Smith. Slender Willow.
- Salix glauca L. Northern Willow.
- Salix phylicifolia L. Tea-leaved Willow.

Salix Missouriensis Bebb. Missouri Willow.
Salix adenophylla Hook. Pussy Willow.

Juglandaceæ—
Juglans nigra L. Black Walnut. ,
Juglans cinerea L. Butternut.
Hicoria Pecan (Marsh) Britton. Pecan.
Hicoria minima (Marsh) Britton. Bitternut.
Hicoria aquatica (Michx. f.) Britton. Water Hickory.
Hicoria ovata (Mill.) Britton. Shagbark Hickory.
Hicoria laciniosa (Michx. f.) Sarg. Big Shagbark Kingnut.
Hicoria alba (L.) Britton. Mockernut.
Hicoria microcarpa (Nutt.) Britton. Small-fruited Hickory.
Hicoria glabra (Mill.) Britton. Pignut Hickory.

Betulaceæ—
Carpinus Caroliniana Walt. Blue Beech. Water Beech. Hornbeam. Ironwood.
Ostrya Virginiana (Mill.) Welld. Ironwood. Hop-hornbeam.
Corylus Americana. Walt. Hazelnut.
Corylus rostrata Ait. Beaked Hazelnut.
Betula populifolia Marsh. American White Birch.

Fagaceæ—
Castanea dentata (Marsh) Borkh. Chestnut.
Quercus rubra L. Red Oak.
Quercus palustris Du Roi. Pin Oak.
Quercus coccinea Wang. Scarlet Oak.
Quercus velutina Lam. Black Oak. Quercitron.
Quercus Marylandica Muench. Blackjack.
Quercus phellos L. Willow Oak.
Quercus imbricaria Michx. Shingle Oak.
Quercus digitata (Marsh) Sudw. Spanish Oak.
Quercus alba L. White Oak.
Quercus minor (Marsh) Sarg. Post or Iron Oak.
Quercus macrocarpa Mich. Mossy-cup Oak.
Quercus platanoides (Lam.) Sudw. Swamp White Oak.
Quercus Michauxii Nutt. Cow Oak. Basket Oak.

Ulmaceæ—
Ulmus Americana L. American Elm.
Ulmus alata Michx. Winged Elm. Wahoo.
Ulmus fulva Michx. Red Elm. Slippery Elm.
Celtis occidentalis L. Hackberry.

Moraceæ—
Morus rubra L. Red Mulberry.

Anonaceæ—
Asimina triloba (L.) Dunal. North American Pawpaw.

Lauraceæ—
Sassafras Sassafras (L.) Karst. Sassafras.

Platanaceæ—
Platanus occidentalis L. Plane Tree. Sycamore.

Pomaceæ—
Malus angustifolia (Ait.) Michx. Narrow-leaved Crab Apple.
Malus coronaria (L.) Mill. American Crab Apple.
Amlenchier Canadensis (L.) Medic. June-berry. Shad-berry.
Cratægus Crus-galli L. Cockspur Thorn. Newcastle Thorn.
Cratægus punctata Jacq. Large-fruited Thorn.
Cratægus coccinea L. Scarlet Thorn. Red Haw.

Cratægus flava Ait. Summer or Yellow Haw.

Drupaceæ—

Prunus serotina Ehr. Wild Black Cherry.

Pinnus Pennsylvania L. Wild Red Cherry.

Prunus Virginiana L. Choke-cherry.

Prunus Americana Marsh. Wild, Yellow or Red Plum.

Prunus angustifolia Michx. Chickasaw Plum.

Prunus hortulana Bailey. Wild Goose Plum.

Cæsalpinaceæ—

Cercis Canadensis L. Redbud.

Gleditsia triacanthos L. Honey Locust.

Gymnocladus dioica L. Kentucky Coffee Tree.

Papilionaceæ—

Robina Pseudacacia L. Black Locust.

Rutaceæ—

Xanthoxylum Americanum Mill. Prickly Ash.

Anacardiaceæ—

Rhus hirta L. Staghorn Sumac.

Rhus glabra L. Smooth Upland or Scarlet Sumac.

Celastraceæ—

Euonymus atropurpureus Jacq. Burning Bush. Wahoo.

Aceraceæ—

Acer saccharinum L. Soft Maple. Silver Maple.

Acer saccharum Marsh. Sugar Maple. Hard Maple.

Acer nigrum. Michx. Black Sugar Maple.

Acer Negundo L. Box-elder.

Hippocastaneæ—

Aesculus glabra Wild. Buckeye. Ohio Buckeye.

Tiliaceæ—

Tilia Americana L. Basswood. American Linden.

Tilia heterophylla Vent. White Basswood. Bee Tree.

Cornaceæ—

Cornus florida L. Flowering Dogwood.

Ebenaceæ—

Diospyros Virginana L. Persimmon.

Oleaceæ—

Fraxinus Americana L. White Ash.

Fraxinus lanceolata Borck. Green Ash.

Fraxinus quadrangulata Micx. Blue Ash.

Fraxinus Caroliniana Mill. Water Ash.

Fraxinus nigra Marsh. Black Ash.

Caprifoliaceæ—

Sambucus Canadensis L. American Elder.

Viburnum Lentago L. Sweet Viburnum. Sheepberry.

THE VEGETATIONAL HISTORY OF A RIVER DUNE.*

HENRY ALLAN GLEASON.

Sand regions and dunes have long been a popular field for the plant ecologist, and studies of them have been of great importance in developing and widening our ideas of plant ecology. Of the many interesting features of the Illinois sand areas, the single physiographic structure, the river dune, has been chosen for description, since it illustrates in a striking manner the action of water and wind, the role of vegetation in sand-binding, and some important phases of succession.

Three of the chief sand areas of Illinois lie along the east bank of a river; the Havana area parallels the Illinois River for many miles south of Pekin, the Hanover area extends along the Mississippi River in Jo Daviess and Carroll counties, and the Oquawka area borders the same river in Mercer and Henderson counties. In each of these the river dune is developed to some degree, but it is especially prominent in the last two, which are the only ones referred to in this article.

The sand deposits constitute the so-called second bottom, which extends from the swampy, alluvial first bottom, the modern flood-plain of the river, inland usually to the bluffs. While they are always more or less undulating, their general level is fairly constant. This level in the Hanover area is approximately twenty feet above high-water mark in the river. The river meanders over its modern flood-plain from one side to the other, and when it flows at the eastern margin, directly against the deposits of sand, the conditions are such that a river dune may be formed. Erosion by the river carries away the sand from below, and that portion of the sand above the river action stands at a steep slope, the angle

*The field work, a portion of the results of which are here presented, was carried on during the summer of 1908 through the aid of a grant from the Botanical Society of America.

depending upon the wind and the rapidity of erosion. The surface sand on this slope is exposed to the full sun and keeps loose and dry. The wind, which in Illinois is prevailingly from a westerly direction, carries a part of the loose sand up the slope and piles it up in a long dune parallel with the river and higher than the general level of the sand plain. The whole dune consists therefore of two divisions, the lower of sand now being uncovered by the wind and erosion and removed by wind, and the upper of sand deposited by the action of the wind.

In spite of general current opinion regarding the relation of wind to the formation of dunes, the general effect of wind alone on sand is to reduce the elevations, fill up the depressions, and make the general surface more nearly level. While wind furnishes the actual force in piling up sand into dunes, the sand does not remain so indefinitely unless it is held by some efficient means, usually by the action of plants. So, in the region under discussion, the river dune is initiated by the wind, but perpetuated by sand-binding plants upon its crest. Most notable among these are the redroot, *Ceanothus ovatus* Desf., switch grass, *Panicum virgatum* L., and, most important of all, sumach, *Rhus canadensis* Marsh. var. *illinoensis* (Greene) Fernald. The latter grows in dense thickets, and possesses the ability to grow up indefinitely, keeping the tips of its twigs always at least six inches or a foot above the surface of the sand. The sand beneath these thickets is effectually protected from wind action, while more may be added with every wind storm. Aided by these three species and some others of less importance the wind builds up the river dune to a height which may reach eighty feet above the general level, or one hundred feet above the river. The amount of sand thus exposed offers a considerable surface for colonization by plants, and is occupied in turn by several distinct associations.

Contemporaneous with the sand-binders there appears on the riverward side of the ridge a group of herbaceous plants which may be called the blowsand association. It consists primarily of annuals, such as the partridge-pea, *Cassia*

Chamaechrista L., and button-weed, *Diodia teres* Walt., or someimes also of deep-rooted perennials as bush clover, *Lespedeza capitata* Michx., puccoon, *Lithospermum Gmelini* (Michx,) Hitchc., and spurge, *Euphorbia corollata* L. The density of the plant-covering depends primarily upon the rapidity of movement of the sand, and partly upon the portion of the slope occupied. The area below the general level, which is being freshly exposed, is much more thinly covered than the upper portion, composed of deposited sand. The same type of vegetation is also found on the lee side of the dune.

The upper margin of the lower part of the slope, which indicates the former level of the region before the formation of the dune, is usually marked by a thin layer of dark-colored sand. This is caused by organic matter deposited by past generations of plants which occupied this surface before the dune was formed, or at least before it had migrated so far inland. The outcrop of this old soil layer along the river front affords better conditions for plant life then the sterile sand above and below it, and is usually marked by a line of wild rye, *Elymus canadensis* L.

The next group of plants to appear may be termed the thicket association, and is composed of several species of plants aggregated into dense thickets. Green ash, *Fraxinus pennsylvanica* Marsh. var. *lanceolata* (Borkh.) Sarg., is the first of the group to appear, its seeds being blown in by the wind from the neighboring bottom-land forests. Honey-locust, *Gleditsia triacanthos* L., appears at an early stage, although the way in which its pods are scattered is not known. These young trees attract a bird population, which in turn are instrumental in the dissemination of various plants with edible fruits. The mature thicket is composed of an impenetrable tangle of green ash, honey-locust, crab, *Pyrus ioensis* (Wood) Bailey, plum, *Prunus* sp., and choke cherry, *Prunus virginiana* L., with some admixture of other species. It is covered with a luxuriant growth of tangled vines of wild grape, *Vitis vulpina* L., moonseed, *Menispermum canadense* L., poison ivy, *Rhus Toxicodendron* L., Virginia creeper, *Psedera quinquefolia* (L.)

Greene, green brier *Smilax hispida* Muhl., carrion flower *Smilax herbacea* L., and bittersweet, *Celastrus scandens* L. These thickets extend most rapidly down the lee side of the dune, but also encroach gradually on the riverward side as well. The later fate of these thickets is not known.

During these two early stages in the history of the dune the wind sometimes breaks down the defense of the sand-binders at the crest and excavates a trough-shaped hollow perpendicular to the river. These hollows are known as blow-outs. The sand is removed from the windward end and from the bottom and is poured out in a steep incline on the land-ward side. The sides of the blowouts are held by thickets or by clumps of sand-binders, and if the movement is not too rapid the lee deposits are also soon covered with plants.

A third stage in the history of the dune is characterized by an oak forest, which in the Hanover area consists of black oak, *Quercus velutina* Lam., and in the Oquawka area of black oak and blackjack oak, *Quercus marilandica* Muench., together. This is the oldest* stage represented in the Hanover area and the youngest in the Oquawka area, so that the latter serves to complete the history and to indicate the fate of the Hanover dune. The blowing of the sand is effectually prevented by the forest cover, and if the river is not eroding its banks too rapidly the forest soon extends down to the water's edge.

This forest is composed of gnarled, crooked trees with short trunks. They are not close together and the underbrush, if any, consists almost entirely of young trees of the same species. The herbaceous vegetation is somewhat different from that of the preceding stages in its specific composition. One particularly characteristic species is *Synthyris Bullii* (Eaton) Heller. The poisonous fly-mushroom, *Amanita muscaria,* and an earth-star, *Geaster* sp., are quite abundant. The trees produce a bountiful

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*The meaning of the terms old and young, as applied in ecology, is sometimes confusing. "Old" signifies that the particular area has passed through a greater number of physiographic or ecological stages than those designated as "young." In the case in point, the oak forest in the Hanover area is itself relatively young in age (i. e., of recent development), but the portion of the dune so occupied has passed through one or more previous stages. This is in contrast to the blowsand association, which may be considered as occupying new ground: it is therefore the first ecological stage in the vegetation, and is designated as young.

crop of acorns, but comparatively few of them germinate. This association is not peculiar to the river dune, but is widely distributed over all the sand deposits of the state.

The presence of these trees, together with certain of their life processes, makes a gradual change in the environmental conditions for the plant. Chief among these is the annual leaf-fall, covering the sand with a thick layer of vegetable material rich in organic matter. This, and the shade of the trees during the summer and autumn, also tend to check the evaporation of water from the sand and to aid in retaining water in the superficial layers. Naturally the shade also tends to reduce the transpiration from the herbs and shrubs beneath the trees. By the combined and long-continued action of these two agents, shade and ground cover, the association is prepared for invasion by moisture-loving species; or, in other words, it changes from xerophytic to mesophytic. Moreover, their effect is cumulative and proceeds with ever increasing rapidity, so that while the first mesophytes appear only after a long period, the remainder follow them at shorter intervals.

A hillside north of Oquawka shows the order of appearance of the mesophytes very clearly. The river dune here has a maximum height of about one hundred feet, indicating a very strong and continued wind action at some time in the past. Now it is covered with trees to the very base and the upper layers of sand are well mixed with organic matter. Just off shore lies a series of wooded islands, which serve to shelter the dune from erosion by wind or water. At the north end the forest is composed exclusively of black oak and blackjack oak, which are found over the whole length of the dune. Farther towards the south, trees of scarlet oak, *Quercus coccinea* Muench., are soon noticed near the base of the hill not far above water-level; farther down they extend higher, and soon appear even at the very crest of the dune. The black walnut, *Juglans nigra* L., next appears near the base, and in the same way climbs towards the top. It is usually accompained by the redbud, *Cercis canadensis* L. In a similar way there appear in order the river birch, *Betula nigra* L., American elm, *Ulmus americana*

L., green ash, and finally the soft maple, *Acer saccharinum* L. It will be noticed that each of these species is more moisture-loving than its predecessors, until as a climax there appears the soft maple, a characteristic tree of the river-bottom swamps.

These changes in the arborescent vegetation are by no means the only ones which occur. Even before the scarlet oak appears, various species of lianas invade the association. The Virginia creeper is one of the most abundant, but several other species may be found with it. These climb up the trunks of the oak trees or, more generally, trail along the ground.

There is also a profound change in the herbaceous vegetation corresponding with the gradual increase in moisture. Horsemint, *Monarda mollis* L., starry campion, *Silene stellata* (L.) Ait.f., and columbine, *Aquilegia canadensis* L., are among the early additions. At a later stage alum root, *Heuchera hispida* Pursh, comes in, the ground has some dense carpets of moss and foliaceous lichens, and at the last a fern, *Woodsia obtusa* (Spreng.) Torr., and anemone, *Anemone canadensis* L., appear. Both of these species appear singularly out-of-place when growing in sand on a hillside, possibly at the base of a tree of blackjack oak. The anemone among the herbaceous plants corresponds to the maple among the trees; like the latter it grows normally in river-bottoms subject to overflow. The presence of these two semi-hydrophytes indicates how great has been the environmental change from the original xerophytic oak forest.

It must not be assumed that this development could continue in the same direction indenfinitely, leading to the ultimate establishment of a hydrophytic plant association. The climax or final stage of ecological successions in this region seems to be a mesophytic forest characterized by sugar maple, *Acer saccharum* Marsh., basswood, *Tilia americana* L., and other species. There is no indication in this latest stage of the river dune of the appearance of this climax association, yet on the other hand there is no reason to doubt that it would eventually come in.

The frequent changes in the channel of the Mississippi have long been well known, and are very characteristic of the restless energy of that immense river. Near the south end of the river dune just described, the river is even now operating to destroy the product of many years of plant activity. Below the islands already mentioned the current sets across from the Iowa side, and striking the base of this river dune veers off to the south along the Illinois shore. The current has broken down the barrier of leaf-mold and intertangled roots and is rapidly eroding the sand. This erosion begins at the base of the dune, exposing the bare sand. As more and more of the sand is carried away, the upper portion of the dune is undermined and begins to settle down toward the river. It is now seen that the principal mass of roots has extended only one to one and a half feet below the surface, forming a coherent stratum resting on the loose sand beneath. The loose sand rests at as steep an angle as possible, and irregular detached blocks of the coherent surface layer slide slowly down the incline toward the river. Their motion is of course very slow, and partially dependent upon the rate of erosion. But that they are loose is at once demonstrated by stepping on one, which then immediately starts down and in ten seconds to a minute, depending upon the distance, comes to rest on the flat beach at the base of the dune. That the plant population is a relic of the former mesophytic conditions is shown by the species, which are largely perennials found also on the mesophytic slope. Prominent among them are bush clover, spiderwort, *Tradescantia reflexa* Raf., horsemint, goldenrod, *Solidago nemoralis* Ait., and wormwood, *Artemisia caudata* Michx. Naturally such species as the anemone or the fern could not be expected to persist under such conditions. The flora of the sliding masses stands in sharp contrast with the meager vegetation of the general slope, composed mainly of partridge-pea and a few other annuals. These plants constitute the blowsand association, identical with the first association of the river dune.

At the top of this interesting slope the trees are being undermined also, and such a mesophytic species as river birch appears singularly out-of-place above a steep hillside of almost bare sand.

Just as the conversion from a xerophytic to a mesophytic association proceeded from south to north, so is the reversion proceeding in the same direction. At the south end the hillside is already bare to the top, while farther north the erosion has extended but little above the high-water mark.

The general effect of the vegetation on the river dune, form its beginning on, may be summarized as tending toward stabilization, and, as elsewhere also, toward a mesophytic environment. The accompanying physical factors may hasten or retard or even destroy the effect of the vegetation. It is interesting to note that on the crest of the newly destroyed dune the thickets of bunch-grass and sumach of a new cycle of successions have already appeared.*

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*In this popular discussion of the subject no attempt has been made to give full lists of plants, or to correlate the associations and successions mentioned with similar conditions elsewhere. A fuller treatment is now in preparation. The reader who desires further information on the plant successions in sand is referred to the following articles, in which many of the ecological features treated in the present paper are described in detail:

Cowles, H. C. The ecological relations of the vegetation of the sand dunes of Lake Michigan. Bot. Gaz. **27**:95-117, 167-202, 281-308, 361-391. 1899.

Gleason, H. A. A botanical survey of the Illinois river valley sand region. Bull. Ill. State Lab. Nat. Hist. **7**:149-194. 1907.

Jennings, O. E. An ecological classification of the vegetation of Cedar Point. Ohio Naturalist **8**:291-340. 1908.

Jennings, O. E. A botanical survey of Presque Isle, Erie County, Pennsylvania. Annals Carnegie Museum **5**:289-421, pls. 22-51. 1909.

SOME OBSERVATIONS ON ROBIN NESTS.

Fred L. Charles.

In the main building of the Northern Illinois State Normal School, at DeKalb, are several partially vine-clad windows which afford attractive nesting sites for robins. Two robin nests on window-sills were under close observation for a few days each by classes in the above-named instituion during May and June of 1908. That such complete data were secured is due largely to the enthusiasm and ability of Miss Jessie R. Mann, assistant in Biology.

We shall speak of the two groups of nestlings as the May brood and the June brood. There is no evidence that the parents were the same for these two broods, although it is wholly possible. The nests were located in widely separated portions of the building, the May nest having an eastern exposure and the June nest a northern. Both, however, were in fairly sheltered situations and we were able to obtain excellent photographs of both. The observations were taken under absolutely normal conditions, from within the building, the window (in the second story, in each case) being raised after the first few days and the observer sitting at ease at close range.

The May nest was first noticed April 23 and was completed April 27. The first egg was laid during the forenoon of April 29; the second, on April 30, between 9:42 and 10:32 a. m., the female being on the nest during that period. The third and last egg was laid between 10:45 and 11:30 a. m., May 1. The female began sitting that afternoon and was on the nest the greater part of the time through the cool or rainy days that followed. The male was first seen May 8, when he was heard chirping and was seen to be having some unpleasantness with the sparrows. Two of the young were found hatched on the morning of May 14, and throughout the day the male brought food, most of which was fed to the young by the mother bird, which left the nest occasionally but rarely brought food. These first feedings consisted chiefly of earthworms, myriapods (?)

and various lepidopterous larvæ. The third of the young was hatched early on the following day (May 15).

Occasional notes were taken until May 19, when all-day observations were made and continued on May 20 and 21, thus giving complete data for the sixth, seventh and eighth days in the life of the two older nestlings. Frequent observations—including the weight of the young—were made May 22-25, and on May 26 all-day observations were resumed and continued until the young left the nest on the morning of May 28, the fifteenth day.

Quantitatively the data on the feedings for these five complete days are fairly accurate; qualitatively they are not as satisfactory as could be desired, although several pieces of food were obtained and identified through the courtesy of the state entomologist's office.

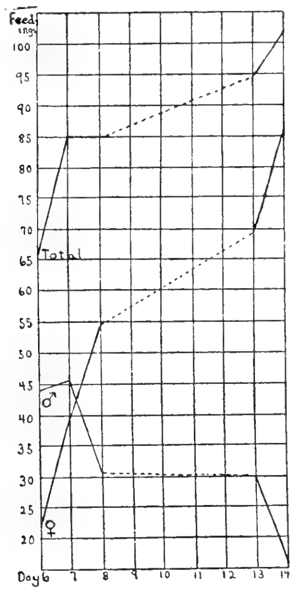
For the five days of full observation, the working day—meaning the period of activity of the parents at the nest—averaged nearly 15½ hours, from 4 a. m. to 7:30 p. m. At first the female brooded throughout the night, but toward the end of the period, when the fairly fledged young filled the nest, both parents were absent at night. On the sixth day (May 19) the number of broodings — number of times the female settled—was 17; the minimum duration of a single brooding was 5 minutes, the maximum 65 minutes, the average 28 minutes. Thus the young were brooded on their sixth day for a total of 8 hours, or somewhat more than half of the working day, or daylight period. Two thirds of the feeding was done by the male. In contrast with this, on the thirteenth day (May 26) the female did not settle once during the day, nor did she spend the previous night or the following night upon the nest. During the day, while near the nest, she perched either on the edge of the nest or near by on the window-sill. Once she stood over the nest. Usually, however, she left promptly after feeding. The cock robin did less than one third of the feeding on this day.

For the five days on which complete data were taken, the number of feedings was as follows:

The May Nest

THE JUNE NEST

Day	By Female	By Male	Total
Sixth	22	44	66
Seventh	39	46	85
Eighth	54	31	85
Thirteenth	64	30	94
Fourteenth	86	16	102



NUMBER OF DAILY FEEDINGS.

The data of feedings by hours—from four to five, five to six, etc.—when plotted, reveal a rather sharp maximum frequency of feeding from 4 to 7 p. m., a more or less level period during the greater part of the day, and a less pronounced maximum from 5 to 7 a. m. The greatest number of feedings in any one hour during these five days was 14; there was never an hour without at least one feeding; the average number per hour (from 4 a. m. to 7:30 p. m.) during the five days was 5.6.

The maximum number of pieces of food given to the young by the parents in one day was 444; the minimum, 278; the average, 356. The average number of pieces brought in one visit was 4. In the observations of the eighth day, the greatest number of pieces was fed from 6 to 7 p. m. For the five days, lepidopterous larvæ comprise one half of the food pieces; earthworms, 28.8%; ants, 6.6%; Diptera, 5.7%; and Coleoptera, Orthoptera, Myriapoda, adult Lepidoptera and other winged insects the remainder. Certain species were especially prominent in the diet, and of these, specimens were captured and identified as above mentioned. Some of them are of considerable economic significance. In passing it may be stated that the data obtained throw interesting light on certain problems in entomology.

The weights of the three young birds increased very rapidly until about the tenth day, after which they remained practically stationary save for the nocturnal shrinkage and diurnal gain. There was a slight daily increase during these last few days in the nest.

In many particulars the observations show important variations from previous accounts of observations made under less favorable conditions.

From the view-point of behavior, or comparative psychology, some notes of interest were taken. Almost invariably, after feeding, the excrement was promptly voided, the parent waiting for this act and usually swallowing the excreta. The nest was not soiled. The sun shone directly upon the nest for about one hour each day, during which time the female brooded in striking attitude. At one time when the young had been weighed in a bowl and the bowl had been placed upon the sill close to the nest preparatory to returning the nestlings, the mother appeared and brooded for some time upon the empty nest, utterly indifferent to the presence of the young in the bowl. We can not here refer to many other observations of interest.

The June brood was under observation throughout the entire sixth and seventh days (June 24 and 25), paralleling the data for corresponding days in the May brood. All-day observation was resumed on the thirteenth day, as in the case of the May brood, but the young left the nest during the morning of that day, making comparison impossible for the later period. In the main, the essential points in the two sets of data are in harmony, although the fact that the male was found dead on the ground below the nest after a storm (cause unknown), before all-day observations were begun, prevented any comparison of the activities of the two sexes. This circumstance, however, gave opportunity to note what adjustment was effected by the widow under the pressure of hunger of the nestlings. She came with food on the sixth day 98 times, and on the seventh day 127 times, as against 66 and 85 for both parents on the corresponding days for the May brood. In both cases the number of young was 3.

In the June brood the period of most active feeding was from 4 to 8 p. m., with a less pronounced maximum in the early morning, as in the May data. On the basis of number of pieces of food, the results are similar, the morning and evening morsels greatly outnumbering those fed at midday.

The young from each nest were followed after their first flight—which was witnessed in both cases—and their experiences on the "first day out" were noted. The struggle for existence became a very real affair to the passive observer, and the records are not without mortality tables.

Note.—Since this paper was read, two additional broods have been under observation, one of them throughout the entire period from hatching to leaving the nest, with complete data. Results will be published in full in due time.

THE CLIFF FLORA OF JO DAVIESS COUNTY.

H. S. Pepoon.

Nearly all the numerous streams that drain Jo Daviess county and, after a longer or shorter southwest course, discharge their waters into the Mississippi River, have their narrow, alluvial "bottoms" bordered by limestone cliffs of varying height and extent. These cliffs are a marked feature of the landscape, and by reason of their precipitous nature make roads having an east and west direction a very difficult proposition, and ordinary tramping across the country very difficult, and in many places absolutely impossible. In height there are all variations, from a low wall of rock, easily overlooked and overtopped by a man of average stature, to towering and vertical precipices.

Regarding the physical condition of the cliffs, there is to be found a great degree of diversity, according to the direction and amount of exposure, the amount of sunlight received, the water content of the rocks, and, to a limited extent, the diverse physical constitution of the rock itself. Some cliffs are dry as dust, others are constantly dripping cold clear lime-water; some never see the sun's rays, and others receive the full effect of the midday sun; while in exposure all gradations are found, from the sheltered nook, where a cold blast never penetrates, to a bald cliff exposed to the full fury of the north wind. All the rock is limestone and of the Galena and Niagara formations, but some variation is to be noted in the amount of sandy admixture, or in the narrow zones of chert at varying levels.

Practically all the plants found on these circumscribed and seemingly inhospitable rocks may be grouped with those of xerophytic or hydrophytic tendencies, but it is to be predicated that many of the latter are really water-xerophytes, if such a term may be used for plants that, by all sorts of protective features, try to isolate themselves from the all-surrounding moisture. Nearly all the species that exhibit a water-association habit are bog plants, of the botanical textbooks, and it is believed that they have resorted to the cliffs because of the lessened competition and the lack of the more intense struggle for existence which apparently overbalance the drawbacks attendant on the new environment.

The first noticeable feature of the flora is the remarkable mingling of the forms of the colder and warmer latitudes, although it is plainly manifest that there is a great preponderance of species of northern regions. It perhaps ought to be stated that the driftless condition of this whole area is, in all probability, the explanation in large part, for the first presence of these species from diverse latitudes. (See School Science, 1909, paper by the author.) Another marked character is the luxuriance of growth in many places, the rock soil seeming to afford very congenial habitation, and one is forced to conclude that many forms derive a large measure of their sustenance from the damp air surrounding. A third feature, and the one that adds spice to the collector's trips, is the exceeding scarcity of localities for many forms, and the further fact that they are isolated examples of species found abundantly in other parts of North America.

For convenience in studying the plants of the cliffs, it will be well to divide them into five groups acording to the physical features most predominant in their habitation:—

1. The plant-association of dripping and well-lighted cliffs, facing northerly.
2. The plant-association of dry and well-lighted cliffs, facing northerly.
3. The plant-association of twilight cliffs, densely shaded.
4. The plant-association of cliffs with southern exposure.
5. The transition-cliffs association.

The dripping cliffs almost invariably have an exposure toward the north and east, are usually massive, thick-bedded and towering, and very often have a most pronounced overhang, due to erosive agency of the adjacent stream. The water is always clear, cold and surcharged with lime, and often concentrated in springs. Many rock mosses form green matted layers covering the rock face, with numerous algæ intermixed, particularly Spirogyra species. *Marchantia* and *Lunulria* or, less abundantly, *Concephalus,* are liverwort forms that often clothe great spaces with a solid green covering, and winter or summer are obtainable for purposes of study or collection.

A half dozen flowering plants form an association at once interesting and attractive. The most remarkable species is *Primula Mistassinica,* which forms a thick mat-like growth, covering in one instance a space about three rods long by about six feet of vertical height, on that part of the cliff with the greatest amount of drip. The winter rosettes of this plant are well formed by September 1, and the numerous leaves evidently act as a cold protection for the innermost, immediately surrounding the root-crown, and these latter, are doubtless full of elaborated food fit for the immediate use of the plant the following spring, for in average years it is in full bloom by April 20, and then often tints the otherwise bare rock a lavender purple with the multitudes of its blossoms. By the end of May its seeds are ripe, and evidently many soon germinate, for tiny plants with but three or four root leaves are common in August. *Steironema quadriflorum* adds a brilliant hue to the green of these same zones, in July and August when nothing but the leaves of the primrose are to be seen. The yellow flowers of this species are produced in great abundance, and as a rule, the plants seem in every way more vigorous than when found growing in the ordinary boggy home of other regions. *Dasiphora fruticosus* is a very abundant form and extends vertically over much more of the cliff face, blooming until cold puts an end to its growth. This plant never assumes on the cliffs the robust habit it has in the tamarack marshes of Michigan and Wisconsin. *Galium tinctorium* is another very common plant of this association but not at all conspicuous. In the crevices and narrow ledges occasional robust specimens of *Cypripedium reginae* are to be found. So astonishingly different is such a habitat from the slough margins of Lake county, Indiana, where this plant grows by the thousand, that one can hardly believe the testimony of his eyes, and we must needs look twice and handle to be convinced. *Parnassia* is always in evidence and flourishes. On some cliffs, notably one on Clear Creek, *Gentiana crinita* fairly covers the damp face of the rock and makes a most beatutiful showing in October. This plant, however, is very local, and is not a generally present cliff species. Why it should have adopted the one locality is a hard problem. There are scattering plants of a number of other species, but the ones named are characteristic.

The dry exposed cliffs have a covering of crustaceous lichens, and a few higher forms that give a marked aspect to the plant life. *Pellaea atropurpurea* grows most luxuriantly and adds much to the beauty of the massive rocky front. *Campanula rotundifolia* abounds and shows abundantly its round root leaves, so commonly lacking in the form growing on the clay banks of Michigan and Indiana. *Solidago flexicaulis* and *memoralis* are frequent and showy in late summer. These dry cliffs, however, are the barren areas, comparatively, and large stretches are utterly devoid of plant life.

The cliffs that have such an overhang as to shut out much of the light, and in particular the gorge-like side ravines with vertical sides, almost dark at midday, have a peculiar flora, that nowhere else is found, or that appears much abated in luxuriance. These cliffs are generally damp, but rarely drip, the moisture being the general result of the lack of heat. The overhang in some places amounts to 20 to 25 feet, and it goes without saying that direct sunshine never enters. The characteristic plant is *Sullivantia Sullivantii,* which is excessively abundant, almost covering the rock in most places, and in June made daintily beautiful by its tiny but numerous white blossoms. Delayed blooms appear as late as mid-August. Here and there *Zygadenus elegans* will be found, but in the lighter parts of the cliffs. It is not, however, exclusive in its choice of a home as are the other plants named above. *Taxus* is exceedingly common on all such rocks and adds much to the beauty of the scene. On ledges an occasional *Jeffersonia diphylla* grows, but the species is a very rare one, and the seeker may climb many a cliff and never find one specimen. Several ferns are at home in these dark spots, notably *Flix bulbifera, Cryptogramma Stelleri,* and *Asplenium angustifolium.* The finding of the latter will always be an occasion of note, and the writer scoured these identical cliffs for many years before he found a plant. This simply emphasizes, however, the extreme nicety of nature's selection of habitat; for knowing the proper recipe of so much shade, rock-moisture and humus, a fine plant may now be found at any time.

The southern cliffs are not, as a rule, characteristically clothed with plant life, or rather unclothed, for they are more commonly bare. A few species, however, have here their greatest distribution. *Juniperus Virginiana* is, in places, very common, but never assumes more than the proportions of a small telephone pole, and always seems to mutely protest, by its unkempt condition, against the irony of fate that relegates it to such a place. *Aquilegia Canadensis* is often common; so is *Campanula rotundifolia,* for any bare wall dry enough suits the latter. *Pellea* is again in evidence. If the cliff happens to have a moist base, it is a congenial habitation for *Mimulus Jamesii, Epilobium adenocaulon, Chelone glabra, Caltha palustris, Salix Bebbiana, Carex hystricina,* and *Mimulus alatus.* None are characteristic.

The transition cliffs are those that connect, say, a vertical cliff facing north with a second cliff facing east, the various fronts being due to the sinuous course of the waterway that carved them out. In character they are compromise of cliff and talus, a vertical band and then a steep slope, and so on from base to summit. Having all directions of front and all kinds of soils, these places are remarkably rich in species, but very few of these latter are definitely and peculiarly cliff dwellers. These rough, untillable, non-pasturable, and largely *untreadable* slopes, have, however, a very great influence on the plant life of the region, for here are collected, for the *last* stand against the *civilized* death-warrant, a host of species that, each selecting its circumscribed dry or moist rock or sunny or shady nook, flourish as the green-bay tree. It will suffice to give a small list, to show the mixed social nature of the vegetation:—*Marchantia, Polystichum, Adiantum, Pinus strobus, Muhlenbergia* sp., *Carex albursina, Morus rubra, Calcorchis, Actaeo rubra, Caulophyllum, Bicuculla Canadensis, Arabis* sp., *Dirca, Pyrola elliptica, Chimaphila umbellata, Gentiana quinquefolia, G. flavida, Thalesia uniflora, Diervilla, Viburnum Opulus, Symphoricarpus racemosus, Betula papyrifera.* The last is everywhere, a marked and remarkable species.

This has been but a mere surface scratching of the soil, but I hope that I have made it plain that the cliffs of Jo Daviess are plant resorts of great interest and that many ecological problems are involved in the question of how such species have taken up their abode in the seemingly inhospitable soil of rock, and that, further, I have at least suggested the answer in some cases. As a conclusion, it might be noted that the seeker after plant knowledge on these precarious rocky heights may on occasion be stopping to admire the brazen beauty of the poison ivy or wonder at the innocent immaculate appearance of the deadly *Amanita* and meet (with a backbone chill) the unwinking glare of a huge timber-rattlesnake and stepping backward to avoid the triple danger, plunge downward a hundred feet into the cold river beneath.

THE CLAY SEAMS (HORSEBACKS) IN THE NUMBER 5 COAL BED, NEAR SPRINGFIELD, ILLINOIS.

T. E. Savage.

The principal coal seam exploited in western Illinois, over the area between Springfield and Peoria, was designated in the Worthen reports as number 5. The following section shows the character of the strata associated with the number 5 coal in the Springfield quadrangle:

	Feet
Sandstone or shale	10 to 30+
Light gray shale or soapstone	1½ to 4
Limestone cap rock	½ to 1⅔
Black, fissile shale	2½ to 4½
Coal (Number 5)	5 to 6½
Fire clay	1½ to 5

One of the conspicuous features of the number 5 coal seam is the presence of numerous clay-filled fissures that extend down into, or through, the coal seam from the overlying beds. The fissures are generally from two or three to sixteen inches in width, although the larger ones attain a width of three or four feet. Their walls are slickensided, but do not show any traces of weathering. The spaces between the walls are filled with a light gray shale or soapstone.

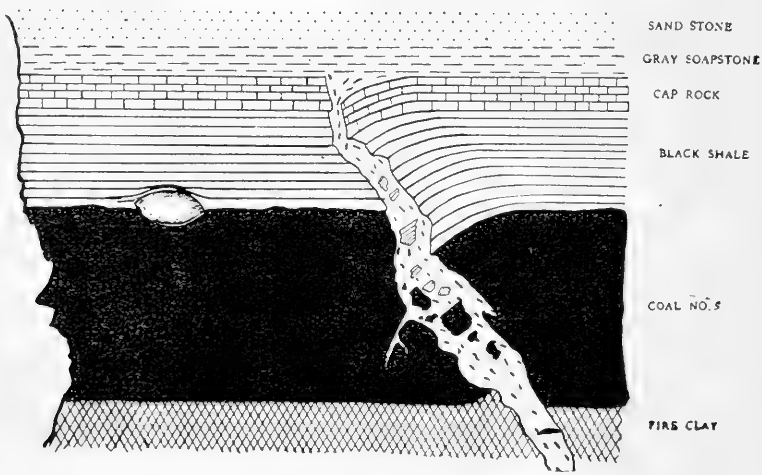
These fissures, with their fillings, are known to the miners as horsebacks. There is no regularity in the distance between these horsebacks, or clay seams, or in the direction in which they extend. In some mines they are encountered about forty to sixty feet apart, while in others they are separated by a distance of two hundred to four hundred feet, or more. They traverse the coal seam in various directions, no single direction greatly predominating even in the same mine.

The shale filling the fissures is light gray in color and is generally rather soft. In rare cases it is so hard that it emits sparks when struck with a hammer, but usually it soon slakes down into an incoherent mass upon exposure to the air. Where the horseback enters the top of the coal seam the fissure at once becomes wider. The upper laminæ of the coal, immediately adjacent to the fissure on the overhanging side, are more or less steeply bent downward, the bending or buckling of the layers fading out laterally within a few feet from the fissures. Fragments of the black shale, from the roof of the coal, were seen at many points in the clay filling of the horsebacks from five to twenty-nine inches below the top of the coal. In mine number 5 of the Springfield Coal Mining Company, a fragment of coal, six inches long and three fourths of an inch in thickness, was found in the clay of a horseback nine inches below the bottom of the coal seam.

In the mine last mentioned there was seen in three of the horsebacks a slight upward bending of the lower edge of the coal on the side of the fissure opposite to that in which the down-bending at the top occurred. This upward bending at the bottom, however, is only one third to one half as great as the down-bending of the coal at the top of the seam in the same horseback. When the clay seam passes into the coal bed in a nearly vertical direction there is a down-bending of the coal at the top of the seam on each side of the fissure. However, the more nearly vertical the direction in which the horseback cuts through the coal, the less is the distance through which the edges at the top and bottom of the seam are bent.

In no instance was there seen a true faulting of the beds. I wish to emphasize the fact that in no case was there a slipping of the middle part of the coal seam on one side of the fissure above the level of the corresponding part of the seam on the opposite side. The only vertical displacement is a downward pushing of the cap rock and roof shale, and a down-bending of the upper laminæ of the coal on the overhanging side of the fissure, through a vertical distance of from two to twenty inches; and, less frequently, a much smaller upward bending of the lower edge of the coal seam on the opposite side of the fissure, as shown in the accompanying figure.

HORSEBACK IN MINE NO. 5
OF
SPRINGFIELD COAL MINING CO.



In this area the fissures have a very limited vertical extent. In the Mechanicsburg mine a coal seam was formerly worked about thirty-five feet above the number 5 bed which is at present being mined.. Although these two coal seams are separated by an interval of less than forty feet, the number 5 coal is traversed by numerous clay seams, while none were encountered in the upper bed.

It seems certain that there was a somewhat ready yielding of the coal mass in a lateral direction when the fissures were formed. This is shown in the fact that the walls of the fissure are much wider apart in the coal bed than in the overlying roof shale and cap rock. The clay seams always cut the bed in an oblique or a vertical direction, never following the partings or stratification planes of the coal seam, even where these are well marked. The amount of downward slipping of the cap rock is always less than the extent to which the upper edge of the coal seam overhanging the fissure is bent downward. All of the movement, both horizontal and vertical, that has taken place in connection with the clay-filled fissures seems to have been made possible by the yielding of the materials within the coal seam itself.

That the coal offered accomodation to the strains that caused the formation of the fissures is shown by the fact that within the coal seam the smaller fissures often divide into a number of branches which eventually die out without passing entirely through the bed.

The clay filling the fissures is thought to have been pressed downward through the break in the cap rock and roof shale into the coal from the bed of gray shale or soapstone overlying the cap rock. As this clay was forced downward into the fissures it caught the overhanging and unsupported edges of the cap rock, roof shale and coal, bending those edges downward on the overhanging side of the fissure.

That this clay was, for the most part, squeezed downward from above the coal horizon is indicated by the manner in which the upper edge of the coal seam overhanging the fissure has been bent downward to a much greater extent than the lower edge of the coal on the foot-wall side has been forced upward. It is shown in the fact that fragments of black shale from the roof of the coal are common in the clay filling of the horseback several inches below the top of the coal seam; and fragments of coal also occur in the clay some inches below the bottom of the seam. In no case were coal fragments found in the clay filling at a level higher than the top of the coal.

SUGGESTED ORIGIN OF THE CLAY SEAMS.

It is thought that the formation of these clay filled fissures was intimately related to the character of the beds above the number 5 coal. It is probable that the character of the underlying fire clay, which here is dry and does not creep readily, is also a conditioning factor. The fissures were not formed, as at present, until after the vegetal mass composing the coal seam had been compressed to near its present volume. This is shown in the fact that the clay seams show no bending or buckling such as would result if much compression of the coal had occurred after the horsebacks were completely formed. Where the lower edge of the coal rests upon the clay filling of the horseback, the laminæ are not curved upward adjacent to the fissure as they would be if the coal at a distance from the fissure had been compressed or settled downward since the horseback was formed. That a degree of consolidation of the coal sufficient to permit of jointing had occurred prior to the formation of the horsebacks is shown by the fact that in some places the clay from the fissures has spread into the joints of the coal adjacent to the horseback.

Campbell* suggests that joints are developed early in the process of coal formation, and that the carbonization of the coal, beyond the lignite condition, depends upon the presence of joints and cleavage planes along which the gases could find a way of escape. If this is the case, there would be a considerable amount of compression and contraction of the coal seam after the joints were formed, before the vegetal mass reached the condition of bituminous coal.

It is assumed that as the mass of vegetal material, under the weight of overlying sediments, was slowly transformed into coal, there would be somewhat unequal contraction in different parts of the seam, owing to the lack of homogeneity of the vegetal materials making up the coal beds; and that the contraction of the coal materials continued long after a high degree of consolidation of the coal had taken place. So long as the materials possessed some degree of mobility the unequal shrinking in the different parts of the coal seam would be equalized by the movement of some of the mass towards the points of least pressure. When the consolidation reached a certain point such adjustment would be no longer possible. After this, the continued unequal shrinking of the vegetal mass would cause unequal strains in the roof of the coal under its load of superposed sediments.

If the roof of the coal seam was a soapstone, or somewhat

*Campbell: Economic Geology, Vol. I, No. 1, p. 30.

plastic shale, the mobility of the shale particles would permit this zone to adjust the inequalities of strain resulting from the unequal contraction in the coal seam. Such conditions exist in the roof of coal number 6 in the Carterville-Zeigler district of southern Illinois. Rock rolls occupying depressions in the top of the coal are here common, but no clay seams penetrate the coal bed. In the vicinity of these rolls the roof shale is cut by slickensided zones for a distance of several feet from the center of the roll, indicating a considerable lateral movement in the shale in accomplishing the adjustment of the strains. However, the roof of coal number 5 is a hard, brittle shale whose constituent particles do not possess the mobility requisite for such adjustment. If the limestone cap rock was very thick it might be able to withstand, without fracture, the unequal strain due to unequal contraction in the underlying coal seam. But the cap rock of this coal is thin, averaging only twelve to fourteen inches. The combined strength of the roof shale and cap rock was not sufficient to withstand the unequal strain to which they were subjected, and fissuring of the beds resulted.

Immediately above the cap rock of this coal seam is a bed of rather soft, gray shale or soapstone whose particles were sufficiently mobile to bring about adjustment in the unequal strains which, by the fissuring of the roof shale and cap rock, had been transferred to this higher horizon. The materials from this shale horizon were immediately squeezed downward through the fissures as wedges into the coal seam, until the inequality of pressure was adjusted. Under these conditions the place in which adjustment was accomplished was limited to a narrow zone below the point where the fracture was made in the roof shale and cap rock. Hence the effects were confined to a narrow zone horizontally, but they became thus strongly marked in a vertical direction.

It is probable that from time to time, as the shrinking in the coal mass continued, more clay was forced downward into the coal seam, fissuring it still deeper and spreading the walls of the fissure constantly wider apart. The abundant evidences that the clay filling the fissures in the Springfield coal seam was pressed down from above the coal have been given on a preceding page. In this manner, also, the slickensiding was accomplished by the slipping of the clay in the fissure, and not by the movement of the walls of the fissure upon each other.

It is thought that the principle of unequal contraction in the different parts of the coal seam, during the progress of its consolidation, applies also in the formation of the more common types of rock rolls in the top of coal seams in Illinois. The character and sequence of the beds above the coal seam are considered the chief factors in determining whether rolls or clay seams will be formed in the adjustment of the strains arising from such unequal contraction.

It seems probable that clay seams have been formed in different ways in different areas, under varying conditions of roof and floor, and varying degrees and kinds of strains to which the strata were subjected. It is not possible that earthquake phenomena or general crustal strains, such as produce wide-spread faulting, could be concerned in the formation of the fissures of the clay seams in the Springfield region. Fractures from the above-mentioned causes would not be limited to a few feet in vertical height, or to one particular coal seam, as in the area under discussion.

THE HARDNESS OF ILLINOIS MUNICIPAL WATER SUPPLIES.

Edward Bartow.

It is not the purpose of this paper to show the advantages of a soft water. We are all agreed that a soft water is best. The large majority of the municipalities of Illinois have hard waters, and therefore what we wish to know is how to make them soft and when it is practicable to do so.

Whenever it is necessary to purify a water for drinking purposes an additional installation to soften the water is comparatively inexpensive. The same is true when it is found necessary to remove the iron from a water supply. To soften a hard but pure and clear water would mean a complete installation for softening purposes alone. In the latter case there will therefore be much hesitation on account of the expense before general softening plants are established. In all plants also there is a reluctance to treat all of the water supply when a soft water is not needed for all purposes.

Railroads are finding it profitable to soften the waters used in their locomotives, and plants for water treatment are in operation on all of the principal lines. The matter is of so much importance to them that an extended report has been made by the Committee on Water Service of the American Railway Engineering and Maintenance of Way Association*. The Committee discusses the matter from the standpoint of use in locomotives quite fully. What has been found practicable in locomotive practice may be extended to general boiler uses or even to domestic practice.

The whole supply of a municipality may be softened or, where this is impracticable, plants may be established by the

*Am. Ry. Eng. and Maintenance of Way Assn. Bull. No. 83, Jan. 1907.

TABLE SHOWING THE HARDNESS, AND THE AMOUNT OF LIME AND SODA ASH REQUIRED TO SOFTEN THE WATER FURNISHED TO NINETY-EIGHT ILLINOIS MUNICIPALITIES.

CITY	Class	Mineral Content—Parts per Million							Soda Ash			Lime			Chemicals Approximate Cost per 1000 Gallons	REMARKS
		Residue	Na_2CO_3	$MgCl_2$	$MgSO_4$	$MgCO_3$	$CaSO_4$	$CaCO_3$	Parts per Million	Grains per Gallon	Lbs. per 1000 Gals.	Parts per Million	Grains per Gallon	Lbs. per 1000 Gals.		
Amboy	I	389	14.1			125 2		212.6				285.	16.6	2.38	$.00714	
Atlanta	I	517	46.8			154.6		238.5				340.	19.8	2 83	.00849	
Aurora	II	458			35.4	35.1		165.0	31.	1.8	.26	156.	9.1	1.30	.00650	
Beardstown	II	373			65 0	56 4		189 2	57.	3.3	.48	211.	12.3	1.76	.01008	
Belleville	I	370	201.0			53.3		43.4								Deep wells.
	II	393			21.6	95.2		187.2	19.	1 1	.16	241.	14.1	2.01	.00763	Edgmont.
Belvidere	II	352			1.5	116.5		193.4	1.3	.1	.01	264.	15.4	2.20	.00670	
Berwyn	II	735			182.4	9 7		256 8	160.	9.3	1.33	242.	14 1	2.02	.01936	
Bloomington	II	810			436.2	130 2		156 3	384.	22 4	3.20	463.	27.0	3.86	.04358	
Bushnell	II	2038			228.0	16.4		279.8	201.	11 7	1.67	285.	16.6	2.38	.02384	
Byron	II	298			4.0	119.0		139 5	3.5	.2	.03	238.	13 9	1.99	.00627	
Cairo	II	235			7.3	21.4		47.4	6.4	.4	.05	58.	3.4	.48	00194	Clay and silicious matter 103.5.
Cambridge	I	1052	49.0			68.6		104 9				177.	10.3	1.48	.00444	
Canton	II	1020			205.		119.3	157.8	283 0	16.5	2.36	184.	10.7	1.53	.02819	
Carbondale	I	1818	244 0			48.0		79.0				237.	13.8	1.98	.00594	Average of 3 analyses from different wells.
Carlyle (a)	II	248			20.0	55.4		117.3	17.6	1.0	.14	149.	8.7	1.24	.00512	Artesian well.
Carmi (a)	II	176			15.8	20.4		50.0	13.9	8	.12	63.	3.7	.53	.00279	Spring.
Carrollton	II	3121			289 0		162.0	228.4	381.0	22.2	3.17	263.	15.3	2.20	.03830	
	II	348			4.8	92.1		195 0	4.2	.2	.03	234.	13.6	1.95	.00615	
Chadwick	I	429	35.4			148.6		212.4				335.	19.5	2.80	.00840	
Champaign	I	408	56.0			101.0		202.0				276.	16.1	2.30	.00690	
Charleston (a)	II	270			21.1	68.0		127.0	18.6	1.1	.16	171.	10.0	1.43	.00589	
Chatsworth	I	702	124.3			121 5		190.0				334.	19.5	2.78	.00834	
Chillicothe	III	420		16.9	94.4	41.1		202 9	102.	5.9	.85	222.	12.9	1.85	.01405	
Chrisman	I	2216	343.5			30.2		38.6								Well 140'—Suspended matter 83.9—
	III	571		22 1	194.		1.5	290.0	197.	11.5	1.64	266.	15.5	2.21	.02303	Well 17'
Clinton	I	310	18.6			118.		137.				243.	14.2	2.03	.00609	Wells.
	I	431	7.2			144.		236				327.	19.1	2.73	.00819	Springs.
Collinsville	II	392			41	104.		184.	36.	2.1	.30	260.	15.2	2.17	.00951	
Danville (a)	II	281			38.0	60.0		135.	33.	1.9	.27	173.	10.1	1.44	.00702	
Decatur (a)	II	293			24.8	73.		137.	21.9	1.3	.18	185.	10.8	1.54	.00642	
DeKalb	I	301	60.			87.		132.				221.	12.9	1.84	.00552	
Dwight	II	1087			253.		101	247.	222.	12.9	1.85	256.	14.9	2.14	.02492	
East Dubuque	I	361	48.3			109.5		113 3				234.	13.6	1.94	.00582	
East St. Louis	II	233			5.5	41 3		90 0	4.8	.3	.04	108.	6.3	.90	.00310	
Edwardsville	II	260			55.4	23 2		131.1	49.	2.9	.41	130.	7.6	1.08	.00734	
Effingham	II	257			38.4	42.9		69 2	33.8	2.0	.29	114.	6.6	.94	.00572	
Elgin (a)	II	290			30.0	83.0		127.0	26.4	1.5	.21	196.	11.4	1.63	.00699	(a) U. S. G. S.
Elgin	I	347	63.0			98.		150 0				248.	14.5	2.07	.00621	Deep wells.
Elmhurst	II	478			86.	78.0		255.0	76.	4.4	.63	287.	16.7	2.40	.01350	
Farmer City	I	719	255.1			85 0		146.4				330.	19.2	2.75	.00825	
Freeport	II	463			62.0	109.4		221.4	55.	3.2	.46	298.	17.4	2.48	.01204	
Galesburg	II	951			135.1	47.9		259.3	119.	6.9	.99	272.	15.9	2.27	.01661	Mixture of deep and shallow wells.
Geneseo	II	396			15.6	103.3		192.1	14.	.8	.12	252.	14.7	2.10	.00750	
Greenville	II	552			65.1	96.4		277.3	57.	3.3	.48	313.	18.3	2.61	.01263	
Harvey	II	1204			239.7		225.2	267.5	386.	22.5	3.21	261.	15.2	2.18	.03864	
Havana	II	196			15.5	35.9		96.1	14.	.8	.12	109.	6.4	.91	.00393	

CORRECTIONS IN TABLE.

Artesian well and spring are at Carrollton not Carlyle, and Carmi
Under Shelbyville, parts per million soda ash, reads 22.0 instead of 220,
Free acids and sulphates are in water at Staunton, not Springfield.

Henry	I	2497	259.1			60.3		94.1				209.	13.7	2.25	[illegible]	
Jacksonville	II	374			33.2	96.0		208.0	29.	1.7	.24	260.	15.2	2.17	.00891	New supply.
Jerseyville	II	2506			250.0		161.0	157.0	345.	20.1	2.87	204.	11.9	1.70	.03380	
Kankakee (a)	II	288			52.0	37.4		145.0	46.	2.7	.38	155.	9.0	1.28	.00764	
Kewanee	II	1265			87.0		40.0	175.0	108.	6.3	.90	138.	8.0	1.15	.01245	
Knoxville	II	1198			27.9	71.0		144.0	25.	1.5	.21	188.	11.0	1.57	.00681	
Lacon	III	446		6.4	47.0	97.0		218.0	49.	2.9	.41	277.	16.2	2.31	.01103	
LaGrange	II	571			58.0	111.0		288.0	51.	3.0	.43	336.	19.6	2.80	.01270	
LaSalle	II	432			80.0	56.0		216.0	70.	4.1	.59	233.	13.6	1.94	.01172	
Lewistown	II	293			48.8	50.0		153.0	43.	2.5	.36	175.	10.2	1.46	.00798	
Marshall	II	228			20.0	35.5		131.0	17.6	1.0	.14	130.	7.6	1.08	.00464	
Mascoutah	III	1060		10.2	299.0		119.0	453.0	368.0	21.5	3.06	399.	23.3	3.33	.04059	
Mattoon	I	611	16			185.		258.				399.	23.3	3.33	.00999	Mattoon Clear Well Water Co.
	II	222			42.	67.		96.	37.	2.2	.30	162.	9.4	1.34	.00702	Kickapoo Drain.
	II	298			66.	50.		144.	58.	3.4	.48	178.	10.4	1.48	.00924	Little Wabash Reservoir
Maywood	II	619			190.2	39.1		233.9	167.	9.7	1.38	272.	15.9	2.28	.02064	
Metropolis	III	233		2.7	20.0	17.7		163.0	17.6	1.0	.14	137.	8.0	1.14	.00482	
Minonk	I	2226	372.8			14.6		20.4								
Moline (a)	II	177.4			8.3	38.4		80.9	7.3	.4	.05	100.	5.8	.83	.00299	Suspended 108.
Morrison	I	314	6.6			110.8		153.9				237.	13.8	1.97	.00591	
Mound City	I	281	3.5			38.0		97.1				107.	6.2	.89	.00267	
Mount Morris	III	436		74.9	30.2	53.6		196.2	110.0	6.4	.91	240.	14.0	2.00	.01510	
Mt. Sterling	I	1542	88.			70.0		142.0				219.	12.8	1.83	.00549	Variable.
Newman	I	1221	76.			86.0		127.				226.	13.2	1.88	.00564	
Normal	I	410	153.			83.		131.				263.	15.3	2.20	.00660	
Oak Park	II	856			175.0		9.0	211.	154.	9.0	1.28	200.	11.7	1.67	.01781	Average of 2.
Onarga	II	1068			356.4		5.2	458.	314.0	18.3	2.61	418.	24.3	3.48	.03654	
Oregon	II	331			8.0	125.7		161.5	7.0	.4	.06	260.	15.2	2.16	.00708	
Ottawa	I	398	69.7			95.2		159.9				253.	14.8	2.12	.00636	
Palatine	II	701			269.4		62.1	118.8	237.0	13.8	1.97	192.	11.2	1.60	.02450	
Paris	II	443			58.4	102.1		188.2	51.4	3.0	.44	268.	15.6	2.23	.01109	
Pekin	III	416		41.7	82.1	46.4		187.5	119.0	6.9	1.00	229.	13.3	1.90	.01570	
Peoria	II	339			1.8	85.0		160.0	1.6	.1	.01	203.	11.8	1.70	.00520	
Peotone	II	604			126.0	35.0		302.8	111.0	6.5	.92	274.	16.0	2.28	.01604	
Plainfield	III	854		66.6	171.0	42.2		198.0	225.0	13.1	1.90	286.	16.7	2.38	.02614	
Polo	II	367			8.6	134.4		173.2	7.6	.4	.06	279.	16.3	2.33	.00759	
Prophetstown	II	339			60.8	35.7		195.9	53.6	3.1	.44	186.	10.8	1.54	.00902	
Quincy (a)	II	203			12.3	47.0		90.0	10.8	.6	.09	119.	6.9	1.00	.00390	
Rantoul	I	357	38.0			112.4		167.9				263.	15.3	2.20	.00660	
Riverside	I	807	60.0			70.0		157.0				213.	12.4	1.78	.00534	Well No. 1.
	II	689			229.	56.0		295.0	202.	11.8	1.70	346.	20.2	2.88	.02564	Well No. 2.
Rochelle	II	337			1.1	85.2		203.7	.9	.1	.01	228.	13.3	1.90	.00580	
Rockford	I	351				120.0		187.0				264.	15.4	2.20	.00660	
Rock Island	I	82				6.5		10.7								March, 1902.
	II	191			11.0	40.0		87.0	9.7	.6	.08	107.	6.2	.89	.00347	February, 1906.
Roseville	II	2591			443.8		480.4	194.6	765.	44.6	6.38	314.	18.3	2.61	.07163	Use $BaOH_2$
Rushville	II	4121			380.4		339.7	189.0	599.	34.9	5.00	283.	16.5	2.36	.05708	Use $BaOH_2$
Ste. Anne	II	943			301.		105.	293.0	347	20.2	2.90	304.	17.7	2.53	.03659	
Shelbyville	II	408			98.0	53.0		210.0	86.	5.0	.72	234.	13.6	1.94	.01302	City supply.
Shelbyville (a)	II	279			25.0	73.0		132.0	220.	1.3	.18	183.	10.7	1.53	.00639	Auxiliary.
Sheldon	I	796	166.9			25.8		35.5								
Springfield	II	276			21.0	69.0		130.0	18.5	1.1	.16	174.	10.1	1.44	.00592	Free acid and sulphates.
Staunton	II	554			153.3		185.8		360.	20.9	3.00					
Sterling	II	332			25.5	107.2		160.6	22.4	1.3	.19	244.	14.2	2.03	.00799	
Streator (a)	II	325			61.0	59.0		137.0	54.0	3.1	.45	184.	10.7	1.53	.00909	
Taylorville	III	458.3		23.7	65.4	35.0		243.0	84.0	4.9	.70	227.	13.2	1.90	.01270	
Tolono	I	656	277.4			104.9		202.0				399.	23.3	3.33	.00999	
Urbana	I	408	56.0			101.0		202.				276.	16.1	2.30	.00690	
Warren	III	379		3.3	36.0	85.2		207.0	35.3	2.1	.30	248.	14.5	2.07	.00921	
West Chicago	II	381			22.0	109.1		151.1	19.4	1.1	.16	240.	14.0	2.00	.00760	
Wyoming	I	781	95.5			85.3		73.6				204.	11.9	1.70	.00510	
Lake Michig'n	II	140			7.3	29.4		81.4	6.4	.4	.05	89.	5.2	.43	.00179	Ave. for southern end.

larger consumers, or even household softening plants may be erected. In order to furnish the chemical data necessary for such treatment the accompanying table has been prepared.

The samples of water analyzed have been sent to the Water Survey from the various towns by the water-works men, the city officials, or by other citizens. The Water Survey has not been able to collect the samples itself, and thus can not be absolutely certain that the samples are authentic. The probability is that most of them are all right.

The analytical work reported has been done in the Laboratory of the State Water Survey at the University of Illinois during the past fifteen years. There is a possibility that some of the waters have changed in character, but most of the well supplies are very stable.

Ninety-seven of the 216 separate sources of supply within the State have been examined. The analytical data which is needed to determine the method of water softening is given. Most all of the analyses are reported in full in a Bulletin of the State Water Survey.*

The mineral content given in the table shows hypothetical combinations which have been calculated from the ionic content by calculating bases in the order, potassium, sodium, ammonium, magnesium, calcium, iron and aluminum, to the acid ions in the order, nitrate, chloride, sulphate and carbonate. By using this order the waters can be divided into several classes. To facilitate comparison we made three classes.

Class I. Includes those waters which contain more than enough sodium to unite with all of the nitrate, chloride and sulphate ions. These waters would, therefore, contain sodium carbonate, and possibly the carbonates of magnesium, calcium and iron. The waters of this class will form a sludge or soft scale when used in boilers. They may have a high soap-consuming power when used for laundry or in the lavatory. The hardness, which would necessarily consist of the carbonates of calcium and magnesium, will be almost entirely removed by boiling, or by treat-

*University of Illinois Bulletin, State Water Survey Series, No. 5.

ment with the necessary amount of lime. The relative cost of softening by boiling and by lime is given by Collett* as 50 to 1.

Class II. Includes those waters which have sufficient sodium to unite with all the nitrates and chlorides and with part of the sulphates present. These waters contain the sulphate of magnesium and sometimes the sulphate of calcium, iron and aluminium. The waters of this class will form a scale more or less hard, according to the proportion of sulphate present. Their soap-consuming power may be high, and boiling will not remove all of the hardness. Boiling will remove the carbonate hardness, but the sulphate hardness will remain. Lime will remove the carbonates, but soda ash or caustic soda must be used to change the sulphates to sulphates of sodium.

Class III. Includes those waters in which the sodium is not present in sufficient quantity to unite with all the nitrates and chlorides present. These waters will therefore contain magnesium chloride. The hardness may be due to chlorides, sulphates and carbonates of magnesium, calcium, etc. These waters will be corrosive, and will form a hard scale and pit when used in boilers. They will also consume a considerable quantity of soap, and the hardness will not all be removed by boiling. As in Class II lime will remove the carbonates, but soda ash or caustic soda must be used for the mineral acid hardness.

It is noted that the waters of the second class are most common, there being 64 waters in this class. The first class is next in order with 32 waters, and the third class numbers 10.

Most of these waters will yield to treatment, the exception being those containing a large residue. These may be softened, but because of the necessary addition of sodium salts in the softening process the foaming constituents will be increased so that they will be unsatisfactory for boiler uses. With the exception of the waters just mentioned, it is possible to so treat the Illinois waters that corrosion will be prevented and the scaling ingredients reduced to less than 85 parts per million (5 grains per gallon).

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*Water Softening and Purification, London, 1908, p. 3.

The amounts of sodium carbonate (soda ash, Na_2Co_3) and lime (CaO) needed to treat the waters were calculated, using factors as follows:

Magnesium chloride, $MgCl_2$ to Soda ash, Na_2CO_3..1.1130
Magnesium sulphate, $MgSO_4$ to Soda ash, Na_2CO_3... .8811
Calcium sulphate, $CaSO_4$ to Soda ash, Na_2CO_3..... .7792
Sodium carbonate, Na_2CO_3 to Lime, CaO.......... .5287
Magnesium chloride, $MgCl_2$ to Lime, CaO.......... .5889
Magnesium sulphate, $MgSO_4$ to Lime, CaO......... .4659
Magnesium carbonate, $MgCo_3$ to Lime, CaO.........1.3300
Calcium carbonate, $CaCO_3$ to Lime, CaO............ .5600
Parts per million to grains per gallon.............. .05833
Parts per million to pounds per thousand gallons.... .008345

The amounts are calculated on the basis of pure soda ash and pure lime, and no account is taken of the residual carbonate of calcium and magnesium which can not be removed. Practice would probably show that the approximate cost is therefore a trifle high. The amount of soda ash present has been included in the calculation of the lime needed for the waters of Class I. This is according to the laboratory experiments of Bartow and Lindgren.*

The results are given in parts per million, grains per gallon and pounds per thousand gallons. This will make it convenient for treatment on a large or small scale. Those desiring to soften water for use in the household, where the whole supply is not softened, may soften from a few gallons up by adding the calculated amount. We have tried the experiment with the water at the University of Illinois on a laboratory scale, using 30 liters of water; and on a household scale, using 1,000 gallons of water. The Champaign and Urbana water supplies are in this way softened so that the soap-consuming capacity is very much decreased and so that the possibility of staining white goods from the iron present is entirely eliminated, and there is no danger of clogging the water-backs in the ranges.

Should plans be made to soften the water furnished from

*Bartow and Lindgren, Proceedings of the Am. Water Works Assn. Vol. 27, page 505, (1907.)

streams it is necessary to consider that the waters vary from day to day and that no specific rules can be laid down for the treatment. The results given are the averages. The analyses which are marked (a) are average analyses covering a period of one year, and were made by Mr. W. D. Collins, Assistant Hydrographer of the United States Geological Survey, and Mr. C. K. Calvert, Field Assistant of the United States Geological Survey, under the cooperative agreement with the State Water Survey, State Geological Survey, and the University of Illinois Engineering Experiment Station in a study of the streams of Illinois.

The cost of treatment has been calculated on the basis of lime at $6.00 per ton and soda at $1.00 per hundred. The cost at any place can be readily calculated by noting the relation between this estimated cost and the actual cost on the spot.

The above illustrates one of the lines of work planned for the survey. We wish to make analyses of all the supplies, and we wish also some day to have the privilege of collecting our own samples.

As an illustration of the possibility of success in water softening, I will mention an incident. My own cistern was dry, so I arranged to treat 1,000 gallons of water. When I was about to begin my wife expressed the wish that I experiment on some one else. The experiment was carried out, however. A few days later I was informed that the water I had treated was better. A few days later my attention was called to some curtains. "Don't they look nice? They were washed in the water you treated." I had thus one convert to water softening.

ELECTROLYTIC SEPARATION OF METALS BY GRADED ELECTROMOTIVE FORCES.

Albert Carver.

I give herewith some observations on a new method of electrolytic separation of metals by graded electromotive forces. This experimental physical work depends upon the fact that the salts of the different metals have different decomposing values. Freudenburg showed how it was possible to separate metals quantitatively in this manner.

It is only necessary to have two salts of the metals, which have decomposing values as far apart as possible. When an E. M. F. between these limits is passed through the cell, the metal with the lower decomposing value will separate; after that is separated the current will cease and it is only necessary to raise the E. M. F. in order to deposit the other metal.

When the concentration of the ions in the salt of the metal separated becomes decreased, as it almost invariably does, it is only necessary to raise the E. M. F. slightly. The amount of increase is small and may be readily calculated from the following formula:

$$\pi = \frac{R\,T}{N\,Eo} \log. \frac{P}{p}$$

If p decreases from 0.1 normal to 0.000001 normal, P must be increased 0.3 volts for a monovalent element and but half that amount for a divalent element. For example $AgNO_3$= 0.70 and $Pb(NO_3)_2$=1.52.

When these two solutions are together the Ag will be entirely decomposed by an E. M. F. of less than one volt; then the E. M. F. may be raised to 1.52 or more, and all the lead will be deposited. Separations are easily made in this way.

Below are given the separation values of a few ions. They are based on the value of H taken as zero. That is if the value of H is added to that of OH, we will have the decomposition value of H_2O 1.68. These values are for molar concentrations.

Ag = —0.78	1 = 0.52
Cu = —0.5	Br = 0.94
H = +0.0	O = 1.08 (In acids)
Pb = +0.17	Cl = 1.31
Cd = +0.38	OH = 1.08 (In acids)
Zn = +0.74	OH = 0.88 (In base)

The table is applied to the quantitative determination of Cl, Br, and I, in solutions.

The minimum E. M. F. of decomposition of this system for a solution of Ag and separation H, is given by the following equation:

$$\pi = 0.5075 \log. \frac{P_1}{p_1} - 0.0575 \log. \frac{P_2}{p_2}$$

at 17°, when P_1 and P_2 are the electrolytic solution pressures of the Ag and H, p_1 and p_2 being the osmotic pressures of the ions Ag and H.

SYMPOSIUM

ON THE SCIENTIFIC ACTIVITIES OF THE STATE; THEIR HISTORY, METHODS, AND PURPOSE.

THE ILLINOIS STATE LABORATORY OF NATURAL HISTORY AND THE ILLINOIS STATE ENTOMOLOGIST'S OFFICE.

Stephen A. Forbes.

The State Laboratory of Natural History has for its principal function the making of a natural history survey of the State, preference being given to subjects of educational and economic importance. It is also charged with the supply of natural history specimens to the State Museum, to the state educational institutions, and to the public schools, and the director of the Laboratory is required to present for publication, from time to time, a series of systematic reports covering the entire field of the zoology and the cryptogamic botany of Illinois.

It is established by law at the University of Illinois, the Trustees of which are the custodians of its property. They also appoint its director, and, upon his nomination, such assistants as the work of the establishment may require. Its appropriations are made as an item in the general appropriation bill for the expenses of the state government, and consequently come to it immediately from the State Treasury upon the requisition of the director of the Laboratory. It is now receiving from the state $9500 per annum, $8000 of which are for the expenses of the natural history survey, $1,000 for the publication of bulletins and reports, and $500 for the supply of natural history specimens to public schools. No appropriations have been made to it for many years for the supply of material to the state educational institutions or to the State Museum.

The staff of the survey now consists of the director, an entomologist, two zoological assistants, an artist, and a secretary. Special assistants are employed from time to time for special purposes. Two such assistants were engaged, for example, for a year during 1906 and 1907 in making field observations and collecting data for a statistical survey of the bird life of the state, and a computer has been engaged for some months in organizing and tabulating these data for discussion. Furthermore, the relations of the Laboratory to the State Entomologist's office are so intimate and long-continued, as will presently be explained, that the service of several assistants in both offices is rendered first in one direction and then in the other as the exigencies of the work require. Indeed, the State Entomologist's work is essentially a specialized part of the natural history survey, directed primarily to economic ends, but so managed as to make the greatest possible contribution also to the scientific and educational purposes of the general survey.

The State Laboratory is quartered in the Natural History Building of the University of Illinois, in which it occupies at present five rooms. It has further assigned to its use, to become available as soon as the addition to the Natural History Building—now nearly finished—is ready for occupancy, two more large rooms, to which a third is to be added in the near future.

Apart from its collections, which have naturally become very large—about a quarter of a million of specimens of Illinois fish, for example—the most useful possession of the Laboratory is its library, which is the product of many years of careful selection and purchase of the literature of the world necessary to an investigation of the zoology and entomology of Illinois. It contains also many botanical and general biological works, and includes complete series of all the bibliographies of zoology. It now contains nearly 7000 books and something over 17,000 pamphlets, all of which are catalogued to date by titles of articles and by authors' names.

It has been the general purpose of the natural history survey, first, to work up those parts of the zoology and the cryptogamic botany of the state which are least likely to be studied thoroughly by other public agencies or by private investigators, publishing the results of these studies from time to time in special bulletin articles; and, second, to present comprehensive summaries of knowledge in each department of the zoology and botany of the state in the form of final reports. As the continued maintenance of the survey seemed for many years precarious, under the conditions then existing, its funds were for a long time used principally for the accumulation of material, and this has gone on far in advance of studies for publication. Highly valuable collections have been made, for example, from Lake Michigan, from the northern lakes of Illinois, and from the waters of the state at large, which have never yet been studied and reported on.

The controlling idea in the management and development of the survey is expressed in the introduction to the first volume of its reports, written by its director—the present writer—in 1889, four years after its legal establishment as the recognized agency of the state for the performance of this work. "Neglecting the flowering plants, and the classification and description of birds and mammals," says this report, "already fairly well studied for this region, we have paid particular attention, so far as descriptive work is concerned, to the lower plants, to reptiles, amphibians, and fishes, and to insects and aquatic invertebrates. Still greater prominence has been given to a general research on the system of actions and reactions occurring within the assemblage of living forms native to Illinois, with a view to exhibiting the laws of interaction and coordination by which the innumerable host and vast variety of the plants and animals of our region are held together as a definitely organized, living whole.

"In the preparation of the volumes of this report it will be our main final object to furnish the materials for a full and accurate picture of the native plant and animal life of Illinois as it actually exists in our fields, woods, and waters, and to bring most prominently into view those parts of the subject which have a peculiar educational or economic value. Especially we have hoped to furnish in this series a solid and permanent basis for the study and teaching of the natural history of this state and of its different sections, thus opening to the student and the teacher the way to a familiar knowledge of the life of his neighborhood in all the relations likely to have any important bearing on popular education or on the general welfare.

"Classification and description must furnish the foundation of such a work; but to these will be added accounts of habits, of life history, and of relations to nature in detail and at large, as full as the state of our knowledge and the funds at our disposal will permit."

Although the word *ecology* had not become current in America twenty years ago, and the idea covered by it can hardly be said to have been a familiar one, it will be noticed that the survey here characterized is essentially an ecological one—a fact which has enabled us to harmonize very easily our plans, and the operations in progress, with the ideals and aspirations of the young ecologists of the Illinois Academy.

Consistently with the general idea of the study by the state, within our field of ecological biology, of those subjects of educational or economic importance which are not likely to be pursued by others, the general topic of the food of birds, fishes, and certain groups of insects was taken up, many years ago, with a view to a precise knowledge of the place and efficiency of these groups in the general system of nature—a topic of such special difficulty, and requiring so unusual a preparation and so large an expenditure of time and money, as to put it beyond the reach of the ordinary worker. The Illinois survey was, in fact, the pioneer in this field, and its papers, published in the first two volumes of the State Laboratory Bulletin, still remain standard on this subject.

A statistical study of the birds of the state, made with a view to a determination of the number of birds of each species and the local and seasonal distribution of each, is a related subject also requiring the resources of an institution, and has consequently been entered upon by us recently.

Another topic likewise beyond the reach of ordinary agencies is the study of the whole system of the minute plant and animal life of the waters of the state—the so-called plankton,— and in this field extensive researches were made by us during five successive years, from 1894 to 1899, by means of a biological station equipment maintained on the Illinois River at Havana, in which practically continuous work was done throughout the year. This is by far the largest and most elaborate study of the plankton of a river system ever prosecuted, and a part of its results—those pertaining to the plankton of the main stream —have been published by us in two volumes of the Bulletin, containing 890 pages of text and illustrated by fifty-six plates. Although strictly scientific in its aims and methods, this aquatic work lies really at the foundation of intelligent fish-culture, the plankton of our waters being an important element in the food of the young of all fishes, and hence an important part of the natural resources of the state.

The publications of the survey thus far include eight volumes of bulletins,—the last not yet complete,—containing 4224 pages and 246 plates, and three volumes of final reports—two on the birds and one on the fishes of the state, the latter accompanied by a separate atlas of 102 maps.

Some of the more important papers of the bulletin series are those on the food of birds, fishes, and insects, already referred to, and descriptive articles on the *Hepaticae* of North America and on certain families of fungi; lists and descriptions of Illinois fishes; several articles on the *Crustacea* of Illinois; studies on the contagious diseases of insects, made especially with reference to their economic utilization; descriptive papers on Illinois reptiles and amphibians; a paper on the animals of the Mississippi bottoms near Quincy; many articles on various families of Illinois insects; a study of the entomology of the Illinois River and adjacent waters; numerous studies of the earthworms of the state and their allies; papers on the *Protozoa* and *Rotifera* of the Illinois River and adjacent lakes; a series of articles on the plankton, resulting from our biological station work; a paper on the leeches of Illinois; articles on the species, local distribution, and ecological relations of Illinois fishes; and an article on the biology of the sand areas of Illinois.

The character and object of the final reports of the survey are best illustrated by the volume on the fishes of the state, now just out of press. I have two additional volumes of this series in early prospect—one a long-delayed treatment of the more important birds of the state from an ecological and economic standpoint, intended to bring together in a single volume the essential substance of our statistical and economic work and that of the United States Biological Survey on the more abundant and significant species of Illinois birds; and another on the entomology of the state, which shall similarly summarize the more prominent and important results of economic work in this field, treated, however, in a broad way, from the standpoint of the modern ecologist.

Operations now actually in progress include continuous work on Illinois insects, on which several bulletin papers are in course of preparation by assistants of the survey; a study of the mammals of the state, particularly those of Champaign county, which subject is being worked out in full local and ecological detail; a survey of the forest resources of the state, begun during the past summer under a cooperative arrangement with the United States Forest Service; and a census of the birds of the state, upon which two papers have already been published, and the complete data for which are now being organized by statistical methods.

I am hoping next to develop our work by a further investigation of our natural resources, with reference to their present condition and management, and to measures for their conservation and improvement. I hope to finish the forest survey, already begun, to complete and extend our statistical work on the birds of the state, and to continue and complete our study of our aquatic resources, particularly those contained in the Illinois and the Mississippi rivers and the waters most closely connected with those streams. The Illinois River especially is an enormous storehouse of material wealth, the natural product of which is little appreciated, and the conditions of whose improvement have but just begun to be understood. With the extraordinary advantage given us by our biological station work on the river we could readily make a quantitative study of the plankton and the other biological products of the entire stream, and I am asking from the state legislature an opportunity to do this work.

Our previous five-year period of active operations on the river at Havana closed just before the opening of the Chicago drainage canal. Sufficient time has now elapsed since that revolutionary event to allow a reestablishment of the biological equilibrium in the waters of the Illinois, and a repetition of that work on quantitative lines would enable us to determine the influence on the life of the river of a large and sudden increase in the flow of water down its bed. An economic survey of the plant and animal life of the stream would give us a better basis than we now have for a convincing estimate of its value to us, present and prospective, actual and possible.

With all the operations being planned for the drainage and protection of its bottom-lands, for the deepening of its channel, and for the erection of enormous manufacturing plants upon its banks, there is imminent danger that it will presently be converted into a mere drainage ditch, barren of useful life, and a menace to the public health. A knowledge of its present and prospective values will be a great aid to us in providing against its pollution and economic destruction by the unregulated development of manufacturing plants along its banks.

In connection with the proposed work at Havana I hope to set on foot a general ecological survey of a cross-section of the Illinois basin, beginning with the black lands of Logan county and extending across the river to the similar lands of Fulton county. Such a work I hope to see begun the coming summer, with the aid of the ecologists of the Academy, and carried through as an example and model of work of this description.

Thinking that you would doubtless be more interested in a statement of the work now in progress and in immediate prospect than in an account of the development of our operations, I have left myself time for only a brief sketch of the history of the State Laboratory from its origin in the Museum of the old State Natural History Society. This museum, transferred to the State Board of Education at Normal in 1871 for the use and benefit of the state, received from them the name of the Illinois Museum of Natural History, and their intentions concerning it were described in resolutions adopted December 15, 1875, in which they say: "We regard the Museum as a State Institution, devoted to the prosecution of a natural history survey of the state, * * * * and we consider it an important part of its work to supply collections of specimens to public schools, * * * * and especially to provide all needed facilities for the instruction of teachers in natural history, and in the most approved and successful methods of teaching the same."

In the law of 1877, however, which established a State Museum at Springfield under the name of the Illinois State Historical Library and Natural History Museum, it was directed that the old museum of natural history at Normal be converted into a state laboratory of natural history, at which the collection, preservation, and determination of all zoological and botanical material for the State Museum should be done; and it was further made a part of the duty of the director of this laboratory to provide, as soon as possible, a series of specimens illustrating the zoology and botany of the state, and to deposit them from time to time in the State Museum. In this same act $1000 per annum was appropriated, to be expended under the direction of the director of the State Laboratory at Normal, for the purpose of increasing the collections in natural history in the State Museum at Springfield. The collection of birds now in the museum, the mounted mammals, the casts of fishes, most of the insect collections, and a considerable quantity of botanical material are among the products of these appropriations so made.

In 1883 the status of the State Laboratory was materially changed by the appointment of its director to the office of State Entomologist, then made vacant by the resignation of Dr. Cyrus Thomas,—an appointment made and accepted with the understanding that the work of the State Entomologist and that of the State Laboratory of Natural History were to be merged and managed as one.

In 1884 the opportunity arose for a transfer of both the State Laboratory and the Entomologist's office to the State University at Urbana, a situation evidently more natural and more promising for its future than association with a normal school, and this transfer, arranged by friendly agreement of all the parties concerned, was ratified by an act of the state legislature approved June 27, 1885, which act is the present fundamental law of the State Laboratory of Natural History.

At the University it has remained for twenty-five years, nominally controlled by the university Trustees, but practically independent in its management. The most notable fact of its history was the opening, by joint arrangement with the Uniersity in 1894, of a station on the Illinois River for the investigation of the biology of that stream, and the maintenance of this station for continuous work during the five following years.

The office of State Entomologist stands second in point of origin and first in period of service, on the list of the state agencies of scientific and economic research. Established by law in 1867, it has been continuously maintained for forty-two years— a longer period of activity, in fact, than that of the geological survey, which, although estalished in 1851, was suspended for twenty-eight years. It had its origin in an energetic demand of the State Horticultural Society of Illinois, whose president, Parker Earle, in 1865, seems to have been the first to make prominent public mention of the subject. In a meeting of the society held at Normal, December 19 of that year, he says: "And first, the appointment of a state entomologist. The time has been in this state when it required some moral courage for any one to advocate the appointment, and *compensation from the treasury,* of an officer to look after the bugs, but I venture the opinion that there is no subject in which you, as amateur or professional horticulturists, have a more direct, immediate, or larger pecuniary interest than in entomology—the laws of insect life, a discriminating knowledge of the forms and habits of your insect friends and foes. * * * * No one who has given the subject any attention will question the truth of the statement that the people of Illinois are to-day many millions of dollars poorer by reason of noxious insects; nor the additional statement that a very large proportion of this loss might have been averted by the labors of a competent entomologist with a little means at his disposal. * * *

"*Let us have* a state entomologist; and luckily we need not go beyond the limits of our own state to find one of the most competent character."

This suggestion was approved by the society at this meeting, and was followed the next year by the hearty endorsement of its next president, who said, in his annual address: "The lessons of the year are instructive, and strengthen the conviction that fruit-growers had better give up the business, or give more attention to the insects that are laying waste their orchards. It is my belief that fully one half of the fruit trees within the range of my acquaintance are suffering from diseases wholly the result of insect ravages, and that more than half of their fruits the past summer have been wasted from the same cause." He expresses a desire for "a bureau of entomology, to act independently until it shall be adopted by the long-looked-for agricultural college, to be provided by the state with all facilities for organizing and carrying on a systematic warfare upon these, so far, triumphant enemies of the farmer and the horticulturist."

The resolution of the society upon this feature of the president's address was expressed in the following emphatic form: "*Resolved,* That we most urgently pray the honorable legislature of our great state to appoint a state entomologist, that agriculturists and horticulturists may not quite despair of ever overcoming the giant insectivorous difficulties in the way of success in their professions. As one eminently qualified, and the highest in his profession in the whole West, we most hopefully mention the name of Benjamin D. Walsh, of Rock Island."

As a result of this movement an act was passed in 1867 authorizing the Governor to appoint, with the consent of the Senate, some competent scientific person as state entomologist, whose duty it should be to investigate the entomology of the state of Illinois, and to study the history of the insects injurious to the products of the horticulturist and the agriculturist. Under this general and rather inadequate warrant the work of the office was prosecuted by Walsh, LeBaron, Thomas, and the present writer, expanding with the development of its field and becoming more complicated and precise in response to the various demands made upon it, until, in 1907, a new law was passed, by which it was made the duty of the Entomologist to investigate, by himself or by his assistants, all insects dangerous or injurious in this state to agricultural and horticultural plants and crops, to live stock, to nursery trees and plants, to the products of the truck-farm and the vegetable garden, to the shade trees and other ornamental vegetation of cities and towns, to the products of mills and the contents of warehouses, and to all other valuable property; and to investigate all insects in the state injurious or dangerous to the public health. He is further required to conduct experiments for the prevention and control of injuries to person and property by such insects, and to instruct the people of the state, by lecture and demonstration, in the best methods of preserving and protecting their property and their health against insect injuries.

Consequent upon the appearance in Illinois of the San Jose scale, first discovered here in 1896, a law was passed in 1899 putting upon the State Entomologist the further duty of inspecting annually all nurseries in the state, and, where the stock and premises of these nurseries were found free from dangerous insects and fungus pests, of issuing to their owners certificates of inspection, without which it became illegal for them to do a nursery business. He is likewise required to supervise importations of nursery stock into the state, and to inspect all orchards and other similar property which he has reason to suppose to be infested by dangerous insects or infected with contagious plant diseases. Power to quarantine, and to issue directions for the treatment of diseased or infested property, are likewise given him by this law, which is enforced by the provision of fines for its violation. Although drawn with special reference to nurseries and other horticultural property, and with principal reference to the San Jose scale, I am advised by the Attorney General of the state that this law is broad enough in its terms to enable the entomologist to interpose for the protection of any property whatsoever endangered by insects or fungus pests on adjoining premises. Minor modifications of the law were made at the last session of the legislature, without affecting, however, the provisions just described.

It was by this law of 1899 that the office of State Entomologist was first given a legal habitation and abiding place; although upon the appointment of the present incumbent in July, 1882, quarters had been assigned the office, by courtesy of the State Board of Education, in the building of the State Normal School at Normal, and on the transfer of the office to the Illinois Industrial University two years later, it was, by similar courtesy of the Trustees, adequately housed in one of the university buildings. The preceding entomologists had, however, been virtually without office accommodations, each making such arrangements for himself as he found necessary, and the location of the office shifted, consequently, with the residence of the entomologist. In Walsh's time it was at Rock Island; in LeBaron's, at Geneva; and in Thomas's, at Carbondale.

The practical merger of the work of the entomologist with that of the State Laboratory of Natural History in 1883, as already described, greatly increased its facilities and opportunities for special work. At the time of this merger it had neither appropriations for its expenses, nor a dollar's worth of property of any description, its sole resources being the private library and collections of the entomologist himself. From that time forward, however, it had at its disposal the collections, library, quarters, and assistants of the State Laboratory of

Natural History; and appropriations in its support were thereafter regularly made in connection with those for the Laboratory. By the transfer to the University, and the subsequent establishment of an Agricultural Experiment Station there, its opportunities and resources were, of course, greatly increased, and it now receives separate appropriations to the amount of $27,000 per annum, $5,000 of which are set aside each year for the expenses of its inspection and insecticide work.

It has on its staff at the present time, besides the entomologist himself, ten regular assistants, a draftsman, a chief inspector, four sub-inspectors on temporary engagement only, and a foreman of insecticide operations with about a dozen laborers under his charge.

The principal subjects now under investigation are the life histories and economic control of the various species of May-beetles and click-beetles, and their larvæ, the white-grubs and wireworms; the economic control of the corn root-aphis; the forest insects of the state; those affecting shade trees and other ornamental vegetation in cities and towns; insect pests of greenhouses and the truck-farms in the vicinity of Chicago; the house-fly pest in cities and towns, upon which a large amount of experimental work was done last summer; and various insects injurious to fruits whose life histories have not yet been worked out, and whose economic control presents problems requiring special investigation.

The published reports of the office are twenty-four in number, thirteen of which have been prepared by the present incumbent. The twenty-fifth report is now going through the press. The twenty-four now printed contain, in all, 4827 pages, of which 104 were contributed by Walsh, 419 by LeBaron, 1187 by Thomas, and 3117 by Forbes. Their contents are too varied to be capable of a brief classification. They consist mainly of miscellaneous articles on single topics, worked out to the practical end of an economic control of some form of insect injury, usually verified by repeated trial in the field; or of comprehensive, monographic articles on all the insect injuries to some single crop, with elaborate recommendations for general management and for special treatment directed to the prevention or arrest of such injuries.

Most of these articles are now issued first as bulletins of the Agricultural Experiment Station, in an edition of 50,000 copies, an additional thousand copies being run off in form for subsequent binding as the biennal report of the entomologist. By this arrangement the entomologist has the benefit of the mailing list and the postal frank of the Experiment Station, of which he is in fact the Consulting Entomologist by formal appointment, and is able also to get his finished papers at once distributed, without waiting for the completion of his entire report.

While the lines of work represented by these two closely affiliated state departments of scientific investigation have been carried forward frequently under many difficulties, due largely to the fact that their constituencies were unorganized or imperfectly organized, and hence could not exert their proper influence in favor of their own interests, this condition has now virtually disappeared in the State Horticultural Society, in the State Farmers' Institute, in the State Association of Florists, and other like organizations, and now in the State Commission for the Conservation of our Natural Resources, and especially in the Illinois Academy of Science, we have active, powerful, public-spirited agencies which can be relied upon to promote every good work of this description with their endorsement, with their aid, with their judicious criticism of its aims, plans, and methods; and the next ten years will, in my judgment, see greater progress than the last twenty-five in the advancement of a useful knowledge of the State of Illinois, set forth in such forms as to make it available for the educational and economic welfare of its people.

THE STATE WATER SURVEY.

EDWARD BARTOW.

The late Arthur W. Palmer, Professor of Chemistry of the University of Illinois, began the systematic survey o fthe potable waters of the State in 1895. In 1897* the work was officially recognized when the Legislature made it the duty of the University to collect facts and data concerning the water supplies of the State; to collect samples of water from wells, streams and other sources of supply; to subject these samples to such chemical and biological examination and analysis as would serve to demonstrate their sanitary condition; to determine standards of purity for drinking waters for the various sections of the State; and to publish the results of these investigations to the end that the condition of the potable waters of the State may be better known, and that the welfare of the various communities of the State may thereby be conserved.

Three thousand dollars per annum was appropriated at first. This has since been increased to $6,000 per annum with additional money made available for the work by the State Board of Health and the University.

The work of the Survey may be classified in three divisions: first, Analytical and Experimental; second, Diagnostic; third, Education and Publicity.

Under the first division, Analytical and Experimental, the Survey collects waters and determines the normal constituents for a district. Some of the investigations along this line that are being carried on are, a study of farm water supplies; a study of well waters in villages; and a study of the character of the water of Lake Michigan along the Illinois shore. In order to study methods the Water Survey

*Laws of Illinois, 1897, page 12.

has joined with the laboratories of the State Boards of Health of Michigan, Wisconsin, Indiana, and the Health Department Laboratory of Chicago, in a comparative analysis of Lake Michigan water. It has also made a special study of methods of determining nitrogen as nitrates, a test which is of great importance as a sanitary test for Illinois waters.

Under the second division, Diagnostic, are included the large number of analyses made at the request of the health officers or other citizens to determine the character of waters. The Survey is working in conjunction with the State Board of Health in endeavoring to prevent and check epidemics of water-borne diseases. In 1908, 1862 samples of water were sent in by people not connected with the Survey staff, and a large proportion of the time of the active staff has been occupied with this work. Because of the great demand for work of this kind the Trustees of the University have recently passed a resolution concerning the work of this class to be done by the Water Survey, which is summarized as follows:

"The State Water Survey will make a sanitary analysis free of charge of any water from the State of Illinois, when there is any suspicion that there is danger to health.

"The Water Survey will make sanitary and mineral analyses free of charge of any present or proposed municipal water supply.

"A fee will be charged for the examination of the mineral content of waters, other than municipal supplies. This includes analyses to determine the medicinal value, and to determine the character of a water with reference to its use in boilers or for manufacturing purposes."

Under the third division, Education and Publicity, the Survey issues bulletins describing the work done. Lectures are given to communities on problems connected with water supplies. Water-works men have taken and can take advantage of the Water Survey Laboratories to learn methods of chemical or bacteriological control for their water-works plants.

The Survey should examine every water-works plant in the State at least once in a year. It aims to become a clearing house for information concerning water supplies. Information that has proved of advantage to one supply may thus be passed from plant to plant. This aim may be more quickly realized through the Illinois Water Supply Association recently formed. The objects of the Association are the advancement of knowledge relating to water-works and water supply, and the conservation of water supplies for public use. The Association is to meet annually at the University of Illinois, where it can take advantage of the facilities of the State Water Survey and the Laboratories for Hydraulic and Mechanical Engineering. The Association can make valuable suggestions to the Water Survey, and can also strongly support the Survey in its endeavors to conserve the welfare of the people of the various communities of the State.

THE STATE HIGHWAY COMMISSION.

A. N. Johnson.

Road making is a science. Not until this fact is appreciated and our roads are built and maintained in accordance with the underlying scientific principles, both as regards construction and business methods employed, there will be a just return to the taxpayers for money raised for this purpose.

We are apt to think that the art of road making is much farther advanced in Europe than in this country. This is not so, for, as a matter of fact, some of the best constructed roads, and roads employing the best methods of construction, are to be found in the United States, but it is a fact that such construction is not very general. The prevalence of better road conditions in some European countries is due in part to the improved methods of maintenance rather than to advanced methods of construction. But here, again, we can point to certain sections of this country where the roads are not only as well constructed but as well maintained as will be found in any European country. This fact applies to the state highways of Massachusetts, which are thoroughly well constructed and equally well maintained.

Illinois has recognized that road building is a science, by creating a State Highway Commission whose duties are to give information concerning the best methods of construction and maintenance of roads and bridges; to find out existing conditions, and suggest means of improvement.

The work carried on by the Commission during the past three years has had for its object the encouragement of the application of practical scientific principles in the construction and maintenance of the roads and bridges of the state; to the end that more improvement may be secured by the taxpayers for the money which they now expend for this purpose.

It is perhaps unfortunate for the scientific road-builder, or the highway engineer, that there exists a deep-founded conviction that, howsoever one may be lacking in knowledge on other subjects, all know how roads should be built. Doubtless acting on this theory, we find the road work of this state divided among some 4500 officials, 3 to a unit, either a township or road district as the case may be. These officials rotate in office so that all in a given community may have a reasonable opportunity to exercise practically their ideas concerning road work.

The road unit in Illinois is too small to handle economically the improvement that most communities need and demand. Until it is possible to do the work under the control of large units, or arrange to have a number of the smaller units combined to come under a single control, it will be impossible to accomplish any considerable systematic work; in fact, it may be said generally that no systematic road work in this country has been done except through a larger central control than is possible under the township method. This phase of the question affects the scientific business methods that should be followed.

Modern scientific investigations have made it possible to tell in the laboratory very closely how a given material will act upon a road without the necessity of the more costly experiment of actually putting it on the road and observing it. We have to-day a number of laboratories in this country especially devoted to tests upon road materials. The methods of making these tests have been the subject of careful investigation by physicists and chemists. Such a laboratory is to be found in the University of Illinois, where a number of tests for the State Highway Commission have been conducted.

The State Highway Commission is concerned not alone with road construction but with the construction of highway bridges. The fact that nearly one half of the $5,000,000 raised by the rural taxpayers for maintenance of roads and bridges is spent on bridge construction shows the relative importance of this branch of the work.

What will be one of the largest reinforced concrete tests carried on in this country, the State Highway Commission has at present under way. We have built at the Southern Illinois Penitentiary a 40-foot concrete bridge, which it is proposed to investigate thoroughly and finally load to destruction. It is perhaps one of the first instances of using convict labor for purposes of scientific investigation.

The construction of bridges involves the public safety as well as the public pocketbook, and it therefore demands perhaps more careful study than the matter of road construction, where the pocketbook alone is concerned. The State Highway Commission offers to local officials designs and estimates for their bridges, to the end that they may have a safe structure and also an economical structure.

As a whole, the work of the State Highway Commission may be considered broadly educational. Practical demonstrations are made of the application of proper principles to road and bridge construction. It is by this method alone that the people generally come to appreciate the practical value of having work done in this manner. As a rule, but a few samples suffice for a community to demand or endeavor to have the whole of their work of a similar character, done in the same manner as outlined by the demonstrations. Thus it is that the actual work done by the Commission is not a true measure of its influence, which is much greater in extent.

Better roads in the country are no small factor toward a solution of some of the gravest sociological and economic problems connected with country life, and the methods to be employed to secure better roads, and the methods to be used in their construction are well worthy the consideration of the State; and money so spent is a good, practical investment that in no great length of time will give a good return to people in every section.

THE WORK OF THE STATE GEOLOGICAL SURVEY.

FRANK W. DEWOLF.

One is likely to think of our state as essentially agricultural, but Illinois ranks third in mineral production and the latest complete returns, those for 1907, value our output at more than $152,000,000. The State now ranks second in the production of coal, second for oil, fourth for clay products, and well toward the top of the list for a number of other materials. This creditable showing is nevertheless a mere beginning in comparison with our possibilities.

The study of our geology and mineral resources was authorized by a legislative act of 1851 and for the first six years was in charge of Dr. J. C. Norwood. After him Dr. A. H. Worthen directed the work till its discontinuance and the establishment of the State Museum of Natural History in 1877, of which he was made curator. The present Survey was created in 1905 to operate under the direction of a commission composed of the Governor, the President of the State University and a third member, Dr. T. C. Chamberlin, President of this Academy. Dr. Bain, director of the Survey, regrets that he can not be here to speak of the scope and progress of the work.

The Geological Survey was created to assist in the economical development of our resources. Its functions are broad enough to give it a part in the solution of all public problems into which a knowledge of geology enters. The finding of adequate public water supply, of materials for use on the public highways, of limestone suitable for use on acid soils, the regulation of our rivers and reclamation of undrained lands, bettering of conditions in our coal mines, the better direction of exploration for oil, coal and our other buried resources,—with all these problems, the State Survey is concerned either alone or in cooperation with other bureaus. The work involves field studies, laboratory tests, library research and study of conditions in other states. When the present Survey was created there was, in a sense, thirty years of back work to do in collecting data and noting changes which had taken place. The work is now well under way and the methods adapted to this field are determined. The rate of progress will depend largely on the funds available.

The Survey is organized into three sections, geologic, topographic and drainage. There is close cooperation with allied bureaus in the state, with the U. S. Geological survey and the U. S. Department of Agriculture. Through fortunate situation at Urbana there has been valuable consultation with geologists, chemists, and engineers of the State University as well as with those of other institutions.

The first necessary step has seemed to be the preparation of topographic base maps. The accompanying map illustrates the progress of this work. The topographic map of the state will be composed of unit quadrangles measuring about 13 by 18 miles each. They serve as a base for geologic studies and also for general engineering and educational purposes. They are prepared in cooperation with the U. S. Geological Survey, and progress so far has been designed especially to meet the need of surveys in our mining regions.

The geologic work has been of several degrees of refinement, detailed reports have been prepared in many of the quadrangles, while general reconnaissance studies of stratigraphy, structure, and mineral resources have been pursued over the state so as to meet pressing needs and to lay the foundations for further detailed work.

The drainage section has worked in cooperation with the Internal Improvement Commission and the Drainage Section of the U. S. Department of Agriculture in the preparation of large scale maps of the overflowed areas along our largest streams. Such work is a prerequisite to any successful attempt to reclaim the land and promote sanitary and economic improvements.

To the present there have been distributed eight bulletins and four circulars. They include data of general geology, petroleum, coal, water resources and miscellaneous subjects, and the first of a series of educational bulletins on physical geography which are designed especially to meet the needs of teachers in our public schools. There are at the present time seven reports ready for the printer, besides others in preparation.

At the last meeting of the Academy a committee was appointed, I believe, to provide a means of cooperation in the collection of records of deep wells in the state. The Survey has organized a new line of research involving the study of underground water resources. This requires the collection and study of drill records, and where possible the study also of the drillings themselves and of the outcropping beds. Members of the Academy can render our work much more efficient, if they will bring to our attention any drilling which may be done for water, coal, or for other purposes throughout the State, and cooperation along this line is urgently requested.

SCIENTIFIC ACTIVITIES OF THE ILLINOIS STATE MUSEUM OF NATURAL HISTORY.

A. R. Crook.

The Museum is fifty-eight years old. It is thus older than any other department represented here. For the first twenty-four years of its existence it was a part of the State Geological Survey. Then for twelve years the Museum and Historical Library were under the control of the former State Geologist. For the last twenty years it has existed strictly as a Museum of Natural History.

When in '75 the State Survey was discontinued there was a period of two years during which the Museum was not recognized officially, but the fossils and rocks could not be "discontinued" and consequently perpetuated the influence and spirit of the institution till a time when Professors Forbes and Worthen introduced into the legislature a bill creating the State Museum and Historical Library.

During all these years of its existence it has been pre-eminently a geological museum.

In spite of the fact that the law creating the survey in '51 provided that it should be in charge of a so-called "practical geologist" circumstances brought it about that the men who directed the affairs of the survey during the first twenty-four years were paleontologists—men whose work may be regarded as leaning more toward the scientific side than toward the practical side of geology.

But that Dr. Norwood and Prof. Worthen should work with the greatest enthusiasm along paleontological lines was natural and fortunate since at that time the fossils of Illinois offered a most attractive field for labor. As a result of their work large quantities of valuable materials were brought together in the museum, and the museum became a laboratory and workshop rather than an institution for exhibition. The study and classification of this material yielded extremely valuable results and formed the basis for the publication of eight volumes of geological reports. These reports embodied practically all that was known of the geology of the State of Illinois at that time, contributed in an important manner to geology in general, and extended the reputation of the survey throughout this country and Europe.

After Worthen's death, his successor, Dr. Lindahl, while preparing an exhibition for the World's Columbian Exposition, extended the work of the museum so that it embraced somewhat more general geological lines. Some of Lindahl's energy was directed toward editing the last Worthen reports, and more toward overhauling and re-classifying the museum material which during the last years of Worthen's incumbency, much against his wish and during his absence from the city, were moved from one floor to another in the State House and thrown into endless confusion.

During Mr. Gurley's curatorship the work along paleontological lines was continued and eight bulletins on paleontology were published in collaboration with S. A. Miller, of Cincinnati.

During Mr. Crantz's incumbency the work was in the line of exhibition of material rather than in collection or investigation. The chief additions made to the museum were a collection of birds' eggs.

Some zoological and botanical material had come to the museum as early as in 1871, when upon the disbanding of the State Natural History Society a portion of its collections were given to the museum. From time to time the State Laboratory of Natural History, under Prof. Forbes, has added to the zoological collections of the State Museum. But taken as a whole the museum has been geological in character, and all of its contributions to science have been in the field of geology.

Such has been the history of the institution. What of its present and future? In what direction lies its greatest promise of useful service? In considering this question one should not be largely influenced by obstacles and difficulties in the way—difficulties such as arise from unfavorable method of control, lack of adequate housing and material equipment, and preoccupation of the field by other organizations and departments.

Its method of control is unfortunate. When a museum is dependent upon trustees who are preoccupied with other affairs and who are trustees simply because of other positions which they hold and not because they have any interest in the museum, the service which they render the museum and the aid which they give to it for fulfilling obligations imposed upon it are a minimum.

In President Eliot's recent book on "University Administration" light is thrown on the great advantages enjoyed by institutions free from ex-officio boards of control. Such freedom would be to the advantage of the museum. For example, the State Academy might nominate a committee of six competent men willing to serve, and from them the Governor could select three to act as trustees. There are many men in the State who would give the museum their best thought and support and could help it to more nearly accomplish the work that is crying for attention.

An even more serious obstacle to progress is encountered in the lack of room for work and for exhibition. Many other states have surpassed Illinois in provision for their museums. Some have fine buildings. Here again the Academy could render a great service by urging that suitable museum room be provided. While the members of the General Assembly respect science and have a vague notion that it is worthy of encouragement, they will never do anything unless scientific men not only ask but urge each legislator to vote for a building. With legislators people count, abstract principles play an insignificant part. The State needs a fire-proof building where collections which have been growing for half a century may be preserved and where much needed work in natural history may be done.

Some idea of the scope and importance of the work that may reasonably be expected of the museum can be obtained by considering the magnificent work being carried on by the greatest of the museums in the United States, such as the American Museum of Natural History in New York, the National Museum in Washington, and the Field Museum in Chicago. These institutions send out exploring expeditions, collect, prepare, study and exhibit materials, publish reports of investigations along special lines and furnish lecture courses. They are educational institutions of an effective type. Any museum which is doing its work properly is an educational institution. The State Museum aims to be such. Two years ago the writer applied to a United States Government official for tax-free alcohol for preserving museum specimens, but was refused on the ground that the museum is not an educational institution. Some discussion was necessary to make it clear that the institution exists for nothing else than to educate. Its collecting is with that end in view. Its study, preservation, exhibition and publication is for that purpose and for that alone.

While dealing with historical objects in archæology, palæontology and other sciences, it affects modern questions and present-day issues. When attention is being so strikingly called to the necessity of conserving the natural resources of the country, museum collections are of unusual interest, since they offer tangible illustration of the passing of fauna and flora and of the origin, value, and limited quantities of our mineral resources. One needs but to pass through a good museum to gain a vivid impression of the changeableness of nature, of the destructiveness of man and of the danger of watchfulness. The museum should make a concrete and compact plea for care and wisdom in the use of natural resources.

The excellent work which is being performed by a number of departments of the State would be better appreciated if the material results were well exhibited in the State Museum. The law provides that the Geological Survey may deposit materials in the museum, and it is the wish of the director of the survey and of the curator of the museum that this work be carried out in a thoroughgoing manner. The director of the Natural History Survey is ready to furnish materials which may visually illustrate the work of his department, and no doubt such a relationship would be extremely desirable for many other departments, such as the Water Survey, Soil Survey, Board of Health, State Highway Commission, etc. The present obstacle to carrying out this plan is the absence of room in the museum. The museum may thus become a great and popular representative of the various lines of scientific activity in the State.

It should aim above all things to be a popular institution; one for the people. But while so doing it does not cease to aid investigation and to promote the advance of science. As Dr. L. A. Baur, of the Carnegie Institution has said, "Sight plays the greatest part in investigation." The museum appeals first of all to this faculty, and is aiding investigation when stimulating a boy in his early efforts to observe nature, as well as when furnishing material for the trained specialist in some particular line of investigation.

One of the greatest needs of the museum is the interest and cooperation of some permanent organization. Individuals may come and go, but the museum will last indefinitely. Situated as it is at some distance from the scientific center of the State, it may be regarded as being on the frontier and extending the influence of science to the south and west. Fortunate indeed would it be in having the hearty support of the State University, of the University of Chicago, of the Northwestern and of every educational institution of the State. That interest might well be expressed through the State Academy of Science. As the State Historical Society is closely associated with the Historical Library and is asking for a room for its meetings in the proposed new building, and actively cooperates with the library, so the State Academy may well be provided with a room in a new museum building and use its influence to see that the museum collections are properly preserved and utilized. If the Academy would make itself felt effectively in this regard the museum would be protected from many errors and dangers and would be aided in its work.

Wm. A. Hornaday at the "Founder's Day" of the Carnegie Institution, in Pittsburg, last year said the function of the museum is "to furnish food for thought, to expand the human mind, and to illuminate the soul."

Morris K. Jesup said at the American Museum of Natural History of New York, "I believe the museum to be to-day one of the most effective agencies which exist for furnishing education and innocent amusement and instruction to the public."

This should be true of the State Museum, and will become increasingly so as the museum is enabled to do some exploring in fields not already occupied, to do some collecting, to care for the results of the work of different scientific departments of the State, to preserve vanishing natural history data, and to properly exhibit materials which show our natural resources and their well-marked bounds.

ADDRESSES AT THE CHAMBER OF COMMERCE BANQUET.

(*Stenographic Report.*)

Mr. Hall—President of Chamber of Commerce.

"Ladies and Gentlemen of the Academy of Science:—It is my pleasant privilege to extend to you a hearty welcome and to assure you of the very great pleasure we have in your presence to-night. There is an old saying 'All work and no play makes Jack a dull boy.' This is equally true in selling merchandise or in any other calling in life, and to mix a little play with work, to have the recollection, when you return to your home and to your work, to have the memory of a pleasant hour this informal meeting was planned. It is now my pleasure to present to you Professor Blair, who will act as your toast-master."

In introducing Dr. Trelease Prof. Blair said: "I am very glad that we have a program here to-night that will help those who did not hear the program to-day. That great reformer, Luther, was a student of this life, but you would be surprised how many childlike things this great man planned for children. He said, 'I would have them study plants and flowers and only the flowers that teach some moral lesson. Only those flowers were allowed in the creed of Martin Luther. They not only teach a moral lesson but relate to our great commercial industries, and it is my great pleasure to introduce to you, Mr. Trelease, who will speak upon "Botany and Commerce."

BOTANY AND COMMERCE.

WILLIAM TRELEASE.

"Mr. Toastmaster, ladies and gentlemen:—It strikes me that it is indicative of the times that on the occasion of a gathering of scientific men of the State of Illinois in your capital city, you should be entertained by the Chamber of Commerce of that city. Nothing more clearly indicates the recognition on the part of the commercial men who are making the higher life of our time possible, that they are themselves dependent for what they are doing on the results that the scientific experts are placing in their hands as tools to work with.

In a State like this, flowing with milk and honey, and a land which gushes forth its fatness if you break it, it would seem fitting that your first speaker should be a zoologist or a geologist, but I am delighted that you have selected a botanist as the first speaker,—for if corn is king anywhere in the world, he is certainly king in Illinois; and coupled with King Corn, making one-half of the great eight billion dollars' worth of national products poured into the national granary last year, a few of the other leading products are also vegetable.

I want to call attention, in passing only, to the fact that nearly all of human life is really dependent directly upon plants, and of course botany is concerned with the study of plants. A large part, an essential part, of our food comes from the vegetable kingdom. A very large and necessary part of what goes into the manufactures and the arts, and the essential part used in healing us, comes from the vegetable kingdom. After all, I take it you do not want me to analyze these, they belong not to the botanist but to the commercial man: it is an actual fact that that which is not patented no longer belongs to the person who brought it forth but belongs to those who know how to use it. But there are certain other things that I do wish to present as still belonging to the botanist. They will belong, in the course of the generation now living, in almost equal part to commerce and manufacture. A generation ago a botanist traveling through the northwestern Canadian region made a casual observation of the trees and plants he saw growing there and found some plants that generally grow where wheat and corn are grown. To-day all of that northwestern country has been converted into one of the great wheat fields of the world. The way was pointed by a botanist, traveling through the country, looking at the vegetation alone. To-day there is never a question of introducing crops into a new district without first studying the life zone the district belongs to; and year by year the possibilities of agriculture are being increased, through simple observation of what animals and plants naturally grow in the region that the plants to be cultivated come from and that you propose cultivating them in.

There has been of late years an application of botanical knowledge in more than one commercial field, just as great, just as extensive as this. Your own state of Illinois is increasing enormously the product of that crop which is the domineering and dominating crop of this country—corn—by simple observation of, first, what constitutes good corn; second, how certain changes can be made in corn which will give it greater value; and, third, how those changes can be brought about. You are spending enormous sums of money; other states are doing the same. You are getting returns year by year for what you put in it, and the return is going to be increased on greater investment. It is not what you get this year but what you get as long as corn is cultivated—until others have, in some way, improved upon these gifts that are now being made. Our Assistant Secretary of Agriculture, while he was in Minnesota, was active in breeding a new variety of wheat. Five years ago that variety of wheat had increased acreage enough to give something like a million dollars added revenue. I might give other lessons pertaining not simply to field-crops; orchards, nut-bearing trees—it matters not what,

—everywhere the field is the same. If there is any use in growing plants, they can be improved.

A number of years ago in the neighboring State of Wisconsin it was shown how it was possible to treat seed oats in such a way as to reduce the loss from smutting of the oats. In Wisconsin alone, the saving through that practice amounts to more than the entire cost of operating the great University of that State; and it is not limited to the State of Wisconsin.

Every little while I have an opportunity to talk with a railroad man, and he tells me about the terrible problem that cross-ties and structure-timbers present. White oak sticks that a few years ago were being cut down for cross-ties are now becoming available for cabinet-wood purposes. To-day tie-sizes are too valuable to be so used. What the future is to be is very much of a question. Of late years the same attention has been given to this problem as to those of plant breeding and of protection against fungi, in the treatment of timber as a practical means of preservation, and Dr. von Schrenk, and the people who have worked with him in the conservation and careful handling of timber have done more than we, to-day, realize, in enabling us to leave standing on their own roots the trees that are going to be absolutely neded for construction in a very short time.

If it were not for the botanists who studied the Cinchona tree and who discovered how it could be planted and, cultivated profitably, we should to-day stand in much greater dread of malaria than we do, because quinine is derived largely from trees planted in the Old World, originally from New World derivatives. To-day, we do not know where to turn for that indispensable article we have in hand at all times—the lead pencil, and as for India rubber, this is narrowing down to such an extent that it is hard to tell where it is going to come from. Gutta-percha is absolutely essential for electrical wiring and electrical construction. Botanists are at work the world over studying the origin of every kind of gutta and gum that can be applied to these industries, and cultivation is going to bring into the market of the future just the same sort of relation that the cultivation of Cinchona has done.

Bacteria are moot creatures; call them animals if you choose; call them plants; but the botanist still looks on them as plants. If it were not for what students have learned of this group of plants we should have no such thing as rational sanitation or aseptic surgery. In a dairy the quality of butter and cheese depends on these lowly creatures; and what has been made out about them is still unfinished. More and more, scientists in this line are going to bring practical returns in dollars, with the decimal point moved away off to the right. Soil fertility comes in the same category. One of our American botanists, Dr. Moore, giving attention to the minute creatures, algæ, which grow in fresh water everywhere, made a discovery which has enabled any community in this country which has polluted water to purify it. I might give you a dozen other illustrations; but I do not mean to take more time for illustrations; it is unnecessary: I trust the few I have selected are such as to show you that the botanist is worth something to commerce, to the manufactures and arts.

But this botanist is not the botanist who picks flowers to pieces and quarrels over the shape of a stamen. He is the botanist who, looking to see what there is in the first place, takes scientific interest in the next, and turns himself to that; and then turns to see what there is of practical utility in the discoveries that have been made, and makes them directly available for human progress. The man who breeds better plants to grow in your gardens and along your streets, and who has the faculty of the book-agent or the tree-seller of making you buy them and use them, is a man who is doing a great deal for the community in which he operates.

In conclusion I would like to say that the world to-day is absolutely dependent on the standing and pulling together of individuals and organizations of men. We have gone so far in our civilization that it is impossible for one of us to stand by himself on his own feet and carry along all that he ought to be able to carry along. It is in the touch of elbows and the stimulus of marching side by side that our advance is to be found. You commercial gentlemen are making money. You are dependent on the investigator for the power of making money in the way in which you want to make it. The investigator is dependent upon you for the power of investigation. Investigation is what some people think of as being in a class that is of no value or interest to mankind; but our civilization rests upon it. What we are going to do in the next fifty years is going to amount to more than what we have done in the last fifty years. The fruit of abstract scientific study must be applied through schools of experience, through engineering and through practical schools; and that is exactly the course that things are taking. I take it that there is not to-day a single field of science which affords to the commercial and industrial world such great opportunities of wealth as the science of botany does. I do not except chemistry. The time is ripe now for developing each one of these fields I have spoken of as fields of abstract investigation and of applied instruction. The *time* is ripe for it. Our children are going to the operetta "The Time, The Place and The Girl." The question is where "The Place and the Man" for this happy co-ordination are to be found."

Prof. Blair:—

"Perhaps the contrast between the purely theoretical, such as speculation on practical affairs, and the modern practical way could not be brought forward more clearly than in the way we treat the matter of transportation. Zeno proved to the world that there was no such thing as motion, and there was no transportation in his sense. We have quit speculating on that sort of thing and our question is 'How to get the wheat products of the West to New York City and load them on to the boat,' and we are relating ourselves to the question of transportation in the sound, practical way we are in others. But I want to tell you of a little bit of scientific transportation.

Over in the little State of Indiana they have a very fair sort of a University. It was discovered that in that University was a man who had outgrown the institution. Over here in the State of Illinois was a tremendous opportunity for a man who had outgrown the place and this was the question: here was 'The Place.' 'There was the Man,' and the Board of Trustees of the Illinois University, through its president, found the means of transportation by that scientific information which we want ,and I think we are to congratulate ourselves and the State of Illinois that the feat of transportation has been successfully performed, and that the State University has at the head of its engineering department such a capable man. It gives me pleasure to introduce Professor Goss, of the University of Illinois, who will respond to the toast, 'Science and Transportation.' "

SCIENCE AND TRANSPORTATION.

W. F. M. Goss.

"No department of human endeavor is more typical of modern thought and action than that embraced by the transportation industry; an industry which constitutes the response which mankind has given to a natural desire for intercommunication. From meager beginnings transportation facilities have been multiplied, improved and extended until the whole civilized world has been brought together almost as a single people.

So engaged are we with the things of the day that we do not often consider how rapid has been this development, nor how great has been its effect. A hundred years ago when men went down to the sea in ships, they sailed subject to the caprice of the wind and in frequent danger of being blotted out of existence, unknown to the rest of the world. To-day the sea has become a course for immense steam-driven ships which, with a shuttle-like movement between shore and shore, proceed with a degree of regularity that is but little affected by wind or weather. On one ocean at least such ships are at all times in communication with others of their kind, or with the land. Four weeks ago two such ships well out upon the Atlantic, enshrouded in fog, came into collision, and almost immediately the fact was known everywhere. For hours following the accident, the friends of those involved, in America and Europe, kept in touch with the progress made in applying relief. Ships from the east and from the west a hundred miles away, were called, and they left their course and headed for the scene of the accident. Others more distant were told that their services were not needed. The transhipment of passengers began, was finished, and later a second transhipment occurred. Supporting ships, feeling their way through the fog, arrived. For more than 24 hours this drama of the ocean proceeded, while interested people the world over, followed the progress of each event as it occurred. No accident of modern times has better served to illustrate the protection which modern science has thrown about ocean travel, than the collision between these steamships, the "Florida" and the "Republic."

Equally great have been the changes which recent years have wrought in the transportation upon the land. I have been told that 60 years ago in this State of Illinois, the corn crop of several years was allowed to accumulate in anticipation of the coming of a proposed railroad which would carry it on to market. In that day railroads were rare, while to-day the country is covered with their network, the mileage of the freight car wheels which traverse them exceeding 100,000 million every year. In passenger service the changes are equally significant. The 18-hour specials running between Chicago and New York, proceed, day after day, with a wonderful regularity of movement and pass long stretches of track at speeds above 70 miles per hour.

Now these achievements in transportation and travel, which for the most part have been worked out within the brief period of a hundred years, are not the result of chance; they are made possible through the existence of a wonderful fabric of science and technology. A ship is designed for strength by processes that are mathematically correct. Its lines are laid down and the amount of power it is to have is fixed with the certainty that a predetermined displacement and speed will result. It is the same with the railroad, steam and electric, with the transportation of power by electricity, and with the transportation of speech and thought by telephony and telegraph. In all of these directions success in the development of practice has depended upon the security of a series of successive steps, each one of which has been fundamental and in its time necessary to those that have since followed it. A definition of these fundamental steps or stages constitutes the basic principles of the science of transportation.

But while science has guided practice in transportation to its present state of development, it is not true that practice has always been scientific, nor is it, in all cases, so to-day. The reverse is true. It is to this phase of my subject that I wish especially to direct your attention. A railway friend of long experience, a self-made man, well described the situation, when after talking of his early experiences as a motive-power official, and especially of the mistakes he had made, he concluded by saying, "My railroad has paid a lot of money for the things I have found out." The statement was undoubtedly true, and it would still be true if applied to railway companies in general, or to companies engaged in other forms of transportation. If we except certain very recent developments in transportation, chiefly those depending upon electrical power and those involving aerial flight, it is the inventor and the promoter who have led the way rather than the scientist. The scientist has studied the phenomena resulting from the work of the inventor, has formulated principles of action into laws and has announced these laws for the more orderly marshaling of subsequent movements, but too often he has not himself been constructive. Captains of transportation and many of their lieutenants, impatient in their desire to secure tangible results, not infrequently prefer a headlong process with all the dangers and expense which such a course involves, to slower and more certain methods. Moreover, many such practical men believe that the things which they do, and do well, are beyond the ken of the scientist. In the matter of rate making, for example, and in many of the problems of train operation, the belief is current that experience and common sense are the only safeguards.

Now the fact is that in the conduct of every system of business, there are principles which underlie procedure. They may not be recognized as principles by those most concerned, but they are there nevertheless, and it is the part of the scientist to discover them, to determine the relation which each one bears to others, and to formulate these relations into rules of practice. Railway and other transportation companies will not attain their highest efficiency nor will the public be served at lowest cost, until the business of every department of the transportation industry has been reduced to such a basis. It is in recognition of this fact and as an aid in training young men for positions of responsibility in such transportation companies, that the University of Illinois conducts a School of Railway Engineering and Administration, the purpose of which is to deal with such great questions as the design, construction and maintenance of railway equipment, with the problems of accountancy, operation and management; subjects which many people believe can not be taught in a college, but which are in fact easily capable of successful treatment there. It is the province of this School so to train students that they may be ready to assume the business of the transportation companies when the present-day officials give up their duties, and to carry it forward on a plane which will be in keeping with the advanced requirements of their day.

The introduction of this work is difficult because those who are to profit most by its success can not at once appreciate its significance. If we were to say that we plan to train men in college in railroad management, public opinion would discredit the effort just as thirty years ago it discredited the college when it attempted to train men in agriculture. But the day is at hand for a new era in the management of transportation, when science must take the place of the rule-of-the-thumb, and I ask the interest of the membership of the Academy, in the efforts which the University is putting forth to make a contribution to such a result."

Prof. Blair:—

"In the present legislature there is a gentleman who said he thought science was mere twaddle. Why, he said, 'I was walking down the street the other day with my boy and a toad jumped across the sidewalk and my boy picked it up and I said, put that down; it will make warts all over your hand, and he just laughed and said that was all nonsense; and I said, who told you that? and he said I learned that at school.' Now I want to say to you men that when you let loose a scientific idea and think it will filter down into the grades, you are mistaken. At our great corn show here, a gentleman spoke about prejudice and superstition. After the talk was over a farmer came up to him and said, 'Well, I agree with most of what you said, but I am against you in what you said about the moon influencing potatoes. I always plant mine in the dark of the moon and always have fine potatoes. If the moon influences tides, why don't it influence the size of potatoes?' Immediately, another man from Mercer came up to speak to the gentleman who delivered the talk, and he says, 'I agree with about all you said; I always plant my potatoes in the light of the moon and they are mighty fine, I tell you.'

Gentlemen, it gives me great pleasure to propose as the next topic "'Illinois With or Without Science" and name as the gentleman, Professor R. O. Graham, who is president of the State Horticultural Society."

ILLINOIS WITH OR WITHOUT SCIENCE.

R. O. Graham.

"Honorable Toastmaster, President of the Chamber of Commerce, Ladies and Gentlemen:—The committee on arrangements has seen fit to sandwich me, the representative of one of our smaller colleges, in between those of two of our largest universities. I am inclined to feel complimented, however, by this arrangement when I remember that the ham layer, though the thinnest of the three, is after all the essence of the sandwich; and I trust that in spite of the situation, when all is over, I shall not feel as did the carpenter who rolled from the roof of a three-story building in Chicago, struck the sidewalk and skidded off on to the pavement where he was run over by an automobile. The ambulance came along, gathered him up and took him to the hospital, where, on returning to consciousness, he found a young doctor experimenting on him, who at once proceeded with an attempt to establish his identity; and among other questions, asked him, 'Are you a married man?' 'Oh Lord, no!' groaned the sufferer, '*this* is the worst thing ever happened to me.'

I have been asked to talk briefly on 'Illinois With and without Science.' We Illinoisans, like Paul, are citizens of no mean city. Among great commonwealths, ours stands second to none. We are proud of her wealth and of her past history. On the record of her years, Abraham Lincoln's name appears; Grant and Logan, and a score of others scarcely less well known to fame. We rejoice in the Great Lakes, whose waves dash against our northern borders; in the Mississippi that washes our western boundary; in the beautiful Ohio that divides between us and Dixie. We boast ourselves of Chicago, the world's emporium, city of fair women and wise, virtuous and unselfish men; city of great universities, and of various other things that need not be mentioned here. We boast of Peoria on our western borders, whose constant flow of good spirits spreads a stream of cheer throughout the state; of Springfield, where our law-makers, laying aside all personal prejudice and factional strife, putting behind them the sins and weaknesses that beset the ordinary mortal, press forward eagerly to the crown of civic righteousness, meantime spreading beneficent laws like a halo along their pathway. We are proud of our great commercial and manufacturing interests; of the lead mines in the northwestern counties; of the coal mines everywhere. In short, we are inclined to be proud of our beauty, and of our pride, and of a hundred things beside that would scarcely bear inspection.

But after all, Mr. Toastmaster, it is not in any or in all of these that Illinois finds the true source of her wealth and greatness. This is found in the fertile black soil of our corn belt, which stretches like a broad band across the fair bosom of our state, and which gives to the world more than one tenth of the world's corn supply. Illinois is preeminently a farmers' state; and to this fact she owes her preeminence among commonwealths. These black soils have been tilled for almost two generations, and, until recently, without thought that their fertility could ever be exhausted. But Science has sounded the warning. The chemist is pointing to the fact that the crops from these soils, as they go out to market, are carrying with them their due proportion of the essential elements of fertility—the nitrogen, the phosphorus, and the potassium; that already some of these soils have reached the point of incipient exhaustion; and that unless the warning of Science is heeded, these black soils of Illinois will surely follow in the wake of the soils of Ohio and of the older states whose value during the last two decades has been decreased by many millions of dollars through soil exhaustion.

At this point enters the controversy which doubtless many of you have noticed between the Bureau of Soils at Washington on the one hand and our own Soil Department, under Dr. Hopkins, on the other. 'Soil fertility can be indefinitely maintained by cultivation and proper rotation of crops,' declares the Bureau of Soils. 'The fertility of our Illinois soils is being gradually depleted,' says Hopkins. 'Each crop that goes out to market carries with it its share of these essential elements. Potassium fortunately is here in sufficient abundance for centuries to come. Nitrogen, the farmer himself has been taught to replace from the air. But phosphorus, which goes out to market with every grain of corn, and which is already none too abundant in our soils, is being gradually lessened, and can be replaced only by direct addition of phosphate.' 'Cultivate and rotate,' says the Bureau of Soils. 'Cultivate, rotate, and rock phosphate,' says Dr. Hopkins. It reminds us of the married man who, while on a journey, received a telegram which read, 'Your mother-in-law is dead. Shall we cremate or bury?' 'Cremate *and* bury; take no chances,' went back the answer.

When distinguished doctors differ, who shall decide However, the proof of the pudding is in the eating. Hopkins justly points with pride to the fact that thousands of acres of our Illinois soils have had their crops increased under the direction of the Bureau of Soils from fifteen bushels of corn to the acre to forty-five bushels; to the fact that many of our black soils, under like direction, have had their productiveness increased, and that, too, without loss of fertility; to the fact that during the six years between 1902 and 1908, under this same direction, the value of the corn crop of Illinois was increased, on the average, more than twenty million dollars annually, above the average crop of the twelve years previous. The weight of argument seems to lie with Dr. Hopkins.

After all, the remedy proposed is only a temporary remedy. These great beds of phosphate will surely become exhausted. What then? The needs of to-day and to-morrow are provided for; but what about to-morrow's to-morrow,—the long line of to-morrows of the future? How shall their needs be met? The generation that legislates for itself alone is a selfish generation. The generation that legislates only for itself and its immediate successors is an unstatesmanlike generation. The generation that, through carelessness or greed, is willing that its heritage should pass on to succeeding generations impaired and impoverished, is an unworthy generation; and it were better for the world it had never been born.

Is the problem of the world's daily bread supply for future generations a hopeless one? We are comforted when we remember that all the elements essential to fertility, all of the potassium, the nitrogen and the phosphorus that were in the world when Adam delved and Eve span, are still in the world somewhere, in some form. We are comforted when we remember that the elements of fertility in the black soil under our feet, that to-day gives to it its wonderful productiveness, will be in the world a thousand, ten thousand, untold thousands of years from now, somewhere, in some form. The problem of science, then, is the proper conservation of these elements. Indeed this is the great problem of our nation, of all nations to-day, conservation of their natural resources. When the question of food supply presses hard, Science will follow the crops as they go out to the markets to do their work in feeding animal and man, will gather up the fragments, will save the refuse and restore it to the soil. Science will teach the farmer that it is as important to care for the manure heap as for the milk supply. In that day of pressure, Illinois with Science will not dig million dollar canals to carry millions on millions of dollars' worth of fertility annually past our borders to be dissipated and lost; but will properly treat the sewage of our cities, and restore this to the soil where the elements may do their work over again. It is said that in China are found farms that have been tilled for untold generations without decrease of their fertility. What the Chinaman has done, the American can and will do when the pressing demand comes upon him.

Illinois without Science? Her black soils gradually robbed of their fertility; fruits and orchards destroyed by insects and fungus pests; the fountains of her wealth and greatness slowly but surely dried up; her preeminence among commonwealths lost. Illinois with Science? Soil fertility maintained, products protected, the streams from the fountains of her wealth kept up and even increased as the world's increasing population makes added demands upon that which she has to supply. This is the contrast."

Prof. Blair:—

"There was a man in a certain university in the department of mathematics who was uniting the sciences there. He had formulated a mathematical tablet. He wrote upon that tablet certain propositions in geometry and when the time came for the solution of a certain problem he claimed he based his solution upon materia medica, physiology and mathematics. This matter of bringing the sciences to act together, hand in hand, is not new, but I am sure that from the Northwestern University and the retiring Vice-president of the State Academy we can hear new reasons for and on the relation of the sciences to each other."

THE RELATION OF THE SCIENCES TO EACH OTHER.

Henry Crew.

"Mr. Toastmaster, Ladies and Gentlemen:—I do not know just how it happened that I find myself on this program, after a delightful dinner and interesting speeches, to speak upon such a subject as "The Relation of the Sciences to each other," but I think it is due nine-tenths to the persuasiveness of the genial Secretary of the Illinois Academy of Science and about one-tenth to the fact that I thought this would be a good subject to bring before an Academy interested in so many different subjects.

However, I can offer the same assurance offered by a certain cab driver, according to President Harris. A friend of his traveling in Porto Rico hired a carriage to take him to some point four miles out in the country, and after he had ridden a distance which seemed to him about six miles he called the driver and said 'Is it much farther?' 'O, no, sir, its nearer,' answered the driver. I can assure you that the end of the program is already nearer than it was before I began to speak.

I am not going to indulge in any history of the classification of the sciences ranging, perhaps, from Aristotle to Swift, but I am going to use what little time is at my disposal to call your attention to a system which has been helpful to me; one which we owe to a group of American gentlemen, and one which was put into practice and given a severe test at a city less than one hundred miles from where we are sitting this evening. The system was proposed by a committee of seven gentlemen and adopted in the International Congress of Arts and Science in St. Louis in 1904. My reason for calling attention to this system is the fact that it has been very helpful to me and the fact that I find it very little known even among scientific men.

The chief attraction of this classification to me is the fact that it recognizes that phenomena are not the only thing in the world worth studying. There are certain ambitions and purposes and strivings and tendencies and will-acts which are just as important and contribute largely to the most important work of the world; these as well as phenomena are legitimate subjects of study; and this leads to the first great rift in human knowledge. On one side *phenomena* and on the other side *purposes*.

Take for instance, a substance such as copper, stones or stars, plants, animals,—these are all investigated with respect to certain properties which are identical at all times. The atomic weight of copper is 63. If we found it to be different from 63 we would conclude that the substance was not copper or that it was impure copper. So we put in a certain group the sciences which investigate phenomena common to every specimen and not dependent upon the peculiarities of the individual. These sciences are called the physical sciences and include such as Chemistry, Biology, Astronomy. But there is another group of phenomena, peculiar to individuals—such, for instance, as what is going on in your mind or my mind at this instant. I am thinking how to say what I want to say most clearly and in the shortest possible time; and you are probably wondering at the slowness with which I am saying it. There is a set of phenomena peculiar to every individual. These phenomena are called mental. So then we have phenomena divided into two great classes—those peculiar to individuals and those which are over-individual.

If we pass now to, the will-acts of humanity we find the same distinction. There are certain will-acts, certain judgments upon which all humanity agree. For instance, that two and two make four is just as evident to the Hottentot as it is to you and me. Such judgments as these are wider than any group of individuals and are common to all sane human beings. We have sanitariums all over the country for people who do not agree that two and two make four. So the over-individual will-act are the general phenomena of the sciences of purpose, and are grouped in one class—called the normative sciences. But what you determine upon, what you propose to carry out, what your ambitions are, what the ambitions of all the best thinkers of the world have been, these constitute what are called the historical sciences. In literature or political history, the same is true. Take such a thing as the story Homer tells. It may be hard to determine whether Homer was written by one individual or by a dozen; but in each line of Homer there is an execution of a certain purpose on the part of some individual; so in political history—take for instance the Franco-German War; we know it was the result of the individual will-acts of a certain group of men. So when Abraham Lincoln signed the Emancipation Proclamation, however we may speak of it, we know it was the individual determination of one particular man who actually brought that action to a focus, so to speak. All those sciences which deal with individual will-acts are grouped under the head historical.

So much for the pure sciences; but pure science is not the whole of science. There is the great field of the utilitarian sciences, of which we have already heard this evening, which are certainly a great deal more than merely applied science. Every one knows that an engineer does more than merely apply physics, mathematics and mechanics. He has opinions of his own and carries them out in his own methods. The same is true of education. I believe everybody who has seriously considered the problem wil admit that the science of education is a great deal more than applied Psychology. How can we group these applied sciences? Professor Moore, the great authority on international law, and three or four other gentlemen decided upon the following classification:

All those sciences which deal with objects were called utilitarian sciences, including medicine, engineering, transportations and commerce; those sciences which deal with subjects other than one's self are grouped under the head of sciences of social regulation, including such problems as politics, administration, municipal government, colonial affairs; and there still remains one other group of applied sciences—those which refer to the individual himself, incuding such subjects as education and religion. These are called the sciences of social culture.

So we have in addition to the four pure sciences, three utilitarian sciences; namely the sciences that deal with objects—sciences of social regulation dealing with other subjects—and, finally, the sciences of social culture dealing with the subject himself.

These seven sciences, as I say, were represented at the International Congress at St. Louis, and I want to take just the few seconds that remain to call your attention to the eight superb volumes of the report of that congress. The American gentlemen who were invited to participate in that Congress, together with the foreign guests, form what I believe is the most remarkable group of men ever gathered together at one time and one place in the history of the world.

You will find in the first volume of this report a description of this classification, largely due to Professor Munsterberg. You will find those volumes exceedingly well worth looking over, if you have not already done so; and if you will take the pains to read the first two or three hundred pages, you will realize that the republic of science and letters is a very large nation, not made up of many states closely touching one another; its departments are more like the claims of the western mining camps, overlapping one another, and are nothing like the water-tight compartments that sometimes seem to separate us when at work in the laboratory.

Allow me, in behalf of my fellow-members in the Academy of Science, and in my own behalf, to thank the gentlemen of the Chamber of Commerce for the delightful hospitality which have extended to us, and for allowing us to come together and talk matters over in this way."

Prof. Blair:—

"On behalf of the Chamber of Commerce, I want to thank the gentlemen for their presence here to-night. Gentlemen, you stand adjourned."

COUNCIL MEETING OF STATE ACADEMY OF SCIENCE. BOTANY BUILDING, UNIVERSITY OF CHICAGO, 4 P. M., MONDAY, NOV. 1st.

There were present S. A. Forbes, J. M. Coulter, A. R. Crook, J. C. Hessler.

It was voted to accept the cordial invitation of the University of Illinois to hold the next meeting at Urbana. It was further voted that the meeting begin at 2 P. M. on Friday, the 18th of February and close Saturday afternoon, February 19th, after finishing the reading of the papers presented. The program shall consist of a business meeting, presentation of papers, address by the retiring president, and a symposium on "The Relation of Pure and Applied Science respectively,

(A) To the Progress of Knowledge and to Practical Affairs, and

(B) To Secondary Education."

The symposium shall be participated in by five speakers chosen by the council to present the subject from the point of view of the biologist, the chemist and the physicist.

Miss Isabel S. Smith of Illinois College, Jacksonville, was chosen as third member of the publication committee in place of Dr. H. Foster Bain, who was elected at the last Academy meeting, but who had resigned on account of his removal to California.

The meeting then adjourned.

A. R. Crook, Secretary.

CONSTITUTION AND BY-LAWS

ILLINOIS STATE ACADEMY OF SCIENCE

CONSTITUTION.

ARTICLE I. NAME.

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

ARTICLE II. OBJECTS.

The objects of the Academy shall be the promotion of scientific research, the diffusion of scientific knowledge and scientific spirit, and the unification of the scientific interests of the State.

ARTICLE III. MEMBERS.

The membership of the Academy shall consist of *Active Members, Non-resident Members, Corresponding Members, Life Members, and Honorary Members.*

Active Members shall be persons who are interested in scientific work and are residents of the State of Illinois. Each active member shall pay an initiation fee of one dollar and an annual assessment of one dollar.

Non-resident Members shall be persons who have been members of the Academy but have removed from the State. Their duties and privileges shall be the same as those of active members except that they may not hold office.

Corresponding Members shall be such persons actively engaged in scientific research as shall be chosen by the Academy, their duties and privileges to be the same as those of active members, except that they may not hold office and shall be free from all dues.

Life Members shall be active or non-resident members who have paid fees to the amount of twenty dollars. They shall be free from further annual dues.

Honorary members shall be persons who have rendered distinguished service to science and who are not residents of the State of Illinois. The number shall not exceed twenty at one time. They shall be free from all dues.

For election to any class of membership the candidate's name must be proposed by two members, be approved by a majority of the committee on membership, and receive the assent of three fourths of the members voting.

All workers in science present at the organization meeting who sign the constitution, upon payment of their initiation fee and their annual dues for 1908 become charter members.

Article IV. Officers.

The officers of the Academy shall consist of a President, a Vice-President, a Chairman of each section that may be organized, a Secretary, and a Treasurer. These officers shall be chosen by ballot on recommendation of a nominating committee, at an annual meeting, and shall hold office for one year or until their successors qualify.

They shall perform the duties usually pertaining to their respective offices.

It shall be one of the duties of the president to prepare an address which shall be delivered before the Academy at the annual meeting at which his term of office expires.

The secretary shall have charge of all the books, collections, and material property belonging to the Academy.

Article V. Council.

The Council shall consist of the President, Vice-President, Chairman of each section, Secretary, Treasurer, and the president for the preceding year. To the Council shall be entrusted the management of the affairs of the Academy during the intervals between regular meeetings.

Article VI. Standing Committees.

The Standing Committees of the Academy shall be a Committee on Publication and a Committee on Membership.

The Committee on Publication shall consist of the President, the Secretary, and a third member chosen annually by the Academy.

The Committee on Membership shall conist of five members chosen annually by the Academy.

Article VII. Meetings.

The regular meetings of the Academy shall be held at such time and place as the Council may designate. Special meetings may be called by the Council and shall be called upon written request of twenty members.

Article VIII. Publication.

The regular publications of the Academy shall include the transactions of the Academy and such papers as are deemed suitable by the Committee on Publication.

All members shall receive gratis the current issues of the Academy.

Article IX. Affiliation.

The Academy may enter into such relations of affiliation with other organizations of appropriate character as may be recommended by the Council and be ordered by a three-fourths vote of the members present at any regular meeting.

Article X. Amendments.

This constitution may be amended by a three-fourths vote of the members present at an annual meeting, provided that notice of the desired change has been sent by the Secretary to all members at least twenty days before such meeting.

BY-LAWS.

I. The following shall be the regular order of business:

1. Call to order.
2. Reports of officers.
3. Reports of standing committees.
4. Election of members.
5. Reports of special committees.
6. Appointment of special committees.
7. Unfinished business.
8. New business.
9. Election of officers.
10. Program.
11. Adjournment.

II. No meeting of the Academy shall be held without thirty days' previous notice being sent by the Secretary to all members.

III. Fifteen members shall constitute a quorum of the Academy. A majority of the Council shall constitute a quorum of the Council.

IV. No bill against the Academy shall be paid without an order signed by the President and Secretary.

V. Members who shall allow their dues to remain unpaid for three years, having been annually notified of their arrearage by the Treasurer, shall have their names stricken from the roll.

VI. The Secretary shall have charge of the distribution, sale, and exchange of the published Transactions of the Academy, under such restrictions as may be imposed by the Council.

VII. The presiding officer shall at each annual meeting appoint a committee of three who shall examine and report in writing upon the account of the Treasurer.

VIII. No paper shall be entitled to a place on the program unless the manuscript or an abstract of the same shall have been previously delivered to the Secretary.

IX. These by-laws may be suspended by a three-fourths vote of the members present at any regular meeting.

LIST OF MEMBERS

*Abbott, G. A., A.M., 945 Marquette Building, Chicago. (Ornithology.)
Abbott, J. F., A.M., Washington University, St. Louis, Mo. (Zoology.)
Ackert, J. E., A.B., University of Illinois, Urbana. (Zoology.)
*Adams, C. C., Ph.D., University of Illinois, Urbana. (Biology.)
Akeley, C. E., Field Museum, Chicago. (Taxidermy.)
*Andrews, Clement W., A.M., The John Crerar Library, Chicago. (Scientific Biblio.)
*Atwell, Chas. B., Ph.M., Northwestern University, Evanston. (Botany.)
*Atwood, W. W., Ph.D., University of Chicago, Chicago. (Geology.),
*Bachmann, Frank, State Water Survey, Urbana. (Chemistry.)
Bagg, R. M., Jr., Ph.D., University of Illinois, Urbana. (Geology.)
*Bain, H. Foster, Ph.D., 667 Howard Street, San Francisco, Cal. (Geology.)
Bain, Walter G., M.D., City Board of Health, Springfield. (Bacteriology.)
Baird, Miss Grace J., A.B., 608 S. Mathews Avenue, Urbana. (Biology.)
Baird, Leo P., A.B., (Eugenics.)
Baker, Frank C., Chicago Academy Sciences, Chicago. (Conchology.)
*Balke, Clarence W., Ph.D., University of Illinois, Urbana. (Chemistry.)
Barber, E. H., Field Museum, Chicago.
Barker, Perry, Box 3024, Ann Arbor, Mich.
Barnes, Charles Reid, Ph.D., University of Chicago, Chicago. (Plant Physiology.)
*Barnes, Frank G., D.D., Ann Arbor, Mich. (Ethnology.)
*Barnes, H. O., A.B., High School, Springfield. (Mathematics.)
Barnes, R. M., LL.B., Lacon. (Oology.)
Barnes, Will F., M.D., Decatur. (Medicine.)
Barrett, J. T., Cornell University, Ithaca, N. Y.
Barrows, H. H., University of Chicago, Chicago.
*Bartow, Edward, Ph.D., University of Illinois, Urbana. (Chemistry.)
Barwell, John William, Waukegan. (Anthropology.)
Basquin, O. H., Ph.D., Northwestern University, Evanston. (Physics.)
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*Bjorkland, Alfred, M.S., Michigan City, Ind. (Chemistry.)
Blatchley, R. S., Illinois Geological Survey, Urbana. (Geology.)

(Charter Members indicated by asterisk, honorary, by obelisk.)

Bleininger, A. V., U. S. Geological Survey, Pittsburg, Pa. (Ceramics.)
Bloom, Miss M. E., Jacksonville.
Boerner, Wunibald R., Ravinia, Lake County. (Biology.)
*Bretnall, G. H., A.M., Monmouth College, Monmouth. (Botany.)
Brewer, J. M., Lebanon.
Browning, James H., Taylorville.
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*Carpenter, Chas., D.D., Aurora. (Ornithology.)
Carr, J. H., Morris.
Carus, Paul, Ph.D., Editor Open Court Pub. Co., LaSalle. (Philosophy.)
*Carver, Albert, B.S., Springfield High School, Springfield. (Physics.)
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*Charles, Fred L., M.S., University of Illinois. (Zoology and Botany.)
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*Collett, E. B., B.S. (Biology.)
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Ferry, John F., Field Museum, Chicago.
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*Fisher, Fannie, Asst. Curator State Museum, Springfield. (General Interest.)
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*Haddock, F. D., A. B., Porto Rico. (General Interest.)
*Hague, Stella M., M.S., Rockford College, Rockford. (Botany.)
*Hale, John A., M.D., Ed. "The Enterprise," Alto Pass.
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OF THE

ILLINOIS STATE ACADEMY

OF

SCIENCE

VOLUME III

1910

SPRINGFIELD
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TRANSACTIONS

OF THE

Illinois State Academy of Science

THIRD ANNUAL MEETING

URBANA, ILL., FEB. 18 AND 19, 1910.

VOLUME III

1910

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THIRD ANNUAL MEETING.

Hall of Chemistry, University of Illinois.
Urbana, February 18 and 19, 1910.

SESSION OF FRIDAY FEBRUARY 18.

Afternoon.

President Forbes called the meeting to order at 2:15 and announced that the first item of business would be reports of officers. The Secretary presented the following report:

SECRETARY'S REPORT.

The reading of the minutes of the last meeting and of the council meeting may be dispensed with since they are reported in Vol. II of the Transactions, a copy of which has been sent to all members whose addresses are known.

The secretary will be obliged if any one can give the addresses of the following: Baird, L. P.; Collett, E. B.; Collier, J. S.; Dawson, L. A.; Haddock, F. D.; Montgomery, O. C.; Putnam, J. R.; Winter, S. G.

Publication of the last volume of the Transactions was delayed, since the committee which was appointed to ascertain whether or not the State would publish our papers was long kept in doubt by the condition of business in the legislature. Seeing no hope of favorable consideration during the current session, the committee decided not to make the request but to postpone action till a more favorable time. As soon as that decision was reached, the secretary began to collect material for the volume.

At another time the Transactions can be brought out more promptly. When not handicapped by the necessity of haste, the appearance and character of the volume can be improved.

At this third annual meeting it is gratifying to note that the Academy has 275 active, six corresponding and one honorary members—a total of 282 members. The membership committee and individual members of the Academy have been busy in adding to our list and before the organization is five years old we shall no doubt enroll 500 names.

In order that the Academy might be known to people who on the one hand should obtain the advantages of membership and on the other hand should advance its interests, the secretary by correspondence obtained the names of over 1100 teachers of science in the public schools, normal schools, colleges and universities of the State. A card catalog of these has been prepared and one or more announcements, programs, list of members, etc., sent to them.

To 700 newspapers in the State special notices of this meeting have been sent. Separate articles have been written for some papers upon request of the editors, and several hundred letters have been written to individual members. Altogether more than 4,000 notices have been sent out during the last two months. This extra effort has been made because of a realization of the many claims which clamor for the attention, time and finances of men of science, and because of the conviction that to be widely known and numerously supported, the Academy must be brought prominently to the notice of acceptable candidates.

Men engaged in teaching are usually engrossed with students, laboratories and their immediate institution, and give hardly a passing thought to the larger circle.

The Academy affords a means of extending the circle of influence of each individual member to *non-academic territory.* There is a work of magnitude to be performed in this State; a work which men of your education and men with your knowledge can best advocate; a work which can be accomplished, not by individuals but by an organization; a work which will contribute to the general prosperity and happiness of the people of the commonwealth.

The larger our association, the more effective our influence. May not each one of us constitute a membership committee to bring in acceptable candidates until the roll of members will be a well nigh complete roster of the scientific workers of the State.

Respectfully submitted,

A. R. CROOK, Secretary.

It was voted that the Secretary's report be accepted and placed on file.

The Treasurer presented the following report:

TREASURER'S REPORT.

ILLINOIS ACADEMY OF SCIENCE.

Feb. 18, 1910.

Balance on hand Feb. 10, 1909	$123.83	
Receipts from Initiation Fees and Dues	219.20	
Total	$343.03	$343.03
Disbursements made upon order of President and Secretary	$141.03	$141.03
Balance on hand *Feb. 15, 1910*		$202.00

Respectfully submitted,

JOHN C. HESSLER,
Treasurer.

Upon motion of Stuart Weller the Treasurer's report was placed on file and upon motion of T. C. Chamberlin the chair appointed the following auditing committee: W. S. Strode and T. L. Hankinson.

T. W. Galloway presented for the membership committee a list of candidates and they were unanimously elected to membership. The list of all members elected during the meeting is given on page 156.

Thereupon the presentation of papers was taken up. A. R. Crook read a paper as follows:

DR. AMOS WILLARD FRENCH: IN MEMORIAM.

As far as the writer is aware Dr. French of Springfield is the first member of the Academy to be removed from our number by death. Many may remember him as the gentleman with white hair and beard, evidently the veteran among those present at the organization meeting of the Academy in Springfield, December 1907, who spoke of the value of scientific work and expressed the hope that the Academy might be a means of increasing the influence of science in the State.

At the time of his death he was nearly eighty-eight years of age, was the oldest alumnus of Washington University, St. Louis, and the oldest practicing dentist in the United States. Many residents of Springfield had never employed any other dentist.

To me he was an interesting personality especially because of youthful interest in things, in men and in ideas. Intellectually he was emancipated from many of the bonds which restrain thought and discourage mental progress and hence he retained a receptive and creative attitude of mind which was intellectually life giving. From early times he was interested in many things outside of his profession. Among his particular friends were A. H. Worthen, who, as State Geologist or Curator of the State Museum for thirty years, left his impress on the geology of the region; and Major J. W. Powell, first widely known for his exploration of the Colorado River, and later as the Director of the U. S. Geological Survey. With such friendships, French naturally was greatly interested in geology, and gave much time to its study, collecting a fine geological library and bringing together an extensive assemblage of minerals and rocks. Thought on geological subjects and discussions of related questions gave him great pleasure and, as is often the case, the result of such first-hand information and contact with actual facts enabled him to free his mind of many of the clouds which darken reason and to see clearly in paths where his contemporaries darkly grope.

The record of his life reads:

Born at Brighton, New York, July 24, 1821. Died at Springfield, Illinois April 27, 1909. Graduated at Washington University (Missouri Dental College) 1867. Married Sarah T. Foster 1851. His four daughters grace the communities in which they reside. Member of Board of Trustees and of Building Committee of Springfield City Library; Secretary of the Capitol Building Co., which built the first street car line in city. Interested in building the Leland Hotel and Watch Factory. One of six founders of the Bettie Stuart Institute and till the time of his death, President of Board of Trustees. Active in meetings of dentists, in a Springfield scientific society, in the State Historical Society, and in college gatherings. A public spirited citizen, a fine gentleman, a man whose loss even the most recent of his acquaintances sadly deplore. With sorrow we record his death.

W. A. Noyes moved that the paper be filed with the Secretary and a copy sent to the relatives of Dr. French.

T. W. Galloway then presented the following paper:

A WORK NEEDING TO BE DONE BY THIS ACADEMY.

I presume we are agreed that the chief function of a miscellaneous association of scientists such as this lies in the synthesis of our work and in the suggestion of cooperation among us. The academy offers the machinery for a kind of *state consciousness* in respect to scientific matters. Another function, partly incidental to this and partly new, has been suggested from time to time:—viz., the encouragement and increased efficiency of the amateur, or *independent isolated* worker, who lacks the guidance both as to method and matter which is possible to students of experience on the one hand or to those immediately guided in the university on the other.

To the latter of these two functions of the academy I want to direct a few remarks; and I will become concrete at once.

In Biology as in other sciences, there are certain lines of work which cannot be pursued to advantage by the student away from laboratories and libraries. On the other hand, there are certain problems of extension, of behavior and relation—i. e. of distribution and ecology—which are quite open to such study. As a matter of fact our present situation calls for thousands of just such scattered or distributed studies.

Furthermore, if we can bring these *needs* clearly to the consciousness of the workers, there are probably hundreds of possible workers who would find it a pleasure to do something, if they only knew what to do and how to go about it.

For these reasons the conviction has been growing on me, since the organization of this Academy, that we can do something in the *conservation* line ourselves; and that the time has come when a wise committee, who does not want a monopoly of the honor of doing the scientific work of the state themselves, could render a tremendous service to the great body of biological workers who may not be quite equal to self-guided work; and at the same time advance the knowledge of Illinois biology.

In my own observation of conditions it appears to me that the lack of initiative on the part of many who might be adding to our knowledge arises from the following things:

1. They do not know what has been done and fear that their efforts would be wasted.

2. Hence, they do not know what are considered the needful things to be done, and where to put their energies.

3. They quite probably are uncertain as to the best mode to proceed to accomplish something which would really contribute to knowledge.

I hasten to say that I am not assuming that the Academy can make finished scientists of these; but merely that a conservation of scientific energy can be secured, and that actual additions may be made to our knowledge which might escape the finished scientists for years.

Briefly, the work that I am suggesting at the hands of such a committee would consist (1) in the preparation of a bulletin which would, in some degree, indicate some of the most significant gaps that exist, in whose closing amateur investigators might readily take part, and (2) the distribution of this bulletin to all teachers of biology and physiography and geology in our high schools and colleges and to interested observers everywhere.

More specifically, such a bulletin should contain:

1. A statement of the fields in which the best work has already been done in Illinois biology of the kind already referred to as suitable to the amateur worker. This would not be a tremendously large task.

2. An analytic display of the fields of work in which the best possibilities now open to such workers. This analysis should go on down even to the statement of some particular problems, of suitable dimensions for unguided workers.

3. A somewhat detailed outline of proper methods of procedure in one or two concrete problems, either of some work already done or of some still needing to be done. Stress should here be put on the attitude of mind necessary to successful scientific work.

4. Citations to some of the very best literature of any region illustrative of proper method and spirit in such work.

5. A good classified bibliography of Illinois titles of biological literature pertaining to the types of work outlined as feasible.

Such a bulletin would prove useful to many people perfectly competent to work, who for one reason or another are not quite equal to wise selection of a field of study or to complete self-guidance after it is chosen. This kind of exploitation of the field would make it possible for many teachers in schools and colleges to use their classes in the getting of needed data, incidentally much to the benefit of the courses they are giving.

This proposition would call, as a second step of course, for a bureau of some sort to whom the results—whether of material or of observations—may be returned and there edited, collated, and published if need be. The State Biological Survey suggests itself to me as the appropriate agency, for this is largely the very purpose of its existence. In this way the Academy, on the biological side, would become the field representative of the Survey. The Survey would become an executive committee and guiding spirit of our Illinois workers in biology —in so far as our work is geographical.

This Committee would need (1) a member who knows well what has been done and what needs to be done in the state; (2) a member who would be good at an analytic statement of the problems and opportunities, in detail: and (3) a member full of sympathy and knowledge of the limitations and possibilities of the grade of biological workers for whom these suggestions are spoken.

John M. Coulter said in substance.—"One of the functions of a State Academy has been well indicated by the gentleman who just spoke. He has given an idea worth following out. It has been my experience—and I have been attending State Academies for many years, having recently been present when the Indiana Academy held its silver wedding—that one of the chief reasons for our meeting together is not to read papers, but to hold a fellowship conference. We can read the papers at home. We all may be fired by attending an enthusiastic meeting.

F. C. Baker.—"Could not these amateur workers under proper directions assist in the general ecological study of Illinois by contributing notes and data on the natural history of their immediate home region. These notes could be correlated with the work of the trained workers."

S. A. Forbes.—"This subject of Prof. Galloway's paper may come up later when the report is presented by the ecological committee.

H. A. Gleason presented an illustrated paper of which the following is an abstract.

THE VEGETATIONAL HISTORY OF A BLOWOUT.

Blowouts are saucer-shaped or bowl-shaped excavations caused by the action of wind on sand which is not sufficiently protected by a plant covering. They may reach in Illinois a length of 200 yards or more, and a depth of 10 to 30 feet. They consist of four physiographic divisions, with each of which a definite association is correlated. The windward slope, occupied by the windward slope association, is situated at the west end of the blowout. On it the sand is being removed by wind and is also sliding down by gravity. The vegetation is composed principally of grasses derived from the vegetation outside the blowout. The deepest part of the blowout is the basin, from which sand is being removed by wind alone. The basin association is composed of a few individuals of deep-rooted perennials. The upward slope at the east side of the basin is called the lee slope. On it the sand is merely in motion, without any essential change in level. It is occupied by the blowsand association, consisting of large numbers of slender, quick-growing annuals. The east end of the blowout is occupied by the deposits, on which sand is being piled by the wind. The vegetation of the deposit association is principally composed of sand-binding perennials, through the agency of which the sand is accumulated into dunes.

The successional relations of these four associations are complex, but lead as a rule to the ultimate dominancy of the blowsand association. When the sand has ceased blowing, stabilization of the blowout begins in all four parts, and the area is soon reoccupied by a more luxuriant vegetation.

C. C. Adams presented a paper which is given below in abstract.

RECENT HABITAT CHANGES IN THE ILLINOIS RIVER.

This paper is a report of an ecological reconnoissance of the Illinois River at Havana carried on by the cooperation of the State Laboratory of Natural History and the Ecological Survey Committee of the State Academy of Science.

During recent years the increased amount of water in the river has raised the water level about 3 feet. This has submerged the lowlands, killed many trees and produced numerous changes in the animal habitats. The paper describes some of the changes observed in 1909 and compares them with conditions previous to the high water.

A. R. Crook inquired concerning the cause of the sudden changes in the height of water as shown by the "lily pads" left standing and the changes in the amount of vegetation in the waters of the region described, from year to year.

C. C. Adams replied that Prof. Forbes could answer the questions.

Mr. Forbes said that the cause of the changes were extremely complex and necessitated close study for a series of years, study which was being prosecuted by the survey.

W. S. Strode.—"This paper touches me in a tender spot. The Thompson lake region so ably portrayed is my old stamping ground, and I have explored every foot of it. It is the richest faunal region in the state or anywhere else; rich in shells, fishes, birds, plants, aquatic life of all kinds. The turning in of the drainage ditch water a few years ago made a great change; plants and trees died; there are hundreds of acres of dead trees all about the lake. The lake is high water now all the time. A few years ago one could wade across it. This lake at one time during a very low period nearly caused the death of all the unios or fresh water mussels it contained, almost car loads of them indeed and windrows of the dead shells extended all the way around the lake, and it looked like the extinction of a very interesting species, *anodonta suborbiculata,* perhaps the handsomest of all mussels and quite scarce every where except in this lake. The late state geologist Worthen discovered this beautiful unio in this lake and kept it a secret for many years, sending specimens to nearly every museum in the world, and to many private collections. There are plenty of them in the lake now but they keep to the southern half of the body of water, while a companion almost equally interesting, *anodonta corpulentii,* holds possession of the northern half.

This lake is also headquarters of a bird that is the gem of the swampy place—the prothonatory warbler, which builds always over the water in holes of old stumps or trees and uses only green moss for nest material.

Water birds of all kinds are abundant in this region. On December 12th last, one of the stormiest days of the month, my father and I killed the legal limit of red-legged mallards in a few hours. Many other animals are to be found here. On one excursion four big water snakes dropped from over-hanging willows into my boat.

It was here that I first met the essayist Mr. Adams and also some years ago discovered a big man in rough wading clothes and big sun hat in water up to his arm-pits and on inquiring of some fishermen who it was got the reply that he was an old crank soldier, a little queered. Further investigations disclosed the fact that it was the now honored president of the Illinois Academy of Science, Stephen A. Forbes, one of the most noted scientific investigators in the world.

Mr. Forbes.—"In locating our station on the Illinois river we were fortunate in having the acquaintance of a man who from his boyhood had been familiar with the region—Dr. Strode."

William S. Cooper then gave an illustrated paper of which the following is an abstract.

PRELIMINARY ACCOUNT OF THE FOREST SUCCESSIONS ON ISLE ROYAL, LAKE SUPERIOR.

Isle Royal, an island near the northwest shore of Lake Superior, is fifty miles long and six to ten miles wide. Its topography is determined by a parallel series of tilted beds of Keweenawan and Cambrian age, which dip southeast under Lake Superior. The result of this structure is a series of ridges extending northeast and southwest, parallel to the long axis of the island, with steep faces on the northwest, but sloping gently to the southeast. The ridges bound long narrow valleys which contain bogs and lakes, or harbors if below the present lake level.

The island was overridden by the continental glacier, and on the retreat of the ice was left entirely submerged beneath the waters of Lake Duluth. As the lake level subsided the island gradually emerged, finally reaching its present size. It has never been connected with the mainland since glacial times.

The dominant forest of the island is composed of white spruce, paper birch, and balsam fir. Whether this is the climax forest toward which the earlier successional stages tend cannot be determined at present. The uncertainty is due to two causes: the presence on the southwestern end of a well developed forest of sugar maple, which is the most important tree of the climax forest farther south; and the apparently unstable character of the dominant forest. It can be said with certainty, however, that the successional stages lead to the spruce-birch-balsam forest. Whether this in turn will tend to become maple forest is the doubtful point.

The devil's club (*Fatsia horrida*), first discovered on the island by W. A. Wheeler, was found in four isolated localities in the forest at the northeast end. It is a very common plant in the western mountains and is known nowhere in the east except on Isle Royal.

There are two main lines of normal succession leading to the spruce-birch-balsam forest as their ultimate or penultimate stage: the rock shore series and the lake bog series.

The rock shore succession is made up of the following stages: 1, crustose lichen stage; 2, crevice plant-lichen stage (Fig. 1); 3, Cladonia-Juniperus stage; 4, mature forest. The abrupt transition from the comparatively youthful third stage to the mature forest may perhaps be explained by the former presence of intermediate societies which have been "pinched out" by the advance of the forest toward the lower limit of plant growth, at the present time practically stationary, which is determined by wave action and ice. Suggestions of a xerophytic transitional society, dominated by jack pine, were found at a few points by Adams.

The lake bog series develops in the valleys and depressions which have been shut off from the main lake by the emergence of the island. The early stages are as follows: 1, aquatic stage; 2, bog sedge stage; 3, bog shrub stage. From this point two types of bogs develop. The first, in undrained depressions, is characterized by abundance of sphagnum and heaths, especially Labrador tea, followed by bog forest composed of tamarack and black spruce. The second type (Fig. 2), developing in basins possessing active inlets and outlet, is characterized by practical absence of sphagnum. The shrub zone is made up of Chamaedaphne and alder, and the bog trees following are tamarack and arbor vitæ. The condition and causes of the two bog types are still to be worked out. Both types develop into the spruce-birch-balsam forest, usually very soon after the bog forest is mature.

The changes brought about in the dominant forest by fires are as follows. If the humus is completely burned from the rocks, a succession is instituted which is essentially like the rock shore succession. If more or less of the humus and forest vegetation remain, certain species develop to the exclusion of the rest, and dominate for a time. The balsams are exterminated, while the birches increase enormously by sprouting from the stump. The result is a birch forest, under the shade of which the spruces and finally the balsams develop, the ultimate result being a return to the spruce-birch-balsam type of forest.

J. C. Hessler.—"What is the character of the rocks on Isle Royal?"

W. S. Cooper.—"They belong to the Keweenawan and Cambrian."

J. C. Hessler.—"I have a series of photographs taken on Silurian formations several hundred miles south of Isle Royal which show the same topography and same general type of vegetation."

T. C. Chamberlin.—"There is no doubt a calcareous factor influencing the character of the vegetation."

J. G. Coulter.—"Mr. Cooper's interesting chart, indicating tree successions on the basis of contrast of ages evidenced by growth rings, suggests the old question of the dependability of these rings as indicative of annual increments. Of course even large fluctuations from the year-value would not, however, invalidate Mr. Cooper's striking chart, which is constructed upon a comparative rather than an absolute basis.

In tropical trees the question of the time-value of these rings is more complex. The interesting fact is that these rings are readily discernible in many tropical woods, although not so clearly marked as in trees of the temperate regions. In the Philippine Islands, for example, such rings have been observed in the wood of members of the Leguminosae and of the Dipterocarpeae. In the former, a year-value suggests itself since these trees do regularly lose the bulk of their foliage in monsoon-forests during the dry season. In the latter case, however, the time-value is more perplexing since there is no evident general loss of foliage at any time of year, nor do the climatic variations indicate any necessity for a stoppage or even any serious pause in nutritive activities during the year. at least not in the case of deep rooted old trees. However the rings appear to be as well marked near the bark as near the core of such trees.

Fig. 1.

Fig. 1. Lichen and crevice plant societies on shore rocks. *Potentilla tridentata* as crevice plant.

Fig. 2.

Fig. 2. Bog of drained depression type. Sedge zone in foreground with pitcher plant and Alpine cotton-grass; alder and chanaedaphne in center and in front of trees; open water and aquatics at right; tamaracks behind, with spruce-birch-balsam forest on high ground at right.

I would like to ask Mr. Cooper whether, under the climatic conditions of Isle Royal, there is not good reason to believe that these rings have practically an absolute year-value?"

Mr. Cooper.—"No attempt was made to study that subject, but in a general way the method yields fairly accurate results."

W. S. Bayley called attention to the fact that the more intelligent woodsmen on the neighboring mainland believe that the rings indicate the ages of the northern trees, basing their belief upon the fact that the positions of several double sets of rings seen in almost all trees correspond accurately to the dates of several seasons, when the trees budded twice.

He also stated that the rocks on Isle Royal comprise a series of sandstones, conglomerates and lavas of very different compositions. The Cambrian, on the south side of the island, is almost a pure quartzite. The same types of rocks occur in that portion of Minnesota north of Lake Superior, and so far as known there is no difference in the character of the forest corresponding to differences in the character of the rock. He asked the speaker if the forest covering over the Cambrian quartzite on Isle Royal was noticed to be different from that over the Keweenawan beds.

Mr. Cooper.—"The forests on the different formations seemed to be of the same general type."

T. L. Hankinson presented the following paper:

AN ECOLOGICAL STUDY OF THE FISH OF A SMALL STREAM.

In this paper I will attempt to set forth the nature of my studies of the fish life of the streams about Charleston, Ill., by considering some of the methods employed and the results obtained in investigating the fish of a particular stream, called by a few of us "Campus creek" because a portion of its water comes from the Normal School campus. Although more or less attention has been given to this stream for about six years, a systematic investigation of its fauna and flora has been carried on for about three years. The work is but fairly begun; and this paper by no means represents a culmination point in the accumulation of facts concerning this body of water.

Campus creek meanders in a southerly and westerly direction through pasture and cultivated fields and thickets, keeping to the south side of its rather broad valley, which reaches a width of about a half mile near the mouth of the stream. The country along the sides of this valley is high and gently rolling morainal region. Like other streams about Charleston, Campus creek is a part of the Wabash system, its waters entering this river through the Embarras river and Kickapoo creek. To the latter stream it is a tributary. Campus creek has four principal branches, all of which flow in a southerly direction, entering the main stream on its north side. The different portions of this little system vary considerably as to direction and rate of flow, width of bed, depth of water, topography of bottom and shore, and biological conditions present.. Throughout most of its course it is broken into a series of pools with intervening narrows or broad shoals. The average maximum depth of these pools seems to be about two feet, but a few have depths as great as three feet. The current is swift in narrows and about perceptible in pools. The water is very clear under ordinary conditions. The bottom is, for the most part, firm and light-colored, composed of various combinations of clay, sand, gravel, and cobble stones. Small boulders are not infrequent in the stream bed. In the deeper parts of pools, a thin, dark sediment, rich in humus, often covers the bottom. Dead leaves accumulate here, also, in many cases. The bank in most places is grassy, and the long blades often completely conceal narrow stretches of the stream. Many kinds of plants grow along the shore, but distinctly aquatic seed plants are scarce. The stream is rich in algæ, and these organisms are being studied by Mr. Transeau. Diatoms produce a brownish scum over submerged stones, sticks, and other objects as well as over some areas of the bottom soil. This scum is especially noticeable in early spring.

An attempt has been made to get a complete collection of invertebrate animals from each collecting station along the stream, and notes on the habits of these forms are being made as well as upon fish, but at present no detailed report upon them can be made. Campus creek is a good crayfish steam. Amphipods and isopods are common in its headwaters and those of some of the larger tributaries. Snails of several kinds are numerous. Such aquatic insects as dragon-fly larvæ, damsel-fly larvæ, and caddice worms are abundant, and some interesting problems concerning these and other invertebrate forms have presented themselves. Of the species of aquatic vertebrates other than fish, no one is abundantly represented. Crickets frogs, *Acris gryllus* LeConte, leopard frogs, *Rana pipiens* Schreber, and green frogs, *Rana clamitans* Latreille, are found in numbers in spring. Careful search has failed to reveal any amphibian eggs in any part of the stream, and tadpoles are scare at all seasons. Only one turtle, a large snapping turtle, *Chelydra serpentina* Linnæus, has been seen by me about the creek. Water snakes, *Natrix sp.*, are now and then noted, and are especially common in late spring. The following water birds have been recorded by me from different parts of Campus creek system Carolina rail, *Porzana carolina,* king rail, *Rallus elegans,* Wilson's snipe, *Gallinago delicata,* spotted sandpiper, *Actitis macularia,* green heron, *Butorides virescens,* and American bittern, *Botaurus lentiginosus.*

Of the fifty-four species of fish found to my knowledge about Charleston, seventeen are represented in Campus creek. A list of these, using the names employed in the recent work on the Fishes of Illinois by Dr. Forbes and Mr. Richardson, is here given:

Chub sucker, *Erimyzon sucetta oblongus* (Mitchell).
Stone roller, *Campostoma anomalum* (Rafinesque).
Black-head minnow, *Pimephales promelas* Rafinesque.
Blunt-nosed minnow, *Pimephales notatus* (Rafinesque.)
Horned dace, *Semotilus atromaculatus* (Mitchell).
Golden shiner, *Abramis chrysoleucas* (Mitchell).
Straw-colored minnow, *Notropis blennius* (Girard).
Silverfin, *Notropis whipplii* (Girard).
Common shiner, *Notropis cornutus* (Mitchill).
Blackfin, *Notropis umbratilis atripes* (Jordan).

Black bullhead, *Ameiurus melas* (Rafinesque).
Silver-mouthed minnow, *Ericymba buccata* Cope.
Yellow bullhead, *Ameiurus natalis* (LeSueur).
Blue-spotted sunfish, *Lepomis cyanellus* Rafinesque.
Black-sided darter, *Hadropetrus aspro* (Cope and Jordan).
Johnny darter, *Boleosoma nigrum* (Rafinesque).
Rainbow darter, *Etheostoma caeruleum* Storer.

Of these only seven may be considered common and permanent inhabitants of the stream. These are, named in the order of their apparent abundance: stone roller, blunt-nosed minnow, horned dace, blue-spotted sunfish, black head minnow, silver mouthed minnow, and chub sucker. The following have been noticed common at particular times only: silverfin, common shiner, and black bullhead. Species that have been recorded in a very few instances and which are certainly very scarce in the creek are: straw-colored minnow, blackfin, yellow bullhead, and each of the three kinds of darters that have been seen in the stream. There are some species common in Kickapoo creek that I have never notd in Campus creek, although some of them, at least, probably come into it at times in the vicinity of its mouth. These are: hog-nosed sucker, *Catostomus nigricans* LeSueur, white sucker, *Catostomus commersonii* (Lacepede), red horse, *Moxostoma aureolum* (Le Sueur), suckermouth minnow, *Phenacobius mirabilus* (Girard), brindled stone cat, *Schilbeodes miurrus* (Jordan), common top minnow, *Fundulus notatus* Rafinesque, and green sided darter, *Diplesion blennioides Rafinesque.* On the other hand, a few species seem to prefer Campus creek to the larger Kickapoo creek. These are the horned dace, black head minnow, chub sucker, and blue-spotted sunfish. Species found in numbers in both streams are: stone roller, blunt-nosed minnows, silver minnows, and silverfin.

The chief problem under consideration, concerning the fish, in this work on Campus creek and on other steams about Charleston is to determine the local distribution of each species, the type of habitat that it prefers and the way it is related to its surroundings. When these habitats are discovered, a successional study of them can be made. The rapidly changing conditions in Campus creek due to freshets and other causes render the stream very favorable for such work.

To find these preferred habitats is difficult on account of the great variation in distribution of fish noted at different times. There are not only annual and seasonal fluctuations in numbers, but also daily and even hourly ones. Often they can be correlated with changing environmental conditions but in many cases, they can not be. An abundance of statistical data for each type of habitat is needed, but this is not easy to obtain even under the specially favorable conditions afforded by a small, clear creek like the one under consideration. Unless much precaution is taken in making direct observations, the proportions of species and individuals seen will be very different from those that actually exist for wary fish, like horned dace, hide, making the less shy fish seem to be the only ones present. Collections will not always give accurate information, for fish have different ways of responding to the presence of a net. Some go at once into the mud and beneath stones, and are easily missed, and the collection may contain only individuals that seek to escape by swimming. Often under very favorable conditions for collecting have I failed to get a single representative of a species which I knew, through observation, was present in the place where collecting was done. To obtain correct conclusions, therefore, concerning habitat preferences on the part of a species of fish, it seems necessary to get an abundance of data by every possible method during many seasons and obtained at all times of the day and year. These data for Campus creek are not yet at hand, so this paper will not attempt to set forth habitat preferences, but will deal with some of the more obvious environmental factors affecting the distribution of fish in Campus creek, which are: barriers, current, fish food, water temperature, and shore vegetation.

Barriers. Like most of the creeks about Charleston, there is a long stretch of shoal just above the mouth of Campus creek. This has a sandy bed with many ripple marks, and is usually dry in late summer and early fall, while the part of the stream above this area persists in its usual condition. This forms an obstacle to fish when they are trying to come up the stream in the spring, except when the water is unusually high, and at such times fish are noticeably more numerous in the creek. Barriers in the form of leaf dams exist. There are accumulations of dead leaves against fallen limbs, brush, tree roots, fences, and the like, that are in the water. These dams often change the surface of the stream a foot or more in elevation, and fish can not get by them except at times of freshet. A little fall, about a foot in height in a piece of narrows, has been an obstacle to migrating fish in Campus creek during the last three springs; and it was interesting to watch them attempting to leap over the fall and to swim up it. Last year this fall seemed a perfect barrier till about the middle of April, when a period of high water obliterated it temporarily. After this time, stone rollers in large numbers were found nesting in the part of the stream above the fall, while prior to it they were only abundant and found spawning below it.

The Current. The direct effect of this on fish distribution in Campus creek has not been definitely made out. All the common species in the creek certainly prefer the deeper and quieter waters for permanent abodes, but many individuals come to the shoals from the pools at night and rest on the bottom where the water is swift. From observations made with a bicycle lamp in some of the streams about Charleston, including Campus creek, it appears that shoals constitute the chief nocturnal habitats for stream fish; the pools seem almost deserted at that time, and those shoals with rapidly moving water seem to be preferred, but more data are needed on this point. Stone rollers, with some exceptions, and also horned dace, go to the rapid and shallow water areas for spawning, usually just above the patches of riffles at the lower ends of pools. Male stone rollers, by pulling away the small stones of gravel bottoms, in the situations described, make little pits in which the females lay the eggs. These were very noticeable above many pieces of riffles in Campus creek last year, and these fish were seen working here from the last of March till after the middle of May. Some fish were found spawning

Fig. 3. Nesting habitat of stone roller.

Fig. 4 Nesting habitat of horned dace.

in very swift water of shallow riffles, where their bodies were out of water much of the time while working at the gravel. The only undoubted horned dace nest found in Campus creek was located in one of the tributaries of the stream in a narrow, shallow piece of swift water; but a number have been found in other streams in the region and all were located in a good current. Some silver-mouthed minnows were found spawning upon a sandy shoal where there was a moderate current last spring. The shoal with swift water seems to be least frequented by fish of all habitats in Campus creek except at night and by certain species at the spawning time. Its main function for fish appears to be that of a general highway connecting their diurnal dwelling places, the pools and deep narrows.

The current also has an indirect effect upon the distribution of fish by changing the bottom topography; for example, I noticed this winter that there is a broad shoal where a deep pool existed last fall; and in another place, where there was an extensive area of riffles used by stone rollers for nesting purposes last spring, there is now a deep pool. These changes will necessitate biotic changes involving fish as well as other organisms; and an opportunity will thus be afforded to observe directly the succession of forms inhabiting a particular part of the stream due to a change of environmental conditions. After a hard rain last April, the swift water completely denuded an area of gravel, which formed a piece of riffles used by many stone rollers for nesting purposes, and left in its place a shallow area a few inches deep, having a hard, blue clay bottom with a few pot holes and scattered cobble stones. Fish were found using these objects as places of concealment. Thus in a few hours one type of habitat was transformed into another, and each had a fish fauna different as to the species present and the way they reacted to their surroundings.

Food. This is undoubtedly a strong factor in determining the distribution of fish in Campus creek. Diatoms, entomostracans, and Chironomus larvæ are the chief objects that I have found by dissecting many examples of the common species.

Stone rollers, blunt-nosed minnows, and black head minnows feed largely on soil rich in diatoms. Chironomus larvæ and entomostracans formed the bulk of the food found in silver mouthed minnows and the blue-spotted sunfish. Some chub suckers had fed entirely upon soil and diatoms, and others upon entomostracans and Chironomus larvæ. The horned dace examined had a miscellaneous lot of insect fragments in their intestines including Chironomus larvæ and terrestrial insects. By further studies of the food of the fish of Campus creek, it is hoped that the distribution of the organisms used as food can be correlated with that of the species of fish that feed upon them.

TEMPERATURE. This effects the distribution of the fish in the stream indirectly and probably directly, but I have failed as yet to find any marked relation between temperature of water and fish distribution. They have been seen both active and inactive in winter when the water was near the freezing point. The largest number of fish ever seen by me in Campus creek was on January 28, 1906, when the water temperature was 6 degrees centigrade.

Some stone rollers taken at this time had their intestines filled with soil and diatoms. One winter I gave particular attention to a lot of fish that were remaining over winter in a pool in one of the tributaries of Campus creek, and I could see no relation between their behavior and the water temperature.

SHORE VEGETATION. As above stated, a grassy bank borders the stream almost everywhere, and this in many places overhangs the water due to the mat of soil and roots at its top edge, which resists erosion more than the portion below it. Under this shelf, fish and other aquatic animals like snails and various insects find a place of seclusion. From observations made on Campus creek it appears that fish are more often found where overhanging banks are present than at other places. Roots of trees also hold on to the soil, and often produce large overhanging banks; and where the roots are submerged, a habitat of a peculiar type is produced, for among them there is an intricate series of cavities in which fish often stay. The leaves forming leaf dams and accumulations on the bottoms of pools, in which fish often conceal themselves, are contributed largely by the trees along the shore.

President Forbes appointed the following committee on nominations suggesting that, if possible, it report the first thing Saturday morning:

C. W. Andrews, E. J. Townsend, W. S. Bayley, F. C. Baker, E. N. Transeau.

Frank DeWolf announced that the apparatus in use at the newly established Mine Rescue Station would be on exhibition any time during the meeting.

T. W. Galloway reported for the membership committee the approval of an additional list of nominations and these nominations were voted in.

J. G. Coulter gave notice of a motion intended for presentation on Saturday.

The meeting adjourned at 5 P. M.

Evening.

8:10. John M. Coulter called the meeting to order in the gymnasium of the Woman's Building.

President Edmund J. James, in behalf of the University of Illinois, gave an address of welcome.

Mr. Coulter replied in behalf of the Academy: "I am happy to respond to this cordial welcome. No place could be more fitting for our meeting that at an institution which is the climax of the educational work of the State. This organization represents the cooperation among the scientific men of the State, and as an organization greatly appreciates the work of this university. We shall be stimulated by our meeting here. We shall now have the pleasure of listening to the presidential address which is the immediate reason for my presiding tonight.

The presidential address was then delivered by Stephen A. Forbes as follows:

RELATIONS OF THE ILLINOIS ACADEMY OF SCIENCE TO THE STATE.

The Illinois Academy is meeting this year at what we may now truly call a great state university, with its thoroughly organized and well-equipped departments of instruction and investigation in science both pure and applied; the home also of other organized public agencies for scientific work not immediately connected with instruction,—the Geological Survey, the Agricultural Experiment Station, the State Water Survey, the Engineering Experiment Station, the State Entomologist's office, the State Laboratory of Natural History, and the Soil Survey of the State; and we know that there are other active organizations elsewhere in Illinois of equal interest to us with those about us here,—the State Museum, the Field Museum, the Chicago Academy of Sciences, the great universities in and about Chicago, and the active scientific departments of the several colleges of the state, and of our five state normal schools.

Under these conditions we may reasonably ask ourselves the question: What is the place and proper work of this Academy in the midst of all this great array of established agencies for the scientific work of the State? What elements of scientific activity still remain in Illinois unorganized, or imperfectly organized, which can be brought together in a state society for their improvement in efficiency? What service may we possibly do to institutions and movements already in existence, by establishing useful bonds of affiliation and practicable systems of cooperation among them? What may we do to strengthen them? to supplement their work at any point by our own undertakings? to make them more immediately and more widely useful to the people of the state?

The earlier state scientific societies, in other states, had, in their beginning, a comparatively open field. They originated many movements and nourished the germs of many institutions which we now find permanently organized and in full operation here. We can not imitate them, consequently, even if we would, but must adjust ourselves independently to our own environment. Now, after two years of active operation, and with a membership list which insures us opportunity and promises us power, this seems a suitable time to start some fundamental inquiries as to our ends and purposes, and to begin the earnest discussion of practical answers to them.

Although I hold today a place of temporary advantage, and might assume to speak to some extent at least in the name of the society itself which has chosen me as its president for the year, I wish to disclaim any such privilege, and shall merely undertake to express my personal views from my own standpoint.

Our most immediate duty, as it seems to me, is to our otherwise unattached, active membership—to the private student, the isolated investigator, the occasional scientific worker in an unscientific environment, to whom we may, through our organization and our meetings, bring helpful acquaintanceship, appreciation, stimulus, and aid. Next we especially owe opportunity and elementary inspiration to the young—to the beginner, who may find in our meetings and in his own first paper on our program a not too difficult first step in a career which may lead him no one knows how far or how high. And then we owe to all of us, young and old, beginner and veteran, attached and unattached, an opportunity to know each other, and to learn something of each other's interests and accomplishments, and a look, at least, now and then, over some easy place in the wall of division between specialties and departments,—a chance to hear and to see the best and the latest thing in some other field than the one which we know best. And out of all this will come good fellowship and a broader knowledge, and not infrequently a reflected light on some problem of our own, involved in darkness hitherto, which no direct light could penetrate; and best of all, there will sometimes come a chance and a disposition to get together, ignoring division lines, on some joint cooperative enterprise too large and too complex to lie wholly within the field of any one or any class of us, and likely otherwise to be ignored or imperfectly provided for.

The State Academy of Science may, like any other state society, do its part towards making the state interesting to its own people, and especially to those who are newcomers within its borders. In each of our great universities, and in many of our colleges and scientific institutions, there is an almost continuous stream of newcomers, some to take new places, others to replace those who are going away. Most of these, as a rule, come to us from other states, and some from foreign countries. They are often well prepared to make important contributions to our civic and our public life—to our scientific and industrial progress—but are sometimes little disposed on their arrival to go outside their special spheres of interest. They may even live among us, and yet not be of us, for years, concerning themselves but little with the state or its people except as their duties bring them into necessary contact with us,—a situation unfortunate for us and doubly so for them. Often their training and learning, their special abilities, their different standards, their tastes acquired elsewhere, make them precisely fitted to do some needed thing for us which we are not likely to do ourselves, and which does not get done because nothing is done to effect a real transfer of their allegiance. The very loyalty of their tempers, which would make them invaluable to Illinois if they were really to become identified with its interests, leaves them cold to us and makes them useless here for any general purpose, because it holds them still to other interests and places which they have left behind. Their own lives are more barren and lonely than they might be, and their stay with us perhaps is short, because they take no sufficient root in our soil. An acclimatization society is needed to adjust them fully to their new environment; and such a society the State Academy should actually be.

The Academy may do a great service also to our own people, by helping to increase their interest in their native state by increasing their knowledge of it, and by giving them new opportunities to contribute to its welfare. Loyalty is an emotion based on personal knowledge, on personal experience, and especially on personal service. The more we know of this great, rich, powerful, prosperous, and progressive commonwealth; the more definitely we can realize the conditions out of which, and the processes by which, it has come to its present high estate: the more justly we can estimate the energies working in its bosom for the future welfare of its people; and especially the more confidently we can be permitted to feel that we have personally contributed something, however little, but still our best, to its progress and its happiness,—the more devoted will be our attachment to it, and the greater, consequently, will be our future service. It is the one greatest and best function of this State Academy to make the State of Illinois known to itself.

Loyalty and state pride are, however, by-products of a scientific society, to which many other societies of various kind and aim may contribute equally. Our own *special* mission is the aid and advancement of scientific research and the popularization and propagation of its results. For both these aims we need to bring the scientific men and the people of the state into closer and more frequent contact, in ways and under conditions to increase the popular respect for scientific work and the popular appreciation of its outcome, and also to interest our scientific men more strongly in problems affecting the general welfare. Especially we must remind the absorbed investigator that it is the part of science to understand its own environment, and to adapt itself thereto; that science is not, and perhaps can never be, wholly self-sustaining, especially in a democracy; and that without the broadest possible basis in popular gratitude and regard, the progress of science will be needlessly retarded and its development delayed. The happy thought of an annual symposium on some subject of primary importance and strong human interest is, I think, a great help to these ends; and the discussion of the relations of the pure and applied sciences which our representatives for the year are to hold tomorrow forenoon is an excellent example of what I now have in mind. I hope that we may make even more than we have done of the symposium idea; and that we may select and assign our topics for discussion with great care and early in the year, that those chosen for this service may have ample time for the careful preparation which its importance demands.

I have spoken of the Academy on the one hand, and the people of the state as its constituents on the other; but from another point of view we are the representatives of the people and the immediate constituents of the scientific institutions of the state. We have in our membership not only the managers and the workers of these institutions, but a select group of citizens also, especially concerned in their work and especially intelligent with respect to it. Our geologists and geographers and certain of our biologists follow the operations and study the reports of the Geological Survey with an interest at least as great as that of the miners and quarrymen, the clay men and the oil promoters, for whose benefit its work is primarily done. The Soil Survey concerns not only the farmer, but the botanist and the zoological ecologist as well, and so of most of these departments of state activity. Although not established, as a rule, for our purposes, but with some economic end in view, each of them is of great interest and importance to one or the other group of us, and virtually all of them contribute materials highly valuable to those of us responsible for scientific teaching of whatever grade. Our interest in the work of these institutions is mainly scientific, while that of their other constituents is merely economic, and it goes almost without saying that we may have, and ought to have, a strong and helpful influence over it. There is nothing that is more needed by any active department of economic work than an intelligent, watchful, and appreciative scientific constituency. Its more immediate beneficiaries and supporters are commonly in a position to criticise only its more practical results, and can usually know but little of the scientific wisdom and validity of the methods by which these results are reached. They may even embarass, discourage, and delay a correctly managed undertaking, by an impatient demand for a practical outcome before any such outcome is fairly attainable. They may overvalue and overpraise the empiric at the expense of the scientist, and may greatly overstimate a relatively easy and simple piece of work, which yields an immediate and important economic product, as compared with a difficult and complicated one whose progress is necessarily slow. A sufficient body of intelligent, conscientious, and disinterested critics of the scientific work of the state, such as I hope this Academy may always be able and ready to supply, would help greatly to correct the distorted perspective in which an economic science is commonly seen by the economic citizen. Furthermore, the membership of this Academy is the natural and immediate constituency and support of such *purely scientific* work as the state, or any other public agency, may choose to foster or initiate. With its general outlook over the whole field of human welfare and scientific activity, it ought to be in a position to suggest or to set on foot new work in lines neglected hitherto. This view of the legitimate and possible relations of the Academy to public scientific work seems to have been foreshadowed, whether consciously or unconsciously I do not know, by the description and resume of that work contributed by our last year's symposium, and contained in our Transactions for 1909. I commend this review to your attention as worthy of careful study. I would like to see, and am indeed ready to advise, the appointment of annual committees of this Academy on scientific progress within the state, to present reports which, published in our Transactions, will form a continuous and, in course of time, an invaluable record of the history of scientific enterprise in Illinois.

These are delicate and important functions which I am proposing to you, and all this implies, as you will see at once, that the State Academy is really to succeed and to continue to succeed; that it is to attract and to hold in its membership the best, the most experienced, and the most public-spirited scientific men of the state; and that they are to enter into its work with interest and energy as worthy of their time and serious attention. I would, indeed, *make* this work worthy of the best thought and service of the best men among us. If we do that, their thought and service, I am sure, will be forthcoming; and if we do not, we shall shortly find that those whose presence and assistance we most need are conspicuous by their absence from our meetings. I must make, also, this assumption of continued success and of high-grade, disinterested service, in what I shall have next to say of the relations of the Academy to the State. If I shall seem to make this topic too prominent at this meeting, paying too little attention to other allied interests, I trust that you will accept my apologies in advance. There are many others far better qualified than I to deal with other aspects and relations of our work and influence, but if there is any such topic on which I may be thought somewhat competent to speak it is this of our relations to the State, in whose scientific service I have really spent, I suppose, a longer time than most of us have lived.

In all that we may do or propose with respect to general state work, we should of course be sure that we are assisting and strengthening existing active agencies, and not weakening them or supplanting them. We should, in other words, hold and develop what we have, and add to it what and where we can. For this reason any general plan for state-wide work which may be presented to the Academy should be carefully scrutinized and reported upon by a special, disinterested committee, which should act conjointly with any state agency operating in the same field. This is essentially the course taken by us with respect to a proposition for an ecological survey of the state made to the Academy by some of our ecological members at its Decatur meeting in 1908. As the survey proposed came within the field of operations of the State Laboratory of Natural History, charged by law with a natural history survey of the state, the forces of the Academy were united with those of the State Laboratory by means of a committee report approved by the Laboratory management and accepted by the

Academy; and a standing committee was appointed, with the Director of the Laboratory at its head, to organize and conduct this work. The principal, actual outcome of this experiment—for an experiment, of course, it is—has thus far been a review and endorsement, by this committee, of the State Laboratory plans and operations, and a common understanding among the active investigators in this field as to their respective subjects, fields of operation, and interrelations, arrived at with a view to the coordination of all parts of this work and a fairly uniform and symmetrical final product. The publication of several papers on the ecology of the state by members of the committee has been provided for by the State Laboratory, and these papers are appearing as articles in its Bulletin. Both state and individual work have thus been stimulated and somewhat expanded, so far without increase of expense, and with notable addition to the scientific and educational value of their product.

Possibly other plans of cooperative aid to other state agencies might be profitably set on foot by committees of conference appointed for the purpose. Others of our members may be so situated, so educated, so interested, and so experienced, that by coming together and by allying themselves with the Water Survey, the Geological Survey, the Soil Survey, or the State Museum of Natural History, they could at once give greater system, definiteness, and value to their own work, aid to each other, and important assistance to these organizations, either by the contribution of useful observations and material, by supplementary studies made along allied lines, by intensive local work and other continuation studies, beginning where the state work leaves off, or by adapting the products of special work to educational uses.

In order to insure the success of such cooperative plans, it is, of course, a prime necessity that thoroughly disinterested motives should prevail, and that the advancement of science in the interest of the state should be the touchstone by which all plans and persons shall be judged. I fully believe that we can trust each other confidently in these matters, and that the way is open on all sides to various forms of helpful organized activity, which ought in a few years, if properly directed, to give a new aspect to the status of science in Illinois.

There are, however, certain limiting and controlling conditions to joint enterprises of this description, which must not be overlooked or ignored. Agents of the state, placed in charge of work provided for at public expense because of its importance to the state at large, can neither divide their duties with others nor share their responsibilities except as required or permitted by law. A considerable administrative discretion is commonly vested in them, however, within which any such adjustments as I have had in mind might readily be made. They can thus often assist materially an independent society or even a private citizen, and can receive material assistance from such sources with real profit to their enterprises, and an enlargement of their usefulness. Most of them are, in fact, really eager for such mutually profitable connections, and often take great pains to establish them, and it is, of course, good public policy to secure for any public enterprise all the really competent volunteer aid possible, in order that its results may be most quickly reached at a minimum cost to the public as a whole.

On the other hand, an academy of science is not a compact organization capable of carrying forward long, complicated, laborious, and expensive undertakings, requiring for their accomplishment the continuous cooperation of a group of men working, each in his place, to a common end. Such undertakings belong to established institutions and not to volunteer societies. Consequently we should not seek to do the work which the State has undertaken, or is likely to undertake, on its own account and at public expense. *Per contra*, the State should not tax its people for what any of them are willing to do for their own purposes, and which they can do well enough and quickly enough to serve also the public interests concerned. It may, however, provide agencies of coordination, may supplement private work, especially where extensive, complicated, and expensive operations are required, and may give such assistance to that work as is warranted by its general value as an aid to education, as a foundation for more immediately productive operations, and as helping to create a background of appreciation for the work of the state agencies themselves. It is in this sense that it seems perfectly proper that the State of Illinois should provide at its own expense, as so many other states have done, for the publication of the Transactions of its State Academy of Science. Whatever tends to stimulate a general activity in scientific work throughout the state and to increase the public interest in it; whatever makes available for the general public the product of valuable unpaid services of private citizens; whatever helps to familiarize our people with the true objects and methods and the outcome of scientific investigation, will have consequences, immediate and remote, so important to the public welfare, material, intellectual, and social, that the petty sums needed for the publication of our papers will certainly, as it seems to me, be invested at an enormous rate of final profit.

It is especially in this period of an emotional reaction against science and the scientific method, when whole sections and sects of our people seem fairly rushing down a steep place into the sea of fantastical speculation and conjecture, that we need in every community the sane, cool, impartial spirit of science, at work along all lines of intellectual activity. It is not an empty reproach which Professor John Dewey, of Columbia University, brings against those of us who are science teachers, in his recent address as chairman of the educational section of the American Association for the Advancement of Science, when he speaks of the slight extent to which the teaching of science has hitherto protected the so-called educated public against the recrudescence of all sorts of occultism, superstition, and silliness. "The future of our civilization," he continues, "depends upon the widening spread and deepening hold of the scientific habit of mind; and the problem of problems in our education is, therefore, to discover how to mature and make effective this scientific habit. Scientific method is not just a method which it has been found profitable to pursue in this or that abstruse subject for purely technical reasons. It represents the only method of thinking that has proved fruitful in any subject—that is what we mean when we call it scientific. It is not a peculiar development of thinking for highly specialized ends; it *is* thinking, so far as thought has become conscious of its proper ends and of the equipment indispensable for success in their pursuit."

Our relations to the progress of scientific investigation within the state, important as they may be, are really overshadowed, as it seems to me, by those which we bear, or ought to bear, to the progress and improvement of scientific education. Topics of this description are most commonly dealt with by bodies too narrowly limited in their membership to see the subject equally well in all its bearings, and their conclusions are hence likely to be partial and tentative only. The Academy has, however, within its active membership, scientific investigators of various sorts, university and college professors, normal and high school teachers of the several sciences, and a considerable body of picked, but fairly representative patrons and supporters of all kinds of schools; and I can think of no organization better constituted to discuss our special educational problems in a broad, intelligent, and effective way. We shall have tomorrow, I hope, a favorable example of such a discussion in the contributions of our symposium; and to the participants in that discussion I am pleased to be able to leave the illustration and development of some of the ideas which I have here tried to present. If the outcome shall be the appointment of a carefully selected, composite committee on scientific education in Illinois, and if that committee shall do its best to present to the Academy next year a well-grounded, well-rounded discussion of the subject, with recommendations for our procedure, I think that we shall all have reason to congratulate ourselves that this Academy exists; and if, in addition, the Academy shall be able to exert continuously upon scientific investigation, upon education, and upon the life of the people, something of the unifying, organizing, rationalizing, and corrective but generally stimulating and educative influence which I have here described as its reasonable function, I am sure that it will presently come to be regarded as one of the most powerful of agencies for the advancement of science and the promotion of human welfare in this State of Illinois.

The chairman then introduced T. C. Chamberlin who gave the following address.

THE CHINESE PROBLEM.

When I replied affirmatively to the Secretary's request that I give some account of my recent studies in the East it was with the thought that my remarks would fall into a much less important place on the program. I should in any case have been embarrassed to select from the many things which ought to fall under observation on such a trip, but I am especially embarrassed in choosing what may be appropriate to a talk following the scholarly address just delivered by the President of the Academy. My trip to the Orient had an educational rather than a scientific purpose, but the educational and the scientific are intimately related, and a study of educational development in the Orient is scarcely less than a scientific study in itself, since in its broader aspects it embraces everything that enters into the welfare of the people.

The education of the Chinese people, to which I shall confine myself, is essentially a problem of transition from an old adjustment to a new adjustment. What we see today are but the early stages of the transition from an adaptation to a past set of conditions to an adaptation to a coming set of conditions. The past evolution of China has been controlled by conditions of isolation; the coming evolution is to be controlled by contact with the rest of the world. The past evolution illustrates the influence of the factor of isolation in evolution, a factor much discussed recently by Jordan and others. The evolution of a civilization is indeed broader than the evolution of a biologic species, for it is at once a physical, a biological a mental and a moral evolution, but it carries the same philosophic import.

I can only point out a few of the suggestive features of Chinese evolution under her past conditions of isolation; and first among these, the physical setting of the evolution. Until the sea became a highway, the Chinese were measurably shut off from the rest of the world; on the west by lofty mountain ranges, the Thibetan plateau, and the great deserts; on the north measurably by the Mongolian plateau; on the east and southeast by the sea; on the south partially by lofty parallel ridges and deep valleys. The Chinese seem always to have been a stronger people than their neighbors on the south, and the tendency in that quarter has been for the Chinese to flow out rather than suffer incursion. On the north, where the natural barriers were weakest, the great wall of China was added as a supplementary barrier. This implies that isolation was a condition earnestly desired by the Chinese people. They preferred to work out their destiny alone. They therefore at great labor erected the most remarkable of artificial barriers, and yet a barrier whose efficiency was confined rather to protection against marauders, hostile bands, and turbulent neighbors than against well equipped armies. It is significant that the Chinese chose thus to guard themselves by a passive defense rather than go out aggressively to attack and destroy their enemies or take possession of their lands. They thus demonstrated that they long have been what they still are, conspicuously a peaceful people, non-aggressive and non-belligerent by preference. Under such natural and artificial isolation their remarkable development and their former adjustments took place.

The natural features that constituted these barriers of isolation had not only their general effect on the Chinese people, but their influence on such special factors as the climate and the soil, and these in turn gave shape to the Chinese industries and determined many of the conditions of life. The high interior on the one side and the sea on the other formed and still form a working climatic couplet.. In the winter the coldness of the mountains and plateaus of the interior give density to the air and cause it to flow down the slopes eastward and southward toward the sea. As it descends it becomes absorbent and hence the winters are dry and cool. In the summer, the interior air is heated and, pressed by the cooler air from the sea, becomes ascensive. As the moist air flowing inland from the sea rises, it becomes precipitant, and hence the summers are warm and moist. In north China notably it is the July and August rains that are the foster parents of the crops.

The moisture borne inland by the ascensive summer winds and precipitated on the slopes of the interior, on the barrier mountains, and on the bordering plateaus, bears back from them to the lowlands a constant burden of new soil material, a means of natural fertilization. By this fresh material the alluvial plains are built up and built out seaward, and their fertility is naturally renewed wherever such accessions take place. In the northern tracts there is added an annual film of dust from the deserts. Thus even the deserts make some compensation for their barrenness.

But the extraordinary preservation of the fertility of China is due mainly to the unusual care and intelligence of the Chinese people in the management of their soils and the handling of their plants. The plants they cultivate may almost be said to be treated individually, as animals are by other peoples. Seed is rarely sown broadcast. Even cereals are planted in hills or rows. Fertilizers also are often planted with the seed or applied to the hills tho often also spread broadcast. The fields are carefully prepared and scrupulously tilled. Interestingly enough, plant reciprocities have been discovered, no doubt by pure empiricism and without even now knowing the reasons that lie back of the observed effects. One often sees rows or hills of wheat alternating with beans, mustard alternating with peas, and various other alternations of legumes with cereals and other plants, thus securing the simultaneous cooperation of plants well fitted to one another. We seek the mutual good offices of plants by rotation, but the Chinese go a step further and secure this by inter-planting. The results obtained astonish one acquainted simply with what is usually seen on Wisconsin or Illinois farms. The cereal crops, even when raised wholly by themselves, reminded me of those grown on the virgin soils of our interior plains in the early days. Fields of grain of great luxuriance were common, and fields of mustard, a crop much raised in central and western China, often overtopped one with plants 8 or 10 feet high. These results no doubt follow from the long and patient trials of the Chinese under the stimulus of their critical dependence upon the fruitfulness of their crops to feed their vast multitudes. It is their solution of the best relations of plant to man and man to plant.

To better adjust themselves to the severe demands of a dense population, the Chinese have resorted to a suggestive biological selection; the choice of the fittest, as they see fitness; the selection of man at the expense of the domestic animals. Plants are obvious necessities, but, especially in the central and southern districts, animals other than man are reduced to a minimum rather than multiplied to serve as convertors or burden-bearers, as is our practice. Biological evolution in China has thus tended toward a bilateral form, man and plants. The animal intermediaries of nature have fallen in some districts almost to a negligible element. Instead of one man and a horse to help him, it is three men.

But the barriers which had isolated China for thousands of years have been broken down, and the question now arises, what will be the nature of the new adjustment, what form will the new evolution take. We may pertinently ask ourselves, have these barriers been broken down because westerners wish to carry to China the benefits of their best civilization, or because westerners wish to exploit the people, and the resources of China. Or, if motives have been mixed, what is their ratio? Must China now adjust herself to a militant world where force dominates, or need she merely become receptive toward the best that civilization offers? Is it the soldier or science that is to creep in through the gaps in her broken barriers? No doubt the historical answer will be, both the soldier and science. It is clear that two quite diverse phases of western civilization are struggling for dominance in the readjustment now in progress, that of aggression and appropriation by force, and that of benevolence and broad humanity.

It may be idle to preach the relative virtues of these, but the western world may well sit down and compute the respective costs to itself. China has some four hundred million inhabitants. I was skeptical about these large numbers when I went to China and cannot now say I am wholly convinced of their accuracy, but taxes are said to be apportioned to the provinces and other districts subject to levy on the basis of the number of inhabitants recorded. The local temptation is, therefore, toward scant registration rather than an exaggeration of the census, so much so that penalties are imposed to correct this. It is hence cogently urged that the census returns give less rather than more than the real number of the people. At any rate, they are a very numerous people, a people of declared character and of persistent traits. It is therefore a matter of no small moment to foresee what new traits they will take on as they readjust themselves to the new situation. This is none the less important to the rest of the world because the essence of the new adaptation is *adjustment to the rest of the world.* It is the outside world that has broken down the barriers of isolation and forced the issue. The outside world must, therefore, stand by the consequences of its own forceful intrusions, and it does well to consider what those consequences will be—to weigh well its own part, in shaping them, at least from this time on.

The Chinese of the south, acclimated for some thousands of years to sub-tropical conditions, have physical and mental characteristics which I cannot better express in a word—tho inadequate—than to call them feminate—I do not say effeminate—men of small bones, small hands, small physique generally, with a touch of the feminine cast; bright, active and enduring, with some predisposition to restiveness and migration, but on the whole non-aggressive as compared with Europeans.

In the middle and high latitudes, the Chinese are larger, stronger, bigger-boned, more masculine, more individualized, perhaps slower and seemingly duller, but more independent and more aggressive, notably so as they merge into the co-national and kindred peoples who dwell on the Manchurian plains and on the Mongolian plateaus. At Hankow, a metropolis of the south, you many note a policeman—one of the signs of the new order of things—standing on the side of the street and looking apologetic; in Mukden, the policeman stands in the center of the street with the bearing of a soldier, and cart and rickshaw and coach alike pass scrupulously on the appointed side. There was no temptation to test it, but the policeman's bearing suggested that you might easily look down the barrel of a revolver if you insisted on taking the street at your own sweet will. Chinese immigrants to America are almost wholly from the south and center of China, where the ancient tendency to outflow is most marked. There are few immigrants from the more sturdy races of the north, practically none from the open fields of Manchuria and Mongolia, or from the adjacent provinces which are overflowing into these uncrowded tracts.

Now we may well ask ourselves, whether, having thrown down the barriers and forced these peoples to adjust themselves to contact and intercourse with ourselves and the rest of the world, the adjustment shall be on the lines of peace, equity and the truer forms of cooperation, attended by all the higher qualities of which the western world boasts, not the least of which is its scientific spirit and method, or shall it be on the lines of war and aggression in which the west, notably the European west, is past master. In a world, is the readjustment to be a fitting together for peace, or a fitting out for war; a fitting together for mutually profitable intercourse or a fitting out for inequitable trade and the fierce rivalry of grab.

If we continue to elect the latter alternative what may be the issue of a forced education of four hundred million people in the art of war and the spirit of aggression? In traveling from the metropolis of the southern interior toward the capital, it was our fortune to take a train on which the young son of a high official of the general government also traveled. For the two days we journeyed together, at every important station on the line a company of soldiers paid their military salutations to the representative of the official, and incidentally thus revealed to the foreign student of education what sort of education is in progress in China. I may have misinterpreted, but the military display did not seem so much a matter of obligation, since only the young son of an official was journeying by, as a good chance to drill the soldiers, to create a public impression, and to foster a military spirit among the people. To a civilian the troops seemed well drilled and well equipped with modern weapons. They were uniformed, not in Chinese costume, but in western fashion, in boots, caps and khaki. Traveling later from Peking northeastward into Manchuria, in the complete absence of any special occasion, a squad of soldiers was found drawn up at practically every station, soldiers of good appearance and apparently well armed. These squads at the station seemed to be merely the natural response of the Chinese to the example of "guarding the railroad" set by the Russians and Japanese farther to the east and north in Manchuria, the natural Chinese response to the compulsory education forced upon them by their instructors. In hunting a salubrious site for a possible educational institution outside a populous city in the south, we ran into a sham battle of approved European type. In far west China, when we called to pay our respects to an official, we found a company of soldiers drilling in the court of the yamen. We saw military schools and military drill in the common schools. These are merely incidental evidences of one phase of the education that is going on in China.

Now let us compute a bit. If one person in every hundred —an approved European ratio, I believe—is kept in military service in a population of four hundred millions, with rotation to develop the reserves, and if an eye is kept open to working into the permanent service as much of the blood inherited from the soldiers of Gengis Khan and Kublai Khan as practicable, what will be the *reciprocal effects* on western military requirements and what will be the inevitable financial burden, some touches of which Europe is even now feeling on her own account. We may leave to the Orientals to count their own costs, for if we force them we perhaps do not care, but what will it cost the western peoples to be ever ready to meet the possible aggressions of four million soldiers inspirited and drilled to fight for their nation's life, backed by proportionate reserves and supported by well developed resources. What will it cost Europe if the four hundred millions of China are forced to acquire the skill and the spirit of the forty millions of Japan?

I think there is no necessary "yellow peril" now, but if a "yellow peril" is foreshadowed, of whose creation is it to be? If China is to enter the lists of aggressive military powers, is it of her own free choice, or is it under compulsion? If under compulsion, whose compulsion? If the result be expensive, who ought to foot the bills? Who will ultimately be likely to foot the bills?

Fortunately China loves peace; China has given historic demonstration of her love of peace as few peoples have ever done. Is not this love of peace an asset worth cultivation by western nations? It is not indeed worth importing and cultivating on western soil?

China desires scientific education. Just now she is more anxious for the results than the method and the spirit. She would like to put her four hundred millions into the western type of efficiency which Japan has given to her forty millions. But still China prefers peace. And the radical educational question of the hour is this: May she have the scientific education of peace which she prefers or must she have first a scientific education for war? May she secure peace by peaceableness or only through prowess in battle?

In the past the Chinese have placed the scholar at the top of the social scale and the soldier at the bottom. Will the western world permit this scale to stand and adopt it for themselves or will they force its reversal? Will the West do what is best for the East and for the West alike? Will the West join in promoting the spirit and method of science, in the spirit and method of peace? In a word, will the West be eminently wise or stupendously foolish?

The Chairman then announced that a reception would be given by the Illinois Chapter of Sigma Xi in the parlors of Woman's Hall and the audience repaired thither.

SESSION OF SATURDAY, FEBRUARY 19.

Morning.

The meeting was called to order by President Forbes at 9:15. T. W. Galloway proposed an additional list of candidates for membership and upon motion of E. J. Townsend the persons named were elected. After some announcements the following report of the committee on Ecological Survey was presented by H. A. Gleason.

REPORT OF COMMITTEE ON AN ECOLOGICAL SURVEY.

Your committee on an ecological survey has practically resolved itself into a body of associate workers, engaged, each on his own line, in a study of the ecology of the situations open to him, the various lines of work being conducted, however, with reference to subsequent unification and amalgamation as parts of a comprehensive scheme of work for the entire state. The committee has had two meetings, one held June 18, 1909, at Havana, on the Illinois river, the site of the operations of the Illinois Biological Station, and the other at Urbana last evening, for the purpose of formulating this report. At the Havana meeting the plans and lines of work of the Biological Station, and those of individual members, were fully presented, discussed, and approved. A brief outline of the work of the group for the year will be of interest to the Academy.

Virtually all the work of the State Laboratory of Natural

History and of the State Entomologist's office is ecological in the broader sense, having to do with the relations of animals to their environment; but much of this work, directed to economic ends, is too miscellaneous to be taken into present account as a contribution to a systematic survey of the ecology of the state.

Five special lines of work, however, fall strictly within this field; namely, the aquatic work of the Biological Station at Havana; statistical work on the numbers and local distribution of Illinois birds; the work of the forestry survey of the state; a systematic survey of the mammals of Champaign county, a report on which is now nearly ready for the press; and a study, by the State Entomologist's office, of the local distribution, peculiarities of food, and other relations to nature, of the various species of *Lachnosterna*, or May-beetles, the parent insects of the white-grubs.

The aquatic work of the Biological Station was recommenced July 1, with Mr. R. E. Richardson in charge as resident naturalist. An important part of the season's work has been the making of a series of plankton collections comparable with those made in the same places during the five-year period 1894-1899. It is the object of these collections to bring into quantitative comparison the present productivity of the waters of the river and connected lakes with that of the time preceding the opening of the drainage canal from Lake Michigan into the Illinois river. Large collections have also been made, necessary to a study of the food of various kinds of fishes in various parts of the area under command from the Biological Station, and data have been obtained for a comparison of two strongly contrasting overflow lakes in the vicinity—Thompson's lake, north of Havana, and Matanzas lake, southwest of it.

Field work on the statistics of ornithology was carried on during June, July, and August, in a way to verify and extend our knowledge of the resident midsummer bird population of the state in northern, central, and southern Illinois respectively. The work was done in a way to enable us to eliminate differences due to an advance of the season merely, and to distinguish clearly those due to latitude, and to climate corresponding.

The forestry survey work has been resumed under an arrangement with the United States Forest Service, which insures its completion within the next two years. The State Laboratory of Natural History and the U. S. Department of Agriculture share equally in the expenses of operation. Two assistants of the Survey and one from the Entomologist's office are now in the field in southern Illinois.

Collections of Lachnosternas were made last spring by entomological assistants in all parts of the state from various situations, and on a selected list of food plants. Some sixty thousand specimens have this year been determined as to species, and a tabulation of their ecological data is now in progress.

A report on the mammals of Champaign county, prepared by F. E. Wood, is based on a large amount of exact and careful field observation extending over three years. Ecological data of every description are included in this report.

It was hoped that we might be able to begin, as a regular part of the program of the biological survey, a systematic analysis of the state of Illinois with reference to habitats as a foundation for an ecological map, or series of maps, of the state, and the legislature was asked for a sufficient increase of State Laboratory appropriations to enable us to begin this work. No such increase was made, however, and the operations of the Laboratory are consequently limited, for the present two-year period, practically to lines already established.

Mr. Baker has made a survey of the Skokie Marsh region near Chicago, an area three miles long and about a mile wide. The results have been embodied in a paper in which the mollusks and associated plants and animals are listed and the habitats described. This paper, illustrated by a number of photographs of the several stations and several maps, is in course of publication in the Bulletin of the Illinois State

Laboratory of Natural History. Collections have also been secured and some studies made at Fox lake and Cedar lake, in Lake county.

Mr. Shelford has made some original observations, and a study of the literature, on the gross features of the Chicago region which influence the ecological distribution of animals, and has brought the results together in a base map of the Chicago area. He has conducted a study of the animal societies of twenty stations in the Illinois portion of the Chicago region, so selected as to represent the most important ecological features. These results, together with a detailed study of as many more stations in Indiana, a large part of which represent conditions which existed in Illinois before the building of the city of Chicago, are being brought together in a paper on the animal societies of the Chicago area, now nearing completion. This paper discusses the succession of pond and stream animals, and the succession of animals associated with the forest development.

One of the students working under Mr. Shelford's direction has begun a detailed study of the region from the Skokie Marsh to the Lake, in continuation of the work done by Mr. Baker. Another is making a study of some of the older sloughs inside one of the old lake beaches, and has followed one of these sloughs for nearly a year. A third is following throughout the year the fauna of a small plot which is a temporary pond in spring and low prairie in summer.

Mr. Hankinson is making an ecological study of the fishes of the streams about Charleston, ascertaining their feeding and breeding habitats, the character of the bottom, the depth of the water, and the speed of the current preferred for these purposes. He divides each stream into stations, and makes collections from each as often as possible at all seasons of the year, taking detailed notes of the depth and width of the water, the temperature of air and water, and of the vegetation and the species of vertebrates associated with fishes in these collections. A qualitative study of the food is made for each species, and correlated with the numbers of organisms available at the time in a way to explain the habit preferences on the part of fishes. Special attention has been given to a small stream near the grounds of the Normal School, the product of which will be presented by Mr. Hankinson in a paper to be read at this meeting.

Mr. Transeau's work relates to the plant formations of the Charleston region, and to habitat and seasonal relations of the algae. Under the first of these heads he has made record of the vegetation of about thirty localities, in an attempt to get at the trend of succession. He has made some progress in the determination of the evaporation constants for several woodland types and topographical situations. He has made more than a hundred collections of algae representing all the habitats and all the seasons and about forty-five species of algae. In connection with this work some experiments have been made on the effect of a change of environment on the form of algae.

Mr. Gleason began, during the summer of 1909, preliminary work on the forest associations of Champaign county, with particular reference to their relation to the drainage systems. It is planned to push the investigation further during the spring and autumn of 1910, and to produce eventually a complete vegetation map of the county, showing the present and past distribution of every plant association, and accompanied by descriptions of the vegetation and its ecological relations. Since this work will be done chiefly in connection with the advanced classes in ecology in the University, it will probably require several years for its completion. Material is being slowly accumulated from the Mason Historical Library relative to the original distribution and structure of the various types of vegetation of the state.

The results of the field work on the sand dune vegetation of the state have been elaborated and are now ready for publication.

Mr. Adams has begun an inquiry into the sources of ecological data preliminary to a general treatment of the subject of Illinois as a biotic environment. He also made, for the State

Laboratory of Natural History, an ecological reconnaissance of the aquatic habitats of the Illinois river at Havana in comparison with those of the period before the opening of the Chicago drainage canal, some of the results of which studies will be presented in a paper to be read today.

The committee greatly desires the assistance of the Academy in two directions. First, we should have a larger number of local workers engaged, like most of us, in ecological studies within their own neighborhood; and, second, the State Laboratory of Natural History should have an increase of its appropriations sufficient to enable it to engage seriously in state-wide studies of types of habitat, with a view to the construction of an ecological map of the state. It naturally falls also to the State Laboratory to prepare a synopsis of the various species of animals not sufficiently described in works available to the student, without which local work must be done imperfectly and under very serious disadvantages.

Respectfully submitted.

Stephen A. Forbes, Chairman.
T. L. Hankinson,
Victor E. Shelford,
H. A. Gleason,
E. N. Transeau,
Frank C. Baker,
Chas. C. Adams,

Urbana, Ill., Feb. 18, 1910.

T. W. Galloway.—"Mr. Chairman, I should like to ask whether your ecological committee has yet found itself able to do anything in the determination of the ecology of Illinois biologists themselves."

T. J. Burrill.—"I am glad to see that the committee has not only announced plans, but has made positive contribution in this work. The report shows how much work there is at our own doorstep in our immediate neighborhood."

Isabel Smith.—"In Morgan county we are trying to prepare a complete report on the flora and especially the trees, and in a year or two we hope to be able to submit results."

T. J. Burrill.—"I wish we had a Miss Smith in every county."

J. A. Udden.—"I wish to make a suggestion and that is that it would, in my opinion, be a good idea if this survey might make itself more generally known by the use of existing publications. There are people in every county who would be interested."

Mr. Andrews.—"The committee on nominations is ready to report."

Mr. Forbes.—"We will hear the report of the committee."

Mr. Andrews.—"Your committee unanimously nominated the following as officers for the coming year."

For President, John M. Coulter, University of Chicago.
" Vice-President, R. O. Graham, Illinois Wesleyan University.
" Secretary, A. R. Crook, State Museum of Natural History.
" Treasurer, James C. Hessler, James Millikin University.
" Third Member of Publication Committee, H. H. Stoek, University of Illinois.
" Membership Committee, Fred L. Charles, University of Illinois, Chairman; Thos. L. Hankinson, Eastern Illinois State Normal; V. F. Shelford, University of Chicago; W. E. Tower, Englewood High School; Isabel Seymour Smith, Illinois College.

Mr. Burrill.—"I move that the Chairman of the committee on nominations be instructed to cast the ballot for the gentlemen named." Carried.

Mr. Andrews.—"The Chairman of the committee announces that he has cast the ballot for the names nominated. They are elected."

Mr. Forbes.—"Prof. Udden has a report for the committee on drill records."

J. A. Udden presented the following report:

REPORT OF THE COMMITTEE ON DEEP DRILLINGS.

The Committee on Deep Drillings can report progress in its work. Early in November last year circular letters asking for various data on wells in the state were mailed to the members of the Academy. Replies have been received from nearly all the recipients of these letters, and data of importance have been furnished by many of the correspondents.

The committee desires to express its high appreciation of the courtesies which have been extended to it by the members of the Academy and acknowledges with gratitude the aid which has been received.

J. A. Udden,
U. S. Grant,
Frank W. DeWolf.
Committee.

February 18, 1910.

President Forbes then announced the symposium which was presented by Cornelius Betten, Julius Stieglitz, J. F. Hayford, C. G. Hopkins and Worrallo Whitney as follows:

SYMPOSIUM

THE RELATION OF PURE AND APPLIED SCIENCE TO THE PROGRESS OF KNOWLEDGE AND OF PRACTICAL AFFAIRS.

1. The Relation of Pure and Applied Biology.

Cornelius Betten.

It may be well to call attention to the fact that the subject set for discussion makes distinctions which, if they are convenient, are after all largely fictitious. The contrast between pure and applied science, as generally conceived, is that implied in the statement of the subject, namely, that applied science has to do with the practical affairs of life, while to pure science we indefinitely ascribe the progress of knowledge. This distinction means little or nothing to us. If history teaches us anything, it teaches that the advance of knowledge is the most practical affair in which we may engage. It shows us that scientific investigation which seems farthest removed from the life of the people today, may before long have tremendous bearing upon the welfare of our own species. It is, of course, for us individually to decide where we can most advantageously help the cause and train and broaden ourselves in the doing of it; by remaining close to what is today the vital practical application of science, or to venture into studies whose ultimate bearing upon human life can only be conjectured. To those of us who are in the work of education it becomes a pressing problem also to decide this question for those who come under our guidance. There are certain apparent dangers in the introduction of vocational work in non-technical education, and so guarded have we been against them that the general attitude is to admit only the minimum that is needed to enlist the interest of the student. At present however, it is becoming more common to admit the maximum that will not conflict with well established educational principles. It seems to be becoming more clear that the practical bearing of a subject is a real asset. We should understand, however, that the aloofness of science from common affairs is obviously a matter of degree, and time generally wipes out that difference or not infrequently inverts its terms. We may hope that our pure science, in the pursuit of it or in its direct results, may some day bring benefit to mankind, and we may at the same time fervently believe that the immediate relation of applied science to the needs of the human race does not vitiate its educative value to him who engages in it.

It is obviously not possible in the time here allotted to review with any degree of care the multitudinous ways in which the biological sciences are today affecting the progress of the race. At the risk of dealing only in what may be platitudes to this audience, I limit myself to some of the more general aspects of the question.

Any science evidently affects the progress of the race in three ways: it trains men in methods of thought and work, it furnishes a body of directly useful information, and it establishes a few general concepts that have great influence in determining men's approach to the problems of life.

In method the sciences are fundamentally the same, though they may differ in the stage of their development. Thus today biology is only entering that phase in which physics has for a long time been and into which chemistry has more recently entered, namely the stage of experimentation. There still remains an inexhaustible supply of material for new descriptive work, and all of the old material will have to be worked over again and again with the old methods but with new points of view. But in addition, we are recognizing in all fields of research that significant advance must now come from the adoption of the experimental method rather than from the older method on either old or new material.

It is probably a difficult matter to get an estimate of the results which scientific work, whether in the schools or in the shop and factory, is having in improving the habitual methods of thought and action in those pursuing it. I know of no reason for discouragement in this respect, though we may all regret that the results are not more marked, and may welcome such sympathetic criticism as Dewey has recently given in this connection. (Science Jan. 28, 1910.)

As to what biological science is doing in amassing information directly useful to man, it is hopeless to attempt a categorical account. In agriculture, horticulture, in plant and animal breeding, in relation to the cure and prevention of disease, and in allied fields, biological investigation is transforming our world. It is not too much to say that the advances in these lines are among the most significant facts of contemporary history. The work centering about the subject of heredity and plant and animal breeding is perhaps just now in the center of interest. On the theoretical side this work has of course raised about as many questions as it has answered, but the practical results of the careful study of hybridization and selection will soon be universally felt, and the possibilities now seem enormous. I mention this subject of heredity especially because it is such a capital illustration of the way in which years of independent and apparently unrelated work in taxonomy, morphology, cytology and embryology may come to converge sharply upon a definite problem of universal human interest.

Finally, what has biology done in giving us fundamental concepts which may dominate in our mental habits? We often say that great questions are likely to be decided by relatively trivial things, by the feelings of the moment, determined perhaps by the last previous meal or by the nature of our night's rest. In saying this we are doubtless taking the interesting exception as the rule. The educated man views his problems and determines his course largely by a few fundamental principles that have become part of his mental make-up. The special field of one's work may therefore readily affect one's general attitude by making its peculiar basic principles pronounced in him, quite as well as by the method with which it equips him. These broad principles naturally overlap in other fields, and the danger of not appreciating the differences in their applications to different materials is very great. It is the fortune of biology to have as its dominating concept the idea of genetic continuity in the forms which which it deals, a concept which after it has been vitalized by biological investigation has become quite as dominant in many other fields. The man who has once seen the organic world as the biologist sees it, who has some conception of the intricacies of phylogenetic relations and the factors concerned in development, is not likely ever to lose the dynamic point of view. He may not know as much as he would like to know of the political, social, or religious movements of the world, or of the philosophical systems which have held their sway, but his approach to all of these will be immeasurably improved if he regards this world in its forms and its activities as a "stage" in more than one sense of that term. In spite of the misconceptions arising from superficial contact with the facts, we shall not likely overestimate the beneficent results of the general adoption of the dynamic view of the world and of our own ideas and activities. The adoption of that point of view may be obtained in any subject; it cannot well be missed in biology.

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2. The Relation of Pure and Applied Chemistry.

Julius Stieglitz.

One may consider applied chemistry to be chemistry applied to further utilitarian ends in manufacturing, commerce, agriculture, mining, medicine, and similar fields; pure chemistry as chemistry devoted to the discovery and spreading of truth irrespective of any question of commercial profit in it. The contrast, we note, is in the conscious aim and purpose of the chemist, a contrast, to use a trite parallel, akin to the common distinction made between murder and manslaughter, which differ, I believe, only in the intent of the slayer. But the *net result* of the act, one must remember, is the same in both cases. In the same way, it may be said if one considers pure and applied chemistry in their highest forms of development—and I wish to use the very short time at my disposal for the teatment of the large question before us from this single point of view—it would be extremely difficult in most cases to distiguish positively and justly wherein the *result* of so-called pure chemistry differs from the net result of so-called applied chemistry in their relations to the progress of knowledge and to practical affairs. It would be a most hazardous undertaking to predict what discoveries of pure chemistry will or will not sooner or later have effects which may be even revolutionary in their consequences in the field of commercial applications. It is not overstating the case to say that such revolutionary consequences have already followed in almost every branch of modern industry since the enunciation, some twenty years ago, of van't Hoff's theory of solution and as the result of the vast development of physico-chemical theory that has grown out of it. To give but a single, small, but significant instance, chosen because it is taken from the field of every-day occurrences, railway accidents, which one would suspect to have only the remotest connection with pure chemistry, I will repeat briefly the interesting account given by one of the chemists of the Illinois Steel Co. at a meeting in Chicago. Dr. Cremer told us how after a train had been wrecked by a broken rail, the results of miscrocopic examination of the rail, considered in the light of our physico-chemical knowledge of the conditions of equilibrium of the various components in steel, showed that the upper surface of the rail must have been subjected to a very high temperature and then suddenly cooled, with the result that the surface had been made brittle. Investigation showed then that the locomotive of the preceding train had taken in water in a violent snow storm and that the rail in question had been directly under the fire-box of the engine and when the train moved on, the falling snow prevented the required slow passage of the heated surface through the transition points of steel; the surface thus became brittle and the impact of the next train broke the rail by starting a fissure in the surface.

This is only a small instance of the profound change in methods of technical investigation and work which have followed van't Hoff's discovery of the laws of solution in the field of pure chemistry. On the other hand, Otto N. Witt, in the course of his work as expert in one of the leading aniline-dye manufacturing houses, in 1876 developed the fundamental points of a theory of the *cause of color* in organic compounds and the theory of their capacity to form dyes—theories, which, emanating from a technical chemist, have been of profound importance in the development of the pure scientific examination of the question, and form even after thirty years the basis for the present views on this subject. In developing for the Badische Anilin-Fabrik the contact process of manufacturing sulphuric acid, a process which is rapidly displacing the older, awkward, lead-chamber process, Knietsch, as he himself explains, was led from the beginning by considerations of pure theoretical chemistry; he was *not* led by the experience gained and conclusion reached by applied chemistry; on the contrary he had sixty years of practical failures and costly disappointments before him in the previous experiments of technical or applied chemistry. And yet he persisted, secure in his faith in the predictions of pure chemistry. Who would say whether his triumph, which revolutionized one of our fundamental chemical industries, should form a further leaf in the laurels of pure chemistry or in those of applied chemistry? It would be impossible to say which parts of Professor Baeyer's classical researches at the University of Munich on the structure and artificial synthesis of indigo must be credited to the efforts of pure chemistry, which to the domain of applied chemistry; the investigations did, as a mater of fact, after some thirty years of conscious effort by Baeyer, Heumann and others, lead to the successful exploitation of the manufacture of artificial indigo on a scale which must finally bring about the disappearance of the natural article from the markets and make vast areas formerly used for the cultivation of the indigo plant available for the production of food. At the same time, besides these ultimate utilitarian results, these same researches of Baeyer led to such proprofound questions of pure chemical interest as the problem of the real structure of the benzene nucleus, the problem of polymethylene rings, of unsaturated carbon valences, of tautomerism as shown in enolic and ketonic forms, of acid amides and amido acids; all present day organic chemistry is permeated with results of that work on the structure and synthesis of indigo.

The same difficulty that confronts us when we attempt to distinguish in such great investigations between pure and applied chemistry and their relations to the progress of knowledge and to practical affairs meets us if we attempt to assign our great investigators to one field or the other: A. W. Hofman was equally successful in extending the lines of discovery into the great domain of organic nitrogen bases, which before him, had been practically a "dark continent" and in developing extensive and profitable manufacturing of aniline dyes: Baeyer pre-eminently a disciple of pure chemistry was, as we have seen, the originator of the line of work which has established the commercial preparation of artificial indigo: Bernthsen, professor of organic chemistry at the University of Heidelberg, investigator and author of a standard text-book on organic chemistry, became the head of a great house at a salary said to be $25,000 a year. The enormous, indirect consequences of van't Hoff's work in industrial chemistry have already been referred to; but he has also been a most valued adviser of the great Stassfurt works in the exploitation of their salt deposits. The names of Perkins, Liebig, Pasteur, Liberman, Graebe, Tiemann, Moissan, Nernst, Bredig, Haber and others too numerous to mention are current in the texts of pure chemistry as well as in important chapters of applied chemistry. And today, Nef's present researches on the oxidation of sugars, carried out for the discovery of truth only, may have extremely valuable results in their application to the treatment of diabetes.

I have purposely dwelt on this side of the question before us, leading to the recognition of the very intimate, almost inextricable relations of pure and applied chemistry in their highest forms of development, in order to express explicitly the belief that the highest interests of chemistry, of our universities and lower schools, and of our commercial and national development, would be the better preserved, the clearer we are in our own minds that sharp lines of division between pure and applied chemistry are unnatural, unnecessary and undesirable. I have done this in order to present three conclusions as the logical outcome of such a point of view: In the first place, in this practical, fast growing land of ours, in which the quest for values that cannot be measured in dollars and cents, the quest for truth and beauty, is just beginning to have a footing and not too firm a one at that, it would be well for the irremediably practical man, if he must apply his own standard of measurement, to remember that the discovery of new truth for its own sake in the field of pure chemistry may well contain the germs of revolutionary developments enhancing the wealth of the nation in many directions; it has been true so often in the past in all sciences—as shown in the development of the telegraph, the dynamo, the wireless, in the development of modern methods in the steel, sugar, copper industries, in agricultural chemistry that it would be folly not to believe in similar developments in the future. To give only one problem illustrating the point: it is well known that by ordinary combustion we use only a small fraction of the fuel value, of the energy, in our coal, say 10 to 17% of it, wasting no less than 80 to 90% of this, our most precious source of wealth. The electrical oxidation of coal ought to reduce this loss to a small figure, and with one stroke thus treble or quadruple the economic value of our great coal deposits; pure chemistry has indicated such a possibility and it is a question who will overcome the inherent mechanical difficulties first, the worker in the field of applied or of pure chemistry.

In the second place, the professor of chemistry, whose life is devoted to research as an article of faith rather than for utilitarian results, is an ultimate, unprejudiced court of appeal to which the public can resort in questions of great practical moment to its welfare. The best precedents of the past generations then rather rare, that university and college chemists hold themselves aloof from every kind of technical and commercial obligations and entanglements, is in our generation becoming the rule, rather than the exception; but these same men, who refuse tempting offers from private corporations as a matter of principle, are, also as a matter of principle, available for active service in the practical interests of the public. In the third place—and this is a main object in my argument —I trust that the future development of schools of applied chemistry in his country will be altogether along the lines of *graduate* schools of technology, schools which will prepare the technical chemist for investigation, train him to find possibilities of improvement, of development, even of revolutionizing the methods of work in his own fields, train him to test his reasoning closely by the result of experimentation. For such results the schools must not only give instruction in the technical methods of the day and a bare outline of general and theoretical chemistry, say in fields where they have already been applied in technical work but they must give in particular *the broadest and most thorough instruction in the purest type of* *pure chemistry;* only by doing this can the fertilizing ideas of pure science be planted where they ultimately will be of use in the improvement of applied chemistry. Germany has recognized the high level of the training given by these means in its schools of technology by granting to its polytechnics the right to confer the doctorate of science on its graduates. America can be satisfied only when it has schools of technology on a level no lower than those which have contributed so much to the wonderful industrial success of Germany. In such schools, then, pure chemistry and applied chemistry would stand side by side, each giving its best to the student, each free to develop to the fullest extent, each ready to contribute to the progress of knowledge and to the advancement of practical affairs.

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3. The Relation of Pure and Applied Physics.

John Fillmore Hayford.

Pure science is an absolute prerequisite to the development of applied science. Both pure and applied science contribute directly to the progress of knowledge. Applied science has also an indirect influence on the progress of knowledge which is much more important than its direct influence. The very nature of our practical affairs, as well as our success in dealing with them, depends upon the state of our knowledge. Hence these four, pure science, applied science, the progress of knowledge and our practical affairs form a continuous line of related matters in which each is dependent upon all of those which precede it.

New discoveries in science, or more accurate determinations of known laws, are an absolute prerequisite to continued progress in applied science. If all discoveries in science should stop at the present moment, that is if all progress in pure science ceased, the progress in applied science would continue for a time at a decreasing rate, until the present acquisitions of pure science had been largely turned to the use of a man. The progress in applied science would then practically stop until new lines of application were opened by developments in pure science. I make no attempt to estimate the time required to reach this state of stagnation in applied science. It is certain that the stagnation would come under the stated conditions. It is relatively unimportant how soon it would come. The important point to be kept in mind is that progress in pure science is absolutely necessary in the long run to progress in applied science.

It is this which makes it fundamentally important to encourage and to foster pure research in science in all feasible ways, by establishing well equipped laboratories, by organizations for research, by generous rewards to those who are successful in research, by every possible device to enable the exceptional man with unusual gifts in this line to devote his whole time in a favorable environment to pure research. An abundant harvest can not be gathered in applied science unless plenty of good seed is secured from pure science.

Although history shows that each discovery in pure science is ordinarily followed sooner or later by corresponding advances in applied science, yet it also shows that the lag which occurs between the discovery and its useful application, though sometimes short, is frequently very long. Applied science should be encouraged and fostered in order to shorten the lag. The application is as important to man as the discovery. Much less of genius is needed to make the application than to make the discovery. The rewards are also more obvious and more certain. On the other hand, the total amount of work awaiting the laborers in the field of application is very large and the total lag of application behind discovery is great. The harvest being gathered in applied science is much smaller than the possible maximum from the seed already furnished in pure science.

It seems to me that universities are responsible in part for the unnecessarily great lag of application behind discovery in science. The atmosphere of universities leads one to put strong emphasis on knowing and very light emphasis on doing, leads one to be rightly and fully appreciative of discovery, but to appreciate in a half-hearted way only the effective application of discovered truth. It tends to lead one to accord enthusiastic praise to a Faraday, the discoverer, but to be mild and cynical in appreciation of a Westinghouse who makes applications of great value to man.

The history of any well developed branch of applied science furnishes illustrations of the relation which has been stated between pure and applied science, and of the variable lag of application behind discovery. A catalogue of the ways in which applied science touches and influences our practical affairs would be very long and would be a recital of ideas familiar to this audience. Most articles of food and all articles of clothing have been either improved in quality or reduced in labor cost by the accomplishments of science, and the same is true of practically every artificial object within your present range of vision. The stories of the railway, the steamship, the printing press, the telegraph, and the telephone have many times been told.

To stop here in our thinking, to stop with the contemplation of the accomplishments of science as seen in material forms, is to miss the most important features of the relation of science to the progress of knowledge, and to our practical affairs. The material accomplishments of science, engines, dynamos, machines, processes of manufacture, etc., are but the foundation of its influence in the world. The two hundred thousand miles of railway in the United States are much less important than the strong influence of these railways upon the spread of knowledge, the condition of the race, the development of character. Let us look beyond the mere material accomplishments of science to its all pervading influence upon civilization. Within the allotted time it is possible to indicate this influence in a sketchy way only, by a touch here and a touch there.

The locomotive, the marine engine, the printing press, and the telegraph have made all the peoples of the world acquainted and changed them from enemies into friends. The people of the United States and the Japanese, living on opposite sides of the world, are better acquainted and therefore more friendly today than were the French and the Prussians one hundred years ago, living as close neighbors. If two hundred thousand miles of railway had existed in the United States from 1800 to 1860, the people of the North and of the South would necessarily have been so well acquainted with each other that the Civil War could not have occurred. All agencies which make different peoples understand each other tend to abolish war, for wars are based primarily upon the failure of nations to understand each other. Science by furnishing quick and cheap transportation has caused man to develop the travel habit, by putting printed matter within the reach of every one has made reading a habit of the masses, and by furnishing quick convenient means of communication, the mail and the telegraph, has produced the habit of keeping in touch with all the world. Thus science, by promoting mutual understanding between nations, has been the greatest of peace makers.

Science has also been very powerful as a peacemaker by producing such powerful weapons and such efficient means of concentrating quickly vast numbers of troops and their supplies that war is now so costly and so deadly that we can not afford to indulge in it.

In improving personal morals, as well as national morals, and thereby advancing civilization, the workers in applied science are extremely powerful. They build a smooth steel road and a one-hundred ton locomotive which draws a massive train at a mile a minute. Then it is found that the safety, the lives, of the hundreds of passengers on the train depend upon the quick and certain action of the man in the cab of the locomotive. He must not only see the faint danger signal within a few seconds, every time it appears before him, he must also act promptly and with good judgment, or pay the forfeit with his own life and possibly the lives of many others. This and other situations created by science, in which certainty and quickness of action of the nerves and brain are absolutely necessary, because great responsibility is concentrated in one man have been most powerful influences in changing this from an irresponsible, drunken world into a responsible temperate one. Contrast the sober alert locomotive driver of today with the drunken and relatively dull stage driver whom he superseded.

This was formerly a world in which the winner was the man with the brute strength and physical bravery which gave him the power to win in a hand to hand battle. It was a world in which all, even the fighters who secured the spoils and the kings who ruled the fighters, lived in comparative discomfort. It was a world in which the higher thoughts, aspirations, and the impulse to render unselfish service, which are the essence of civilization, came to but very few. The masses of humanity were too heavily loaded with hard labor, with real oppression from the classes above them, and with the effects of ignorance and superstition, to have a part in the crude civilization which existed. It was a world in which men knew only their nearest neighbors, in which nations perpetually fought against each other, in which each people was densely ignorant of every other and correspondingly suspicious.

The workers in pure and applied science, by bringing into general use a method of thought which is the antithesis of superstition, by providing efficient means of intercommunication and for the general diffusion of knowledge, and by turning the forces of nature to the uses of man, have changed this into a world in which the winner is the man who thinks clearly, controls himself, and may be depended upon, the man who serves rather than the man who fights. It is now a world in which millions live in greater comfort and security than did even the kings of the ages before the scientist. It is now a world in which the average man works such short hours and under such comfortable conditions that he has abundant opportunities within his reach to share in the real benefits of civilization, to develop himself to his full capacity.

Possibly it may seem that I have exaggerated the influence of science upon the progress of knowledge and its influence in changing the very nature of practical affairs. In terse statements there is apt to be some exaggeration. But I challenge a critical examination of the thesis which has been put forward that the progress of civilization in the past century has been founded upon science and would have been impossible without science.

4. The Relation of Pure and Applied Science in Education.

Cyril G. Hopkins.

The dative of indirect object is used with most Latin verbs compounded with ad, ante, con, in, inter, ob, post, pre pro, sub, and super, and sometimes circum; the elements essential for the growth and maturity of the plants which furnish, directly or indirectly, the food and clothing for the human race are carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, magnesium, calcium, iron, and sulfur, and possibly chlorin; and I think I am expected to discuss the general question whether there may be as much educational development in a study of these elements, for example, and of their application to the preservation of American soil and to the preservation of American prosperity, civilization, and influence, as in learning a like number of Latin prepositions and their application to language development, and to philological research.

The question is, whether the culture of corn roots and the investigation of corn-root insects and diseases or the culture of clover roots, with their millions of symbiotic bacteria and their wonderful power to transform much of the improverished lands of that part of Illinois whose name is Egypt, and much of the exhausted and abandoned lands of India, whose fame is famine. into fruitful and valuable lands, may serve as well for the development of the mind and for the advancement of education and civilization, as the culture of Greek roots, and Sanskrit roots, and Hindu roots, from which we learn that the people of India, of whom only one man in ten, and only one woman in a hundred are able to read and write,—from which we learn that these people are our own cousins; that many words still live in India and in America that have witnessed the first separation of the northern and the southern Aryans; and, in the words of Max Muller, "these are witnesses not to be shaken by any cross examination. The terms for God, for house, for father, mother, son, daughter, for dog and cow, for heart and tears, for axe and tree, identical in all the Indo-European idioms, are like the watch words of soldiers. We challenge the seeming stranger, and, whether he answer with the lips of a Greek, a German, or an (East) Indian, we recognize him as one of ourselves. There was a time when the ancestors of the Celts, the Germans, the Slavonians, the Greeks and Italians, the Persians and Hindus, were living together beneath the same roof."

Why has the southern Aryan civilization developed but one school for every five villages, while the northern Aryan, save in Russia, opens to every child the door of the school which leads on, for those who will, to the college and university? Why? Because only a prosperous nation can afford the trained intelligence or education of its people.

Education in America is not the cause but the product of our prosperity; and, thus far, the prosperity of this nation is due to our conquest of the former inhabitants, and the uninhabited wilds, and to the consequent acquisition of the great natural resources of this country, including primarily vast areas of rich virgin soil; and secondarily immense supplies of timber and coal.

American prosperity has done more than educate Americans; it has educated western Europe, first of all by relieving the over-crowded condition of those impoverished lands, and subsequently by making large direct contributions to European prosperity, in supplying cheap food and fertilizer and a good market for European products, manufactured in large part from the low-priced raw materials secured from this and other new countries.

Applied science has already made some contributions to American education and civilization, and so far as its use in the school room is concerned, applied science, as an educative agency, is not exceeded in value by any other instrumentality. Its very general acceptance by teachers and students in our leading educational institutions does not prove its value, but does prove that its value is being appreciated; and I need not remind you that pure science is the foundation of applied science.

While education has not been in any sense the prime cause of our national prosperity, the future prosperity of America depends absolutely upon the application of science and education to industry. For three full centuries America has lived upon the spoils of conquest and inherited wealth and resources, and for three full centuries America has wasted her substance or scattered it abroad. But even among nations there is a limit to inherited wealth. The land which flowed with milk and honey is now almost a barren waste, supporting only wandering bands of marauding Arabs and villages of beggars.

Truly the two most characteristic attributes of rich young America are wastefulness and bigotry. Other nations have risen to positions of world-power and influence and fallen again to poverty, ignorance, and insignificance. Thus far American history has been in large part a repetition of the history of nations long since gone to decay.

Following the rise and fall of the great empires of Babylon, of Carthaginia, and of Greece, the Roman Empire also rose and fell. From what cause? Some tell us that the fall of those great empires was due to the development of pride and immorality among their peoples, forgetting the fact that civilization tends rather toward peace and security, and that universal education depends and must depend upon material prosperity. Poverty is at once helpless and soon ignorant.

History tells us that Roman agriculture declined until a bushel of seed brought only four bushels in the harvest, declined until the high civilization of the Mediterranean countries passed into the Dark Ages which covered the face of the earth for a thousand years, until the discovery of a New World brought new supplies of food, renewed prosperity, and new life and light to Western Europe; but the Dark Ages still exist for most of your own Aryan race in Russia and in India, where, as an average, day by day, and year by year, more people are hungry than live in the United States, where the average wage of a man is fifty cents a month, where famine rages always, and where the price of wheat sometimes rises to a point where six months' wages of a working man are required to buy one bushel. This is the condition where the absolute needs of the population exceed the food supply; and just so sure as the intelligent and influential men and women of America continue to ignore the material foundation upon which national prosperity depends, just so sure will future Dark Ages blot out American civilization.

That most of the lands that were once cultivated with profit in the original thirteen states are now agriculturally abandoned is common knowledge; that much of the land in all adjoining states is in the process of abandonment is known to many; and that the common lands in the great agricultural regions in central United States are even now in process of the most rapid soil depletion ever witnessed is known to all who possess the facts.

Already the question of food has begun to exert pressure in this country. Already the masses, the common people, the "ninety percent," must consider a reduction in their standard of living. Poverty and degeneracy are even now making such demands upon the revenues of the state that education and research already suffer from inadequate support; and the only hope of the future lies in the application of science and education to the control of industry and to the control of population; and let us never forget that agriculture is the basis of all industry, and that the fertility of the soil is the absolute support of every form of agriculture.

Some will say that the economic conditions have been such that the depletion of the lands of the eastern states has been a necessary sequence, and that the restoration of those lands will now follow as an economic necessity. I beg of you, do not accept any such theoretical deductions. If systems of permanent progressive agriculture are ever to be adopted anywhere in this country, it must be done while the landowners are still prosperous. Some investment is necessary for the restoration of depleted soil, and poverty makes no investments. Much of the abandoned lands of America are far past the point of possible self-redemption. They were depleted not because of any economic necessity but because of ignorance, and the fault lies not with the farmers and landowners, but with the educators who even until the present generation have taught almost everything except the application of science to agriculture. The fault lies also with the statesmen who, as James J. Hill says, have "unduly assisted manufacture, commerce, and other activities that center in cities, at the expense of the farm."

There was no need whatever that the cultivable farm lands of the eastern states should have been depleted. Lying at the door of our greatest markets, with the application of knowledge and with such encouragement as should have been given, those lands could easily have been preserved and even increased in fertility until their present value would have been not five dollars but five hundred dollars an acre.

Even now are the young men of the United States putting ninety million dollars a year into Canadian farms. Why? Because they were not taught in the schools that by investing those millions in the application of science to agriculture they can remain in the United States and secure greater profit and also save our soils from depletion; yes, make our partially depleted lands even more productive than they ever were, and at the same time provide the food that will soon be required to feed our own children.

Why do we premit the annual exportation of more than a million tons of our best phosphate rock, for which we receive at the mines the paltry sum of five million dollars, carrying away from the United States an amount of the only element of plant food we shall ever need to buy, that, if retained in this country and applied to our own soils, would be worth not five million, but a thousand million dollars, for the production of food for the on-coming generation of Americans?

Why this exportation? Because the present owners of American land learned only the art of agriculture and were never taught the science of farming; and it may well be repeated that the responsiblity rests not with the farmer, but with the statesman and the educator.

Note well the following facts:

During the past dozen years the average acreage in corn and wheat in the United States has been increased by 30 percent;

but notwithstanding the enormous increased production thus made possible, we have been obliged to decrease our average exportation of corn and wheat from nearly one-fourth to only one-tenth of our total production; and at the same time the average price of these great basic food materials has increased by 52 percent, corresponding approximately to the increase in the value of land in the great corn and wheat states, and to the consequent and inevitable general advance in the cost of living.

You will remember that the population of the United States has increased 100 percent in thirty years, and without doubt will number more than ninety millions in 1910; but, notwithstanding the great areas of rich virgin lands brought under cultivation in the West and Northwest, and notwithstanding the abandonment of great areas of depleted soil in the East and Southeast, during the last forty years the average yield per acre of these two great grain crops has not even been maintained according to the twenty-year averages of the crop statistics of the federal government for the forty years from 1866 to 1905, as reported in the 1908 year book of the United States Department of Agriculture.

Shorter periods might be selected which would give apparent indications of a different tendency, but less than 20-year averages are not trustworthy for ascertaining the average yield per acre; and these two 20-year averages show that the decrease in yield of corn has exceeded the slight increase in yield of wheat, much of which, it should be remembered, is now grown on land less than forty years under cultivation. And this statement holds not only for the entire United States, but also for the great North Central grain belt, including Ohio, Kansas, North Dakota, and the ten other states lying within that triangle.

Thus, in this boasted "granary of the world," the records of forty years show that the average yield of wheat has increased one-half bushel per acre, while the average yield of corn has decreased two bushels per acre.

Why should the average yield of corn in the United States be only 25 bushels per acre and the average yield in Illinois be only twenty-five bushels per acre and the average yield in Illinois be only thirty-five bushels per acre, when the average yield upon the farm of the University of Illinois, on normal soil under practical, profitable and permanent scientific systems of farming is eighty-seven bushels per acre?

There are at least four factors involved in the solution of the problem of maintaining prosperity, civilization, and universal education in this country. These four factors may be classified as exploitational, scientific, legal, and economic.

1. Further exploitation of our remaining virgin soils, as by irrigation and drainage, neither of which is of large significance in comparison with the magnitude of our present agricultural development.

2. The restoration, by practical scientific methods, of depleted lands and large increase in productive power of practically all lands now under cultivation. This is the only great positive factor.

3. The legal control of increase in pouplation by the enactment and enforcement of suitable laws.

4. The reduction in the standard of living, by extending the tendency already enforced to some extent, as in the gradual withdrawal of meat and other valuable food products from the daily diet, and adopting such standards as are common in China and Japan, where beef, butter, and milk are practically unknown.

The greatest study of mankind is not man, but the application of principles upon which depends the preservation of man's prosperity and civilization; and this study must not only include the application of science to raise high the limitations of the production from the soil of necessary food supplies, but it must also include the application of sense in placing some just and necessary limitations upon the reproduction of the least fit of human kind.

5. The Relation of Pure and Applied Science in Secondary Education.

Worrallo Whitney.

The field which the subject of this symposium covers is so great that, for the limited time at my disposal, it seems best to confine my inquiry to some one phase of the question. I have chosen, therefore, a topic that has interested me for some time, one which is finding expression among science teachers in the agitation for a general science course for the first year of the high school course of study. I shall inquire into the position of science in the curricula of the high schools, especially as to whether science is receiving the attention it deserves in comparison with its importance in every day life and in comparison with other departments in the high school. The question also as to whether the applied sciences now being added to the curricula of many schools are being articulated with the pure science courses already in the course of study is an important one.

It does not seem very necessary to call attention to the increasing importance of science in every day life. Every one is familiar with the facts of the achievements of science, especially those that are spectacular, but these achievements are becoming such an every day matter, taken for granted that one must pause to think, before he realizes fully how far-reaching the field of science really is, and how fast it is increasing these days, with the advances in electricity, transportation, gas, sanitary and medical science, agriculture, forestry, etc. Take the one field of sanitary science; the advance from simple guess work to accurate scientific knowledge has meant the saving of untold thousands of lives, and its work for good has just begun. Its field is in every home, of more importance in the homes of the ignorant and poor than in the homes of the educated and rich.

Few can doubt that agriculture will, in the near future, be rescued from the ruts into which it has fallen on account of the virgin fertility of the soil and put upon a scientific basis. Many are beginning to recognize that the hope of a prosperous future of our country depends upon this.

In view of the supreme importance of science in life, one would expect to find it occupying a commanding position in the curriculum of every secondary school. But educators are conservative. Tradition and custom are binding forces that tend to hinder rational response to changed conditions. A glance at the history of educational methods shows this tendency toward conservatism to be very strong.

In mediaeval times education was solely for those who did not work with their hands. The classics furnished the basis for educational training, for indeed there was little else, and it answered the purpose. In time, human freedom gradually broadened and with it education reached down from the idler and scholar to the workers. As education became more widespread and free schools established, the number fitting for college greatly increased. Finally, little more than a half century ago the first public high schools were established. But instead of these schools growing up out of the elementary schools, they were patterned after the colleges.

The colleges had been the bulwark of conservatism, and till a few years ago, comparatively, the classics still held their place in the front rank of what was deemed best for educational training, almost a fetich to the educators of the colleges. The men who were called to make the curricula of the high schools came from the colleges, and we need not be surprised when we find the languages still occupying the front rank in the high schools, even more than in the colleges themselves.

Let us now inquire into the actual conditions we may find in the curricula of the high schools. I will first analyze the course of study of the Chicago high schools, since I am more familiar with these schools. Some explanation of terms is necessary for a clear understanding of the figures. High schools usually give one credit toward graduation for five recitations per week in one subject for a year, two laboratory periods counting as one recitation period. Manual training, music, drawing, and domestic science usually required two periods of work as an equivalent to a recitation period. The unit course then is five recitations per week in one subject for one year. But as a few schools, including those of Chicago, have many courses with only four or even fewer recitations per week, giving however corresponding credit, it will be more convenient in this paper to use hours (periods) in place of unit courses, understanding that five hours constitute a unit course.

Chicago offers a total of 211 hours work, about forty-two courses, in her high schools, not including manual training which is localized in a few schools, and omitting domestic science and art which are not fully organized. By departments the courses are distributed as follows:

Foreign language........91 hours, or about 45% of the total number of hours offered.

English	16	hours, or	about		8%
History	20	"	"	"	10%
Commerce (including arithmetic)	26	"	"	"	13%
Mathematics	14	"	"	"	7%
Science	24	"	"	"	12%
Music, drawing, etc.	20	"	"	"	10%

The cultural subjects, language and history, constitute 63% of the total courses offered against 37% in all other subjects. It will be noticed, also, that the commercial department, one of the most recently established, offers a greater number of hours than science, twenty-six hours of commercial work to twenty-four hours of science, and this is counting physiology, geology and astronomy as sciences though they are not usually given with laboratory courses in the Chicago schools, and should really not be counted as science. Excluding these subjects, Chicago offers only nineteen hours work in the laboratory sciences. Excluding from the foreign language group Greek and Spanish, which are not given in most of the schools, Chicago offers 57 hours in foreign language to 19 hours in science, exactly three to one.

In order to compare this with other schools of the state I sent out fifty requests for courses of study, twenty-five to township high schools and twenty-five to city and village high schools and received forty replies. With these forty courses of study I constructed a table showing the number of hours offered in each department and showing also the distribution of the science courses offered by each school.

Studying this table I find that the ratios remain about the same as in Chicago except that there are fewer courses in the foreign languages and often more in the sciences (not including domestic science). The courses offered in the foreign languages in the various schools range from 20 hours to 95 hours in amount. While the courses offered in science range from 15 hours to 35 hours, averaging 41 hours of foreign language to 23 hours of science. No distinction is here made between laboratory science and text-book science, since many of the courses of study did not indicate the methods used in the school. Physiology is required and is usually given without an accompanying laboratory course. I estimate that 20 hours is about the correct average of the laboratory sciences, or about 13% of the average total number of hours offered.

Of equal importance with the amount of time given, and growing directly out of this, is the organization of the courses. In Latin, for example, we find a well organized four year course, each succeeding year building on the work of the preceding year, the whole forming a graded series with one object in view. The same is true of the other foreign languages and of English as now taught in the schools. In history the courses are consecutive, beginning with ancient history and ending in most schools with American history and civics. In even the latest subjects to be added to the curriculum as in the case of the commercial department, most schools offer a graded series of four to six unit courses preparing for business life.

Now, how is it with science? We find four years work usually offered, consisting of physical geography and physiology in the first year, botany and zoology or a year of either in the second, and physics and chemistry or chemistry and physics in the third and fourth years. This is not, in any sense, a graded course as in Latin, German and other subjects. It is rather a series of fragments of science, with a half year or a whole year devoted to each fragment. The series cannot be called a four year course comparable with the courses in other

COMPARATIVE TABLE OF HIGH SCHOOLS, SHOWING:

(1) The total number of hours* (periods)* work offered in all departments and in each department;
(2) The courses in science by years.

Township High Schools.	Total No. periods ("hrs.") offered in all departments.	Total periods ("hrs.") offered in each department. Foreign language.	English.	History.	Mathematics.	Commercial.	Science (pure.)	Dom. Science.	Man. Training.	Agriculture.	COURSES IN SCIENCE BY YEARS. First Year.	Semesters.	Periods per w'k.	Second Year	Semesters.	Periods per w'k.	Third Year	Semesters.	Periods per w'k.	Fourth Year.	Semesters.	Periods per w'k
Savanna	* 117	* 30	16	15	12½	21½	20	..	2	....	Physiology ...... Phys. Geog	1 1	7 6	Zoology .... Botany	1 1	7 7	Chemistry	2	7	Physics	2	7
Pontiac	127½	30	20	20	17½	20	20	..	...	..	Phys. Geog ..... Physiology	1 1	5 5	Zoology .... Botany	1 1	7 7	Physics	2	5	Chemistry	2	5
Streator	180	45	20	20	20	30	20	15	10	....	Phys. Geog. ..... Dom Science ..	1 2	5 5	Botany .... Zoology .... Dom Science ..	1 1 2	7 7 5	Physics .... Physiology ...... Dom Science .	2 2 2	7 1 5	Chemistry	2	7
New Trier	237	75	20	20	20	40	25	12	20	....	Phys. Geog. ..... Dom. Science ...	2 2	7 5	Botany .... Dom. Science ... Zoology	2 2 2	7 5 7	Chemistry ...... Dom. Science ...	2 2	7 5	Physics .... Dom Science ...	2 2	7 5
Sterling	135	45	20	15	17½	5	32½	..	....	....	Biology .. . Phys. Geog. ..... Physiology	2 1 1	10 5 5	Botany .... Zoology	2 2	10 10	Physics	2	7	Chemistry .... Astronomy	2 1	8 5
Geneseo	124	30	20	15	15	15	21	4	4	....	Phys. Geog.	2	..	Zoology Physiology ...... Dom Science .	1 1	.. .. ..	Botany .... Physics .... Dom Science	2 2	.. .. ..	Chemistry	2	..
Evanston	155	65	15	20	20	....	25	..	10	....	Phys. Geog .... Physioloy . . .	1 ½	5 5	Botany .... Zoology . ..	2 2	7½ 7½				Physics, or ...... Chemistry .	2 2	7 7
Waukegan	195	50	20	15	15	35	25	10	10	....	Phys. Geog. ..... Dom. Science ...	2 2	7 10	Zoology . . Botany .... Dom Science ...	2 2 2	8 8 10	Physics	2	7	Chemistry	2	7
Centralia	165½	30	20	20	15	35	22½	20	....	....	Phys. Geog. & Gen Science .. Dom Science ...	2 2	.. ..	Dom. Science ... Zoology .... Botany .... Physiology	2 1 1 1	.. ..	Physics .... Dom Science ...	2 2	.. ..	Chemistry ...... Dom Science ...	2 2	.. .
La Salle ..	240	65	20	15	17½	30	32½	20	20	20	Gen. Science ... Phys. Geog ..... Physiology ...... Dom Science ...	1 1 1 2	10 10 5 10	Biology .... Botany .... Zoology .... Dom Science ...	2 2 2 2	10 10 10 10	Physics .... Dom Science ...	2 ..	10 ..	Chemistry .... Chemistry .... Agriculture ..... 4 yr course	2 2 ..	10 10 ..
La Grange .	150	45	20	15	17½	10	22½		20	.	Botany	2	5	Zoology	2	5	Chemistry Phys Geog	2 1	5 5	Physics	2	5
Murphysboro ..	124	40	20	20	15	.	20	6	3		Physiology ...... Phys Geog ..... Dom Science ...	1 1 2	7 7 3	Zoology .... Botany .... Dom. Science ...	1 1 2	7 7 3	Chemistry	2	7	Physics	2	7
Joliet	245	95	30	30	25	20	42½		.	2½	Phys. Geog	2	..	Botany	2	..	Physics .... Adv. Botany .... Zool & Physiology Agronomy .	2 1 2 1	.. .. ..	Adv. Physics .... Chemistry .... Chemistry Inorg . Geol & Astron	2 2 2 2	. . .
Marshall	115	35	20	15	15	10	20	..	..	.	Physiology ...... Phys Geog .	1 1	5 5	Biology .	2	7	Chemistry	2	7	Physics	2	7
Gibson	100	25	20	15	15	10	15	..	....	....	Physiology	2	5				Zoology .... Botany	1 1	.. ..	Physics	2	..
De Kalb	142½	35	20	20	17½	20	20	5	....	5	Agriculture ..... Zoology .... Physiology ...... Dom Science	1 1 1 2	 3	Agriculture ..... Botany .... Phys. Geog. .. .. Dom Science	1 1 1	.. .. ..	Physics	2	..	Chemistry	2	
Oak Park	182½	65	20	20	20	15	25	..	17½	....	Gen. Science	1	7	Phys Geog.	1	7	Botany .... Zoology ... . Physics	2 2 2	7 7 7	Chemistry	2	7
Princeton	160	40	20	15	15	30	30	5	....	5	Phys. Geog ..... Physiology	1 1	5 5	Zool & Bot . Botany .... Agriculture	2 2 2	7 7 7	Physics .... Dom Science .	2 2	7 8	Chemistry	2	7
Ottawa	187½	70	20	10	15	25	27½	10	10	....	Gen. Science ...	2	3	Botany .... Zoology ..	2 2	.. ..	Phys Geog . ... Chemistry ...... Dom Science	2 2 2	5 7 .	Physics .... Dom Science .	2 2	7
Lisle					.		20			.	Phys. Geog	2	5	Zoology	2	6	Physics .	2	8	Chemistry . .	2	8
Lockport	200	30	20	12½	27½	30	35	20	20	5	Botany .... Phys. Geog ..... Physiology . . Dom Science	2 1 1 2	7 6 5 4	Geology .... Zoology . . Dom Science	1 1 2	5 7 4	Agriculture ..... Chemistry . Dom Science	2 2 2	7 7 4	Physics .... Surveying ...... Astronomy . . Dom Science . .	2 1 1 2	7 7 7 4

City and Village High Schools.	Total No. periods offered in all departments.	Total periods ("hrs.") offered in each department.									COURSES IN SCIENCE BY YEARS.											
		Foreign language.	English.	History.	Mathematics.	Commercial.	Science (pure)	Dom. Science.	Man. Training.	Agriculture.	First Year.	Semesters.	Periods per w'k.	Second Year.	Semesters.	Periods per w'k.	Third Year.	Semesters.	Periods per w'k.	Fourth Year.	Semesters.	Periods per w'k.
Alton	** 125	40	20	15	15	10	25	....	....	..	Phys. Geog. ... Physiology	1 1	4 4	Botany .... Zoology	1 1	4 4	Physics	2	7	Chemistry .... Geology .... Astronomy	2 1 1	7 4 4
Aurora	160	35	20	20	20	20	20	10	10	..	Phys Geog .... Dom. Science ..	2 ...	7 ..	Botany .... Zoology .... Dom. Science ...	1 1 ..	7 7 ..	Chemistry	2	7	Physics	2	7
Canton	132½	30	20	20	15	20	27½	....	....	..	Phys. Geog .... Physiology	2 1	.. ..	Botany . ... Zoology	1 1	.. ..	Physics .... Geology .... Astronomy	2 1 1	..	Chemistry	2	.
Champaign	150	35	20	15	15	35	20	....	10	..	Physiography . Phys. Geog.	1 1	5 7	Biology .... Physiology, or .. Physiology	1 1 1	7 7 5	Physics	2	7	Chemistry	2	7
Charleston	112½	20	20	12½	15	7½	20	7½	10	..	Phys. Geog. .... Botany .... Dom. Science ..	1 1 2	 2	Zoology .... Physiology ...... Dom. Science ...	1 1 2	 2	Chemistry	2	..	Physics .... Dom. Science ...	2 2	.. 2
Clinton	133	30	20	15	17½	20	22½	8	....	..	Physiology ... Botany .... Dom. Science ..	2 1 2	5 7 4	Phys. Geog ..... Zoology .... Dom. Science ...	1 1 2	5 7 4	Chemistry . . . . Dom. Science ...	2 2	7 4	Physics . .. .. Dom Science ...	2 2	7 4
Belleville	.	.	.	....	....	....	22½	.	....	.	Physiology ..... Phys. Geog ...	2 1	5 5	Botany	2	5	Chemistry	2	7	Physics	2	7
Elgin	172½	35	20	15	17	20	27½	5	10	..	Physiology ... . Phys. Geog ... Dom Science ..	1 2 2	5 5 7	Botany .. .. .. Zoology	2 2	7 7	Chemistry ..	2	8	Physics	2	8
Galesburg	123	25	20	15	15	25	15	3	5	..	Zoology .... Botany .... Physiology	1 1 1	.. .. ..	Physics .... Dom Science ...	2 2	.. ..	Chemistry ...... Dom. Science ...	2 2	.. ..			
Mattoon	107½	30	20	17½	15	5	20	. .	..	.	Physiology .... Phys Geog ...	1 1	5 5	Zoology .... Botany	1 1	7 7	Chemistry	2	7	Physics	2	7
Danville	170	45	20	25	15	35	25	5	..	.	Phys. Geog. .... Dom Science ..	2 2	5 5	Botany	2	5	Physics .... Zoology	2 2	8 5	Chemistry .	2	8
Moline	175	40	20	15	17½	30	25	6	25	..	Botany . . Physiology .. .. Dom. Science ..	2 1 2	7 3 4	Zoology .. Phys. Geog . Dom. Science ...	2 1 2	7 5 4	Chemistry .	2	7	Physics	2	7
Freeport	187½	35	20	10	17½	35	20	20	20	10	Bot. or Zool. .. Dom Science .. Agriculture	2 2 2	.. .. ..	Zool or Bot. .... Dom. Science ... Agriculture	2 2 2	.. .. .	Physics .... Dom. Science ...	2 2	.. ..	Chemistry .... Dom Science ...	2 2	
Decatur	137½	45	20	20	20	10	22½				Phys Geog .... Physiology	1 1	5 5	Zoology .... Botany ...	1 1	7 7	Chemistry	2	7	Physics .... Astronomy	2 1	7 5
Pekin	140	40	20	15	15	30	17½				Phys. Geog ..	1	..	Biology	2	..	Physics	2	.	Chemistry	2	
Rockford	175	45	20	15	17½	30	27½	....	15	..	Phys Geog & .. Physiology ...	... 2	.. 5	Botany .... El Chem. & Dom Science .	2 2	7 3	Zoology .... Physics .... Dom. Science ...	2 2 2	7 7 3	Chemistry .... Astronomy	2 1	7 5
Springfield	200	55	20	[illegible]	20	20	25	20	20		Physiology Phys Geog .	1 1	5 5	Zoology .. Botany .	1 1	10 10	Physics	2	7	Geol & Astron Chemistry .. .	2 2	5 7
Watseka	120	20	20	10	10	20	20	5	5	..	Phys Geog .... Botany	1 1	6 7	Zoology .... Physiology	1 1	8 6	Physics	2	7	Chemistry	2	7
Peoria	185	65	20	15	20	35	20	....	10	..	Phys. Geog. ...	1	..	Zoology .... Botany	1 1	7 7	Physics	2	7	Chemistry	2	7
Kewanee	137½	35	20	15	17½	30	20	7½			Physiology ..... Phys. Geog .	1 1	.. 5	Zoology .... Dom Science	2	..	Chemistry	2	..	Physics .... Dom Science .	2 2	
Paris	110	30	20	10	15	5	20				Phys Geog ... Physiology	1 1	5 5	Botany .... Zoology	1 1	7 7	Chemistry	2	..	Physics	2	7
Chicago	191	91	16	20	14	26	24				Physiology ..... Phys Geog ...	½ 1½	4 6	Botany & Zool. .. or Botany .... Zoology	2 2 2	6 6 6	Physics	2	6	Chemistry .... Geology .... Astronomy	2 1 1	6 4 4

Note The utmost care has been taken in compiling this table to insure accuracy, but the author is conscious that there may be some errors. Often the information sought was either omitted from the courses of study, or was given in such a manner that it was not easy for a stranger to interpret it or gather just the information needed.

* For the sake of comparison double laboratory periods and all work on laboratory basis are reduced to equivalent recitation periods. Five recitation periods ("hours") per week for one year constitute a course as usually given.

** The amounts given in this column do not include the special studies such as drawing, music, rhetoricals, etc., for which many schools give credits.

departments. The principal value of Latin as an educational factor in high schools has been due not so much to any intrinsic merit in the study *per se,* as to the carefully graded work on one single subject for four years, thus giving time and opportunity for cumulative development and disciplinary training of the mental activities of the pupil. What would be thought of any school that offered four or more one-year courses in as many languages as a substitute for the usual well graded courses now offered? I wish to quote a passage from a recent address by [1]Professor John Dewey on this point. He says, "Imagine a history of the teaching of the languages which should read like this: 'The later seventies and eighties of the nineteenth century witnessed a remarkable growth of the attention given in high schools to the languages. Hundreds of schools adopted an extensive and elaborate scheme by means of which almost the entire linguistic ground was covered. Each of the three terms of a year was devoted to a language. In the first Latin and Greek and Sanskrit were covered; in the next French, German, and Italian; while the last year was given to review and Hebrew and Spanish as optional studies.'" This imaginary picture by Dewey vividly illustrates the position of science at the present time.

How has it happened that the four sciences are arranged as they now are for the order given above is the usual one? Is it due to grading, forming a graded course in any strict sense of the word? I think not. Any one acquainted with high school science work knows that this arrangement depends upon other factors and not upon anything inherent in the subjects themselves. Take chemistry and physical geography, one usually given in the fourth year and the other in the first year. Chemistry could be adapted to first year grade just as well as physical geography so far as anything in the subject itself is concerned. But it happens that chemistry requires a more expensive laboratory and small classes, while physical geography requires a relatively less expensive equipment, is less expensive to run, and larger classes can be handled. Botany and zoology do not

1 Science, Jan. 28th, 1910, page 124.

necessarily depend upon anything taught in physical geography. Physics is given late in the course of study because the college requirements are so stiff that the work cannot be done in the first year. In fact the physics teachers of Chicago find it easy to arrange a course in physics for a proposed first year general science course. I think we can take it as proved that the sciences do not form a graded course comparable with courses in other departments and that the present arrangement is due primarily to extraneous factors such as cost of laboratories, size of classes and college entrance requirements.

It cannot be said, however, that school officials in planning courses of study consciously intended to slight the sciences. The fault is largely due to the newness of the sciences themselves. There has been action and reaction both in content and in methods of teaching of the sciences, and the end is not reached. The present laboratory method of teaching science in secondary schools does not date back two decades, while the classics have had the advantage of centuries of teaching, in which a great body of principles and methods has been firmly established. But it appears that school authorities have settled down to the belief that this fragmental practice of teaching science is sufficient, for we see a great uniformity in courses of study in this respect. The only straw that indicates a measure of dissatisfaction with the present arrangement lies in the agitation for general science courses in the first year of high school. A few schools have already established such a course.

A good test of the inadequate organization of the science courses is the manner in which the new courses of applied science are being added to the curricula of many schools. I refer to domestic science and agriculture. One would naturally expect that when these sciences are added to the curriculum of any school, they would be articulated with the existing courses in pure science. Before a pupil enters upon a course in an applied science, he ought to have received training in scientific method and habit of thought by studies in pure science, preferably of course in those sciences that underlie the applied science in question. Thus chemistry and botany at least should precede or accompany domestic science courses and all the biological and physical sciences are necessary to adequate teaching of agriculture.

But instead of an attempt to establish well graded or correlated courses of this sort, in which the pure sciences are prerequisite to or coordinate with the course in applied science we find that the new courses are usually being added without any reference to existing courses in pure science. Among the 40 courses of study I have examined, only two have any specific requirement of a pure science as a prerequisite. In Chicago, a four-year course in domestic science is being planned with no requirements in other sciences. Such extended courses in applied science must of necessity repeat, in a more or less complete way, science work which is already being done in the pure science or might be done readily if there were concerted action. This is surely a waste of effort.

But the case with agriculture is much stronger. We may have agriculture of a sort, but not "scientific" agriculture without the training and facts yielded by the pure sciences. Yet so-called courses in agriculture are being added as if the science were wholly unrelated to other sciences. Often these courses are placed in the early years of the course of study, where it is not to blame for the way it is being done. The arrangement any preliminary training in science. The result is, of course, a very superficial and unscientific kind of training.

But, after all, the school officers who are placing these new courses in the curriculum in reponse to the demand for them are not to blame for the way it is being done. The arrangement of the pure science courses does not offer any chance for the development of well graded courses in the applied sciences. Chemistry, which is needed in both agriculture and domestic science, is given in the fourth year in most schools and physics in the third year. Neither of these studies as now given can be utilized.

Another testimonial to the inadequate and unscientific organzation of science in secondary schools is seen in the establishment of separate schools of agriculture and other industrial and technical schools of secondary school grade. These schools are a waste of the resources of the state, for they duplicate the regular schools in all respects save the one department. They are deterimental also in developing a false notion of the relative importance of the various departments of learning. The establishment of these schools is direct condemnation of the existing systems in the regular schools. The reason is not far to seek. The curriculum of the average school is not flexible, on the contrary it is so fixed that needed changes for adjustment to new relations cannot be made without a serious fight with the "ins." Rather than have this fight with an inflexible system, resort has been made to separate schools. Those who have the interests of the public high schools at heart should see to it that there is proper response to the demand for the teaching of agriculture and other industrial subjects in high schools. It should be met by honest endeavor to adjust old relations to new demands, else separate schools are bound to come with consequent division of funds and effort. I may add here an interesting fact in our experience in botany classes in Chicago. Of late, boys in our botany classes are strongly attracted by the advantages offered in scientific agriculture, forestry, and sanitary science. This movement is quite marked though we give only one year of botany with little that suggests agriculture in it. It is a trend country-ward from the city of city youth, in contrast with the usual movement.

We may now summarize the points I have made with respect to the position of science in secondary schools. First, the time usually given to science is very small in comparison with the importance of the subject and in comparison with the cultural subjects, averaging only one-half to one-third the time given to foreign languages alone. Secondly, the science courses as now planned are fragments of larger subjects and not enough time is spent on any one of them to secure good results either in disciplinary training or in information. Third, the science courses do not form a graded orderly development of knowledge such as we find in other departments. Each year's work is a detached piece and contributes but little to any other year's work in science. In consequence of the limited time given to each science, there is an attempt to cover too much territory in the allotted time. The pupil, instead of feeling the growth of power and grasp of the subject, is apt to be overwhelmed and paralyzed by matter that he cannot assimilate. Fourth, the pure science courses are organized in such a way that courses in applied science cannot be articulated with them and cannot take advantage of the expensive laboratory equipment of the pure sciences. Fifth, the inflexibility of the curriculum and the inadequate organization of the science courses have resulted in the establishment of many separate schools of agriculture and other industrial sciences.

It is not within the province of this paper to propose remedies for the cure of these defects. If a solution of the problems were easy, it doubtless would have been hit upon long ago. In closing, however, I would like to suggest what I think are the lines the reorganization of science must tae. These lines are first, foundational science in the first year of the high school; second, more time for each of the pure sciences; third, courses in applied science should be articulated with the pure sciences; fourth, all high schools in towns and cities tributary to agricultural districts should have a carefully planned course in agriculture and sufficient farming land for practical laboratory work.

It has been indicated that elementary physics and chemistry should be given in the first year as a foundation for courses in applied sciences and for the pure sciences as well. I would suggest a half year of physical geography, made less technical than it is usually given, followed by a half year of elementary physics and chemistry, this to be perequisite for all science courses, or a full year of general science consisting of physical geography and biology the first half and physics and chemistry the second half. In this latter case a more advanced type of physiography could be given later in the course. Physiology, now required in the first year, should follow zoology in the third year, but if it cannot be taken from the first year then it might be given without home work in informal lectures on hygiene and physiology, as an extra, time being given for it from the home work of all the other studies of the first year. It is now usually given in a perfunctory manner from a text-book and the method I suggest would be more dignified and beneficial, especially if physicians were invited in to give many of the talks. By this or some similar device the continuity of the science courses could be preserved.

Botany and zoology occupy at present an advantageous position that probably cannot be bettered. I would, however, give two years to each. The second year in botany could be given to systematic and economic botany, preparing the way for agriculture. A good second year's work in zoology would be formed by giving a half year to study of insects and economic zoology and a half year to vertebrates with special reference to physiology, including human physiology. In physics there is plenty of important work in electricity and other topics. But these are merely suggestions of my own. The great need is for careful study of the situation and experimentation with a view to improving not only the organization of the courses but also the methods employed in presenting the various sciences.

No one can justly say that this proposed increase of the science would burden the course of study for we have only to look to the foreign language courses to get a refutation of such a charge. The cost would be but little greater, nothing at all except perhaps in physics. The added time for better developed courses and the cutting out of hurry and scrimping will add dignity, interest and attractiveness to the courses in science and greatly increase their value. It has been found in the past that increased facilities for education always meet a prompt response in increased patronage. So with increased facilities and saner methods would come greater appreciation of science and still greater appreciation of the work the high schools are doing for the people.

S. A. Forbes.—"The series of able and really brilliant papers contributed to our symposium this morning are a justification of the symposium idea, and also of the judgement of the council in their choice of a subject. It seems that the council needs defense against the reflections of some of the speakers upon the form and wording which we gave to the topic of discussion. We agreed among ourselves that there was no dividing line or essential difference, in the last analysis, between pure and applied science; but this is not the common view, and we really set ourselves up as a target to draw the fire of our symposium speakers, as a means of demonstrating the fallacy of the common view.

Mr. Coulter has a resolution in hand, which, as it applies to the subject of scientific education, may be offered here."

In the absence of John G. Coulter, John M. Coulter persented the following motion, notice of which had been given at the Friday meeting by the former. *Moved*: That the President shall be authorized to appoint a committee of five, to discover whether the Academy may be of assistance to the high schools of the State in the teaching of science; and, if so, to report at the next meeting a plan of action; and that the Council shall be authorized to place at the disposal of this committee such funds for its expense of correspondence as may seem expedient."

This was voted and the President appointed the following committee: Cyril G. Hopkins, J. F. Hayford, John G. Coulter, Worrallo Whitney, W. S. Strode.

The Secretary inquired after the addresses of some of the members whom he had been unable to locate. He expressed a hope that at some time during the meeting opportunity might be found for a discussion of the needs of the Academy, stating that at no time since the organization meeting had there been general opportunity for individual members to offer suggestions.

T. W. Galloway reported on additional names recommended for membership and the persons named were elected.

W. S. Strode reported for the Auditing committee as follows:

Your committee appointed to examine the books and acounts of the Treasurer J. C. Hessler have done so and found the same correct."

Isaac E. Hess presented the following paper:

THE PASSING OF OUR GAME BIRDS.

What has the future in store for the game birds of the Mississippi valley? My paper will refer in particular to the resident game birds: the prairie chicken, ruffed grouse, bobwhite and woodcock.

Of the migrators, including such species as Wilson's snipe, golden plover, yellow-legs, and the several ducks and geese, there is no immediate danger of extermination.. Just so long as these birds extend their summer range beyond the bounds of man, the long black lines and curves and angles of migrating birds will continue to be seen traveling northward in the spring and returning each autumn.

When civilization has followed them until farther northward is denied, then will their numbers fade away like those of the beautiful wood duck; and like the passenger pigeon they will gradually disappear.

Time was, and not in the distant past, when prairie chickens and quail were more common in the fields of the prairie states than domestic fowl about the barnyards. Several times within recent years, bobwhites have so rapidly increased as to excite comment from even non-observers, only to be swept away in such an avalanche of destruction, that the following season they are rarely met with. And nature is his great destroyer, not man.

The winter of 1902-1903 was a fair illustration of how nature performs her work of equalization. In the fall of 1902 bobwhites were more numerous, with one possible exception, than any other bird of central Illinois. A walk through any stubble or meadow would send at least one flock scurrying to shelter, and a ride along country roads would reveal covey after covey runing along the hedge rows; while dozens would be

Fig. 5. Prairie Chicken (*Tympanachus americanus.*)

seen hurrying across the road ahead of approaching teams. The winter was moderately mild until February, when one evening came a heavy fall of snow and the thousands of bobwhites, out battling with the elements, burrowed to the bottom of the snow-banks for warmth and shelter.

During the night the wind shifted and a rain and sleet set in. In a short time the tunnels were covered with the drifting snow, and by morning a thick hard crust of ice imprisoned the little bands of living pulsing creatures. A new experience now confronts them and they huddle close together. Their world has narrowed to small proportions, but they are warm and comfortable, and the first day passes with little inconvenience. But prison without succor means death, and slowly but surely the little flocks succumb to the pangs of hunger. With horns of plenty all about them, they gradually starve, and not until the warm spring winds unlock the prison doors, do we behold the awful results of nature's tragedy.

The bobwhite army quickly recovers, however, from these terrible reverses, and two or three good seasons are sufficient to restore them to their former numbers, as they rapidly multiply. If the sumer season be dry and favorably, two sets of eggs will be deposited, and each female will bring forth two broods averaging fifteen chicks each.. The first brood will hatch in late May, and the second in early July. Twenty chicks of the thirty should arive at maturity, and if the winter season be not of the quail killing sort, a dozen should survive its rigors, leaving seven pairs to begin the following season. Computing by compound interest, these seven pairs should increase to 606 birds by the third season. With one pair of quails on each section of land, one township should furnish the enormous number of 21,816 birds in three productive seasons.

Is it not plain that without the intervention of nature, quails would soon become more numerous than the grasshoppers in the fields, and in the course of events would prove a serious menace to the harvests?

But nature does not need the help of man in her work of reducing the over supply to normal conditions, and when man interferes, the result is sometimes extinction.. Nature has seldom caused the extinction of species since the modern era, but through human agencies alone has disappeared the great auk, the passenger pigeon and the Carolina parroquet.

From man the bobwhite, however, has little to fear, and for this reason he seems to have brighter prospects than the other game birds about us. The day is past when he furnishes the zest for the hunting trip. Through wise legislation, the time for shooting him has been diminished, until now he is protected nearly eleven months of the year.

Another point in his favor is the growing sentiment that he should not be considered a game bird. His economic value has been established, and this with his inocent harmless life has appealed to those who used to seek his life, and many hunters now will allow a fine covey to flush at their feet with never the temptation to lift a gun. As one old hunter said, "Did you ever dress a pretty little quail and find its crop bursting with weed seeds of which it had kindly cleared your land? And did you stop to think that for the fun of killing and for two or three ounces of meat—delicious, it is true—you had destroyed a friend that was working hard every day in your interest? Well, that is my experience, and I must say it took some of the zest of quail shooting away, when I thought of what I had done."

The prairie hen has had a harder row to hoe. That noble bird has been forced to adapt itself to a violent change of conditions since the days when it felt so much at home in the broad expanse of rolling prairies.. The fates have been unkind to it and its enemies relentless. Big and strong and swift of wing, it has furnished rare sport for the hunter, and the flavor of its flesh has found great favor with the epicure.

With its enemies so much in evidence, the natives seeking it for food, the hunter shooting it for sport, and the pot-hunters slaughtering it for gain, it has been running a continual gauntlet.

Add to this the constant danger confronting the young prairie chickens from their natural enemies, the foxes, minks, skunks, weasels, and hawks, and the difficulties the hen must meet in saving her eggs from the ravages of cows, snakes, and squirrels (to say nothing of the farmer's plow), and you need not think it strange that the prairie hen has been unable to hold its own. No more do we see those great flocks, numbering in the hundreds, sailing rapidly over the fields to their feeding grounds. Only little bands scattered here and there are left of that vast army of birds so conspicuous in the early settlement days. They have been rapidly disappearing of late years, and it seemed for a time that their days were surely numbered.

Fortunately, however, the legislature of Illinois became sufficiently alarmed to pass a law protecting this bird for a period of years, giving it in this state at least a new lease of life. The next few years will determine whether or not the prairie chicken is doomed to destruction. If the clause be not renewed, this pioneer bird will pass into history. A renewal of the law at its expiration July 1, 1911, for an additional five years will give him another chance in the great battle of the survival of the fittest.

If the prairie chicken is a native of your locality, you will know it about the last week in February.. It is then you may hear the loud drumming noise made by the male at the first signs of opening spring, and be enabled to number and locate each flock in the vicinity. If you have never seen the male at his drumming, you have missed a novelty indeed. On either side of his neck is a large yellow spot devoid of feathers. The skin is quite loose and very elastic and capable of being blown up like a small rubber balloon. As the cock struts to and fro, displaying his many charms before a bevy of admiring females, these wind-bags are distended to the size of oranges.

With his head swaying back and forth near the ground, the drumming noise is made by expelling the collected air through the mouth. Beginning about four o'clock in the morning, the cocks drum with marked regularity until six or after. On still mornings they may be heard at a distance of three or four miles.

His "boo-ro-roo" is a long-drawn out roll, and resembles nothing so much as the expression "you-ole fool." Indeed, when the drumming is followed with these syllables in mind, the resemblance is ludicrous. Not the most gallant way perhaps, for father Tympanachus to announce to the sleeping world the birth of a new day, but really quite excusable when we think of his many trials and crosses at the hand of man. It is, in fact, his only way of resenting the plowing up of his foraging grounds and the turning of his nests in the furrows.

To see him in his most interesting moods, you must find him during courting hours. Then the determined swains meet in battle royal to decide the great question as to which shall be "king of the flock," the victor of course claiming the choice of the females for his mate.

When you have gazed upon the proud fellow dragging his stiff wings on the ground in scornful challenge; when you have seen the excited cackling females encouraging their lords to battle and have heard their wild nerve shattering laughter (so like the babble of a gathering of maniacs), you will have felt repaid for the inconvenience of an early morning trip to the rendevous.

The bobwhite and prairie chicken may both be saved to us by simply protecting them. That they are gradually adapting themselves to the changed conditions is amply proved. Recently I found a nest of the prairie hen containing thirteen eggs placed in a small clover field within a hundred yards of our town park, and last summer I photographed a nest with eggs only four blocks from my place of business. Bobwhite is already a semi-domesticated bird and will nest and feed in company with the barnyard fowl when undisturbed.

The ruffed grouse and woodcock, however, will soon be gone. The only possible way to keep them would be to save the forests, and this of course will not be done. These interesting game birds cannot change their mode of life, and man's advent was the beginning of the end for them.

I have in mind but one spot where I may now find the woodcock, that queer almost silent bird of the night. Untouched by the woodman's axe, a bit of forest in its primeval state still shelters a thick swampy undergrowth. The soil remains wet and soft throughout the summer season, and here where the woodcock may penetrate its oozy depths with his long soft mandible he feels at home. When the last of these wild spots of nature is gone, then will the woodcock be no more.

The passenger pigeon is gone, and now it does not lie within our power to bring back the magnificent flocks that used to darken the sun for our ancestors. Perhaps my hearers have noticed the desperate efforts that are recently being made in behalf of the passenger pigeon. Offers of hundreds of dollars are made to the public, not for the dead body of this now rare bird, but merely for the evidence that a single one is in the land of the living. Excellent motive, but too late! too late! Wise legislation a score of years ago would have prevented this fine bird from extinction.

We of Illinois have an apportunity to improve upon the lax methods of twenty years ago. This is the age of conservation of resources. We have tasted of the fruits of carelessness. Are we to learn from experience?

The past months of December and January, with their abnormal periods of ice and snow, have wrought sad havoc among the quail of the north Mississippi valley. It is doubtful if any season of recent years has proved so disastrous as the one just past. Reports from all over the state tell the same pitiful story of covey upon covey of bobwhites found huddled together, all dead.

I think it is obvious to us all that without protection for the bobwhite at this stage for a period of three years at least, we shall be in danger of losing for all time this valuable citizen.

Through the protection of the prairie chicken during recent years, this part of Illinois (at least Champaign county) may claim a very appreciable increase in numbers. Just as they are geting a good start, we are confronted with the knowledge that the protective clause expires on July 1st of next year. Listen while I tell you of a secret. Within six miles of the University of Illinois, at this moment there is a grand flock of sixty of these splendid birds that have successfully coped with the severe winter months.

Gentlemen of the Illinois Academy of Science, how many of you would wish to see that band of pioneer birds exterminated within a month from July 1, 1911?

I have a letter in my pocket from W. F. Henninger of Ohio, who is Secretary of the Wilson Ornithological Club of that state, stating that he seriously doubts if a single live prairie chicken is now to be found within the boundaries of Ohio. Is this to be said of Illinois in the near future??

I would be much pleased should the Illinois Academy of Science go on record as favoring the repeal of the quail law for a protecting period of three years, and an extension of the prairie chicken protecting clause for an additional period of five years from July 1, 1911.

W. S.. Strode.—"The quail is holding his own pretty well since the farmer is awakening to the fact that he is a very useful bird, destroying great quantities of weed seed, chinch bugs, and other obnoxious insects. The Cooper's hawk and sharp-shinned hawk are great destroyers of the quail. The former will eat nothing else if he can get a quail every day, and the latter is no better.

Only absolute protection to the prairie hen will result in its introduction again to the prairies of Illinois, as it is a conspicuous bird, an easy mark, and a touch of shot kills it. The average boy with his automatic or pump gun would quickly get the last of a flock.

The ruffed grouse is almost extinct. Some years ago in Fulton county a disease broke out among them and destroyed nearly the last of them.

The wild turkey is practically extinct in the state and can never successfully be introduced again as their habitat has been destroyed. The speaker killed his last one on Christmas day 1883, and then awoke to the fact that he had killed the last one in Fulton county."

I. E. Hess.—"We have a legislative committee, and I move that they be instructed to see what steps can be taken to have the game law so modified as to offer quails absolute protection for three years and prairie chickens for five years." The motion was carried.

F. C. Baker.—*Moved,* "That a committee be appointed to look into the matter of permits for collecting birds and their nests and eggs, and to ascertain if a law is feasible for the absolute prohibition for a period of years of the collection of birds and eggs by all, excepting by accredited scientific institutions; or if this prohibition be not desirable, that efforts be made to secure the substitution of the Illinois State Academy of Science as the issuing agent for the permits, in place of the existing agent."

President Forbes appointed the following committee: F. C. Baker, Isaac E. Hess and Fred L. Charles.

P. B. Hawk presented a paper of which the following is an abstract:

FURTHER STUDIES ON THE INFLUENCE OF COPIOUS WATER DRINKING WITH MEALS.

The subjects of these experiments were young men who were placed on a uniform diet, and all urine and feces were collected in twenty-four hour periods and analyzed. Each experiment consisted of three parts, a *preliminary period* of six days during which time the subjects were brought into "nitrogen equilibrium." During this period 900 cc. of water was daily ingested, 300 cc. of this amount being taken with meals. The second period or *"water period"* was five days in length and during each of these 1000 cc. of water above that already mentioned was taken at each meal. The *third period* was from three to eight days in length and during this period the amount of water ingested was the same per day as in the preliminary period. The daily drinking of three liters of water with meals, for a period of five days by these three normal young men, who were in a condition of nitrogen equilibrium through the inges-tion of a uniform diet, was productive of the following findings:

1. An increase in body weight, aggregating from one and one-half to two pounds in five days.

2. An increased excretion of urinary nitrogen, the excess nitrogen being mainly in the form or urea, ammonia and creatine.

3. A decreased excretion of creatinine and the coincident appearance of creatine in the urine. The decreased creatinine output is believed to indicate that the copious water drinking has stimulated protein catabolism. The appearance of creatine is considered evidence that the water has caused a *partial* muscular disintegration, resulting in the release of creatine, but not profound enough to yield the total nitrogen content of the muscle. The output of creatine is therefore out of all proportion to the increase in the excretion of total nitrogen.

4. An increased output of ammonia which is interpreted as indicating an increased output of gastric juice.

5. A decreased excretion of feces and of fecal nitrogen the decrease in the excretion of fecal nitrogen being of sufficient magnitude to secure a lowered excretion of both the bacterial and the non-bacterial nitrogen.

6. A lower creatinine coefficient.

7. A more economical utilization of the protein constituents of the diet.

8. A decreased excretion of fecal extractive nitrogen.

9. A strikingly lowered output of carbohydrate in the feces, thus indicating a more economical utilization of the ingested carbohydrate.

10. The increased body weight; the lessened output of feces and fecal nitrogen; the decrease in bacterial and extractive nitrogen of the feces; the more economical utilization of the protein and the carbohydrate constituents of the diet, all continued throughout the final period on a plan similar to that established during the water period, instead of returning to the conditions in force during the preliminary period. These facts indicate that the influence of the water is not simply temporary.

11. The general conclusion to be reached as the result of these experiments is contrary to the current medical teaching, and is to the effect that the drinking of a large amount of water by normal individuals, with meals, was attended by many desirable and by no undesirable features.

Q. I. Simpson presented the following paper:

BIOLOGY AND OTHER SCIENCES AS APPLIED BY A BREEDER.

About the time when Dr. Burrill was teaching *all* the sciences at this university, a professor of Natural Science, my father, was leading a class of six, all the product of his own loin. He taught causality for all nature's phenomena, the immutability of law and universal kinship. Hence the application of science to our life work.

Two centuries of nursing, pampering and inbreeding of the English thorobred had brought the foals to almost the delicacy of *Homo,* and the country "hoss" doctor and our own experience could not cure their many baby ailments. But *"kinship"* brought the village physican, and our losses were then at an end. The Government, after many researches concerning hog cholera, had discovered an impractical form of immunization, and had put out a *drug* formula for cure and prevention that was as useless as a *drug* cure and preventive for small pox. We were lost and feared we must lay aside the most profitable money maker of the farm. But we read how a physician in Georgia had lowered the death rate in typhoid by abstinence from all diet. We had seen the bacteria of typhoid and of cholera in a Government laboratory, and noted that they were in appearance alike. Dissection of our swine showed that they were diseased as described for typhoid. The intestines were weakened by numerous little boils, so that a little pull or pressure would produce a hole which allowed foods to escape into the abdominal cavity. Even the pulling of the lateral and longitudinal muscles which causes peristaltic action was sufficient to tear these tissues. Then we *fasted* all cholera swine and the disease to us lost its terror. We do not court this enemy, but by the application of strict quarantine prevent it, or hold it to a particular field or pen. A neighbor, his dog, or horse, or vehicle, from a cholera farm would be as little welcome at our farm, as would a leper at our residence.

I am proud to know that Illinois has now a better method of preventing great loss from cholera, in the immunization now being directed by Dr. Pèters, and which has been so well established by Dr. Connaway of Missouri.

The isolated farmer has not the "atmosphere" that you men of the universities have, and you will laugh at our modes for research and inspiration, but when we looked thru the libraries for laws and rules and principles governing breeding, we found just one, handed down from Aristotle, the law that like begets like; and it is a lie.

It seems that most of the research, which during the last half century has changed biology, was instigated in some way by the great truth propounded by Charles Darwin. He and Mendel brought life down from the clouds where thinking men may handle, analyze, and theorize as they do in the exact sciences of dead elements. The sexual principles of Gregor Mendel were the first that were absolutely true in their application to the breeding of plants, animals, and man. They were given before the Society of Brunn in 1865, but lay unnoticed until the spring of 1900, when three papers by DeVries, Correns, and Von Tschermak were published stating again its substance. Each of these three writers was able to confirm Mendel's conclusions from his own cases.

At this time Spillman was developing these laws in wheat hybrids, and they were almost immediately confirmed by Castle, Bateson, and others with small pet stock. Your writer, on a farm, isloated from learning and with little scientific literature, did not hear of these principles until he read an article by Castle in 1904. We had been making a variety of hybrid experiments with swine; using pedigreed animals of strongly contrasted visual features, partly for determining the economic value of their many mixtures, but chiefly to determine the then mooted question of sex value, the relation of potential between male and female, and when we read thees laws we had in our fields a half hundred pig hybrids proving their truth and accuracy.

We at once became Mendelian enthusiasts; for these were the first proven laws for the guidance of heredity characters. We do not now require Pearson biometries nor Galton tables, but try to simulate the chemist, physicist, and astronomer by direct application, borrowing the principles of exactness and law from kindred sciences.

With Mendel's laws we five years ago propounled the theory of magnetic-polarity, the why-for of sex as shown by the action of chromosomes at fertilization and thruout all the mitotic divisions and reproductions of the cell, to old age in the individual. And the theory has been established by other lines of research under the more general name of "the electro-chemic theory of life." This was well illustrated by Dr. Lillie at the Boston meeting of the A. A. A. S. recently, in a paper on fertilization, wherein he showed how the entrance of a single sperm negatively polarized the egg against further encroachment.

When we learned of Mendel laws, we had in our group of pig hybrids much diversity and non-correlation of characters on single individual hybrids, which told us that the conception of the half nuclei was an insufficient explanation. . Some experimenters and cytologists were claiming that the independence of the finer division of these half nuclei—the chromosomes—were the origin of the independant unit characters that showed a non-correlation with other characters from their four grandparents. In our first reprints sent to Mendelian and cytological workers, many of these men would advise us "to go slow with the chromosomes as bearers of heredity; that we are not yet sure that they are the vehicles." But further hybridizing of strongly contrasted breeds and the aggregating of three and four of these contrasted breeds in a single hybrid brood has enabled us to almost count the chromosomes, and convince *ourselves,* if none else, that *they* are the *things* that *do it.*

From these experiments and the Mendel-chromosome combination of theories, we are now able to analyse supposedly pure animals and prove and name their specific impurity. We are doing it now with swine purchased from reputable foreign breeders with the exactness and surety of a chemical laboratory.

Many experimenters are using the same methods under different terms. The "allelomorphs" of Bateson and Castle and the "factors" of other experimenters are proof of the chromosomes' action. The direct experiments of myself that have cost me far more work than a doctor's title, have enabled me to say that the individual, independent chromosomes of the male and female nuclear colonies are the things that determine units of heredity.

With this chromosome-Mendelian-unit-seggregation-idea, we are synthesizing the units from various individuals as does the chemist; and building animals to "blue print" as does the architect. And when built, we then with these same principles and some empirical knowledge test the individual as to the purity and homogeneity of its inner germs.

With these we do not fear *latency, reversion,* or *throwing back,* and can create *reversion* at will when so desired. We can formulate new "made-up breeds" to suit the economy or the fancy. We can fix these breeds in the purity of their characters with certainty and precision, without the long line of inbreeding, as used by disciples of Aristotle. We are working in an advanced field on a dim trail, and must use every finding from kindred experimenters that will lead the way.

The climatic mutants from Tower's potato bugs, the mutants of Webber's frozen orange stump, the variants from McDougal's chemical plants, and the feather-pigment researches, by Riddle, are all telling things that relate to our work of creating pigs to order; and show that life is only a chemical laboratory and subject to chemical and physical laws.

Weismann brought Mendelism into unity, by showing that *albinos* were of *no* pigment; and *whites,* like white hogs and white leghorns, an over oxidation of pigment, a fading out to white. This explained the *dominance* of *white* hogs, and the *recessiveness* of *albino* mice, when crossed with pigment. His graduation of pigment colors worked out in the chemical laboratory agree, in my opinion, with Emerson's and Shull's hypostatic and epistatic grades of pigment in bean hybridizing, and the dominant and recessive colors in swine of our own mixtures.

Men with biometrics had found little gain from outcrossing corn, but the precise individual methods of Dr. Shull and Dr. East in producing absolutely pure types, and crossing these, have brought this grain under the general law of "magnetic polarity," the out-cross rejuvenation as found in crossing inbred animals. Former experimenters had been trying to inbreed hybrids (corn with *biotypes*), and it was like the inbreeding of the Collings nondescript short horns, *not* inbreeding.

The facts found by cytologists that all animal cells from paramecium to man inclusive, and all plants above bacteria contain chromosomes; that they show precise division and reduction of these at prefertilization, and an exact fixed number in all germ and somatic cells of any particular variety of plant or animal; and that they constitute a mode of reproduction of these chromosomes, has led us to offer a theory, which I gave at Omaha. This tries to account for the mutability and varietal changes of organisms by explaining the chemical and miscropical action of the finer details of these organisms. Unless we can guess the specific units that make and regulate life, we will be hardly able to make and control it to our own particular fancy. The chemist and physicist have found usually that what nature can do man may also accomplish when he learns how she has done it. That she has and is doing things in the lines of mutability in life we have abundant proof.

When we had apparently found to our satisfaction that the chromosomes are the builders of the cells, then we asked how they do it. And this I will try to tell you, accepting the hypothesis that the chromosomes are bacterial catalytic entities, and act on the blood or lymph of animals and the cell sap of plants, analysing and synthesizing the chemical cytoplasm of the cells, as their kindred the bacteria work chemical change in a jar of agar, or starch solution. Boveri in the year of 1888 had said "The splitting of the chromosomes appears to be a vital manifestation; an act of reproduction on the part of the chromosomes." And every authoritative cytologist since has said that they divide and reproduce by fission, making two from one. But some of these have thought that they sometimes arise anew from simple cytoplasm, because they have not found them under certain conditions in some cells.

McClung, Wilson, Miss Foote and Miss Stevens have found that sex is determined by the odd or even number of these chromosomes; and all the direct breeding experiments of artificial mutability of individuals have led to this idea of their bacterial semblance.

When we consider the embryo's development from a fused germ cell, and the many different chemical forms of hoof, hair, pigment, bone, and glandular cells, we must surely ask if there is not something inside these particular cells that works a chemical change, or metabolism, on the homogeneity of the common lymph and common sap.

We were ready to spring this theory of "the bacterial semblance of the chromosomes" a year ago, but some cytologist said these chromosomes at times lose their identity. Further work in complicated hybrids of contrasted breeds, enabled us to nearly count these chromosomes by the non-correlation of distinct and heritable units. We searched volumes on chemistry for a perpetuating chemical enzyme. Platinum finely divided and some sulphates would work catalytic change on lymph, sap, or starch solution, but would not reproduce.

There is but one reproducable catalyser yet known, the hated bacteria. So by the logic of simple elimination we attribute to bacteria the building of plant and animal cells from the undiferentiated lymph or sap that filters thru the cell wall into the cell. First the lymph exists as cytoplasm. Then after metabolism by bacterial chromosomes it becomes pigment, bone, hoof, or epithelium. Since this theory was given at Omaha, we have found much further confirmation, and we are receiving support from able men.

We had assumed that a bunch of bacteria had balled-up and by secretion of slime, had caused the first cyst or cell sac. Dr. Condon and Dr. Fischer showed us there was not need for the assumption, for there are now in the evolutionary stage capsulated and non-capsulated bacteria in single species. An editorial in the Journal of the Am. Med. Assn. of Dec. 18, 1909, gives Jensen's classification of bacteria and their supposed evolution into higher plants and animals.

The theory that we present is in substance that the chromosomes are the vital entities that make life, and that carry heredity from germ to maturity and from generation to generation. These chromosomes are of bacterial evolutionary origin, yet retain the bacterial properties of creating metabolism. In the slow reproduction of germ cells from the blastomere to the ovary or testis, thru only a line of epithelial cells, they do not change their species, but in the rapid division of the somatic cells mutate into the various properties required for the particular cells which they build.

In conclusion, I wish to express a breeder's gratitude to you scientific workers, who by your exact methods of thought and research and your accomplishments set example to the slipshod methods of my class, and show us what may be found by direct experimentation. Our application of evolutionary kinship we owe to the precision of the systematist. The Mendel laws, by which all accurate determination of the action of genetic units is derived, was formulated by a trained botanist. Proofs of the cause for these laws are obtained with the aid of the microscope by workers of your universities. Most that the breeder has obtained since Aristotle's time has been learned from trained scientists.

The meeting then adjourned till 2 p. m.

Afternoon Session.

After the calling to order by the Chairman, upon motion of T. W. Galloway, the committee on Ecological Survey was continued.

Notice was given of opportunity to visit the Mine Rescue Station.

F. C. Baker presented a paper which is given in abstract below:

THE ECOLOGY OF THE SKOKIE MARSH AREA WITH SPECIAL REFERENCE TO THE MOLLUSCA.

The present paper is an attempt to place on record a minute study of a small territory with special reference to its molluscan inhabitants. The area chosen is in the Skokie Marsh Region north of Chicago. The territory actually surveyed included a tract of land three miles long and one mile wide, extending from Glencoe west to Shermerville. It is situated in the Glacial Skokie Bay, which, by natural drainage, has become a swamp of large extent. Three streams traverse the area in a southerly direction: (1) a small stream through the center of the marsh near Glencoe, which is for the most part of a transient character; (2) the east branch of the Chicago river; and (3), the north branch of the Chicago river, flowing through Shermerville. This area divides into five subordinate areas: A, the marsh, which is low and wet with the characteristic Typha and Calamagrostis plants; B, an intermediate ridge west of the marsh, which is low and wet on its eastern edge, but which rises to a height of twenty feet above the Skokie stream on its western edge; this region contains several forested areas of oak, cottonwood, maple, elm, and other large trees; C, the east branch of the Chicago river which embraces a wide flood plain bordered by rather high terraced banks, and supporting a characteristic swamp and bog vegetation, notable among which is the button-bush; D, a large area west of the east branch, which rises to a height of forty feet above the river and is heavily forested with large trees of elm, oak, cottonwood, maple, etc.; E, the north branch of the Chicago river, which flows through a flat, more or less marshy plain.

Each of the above five areas is divisible into several stations, each more or less characteristic. Thirty-six such stations have been closely examined and a study made of their biotic contents. The mollusca were exhaustively studied, the associated animals (as birds, reptiles, batrachians, insects, and crustaceans) being also listed. As a study of animal ecology is not complete without a consideration of the associated plants, this important branch of biology has been studied and lists made of the important plant societies.

A taxonomic study of the mollusca of this region shows the collections secured to embrace two classes, three orders, fourteen families, twenty-three genera, thirty-eight species and varieties, all living within the area three miles long and one mile wide. Of interest in this connection is the discovery that, apparently, several species in two families were founded upon age variation. One, *Lymnaea reflexa* Say, included *Lymnaea palustris michiganensis* Walker (young) and *Lymnaea crystalensis* Baker (immature); the other, *Physa gyrina* Say, included *Physa oleacea* Tryon (immature.) Twenty terrestrial and eighteen fluviatile mollusks were identified.

The typical molluscan societies and their habitat relations may be summed up as follows:

Terrestrial Species.

In swamp with Typha or Iris.

Succinea retusa, Succinea avara, Agriolimax campestris.

On low ground subject to overflow.

Agriolimax campestris, Polygyra thyroides, Polygyra fraterna, Pyramidula alternata, Zonitoides arborcus, Vitrea hammonis.

On higher ground, raised above overflow.

Succinea ovalis, Agriolimax campestris, Polygyra albolabris, Philomycus carolinensis.

On dry ground.

Strobilops virgo, Helicodiscus parallelus, Vitrea indentata, Euconulus fulvus, Bifidaria contracta, B. pentodon.

Living under "started" bark, etc.

Zonitoides, Vitrea, Strobilops, Helicodiscus, Vertigo, Euconulus, Bifidaria, and *Carychium.* *Pyramidula* is frequently found under "started" bark, and *Polygyra albolabris* haunts holes and large crevices in dry weather.

Fluviatile Species.

Found in all varieties of habitat.

Physa gyrina.

In large summer-dry ponds.

Physa gyrina, Planorbis trivolvis, Planorbis parvus, Planorbis exacuous, Segmentina armigera, Musculium partumeium, Ancylus parallelus, Lymnaea reflexa.

In small pools of very transient character.

Lymnaea caperata, Aplexa hypnorum, Sphaerium occidentale.

In the river, which does not run dry.

Sphaerium stamineum, Musculium transversum, Lampsilis, Anodonta, Anodontoides, Physa gyrina, Planorbis trivolvis, Ancylus rivularis.

Semiaquatic; on the edge of river and pools.

Lymnaea parva sterkii.

In brooks and overflow from river.

Lymnaea caperata.

C. W. Andrews.—"Is Skokie Marsh connected with the outer belt area in Chicago?"

F. C. Baker.—"It is."

Victor E. Shelford presented an illustrated paper of which an abstract is given below.

ECOLOGICAL SUCCESSSION OF FISH AND ITS BEARING ON FISH CULTURE.

The investigation with which my paper deals is not yet completed. The results are too extensive for reading before the Academy. Accordingly, only an abstract of the chief facts and conclusions is given here. The completed work will be published elsewhere later.

I. Definition. Ecological succession differs from geological succession or the succession of species, in that species may be ignored, except as names are necessary, and only the *habits* of the forms taken into consideration.

II. Area studied. The area studied is at the head of Lake Michigan where deposition of sand and the recession of the lake have caused the formation of a series of long sloughs parallel with the shore. Attention has been concentrated on the first, fifth, seventh, and fourteenth of these, as counted from the lake. The first is youngest. The fifth may be considered as at least five times as old as the first; the seventh, seven times as old; and the fourteenth, fourteen times as old.

III. Succession. Slough XIV was once in the same stage as slough I, and was then occupied by fish ecologically similar to those in slough I at present. The vegetation grew and humus accumulated, making it impossible for the ecological types of slough I to continue, and these were succeeded by the ecological types such as we now find in slough V; in due time these gave way to the ecological types in slough VII, and these likewise to those of slough XIV.

IV. Causes. This includes causes of succession of fish, and the factors governing the distribution of fish with reference to the disappearance of the food fishes (large mouthed black bass, the green sunfish, and bluegill) from the sloughs as they grow older or in other words their absence from all but slough I when they colud have gotten into the other until recently, when certain railroad culverts were discontinued and filled.

1. *Size and depth.* It is not due to their selecting the largest and deepest bodies of water. These fishes are found in the shallowest and smallest of the ponds (slough I).

2. *Chemistry of water.* An analysis has shown difference too slight to be recognized by fish.

3. *Food.* The fish are not where the food supply is greatest.

a. Food has been shown to be greatest in the sloughs which do not contain these fish.

b. The fish food consumed in each slough is about the same, but the consumers in the older sloughs are different and undesirable fishes.

c. The fish food supply is greatest in the older members of another series of ponds studied for comparison. In these fishes are numerous in the older ponds, and fish are almost absent from the youngest which is artificial. The greatest food supply in the older sloughs is not, due therefore, to the absent of the fish in question, but to *other causes.*

4. *Living place of the fish.* The fish are not in the situations which they are known to frequent in large bodies of water, as these situations are not present in slough I, but are present in the others.

5. *Breeding place.* These fish are known to breed chiefly on bare bottom. The vegetation and humus which come with age *destroy bare bottom and hence fish breeding places.* Slough I is the only one having extensive bare bottom. The fish in question are in the pond containing suitable breeding places, to the neglect of other factors.

V. CONCLUSIONS. 1. *Scientific.* The breeding habits and distribution of suitable breeding places are the first factors in the distribution and succession of fish, as has been shown for certain beetles and is held for birds. This is crucial to ecological study.

2. *Economic.* a. These data indicate clearly that the pro-oduction of food fishes of a given area depends upon the availability of suitable breeding places.

b. Economic effort should be directed toward: (1) The study of the behavior of fish, especially during the breeding season. (2) The cultivation, preservation, and protection by legislation of the breeding places of food and game fishes.

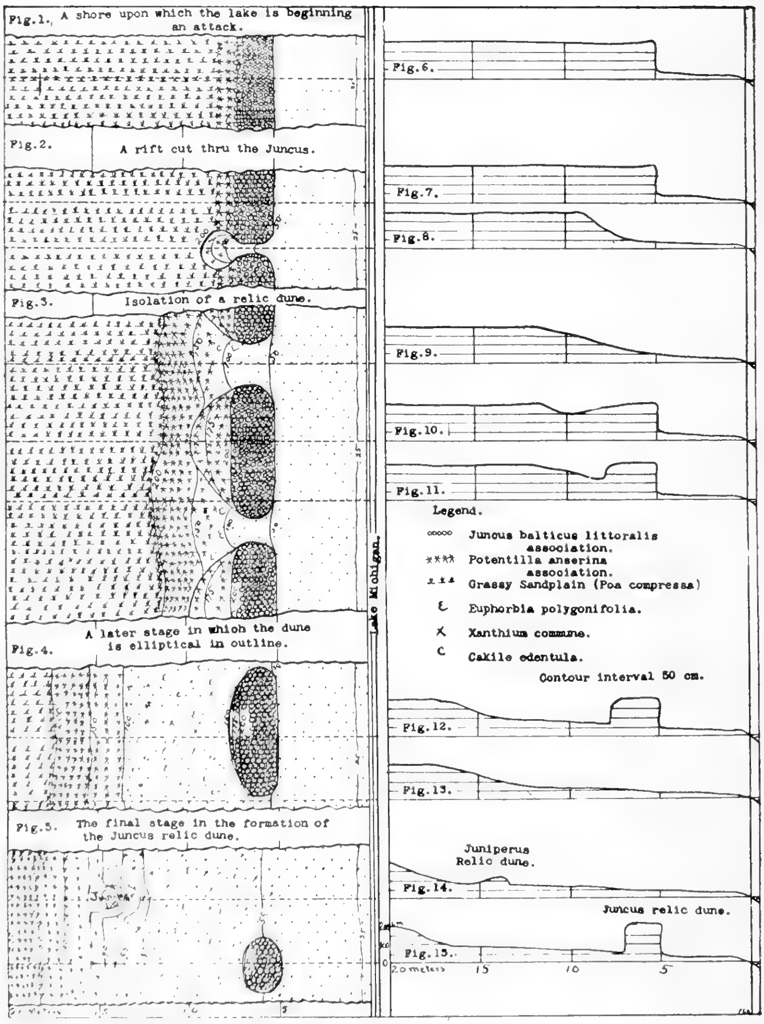
The following paper was presented by Frank C. Gates:

RELIC DUNES, A LIFE HISTORY.

A relic dune is a mound of sand left for a time during the washing away of a beach. It is but a temporary stage even when well protected by an efficient plant covering. The relic dunes with which this article deals are to be found along the western shore of Lake Michigan from Kenosha, Wisconsin, down to the Illinois-Wisconsin state line. In that locality the shore is being gradually washed away by the action of Lake Michigan. The dunes were studied during 1908 and 1909, during which time the complete stages of destruction of some of the dunes were observed.

To explain the formation and the stages of destruction of these dunes, it is necessary to go into the historical development of this part of the lake shore. This beach is the exposed lake bottom and sand bars of a glacial Nipissing lake which preceded the present Lake Michigan and was from 3 to 17 meters above it in level. Since the low-water period, which ended about 1896, the rising waters of the lake have been cutting into the beach in places and carrying the sand along the beach toward the southwards. From Winthrop Harbor north to Kenosha is a place where the shore is being washed away fairly rapidly. When such action commences, there is usually a bluff formed at the line of contact of the storm waves and the beach. The bluff, however, is maintained by plants, for the sand of which the soil is composed will not of itself remain in such a position. The profile of such a beach is shown in Fig. 6 of the diagram.

The plant association that is all important in maintaining the bluff is the *Juncus balticus littoralis* association. From 97 to 99% of the individual plants belong to that species of *Juncus*. The rhizones form a very dense tangle, which not only helps to protect the beach from the attack of the waves, but also serves to protect the sand from desiccation, for dry sand forms a gradual slope instead of an adrupt bluff. Back of the *Juncus balticus littoralis* association is the *Potentilla anserina* association, a narrow zone, separating the *Juncus* from the grassy sand plain which stretches back for many meters. As was the case with the *Juncus* association, the facies comprises more than 80% of the *Potentilla anserina* association. The secondary species which make any showing whatsoever are *Monarda punctata, Sporobolus cryptandrus,* and *Cenchrus carolinianus.* Both of these grasses usually occur in the tension zone between



Diagrams showing the development of a relic dune.

this association and the grassy sand plain. This later association is composed of over 90% of *Poa compressa,* which, however, does not grow sufficiently thick to prevent the sand from giving the color tone to the area. Secondary species appear scattered throughout, but they are never of much importance, as they occur only as individuals here and there in the grass. Some of the most frequently occurring secondary species are:

Euphorbia corollata,
Verbena hastata,
Erigeron canadensis,
Verbascum thapsus,
Cacalia tuberosa
Monarda punctata,
Pycnanthemum virginicum,
Panicum (?pseudopubescens),
Isanthus brachiatus,
Erigeron divaricatus,
Poa pratensis,
Rumex acetosella,
Achillea millefolium,
Anaphalis margaritacea.
Oxalis stricta,
Lobelia spicata,
Scutellaria parvula,
Hypericum kalmianum,
Potentilla arguta.

The most important secondary species of this association from the view-point of this article are *Juniperus horizontalis* and *Juniperus communis depressa,* because they are the only secondary species that can form relic dunes. There are a few mats of each of these junipers at intervals in the sod. These together with the *Juncus balticus littoralis* are the only species which, in this region, are instrumental in the formation of relic dunes.

With this brief consideration of the physiographic appearance of the region and the plant associations which occupy it, the steps in the formation of the relic dunes are now in order. In places where in every storm, not merely the more violent ones, the waves attack the bluff, sooner or later passageways or rifts will be cut thru the *Juncus* association. This allows undermining of the sand plain, whose surface is sparsely covered with vegetation, the roots of which have but a very limited sand-binding capacity. Consequently the plain is washed away as far as the waves have power. A few of the stages that follow are shown in the accompanying plate, in which the structure of the surface is shown on the left, and on the right selected profiles have been constructed.

The sand from immediately to the landward of the *Juncus* is carried into the lake in the backwash of the waves, thus leaving a mound of sand, thoroughly permeated with *Juncus* rhizomes and usually having a coat of exposed rhizomes, which become dry under the desiccating action of the wind and sun.

At first the relic dunes are elliptical in shape, with their major axis parallel with the shore line. By washing away the ends, however, succeeding storms reduce them to an approximately circular outline. In this form they may endure for a couple or more years, depending upon the violence of the storms.

The relic dune itself is a mound of sand about 2 meters high and about 2.5 meters broad. At the top is a very dense growth of *Juncus balticus littoralis,* whose rhizomes thoroughly permeate the dune. At the outside the exposed rhizomes, which usually form a rather dense matwork, protect the dune from both the desiccating and mechanical effects of the wind. From the attack of the waves the rhizomes are of relatively smaller value. The sides of the dunes are cut out in grooves, especially near the bottom where the wind and wave action is more pronounced. A few secondary species occur on the cap, such as *Sporobolus cryptandrus, Cornus stolonifera, Calamovilfa longifolia,* and *Salsola kali tenuifolia,* but the number of individuals is so small that they are of relatively no importance.

The *Juniperus communis depressa* relic dune, of which at the present writing there is only one in the area, is a poorly developed dune near the limit of wave action. The roots of this plant have not the sand binding power that those of the *Juncus* have. Consequently any exposed sand would be blown away. As the sand is removed by blowing or otherwise, the outermost branches of the juniper sink down and cover the sides of the mound with vegetation which protects it in quite a fair measure from much further action by the wind. Toward the west or landward side the prevailing westerly winds keep piling up sand faster than the juniper can cover it up. Within the next few years, if the present rate of erosion continues, there will be seven or eight more relic dunes of both species of juniper, at which time a better understanding of this class of relic dunes will be possible.

The destruction of the relic dunes takes place thru the same agencies that were instrumental in their formation. The wave action during violent storms is one of the most potent agencies of destruction, both because of its mechanical force and the ready movement of sand grains when submerged. The wind in general acts as a desiccating agent, but obtains direct action where the sides of the dunes are unprotected. As the surface dries, the outside grains no longer stick to the moister ones within, but either fall to the base of the dune because of gravity, or are blown away by the wind. This method of destruction is very slow because the dunes are abundantly supplied with water by capillary attraction from the water table, by spray blown in from the lake, by the quite frequent rains of this region, and by dew which is often deposited upon them during the nights when the sand cools down much faster than the surrounding air.

A more violent, though rather infrequent agency, is the disruptive power of freezing water. In instances of the action of this agency in 1909, the dunes were thoroughly soaked by a heavy rain, which was followed immediately by a drop in temperature from 0.5° to 12°C, the result of which was the cracking of the dunes. The broken pieces were like rocks on account of the ice, but as soon as the ice at the surface evaporated, the wind scattered the loosened sand grains over the surface of the beach. Several of the smaller relic dunes were thus disintegrated during November 1909. The larger dunes merely suffered the removal of 10-20 cm. of sand from around the edge of the crown. The vegetation of the rim slipped down and now serves to protect the dune during the winter.

In the part of the area which has been under consideration, the lake is advancing upon the shore rather rapidly, so rapidly that the *Juncus*, even with its relatively rapid means of vegetative propagation, has been unable to retreat. It merely holds the ground upon which it had formed a zone parallel to the shore line. Consequently, as soon as the *Juncus* relic dunes are destroyed, the *Juncus* association will become non-existent in this particular area. The *Potentilla anserina* association, on the other hand, spready by seeds as well as vegetatively. It has widened out from a strip 0.5-1.0 meters wide back of the *Juncus,* to large mats 5 to 7 or more meters in diameter, which occupy the sand area between the relic dunes and the grassy sand plain. The maximum development occurs just below the grass. Where it overlaps into the grass the vegetation is noticeably heavier than in either of the two associations. This is aided by a few secondary species, especially *Sporobolus cryptandrus* and *Monarda punctata.* The grass (*Poa compressa*) forms a permanent vegetative covering, but the *Potentila* dries up during the winter. During the growing season much blowing is prevented by the covering of *Potentilla,* but with the removal of this in the fall the blowing of sand commences, and during the winter the amount that is blown away is noticeable. Much of it tends to accumulate southward of this area.

From the state line south to Winthrop Harbor the shore dips away from so direct an attack from the waves. Here the *Juncus* is able to retreat from the shore line, and although relic dunes still are being formed, there is still a relatively wide zone of *Juncus* behind them which protects the grassy plain from being washed away.

T. E. Savage presented the following paper:

THE GRAND TOWER (ONONDAGA) FORMATION OF ILLINOIS, AND ITS RELATION TO THE JEFFERSONVILLE BEDS OF INDIANA.

The name Grand Tower formation was proposed by Keyes[1] for the Devonian strata in southeast Missouri, which were considered the equivalent of the Onondaga and the Oriskany of the New York section. The name is taken from the town of Grand Tower, in Jackson county, Illinois. The term is here amended to include only that part of the Devonian strata in southwest Illinois, and adjacent portions of Missouri, which is the western representative of the Onondaga

1 Keyes. Mo. Geo. Survey, Vol. III, p. 339, 1894.

limestone of New York. The name Clear Creek formation has been applied to the Devonian beds in Illinois that correspond in age with the upper Oriskany portion of the New York Devonian.

Distribution and Conditions of Deposition.. The Grand Tower formation, like the lower Devonian strata in Illinois, is thought to have been laid down in a narrow arm of the sea that had connection southward with the Gulf of Mexico. It is found in our state over only a small area in the extreme southern part. At the base it consists of 25 to 30 feet of sandstone, which is succeeded by about 125 feet of limestone, making an aggregate thickness for the formation of about 155 feet.

. The sandstone of the Grand Tower formation overlies the Clear Creek, or Upper Oriskany, beds with no intervening break in sedimentation. The quiet conditions under which the Oriskany strata were deposited in this region were broken by a movement to the westward, in Ozarkia, which increased mechanical sedimentation over this portion of the basin. The movement was intermittent, and resulted for a time in the deposition, along the west border of the embayment, of layers of sand containing a mingling of Onondaga and Oriskany fossils, alternating with periods of quiet during which limestone layers, containing typical Oriskany fossils, were accumulated. As a result, there is in this region an interwedging of the upper layers of the Oriskany and the basal portion of the Grand Tower strata along the zone of contact of these formations. Eventually sand deposition prevailed, and there was spread over the basin a mantle of sand 20 to 30 feet in thickness, which constitutes the lower member of the Grand Tower formation. This sandstone is exposed in the southwest part of Jackson county, and at numerous points further south, in the counties of Union and Alexander.

After the deposition of the basal sandstone, there was a further movement in the Ozarkian region of Missouri, that resulted in pushing the west shore of the sea further eastward in southern Union and in Alexander county, and put a stop to sedimentation in that portion of the basin during all of the remaining Onondaga time. In the vicinity of Grand Tower, and in the north part of Union county, however, deposition was uninterrupted, and there was laid down above the sandstone a thickness of 125 feet of Onondaga limestone.

The transition beds from the sandstone to the overlying limestone, and all of the limestone member, are well exposed in what is known as the Devil's Backbone and Bake-oven ridge, one-half mile to one mile north of Grand Tower. The contact of the Grand Tower limestone with the succeeding Hamilton beds may also be clearly seen in the Backbone bluff.

The strata in this region are all inclined to the eastward at an angle of about 24 degrees. This is due to the upthrow on the east side of a north-south fault plane that cuts the strata some distance further west, in Missouri.

Method of Work. In the detailed study of the strata of the Grand Tower formation, and effort was made to obtain as nearly as possible the entire fauna of the vorious rock layers, and also to determine the vertical range and relative aboundance of the different species of fossils. To this end the exposed rock ledges were arbitraril divided into zones from six inches to only a few feet in thickness. The fossils from each of these layers of zones were kept separate, in order that the range and the relations of the successive faunules might be ascertained. This method of work has made it possible to determine the species of fossils that are distinctive respectively of the various horizons of the formation, and has furnished much information concerning the fauna that could be obtained in no other way.

Detailed Sections. There are given below detailed sections of the Grand Tower strata exposed in Illinois, accompained by lists of fossils that were collected from the successive horizons. In these lists the relative abundance of each species is indicated by the suffix r (=rare), c (=common), or a (=abundant) after the name.

Section of the basal portion of the Grand Tower formation exposed along a small stream in the northwest quarter of sec-

Fig. 7. Exposure of Grand Tower limestone in the back-bone ridge, one-half mile north of Grand Tower, in Jackson county, Illinois.

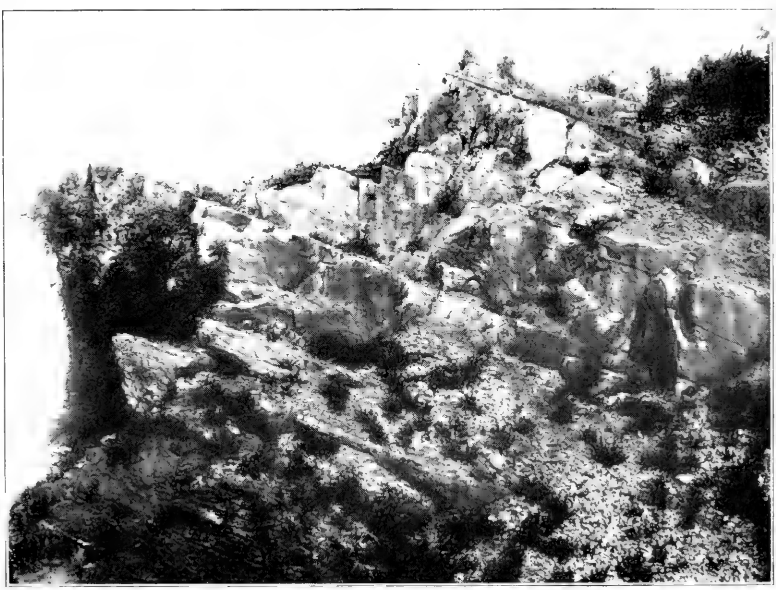


Fig. 8. Upper portion of Grand Tower limestone showing massive character of the layers, and eastward dip of the strata. Contact of Grand Tower and Hamilton exposed near the top.

tion 26, Jonesboro township (T. 12 S., R. 2 W.) in Union county. The section is designated S. 60, and the sequence is from the bottom upward.

S 60 a. Bed of gray to yellow chert in layers four to nine inches thick (Clear Creek formation) ....9 feet.

S 60 b. Reddish-brown, rather friable sandstone (Grand Tower formation).. .. ..2 feet.

S 60 c. Gray chert in layers three to eight inches thick, containing numerous Clear Creek fossils ....1 foot, 6 in.

S 60 d. Reddish-brown, friable sandstone, in layers ten to eighteen inches thick (Grand Tower formation) ....2 feet, 10 inches

Michelinia stylopora a,
Amphigenia curta r,
Meristella cf. *lentiformis* r,
Pentamerella cf. *arata* r,
Spirifer duodenarius r,
Spirifer cf. *granulosus* c.

S 60 e. Layers of gray chert, three to nine inches thick, containing numerous fossils characteristic of the Clear Creek formation .... 5 feet, 7 inches

S 60 f. Reddish-brown, rather soft sandstone, containing many fossils .. ..6 feet, 8 inches

Favosites hemisphericus? c,
Michelinia stylopora a,
Zaphrentis exigua c,
Zaphrentis cf. *nitida* c,
Zaphrentis cf. *recta* c,
Zaphrentis ungula c.
Amphigenia curta r,
Leptostrophia perplana r,
Meristella cf. *lentiformis* r,
Nucleospira cf. *elegans* r,
Spirifer sp. c,
Tentaculites elongatus r

The interwedging of the upper layers of the Clear Creek cherts with the lower layers of the succeeding sandstone of Onondaga age, as shown in the foregoing section, indicates that the Onondaga deposits follow the cherts without any break in sedimentation, and that the Clear Creek formation in Illinois represents deposits of Upper Oriskany time.

A sandstone ledge, eleven feet in thickness, representing a horizon slightly higher than the preceding, is exposed in the southeast quarter of section 34, T. 11 S., R. 2 W. From this outcrop the following fossils were obtained:

Aulacophyllum trisulcatum? r,
Favosites sp. undt, r,
Michelinia stylopora c,
Zaphrentis exigua c,
Zaphrentis nitida? c,
Zaphrentis recta c,
Zaphrentis ungula c,
Athyris vittata r,
Centronella glansfagea r,
Leptaena rhomboidalis r,
Leptostrophia perplana a,
Meristella cf. *lentiformis* c,
Rhipidomella cf. *musculosa* c,
Rhipidomella vanuxemi r,
Schuchertella chemungensis arctistriata r,
Spirifer duodenarius c,
Spirifer sp. c,
Spirifer cf. *macrothyris* r,
Stropheodonta demissa c,
Conocardium cuneus var. c,
Odontocephalus arenarius c,
Phacops cristata c,
Proetus crassimarginatus c,
Proetus marginalis c,
Proetus cf. *folliceps* c,
Proetus sp. r

The names of the fossils collected from this sandstone are prefixed by a star in the general table of fossils from the Grand Tower formation, given on a later page.

The following is a section of the Grand Tower strata excellently exposed in the Backbone-Bake-oven ridge, a short distance north of the town of Grand Tower. The lower part was made from the north and west sides of the Bake-oven bluff, while the middle and upper portions were taken from the west face of the Backbone ridge, one-half mile further south. The section bears the field number S 56, and begins with "a" at the bottom. The total thickness of strata exposed here is about 129 feet.

S 56 a. Bed of coarse grained, gray, crystalline limestone, in layers six to eighteen inches thick, somewhat arenaceous in the lower part. To the level of the water in the river ....8 feet.

Dendropora neglecta r,
Ambocoelia umbonata r,
Atrypa reticularis r,
Camarotoechia cf. *carolina* c,
Centronella glansfagea r,
Chonetes mucronatus r,
Dalmanella sp. r,
Leptaena rhomboidalis c,
Leptostrophia perplana r,
Meristella cf. *lenta* c,
Nucleospira concinna c,
Nucleospira ventricosa r,
Pholidops hamiltonae r,
Productella sp. r,
Rhipidomella cf. *musculosa* r,
Rhipidomella livia c,
Rhipidomella sp. r,
Schizophoria propinqua r,
Spirifer cf. *disparilis* r,
Spirifer duodenarius r,
Spirifer macrothyris c,
Spirifer macrus r,
Stropheodonta concava c,
Stropheodonta demissa r,
Strophonella ampla c,
Platyceras carinatum r,
Platyceras erectum c,
Platyceras dumosum r,
Platyostoma sp. r.

S 56 b. Alternating and somewhat mixed layers of gray, crystalline limestone, and of rather coarse grained sandstone, the sandstone element somewhat predominating ....7 feet, 6 inches.

Coscinium cribriforme r,
Atrypa reticularis c,
Centronella glansfagea c,
Charionella scitula r,
Chonetes mucronatus r,
Dalmanella lenticularis r,
Eatonia? sp. r,
Leptaena rhomboidalis c,
Meristella lenta c,
Rhipidomella vanuxemi c,
Spirifer duodenarius c,
Spirifer intermedius r,
Spirifer macrothyris r,
Spirifer macrus r,
Stropheodonta sp. r.
Strophonella ampla r,
Tentaculites scalariformis r,
Platyceras carinatum r,
Platyceras erectum c

S 56 c. Bed of gray, granular, sub-crystalline limestone, fossils most abundant in the lower part, an iron stained zone present at the top ....4 feet.

Coscinium cribriforme r,
Atrypa reticularis c,
Centronella glansfagea r,
Chonetes mucronatus r,
Eatonia whitfieldi? r,
Leptostrophia perplana r,
Rhipidomella vanuxemi c,
Spirifer duodenarius c,
Spirifer intermedius r,
Spirifer macrothyris c,
Spirifer macrus r,
Spirifer cf. *varicosus* r,
Stropheodonta inaequiradiata r,
Strophonella ampla c,
Igoceras conicum r,
Platyceras erectum c,
Platyceras carinatum r,
Platyceras thetis r,
Platyostoma lineata r,
Dalmanites sp. c,
Odontocephalus aegeria a,
Proetus sp. r,

S 56 d. Gray, crystalline limestone, in imperfect layers fourteen to twenty-four inches thick. Trilobite remains most abundant in the middle and upper parts ....14 feet.

Atrypa reticularis r,
Centronella glansfagea c,
Leptaena rhomboidalis c,
Pentamerella arata? r,
Rhipidomella sp. r,
Spirifer duodenarius r,
Spirifer macrothyris c,
Spirifer macrus r,
Spirifer cf. *segmentus* r,
Spirifer varicosus r,
Dalmanites calypso c,
Odontocephalus aegeria a,
Phacops sp. r.

S 56 e. Gray, granular to sub-crystalline limestone, in layers six to eleven inches thick. Fossils imperfectly preserved ....6 feet.

Anoplia nucleata? r,
Camarotoechia carolina c,
Centronella glansfagea c,
Leptaena rhomboidalis r,
Meristella cf. *nasuta* c,
Spirifer duodenarius r,
Spirifer macrothyris c,
Platyceras dumosum r,
Platyceras sp. r.

S 56 f. Gray, sub-crystalline limestone, with a two-inch band of much broken fossils at the base ....5 feet, 2 inches.

Atrypa reticularis c,
Camarotoechia carolina c,
Centronella glansfagea c,
Leptaena rhomboidalis r,
Rhipidomella vanuxemi c,
Schizophoria propinqua r,
Spirifer sp. r,
Spirifer macrothyris c,
Platyceras sp. r,
Dalmanites sp. c,
Odontocephalus aegeria c,
Fish remains c,

S 56 g. Light gray, sub-crystalline limestone, in layers ten to twenty-four inches thick. A three-foot barren zone near the middle, and a trilobite zone near the top ....5 feet, 4 inches.

Camarotoechia carolina c,
Camarotoechia tethys r,
Centronella glansfagea c,
Charionella scitula r,
Cyrtina hamiltonensis r,
Leptaena rhomboidalis r,
Rhipidomella vanuxemi r,
Schizophoria propinqua c,
Spirifer duodenarius r,
Spirifer varicosus c,
Platyceras dumosum r,
Odontocephalus aegeria c.

S 56 h. Layer of light gray, sub-crystalline limestone ..3 feet, 2 in.

Cystiphyllum americanum r,
Dolatocrinus sp. r,
Nucleocrinus sp. r,
Athyris vittata c,
Atrypa aspera r,
Atrypa reticularis a,
Camarotoechia carolina c,
Centronella glansfagea a,
Charionella scitula r,
Chonetes mucronatus r,
Craniella hamiltonae r,
Cyrtina hamiltonensis c,
Eunella sp. r,
Leptaena rhomboidalis r,
Meristella sp. r,
Nucleospira ventricosa c,
Pentamerella arata? r,
Pholidops hamiltonae r,
Pholidostrophia iowensis r,
Productella spinulicosta r,
Reticularia fimbriata c,
Rhipidomella vanuxemi a,
Cf.*Rhynchonella* sp. c,
Schizophoria propinqua c,
Schuchertella cf. *pandora* r,
Spirifer duodenarius a,
Spirifer varicosus c,
Stropheodonta concava r,
Stropheodonta demissa r,
Stropheodonta inaequistriata c,
Stropheodonta patersoni r,
Stropheodonta sp. r,
Actinopteria sp. r,
Aviculopecten terminalis r,
Orthonychia dentalia r,
Platyceras blatchleyi c,
Platyceras carinatum r,
Platyceras dumosum c,
Platyceras erectum r,
Platyceras subrectum r,
Platyostoma turbinata cochleata r,
Dalmanites cf. *calypso* r,
Dalmanites sp. r,
Odontocephalus aegeria r,
Proetus cf. *clarus* r.

S 56 i. Impure, dark colored, fine-grained limestone, in imperfect layers nine to twenty-three inches thick. A band containing numerous shells of a small Chonetes occurs about twenty inches below the top ....7 feet, 9 inches.

Heliophyllum sp. r,
Atrypa reticularis c,
Atrypa spinosa r,
Chonetes cf. *pusillus* a,
Craniella hamiltonae r,
Leptostrophia perplana r,
Pentamerella arata r,
Pholidops hamiltonae r,
Pholidostrophia iowensis a,
Productella spinulicosta r,
Reticularia fimbriata r,
Reticularia fimbriata var. r,
Rhipidomella vanuxemi a,
Schizophoria propinqua a,
Schuchertella chemungensis pectinacea r,
Spirifer sp. r,
Schuchertella chemungensis perversa r,
Spirifer duodenarius r,
Spirifer cf. *grieri* r,
Spirifer varicosus c,
Strophalosia truncata r,
Stropheodonta concava c,
Stropheodonta crebristriata r,
Stropheodonta inaequistriata r,
Stropheodonta patersoni c,
Cf. *Aviculopecten ignotus* r,
Callonema lichas r,
Loxonema terebrum r,
Platyceras blatchleyi c,
Platyceras carinatum r,
Platyostoma lineata r,
Gomphoceras sp. r,
Phacops sp. a.

S 56 j. Impure, gray limestone, with few fossils ....3 feet, 4 inches.

Camarotoechia carolina r,
Spirifer cf. *intermedius* r,

S 56 k. Dark colored, impure limestone, in imperfect layers four to ten inches thick ....2 feet, 3 inches.

Atrypa reticularis a,
Camarotoechia carolina c,
Chonetes mucronatus a,
Cyrtina hamiltonensis c,
Leptostrophia perplana c,
Nucleospira concinna c,
Pholidostrophia iowensis a,
Productella spinulicosta r,
Rhipidomella vanuxemi c,
Schizophoria propinqua a,
Schuchertella chemungensis arctistriata c,
c,
Spirifer duodenarius r,
Spirifer raricostus r,
Spirifer varicosus c,
Spirifer sp. r,
Stropheodonta concava a,
Stropheodonta inaequistriata c,
Stropheodonta inaequistriata var. a,
Stropheodonta patersoni a,
Strophonella ampla r,
Aviculopecten sp. r,
Aviculopecten terminalis r,
Conocardium cuneus var. r,
Bellerophon sp. r,
Callonema lichas r,
Euomphalus decewi r,
Murchisonia sp. r,
Orthonychia dentalia r,
Platyceras carinatum r,
Dalmanites sp. r

S 56 l. Bed of impure limestone, in layers eight to twelve inches thick ....1 foot, 8 inches.

Atrypa aspera r,
Atrypa reticularis r,
Camarotoechia horsfordi c,
Chonetes lineatus c,
Chonetes yandellanus r,
Leptostrophia perplana c,
Meristella rostrata r,
Productella spinulicosta r,
Rhipidomella vanuxemi c,
Stropheodonta cf. *callosa* r,
Stropheodonta concava r,
Stropheodonta inaequistriata var. r,
Schizophoria propinqua c,
Spirifer sp. r,
Spirifer varicosus c,
Platyceras carinatum r,
Phacops cristata r,

S 56 m. Layer of dark gray, impure limestone ....10 inches.

Atrypa aspera r,
Atrypa reticularis c,
Camarotoechia carolina c,
Chonetes yandellanus c,
Leptostrophia perplana a,
Productella spinulicosta c,
Rhipidomella vanuxemi c,
Schizophoria propinqua r,
Spirifer acuminatus? r,
Stropheodonta concava r,
Stropheodonta demissa r,
Stropheodonta inaequiradiata r,
Tentaculites scalariformis c,
Aviculopecten exacutus r,
Schizodus sp. r,
Orthonychia dentalia r,
Platyceras sp. r,
Platyceras carinatum r,
Phacops cristata c,
Proetus sp. r,
Onychodus sigmoides r

S 56 n. Bed of dark gray to drab limestone, in imperfect layers three to eight inches thick, with intercalated thin bands of chert ....3 feet, 6 inches.

Amplexus yandelli r,
Dendropora cf. *elegantula* r,
Nucleocrinus sp. r,
Nucleocrinus verneuili r,
Cystodictya gilberti r,
Fenestella stellata r,
Orthopora sp. r,
Polypora cf. *quadrangularis* r,
Semicoscinium sp. r,
Ambocoelia umbonata r,
Athyris vittata c,
Atrypa aspera c,
Atrypa reticularis a,
**Camarophoria gainesi* c,
Camarotoechia carolina c,
Camarotoechia sappho c,
Charionella scitula c,
Chonetes mucronatus c,
Chonetes yandellanus r,
Crania crenistriata r,
Craniella hamiltonae r,
Cyrtina hamiltonensis c,
Leptaena rhomboidalis r,
Leptostrophia perplana a,
Orbiculoidea ampla r,
Pentamerella papilionensis r,
Pholidops hamiltonae r,
Pholidostrophia iowensis r,
Productella spinulicosta a,
Rhipidomella vanuxemi c,
Rhynchonella cf. *louisvillensis* r,
Roemerella sp. r,
Schizophoria propinqua c,
Schuchertella chemungensis perversa r,
Spirifer sp. r,
Spirifer macrus r,
Spirifer varicosus r,
Stropheodonta concava c,
Stropheodonta inaequistriata r,
Stropheodonta inaequistriata var. c,
Stropheodonta inaequiradiata r,
Stropheodonta patersoni c,
Aviculopecten sp. c,
Aviculopecten sp. c,
Aviculopecten exacutus r,
Aviculopecten terminalis r,
Cf. *Actinopteria boydi* c,
Glyptodesma occidentalis r,
Cypricardinia indenta r,
Modiomorpha linguiformis r,
Cf. *Pterinopecten multiradiatus* r,
Igoceras conicum c,
Murchisonia sp. r,
Platyceras blatchleyi c,
Platyceras carinatum r,
Platyceras dumosum r,
Strophostylus varians r,
Gomphoceras sp. r,
Dalmanites calypso r,
Phacops rana c,
Proetus clarus r,
Proetus sp. r.

*Ths species was described by Nettelroth as *Rhynchonella gainesi,* but it possesses a spoon-shaped spondylium as in Camarophoria.

S 56 o. Bed of hard, grayish-brown limestone, in imperfect layers which on weathering appear to be three to twelve inches thick. Fossils most abundant in a two-foot zone near the middle..22 feet, 6 inches.

Atrypa reticularis r,
Camarotoechia carolina c,
Camarotoechia horsfordi c,
Camarotoechia tethys c,
Chonetes yandellanus a,
Leptostrophia perplana r,
Pholidops hamiltonae r,
Pholidostrophia iowensis r,
Productella spinulicosta r,
Spirifer macrus? c,
Spirifer varicosus c,
Stropheodonta concava r,
Stropheodonta demissa c,
Tentaculites scalariformis a,
Paracyclas elliptica r,
Platyceras blatchleyi r,
Platyceras carinatum r,
Platyceras erectum r,
Proetus sp. r,

S 56 p. Dark colored, impure limestone, in layers three to ten inches thick. Shells of large Stropheodonta near the middle. .3 ft., 6 in.

Atrypa reticularis c,
Camarophoria gainesi r,
Chonetes mucronatus a,
Leptaena rhomboidalis c,
Leptostrophia perplana r,
Lingulodiscina? sp. r,
Pholidostrophia iowensis r,
Productella spinulicosta r,
Rhipidomella vanuxemi c,
Schizophoria propinqua r,
Spirifer acuminatus r,
Spirifer sp. r,
Spirifer varicosus r,
Stropheodonta concava c,
Stropheodonta demissa r,
Stropheodonta patersoni r,
Stropheodonta inaequistriata r,
Tentaculites scalariformis r,
Gomphoceras sp. r

S 56 q. Dark gray, somewhat shaly limestone, in layers six to eleven inches thick ....2 feet, 8 inches.

Camarophoria gainesi r,
Chonetes yandellanus c,
Pholidostrophia iowensis r,
Productella spinulicosta a,
Rhipidomella livia r,
Schizophoria propinqua r,
Spirifer cf. *segmentus* r,
Spirifer gregarius var. r,
Strophalosia truncata r,
Paracyclas elliptica c,
Gomphoceras sp. r

S 56 r. Gray to dark drab, somewhat shaly limestone, in layers two to eight inches thick ....6 feet.

Camarotoechia horsfordi r,
Chonetes konickianus c,
Chonetes yandellanus c,
Productella spinulicosta r,
Rhipidomella livia c,
Spirifer varicosus c,
Strophalosia truncata r,
Stropheodonta concava r,
Paracyclas elliptica r

S 56 s. Gray limestone, in rather thick, imperfectly separating layers, composed largely of shells of Chonetes ....1 foot, 7 inches.

Chonetes yandellanus a,
Pholidostrophia iowensis r,
Spirifer gregarius var. r,
Spirifer sp. r,
Aviculopecten terminalis r,
Paracyclas elliptica r,
Gomphoceras sp. r.

S 56 t. Dark colored, impure limestone, composed largely of shells of Chonetes ....1 foot, 2 inches

Chonetes konickianus c,
Chonetes yandellanus a,
Productella spinulicosta r,
Paracyclas elliptica r.

S 56 u. Gray to dark colored, somewhat shaly limestone....2 feet.

Atrypa aspera c,
Camarotoechia horsfordi c,
Chonetes yandellanus a,
Cyrtina hamiltonensis r,
Leptostrophia perplana r,
Pholidostrophia iowensis c,
Productella spinulicosta r,
Schizophoria propinqua c,
Spirifer gregarius var. r,
Spirifer perextensus c,
Spirifer varicosus c,
Strophalosia truncata r,
Stropheodonta concava c,
Stropheodonta inaequistriata r,
Paracyclas elliptica c,
Bellerophon pelops r.

S 56 v. Gray, impure limestone ....2 feet, 3 inches.

Nucleocrinus sp. r,
Atrypa reticularis r,
Atrypa aspera r,
Chonetes pusillus c,
Leptostrophia perplana r,
Pholidostrophia iowensis c,
Rhipidomella penelope r,
Rhipidomella vanuxemi c,
Rhipidomella sp. r,
Spirifer perextensus r,
Spirifer varicosus c,
Strophalosia truncata c,
Stropheodonta concava r,
Paracyclas elliptica r.

S. 56 w. Hard, gray to drab limestone ....1 foot, 8 inches.

Atrypa reticularis r,
Chonetes yandellanus r,
Nucleospira concinna r,
Pholidostrophia iowensis c,
Productella spinulicosta a,
Schizophoria propinqua r,
Schuchertella chemungensis arctistriata c,
Spirifer sp. r,
Spirifer varicosus r,
Strophalosia truncata a,
Paracyclas elliptica c,
Gyroceras sp. r.

S 56 x. Hard, dark gray limestone, with many small nodules of chert in the upper three feet, and a zone of Chonetes eight inches below the chert ....5 feet, 6 inches.

Chonetes konickianus c,
Pholidostrophia iowensis c,
Productella spinulicosta r,
Spirifer gregarius var. r,
Phacops rana r,
Tentaculites scalariformis r

S 56 y. Massive ledge of hard, gray, sub-crystalline limestone ....7 feet, 6 inches.

Cyathophyllum rugosum c,
Favosites emmonsi c,
Cystodictya meeki r,
Chonetes konickianus c,
Chonetes yandellanus c,
Cyrtina hamiltonensis c,
Eunella sullivanti r,
Pholidostrophia iowensis a,
Productella spinulicosta a,
Cf. *Camarophoria gainesi* (young) r,
Spirifer gregarius r,
Spirifer gregarius var. a,
Spirifer segmentus c,
Strophalosia truncata r,
Stropheodonta concava c,
Leptodesma sp. r,
Loxonema sp. r,
Bellerophon pelops r,
Platyceras blatchleyi r

Immediately above S 56 y the lithology changes abruptly from massive, subcrystalline limestone below, to thinner bedded, more argillaceous material above. Above this member the characteristic Onondaga fossils *Cyathophyllum rugosum, Chonetes konickianus, C. yandellanus, Eunella sullivanti, Spirifer gregarius,* and its variety, *S. segmentus, Bellerophon pelops* and *Platyceras blatchleyi* have disappeared. In their places such Hamilton species as *Microcyclus discus, Chonetes pusillus, Eunella attenuata, Spirifer fornacula, S. divaricatus* and *Actinopteria boydi* become the conspicuous froms.

There is given in tabular form below a list of the fossils collected from the Grand Tower formation in Illinois. In this table the species having a star prefixed to their names, occur in the sandstone member at the base. In column No. 1, on the right, there are indicated by a cross those species occurring in the Grand Tower strata, below the horizon of S. 56 h of the major section, which have also been reported by Kindle[1] from the Jeffersonville beds of Indiana. In column No. 2 there are shown by a cross those Jeffersonville species which are

1Kindle: Devonian Fossils and Stratigraphy of Indiana. 25th Ann. Rept. Geol. and Nat. Hist. of Ind., 1900.

also found in the Grand Tower limestone above the base of S 56 h of the major section. In the third column, crosses indicate those of the Grand Tower species that have been reported from the Onondaga strata of New York[2]. Those species that were also present in the underlying Oriskany (Clear Creek) strata of this region are indicated in the table by the word Oriskany after their names.

General Table of Fossils of the Grand Tower Formation.

	1	2	3
Amplexus yandelli Ed. and Haime			
**Aulacophyllum trisulcatum* Hall			
Cyathophyllum rugosum Hall		x	x
Cystiphyllum americanum Ed. and Haime		x	x
Dendropora cf. *elegantula* Davis			
Dendropora neglecta Rominger			
Favosites emmonsi Rominger		x	
**Favosites* cf. *hemispherica* Troost			
Heliophyllum sp.			
**Michelinia stylopora* Eaton (Oriskany)			
**Zaphrentis exigua* (Billings)			
**Zaphrentis nitida* Hall?			
**Zaphrentis recta* Meek			
**Zaphrentis ungula* Rominger			
Dolatocrinus sp.			
Nucleocrinus verneuili Troost		x	x
Nucleocrinus sp.			
Coscinium cribriforme Prout			
Cystodictya gilberti (Meek)			
Cystodictya meeki (Nicholson)			
Fenestella stellata Hall			
Orthopora sp.			
Polypora cf. *quadrangularis* Hall			
.*Semicoscinium* sp.			
Ambocoelia umbonata Conrad	x	x	x
**Amphigenia curta* Meek and Worthen (Oriskany)			
Anoplia cf. *nucleata* Hall (Oriskany)			
Athyris vittata Hall	x	x	
Atrypa aspera Hall			x
**Atrypa reticularis* (Linn) (Oriskany)	x	x	x
Atrypa spinosa Hall			x
Camarophoria gainesi (Nettelroth)		x	
**Camarotoechia carolina* Hall (Oriskany?)	x	x	
Camarotoechia horsfordi Hall			
Camarotoechia sappho Hall		x	
Camarotoechia tethys (Billings)		x	x
**Centronella glansfagea* Hall (Oriskany)			x
Charionella scitula Hall (Oriskany)			x
Chonetes konickianus N. and P.			
Chonetes lineatus (Conrad)			x
Chonetes mucronatus Hall (Oriskany)	x	x	x
Chonetes pusillus Hall			
Chonetes yandellanus Hall			
Crania crenistriata Hall		x	x
Craniella hamiltonae Hall	x	x	
Cryptonella sp.			
Cyrtina hamiltonensis Hall		x	x
Dalmanella lenticularis (Vanuxem)			x
Dalmanella sp.			
Eatonia cf. *whitfieldi* Hall (Oriskany?)			
Eunella sp.			
Eunella sullivanti Hall		x	

[2]Hall: Paleontology of New York. Vol. IV, 1867.

General Table of Fossils of the Grand Tower Formation—*Continued.*

	1	2	3
**Leptaena rhomboidalis* (Wilckens) (Oriskany)	x	x	x
**Leptostrophia perplana* (Conrad) (Oriskany)	x	x	x
Leptostrophia perplana var,			
Lingulodiscina sp.			
Meristella lenta Hall			
**Meristella* cf. *lentiformis* Clarke (Oriskany)			
Meristella cf. *nasuta* (Conrad)	x		x
Meristella rostrata Hall			
Nucleospira concinna Hall (Oriskany)	x	x	x
**Nucleospira* cf. *elegans* Hall			
Orbiculoidea ampla Hall			
Reticularia fimbriata (Conrad)		x	x
**Pentamerella arata* (Conrad)	x	x	x
Pentamerella papilionensis Hall		x	
Pholidops hamiltonae Hall			
**Pholidops oblata* Hall			
Pholidostrophia iowensis (Owen)		x	x
Productella spinulicosta Hall		x	x
Productella sp.			
Reticularia fimbriata (Conrad)		x	x
Reticularia fimbriata var.			
Rhipidomella livia (Billings)			x
**Rhipidomella musculosa* Hall (Oriskany)			
Rhipidomella penelope Hall			
**Rhipidomella vanuxemi* Hall	x	x	x
Rhynchonella cf. *louisvillensis* Nettelroth			
Rhynchonella sp.			
Roemerella sp.			
Schizophoria propinqua Hall (Oriskany?)	x	x	x
**Schuchertella chemungensis arctistriata* Hall	x	x	
Schuchertella chemungensis pectinacea Hall			x
Schuchertella chemungensis perversa Hall			
Schuchertella pandora (Billings) (Oriskany)			x
Spirifer acuminatus (Conrad)		x	x
Spirifer disparilis Hall			x
**Spirifer duodenarius* Hall			x
Spirifer sp.			
Spirifer gregarius Hall		x	x
Spirifer gregarius var.			
Spirifer grieri Hall		x	x
Spirifer intermedius Hall			
**Spirifer macrothyris* Hall (Oriskany?)			x
Spirifer macrus Hall			x
Spirifer perextensus M. and W.			
Spirifer raricostus Conrad (Oriskany)		x	x
Spirifer segmentus Hall	x	x	
Spirifer varicosus Hall	x	x	x
Strophalosia truncata (Hall)			
**Stropheodonta callosa* Hall			x
Stropheodonta concava Hall	x	x	x
Stropheodonta crebristriata Hall			x
**Stropheodonta demissa* (Conrad)	x	x	x
Stropheodonta inaequiradiata Hall			x
Stropheodonta inaequistriata (Conrad)		x	x
Stropheodonta inaequistriata var.			
Stropheodonta patersoni Hall			x
Strophonella ampla Hall			x
**Tentaculites elongatus* Hall (Oriskany)			
Tentaculites scalariformis Hall	x	x	x
Actinopteria sp.			
Cf. *Actinopteria boydi* (Conrad)		x	
Aviculopecten exacutus Hall		x	
Cf. *Aviculopecten ignotus* Hall			x
Aviculopecten terminalis Hall		x	x
Aviculopecten sp.			
**Conocardium cuneus* var.	x	x	
Cypricardinia indenta Conrad		x	
Glyptodesma occidentale Hall			
Leptodesma sp.			

General Table of Fossils of the Grand Tower Formation—*Continued.*

	1	2	3
**Megambonia* cf. *cardiiformis* Hall			
Modiomorpha linguiformis Hall			
Paracyclas elliptica Hall		x	x
Cf. *Pterinopecten multiradiatus* Hall			x
Schizodus sp.			
Bellerophon sp.			
Bellerophon pelops Hall		x	x
Callonema lichas Hall		x	x
Euomphalus decewi Billings		x	x
Igoceras conicum Hall (Oriskany)			
Loxonema sp.			
Loxonema terebra White			
Murchisonia sp.			
Orthonychia dentalia Hall	x	x	x
Platyceras blatchleyi Kindle		x	
Platyceras carinatum Hall	x	x	x
**Platyceras dumosum* Conrad			x
Platyceras erectum Hall			x
Platyceras subrectum Hall			x
Platyceras thetis Hall			x
Platyostoma lineata Conrad			x
Platyostoma turbinata cochleata Hall			x
Strophostylus varians Hall		x	x
Gomphoceras sp.			
Gomphoceras sp.			
Gyroceras sp.			
Dalmanites calypso Hall			x
Dalmanites sp.			
Odontocephalus aegeria Hall	x	x	x
Odontocephalus arenarius Meek (Oriskany?)			
**Phacops cristata* Hall (Oriskany)	x	x	x
Phacops rana Green		x	
Proetus clarus Hall		x	x
**Proetus crassimarginatus* Hall			x
**Proetus* cf. *folliceps* Hall			
**Proetus marginalis* Conrad			
**Proetus rowii* Green			
**Proetus* sp. (Oriskany)			
Onychodus sigmoides Newberry			

Both the Grand Tower formation in Illinois, and the Jeffersonville beds in Indiana, have been considered a western extension of the Onondaga strata of New York.

A total of 162 species of fossils were collected from the Grand Tower formation in Illinois, 142 species exclusive of the corals and bryozoa. Kindle lists 158 species from the Jeffersonville beds of Indiana. Out of this almost equal number of species from the respective areas, only 55, or 34 per cent, are common to the strata in the two localities. Of the Grand Tower fossils in the above table, 70 species, or 49 per cent, occur also in the Onondaga beds of New York. The resemblance of the fauna of the Grand Tower formation is thus shown to be closer with that of the Onondaga strata of New York than with that of the Jeffersonville beds of Indiana.

The thickness of the Jeffersonville limestone in Indiana is very much less than either that of the Grand Tower formation in Illinois, or of the Onondaga limestone in New York. Moreover, it is in New York and in Illinois that the transition from the Oriskany to the Onondaga is complete, no trace of Oriskany strata occurring in Indiana.

From the foregoing table, it may be seen that all of the identified species of fossils of the Grand Tower formation that occur also in the Jeffersonville beds of Indiana appear in the Grand Tower section above the base of the horizon S. 56 h (about the middle part). A number of the Jeffersonville species appear below that horizon, but all of these are forms that have a considerable vertical range and are present also in the beds above S. 56 h, as shown in columns 1 and 2 of the table. With the exception of the single species, *Odontocephalus aegeria,* that appears for the last time in S 56 h, not a single one of the diagnostic fossils of the lower 75 feet (practically the lower half) of the Grand Tower strata, occurs in the Jeffersonville limestone of Indiana. From these facts it is concluded that no strata corresponding with the lower half of the Grand Tower formation are present in Indiana; and that the Jeffersonville limestone represents deposition during only the latter half of Onondaga time.

EVIDENCE BEARING ON THE SOURCE OF THE ONONDAGA FAUNA. Concerning the origin of the Onondaga fauna, Weller[1] has suggested that, "From the geographic distribution, it may have originated somewhere in the Arctic regions; and that representatives of it migrated southward, both into North America and into Europe. The typical Niagaran fauna, as it is found in the Appalachian province, is thought to have come into the region from the north through the junction of the Hudson's Bay basin with the interior basin, and, when it withdrew from the interior, it doubtless followed the same route by which it had entered. During the period of readjustment between Silurian and Devonian time it is not im-

1 Weller. Journal of Geology. Vol. X, p. 429, 1902.

probable that the restricted Niagaran fauna became isolated in the Arctic region, and that from the elements of this fauna during a long period of time, the Onondaga fauna was evolved; and that this modified fauna once more entered the interior basin from the north when the Onondaga seas overspread this region."

The fact that corals and cephalopods were conspicuous elements of the Niagaran fauna, and that representatives of these classes, changed to be sure from their Silurian ancestors, are important elements in the Onondaga fauna of Ontario, New York, Ohio and Indiana supports this view. The distribution of the fish remains of this time also favor such an origin.

Schuchert[2] has suggested that the Onondaga fauna entered the interior basin of North America from the south. He bases his view on the great abundance of corals in the Onondaga strata of Ohio and Indiana. Since reef building corals of the present are limited to warm seas, he assumes that this is a warm water fauna, and that its source was in southern waters.

The evidence furnished by the sequence of fossils in the Grand Tower section is interpreted as indicating that the Onondaga fauna reached the interior of North America from two different sources. The fact that deposition was continuous in southern Illinois from the upper Oriskany into the Onondaga shows that early Onondaga sediments are present in the Illinois region. It is to be noticed that the great Onondaga coral development that occurred in Indiana and Ohio was not present in southwestern Illinois. Some of the characteristic coral species, as *Cyathophyllum rugosum* and *Favosites emmonsi,* are not rare in the Grand Tower section, but they appear only in the upper part. The fact that the greater portion of the Grand Tower strata are quite pure limestones shows that it was not the muddy condition of the seas that barred the corals from this region. It is not probable either that the greater coldness of the water here was an inhibiting factor.

It may be seen from the table that a few corals were present

2 Schuchert. Bull. Geol. Soc. of America, Vol. XX, p. 491.

in the Illinois basin during the time of deposition of the lowest of the Grand Tower strata. Of these forms *Michelinia stylopora* and a species of *Zaphrentis* occurred in the underlying Oriskany (Clear Creek) beds. Out of twenty-eight species of fossils associated with the corals in these lower sandstone layers, thirteen, or nearly 47 per cent, were present in the Upper Oriskany (Clear Creek) strata of Illinois. Seven out of these thirteen species have not been reported from the Jeffersonville limestone, while the other six are forms having a wide distribution. Of the remaining fifteen species from the sandstone layers, ten are not reported by Kindle from the Jeffersonville beds of Indiana. The other five forms have a considerable vertical, and a wide geographical, range.

The small number of these coral species in the lower Grand Tower strata, and the absence of the greater number (60 per cent) of their associates from the Indiana area, would preclude the assumption that the Jeffersonville limestone fauna could have been derived from this source.

It may also be seen from the faunal lists in the foregoing section that the cephalopod element in the fauna is limited to the upper portion of the Grand Tower beds, although in New York the cephalopods become conspicuous in the early Onondaga strata; also that the characteristic Onondaga fish fauna of Ohio never reached this Illinois basin.

From the above considerations it is assumed that one arm of the Onondaga sea advanced on the continent from the south, as in the preceding Oriskany time, reaching as far north as Jackson county, Illinois. Other sea incursions are thought to have come in from the north and east, bringing the corals and the cephalopods into the interior of the continent. This northern interior sea is thought to have been separated by a land barrier from the southern basin in which the Grand Tower limestone was deposited, until the middle of Onondaga time. Not until near this same time is it thought that the northern sea, bringing the Jeffersonville fauna, extended as far south as southern Indiana. Not until somewhat later still was the barrier which separated the northern and southern basins entirely submerged, so that the cephalopods and corals of the northern province were permitted to spread into this southern sea embayment, and the general Onondaga fauna was able to migrate freely from north to south across the eastern interior portion of the continent.

J. A. Udden presented a paper of which the following is an abstract.

OBSERVATIONS ON THE EARTHQUAKE IN THE UPPER MISSISSIPPI VALLEY, MAY 26, 1909.

Earthquakes are infrequent in this region, and notes on our seismic phenomena are the more desirable. This communication is based mostly on items gathered from forty weekly and ten daily newspapers published in the disturbed area, and includes observations made in more than one hundred different localities. These data are given below, referred to the several localities.*

The area sensibly disturbed by this earthquake extended over the greater part of Illinois, Iowa, Wisconsin, Michigan, Indiana, Missouri, and Minnesota, a region about eight hundred miles in diameter. The mesoseismal area appears to have been triangular in form and unusually large, the greatest violence having been noted near Platteville, in Wisconsin, and in Waukean and Bloomington, in Illinois, which places probably were separate epicenters. The velocity of the earthquake waves, calculated from the reported observations on time recorded by government observers in Peoria (8:38 A. M.) and in Washington, D. C. (8:41 A. M.), is 3.3 mile per second. While no great reliance can be placed on these figures, as the data are too few and their authenticity uninvestigated, yet the great size of the mesoseismal area is in harmony wih the velocity of the wave. Both indicate a great depth of focus. The highest seismic intensity was above seven of the Rossi-Forell scale.

The facts presented in the reports are sufficiently full to indicate approximately the position of the isoseismals. When these

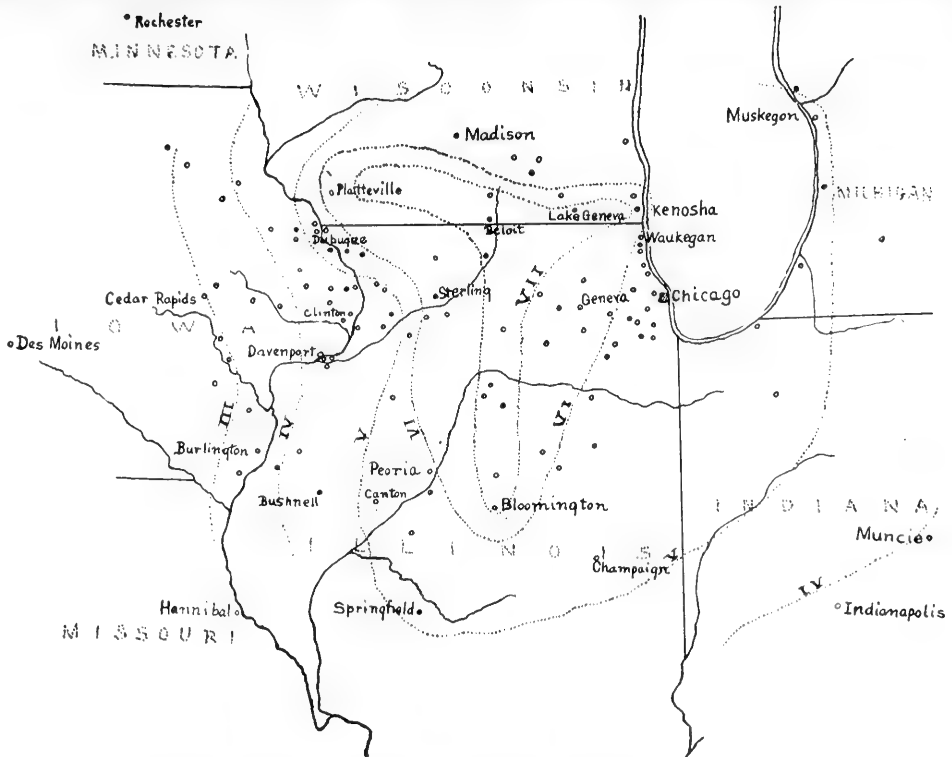


Fig. 9. Map of area disturbed by earthquake May 26, 1909.

are drawn on the basis of the intensities adopted in the Rossi-Forell scale, they run about as indicated on the accompanying map. It will be noticed that they center around one of the oldest lines of disturbance in Illinois, the LaSalle anticline. The parallel flexures in the lines on the west side are presumably due to the northwest center.

Two maxima were noted in the disturbance in the following places: Bushnell, Canton, Champaign, Chicago, Geneva, and Sterling in Illinois; Davenport and Dubuque in Iowa. In Madison, in Wisconsin, Professor W. H. Hobbs is reported having noted three shocks. These may have originated in the three epicentra noted. Observations on the duration of the disturbance sustain this evidence. Estimates on the duration of the quake fall roughly into three groups, which average respectively four seconds (28 observations), thirteen seconds (12 observations), and sixty seconds (6 observations). It appears likely that only one of the shocks was felt in the places where the duration was briefest, and that two shocks, or three, were felt where the quake lasted more than ten seconds. All places where the disturbance lasted for more than a minute are centraly located and may have been affected by all three shocks.

A classification of the senses involved in the observations shows that the general sense of "well being" was concerned in two instances. The sense of equilibrium was affected in several cases in the mesoseismal area. Visible earthquake waves are indicated for one of the epicentral tracts. Earthquake sounds were heard by five observers. The shock was *felt* in many instances.

A classification of the terms used in describing the manner in which various objects were affected by the disturbance is shown in the table below, where the figures in parenthesis indicate the number of times each term occurs in the reports.

Houses and buildings.	Dishes, bottles and tinware.	Ttables, beds, bookcases and stoves.	Windows and doors.
Shook (17)	Rattled (15)	Shook (8)	Rattled (12)
Rocked (7)	Were broken (8)	Were moved (6)	Shook (3)
Trembled (4)	Dashed to the floor (6)	Were overturned (3)	Were sprung (1)
Swayed (3)	Fell (3)	Swayed (2)	
Cracked (2)	Were shaken (3)	Quivered (2)	
Were jarred (2)	Were moved (2)	Trembled (2)	
Quivered (2)	Rocked (1)	Broke (1)	
Creaked (1)	Trembled (1)	Were upset (1)	
Heaved (1)	Wobbled (1)	Tipped over (1)	
	Was disturbed (1)	Rattled (1)	
		Rolled (1)	
		Rocked (1)	
		Heaved (1)	
		Had glass shattered (1)	

Lights and lamps.	Pictures and mirrors.	Chimneys.	Bric-a-brac.
Swayed (4)	Swung (3)	Fell (4)	Were shaken off (1)
Heaved (1)	Were shaken (3)	Toppled over (2)	Were thrown down (6)
Shook (1)	Were thrown (1)	Were razed (1)	Were tipped off (1)
Were shaken (1)	Tumbled (1)	Were shaken down (1)	Fell (1)
Were overturned (1)	Fell (1)	Cracked (1)	
Fell (1)	Jumped (1)		
Broke (1)			
Were knocked down (1)			
Were shaken out (1)			

In some places in the mesoseismal area the severity of the quake is reported as having frightened women, but no mention is made of fright among men. In a few cases fright was general. It would appear that this difference between the sexes in central inhibitory resistance is most evident in that belt where the intensity of the seismic waves was a little less than seven in the Rossi-Forell scale.

If the intensity of this earthquake had been only a little greater than it was, much damage to buildings would have resulted. Experience has shown that earthquakes are not frequent in this part of the world, but we can not be certain that the late disturbance represents the greatest intensity of future earthquakes.

*NOTE.

The following observations were collected from daily and weekly newspapers published in the disturbed area, and from various personal communications. They are arranged by localities, in alphabetical order:

Aurora, Ill.—Chimneys fell, causing several fires.—A stove was overturned and started a fire.—Many chimneys fell.—Gas mains had connections loosened.—Some fires started the report "Aurora is burning."—Men were excited, women and children frightened.—People filled the streets.—The schools were closed.

Batavia, Ill.—A horse ran away, and the driver's leg broken.

Beloit, Wis.—Buildings were violently rocked.—Houses were jostled out of plumb.—People had difficulty in staying on their feet.

Benton Harbor, Mich.—Chinaware was broken.

Berwyn, Ill.—A vase with flowers was thrown from a mantle.—Dishes were broken.—A book was thrown down from a radiator.—Book cases were shaken.—A building swayed.

Bloomington, Ill.—Cracks were made in the brick walls of the jail. These were as wide as a man's hand.

Braidwood, Ill.—Vibrations were noted.

Burlington, Ia.—The taller buildings were shaken.—plates (dishes) were thrown down.—The shock was felt most in the upper stories of tall buildings.—Rumors of the shock caused people in neighboring towns to inquire about friends in the city over the telephone.—The shock frightened people who were in the upper stories of buildings.—There were perceptible tremors.

Cabery, Ill.—The earthquake was felt by everybody.

Cedar Rapids, Ia.—There was a slight shock.—The earthquake was felt by hundreds of people.—Buildings were slightly jarred.—Doors and dishes rattled.—There was a slight tremor.—Students in the Coe College building rushed down from the fourth floor.—The shock was by some attributed to explosions in a quarry.—Doors rattled in the Masonic library.—Many residents recognized the disturbance as an earthquake.

Chadwick, Ill.—Dishes and tinware rattled.

Champaign, Ill.—Buildings shook.

Chicago, Ill.—"Buildings standing on cassion foundations shook perceptibly, structures on old style floating piles were observed to sway." Benjamin H. Marshall, architect.—Western Union Gas and Electric Company had pipes broken, entailing a loss of several thousand dollars.—The balance of a rain gauge was displaced in the office of the U. S. Weather Bureau.—The earthquake was not felt on the ground floors of large buildings, but more generally in the upper stories.—Several chimneys were shaken down in the suburbs of Chicago.—Lighting fixtures were violently shaken in the federal building.—Office tables were moved in the federal building.—Ornaments were shaken from mantle pieces.—Dishes were broken.—Telephone wires swayed.—A mirror swung on a wall.—Dishes rattled on a table.—Bric-a-brac fell from a mantle piece.—Telephones were put out of commission.—Heavy safes were jarred from their positions.—Wall decorations were thrown from their fastenings.—Drop lights swayed.—A bed was rolled back and forth, on its castors.—Electric light fixtures swayed alarmingly. —A receiver was knocked off from a telephone hook.—A glass shade on a gas light fell and broke.—Gas fixtures swayed.—A mirror oscillated.—The shock caused some people to run on the streets.—Some Italians, recalling the earthquakes in Italy, quit work for some time and fell down to pray.—Families ran out of their flats, fearing the walls would collapse.—Some people thought an explosion had occurred somewhere.—The falling of a tall chimney on a home for young women, scared the occupants out.—Telephone girls left switchboards. —A domestic was thrown off her feet.—A frightened wife called her husband.—Some people thought an explosion had occurred.—One man reported: "My wife and my sister were frightened and ran to me."—Hundreds of later risers were awakened by the earthquake.—A young woman stenographer, thinking some one had stepped up behind her chair, rocking it, exclaimed: "You stop that."—A man in a bath tub, seeing his image in motion in a swinging mirror, thought he was "verhext."—Many thought the shock due to blasting.—Some residents fled from their homes.—Some people experienced a dizzy feeling due to the motion.—One report says: "There was great excitement along the shore of Lake Michigan."—People feared a tidal wave.

Clinton, Ia.—Dishes were disturbed and broken.—Windows rattled. —The earth trembled as when there is an explosion.—The floor shook, as when there is an explosion.—The floor shook in the upper story of a large building.—Dishes were rattled down from shelves.—A door was sprung so it would not close.—Many people realized that it was an earthquake, and were stricken with fear.—Some thought the wind rattled the windows, or an explosion.—Occupants of large buildings told of feeling an unusual sensation.—Occupants of one building thought the shock was due to some work in progress on the upper floor.—A message, without signature, was received by one of the dailies, announcing the earthquake in a town near the city.—Telephone girls were scared

Davenport, Ia.—The tremor was most noticeable in large office buildings.—Two shocks were felt.

Des Moines, Ia.—The earthquake was noticed by few people.

Des Plaines, Ill.—Chairs were overturned.—Mirrors were demolished.

DeWitt, Ia.—Buildings shook.—Dishes rattled.

Dixon, Ill.—There was a slight trembling of the earth.—Gas fires were shaken out.

Dubuque, Ia.—Office buildings were shaken.—The shock was felt most in the downtown districts.—Machinery rattled in factories.—Boxes and crates fell in stores.—Two shocks were felt.—Dishes to the value of eight hundred dollars were broken in a crockery store.—The upper part of high buildings swayed.—One-third of the inhabitants knew nothing of the earthquake.—Furniture moved in strange directions.—Furniture trembled.—Some claim they heard a rumbling sound before the shock.—Lamps were shaken from their rests.—Tables heaved.—Houses rocked perceptibly.—Dishes rattled on tables.—Chairs moved on their rockers.—Chandeliers heaved.—Floors heaved.—Windows rattled.—Elevators swayed slightly.—Dishes and silverware moved on tables in hotels.—In the upper story of a hotel a sewing machine was tipped over.—In the upper story of a hotel a servant woman was pitched forward and nearly fell.—A house quivered.—People rushed from windows in terror, and alarm was widespread.—Several hundred people made their exit from a seven-story building, choking the stairways in their haste to escape.—Some people thought th shock was a blast in the stone quarries.—In factories where girls and women worked in upper stories, small panics were narrowly averted.—The women employed in the upper stories in an office building rushed in a panic to the stairs.—Men ran up from below, meeting them and quieting them.—A seamstress was surprised and alarmed when her sewing machine moved.

Eagle Point, Ia.—A high bridge swayed.—Buildings rocked.—Dishes rattled.—Bottles rattled in a drug store.—Bottles moved along a shelf in a drug store.—The shock caused alarm.

East Dubuque, Ill.—Dishes rocked from shelves and dashed on the floor.—Printing type in form, in a newspaper office, was pied.

Elgin, Ill.—Delicate instruments in the Elgin Watch Works were thrown out of gear.

Elizabeth, Ill.—Dishes were shaken and the contents spilled.—Buildings were noticeably jarred.—Windows rattled.—Two men in a store thought sacks of flour, stacked upstairs, had fallen down.

Elkader, Ia.—Windows in stores were shaken.—Articles were shaken from stands and dressers in a bed room.—Excitement was intense.—The earthquake was felt by several persons in town.

Evanston, Ill.—A chair in which the chief of police was seated, shook twice. The top floors in one of the University buildings shook.—Water in a tumbler was tippled.—Windows rattled.—A book case swayed one and one-half inch.—A vacant chair was rocked, hitting a man.—A team of horses were started on a runaway.—Instruction was interrupted in one of the classes in Northwestern University.—Occupants of some residences fled to the streets.—Patients and nurses in a hospital were alarmed.

Fort Madison, Ia.—Dishes and windows rattled.

Freeport, Ill.—Cracks were formed in cement walks.

Geneva, Ill.—A clock was stopped in the court house.

Gordon's Ferry, Ia.—The operators in a railroad depot rushed out.

Hannibal, Mo.—Two shocks were felt, lasting eight and thirty seconds, respectively.

Indianapolis, Ind.—The federal offices quivered.—A heavy iron bed was shaken.—A writing table shook.—The tower of the courthouse shook.—A woman, reclining on a couch, rolled down on the floor.—A man in a chair, resting his legs on a railing in the tower of the court house, felt his legs shake.

Jackson Junction, Ia.—There were heavy tremors.

Joliet, Ill.—Chairs were overturned.—Gas mains were made to leak

Kalamazoo, Mich.—The earthquake was noted.

Kenilworth, Ill.—Dishes fell from plate rails and broke.

Kenosha, Wis.—Plaster fell.—Wall paper cracked.—Chimneys toppled over.—One man thought the powder mill had exploded.—Some inhabitants "thought the island would sink."

Kewanee, Ill.—Some windows were broken.

Knox, Ind.—The shock frightened many people.—People rushed from buildings.—Some people thought the shock was an explosion in a distant powder mill.

Lake Forest, Ill.—Young people left the dormitories in Lake Forest University.—One professor dismissed his class.—Professors at the University recognized the earthquake.

Lake Geneva, Wis.—Two shocks were noted.—Water and milk were spilt.

Leonore, Ill.—A number of persons reported having felt the earthquake.

Lone Tree, Ia.—A rheumatic woman felt the vibration keenly, and told others of the disturbance, before it was generally known.

Lowden, Ia.—Buildings rocked.—Dishes were thrown off from a table.—Clocks stopped.

Window sashes were shaken.

Lyons, Ia.—Window sashes were shaken.—Dishes rattled.—Dishes were thrown from shelves.—A tea kettle was shaken from a stove. —There was a severe shaking up of dishes.—Dishes were broken.—Many thought the disturbance was due to the passing of heavy wagons.—On learning that the disturbance was general, an editor says he became convinced that there had been an earthquake.

Madison, Wis.—Some of the solution was spilled from the batteries in a railroad station.—Professor W. H. Hobbs, a prominent geologist and seismologist, is reported as having noted three distinct shocks.

Maquoketa, Ia.—The earthquake was very plainly felt.

Mason City, Ia.—There was a slight shock.

Maywood, Ill.—Plaster was loosened from a wall.

Milan, Ill.—Windows rattled in some buildings.—Dishes trembled in cupboards.—Pictures trembled on walls.—A woman thought she had an attack of heart trouble and sank frightened on a bed.

Monmouth, Ill.—Buildings were badly shaken.

Montague, Mich.—A man felt a swaying motion, while seated in a chair.—The earthquake was felt by several citizens.

Morning Sun, Ia.—Bottles and tinware rattled in a store.—The editor of the News Herald notes that the quake was not sufficiently severe to disturb his print shop.

Morrison, Ill.—A lamp was overturned.—Dishes were knocked off from a table.—Houses were shaken.

Mount Carroll, Ill.—Goods were thrown from shelves in the stores.—Chimneys toppled over.—Stove pipes were shaken out of chimneys.—Water was spilled from pans.—Racks were moved in the court house. —Bars in the jail rattled.—Windows in the jail rattled.—Everybody rushed into the streets.—There was much excitement.

Muncie, Ind.—The shock was variously attributed to blasting operations, to the rolling of heavy wagons, and to the passing of street cars.

Muscatine, Ia.—A quiver was felt by a few people.—Several people afterward remembered feling a vibration, and attributing it to the moving of heavy objects in the building.

Muskegon, Mich.—Bric-a-brac fell to the floor.—Pictures swung.

North Chicago, Ill.—Bricks were hurled from a high scaffolding. —Workmen on a high scaffolding nearly fell.

Oak Park, Ill.—A leg was shaken loose from a piano in a school and this caused the piano to foll.—The cornice of an old mansion fell. —A hospital building rocked.—A baby was thrown out of bed.—Pedestrians were scared by falling brick.—A woman was thrown out of a chair.

Ottumwa, Iowa.—Some citizens claimed to have felt the quake.

Paw Paw, Ill.—There was no damage, but many people were frightened.

Peoria, Ill.—Plaster fell in a school building.—Many large buildings were shaken.—The shock was felt more on the bluffs than in the down town districts.—A rumbling sound was noted by a janitor in a school building.—Falling plaster caused a panic among the children in one school.

Peosta, Iowa.—Houses rocked.

Platteville, Wis.—An old building rocked.—A school building was cracked.

Pontiac, Ill.—Windows were shaken.—Articles were shaken from walls.

Princeton, Iowa.—A farm hand, who was standing in a barn, saw some hanging ropes gently vibrate. He also saw an iron support for a receptacle for water on a grindstone vibrate and heard a slight creaking in the building.

Rariton, Ill.—The earthquake caused buildings to creak and tremble.

River Forest, Ill.—A woman, who had been walking on crutches, ran out without them.

Rockford, Ill.—A street car was started down a hill.

Rock Island, Ill.—A man sitting in a chair noticed a dull shock which he referred to as something heavy that might have fallen in the attic.—The jar was distinctly felt in the third story of the main building of Augustana College, where book cases in the library were gently disturbed.—The first part of the disturbance was weakest. —The disturbance was felt by several persons at rest.

Sabula, Iowa.—Chimneys cracked.—Pictures rattled on walls—Furniture threatened to tumble over.—Heavy machinery in a printing office shook in good shape.—A ferry captain saw a large wave come to the Illinois shore in the Mississippi river.—The shock brought people out of their homes, some with alarm, others with curiosity.

Savanna, Ill.—Operators in a railroad depot rushed out.

Sears, Ill.—A desk rattled.—Goods rattled on the shelves in a store. —A heavy dresser quivered and shook.—Beds shook and quivered. —A lady thought she was affected by heart trouble and sank frightened on a bed.

Sinsinnawa, Ill.—Dishes and windows rattled.—Articles fell from walls..

South Haven, Mich.—Windows rattled violently.—Much china was broken.

Springfield, Ill.—A faint rumble was heard.—Windows rattled.—The earthquake was noted by nearly all people.—Many refused for hours to return to houses from which they had fled.—People rushed from houses.

Sterling, Ill.—Chandeliers were knocked down.—Pictures fell from walls.

Strawberry Point, Iowa.—Buildings were badly shaken.

Sycamore, Ill.—A clock was stopped in the court house.

Waukegan, Ill.—Clocks were stopped.—Pictures were thrown from walls.—Chimneys fell.—Linotype machines swayed violently.— A kitten was thrown across the room.—Two small children jumped out of bed crying, thinking the bed was falling to pieces.—Women fell on their knees and prayed.—People wobbled.—A prisoner in jail thought walls would fall and liberate him.—A woman came near being pitched through a glass door.—One man woke up from the shaking of the bed.—People in upper stories of houses ran down and out on the street.—A janitor in a school house thought a man had fallen from the flag pole, which was being repaired.—Sidewalks were seen to tremble and gently heave.—Tables shook.—Dishes rattled.—A house trembled.—A house gave a distinct raise, then trembled.—Pictures swung out from a wall.—A fern (in a pot) tipped over in one house. —Buildings were shaken.—A bed trembled.—A school house shook for one minute.—Books fell from cases in the court house.—The glass in a book case was shattered.—Chandeliers swayed in stores.—Plaster fell from a ceiling.—Book cases teetered.—Windows rattled.—A heavy safe rolled on timbers on which it rested.—A school (teacher and pupils) was curious, but not alarmed.—Some hands in the Corn Products Company's factory thought some heavy machinery had collapsed.—The city hall employees ran out on the streets.—One man described the sound accompanying the shock as a rush of wind, and said he heard it.—Grain was let out through cracks which were opened in the bins of a feed store.—One man heard a sound "like the rattling of a locked door."

West Union, Ia.—Buildings shook.

Wilmette, Ill.—Bottles rattled on the shelves in a drug store.

Winnetka, Ill.—Falling dishes were broken.

Zion, Ill.—Some Zionists, recalling a prophecy of the coming of the end of the world on the 29th of the month, are reported to have fallen on their knees to pray.

A. R. Crook.—"I am glad to see that in these interesting papers by Mr. Savage and Mr. Udden, we are at last getting down to 'rock bottom,' even though in this last paper on earthquakes the bottom appears to be somewhat shaky! While newspaper accounts of such occurrences are extremely interesting, I am not inclined to place confidence in their reports, and think that care should be exercised in accepting any contributions which they may make in any department of science.

For example, within the last few years, upon reading at fifteen different times of the falling of a meteorite in some region where Mr. Blank had found the specimen, I have written to Mr. Blank. In twelve out of fifteen cases my letter was returned from the post office marked 'no such person known at this office,' From the other three letters nothing was heard."

F. C. Baker.—"The Chicago papers described a case of heads of mammoths which was put on exhibition at the Chicago Academy of Science, as an interesting collection of humming birds."

R. M. Bagg.—"There is interest in determining the causes of the earthquakes which occur in the great Mississippi region, a region looked upon as practically free from siesmic action.

These earthquakes may be possibly accounted for by supposing that they are due to crustal disturbance through faulting due to depression of the Gulf of Mexico through *loading* of *sediment* carried by rivers emptying into the Gulf, especially the Mississippi river, which deposits each year one subic mile of sediment 268 feet high in the gulf. This causes continual sinking though not the initial subsidence. The erosion of the Mississippi valley and deposit southward in the gulf may cause readjustment of equilibrium through faulting as Mr. Savage and members of Geological Survey know and have shown on their maps of the State. These earthquake movements may be reasonably expected to recur from time to time, due to readjustment and an attempt of the crust of earth to regain isostatic conditions."

J. A. Udden:—With regard to the reliability of newspaper data, they must be taken for what they are worth and should be used with common sense discretion. Much of the material collected for this study was not used. The character of the isoseismals, based on separate determinations of intensities of the earthquake for a hundred localities, speaks well, it appears to me, for the reliability of the data used. The use of such data in the study of earthquakes is nothing new. In the nature of the case, the isoseismals below seven in a scale of ten are largely located on hearsay evidence for all earthquakes which are studied. Such data are necessarily obtained from untrained observers. They are the best that can be obtained. The author's chief object in presenting this paper has been to awaken interest in these phenomena, in order that more and better observations may be secured in the future.

H. S. Pepoon then presented the following paper:

THE FOREST ASSOCIATIONS OF NORTHWESTERN ILLINOIS.

A large area in northwestern Illinois, which, roughly speaking, occupies practically all of Jo Daviess county, except a narrow strip along the northeastern border, and a small portion of the adjacent counties of Carroll on the south and Stephenson on the east, is or rather was occupied by almost continuous forest growth. In Illinois. as a rule, the wooded lands lie adjacent to streams, but here there is no such distribution. Ridge and valley alike have this forest covering. The accompanying map will show the distribution of woods, which sustain a remarkably close relation to that peculiar physiographic feature called the "driftless area."

A very large percent of the original woodland has disappeared before the ax and "grub-hoe," and it is no exaggeration to state that in many parts not more than ten percent of the first growth remains standing, so that the aspect of large areas is that of a rolling prairie; but even now the remaining portion is amply sufficient to form a basis for the study of the forest associations, and all the more so because each passing year further decreases the number of remnants.

This paper, therefore, will partake of the historical as well as the actual in dealing with the subject, and it is largely with the idea in mind of preserving many interesting facts of distribution that it is undertaken.

The Forest Associations are so intimately and vitally connected with the character of the soil, the amount of water supply, and the greater or less perfectness of drainage, that it

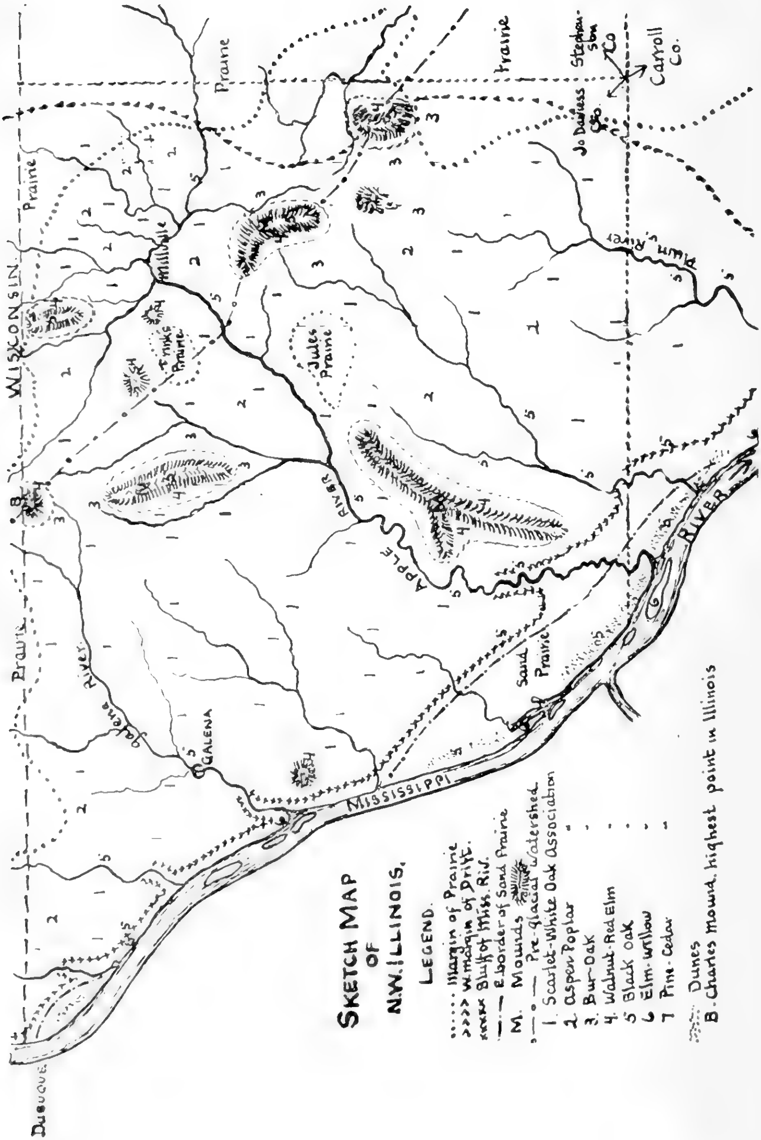

SKETCH MAP OF N.W. ILLINOIS.
LEGEND.
Margin of Prairie
W. margin of Drift.
Bluff of Miss. Riv.
E. border of Sand Prairie
M. Mounds
Pre-glacial Watershed
1 Scarlet-White Oak Association
2 Aspen-Poplar
3 Bur-Oak
4 Walnut-Red Elm
5 Black oak
6 Elm-willow
7 Pine-Cedar
Dunes
B. Charles Mound, highest point in Illinois
WISCONSIN
DUBUQUE
GALENA
Galena River
Prairie
Millville
Jules Prairie
Sand Prairie
APPLE RIVER
MISSISSIPPI RIVER
Plum River
Jo Daviess Co.
Stephenson Co.
Carroll Co.

Fig. 10.

is necessary to obtain a reasonable conception of these elementary factors in distribution. No region of Illinois probably compares to Jo Daviess county in the extent and perfection of the drainage elements, for it must be remembered that we are dealing with an ancient land surface that for milleniums has been subjected to the erosive action of frost and rain, so far as we know, without a break since the days of the Niagara limestone. Countless ravines and small and large valleys cut up the surface in every directon, so that a plot of level land is a rarity, every where slopes, more or less pronounced, being the topographical feature paramount in the landscape. Only on the expanded summits of the watersheds are there any areas of poor drainage found and these are of limited extent, and yet, as shown hereafter, they are sufficiently potent to produce a forest association. The water table is in many parts very deep in the earth, this being practically true of large portions of the Galena limestone, and yet only on very limited and very local land surfaces is a genuine scarcity of water to be found. As the rainfall is about forty inches per annum, plant life rarely suffers any serious drawback from this source. The soil is everywhere the result of disintegrated rock remaining in situ except on the "bottoms" of the streams, small and large, where considerable areas of alluvium are found, and again some more or less pronounced loess soils, particularly in evidence in some of the area bordering the Mississippi river (see Soil Survey of the Dubuque Area). A clay subsoil, grayish, yellow, or even ocher red, with a few flints here and there, of many feet thickness, merges into a surface soil of clay, clay-loam, or even a black humus in limited districts, the latter particularly in evidence as border deposits where the forest and prairie join, or at the junction of Niagara and Cincinnati shales. A very limited amount of sand is found in these soils, but near the Mississippi river are several square miles of sandy soils of varying purity, evidently of river and wind formation.

Owing to the general uniformity and topography, we find one general forest association and a number of minor ones that may be designated as follows:

a. The scarlet and white oak, a general forest growth.
b. The aspen-poplar.
c. The red elm-walnut.
d. The white elm-willow.
e. The black oak.
f. The bur oak.
g. Pine red cedar.

The scarlet and white oak association is the all pervading one and everywhere gives the general tone to the woodlands. The association consists almost entirely of the oaks named, but varies in every possible degree between a pure white oak and a pure scarlet oak growth. In general, however, there will be a small preponderance of one or the other species according as the soil has more or less humus and less or more clay. The richer the soil, the more the scarlet oak abounds, and the poorer and more clayey, the more abundant will be the white oaks; most of the trees of this association are second growth; a typical example, extending over one-half mile square, having a tree for every five or ten feet square of land surface, or 400 to 1600 to the acre. These trees will average 12 to 16 inches in diameter, 50 to 70 feet in height, and represent a time growth for the scarlet oaks of 50 years, and for the white oaks 75. Here and there large white oaks are to be seen, two to four feet in diameter and up to 300 years of age. Many such are suitable for sawmill material, but their number is very rapidly diminishing. Occasional scarlet oaks 2 feet to 30 inches in diameter are found, of a probable age of a century or more. Often there are absolutely no other tree species included, and this will certainly be the case where the soil is of moderate fertility. As the soil thins, the white oaks with an occasional shag bark hickory presents a solid front. Running to the other extreme of soil richness, there will be found a few specimens of black cherry, pig-nut hickory, red oak and very rarely a red elm and bass wood.

As this exclusive association constitutes most of the forest growth of Jo Daviess county, it follows that the two oak species are the source of practically all the wood and timber supply of the region. The height noted above nowhere approaches the till growth so commonly seen in Michigan, Indiana, and Ohio. For post timber the young white oaks are very valuable; but the scarlet oaks are almost worthless for such a purpose, having but little durability in contact with the soil.

The undergrowth in the association is as a rule more marked by its absence than presence, great portions of the woods being absolutely devoid of it. The most common shrub is the hazel (*Corylus americana*), that in some of the moister places attains a height of 16 feet and a diameter of 2½ inches. Blackberries (*Rubus nigrobaccus*) are abundant in isolated patches that bear a constant relation to abundant water, being a certain feature of ravine heads. An occasional grapevine (*Vitis vulpina*) is seen and in rich soil the Virginia creeper (*Psedera*). Of substratum trees, certain hawthorns (*Crataegus tomentosus* and *C. mollis*), the wild plum (*Prunus americana*), black haw (*Viburnum prunifolium*), and choke-cherry (*Prunus virginiana*) complete the list. The plums are remarkable for fruit variation of every size, from bullets to great oval fruits 1½ inches in diameter, green, red, yellow and variegated, acerb, sour, and sweet in flavor.

The herbaceous plants in the white oak type are very few in number, either in individuals or species, and the botanist has hard work to obtain anything of note. Only a very few plants are in any sense characteristic. *Carex pennsylvanica is* everywhere, so also are innumberable spots of *Antennaria;* in the open places *Potentilla canadensis* is common; this is certainly a scant list. As the scarlet oaks predominate, and particularly where the humus is in large amount, there is found a great increase in these forms of plant life, and individuals and species become exuberant in numbers and growth. As an example, it may not be amiss to record again what I stated in Plant World, volume VII, that on the old home farm in Warren township of this county, 230 acres in extent, and having

130 acres of the scarlet oak woodland, there were found 355 species of plants.

In the scope of this paper it will be necessary to mention but a limited number of the more characteristic forms. Nowhere is the fact more plainly emphasized than here, that the *exposure* is a dominating factor in determining distribution of plant life. In this association type it is only on northeasterly slopes that the yellow lady slipper (*Cypripedium hirsutum*) is found, and then only in dense shade. This species is very local, not more than one or two "patches" being found in a township, and it is always in close proximity to the two ferns *Osmunda Claytoniana,* and *Asplenium Filix-foemina,* both in great abundance. These patches are invariably in the moist rich shade of ravines having an eastward trend. The twayblade (*Liparis liliafolia*) is a rare associate, and *Habenaria bracteata* and *Orchis spectabilis* are yet rarer. It is worth recording here that the last species was found by me in 1891 in identically the same situation and exposure, three miles southwest of Lewiston, Fulton County, growing so abundantly as to tint the woodland with its beautiful colors. Other species not so "finicky" as to exposure are *Trillium, declinatum, Uvularia grandiflora, Allium tricoccum, Podophyllum, Geranium maculatum, Desmodium grandiflorum, Viola sororia, Sanicula canadensis, Osmorhiza, Aralia racemosa, Steironema ciliatum, Triostium aurantiacum.*

On the flattened crests of nearly all the watershed ridges, or rather, in many cases, the broad elevations between adjacent streams are poorly drained areas, thin-soiled as a rule, and occasinally with a small circular pond, the remains of an ancient "buffalo wallow." These tracts are the ideal home of the *aspen-poplar association.* They are generally of small extent, but now and them assume the proportions of a respectable woodland. The individual trees are commonly scattered, though not infrequently forming dense growths. Here and there are small open spaces surrounded by luxuriant clumps of hazel, which send out arms and straggling bands among the aspens. Practically the only other woody plant of size is the pussy willow

(*Salix discolor*). The roots of the poplar barely penetrate the soil, which is water-saturated in spring and early summer, and often they lie on the surface for a rod or more. The aspens attain at times a height of 60 feet and a diameter of 28 inches, but more commonly they are dense growths, 30 to 40 feet tall, and 4 to 6 inches in diameter. The ultimate fate of these latter trees is the grove of scattered adults, all that remains of the former hosts in the struggle for existence.

In these aspen associations there is practically nothing herbaceous that is characteristic, except that it is here that the rare orchid *Habenaria bracteata* is most surely to be found. In the small prairies that have been referred to as certain to be found with every such association, and doubtless of Indian fire origin (see later) a few species are ever present. *Baptisia leucantha, Polygala viridescens* carpeting large areas, *Koellia virginiana, Gerardia tenuifolia,* the rare *G. auriculata,* and a few plants of *Rumex Britannica,* make up the list. As hinted, these aspen flats were prairies of considerable extent in the days of Indian control, and were continued as such by the habit of firing the grass in spring that new and fresh growth might be afforded to the game of the region. When the first white men came to the country about 1800, a horseman could ride through the open woodland or through the openings in every direction. With the coming of the whites there was a cessation of the fires, and the lodgment and growth of the wind-snow aspen seed on the moist open lands caused their gradual reduction to the small open spots which are now so characteristic.

Most of the soils on which these aspens grow are what locally are termed "hard pan," having a dense impervious clay subsoil that renders the areas very marshy in spring. Usually in clearing the woodland these places are the first to be grubbed out, on account of the ease with which the laborer can remove the tree, root and trunk. The surface roots aid greatly in this undertaking. Properly fertilized and particularly so if holes are dug through the hard pan for drainage, the land produces good crops. This hard pan explains the formation of the wallows before mentioned, which were very common on all such flat lands as late as 1890, but which have now almost entirely disappeared. These circular ponds were rarely more than 18 inches deep and generally contained water during the entire year.

The remaining associations are very local, or are very much circumscribed by the encroachments of agricultural operations, but even now in the aggregate covering many square miles of Jo Daviess county. So scattered are they that they show but little influence on the general tone of the forest features, and without reference to the order given above each may be briefly considered.

While it is true that occasional bur oaks may be found widely scattered, as isolated specimens here and there, and in all probobility squirrel or pigeon sown, it is equally true that genuine associations of this species occur as fringes or limited patches, always denoting good strong soil, well drained, and in many places designated by the term "bur oak openings." The origin of such a term is obscure and I make no attempt to solve it. In general, while the bur oak is the dominant species, this association is not a pure growth, but a number of different trees is almost certain to be found. The oaks are often very large, with wide-spreading branches, and have a trunk diameter of 2 to 4 feet, and height of 80 feet, and in a typical woodland will stand 50 or 60 feet apart.

Just what the cause may be for these limited areas devoted to a particular species is not positively determined, but the conjecture is made that where the underlying lime rocks have become disintegrated sufficiently and are near enough the surface for good drainage, and where finally much humus has accumulated, such places seem to be the ideals for bur oak development. In nearly all of the best examples that are known to the writer, this association occupies the highest horizon of the Galena limestone at the point where it is overlaid with crumbling shales of the Cincinnati formation. Such a region has an abundant moisture from the innumerable springs that have their origin in the sloping steeps of the latter strata, rising in disintegrated masses to meet the weather worn escarpments of the Niagara.

An external factor, strangely enough, almost entirely precludes the determination of a peculiar herbaceous flora for this association, viz: that owing to the enormous production of very nutritious acorn food, such groves are almost invariably "hog pastures," and all wild growth has either become exterminated, or so mixed with pasture weeds as to become useless for purposes of study.

Above this growth on all the lands lying adjacent to the great Niagara mounds, so common and conspicuous a feature of the landscape of northwestern Illinois, is to be found an irregular belt or zone, occupied largely by black walnut and red elm, which here and there, by reason of the erosion caused by some drainage line, assumes the form of a great amphitheater, surrounded on all sides, but the outflowing, by the steep slopes of the mound, partly Cincinnati and partly Niagara, both talus-like in appearance. In such places the species named reach magnificent proportions, are very numerous in individuals, and are commonly associated with basswood and red oak in much less numbers. The soil is very rich, full of humus, plentifully supplied with moisture, and is by all odds the most prolific in species of any area in the entire region. Here are to be found in great profusion those species that are the rarest of plants elsewhere.

Nowhere except in the immediate valley of the Mississippi river are the trees so luxuriant. The undergrowth resembles in most particulars the rich scarlet oak type of the first association and many of the herbaceous plants are the same. From this it would seem that shallow-rooted plants find the areas quite similar, but the deep-rooted trees evidently discover something in the one region not found in the other, and this something is potent enough to produce a great difference in tree growth.

In these favored ampitheaters are to be found, among others, the following herbaceous plants various rare Carices as *C. albursina, pedunculata, plantaginea, Frankii, Erythronium albidum* by thousands, *Uvularia grandiflora, Orchis spectabilis, Asarum canadense Actaea rubra, Sanguinaria, Dicentra cucul-*

laria, Caulophyllum, Podophyllum, Dentaria laciniata, Viola scabriuscula, Geranium, maculatum, Impatiens aurea, Oxalis racemosa, Phlox divaricata, Hydrophyllum virginianum, Scutellaria versicolor, Agastache, Campanula americana.

The *black oak association* is remarkable for at least two things, viz: that commonly the oak is the only notable tree species, and further that wherever dry, barren, or eminently unfavorable land surfaces are found, there it will be certain to grow. These barren soils are to be found in three well-marked and seemingly quite different topographic areas: first, on the elevated summit ridges of the Niagara mounds; second, on the equally dry and rocky brows of the Apple river and Mississippi river bluffs; third, in the dune region adjacent to the Mississippi on sand prairie in the southwestern part of Jo Daviess county. A height of 60 feet and a diameter of 2 feet will mark the largest growths. They are generally scrawny, often hollow, and only in young trees thriftly in appearance. The most thrifty specimens are found on the tops of the mounds and in spots of some comparative richness of soil. May it not be true that the oak grows in pure sand of the dune or on the dry rocky knoll because it there finds little or no competition, and not because it would not do better on a richer soil if it were to be given possession. Seemingly an isolated species it consorts poorly with other plant growths of tree proportions.

With the black oak are to be found a very few tree species, most prominent among them an occasional great-toothed poplar (*Populus grandidentata*), June berry (*Amelanchier canadensis,*) and several species of *Crataegus.* The shrubby growth is mostly hazel, Jersey tea, and white dogwood (*Coruns paniculata*). Among herbaceous species a few only are conspicuous: various species of *Desmodium* and *Lespedeza, Viola pedata, Dodecatheon, Lithospermum canesens, Isanthus, Hedeoma, hispda, Gerardia laevigata, Liatris scariosa, Kuhnia, Aster linarifolius, A. ptarmicoides.* The sand dune flora of this oak association has some interesting additions to the above, notably *Opuntia, Rhus canadensis, Synthyris, Krigia virginiana, Tephrosia virginiana* and

Anychia. The oaks of this sandy district are never tall, generally very scraggy, and at best do not show any luxuriance of growth. This black oak forest, if it can be so called, varies from a few rods to three-eights of a mile in width, and extends along the Mississippi river for a number of miles, covering the river dune, and speading out over the gently rolling sandy prairie, but everywhere cut off from the forest growth of the uplands by a mile or more of sandy plain. On the bluffs, as before mentioned, the species is again found. The history of how it found a lodgment in the sand prairie nearest the river is an interesting bit of plant distribution. Probably carried by squirrels from woods adjoining the northern and southern ends of the prairie to the occasional trees of other species, as ash, honey locust and cottonwood, the acorns were covered by the drifting sand and so found soil and moisture enough to germinate and attain the tree estate. Plain grasses and other plants preclude much sand movement further from the immediate source of the sand, the river sand bars, and there is no possibility of the acorns becoming covered. It is interesting to note that the oak margin is not an even front, but is sinuous with advancing or retreating angles, indicative of the combat between forest and plain for the possession of the sands.

The *pine-cedar association* is one of vertical rather than horizontal aspect, occupying as it does all the cliffs of the Apple river and its tributaries, as they cut through the Galena limestone to reach the main stream or the Mississippi river into which it debouches. Certain sections of the Galena river also possess these cliffs and have the same trees. Undoubtedly we have here the evidences of either the *last stand* of a dying race, or the choice of such an inhospitable habitat to avoid competition, both pine and cedar having many xerophytic characteristics that fit them for life on the solid rock, into the crevices of which their roots are insinuated. The white pines attain a height of 110 feet, a diameter of 4 feet. The red cedar rarely assumes a growth of more than 30 feet. The herbaceoous plants of these cliffs have been fully discussed in the Cliff Flora of Jo Daviess county (Vol. II. Transactions Ill. State Academy of

Science). Perhaps no better illustration is needed to show that anchorage is a chief end of a tree root system, and not primarily to obtain a major amount of the plant food needed in up-building trunk and branches. Here again the writer must remark on the marvelous difference in the habitat of these two trees from the swamp home of the one in Michigan and the other in Massachusetts.

The alluvium of all the streams of any size, and reaching the greatest development along the Mississippi river, is the chosen home of the last association to be discussed, the *elm-willow.* As a matter of course, the soil is exceedingly rich but often very wet, although rarely marshy, and subject to every considerable overflow of the adjacent river. White elms are everywhere the common tree on the drier portions, assuming magnificent proportions (100 feet high and with a diameter of 6 feet). On the moister lands the soft maple grows to immense size, one specimen having a diameter of 7 feet. Near the water the black and peach willows are common, and commonly are the river bank trees. White and black ash are common, the latter in genuine swamps. Here and there are clumps of giant sycamores, that are the largest trees of the entire region. Where alluvial soil disappears and sand begins, the sand-bar willow, (*Salix longifolia*), is the dominant form, growing in dense thickets, and serving as a catch-all for all the debris of the great river, which debris is the beginning of the true bottoms.

Associated with these trees are a number of herbaceous plants that are characteristic. Among them we note *Leersia virginica* and *oryzoides, Cinna, Elymus, Polygonum* of many *species, Impatiens pallida* and *biflora, Convolvulus sepium, Cuscuta* of several species, *Stachys palustris* and *aspera, Scutellaria lateriflora, Chelone, Mimulus ringens, Lobelia cardinalis, Helianthus,* and *Solidago.*

In concluding these words about the forest trees, it will be advisable to mention a few species that may be called sporadic, to use a medical term, that is a few of one species found in a circumscribed locality, and perhaps no others known in the whole district or separated by miles of intervening territory.

The coffee bean is a marked example. A clump of six trees, 50 feet in height, occurs on the gravelly border of Apple river bottom, two miles below Millville, and no others are known until the bluffs of the Mississippi are reached, 25 miles northwest. *Morus rubra,* the mulberry, has exactly the same distribution. *Carya illinoiensis,* the pecan, occurs at one place on the elevated bottom of the Mississippi river, a single specimen 90 feet in height, and 3.5 feet in diameter, in the midst of a woodland of elm and maple. *Betula alba* is occasional along the bluffs of the Apple river, and again on the summits of Benton mound, at 300 feet greater altitude (1200 feet above the level of the sea,) and 10 miles distant. Honey locust exists as few specimens on sand prairie; *Ulmus racemosa* is seen only on the west branch of Apple river. It would be a difficult task to explain the origin of these species, some seemingly from the south, and one or two from the far northeast.

Enough has been said to give a glimpse of the tree distribution of the region, and the grouping that seems to be rational and most easily accounted for. Errors of judgment there may be, but the points of distribution are facts that I have sought the best explanation for, from the data at my command.

LIST OF TREES OF NORTHWESTERN ILLINOIS.

1 *Pinus strobus,*
2 *Juniperus virginiana,*
3 *Salix nigra,*
4 *Salix amygdaloides,*
5 *Salix lucida,*
6 *Salix longifolia,*
7 *Salix discolor,*
8 *Salix rostrata,*
9 *Populus tremuloides,*
10 *Populus grandidentata,*
11 *Populus deltoides,*
12 *Juglans cinerea,*
13 *Juglans nigra,*
14 *Carya illinoensis,*
15 *Carya ovata,*
16 *Carya glabra,*
17 *Carya cordiformis,*
18 *Ostrya virginana,*
19 *Carpinus caroliniana,*
20 *Betula alba,*
21 *Quercus alba,*
22 *Qucreus macrocarpa,*
23 *Quercus bicolor,*
24 *Quercus muhlenbergii,*
25 *Quercus rubra,*
26 *Quercus palustris,*
27 *Quercus coccinea,*
28 *Quercus velutina,*
29 *Ulmus fulva,*
30 *Ulmus americana,*
31 *Ulmus racemosa,*
32 *Celtis occidentalis,*
33 *Morus rulra,*
34 *Hamamelis virginiana,*
35 *Platanus occidentalis,*
36 *Pyrus coronaria,*
37 *Pyrus ioensis,*
38 *Amelanchier canadensis,*
39 *Crataegus punctata,*
40 *Crataegus tomentosa,*
41 *Crataegus mollis,*
42 *Crataegus macracantha.*

43 Crataegus macrosperma,
44 Prunus serotina,
45 Prunus virginiana,
46 Prunus pennsylvanica,
47 Prunus nigra,
48 Prunus americana,
49 Gymnocladus canadensis,
50 Gleditsia triacanthos,
51 Zanthoxylum americanum,
52 Ptelea trifoliata,
53 Rhus typhina,
54 Euonymus atropurpureus,
55 Acer saccharum,
56 Acer saccharum nigrum,
57 Acer saccharinum,
58 Acer negundo,
59 Tilia americana,
60 Cornus alternifolia,
61 Fraxinus americana,
62 Fraxinus pennsylvanica,
63 Fraxinus pennsylvanica lanceolata,
64 Fraxinus nigra,
65 Viburnum opulus,
66 Viburnum lentago,
67 Viburnum prunifolium.

F. L. Charles moved that the President be authorized to appoint a committee of three to cooperate with existing agencies for the advancement of nature study in elementary schools, and to report at the next meeting; and that the Council be authorized to place at the disposal of this committee such funds for correspondence as may seem expedient.—Carried. (See Page 3.)

Upon motion of J. A. Udden it was voted that the Academy express its gratitude for the pleasant way in which it had been entertained by the University, by organizations and by individuals.

Isabel Smith extended an invitation to the Academy to hold one of its meetings at some future time at Jacksonville, stating that the Illinois College, one of the oldest institutions in the state, would do what it could to give the Academy a cordial welcome and successful meeting.

President Forbes stated that the committee on Ecology was ready to enlarge its membership. Since the committee was to be continued, this action would be in line with Prof. Galloway's suggestion.

C. W. Andrews gave notice concerning the work of scientific bibliography which was being carried on at the Crerar Library.

T. J. Burrill.—"It is proper to say that the twin cities of Urbana and Champaign invite you to return next year and the next and the next."

Upon motion of C. C. Adams it was voted to adjourn.

The following is the complete list of members elected Feb. 18 and 19, 1910.:

Babcock, Oliver B., M.D., 1100 South 2nd, Springfield. (Physician.)

Baer, Carlyle, Chicago Academy of Sciences, Chicago. (Nat. History.)
Bagley, W. C., Ph.D., Uni. of Ill., Urbana. (Educational Psychology.)
Baker, Charles Lawrence, B.S., Uni. of Chicago, Chicago. (Geology.)
Baker, I. O., C.E., University of Illinois, Urbana. (Civil Engineering.)
Benson, Peter, A.B., Augustana College, Rock Island. (Mathematics.)
Berg, E. J., Sc.D., Uni. of Ill., Urbana. (Electrical Engineering.)
Blair, J. C., M.S.A., 810 Oregon St., Urbana. (Horticulture.)
Bryant, Earl R., A.B., Millikin University, Decatur. (Biology.)
Burgess, L. L., Ph.D., 409 East Green St., Champaign. (Chemistry.)
Burke, C. E., University of Illinois, Urbana. (Chemistry.)
Burns, Wm. G., Section Director, U. S. Weather Bureau, Springfield.
Carpenter, F. W., Ph.D., 1008 W. Oregon St., Urbana. (Zoology.)
Cederberg, Wm. E., Ph.D., Augustana College, Rock Island. (Math.)
Child, C. M., Ph.D., University of Chicago, Chicago. (Zoology.)
Coad, Bert R., 1817 Spruce St., Murphysboro. (Entomology.)
Coe, Chester M., Danville. (Entomology.)
Collins, J. H., A.M., Supt. City Schools, Springfield. (Nature Study.)
Cooper, Wm. S., University of Chicago, Chicago.
Cort, W. W., A.B,. 1206 W. Springfield Ave., Urbana. (Zoology.)
Crowe, A. B., Charleston. (Physics.)
Daniels, L. E., LaPorte, Ind. (Conchology.)
Davenport, Eugene, M. S., Uni. of Ill., Urbana. (Agriculture.)
Egan, J. E., A. B., 906 South Fifth St., Champaign. (Chemistry.)
Emmett, A. D., A.M., 707 W. Illinois St., Urbana. (Chemistry.)
Emmons, W. H., Ph. D., Uni. of Chicago, Chicago. (Economic Geology.)
Ernest, T. R., A. M., 605 E. Springfield Ave., Champaign. (Chemistry.)
Finley, C. W., 5620 Kimbark Ave., Chicago. (Zoology.)
Gault, B. T., Glen Ellyn. (Ornithology.)
Gill, F. W., B.S., 601 W. Illinois St., Urbana. (Chemistry.)
Girault, A. A., M.S., Urbana. (Entomology.)
Gooding, Chas. W., High School, Champaign. (Biology and Chemistry.)
Gordon, H. B., University of Illinois, Urbana. (Chemistry.)
Gordon, W. O., 905 S. Sixth St., Champaign. (Chemistry.)
Green, Bessie, A.B., 401 S. Wright St., Champaign. (Zoology.)
Hagler, Elmer E., M.D., Capitol & 4th Sts., Springfield. (Physician, Oculist.)
Hand, E. E., Wendell Phillips High School, Chicago. (Zoology.)
Harrison, B. H., 304 East Daniel St., Champaign. (Chemistry.)
Hawk, P. B., Ph.D., 801 West Nevada St., Urbana. (Chemistry.)
Hayford, John F., C.E., Northwestern Uni., Evanston. (Engineering.)
Henriksen, Martin E., B. S., 509 E. University A., Champaign. (Zoology.)
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Hinkley, A. A., Dubois. (Conchology.)
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Jacobson, A., B.S., 501 E. Clark St., Champaign. (Chemistry.)
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Jessup, J. M., Uni. of Chicago, Chicago. (Geology and Paleontology.)
Johnson, H. W., Mt. Olive. (Psychology and Biology.)
Jones, G., Ph.D., 409 East Green St., Champaign. (Chemistry.)
Kindred, Granville L., Ill. Watch Co., Springfield. (Mechanical Eng.)
Kingsbury, H. B., A.B., 607 S. Sixth St., Champaign. (Mathematics.)
Kinnear, T. J., A.B., M.D., 400 Myers Bldg., Springfield. (Medicine.)
Knight, Luther, M.S., 401 Springfield Ave., Champaign. (Chemistry.)
Kressman, F. W., B.S., 210 E. Clark St., Champaign. (Chemistry.)
Langelier, W. F., B.S., 1005 West Illinois St., Urbana. (Chemistry.)

LaRue, Geo. R., A.M., 612 S. Coler Ave., Urbana. (Zoology.)
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Lehenbauer, P. A., A.M., University of Illinois, Urbana. (Botany.)
Linder, O. A., 22 Fifth Ave., Chicago. (Editor Svenska Amerikanaren.)
Lindgren, J. M., A.M., 306 S. Fourth St., Champaign. (Chemistry.)
Lumbrick, Arthur, (College of Agriculture,) Urbana. (Agriculture.)
Lyon, Thos. E., B.S., L.L.B., Hay Bldg., Springfield. (Lawyer.)
MacInnes, D. A., University of Illinois, Urbana. (Chemistry.)
MacNeal, W. J., Ph.D., Urbana. (Bacteriology.)
Marshall, Ruth, Ph.D., Rockford College, Rockford. (Biology.)
McAllister, H. T., 1002 W. California St., Urbana. (Chemistry.)
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McDunnough, Dr. J., Decatur. (Lepidoptera.)
Miller, G. A., Ph.D., University of Illinois, Urbana. (Mathematics.)
Mitchell, H. H., University of Illinois, Urbana. (Chemistry.)
Morrison, H. T., M.D., First and Miller, Springfield. (Gen. Medicine.)
Mortensen, Henry T., Frances W. Parker School, Chicago.
Mumford, H. W., Champaign. (Animal Husbandry.)
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Partridge, N. L., Y. M. C. A., Champaign. (Agriculture.)
Patterson, Alice J., Normal. (Entomology: Nature Study.)
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Read, J. W., M.S., Illinois College, Jacksonville. (Chemistry.)
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Smith, A. L., 205 E. Stoughton St., Champaign. (Zoology.)
Smith, G. McP., Ph.D., 708 South Fourth St., Champaign.
Smith, Huron H., Field Museum, Chicago. (Dendrology.)
Smith, Orrin H., High School, Champaign. (Physics.)
Smith, Sidney B., B.S., 710 S. Sixth St., Springfield. (Farming.)
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Thomson, Frank D., A.M., Prin. H. S., Springfield. (Economics-Hist.)
Udden, Anton D., Rock Island H. S., Rock Island. (Physics and Math.)
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Wagner, C. L., 405 E. Green St., Champaign. (Chemistry.)
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Watt, L. A., 405 E. Green St., Champaign. (Chemistry.)
Welch, Paul, A.B., Decatur. (Zoology.)
Wilczynuski, E. J., Ph.D., Uni. of Ill., Urbana. (Mathematics.)
Williamson, Warren, A.B., University of Illinois, Urbana.
Zeleny, C., Ph.D., 606 S. Matthews A., Urbana. (Experimental Zoology.)

A. R. CROOK, Secretary.

CONSTITUTION AND BY-LAWS

ILLINOIS STATE ACADEMY OF SCIENCE

CONSTITUTION

ARTICLE I. NAME.

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

ARTICLE II.. OBJECTS..

The objects of the Academy shall be the promotion of scientific research, the diffusion of scientific knowledge and scientific spirit, and the unification of the scientific interests of the State.

ARTICLE III. MEMBERS.

The membership of the Academy shall consist of *Active Members, Non-resident Members, Corresponding Members, Life Members, and Hororary Members.*

Active Members shall be persons who are interested in scientific work and are residents of the State of Illinois. Each active member shall pay an initiation fee of one dollar and an annual assessment of one dollar.

Non-resident Members shall be persons who have been members of the Academy but have removed from the State. Their duties and privileges shall be the same as those of active members except that they may not hold office.

Corresponding Members shall be such persons actively engaged in scientific research as shall be chosen by the Academy, their duties and privileges to be the same as those of active members, except that they may not hold office and shall be free from all dues.

Life Members shall be active or non-resident members who have paid fees to the amount of twenty dollars. They shall be free from further annual dues.

Honorary members shall be persons who have rendered distinguished service to science and who are not residents of the State of Illinois. The number shall not exceed twenty at one time. They shall be free from all dues.

For election to any class of membership the candidate's name must be proposed by two members, be approved by a majority of the committee on membership, and receive the assent of three-fourths of the members voting.

All workers in science present at the organization meeting who sign the constitution, upon payment of their initiation fee and their annual dues for 1908 become charter members.

Article IV. Officers.

The officers of the Academy shall consist of a President, a Vice-President, a Chairman of each section that may be organized, a Secretary, and a Treasurer. These officers shall be chosen by ballot on recommendation of a nominating committee, at an annual meeting, and shall hold office for one year or until their successors qualify.

They shall perform the duties usually pertaining to their respective offices.

It shall be one of the duties of the President to prepare an address which shall be delivered before the Academy at the annual meeting at which his term of office expires.

The secretary shall have charge of all the books, collections, and material property belonging to the Academy.

Article V. Council.

The Council shall consist of the President, Vice-President, Chairman of each section, Secretary, Treasurer, and the president for the preceding year. To the Council shall be entrusted the management of the affairs of the Academy during the intervals between regular meetings.

Article VI. Standing Committees.

The Standing Committees of the Academy shall be a Committee on Publication and a Committee on Membership.

The Committee on Publication shall consist of the President, the Secretary, and a third member chosen annually by the Academy.

The Committee on Membership shall consist of five members chosen annually by the Academy.

Article VII. Meetings.

The regular meetings of the Academy shall be held at such time and place as the Council may designate. Special meetings may be called by the Council and shall be called upon written request of twenty members.

Article VIII. Publication.

The regular publications of the Academy shall include the transactions of the Academy and such papers as are deemed suitable by the Committee on Publication.

All members shall receive gratis the current issues of the Academy.

Article IX. Affiliation.

The Academy may enter into such relations of affiliation with other organizations of appropriate character as may be recommended by the Council and be ordered by a three-fourths vote of the members present at any regular meeting.

Article X. Amendments.

This constitution may be amended by a three-fourths vote of the members present at an annual meeting, provided that notice of the desired change has been sent by the Secretary to all members at least twenty days before such meeting.

BY-LAWS

I. The following shall be the regular order of business:

1. Call to order.
2. Reports of officers.
3. Reports of standing committees.
4. Election of members.
5. Reports of special committees.
6. Appointment of special committees.
7. Unfinished business.
8. New business.
9. Election of officers.
10. Program.

Adjournment.

II. No meeting of the Academy shall be held without thirty days' previous notice being sent by the Secretary to all members.

III. Fifteen members shall constitute a quorum of the Academy. A majority of the Council shall constitute a quorum of the Council.

IV. No bill against the Academy shall be paid without an order signed by the President and Secretary.

V. Members who shall allow their dues to remain unpaid for three years, having been annually notified of their arrearage by the Treasurer, shall have their names stricken from the roll.

VI. The Secretary shall have charge of the distribution, sale, and exchange of the published Transactions of the Academy, under such restrictions as may be imposed by the Council.

VII. The presiding officer shall at each annual meeting appoint a committee of three who shall examine and report in writing upon the account of the Treasurer.

VIII. No paper shall be entitled to a place on the program unless the manuscript or an abstract of the same shall have been previously delivered to the Secretary.

IX. These by-laws may be suspended by a three-fourths vote of the members present at any regular meeting.

LIST OF MEMBERS

HONORARY MEMBER

Trelease, Wm., LL.D., Mo., Bot. Garden, St. Louis, Mo. (Botany.)

CORRESPONDING MEMBERS

Abbott, J. F., A.M., Washington Uni., St. Louis, Mo. (Zoology.)
Coulter, S. M., Ph.D., 3883 Juniata St., St. Louis, Mo. (Botany.)
Eycleshymer, A. C., Ph.D., St. Louis Uni., St. Louis, Mo. (Anatomy.)
Lyon, E. P., Ph.D., St. Louis University, St. Louis, Mo. (Physiology.)
Turner, C. H., Sumner H. S., St. Louis, Mo. (Invertebrate Zoology.)
Widman, O., Ph.D., 5105 Morgan St., St. Louis, Mo. (Ornithology, Bot.)

ACTIVE MEMBERS

*Abbott, G. A., A.M., 945 Marquette Building, Chicago. (Ornithology.)
Ackert, J. E., A.B., University of Illinois, Urbana. (Zoology.)
*Adams, C. C., Ph.D., University of Illinois, Urbana. (Biology.)
Akeley, C. E., Field Museum, Chicago. (Taxidermy.)
*Andrews, C. W., A.M., The John Crerar Library, Chicago. (Sci. Biblio.)
*Atwell, Chas. B., Ph.M., Northwestern Uni., Evanston. (Botany.)
*Atwood, W. W., Ph.D., University of Chicago, Chicago. (Geology.)
Babcock, Oliver B., M.D., 1100 S. 2nd St., Springfield. (Physician.)
*Bachmann, Frank, State Water Survey, Urbana. (Chemistry.)
Baer, Carlyle, Chicago Academy of Sciences, Chicago. (Natural Hist.)
Bagg, R. M., Jr., Ph.D., University of Illinois, Urbana. (Geology.)
Bagley, W. C., Ph.D., Uni. of Ill., Urbana. (Educational Psychology.)
*Bain, H. Foster, Ph.D., 667 Howard St., San Francisco, Cal. (Geology.)
Bain, Walter G., M.D., Prince Sanitarium, Springfield. (Bacteriology.)
Baird, Miss Grace J., A.B., 608 S. Mathews Ave., Urbana. (Biology.)
Baird, Leo P., A.B., (Eugenics.) Address unknown.
Baker, Chas. L., B.S., Uni. of Chi., Chicago. (Paleontology & Geology.)
Baker, Frank C., Chicago Academy Sciences, Chicago. (Conchology.)
Baker, I. O., C. E., 702 W. University Ave., Champaign, (Civil Eng.)
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Barker, Perry, Box 3024, Ann Arbor, Mich.
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*Barnes, H. O., A.B., High School, Springfield. (Mathematics.)
Barnes, R. M., LL.B., Lacon. (Oology.)
Barnes, Will F., M.D., Decatur. (Medicine.)
Barrett, J. T., Cornell University, Ithaca, N. Y.
Barrows, H. H., University of Chicago, Chicago.
*Bartow, Edward, Ph.D., University of Illinois, Urbana. (Chemistry.)
Barwell, John William, Waukegan. (Anthropology.)

*Charter members.

Basquin, O. H., Ph.D., Northwestern University, Evanston. (Physics.)
*Bayley, W. S., Ph.D., University of Illinois, Urbana. (Geology.)
Bement, A., M.E., 2114 Fisher Bldg., Chicago. (Mining Engineering.)
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Berg, E. J., Sc.D., Uni. of Ill., Urbana. (Electrical Engineering.)
Berry, Daniel B., M.D., Carmi. (Medicine.)
Berry, Rufus L., 511 North Side Square, Springfield.
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Bleininger, A. V., U. S. Geological Survey, Pittsburg, Pa. (Ceramics.)
Bloom, Miss M. E., Jacksonville.
Boerner, Wunibald R., Ravinia, Lake County. (Biology.)
*Bretnall, G. H., A.M., Monmouth College, Monmouth. (Botany.)
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Browning, James H. Address unknown.
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Bryant, Earl R., A.B., James Millikin Uni., Decatur. (Biology.)
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Burke, C. E., University of Illinois, Urbana. (Chemistry.)
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*Clawson, A. B., A.B., Dept. of Agri., Washington, D. C. (Biology.)
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Cohn, M. L., Continental Bank Bldg., LaSalle St., Chicago. (Mining.)
*Collett, E. B., B.S. (Biology.) Address unknown.
Collier, J. S., B.S. Address unknown. (Biology.)
Collins, J. H., A.M., Supt. City Schools, Springfield. (Nature Study.)
Conrad, A. H., Crane Technical High School, Chicago. (Biology.)
Coonradt, J. H., High School, Decatur.
Cooper, Wm. S., B.S., Uni. of Chicago, Chicago. (Botany.)
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*Cowles, H. C., Ph.D., University of Chicago, Chicago. (Botany.)
*Crandall, Charles S., M.S., Uni. of Ill., Urbana. (Botany.)
*Crew, Henry, Ph.D., Northwestern University, Evanston. (Physics.)

*Crook, A. R., Ph.D., Curator State Museum, Springfield. (Geology.)
Crowe, A. B., A.M., Eastern Ill. State Normal, Charleston. (Physics.)
*Curtiss, R. S., Ph.D., University of Illinois, Urbana. (Chemistry.)
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Daniels, L. E., LaPorte, Ind. (Conchology.)
Davenport, Eugene, M.S., Champaign. (Agriculture-Thremmatology.)
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Davis, N. S., M.D., 291 Huron St., Chicago. (Medicine.)
*Davis, Wm. E., Hubbard's Woods, Chicago.
*Dawson, L. A., A.B. Address unknown. (Chemistry.)
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