University of the State of New York

High School Department

Bulletin 13 May 1901

New York State Science Teachers Association

PROCEEDINGS OF THE FIFTH ANNUAL CONFERENCE

Held at University of Rochester, Rochester, 28-29 December 1900

SUMMARY OF SESSIONS

Friday, 28 December, 9.30 a. m.

Meeting of executive council

Registration

Opening session; called to order by Prof. LEROY C. COOLEY, *chairman*

Address of welcome

Pres. RUSH RHEES, University of Rochester

Response

Prof. LEROY C. COOLEY, Vassar college, retiring president of the association

Introduction by Prof. LEROY C. COOLEY of Pres.-elect CHARLES W. DODGE, University of Rochester

Remarks

Prof. CHARLES W. DODGE

tifically, and it would be a very excellent thing if it could be; but the truth is, we are required to teach physiology in the first year, and before we can carry out scientific courses it will be necessary to add another course in the senior year of the high school. If that can be brought about, we can perhaps have physiology taught more scientifically than we now do.

HOW SHALL A YOUNG PERSON STUDY BOTANY?

(A sequel to the *New botany* printed in 1879)

BY PROF. W. J. BEAL, MICHIGAN AGRICULTURAL COLLEGE

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

Agassiz said he was glad to see me there and asked a few questions, observing that, "You must make up your mind to be a poor man all your life if you become a naturalist. With my mode of treatment students are about sure to become discouraged at first. I shall try your patience. You have read books, but have not studied the subjects themselves. If you study with me, you must not look at a book for some time, for several months. You must learn to see, to observe for yourself. After students get started once in this way, the longer they study here the better they like it, and the more reluctant they are to leave." After some more questions, he handed me half a dozen dead sea-urchins, and left me with the remark: "I want you to see what you can make of them, and in a day or two I will see how you get along." He assigned me a table in the laboratory, where ten or a dozen other special students were at work, the floor being largely covered by cords of shallow wooden boxes set tightly over each other, containing various kinds of specimens. This was a queer way to study—six dry specimens about as large as so many

Baldwin apples and no books! I looked them over and over, part of the time using a small hand lens. I was glad when night came, for it seemed as though I had learned all there was to be learned of sea-urchins. I broke them to pieces and made some drawings. The next day the professor called with a smile, saying, "Well, Mr Beal, what have you seen?" He glanced at the drawings, and I told him what I had done. He gave me a very few general hints of what to look for, and a few names of the parts, noticing some mistakes, but made no corrections.

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

In a similar manner one species of star fish was examined, its examination occupying a week or so. Agassiz says: "These two animals, the sea-urchin (a flattened sphere) and the starfish (with five rays or arms), are composed of similar parts arranged in a similar manner. Learn how it is." The comparison occupied several days. The next specimen was a spatangoid, an animal somewhat different from either of the others. "Now homologize these three." Then a third and a fourth specimen were given me, differing from the others in appearance; and I was told again: "Compare. It is easy to observe isolated parts—any one can soon learn to do that; but, when you compare two objects, you

take a step in philosophy." In one case I was asked to make a paper model of a coral, to illustrate my idea of the hard portions. Corals were compared with sea-urchins and starfishes. This work occupied me for more than two months, and during all this time Agassiz never corrected a mistake, but kept me working till I found out for myself. Perhaps it was three months before I was permitted to see books on these subjects, but at that time their contents were carefully read and fully understood. Agassiz often said: "Study specimens and refer to books, and not the reverse, as is usually done. Textbook knowledge about nature does not amount to anything; it is a very poor basis of culture."

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

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

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

After the students have learned well how to see for themselves by practising for 18 or 20 weeks, in succeeding terms, I am by no means so particular to adhere to this plan.

In many of our elementary textbooks in these times—and they are numerous and multiplying rapidly—authors recommend the study of what they call types. For example, they advise studying one spirogyra, one vaucheria, one mucor, one puccinia, one ascomycete, one marchantia, one polytrichum, and so on through, from low protococcus to one of the highest—the dandelion. In pursuing this plan, my experience convinces me that most students fail to see the connection and lose interest in passing from one isolated family or class to another. It may be well enough to study types, but pupils should not fail to study in that connection a considerable number of species that are somewhat nearly related, and by this means have the benefit of comparing similar objects. After learning the structure of one violet, it is better to examine the structure of at least 10 other species than to spend the same time studying a single crowfoot, a chickweed, a geranium, a spiraea, a rose, a mint, a phlox, a mallow, a dandelion, a fern; though each of these may be studied at other times in connection with allied forms.

25 years ago, we often met teachers in Michigan who required their pupils to begin botany by getting lessons from a textbook, where they saw some pictures and diagrams, instead of plants or some of their parts. This was the practice, specially in winter, when it was declared no specimens were to be obtained. I am sorry to say that such persons in the back districts are still retained as teachers. Perhaps I ought not to mention this matter in New York; but it is not three years since I met one of your teachers, occupying a high place, who followed the book lesson plan, with little or no use of specimens. Is it possible that he was unable to procure large seeds of some common plants and set his pupils to observing, experimenting with, and growing them in the classroom? Had he not collected many dry seeds, fruits, and racemes in summer and kept them in bunches or in loose sacks hung on the nails in the rafters of an attic till wanted in winter? The fact appears not to

have entered his head, that he could secure, each in its season, a great assortment in quantity of the soft fruits and buds of flowers—that he could keep these in jars in 2% of formalin till wanted. They will retain their shape and part of their color very well, and the odor of formalin disappears after washing in water for a few minutes. True, we can not collect roses from a New York garden in January, nor maple blossoms in February, but our trees and shrubs in their winter garb furnish excellent lessons to employ pupils profitably for many weeks of winter, and this all comes within the scope of botany, just as much as if we examined flowers in May or June. By the roadside, in the swamp, in the woods or the front yard, are hundreds of branches of a hundred kinds of woody plants, the buds of which are formed in summer and resting in winter, some of them waiting to be studied by inquisitive pupils. The branches have pith, wood and bark, to say nothing of the delicate contents of buds. Students can pursue the following order with branches of our elms and find plenty to do.

1 Note general characteristics of branches, including the arrangement of buds and the abortive stem above the upper bud.
2 Lenticels, corky ridges, and the bark.
3 Leaf scars, their position, shape, structure.
4 Scars left by the bud scales, and minute buds in their axils.
5 Scars left by some of the dying buds.
6 The buds { 1) those containing a stem and leaves,
2) those containing flowers.

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

than to work it out for themselves. They do not reflect that they are pursuing the study to learn how to work rather than to acquire information.

In 1869 I gave members of the junior class in Chicago university some lectures on zoology; I was particular to tell them about the structure of the heart, and the circulation of the blood. Two of the class afterward dissected a dog that was good for nothing else. They wondered what those broad things were at the large end of the heart, and were going to cut them off and throw them away, not mistrusting that these were the auricles about which I had told them the day before. In 1885 I gave to an advanced class five illustrated lectures on the pollination of flowers. After the course, I asked questions and made the following record in my notebook. "As far as the lectures are concerned, many points were imperfectly understood, erroneous notions were entertained. The five lectures were to a great extent a loss of time, which could have been spent to better advantage by a careful study of the flowers of several living species."

Better than lectures I have found the following, not omitting laboratory work. I teach agricultural students something concerning grasses, weeds, parasitic fungi, forestry, plant physiology. After they have done some laboratory work, students are supplied with duplicate books, bulletins, or separates, which treat specially of the subject in hand. These are read by each one during the laboratory hours, and the students take their time for making good notes. These books and bulletins are a part of the laboratory equipment. For example, beginners study seeds and seedlings of peas and beans for four hours, making some notes and drawings, after which I give each a copy of my bulletin, no. 1, on elementary science, which treats of the same kinds of seeds and seedlings. Copies of this bulletin are on the table at this meeting. Wheat and buckwheat are studied in the same manner, and later seeds and seedlings of timothy and clover, each time finishing up with a bulletin. I can conceive no more desirable method than to have the whole series of topics which

are studied during a term, written up and illustrated in this manner, that the text and cuts may not be seen till considerable attention has been given to the objects. In case a book is furnished to a beginner, while he has specimens, he is almost certain to use it as freely as a student would use the translation of a German or Latin text which he is trying to translate.

In Michigan, many persons preparing for examinations with a view to securing certificates, cram in botany and zoology, physics and chemistry, instead of making original observations or of making the experiments for themselves. Not long ago our state superintendent of public instruction introduced a fine scheme for a part of his examinations in botany. Those who were trying for state certificates, were given some questions to be answered in writing on the usual plan, while another part of the examination consisted in using a stage misroscope with paper and pencil and no books to give the result of their observations concerning some fresh plants placed in their hands. Such questions are most admirable, and are fair, but in this case most of them were unanswered, showing that the candidates were destitute of the most important part of the preparation. Some of them failed to make a passing record. In examining candidates to enter an advanced class, I invariably make considerable use of laboratory work and less of oral quizzes.

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

1 Where possible, examine many specimens of one species.

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

3 Carefully compare homologous parts of allied species.

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

As we must expect, beginners are often at a loss to know how to express themselves clearly and fully, specially in writing descriptions of plants or parts of plants that they have never seen before. Their notes are very often too meager. After all have tried and done the best they can, I show them what I can do,

or permit them to copy an apt description from some book or from a blackboard. After repeating this process for several times, they soon begin to acquire considerable skill in description.

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

Many textbooks contain in the introduction or in some of the early chapters a lengthy account of the classification of the subjects treated in later chapters. Here they attempt to teach classification before the beginner has acquired a knowledge of facts as a basis sufficient to comprehend the text. I wish to call your attention to a notable exception to this rule in a *First book of zoology* by E. S. Morse, published more than 25 years ago, before some of you were born. The plan is admirable. The author speaks to his pupils by text, and excellent illustrations of snails, clams, insects, centipedes and lobsters, and in the last part of the book, where you would least expect to find it, he inserts a few chapters concerning natural groups. Here we have the natural order of work; a multitude of facts are given before the author attempts to generalize or classify.

What I term beginning botany, is expected to continue daily for 18 or 20 weeks, devoting an hour and a half a day to the laboratory, with sections containing each 25 to 30 persons. Each student is furnished with a stage microscope, with two needles in handles, a pair of forceps and usually a small knife. During this period the teacher must see:

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

In certain cases, I find it very instructive to require students to make models out of paper or out of large rutabagas or potatoes.

Certainly in no course should a student attempt to study everything pertaining to botany. We must select with reference to that which is most suitable for students that we teach and the apparatus that is available. We select what will give the best

training, and lastly that which will give the most useful information. If all were intending to pursue the study of medicine, or of mechanical engineering or of agriculture, or of horticulture, the fact might influence more or less the topics to be selected, but the pupils in most schools will pursue a great variety of callings after completing a course, or before that time. We must keep in mind all the time that "what a man can do is more important than what he knows."

For acquiring the power of daily observation, there can be nothing better than the study of the gross anatomy of plants, and for cultivating the judgment, plant morphology is unsurpassed, specially where frequent comparisons are insisted on. While these two lines of work are kept at the front, from the first lesson on the first day and all through the course, I encourage every student not to forget to ask himself the question, "Why and how?" This will call in more or less physiology, oecology, description and classification or relationship. Under oecology specially these questions are always interesting: why plants are not all found in the same region, why they do not all flower at once. Here come in the modes of plant dispersal, the struggle for existence and more room, zonal distribution, plant communities, adaptation to climate, how plants protect themselves.

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

No person for the first 20 weeks of botany should be at the trouble of learning to use a compound microscope. He should leave it, till he has made a somewhat intimate acquaintance with the gross anatomy of plants.

There are a dozen or so designs or blank forms published, having spaces opposite printed names, in which to answer direct

questions about a plant in flower. It is well enough to place about three copies of this in the hands of each student as he examines three different plants, but to continue their use for a greater length of time will tend to relieve the student of thinking and make a machine of him. The quicker he learns to ask his own questions and answer them the better, even at the risk of some omissions.

It seems to be necessary to spend some time in the classroom, to aid pupils in becoming familiar with artificial keys which lead to families, where a plant in hand may be described and named, but, with the other instruction provided for, but little time need be given to this work. This work is too often spoken of as analyzing plants, instead of identifying plants. I place a very low estimate on a common practice of requiring each person in a class to collect, dry and mount 50 to 100 plants.

I have not had much experience in conducting field excursions, because my teaching has been done at a college which has a large campus containing a great assortment of trees and shrubs, and because there is at hand a botanic garden where the plants are arranged in families, each plant growing back of a label which contains its name. It is a part of our plan in the spring term to go once a week, with the students in small companies of about a dozen, where some interesting features can be pointed out.

A botanic club or a natural history society in a school is well worth encouraging. Let it be officered by the students, and help them to get up programs, remembering that no society of this kind can long maintain an interest among its members, if they plan to have little else than a lecture at each meeting. The members should be the actors on the program.

I inclose a copy of a reprint from the first report of the Michigan academy of science, entitled:

SUITABLE TOPICS FOR DISCUSSION BY YOUNG MEMBERS OF A BOTANICAL CLUB

BY W. J. BEAL, AGRICULTURAL COLLEGE

(Read before the Academy, April 1, 1897)

In some respects the botany taught in our agricultural college should be unlike that introduced into a portion of the courses in a university. For example, the young person bent on agriculture or horticulture in any of their departments would not need to spend time in the study of mosses, liverworts, lichens, or algae, or many of the saprophytic fungi. On the contrary, he does need to learn the names and many of the peculiarities of our native and introduced trees and shrubs, the same of the leading grasses, clovers and other forage crops; he needs a familiarity with our weeds, including the seeds of cereals and other field crops, our parasitic fungi, especially those injurious to cultivated crops and weeds of all kinds, and some knowledge of the anatomy and physiology of the higher plants. In a word, he seems to have a greater need of the old-fashioned systematic botany than is generally expected in these times in the courses of a university.

Especially should the agricultural student from the start take much pains to become a close and accurate observer of plants in the field, orchard, and garden, in fact anywhere found.

For such a course the electives need not be numerous.

For many years past at the state agricultural college there has been a natural history society with meetings once a month, at which the observations reported referred mainly to agriculture, horticulture, botany, zoology, and entomology.

A little over six years ago, a botanical club was established with meetings in the botanical laboratory three or four times a month. The attendance averages from 10 to 20, with a membership of about 50.

During these six years of its existence, there have been presented 219 topics. Most of the members are mentally young. I have here a list of 75 or more of these topics, which seem to be models of their kind for such members to consider. As one of the objects of the State academy of science is to encourage young people—or older ones either—to pursue some lines of investigation appropriate to our aims, I thought this list of topics would be interesting to such young workers or members of a young natural history society. It may be needless to say that in nearly every instance the paper or talk gave the results of personal observation.

A comparison of the fruits of our three elms.

The flora of Michigan, some notes on.

Beech drops.

The odor of plants.
The box elder.
Proper work of a botanical club.
Thistles of the neighborhood.
A study of the leaves of arbor vitae.
Comparison of the buds of several oaks.
The fruit of the red mulberry.
Comparison of the twigs of three pines.
The roots of the red clover.
Pop corn, before and after popped.
The roots and leaves of a young wheat plant.
The report of a field day.
The flowers of campanula.
The flowers of the common sage.
Petiolar glands.
The life history of corn smut.
Notes on how to observe.
Notes on leaf galls.
The attractions of the botanic garden.
A talk on wheat.
Remarks on native goldenrods and asters
A comparison of beechnuts from several trees.
Large varieties of fruits of a hawthorn.
Autumn leaves.
How botany is taught at the state university.
Notes concerning Dr Watson of Harvard, recently deceased.
Detecting the adulteration of buckwheat flour.
A talk on some of our ferns.
A talk on the origin of cultivated plants.
Some of our fresh-water algae by an amateur.
A fungus growing from the neck of a larva.
The adulterations of tea.
Observations on the black knot of the plum.
The adulteration of coffee.
Fasciation in a dandelion.
Our erysiphae and their hosts illustrated.
Report of the meeting of the A. A. A. S.
Different forms of leaves on the same plant.
Carnations, structure, etc.—the models.
The "flow" of sap in the sugar maple.
Questions asked of the botanist of the experiment station.
Our willows—illustrated.
Some of our earliest grasses.
The structure of a puffball.
Plans of some experiments for preventing smut in oats and barley.

How to kill quack or couch grass—why?
Botany as seen in the German exhibit at Chicago.
Some of the curious plants grown in the greenhouse.
Four persons talked of as many different kinds of smuts.
Our native orchids.
Two kinds of wild potatoes grown in the botanic garden.
Some of the fungi grown on tomatoes.
The cross-fertilization of wheat.
The improvement of our wild fruits.
Some monstrosities among plants and their meaning.
History and development of some of our grapes.
The mode of distribution of some seeds.
Observations on Michigan pines.
The irregularity in the germination of seeds of weeds and the advantage to these plants.
Sub-irrigation in the forcing house.
An exhibit of seedling willows.
Observations on oak galls.
A comparison of plants of wheat and chess.
An exhibit of tomatoes grafted on potatoes, both bearing crops —double cropping.
Experiments with smut on wheat.
Concerning the State academy of science which met at Ann Arbor June '94.
A visit to Greenland by one of the founders of the club, Mr Orth.
An exhibit of fruits of our native trees and shrubs.
A plant of wild strawberry in the botanic garden had produced by runners 1234 plants in one year.
The structure and use of bulliform cells in the leaves of some grasses.
The structure of root tips of wheat, and some branching hairs.
Squirrels dropping cones from trees and biting off limbs.
Exhibition and description of an artificial cell to show turgescence.
Report regarding the abundance of variegated corn in the field.
The life history of Monilia—plum rot.
An exhibit of chess which had germinated on ice.
An account of cutting wild rice, rafting down the river and curing for hay in '95.
Report concerning a visit to the U. S. department of agriculture and the M. A. C. men there employed.
The management of the woodlands of the college farm.
The structure and history of the navel orange.
Fairy rings on our lawns (marasmius).

A meeting in the evening at the botanic garden to observe the opening of flowers of the evening primrose and to see insects at work on various flowers.

The crossing of pop corn and field corn.

Life history of rust on wheat and barberry.

The seeds of weeds.

I hardly need to add that any botanical club or natural history club will make slow progress and work to very great disadvantage unless one or more of the members possesses already a very good knowledge of one or more divisions of natural science. If possible, such members will be of more aid in securing interest than a library.

For many years, I have assigned each term one or more suitable topics, a different one to each member of the class, which he considers his personal property. These topics the pupil investigates thoroughly so far as he can, and each member in turn presents his paper, or talk, usually with illustrations, to the other members. The quality of the work like that of a recitation is credited as equivalent to two or three or more good or poor recitations. I have uniformly found that students took an interest in this plan. For numerous suitable topics consult the *New botany*, noticed elsewhere.

Frequently an opportunity arrives for advertising the members of a class a little. I consider the time well spent, provided the preparation is all of it in line with the legitimate work of the class during that term. Some of the teachers may be interested in a plan which I tried in 1886. In Michigan we have a thrifty state horticultural society that holds meetings in different parts of the state, thus performing missionary service. A meeting was to be held near the college with which I am connected. College was in session. I thought to stimulate the students of a certain class and interest the members of the society. 17 young persons gave three minute talks to the horticulturists on topics which they had been studying by the aid of the compound microscope. The subjects of the talks given were as follows: 1) structure of a leaf; 2) the mouths of a leaf; 3) young hairs of a leaf; 4) sting of a nettle; 5) talking and showing drawings of protoplasm in motion; 6) palisade cells in a leaf; 7) starch of

common and wild potato from Arizona compared; 8) the framework of a leaf; 9) fibers of cotton, flax and wool compared; 10) why nuts are hard; 11) tough and brittle white ash compared, as seen magnified; 12) structure of a grain of wheat; 13) pollen and its growth; 14) quince rust; 15) corn smut; 16) a study of common bread mold; 17) effect of severe cold or heat on the cells and their contents.

The secretary reported: "The drawings were admirably executed, and on the whole the entire exercise was as interesting as anything ever presented to the society." The illustrations were copied and with the text appeared in the report of the society in 1886, which gratified the students and probably did them no harm. Some of you may find occasion where a short exercise illustrated and presented by a class, each saying a little, will attract much greater interest than where only one or a very few speak longer. And no doubt some of you may have already tried this plan.

Even for college students I have found it beneficial to write neatly on the blackboard some motto or sentiment which shall catch the eye for two or three days. Here are some that I have used. No real progress can be made in botany, till the student learns to observe. Neatness begets accuracy. "Mere book knowledge of natural history is a sham and a delusion." (Huxley) "The pupil must earn his facts." (Goodale) "The teacher of biology will keep the student on the right track, but let him find the truth himself." (Farlow) Make frequent and thorough comparisons of two or more plants or similar parts of plants. "In biology, laboratory work should precede any detailed course of lectures." (Farlow) Details and facts before principles and conclusions. To learn to observe well, concentrate the attention for some time on a very small portion of the field, then in like manner study other portions. As an instrument of research, the microscope now occupies a position which is second to none. A trained eye is valuable in any kind of business. Merely learning the name of a plant or part of a plant can no longer be palmed off as valuable training. Correct teaching of botany is

simply giving the thirsty a chance to drink. He who expectorates on the floor must not expect to rate high in his class. To lose a lesson is to unsettle a week. "He who can teach only by the book had better not begin." (Prof. Wesley) "From first to last the student should be an investigator." (Prof. Wesley) "Patting one on the back and saying, 'Don't you see this?' and 'Don't you see that?' does not tend to produce a very robust mental development." (Farlow)

You should not neglect to tell the members of your board of control, whether they like to hear it or not, that giving good instruction in natural history is costly, but, notwithstanding the cost, no one in these times can lay claim to a liberal education who has not had a pretty good drill in botany or zoology or both of these. By costly, I mean not only to take into account the apparatus required, but the sizes of the sections and the hours for the work. For example, it costs about five times as much to teach a class of 30 in the subject of parasitic fungi as it does to teach the same students history or political economy.

None of us will ever live to perfect a course in botany that will stand the test of future discoveries and methods of teaching, nor shall we ever agree for a single year as to what should be taught or how it should be taught. In his report for 1888-89, Pres. Eliot said:

> During recent years every college teacher has been forced to answer anew the personal questions, What can I best teach, and how shall I teach it? Every man has really been obliged to take up new subjects and to treat them by new methods. There is not a single member of the faculty who is today teaching what he taught 15 years ago, as he taught it then. Each teacher has to recast his work . . . and the faculty has to invent, readjust, and expand the comprehensive framework of the course.

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

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

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

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

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

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

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

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

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

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

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

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

In these times textbooks for beginners are appearing in rapid succession. It is a barren month in which one or more are not published. In two instances within my knowledge, the editor has prepared two books for young students, and in one case three books by one author have appeared within a period of two years. New textbooks are always welcome to teachers, but the difficulty of selecting just the right one is not so easy. What does this

influx of botanical textbooks mean? Simply this, there are many persons interested in botany, and the subject is undergoing rapid changes. New discoveries in new channels make it an inducement for teachers to try a hand in making a new book. At present, the subject is in a somewhat chaotic condition. I have shown myself lacking in decision of character, by inability to select a textbook for beginners that just suited me. I have tried several, to discard at last all of them; and finally, to put into the hands of competent instructors—and no others should attempt to teach—I made a small work myself. Of course you have not seen it, for it is not in the list of any publisher. In the preface I wrote the following lines:

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

With those views in mind, all we need to put in the hands of a student is a brief outline of the course and a good glossary at the end of the pamphlet. Students are all supplied with good specimens in abundance at all times of the year; then what are pictures for except to tell the student what to look for? Having seen that, he believes he has seen all there is to be discovered. His curiosity ends then and there. Neither is it a good plan to lecture a class of young students implying that you are telling all there is known on a certain point—that there is nothing more to learn about the subject. Tell them rather, that no one knows it all, that here is a fine chance to make original investigations and you are about sure to be right in such statements.

As helps to teachers of botany, no one can afford to neglect to read the *Teaching botanist*, by W. F. Ganong, published in 1899 by Macmillan.

To my students, who are about to study with the aid of a com-

pound microscope, I take great pleasure in reading parts of a most admirable paper by Dr W. G. Farlow on biologic teaching in colleges, printed in the *Popular science monthly*, March 1886. Some of you may like to secure a copy of the *New botany*—a lecture on the best method of teaching the science by W. J. Beal. Third edition. 1890. 10c. Published by the *Rural New Yorker*, 409 Pearl st. New York.

PARTIAL LIST OF ELEMENTARY TEXTBOOKS ON BOTANY

Atkinson, G. F. Elementary botany. N. Y. 1898. Holt $1.25.

——— Lessons in botany. N. Y. 1900. Holt $1.

Bailey, L. H. Lessons with plants. N. Y. 1898. Macmillan $1.10.

——— First lessons with plants. N. Y. 1898. Macmillan 40c.

——— Botany: an elementary textbook for schools. N. Y. 1900. Macmillan $1.25.

Barnes, C. R. Plant life considered with special reference to form and function. N. Y. 1898. Holt $1.12.

——— Outlines of plant life, with special reference to form and function. N. Y. 1900. Holt $1.

Bergen, J. Y. Elements of botany. Bost. 1896. Ginn $1.20.

——— Foundations of Botany. Bost. 1901. Ginn.

Bessey, C. E. Essentials of botany. N. Y. 1896. Holt $1.08.

Bower & Vines. Course of practical instruction in botany. Lond. 1885. Macmillan.

Campbell, D. H. Elements of structural and systematic botany. Bost. 1891. Ginn $1.

Clark, C. H. Laboratory manual in practical botany. N. Y. 1898. American book co. 96c.

Coulter, J. M. Plant relations: a first book of botany. N. Y. 1899. Appleton $1.10.

——— Plant structures: a second book of botany. N. Y. 1899. Appleton $1.10.

Darwin, F. Elements of botany. Cambridge Eng. 1895. University press.

Evans, E. Botany for beginners. Lond. 1899. Macmillan.

Gray, Asa. Elements of botany. N. Y. 1887 and later editions. American book co. 94c.

——— How plants grow. N. Y. 1862 and later. American book co. 60c.

Kellerman, W. A. Elements of botany. Phila. 1883.

Macbride, T. H. Lessons in elementary botany. Bost. 1896. Allyn & Bacon.

Macdougal, S. T. The nature and work of plants. N. Y. Macmillan. 1900.

Massee, G. The plant world. Lond. 1898. Whittaker 2s 6d.

Newell, Jane H. Outlines of lessons in botany, pt 1 and 2. Bost. 1892. Ginn 90c.

Rattan, V. A popular California flora. San Francisco 1882. A. L. Bancroft & Co.

Setchell, W. A. Laboratory practice for beginners in botany. N. Y. 1898. Macmillan 90c.

Spalding, V. M. Guide to the study of common plants. Bost. 1895. Heath 90c.

Willis, J. C. Manual and dictionary of the flowering plants and ferns. Cambridge Eng. 1897. University press 10s 6d.

Prof. James H. Stoller—I would suggest that the discussion of Prof. Beal's paper, so interesting and so full of practical suggestions, may be had very well in connection with the paper to be read tomorrow morning, the "Framing of a course in biology for untrained minds". I suggest, with Prof. Beal's consent, that we defer the discussion till that time, and, if we come promptly together, we shall have time for the discussion of both papers.