A COURSE IN ELEMENTARY HIGH SCHOOL BIOLOGY
WITHIN THE STUDENTS ENVIRONMENT

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PREFACE

This thesis is an attempt at the solution of a problem which has grown out of some discouragements and difficulties experienced in connection with three years of teaching biological sciences to first year high school students in the public schools of this state. The problem is the outcome of two convictions. The first of these is that the discouragements and difficulties mentioned were the natural consequences of an attempt to teach, in the most direct way possible, the fundamental facts and principles of the science. The second of these is, that to accomplish the best results in such a course, the fundamental aim should be to teach those things of biology which meet the immediate needs of the students and which, incidentally, will be of most use to them in after life whether school work is to be continued or not.

During the years 1913-1914 and 1914-1915, while a student at the University of Missouri, an opportunity was given me to organize a course in elementary biology based upon such principles and to teach the course to a class of twenty five first year high school students at the University High School.

At the same time I was permitted to do some nature-study teaching in the upper grades of the University Elementary School in order that I might more thoroughly develop the young pupils' point of view. It is the purpose of this thesis to present an outline of the course in elementary biology as organized and, as far as possible, to evaluate the success with which it was taught. Before giving the outline, however, an exposition and criticism will be made of some typical elementary text books of biology that are being used in the high schools of this country. This will be followed by a more thorough statement and discussion of the principles underlying the organization of the course.

This thesis has been developed under the supervision of Professor J. L. Meriam, whose encouragement and inspiration have made possible the carrying out of the work. To Professors Curtis and Reed acknowledgement is made for various suggestions.

CHAPTER 1

EXPOSITION

Education Department Bulletin, Syllabus for Secondary Schools, Biology, 1910, Albany, N. Y.

This syllabus contains the general aims and outline for a first year high school course in biology as is suggested to be taught in the high schools of the state of New York. Four aims are mentioned as follows:
" (1) To give the boy and girl first hand knowlege of some plants and animals.
(2) To lead them to some understanding of some under-standing of the essential functions carried on by living things.
(3) To teach them something of the enormous economic importance to man of plant and animal products, and the necessity of conserving the national biological resources of our country.
(4) To emphasize especially the essential conditions of individual and public health in the city and state" (1)

The course in general biology as outlined in the syllabus is introduced by class discussions to bring out " some of the essential functions of the human body and the idea of adaptations of certain structures to function illustrated by some part of the human body or some part of an animal, e.g. hand of man, claw of cat" (2)

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The composition of living things, also an introductory topic, follows. This consists of experimental and observational studies of the character of the more common elements and compounds which are used by plants in making food, and of those elements present in the nutrients of food compounds.

The introduction is followed by four divisions: animal biology, human biology, plant biology and general biology. Animal biology consists of the study of insects, crustaceans, fishes, frogs and their relatives, birds and one-celled animals. For each of these groups the outline calls for the laboratory study of a type form. This includes (1) the location and adaptations to functions of the external regions and appendages of the body, (2) the life history and methods of locomotion, feeding and breathing of the animal. This study, in each case, is followed by some general topics which bring out the economic importance and general relations of the particular group of animals to man. In the study of the frog and their relatives, however, some additional topics are included; the study of the cell, the gross position and gross structure of some of the internal organs, and a consideration of some of the functions of these organs including the processes of digestion, respiration, excretion, sensation and reproduction.

The portion of the outline on human biology includes a study of the location, general structure and

functions of the various organs of the body. Throughout this study emphasis is placed, so far as possible, upon the essential conditions of individual and public health.

The outline on the study of plant biology is planned, it seems, for the purpose of acquainting the student with the fundamental physiological processes of flowering plants as well as with considerable information concerning the relation of plants to human welfare. No attention is given to the study of the cryptogams.

The outline is concluded by the portion on general biology. The first includes a review of many of the things studied in the first part of the course for the purpose of directing the pupils to the formulation of some generalizations such as the cell as the unit of structure of all living plants and animals, the similarity in composition and essential characteristics of the protoplasm of all parts of animals and plants, and the part played by certain fundamantal physiological processes in all living matter and the interrelations of plants and animals. Considerable attention is given at the close to some of the biological problems of national and local concern as the preservation of health, forest protection, and animal and plant improvement.

Elementary Biology, by James Edward Peabody and Arthur Ellsworth Hunt. 1912. The Macmillan Co., New York.

This book, according to the authors, is intended as a text and laboratory manual to meet the needs of fourteen-year-old boys and girls. The scope of the book may best be indicated by a quotation from the preface. " In the preparation of the text the authors have sought to keep continually in mind three classes of activities- nutritive functions, the reproductive functions and the relations of plants and animals to the general welfare of mankind-, and to unify the study of plant, animal and human biology by choosing those topics for laboratory work and text description that have to do in a broad sense with one or the other of the three great groups of functions of living things to which we have just referred." (1)

The text consists of three parts; plant biology, animal biology and human biology. Plant biology is considered first, due to the fact that plants lend themselves more readily to laboratory observation and experiment and are better illustrative of many of the physiological processes than are animal forms. Chapter 1 discusses the fundamental differences between lifeless and living things from a physiological point of view and this leads directly to a discussion of the composition of each in chapter 11. Following this, two chapters are given to a consideration of some of the fundamental physiological

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processes of plants with some facts of morphology, including cellular structure, the knowlege of which the authors, according to their statement in the preface, feel necessary to the proper understanding of the processes. The adaptations of plants for performing nutritive and reproductive functions and the methods of plant propogation occupy the next two chapters and the portion of the book on plant biology is concluded by a consideration of the relation of plants to human welfare.

In this part of the text the authors have given consideration to the three classes of activities of plants mentioned above, i.e. the reproductive functions, the nutritive functions and the relations of plants to man. The first two of these seem to be paramount. The third, the relation of plants to man, comes as a chapter appended at the last.

The same may be said of the second division of the book, Animal Biology. This part is introduced by a chapter on insects. A study is first made of the anatomy and physiology of a few representative forms. This is followed by a consideration of the life history and economic relations of some of the injurious insects. The chapters that follow are given to the study of birds, frogs and their relatives, fishes, crayfish and their relatives, the paramoecium and its relatives, porifera, coelenterata, annelida,mollusca, reptilia, and mammals. In each of these studies the consideration of the nutritive and reproductive functions precede that of the economic relations.

The third division of the book is entitled Human Biology. In this, attention is given to the fundamental physiological processes of the human body with special emphasis placed throughout upon the essential conditions for individual and public health.

Introduction to Biology, by Maurace A. Bigelow and Anna N. Bigelow. 1913, The Macmillan Company.

This course in biology begins with some preliminary studies of the facts and generalizations of science that the author feels the student will need to know later in the course in connection with the study of biology that occupies the bulk of the book. The preliminary studies include definitions of science and its subdivisions, differences between organisms, organic and inorganic matter, the three states of matter, physical and chemical changes, elements and compounds, comparison of the chemical composition of living with lifeless things, the characteristics and activities of lifeless and living things and the differences between plants and animals.

The lessons in plant biology, which follow, consist of the usual study of the structure and physiology of flowering plants. There are no evidences of any attempt to correlate structure and function. The chapter on the structure of flowering plants precedes the chapter on plant physiology.

This is followed by the portion of the book on animal biology which consists of chapters on insects, the anatomy and physiology of the frog and the structure, physiology and life history of some of the simpler organisms, viz. the paramoecium, the amoeba and the hydra. The anatomy and the physiology of the frog is studied more at length than is the study o any of the forms included in this portion of the book. Here, again, there is no correlation between structure and function. The study of the anatomy of the frog is completed before any consideration is given to physiology.

A lengthy chapter follows entitled "Human Structure and Life -activities" In this chapter considerable space is given to the study of digestion, respiration, excretion and the special senses with especial attention given to the location and structure of the various organs concerned with such physiological activities.

In the preface the author, in speaking of this book, says" It is simply what the title suggests; an introduction to biological facts and ideas. These have been selected with reference to their direct bearing on the daily life of the intelligent citizen." This attempt, on the part of th author,to select those facts and ideas with reference to their direct bearing on the daily life of the citizen is especially noticeable in the last four chapters of the book; Biology applied to Personal Hygiene, Organisms and Health, The Economic

Relations of Organisms, and the Reproduction of Organisms.

The Elements of Biology, by George W. Hunter. 1907. The American Book Company.

George W. Hunter, of the DeWitt Clinton High School, New York City, has recently written three text books of Elementary Biology for first year high school students. The Elements of Biology appeared in 1907. This was followed in 1911 by the Essentials of Biology and in 1914 by A Civic Biology. The principles upon which the subject matter of each of these books is based differ to some extent in each text.

The first of these books, The Elements of Biology, consists of three parts. Part one is a study of botany. It begins with a consideration of protoplasm and cell structure, which necessitates the use of a compound microscope. This, together with a chapter given to the presentation of some of the fundamentals of chemistry, the author explains, is a preliminary study to enable the student to better understand the chapters that follow. The study of the flower, fruit, seed, stem and leaf follow in order, emphasis being placed on

function rather than on structure. The last chapter of part one is given to the study of flowerless plants. In this the student is first introduced to the system of classification. This is followed by the study of a series of plants representative of the pterido-phytes, bryophytes and thallophytes respectively. In connection with the study of these representative forms some consideration is given, in an incidental way, to their relations to man.

In part two, Zoology, the animal types are studied in the evolutionary order beginning with the protozoa. This part of the book is simply a study of the anatomy and physiology of a series of animals representative of the various orders and classes of the animal kingdom. Considerable attention is given throughout this portion of the book, however, to the relations of the forms studied to human life and human interests.

Part three is given wholly to human physiology. It is explained by the author in the preface that the topics in this third part of the book on foods, digestion, assimilation, blood making, and circulation may well be taken up in connection with the laboratory work outlined on the frog in part two, and that the topics on breathing, oxidations in the body, muscular activity, and excretion come well with the treatment of the insects in part two.

Such a selection and organization of subject matter indicates the author's main purpose to be that of acquainting the student with the fundamental principles and facts of the various fields of the sciences of botany, zoology and human physiology. These three sciences he desires to unite into one general course in order to give the student a conception of the fundamental properties and activities of living protoplasm that are manifested in all phenomena of life whether plant are animal.

The Essentials Of Biology, by George W. Hunter. 1911. The American Book Company.

The essentials of biology contains for the most part all the subject matter appearing in the Principles of Biology. The organization and presentation is somewhat different. The book is not divided into three distinct parts. The first third, however, is given to plant study, the middle third to animal study and the last third to human physiology.

In this book the subject matter is presented in the form of problems. The purpose of

each problem, the author states in the introduction, is to demonstrate some principle of biology. He also states that these problems are related, when possible, to the daily life of the student. This relation is shown by the following problems selected at random from the various parts of the book.

Problem 1V The Economic Value of Some Fruits

Problem X111 The Relations of Fungi to Man

Problem XXV1 A Study of Some Methods of Plant Breeding

The statement of the author that the problems are related, when possible, to the daily life of the student indicates that the relation in some cases was not possible. This permits the statement here that the author, in selecting problems best fitted to demonstrate fundamental principles, in some cases found it impossible to present such as would, at the same time, have a close relation to the daily life of the student. The following problems are examples:

Problem XX1V The Introductory Study of Many Celled Animals

Problem XXV A Study of Some Animal Likenesses and Differences and the Classification of Insects

A Civic Biology, by George W. Hunter, 1914, The Macmillan Company.

The subject matter of A Civic Biology is also represented in the form of problems as in the Essentials of Biology. There is some difference, however, in the nature of the problems of the two books. This is well shown by a comparison of the problems found in Chapters lV, V, Vl, Vll, Vlll and lX of each text. Such a comparison follows:

Essentials of Biology.	A Civic Biology.
The structure and work of the parts of a flower.	What causes a plant to grow? (a) Relations of the young plant to its food supply. (b) The outside conditions necessary for germination.
A study of cross pollenation and some means of bringing it about.	(c) What the young plant does with its food supply.
A study of fruits to discover: (a) Their use to plants. (b) The means of scattering. (c) Their protection from animals and other enemies.	(d) How a plant or animal is able to use its food supply. (e) How a plant or animal prepares food to use in various parts of its body.

The economic value of some fruits.

A study of the factors necessary for awakening the embryo within the seed.

A study of some methods of plant breeding.

A study of roots.

A study of some of the relations between roots and the soil.

Relations of buds to the growing plants.

The structure and work of stems.

The study of leaves in relation to their environment.

What a plant takes from the soil and how it gets it.

(a) What determines direction and growth of roots.

(b) How is the root built.

(c) How does a root absorb water.

(d) What is in the soil that a root might take out.

(e) Why is nitrogen necessary and how is it obtained.

How, when and where green plants make food.

(a) How and when is moisture given off from leaves.

(b) What is the relation of leaves to light.

(c) What is made in green leaves in sunlight.

(d) What by products are given off in the process.

(e) Other functions of leaves.

The problems listed from A Civic Biology seem to be more specific, tangible and vital than those from the Essentials of Biology. The author states in the introduction of A Civic Biology that he has made an attempt in the text to select only real vital problems that have arisen within the minds of the students. He thinks, "the first science of the sedondary school, elementary biology, should be primarily the vehicle by which the child is taught to solve problems and to think straight in so doing." (1)

While the text contains a great many real vital problems that would arise within the students environment, it also contains many others, the nature of which would lead one to believe that the author had some other guiding motive in the selection of the subject matter than simply a desire to meet real and vital needs of the students. Such problems as the following, taken at random from the text, would lead one to think that the author also had in mind a desire to introduce the students to the essential facts and fundamental principles of the science. (1) What is division of labor? (2) What are the chief differences of some of the great animal groups? (3) What is the structure of a single celled animal?

Other problems seem to be selected for

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the purpose of giving the student a conception of the unity of life, i.e. the conception of the fundamental properties and activities of protoplasm that are manifested in all phenomena of life whether plant or animal. Following are a few of this nature: (1) To discover the general interrelations of green plants and animals. (2) To discover the functions of living matter. (3) To determine the general biological relations existing between animals and plants. (4) To determine what makes the offspring of animals and plants tend to be like their parents.

It may then be said that Hunter's A Civic Biology is a collection of problems and topics of a biological nature so selected and arranged as to give the student a knowledge of the fundamental processes of the various fields of biological science and at the same time, as far as possible, to present vital problems that have actually arisen within the students environment.

<u>Summary</u>: From the above exposition it would seem that the six texts are quite similar in two respects. The aim of each is (1) to teach the principles of botany, zoology and human physiology as one science rather than three distinct ones and (2) to teach to the student those facts of the various fields of the science which, from the scientists point of view, are essential.

CHAPTER 11

CRITICISMS OF THE SIX TEXT BOOKS REVIEWED

These criticisms are to be made in the light of the three principles that underlie the organization of the course outlined in chapter IV. Following, in brief, is a statement of these principles.

(1) The course should consist, for the most part, of subject matter which the student may obtain first hand.

(2) Only that subject matter should be included in the course for which a fourteen year old boy or girl might reasonably be expected to feel a specific need.

(3) The course should, as far as the two principles above will permit, include those biological facts and ideas which are most useful and common to the life of the average adult intelligent citizen who has had no opportunity of completing more than one year of high school work.

For a more detailed statement and explanation of these principles the reader is referred to chapter III.

Education Department Bulletin, Syllabus for Secondary Schools, Biology, Albany, New York.

In criticism of the course in biology as described in the Syllabus for Secondary Schools of the University of the State of New York it may be said in general that the point of view of the fourteen year old boy or girl has not been taken enough into consideration. This is evidenced by the very nature of the four aims of the course as well as by the content of the outline. The first of these aims is to give the pupil some first hand knowledge of plants and animals. An examination of the outline indicates that this ' first hand knowledge'has been selected,for the most part, to best meet the requirements of the second aim, i.e. to best lead the pupils to an understanding of some of the essential functions carried on by all living things. 'First hand knowledge' which best illustrates essential functions may not and very likely is not, in most cases, the type of subject matter which, from the students point of view, is valuable. The outline in the syllabus on the grasshopper and its relatives is illustrative of this.

"The Grasshopper and its Relatives.

1. Regions of the body and appendages.
   a. Drawing of the head to show compound eyes, antennae, and upper lip; adaptations of mandibles for feeding.
   b. Thorax: position, number and structure of legs and wings; adaptations for locomotion; drawing of hind leg.
   c. Abdomen adaptations for breathing; drawing of several segments.
2. Study of living grasshopper to show methods of locomotion, feeding and breathing.
3. Life history." (1)

There are unquestionably many things about a grasshopper that fourteen year old boys and girls are eager to know. The experiences of the writer, however, leads him to feel that young people, in general, have no direct desire or specific need for such information as that concerning the structure and adaptation of the appendages and various regions of the grasshopper's body. An interest in such things is characteristic only of people who have acquired the scientific point of view. The same criticism may be made of this outline for the study of the grasshopper as may be made of any other outline in the syllabus for the study of a plant or animal, i.e. the authors in

(1) p. 126

selecting subject matter which can best be taught first hand by laboratory observations and at the same time illustrate some fundamental biological principles, have failed to select that which, from the pupils point of view, is worth while. And in so far as they have selected that which the pupils consider of no value, they have failed to select that which will meet the requirements of the very two aims that guided them in the selection. The young student who is pushed by some kind of artificial or generic motive into making observations and conclusions as outlined in the syllabus on the grasshopper will not secure first hand knowledge, if we are to define first hand knowledge as that which comes to one in connection with "a search for information guided by ardent curiosity, fertile imagination and a love of experimental inquiry." (1) Futhermore the student, in connection with such a study of the grasshopper or any other form, will not be led to the best understanding of the fundamental functions carried on by all living things as stated in the second aim. "Most of us know, if we could think back over our experiences, that we could never really learn these so called fundamental principles until they come to us as an interpretation of some of our life problems." (2)

(1) John Dewey, How We Think.

(2) John F. Woodhull, Science Teaching by Projects, School of Science and Mathematics, Vol. XV, No. 3, p. 22

This criticism is not directed at the first two aims mentioned. It is well that the student should acquire first hand knowledge about plants and animals and that he should have an understanding of some of the essential functions carried on by living things. It is the method used by the authors of realizing these aims that are here questioned.

The topics included in the outline to meet the requirements of the third and fourth aims may be criticised in somewhat the same way. These aims are as follows: (3) to teach the student something of the enormous economic importance to man of the animal and plant products, and the necessity of concerving the biological resources of our country, and (4) to emphasize especially the essential conditions of individual and public health in city and state. The following topics taken from the syllabus seem to have been selected in accordance with these aims.

Economic Importance of Seeds and Seed Products

Important Uses of Roots to Man

Uses of Stems to Man

Economic Importance of Leaves for Shelter, Food and Medicine

Economic Importance of Common Fruits and Common Plants including Weeds

Work of National and State Governments bearing on the Conservation of National Resources

These problems are not school boy and school girl problems. It is true that such information as the important uses of roots to man or the uses of stems is, in a way, rather closely related to the normal interests of the young student. In the study of the stem or the root of any one particular plant that he comes in contact with he will perhaps desire to know its uses. The problem, however, of collecting information about the uses of all stems and roots in general is, to him, not a very vital one. It is the question of psychological vs. logical organization of subject matter. The logical order, which is followed in the syllabus, is the result of close analysis and classification of a large body of related phenomena by one who has had a long experience in the particular field. Such a classification naturally comes late in the students life and is not suitable for young students. The psychological order is the order in which one, who is not a specialist in the field, might acquire the information and is consequently more suitable for use with young immature students. Such information then, as the economic importance to man of the plant and animal products, the necessity of conserving the biological resources of our country, or the essential conditions of public health in the city or state should not be taught in such a logical way as it appears in the syllabus.

Such information should come incidentally in connection with the solution of the real problems that the student encounters from day to day.

Elementary Biology, by James Edward Peabody and Arthur Ellsworth Hunt.

The authors of this text, in attempting to select subject matter best illustrative of the three activities of plants and animals named in the preface , i.e. the nutritive functions, the reproductive functions and the relations of plant and animals to man , have given too little consideration to the students' point of view. This is especially true of the first part of the book. Here, as a preparation for the study of the nutritive and reproductive functions of plants and animals, the student is given some elementary information concerning the composition of lifeless and living things. This includes the study of the properties of some common elements, the nature of compounds and mixtures, and the chemical composition and tests for the various food substances of plants and animals.

Young students who have had no training in science could hardly be expected to feel a specific need or interest for such information (1) as listed above. It is true that they might enjoy the simple experiments outlined in this part of the text, such as the testing of foods for starch, grape sugar, protein, fat or mineral matter. Their enjoyment is more likely due,however, to a sort of passing interest in the mechanical manipulation than to a desire for the information to be obtained from the experiments. It may be said that experiments and observations in science study are of value only in so far as they are made in connection with a search for information for which the student feels a direct need. This point is to be discussed more at length in Chapter 111.

The authors in this part of the book are evidentally expecting students to acquire knowledge, for which they at that time feel no specific need, in order that they may have this information ready for use at some future time when a need arises. The same may be said of various other parts of the text. As another illustration, chapter four contains some directions for laboratory work, the purpose of which is to give the student

(1) A discussion of the meaning and value of specific needs and interests will be be found in Chapter 111.

an understanding of the process of osmosis and its relations to plants and animals. Preliminary to the formulation of a definition for osmosis the student is asked to solve the following four problems:

"(1) Will water go through a membrane?

(2) Will grape sugar pass through a membrane?

(3) Osmosis in the living cell.

(4) Will starch pass through a mambrane? " (1)

This is followed by a formulation of a definition of osmosis. The student is then told that he will later find that the principles of osmosis explain in a large measure the absorption of soil water by roots, the transfer of sap from one part of the plant to another as well as the process by which the blood of animals obtains and gives off food to the various parts of the body.

In this the student is called upon to spend much time in the solution of four problems which to him, at the time, are meaningless and purposeless. The information obtained therefrom is to be used at some future time in connection with the study of the absorptive power of roots or the transfer of sap. It would be much better if such a study could be

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(1) pages 33-36.

postponed until such a time when the student, in connection with the study of the root or the movement of sap or the transfer of food from the blood to the cell, might feel a need for information concerning the process of osmosis. This method might mean a sacrifice in logical arrangement to one who desired to present the fundamentals of the science in the shortest space possible; but such a sacrifice is desirable as long as it results in the arrangement of subject matter in harmony with the needs and interests of young students.

The criticisms made above are by no means applicable to all parts of the text. In fact the authors, in attempting to include in the text much subject matter illustrative of some of the important relations of plants and animals to the wellfare of man, have inserted in many of the chapters an abundance of information which is closely related to the needs of young students. This is especially noticeable in the chapters on the reproduction of plants, plant propogation, plants and their relation to human welfare microorganisms and human welfare, insects, birds, frogs, fish and crayfish. It is to be regretted that in some of these chapters, especially in the last five mentioned,

the consideration of the relations of the organisms to man is added at the last of the chapter instead of coming at the first where it rightfully belongs. As an example of this the chapter on fishes begins with a study of the regions and appendages of the various kinds of fishes and their adaptations. This is followed by a study of the adaptations for food getting, digestion and digestive organs, blood and circulation, respiration and the senses of fishes. In the last part of the chapter consideration is given to such topics as the reproduction and life history of the fish, artificial propagation, economic importance, the salmon, the codfish and the conservation of food fishes. It is noticeable that the chapter begins with those topics most foreign to the interests of young people and closes with those of a closer relation. It would seem that the reverse order might be preferable. The chapters might better begin with that information in which the student has an immediate interest. In connection with such a beginning the student's interest might be broadened until they will begin to feel a need for that subject matter which before had been foreign to their interests.

Introductory Biology, by Maurace A. Bigelow and Anna N. Bigelow.

It would seem that the authors of this text also believe in inducing students to acquire subject matter for which they feel no need at the time of acquirement but for which they will feel a need later in the course. The facts included in the first two chapters on the preliminary studies of the chemical composition and characteristics and activities of lifeless and living things are those for which a student may feel a need later in the course but not at the beginning. Again, in the study of plant biology as well as in the study of the frog the chapters on the study of structure precedes those on the study of function. The authors of the text evidently feels that a student must know the structure before he can understand the function. He does not take into consideration, however, the fact that the study of structure alone is of little interest to the student. The student feels no specific need for the study of structure and he cannot forsee that he will have use for such information later in connection with the study of functions.

Little of disciplinary value may be said

to result from observational and experimental studies of structure or processes where such study is done wholly in response to generic needs such as the desire to make a grade or to avoid the displeasure of the teacher. To this may be added the writers belief that facts, for which students feel no specific need, acquired by means of artificial motives are soon forgotten, probably before the arrival of the time when such facts are to be used. "Learning things that are not immediately useful means that we temporarily load the memory with junk which will be a present incumbrance and, before the time for using it arrives, will have been unloaded." (1)

As a whole the information contained within the text, especially within the last four chapters, represents those biological facts and ideas a knowledge of which would be very useful in the daily life of the average citizen. This accomplishment seems to have been the author's main purpose in the preparation of the text. Provided each student could acquire these facts in the course of a year's study and provided he would remember them and make use of them after the completion of the course, the text would be an ideal one. However, when one takes into consideration the fact that much of the subject matter for the most part satisfies no specific

(1) Charters, Theory of Teaching. p. 174

needs of the student, it becomes questionable whether a teacher, however skillful, might expect the student to acquire such facts, much less remember them and use them later in life.

The Hunter Biologies, (Elements of Biology, Essentials of Biology, A Civic Biology), by George W. Hunter.

As has been stated the selection and organization of the subject matter of the first of these books, the Elements of Biology, seems to be based upon a desire on the part of the author to present the fundamental principles and facts of the various fields of botany, zoology and physiology and especially to present them in such an organized way as to give the student a conception of the basic principles underlying all phenomena of life. The author's attention is thus focused, throughout the text, upon teaching the subject rather than upon teaching fourteen year old boys and girls the things they aught to know; unless it may be said that the fundamental principles and facts of the science are the things that such students need to know. " The trouble with most of these so called 'fundamental principles' is that they are never again met with either in school ar life, and the

majority even of enlightened men get on very well without having ever heard of them, or, having heard, they have forgotten them because they did not prove to be fundamental to anything. A principle which occurs, or is likely to occur, so often that one cannot forget it, is fundamental, and few others need be considered." (1) From Mr. Woodhull's point of view it would seem that the author has included in this text much information that first year high school students have no need for and on the other hand that he has failed to include much information about plants and animals that is worth while for them to know.

In the second of these books, the Essentials of Biology, some improvement has been made in that the author has given more consideration to the needs and interests of students. Some of the subject matter contained in the Elements of Biology has been omitted from this text, such as the characteristics of the pteridophytes, bryophytes, and thallophytes, because of its unsuitability to the needs of students. It is also noticeable that much information closely related to the students' interests is included in the second text that does not appear in the first. As a whole, however, the same subject matter has been incorporated into the two. The greatest difference in the two lies in

(1) Woodhull, J.F., Chairman of the Committee on General Science of the N.E.A. Science, Vol.XL, No. 1034, p. 601

the method of presentation used in each.

In the Essentials of Biology an improvement is made in the method of presentation over that used in the former text in that the subject matter is presented in the form of problems. This is an excellent improvement, especially so when the problems happen to be real boy and girl problems, dealing with the phenomena closely related to their everyday lives. A large number if not the majority of these problems, however, are not of this nature. In Chapter 111 an attempt will be made to show that little is to be gained by students in connection with the solution of problems which to them are not real problems.

In the third of these books, A Civic Biology, the author has attempted especially to make an improvement in his selections of problems. According to his statement in the introduction he has attempted to include in this book only real vital problems that have arisen within the minds of the students. Consequently the book seems to be well adapted for use as a text for first year high school students. The problems are, for the most part, those that a young student might desire to solve. It is to be regretted, however, that the author, in his fear of omitting some of the fundamental principles, has allowed himself to include within the text some problems the close relation of which to the students' interests and every day experiences is to be questioned. The following problems taken from the text are indicative

of this:

What are the chief differences of some of the great animal groups?

What is division of labor?

In what does it result?

What is the structure of a single celled animal?

It is due to the inclusion of such problems as these that the suitability of the book as a guide for a first year high school biology course may be questioned.

<u>Summary</u>: The above criticisms are not made for the purpose of supporting a contention that these books are unworthy of use in the high schools. The six books are, all of them, good ones. Their wide use in the high schools of this country is indicative of this. The criticisms have been made to point out that the authors of these books have not taken fully into consideration certain principles which, from the writer's point of view, are important ones and which serve as the basis of the organization of the course in biology that appears in Chapter IV of this thesis. These principles are to be stated and discussed in the following chapter.

CHAPTER 111

STATEMENT OF PRINCIPLES

Three principles are here proposed as a basis for a biology course for first year high school students. It is suggested that these principles may be the means of escaping the criticisms made above of biology courses. They underlie the selection and organization of the subject matter of the course in biology that appears in outline form in the following chapter and are as follows:

(1) The course should consist, for the most part, of subject matter which the student may obtain first hand.

(2) Only that subject matter should be included for which a fourteen year old boy or girl might reasonably be expected to feel a specific need.

(3) The course should, as far as the two principles above will permit, include those biological facts and ideas which are most useful and common to the life of the average adult intelligent citizen who has had no opportunity of completing more than one year of high school work.

There is nothing new or unusual about the first principle mentioned. All modern science teaching stands for the obtaining of information first hand. Such a basis for science teaching serves two considerations:

(1) It is an assurance that the student will get the proper conceptions of the facts studied when such conceptions are based upon the sense impressions received from a direct contact witht the objective realities with which the science deals.

(2) It has been claimed that the obtaining of information first hand and the formation of intellectual interpretations based thereupon affords a disciplinary training that is especially fitted to promote sound citizenship. Maurice A. Bigelow summarizes this disciplinary value of the study of biology as follows, "The disciplinary value of the study of zoology, as indeed of any other science, is found in that it may contribute to the development of the scientific attitude of mind, by directing various mental processes such as those involved in scientific observing, classifying facts, reasoning on the basis of demonstrated facts, exercising judgment and discriminations, and learning to appreciate demonstrated knowledge." (1) There need only to be pointed out and discussed here certain fallacies that have arisen in the minds of biology teachers in connection with a failure to recognize the limitations of this so called disciplinary value of the study of biology.

(1) Loyd and Bigelow, The Teaching of Biology, p. 244

In the first place the value of biology as a disciplinary study is limited by the interests of the students. It is characteristic of the great majority of biology courses that the students are led to acquire, for the most part, first hand information in which they have no interest and for which they feel no specific need. The teacher who feels that it is possible to force young students into acquiring such information by means of scientific observations and experiments and thereby to direct their minds into those mental processes which may best contribute to the development of a scientific attitude of mind is laboring under a misconception. We must not deceive ourselves into thinking that students, in performing such laboratory work which, from their point of view, is of no value, go through those desirable logical processes of thinking that we may have in mind. It is here contended that in such cases the desirable forms of thought are not experienced at all but, instead, the student acquires his information by mere feats of memory; an acquirement which neither affects the judgment or character of the pupil nor remains long with him as permanent or useful knowledge.

The real scientific attitude or real scientific thinking is characterized by a search for truth guided by " ardent curiosity, fertile imagination and a love of experimental inquiry. " (1) This attitude can be

(1) John Dewey, How We Think.

assumed only by one who really feels a specific need for the information sought. We should not expect students in the laboratory to assume this attitude or to think scientifically unless we are attempting to guide them in a search for something that they really want. It would seem then that we should expect our teaching of biology to result in the students acquiring scientific habits of thinking only in so far as we teach them the things for which they feel a specific need.

The value of biology as a discipline is further limited by some facts that investigators have recently brought to light, facts which prove that there is a psychological fallacy involved in thinking that an acquired ability to do one kind of work may become available for other forms of mental activity which we may call by the same general name. Even if the student acquires that subject matter in the laboratory for which he feels a specific need, the ability of thinking and reasoning mastered in its acquirement may not thereby become available for the acquirement of other information that he may desire to obtain later in life. According to Thorndike (1) it may become available only in so far as the new situation later in life corresponds in subject matter and proceedure to the situation in the laboratory, provided the student recognizes

(1) Thorndike's, Principles of Teaching, Chapter XV.

and feels the similarity.

These limitations then are necessary to be placed upon the first principle mentioned, if the course is to result in an ability to think scientifically. As has been pointed out the first hand information selected for the course must be limited to that which meets specific needs or interests of the students. Futhermore it must be obtained by ordinary methods. The methods of thought used in the classroom must be those that are directly applicable to the everyday problems of life. The laboratory technique and proceedure must be that which has not become so perfected and refined as to be materially unlike the surroundings of the student outside of school.

As will be pointed out later, these limitations have really been placed upon the selection of the first hand subject matter for this course. The course has been subjected to these limitations, however, not for the purpose of insuring the acquirement by students of habits of proper thinking. Disciplinary training is, as an end in itself, too indefinite and evasive. We are not even sure when we have been successful in its acquirement. The requirements for disciplinary training have been mentioned and discussed here merely for the purpose of pointing out a fortunate coincidance, i.e. the

limitations on the selection of subject matter, which seem to be necessary for the best disciplinary training, are exactly the limitations that have been imposed upon the selection in order to accomplish the real purposes of this course, which purposes are to be brought out in the discussions of the second and third principles.

According to the second principle this course contains only that subject matter for which the student might reasonably be expected to feel a specific need. It is to be pointed out here, the meaning of specific need, the advantages that may result from selecting only that which satisfies specific needs, and some of the difficulties encountered in such a selection.

<u>Meaning of Specific Need and Specific Interest</u>

When a student desires to acquire certain information because of some peculiarity of the information itself that attracts his attention we may say he has a specific need for or a specific interest in that particular subject matter. Such needs and interests are called specific to destinguish them from those that are generic. (1) We may say a student has a generic need or interest in a thing when he desires to know about it, not

(1) Compare with the discussion of specific and generic motives in Charter's Methods of Teaching, pp. 166- 170.

because the information itself commands his attention, but because he fears punishment or desires a grade or is eager for approbation. This latter type of need is here called generic because it may be a need that the student may have for a great variety of facts. . . . There is no necessity here of making an exact distinction between need and interest. (1) Suffice to say that wherever a specific interest is felt there must be also present a specific need and vice versa.

We must not confuse specific needs and interests with those superficial passing interests which are due to an idle fleeting kind of curiosity. Such interests encourage very little activity and effort on the part of the student. When we cater to this kind of interest our teaching becomes mere entertainment and superficial amusement. By specific interests we mean those that produce eagerness for some definite attainment and which prompts the student into devising some definite method of reaching that attainment.

Neither should we confuse specific needs with those needs the student may have for certain information in preparation for future work. The teacher may feel that the student needs to know certain things that will be of value to him in connection with future courses to be taken in the high school or university.

(1) The difference between need and interest is discussed in Charter's Methods of Teaching, p.162.

The student, however, may feel no such need and for that reason they cannot be called specific.

With these limitations put upon the meaning of specific interests and needs it becomes clear that, in attempting to organize a course containing only subject matter for which students might reasonably be expected to feel a specific need, we are not simply following the students' lead in a blind and haphazard way. The course attempts to follow the larger and broader interests of the students. As will be pointed out later, the purpose is not solely to meet present needs and to satisfy present interests, but also as well to give the student, at the same time, that information which will be most useful to him in later life.

<u>Advantages of Recognizing Specific Needs</u>

There are two advantages that may result from teaching where the subject matter taught is selected in accordance with specific needs and specific interests.

<u>Interest as an end in itself</u>

<u>First</u>, such teaching tends to keep alive that spirit of inquiry which may be said to be so common with young people and so rare with adults. Futhermore it insures a continuance of mental alertness which, again, is so characteristic of young students. A person's success in after life depends much upon the intersets he has which encourage within him initiative and which leads him to attempt various activities and to acquire various kinds of knowledge. By all means care should be taken

to exclude from the high school any subject matter, the study of which, is likely to destroy the very foundation of successful living.

Second, by availing ourselves of the opportunity of taking advantage in our teaching of the students needs and interests we insure the acquirement of certain ends with the least waste of time and energy. As has been pointed out above, one important aim of this course is simply to develop broad and lasting interests. Another aim brought out in the third principle, which is yet to be discussed, is ~~the aim~~ to put the student in possession of information which will be most useful to him as a citizen. The principles of the course necessitate a close relation to the existing needs of the students of all information that is selected for its usefulness. The necessity of this relation is not for the sole purpose of developing lasting interests, but as well for the purpose of economizing time and energy in the acquirement of such information. In acquiring information students are at the mercy of their interests. Such interests must be given some consideration if we expect the quickest and most thorough results of our

Interest as a means

teaching. If interests be ignored, i.e. if, by means of artificial or generic needs, students are induced to acquire information in which they have no specific interest, two results may be expected. First, the student will very likely give to the work just as little attention as possible. There is thus a failure to obtain the maximum efficiency. Second, the student will soon forget the facts mastered. Should we expect him to long remember them when they have no connection with any need that he has ever felt, and possibly not connected with any experience that he has ever had?

Difficulties

Difficulties are always to be encountered in connection with an attempt to limit the selection of the subject matter to that which meets the needs of the students. In the first place it is not always possible to tell in advance what the specific needs of the students are. Often they are self evident. The students' actions and attitude betrays his desire to obtain information about certain things. On the other hand the students' needs may be potential. He may not be aware of them until we point them out. He then, possibly for the first time, feels the need.

There are no rules to guide one in a search for those things in which students have specific needs either active or potential. It is a matter of common sense and experience with young people. Any teacher, who has during childhood experienced those things that the ordinary child experiences , and who has been in his teaching connected long enough with young people to get their point of view and to acquire a better understanding of the contents and abilities of their minds, ought to be able to decide with a fair degree of accuracy what will be of interest and what will not. But in all cases many mistakes will be made. One of the purposes of teaching this course at the University High School is to discover and profit by such mistakes.

In the second place students have a great many specific needs and interests, so many that a difficulty is often envolved in selecting those that are most valuable for the purposes of the course. Where a variety of interests are at hand those should be selected for use which meet the following three conditions; (1) the need should be as intense as possible, (2) the need should, as far as possible, be felt by every member of the class and (3) the need should

be for that type of information which may be considered useful to the average citizen.

A third difficulty arises in connection with the fact that students of the same age do not always have similar interests and needs. That which satisfies a need of the majority of the class may not satisfy every member. Such students, of course, who do not feel a need for that which meets the needs of the greater number of the class must be considered an exception and must be treated as such.

According to the third principle the course should, as far as the first two principles will permit, include those biological facts and ideas which are useful to the life of the average adult intelligent citizen who has had no opportunity of completing more than one year of high school work. By useful is meant here that which has a close relation to some real need of life, whether aesthetic, ethical or utilitarian. It must be borne in mind, however, that not all useful information is suitable to be taught in this course. To be suitable for that purpose it must, in addition to being

useful to the average citizen, be closely related to some present specific needs of the students. It must also be, for the most part, that type of information that may be taught first hand. It may be well here to consider some of the important types of useful biological information and to decide which of these types are best suited to meet the requirements of this course.

An acquaintance with plants and animals

(A general acquaintance with the common plants and animals of the community in which one lives ~~may be said to be very useful~~ as information for the ~~average citizen~~. Those who acquire a store of such information are thereby more capable of appreciating the world in which they live and of finding satisfaction in living.) Information of this type meets all the requirements that have been named for this course. Such information is useful. It meets the specific needs of the students. It may also be obtained first hand.

However, two criticisms are commonly made of the inclusion of such information as this in high school biology courses. In the first place it is claimed that such information is more

suitable for the nature study work of the elementary schools. This is true, to some extent. However, the students are not receiving such information from nature study work in the elementary schools at the present time. The high school teacher must plan his course to meet the conditions that exist rather than to meet conditions that he would like to see exist. If the teacher, then, desires the student to leave his course in biology with an acquaintance of common plants and animals it is necessary that he include within the course much information of this type.

Another criticism often made of the teaching of such information in high school biology courses is that too much attention to such popular studies may lead to a conception of plants and animals as static, formal and changeless objects. This is the conception that the student is apt to get from field studies in which he merely learns the names of interesting plants and animals. The more desirable attitude for the student to take towards a plant or an animal is that it is a " center of activities, physical and chemicel, that it is a seat of struggle and response to the factors of its environment, internal and external, and that its form and structure

are nothing more or less than a record of these motions and changes, and a measure of their forces and directions." (1)

It is then desirable to include within this course as much information as possible that will give the students an acquaintance with the common animals and plants of their environment but to limit such information to that which will tend to foster the point of view that emphasizes the active life of plants and animals.

A second type of information that may be considered useful to the average citizen is striving to attain a knowledge and appreciation of some of the fundamental laws underlying the phenomena of life with which he comes in daily contact. Such would include a knowledge of (1) the fundamental physiological processes of plants and animals, (2) the methods of reproduction, sexual and asexual, and their significance, (3) the more common factors of embryonic development, (4) the interrelations of plants and animals, (5) the adaptations of plants and animals to their environment, (6) variation, (7) heredity, and (8) the forces of organic evolution. Such information, however, studied as such, would not meet the needs of young students. It is the

<u>fundamental laws of animal and plant behavior</u>

(1) Loyd and Bigelow, The Teaching of Biology, p.105

purpose of this course to give the students as much of this information as possibly can be given incidentally in connection with the study of those problems in which they have an immediate interest. Information of this kind, which cannot be found in any way to be related to the student's needs, must be omitted from the course. Futhermore, information of this type, which cannot be obtained by the most ordinary methods of thought and with the use of the simpler , less complicated laboratory apparatus and equipment must be omitted for reasons stated in the first part of this chapter.

It is readily to be seen that the students of this course will not get what is often called a fair and well proportioned view of the various fields of biological science. It is not necessary that they should. It must be borne in mind that the course is not an attempt to teach biological science, but rather an attempt to teach students those things of biology that they need to know.

<u>Facts of evolution</u>

Those facts may be considered useful which the student might obtain from a study chiefly of the morphology of a series of plants and animals

last but not least

selected because of their illustration of the hypothetical progressive steps of evolution. A course, based upon such facts and consisting of a review of the plant and animal kingdom from the lower forms through a gradual increasing complexity of forms to the higher animals and plants, serves to give a well founded belief in the theory of evolution. Such facts, however, have no relation to the needs and interests of young people of first year high school age and for that reason may be here dropped from further consideration. More advanced courses in zoology or botany, given in the second, third or fourth year of high school work, might well contain some work of this nature.

Facts of economic importance

Finally some consideration ~~may~~ will be given to those biological facts and ideas which are valuable to the average citizen because of their economic relations such as insect to the welfare of man. The more recent text books of elementary botany and zoology are giving considerable attention to this phase of biology teaching. There are two dangers in this. In the first place a selection of that information which is of greatest economic importance may sometimes result in the selection of that which cannot be taught first hand. This is well illustrated in the study of insects. Those insects

that are most important economically are often difficult to collect in sufficient numbers to supply a class for study. Futhermore such forms usually have life histories too complicated to be worked out in their natural habitats by amateur observers.

In the second place that which is of greatest economic importance to the race may not be of greatest interest to the young student, or, in other words, a students interests in an organism are not always determined by their economic relations. Some would begin the study of birds with a consideration of their beneficial and destructive relations to crops. All young students are interested in birds. Their interests however do not begin with the economic aspects of the subject. They are interested in birds simply because birds are living creatures in their environment that they have seen and wondered about always.

CHAPTER 1V

OUTLINE OF COURSE

Pond Life (Cat-tail Pond) September and October

1. Insects of Cat-tail Pond.

A. Field Work- Preparation of a collection of pond insects by each student.

1. Predaceous diving beetle.
2. Giant water beetle.
3. Whirligig beetle.
4. Back swimmers.
5. Water boatsmen,
6. Giant water bug.
7. Water scorpion .
8. Damsel fly and larva.
9. Dragon fly and larva.

B. A study, by means of field and laboratory observations, class discussions and readings, of each of these insects; the study of each including a consideration of (1) habitat, (2) food, (3) adaptations to environment including relation to other forms of animal and plant life, (4) economic relations, (5) habits and functions, and (6) life history.

Pond Life(continued)

11. The Pond Snail (Lymnaea).

A. Movements of the snail.

1. Methods of locomotion.

a. Possible relation of muscular contractions on under surface of foot to movement on a plane surface.

b. Relation of change in specific gravity to movement up and down through the water.

c. Relation of mucous threads to movement through the water.

B. Respiration of snails.

C. Food of snails ; mouth parts.

D. The snail an example of hermaphroditic animals.

E. Eggs: time deposited; where deposited ; time required for development of eggs into young snails.

F. Enemies of the pond snail.

G. The snails ability to resist droughts and cold weather.

H. Variability of snails in general and its significance.

I. Relation of snails to mussels, clams, oysters and slugs.

Pond life (continued)

J. Behavior of the snail.

1. An experiment to show that snails have a memory, i.e. intelligence.
2. Nature of reflexes and instincts.
3. Definition of intelligence.
4. Difference between instinctive action and intelligent action. Examples.
5. Difference between intelligent actions and rational actions. Examples.

111. The Water Spider (Dolomedes sexpunctatus).

A. Differences between spiders and insects.

B. Breathing organs.

C. Position of eyes.

D. Spinnerets.

E. Food. Method of capturing prey.

F. Nests.

G. Egg laying.

H. Care of young.

I. Some relatives of the water spider.

1. The orb weavers.
2. The tunnel weavers.
3. Tarantulas.
4. Harvestmen.
5. Ticks.
6. Mites and chiggers.
7. Scorpions.

Pond Life (continued)

IV. Cat-tail Pond Plants.

A. The pond weed (potamogeton sp.)

1. Distribution.
2. Provisions of the plant for pollenation, seed formation, seed dispersal, resisting currents and obtaining the maximum sunlight.
3. An experiment to prove that the pond weed gives off oxygen into the surrounding water when the sun is shining.
4. Preparation and properties of oxygen.
5. An experiment to prove that carbon dioxide is absorbed by the plant from the water in which it grows.
6. Preparation and properties of carbon-dioxide.
7. A test for starch in the pond weed lead.
8. Photosynthesis. Readings and class discussions.
9. Digestion in plants. Demonstration of the effect of diastase on starch by means of the iodine and Fehling's solution test.
10. An experiment to prove that the pond weed gives off carbon-dioxide while in the dark.
11. Respiration in the pond weed. Readings and discussions.
12. Experiments with germinating seeds to illustrate respiration.

Pond Life (continued)

13. Absorption by means of the roots of the pond weed.
    a. Examination of roots for root hairs.
    b. Demonstration of osmosis to illustrate the function of the root hairs.
    c. Synthesis of proteids and fats in the pond weed.

B. The water smart weed(polygonum acre).

Habits of growth. Provisions for protection from grazing animals and from the stamping of animals that come to the edge of the pond to drink. Provisions for propogation by means of underground rootstocks and floating seeds.

C. The cat-tail (thpha latifolia),

V. Interrelations of the Plants and Animals of Cat-tail Pond.

A. Factors which control the amount of plant and animal life in the pond.

1. Percent of carbon-dioxide in the water. The percentage remains constant as a result of:
    a. the absorption of carbon-dioxide from the water by means of plants.
    b. the supplying of carbon dioxide to the water by means of the respiration

of animals and the decay of dead animal and plant life.

2. Percent of oxygen in the water. The percentage remains constant as a result of:
   a. The removal of oxygen from the water as a result of the respiration of of plants and animals and of oxidation processes.
   b. The supplying of oxygen to the water by means of photosynthesis in plants and as a result of the mechanical stirring of the water by winds.
3. The supply of sunlight.
4. The supply of animal foods (starch, sugars, fats, proteids). The pond weed's contributions to the life of the pond by means of its absorption of chemical substances from the soil of the bed of the pond and the convertion of them into foods of various kinds.
5. Temperature.

Vl. Metabolism in Animals. (Readings and Class Discussions.)

A. Dependence of animals upon plants for their supply of foods.
B. Role of oxygen in metabolism. Combustion and respiration.
C. Conservation of energy.

Pond Life (continued)

VII. A Struggle for Existance and the Survival of the Fittest in Cat-tail Pond.

A. Animals and plants have a tendancy to reproduce in a geometrical ratio, as illustrated by the number of eggs laid yearly by the pond snail, dragon fly and leopard frog or by the number of seed formed each season by the cat-tail plant.

B. Some of the checks upon the rapidity of reproduction of the animals and plants of the pond.

C. The total number of each species in the pond from year to year remains approximately the same.

D. Necessity for a struggle for existance in the pond.

D. Survival of the fittest.

E. Charles Darwin and the theory of natural selection.

F. The mutation theory.

G. Criticisms of these theories.

H. How the pond weed may have become adapted to the environment in which it grows.

Stream Life (October)

A. Field Work. Collection fo water insects, fish, crayfish, mussels and fish found in a small stream.

B. Preparation of aquaria in the laboratory for rearing the animals collected.

C. Preparation of a list of all water plants observed, arranged in a table with column headings as follows:

1. Name.
2. Grows where(that is in which of the positions examined).
3. Depth of water.
4. Growth habit (erect or trailing, simple or branched, stemless, leafless, etc.)

D. List of all water animals observed, arranged in a table with column headings as follows:

1. Name.
2. Lives where.
3. Depth of water where found.
4. Food.
5. Methods of locomotion.
6. Remarks.

E. Careful study of the habitat, food, adaptations to environment, economic relations, habits and life history of each of the following:

1. The caddice fly.
2. The horse fly and its relatives, the bot fly, the house fly and the blue bottle. (1)

(1) The horse fly larvae were found in the quiet waters of the stream at this time of the year.

3. The mosquito.

4. The mussel.

5. Creek fishes.

Careful study of the following:

a. The common bull head(Ameiurus nebulosis).

b. The common sunfish (Eupomatis gibbosus).

c. The common sucker (Catostomus commersonii).

d. The sand darter.

Recognition of the following:

a. The channel cat (Ictalurus punctatus).

b. yellow cat (Ameiurus natalis).

c. The rock bass (Ambloplites rupestris),

d. Crappie (Pomoxis annularis).

e. The blue gill (Lepomis pallidus).

f. The calico bass(Pamoxis sparoides).

Brook Life (November and December)

1. Field Work on Quarry Brook. (1)

A. An examination of the general physiographic features of the stream from its origin to its outlet. (2) In connection with the field work the students were cautioned to look for the following:

1. Origin of stream.
2. Sources of water supply.
3. Course followed by the stream from, origin to outlet.
4. Nature of the banks of the stream .
5. Changes in the bed of the stream from the origin to the outlet.

11. Class Work Work of the Stream.

A. The mission of the stream- to reduce Quarry Hill to base level.

B. Transportation by the stream.

1. Getting a load.
   a. Mechanical suspension.
   b. Solution.

(1) A small, perennial, spring fed brook beginning with a ravine on the side of Quarry Hill, thence winding through a low field and finally emptying into the Hinkson.

(2) Some attention to physiographic features seem to be here necessary.

Brook Life (continued)

2. Carrying a load.

a. By direct impact of current.

b. By friction of bottom water.

c. By means of moving currents.

C. Preparation for transpiration- weathering.

1. The work of the atmosphere as an agent in weathering .

2. Chemical work.

3. Work of water.

4. Work of animals and plants.

D. Corrasion.

E. Development of the stream.

1. Gulley stage.

2. Developing and widening into a ravine.

3. Formation of falls and pot-holes.

4. Deposits at base of hill.

111. Field Work. A Collection and Study of the Plant and Animal Life found in Sunny Pools along the Stream.

A. Pond scum (Spirogyra sp.).

B. Flat worms (Planaria Sp.).

C. Isopods (Isopoda sp.).

D. Snails (Lymnaea sp).

E. Hydra (Hydra virdis).

1V. Class Work. Providing and preparing aquaria in the Laboratory for the above Animals and Plants.

Brook Life (continued)

V. Pond Scum (Spirogyra sp.).

A. Structure,- simple unbranched threads tangled together into a mat.

B. Methods of growth,- threads or filaments increase in length in the sunshine.

C. Propogation and reproduction.

1. The plant may be carried by water birds from one body of water to another.

2. The filaments may be broken up and the pieces carried long distances by currents of water.

3. The filaments may break up into spores (zygospores) which may be carried distances by currents of water and which may resist cold weather and droughts.

D. Requirements for growth. (1)

1. Carbon dioxide.

a. Experiment to prove that the plant absorbs carbon dioxide from the water

b. Experiment to prove that the plant will not live in the absence of carbon dioxide.

(1) To some extent this is a repetition of the same kind of study that was made of the pond-weed. Such a repetition is here thought to be desirable.

Brook Life (continued)

2. Sunshine.

a. Experiment to show that the plant cannot live long without sunshine .

3. Water.

4. Minerals.

a. Experiment to prove that the plant will not live in distilled water.

E. Contributions to the other animals and plants in the pool.

1. Oxygen.

a. Experiment to prove that pond scum liberates oxygen during growth.

2. Foods(starch, proteins, sugars, fats).

a. Pond scum manufactures starch while growing in the sunshine.

b. Digestion.

c. Production of fats and proteins.

VI. The Flat Worm (Planaria Sp.)

A. Observation of living worms in glass dishes in the laboratory.

B. Food of the flat worm.

C. Methods of reproduction.

1. Normal fission.

2. Egg laying.

D. Regeneration.

E. Some allies of the flat worm.

1. Parasitic flat worms.

a. The liver fluke.

b. The tape worm.

Brook Life (continued)

2. The round worms.

a. Hair worms.

b. Vinegar eels.

c. Trachinas.

3. The hook worm.

VII. The Pond Snail (Physa sp.). A Comparison with the Pond Snail (Lymnaea) found in Cat-tail Pond.

VIII. The Hydra.

A. Observations of living specimens.

1. General form and regions of the body - Symmetry.

2. Methods of attachment.

3. Changes of form.

4. Sensitiveness to touch and to light.

5. Sense of taste.

6. Methods of taking food.

B. Readings and discussions.

1. Feeding habits.

2. Reproduction.

a. Sexual, sperm and egg.

b. Asexual, by budding.

3. Regeneration.

4. Methods of protection.

5. Movement.

Brook Life (continued)

6. Digestion.

7. Allied forms of the hydra.

   a. The coral.

   b. The hydroid .

IX. Study of a Balanced Aquarium containing Pond Scum, Snails, Water Fleas, Flat Worms, Hydra and Isapods.

A. The balance of oxygen.

B. The balance of carbon-dioxide.

C. Sources of plant food.

D. Sources of animal food.

E. Constructing a table to show balance.

F. Application of this balance to the plants and animals of the world.

G. Differences between plants and animals.

   1. Character of foods used .

   2. Motion .

X. Field Work. A Collection of the Various Kinds of Plants found Growing in the Beds and at the Edges of the Brook. The Collection Included the Following: Lichens, Liverworts, Mosses and Ferns.

Brook Life (continued)

XI. Class Work. A Study of Some of the Advance Guards of Vegetation in the Newly formed Soil along the Edges of the Brook.

A. The Lichen.

1. Work of lichens in soil building and in preparing a way for the growth of such plants as liverworts, mosses and ferns.

2. Uses of lichens.

a. Reindeer moss of the arctics.

b. Iceland moss.

c. Mosses used in the manufacture of dyes and litmus paper.

B. The liverwort.

1. Habitat.

2. General features of the plant body.

3. Reproduction.

a. Vegetative propogation by means of the vegetative notch.

b. Asexual reproduction by means of the brood buds or gemules which are developed within the cupules.

c. Sexual reproduction.

1) Difference between male and female plants.

2) Examination of female plant to locate and study the grosser features of the egg bearer.

Brook Life (continued)

3. Examination of the male plant to locate and study the grosser features of the sperm bearer.
4. Fertilization.

C. The Mosses.

1. Habitat.
2. Relation to soil formation.
3. The moss cycle.
    a. Two kinds of plants ,male and female; the one with a star -cup holding the 'moss pollen' which is sifted by the wind over to the waiting egg, the other with an egg or ovule at its tip.
    b. The egg or ovule as soon as fertilized develops into a spore capsule and is lifted up into the air on a long black stem and is protected by a silky cup.
    c. The cup and lid comes off of the spore case. The spores are shaken out and scattered.
    d. Those spores that find suitable places grow into a net of green threads.
    e. From these threads male and female moss plants are sent up which repeat the cycle.

Brook Life (continued)

D. The ferns.

1. Habitat.

2. Tropical ferns.

3. Fossil ferns.

4. Relation of ferns to soil and coal formation.

5. Reproduction of ferns.

    a. By means of underground rhizoids.

    b. By spores.

        1) Location of spores on under surface leaves.

        2) Germination of spores in soil under glass into prothallia.

        3) The prothallia.

            a) Study of chart to locate the structures on the prothallium connected with the formation of eggs and sperms.

            b) Fertilization. (chart)

            c) Development of fertilized egg. (chart)

6. Ornamental ferns.

    a. Care of house ferns.

    b. Kinds of house ferns.

7. The walking fern.

The Evergreens of Columbia. (December)

1. Trip to Rollin's Estate for the Field Study of the White Pine, the Scotch Pine and the Red Cedar. Comparison of these trees as to

   A. Habit of branching.

   B. Height.

   C. Fruiting bodies.

   D. Form and arrangement of leaves.

11. Class Work.

   A. The white pine (pinus strobus).

      1. Distribibtion.

      2. Economic Importance.

      3. Relation of the arrangement of the buds to the method of branching.

      4. The female cone. Gross structure.

      5. The male cone. Gross structure.

      6. Pollenation and fertilization.

         a. Meaning of pollenation and fertilization.

         b. Time at which pollenation and fertilization occur.

         c. Length of time after pollenation required for the development of the seed.

   B. The Scotch pine. (pinus sylvestris).

      a. Distribution.

      b. Economic importance.

C. The red cedar (juniperus virginiana).

a. Distribution.

b. Economic importance.

c. Relations of the blue berries to the cone of the white pine.

111. Field Work. A Study of the Evergreens of the University Campus; the Study to include the Characteristics, Distribution and Economic Importance.

A. Austrian pine (pinus Austriaca).

B. Norway spruce (picea excelsa).

C. Colorado blue sprice.

D. Arbor-vitae (thuya occidentalis).

E. Bald cypress (taxodium distichum).

F. Hemlock (tsuga canadensis).

Winter Buds (January)

1. Field Work. Difference in the size and location of the fruit and leaf buds of the apple, peach and pear.

11.Class Work.

1. Method of determining the effect of a freeze on the peach crop of Missouri.
2. Probable causes of the unsuitability of the weather conditions in Missouri for growing peaches.
3. Probable reasons for the suitability of the weather conditions of the Great Lake region for the growing of peaches.
4. Methods of delaying the opening of buds in the spring.
   a. Spraying with white wash.
   b. Spraying with sodium nitrate.
   c. Air drainage.
   d. Fallacy of packing the base of the trees with ice.
5. The use of smudge pots in orchards.

111. Laboratory Work. Structure and Function of the Various Parts of the Buckeye Bud.

1V. Class Work.

1. Bud scales and the protection they give to the dormant growing points. Effect of freezing

on plant tissue.

2. Definition of a bud.

3. Advantages of buds to the plant.

   a. The plant is able to take quick advantage of the growing season.

   b. The plant is able to quickly replace lost or injured branches.

   c. The dormant growing parts are protected during the winter.

4. Significance of the over production of buds.

5. Kinds of buds.

A Study of Some of the More Common Fungus Plants that are to be Found in the Woods During January.

1. Field Work. The students record in the note book the common name of each form found, its distribution, the position and conditions in which it is usually found growing, and any other interesting facts that may be found about it. The following forms were found by the biology class during February 1915.

   A. The willow daedalea (daedalea confragosa).
   B. The aged fomes (fomes igniarius).
   C. The locust fomes (fomes robiniae).
   D. The common fomes (fomes applanatus).
   E. The common zoned polyporus (polyporus versicolor).
   F. The resinous polyporus.
   G. The hairy polyporus (polyporus hirsutus).
   H. The toothed fungus (hydnum sp.).
   I. The maple chizophyllum (chizophyllum commune).
   J. The oyster mushroon.
   K. Puff balls.

Note. The students, of course, cannot be expected to remember the names of these forms. Some of them will be remembered. However, should they forget the names of all of them, they will, nevertheless, as a result of the work, continue to feel a familiarity with and an interest in the woods that they might never have felt otherwise. Incidentally they have developed a desire to know something about the growth and reproduction of fungi and their economic relations.

11. Class Work.

A. The mushroon.

1. Structure.

a. Cap.

b. Stalk.

c. Gills and spines.

d. Spores.

e. Mycelium.

2. Nutrition and reproduction.

3. Artificial reproduction.

4. Explanations of 'fairy rings!

B. The wood destroying fungi.

1. Structure.

2. Reproduction.

3. Nutrition.

4. Economic importance of wood destroying fungi.

a. Usefulness of the saprophytic forms.

b. Undesirability of some of the parasitic forms and methods of preventing their spread used by foresters and 'tree dentists'.

C. The humus saprophytes and their relation to soil formation.

Bread Mold (February)

1. A Study of the Conditions Favorable for the Growth of Bread Mold.

    1. Observations on the development of molds on pieces of damp bread in

        a. Covered tumblers in a warm room exposed to direct sunlight.

        b. Uncovered tumblers in a warm room exposed to direct sunlight.

        c. Covered tumblers in a dark warm room.

        d. Uncovered tumblers in a dark warm room.

        e. Covered tumblers in a dark cool place.

        f. Uncovered tumblers in a dark cool place.

        g. Covered tumblers in a light cool place.

        h. Uncovered tumblers in a light cool place.

    2. Conclusions: Bread mold, in order to grow rapidly, needs moisture and moderate heat. It prefers dark, damp places where there is no free circulation of air.

11. Gross Structure, Life History and Physiology of the Bread Mold.

111. Sterilization. Observations of mold development on ten pieces of bread in ten cotton plugged bottles that are exposed for various lengths of time to 100 degrees C. in a steam sterilizer.

Bottle no. 1	100 degrees C.	20 minutes.
Bottle no. 2	100 degrees C.	30 minutes.
Bottle no 3	100 degrees C.	30 minutes each day

for three days.

IV. Growth of Pure Cultures.

Inoculation of the pieces in sterilized bottles numbers 3,4,5,and 6 with spores from molds growing at various plaves.

V. To Prove that Bread Mold Spores are Present in the Air.

Observations of mold development in

bottle	no.	7	after	removing	plug	for	10	minutes	in	the laboratory
"	"	8	"	"	"	"	20	"	"	basement.
"	"	9	"	"	"	"	20	"	"	kitchen.
"	"	10	"	"	"	"	20	"	"	street.

VI. Some Positions in Which Molds are Often Found Growing.

A. Upon cakes and breads.

B. Meats and cheeses.

C. Jellies

D. Many raw vegetables.

E. Decaying ripe apples, peaches and plumbs. (green or blue mold.

F. Damp flour.

G. Moist wood or paper.

H. Damp leather or cloth.

I. Human skin (ringworm).

VII. What Molds do to Foods.

VIII. How to Prevent-Molds.

Yeasts (February)

1. Observations of the Conditions and Results of Growth Resulting from Mixing a Part of a Cake of Compressed Yeast with

   A. Tap water in a wide mouth bottle to be kept in a warm place.

   B. Tap water in bottle to be kept in a refrigerator.

   C. Tap water in a bottle to be boiled and kept in a warm place.

   D. Tap water and molasses to be kept in warm place.

   E. Tap water and molasses to be kept in refrigerator.

   F. Tap water and molasses to be kept in warm dark place.

11. Conclusions:

   A. Yeast does not grow in tap water.

   B. Yeast grows in sugar solution.

   C. Carbon dioxide and alcohol are liberated when yeast grows in a solution.

   D. Yeast is killed by boiling water.

   E. Yeast grows best in a warm place. Sunlight is not necessary.

111. Fermentation.

1V. Size, Shape and Manner of Growth of Yeast.

V. Wild Yeasts.

V1. Carbohydrates Necessary to Yeast Fermentation.

V11. Relation of Yeasts to Bread Making.

1X. Relation of Yeasts to Beer and Wine Making.

X. Commercial Yeasts.

Bacteria (March).

1. Where Bacteria Grow. How Bacteria may be Caught and Studied.

Growths of bacteria are started in petri dishes, containing agar, in the following ways.

1. By placing one or two hairs from the head on the surface of the agar of a steril petri dish.
2. By touching the agar with the finger.
3. By opening and exposing a dish for five minutes in the laboratory.
4. By touching the surface of the agar with a dirty coin.
5. By touching a steril glass rod to the inside of mouth and then to the surface of the agar.
6. By touching the surface of the agar with decayed vegetable or meat.
7. By dropping on the agar a drop of soil water.

11. Isolation of Pure Cultures of Bacteria in Tubes of Agar from Colonies Appearing in the above Dishes.

111. Size, Shape and Manner of Growth of Bacteria.

1V. Foods Preferred by the Bacteria.

V. What Bacteria do to the Foods.

1. Meaning of bacterial decomposition and putrefaction.
2. Variety of products of bacterial decomposition.
    a. Poisonous and harmless.
    b. Gaseous and Liquids.

Vl. Manufacture of Vinegar by Means of Acetic Acid Fermentation.

Vll. Bacteria in Relation to the Souring of Milk.

lX. Bacteria in Butter Making.

X. Conditions of Moisture, Light, Air and Heat Favorable and Unfavorable for the Growth of Bacteria.

Xl. Methods of Sterilization.

Xll. Methods of Preventing Bacterial Decomposition in Foods.

1. Canning and sterilization.
2. Refrigeration.
3. Pasteurization.
4. Canning of meats.
5. Preservation by means of benzoic acid, borax, boracic acid and formaldehyde. The pure food laws.
6. The silo.

Xlll. Disinfectants and Anticeptics.

XlV. Bacteria as Agents in Nature's food Cycle.

1. A review of the manufacture by plants of carbohydrates, fats and proteids from-
   a. Water from the soil.
   b. Carbon-di-oxide from the air.
   c. Sunlight.
   d. Compounds in solution in the soil water, for the most parts nitrates.
2. The change in Nature of these food products into those which make up the bodies of animals.

3. The part played by the nitrifying bacteria and by the tubercle bacteria and legumes in breaking down these complex compounds of animal and plant bodies and restoring the nitrates to the soil.
4. Methods by which the carbon-dioxide, taken from the air by the plant, is restored.
5. Final disposition of the energy which the plant originally took from the sunlight.

XV. A Study of Diphtheria as an Illustration of How Bacteria Cause Disease.

1. Events connected with the disease.
2. Interpretation of these events in the light of the germ theory of disease.
3. Preparation and use of diphtherial antitoxins.

XVI. Tuberculosis.

XVII. Typhoid Fever.

XVIII. Smallpox and Vaccination.

XIX. A Brief Consideration of Other Diseases due to Bacteria.

A Study of the Common Frogs, Toads and Salamanders of Columbia and Vicinity. (March and April)

1. Preparation of Laboratory Aquaria for the Rearing of the Forms Collected.

11. Collection, Field studies and Class Work on the Following Forms:

A. The leopard or meadow frog, (rana pipiens).

B. The green frog, (rana clamata).

C. The bull frog, (rana catesbiana).

D. The wood frog, (rana sylvatica).

E. The tree frogs.

1. The common tree toad, (hyla versicolor)

2. The peeper, (hyla pickeringi).

3. The cricket frog, (acris grillis).

F. The common toad, (bufo lentiginosus Americanus).

G. The salamander, (amblistoma sp.).

The study of each form includes a consideration of the following: (1) habitat; (2) food; (3) adaptations, including relations to other forms of animal and plant life; (4) general activities, and (5) economic importance.

111. Breeding Habits of Frogs, Toads and Salamanders.

Amphibian Eggs and Their Development

1. Significance of the Over Production of Eggs Among Frogs, Toads and Salamanders Compared with the Small Number of Eggs Produced by Birds and Mammals.

11. Observations of the Development of the Frog Egg.

    Two cell stage.

    Four cell stage.

    Eight cell stage.

    Twelve cell stage.

    Mulberry stage.

    Blastula and gastrula stages.

    Neural fold stage.

    Early tadpole stage.

    Late tadpole stage.

111. Comparison of the Matamorphoses of Frogs, Salamanders. Mudpuppies and Sirens as an Illustration of the Recapitulation Theory.

Fertilization

1. Origin of the Egg and Sperm.

11. Entrance of Egg into Sperm.

111. Fertilization.

1V. Purpose of Fertilization.

    A. Provides for initiation of develppment.

    B. Provides for biparental inheritance.

V. Parthenogenesis , Normal and Artificial.

Vl. Cross Fertilization.

Vll. Inbreeding.

A. Effects of inbreeding on the vitality of plants and animals.

1. Darwin's ten generations of morning glories.

2. Weismann's twenty nine generations of mice.

3. Castle's fifty nine generations of pomace flies (drosophila).

B. The part that may be played by inbreeding in emphasizing hereditary defects.

C. Some provisions in the animal and plant kingdom which may serve to prevent inbreeding.

Vlll. Hybridization.

Flower Study (April and May)

1. Preparation by Each Student of a List of All Wild Plants Observed in Bloom during the Month, Arranged in a table with Column Headings as Follows:

    A. Common name of plant.

    B. Family.

    C. Date.

    D. Habitat.

11. Preparation by Each Student of a List of all Ornamental Plants Observed in Bloom on the University Campus, Arranged in a Table with Column Headings as Follows:

    A. Common name of plant.

    B. Family.

    C. Date.

    D. Color.

    E. Use.

111. Studies of Selected Angiosperms.

    A. The hazel as an example of the plants of the willow, birch and beech families that have flowers in catkins.

    B. The dog's tooth violet as an example of the lily family.

        1. Position number and importance of flower parts.

        2. The pollen.

        3. Internal structure of the ovary.

        4. Pollenation and fertilization.

        5. Adaptations for cross fertilization.

            a. The hanging position of the flower

unfits it for self pollenation or cross pollenation by the wind as well as protects the pollen from rain.

b. The coloration of the perianth and the secretion of nectar points to insects as agents for cross pollenation. Bees are known to be frequent visitors.

c. It is thought that the anthers and stigmas mature at different times thus preventing self pollenation.

6. History of the discovery regarding pollenation and fertilization.
7. Development of the ovule into the seed.
8. The fruit of the dog's tooth violet.
9. The bulb.

a. Formation of bulbs during successive years by means of offshoots which bear new bulbs at their tips and which form the new bulbs each year deeper in the ground.

b. Advantages of the bulb to the plant.

10. Characteristics of the lily family.
11. Other members of the lily family.

C. The tulip.

1. Culture.

2. Propogation.

a. Naturally.

1) By slabs.

2) By seeds.

b. Artificially.

1) By scooping mother bulbs.

2) By scoring mother bulbs.

D. The Anemone (anemonella thalictroides) as an example of the crowfoot family.

E. Shephards purse as an example of the mustard family.

F. The crab apple, the pear, the plumb, the peach and the cherry as examples of the rose family.

1. Differences between apples, pears, plumbs, peaches and cherries in flower and in fruit.

2. Determination of the characteristics of the family.

3. How men have improved orchard trees in the past by artificial selection.

a. Artificial selection.

b. Difficulties encountered in artificial selection. Reversion.

c. These difficulties met by use of budding and grafting.

G. The violet as an example of the violet family.

H. The common locust as an example of the pea family.

1. Number and arrangement of flower parts.
2. Special adaptations for pollenation by insects.
3. Characteristics of the pea family.
4. Other members of the family.
5. Value of legumes as soil restorers.

I. The dead nettle as an ~~examp~~ example of the mint family.

J. The dandelion as an example of the composite family.

1. Position and arrangement of flower parts.
2. Peculiar adaptations to prevent cross ppollenation. (dichogamy).
3. The fruit of the dandelion and its formation.
4. Seed dispersal.
5. Reasons why the dandelion is hard to control as a weed.
    a. It grows in all sorts of situations.
    b. It produces an enormous number of seed. It blossoms from early spring until late fall.
    c. It has a deep tap root which obtains food and moisture not obtainable by other plants.
    d. Food is stored up in this root. It

thrives through the winter and starts growth the following spring. Small portions of this root left below the ground will grow.

e. The leaves crowd out and shade out surrounding plants.

f. Seeds have plumed attachments.

g. Vigorous leaf rosettes are formed in the fall , and thus the plant is able to begin growth early in the spring.

Plant Breeding (May)

1. Wheat Breeding.

A. Its purpose.

B. The methods.

C. Principles upon which these methods are based.

1. Each species of grain contains many varieties of elementary species.
2. These varieties differ by various unit characters.
3. Each variety usually comes true from the seed, so that, when one has been chosen and isolated, it may be grown indefinitely with little change.

11. Corn Breeding.

A. Qualities sought by the corn breeder.

B. Methods of corn breeding.

C. Principles upon which the methods depend.

111. Perpetuation of the Desirable Varities once they are Found.

A. Propogation by means of cuttings, bulbs, tubers, grafting and budding.

B. The seeds of some grains come true.

C. Seeds of other plants run out. (sugar beet). With such plants the process of roguing must be practiced.

1V. Breaking a Type.

A. By changing the conditions in which a plant grows.

B. By hybridization.

V. Hybridizing.

A. Meaning.

B. How hybrids are artificially produced.

C. Variation among plants grown from hybrid seeds. Mendel's Law.

D. Instances of successful hybrids.

Plant Diseases (May)

1. A list of all plant diseases found during the month arranged in a table with column headings as follows:

    A. Name of disease.

    B. Host.

    C. Date.

11. Wheat Rust.

111. Smuts.

Some of the More Important Insect Pests Of Grain Crops. A Study of their Life Histories and the Means of Combatting them. (May)

1. The wire worm, (Elateridae).

11. White Grubs, (Lachnosterna spp.).

111. The corn root louse, (Aphis maidiradices).

1V. The cut worm, (Nocturidae).

V. The army worm, (leucania unipunctata).

V1. The hessian fly, (Cecidomyia destructor).

V11. The wheat joint worm, (Isosoma Spp.).

V111. Wheat lice or green bugs, (Aphididae).

Birds.

No regular periods are set aside in this course for the study of birds. Such study comes at irregular times through the year. At times a few minutes are given at the beginning of a class period for students to report birds seen. After field trips an entire period is often given to the study of these birds seen in the field. It has been thought best to begin the work in January and February. During these two months there are comparitively few birds in the region and the student can easily be expected to get acquainted with them. During the months of March, April and May the birds are studied as they return from their migrations. Following is a list of the birds studied through the year.

January.

- Hawks.
  - Red-shouldered Hawk.
  - Red-tailed Hawk.
  - Marsh Hawk.
  - Sparrow Hawk.
  - Sharp Shinned Hawk.
- Owls.
  - Screech Owl.
  - Barred Owl.
  - Short Eared Owl.
- Tree Sparrow.
- Bob White.
- Red Headed Woodpecker.

Flicker.

American Crow.

Purple Finch.

Cardinal.

Carolina Wren.

White Breasted Nuthatch.

Northern Shrike.

Loggerhead.

February.

Golden-crowned Kinglet.

Hairy and Downy Woodpecker.

Chickadee.

Cedar Waxwing.

Blue Jay.

Gold Finch.

Tufted Titmouse.

Junco.

March.

Blue Bird.

Song Sparrow.

Red Winged Blackbird.

Robin.

Tohee.

Fox Sparrow.

Chipping Sparrow,

Field Sparrow.

Cow Bird.

Phoebe.

Mourning Dove.

Wilsons Snipe.

Pin Tail.

Mallard.

Green-winged Teal.

Blue- winged Teal.

April.

Barn Swallow.

Chimney Swift.

Indigo Bunting.

Cat Bird.

Purple Martin.

Bank Swallow.

Cliff Swallow.

Barn Swallow.

Wood Pewee.

King Bird.

Crested Flycatcher.

Whip-poor-will.

American Coot.

May.

House Wren.

Rose-breasted Grossbeak.

Baltimore Oriole.

Orchard Oriole.

Mourning Dove.

King Fisher.

Humming Bird.

Red Headed Woodpecker.

Brown Threasher.

Wood Thrush.

Warblers.

Black Birds.

Dicksissel.

Night Hawk.

Cuckoo.

CHAPTER V

EVALUATION

While the results of this course in biology are too indefinite to be measured accurately it is felt that the course has avoided the ~~objections~~ criticisms made of text books ~~made~~ in Chapter 111 and in addition has accomplished four noteworthy results.

Best Preparation for life

First, the students as a result of this course, are better prepared for present and future living. They have developed large interests in plants and animals of their environment. This alone will possibly add to their pleasure of living more than any other accomplishment of biology teaching. They have gone far enough into the study to discover and develop a desire to solve a great many problems of plant and animal life. This means an endless opportunity for profitably spending leisure hours in all future time. Futhermore, they have developed an appreciation of the value of scientific research. It is hoped that they realize as they have never realized before the value of such work in its relation to human progress. Lastly, they have acquired much information that will be of direct use to them in any occupation they may desire to follow in the future.

Second, while their knowledge of the

fundamentals of the science has, by the nature of this course, been somewhat limited, it is felt that they do know well some of the things that the scientist might consider fundamental. It is hoped that such fundamentals as they do know have come to them as interpretations of life problems and for that reason will be remembered and appreciated and more often used in the future in the solution of other problems that may arise. The young student who acquires principles of science through the laboratory study of type forms in which he has no particular interest cannot be expected to realize and appreciate the part played by such principles in the phenomena of life about him. Neither can he be expected to interpret phenomena which he may experience in the future in terms of such principles. On the other hand the student who once finds a real use for a principle of science in satisfying his desire to solve a mystery of plant or animal life will be more apt to make use of it again.

<u>Knowledge of the science as such</u>

<u>Third</u>, the greater majority of these students will never take another course in biology. For that reason no attempt has been made in the course to prepare them for future biological study. However, it is believed, that the students, after all, have had the best kind of training for future work of this nature. The teachers of college zoology, botany and physiology are not eager that students of their

<u>Preparation for college</u>

elementary courses have had as a prerequisite a high school course in the science covering practically the same ground as the university course only in a less satisfactory manner. They are, however, very anxious to have students in their courses who have an acquaintance with and a broad interest in the plants and animals of their environment and who are acquainted enough with some of the problems of science to desire a more intensive study of them.

Fourth, disciplinary aims have had no influence on the selection and organization of the subject matter of this course. However, as has been pointed out in chapter three, the course has, for other reasons, been subjected to these requirements which are thought to foster the acquirement of the scientific habits of thinking. Throughout the course an attempt has been made to guide the students in the scientific solution of some of the normal problems of everyday life. It is believed that the students have acquired an appreciation of the scientific method instead of the feeling that many have towards science, described by Huxley: "Many persons seem to believe that what is termed Science is of a widely different nature from ordinary knowledge, and that the methods by which scientific truths are ascertained involve mental operations of a recondite and mysterious nature, comprehensible only by the initiated, and as distinct in their character as inn their subject matter, from the processes by which

<u>Scientific discipline</u>

we discriminate between fact and fancy in ordinary life." (1)

(1) Huxley, T. H., The Crayfish, p.1.

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UNIVERSITY OF MISSOURI
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May 21. '15

Dean Walter Miller,
Univ. of Mo.

My dear Dean Miller:- I have examined the thesis presented by Mr Chas H. Philpott and it seems to me a very creditable attempt at a solution of the vexed questions of High School teaching in Biology

Very truly yours

W. C. Curtis
Prof of Zoology