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Scope of Study: The general biology course in the secondary schools can be both interesting and practical. The writer has observed that many teachers of general biology do not know what they are trying to accomplish. Consequently their courses are seldom practical. This report is a study of the aims and objectives of general biology course for the secondary school, together with some suggestions as to how these objectives may be accomplished. An effort has been made to collect ideas about the content of a modern course and also to demonstrate justification for that content.

Findings and Conclusions: The range of biological concepts that can be considered important is so great that sufficient time is not available to present all of them in one year. The superficial coverage of a great many concepts does not impart as much learning as does the thorough coverage of fewer concepts. The foremost aim of the general biology course is to produce the biologically literate individual. The best possible material should be used to present in an understandable form the most important principles of biology; to make clear certain biological concepts; to demonstrate what biology is today and what it is not; to inculcate in the student an understanding of and the desire for critical mindedness so as to foster accuracy of observation and clear reasoning; to inspire the spirit of science as an adventure into the unknown; to help him correlate his religious and philosophical thought with scientific fact and theory; and finally to help students to understand the world, and man's place in it.

ADVISER'S APPROVAL

ON TEACHING LESS BIOLOGY BETTER
IN THE SECONDARY SCHOOL

By

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ON TEACHING LESS BIOLOGY BETTER

IN THE SECONDARY SCHOOL

Report Approved:

Report Approved

Dean of the Graduate School

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R. R. C.

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CHAPTER I

INTRODUCTION

The material in this report has been gathered primarily for the writer's own edification. The experience of teaching general biology in the high school has left the writer curious as to what the objectives of such a course should be. There are two prime reasons for this curiosity. First, the number of concepts and ideas that could be included seem to be almost boundless. Second, modern innovations and advancements in the field of biology have been and will be tremendous. Now only is there already too much to teach, but there is also need to pare the old to make room for the new.

The origninal plan was to set down a definite list of objectives together with suggestions as to how they might be accomplished with a minimal waste of time. Discussions with many biology teachers revealed the folly of this plan. Too many variables are entailed to allow a dogmatic declaration of objectives or methods.

The title "On Teaching Less Biology Better In the Secondary School" requires some explanation. No "watering down" of the course is implied. To the contrary, the idea is the thorough mastery of essential and fundamental biological concepts. If the thing is worth doing, it is worth doing well. The secondary school is not the place to present the details of advanced biological concepts. Such presentation leads to superficiality. It is well to discuss radioactive tracer methods, <u>if</u> <u>and</u> <u>only</u> <u>if</u> the students know the fundamental biology involved. A football coach may teach his boys fifty plays used by a national championship team, but his teaching is worthless unless he has first taught the fundamentals of blocking and tackling. This too could be misconstrued. It is also axiomatic of good teaching that once fundamentals are learned, their application will be stressed. Should the teacher find it difficult to determine applications for a given concept, he should check as to the limitations of his own knowledge. If then no important applications are revealed, he has found a place to make room for something more important. From a standpoint of motivation and interest, it is desirable to make incidental reference to modern, advanced developments. However, this should be done in a manner designed to make the student aware of the fact that he must master fundamentals before he can think intelligently about advanced concepts. At the same time, it must be conceded that the old biology is not necessarily the fundamental biology.

Various ideas as to essential objectives and content will be presented. Many beginning biology teachers are confronted with problems for which they have little or no preparation. The beginning teacher may find the information herein to be of value in planning his work. The experienced teacher will, it is hoped, find some challenging ideas with which he may or may not agree.

CHAPTER II

THE SELECTION OF OBJECTIVES

Since there is great variation in communities and in schools, several assumptions must be delineated as a starting basis for the discussion of the objectives of the general biology course in the secondary school. First, the course in question is a course in general biology such as is usually offered to tenth grade students. Second, it is assumed that most students in the school will take this course, and that it is likely to be their only formal study of biology. Third, only a small percentage of the students are likely to major in a biological field, if they attend college. Fourth, many school administrators oppose the division of students into classes according to their individual abilities. Fifth, few high school teachers can obtain adequate training in all areas of biology. Sixth, objectives stressed in an agricultural area will differ in some ways from those stressed in an industrial area. Seventh, approximately 180 class hours will be available for biology instruction, with no special time provision being made for laboratory work.

Is there need for the study of objectives in the general biology course? Some may contend that the objectives listed in any good text are adequate. After all, the authors of the text are specialists who have carefully developed their work. Why then, not adopt a good text and follow it unit for unit throughout the school term? The teacher that has not personally thought out the things that he wants to accomplish is either inexperienced, lazy, or ignorant. No one text can fit the purposes of all teachers and all types of classes. Oscar Riddle, founder of the National Association of Biology Teachers, has recently stated:

> The riches of our science are such, especially when its numberous technologies are lumped with it, that a dozen (or dozens) of wholly distinct one year courses--each a worthy one--can easily be built from its subject matter. Indeed, precisely this fact of riotous over-abundance provides part of the reason that current courses and texts aimed at biological literacy do not exist.[1] [Italics not in the original]

It is not intended here to condemn the use of textbooks. A text should be used. It will give the student something upon which to anchor and orientate himself. Furthermore, it is an always available source for reference. However, Miller and Blaydes in their book on biology teaching methods stress a pertinent point. These authors ask,

> How should the teacher determine the amount of subject matter to be included in a course?....The most widely used criterion for making the decision seems to be the size of the text selected. It is the general rule that the course consists of the subject matter included in the book and that it is the business of the teacher to crowd that amount of subject matter into the semester or year, as the case may be, if the content is large, and to stretch that amount out over the same time, if the content is small. Under the most favorable circumstances this is a poor method.[2]

Much thought is currently being given to the aims and objectives of the college general biology course. Most seem to agree that the

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[1]O. Riddle, "High Schools and Biological Literacy in the United States," The American Biology Teacher, Vol. 16, (November, 1954), p. 180.

[2]D. F. Miller and G. W. Blaydes, Methods and Materials for Teaching Biological Sciences (New York, 1938), McGraw-Hill Book Co., Inc., p. 29.

primary aim is to impart sufficient knowledge of biological principles to enable the individual to think intelligently about biology as it is connected with his experiences. One finds less literature indicating parallel thinking for the high school course. However, both courses have essentially the same fundamental aims. In her article entitled "Teaching Biology Today," Harriet B. Creighton, Dept. of Botany, Wellesley College, has said,

> Biology teachers must continue to give attention to the selection of the content of the biology course. They are the only people qualified to decide which concepts, which principles, which facts and which techniques can be cogently presented in one year to the college students of today. Teachers are painfully aware that to make room for new topics and to insure that any large proportion of the ideas presented are really received by the students. Some topics must be either eliminated or markedly curtailed. Many teachers have concluded that it is no longer possible to present a single introductory course for all students. One strong reason for this is that 40 or 50 or even 20 or 30 years ago, a large proportion of all that was known could be presented in one year. A student could come nearer then than now to grasping what the teacher knew.... *Tragically too many introductory courses of today still follow blindly the pattern of the past, attempting to survey the whole field of modern biology.*[3] [italics not in the original]

When he is determining the objectives of his course, the biology teacher should keep another thought in mind. A. E. Holch of the University of Denver puts it this way.

> Often the teacher of general biology is better trained in either botany or zoology, usually the latter, and altogether too many times the course in general biology becomes largely a technical zoology course.[4]

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[3]G. S. Avery, Jr., Editor-in-Chief, *Survey of Biological Progress Volume I*. (New York, 1949) Academic Press Inc., p. 3

[4]A. E. Holch, "Combining Thoroughness with Conservation of Time in Teaching Biology and General Science," *The Science Teacher*, Volume XI, No. 4 (December, 1944) pp 20-21.

In other words, most teachers are weak in some areas. Yet they must make every effort to keep the general biology course well balanced.

The same author has some interesting observations on science education in general.

> A man is well educated if he is in as good health as is possible for him, if he is able to make an honest living, if he exhibits good taste in his amuseuments and recreation and intellectual pursuits, and if he is tolerant and considerate of the opinions, ideas, and ideals of others.
>
> Of course, in an age of applied science it is essential that our courses do more than lay the foundations. After the fundamentals have been stressed, their applications to modern living should be emphasized. Indeed, it is the applications, rather than the basic fact, which constitute the real motivation of most of our science learning in the schools.[5]

The implications of these observations should not be lost on the competent biology teacher. The subject matter of biology contains many principles which should be applied to modern living.

Author O. Baker, Directing Supervisor of Science in the Cleveland Public Schools, and Lewis H. Mills, Principal of Audubon Junior High School, Cleveland, list the purposes of the biology of today in the preface to their book, "Dynamic Biology Today."

> The purposes of the present-day biology course emanate from the principle that education is concerned with the needs and interests of the learner. These purposes are manifestly different from the purposes in vogue when biology was considered a set body of subject matter to be mastered for its own sake.
>
> One purpose of the present day biology is to help the student think critically about biological problems. ....Critical thinking enables him to break down super-

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[5] A. E. Holch, "Combining Thoroughness With Conservation of Time in Teaching Biology and General Science," The Science Teacher, Vol. XI, No. 4 (December, 1944) pp. 42-43

stitions, analyze propaganda, become systematic and accurate, and use the facts and principles of biology more intelligently in solving his own problems.

A second purpose of present day biology is to provide a student with fundamental concepts in life science.... An analysis of practical requirements indicates that biological facts and principles are fundamental only when they serve useful purpose in the present or future life of the student. [italics not in the original]

A third purpose of present day biology is to help the student apply biological concepts to practical situations. The student is concerned with scientific knowledge about bacteria, insects, birds, trees, and other forms of life because of their effect upon man. How these forms of life affect man or handicap him and what man should do about them are as fundamental to the student as the scientific knowledge itself. Consequently, biology becomes a factor in achieving such worthy aims as maintaining health, choosing a vocation, securing recreation, and practicing conservation.[6]

Most students in the average class will receive a total of about 180 hours of biology instruction (less activity interruptions) during their formal education. How can the biology teacher best use those precious 180 hours? Can he, for instance, use 15 or 20 hours for instruction in classification and the use of keys? Will such limited instruction leave the student sufficiently skilled to actually make use of biological keys in later life? If not, the time is practically wasted. Assuming that such skill can be taught in about 20 hours, can one justify using one-ninth of the available time for this purpose? Perhaps it would be better to bring in classification as one of the considerations in a philosophical discussion of evolution. Certainly the student should be made aware of classification methods. However, is it not more important to the student for him to establish rapport between his religious and scientific philosophies than it is for him

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[6]A. O. Baker and L. M. Mills, Dynamic Biology Today. (New York, 1943) Rand McNally and Co., pp 3-4.

to be able to give the scientific names of the flora and fauna in the local park?

A biologically literate individual should probably know the difference between the elasmobranchs and the marsupials, if for no other reason than to answer questions on a college entrance or similar type examination. However, it is here contended that it is more important for the individual to know about such things as blood types or soil fertility. The reason is simple. Such knowledge is more useful. Everyone should understand the importance of blood typing. Many wonder why their lawn or garden is not thriving. Few have personal problems with the marsupials.

The teacher is supposed to present the "fundamental principles" of biology to his students. Committees on curriculum often make glib use of the words "fundamental principles" without making any clear statements as to what these principles are. Various ideas as to the nature of these principles will be presented in the following chapter.

There is so little time. The superficial learning of great quantities of material is a waste of time. We must cut the general biology course down to size. Then we must teach thoroughly. The students must be able to transfer well-learned principles from the classroom to use in their future living.

Our science students should be graduated from high school in possession of sufficient scientific information to have ideas of their own concerning scientific subjects. We do not want our students to be in the predicament described by a research man in general education who had traveled to many college campuses.

He said that he had noticed that all people giving general education courses in science complain about how stupid and unresponsive the freshmen are, and how they would prefer giving their courses to seniors, while people in the humanities feel that the freshmen are more intelligent, more responsive, more eager to learn than upperclassmen. The reason for this, he said, was simple to see: in the humanities, such as literature, any novice can have definite, however unsophisticated, ideas concerning morals, taste, human conduct, and so forth, for these are problems common with his experience, but in science he can have no ideas of any interest until he first accumulates facts. So, in a science there is bound to be a long period of fact gathering that is likely to bear fruit, only after the course is over.[7]

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[7] J. T. Bonner, "On Understanding Biology," The American Biology Teacher, Vol. 16, (April, 1954) p. 87.

CHAPTER III

IMPORTANT PRINCIPLES

Each thinking teacher has his own ideas as to the important principles to be presented in the general biology course. Most will agree on certain key concepts. For instance, there is little disagreement as to the need for presenting the principles of heredity. Other principles do not have general support. There seems to be much disagreement as to how much stress should be placed on any given principle. Discussions concerning these things are usually heated and unending. Hence, only general conclusions can be reached. For this reason, materials from various sources will be presented to allow contrast and comparison.

The writer examined five different high school biology text books. The oldest copyright date was 1950 and three of these texts had copyright dates as recent as 1955 and 1956. There was no particular selection of texts made. Those used happened to be easily available. The following eleven selected principles are more or less a digest of principles revealed by the examination of these texts.

1. Living things are composed of cells. This is the first main principle presented by two of the five texts. Two more present this principle relatively early in the text, although one masks it with the heading 'the physical basis of life.' The fifth text does not present this concept as a specific principle but rather as incidental information. Many students study cells and cell structure without

recognizing the fundamental importance of this study. They observe one-celled plants and animals, then fail to see the connection between these observations and the study of more complex forms. Cells build into organs; and organisms are made up of organs. This is basic information.

2. Green plants make the food for all living things. Surprisingly, two of the texts do not seem to present this principle as being a basic concept. Failure to stress the importance of the balance in nature as demonstrated by such things as the carbon, oxygen, and nitrogen cycles indicated a tendency to present isolated facts without regard to the over all scheme of nature. Many science courses are presented in such a way as to be guilty of this weakness. Perhaps some authors and teachers feel that the average tenth grade student knows too little chemistry to think about such things. The duty of the good general science teacher is here apparent. Isolated facts and details are important only because they are a part of a whole picture.

3. Our energy sources can be traced to the sun. The texts examined were consistent in showing the processes involved in deriving human energy from foods. One or two seemed to trace the more comprehensive energy patterns. Plants utilize energy from the sun to manufacture substance which store chemical energy. This energy may be released in a short time through the plant or animal organism. Or, the chemical energy may be stored for great lengths of time and then used as fuel in the form or oil or coal. The water behind a hydro-electric dam has potential energy because the sun provided energy to raise that water to the necessary elevation. Correlations with other sciences should be made. Over all understandings are otherwise impossible. Here again the student needs to have the concept of energy from his

general science. Should the student not have this concept, it is up to the biology teacher to give it to him. Unfortunately, some biology specialists don't know the difference between potential and kinetic energy themselves. Somehow one tends to miss these connections when he spends too much time with his nose in an insect key or in the innards of a shark or cat.

4. Microscopic organisms both help and hinder other organisms, including man. The average individual does not realize the tremendous effect the denizons of the microscopic world have upon man and other organisms. The saying "out of sight, out of mind" seems to apply here. People know about germs from general health education. However, the average beginning biology student has some weird and limited notions as to what these germs are and how they function. The American public is notoriously gullible in these matters. All of the texts examined presented information on disease control. This subject is admittedly important and should be stressed. The beneficial aspects of microbial functions are apparently somewhat understressed in at least three of the texts. For instance, decay and putrifcation may be disagreeable topics but these functions are very essential to nature's plan.

5. Classification is necessary to the orderly study of living things. Years ago much time was spent in finding and classifying various specimens. Particular interest was given to the unusual. Such might be termed "hobby type biology". The practicality of this procedure was given little thought. The texts of today take a more realistic approach. Classification is necessary but it need not be overdone.

6. Living things are affected by their surroundings. Ecological principles were stressed in all the texts examined.

7. Reproduction is a normal and essential biological function. This subject is often dicussed under such headings as 'living things tend to produce more of their kind' or 'the origin of new individuals.' Much has been said about ways and means of teaching about sex and reproduction. Most modern biology texts treat this principle the same as any other of equal importance. The teacher of general biology has an excellent opportunity to combat the 'reverse english' generated by our Puritanical heritage. Most of us have been indoctinated with the idea that the sexual organs are obscene and that the processes of reproduction are something that children should not know about. Our ancestors should be turning over in their graves for this curse they have left us.

8. The nutritive requirements of most plants and animals are similar. Few texts treat this principle adequately. Pupils are astounded to learn that a well balanced ration for a pig would be adequate for the human being. True, one would not care to dine on yellow corn, tankage, dehydrated alfalfa, and mineral block. However, most of our needs in the way of proteins, carbohydrates, fats, vitamins, and minerals would be met. A discussion of soil fertility is in order in connection with the main principle of nutrition. As mentioned before, information on plant and animal nutrition is extremely practical.

9. Plants and animals receive traits from their ancestors through the processes of heredity. Every text examined contained a unit covering this principle. This is a prime biological principle. Time usually does not permit adequate coverage. The mere study of simple Mendalian laws leaves too many unanswered questions in the minds of the students.

10. The earth and its inhabitants have undergone marked changes through the ages. Nothing in this world is so certain as change. Since

biological changes take place so slowly as to have little affect during a human lifetime, it might be argued that the principle of change is of little practical value. However, men have a basic, philisophical couriosity which must be satisfied. This curiosity can be partially satisfied through scientific study. Otherwise, it is likely to be satisfied through reading such things as the Police Gazette or Readers Digest. The first method is preferable.

11. Most biological principles learned can be applied to ourselves or to our well being. This is the foremost principle for the general course. It is meant to include the nine fundamental systems, i.e. nervous, digestive, circulatory, respiratory, skeletal, muscular, lymphatic, endocrine, and excretory. We respond to stimuli; we obtain food and utilize it for growth and energy; we excrete; we reproduce, et caetera; just as do other organisms. These connections are of the utmost importance. Human biology or physiology is the most important single aspect of the general biology course. Authors of general biology textbooks are beginning to realize this. Something is wrong with our biological education. This is amply attested by the millions of dollars spent annually on worthless patent medicines and quack healers. People read about "you wonder what it does" drugs (usually in the Readers Digest) then demand a prescription from their family doctor, whether or not the drug is specific for their current ailment. This is the country whose people make so called faith healers rich.

The eleven priciples selected are not all-inclusive. Obviously, others can be added. Some could possible be deleted or restricted. But for the moment, let us take them as they are. If a student were to learn these principles and their main ramifications thoroughly, would he not be comparatively literate in a biological sense?

A noted biologist and author recently made a speech on the importance of biology in liberal education. He felt that all individuals need to know about animal and plant bodies being complex machines for using energy stored as a result of photosynthesis, soils, parasites, sex, the origins of life, the nature of man (a terrifically complex beast), irritability (the nervous system), the race problem (applied genetics), the use of a key to classification, evolution, and the place and significance of life in a lifeless universe. His is a big order for one year of instruction. Yet, a comparison of the eleven principles discussed with his objectives shows many parallels. The glaring exceptions are the use of keys to classification, and a study of the nature of man. The high school biology teacher of today need not apologize for not teaching the use of keys. For a biologist to single out man as being a terrifically complex beast seems peculiar. Physically, man is no more complex than many other beasts. If he had reference to psychological complexities, he is going beyond the scope of the general biology course. There simply isn't time to consider such things.

Many colleges have made an effort to incorporate a realistic general biology course into their curriculum. This type of course is aimed at the individual who is specializing in a field other than biology. The following material was taken from the biological science notebook used at Oklahoma A. & M. College. The notebook is an outgrowth of a co-operative study conducted by the staff of the Biological Science Course and the faculty committee on General Education in the School of Arts and Sciences at Oklahoma A. & M. College.

> In co-operation with students in the classes and the members of the committee on general education, the Biological Science Staff has formulated the following list of "key concepts"

about which the course has been organized.

1. The cell is a unit of structure and function in any individual, although the individual may be more than a sum of its parts. (That is, more value may be attached to arrangement than simple anatomical structure might suggest).

2. Any living plant or animal consisting of one cell, or many cells, demonstrates the organizational attributes of an individual.

3. Food manufacture by green plants is basic to all life on earth in converting energy from light to food.

4. The food that we eat is relatively complex in structure and must be digested to smaller particles and absorbed before it becomes available for our use.

5. Energy is released for biological activities only through combination with oxygen so that a supply of oxygen must be secured and waste gases must be eliminated.

6. The principle of levers applies in animal movements by the use of muscles, bones and joints.

7. Some biological wastes are toxic and must be removed by special organs.

8. Complex transporting systems are necessary to supply the body needs for food and oxygen and to remove waste products from the cells.

9. Mechanisms for response to stimuli exist of two types (chemical and nervous) and these regulate and co-ordinate the body functions.

10. Reproduction is a biological function normal to all organisms and may require special structures.

11. Organisms of every type reproduce their kind by means of unit characters (genes) that segregate and recombine to provide individual variations.

12. Organisms exist with life characteristics of many kinds, but these organisms may be arranged into groups of species related by their similarities, and separated by their differences.

13. Life is dependent upon the establishment of successful relationships between organisms of the same and different types and their respective environments.

14. Changes have taken place in the composition and relationships of animals and plants since life first existed. Man's attempts to explain these changes have profoundly influenced his thought.

15. It is the duty of all citizens to conserve their biological resources (human, plant, and animal) if these resources are to properly serve human needs.

16. Biological information is the only sound basis for any program related to public health.

17. Most social problems are biological and recognition of this fact will assit us in our search for answers.[1]

This seems to be an exceptionally good listing of key concepts. It is both specific and inclusive. The eleven principles previously selected are broader but imply most of the concepts in the A. & M. listing. Exceptions are the concept of conservation and the concept of social problems being biological.

The teaching of conservation has been strongly urged by educators. It has almost become a fad. To ignore it completely in the biology course is probably a mistake. However, children in an agricultural area have conservation preached to them from many sources. They hear it from the elementary teacher, from the county agent, from the vocational agriculture teacher, from the social science teacher, from the F. F. A. and 4-H speakers, and from propaganda put out by such specialized government agencies as the Soil Conservation Service, the Forestry Service, and the Fish and Wildlife Service. It is not necessary for the biology teacher to compound the redundancy. The pupils tend to become extemely bored. It seems reasonable to de-emphasize or drop this objective except for incidental reference in connection with the balances

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[1]. R. W. Jones and I. E. Wallen, <u>Biological Science Notebook</u> (Minneapolis, 1954) Burges Publishing Co., pp. 2-3.

in nature.

Most social problems are biological. This concept seems to be little remote from fundamental biology. Perhaps it is within the realm of social science. Most high schools have a senior course in social "problems". With a background in fundamental biology, the student should be able to get the social implications from such a class. This situation may not hold true for the college curriculum.

Comparing the objectives of the general biology course in college with those of the high school course may seem odd. The justification for this comparison is not difficult. After all, the ultimate objective in each case is exactly the same--to produce the biologically literate individual. There should be only a difference in degree of accomplishment. A student exposed to a good general biology course in both institutions should indeed be well prepared. But again, it must be remembered that only a small percentage of our people will study college biology. Thus, in a sense, the high school biology teacher has a greater duty to perform than does the college teacher.

A somewhat, though not radically, different approach to the problem is demonstrated by an outline for a college course. In an article entitled "The General Education Type of Biology Course" Sister Mary Aquin Miller of the Cardinal Stritch College, Milwaukee, Wisconsin, presented the following outline for a general education type of survey course in biology. This is a one semester course at this college

The Study of Living Things

1. Interest in living things throughout the ages.
    A. Work of the ancients in establishing biological science.
    B. Biology during the Roman age.
    C. Biology during the middle ages.

D. Revolutionists and highlights.
E. The age of microscopic technique and evolutionary ideas.
F. Biology today.

Diversity of Living Things

1. The Plant Kingdom
   A. Four great divisions
2. The Animal Kindom
   A. Usually divided into 13 large groups--phyla

Protoplasm---The Physical Basis of Life

1. Composition of protoplasm
2. The cell
   A. Component parts
   B. Cell variations--animal cells; plant cells

Unicellular Organisms

1. Animals--Protozoa
   A. Amoeba (morphology in detail)
   B. Other protozoa
2. Plants
   A. Some unicellular algae
   B. Some unicellular fungi

Multicellular Organisms

1. Diversity of cells---tissues---organs (examples both plant and animal)
2. Multicellular plants
   A. Moss---example of simple multicellular plant
   B. A typical spermatophyte
3. Multicellular animals---Metazoa
   A. Hydra example of simple multicellular animals
   B. The vertebrates (fundamental plan)

Food For Living Things

1. Definition of food
2. Kinds of food
3. Function of food
4. Source of food
   A. Photosynthesis---energy storing process

Utilization of Food

1. Explanation of diffusion and osmosis
2. Digestion of food
   A. Definition of digestion
   B. Digestion in simple organisms like amoeba

C. Digestion in complex organisms like man.
a. Digestive system and process of digestion
D. Digestion as found in plants
3. Absorption and circulation
A. In simple organisms like amoeba
B. In complex organisms like man
4. The assimilation of food
5. Respiration---energy-releasing process
A. In plants and animals
6. Excretion
A. In plants and animals

Response to Enviroment

1. Irritability---A physiological characteristic of protoplasm
2. Plant tropisms---growth movements
3. Irritability in unicellular organisms as amoeba
4. Nerve net---hydra
5. Simple nervous system of insects and earthworm
6. Complex nervous system of vertebrates
7. Hormones as related to the organisms response to the environment.

Reproduction---Embryology

1. Types of reproduction
2. Reproduction in unicellular organism (Plant and animal)
3. Reproduction in simple metazoa
4. Reproduction in the vertebrates
5. Seed production in plants

Heredity

1. Structure of cell nucleus
A. Mitosis---meiosis
2. Laws of heredity
3. Human heredity

Interrelations Among Organisms

1. Free living organisms
A. Dependence of animals on plants
B. Examples of mutual helpfulness
2. Parasitism
A. Definition of parasite and host
B. Unicellular parasites---plants and animals
C. Parasitic worms
D. Parasitic fungi

Plant and Animal Ecology

1. Ecological types of plants

2. Vegetation areas and plant associations---plant succession
3. Animal habitats
4. Laws of distribution
5. Expansion and repression factors

Evolution

1. Various theories of evolution
2. Evidence for evolution[2]

Here is a good, comprehensive outline for the survey or general type course in biology. Few of the "high points" in biology have been omitted. The historical build-up is a good aspect. High school students usually dislike history but proper presentation can cultivate a better attitude. Note the careful study of unicellular organisms followed by a rather quick jump to the most complex organisms. i.e., from digestion in a simple organism like amoeba to digestion in a complex organism like man. The important principles can be thus taught with conservation of time.

The biology teacher's obligation is to determine his objectives and then to determine the most effective and least time-consuming methods for imparting these objectives to his students.

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[2]M. A. Miller, "The General Education Type of Biology Course," _The American Biology Teacher_, Vol. 15 (February, 1953).

CHAPTER IV

THE MERITS OF THE BIOLOGY PROJECT

Biology is a study of living things---a trite but true (sometimes) statement. The "sometimes" is inserted because some courses involve the study of dead text books, dead earthworms, dead frogs, etc. Admittedly, the classroom can not be a combination of Noah's Ark and a green house. Still, much can be done to bring living things into the classroom. The dead frog has its purpose. It may be the specimen selcted for the one thorough dissecting job necessary to the study of anatomy. The aquarium and a few potted plants are usually present. These are good but inadequate for learning by the individual student. Where possible, let us eliminate "dead wood" and consider more of the living.

> The best argument in favor of an abundance of live things in the classroom is to provide a variety of real experiences for all students. For the "gifted" student, an atmosphere of individual experimentation is provided. He is surrounded with the possibilities of carrying on original research to answer his own questions, or those that may arise in connection with the work of the classroom.....The student of average or below average ability also has opportunity to participate. Actually, many of these students are just as interested in solving problems that arise as are those of superior ability.[1]

Many interesting and worthy projects are available for use in the biology class. The terms "project" and "experiment" have come

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[1] R. E. Wheeler, "Living Biology," The Science Teacher, Vol 24, No. 2 (March, 1957).

to carry somewhat different, albeit erroneous, connotations. One tends to think of an experiment as being a set procedure taken from a laboratory manual. The project infers a more or less spontaneous investigation of problems arising from a given endeavor. The project is especially adapted to biology teaching. Through it, the alert teacher can lead the students into careful, scientific procedures. Skills of measurement and observation become incidential tools to the more interesting whole project.

There are those in college teaching who would have the high school teacher emphasize biological vocabulary and nomenclature. The idea being that the student will then know the "lingo" well enough for the college teacher to communicate biological information to him. Probably no better method for killing interest in the study of biology could be devised. This same type of college teacher feels that the high school teacher need not teach the use of the microscope and other specific skills. He maintains that these skills can be learned <u>properly</u> at college. What about the vast majority that never gets into the college biology class? Those that do attend college often have to learn such skills as best they can because, more often than not, the college laboratory instructor has little interest in teaching. The project can be a strong motivating factor for all students. Its proper place is in the high school where the student gets his first impression of biological study.

A few comprehensive projects are probably better than several isolated small experiments. Too often, the lesson learned (?) from an experiment is not transferred to the student's concept of the whole picture. This can also be true of a project but the probability of this happening is less.

The teacher can not properly prepare and supervise great numbers of diverse projects. For this reason, it is better to choose three or four that will exemplify the most biological principles, and also fit the resources available. A chosen project should then be performed individually by all members of the class. The teacher chooses the project rather than the students. This is a little undemocratic but eliminates much waste of time and energy. After all, the students have no way of knowing in advance how a project will demonstrate important principles. The students should be at liberty to attempt other projects in addition to those required. This, however, should be done on their own time and at their own expense. Any good biology teacher stands ready to assist students with extra projects.

The project should be presented and attacked in a business-like manner. All of the students will not get the same results but each should be required to get positive results of some kind. It takes a lot of time for a teacher to prepare a decent project. There is no sense in wasting the teachers time---it's too expensive. Therefore, the student should be made to understand from the beginning that he will pass the course only if he gets results from the projects.

One typical project is here presented to demonstrate its usefulness. Many others could have been selected. This one deals essentially with the animal kingdom. Others equally good, deal with the plant kingdom. For instance, a soilless garden project is very versatile in the number of biological concepts that can be demonstrated and much can be learned from it. Students like to grow things and the competition for best results can be very stimulating.

A TYPICAL PROJECT

Drosophila melanogaster is a little beast ideally suited for use in the high school laboratory. Equipment and stocks are not expensive. Space is not a problem. The fly's short life cycle allows conservation of time. The messiness and odors of animal cages are not problems. Each student can do individual work with his own specimens. If necessary, the student can take his animals with him for the purpose of observation at crucial times which may not coincide with biology class time. Special arrangements are not necessary for week-end care. Drosophila literature is plentiful and easily available to both teacher and students. "Drosophila Guide"[2] by Demeric and Kaufman is an excellent source book.

The use of Drosophila is not a new thing in high school teaching. It is doubtful that many teachers utilize the full potential of a Drosophila project. Current literature contains several articles on the subject as pertaining to the high school. "Drosophila Experiments for High School Biology"[3] by A. B. Burdock and "The Use of Drosophila Melanogaster in High School Genetics"[4] by A. A. Paloumpis are good. These point out the merits of such a project for teaching the principles of heredity. However, much more than heredity can be taught. Let us ex-

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[2]M. Demerec and B. P. Kaufman, Drosophila Guide. Carnegie Inst. of Washington, 1950.

[3]A. B. Burdick, "Drosophila Experiments for High School Biology," The American Biology Teacher, Vol. 17, (May, 1955).

[4]A. A. Paloumphis, "The Use of Drosophila Melanogaster in High School Genetics," The American Biology Teacher, Vol. 15, (December, 1953) pp.213-216.

amine this thing a little more carefully.

In the case of the average experiment taken from a laboratory manual, the student comes to the laboratory, reads the directions, follows them, fills in the blank spaces in the manual, and leaves as soon as he can. Little thinking is involved. However, much thinking and planning is mandatory in the case of a Drosophila project. This thing is not a matter of hours; it is a matter of months. The teacher must order the original stocks well in advance of the time that they will be given to the students. He must consider such possibilities as that of the flies arriving in a frozen condition. He wants them alive so he must consider the environment of the mailing system. Preparation must be made for their arrival. Food components must be on hand. Containers must be available. The students should be kept informed of all these preliminary steps. They must also be learning about the environmental and nutritive requirements of their future charges.

The students prepare the food for their little beasts. Drosophila feeds on yeast. Why yeast? These are fruit flies so they should be given fruit, or shouldn't they? Yeast is a living thing and requires food. This is usually a new idea. The fly larvae feed in a manner different from that of the adult. We have an example of metamorphosis in our project. The culture medium must be boiled to eliminate harmful bacteria and yeast. Some unsterilized medium is kept to see why the sterilizing precautions are necessary. The principles of sanitation are easily demonstrated. Molds are controlled with a chemical mold preventative and through temperature control. Later, the students will use ether. The difference between the words antiseptic and anaesthetic should not be easily forgotten.

The student must learn to distinguish between the male and female flies. We have need for virgin females in making our crosses. Sex and reproduction can be discussed with a nary a blush.

The techniques involved are quite rigid and yet not beyond the skill of the high school student. Unless he plans each step carefully ahead of time, he is likely to lose his flies. If he does lose them, he should be required to start anew. Such discipline tends to develop careful work habits. Careful observation is a must. The student needs virgin females for his first cross. He'll not get them by shaking a few flies from a bottle and hoping they will do. The counting and tabulating of progeny requires manipulative skill and organization. His flies will recover from the ether in about five minutes and his counting must be done in that time. He dares not risk giving them ether a second time because this often renders them sterile. He must have been careful not to kill with the ether in the first place. Statistics are involved. The student will find that his progeny counts do not turn out to be in the exact ratio he expected. Perhaps the combination of all the progeny counts in the class will show a ratio more nearly that expected.

One must be careful in culturing Drosophila because they have enemies. Certain mites are parasitic to Drosophila. An epidemic can get started. Here is another principle. The vials must not be left in direct sunlight because the temperature inside will get very high and damage the flies. This has to do with environment. The story goes on and on with more and more principles becoming involved.

The Drosophila project can be used to emphasize many of the main principles formerly listed. These are: (1) Miscroscopic organisms both help and hinder other organisms; (2) Living things are affected by their surroundings; (3) Reproduction is a normal and essential biological function; (4) The nutritive requirements of most plants and animals are similar; (5) Plants and animals receive traits from their ancestors. The beauty of such a project is that a great many principles are involved in a living study. Textbook knowledge and practical knowledge become correlated. This isn't make believe stuff; it is real. The work take sufficient time to almost guarantee that it will not soon be forgotten. Yet the daily time requirement is not large. It is just persistent. Regular class procedure and even another project can be carried on simultaneously with the Drosophila project.

The project can indeed be a time saving but highly effective tool for teaching general biology. Too often we teachers feel that we have done a good job because our students answer test questions properly. The writer has been deflated more than once. The following example seems too ridiculous to be true. Unfortunately, it is a true story. It happened in a general biology class near the end of the school term. The general topic of tropisms had been dicussed quite thoroughly. Due to a shortage of time, only phototropism had actually been demonstrated. This question was put to one of the students. "What would happen, if your father (a farmer) should make a mistake and plant some of his corn seeds upside down?" After a moments thought, she answered, "I don't know---I guess they wouldn't grow." The moral of the story is obvious. We must take the time to teach thoroughly. Learning is almost worthless unless it can be transferred from the classroom to actual situations.

CHAPTER V

CONCLUSIONS

There is need for studying the aims and objectives of the high school biology course. This study should be made by each teacher of high school biology. No one else can satisfactorily determine aims to suit his particular teaching situation.

In determining aims and designing the course, the teacher must avoid certain common mistakes. Some of these are: (1) The tendency to cover so much so thin as to actually cover nothing----superficiality (2) Failure to stress living things and real situations causes learning to not be transferred. (3) Failure to connect biology with other sciences. (4) The tendency to teach biology as being a hobby rather than a practical thing. (5) The tendency to over-stress the particular area of biology for which the teacher is best prepared.

The range of biological concepts that can be considered important is so great that sufficient time is not available to present all of them in one year. A selection must be made which will do the most people the most good.

One good project can be worth many experiments and has the advantage of correlating many biological principles with respect to one comprehensive endeavor. The project tends to eliminate the make-believe atmosphere that surrounds many experiments.

The foremost aim of the general biology course is to produce the biologically literate individual. The best possible material should be used to present in an understandable form the most important principles of biology; to make clear certain biological concepts; to demonstrate what biology is today and what it is not; to inculcate in the student an understanding of and the desire for critical mindedness so as to foster accuracy of obervation and clear reasoning; to inspire the spirit of science as an adventure into the unknown; to help him correlate his religious and philosophical thought with scientific fact and theory; and finally to help students to understand the world, and man's place in it.

BIBLIOGRAPHY

Avery, G. S. Jr. Editor-in-Chief. Survey of Biological Progress Volume I. New York: Academic Press Inc., 1949, p. 3.

Baker, A. O, and L. M. Mills. Dynamic Biology Today. New York: Rand McNally and Co., 1943, pp. 3-4.

Bonner, J. T. "On Understanding Biology." The American Biology Teacher, Vol XVI (April, 1954) p. 87.

Burdick, A. B. "Drosophila Experiments for High School Biology." The American Biology Teacher, Vol XVII (May, 1955)

Demerec, M. and B. P. Kaufman. Drosophila Guide. Carnegie Inst. of Washington, 1950.

Farris, E. J., Ed. Care and Breeding of Laboratory Animals. New York: Wiley, 1950.

Holch, A. E. "Combining Thoroughness With Conservation of Time in Teaching Biology and General Science," The Science Teacher, XI (December, 1944) pp. 20-21.

Hunter, G. W., and F. R. Hunter. Biology in Our Lives. Ne York: American Book Company, 1955.

Jones, R. W., and I. E. Wallen. Biological Science Notebook, Minneapolis: Burgess Publishing Company, 1954, pp. 2-3.

Kroeber, E., and W. H. Wolff. Adventures With Animals and Plants. Boston: D. C. Health and Company, 1950, pp. 9-11.

Miller, D. F., and G. W. Blaydes. Methods and Materials for Teaching Biological Sciences. New York: McGraw-Hill Book Company, Inc., 1938, p. 29.

Miller, Sister Mary Aquin, "The General Education Type of Biology Course." The American Biology Teacher, Vol. 15 (February, 1953).

Moon, T. J., P. B. Mann, and J. H. Otto. Modern Biology. New York: Henry Holt and Company, 1956, pp. 7-9.

Paloumpis, A. A. "The Use of Drosophila Melanogaster in High School Genetics." The American Biology Teacher, Vol. XV (December, 1953) pp. 21-3-216.

Riddle, Oscar. "High Schools and Biological Literacy in the United States." The American Biology Teacher, Vol XVI (November, 1954) p. 180.

Vance, B. B., and D. F. Miller. Biology For You. Chicago: J. B. Lippincott Company, 1954.

Wheat, F. M., and E. T. Fitzpatrick. Biology. New York: American Book Company, 1955.

Wheeler, R. E. "Living Biology." The Science Teacher, Vol. XXIV, No. 2 (March, 1957).

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