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Thesis

THE PLACE OF BIOLOGY IN THE HIGH SCHOOL CURRICULUM

Submitted by

Alice Marrin Kerrigan

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The Place of Biology in the High School Curriculum

Outline

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Biology

(1) Meets the objectives for which American Education Exists.

(2) Serves a greater number of ends of education than any other single subject.

(3) Should be a required subject in High School Course.
The Place of Biology in the High School Curriculum.

That biology is of value in education may be proven upon general and upon special grounds. Biology being a science has the value of a science in the high school curriculum. All sciences have a like general value in education, based upon their common use of similar mental operations, but the special values of each of these may be different. Among the results that should accrue to high school pupils as the outcome of pursuing scientific studies, the following may be named as most important. *

(1) Training the pupil in close observation.
(2) Developing the powers of organization, comparison and inductive reasoning.
(3) Developing the imagination.
(4) Providing valuable information.

Biology as a science then has these values.

Let us now examine the field of biological thought, in order thereby to get some appreciation of its relation to human life, and at the same time of its educational value.

We shall first consider its economic value. Our manufacturing and commerce have attained a wonderful growth, but they are based upon our agriculture, which owes a great debt to biological science and agriculture is nothing but the working out of nature's laws. The efficiency of the labor of the agricultural class depends upon the intelligent use of the soil, which is depleted by the growth of crops. How to get the best results in food value from these crops, and at the same time to maintain the quality of the soil are questions, therefore, worthy of the most earnest efforts of the human mind. Such

*"Biology in the High School"- G.H.Oberteuffer
School Science & Math. 1918
vital subjects as pure air, pure water, bread making, shade trees, forest conservation, disease prevention, game birds, fungus, and bacterial growths and weeds are studied in economic biology. In one year the cost of our entire school system in the United States is 285 million dollars, while crop destruction by insects is 300 million. When we ponder over such figures as these, the economic value of biology is clearly seen.

The aesthetic value of biology is also great. The love of the beautiful, forms a large part of the life of us all. Flower culture is an evidence of an instinctive love for beauty. It is as old as man himself. Much of our literature and poetry has for its theme nature. In fact this has been a large source of inspiration for the works of such poets and essayists as Burns, Tennyson, Wordsworth, Shelley, Thoreau, Emerson, Ruskin, John Burroughs and John Muir.

Biology has an ethical and social value, in that the knowledge therein helps a child in the determination of what is right and wrong. No student of biology maliciously robs a bird's nest or is guilty of cruelty to animals. The pride for the outside of his home and the caring of his garden are evidences that the child obtains some ethical value from biology.

Biology is replete with examples of the advantage of cooperative effort and symbiotic relationship—for instance such as the community life of bees and ants, mutual help of bacterial nodules and legumes, etc. We are correct then when we say that biology has some social value, when we consider the lessons we may draw from the ant colony. The type of civilization found among the ants in some respects surpasses human civilization. The ant community is the personification of industry. There are no slackers, each ant has its
service to perform in the world and the division of labor is remarkable. Doctors are not necessary in the ant colony and the physical development of the ants is perfect, when we consider the enormous strength of the ants, as evidenced by the weight that they are able to sustain.

Lastly, we find that biology has before it a great part in the solution of the most profound problems, concerning the moral and physical well-being of the race. One has but to point to the results of the physical examinations of our men prior to their enlistment for service in the recent World War, and to note the percentage of rejections, to see the possibility for social service which biology has in this field. As a first corollary to health comes sex instruction, which is of vital importance. The bringing to the young mind clean, accurate knowledge of the essential facts of physiology and of reproduction, through the agency of a skillful teacher of biology is of utmost importance. This knowledge to be the most useful, must come in its natural place in a course in biology, and every appearance of unusual effort to come at or to avoid the subject must be eliminated. Dr. Prince Morrow of the Society of Moral and Social Prophylaxis says "200,000 persons walk the streets of New York City loaded with venereal diseases. To stem this tide of disaster, the work of the preacher, physician and parent is materially aided by teachers of biology."

Another important field of social service is eugenics. All biologists and sociologists will agree that the future welfare of mankind is inseparably tied up with the practical application of some form of eugenics. Its principles should be known and there is no place so well adapted to it in the high school curriculum, as biology. Eugenics can and should be taught in two ways. Either would
be incomplete without the other. In the first place the background should be prepared by a study of the principles of heredity among plants and animals. Practical and familiar illustrations should be chosen and if possible illustrated by experiments. Next, eugenics can and should be taught directly. The Juke and Kallikak families can be compared with the descendants of Johnathan Edwards. When a pupil has these facts clearly in his mind's eye and has the proper mental "set", the capable teacher can easily rise to the occasion and say a few words about choice in marriage (just the right number - not too many) that may prove of profound service to the adolescent that is absorbing them. Facts and suggestions of this sort given to a pupil of high school age is oftentimes remembered and appreciated by him in after life.

The next field is sanitation and in this community cleanliness should be emphasized. The biological necessity for sanitary conditions in public shops, toilets, streets, etc. and the proper disposal of waste can be proven by the study of diseases, bacteria, and social welfare. The biology class may well be a forum or natural community outlet for information and facts concerning recent medical research. The principles of first aid may well be given in biology and this knowledge alone is often sufficient to justify the whole course because it means the saving of life.

The only logical and rational biology is one that is rooted and clinched in all the mazy complex of forces, that are at work in the child's individual and social life. Biology - rational, human, social, and natural, is needed. Elementary biology, I repeat, is a field of unusual potentialities for social service. It brings to the humblest rural school many messages that humanity needs. Biology is fundamental. Elementary biology studies man and pictures him in
his proper setting as one living creature amongst a world of others
with which he has relationship, intimate and always vital. It is the
root and trunk subject from which spring all the deliquescent branches
of the tree of the knowledge of life in all its manifold manifestations.
It is unique and no other subject can take its place for this reason.

The situation in the Minnesota High Schools* is especially inter-
testing and gives some interesting facts about biology in secondary
schools. A questionnaire was directed to 165 out of 240 high
schools of the state during the spring of 1921. The questionnaire
included detailed questions relating to zoology, general biology
and botany. It was desired to know the attitude of educators of the
state, what the demands were, what developments, if any, were taking
place, and how the subjects were being conducted. 109 of the 165 re-
turned with the information desired, from schools of all sizes rang-
ing from a high school enrollment of 46 to 3,078. The results of the
questionnaire showed that biology, zoology, physiology, and botany
are practically the only purely biological subjects taught. Nine of
the schools (8%) reported no biology, twenty-six schools (24%) gave
only the little biology occurring in general science, an amount not
worth mentioning. So it may be said that thirty five schools (32%)
had little or no biology in their curricula. The remaining seventy-
four schools (68%) offered courses in biology in some form or other.

One of the most interesting facts noted is the increasing pop-
ularity of general biology. It is finding its way into the high school
curricula by leaps and bounds, and is equally popular with large and
small schools. According to the report of the state high school in-
spector in Minnesota, less than 9% of the high schools of the state

*Biological Sciences in Minn. High Schools - Holmquist
School Sci. & Math. 1922
offered the subject in 1919-20. The next year, 30% of the high schools heard from, reported it in their curricula. A great many more signified their intentions of introducing the subject in 1921-22 or soon, so that the percentage mentioned above, will be greatly increased. It would seem that this growing popularity indicates a longfelt demand among educators for a general course embodying the fundamentals of all the biological sciences with much of the details and technicalities omitted.

Zoology enjoyed a fair amount of prominence in the high school curricula up to 1914-15. Since that time, there has been a steady reduction in the number of schools offering the subject. Since 1919-20 there has been a reduction from 28% to 23% that gave it in 1920-21. There are indications that the percentage will be further reduced owing to the fact that zoology, together with botany and physiology, is being replaced by general biology in many places. Evidently zoology has not been adapted to the demands of the school administration in the past and is failing. It is thought by some to be too technical, specialized and detailed for high school students. It is also criticized for lack of practicability and inclusion of too much material that is not of any benefit to the average student. However, there are those who defend the subject and believe in its retention as a subject of real value in the curriculum.

Botany is suffering the same fate as zoology. It has always held a greater prominence than zoology but like zoology is at present losing ground due, to a great extent, to the encroachment of general biology. From 1919 to 1921 the number of schools offering botany went from 47% to 28%. Botany is subject to the same criticism as zoology. Even physiology is losing its prestige, dropping from 50% to 23% in
these same years. The reduction in the number of schools, offering zoology, botany, and physiology is no doubt due to the rapid rise in popularity of general biology. Some of these subjects are being removed from the curricula in order to give place to general biology. This change is occurring mainly in the smaller schools. In the larger ones, general biology is merely one of the biological subjects given.

Conditions in the State of Washington* are also interesting and throw some light upon this same problem. A questionnaire was sent to 211 high schools in the state. There was a return from 147 or 69%, which furnished the basis of the report. Many of the schools in the state of Washington alternate the subject of biology with botany or zoology. 37% of the schools reporting taught biology during the school year 1920-21. 52% of the schools taught botany in 1920-21. Zoology represents a very small part of the science taught. The reason for the predominance of botany over zoology can be ascribed to the fact that the agricultural communities of this state demand botany in the school. Also the teachers select botany as a teaching subject because the laboratory material is easily obtained.

There is a decided preference expressed for general biology over the usual courses given in zoology or botany and biology is replacing zoology and botany in many places as shown by the statistics in Minnesota and Washington. Some of the reasons mentioned for the preference follow.

(1) General biology is a course embodying the essential of all the biological sciences with much of the detail left out. Hence,

(2) Greater economy of time and teaching force in the crowded curricula of the smaller schools especially.

*Sciences in the Accredited High Schools of Washington-Frank K. Foster School Review 1922
Since the life processes are fundamentally the same in plants and animals, this fact can be better shown in a general course.

Greater correlation between the various biological sciences can be effected through a general course.

General biology is practical, broad in its scope and less technical than either zoology or botany and therefore better adapted to high school work. However, general biology is also criticized on the following points:

It is too generalized, vague in content, and lacking in concreteness.

It is apt to be merely a snap course in the hands of a poorly prepared teacher.

It is often poorly organized.

While a fair idea of life processes may be obtained, an adequate idea of the plant and animal life of the community is hard to obtain because the course is too brief.

As an introductory course to more advanced work, or as a short course, it is good, but as a complete and all sufficient course it falls far short.

Biological sciences have declined in the high school in recent years,* as shown by a questionnaire which was sent in the spring of 1919 to 275 high schools in larger cities of the United States whose population was over 50,000. This same sort of work had been done in 1910. A comparative study was made. In 1910, 47% of the total number

of sciences were biological, while in 1919, 45.3% were biological, a slight decrease being shown (1.7%). This might probably be within the limit of error of the statistics considered but a comparison of the number of courses in botany, zoology, physiology, and biology studied in schools in 1910 and 1919 show that the percentage value in every case except biology indicates a decrease in the number of courses given. Whether this change is due to actual replacement of separate distinct courses in botany and zoology by a unified course in biology or rather the half year course in botany and half year course in zoology have been merely combined and called biology, it is impossible to say. The fact is however that the demand for biology is increased while the other biological sciences are losing their former prestige.

The decrease in the demand for zoology, physiology and botany is to be regretted. The charges brought against these subjects are unfounded. They are due to several causes: (1) The teachers themselves are largely to blame for the criticisms heaped upon the subjects. Their lack of sufficient preparation and consequent poor pedagogy and their failure to see and appreciate the needs of the community and to adapt the courses thereto, have caused much of the criticism. (2) Many school administrators lack a knowledge of the biological subjects and are therefore unable to see the possibilities in them. (3) Mollycoddle ideas of education to-day demand a removal of technicalities and details from the subjects so that the courses are made very superficial, shallow and inadequate. Those, who entertain these ideas furnish much of the criticism of zoology and the other special biological sciences.

To say that zoology, physiology, and botany are impractical is a huge mistake. These subjects are studies of the living things
of our environment. The daily contact with life should be a strong argument for the practicability of these subjects, just as the daily use of English is the oft-repeated argument for the practical value of the subject.

One needs only to visit the homes in one's own community to see the lack of knowledge of the principles of hygiene and sanitation and the need of more education along this one line. A good solid course in physiology, sanitation, and hygiene is not only practical, but necessary and should be required along with a course in general biology.

Some assail zoology and the other special biological sciences, because of their so-called technicality. It is true that these subjects can be made very technical or much of the technicality can be omitted within certain limits, at the discretion of the teacher. It would, of course not do to transplant a college course in zoology to a high school, because of the technicalities of such a course. The subject must be adapted to high school needs and to the age of the pupil.

Failure of these subjects is not due to the inherent nature of the subject matter, but to impractical, unadaptive pedagogy on the part of the teacher, or to misconceptions as to the value of the biological studies by high school authorities. Biological sciences have been unjustly criticized because of their content, whereas the blame should have been placed in many cases on the teacher.

Biology is something more than zoology, and it is something more than botany. A course in biology has been found to fail just as the other biological sciences failed. Biology to meet the exacting requirements should be a composite unit. The course should be stan-
standardized and certain definite material required. Another cause of the failure of biology is due to the oversided training and consequent bias of the teacher. The teacher, if a specialist in zoology, will emphasize that phase of biology and if a specialist in botany will favor this particular side of biology. Lastly, the teacher himself, is the cause of failure of the subject oftentimes. He should use similes that the student can understand. He must relate the ideas and processes from the student's viewpoint and most important he should present what is interesting.

Teachers in biological sciences have been criticized and justly too. Statistics* show that less than 20% of the people teaching biology have majored in that subject. We need teachers and we need university courses which will give us teachers with vision, with a sense of proportion, with a sense of correlation, with broad human sympathies—teachers that can root the study of life down into the very foundations of things—not those who will give the pupils hard, mechanistic, unfeeling, and animal like views of life. It is of little use if the teacher has the proper academic training, if he lacks the understanding of life which he must transmit to his pupils.

Let us now summarize the requirements of the teacher of biology. The teacher

(1) Should have a broad knowledge of the whole field of natural science.

(2) Should know the aims and best methods of teaching science and should be given an opportunity to acquire skill in presenting the subject.

(3) He should have a grasp of the psychology and pedagogy of the adolescent.

One of the most important elements of this teacher training

* Biology teaching in Indiana Schools  C.E. Montgomery
School Sci & Math 1916
is ample opportunity for practice teaching under the direction of
those who have had successful experience in secondary school teach-
ing. The teacher must not forget also that he should be guided
by the environment in which he is working. Yet a warning must be
given for although the "local needs" and "practical botany" should
be very carefully considered in the making of a course, yet they
should not be permitted to destroy the organization and essential
purposes of the subject. An enormous task then falls on the teacher.
It is up to him to say whether or not his course will be a failure.
Let him launch himself ahead with the determination that he will make
something or other of his present opportunities with the full con-
viction that if he is teaching biology for biology's sake, he will
get out of it what he puts in.

There has been a decline in the number of students taking
biological sciences in recent years. Biology has become an elective
subject. In the opinion of leading biologists who have become ad-
ministrators the decline in the number of students taking this sub-
ject is due to ineffective teaching. Undoubtedly this is true, but
until recently there has been few teaching courses in the subject.
Even though poor biology teachers are known, yet there are some
good botany and zoology courses. These courses however, are largely
elective. The large majority of our high school graduates have not
had them,* or have had plant studies without animal studies or animal
studies without plant studies. Coulter has found in a number of
important high schools that the percentage of graduates having no
biology at all, except the legal requirement for human physiology,
runs as high as 85 and it is quite common for it to run well above 50.

*Biology in the High School from the Administrative Point of View-
John G. Coulter 1916
The questionnaire in the State of Washington showed that biology is required only in the larger schools where a scientific curriculum is offered, but it is found as an elective in the majority of schools. As many as 32% of the high schools heard from in Minnesota failed to give biology.

It is to be regretted that so many schools fail utterly in seeing the value and necessity of biology to high school students. In these days the public is clamoring for the practical in the high school curriculum. What subjects are of more practical value than the biological sciences? Surely to familiarize high school students with the plants and animals of their own community - a part of the environment with which they come in contact every day - to teach them the fundamental facts of life through a study of the life processes of plants and animals, and to teach them how to live themselves, is of the utmost practical value. To teach students to use their hands to make a living is practical, but of what use is this to them if they know not how to care for their bodies and keep fit? Efficiency in work depends upon efficiency in living. This is a well established fact. Hence, the study of biology is fundamental and deserving of first consideration in preparing students for earning a livelihood. Not only should biology be given in every high school, but it should be required of every student.

General biology is only an elementary course, and by no means an adequate one where it is possible to give more. A sufficient knowledge cannot be obtained of the plant and animal life of a community, of physiology, hygiene and sanitation, and fundamental processes of life, all in one year. The subject is a good short course for those who are taking vocational courses and whose selection of the regular
academic courses is limited. It should be required of these students but for those who are taking the regular academic work, a course in general biology is too meager. For these students, the usual courses in zoology, physiology, and botany are preferable and should be available and at least some of them should be required.

A conference on high school biology was held recently in New York City*, the purpose of which was to secure an expression of opinion primarily from administrative officials of New York City high schools as to the actual and possible value of elementary biology as a high school subject. The proposed introduction of courses in general science and community civics in the first year of New York City high schools created the possibility of the elimination or serious curtailment of biology. It was the unanimous opinion of every speaker that biology, both in content and in educational discipline, contributes something essential in the preparation of young men and women for citizenship, which is not afforded by any other subject and it was the expressed opinion of all the principals, that the elimination or curtailment of general biology from the high school course of study would be an educational mistake. All of the speakers emphasized the necessity of planning a content of the course so as to make a very intimate and obvious correlation with the every day life of the individual. It has been shown and proven then, that biology is essential in the high school course of study and now the place in the curriculum must be determined.

The majority of schools in the country as shown by the questionnaires teach biology in the second year of the high school. This seems to be the best, for a course in general science is given in the first year, and chemistry and physics are usually studied in the

*Conference on High School Biology in N.Y. City. Science '19
third and fourth years, therefore the work in biology is placed in the second year. And wisely so, for thus it is presented to the student at an age when he is keenly alert to all the phenomena of life and deeply interested in them, and it will, accordingly, make an urgent appeal to his interest. Our conclusion then is that biology finds its proper place in the second year of the high school. It should follow a year course in general science and it should be a required subject for pupils who are not going on to college. For college preparatory students a more detailed course in botany or zoology should be given.

It is only fair now to ask the opinion of the pupils themselves. Why study biology? Is it interesting? Is it useful? A group of pupils were asked these questions by Miss Mac Rae, head of the science department in the South Boston High School. The following are typical answers that she received:

"Biology should be studied for various reasons. The pupil learns certain things about his body that he can profit by immensely. He learns the simple rules of health. He discovers just how much to tax his body and brain so as to get the greatest efficiency. Germs and microscopic animals become a reality when seen under the microscope and the pupil learns how to avoid taking unnecessary risks. Biology is furthermore an interesting subject. It deals with plants and animals that we come in contact with every day. From the dissection of the frogs we learn how the different organs of our body appear. This subject is useful as well as interesting. When on a vacation in the country we learn what poisonous plants and animals and insects should be avoided and how to exterminate certain pests such as mosquitoes etc. On the other hand certain miracles of nature and
the exquisite coloring of certain flowers are brought to our attention. Also your vocabulary is enlarged and any biological term which may be met in reading can be readily understood."

"Biology is an interesting subject because it opens to us a new field of vision. In biology we are told of things we never knew existed. It makes our vacations and walks more interesting because we know about what is around us.

It should be studied because it broadens the mind. It makes us see and understand why the right habits should be formed early. It makes us understand why we should treat every cell of our body as a living, growing cell. Biology is useful. It teaches us why we should be hygienic. It tells us about molds, mildews, and other pests that so often infect our homes. Biology teaches how to fight these pests. It tells us many other things that are useful in everyday life."

"Biology is the study of living plants and animals. We study it because we want to learn where they come from, how they live, and what they consist of. We also learn their adaptations. It is interesting because the animals are like ourselves and we want to know how to live a good life. We like to see the plants grow and it is interesting to learn to keep them healthy and clean from pests.

It is useful because we learn how to take care of our own body and how to keep healthy. It is very valuable to know about plants because it is very useful. Plants make the world more beautiful to live in."

"Biology is studied so as to give us an idea of all animals and plants. It is the study of plants and flowers, small one celled animals, frogs, sponges, and birds. It is interesting to study because it shows the origin and growth of plants and animals from the beginning
until they reach their full growth. It is useful because it makes you notice things much closer and it teaches a person how to take care of plants and animals. It also helps us to know the habits and usefulness of an animal. It also teaches a better and cleaner way for people to live."

"Biology should be studied because it makes us take an interest in nature. Children destroy gardens, bushes, and trees, but if they had learned something about their usefulness they would not destroy them. Biology is very interesting. Things of nature that have long puzzled us are explained. Things that we have never seen or heard about are discussed. Even biology is needed in cooking in the preparation of bread. Housekeepers knowing biology can make better bread because they know the conditions necessary. These things make biology useful and interesting. It helps to make people realize the many different things besides themselves on the earth."

"There are several reasons why people study biology. In the course of the study one learns and sees the development, growth, structure, and reproduction in both plants and animals. The microscope also aids us. We see cells of different sizes and also the structure of the cells under the microscope.

In studying insects we find which ones are useful and which are harmful. There are a great many things that are useful. We learn all about the small animals. It is interesting to watch the twigs sprout and different experiments such as osmosis, photosynthesis etc. One is always finding out the different inventions the great scientists have found. We have seen all the beautiful colors of the birds. When one is studying bookkeeping and similar studies all day biology changes the monotony."
"Biology should be studied because it puts new knowledge into our minds. It also gives us an idea of how many thousands of plants and animals there are. Biology is an interesting subject because it deals with plants and animals. It has many interesting experiments.

Biology is a useful subject because we study the plants and animals that are useful to man, and also the ones that are harmful to man. It also keeps our minds wide awake."

"Every boy or girl who enters high school should study biology. It increases your vocabulary. It helps you to understand every day occurrences. It helps you to know the plants and animals of your own climate. If you are going further on to a medical school you must know biology. When one lives in the country on a farm he must know harmful bugs, worms and parasites from good ones. He must know the texture of soil, how to breed his cattle, hens etc. All this may be learned in biology. In a city a good healthy house or locality will be picked out by a student of biology. Biology is very interesting and fascinating. I wished to be a civil engineer but after taking biology I have often wondered if I should go into its field. I should like very much to be a scientist or a professor of biology. The best branch I like in this science is that of distinct animals."

These answers show that the pupils fully realize the importance of their work in biology and no further discussion should be necessary to convince the reader that biology should be a required subject in the high school curriculum.

The democratization of the high school has brought about a situation such that our pupils are not being trained primarily for entrance into college. By far the larger majority will never see the
inside of a higher institution. The question of what type of biology we shall teach is therefore conditioned, not simply upon factors internal to the sciences concerned, but also upon the probable future occupations of the pupils and their stations in life. If people possessed the knowledge of the germ theory of disease and its sanitary implications that is possessed by the student of biology, the sanitary regulations of cities would immediately reach a maximum of effectiveness.

If an important part of the office of schools in a democracy is to implant a common body of knowledge which shall enable the citizens of the democracy to cooperate in public questions, we certainly have here a fruitful field for investigation. In addition to concepts which are useful in public matters, there are many biological items which are important to the individual in a strictly personal sense. Again, there is need for some biological knowledge on the part of the individual if he is to intelligently discuss public questions with his neighbors or if he is to read literature of the day appreciatively.

The greatest value of biology lies in its application to life. A knowledge of the laws of life, health of body and mind, the causes and prevention of disease and premature old age, reproduction and heredity, is the most valuable foundation which we can possibly give to the individual for health, morals, and good citizenship. The child must have ingrained into his very being the laws of life as revealed by science, so that they may become habits of right thinking and acting. He will then have a philosophy of life that will be a never failing guide in his own life and will make him most useful in the highest forms of social service to family, community and state.

Plants are especially useful for teaching physiological pro-
cesses, as they are well adapted to experimental study by elementary pupils, while the absolute dependence of the animal world upon them for food is a fact of fundamental importance. Kinds and types of bacteria should be taught on account of their vital relation to human life and should become real to the child. Animals are of the greatest value for teaching the evolution of structure and function, natural relationship and reproduction. If the school is near the ocean, sea forms are intensely interesting; in agricultural regions insects may be of first importance.

Biology is going to cut out many topics which contributed little or nothing to human welfare and human happiness in order that it may elaborate others.* According to H.B. Shinn, it is his belief that in the high school course there is no room for long-winded discussions of the algae, red, green, blue-green, and brown; for taxonomy of ferns and mosses; for anything of echinoderms nor more than cursory treatment of coelenterates; for the fruitless dissection of many forms. In botany there will be more of the planting and care of house plants and grounds, more studies in the ecology of those plants and animals which appear in the landscape and contribute to it, and more study and care of home and farm.

Biology will be economic but not mercenary; its subjects will be taught not because they add a dollar to nor subtract a dollar from the future income of to-morrow's pupils, but because they will add to the joy and the possibility of living. The commercial courses of to-day are not educational because their ideal is the dollar. Our motives will be higher than most of us conceive in the word, economic. The spirit of altruism and community service will give a deeper life to biology.

*Biology in the High Schools of to-morrow." - H.B. Shinn
School Sci. & Math. 1918
Botany will teach principles of soil fertilization, sterilization, and innoculation. It will include more practical work with plants, as forestry, tree planting and tree surgery, pruning, grafting, budding, artificial pollination and breeding. There will be a wider use of indoor gardens and more use will be made of the plant and less of the book. In zoology, the study of invertebrates will consume not over one-half the time of course and that of mammals will have one-fourth the total time. In schools without definite courses in agriculture the zoology will incorporate certain phases of animal husbandry so that it will accredit such home projects as bee keeping, poultry keeping, rearing of pigs and calves and spraying of orchards and gardens for noxious insects. A few good dissections will be demanded.

The health and power of the individual and of the state are so closely dependent upon conformity to the laws of biology that every boy and girl should be given the opportunity to learn something of both the visible and the invisible life that surrounds him upon which his own welfare and existence are conditional. In the fields of bacteriology and entomology alone are found forces, some of which are the deadliest foes, while others are of vital importance to life. Biology alone of all subjects deals with life. In its study, therefore, the needs of the plant should be brought out and that of the animal for sustaining and bringing life to its fullest perfection. Life then should be the dominant thought in giving unity to the work and the approach to the study of morphology should be through the desire to learn how each organ is adapted to aid in securing the requirements of the organism.
Biology has the following definite aims:

1. It should arouse interest in nature by giving boys and girls first hand acquaintance with their environment.

2. It should emphasize some of the most important applications of science to human welfare and especially should familiarize the pupil with the structure and function of their own bodies to the end that they may know how to live healthfully and happily.

3. It should give pupils some training in careful observation and in forming logical conclusions, through the solution of problems and the carrying out of projects.

4. It should make real to the pupils the value of intensive study of any given science as a means through which scientific progress is attained.

These aims may best be realized by the teacher selecting material best adapted to local conditions, by planning out in advance the work that is to be done, and by improving the course with each year of experience.

It has been seen that biology should have a well established place in the curriculum and that as a teaching subject it has certain definite aims but now what about the content of the course? There is absolute variation in the biology courses and this clearly indicates that there is no correlation among the several schools. Many persons scoff at the mention of a standard course in biology. In Indiana,* 57 schools reported on the type of courses of study that they are using: - 14 are following state courses, 17 their own plan, 7 the textbook, one a college course and 18 a combination of the above. In Indiana,** 57 schools reported on the type of courses of study that they are using: - 14 are following state courses, 17 their own plan, 7 the textbook, one a college course and 18 a combination of the above. In Indiana,* 57 schools reported on the type of courses of study that they are using: - 14 are following state courses, 17 their own plan, 7 the textbook, one a college course and 18 a combination of the above. In Indiana,** 57 schools reported on the type of courses of study that they are using: - 14 are following state courses, 17 their own plan, 7 the textbook, one a college course and 18 a combination of the above.

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**Biology teaching in Indiana Schools - J.E. Montgomery School Sci & Math. '16
ana then and in fact all over the country the miscellaneous plan has been tried to the limit. Some good has resulted, indeed, but the work is not keeping pace with other less vital subjects that are thoroughly organized and standardized. A standard course in biology would not mean one that is rigid and would permit of no variation, but a clearly framed set of topics arranged in a definite order. This should neither curb the teacher's individuality nor disregard the needs of the immediate community. The big underlying principles that make the subject universally worth while, however, should not be deposed by a hopscotch mixture of indiscriminate facts. A definitely organized course would also relieve those pupils who are obliged to change from one school to another of much embarrassment and loss of time.

Biology does not consist in some zoology and botany whether administered in the old-fashioned mixture, improperly called general biology or in a more modern separate dose method of consecutive courses. It includes the following topics.*

(1) The structures & functions common to all living things.

(2) The distinguishing characteristics of plants as such and their function in the world.

(3) The essential characters of animals.

(4) The interrelations of plants and animals with one another and with inorganic nature, with special reference to competition, survival, injury, disease, and decomposition.

(5) The processes of nature whereby matter and energy are so conserved and transformed as to permit the ceaseless and indefinitely continuous round of life. To be more specific this means a study of: (a) Protoplasm-

*General Biology & the Junior College - Burlingame & Martin Science '20
ite structure and functions, cells, cell division, colonial and multi-cellular organisms, growth and differentiation, (b) the role of green plants in the transformation of the free energy of sunlight and simple inorganic compounds into complex energy-containing organic compounds to be used as foods—i.e. as sources of energy and building materials—by animals and non-green plant cells; (c) how these foods are used by animals in growth and work and how they produce wastes, eventually to be used again by plants; (d) the sensitivity of protoplasm and its role in relating the plant and animal to their environment; (e) growth and reproduction; (f) heredity and evolution; (g) disease and death; (h) decomposition, putrefaction, and fermentation, and other processes in the soil that render organic materials again usable by green plants; (i) the transformation and conservation of matter and energy as exemplified in the carbon, nitrogen and other organic cycles.

The biology teacher must not overlook the fact that in teaching the topics as outlined above, it is a part of his duty to teach something concerning sex hygiene. Facts of sex cannot be escaped except by deliberate and violent distortion of our material. In the course in biology therefore the following topics* should be touched upon, its implication made clear, its relation to other aspects of life established without ambiguity.

(1) Development—organism—results from cell division.
(2) Origin—cell originates from vegetative cells or reproductive cells which may be sexual or asexual.
(3) Universality of sex—plants and animals.
(4) Parenthood and Infancy.
(5) Embryology.

*The Biology teacher & Sex Education—Benjamin C. Gruenberg
I repeat, the biology teacher has a huge task upon his shoulders but one. Help for the teacher is to remember that as Gruenberg says, "the value of science or knowledge is not in making us do things, but in showing us an even better way of doing what we already wish to do and better things to desire. Its great intellectual contribution is in making its followers hold fast to what they have, always subject to revision - in giving us the experimental outlook upon the problems of life - in habituating us to accept truth as always tentative, a working hypothesis and our beliefs as constantly growing and refining not as a final doctrine to be forced upon all who come under our domination."

A uniform course, in biology, as I have said before, is most desirable and should be agreed upon. At the present time, the science committee of Boston are working upon a curriculum for biology. Miss Mac Rae, of South Boston High School is a member of this committee and I shall give a general outline of the work followed by her in teaching biology. To my mind she is the ideal teacher of biology in the high school. I had the good fortune to observe her work for three months and the interest as shown by her pupils was quite remarkable and most inspiring. First, let us consider biology courses in use in other places. An outline of the course at McMinnville, Oregon
is given in an article in School Science and Math. 1918. This course starts with a series of elementary, introductory, discussions on the purpose and scope of biology, elements of physics and chemistry to explain environment, composition of material etc. The aim as stated of this is to arouse interest and to give the student the tools with which he will later work. In my opinion, this would have the opposite effect. To start a course by defining subjects has a deadening influence, while if we start a course by solving some problem that is related to the child's life, then we have aroused his interest and solved our own problem. The rest of the course as given in McMinnville includes subjects that are essential in a biology course.

In the syllabus for secondary schools as published by the University of the State of New York on Biologic Science, an outline of the course in biology as used in New York State is given. This consists first of the following introductory topics:

1. Discussions to bring out (a) the knowledge of students concerning some of the essential functions of their own bodies (e.g. motion, breathing, nutrition and sensation) and (b) the idea of adaptation of structure to function illustrated by some part of the human body or some part of an animal e.g. hand of man, claws of cat.

2. Composition of living things. (a) Experiments to show some of the characteristics of the more common elements and compounds found in living things, e.g. carbon, oxygen, hydrogen, nitrogen, water and carbon dioxide. In this study the process of oxidation should be specially emphasized. (b) Demonstration of the physical appearance of other elements, e.g. sulphur, phosphorous and iron and some of the compounds used by plants in making foods that are also needed by animals and man, such as nitrates, potash and phosphates. (c) Discuss-
tion of chemical elements present in the nutrients or food compounds, namely, starch, grape sugar, proteids, fats and oils, and mineral matters. Tests for each of these nutrients (if desirable these tests may be introduced later, e.g. in connection with the study of seeds or foods). (d) (Optional laboratory or home work) Testing common foods to prove the presence or absence of the various nutrients (e) Discussion of the meaning and nature of conservation of energy.

The rest of the course is divided between animal biology which includes insects, crustaceans, fishes, frog and its relatives, birds, and one-celled animals; human biology which includes foods, stimulants, narcotics, organs of digestion and their function, blood and circulation, respiration, excretion, bacteria and sanitation; plant biology which includes seeds and seedlings, cellular structure of living plants, roots, stems, leaves, flowers and fruits, forest and forest products. Then follows a review and discussion of important topics which compares plant and animal biology. This last topic is really general biology. I do not consider such a course as meeting the proper requirements of general biology, as stated (see page 23) by Burlingame and Martin. Comparison of animal and plant biology should be made during the course rather than at the end. This course as offered in New York is merely a course containing a half year's work in zoology and a half year's work in botany.

The outline of a course in biology as given in the Maryland School Bulletin, number 10 is very complete and definite. The outline is arranged in the form of problems and the main topics are: Environment of plants and animals, living organisms, the Flower, the Fruit, the Seed and Germination, the Root, the Stem, the Leaf, Forests, the Fern, Microscopic Plants, Classification of the Plant
World, Relation of Plants and Animals, One-celled animals, the Worms, The Crustaceans, The Mollusks, Insects, Birds, Fish or Frog, Value of Mammals to Man, Classification of Vertebrates and Principal subdivision of Mammals.

This outline is exceptionally good, since the topics follow in natural order beginning with the environment of plants and animals, and making a study of plants and comparing with animals and this is followed by a study of animals going from the simple to the complex. This bulletin published by the State department of Education, Baltimore, Maryland is most important and helpful to the teacher of biology. Besides the outline of the course of study, an explanation is given of methods to be used and texts for biology are commented upon and a list of apparatus & materials needed for the laboratory is given which is most helpful to the teacher.

The general course as used by Miss Mac Rae is as follows:

What the animal needs.

What the plant needs.

(a) Oxygen.

Combustion and its products.

Composition of the air.

Respiration

Comparison of the burning candle, breathing plant, and breathing animal.

(b) Water

Importance.

How absorbed.

Imbibition.

Osmosis
The Soil
How conducted.
How eliminated.

(c) Food.
How obtained by the plant.
Formation of sugar and starch.
Mineral nutrients.
How obtained by the animal.
Motion and locomotion.
Special senses.

Digestion.
Transportation of digested food.

Use of food.
How stored and why.

(d) Suitable temperature.

(During the work with plants the needs of the germinating seed and the influences affecting the growth of different parts of the seedling should be carefully studied.)

The living organism.

A simple and a complex animal should be studied as complete organisms for comparison and contrast.

How living cells are propagated.

By cell division.
By the fertilized egg.
By vegetative reproduction.

Cuttings, grafts, bulbs etc.

The flower, fruit and seed.
Seed dispersal.
Simple classification of plants and animals.
Bacteria and other plants and animals which cause decay, fermentation, and disease.

Care of food.
Sterilization and antiseptics.
Health laws.

Insects—foes and friends.
Sources of food, shelter and clothing.

This outline in my opinion is an excellent one for biology because life is the dominant factor in the course. The course begins with the needs of plants and animals for sustaining life. The animal and plant biology are made one in this course and differs from the other courses given in this respect, and consequently, there is unity in the work and our purpose is accomplished.

There are various methods and means used in biology to motivate the work. Project work in biology is being conducted by Miss Perry in the Francis W. Parker School, San Diego, Cal. under the direction of Professor J.L. Merriam of the University of Missouri.* In this class there is no text book, no formal recitation and each student is working on an individual problem. There is a small well equipped laboratory and two periods of 40 minutes each are daily devoted to biology. The last 15 minutes are used for conference. The possible projects (200) are on the bulletin board for students. They choose then their study for themselves. According to Miss Perry, this plan saves the amount of time used. No time is wasted listening to classmates recite a thing that they already know. The student may have several projects under way at once and the pupils refer to several

* Biology & Project Work. Winifred Perry
School Sci and Math. 1922
books before drawing conclusions.

This type of teaching makes greater demands on the teachers' energies, than the recitation method. There is a compensation however in the very evident progress and steady development of pupils in habits of initative and responsibility. The increasing ability to use books easily and intelligently as sources of information and to think a problem through to a logical conclusion is a reward. The problem of discipline has disappeared because everyone is busy. There is a minimum amount of written work employed with a maximum amount of drawings, chart making, and collections. Each student makes a report on a 5 x 8 card and this is filed for future reference.

This "project method" as used by Miss Perry is excellent if the principles of unity in the course are not sacrificed. However, courses that consist merely of a succession of more or less detached projects are quite likely to be lacking in both logical and pedagogical unity. I do not personally favor a course of this type. I believe more can be gained by introducing the project method at frequent intervals in the course. Indeed this method of instruction is commonly employed by every good teacher, no matter what his subject may be, as a means of developing and maintaining interest.

Miss Weckel in her article, "Ways to stimulate interest in zoology"* states that it is,"Possible to make the process of digestion, the action of the heart, the phenomena of development, the laws of inheritance, the symbiotic relationships between animals, or the camouflage in the animal world seem just as wonderful and as remarkable to boys and girls as do the adventures of their favorite movie stars in their latest productions." Miss Weckel told of exhibits that were given in her school under the auspices of the Parent-Teacher

Association and the interest that was aroused in the pupils because
of the charts they made to illustrate such topics as House Fly a
Disease Carrier, Life History of the Mosquito, Protective Resemblance,
Inheritance of the Jukes, Inheritance in the Edwards Family etc.
Other means of motivating the work were - the offering of a prize of
$20 by a woman in the community for the best essay on birds written
by any student taking biology; the making of models from heavy paper
to show the internal structure of the frog; trips to office of health
department, sewage disposal plants, etc.

Johnson* says concerning motivation in biology, that it
should not be the quantity of instruction that we strive after but
have students get spirit and thoroughness. It is not necessary to
cling to the text book as regards materials and method, for plants
are everywhere about us; all we need to do is study them and apply
them to our work. For instance take the class to the weed patch and
discover the different kinds of weeds and compare with home gardens.
The important element is that we have taught the pupils how to record
their observation. Nothing is of greater value in the educational pro-
cess especially as far as the sciences are concerned as the inculca-
tion of orderly habits of recording observation of facts and whatever
pertains to the problem in hand. There are a number of ways then if
we but discover them of motivating the work and stimulating interest
in biology. We have seen that a common weed patch is one method. An
excellent teacher of biology does not need to worry concerning moti-
vation, - her personality and methods are sufficient stimulants for her
pupils. This is shown by the results that Miss Mac Rae obtains from her
pupils.

* Use of the Weed-Patch in the Teaching of H.S. Biology—Arthur Johnson
The matter of securing appreciation for biology must first be the work of the individual teacher. The variety of textbooks constitute the primary material on which to draw. In botany, for instance textbooks dealing with some applied form as agriculture are available for rural districts, where they are more apt to be desired; for cities and larger towns where often more purely cultural values seem to be rated higher there are others, colored with philosophical aspects of botany such as plant ecology. Factors other than the community should enter the selection of a textbook however. A non-technical book should be chosen. We could hardly expect a pupil of high school age to read with any interest a technical book. Facts should be presented clearly and in a simple manner, otherwise the pupil will lose the point or give up in the maze of complex material which surrounds him.

We must remember that the boy or girl of average ability upon admission to the secondary school is not a thinking individual. The training given up to this time, with but rare exceptions, has been in the forming of simple concepts. These concepts have been reached diadactically and empirically. Drill and memory work have been the pedagogic vehicles. Even the elementary science work given has resulted at the best in an interpretation of some of the common factors in the pupils' environment and in widening of the meaning of some of his concepts. Therefore the first science of the secondary school, elementary biology, should be primarily the vehicle by which the child is taught to solve problems and to think straight in so doing. No other subject is more capable of logical development. No subject is more vital because of its relation to the vital things in the life of the child. A series of experiments and demonstrations, discussed and
applied as definite concrete problems which have arisen within the child's horizon, will develop power in thinking more surely than any other subject in the secondary school.

A textbook in biology should serve to verify the students' observations made in the laboratory, it should round out his concept or generalization by adding such material as he cannot readily observe, and it should give the student directly such information as he cannot be expected to gain directly or indirectly through his laboratory experience. For these reasons the laboratory manual should be separated from the text.

I have considered the following books as possible texts in the teaching of biology:

**Botany**
- Bergen - Elements of Botany
- Cook - Applied Economic Botany.
- Coulter - Plant Life and Plant Uses.
- Leavitt - Outline of Botany.
- Transeau - Science of Plant Life.

**Zoology**
- Davison - Practical Zoology.

**Biology**
- Bailey-Coleman - First Course in Biology.
- Gruenberg - Elementary Biology.
- Hunter - Essentials of Biology.
- Hunter - A Civic Biology.
- Peabody and Hunt - Elementary Biology.
- Smallwood, Reveley-Bailey - Practical Biology.
Transeau's Botany, "The Science of Plant Life," is by far the best text on botany for the high school. It is most certainly not technical in contrast to Berge's Botany which is exceedingly technical and consequently of little value in the high school. Transeau has attractively presented and organized in this book such "facts of plant physiology, morphology, ecology and economics," that the high school pupil can assimilate and later use effectively if he should engage in the growing of plants. The fundamental aim is to give the pupil an understanding of how a plant lives and is affected by its environment. The nutrition of the plant is the central theme with the introduction of "sufficient anatomy and morphology to make possible a discussion of the important plant processes, including reproduction." The relation of the plant to its environment is stressed and the treatment is simple. A large amount of economic material is incorporated and it is so fused with the general treatment that it is a natural part of the book, not something tacked on as an after thought. Comparisons are made with phenomena that are familiar to the pupil and it is a readable and interesting book. Most of the botany books tend to give a thorough classification of plants, giving technical names which are of little value and of practically no interest to the pupils while Transeau tells the pupil in familiar language just what the plant does in order to live.

The zoology books, read, seem too technical for high school use. Linville and Kelly's text is much too difficult for a pupil in the second year of the high school. A class of seniors might readily use it however. The biology texts are more suited to the second year of the high school course. "Practical Biology" by Smallwood, Reveley and Bailey is divided into three parts, animal biology, human biology and
plant biology and laboratory work is contained in the book. Likewise the "First Course in Biology" by Bailey-Coleman and the text of Peabody and Hunt are divided in this same manner into plant, animal and human biology. The chief faults of these texts is that this division is made and laboratory exercises are contained in the text.

Of the biology texts, I prefer Gruenberg's "Elementary Biology" and Hunter's "Civic Biology." Gruenberg has not made the usual division of the subject into botany and zoology but has treated life as a whole. There are six parts: The world in which we live; life processes of the organism; the continuity of life; organisms in their external relations, heredity and evolution; man and other organisms. This is an especially commendable textbook, noticeable features of which are its clear arrangement, lucid explanations and an abundance of useful diagrams. This book is particularly readable and one reason for this is that laboratory instructions are omitted. The subject matter is well chosen, is modern, clearly presented, and the illustrations are to the point. It is doubtful if the ordinary high school class will cover the book in one year if projects or the needed laboratory work are added. Still the presentation is so interesting that pupils will take larger doses without protest than ordinarily. For instance, the subjects of tobacco and alcohol are given a statistical presentation with an arrangement of facts that are fascinating and impressive.

"Civic Biology" by G.W. Hunter treats the subject from a new point of view. The author has prepared it in the belief that "the time has come when we must frankly recognize (the pupil's) interests and adapt the content of our courses in biology to interpret the imme-
diate world of the pupil." The book is adapted to the needs of city schools and attempts to show boys and girls living in an urban community how they may best live within their own environment and how they may cooperate with the civic authorities for the betterment of their environment. This book of Hunters, Grunberg's "Elementary Biology" and Trænsæus' "The Science of Plant Life," are texts that are well adapted to the second year of the high school. I would recommend then these three texts for use in the elementary biology course in the high school.

In conclusion let me state that biology meets the objectives for which American Education exists. These objectives were decided upon by the National Educational Association. They are (1) health, (2) command of fundamental processes, (3) worthy home membership, (4) vocation, (5) civic education, (6) worthy use of leisure, (7) ethical character. These objectives of course overlap and obviously ethical character is not placed last because it is least important for it is in all the others. It will be noted that these objectives relate directly to what the high school may do for its pupils, not to what are the essentials of the subjects of study. The essentials of the subject are those things which will meet these stated objectives.

Biological topics which may be expected to meet the stated educational objectives are control and elimination of disease, plants and animals and their relation to the world's food supply, the study of chlorophyll and the proper care of water and milk supplies. It is the business of biological education to instruct, convince and motivate the public in matters of public health, by use of biological

*Contribution of Biological Sciences to Universal Secondary Education
Otis W. Caldwell
School Sci & Math '21
facts and processes as they relate to the community and to ordinary health processes.

In its contribution to command of fundamental processes, biological science is peculiarly rich since it deals with life itself, of which pupils are a part. Biology touches the efficiency of the home and of the life within the home at every angle. Biological instruction should contribute both to vocational guidance and to broad preparation for vocation. It should also assist in the development of ethical character by establishing a more adequate conception of truth and a confidence in the laws of cause and effect. We see that biology as a study meets the objectives of the secondary American education and biology serves a greater number of ends of education than any other single subject. Because biology has been shown to be so important to the student and because the need is so apparent it should then be a required subject in secondary education. In conclusion allow me to quote from a report of the biology teachers of the Chicago High Schools on a conference concerning a new course of study in the schools. *

"We hold that biology is unique among secondary school subjects, when properly taught, in serving a greater number of the ends of education than any single subject and that it should furnish a part of the training of every boy and every girl who is to contribute to the depth and breadth of the democracy in which each is later to take an active part."

Summary.

This paper has aimed to show that biology has a practical value which cannot be overlooked. Although this is the case, biology does not at present hold its proper place in the high school curriculum due primarily to ineffective teaching and administrative difficulties. Biology, as has been shown in the body of the report, is fundamental and essential in the secondary school. Biology, which consists not of a mixture of botany and zoology but of a course which deals with life, finds its proper place in the second year of the high school course.

Biology has the value of a science in the curriculum but it has also economic, aesthetic, ethical and social values, and very important also is its value to the moral and physical well being of the race. Because this subject is so valuable and its scope so overwhelmingly large, it should be a required subject in the high school curriculum and it should follow a course in elementary science. For students going on to college a course in biology is not sufficient, but courses in zoology and botany should be demanded from them.

We have not wholly solved our problem when we make the subject required however. A uniform course is desired and by this we do not mean or need to have a rigid one. We want simply a set of topics arranged in a definite order. This will not curb the teacher's individuality nor disregard the needs of the community. When we have obtained a uniform course in biology and have obtained good teachers by means of special college courses for the training of teachers, then biology will have obtained its proper place in the curriculum. Three things we must do then: first, train our biology teachers;
secondly, make a uniform course for biology; and thirdly, and most important of all - demand that the subject be required because it is so essential in the life of every living person.
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