

## ESSENTIALS OF A PRACTICAL COURSE IN BIOLOGY.

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The most important avowed function of biology in the secondary school is to make of every pupil studying it, a good animal. That means the conservation of the individual and of the race. A second function of biology is to prepare the pupil for efficient citizenship. The nature of the material to be used in accomplishing these two great functions is unimportant provided the objects are accomplished. The personal equation is the determining factor—the personality and enthusiasm of the teacher.

Beyond these above mentioned functions, there is no doubt a cultural, a utilitarian and a disciplinary value in the study of biology. These three considerations may have something to do with the teacher's preferences as to the material to be presented, but they are all summed up in the one word "practical." It is from the practical standpoint that I desire, in all humility, to indicate what topics may be included in a course of biology for the first year of the high school, approximating thirty-six weeks (twelve for plant biology; nine for animal biology and fifteen for human biology) with particular emphasis upon the point and method of attack. The great lack in so many courses of biology is a *unifying* scheme; a method; a plan, which the pupil can see as well as the teacher.

First, then, let me lay down just two propositions, as follows:

(1) *I believe that the average pupil will be more interested in subjects or topics concerning which he knows something, rather than in the topics of which he has little or no knowledge.*

(2) *I believe that there is just as much disciplinary, cultural and practical value in a study of the common and economically important objects in nature as in the study of forms of which the pupil has never heard before and may never hear again, unless he be a very wide reader and the general supposition from the premises is that this he will not be.*

The only excuse that any teacher can have for teaching the secondary school pupil the variable forms of the unimportant cryptogams or invertebrates is to satisfy his own longing to promulgate the grand old theory of evolution. Theory? Why, it is a fact! Why necessary to still drum that into the inoffensive adolescent ear!

To say that a study of such forms is beautiful may be true. It

is even possible that the pupil shall know something about all the forms of plant and animal life. Truth is always beautiful, but life is short and it is the business of each generation to crystallize for the next generation the most exact and useful information which will contribute most to its happiness, its prosperity and its success.

What to teach and how to teach it is the all-absorbing question. The field is large and complex. There must be some central axis; core; unit; call it what you will, about which all topics *naturally* and *logically* revolve. Among these topics there must stand out large principles; moving truths; upon which all subsequent reading and study of the pupil in after life may depend.

Shall it be Structural Biology? May good sense forbid it. Shall it be Type Biology? That is some better! Shall it be Synthetic Biology? That sounds admirable! Shall it be Functional Biology? That, above all, is most natural and most vital! Shall it be Functional Biology with a view to its bearing upon the conservation of the individual, the city, the state and the nation? That is the ideal! That is something to be sought! But how do it? What methods are to be pursued to attain such ideal? This is hard to answer. I can only give suggestions, which may have in them a tendency towards the solution of the problem. A provisionally adopted course in our school attempts to get at the problem. I say, "provisionally" because this course is modified and newly adopted almost every month.

In addition to the propositions laid down above, let me add three more of lesser importance, which guide us in the selection of material for study.

(1) *Common things, which are at the same time of economic value, are studied.*

(2) *Function is raised to an exalted position at the very beginning of the course.*

(3) *Where possible, a practical application is made of every point to the welfare of the individual. The whole subject is socialized.*

Biology is the study of *Life*—a unit principle manifested in a single substance—protoplasm. The pupil is interested in seeing how it acts—how it manifests itself—what it does. Now this protoplasm manifests itself in myriad ways—as a single cell and as many cells in one organism.

Bacteria, sequoia trees, ants, elephants and men—all constructed of this fundamental substance, made up of five elements, non-

living, separated, but alive when combined in the right proportions. What, then, is the object of presenting to the pupil a great category of animal and plant forms, for individual dissection and study when he learns at once that the substance composing them is identical. It simply shows itself in various forms.

It is far more reasonable to show the pupil that *simple existence means something*. Things made of protoplasm are alive and live things have needs which must be fulfilled, else the organism dies. These needs are fundamental and four in number. They are (1) Food, (2) Air, (3) Protection, (4) Reproduction. The only structural work needed in the whole course is to show the pupil how the type animal or plant is adapted to best fulfill those needs. Simple, isn't it? That is the whole substance of our course of study.

Four needs—three for the individual and one for the race—and you have the sum total of all life. Here you have your beginnings of altruism, social feelings and coöperation at the start. Here your cultural as well as your practical side begins.

The Structuralist now comes forward and says:

Give the pupil the microscope. Place beneath its objective a few root hairs and direct the pupil to make a careful drawing of these root hairs, showing them as a part of the epidermal cells of the root. Let him label all the parts (as given by the teacher). Very well! When he is finished, ask him: What is the function of the root hair? Silence. Next ask him: How does the root hair do its work? No answer. The inevitable result is, that the teacher tells him what the root hair is, how it works, and thinks that the lesson is a huge success. But why spend all the time drawing? What connection is there between the drawing and the ultimate knowledge of function which the pupil needs? Absolutely none! The cart is before the horse! What conclusions can the pupil draw? He never draws any conclusions. The work becomes distasteful to him; he sees no plan in it; his mind refuses to work; there is nothing for *him* to do.

The fundamental needs of life can be brought out in a few minutes' discussion with any class in the presence of a growing plant or a kitten. The pupil is at once brought up square against all the natural operations of living things familiar to the child and with entire frankness and absence of cant. Interested? There can be no doubt of it! It is vital, familiar and practical.

A further study of a thrifty plant elicits many questions. What are the uses of the parts seen? Of what are they com-

posed? Why are the roots in the ground? What do they do? What increases the bulk of the plant?

The questions are answered by the pupil himself after a few simple observations of chemicals and experiments upon the nature of soil and plant tissue. He finds them in many cases identical. The pupil finally concludes for himself that all life primarily depends upon the soil and air for its existence—in fact, is soil in a modified form. This opens his eyes. He is *seeing* and *feeling* things. He begins to get his bearings as a living thing. He possesses a viewpoint and this is of more value to him than all the structural study in the universe.

But how does the plant grow? Let the pupil find out for himself. Let him light a match. He finds that it burns; finds by test that it gives off heat, water and carbon dioxide. He finds by analogy that heat is energy because it drives the train along the track; that a growing plant gives off heat, carbon dioxide and water and strange to say, he, the pupil, is warm, gives off carbon dioxide from his lungs and produces a film of moisture on a window pane when he exhales upon it. He finally concludes himself and the plant to be engines as well as the locomotive, and that both have very similar needs and that both are adapted in certain ways peculiar to themselves to fulfill those needs. He has discovered some of the fundamentals of life as far as any of us know them and has done it himself. Ah! that is the appeal to the child. He did it himself. How his eyes brighten! How his face shines! And he sneaks up after the recitation and tells you he likes biology.

Now bring in your structure carefully and gradually. The pupil will devour it with the enthusiasm previously generated. It will seem of vital interest to him now because (1) it will allow him to organize his own ideas; (2) it will provoke him to serious thought; (3) it will develop his limited individuality; (4) it will enhance his power of expression; (5) it will give him growing confidence in himself; (6) it will end in real accomplishment which is the finest flower of logical and enthusiastic effort. To make my point concrete, let me set down here a small portion of the course as we have blocked it out. This is considered the minimum work required and I have selected this topic because it is one in which the boys, by actual test, show the least interest of all the topics in Plant Biology.

## Topic E. Stems.

## A. (a) Need of Stems and Their Use to the Plant.

- (1) Support.
- (2) Conduction.
- (3) Food Storage.

## (b) Structures Adapted for these Functions.

- (1) Support.
  - (a) Monocotyledonous—rind.
  - (b) Dicotyledonous—bark and wood.
- (2) Conduction.
  - (a) Monocotyledonous—ducts.
  - (b) Dicotyledonous—ducts of sap wood and bark.

## Demonstration of Capillarity.

- (3) Food Storage.
  - (a) Monocotyledonous—Pith.
  - (b) Dicotyledonous—pith, medullary rays, sap wood.

## B. Use of Stems to Man.

- (1) Food (potato, etc.).
- (2) Medicines (quinine, etc.).
- (3) Condiments (cinnamon, etc.).
- (4) Aromatics (camphor, etc.).
- (5) Manufactures and Arts (building material, lumber, furniture, tannin, cork, rosin, turpentine, etc., etc.).

Recognition of five most commonly used trees. Study of tangent and quarter sawed blocks of wood with reference to relative values.

## C. Care of Trees.

- (1) Pruning and its use to the Plant.
- (2) Protection against mammals, insects and disease.
- (3) Conditions for proper growth.
- (4) Civic value.

## D. Methods of Growth.

- (1) Cell expansion (monocotyledonous).
- (2) Cell multiplication (dicotyledonous).

## E. Methods of Propagation.

- (1) Grafting—Purposes—Results.
- (2) Stem cuttings (fruit trees).
- (3) Underground stems (potato).

Function here precedes structural in both order and importance. The pupil sees a plan and method in the whole proceeding; his curiosity is naturally and logically satisfied. He learns without

knowing it. Incidentally he is being educated. He is studying civic biology with no dollar mark attached.

In the topic on flowers, the fundamental conceptions of sex hygiene are set forth, and yet, without the knowledge of the pupil. The flower's purpose as fulfilling the fourth great need of living matter is explained or discussed, by the study of one regular simple flower. The economic value is secondly developed, followed by "Three Steps in the Formation of Seed"—(1) Pollination; (2) Fertilization; (3) Changes in the flowers following fertilization (loss of parts and maturing of others). Great emphasis is placed upon the essential conditions of fruit production—the union of two dissimilar cells to form a third cell—having the characters of both parents. The fruits follow naturally; the seed is shown protected in an ovary wall until maturity, fed by the mother plant, and the final scattering is discussed with means for accomplishing it. The relation of this process to that of the higher animals is obvious and it is an exceptional class where one or more boys do not see it and either mention it or ask questions concerning it. Plant breeding and its application to plant improvement are here brought out, making the impression vivid, practical and lasting.

But to proceed. The ultimate result of the study of plant life is to develop in full detail the four great needs of protoplasm and how these needs are met. The swing into zoölogy is gradual and natural. The pupil is armed with his four great principles and shows an instant interest in their application to animal forms. Animals are first discussed at length as a part of the natural resources of the country—wild and domestic; useful and harmful. A rapid resumé of the chief groups of the animal kingdom follows, giving the pupil an intelligent idea of where he is starting, why he starts where he does, and why he cannot study the whole animal kingdom. He begins with the insect, for many obvious reasons, which he is taught to see for himself. The four great principles are applied at once.

Let us give an outline here of the course on the second type animal—the fish.

Topic M—Perch as a Type of Fish:

A. Conditions Necessary for Life.

1. Food getting.

(a) Kinds of food and how obtained. Structures adapted for this purpose (paired and unpaired fins). Relation to escape and higher animals.

- (b) Method of feeding. Structures and their relation to the struggle for existence.
- 2. Respiration.
  - (a) Method of breathing.
  - (b) Structures for breathing. Gills and how guarded and constructed to obtain maximum amount of oxygen.
- 3. Reproduction: Life Cycle.
  - (1) Egg-laying.
  - (2) Fertilization.
  - (3) Young.
  - (4) Adult.
- 4. Protection: Defensive (a) color, (b) scale, (c) spines, (d) fins, etc. Offensive: Teeth and spines (in some cases).
- 5. Economic Value.
  - (a) Useful—foods, byproducts.
  - (b) Harmful—destruction of food fishes.
  - (c) Laws of Protection (open and closed season, etc.).  
Work of state and federal governments.

Here again function precedes structure, but structure has its place. Drawings are made of the head showing the gills. Demonstrations are made of the general plan of the interior from specimens prepared in jars. But very little of this is done, however. This plan is followed in birds and mammals. Among the mammals, the herbivores and carnivores are greatly emphasized. The course in zoölogy is closed by a week's work on parasites, a review of the fundamental needs of all life and an outline of the animal kingdom showing the increasing complexity from the Protozoa to man.

Human biology opens with a discussion of the fundamental needs of living things. The first, that of food, is at once applied to the human body. Foods are studied in all their applications (preparation, composition, kinds, adulteration, laws, etc.). Then follows the apparatus in the body for using foods with simple experiments on digestion of starch, proteids and emulsification of fats. The blood system is found to be simply an extension of the digestive system—an ingenious method of getting the food where it is needed. The functions of the blood are clearly brought out. The hygiene of both systems is specially emphasized. The need of air is discussed, as a need of the body. Its nature, composition and the apparatus using it are correlated,

but function holds sway over structure. Charts and demonstrations are an aid to a reduction of structure study, with just as much, if not more value to the pupil. Dust and its dangers, exercise, disease, construction of heating systems are all developed from the standpoint of function and self-preservation. Protection is a very broad and very important phase of the subject. It is composed of four topics, all closely related, because all are connected with the "locomotor system," which has for its purpose the getting to food or getting away from danger. The skeleton, muscles, nerves and excretory organs are but briefly touched upon, principally from the standpoint of hygiene. Right habits in connection with these systems are dwelt upon at length.

Bacteria next claim attention and here civic biology comes into its own. From one week to ten days is spent upon the nature, kinds, methods of growth and destruction of bacteria in their relation to disease and its prevention. The municipal departments (sewer, street cleaning, water, health) are discussed so that the pupil may know their real purpose and value as a future citizen and that he may show sympathy and coöperation in the attainment of the objects for which they are instituted. The link between the excretory system and sex hygiene is formed by bacteria, and the one week's study of sex hygiene, with a summary of the whole subject closes the year's work. In sex hygiene the purpose and methods of reproduction in all the plant and animal forms studied are reviewed. Man is found to be no exception to the general rule of the fundamental needs. Over exercise of all the principal systems and their bad results serve as an introduction to the presentation of the subject of the abuse of the reproductive system. The sources of disease (such as public lavatories, towels, cups, etc.) are next discussed, and their effects upon the individual and posterity clearly brought out. The subject is supplemented by references to heredity as shown in plant breeding, the Juke family and confirmed criminals. Recent laws are read concerning treatment of criminals from this standpoint and the topic is closed by an appeal to the pupil's common sense and chivalry as against his morbid curiosity, and sense of shame. This, in brief, is a resumé of some of the essentials of what I am wont to call a "Practical Course in Biology."