longer and more expensive, but the investment is still returned with high interest. The problems to be met have been growing more difficult, but they have been met, and successfully solved, by those with laboratory training, or by those who have profited by the knowledge of the facts dug out in the laboratory. More problems, and more difficult ones, will arise, and they in their turn will be solved, if laboratories and their equipments are maintained at their highest degree of efficiency by liberal endowments and grants. But it would be as absurd to expect our men of science to cope with the complex questions of the present and the immediate future with antiquated utensils, as it would be to send our sailors off in the wooden ships of the war of 1812 to grapple with the Japanese navy.

The idea that a given sum will build and equip a laboratory, and that once set going it will run itself and require nothing more than occasional small sums to replace loss by breakage and the like is a pernicious fallacy. New methods, requiring new or improved instruments, appear each year, and these instruments must be had, if there is to be any pushing forward into the unknown in the branch to which they are adapted. It is a noteworthy fact that, crude as the materials of the early experimenters were, they were the best for their purpose to be had in the world of that time. Faraday insulated his wires with bits of string and old calico, but no one had better insulated wire. Davy obtained sodium and potassium by electrolysis, but he had the biggest and best galvanic battery in existence at the time. It would have been practically impossible to discover Hertzian waves, or Röntgen rays, or wireless telegraphy, without the best of induction coils. And so we might continue *ad infinitum*. It is clearly impossible for one laboratory to have the best of everything, but it is equally clear that each laboratory should have a fairly representative equipment on all general lines, primarily for teaching purposes, and should have an outfit equal to the very best for one or two topics. These topics should be different in different places, and may often be adapted to special localities; they should be chosen by the members of the instructing staff according to their individual aptitudes and interests.

Our laboratories have overwhelmingly justified their cost by their past history, and are justified in making greater demands than ever, by the importance of the functions which they fulfil.

It is to be hoped that philanthropists will be still more liberal than they have been, and that the people will tax themselves more than they ever have, through their legislatures, to give to all schools, colleges and universities. Such money is the fire insurance and the life insurance of society as a whole, guaranteeing the maintenance of law and order, and the ability of the next generation to support the burden of advancing civilization, when its turn comes.

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*IS THE COURSE FOR COLLEGE ENTRANCE REQUIREMENTS BEST FOR THOSE WHO GO NO FURTHER?**

The question is an old one. Is there conflict or harmony of interests between secondary and higher education? Should the high-school student be laying foundations for future study, or should he be doing work that is complete in itself, so far as it goes; or may he not secure a maximum of present utility while laying satisfactory foundations for future studies? I should prefer to discuss the question the other

* Address delivered before the Biological Section of the Central Association of Science and Mathematics Teachers in Chicago. General subject of the meeting: 'Essentials of a High-school Course in Biology.'

end about, for the need of the majority is the constant term involved—fairly constant, at least, since that need will change only with the slow alteration of environment—while the entrance requirement is a much more variable quantity. Let us ask then: Is not the course in biology that is best for the student who ends his studies with the high school a good and satisfactory preparation for college?

When the struggle for existence between subjects now contending for place in the school program shall have worked itself out we shall probably know better what is best for the majority 'who go no further.' Now we must needs exercise foresight, while hindsight will be much clearer. We may gain some hints of things to come by comparing the situation with respect to these newer subjects with the state of those that have reached the end of the struggle and established themselves. The subjects now universally conceded a place in the school program, such as reading, writing, arithmetic, spelling, grammar, geography, etc., stand in marked contrast with some of the newer subjects as respects articulation. These older subjects are orderly, consecutive and complete in themselves: the student drops any of them anywhere without loss—with only gain for what he has had—even though, for example, he stop between short and long division. The list of such studies is longer than it once was; and it may well be that other subjects will come to take their places as essentials when they demonstrate the same degree of educational efficiency and adjust themselves in orderly and progressive sequence.

It must be admitted at once that at present there is no biological program. Studies of living things begin in some places in the kindergarten; in some, in the grades; in some, in the high school; in some, in the college; and in some they do not begin at all. In some they are continuous; in some, interrupted; in most there is little effort at articulation. The unsettled state of our subject is remarkably evidenced in three different ways: (1) The rapid shifts of emphasis as to what shall be taught, (2) the diversity of high school text-books and (3) the indefiniteness of the college entrance requirements.

1. The shifts of emphasis are due chiefly to the fact that most of our nature study has been handed down from above, instead of growing up from below. High-school and normal-school zoology and botany have too often been handed down ready-made by university professors. In my own high school days it was all systems of classification they were handing down. In my college days, it was all anatomy; now it is nearly all ecology. It is now hardly more than a decade since many teachers, newly returned from college or normal school, where their zoological training had consisted in dissecting a cat, were trying the same course they had taken, without dilution or alteration, on the little innocent children. This did not last long, however, for the body politic is more or less resistant to the germs of educational diseases; but it lasted long enough to leave in the mind of the public an unsavory impression of zoology, not yet entirely lived down.

2. The diversity of text-books is very great, in both subject matter and method. Some of the recent ones are all reading—storiettes about animals and plants; some are all dissecting; some are all keys and descriptions for determining of forms; some are all physiology; some are all experimentation; some are all ecology, and some are admixtures of some or all of these things. This diversity is the result of trying to fit one of the most extensive subjects with which the human mind has to deal into one of the smallest niches in the high-school program. Each author appears to have included what he has been able to get

in satisfactorily, and to have lopped off the remainder. And if any one wishes to learn whether these different things are considered pedagogical equivalents, just let him read the prefaces of these books!

3. The usual college entrance requirement in biology at present is 'one year of *some laboratory science*'! Surely this is broad enough to meet the demands of pioneer conditions.

What we have settled among ourselves appears to be that it is worth while to study living things at first hand. Since we may not do more, let us congratulate ourselves that we have progressed thus far, and pull ourselves together for a new start.

What of biology shall be taught in the high school? Is not this a pedagogic question? Yes, as are all questions of fitting subject matter to the receptivity of the developing mind. Is it not also a scientific question? Yes, as science must adjudge the worth of the subject matter. But biological education is more than either pedagogy or science—more than details of instruction, or biological phenomena. It must be in the long run orderly and progressive development toward fitness for the activities of life. The place and portion of biology in the curriculum will not be determined by the dictum of the colleges, or the preferences of the schools, or the methodology of philosophers, but by the operation of natural laws chiefly, the law of natural selection. If biological teaching survive in the high school or anywhere else, it will survive by reason of its fitness as a part in the preparation for life. Therefore, we must never lose sight of the peculiarly intimate relations biology bears to human life. On the practical side, what other subject can compare with one whose chief practical applications are:

First, *living in this world*—hygiene, in its very broadest application, including all personal control over the welfare of body and mind.

Second, *getting the materials of livelihood*—agriculture in its very broadest application, including all that relates to our dependence on the organic life of the world.

Third, *medicine*—the healing art, sometimes mistakenly called the principal application of biology.

I will not mention the multitude of newer applications arising on every hand and making ever-increasing demands for knowledge of the facts and principles of life.

Out of these relations there grow, I think, four incontestable reasons why every one should study biology:

1. To know animals and plants better. We have to deal with them in life. We should know how to protect our friends and combat our enemies among them, and to appreciate the place in the world of all of them. The ancient poetic vision of creation ends with the statement concerning every living thing, 'To you it shall be for meat.'

2. To know our environment better, not alone its economic, but also its esthetic side: to know the charm of life, its wonderful beauty of color and form, its grace of motion, its adaptation to place and function. Here poets and naturalists and artists alike have found themes since the beginning of civilization.

3. To know ourselves better—possessors of animal bodies, that are subject to the same laws, that are moved by the same instincts and that feel the same necessities as other animal bodies, and on the normal healthful activity of which all our possibilities of happiness and usefulness in life depend.

4. To know something of the development of life in the world, and thus to get acquainted with those general develop-

mental principles which underlie modern methods of study in all departments of knowledge: which were first fully developed and are still best exemplified in the field of biology.

Now it seems to me that the consideration of these matters will help us to determine what are some of the things that should constitute part of the intellectual stock-in-trade of the average coming citizen, who will go no further in formal studies than the high school. I will venture to name seven phases of biology now more or less commonly studied, the value of which as parts of a high-school course I consider already demonstrated:

1. Elementary classification—the systematizing of the random observations of nature study in the grades and of contact in life with living things. It need not be very extensive, and might about as well use common names as technical; but it should be a genuine gathering together of known forms into natural groups and a fixing of such groups by names. It will not matter much if, through lack of insight, some forms occasionally get into the wrong group, for such slips still occur with accomplished specialists. Classification naturally and properly follows hard upon the heels of observation, and only goes astray when it runs on ahead. Classification furnishes the handles by which we move all our intellectual luggage. Let us have just enough for our needs.

A modicum of collection making may be allowed here; if fondness is shown for it, it may even be encouraged in individuals and outside the allotted program; and the use of keys analytical should certainly be taught by a little practice. How many naturalists have begun their careers by making collections, and how great and how good is the influence in the present day of the ever-increasing number of manuals and hand-books that are spreading abroad the knowledge of living things.

For many years I have heard professional botanists railing against the old-fashioned course in flower analysis; but I want to testify that I once had such a course, and I have never had a better course in botany or in any other subject whatsoever. It was all nature study of the very best sort and full of the delights of discovery; and the worst that could be said of it is that it was one-sided and incomplete—not a very bad charge, considering the limitations of our knowledge and the immensity of the field.

2. *The study of living nature;* whether we call it old-fashioned natural history or new-fashioned ecology does not matter. In either case we mean the study of plants and animals in relation to their environment. This is the study of the phenomena of fitness. It is simple enough to interest the youngest mind, and profound enough to have furnished the basis for our most important biological generalizations.

It should never be merely reading and talking about remote and wonderfully adapted creatures, but instead, detailed and practical studies of the adaptation of common plants and animals. For instance, protective coloration should not begin with the kallima butterfly, but with the grasshoppers and moths of the dooryard, and results should be secured that are as definite as those of the study of the anatomy of the grasshopper. Merely noting resemblance is not studying it. The pupil should record comparatively the details of the resemblance, whether general or specific, whether in form or in color, how brought about, to what particular environment best fitted, the relative perfection of it, the differences in different animals, etc.

With all the emphasis that is placed on ecology in many recent high-school books,

it is astonishing how little attention is given to pointing a way for the inductive study of ecology on the part of students. It seems hardly to be recognized yet that ecological types are as common and as widely distributed as are morphological types, and that their study may be made to yield equally definite results. It is perhaps excusable, therefore, when teachers read the interesting discussions presented in these books, and instead of applying inductive methods to the study of the same subjects, revert to anatomy for pedagogic results, or else lapse into text-book and recitation methods; but it is still painful, and lamentable, and altogether unnecessary.

There are values of one sort growing out of the intensive laboratory study of a few types; these values have long been recognized. There are other and equal values growing out of the observation of nature in a great variety of forms and relations. These latter values a good ecological program will enable us to realize.

3. A few practical, individual exercises in methods of economic procedure, based on and necessitating a somewhat intimate knowledge of structure, functions and habits of important animals and plants and their enemies—not the mere entertaining observations of nature study in the grades, such as feeding a frog on cut worms: such things should have been done already: but simple practical economic experiments under natural conditions, with the fundamental biologic facts and the desired practical results kept clearly in mind. I would include this, not as a sop to 'practical folk,' though it would in many cases make for solidarity between school and home, but because it is justified on good pedagogic grounds. The youthful mind is practical. Interest is sharpened, and the details of scientific knowledge are better appreciated when things taught are recognized as constituting useful knowledge.

4. The study of reproduction and development. This is in a sense half of biology; for the place of a species on the earth is maintained if it (1) get a living and (2) reproduce its kind. I deem the few local and sporadic attempts that have been made to exclude all consideration for reproduction from the high-school course as an unworthy concession to near-sighted pseudo-pedagogy. For my own part I have always deemed it a privilege to bring to young people some real information as a basis for sane consideration of this much abused subject. Aside from the paramount importance of the subject biologically, I should regret to see this (oftentimes the only) gateway of practical knowledge shut before them. Furthermore, I am inclined to think that the teaching of these matters is needed as an antidote to the smut of the ancient classics and of English history. I judge the results of the teaching of this subject not by the attitude of the student when it is first broached, but by his attitude when the study is done.

Life history studies, it seems to me, are worthy of the greater part of the time spent on these matters, and to these may be added a modicum of embryology of the most elementary sort, preferably, for us in the interior, on the eggs of some amphibian, and a brief, clear and straightforward presentation of the essential features of reproduction, illustrated in the lower forms of animal life and in plants.

5. Physiology, especially the physiology of organs. This already holds a secure and well-merited place; so I but mention it in passing.

6. The study of structure. Anatomy, for a considerable period held the field, almost to the exclusion of every other phase of biological study. But with recognition of the fact that the educational values of biology are far from being confined to the dissecting table, some of the anatomical

work has had to go. We must forever give over the attempt to illustrate the whole gamut of evolutionary changes in a series of types. But we may retain enough of anatomy to be comparative, enough to illustrate kinship clearly, enough to illustrate differentiation, homology, analogy, etc. And may we have this with a maximum of fact and a minimum of terminology! Let us give preference to external anatomy and the study of whole micro-organisms, over internal anatomy and microtome sections. Other things being equal, let us give preference to the sort of work that the interested student may continue after he has left the laboratory behind.

7. Lastly, there should be included the more general conceptions that have grown out of the consideration of biological facts and phenomena and that have taken their places in the world of thought. I mean that there should be considered evolution, with practical studies in the survival of the fittest; the biogenetic law, with practical detailed study of some illustration of the correspondence between ontogeny and phylogeny, etc. These should be introduced because they can not in justice be withheld rather than because the majority go no further. I would have them introduced, also, because some, who are accustomed to get their basis for thinking by more roundabout methods, are still maintaining that biology is a purely observational subject. These all but universal principles the world owes chiefly to biology, and may rightly expect that teachers of biology will faithfully teach them and not withhold the indications of their wide applicability.

Let it be understood that these seven phases of the subject are not offered as a program; far from it. They are not topics for study, but matters to be emphasized in connection with any or all of the special topics to which they relate. I submit that among them is nothing that will not commend itself both for present value and for value as a basis for further progress in biology. I do not believe that any one is well equipped for intelligent participation in modern life if ignorant of these things. Without knowledge of them he will not know how to manage his own garden, his own table, his own appetites, his own emotions or his own thinking. It is, perhaps, true that there are those in circles of culture ready to apologize for the mispronunciation of a Latin phrase, or for the admission of not having read 'Ivanhoe' or even 'Treasure Island,' who would think nothing of it if one should call a whale a fish, or try to kill squashbugs by spraying them with Paris green, or ask what beetles turn into. Indeed, our leading newspapers still publish several times a year the circumstantial details of the case of one who, while drinking at a spring, swallowed tadpoles, and later coughed up frogs. But these things will not always be. On the other side of the matter, I would say for my own part that, so far as knowledge goes, it is some little real and first-hand knowledge of just these seven aspects of biology that I should like to have the high-school graduate equipped with when he presents himself for further work in college. It will have become sufficiently evident, in my opinion, that if the course that is best for life is not best for college entrance, it is so much the worse for the entrance requirement.

Even the few general topics I have named I would not at present *require* to be taught anywhere. I would merely recommend them. For while the science is so new, the field of possible studies so vast and the preparation of teachers so diverse, there is great danger that too much definiteness in a set program may curb initiative and curtail spontaneity. I would let the teachers of the present generation of pioneers do what they can do best to teach the rising generation to see and think, to

know and love their environment and to feel their kinship with the life of the world in body and spirit. Out of this work greater uniformity and better correlation will proceed naturally.

For pioneer conditions must pass. I once had a teacher of arithmetic who had a failing for the duodecimal system; that system had its beauties and its educational utilities also; but it has had to go. As it is no longer permissible to pasture one's cow on the common or to pick strawberries in any fence row, the time is sure to come when it will not be permissible for any teacher to teach what he pleases and when he pleases, according to the exigencies of his situation, the limitations of his knowledge or the prevailing fashion of his university. But it is this very freedom that allows the development of the possibilities of the subject; elimination will come later. May it be natural elimination, and not the forced kind that education suffers when 'men of violence take it by force.'

What is best for life is not completeness, for that is unattainable; not so much great knowledge, as a little knowledge rightly attained with an appetite for more. One danger in programs is that knowledge will be the chief end sought. But another and perhaps even greater danger is that they will be arranged from the standpoint of the specialist without due regard to the standpoint of the learner. How often has it been forgotten already that we had fingers before forceps, eyes before lenses, lenses before microscopes, jack-knives before scalpels, scalpels before microtomes. I have never found a truer statement of this matter than the following one from Professor J. Arthur Thompson: 'A circuitous course of study followed with natural eagerness will lead to better results than the most logical programs, if that take no root in the life of the student.'

I can not help feeling that science teaching, while it has earned its place, has fallen far short of accomplishing that public good for which we may reasonably hope: the diffusion of honesty and directness of method and respect for the simple truth; the abandonment of dogmatism and superstition. Perhaps it is because of the essential conservatism of human nature; perhaps it is because this teaching starts too late and finds scant lodgment in soil already stocked with the notions of an unscientific age; perhaps it is because that teaching is not yet direct and forceful enough to take hold upon the life and to touch the springs of conduct. But ultimate failure in these respects would rest especially upon biology, because of the intimate relations it bears to the life of the people.

James G. Needham.

SCIENTIFIC BOOKS.

REPORTS OF THE BELGIAN ANTARCTIC EXPEDITION.

Résultats du Voyage du S. Y. Belgica, en 1897–8–9, sous le commandement de A. de Gerlache de Gomery. Rapports Scientifiques, publiés aux frais du Gouvernement Belge, sous la direction de la Commission de la Belgica. Anvers, J. E. Buschmann. 1901 (et seq.). 4to, with plates and text-figures.

After the return of the Antarctic expedition on the Belgica, in December, 1899, by royal mandate a commission was appointed under the presidency of General Brialmont to supervise the publication of the scientific results. It is proposed to issue these in ten quarto volumes, the edition to be of 500 copies, exclusive of separate copies of the several papers, which, being issued with individual pagination, dates and covers, may appear as promptly as possible after preparation; the assembling into volumes being a subsequent arrangement.

Quite a number of these papers have already appeared, so that it seems desirable to give our readers some idea of what has been accomplished, although considerations of space will restrict our comment to the utmost limit of brevity on the present occasion. In a gen-