ZOOLOGY

By R. P. BIGELOW.

Since the days of Darwin and Huxley's famous essay on Man's Place in Nature it has become generally recognized that man is an animal, and that his structure and activities and even his mental life can be understood only by reference to a long line of animal ancestors. Therefore some knowledge of Zoology, the branch of biological science that deals with animals, is a desirable addition to any scheme of general education, and of course in biology it is necessarily an mportant feature.

The first instruction in zoology comes in the course in General Biology, when a few lowly animals are studied, together with plants, to illustrate general principles of biological science. The student in Course VII. enters upon the study of zoology for itself in the second term of the second year when he takes the course in General Zoology. In this course there are one lecture and two hours of laboratory work each week, and the aim of the course is to give a general survey of the animal kingdom, which will be of value in itself as a part of the general fund of information of an educated man and at the same time form a foundation for future biological study.

In the first term of the third year there is a division of the students in Course VII. into two groups, those electing Option 1 (pure biology(, and those electing Option 2 (applied biology). The men taking Option 2 enter upon the study of the comparative anatomy and development of the lower animals. These subjects are treated from the point of view of the theory of organic evolution and the student has unfolded before him the progressive stages in complicity of structure from the lowest to the most complete along each of the lines of evolution that constitute the main divisions of the animal kingdom. This is done not only by the comparison of the adult structures but also by a study of the life histories, which sometimes reveal unexpected relationships between higher and lower forms. In the laboratory students have an opportunity to become familiar with the chief types of structure by means of careful dissection of a representative from each great group.

For all students in Course VII. the greatest amount of work in Zoology comes in the second term of the third year. This term is devoted to the study of the back-boned animals, of which man himself is the culminating type.

Students in both options take two courses at the same time, one in the gross Anatomy of Vertebrates and the other in Microscopic Anatomy, or Histology. In these courses the emphasis is on quality rather than quantity of work. There are few lectures and there is much laboratory work, and the student is expected and encouraged more than ever before to find out things for himself.

In the course in Vertebrate Anatomy only two or three types are studied, but these are studied very thoroughly by means of dissections, from which detailed drawings are made.

In the course in Microscopic Anatomy attention is confined to the minute structure of the mammals, which is studied in its relation to the origin of the different parts in the development of the individual, and the text-book used is one on human histology. In this course the student prepares a series of specimens to keep for his own use.

It is believed that these courses are of value from two points of view: First, they are valuable as an exercise in a scientific method that is perhaps of more general application in the ordinary affairs of life than the experimental method, that is the method of direct observation and analysis of nature, without previous human interference, followed by mental reconstruction of the the whole from its parts; and second, they are valuable as a source of information that is necessary for the understanding of human physiology, which in its turn forms to a great extent the scientific basis for the practice of hygiene and the preservation of the public health.

In addition to these courses students who have elected Option 1 take a course in the Embryology of Vertebrates. While the lectures cover the general field of the development of the individual in the main divisions of this group, treating in a compartive way the history from the egg to the fully formed animal, the laboratory work, as in the previous courses, is confined to a few types. The students prepare for their own use frog and chicken embryos and have an opportunity to study a fine series of mammalian embryos kept for that purpose in the laboratory collection.

Since Pasteur's study of the diseases of silk worms and Koch's discovery of the bacillus of tuberculosis an ever-increasing number of small plants known as Bacteria have come to have a bad reputation as the cause of most of the ills that man is heir to. Within recent years, however, it has become evident that many of the troubles of men and domestic animals, not to mention wild ones, are due not to Bacteria, but to animals, some of them microscopic, others by no means so small.

For example, malaria, sleeping sickness, tropical dysentery, the Texas fever of cattle, and the horse sickness of South Africa and the Philippine Islands are known to be due to microscopic animals, and there is reason to suspect that small pox and scarlet fever may have a similar cause. Some of these diseases are carried from one victim to another by blood-sucking insects, while some of the troubles of men and lower animals are due to the direct infection of the intestine by parasitic worms, as, for example, the hook-worm disease that has been such a serious addiction in our Southern States and Porto Rico.

The importance of this subject from the pont of view of the public health has led to the establishment of a course in Invertebrate Zoology, or more properly Parasitology, given to all students in Course VII. during the first turn of the fourth year. This is a course of lectures with demonstrations and covers the subject of the classification, structure, and life-histories of the animals which may affect the health of man and the domestic animals.

For Option 1 there is offered in the second term a course in Experimental Zoology. This is really physiology, but differs from the course given under that title by treating the subject from a different point of view. Here we are not concerned so much with the physics and chemistry of the body as we are with the reactions of the body to external conditions. As these reactions are shown in their simplest form in organisms low in the scale of being, attention is confined chiefly inthe course to the primitive forms of animals. Studies are made on the reactions to light, heat, and electricity, to gravity and to various chemical substances, on the factors influencing develpoment, and on the effects of mutilation and the method of repair. Thus may be obtained an insight in to some of the properties of the living substance and indirectly a better understanding of the factors affecting the life of mankind.

PHYSIOLOGY

By PERCY G. STILES, Ph.D.

In the early years of the department, when the regular students were trained as teachers of the Biological Sciences or prepared for Medical Schools, Physiology was obviously important and much time was devoted to it, in both terms of the senior year. With the widening opportunities for workers in Sanitary Science our students have so generally chosen that field of activity that Physiology has been set back to the junior year and compressed into one term. It is clear that its more special aspects are not directly of interest to the bacteriologist. Nevertheless, the retention of the present condensed courses is easily defensible. The life activities of the lower organisms are far better understood when one has some knowledge of the more complex transformations of matter and energy wrought by the higher forms. It is aimed therefore to teach Physiology in a general and comparative way with little emphasis on anatomy but much on the dynamics and the economy of animal cell-systems. The writer cannot refrain from a word in regard to the educational value of the subject. There are few sciences which so constantly call for the sifting of conflicting evidence, for discreet inference, and for the suspension of judgment in default of data. The last faculty is certainly a valuable one and not too common.

The required Laboratory Physiology is of an elementary grade. The experiments illustrate salient properties of the blood, of the muscle and nerve, of the rhythmic heart-tissue, and of enzymes. The work usually supplements the lecture course, but it may be taken separately by students who have had previous instruction in the theory involved. Those who develop a taste for physiological research may pursue special lines in the senior year or return to it in graduate programs. In the past fifteen years the Theses in this Laboratory have furnished material for several published papers. Among the topics treated have been Neuro-muscular Fatigue, Changes in the Capillary Circulation, Tffects of Ions upon Contractile Tissues, Conditions of Enzyme Action. Summer investigations are encouraged.

The short course entitled Personal Hygiene is given in the second term of the senior year. It is intended primarily for those who have had Physiology in the preceding year. Assuming this preparation the instructor aims to make the lectures and conferences scientific rather than dogmatic. The method is not to state many rules for the conduct of life, but to test the probable validity of traditional teachings in regard to these matters. Current views of diet are considered, quantity and kind of food, Fletcherizing and other fads, water-drinking and emotional factors affecting nutrition. The much abused subject of alcohol is discussed judicially. The relation of the vasomotor system to health and resistance receives close attention. The far-reaching effects of muscular activity are brought out at some length. The attempt is made to estimate the scope—and the limitations—of mental states in the preservation of health and the righting of disorders. Rest, variety of occupation, and sleep are kindred subjects which have a place in the course.

BACTERIOLOGICAL COURSES

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had been done, Bacteriology had become a science, investigation was proceeding everywhere, and the parent stock from which development was to take place was strong and vigorous. Year by year advance was made, and in fifteen years the Bacteriological courses have grown in number from one, taken by an average of five students yearly, to six in which the annual enrolment is approximately a hundred. These figures represent with fair accuracy the development of the science during this time. Our one general course has been much extended, while specialized courses in the Bacteriology of Water and Sewage, Industrial Microbiology, Zymology, and Municipal Laboratory Methods have been established as our knowledge of the bacteria and their manifold special activities has increased. Moreover, the course has appealed to a wider clientele than at first, Originally designed for the biologists alone, we now find two or more of the bacteriological courses in the curricula of the Chemical and Sanitary Engineer-departments as well.

Following the principles laid down in the early work, the backbone of our bacteriological courses has been General Bacteriology. While the work has been greatly extended in scope and amount as noted above, its purpose remains primarily the same as in the early days, namely, to give to the student a broad knowledge of the bacteria as a group of organisms, of their distribution in soil, water, air and elsewhere, and their structure and physiology, their mutual relations with the environment, and their more intimate relations to the human organism as parasites or commensals. In the latter connection the student is naturally led to a consideration of the germ theory of disease,—next to the theory of evolution itself the greatest triumph of nineteenth century science,—and the relation of specific types of bacteria as causative agents of infectious disease. Particular emphasis is laid on importance of the germ theory, since it supplies the basis for general preventive medicine and all our special sanitary work in the safeguarding of water, food, and milk supplies, and the disposal of waste such as sewage. On the other hand, the student gets a very distorted idea of the great group of bacteria, in which after all the useful types far outnumber the dangerous ones, if undue emphasis is laid on the disease-producing bacteria in the beginning of the course. The thoughtful student is quite as much impressed with the importance of the germ of typhoid fever and its relation to the public health and much better able to cope with it if he knows also that in its biological relations it behaves like harmless and useful types, just as murderers and bank robbers have the same physical necessities, the same senstiveness to heat, cold and poisons as the honest and helpful members of society. The additional knowledge that certain species have specific powers of the most destructive character serves at once to stamp them as dangerous individualsfi to be feared if at large, and to be fought intelligently and unceasingly by the weapons which general knowledge of the group and special knowledge derived from the investigation of the organism itself puts into our hands.

Our general course, therefore, is intended to give breadth of knowledge of the individual organism and of the methods by which particular characters of the individual may be accurately investigated.

To go from the general to the specialized phases of a subject is the logical method of procedure. Hence it is that after gaining our general knowledge of the microbic world we proceed to the study of special divisions of it. Thus our courses in Bacteriology of Water and Sewage, Industrial Biology, and Municipal Laborotory Methods (really a course dealing with preventive and diagnostic work) rest upon and follow our broad general course.

Twenty-five years of experience has taught that the fitness of a water for human consumption in general can be best determined by its investigation from the bacteriological side. The trained bacteriologist can not only recognize the types of bacteria which are normal to the water, he can also detect the presence of the undesirable, dangerous, and semi-parasitic forms which we now know to be characteristic of pollution and absent in pure waters. The biologist may therefore work hand in hand with the engineers, or as in the case of the sanitary engineers, the knowledge of special methods of investigation on the sanitary side may be added to an engineering equipment. Special attention has been given to these matters in the Biological Department for many years, and it is only necessary to note the work done by Institute men with this training to learn how serviceable Technology has been in the public sanitary service.

In a somewhat similar manner the course in Industrial Biology directs the attention toward the industries in which micro-organisms play an important part. The enormous food preserving, canning, cold storage, and allied industries are esentially biological industries. The dairy industry in all its phases requires highly specialized knowledge of the bacteria and moulds, and of their control, propagation, or destruction, in order to be carried on with the highest efficiency. All the fermentation processes, manifold in character and usefulness, involve the activity of germs of one sort or another. Space does not permit an extended discussion of the scope of this work. The course in Industrial Biology brings to the attention of the student some of the more obvious of these bio-chemical processes, but aims to do more than that, that is to give so comprehnsive an idea of the chemical activity of micro-organisms and their posibilities that inquiry and investigation will be stimulated along new and untried lines. Unquestionably, the future will see a great expansion in the utilization of bacteria, in chemical manufacturing, in agriculture, and in the preparation of foods and beverages. It can hardly be doubted that advanced scientific agriculture will depend to a great extent upon the progress that can be made in soil bacteriology. In the general movement for conservation of natural resources it is safe to predict that the biologist will have a place along with the chemist and the engineer.

The more theoretical side of the problems of fermentation and putrefaction is considered in the course in Zymology. The enzymes, as the chemical reagents by which the micro-organisms eary on their reactions, form a group of substances of great interest. Study of them has already explained many otherwise mysterious processes, and the field is still comparatively untilled. Isolated facts are known, but much remains to be done in the grouping and classification of these facts.

Taken together the courses based upon knowledge of the bacteria form a well co-ordinated group, combining theory and practice, and all tending to render the receptive student capable of becoming of great service to his fellow man.