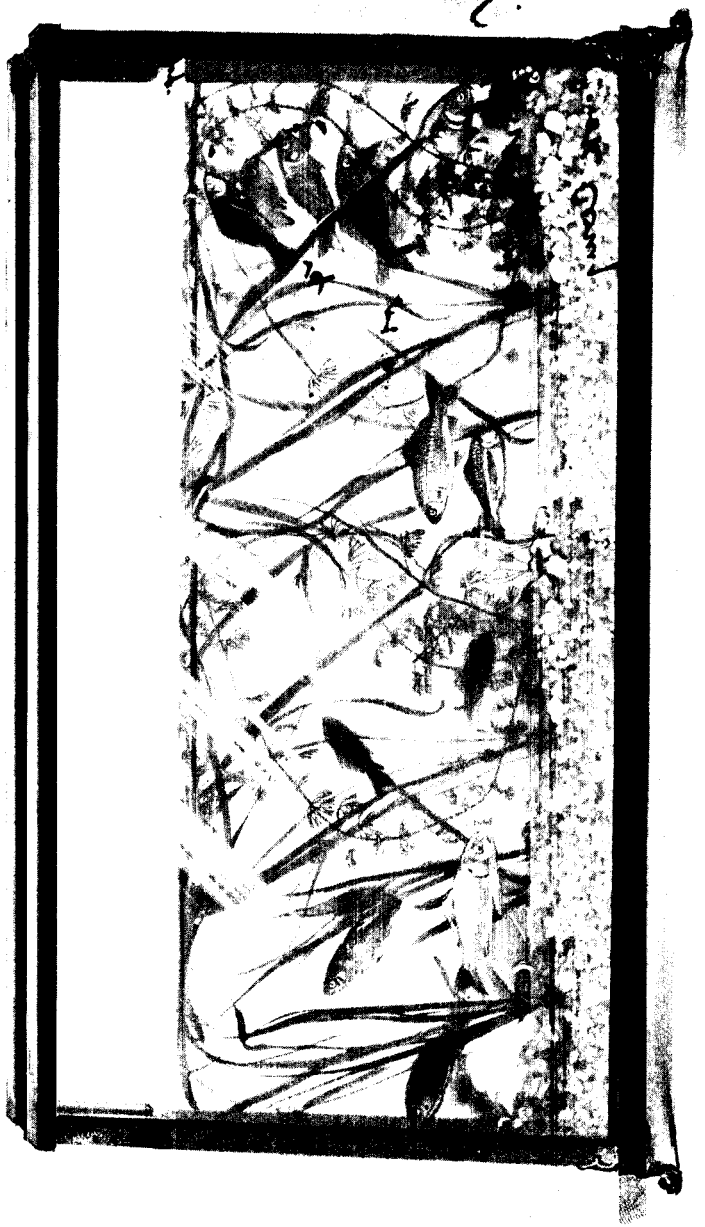

A Balanced Aquarium. The fish and other animals give off carbon dioxide and nitrogenous wastes which, under certain conditions, are used by the green plants for the manufacture of food and living matter. The plants give off oxygen as a by-product during starch-making, and their bodies may be used as food by the animals.

ESSENTIALS OF BIOLOGY

PRESENTED IN PROBLEMS

BY

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THE PLAN AND PURPOSE OF THIS BOOK

The plan of this book recognizes first-year biology as a *science* founded upon certain underlying and basic principles. These principles underlie not only biology, but also organized society. The culmination of such an elementary course is avowedly the understanding of man, and the principles which hold together such a course should be chiefly *physiological.* The functions of all living things, plant or animal, movement, irritability, nutrition, respiration, excretion, and reproduction; the interrelation of plants and animals and their economic relations, all these as they relate to man should enter into a course in elementary biology.

But to make plain these physiological processes, difficult even for an advanced student of biology to comprehend, the simplest method of demonstration is necessary. Plant physiology, because of the ease with which simple demonstrations can be made, is more profitable ground for beginners than is the physiology of animals. The foods which animals use are manufactured and used by green plants; the action of the digestive enzymes, the principle of osmosis, and the subject of reproduction can better be first handled from the botanical aspect. The topics just mentioned introduced from the standpoint of the botanist gain much by repetition from the zoölogical angle. The principles of physiology, after being applied in experiment to plants and animals, emerge in final clarity when applied at the last to man, — the most complex of all living things.

One of the most important factors in successful science teaching is repetition. In a recent address President Remsen of Johns Hopkins University said: —

"The most important defect in the teaching of chemistry to-day is the absence of repetition. There are too many fleeting impressions. We cover too much ground. The student gets only a veneer."

What is true of chemistry is equally true of biological science. We spend too much time in teaching unessentials taken from our immense field, and we do not spend enough time in emphasizing from constantly varied points of attack the *fundamental truths* on which the science of biology is built. The pages which follow are an attempt to drive home by repetition, and from many points of view, some of the important principles of physiological biology.

One sufficient reason for the placing of a course in biology in the first year of the secondary course lies in the fact that at this time the child is receptive to the message of applied biology. Private and public hygiene, the message of protective medicine and sanitation, the story of pure milk and of pure water and what they mean to a community; all these things can most logically be presented in a course that makes man the center. The allied topics of conservation of plant and animal life, the destruction of harmful plants and animals, the relation of insects and other animals to the spread of disease, and the work of civic and government departments in the development of nature's gifts and in the preservation of national health should be treated in their relation to man.

Moreover, the data given should be treated from the *biological* standpoint, not that of botany, zoölogy, or human physiology. Ideally, we might take up general principles and draw from the great storehouses of plant, animal, and human biology to illustrate each principle before going on to the next. Practically, however, such a plan does not seem to be workable, partly because of the difficulty of collecting enough material to make such demonstrations possible. It is impracticable with immature students, because they cannot grasp the many-sidedness of the application at once. This will only come after *repetition* of the principle, each time from a slightly different point of view.

It frequently happens that the related study of plants and animals may be taken up to advantage. Insects and flowers, both plentiful in the fall, may well be studied together for the relation of life habits and adaptations in the insect to cross-pollination of flowers. Applied biology, in its relation to plants or to animals, must of course be treated from all sides. The fungi and the bacteria in their relations to man are conspicuous examples.

The following chapters present such a course as has been outlined above. Beginning with a brief treatment of the constitution of the environment of plants and animals, it is shown that both animals and plants take certain materials from their surroundings, and that they may be profoundly modified by the factors in their environment. The flower and fruit, together with the related topic of insects in their relation to flowers, are taken up in the fall when material is abundant. Reproduction and the survival of certain plants because of their adaptations is the central theme. Considerable emphasis is placed on the subject of fruits useful to man, plant breeding, and other topics of economic importance. In the study of the seed and seedling, the external factors influencing growth are emphasized. The little plant within the seed is seen to be a living organism that breathes, feeds, and grows. Roots are shown to be absorbing organs, the method of osmosis being explained in detail. The subject of soils and the relation of bacteria to crop rotation is taken up at this point. A discussion of the stem introduces the idea of transportation of material. The leaf serves to introduce the pupil to plants as food and oxygen makers. Forestry is developed at this time, considerable emphasis being placed on the need for conservation. Then follows a discussion of plants of various forms, of the simplest of plants, and particularly with the economic relation existing between plants and animals. The lower forms of plants form an excellent introduction to the lowest animals, and the conditions existing in a balanced aquarium or a hay infusion serve as a text to show the larger relations existing between plants and animals. In the study of animal life, a number of types have been introduced, not with the idea that the pupil will take all, but that an option will be given. The best order of topics in the spring term will be: Protozoa; the Metazoa (either sponge or hydra), used to develop the concept of a collection of cells, and the physiological division of labor, worms or crustaceans, the latter to illustrate adaptations in animals; the insects for the sake of elementary classification and some general biological considerations well taken up there; and then the vertebrates. The fish may be used as a study of adaptations (in which case the crustaceans may be omitted), and the frog, when taken at the spawning season, may be studied for its development, and as a

basis for the anatomical basis needed in the study of human physiology. Birds, reptiles, and the Mammalia are discussed from the economic standpoint, no laboratory work being required. Field work on these forms should be encouraged. The later chapters treat of man as an animal and a mammal. After a brief anatomical consideration of adaptations in the skeleton and muscles, the skin as an organ of protection and excretion, and of the functions of the nervous system, a study of foods and dietaries is begun. Then come digestion and absorption, blood and its circulation, respiration and excretion. A final chapter treats of health and disease from the standpoint of private and public hygiene.

If the work begins with the spring term, the introductory chapters may be taken, then the seed and seedling, root, stem, leaf, flower, and fruit, reserving the treatment of the cell, simple plants, and the bacteria until the end of the term. This allows taking up the thread in the fall where it was dropped, with an introduction through the balanced aquarium and the hay infusion to the relations existing between plants and animals. The best order of topics in the fall seems to be : protozoa, some simple metazoan, insects (taken while living insects may still be obtained), then such other groups of invertebrates as desired, the year's work again culminating with the vertebrates and biology as applied to the human animal.

The courses as outlined above are held together and made continuous by certain biological ideas and ideals, which are kept before the pupil from the beginning to the end of the course. Man is the center of the course, and at the last the illustrations are applied to the human mechanism.

This plan includes the solving of a number of problems in biology, each of which is more or less determined by the one immediately preceding it. So far as possible, the problems have a human interest. Abstractions are not part of the thought of a first-year pupil. Concrete problems, related when possible to the daily life of the pupil, have been used. The problems are stated in the form of laboratory exercises or suggestions, the material for which is in the hands of the pupil or is worked out as a demonstration before the class. In all cases the laboratory types or physiological experiments demonstrate some important principle of biology.

The laboratory exercise immediately precedes the textbook discussion, the latter being used to clear up any false inferences the pupil may have made from the specimen in hand and to fix the object of the problem in the mind of the pupil. Too often has a laboratory exercise meant nothing to a pupil but "busy work." A plainly outlined and organized plan of attack, a few references to the text or to previous work performed, and a definite problem will result in better and more definite laboratory work. For use with this book a manual for the solution of laboratory problems has been prepared by my coworker, Mr. R. W. Sharpe. The problems to be solved with the aid of the manual are in boldface italics. It is neither expected or desirable that a pupil take all of the problems so indicated in a year's course.

Two styles of type have been used in the text. The larger type contains material which is believed to be of first importance, the smaller type the less important topics. The manuscript was read in its entirety by Professor H. E. Walter of Brown University. To him I owe sincere thanks for many helpful criticisms and suggestions.

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extracts from his excellent article in *School Science* on the effects of Alcohol. R. W. Coryell and J. W. Tietz, two of my former pupils, made several of the photographs of experiments.

At the end of each of the following chapters is a list of books which have proved their use either as reference reading for students or as aids to the teacher. Most of the books mentioned are within the means of the small school. Two sets are expensive: one, *The Natural History of Plants*, by Kerner, translated by Oliver, published by Henry Holt and Company, in two volumes, at $11; the other, *Plant Geography upon a Physiological Basis*, by Schimper, published by the Clarendon Press, $12; but both works are invaluable for reference.

For a general introduction to physiological biology, Parker, *Elementary Biology*, The Macmillan Company; Sedgwick and Wilson, *General Biology*, Henry Holt and Company; and Verworn, *General Physiology*, The Macmillan Company, are most useful and inspiring books.

Two books stand out from the pedagogical standpoint as by far the most helpful of their kind on the market. No teacher of botany or zoölogy can afford to be without them. They are: Lloyd and Bigelow, *The Teaching of Biology*, Longmans, Green, and Company, and C. F. Hodge, *Nature Study and Life*, Ginn and Company. Other books of value from the teacher's standpoint are: Ganong, *The Teaching Botanist*, The Macmillan Company; L. H. Bailey, *The Nature Study Idea*, Doubleday, Page, and Company, and McMurry's *How to Study*, Houghton, Mifflin Company.

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