EDUCATIONAL BIOLOGY

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PREFACE

Education is essentially a subdivision of biology; it deals with methods of modifying the behavior of organisms. The fact that the organisms are ourselves and that we are intensely interested in problems of human behavior does not at all remove education from the domain of biological law. Children, the usual subjects of formal education, are first of all young animals, with all the problems of physiology, hygiene, and behavior that this connotes. Realization of these facts has caused those who are responsible for the training of teachers to advocate a fundamental course in biology for prospective teachers.

The specific purpose of the course in educational biology requires a somewhat different treatment of the subject from that characteristic of conventional courses in biology. Such courses have been commonly constructed with a view to the needs of the student who will continue his study of biology in college and may possibly make it his major work. The student of educational biology will become a teacher, but not a professional biologist and very probably not even a teacher of biology. The prospective teacher is interested in biology for its immediate use as an introduction to such subjects as hygiene, nature study, physical education, psychology, sociology, and child study, and in its later practical value in the schoolroom in assisting in the solution of problems of behavior.

The teacher is not the only one who is interested in human behavior, nor is it only the behavior of children which is interesting. All of us live with other people. We must always strive to adjust our own behavior to environ-

ment and to understand the behavior of others. Very often we attempt to influence the behavior of others. Fundamentally all these problems of behavior are biological problems.

The present book has been written for the first year of college, but it does not presuppose high-school biology as a prerequisite. Such investigations as have been made indicate that about one half of those enrolling in teacher-training institutions have had no previous training in biology. Since those students reporting previous study of the subject have not studied it later than from three to five years previous to graduation from high school, it may be supposed that a considerable proportion of these have but a limited useful knowledge of biology. The earlier chapters of the book will of necessity be in the nature of a useful review to the few who have had a thorough course in elementary biology. Care has been taken to present the subject from the physiological rather than the anatomical point of view.

It is customary in many places to give educational biology without laboratory work. While the authors do not recommend the omission of laboratory work, they do appreciate the great value of demonstrations when carefully planned and executed. If administrative difficulties or lack of facilities make it impracticable to carry on laboratory work, generous provision should be made for demonstration and visualization. Experiments, charts, specimens, models, lantern slides, and moving pictures will go far toward taking the place of laboratory work. The projection microscope, in spite of its limitations, is an invaluable accessory. If the classroom cannot be darkened, a translucent screen will allow fair results in daylight.

The library should supplement the textbook. Bibliographies are given at the ends of the chapters, but almost

any normal school or teachers college library will contain many valuable reference books which could not be included in the bibliographies. Particularly should the instructor construct his own bibliography of useful articles in the magazines on file at the local library and in current periodicals.

The authors cannot hope to express their entire indebtedness to biological literature or to individuals. They desire, however, to express their particular indebtedness to Dr. O. W. Caldwell, of Teachers College, Columbia University, who has done much toward shaping the present movement toward biology in relation to education, and who has read and criticized the present manuscript; to Dr. C. W. Finley, of the New Jersey State Teachers College at Montclair, New Jersey, who read the entire manuscript; and to Dr. C. G. Coghill, of Wistar Institute of Anatomy, Philadelphia, Dr. J. P. Kelly, of Pennsylvania State College, Dr. D. W. La Rue, of the State Teachers College at East Stroudsburg, Pennsylvania, Dr. O. E. Jennings, of the University of Pittsburgh, Dr. R. T. Hance, of the University of Pittsburgh, and Professor D. C. Porter, of the Teachers College at Slippery Rock, Pennsylvania, who read the parts of the manuscript applying to their own particular fields of interest. All gave valuable criticisms. Much of such excellence as the book possesses is due to generous constructive criticism; its faults are the authors'.

Acknowledgments are also due for permission to publish the quotations from Kipling found in the first chapter and which are taken from "The Seven Seas," copyright 1896 and 1905 by Rudyard Kipling, and reprinted by special permission of the agents, Messrs. A. P. Watt and Son, and Doubleday, Doran and Company, Inc., publishers.

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CHAPTER I

A NEW WORLD

Man is ever an adventurous animal. The child who lives across the road from a woodland can never be satisfied until he has explored it. Grown to manhood, the same urge sends him to the far places of the earth to explore the polar regions, to navigate unknown rivers, to risk his life in desert wastes or among strange tribes. The dreams of adolescent boys are all of adventure. One generation dreamed of fighting Indians and killing buffalo on the plains. Another planned to go to sea, and their intrepidity made of the United States a great maritime nation. The present generation appears inclined to take to the air and fly to the remote parts of the earth.

It may be that Americans are particularly venturesome. Certainly the fact that our fathers and mothers left home and friends to tempt fortune in a new land argues that most of us come from a daring stock. It was the spirit of adventure as much as anything else that sent the thin line of pioneers from the Alleghenies to the Pacific coast in less than a century.

The frontier is gone, and with it has gone much of the opportunity for the older type of adventure. During the last three or four generations the West has beckoned to the adventurous. Many an American family traces its lineage in a series of jumps across the continent as each

generation pursued the frontier. This onward movement of settlement has overflowed the whole country so that there is little room left here for exploration and adventure of the older type. Indeed, the world as a whole is now rather well known, though there are numerous local regions not yet explored or subdued. In general, the period of geographical discovery and the exploration of the unknown has passed, but there are other outlets for the spirit of adventure. There are other fields for discovery.

In all ages there have been those who adventured into a world of new ideas. The man who first tamed fire to his use and made it a servant instead of a menace was one of the world's greatest adventurers. The man who chipped a piece of stone into the first tool had discovered more than Columbus did. Those men who domesticated animals and began the cultivation of plants opened a field of exploration that has not yet been exhausted. It is to this kind of adventure — the adventure into new fields of knowledge — that the human race owes its progress.

Scientific investigators are the lineal descendants of the Stone Age men who brought fire, stone, animals, and plants under their control. The men who in earlier days would have been exploring new lands and exploiting forests, prairies, and mountains are in this generation exploring new continents in the physical and biological sciences, and bringing under man's control his natural environment. Of such Kipling has said,

We were dreamers, dreaming greatly, in the man-stifled town;
We yearned beyond the sky-line where the strange roads go down.
Came the Whisper, came the Vision, came the Power with the Need,
Till the Soul that is not man's soul was lent us to lead.

The present is a period of scientific discovery. In the two centuries following Columbus people came to know more about the world geographically than had been learned during all the previous history of mankind. Similarly, in the last two centuries the advance in knowledge of natural laws and consequent control of environment has been greater than in all the preceding history of the race. Those who have won this new knowledge for us have dared and risked as greatly as have other adventurers in tropic jungles or arctic wastes. It is well known to students of X rays that, while relatively small exposure to the rays may be beneficial, daily exposure for years is harmful and may cause death. In the face of this knowledge, more than one investigator of X rays has continued his task like a soldier on the battlefield when he knew that his own death would finally result from his experiments. At the sacrifice of his life, he contributed to the knowledge

FIG. 1. Hideyo Noguchi

Few persons illustrate the romance of modern science better than Dr. Noguchi. He was born in Japan and received his early medical training there. Coming to the United States to continue his education, he was soon appointed to the staff of the Rockefeller Institution for Medical Research. He carried on bacteriological and other investigations in the United States, South America, Asia, Europe, and Africa. He was one of the foremost American men of science. Much of the advance made in our knowledge of trachoma, spotted fever, yellow fever, and other diseases is based upon his researches. In 1928 he died from yellow fever on the Gold Coast of Africa, where he had gone to continue his investigation of that disease. He honored the United States by his residence in it. The whole world is his debtor

which now makes it possible for others to use the rays in safety. Such heroism is not unusual. The lives of such heroes inspire us to continue their work of discovery (figure 1).

> Follow after — we are waiting, by the trails that we lost,
> For the sounds of many footsteps, for the tread of a host.
> Follow after — follow after — for the harvest is sown:
> By the bones about the wayside ye shall come to your own!

The fruit of knowledge is power. Knowledge of the laws of nature gives man power to control nature to his needs. The old explorers found a continent and showed us its natural features. The new explorers — scientists and inventors — have shown us new ways to make the continent useful. When America was discovered it was looked upon as having little importance excepting as a possible source of gold and other precious substances. There were many who were ready to adventure to the exploration of the interior, but few who cared to settle there to develop farms or cities. There was farming land in plenty, but the work of the farm could be carried on only with hand tools not much different from those used by the ancient Romans, and the products of farms, forests, or mines could be transported only on wagons drawn by horses or on boats that were rowed or poled by men. Under such conditions little could be produced even by great labor, and still less of the products of the great interior of the continent could reach the waiting consumers. For three hundred years little use was made of any part of North America except the seashore.

The application of scientific discoveries changed the destiny of the great interior valley and of the whole country. Just as the pioneers were reaching the treeless but fertile prairies, they were supplied with the steel plow, the reaping machine, and other inventions that made it possible for a few people to cultivate large areas and harvest

large crops. At the same time the application of the steam engine to transportation by railroads, steamboats, and steamships opened the way for the products of the country to reach all markets. The bounty of the prairies overflowed not only to our own cities but to Europe as well. Probably for the first time the civilized world had enough to eat. Thus do man's discoveries give him power to control nature for his own needs. The machines of men and the knowledge of nature's laws are the basis upon which the present civilization rests.

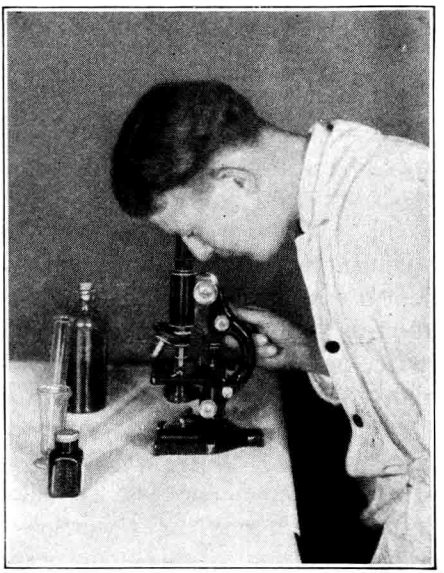

FIG. 2. A modern adventurer

This young man is entering a new world more strange, varied, and interesting than that discovered by Columbus

The bodies of men have not changed greatly through the ages. The cave men, at least, were not greatly different from us. There is no reason to think that in sight, in hearing, in bodily strength, or in mental keenness we are their superiors; yet we can see things that they were never able to see, we can hear where they could find no sound, and our knowledge is immeasurably greater than theirs. This is so because we have supplied ourselves with machines, such as telescopes, microscopes, and radios, which are practically a part of us and which supplement our meager powers.

When a man rides a bicycle, man and machine act as a unit. The man does not think about the machine, but he rides and balances automatically as if he were walking. A person who hears a distant friend speak through a telephone does not have his thoughts upon the sounding instrument an inch from his ear but rather upon the friend miles away, just as if the wire were really an extension of his own nervous system. Similarly, the microscope and telescope extend the range of vision and are accepted as naturally as if they were parts of our own eyes (figure 2). We have in our bodies no organs for the reception of radio waves, but a radio set is in effect an artificial sense organ which interprets these vibrations to us.

Biology has had its full share in the scientific advances that have marked the progress of men. Most notable, perhaps, is the control over germ diseases which has been attained. The mummies of Egypt and ancient human remains from various other parts of the world show evidence that ancient men suffered from germ diseases that were identical with those that now afflict us. The rocks of the earth contain fossilized remains of animals with indications of similar diseases, and this carries the story so much further back that there can be little doubt that disease germs are older than the human race. How greatly they have changed the course of history! Pestilence ravaged Europe repeatedly, almost depopulating parts of it; the fall of Rome may have been due as much to malaria as to the barbarians; yellow fever long prevented the building of a canal at Panama; and even now various tropical diseases make some parts of the world all but uninhabitable by white men. By microbes great conquerors have been stayed in the full flush of success, and statesmen have been stricken down with tasks unfinished.

Although for ages past the human race has been at the mercy of these destroyers, many of the germ diseases are now so well understood that positive means of cure or prevention are known. The black death cannot again decimate Europe as it did during the Middle Ages; the cholera may reach our shores, but it no longer destroys its thousands; and the yellow fever, once an annual menace, has almost disappeared from the earth. The age of pestilences and epidemics is passing. It is even within the possibilities that certain diseases may be wholly abolished from the face of the earth.

Biology has given to man many new and more productive kinds of plants and animals. A single new kind of wheat brought into cultivation just before the Great War added to the wheat production of North America just about the amount that was exported to Europe during the war years. The prehistoric domestication of plants and animals was of great importance because it made a settled abode possible for an increasing population. Present-day improvement of varieties is continuing to increase the possibilities of civilization.

Men have learned from biology something about their own heredity, and a little of this will be discussed in this book. They have also learned that some things are not inherited. The knowledge or the goodness of the parent is not inherited; it must all be learned over again by the child. The accumulation of facts, principles, discoveries, customs, and whatever else goes to make up civilization is not inherited; each generation must learn it anew. Thus it is that teaching is one of the important functions of society. If all teaching were stopped for but one generation, mankind would relapse into barbarism. By so slender a thread do civilized institutions hang.