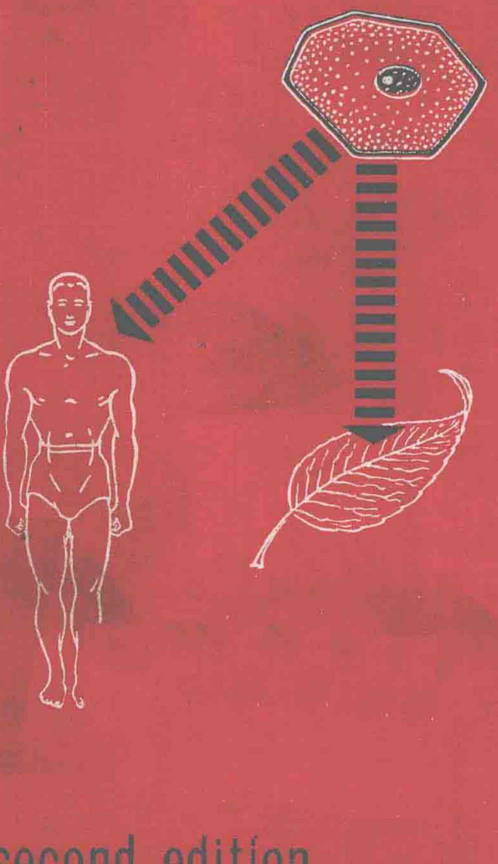
The BIOTIC WORLD and MAN



second edition

THE BIOTIC WORLD AND MAN

LORUS J. MILNE & MARGERY J. MILNE

University of New Hampshire

Second Edition

PRENTICE-HALL, INC. Englewood Cliffs, N.J. 1958

To those who have increased our enthusiasm:
our teachers—and our students

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Henry Burr Steinbach, Editor

Preface To The Second Edition

WERE IT POSSIBLE to thank individually and publicly the many biologists who have generously written us, sending helpful suggestions based on the first edition of this book, we would gladly do so. These comments plus further personal experience have led to several new conclusions.

1. Although each teacher has his own preferred organization of biological subject matter, he should be so broadly based in his subject as to be able and willing to use whatever sequence of topics will best build interest, enthusiasm, and curiosity in his students.

2. Initially, no doubt because students are animals and not plants, discussion of topics related closely and obviously to man and mammals has a far stronger appeal to most beginners.

3. Transfer of comprehension from the more familiar vertebrate anatomy and physiology to the less familiar invertebrate and plant counterparts is easier than the converse approach.

4. Extensive use of the compound microscope is more successful when planned as a block, so that technical skills are built and maintained.

To match these conclusions we have rearranged chapter material. By entering the subject through its economic aspects, the student becomes quickly aware of the social ramifications of biology, and sees the need for a systematic arrangement of the plant and animal kingdoms. By following the discussion of values with a brief consideration of classification, the taxonomic framework comes more naturally. It then holds familiar knowledge and provides a basis for later expansion.

At an early stage, the familiar is met again in examination of the chordates, for which the chief tools are simple dissecting instruments. Non-chordate multicellular animals are presented as alternative designs which meet the same functional specifications. The single-cell organisms provide a logical bridge to the plant kingdom on the one hand, and through the viruses to the non-living chemical world on the other. We have amplified the consideration of plants to emphasize again the alternatives in design features and the limitations each design imposes. For ease of presentation, hormonal coordination is treated separately in connection with multicellular function of animals and of plants; from the teaching standpoint the common denominators in hormones seemed less important.

While up-dating on the basis of new discoveries has been incorporated in all chapters, we have continued to hold taxonomic and anatomical detail to a minimum. We believe that for the student of *general* biology, allocation of

time and space to a discussion of the social implications of the subject—particularly conservation—is of far greater ultimate importance. The chapter on man's future has been reorganized to make its message clearer. We have inserted a selected series of references to informative supplementary material in books and magazines.

As in the previous edition, in lieu of a glossary, each technical term is indexed. We believe that a term or its definition has little importance on its own. It is but the hook on which to hang all future information on the topic. No one gains an understanding of baseball as an exciting game from nine, two-line definitions of the playing positions and a diagram of the field. No one gains an understanding of a community of plants and animals, or of the cooperating cells composing each one, or of the company of molecules in living substance, from brief definitions of the component parts. For this reason we encourage the student to develop instead a general understanding of each word.

L.J.M. & M.J.M.

Acknowledgments

THE LARGEST STOREHOUSES of ideas that we have tapped in preparing this volume are certainly the minds of those who taught us, the books we have read, and the conversations of colleagues. Our gratitude to these sources is nonspecific but strong. For definite and helpful criticism in the presentation of our material we are greatly indebted to Doctors H. G. Albaum and M. L. Gabriel of Brooklyn College, Harold C. Bold of Vanderbilt University, C. A. Lawson of Michigan State College, Louis B. Marks of Fordham University, H. Burr Roney of the University of Houston, R. L. Waterson of Northwestern University, and H. B. Steinbach of the University of Chicago. Dr. E. O. Dodson, then of the University of Notre Dame, suggested ways to improve our chapter on evolution. Editorial assistance of the friendliest and most judicious kind has been available to us in Mr. J. B. Plate, through numberless letters and conferences.

For illustrative material we are grateful to many: the American Museum of Natural History (Photo 403); *Arizona Highways* magazine (Photos 170, 341–342); the Army Medical Museum (Photos 23–24, 114, 203–205); the Australian News and Information Service (Photos 358–368); the Bausch & Lomb Optical Co. (Photos 50–52, 142–143); the Boyce Thompson Institute for Plant Research, Inc. (Photos 193–194); Dr. Ralph Buchsbaum (Photo 99, from *Animals Without Backbones,* University of Chicago Press, revised

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edition, 1948); the Canadian Department of Agriculture (Photos 16, 423–426); the Carolina Biological Supply Co. (Photos 91, 120, 136–137, 201–202, 347, 355); the Chanticleer Press (Photos 397–398, from L. Hogben's *From Cave Painting to Comic Strip,* 1949); Dr. G. W. Corner of the Dept. of Embryology, Carnegie Institution of Washington (Photos 222–225); the Cranbrook Institute of Science (Photos 98, 274, 378, 431); Dr. A. M. Elliott (Figs. 18-10, 20-7, 21-11, 21-18, 24-2, 24-3, from *Zoology,* Appleton-Century-Crofts, Inc., 2nd edition, 1957); the Elsevier Publishing Co. and Dr. Maurice Burton (Photos 138, 231, 302–304, 411, 458); the Federal Bureau of Investigation and Mr. J. E. Hoover (Fig. 19-14); Dr. Paul D. Foote and *Scientific Monthly* (Fig. 7-2); W. H. Freeman & Co. (Fig. 11-4, from G. Hardin's *Biology—Its Human Implications,* 2nd edition, 1954); the Fouke Fur Co. (Photo 446); Dr. J. L. Gamble of the Dept. of Pediatrics, Harvard Medical School (Photos 60–61); the General Biological Supply House, Inc. (Figs. 4-4, 20-2, 20-3, 21-5, 21-6, Photos 64, 79, 88, 103–104, 107, 127, 140–141, 153–155, 163, 197, 210–217, 250, 348–351, 457); Geological Survey of Canada (Photos 401, 407–408, 412–414); Dr. R. B. Greenblatt of the Medical College of Georgia (Photo 124); Dr. L. A. Kenoyer and the Armazy Sponge Co. of Detroit (Photo 87); Dr. L. O. Kunkel of the Rockefeller Institute for Medical Research (Photo 145); the McGraw-Hill Book Co. (Figs. 8-17, 23-4, from T. I. Storer and R. L. Usinger, *General Zoology,* 3rd edition, 1957); Marine Studios, Marineland, Florida (Photos 69–71, 101); Merck & Co., Inc. (Photo 151); the National Audubon Society (Photo 456); the New York Zoological Society (Photo 430); Dr. E. A. Park and the F. A. Davis Co. (Photos 62–63, from Park and Eliot, *Cyclopedia of Medicine,* 1951 edition); the Radio Corporation of America (Photos 54–56); R. C. A. and Dr. R. Wyckoff (Photos 144, 147, 149, from Wyckoff's *Electron Microscopy, Technique and Applications,* Interscience Publishers, Inc., 1949); Mr. C. G. Reather, Dept. of Embryology, Carnegie Institution of Washington (Photo 221); Miss Jane Roller of Washington, D. C., and Dr. L. A. Kenoyer of Western Michigan College of Education, and Harper & Bros. (Fig. 9-8, from Kenoyer & Goddard, *General Biology,* 1945); *Scientific American* and K. Chester (Photo 422); Dr. E. K. Shelton of the Shelton Clinic, Los Angeles (Photos 125–126); Mr. H. Spencer of Chester, Conn. (Photos 20, 22, 34, 157, 180–182, 219–220, 252, 256, 280, 387); E. R. Squibb & Sons (Photos 57–59); Dr. W. C. Stanley of the Virus Laboratory, University of California (Photos 146, 148); C. C. Thomas, Inc. and Dr. Z. P. Metcalf (Figs. 8-13, 8-16, 11-10, 23-10, from *An Introduction to Zoology,* 1932); Mr. H. F. Thornley of Utah State Agricultural College (Photo 26); the U. S. Department of the Interior, Fish & Wildlife Service (Fig. 21-12, Photos 36, 38–41, 49, 68, 288, 445, 447, 449–453, 459, 461–463, Endpaper Photo *O*); the U. S. Department of Agriculture, Forest Service (Photos 14–15, 19, 31–32, 373, 441–442), Soil Conservation Service (Figs. 24-6, 24-7, 24-8,

Photos 433–440), Bureau of Entomology and Plant Quarantine (Photos 27–30, 33, 35, 255, 320–322), Bureau of Plant Industry, Soils, and Agricultural Engineering (Photos 17–18, 21, 427); Ward's Natural Science Establishment, Inc. (Photos 77, 81, 92, 134–135, 162, 246, 261, 310, 316, 415, 419, 429); the Williams & Wilkins Co. (Photos 420–421, from P. Popenoe, *The Child's Heredity,* 1929); Mr. William Woodin III (Photo 2); and Dr. P. W. Zimmerman of the Boyce Thompson Institute for Plant Research, Inc. (Photos 188–190).

The remaining line drawings and photographs were freshly prepared for this book. Drs. Roy L. Donahue and Harry L. Shapiro kindly supplied data for Figs. 21-18 and 23-14, respectively. With many of the photomicrographs we had expert assistance from Mr. John W. Anderson. He has kindly permitted us to use his own photographs in the end papers (*I, K*).

For permission to include extracts from their books we are obliged to Harper & Bros. (Mark Twain's *A Tramp Abroad,* 1880 and G. Eckstein's *Everyday Miracle,* 1948); Houghton-Mifflin Co. (D. C. Peattie's *American Heartwood,* 1949, and D. C. Peattie and N. Peattie's *A Cup of Sky,* 1950); Oxford University Press, Inc. (A. Leopold's *A Sand County Almanac,* 1949); *Science* for the comments by W. M. Wheeler; William Sloane Associates, Inc. (L. J. Halle, Jr.'s, *Spring in Washington,* 1947, and J. W. Krutch's *The Twelve Seasons,* 1949); Mr. Roland Young (*Not for Children,* Doubleday, Doran & Co., 1930); and Dodd, Mead, Inc. for use of passages from our own *A Multitude of Living Things* (1947).

For much needed encouragement during the long gestation period of this book and for critical assistance in correcting errors or improving clarity we are particularly appreciative of the efforts of our friends and colleagues in the biology staff at the University of New Hampshire. Dr. Charlotte G. Nast and Dr. Emery F. Swan have been most helpful in these directions.

L.J.M. & M.J.M.

Foreword

IN THIS NEW BOOK on living things, the authors are expressing their own enthusiasm for the broad and integrated approach. They are convinced that a factual understanding of biological science improves chances for a successful, happy, and useful life.

The field of biology is so vast, and annual additions to it so impressive, that elimination of nonessential information seems of paramount importance. We have striven to include chiefly the background needed for intelligent evaluation of reports on scientific progress in modern magazines and newspapers. Yet appreciation of a science differs markedly from that of art, or literature, or history. Science is an edifice, built on interpretation of a growing mass of facts, whereas a picture or a play stands more on its own. Shakespeare, as studied in 1800, 1850, or 1900, remains basically unchanged. History can assume that driving forces go back only a small number of human generations, and any national or international situation can be analyzed in a definite period of years. But if any major body of scientific fact is omitted from consideration, the interpretations based on them no longer have validity. This is the essence of scientific method.

Biology differs vastly from decade to decade and, like other sciences, must be reviewed repeatedly. Only after 1800 was the significance of fossils appreciated widely; after 1850 the evolutionary point of view linked many previously unexplained correlations; that microbes cause disease became evident less than a century ago; in 1900 biology could offer no solid information on heredity; the use of antibiotic substances from living organisms in the treatment of human ills goes back little more than a decade. Vitamins and hormones are recent discoveries. In 1910 no one had done much to analyze the inter-relationships of animals and plants with their environment, or to survey possible needs for conservation practices. Whole new branches of biology arise at irregular intervals, each built on the old and seldom reducing the importance of earlier information.

To save space for emphasis on biological principles and the values of biological study to mankind, we have dispensed with much cherished terminology and detail. Facts are easy to memorize, to look up, and to forget. Principles require for their understanding both factual background and a higher category of mental activity. Understanding becomes a kind of adhesive web to which present and future facts can cling. Pulling information from any point in such an intellectual fabric stretches adjacent parts of the web and brings related data into use. The well-knit mind, supplied with a

moderate load of facts, seems far more to be desired than a walking encyclopedia arranged only in alphabetical order. Details committed to memory may have a place in elementary schooling, and they must be a part of the working knowledge of specialists. But the information and approach of the present book are concerned with features needed for comprehension of scientific method, for presentation of biological principles, for understanding of human organization, and for a clear conception of the importance of other animals and plants. Through these avenues life takes on new possibilities and new freedoms.

A significant part of scientific method is analysis of a situation, and description of it in as precise terms as can be managed. We have tried to avoid terms for their own sake, introducing only those that would be needed and met again. Often they are familiar words employed with a more exact significance. To draw attention to them as they arise in the chapters, boldface type has been used. Beyond this vocabulary is the application of it, and this need not be technical. Often it is merely normal curiosity directed into profitable channels. Nor have we neglected the natural history approach that is the beginning and basic satisfaction in biology. A sympathetic interest in fellow living organisms brings greater pleasure in watching them, and provides a saner, better informed realization of the value of a sound conservation program. We hold that such is an essential foundation for every educated person.

An education is what remains as an individual's point of view and mode of thinking after most of the details learned in school have been forgotten. Many of the facts may seem useless in prospect and in immediate retrospect. So are the weary footsteps by which a person climbs a mountain. But without the steps there is no view.

Durham, New Hampshire L.J.M. & M.J.M.

This book is written not for knowledge, but for action.

—ARISTOTLE

Endpaper Photos

A *Eastern winter: paper birch trees overlooking a snow-covered, frozen lake at the base of Mount Chocorua, New Hampshire.*

B *Western summer: a young bull moose browsing on vegetation in a shallow beaver pond near Moose, Wyoming, in the broad valley of Jackson Hole.*

C *A bright-eyed robin watching for earthworms.*

D *Frontier vegetation along the milky stream issuing as meltwater from the Nisqually Glacier on the side of an extinct American volcano—Mount Ranier in Washington.*

E *A Pennsylvania katydid on a leaf listens to others of its kind, using "ears" located just below the knee joint of the forelegs.*

F *As a larva, this longicorn beetle bored galleries in a dying pine tree near Lake Ontario. The spread of the insect's sensitive antennae totaled 4½ inches.*

G *Sea purses are black leathery bags with a twisted projection at each corner. The projections become entangled in the seaweed among which these eggs are laid, until the young skate or ray hatches. Storms often toss the empty shells on the beach.*

H *The two large forward-facing eyes of this jumping spider allow it to leap accurately ten to fifteen inches, from branch to branch, or to capture prey. Such a leap amounts to from thirty to fifty times the length of the spider itself.*

I *Wind-catching parachutes provide transportation for the many seeds in a dandelion head. (Photo by courtesy of John W. Anderson.)*

J *Morning dew in the Florida Everglades places pearl-like spheres on every orb web strung by a busy spider during the quiet of the night. Some of these webs are six feet across, and stretch from tree to tree.*

K *A dogfish (shark) just prior to birth, still carrying a supply of food in the large yolk sac. (Photo by courtesy of John W. Anderson.)*

L *The sacred scarab of Egypt rolls a ball of dung to a suitable burying place, there to leave it together with an egg, as a food store for the hatching larva.*

M *A sand collar is the egg mass of a large carnivorous snail. It is formed of a mixture of mucus, eggs, and sand around the outspread foot; then the parent departs through the gap, leaving her six-inch product to wave in the sea water until the eggs hatch.*

N *The chrysalis of a swallowtail butterfly is supported both at the abdominal tip and also by means of a silken loop spun by the caterpillar just before metamorphosis. The transitions from caterpillar to chrysalis and from chrysalis to adult require only a few minutes, but the changes within the chrysalis require a number of days.*

O *Canada geese over an Arkansas wildlife refuge. (Photo by P. J. Van Huizen, U. S. Fish & Wildlife Service.)*

P *This large green turtle staring through a porthole of the giant marine aquarium ("ocean-arium") at Marineland, Florida, is a near relative of turtles at Key West, in pens awaiting conversion to turtle soup and turtle steak.*

Q *The many-branched arms of a basket star may confuse the apparent radial symmetry of its body. Nets reaching the bottom in sea-fishing operations often gather in one of these less familiar echinoderms.*

R *A young buck of the pronghorn antelope exercises by bouts with others of his kind, and by using his horns to uproot sagebrush or other tough bushes of the arid lands—playing with them as though with a ball.*

S *Carl Linnaeus reduced the long Latin descriptions of plants and animals to a pair of words which could serve as a scientific name.*

T *The adult stage of the antlion shows none of the ferocity of the larval stage. The antlion or "doodle bug" excavates conical pits in sandy soil and thrives on the juices of ants or other insects that blunder down the treacherous slopes.*

Contents

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1. FRONTIERS. 2. EVIDENCE. 3. GENERALIZATIONS. 4. PERSONAL RESPONSIBILITIES. 5. PUBLIC RESPONSIBILITIES.

EACH YEAR a new class of students begins college work, headed toward a bachelor's degree. Often the individual student lacks a clear idea as to the significance of the coveted letters.

The general public has a far firmer notion of what a college education means, although this notion is unrealistic. "They" expect the holder of a bachelor's degree to be widely read, familiar with the basic principles in every field of learning, and to have a mind ready to apply this knowledge to each problem or discussion that arises. The press may reflect disappointment that fresh graduates come short of these expectations. But the underlying conviction remains unshaken.

The student must exert himself in every one of his four years to merit even part of this esteem. He dares not specialize in language or science, in history or animal husbandry, to the point where his curiosity has no edge in other subject realms. Life is not so tightly compartmented. Prime interests of the moment often become secondary. Progress in a job may be barred because a graduate has deliberately narrowed his education and avoided the background for broader assignments.

1. FRONTIERS

In the liberal arts tradition, an education is a cohesive and cumulative experience. It is aimed toward helping a person toward intellectual maturity, toward informed, considered, nonemotional judgments. It seeks to develop a way of thinking that can be applied to any problem. The benefits of this education are expected to be more obvious ten or twenty years after graduation than during the educational process.

To be useful into an indefinite future and relate to unpredictable events in years to come, an introduction to biology must acquaint the student with the field as a whole, give some historical perspective to the subject, and encourage interest in its progress. Detailed attention cannot be given to any single aspect without sacrificing the breadth of overview.

Unlike some other fields of knowledge, however, biology requires for appreciation of even basic principles a consideration of underlying facts which are unfamiliar to many people. Moreover, the discovery of new facts may call for a change in understanding and a restatement of a scientific principle. But facts have an eternal quality about them, and give stability to the entire subject. This distinction must become clear before scientific progress can be understood.

A general biology course may provide the chief contact between a student and a research investigator. The student needs to learn what the biologist does to gain new information in the field or in his laboratory, and to see how fresh findings are integrated with earlier knowledge in planning future investigations. The frontiers of knowledge lie close enough in biological sciences for the student to see them. On these frontiers newsworthy discoveries are made every year. Gaining a perspective from which to appreciate new advances in biological and medical science is an essential part of a broad education.

2. EVIDENCE

A laboratory science is a way of thinking, of planning experiments, of analyzing results, of seeking implications from facts. The method, rather than the facts, may seem the most important feature.

Scientific method is a state of mind. It shows progress in a lack of finality in findings. It

stresses open-mindedness, tolerance for judgments toward which factual support is ready, and caution over opinions lacking this background. It displays wide interest in every ramification of any piece of information. With practice, this way of thinking becomes a habit of thought. It encourages a person in any field of endeavor to inquire "What is the evidence?" And to expect an honest, verifiable answer.

3. GENERALIZATIONS

If biology were merely a cataloguing of information, a process of pigeonholing facts, of accumulating an encyclopedia, it would not be a science. But the facts are related to one another. A disease of plants has features in common with a different disease of animals. Human respiration is like the respiratory process in almost any living thing. Even the building blocks of which animals and plants are constructed are composed of corresponding materials throughout. Consequently, information learned about one type of life can often be applied (after testing) to others, including man.

In biology a search is made for generalizations that can be applied. The breadth of each is measured. Underlying causes are sought. And practical advantage is seen in this interchangeability of information. It becomes worth while to study every kind of living thing.

4. PERSONAL RESPONSIBILITIES

Each human being is a separate animal. Like every other living thing, he is a cooperating system of component parts. So long as the components operate normally and coordination is good, the individual is "healthy." If something goes wrong, symptoms of abnormality appear.

Usually the first observer of these symptoms is the person afflicted. This is true partly because a physician cannot live with his patient as intimately as the patient lives with himself. And to know when a physician's help should be asked, a person needs to know as much as possible about what each symptom can mean.

The value of personal understanding of body function and early recognition of significant symptoms can be seen in the statistics for death from cancer. A far smaller percentage of medical men die from this malady than is characteristic of the population as a whole. Most medical men detect their own cancer symptoms early enough to be cured.

5. PUBLIC RESPONSIBILITIES

Whether he likes it or not, man is completely dependent upon green plants for all the food he eats, all the oxygen he breathes, for the continuous flow of many of the springs from which he obtains drinking water, for lumber, and for many other materials used in technology. His welfare is linked to the continued activity of green plants. Anything that is detrimental to green plants is harmful indirectly to mankind.

It is not enough for a few specialists to know how a plant operates, and to understand what affects plant welfare. The future course of civilization depends to only a limited extent upon scientists. It is the general public, their elected officials in government, and appointees of these people, who determine policies affecting the future of all.

The educated person must know enough of the structure, operation, and role of vegetation to be able to express an intelligent, informed opinion when his participation in public affairs demands it. The pros and cons of a new dam for electric power or irrigation may involve the submergence of vegetation. Is the overall picture worth while or likely to be detrimental? Installation of sewage disposal systems or smoke-abatement devices may raise the costs of local commodities. Is the expenditure advisable? What is at stake? The responsible citizen cannot depend entirely on the advice of experts. He must be able to evaluate their recommendations, to ask further facts, and to understand what he is supporting. These responsibilities require knowledge.

Man, with his civilization and domesticated animals, constitutes the chief hazard for plant life today. Unwittingly he can upset age-old balances between local plants and local animals. Neither the plants nor the animals concerned may be of any direct interest to him, but their balanced activities determine in large degree that the land he occupies has the characteristics he finds worth using.

This balance is not merely the problem of

the forester, the lumberman, the farmer, the rancher, the trader, or the businessman. The standard of living of the entire country is threatened. It becomes everybody's business to see that our lands are not wasted, that we build for the future by wise use of the present.

Many of these responsibilities are delegated to government agencies. Agencies, however, function properly only as long as they know the citizenry to be vitally interested in their operations, and aware of recommendations and practices. Agencies cannot succeed without the support, both financial and moral, of the people they represent.

To appreciate better these practical problems, it is important to have a reasonable awareness of the plants and other animals. A nodding acquaintance with the various kinds of creatures leads to a respect for them and their rights to life. This appreciation leads naturally toward enlightened cooperation with conservation programs. It develops at the same time a better understanding of the complexities of human existence.

Even the pursuit of happiness—guaranteed by our Constitution—is easier if hobbies are at hand. In the biology field, hobbies can have the double value of enjoyment by the individual and extension of scientific knowledge for the benefit of all.

Sometimes the information organized in biological science seems impressive. One central fact should be kept in mind: What is now known about living things is infinitesimal in comparison with what remains to be discovered.

EDUCATION

It has been said before that a fundamental aim of education is to enable men to live in time and space beyond the present and the immediate. The majority of uneducated men and women appear to lead entirely somnambulistic lives, never pausing between the cradle and the grave to look up from the immediate task in hand, never raising their heads to take stock of the long past or to survey the plains and mountain ranges that surround them. In their trade, in their daily occupations, even in the thoughts they express and the opinions they hold, they move without consciousness of worlds beyond their own. Ask the uneducated tailor for a description of the universe and see if it does not bear a striking resemblance to his own shop, even though the reality stretches away from his door. To the uneducated politician the goal of life is the advancement of his party, to the uneducated intellectual it is the advancement of his cause or the acceptance of his dogma. Each measures the world by his own shadow, overlooking the assistance he had from the sun in casting it. All these people are the victims of circumstances they cannot hope to understand, whether it is the American mechanic who shouts for democracy or the European barber who shouts for a dictator. In their somnambulism they are bound to the wheel of the immediate present, and will be freed only when education has awakened them to the breadth and scope of the universe they share in common.

—LOUIS J. HALLE, JR. in *Spring in Washington* (New York: William Sloane Associates, Inc., 1947), pp. 40-41.

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