third edition

BIOLOGY

and its relation to mankind

A. M. WINCHESTER

A. M. WINCHESTER, PH.D.
Professor of Biology
Colorado State College, Greeley

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AND ITS RELATION TO MANKIND

THIRD EDITION

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Preface

THIS THIRD EDITION of *Biology and Its Relation to Mankind* has been completely rewritten to include many recent discoveries, especially in the field of molecular biology; our knowledge in this field has been expanding at an explosive rate thanks to the concentration of research in this area in recent years. At the same time, the author has not neglected those basic fundamentals of biology which have served as the foundation of this subject in the past. The new frontiers of investigation are interesting and challenging, yet they have meaning only through their relation to the whole organism.

The author has sought to adhere to principles which proved popular with the many users of the first two editions—namely, to produce a book which is understandable and stimulating as well as instructive to beginning students of biology. As the title implies, biology is presented with special reference to mankind. A beginning student evinces a greater interest in things which are of direct concern to himself. Many biological principles which might otherwise seem dull and uninteresting become vital and compelling when their relation to man becomes apparent. The text is liberally illustrated with diagrams and photographs, most of which were made by the author specifically for this book. In this way there is a correlation between text and illustrations which is difficult to achieve when an author depends upon others for his illustrative material. Yet he also gratefully acknowledges his indebtedness to others for many illustrations. A list of their source will be found following Contents.

The book is ample as a text for a full year's course in biology, yet it can easily be adapted to shorter courses by omission of certain sections. This fullness enables the teacher to exert a greater degree of control over the material to be included than would be possible with a shorter book. Unassigned parts may also serve as valuable reference material for the student. A laboratory manual is available from the William C. Brown Company, Publishers, of Dubuque, Iowa.

Many have been of assistance to the author in preparing this third edition. Lack of space makes it impossible to acknowledge all of these, but some who have been particularly helpful are Dr. Daniel Arnon, of the University of California, for his suggestions on the process of photosynthesis; Dr. H. J. Muller, of Indiana University, for suggestions in the sections on genetics; Dr. William Shull, of the University of Michigan, for suggestions and illustrations concerning human genetics; Dr. C. M. Pomerat, of the Pasadena Foundation for Medical Research, for valuable suggestions and photographs on cell biology. In addition, my colleagues at Colorado State College have always been available for answering questions and making suggestions on specific topics. These include Dr. Arthur Moinat, Dr. Maynard Stamper, Dr. Robert Sund, and Dr. Bert Thomas. To all of these the author is deeply grateful, yet he assumes full responsibility for the content of the book.

Greeley, Colorado
March 1964

A. M. WINCHESTER

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1

The Science of Biology

LIVING matter is a subject of inexhaustible fascination. What marvel can match the transformation of a tiny cell, no larger than a pinpoint, into a complex organism like the human body? Or the instinct that prompts a bird to forsake its southern haunts at a destined time each year and travel thousands of miles over land and water to some ancestral nesting region in the north? Or the manufacturing process carried out in the leaves of plants which converts simple elements from water, air, and soil into food? Such marvels—and the list of them is all but endless—fall within the field of study called biology, a science that seeks to understand the activities of living things. Many and complex are the ramifications of living reactions that must be investigated before such an understanding emerges. But the reward of study is great: it is to share in the fascinating secrets of life uncovered through the centuries by the painstaking work of biological scientists.

For prospective physicians, nurses, laboratory technicians, agronomists, bacteriologists, and teachers in the field, the study of biology is one phase of professional preparation. For the rest of us, no matter what our vocation, learning about biology cannot fail to enrich life. A simple walk through the forest, for instance, takes on a depth of meaning for anyone who has learned to observe and understand something of the boundless activity of the living beings that surround him—activity that might otherwise pass unnoticed. The silvery trail left by the snail in its nocturnal wanderings, the din of the cicada, the flutter of airborne seeds, the green scum on the pond, the decaying vegetation, the mole tunnel—all these have a living meaning; the forest is vibrant with life. Equally valuable is the understanding that a study of biology imparts of one's own body and its functions, so important for its care and protection. Finally, no one can join the ranks of the well-informed in our day without knowing something of such biological questions as the history and development of living things on the earth, the principles of heredity, the web of relations that bind living things together, and the variety of living matter in existence.

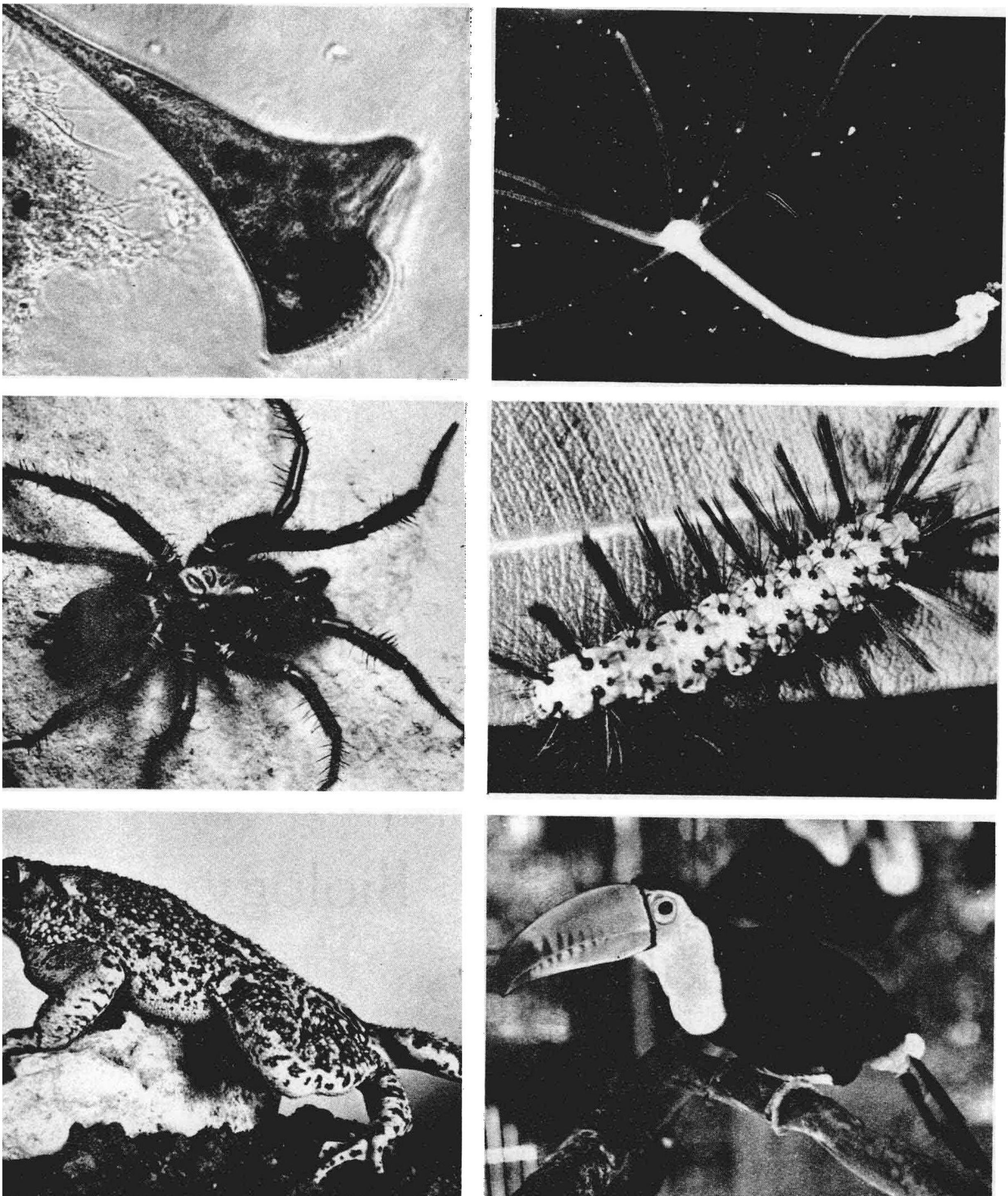

FIG. 1.1. The variety of animal life. All these creatures have characteristics in common which cause them to be classed as animals. From left to right and top to bottom: Stentor, a one-celled animal; Hydra, a small water animal; a tarantula spider; a moth caterpillar; a toad; and a toucan.

SCIENCE

Biology is a science. Traditionally, a science is defined as an organized body of knowledge; and this definition is accurate as far as it goes. But does it imply that science is static—that all scientific discoveries have already been made and that it is our task simply to organize this knowledge, use it as we need it, and pass it on to future generations? If so, we need to enlarge the definition. Science is dynamic, ever expanding as new discoveries pour in from research centers all over the world. Our concept of science should stress the aspects of investigation and discovery that make up its active side. As discoveries are made, they must be organized and integrated with the great body of knowledge that already exists.

THE SCIENTIFIC METHOD

The process typical of scientific research is sometimes called the scientific method. Regardless of topic or field of investigation, there are certain procedures of an orderly, critical method of study that are likely to bring reliable results.

Before any investigation can begin, there must be a realization of a problem. And the starting point for a scientific approach to a study is a clear-cut statement of a **problem.** It is important that the problem chosen should be rather narrow in range. An untrained investigator is liable to select a problem so complex and extensive that he could not begin to solve it in a lifetime of hard work. The simplest problems have a way of growing difficult and complex when investigation starts. If there is to be any hope of success, it is well to be quite conservative when selecting a problem for study. Suppose an eager but untrained investigator selects the method of human inheritance as a problem. Hundreds of investigators working on different phases of this problem for many years have not been able to reach a complete solution. It would surely be better to select a smaller field of investigation—for instance, how freckles are inherited in man. This problem would require extensive study, but there is a good chance that it could be solved in a reasonable time.

Once a problem has been selected, the investigator will next want to survey all of the **scientific literature** available that might have a bearing on it. He needs to know what other workers have discovered in his field in order that he may properly plan his work. He may find suggestions as to techniques of procedure which will be very valuable. The results obtained by others may also save him much time that he might lose in repeating work which has already been done. By learning what has been done in the field he can build upon this foundation, rather than having to start from the beginning. This is the great value of scientific literature. Almost never does a scientist make an important discovery through work that is exclusively his own. We say that Alexander Fleming discovered penicillin. But he could not have done it without utilizing the many discoveries about the culture and observation of molds and bacteria which other workers had made before him. Scientific research is a cooperative procedure; the more widely the results of findings are disseminated, the more rapidly will discoveries in science progress. Difference of language is an important barrier to this free dissemination, so the scientist is usually faced with the task of learning some foreign languages if he is to keep up with the findings in his field reported in foreign

FIG. 1.2. *This girl has inherited the irregular pigmentation of the skin known as freckles. The manner of inheritance of this trait can be solved by the scientific method, using observation.*

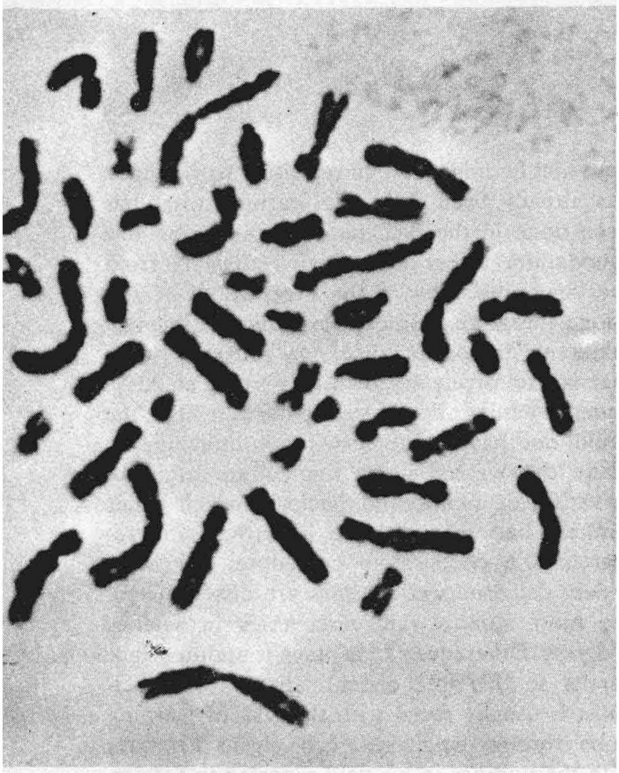

FIG. 1.3. Human chromosomes. This photograph by J. H. Tjio was one of the first that he made by a technique which showed that man had 46 rather than 48 chromosomes in the cells of the body. We continue to expand our knowledge by such improved techniques in science.

journals. Recent translation services from Russian and other languages not well known in the United States have been of great value in this regard.

After a survey of the literature, the investigator may be in a position to make a **hypothesis**—what might be described as an "educated guess." On the basis of previous findings, he formulates what appears to be the most likely explanation. To arrive at a definitive solution of a problem he needs a hypothesis which can be tested for validity. In the case of the inheritance of freckles, let us assume that the information gathered on this subject indicates that they may be inherited as what is called a dominant characteristic. Such a characteristic will show in persons who receive the hereditary factor for it from either parent, and it always is expressed in the parent who transmits it. Accordingly, a hypothesis could be formulated to the effect that freckles are inherited as a dominant characteristic.

When the hypothesis has been formulated the investigator can then test it against facts by **observation** and **experimentation**. Observation must be the primary method of investigation in some cases. In studying how freckles are inherited, we would be limited to observation, since with human beings we cannot conduct experiments in breeding as we could if we were studying inheritance of some of the lower forms of animals. We can, however, study families in which freckles are found and note the relations of kinship of the persons whose skins are speckled with irregular deposits of pigment. By tabulation and analysis of these observations on a large number of families, we might be able to draw some conclusions as to the validity of the hypothesis.

In many scientific investigations it is possible to control the subjects under investigation and to conduct experiments on them. For instance, if we wanted to learn about the inheritance of ear position in dogs, we could breed dogs with erect ears to those with drooping ears, and, through a study of the ear position in the succeeding generations, we could hope to determine the validity of any hypothesis which had been made. Of course, observation and tabulation of results would be necessary where experimentation was used. In general, results can be obtained sooner when both experimentation and observation are used than when we are limited to observation alone.

When the data are analyzed it may be found that the hypothesis which has been formulated will have to be discarded and a new one proposed. At this point the investigator must be careful not to jump to conclusions, but to wait until conclusive evidence has been obtained before advancing any hypothesis to the status of a fact or even a theory.

The word **theory** may be used to describe a hypothesis supported by such facts as are known, but with insufficient evidence for proof. Scientific theories may be very valuable in the advancement of scientific knowledge. We should take care, however, to distinguish scientific theories from scientific facts, for they are sometimes confused in the popular mind. Take the subject of biological evolution, for example. Many phases of this subject are known facts that can be proved to the satisfaction of anyone who will take the trouble to investigate. On the other hand, there are theories as to the mechanism involved and the extent of evolu-