Second Edition

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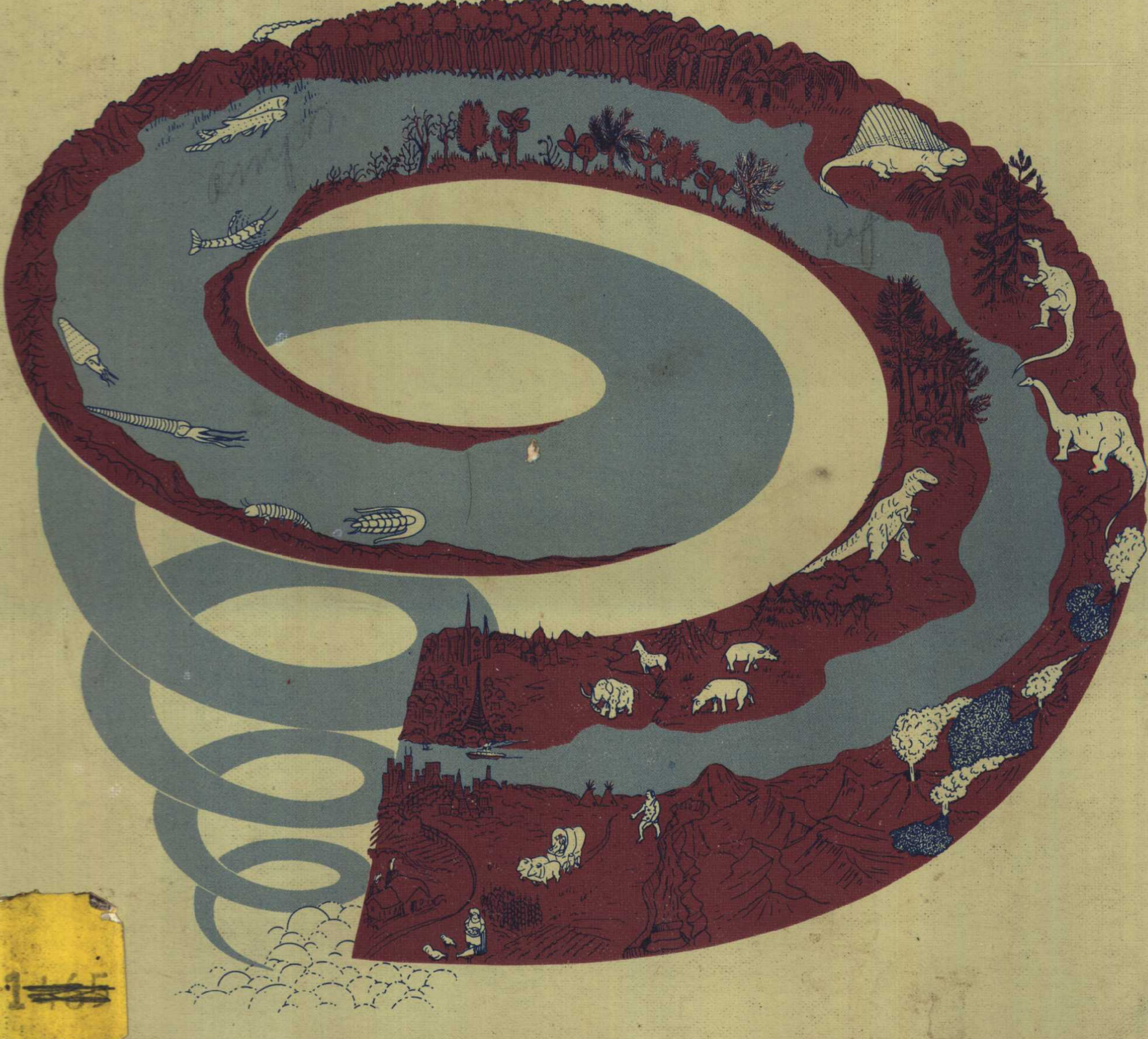
I. Michael Lerner / William J. Libby



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HEREDITY EVOLUTION and SOCIETY

I. Michael Lerner / William J. Libby
UNIVERSITY OF CALIFORNIA, BERKELEY

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The cover is an artist's conceptualization of 4.5 billion years of the evolution of life on Earth. (Illustration by Ray Salmon, after *Geologic Time*, U.S. Geological Survey publication.)

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PREFACE

TO THE FIRST EDITION

This book has grown out of a course in genetics that I have been teaching for several years to students not majoring in biology. The course was designed to satisfy so-called breadth requirements like those in many universities and colleges which force students in the humanities and arts to suffer an exposure to natural sciences. All too often this exposure consists of fact-laden introductory courses in physics, chemistry, and biology more suited for students intending to pursue these subjects in greater detail later. In the past, biology majors and nonmajors alike have been, in effect, "marched through the phyla." With the development of molecular biology the subject matter has been changed but the method remains much the same: the students are now marched through the Krebs cycle.

In my view a different approach to the biological education of a nonscientist is required. It is not simply the presentation of facts that is objectionable; it is difficult (sometimes impossible) to explain principles without resort to facts because abstractions without illustrations have no substance. The difficulty lies more in the selection of facts to be presented. For the student who must live through the last third of the twentieth century, the most important facts are those that have social implications; those bits of information that demonstrate the involvement of every human being in the ethical, social, and political problems of this age of science, problems that are multiplying in geometrical progression in the wake of scientific and technological advances.

Essential details of biology that have daily import in a person's life (what do kidneys do?) should be imparted in high school or earlier. Compulsory laboratory exercises in which nonscientists perform with foreknowledge of outcome do nothing but give wrong ideas of the methods and purposes of scientific endeavor. There is no need for an educated layman to know or to remember the sequence of the stages of mitosis, the order of the geologic eras, or the wavelengths of different kinds of radiation (although such information does appear in this book). Similarly, although much technical language and, on occasion, scientific jargon, is unavoidable in presenting technical ideas, both facts and vocabulary must be servants of ideas and principles and not their masters.

There can be a great deal of disagreement over what emphasis a single-term course on the social implications of biology should take. Problems of ecology, including conservation and pollution, or problems centering on food supply could, no doubt, claim high priority. Allowing for a personal bias stemming from my education and research activity, it seems to me, however, that genetics and evolutionary thought may call for a higher one.

First of all, organic evolution through natural selection is the most important biological generalization of the century preceding ours. The shift that it generated from a typological mode of thought to a statistical one has overwhelming social significance, for example, in connection with stereotype images of racial differences.

Second, the discovery or deduction of the formal mechanism of hereditary transmission, Mendelism, formed a cornerstone of modern biology. Last, the deciphering of the language of biochemical communication within the cell and its relation to biological communication between generations was the most important experimental breakthrough of the biology of our day.

It would be protesting too much to insist at length that the interweaving of these three scientific advances and others accruing from them is having ever-growing effects on the individual, the family, and society. They are the advances that can supply the answers to the kind of questions that Francis Crick suggests intellectuals should be concerned with: "What are we?" "Why are we here?" "Why does the world work in this particular way?" They are the advances that pose novel questions calling for decisions from all levels of existence from that of an individual to that of a world-wide society. Genetics and evolution seem to me therefore to be the main biological areas of concern to the informed layman. Within these fields the choice of topics for a single course is so vast that it has to be made in a rather arbitrary fashion. In part, it is simply dictated by the writer's interests and knowledge. But the choices of particular topics may be defended on other grounds. For example, although I have referred to the molecular revolution in biology as most important, it appears to me that the details of molecular genetics, or of the growing field of biochemical developmental genetics, or, in general, the biology of lower organisms are less pertinent to the purposes of this book than, let us say, the peripheral subject of population explosion. I see no need to defend the particular subjects chosen for discussion, except, perhaps, for the biographical vignettes. Haldane, Galton, and Chetverikov have been singled out in this manner not because they are more important than Darwin and Mendel, but because of the socially significant overtones of their life or work.

The sequence of topics may need an explanation. It was chosen by trial and error to engage the attention and stimulate personal involvement of majors in psychology, economics, history, linguistics, and forty other departments. The progression of subjects is designed to feed tidbits of information of special concern to each of the diverse groups in turn, without losing the interests of any. The book then is structured with this intent in mind.

A word is also necessary about the handling of references. I believe that the names or identities of the architects of modern genetics and evolutionary theory should form part of the cultural equipment of a university graduate (a conviction that I find in my teaching experience shared only by history majors). But it is clearly impractical in a text of this kind to give more than a handful of names or to list all the sources drawn upon. In spite of the fact that many of the ideas presented, some of the expressions used, and most of the data included are derivative. I have therefore cited by name in the body of thc text only a relatively small number of direct or indirect contributors to its contents. At the end of the book, however, is a list of scientists and others scholars whose work has been referred to without citation, and the Teacher's Manual accompanying this book contains a bibliography.

As a further prefatory word to both students and instructors, I want to comment on the problem of up-to-dateness. We are currently living in an era of tremendous scientific explosion. While the human population is doubling once every 35 years, the number of scientists and engineers in the United States is doubling once every ten years, although this does not give grounds for believing that scientists will soon outnumber people. The rates at which costs of research and development are doubling vary from once every two years in China and Japan to about once every five years in the United States, Great Britain, and Canada. Over 90 percent of all scientists who ever lived are alive today. The number of scientific journals has risen in the last two centuries from ten to 100,000. Now, while such statistics may not reflect completely the actual growth of knowledge, they do impose severe limitations on the possiblity of any one single person staying up-to-date in any but a very narrow area of information. In some fields it is even difficult for a teacher to keep up with reviews, if he is also to continue with his own research. Because of this and because it takes time to produce a book, some material to be found within these covers is not the latest and may have been superseded. But it is my hope that the students, after using this book, will be sufficiently acquainted with the principles and prospects discussed to appraise the validity and import of new discoveries that may come to their attention.

Just as the beginning of this century was the age of physics and the middle of it seems to be the era of biology, the concluding years of the century may be expected to be the age of the behavioral sciences. And as knowledge advances along the hierarchy of organization from subatomic particles, atoms, molecules, macromolecules, cells, organs, individuals, to socially organized groups, increasingly complex decisions have to be faced by members of society. In many areas, conflicts between individual and social values have already arisen. Many of us find such developments as conditioning of the mind or social control over the human gene pool or even predetermination of sex of unborn children repugnant. Yet these developments are technically possible and have to be considered. Our biology, our psychology, and our values have evolved over a long period of time to serve in stable or in very slowly changing physical and cultural environments, rather than the swiftly transforming ones of today. As Robert Oppenheimer, among others, has pointed out, in traditional society, culture, including ethics and religion, acted as a homeostatic stabilizing force. Now culture has become an instrument of rapid change. Reasoned decisions have become much more difficult in the absence of historical guidelines. Indeed, there are pessimists, such as Max Born, who think that science and technology have already destroyed the ethical basis of civilization. Scientific attitude, he maintains, creates doubt and skepticism towards both unscientific knowledge and the natural unsophisticated actions on which human society depends and without which keeping society together is impossible. This, I submit, is an unwarranted voice of desperation. There cannot be too much knowledge. But decision-making machinery in the atomic age should not ignore information about human beings and the world around them. Even if ethical principles are not deducible by the rational methods of science, it seems obvious that, wherever possible, consequences of alternatives must be considered before choices are made. It is impossible to foresee all the decisions related to genetics that the users of this book will be called upon to make in their lifetimes. But at least one of the purposes of education is to prepare students to make the more or less obvious ones. This is the aim of the course that I have been teaching, and this is the main goal of the present book.

Finally, a note on the boxes and the use of the boldface type: Descriptive material and most of the tabular material has been segregated into inserts called boxes, some of which include illustrations. Subject matter of peripheral relevance to the central topics has also been so treated. The important technical terms and names usually make their first appearance in **boldface type.** These are the terms and names that the student is expected to remember. In the index the numbers of pages on which they appear are also **boldface type,** for ready reference to their definitions. *Italics* are used for species names, for the introduction of technical terms of transient significance, and for emphasis.

Berkeley and Stanford
May 1968

I. MICHAEL LERNER

PREFACE

TO THE SECOND EDITION

Since 1968, there have been some changes in the course at Berkeley. Libby has replaced Lerner as course instructor, and as a result has assumed the main burden of revising the book for this second edition. The Berkeley "breadth requirements" have been relaxed, bringing fewer students to the course against their wills. Some of the changes in the second edition have been made in response to what the students who do come seem to want (although all well-motivated students surely do not want every fact and concept we have included in this book).

Since 1968, our society has continued to change, and there have been many changes in our knowledge and mastery of heredity and evolution. We have tried to incorporate consideration of some of these changes in the second edition. We have had some additional thoughts on the effectiveness of genetic engineering, and some of its problems. The world is running out of resources, and we have expanded the coverage of population and resources in a new chapter. We have become more concerned with questions of behavior, and have amplified the treatment of this complex topic in a new chapter. We have found that *time* and *diversity* are two concepts that are badly handled by students and most people in our society. We hope that an appreciation of evolution is useful in correcting this.

Based on the many communications we have received from readers of the first edition, the following three comments may allow the second edition to be used more effectively. First, we received many requests for a glossary. After much thought and consultation, we decided against it. We have attempted to define most terms that would appear in such a glossary in the context of a discussion or an example. They are identified in the text by **boldface type,** and the pages on which such definitions appear may be located by the **boldface numbers** in the index. Second, the material in the boxes is designed to serve two purposes. In some boxes, it is our attempt to accommodate the diversity of background of our intended audience. For instance, Box 10.A (The Normal Distribution) can be ignored by those familiar with concepts of probability or statistics, but may be profitably studied by those not at ease with these concepts as they are reading Chapter 10. An understanding of the material presented in some boxes (for instance, in Box 12.B–Schizophrenia) is not important in order to understand the continuing development of the main text, but this material is presented as information additional to that given in the main text, for those particularly interested in the topic. Third, the order of chapters is by no means appropriate for everyone. In particular, those not familiar with molecular biology may find it useful to read Chapter 6 first. An advantage to reading the chapters in numerical sequence is that concepts and terms are rarely used before they have been defined. But by use of the boldface page references in the index, the definitions of unfamiliar terms and concepts can be located in earlier chapters if chapters are read out of sequence, or if some sections are skipped.

We have not attempted to bring the book fully up to date, as we might in a textbook intended for genetics majors. We hope the users of this book, students, teachers, and others, will not allow their knowledge to be truncated at the point of latest information contained in these pages. If that happens, then we have failed, for the focus of the course and of the book is toward the problems that will be encountered in the future, not those that have been solved in the past.

Berkeley
August 1975

I. Michael Lerner
William J. Libby

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I am grateful to Ralph W. Tyler and to O. Meredith Wilson, who succeeded him as Director of the Center for Advanced Study in the Behavioral Sciences, Stanford, California, for the opportunity to write most of the book in the relaxed and intellectually stimulating atmosphere of the Center. Many members of the Center's staff contributed to making my stay here profitable and enjoyable. In particular, I want to thank Mrs. Irene Bickenbach who won against odds the battle with my handwriting.

I am grateful for many suggestions from colleagues and friends who have read and commented on all or parts of the manuscript. Much that may be good in the book is due to them, but they should not be held responsible for what is not: I am afraid I did not accept all of their suggestions. It is a particular pleasure to express my appreciation for the help received from Th. Dobzhansky, B. A. Hamburg, and D. O. Woodward, who read all of the first version of the manuscript for the first edition.

Acknowledgment of sources of illustrations are given in the captions. I am grateful to all who supplied me with pictures. I also want to thank the University of British Columbia for permission to include several paragraphs in Chapter 21 (of the first edition) that first appeared in a publication under its imprint.

Since the preparation of the first edition, Dee Baer, Garrett Hardin, Val Woodward, and Dan Zohary have taught the course at Berkeley as visiting professors. Each has brought something to it, and thus to this edition of the book, as have the teaching assistants drawn from the graduate students of the Berkeley Genetics Group.

We particularly thank the many students, teachers, colleagues, and others at Berkeley and elsewhere who have taken the time to comment on most of the topics included and many of those omitted in the first edition. They have found typos, errors of fact, errors of interpretation, and additional evidence in support of, or in opposition to, positions taken. Their notes ranged from a few lines to many pages of closely reasoned critique. We read them all, and have incorporated much of their information and many of their ideas in the second edition, though responsibility for what is in this book remains entirely ours.

We are also grateful to the colleagues and friends who have read parts of the second-edition manuscript. In particular, we express our appreciation to Yan B. Linhart, who read and helped revise all of the second-edition manuscript.

I.M.L. and W.J.L.

CONTENTS

1 INTRODUCTORY

In this chapter, a brief rationale for tying the concepts and developing knowledge of evolution and heredity to society's concerns, and an explanation of how these facts and concepts and the background fundamental to them are organized in the remainder of the book, are offered.

1.1 ORGANIC EVOLUTION

The concept of **organic evolution** is the most important biological generalization in history. It is highly relevant to our personal well-being, psychology, social organization, and future as a species—as well as to our world outlook and curiosity about ourselves and our immediate and cosmic environments.

A one-term course of lectures, discussions, and readings can cover only in broadest outline what such a potent generalization is based on, and what its implications may be, especially if many of the students are starting with little knowledge of biology. One approach is to organize such a course as one about evolutionary thinking rather than one on details of evolution.