
Evolutionary Studies

Series Editor

Naruya Saitou, National Institute of Genetics, Mishima, Japan

Everything is history, starting from the Big Bang or the origin of the universe to the present time. This historical nature of the universe is clear if we look at evolution of organisms. Evolution is one of most basic features of life which appeared on Earth more than 3.7 billion years ago. Considering the importance of evolution in biology, we are inaugurating this series. Any aspect of evolutionary studies on any kind of organism is a potential target of the series. Life started at the molecular level, thus molecular evolution is one important area in the series, but non-molecular studies are also within its scope, especially those studies on evolution of multicellular organisms. Evolutionary phenomena covered by the series include the origin of life, fossils in general, Earth–life interaction, evolution of prokaryotes and eukaryotes, viral and protist evolution, the emergence of multicellular organisms, phenotypic and genomic diversity of certain organism groups, and more. Theoretical studies on evolution are also covered within the spectrum of this new series.

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Motoo Kimura

My Thoughts on Biological Evolution

 Springer

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ISSN 2509-484X ISSN 2509-4858 (electronic)
Evolutionary Studies
ISBN 978-981-15-6164-1 ISBN 978-981-15-6165-8 (eBook)
<https://doi.org/10.1007/978-981-15-6165-8>

Translation from the Japanese language edition: *Seibutsushinka wo kangaeru* by Motoo Kimura © Akio Kimura, published by Iwanami Shoten, Publishers in 1988. All Rights Reserved.

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In Memory

Motoo Kimura wrote this book in Japanese more than 30 years ago, to serve as an in-depth and then up-to-date introduction to evolutionary biology for students and young researchers not necessarily specializing in this field. Chapters 1–5 deal with the history of evolutionary studies, including concise but thorough accounts of paleontology, systematics, mutation, and natural selection. Chapters 6 and 7 delve more deeply into population genetics and molecular evolution, which are areas of research to which Kimura himself has made significant contributions. Chapter 8 focusses on the neutral theory of molecular evolution, and Chap. 9 is a speculative look at the future of mankind. These last two chapters strike me as being perhaps a little too optimistic, in that everything in evolution is explained within the framework presented in this book.

I worked with Kimura for about half a century. William B. Provine, a noted historian of science, once remarked to me that he had never known two scientists with quite different opinions on their research problem to maintain such a long collaboration. Kimura liked simple and elegant theory, and I remember that he admired theoretical physicists such as Richard Feynman and Freeman Dyson. On the other hand, I was a typical biologist. As a result, we sometimes disagreed on the interpretation of the data on molecular evolution and polymorphism. In particular, he was strongly attached to his simple neutral theory, which posits that mutations are either neutral or definitely selected. I thought that molecular evolutionary processes could not be so simple, i.e., natural selection acting on mutations at the molecular level could not be as simple as all or nothing. So the two of us often had heated discussions on this topic, with James F. Crow once in a while joining in the fray.

In the *Analects of Confucius*, we find words that loosely translate as: “Maintain harmonious relations with colleagues, but do not forfeit intellectual autonomy.” Kimura and I worked together for a long time while disagreeing on the interpretation of data and engaging in heated discussions. Mutual trust and the frank and open-minded discussions based on this mutual trust were what made this long collaboration possible. Kimura, who held the senior position in the Department of Population Genetics, treated me as an independent researcher, whereas in some laboratories in Japan, professors are overly powerful and do not treat younger faculty as such. I am grateful to him for this.

There has in recent years been remarkably rapid progress in almost every field of bioscience at the molecular level. Particularly noteworthy is the clarification of the processes involved in the gene regulation of various tissues and organs, including epigenetic mechanisms; highly complex molecular machineries are connected directly or indirectly, yielding a well-organized system as a whole. To reiterate, this book was written more than 30 years ago, before these and other advances were made. Nevertheless, it remains relevant even today, because Kimura's work laid the foundations for what followed in molecular evolutionary studies. I am happy to see it translated into English—the translators, Yoshio Tateno and Kenichi Aoki, were junior faculty members at the time Kimura wrote this book—so that more readers may benefit from the message it carries.

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Translators' Notes and Acknowledgments

This translation was done on biweekly visits to the National Institute of Genetics, where we had access to the late Professor Motoo Kimura's private library. The translation is complete and faithful to the Japanese original except for the following: (1) the sex of a researcher has been suppressed as being irrelevant; (2) population labels have been revised in Fig. 8.1 to conform to current usage (the original terms have been retained in the text); (3) we have deleted the Japanese language literature (many of which are unavailable) from the reference list (they, however, are mentioned in the text); (4) Muto et al. (1985) in the References has been replaced by Yamao et al. (1985) to be consistent with the citation in the text.

We thank Professor Naruya Saitou and his secretary, Mrs. Masako Mizuguchi, for their patience and hospitality during the 2-year period. We are also grateful to Naruya Saitou for acting as our "agent" in negotiations with (1) Mr. Akio Kimura, who holds the copyright, and with (2) the two publishers involved, Iwanami which published the Japanese language original and Springer which has now published this English language translation. We thank Akio Kimura for his permission, Iwanami for providing the original photographs which have been reproduced here, and Masako Mizuguchi for tracing the original figures.

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Yoshio Tateno
Kenichi Aoki

Preface

Research on the evolution of organisms may be one of the perennial tasks in biology. Questions in evolution are related to almost all areas of biology; whenever a new field was pioneered in biology, the new findings obtained there have led to a deeper understanding of evolution. It may be quite rare that a researcher in biology has not taken an interest in evolutionary questions at least once during his/her entire career.

In retrospect, when I was a college student majoring in botany some 40 years ago, some people openly stated that “serious biologists do not study evolution”; evolutionary research did not have a high standing in scientific circles. Generally speaking, discussions on evolution often were speculative and futile, which is sometimes true even now; but with developments in population genetics and molecular evolution, it is true that the situation has improved. In fact, research on evolution has reached the stage where it deserves to be called “evolutionary studies.”

I have devoted myself for a long time to the theoretical (mathematical) study of population genetics, have had a profound interest in the mechanisms that drive evolution, and have familiarized myself with the literature on evolution based on genetics. From the 1950s to the early 1960s, I was one of the adherents of the “synthetic theory of evolution,” during the period when it was fashionable as the established theory. However, as I incorporated knowledge on molecular genetics into classical population genetics, set myself the goal of constructing a new theory of population genetics, and eventually 20 years ago proposed the neutral theory of molecular evolution, I changed my position from panselectionism to one that recognizes the importance of chance effects.

In this book, I have summarized the current state of evolutionary studies, with the general reader in mind, and have tried to include most of the important issues that are currently under discussion in this area. As a result, this book has unavoidably grown too long for a pocket edition. Nevertheless, I have made an effort to make it readily comprehensible to students in the humanities with an interest in biological evolution and have tried to weave in some original thoughts to make it a distinctive book. For example, in Sect. 8.5 of Chap. 8, I have discussed one of the major problems in today’s evolutionary studies, i.e., “how to relate molecular evolution to phenotypic evolution.” For this reason, this book has been written to contain material that should be of interest even to experts in evolutionary theory, and I hope that it will be read by

a wide range of readers. Moreover, I believe that this short book may be useful as a textbook depending on how it is used.

At present, evolutionary theory is experiencing a boom, and many books are being published on the subject. However, evolutionary theory has always had aspects of a quagmire, and I pray that this book may serve as a guide for young readers to avoid becoming stuck. In addition, I would be happy if I can convey through the various topics treated in this book, how a new academic discipline is created.

I remember that the late Dr. Taku Komai, my mentor to whom I am greatly indebted, published late in his life a tome entitled “*Evolution of Organisms on the Basis of Genetics* (Baifukan, 1963, in Japanese).” This is a great book, which is even now sufficiently informative and which was published when Professor Komai was 77 years old. In the preface to this book he wrote, “I would like to dedicate this book as a token of my gratitude to my mentors, colleagues, friends, and family for their guidance, encouragement, support, and assistance throughout my life.” I am retiring this spring from the National Institute of Genetics where I have worked for many years, and although I am 14 years younger than Professor Komai was at that time, it is with the same sentiments that I dedicate this book to Professor Komai and the many people to whom I am indebted.

The occasion for writing this book was provided by Mr. Shigeki Kobayashi of Iwanami Publisher when some 10 years ago he asked me to write a book on biological evolution. Subsequently, I promised to put together a pocketbook, but was too busy to bring it to fruition. I am very happy to have completed this task at last. Mr. Nobuaki Miyabe of Iwanami Publisher, the editor in charge of this book, carefully read each chapter of the manuscript and made various suggestions that helped to make this book comprehensible to the general reader. In addition, in regard to Chap. 9 where I discuss the future of mankind, I am grateful to Mr. Yoshimasa Yoshinaga, a science journalist, for useful advice on how to convey my intentions clearly. Lastly, Mrs. Yuriko Ishii, who prepared the manuscript of this book, has worked for me for many years with devotion and self-sacrifice. I take this opportunity to thank her with all my heart.

Mishima, Japan
February 1988

Motoo Kimura

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