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“My Thoughts on Biological Evolution” by KIMURA (2020)
– translation of KIMURA (1988) –

SAITOU Naruya

Population Genetics Laboratory, National Institute of Genetics (Main appointment)
School of Medicine, University of the Ryukyus
Department of Biological Sciences, Graduate School of Science, University to Tokyo
Department of Genetics, School of Life Science, Graduate University for Advanced Studies
1111 Yata, Mishima, 411-8540, Japan Email: saitounr@nig.ac.jp

KIMURA Motoo (1924-1994), who proposed the neutral theory of molecular evolution (KIMURA 1968, 1983) published one book in April of 1988 in Japanese (KIMURA, 1988; see Figure 1) just after he officially retired from professor of National Institute of Genetics. One Japanese evolutionary biologist, who was working in USA, initially translated this book into English just after its publication. Unfortunately, Dr. Kimura did not like this translation, and that English translation was never published. After Dr. Kimura passed away, some other Japanese, a science historian, translated this book into English. However, the publisher turned down this translation, and this second translation was again not published. In 2014, I organized one symposium to commemorate the 90th anniversary of Dr. Kimura on November 13th (his birthday) and 14th in National Institute of Genetics. On that symposium, Dr. Tateno Yoshio, Professor emeritus of National Institute of Genetics, declared in his talk that he translated KIMURA (1988) into English. Later, Dr. Tateno asked me to find some appropriate publisher. I became series editor of Springer “Evolutionary Studies” Series at that time, and was wondering of new book other than one I myself was editor (SAITOU ed., 2017). I eventually persuaded the Japanese publisher, Iwanami Shoten, who published KIMURA (1988), to make one translation-related contract with Springer, as well as obtaining publication permission from Mr. Kimura Akio, only child of late Kimura Motoo, for he inherited the copyrights of publications of his father. Meanwhile, I also asked Dr. Aoki Kenichi, Professor emeritus of University of Tokyo, to check English translation made by Dr. Tateno. Dr. Aoki studied many years in Canada and USA from his boyhood, including Ph.D. from University of Wisconsin under supervision of Dr. James F. Crow, and his English is close to that of native speakers. It should be noted that Dr. Aoki was assistant professor at Division of Population Genetics in National Institute of Genetics from 1980 to 1988 under Dr.

Kimura. Dr. Tateno also worked in National Institute of Genetics from 1984 to 2010, and both Drs. Tateno and Aoki personally knew and respect Dr. Kimura pretty well.

According to my record, Drs. Tateno and Aoki visited National Institute of Genetics 24 times during 2016 and 16 times during 2017 for proceeding English translation of KIMURA (1988). After English translation was finished, I asked Dr. Ohta Tomoko, Professor emeritus of National Institute of Genetics, to contribute preface to English translation of KIMURA (1988). She agreed and wrote preface titled “In memory”. Eventually, KIMURA (2020; see Figure 2), English translation of KIMURA (1988), was published in summer of 2020. As successor of the head of at Division of Population Genetics (its name was changed to Population Genetics Laboratory on January 1, 2020), I was very happy.

KIMURA (2020) consists of nine chapters as follows:

Chapter 1: Diversity of organisms and views on evolution

Chapter 2: History of the development of the theory of evolutionary mechanism on the basis of genetics

Chapter 3: Tracing the course of evolution

Chapter 4: Mutation as an evolutionary factor

Chapter 5: On natural selection and adaptation

Chapter 6: Introduction of population genetics

Chapter 7: Introduction to molecular evolution

Chapter 8: The neutral theory and molecular evolution

Chapter 9: An evolutionary genetic world view

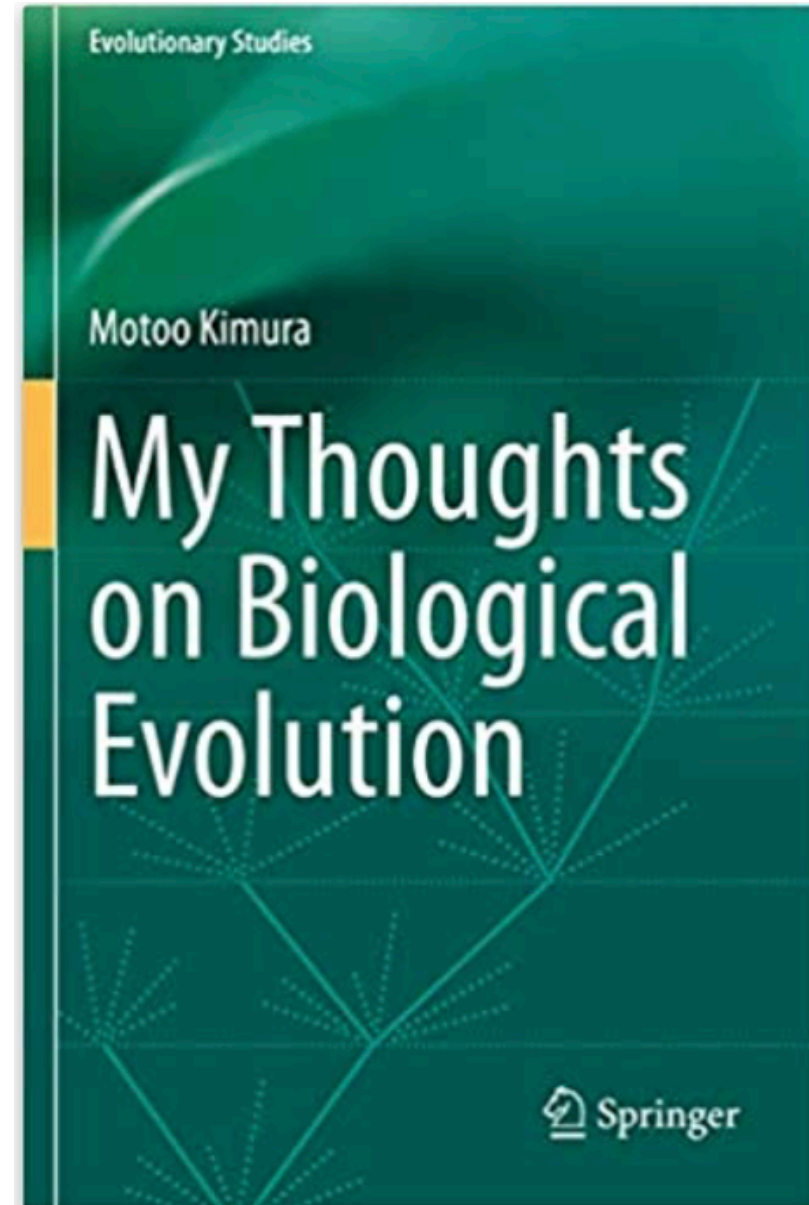
Before starting to give brief explanation of each chapter, I would like to note about preface of KIMURA (1988). Dr. Kimura mentioned KOMAI (1963) that was published when Dr. Komai was 77 years old. Dr. Komai was mentor for Dr. Kimura, and Dr. Kimura was happy to publish KIMURA (1988) when he was still at the age of 63. I myself vividly remember to read KOMAI (1963) when I was an undergraduate in late 1970s. While Dr. Komai passed away nine years later after his 1963 book publication, at the age of 86, Dr. Kimura passed away at the age of 70, only seven years after publication of KIMURA (1988).

KIMURA (2020) first mentioned number of species on earth followed by adaptation and variation, achievement of molecular biology, and biological evolution as a fact in Chapter 1. He then discuss history of the development of evolutionary theory starting from Lamarck, followed by Weismann, and later Darwin and Mendel. Figure 1.2 of KIMURA (2020) shows Dr. Jacques Ruffie and Ohta Tomoko standing beneath the statue of Lamarck in the Paris Botanical Garden. Chapter 2 follows this historical aspect up to the establishment of the neutral theory. The emergence of population genetics theory was briefly yet vividly written, with precious photos. Figure 2.3 shows R. A. Fisher discussing with young Kimura in National Institute of Genetics, when Fisher visited Japan, and Figures 2.5 and 2.6 show Wright, Crow, and Kimura, as well as young Dr. Chung-I Wu

Figure 1. Cover of KIMURA (1988).



Figure 2. Cover of KIMURA (2020).



(only appearing in Figure 2.6) when he was a post-doctoral fellow. It should be noted that Dr. Wu was mentioned only in KIMURA (2020).

Chapter 3 covers the outline of the history of life, evolution of vertebrates, evolution of mammals, and eventually emergence of hominids. Center of Chapter 4 is mutation, however, the first section, titled “A genetic view of life” discuss various key issues of genetics. Natural selection and adaptation is discussed in Chapter 5. Starting from discussion of DARWIN (1859), various types of natural selection was discussed in this chapter. Figure 5.1 shows five orchid flowers, and the center flower is named “Tree Village”, or English character-to-character translation of KI-MURA (木村). This flower was registered in 1976 by Dr. Kimura according to the legend of this figure. Developments of population genetics theory related to natural selection is discussed in section 5.2. I would like to note that “positive selection” and “negative selection” explained in this section were coined by Dr. Kimura himself in his book (KIMURA, 1983), as SAITOU (2013, 2018) mentioned.

Population genetics is fully discussed in Chapter 6, starting from its historical perspective in section 6.1, and Mendelian population to computer simulation are covered here. The Hardy-Weinberg ratio is discussed in section 6.2 to some details. However, Dr. Kimura criticized DOBZHANSKY (1951) for exaggerating this ratio to be called a “principle”. I examined some recent text books of population genetics, and unfortunately still assumptions of no natural selection, no mutation, no migration, no genetic drift are written for obtaining the Hardy-Weinberg “equilibrium” in some books. As Dr. Kimura stated, the Hardy-Weinberg ratio is just useful but simple. The realistic situations for equilibrium are discussed in section 6.3. The genetic load concept is explained in this section, partly because this concept is closely related to the emergence of the neutral theory in 1968. Random genetic drift is discussed in section 6.4, followed by behavior of a mutant gene in section 6.5. A sketch of the early days of molecular evolutionary studies is given in Chapter 7. Genetic code table and its general nature is discussed after a brief historical perspective. How to estimate the rate of molecular evolution and characteristics of molecular evolution are discussed. Finally, accumulation process of mutations are discussed. These are all preludes for the proposal of the neutral theory by KIMURA (1968).

Chapter 8 is thus logically and naturally about the neutral theory and molecular evolution. This is the longest chapter of this book. The approximate constancy of the evolutionary rate in various organisms is first discussed in section 8.1. While the generation time is 40 times higher in mouse than human, the rate of amino acid substitution per year is only 50% higher in mouse than human. In recent years, whole genome sequences became available for many species, and it is now possible to compare genomic evolutionary rates between various organism lineages. For example, BABARINDE and SAITOU (2020) compared genome data of 39 mammalian species, and they found that the amino acid evolutionary rates of rodents is about two times higher than that of primates. This difference is more closer to the physical year difference (no difference) than the generation time difference (40-fold). In KIMURA (2020), discussions on mutation rates continues, including those between mammalian X and Y chromosomes. The mutation rate constancy per generation or per year was again discussed. This enigma is still not fully solved now. Conservative nature of molecular evolution is discussed at the end of this section, and KIMURA was pleased to know that the evolutionary rate of a pseudogene, that is expected to evolve with no conservation, was in fact abnormally high as he predicted. Intraspecific variation at the molecular level is discussed in section 8.2, and

again that DNA polymorphism data supported the neutral theory. NEI's (1972) genetic distance is mentioned in this section, and Figure 8.1. shows the relationship of three major human populations based on NEI and ROYCHOUDHURY (1974). When that paper was published in 1970s, "race" was still used in anthropology and human genetics, and the paper title included three racial names. These are kept in KIMURA (2020), however, Figure 8.1 of KIMURA (2020) uses new terms: "African", "East Eurasian", and "West Eurasian" based on my suggestion. I would like to note that these new terms were first proposed by SAITOU (1995a).

Molecular evolutionary clock and molecular phylogenies are discussed in Section 8.3. Four topics were introduced in this section; 5S RNA data used for phylogeny of many organisms, DNA-DNA hybridization technique used for the bird phylogeny construction, influenza virus gene phylogeny, and oncogene/HIV phylogenies. I am pleased that Dr. Kimura mentioned our work (SAITOU and NEI 1986) on influenza A virus gene data analysis here. When this paper was accepted to *Molecular Biology and Evolution*, I sent one copy of accepted manuscript to Dr. Kimura. He sent me a letter, and criticized us for not citing his neutral theory. I was at that time a devoted neutralist already, and I (and probably Dr. Nei too) thought that it was not surprising to find a higher evolutionary rates for the third position of codons than those for the first and second positions of codons. This pattern is consistent with the neutral theory. In any case, we added KIMURA (1983) in our paper proof. I included this episode in SAITOU (1995b). Other topics related to neutral evolution is discussed in Section 8.4. Two topics, one study conducted by Dr. Ikemura Toshimichi, and the other conducted by Dr. Osawa Shozo's group, are on codon evolution, and the origin of life is also discussed in this section. I was associate professor of Division of Evolutionary Genetics, National Institute of Genetics from January 1991 to February 2001, before becoming professor of the Division of Population Genetics, National Institute of Genetics. Dr. Ikemura was professor of Division of Evolutionary Genetics, and I heard from Dr. Ikemura how Dr. Kimura came to like Dr. Ikemura's codon evolution study many times during the lunch time. This episode was written by Dr. Ikemura in his short memoire on Dr. Kimura (IKEMURA, 1995).

How to bridge between evolution at the molecular level and phenotypic level is discussed at the last section of Chapter 8. After introducing micro- and macro-evolution for phenotypic level changes, Dr. Kimura wrote "In this case, Darwinian natural selection undoubtedly plays the major role." He then discussed evolutionary changes of "regulatory genes" that can include DNA signals that regulate transcription, citing one review article by FUJITA et al. (1986). Dr. Fujita was assistant professor of Division of Molecular Genetics at the National Institute of Genetics at that time, and Dr. Nagata and Ishihama, coauthors of this review article, were assistant professor and professor of this division, respectively, at that time. Dr. Kimura seems to be right on the characteristics of the "bridge" between molecular and phenotypic evolutions. We recently discovered that ancestral sequences of highly conserved noncoding sequences among family Hominidae (SABER et al. 2016) and super-family Hominoidea (SABER and SAITOU 2017) experienced often many substitutions whose evolutionary rates were much larger than those expected under the neutral evolution. This suggests that Darwinian natural selection (positive selection) operates to create regulatory functions to some DNA sequences, after gaining certain function related to

some phenotype, this DNA sequence is now under strong purifying selection (negative selection). I am quite certain that phylogenetic analyses of conserved noncoding sequences are crucial to find the bridge between molecular evolution and phenotypic evolution.

Last chapter of this book is titled “An evolutionary genetic world view”. This chapter was somewhat controversial, because Dr. Kimura discussed about eugenics. One junior evolutionary biologist was asked to write a book review of KIMRUA (1988) to some local newspaper. However, Dr. Kimura got angry against this book review manuscript, and that book review was never published. I do not know this book review manuscript, but someone told me that it contained criticism on discussion of eugenics given in this chapter. Contrary to modern situation of a strong opposition against eugenics, that concept is rather standard in human genetics in the early half of the 20th Century. For example, one journal, named “Eugenics Quarterly” did exist at that time. This journal name was changed to Social Biology in 1969, then again changed to Biodemography and Social Biology in 2008. After briefly discussing human evolution in section 9.1, section 9.2, titled “Thinking about the question of eugenics” starts from subsection “Taboo”. Negative eugenics is explained in this section, as its goal limiting the accumulation of deleterious mutations below a certain level. Positive eugenics is discussed in section 9.3. The aim of positive eugenics is to amplify characters that are thought to be desirable for mankind. Dr. Kimura discussed sperm bank proposed by Muller and clone human proposed by J. B. S. Haldane.

The last section of this last chapter is titled “Human expansion into space and evolution”. Dr. Kimura mentioned Winston Churchill about one famous word “the end of the beginning”, but I suspect that Dr. Kimura was also thinking of “*Childhood’s End*” written by A. C. Clarke. In any case, Dr. Kimura then introduced the space colony project proposed by Gerald K. O’Neill, then mentioned “*Rendezvous with Rama*” written by A. C. Clarke. Dr. Kimura also discussed about SETI (Search for Extraterrestrial Intelligence) project, but he is rather pessimistic for possibility of finding any extraterrestrial intelligence. In contrast, Dr. Kimura supported the idea of “Dyson sphere” that envelops one star with a special surface composed of matter obtained by breaking up a planet. He further speculate creation of super human by practicing Muller’s sperm-bank using plan. Dr. Kimura ends this book with this sentence: we can hold the entire universe inside our heads through the processes of thought. The concept of “super human” reminds me of Kwisatz Haderach, one of the central concepts of the Dune series created by Frank Herbert. In fact, I am also a big fan of science fictions.

Index is not included in KIMURA (2020). It was my mistake as the editor of “Evolutionary Studies” series. I thus chose appropriate words from KIMURA (2020), and index is attached at the end of this article.

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