Natural Selection is the Interaction among Evolutionary Entities and Operates at All Evolutionary Levels §

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Abstract

In the newly proposed theories, the following three novel notions have been summarized: (1) Biological heredity occurs at least at three evolutionary levels (the molecular level, the sub-cellular level and the cellular level), (2) both polyribonucleotide-related and non-polyribonucleotide-related inheritable alterations of evolutionary entities at the molecular, subcellular, and cellular levels can be passed to the next generation; and moreover, (3) inheritable alterations are revealed theoretically and empirically to be the consequence of both endogenesis and exogenesis. The idea that natural selection plays a role in evolution or speciation was first described by Darwin, which, however, arose from the observation on macroorganisms including humans and non-human animals and only accounted for the continuity of "the fittest" macrobiological species. Since the mid-19th century, the tremendous effort to answer the question "what is natural selection?" has unraveled its versatile characteristics, such as a "driving power," an "evolutionary mechanism," or a "process". In this paper, based on the recently proposed UPOEE model,[1] I try to define nature selection as the interaction among evolutionary entities that operates at the same and/or different evolutionary levels. I further elucidate that at the social level of human beings, the biological property of nature selection is humanized by social traits including cultural, racial, political, religious, legal, and economic tint.

Key words: Darwin; Evolution; Nature Selection;

Background

In the recent theories, three novel notions have been recapitulated: (1) Biological heredity occurs at least at three evolutionary levels: the molecular level where DNA-centered genetics is the exemplar, the subcellular level, where fertilized oocyte-mediated cytoplasmic inheritance (FOMCI) is recognized; and the cellular level where pregnancy-associated whole cellular inheritance (PAWCI) was proposed;[1-6] (2) therefore, both

polyribonucleotide-related and non-polyribonucleotide-related inheritable alterations of evolutionary entities at the molecular, subcellular, and cellular levels can be passed on to the next generation via these routes;[1,4-10] (3) moreover, the inheritable alterations are believed to be the consequence of both endogenesis and exogenesis,[1-6] which enriched our understanding of evolution.

One and a half centuries ago, Darwin first proposed the concept of natural selection for his evolutionary theory, which, however, arose from the observation of macroorganisms including humans and non-human animals and only accounted for the continuity of "the fittest" macrobiological species. Therefore, natural selection is critical for understanding evolutionary adaptation. In the Modern Synthesis, a macroorganism individual entity itself cannot evolve at the individual level; evolution occurs only at the population level.[11,12] Moreover, natural selection can occur because individuals within a population differ from one another in how successfully they reproduce. In fact, since Darwin's time, the effort to explain this notion has never ended, partially resulting from our endless explorations and unceasing discoveries in the life sciences, which have resulted in multifarious understanding. Some evolutionary biologists believe that the mechanism of natural selection works not only at the individual organism level and gene level, but also at the group or species level,[13,14] despite the disagreement of some others. Shcherbakov argued, "There is no such thing as synchronic multi-level selection. Natural selection just cannot select anything that is not a unit of reproduction. I say in favor of group selection as the only meaningful level of selection for the obligatory sexual organisms."[15] Eastman and Storfer provided direct evidence for the role of species selection in lineage diversification of salamanders.[16] Moreover, mathematical models have suggested that natural selection may work at multilevel in the bioworld,[14,17] even at the social level.[18-20] Especially, in recent theories, the Modern Synthesis was shown to be theoretically and empirically deficient in accounting for evolution.[1,4,5] Therefore, it is necessary to re-check and define natural selection.

Is Natural Selection an Evolutionary Driving Power, a Mechanism, or a Process?

HMS Beagle to "Darwingle": the conceptual delivery of natural selection

In human history, there have been many famous ships with their tremendous stories, such as RMS Titanic, the USS Constitution, and the HMS Victory; however, none had such a huge influence on human beings as the ship named the HMS Beagle because of its nearly five-year voyage for mapping and collecting expeditions to South America and the South Pacific from December 27, 1831 to October 2, 1836 and during the journey a young naturalist named Charles Darwin (1809-1882) on board, who had shaken the world ever since.[21] After his Beagle expedition, Darwin began to frame his evolutionary theory, and this course was like building an evolutionary "ship" which could be called "Darwingle," on which only limited macrobiological species such as humans, non-human

animals, and plants, but no monocellular lineages or microorganisms, were on board at his time.

In 1858, Darwin and Alfred Russel Wallace, another well-known British naturalist who first applied Malthus's population principle to explain the mechanism of evolution, jointly announced their grand theory for evolution phenomenon. And one year later, Darwin published his book *The Origin of Species* for the "Darwingle," in which the "engine room" could be named "natural selection," in which the installed evolutionary "engine" was Malthus's population principle and the working mechanism of the Malthus "engine" was "survival of the fittest", a term coined by British philosopher Herbert Spencer.[22] Clearly, Darwin's natural selection only account for the continuity of "the fittest" macrobiological species.

What is natural selection?

As early as 155 years ago, Darwin wrote "this preservation of favourable individual differences and variations, and the destruction of those which are injurious, I have called Natural Selection, or the Survival of the Fittest."[23] Darwin himself once admitted "in the literal sense of the word, no doubt, natural selection is a false term"[23] for which, even today, the similar feeling was also expressed by Emiliano Salvucci: "natural selection is a linguistic trap."[24] However, Darwin stressed that "everyone knows what is meant and is implied by such metaphorical expressions."[23] "The theory of natural selection is grounded on the belief that each new variety, and ultimately each new species, is produced and maintained by having some advantage over those with which it comes into competition, and the consequent extinction of the less-favoured forms almost inevitably follows." Darwin said.[25] Frank pointed out that "although the theory of natural selection is simple, it remains endlessly contentious and difficult to apply."[26] Because of the uncertainty of natural selection in its definition, during the past one and half centuries, many types of "selection" have been proposed, such as "positive selection," "negative selection," and "sexual selection" in Darwin's definitions,[27] "ecological selection,"[28,29] "uniform selection" and "stabilizing selection,"[28,30-32] "artificial selection,"[29] "unnatural selection,"[33] and "developmental selection."[34] Moreover, Avise and Ayala even called natural selection "the unconscious broker of adaptive evolution."[29] Even so, Schluter asserted that "we still have not identified all aspects of selection…"[32] and that two major questions in natural selection: "how does selection lead to speciation?" and "what are the mechanisms of natural selection?" are still unsolved today.[32]

Yet, to date, we still have not obtained clear answers to the following paradoxical questions: What is the nature of natural selection? How does natural selection involve in speciation? Is natural selection an intangible concept or realistic entities? If it is an intangible concept, what does it stand for? If it is realistic entities, what are they? And our explanations have been inundated by confusion and disagreement during the past one and a half centuries, which should be largely ascribed to the huge variation of our understanding of the intention and extension of this term.

Natural selection is the power that drives evolution or speciation

In Darwin's view, natural selection was "a kind of metaphysical force."[35] Darwin wrote in the Origin of Species, "It has been said that I speak of natural selection as an active power or Deity… by such metaphorical expressions…" [23] "It may metaphorically be said that natural selection is daily and hourly scrutinizing, throughout the world, the slightest variations; rejecting those that are bad, preserving and adding up all that are good; silently and insensibly working, whenever and wherever opportunity offers, at the improvement of each organic being in relation to its organic and inorganic conditions of life."[36] Since then, such concept has been accepted by many evolutionary biologists; [24,32,37] for example, Schluter wrote**,** "natural selection commonly drives the origin of species … Under ecological speciation, divergence is driven by divergent natural selection between environments."[32] However, de Vries, a rediscoverer of Mendelian inheritance at the turn of the 19th to the 20th century, argued that evolution was driven by mutation not selection.[38]

Forterre further explained, "natural selection is not an 'evolutionary force' but the necessary outcome of variation and multiplication. In particular, natural selection cannot be weakened by mechanisms that promote variations (such as epigenetic mechanisms or symbiogenesis), because these processes provide more substrates for selection."[39] And moreover, Forterre attributed "some confusion on the nature of selection" to "the historical focus of most evolutionists on selection, instead of variations." [39] In fact, if we admit that natural selection is a force, a series of questions arise and should be answered, which include "what is the object of natural selection acting on?"[40] "What is the executor of the force?" "How long dose the force last?" and "Is the force dynamic or unchangeable?"

It is generally accepted that a novelty, such as novel phenotypes, novel functions, or novel structures, is what natural selection selects, and from this perspective, natural selection is a force. Unfortunately, as our thinking enters deeply into the cellular, subcellular and molecular evolutionary levels, we often find that it becomes more and more difficult to define the doers and the object of the force within the traditional theoretical system.

Natural selection is an evolutionary mechanism

Some other researchers believed that natural selection is an evolutionary mechanism.[24,41] For instance, in *The Cambridge Dictionary of Human Biology and Evolution* edited by Mai, Owl and Kersting, natural selection is defined as a mechanism: "This was the first mechanism proposed (by Charles Darwin, 1859) to account for evolution, in which forces in the environment select which individuals will leave the most offspring; still generally regarded as the principle non-teleological forces in evolution."[42] However, Emiliano Salvucci disagreed, stating "we cannot define it [natural selection] as a mechanism, given that in a mechanism there are elements known and arranged to ensure a predictable performance." [24] Lane pointed out, "while the mechanisms of natural selection are correct, and increasingly well understood, they do little to explain the actual trajectories taken by life on Earth."[41] Clearly, our deficiency in understanding of evolution hinders our ability to accept that natural selection is an evolutionary mechanism. In fact, answering the question "how dose natural selection select?" requires

dealing with the mechanism; therefore, it is theoretically suitable, rational, and acceptable to attach the label "mechanism" to natural selection.

Natural selection is a process

In *The Cambridge Dictionary of Human Biology and Evolution*, natural selection is also defined as a "nonrandom process" "by which some individuals in a species who possess adaptive phenotypic traits have a higher net reproductive success than individuals without those traits. This can occur only for those adaptive traits that possess heritability, i.e. genotype that contribute underlying adaptive genes disproportionately to successive generations as the result of differential fecundity, or, differential mortality or fertility by genotype."[42] In fact, asking the question "how long does natural selection need to complete its selection?" already reveals that natural selection is a course or a process. Darwin also said, "It may metaphorically be said that natural selection is daily and hourly scrutinizing," [36] and "we see nothing of these slow changes in progress, until the hand of time has marked the lapse of age, and then so imperfect is our view into long-past geological ages, and that we see only that the forms of life are now different from what they former were." [36]

The only purpose of evolution is for survival, for which the evolved entity differs genetically and morphologically from its origin after natural selection-directed adaptation. Therefore, natural selection should be a process or an adaptive process, resulting in diversity. Moreover, we usually try to identify the beginning and end of a progress: "when did natural selection begin and finish?" However, sometimes we can answer the question and sometimes we can't. For instance, at the social level of human beings, we can clearly remember the beginning and ending of some historical disasters, such as the first and the second world wars during the 20th century, the slave trade between 1538 and 1850,[43],[44] the epidemic outbreak in Rome history caused 2,000 deaths per day in AD 189,[45] the ancient Pompeii being completely destroyed by the violent eruption of Mount Vesuvius on August 24th, AD 79,[46] and Athens plaque from 430 BC to 426 BC, which caused at least 100,000 people (one third of its entire population) to die.[47] However, for disasters that occurred millions of years ago, we can only infer their geological ages from fossils and molecular data.

The Fimpological Perspective

Before continuing my further discussion, it's necessary to define the "natural" of natural selection. Darwin wrote in the Origin of Species: "so again it is difficult to avoid personifying the word Nature; but I mean by Nature, only the aggregate action and product of many natural laws, and by laws the sequence of events as ascertained by us."[23] This already prompts us to consider the necessity of upgrading the intension and extension of natural selection in the future when we uncover new natural laws. For example, "developmental selection" was defined to be a selection "relative to natural selection…within (rather than across) generations and within (rather than among)

individuals." [34] In fact, tremendous advantages have occurred in the life sciences over the past century [5] prompting some pundits to call for a theoretical revolution. In this article, the "natural" refers to all evolutionary entities that naturally exist. Moreover, as the spatial and temporal occupants, evolutionary entities may be invisible or visible with naked eye, inorganic or organic, and abiotic or biotic.[48] As evolutionary entities, if 'A' and 'B' constituted an interactive contradiction, 'A' is the direct environmental factor of 'B', and vice versa.[48] 'A' and 'B' can play the role of doers and/or the object of natural selection. Therefore, from the fimpological perspective, nature selection can be defined to be the interaction among evolutionary entities and operates at the same and/or different evolutionary levels.

Human beings: the role played in natural selection

In Darwin's opinion, natural selection depended on "a struggle for existence in relation to other organic beings or to external conditions;" the result was "death to the unsuccessful competitor;" and therefore, it was more rigorous than sexual selection.[36] In fact, our current understanding of natural selection is no longer limited to elucidating evolution by focusing on macroorganisms, and the fatal consequence is no longer the only criterion for defining natural selection in general. "Developmental selection" occurs within a human pregnant body, for example,[34] which does not cause the clinical death of an embryonic body. As a natural member on Earth, humans activity itself is a kind of nature selection, and its selection power has become stronger and stronger over the past several centuries,[49,50] especially, since the Industral Revolution occurred between the 17th and 19th centuries in Western countries.

Avise**,** Hubbell and Ayala pointed out "humans are the root cause of most ecosystem stresses and biotic extinctions in the modern world." [51] Today, genes modification, nuclei or genome transplantation, artificial fertilization, stem cells techniques, organ transplantation, and eugenic hybridization are all symbols of humans influencing the evolution of humans, non-human animals, and plants. In fact, in a more accurate saying, modern humans' selection operates at almost all evolutionary levels of the life sciences. For instance, the agricultural and aquacultural practices of humans may act as "unnatural" selection acting on the genetics and sustainability of wild populations through affecting their mating system.[33] Selection made or mediated by humans is called the "artificial selection" or "unnatural selection," [29] and therefore, the non-human-made selection is termed "natural" selection. However, if we accept that human beings are a natural macroorganism species and that nature selection is the interaction among evolutionary entities, then "artificial selection" should be treated as a special kind of "natural" selection, because it is the consequence of our intelligence activity. The practice on domesticated species is one of the best examples, both in Darwin's time,[52,53] and today.[54]

Natural selection— an evolutionary driving power, a mechanism, or a process

However, from the fimpological perspective, the variation of defining natural selection should be attributed to the consequence of our standing at different evolutionary levels or our different observing systems. If there is an interaction, such as competition or cooperation, among evolutionary entities, then there should be natural selection. In other words, if there is an interactive contradiction, then there is natural selection. Natural selection is a power, mechanism, and progress for the interaction, adaptation, and evolution of a given evolutionary entity. Evolution cannot be realized without natural selection. Generally speaking, natural selection is derived from the interaction between evolutionary entities and their environmental evolutionary entities.[48]

Considering that natural selection can occur at the same and/or different evolutionary levels,[1] the outcome of natural selection at different evolutionary levels of background evolutionary entities within an evolutionary entity may vary in their evolutionary purpose, which would embody the whole systemic status of the evolutionary entity. Natural selection that acts as a force at a given evolutionary level may be seen as a mechanism or a progress from the perspective of an observer at another evolutionary level. Moreover, the variation of evolutionary entities at a given evolutionary level may also be the outcome of natural selection that occurred at the same and/or different evolutionary levels. For instance, If we observe diseases at the individuals' level of macroorganisms, diseases are a kind of natural selection that acts as a force to kill some patients. If we look at diseases at the cellular level or subcellular level, the etiological factors, such as pathogenic bacteria and viruses become a selecting force to infect other prokaryotic and/or eukaryotic cells. On the other hand, host symbiotic prokaryotic cells and itself eukaryotic immune cells including phagocytes and lymphocytes, also become a selecting force to destroy or eliminate pathogenic bacteria and viruses, and infected prokaryotic and/or eukaryotic cells, which can be explained as a mechanism for accounting for diseases at the macroorganism-individual level. In fact, our understanding of the mechanisms of diseases at the cellular level or subcellular level just began in the 19th century, during Pasteur's time. Moreover, if we look at diseases at the molecular level, on the one hand, toxins or pathogenic molecules may play a selecting role while interacting with other molecules within the body of a macroorganism individual, which may result in alterations of host cellular functions and/or organ system functions. On the other hand, host immune molecules, including specific antibodies and cytokines, also play a selecting role by interacting with toxins or pathogenic molecules produced by pathogenic prokaryotic cells and viruses. Clearly, if we look at natural selection that acts as a force from the perspective of a given evolutionary level, we may find that natural selection at other evolutionary levels may be a mechanism or a progress. The outcome of natural selection further determines whether an evolutionary entity is "evolvamity" or in "evoclash" with other evolutionary entities.[1]

The harmonic outcome of evolutionary entities among different evolutionary levels, or within the same evolutionary level, also called "evolvamity," [1] is one, but not only, outcome of natural selection. For example, altruism and fairness are two features or behaviors of evolutionary entities at the macroorganism-individual level that are admired by natural selection working at the population level because these characteristics are beneficial for cooperation from the group's perspective. However, sometimes from the

macroorganism-individual perspective, altruism and fairness may be in opposition to the best benefit of individuals, such as "maximization of individual reproductive success." [55]

It is worth pointing out that the conflict between diverse results of selection at different levels is not uncommon, [56] a phenomenon recently described by the term "evoclash" refers to the discord of evolutionary entities between different evolutionary levels or within the same evolutionary level.[1] To illustrate this further, I would like to use a special case described by Darwin in his Origin of Species:

"*Mr. Salter has recently given the results of an examination of about 500 eggs produced from various crosses between three species of Gallus and their hybrids; the majority of these eggs had been fertilized; and in the majority of the fertilized eggs, the embryos had either been partially developed and had then perished, or had become nearly mature, but the young chickens had been unable to break through the shell. Of the chickens which were born, more than four-fifths died within the first few days, or at latest weeks, 'with out any obvious cause, apparently from mere inability to live*'; *so that from the 500 eggs only twelve chickens were reared."* [57]

Based on the UOPEE model, [1] the following analysis can be made: the first selection was made by researchers who determined the "*various crosses between three species of Gallus*" at the *Gallus*-individual level; the second selection might have be made at the cellular level and/or at the other lower levels by unrecognized factors that determined that "*the majority of these eggs had been fertilized*" and that the minority of the eggs were sterile; the third selection might have occur at the embryonic level, and/or the organ and systemic level, and/or the cellular level, and/or the other lower levels by unrecognized factors that determined "*the embryos had either been partially developed and had then perished, or had become nearly mature, but the young chickens had been unable to break through the shell;*" and the forth selection might have happen at the organ and systemic level and/or the cellular level, and/or the other lower levels by unrecognized factors unseen by the naked eye, determining that "*only twelve chickens were reared*" finally. Therefore, although 142 years ago, no one knew what caused those newborn *chickens to have "mere inability to live*," today, from the fimpological perspective, we can try to decode the puzzle theoretically at different evolutionary levels.

The Different Evolution Levels where Nature Selection Acts on

The molecular level

Evolutionary entities at the molecular level are the doers and/or the object of natural selection. It is well known that the interactions among molecular entities, including chemical building blocks for nucleotides, peptides, carbon hydrates, and other molecular compounds, have been described widely in many extant academic disciplines such as, physics, inorganic chemistry, organic chemistry, biochemistry, molecular biology, pharmacology, immunology, genetics, and genomics. However, our understanding on molecular evolution is just beginning and we may need a theoretical revolution first for evolutionary physics and evolutionary chemistry.

In the UPOEE model,[1] the evolutionary entities at the molecular level are the "evolutionary background entities" (EBEs) of the other evolutionary entities at higher evolutionary levels, including the subcellular and cellular levels. The gene mutation and fixation of the Modern Synthesis can be recognized as an exemplar for illustrating selection at the molecular level,[58-61] which, however, was believed to have been realized through the "group selection of replicators." [62] For example, natural selection was described as acting on nucleotide variation in the population differentiation of Drosophila ananassae,[63-66] and on mitochondrial DNA (mtDNA) sequence variants of mammalian species.[67,68] Furthermore, the novel notion that non-polyribonucleotide-related inheritable alterations of evolutionary entities at the molecular, subcellular, and cellular levels can be passed to the next generation has expand our attention to the interaction of non-polyribonucleotide entities, such as proteins.[69] For instance, the protein-protein interaction of FlaI, FlaX and FlaH within cytoplasm[70] may be a selection at the molecular level in archaellum rotation. Interactions between PGC-1α and the estrogen-related receptors may be a selection in cellular metabolism and energy homeostasis.[71] Interactions of RNA recognition motifs [72] may be a selection in many bioprocesses. Interactions of RNA recognition motifs, polypyrimidine tract binding protein, and RNA may constitute a selection in splicing of messenger RNA.[73-76] The comparison of the genomes of human pathogenic Francisella strains with the genome sequence of human nonpathogenic Francisella tularensis subspecies novicida U112 revealed that the emergence of human pathogenic Francisella strains might be the selective consequence of the interaction between "IS elements", "point mutations" and "small indels" at the molecular level.[77] The disruptive interaction of the genes, msrA2 (FTT1797c) that occurred in F. tularensis subsp. mediasiatica was shown to select the pathogenic bacterial strain survival in host organisms.[78] The diversity of transposable elements, including DNA transposon, long terminal repeat (LTR), and non-LTR retrotransposon in Capsaspora owczarzaki, a protistan symbiont of the pulmonate snail Biomphalaria glabrata, was believed to be the consequence of natural selection at the molecular level.[79] The diversity of transposable elements in unicellular Saccharomyces cerevisiae may be the outcome of interaction at the molecular level.[80,81] Moreover, selection favored membranes that contain certain mixtures of amphiphilic molecules, which exhibited superior physical properties than membranes that have only single amphiphiles.[82]

The cellular level

Nature selection acting at the cellular level has been descried in many bacterial species, such as Escherichia coli.,[83-86] Mycobacterium species,[87-89] and Streptococcus species.[90-92] Accumulating evidence of interactions between intra- and inter-bacterial species has been shown in experimental and clinical observations, such as Actinomyces israelii, Porphyromonas gingivalis, Pseudomonas aeruginosa, and Escherichia coli against Candida albicans,[93] Alphahaemolytic Streptococci against Haemophilus influenzae, Moraxella catarrhalis, Streptococcus pneumoniae, Streptococcus pygenes, and Staphylococcus aureus,[94,95] and Bifidobacterium bifidum against Helicobacter pylori.[96]

The interaction between bacteria, nematodes, and fungi in the deep-sea biosphere and soils is believed to play a selective role in obligate endoparasitic fungi (microsporidia)

evolution or nematode-host specialization.[97-101] The tripartite interaction among fungi, insects, and plants has been shown to transfer insect-derived nitrogen to plants.[102,103] The interaction between bacterial and fungal endophytes and plants can affect plant productivity.[104,105]

The individual level

Although whether natural selection acts on individual organisms is a debated question,[106] I argue that nature selection acting on the macroorganism-individual level is an indispensable piece for solving the nature selection puzzle. In fact, there are increasing theoretical models and empirical evidence supporting this notion.[34,106-108] Non-man-made natural selection, or simply called natural selection, and man-made natural selection, also called artificial selection are two types of natural selection acting on the individual level. Furthermore, according to the different bioentities acted on, man-made natural selection, or artificial selection, can be further divided into the following categories: (i) artificial selection on microorganisms, (ii) artificial selection on plants, (iii) artificial selection on non-human animal individuals, and (iv) artificial selection on human individuals. Probiotic-strain scanning is an exemplar of artificial selection on microorganism individuals; high quality rice plant selection exemplifies artificial selection on plant individuals; modern domestic breeding practices on non-human animals, such as pigeons, pigs, cows, sheep, dogs, and cats are the result of artificial selection on non-human animal individuals; and marriage-purposed sexual partner selection in human beings is naturally an artificial selection on human individuals.

Sexual selection—the symbolization of natural selection at the individual level

Since Darwin's time, artificial selection on domestic animals and human individuals has been called "sexual selection" and has attracted much research attention, as well as recent discussion.[109-119] In Charles Darwin's Origin of Species, Darwin described sexual selection as follows: "This form of selection depends, not on a struggle for existence in relation to other organic beings or to external conditions, but on a struggle between the individuals of one sex, generally the males, for the possession of the other sex. The result is not death to the unsuccessful competitor, but few or no offspring. Sexual selection is, therefore, less rigorous than natural selection. Generally, the most vigorous males, those which are best fitted for their places in nature, will leave most progeny."[36] Darwin further wrote, "Amongst many animals, sexual selection will give its aid to ordinary selection, by assuring to the most vigorous and best adapted males the greatest number of offspring."[120] Some physiological and psychological characteristics displayed externally at the individual level, such as language, cultural heritage, skin color, race, height, facial characters (including hair, eye color, lips, and eyebrows), voices, intelligence, and kindness,[121-125] are the objects that sex selection acts upon.

Although sexual selection and natural selection were parallel in Darwin's selection theory, which has also been accepted widely by many researchers,[40,112,126,127] I argue that sexual selection is actually the symbolization of natural selection working at the individual level of non-human animals and human beings and such cases can be observed

in nature;[118,119,128,129,130,131] and moreover, the different appreciation of beauty in races at the group level in the modern human societies is one of the many influential factors for the consequence of sexual selection at the individual level.

After one and half centuries of exploration on sexual selection, its contents have been extended from the original "preferred mate choice" at the macroorganism-individual level [55,131,132] to "fertilization opportunities"[113], "reproductive potential," and "reproductive investment." [132] Clearly, such newly added contents are determined not only by sexual selection at the human individual level, but also controlled by other evolutionary entities at multiple evolutionary levels.[1,55] In other words, as the final consequence of sexual selection, "evolvamity" or "evoclash" [1] is affected by the selection working on other evolutionary levels.

As we know, the productivity of a species determines its continuity and bioevolution. In human societies, the realization of hereditary variation of human individuals depends on obtaining resources and making offspring. It is worth pointing out that in human societies, resources are often masked by various social labels, such as wealth, occupational titles, job positions, and social status, etc., and the primary competition for natural resources in human societies has been upgraded into the social competition for a high social status and a good income job among individuals in modern societies. This competition for resources linked to reproduction is also called "social selection," [133] Moreover, for human individuals, if they do not have offspring, their biological heredity will end. The importance of sexual selection in evolutiology is reflected in making offspring, which is a process involving many mechanisms at various other relevant evolutionary levels, such as fertilization,[134-141] embryo growth and development,[142] and birth of offspring, [143-145] etc. Therefore, although sexual selection is believed to be "a potent evolutionary force," [146] from the fimpological perspective, the role and evolutionary significance of it at the human individual level are limited.

Sexual selection of animals at the individual level

Some researchers don't believe that sexual selection is a behavior of non-human animals at the individual level.[115] Jones and Ratterman argued that Darwin's argument "that arthropod, insect, and vertebrate females possess sufficient intelligence to appreciate beauty" [113] for sexual selection to operate "may have been his most significant shortcoming."[113] However, there is increasing evidence supporting the notion that sexual selection has been found to exist in both humans and non-human animals.[40,128-131,146-148] Sexual selection of non-human animals has been revealed in fish species[130] such as trout,[128,129] guppies,[126,149] and insect species such as Laupala crickets.[150] Natural selection at a given evolutionary level can act upon evolutionary entities at the same or lower evolutionary level. Krause, Lusseau and James wrote, "Interactions between individuals generate a social environment at the population level which in turn selects for behavioural strategies at the individuals' level."[151] "How dose natural selection at social organization level act on individual behavior, survival, and fecundity of animals?" is a common research interest of many studies.[151-153]

The group or population level

Interspecies interactions between different microorganisms have been widely studied in the past decades. The complexity of their interactions, with spatial and temporal variation, is far beyond our previous understanding.[154-157] For example, interactions between indigenous microbes and Escherichia coli were critical factors in influencing the fate of E. coli in aquatic environments.[154] Traxler and colleagues indicated that interactions between the bacterium Streptomyces coelicolor and five other actinomycetes displayed specific chemical patterns,[158] which suggested that selection at the group level may be accomplished through the interaction of entities at the molecular level.[159-161] Moreover, the evolution of entities at a given evolutionary level may be directly driven by the interactions of entities at a lower evolutionary level.[160,162-167] Although there is a plethora of evidence supporting natural selection on groups in human evolutionary history, the notion of natural selection acting on groups in human populations was once considered 'the archetypal example of flawed evolutionary thinking' between the mid-1960s and the 1980s.[168] Even today, group selection is still a controversial subject.[9,169,170] Indeed, once a group formed by individuals, the new entity, or called a "superorganism" by some scholars,[171] is actually enabled to have capabilities that previously did not exist in ungrouped individuals. Wilson and Sober believed that "superorganisms are more than just a theoretical possibility and actually exist in nature" despite rejection by modern evolutionary biology.[171]

The original idea of group selection was for explaining altruistic behavior.[9,168] Altruism is a social behavior reflecting the consequence of the new evolutionary functions at the population (or social) level; and its spreading among individual members of populations can be achieved through social learning and selection at the population (or social) level of evolutionary macroentities. Altruistic behavior in humans is traditionally praised and encouraged as a virtue in many cultures. Indeed, altruism concerning individual sacrifice for the welfare of others, is necessary for of populations (or societies), not of the sacrificed individual him/herself. In addition, altruism is certainly determined by multifactors at the different evolutionary levels, not only by the "selfish gene," a term coined by Richard Dawkins in 1976, because gene molecules themselves at the molecular level are not enough to explain the whole evolutionary content of altruistic behavior. In fact, it has been recognized that natural selection can act not only at the level of the individual organism and the level of molecules, such as an individual gene,[172-176] but also at the level of populations, such as insect populations,[177] human populations,[178,179] and plant populations.[180]

Natural selection, as an important driving force of evolution, was first elucidated by Darwin at the macroorganism level. Later, this principle was applied to account for human social problems by some persons who were called "social Darwinians." [181] Unfortunately, the fatal deficiency of social Darwinianism was its failure to recognize the following: (1) evolution is a circulatory and gradational progress, which is the consequence of evoccasion and evoability;[1] (2) natural selection itself, depending on the presence of variations, should act on both advantaged and disadvantaged evolutionary entities at all evolutionary levels; (3) as the majority of a society and the foundation of social superior individuals, the social inferior individuals had not been shown a practical way to change their disadvantaged fate and instead became the victims of various

persecutions; and (4) the effort to eradicate social inferiority actually conflicts with the evolutionary laws and principles and, therefore, should be doomed to failure.

Recently, the revival of group selection theory is the inevitable outcome of advantages in theoretical and empirical exploration on evolutiology.[1,5,182-184] Indeed, in a broad sense, if we accept that natural selection is a driving force of evolution, we should acknowledge that its contents and objects of action have been expending as evolution progressing. In other words, natural selection should exist in the whole biological and population (or social) levels, from molecular entities to organism individuals, and from population (or social) communities to the national level.[182,185] Masters pointed out "once scholars admit the necessity of linking processes of natural selection with human transformations of the natural world, it will seem anomalous that it has taken so long to integrate Darwinian biology and the social sciences."[183] Natural selection at the social group of non-human primates has been shown between bonobos and chimpanzees,[186-190] which reflected in their differences of using socio-sexual behavior,[188] food-sharing behavior,[191,192] emotional responses to decision-making,[186] motor and social development,[187] spatial memory development,[193] cooperative behavior,[190] and even endocrine shifts.[192]

Our social features are deeply rooting in our biological nature.[185,194] For instance, punishment is a critical social behavior of human beings for maintaining social stability, and yet this behavior evolved from non-human animals,[195-198] despite many other interesting theories.[199-204] In some primate societies, the social status of non-human animals determines the power or opportunity to access various resources, including food resources and reproductive resources.[180] Other social behaviors of modern human, such as warfare[205-209] and emotional responses to decision-making, [186] have their biological roots and are the consequence of evolution.

Indeed, once we accept the recognition, we will be more easily able to review and understand the social evolutionary history of modern human beings, correctly make policies and approaches for current various social problems, and effectively predict the possible tendency of social development. Natural selection on the population (or social) level directly and indirectly works through governing, legislation, and policy-making on the distribution of food resources and the reproduction. For instance, policing, as one of natural selection working mechanisms at the population (or social) level, has been shown to enforce social governing ideas, such as cooperation, sharing benefits, and obeying laws and policies among individuals in modern human societies.[180,210-212] In human societies, the social status of individuals, which is determined by cultural, racial, political, religious, educational and economic factors, also plays an important role in obtaining social resources and reproductive success.[184,209,213] For example, the total income of a family determines the quality and quantity of foods for the family, the life-quantity of the family members, and the quality and quantity of offspring. Other natural selection working mechanisms at the population (or social) level that play a role in the repression of competition among group members include "punishment," "altruism," "sanctions," and "randomization of reproductive success." [210,211,213,214] Undoubtedly, humans society is the most complicated cooperative and competitive system in terms of functions and manners on Earth. Human-documented history has partially revealed the evolutionary course that occurred in the formation and development of human social systems at the

different stages, from the primitive to feudal to capitalist to the socialist society in emerging-time order, and has been accompanied by the biological evolution in the mental and physical functions of human beings at the individual level and the practice in competition and cooperation at the group or population level.[215-220]

Concluding Remarks

Natural selection is derived from evolutionary entities at every evolution level, from the molecular level to the population level of macroorganisms,[5,24,56,221-225] and acts/depends on each other.[1,226,227] The fimpological view that evolution happens all the time at every evolutionary level [5] actually reflects Darwin's opinion that "natural selection is daily and hourly scrutinizing."[36] Upon the definition that natural selection is the interaction among evolutionary entities and operates at the same and/or different evolutionary levels, several subbranches of evolutiology, such as molecular evolutiology, cellular evolutiology, and social evolutiology, could be expected to emerge in the future.

Abbreviations

UPOEE: the Universal Pattern of Evolutionary Entities;
EBE: Evolutionary Background Entities;
FOMCI: the fertilized oocyte-mediated cytoplasmic inheritance;
PAWCI: the pregnancy-associated whole cellular inheritance;

[§ This revision of "Natural Selection is the Interaction among Evolutionary Entities and Operates at All Evolutionary Levels" was finished on January 21, 2023.]

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