Selection and Increasing Complexity in Evolution

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Abstract: This paper explores the concept of complexity in the evolution of life and human culture, proposing that the overarching increase in complexity is driven by the fundamental mechanism of selection. From the origin of life to contemporary human culture, selection plays a pivotal role in favoring complexity in reproductive processes and cultural expressions. The paper distinguishes two main phases of life on Earth: the emergence and evolution of life and animals, and the subsequent emergence of the human species with its complex cultural expressions. Despite apparent differences, both phases are argued to be guided by the same fundamental mechanism—selection, taking various forms such as adaptive natural selection, non-adaptive selection, sexual selection, and memetic selection. The paper identifies the acquisition of language as a crucial development, influenced by imitation and sexual selection, and suggests that the strong selective pressure for language has driven the rapid growth of the human brain and intelligence. This enhanced intelligence, in turn, has played a pivotal role in cultural, scientific, and technological achievements marked by unprecedented levels of complexity. The role of memetic selection is explored in the dissemination of religion across human societies, and the unintended consequences of Martin Luther's introduction of literacy and schooling for Western culture are examined. By integrating evolutionary principles with cultural and linguistic insights, this paper offers a comprehensive perspective on the unifying force of selection in the evolution of complexity in life and human culture.

1. Introduction

At her speech at the banquet for Nobel laureates in December 2018 in Stockholm, Frances Arnold gave her vision of a biologist's explanation of gravity: Once upon a time, apples used to move in different directions. Some fell to the ground, thus giving rise to new apple trees with the inherited feature of their apples to fall to the ground. Therefore nowadays, all apples are falling to the ground.

To me, this fairy-tale illustrates that such a central physical phenomenon as gravity cannot be explained by any biological principle. It is equally clear that significant biological phenomena cannot be explained by physical laws.

In his classical book *What is Life?* the physicist Erwin Schrödinger (1944) speculates how it is possible that life can proceed by increasing its complexity—a fact that he, like many other authors, seems to take for granted. Increasing complexity for a physicist, however, means a violation of the Second Law of Thermodynamics, thus implying a bothering enigma to him.

An attempt to solve the riddle of the increasing complexity of evolution has been proposed by Ilya Prigogine (2017) in inferring a process that he calls self-organization. This idea is expanded by Erich Jantsch (1980).

2. Selection, complexity and the origin of life

In this paper, I suggest the mechanism of selection to be an alternative to the notion of self-organization. I maintain that the mechanism of selection can give a sufficient explanation of increasing complexity in its various forms in organic life and human culture. Let me try to show how the mechanism of selection might be able to accomplish all this.

Nobody knows how life started on our planet. There are no traces to be found from these early days of the evolutionary history that could give some hints about the crucial beginning of life and the evolutionary process. Yet, in order to challenge the widespread notion of a divine intervention, I think we should at least present a possible and plausible scientific explanation of the very beginning of life.

Such an attempt was suggested by the Russian biologist Alexander Oparin who in 1936 proposed a process of chemical evolution of gradually increasing levels of organization implying a continuity between inanimate matter and the first living organisms. During the 1950s, Stanley Miller conducted his famous experiments through which Oparin's theory was verified. Especially interesting is that from merely inorganic

substances amino acids were shaped. A recent review of the research about the origin of life is given by Sara I. Walker et al. (2017) providing a detailed analysis of the chemical substances being involved in the first stages of biological evolution.

I adhere to the widely spread notion that, as soon as the temperature of our planet was low enough to allow for *liquid water* to condense, small shallow ponds were formed. In these ponds a great variety of chemical substances was accumulating. Because of the great diversity of these elements, rich possibilities to form larger molecules were opened, notably by means of the dynamic features of carbon. Of special interest, *amino acids* were spontaneously formed by combinations of these substances, and subsequently, *protein* molecules could be shaped. Next step could be that such molecules were attached to each other into even greater conglomerates.

I now suggest the occurrence of a crucial incidence. I think it is reasonable to suppose that once a large conglomerate of several amino acid molecules, and maybe protein molecules as well, had been formed, it could break up into two or more pieces. This process was endorsed if the conglomerates had a chain form that chiefly was growing at its open ends. Such a chain form is indicated by Walker et al. I find it possible and even probable that this chain construction easily could be broken up into shorter parts, as for instance when the water waves were breaking against the rocks. Each of these parts, I suggest, possessed the essential features of its original as well as the ability to grow by attaching additional molecules to its ends. In this way, a kind of *copying process* had come into being.

Most of these constructions were certainly built at random thus resulting in a totally *chaotic* form. Then of course the broken parts got this chaotic characteristic as well and the growth of them didn't result in any less chaotic constructions. Incidentally, the remnants exhibited quite different properties compared to each other.

However, some of these chains, certainly quite few and in spite of extreme low probability, accidently may have got a more *well-ordered form*. Such an order might for instance have included a sequence of the same molecules or shorter sequences of different molecules that were repeated in longer arrays. Actually, for the present purpose it is sufficient to think that merely one such ordered chain was shaped. When such a well-ordered chain in turn grew and decayed, the pond was gradually permeated with its 'offspring' because they were similar, not to say identical, to each other. This is so because of the well-ordered form of the original chain. After some 'generations' of this process a kind of a 'population' of well-ordered entities was created in the pond. It seems reasonable to assume that this population consisted of rather few members as compared to the much greater number of chaotic elements. The important thing is that their number increased successively.

We must now consider the possibility that the pond in which these processes were occurring was located in a tropical environment in which the evaporation of water from the surface was balancing the inflow of water from the surroundings. Actually, such a process is self-regulating inasmuch as the surface of the pond will expand or shrink corresponding to the inflow of water. In this way, the closed pond came successively to contain higher concentrations of abiotic elements; it became what has been called a primordial soup. The resulting chains of molecules were preserved in the pond and the intimated processes could continuously be going on for a long period of time.

Due to random variations, the chains achieved insensibly small changes of their features. If such a change implied a decrease of their level of order, their chance of forming a unitary population was reduced. Therefore, only an unchanged or increasing order was promoted over time. I suggest that the indicated process can be characterized by the mechanism of *selection*. The most well-ordered entities were systematically selected in the process of reproduction.

The entities in the pond can thus be characterized by the properties of variation, copying ability, and selection; in other words, they owned the essential characteristics of living substances. Life had arisen. A Darwinian principle of evolution was set in motion. Indeed, I maintain that the principle of selection is the essential clue to the process by which inanimate physical substances were transformed into living organisms with the ability of evolutionary progression.

As we just have concluded, entities with the highest measure of order were systematically promoted in the Darwinian process. When this process was going on over periods of millions of years, we may conjecture that RNA-molecules, vesicles, cells, and real living creatures was gradually shaped. The very evolution of life was ignited.

As we have assumed, the most well-ordered entities were promoted and furthered in the suggested selection process. The central feature of these substances can be characterized by the concept of *complexity.* Therefore, we may conclude that complexity benefits reproduction in that the most complex entities are systematically selected in an enduring Darwinian process.

Charles Lineweaver and coauthors (Lineweaver et al. 2013) have in their book *Complexity and the Arrow of Time*

brought together a number of scientists exploring the concept of complexity. They find the lack of definition frustrating, but as they ask, even without a definition or a way to measure it, isn't it qualitatively obvious that biological complexity has increased? Do we really need to wait for a precise definition to think about complexity? I strongly adhere to this view.

Like these authors, and like most people's intuitive notion as well, I maintain that the evolutionary process can be characterized by steadily increasing complexity. One may say that increasing complexity makes evolution progressive, a notion analyzed in depth by Michael Ruse (1996).

This conclusion has been disputed because of the fact that the concept of complexity neither is defined nor measurable. Still, I think it is the main concept that can give a sensible basis for the main characteristic of evolution of life on Earth. Many authors seem to take increasing complexity as a central feature of evolution for granted.

It should also be mentioned that an obstacle to this view has been put forward in that most species do not seem to increase their complexity once they had emerged. However, I have (Ekstig 2019) suggested increasing complexity mainly is occurring at the emergence of new species which then in their continued existence don't change much. This notion gives the evolutionary process a staircase form of increasing complexity with the human species occupying the highest level as I will discuss in the forthcoming text.

This primary evolutionary process had to wait for the next step in more than two billion years, indicating that a new step must have been quite difficult to achieve. Nevertheless, at the beginning of the Cambrian Period about 540 million years ago, *multicellular organisms* emerged. This crucial event gave rise to the appearance of many of the major phyla now making up the great diversity of life.

I maintain that selection can be seen as the outermost explanation of the origin of life and I suggest that it may explain the emergence of all organisms and animals up to the spectacular evolution of the human species and our culture with all its multifaceted expressions of unparalleled complexity.

3. The Tree of Life

Our model of biological evolution must of course include its fundamental features. First, life on our planet at present comprises the simultaneous existence of species of highly different levels of complexity; from the simplest bacteria to chimpanzees and man and the later in history they have appeared the higher their complexity. This view is expressed by Edward O. Wilson in pointing out that "biological diversity embraces a vast number of conditions that range from the simple to the complex, with the simple appearing first in evolution and the more complex later." (Wilson 1992 p. 175).

Another fact to be included in our model is that most species do not show any great change after their appearance. Wilson clearly express this feature: "Species emerge quickly and fully formed after a rapid burst of evolution, then persist almost unchanged for millions of years." (Wilson 1992 p. 80, 81)

My ambition is to suggest a model that, in applying the concept of complexity, gives answers to some challenging questions: Why haven't all species increased their complexity to the same level as man. Why is there such a great diversity in nature that we now can see around us? And, if a Darwinian principle is responsible for the increasing complexity as I have assumed, then why haven't those having been subject to this principle for the longest time attained the highest level? In reality, the opposite is the case. I have discussed these questions in my previous work (Ekstig 2019) but due to the focus on complexity in the present work, I think it is motivated to repeat the main arguments.

Let me take a point of departure in a highly schematic picture.

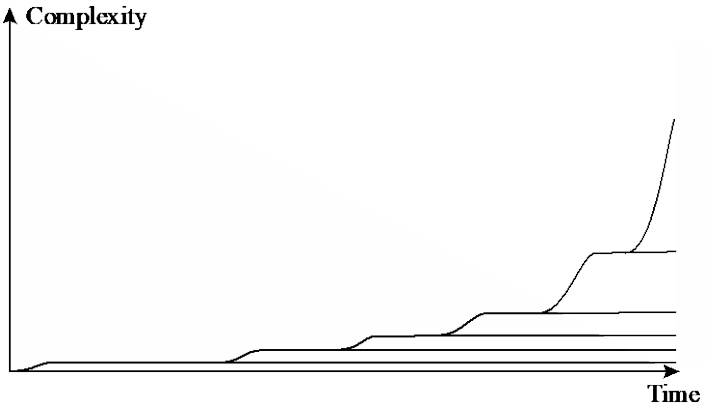

Figure 1 *The Tree of Life.*

The lines in this diagram depict the complexity of species all over the history of life. The lines may be interpreted as species as well. The horizontal lines illustrate species adhering to stabilizing evolution and the steps in the step-shaped line elucidate the emergence of new species. Let us discuss an example.

Imagine that the third horizontal line illustrates a fish species. At some occurrence, some fishes became trapped in a shallow pond, the amount of water of which was varying

with the tides. Those surviving periods of drought for the longest time were selected according to the Darwinian principle. In this way, we may speculate, the ability to breath with lungs was developed and a new species was formed, let us think it was frogs. The new species is illustrated by the fourth horizontal line. The majority of fishes, unaffected by this occurrence, continued their own way of life in the sea as is illustrated by the continuity of the third line.

Let us now imagine that at a later point of time another group of fishes were trapped in a similar pond rendering them the same chance to develop to frogs. But now the conditions are changed. While struggling for their lives in the dried-up pond, they became easy prey to terrestrial predators already adapted to the terrestrial habitat thus being much superior creatures.

The consequence of this reasoning is that, in general, only species of the highest level of complexity get the possibility to change to a habitat of a still higher level of complexity because, for those starting from lower level complexity, the habitats of higher levels are already occupied by superior species that exposes them to strong competition. This conjecture is supported by Daniel Dennett (1995, p. 89) in stating that the odds are heavily against any mutation being more viable than the theme on which it is a variation. **T**he conclusion is that the emergence of a new species occurs only once.

According to this model, complexity increases cumulatively over time. The latest appearing species therefore has the highest level of complexity. At present, this species is the human species. The step-shaped line illustrates the common ancestry of the human species. This reasoning, I conclude, explains why not all species have increased their complexity to the same level as man and why there is such a great diversity of living creatures living simultaneous. It also explains the contra-intuitive fact that animals being exposed to Darwinian evolution for the longest time display the lowest degree of complexity whereas those exposed to this principle for the shortest time show the highest degree of complexity. The diagram illustrates these conditions and I suggest it to be called *The Tree of Life*.

The suggested form of The Tree of Life illustrates the commonly anticipated notion of a general and accelerating increase of complexity of life. This picture of the evolutionary trajectory is similar to that suggested by Kurzweil (2005) in pointing out how an ongoing exponential trend can be composed of a cascade of S-curves.

The suggested model implies that species form a hierarchical order. There is an apprehension that if one admits a hierarchy of species, one must be prepared to accept a hierarchy in human ethnic groups as well. Regarding this highly contentious issue, I would like to refer to Jared Diamond (1997) who asserts that the gaps in power and technology between human societies do not reflect racial differences but rather originate in random initial environmental conditions.

Let us compare this picture of The Tree of Life with the diagrams constructed by Richard Dawkins in his book *The Ancestors' Tale* (Dawkins 2004).

In his pictures, Dawkins follows the human lineage backwards. This line of the human lineage is by Dawkins called "already joined" and corresponds to the step-shaped line in Figure 1. The incidents of appearance of new species are called "rendezvous". Dawkins draws many diagrams with successively more compressed time scales. Actually, Dawkins' diagrams have the same topological form as that of Figure 1.

I conclude that my diagram exhibits great principal similarities to Dawkins' although those of Dawkins are much more detailed in that he specifies the species involved and give rough dates of their appearance. A significant difference, however, is that my diagram displays complexity.

The diagram of Figure 1 can be seen as an illustration of human cultural evolution as well. I suggest that there are cultural, scientific and technological breakthroughs that can be seen as corresponding to the steps in the step-shaped line. Examples are given by the Copernican revolution and Darwin's discovery of natural selection. Such breakthroughs imply increases in mankind's total content of complexity.

Thomas Kuhn (1962) comments on the analogy that relates the evolution of science to the evolution of organisms though reminds us that it can easily be carried too far. But with respect to his idea of paradigms it is, as he states, nearly perfect. In the present context, I think one can interpret paradigm shifts as corresponding to the stepwise elevations of complexity in biological evolution.

The very mechanism behind the discussed process of increasing complexity is natural selection.

4. Natural selection

The principle of selection was discovered by Charles Darwin (1859) in observing that the finches of the Galapagos Islands displayed beaks with somewhat differing forms that matched the types of nuts that they exploited as their main source of food. This observation led him to the conviction that

adaptation was not to be seen as an indication of the widespread notion of purpose and final cause so widely embraced in the Christian faith but rather a naturally emerging phenomenon. He realized that adaptation was a result of a process of selection according to which beaks that were best adapted to the environment were systematically chosen. He called this principle natural selection.

To be complete, it should be mentioned that the discovery of natural selection should be ascribed to Alfred Russel Wallace as well, though the honor is mainly given to Darwin because of his much more elaborated analysis.

Darwin realized that this principle had a far-reaching general application which could explain much of the very evolutionary process. But he also realized that it should evoke strong reactions because it implied such a terrific conflict with common religious faith.

This first discovery of the principle of selection was thus coupled to the mechanism of adaptation. It had such an overwhelming explanatory power that the very principle of natural selection ever since has been intimately associated to adaptation. But as I will argue, this interpretation is unnecessarily restricted. In the forthcoming sections, I will suggest several forms of selection that are not adaptive; they work independently of the external environment. I call this form of selection non-adaptive selection.

All forms of life on earth exhibit a remarkable characteristic in that individual creatures repeatedly reconstruct themselves through a developmental process starting with the zygote and ending in adult creatures which eventually die. This developmental process is governed by genes that propagate inherited instructions for the individual's growth process. Therefore, genes have impact on evolution only indirectly through their control of development. Natural selection is thus a process mainly working during the developmental growth of individual creatures in a population.

Let me express my conviction that Darwin's discovery of selection is the single greatest breakthrough in the history of science. His idea implied a denial of the common sense notion of purpose and final causes of nature. He had to break the spell of religious faith that he himself initially as well as most people were trapped into. He had to find empirically supported evidence for his theory that could be sufficiently convincing for his brave idea. He had to take the risk of being socially reproached by his friends. Yet, he presented a scientific theory of unprecedented explanatory power.

5. Complexity

As I have already suggested, complexity benefits reproduction. Therefore, the most complex entities in the evolution of life at any point of time are systematically selected so that increasing complexity has come to be a ubiquitous feature of the evolution of life. Such an increasing complexity makes evolution progressive, let alone the interpretation of this concept has turned out to be highly controversial (Ruse 1996).

5.1 Arms Race and competition

Let me give an example of arms race. Hares are exposed to a selection pressure from foxes (their environment) that accomplishes, amongst other things, an increasing efficiency of their hearts. A corresponding effect can be envisaged in foxes. There is thus a mutual increase of the efficiency and complexity of the heart accomplished by this special kind of mutual selection. This process is progressive, a statement emphasized by Dawkins (2004 p. 496) in pointing out that arms races are deeply and inescapably progressive in a way that, for example, evolutionary accommodation to weather is not.

To speak in more general terms, competition is always present in any habitat that regularly tends to be crowded up to its maximum capacity. This competition accomplishes a selection pressure on the creatures to steadily increase their complexity because it is by means of increased complexity that they can achieve a reproductive advantage in the competition of others. This competition occurs between members of the same species as well as in the relation to members of other species.

5.2 Selection for efficiency

As pointed out by Stephen Stearns (1992), the growing creatures are during their developmental course vulnerable to the hazardous conditions of the environment including predators. Therefore, it is advantageous to pass this risky period as quickly as possible.

There is actually another advantage of a shortening of generation time. To reach maturation in a shorter time means more frequent occasions of reproduction over time. This circumstance adds to the selection pressure for the speeding up of the development process.

This means that there is a general selection pressure to speed up the development process of every organ and of the body as a whole. I have by means of a mathematical analysis of population growth confirmed the existence of such a selection pressure (Ekstig 2019 ch. 4).

The selection for a speeding up of the development process has implied a very early development of many organs

of present creatures during their ontogeny. Thus, the heart and the kidneys of mammals have reached their complete construction already after only a few fetal weeks.

In order to perform a particular task in a shorter time, one has, so to speak, to work more efficiently. I propose that this concept be applied to the process of evolution. The selection pressure for shortening of generation time can thus be seen as causing an enhancement of the efficiency of the growth of organs during the developmental process without change of their function.

Because of the addition of new traits to the growing creature, its developmental growth may be prolonged. The two mechanisms—addition of new traits and the fine-tuning of existing traits—are acting independently of each other and it may very well be that the total change of development over time implies its prolongation. It is however difficult to separate the respective influences of the two mechanisms.

A mere variation of efficiency of the growth of an organ or an organism without change of its function gives natural selection no alternative which could fit better to any environmental characteristic. Therefore, regardless of the environment, efficiency is always promoted. The selection for efficiency is therefore to be seen as a non-adaptive kind of selection. Examples can be found in the development of the eye, the heart and the kidneys.

The Eye: Ryan Gregory (2008) has given a detailed analysis of the evolution of the eye. He describes how the eye has evolved from a first flat layer of photo-sensitive cells on the skin, then to a cup-formed construction and finally to the vertebrate eye with pupil, lens and retina. All these steps have continually been developed towards ever-higher efficiency of the organism's capacity of sight, obviously driven by their promotion of survival of the organism. This process is not coupled to the external environment because good sight is equally important in any environment. Such an increase of efficiency is strongly contributing to the increase of complexity of the organism.

The Heart: During the course of evolution of vertebrates, the heart has evolved from a two-chamber construction in fishes, to three-chambers in frogs and finally to a four-chamber heart in birds and mammals. These adjustments of the heart construction are driven by the advantage of an increased efficiency of blood circulation. However, the selection for these evolutionary changes is accomplished independently of the external environment because a good blood circulation is advantageous in any environment. Such an increase of efficiency of the heart has strongly contributed to the increase of complexity of the organism.

The Kidneys: The same conclusion can be inferred regarding the development of many other organs as well, as for instance the kidneys. The function of the kidneys is to extract waste from blood. There are three stages of their evolution; pronephros, mesonephros and metanephros, all of which are results of a selection for increased efficiency because of the survival value of this capability.

This selection pressure is independent of the prevailing environment because regardless of the environmental conditions, selection always benefits efficiency. Such an increase of efficiency of the kidneys has strongly contributed to the increase of complexity of the organism.

The Brain: Actually, nowadays there are few new impressive changes of the evolutionary course of animals. It seems that most species now have reached what is called stabilizing selection. And if there are changes, these are very small as compared to changes associated to the emergence of novel species. However, evolution has entered a new avenue practiced by one species only, implying an unprecedented rise of complexity. That is the evolution of the brain and intelligence in the human species. This part of the evolutionary process is accomplished by non-adaptive selection because high intelligence is beneficial in all kinds of environments but also to a great deal by means of an additional kind of selection, sexual selection.

6. Sexual selection

The peacock's tail implied a challenging problem for Charles Darwin because, according to his theory of natural selection, all organs and features of organisms have evolved because they have promoted survival and reproduction. But the peacock's tail seemed rather to be an impediment. It is costly to bring forth, it implies a burden to carry around and it is a conspicuous signal for predators. These circumstances impose a contradiction of natural selection, an enigma Darwin was very frustrated about. After years of contemplating, he solved the challenging problem by introducing the process of sexual selection.

Sexual selection is an extremely complicated evolutionary mechanism as reviewed by Kuijper et al. (2012). There are mainly two variants of sexual election. The first is the struggle between males for access to females. This selection has led to large body size and diverse kinds of weapons like horns. The second variant is that females choose their mate according to arbitrary features, ornaments, for which they have got inherited preference. This mechanism has resulted in a mutually runaway reinforcement of the ornaments as well as of the taste

for them (Dawkins (1988, p. 203).

Adaptive natural selection mainly benefits survival and reproductive success whereas sexual selection exclusively benefits reproduction. Indeed, sexual selection often occurs in spite of a disadvantage for survival, as is the cases of the peacock's tail and the impressive antlers of the deer. Other cases of its manifestations are less costly as can be seen in the color decorations of birds and fishes. The birds' songs offer another testimony of sexual ornaments. Sexual selection sooner or later leads to an equilibrium between the reproductive advantage of the sexual ornaments and their disadvantage for survival.

Sexual selection accomplishes a variation in the characteristics and behaviors especially of birds, mammals and human beings that significantly adds to the complexity that has been achieved by natural selection. Therefore, I conclude that sexual selection is a mechanism of evolution that has driven complexity in evolution to reach much higher levels than otherwise could have been achieved.

6.1 Sexual selection in the human species

Of special interest is of course to what extent sexual selection has formed the bodies, behaviors, and cultural characteristics of our own species. In the majority of cases, sexual selection in animals involves a selective act by females and an exhibition of ornaments by males. As pointed out by Prum (2018 p. 252), the human species demonstrates a remarkable exception to this principle in that also women exhibit traits that indubitably are formed by men's preferences. Sexual selection has significantly increased the complexity of human bodies and behaviors.

I will start by discussing one case of female choice of male features. One such feature is men's talent to seduce women. These men, just think of Don Juan or James Bond, are not seldom preferentially chosen by women. The female behavior is understood because they will achieve a reproductive advantage in mixing their genes with those of such he-men. Their sons will inherit this talent and their daughters will inherit their mothers' preferences. This mode of women's partner choice has continued and been reinforced up to the present day.

6.2 Men's choice of women's features

As I already have emphasized, men's choice of women's features is a human-specific feature, the corresponding process of which is rarely, not to say never, practiced among other species. As Prum (2018 p. 254) states: "Rare among primates, male preferences for female sexual ornaments have clearly evolved on the uniquely human branch of the Tree of Life". This indicates that the evolution of the human species has been directed by additional processes compared to all other animals.

Women's bodily qualities are of course connected to their task of giving birth to as many healthy babies as possible. From the man's point of view, it is advantageous for his envisioned mate to be young in order to encompass as long a fertile period as possible. Therefore, the man has to estimate the age of his prospected mate and therefore women have advanced methods to give an impression of a young age. In our modern time, women's endeavors for this striving involves the wide-spread use of cosmetics to reinforce the impression of youth. Likewise, the use of bust bodices is now commonly utilized to give the bust a young form. Indeed, modern females even use surgical means to improve this feature.

Subcutaneous fat is richer in women than in men. I think this is a result of men's sexual choice because it enhances the pleasure of direct bodily contact and caressing. The fact that it is more pronounced in women than in men and that it has no obvious adaptive value supports the conclusion that it is a sexual ornament in women.

Why, then, is the male choice of female features exclusively restricted to the human species?

I suggest this evolutionary feature to be due to the fact that other animal males have no reason to bother about any choice. They copulate indiscriminately with any available female, a habit that renders them highest possible reproductive success, as it seems, without any expressions of pleasure. In contrast, I think that our highly developed intellectual and emotional faculties have rendered us the capability of pleasure connected to the sexual act, a feature that according to Prum (2018 chapter 9) is unique for the human species. This pursuit of pleasure has brought about the conscious choice of a partner that seems to be able to offer the highest pleasure, a pursuit that essentially has contributed to the sexual ornaments of both sexes.

The modern science of biochemistry has revealed that pleasure is connected to the production of endorphins which increase feelings of wellbeing. Sexual pleasure is thus not merely a good-feeling experience but endowed with a material substrate giving the discussed pursuit for sexual pleasure a concrete underpinning.

7. The emergence of the human species

In the context of big history, I would like to express my view that, on our planet, two really significant breakthroughs

have arisen. The first is the emergence of life, the second is the emergence of the human species. Actually, according to the traditional Christian view, humans have an exclusive position in the envisioned creation. The Christian church had in fact forbidden the dissection of human bodies, as I believe, in their attempt to keep this view unchallenged.

However, the French philosopher René Descartes (1596–1650) defied the decree against dissections and performed extensive comparative studies of the anatomies of animals and human bodies. He then discovered that there were great similarities between the anatomical structure of animal bodies and the human body as testified in the following quotation:

> *There is no one who does not already have some knowledge of the various parts of the human body, that is to say, who does not know that it is composed of a very large number of bones, muscles, nerves, veins, arteries, together with a heart, a brain, a liver, lungs, a stomach; and even who has not sometimes seen various animals opened up, on which occasions they have been able to observe the shapes and positions of their internal parts, which are approximately the same in them as in us (Descartes, 1647).*

Unfortunately, as convincingly disentangled by the German philosopher Theodor Ebert (2009), Descartes in 1650 was by means of arsenic murdered by a catholic priest. I suggest that this evil deed can be seen as a consequence of the competition of rival memes that I will discuss later.

Two hundred years later, the continuity between animals and man was scientifically settled by Charles Darwin, a notion rising fierce protests. People couldn't accept that we were, as it was expressed, descended from the apes.

However, with regard to the tremendous difference in complexity, I think that, without diminishing Darwin's discovery, we may regard the emergence of the human species as an extraordinary accomplishment in the history of the evolution of life on earth.

It has been somewhat surprising that modern genetic science has revealed such a minimal genetic difference between humans and chimpanzees. Therefore, of course, it should be no surprise that our human morphological and anatomic features are very similar to those of apes. But in considering the breadth and depth of all human cultural manifestations, especially the ability of language, I find humans far more complex than anything apes exhibit.

In his ambition to strengthen the preeminence of the human species, American philosopher George Kateb (2011 p.17) passionately articulates the supremacy of mankind amongst all species:

> *We human beings belong to a species that is what no other species is; it is the highest species on earth—so far. /.../ All other species are more alike than humanity is like any of them; a chimpanzee is more like an earthworm than a human being, despite the close biological relation of chimpanzees to human beings.*

I think Kateb expresses many people's intuitive notions.

We may find a supporting expression of the supremacy of mankind in the last sentence of Dawkins's book *The Selfish Gene*:

> We, alone on earth, can rebel against the tyranny of the selfish replicators. (Dawkins 1976).

If we now accept the description of the human species as an extraordinary accomplishment, the question is to what extent the mechanisms that have been in action in the evolution of life, primarily selection, can be applied for the analysis and explication of human culture. The answer is, as I will argue, that the mechanism of selection can be applied in the analysis of human evolution as well. First, however, we will make a short resume of the evolution of mankind.

The human species separated from a common ancestor with chimpanzees some five or six million years ago. After this separation, the size of the human brain has successively increased all the way up to now, whereas the chimpanzees show no such development. This observation indicates where to find the crucial cause of the difference between these two species. But the mere size of our brain just gives a crude hint.

The size of the populations of pre-human species was quite small, a circumstance that facilitated the rapid implementation of genetic and behavioral changes. From remnants of pottery and stone tools we can see a slow but continuous development of such artefacts which indicates a rise of the level of technological abilities.

Unfortunately, there are no fossil traces of the important human-specific capability of language. But this capability must have necessitated a big brain, the size of which may be used as a crude indicator of the development of language.

Agriculture emerged about 12,000 years ago, transforming the human society from small nomadic groups to settlements with hierarchies of governance. Agriculture could feed more people and gave rise to faster population growth in

spite of the fact that crowded living facilitated the spread of diseases, and that a more limited diet might have caused nutritional deficiencies.

So far, the intimated reasoning has been restricted to the material manifestations of the evolutionary process. However, with the evolutionary changes of the nervous system, a systematically more complex behavior evolved because complex behavior has been beneficial for survival and reproductive success. With the appearance of the human species, evolution has employed a still more dramatic and significant avenue. Selection has gradually started to work on immaterial features of the nervous system, generally recognized as intelligence. The target of selection is now what Dawkins (1976) has suggested to be what he called *memes*. Because survival and reproductive success is favored by high intelligence, this process has led to a systematic increase of intelligence having its foremost expression in the human ability to understand and use symbols, especially manifested in language and mathematics. But this is not the whole story. Nowadays, intelligent persons do not necessarily have higher relative survival and reproductive success. Therefore, one may conclude that intelligence has promoted its own evolution.

The study of the coupling between biological and cultural evolution got a breakthrough by Edward O. Wilson through his book *Sociobiology* (Wilson 1980). In this provocative work Wilson claims that gene-culture coevolution is a special extension of the more general process of evolution by natural selection. Wilson's ideas have been sustained by the concept of memes, forming a corresponding kind of hereditary unit in the human cultural evolution as that of genes in biological evolution. Daniel Dennett (1995) has extended Dawkins's ideas, suggesting that the Darwinian process, involving variation, selection and heredity, may be seen as a substrate-neutral evolutionary algorithm that could be applied to the social sciences by applying memes as the bearer of heredity.

I find it interesting to note that Wilson builds his analysis on natural selection. But as I will argue in the following text, natural selection and especially adaptive natural selection, plays a subordinate role in the evolution of the most significant components of human culture—language and technology.

8. Verbal language

In the previous section we discussed the evolution of our big brain. This attribute is of course coupled to our high intelligence, which directly is seen in our superior ability to understand and use symbols as emphasized by Terence Deacon (1997). The most important manifestation of this ability is our talent to talk, which is the preeminent expression of intelligence. Indeed, I claim that the proficiency of language is the essential clue to the process by which man achieved his transformation from the animal to the human kingdom.

Language is a truly advanced mental ability that requires a great brain capacity. I maintain that selection of language has driven the growth of the capacity of the human brain. Of course, language has not appeared instantaneously; rather it has evolved continuously in insensibly small steps all the way after our separation from the chimpanzees. We can get a presentiment of the first steps of this process in the simple grunts and gestures found in chimpanzees. Significant for the development of language is that it is not just a process in individual brains but a collective process. First and foremost, language stands for an interaction between brains of separate individuals, a feature of great significance for the evolution of human culture.

It is interesting to observe the development of the verbal language in children. I think it follows the main course as that of the human evolutionary history. It can thus be seen as a nice example of recapitulation as I previously have suggested (Ekstig 2019).

Verbal activities need a lot of brain capacity. These verbal activities certainly had a high survival value not least in the days when all kinds of hazards constantly threatened the survival of the small groups. But the human brain is costly; it needs a lot of high-quality nutrition for its growth as well as for its maintenance and it makes the birth of a child with its big brain a hazardous event. Its growth during mankind's first evolutionary steps must therefore have been the result of a strong selective pressure. What then are the mechanisms of the acquisition and evolution of language?

8.1 Mechanisms of language acquisition

Language was an all-purpose innovation that was beneficial across various environments. One may therefore conclude that, both on the individual and population level, language in a broad perspective can be seen as an outcome of natural selection. Seen in more detail, one can identify two specific mechanisms for its development, imitation and sexual selection.

Imitation: In her book *The Meme Machine*, Susan Blackmore (1999) suggests that people preferentially copy people with the best language. These people then pass on genetically whatever it was about their brains that made them good at copying these particularly successful sounds. In this

way, the brains and the organs of speech gradually become better to form and make use of just these sounds. This aptitude for imitation seems to have become deeply incorporated in our genetic set up. Actually, we can see it in babies' early ability to imitate adults' facial expressions. Blackmore emphasizes that selection favored those who could make the most intelligent choices on what to imitate.

Parents with high verbal talent will have a positive influence on the language acquisition of their children, who, when grown up and producing children of their own, will have a similar positive impact on the next generation children— a coupling indicating a positive feedback process. Children in the small tribes certainly also took part in common activities as for instance by sitting around the campfire listening to storytelling adults. In these situations, the most verbally talented adult person certainly dominated the talk, and in this way, children benefited from adults with the highest language ability.

In her studies of babies' language acquisition, Patricia Kuhl in her 2015 *Scientific American* article discusses how mothers across all cultures are stimulated by their babies to use "baby talk"; a form of simplified talk characterized by high pitch, slow tempo and exaggerated intonation, a practice called *motherese*. Babies obviously convey a reaction in their mothers to use a simplified way of talking which facilitates their imitation of their mothers. This gives another example of a self-reinforcing feedback process.

The earlier a child's acquisition of speech is achieved during its childhood, the more time will it have during the rest of its growth for additional finetuning of its verbal talent and the greater will its communicative faculty be as an adult. This implies a selection pressure for a speeding up of children's acquisition of language. We may thus conclude that this process is analogous to the selection pressure for the speeding up of the biological development process that we discuss in the above section *selection for efficiency.*

Sexual selection: Blackmore, in addition to imitation, remarks that verbal ability makes the brain visible for sexual selection because, as she points out, being highly articulate makes you sexually attractive.

As she notes, the history of love poems and love songs suggests as much, as does the sexual behavior of politicians, writers and television stars. She emphasizes that people preferentially mate with people with the best language. I suggest that not only a good language ability makes a person sexual attractive, but the very preference for this talent in the mating choice situation is a trait that will be inherited by the resulting children who thus not only will inherit the higher linguistic talent but the preference for it as well. As we may recognize, this process is analogous to the process of sexual selection that we discussed in connection with the development of organic traits. I conclude that we may regard language as a sexual ornament in both sexes in the human species.

9. Cultural endeavors

In addition to language, more recent expressions of human intelligence are to be found in art, literature, and music as well as in religion, mathematics, science and technology. These activities require an extremely high level of complexity of our nervous system. I discuss some of these expressions.

9.1 Arts, music, and literature

The early manifestations of arts, music, and literature seems to originate from a deep human need of creative activity. Music and dance may in addition have contributed to the coordination of group emotions and actions which might have had a survival value of the tribe.

The endowments for arts, music, and literature can in many respects be seen as analogous to the talent of language. Thus, it is observed that successful artists in many cases are notably sexually active. Sexual selection is therefore certainly an important driving force in these endeavors. In analogy with my discussion of the evolution of language, the very preference for artistic endowments in the mating choice situation implies that the resulting children will inherit the higher artistic talent as well as the preference for it. This mechanism enhances the evolution of the manifestations of arts, music, and literature permeating all human societies, ancient as well as current.

9.2 Memetic selection and religion

Our propensity to understand causes of natural phenomena, evolved due to its survival value, became gradually extended to envisage causes of imagined nature, first and foremost of a creator of everything, the foundation of all religions. Furthermore, human consciousness has instigated us to envisage a life after death—a notion that has become deeply incorporated in all religious thinking.

In his introduction of the concept of memes, Dawkins (1976) suggests the occurrence of religions as a typical example. As to the memes of religion, there has been a selection process in action according to which memes that had the best ability to replicate and spread to other human brains also successively became more frequently represented in the meme-pool. This ability can be associated to missionary activity implying that religions with the most effective mission became

most effectively spread. This means a selection for improving missionary techniques. The memes will thus affect their host, the human being, to act to their own advantage and reproduction. Dawkins accentuates that this kind of selection is not good for anything else but for the spreading of the meme itself.

An efficient method in establishing a meme in other persons is by indoctrination of children whose brains are particularly susceptible for such influence because they have developed the vital aptitude to trust their parents and other adults. Once indoctrinated in childhood, a person may have difficulties to make himself free from the acquired notions. Therefore, indoctrination was subjected to a memetic selection pressure for further refinement. An example of this mechanism is found the establishment of school systems, the initial purpose of which was to indoctrinate children in the current religion.

An important feature of the selection process on memes is that they, in their fighting against rival memes, cause a pervading influence on human behavior. I can see several expressions of this phenomenon of which one is the frequent occurrence of wars of religion, as for instance the Thirty Years War. Another expression is to be found in the oppression of heresy that resulted in the establishment of The Inquisition Court, a Catholic special court that was given the task of tracking down and punishing anyone nurturing views contrary to church dogma. A well-known case is the dreadful execution of the scientist Giordano Bruno in 1600 and the trial of Galileo. As I see it, the Inquisition is a dreadful expression of the fighting of memes against their rivals.

Still another example is given by the awful prevalence of witchcraft during the Middle Ages. As seen from a meme´s eye view, the dominant meme for the notion of witches reinforced its control over rival memes and the most efficient and cruel methods became successive selected in spite of the erroneous, not to say quite stupid, logics of the arguments in the trials and the suffering it caused. Fortunately, these devastating expressions of memetic rivalry are now wiped out.

Fortunately, this terrible period of western history came to an end at the Reformation. As Joseph Henrich (2021 p. 9) emphasizes, “Luther not only created a German translation of the Bible, which rapidly came into broad use, but he began to preach about the importance of literacy and schooling”. In this way he initiated a public-school system in Germany which successively became spread over other parts of Europe. I believe Luther’s introduction of literacy and schooling brought about an unintended but crucial opening for freedom of thought and a democratic, varied, and complex societal development as expressed during the period of the Enlightenment—the intellectual and cultural movement in the eighteenth century that emphasized reason over superstition and science over blind faith. This period released the advancement of mathematics, science, and technology.

9.3 Mathematics

The ability to count is certainly as old as the human species itself. Already during nomad living, people had a need to keep track of how many animals they had seen, to tell how many children they had and so on. With the entrance of agriculture, they needed to measure their cultivated land and to keep track of how many cattle they had. The ability to count certainly increased their chances to survive and can therefore be seen as an expression of a selection for survival.

In 1937 archeologists in the region of what now is Czech Republic uncovered a nice wolf thighbone which was found to be 30 000 years old. The remarkable thing was that there were scratches carved on it. Every fifth scratch was somewhat longer than the others which is interpreted as a means of counting something. This is one of the oldest known artefacts with mathematical significance; to use a symbol to represent a real object. This symbol is a number which has a general application. The number 3 may denote the number of children, apples or celestial bodies. Like the use of language, counting means a requirement of the ability to use and interpret symbols.

In this context we must remember Euclid, who about 300 B.C. developed geometry in his work *Elements,* which, up until our own time, has been of profound significance for the teaching of mathematics. The development of mathematics has successively led to higher levels of abstraction and complexity and in many countries, it has been included as a central element in school curricula.

To solve a mathematical problem means an intellectual effort and to find its solution means a kind of satisfaction that may release endorphins. Besides of its practical use, this release of endorphins, I suggest, is the basis of motivation for people to make so great efforts in the development of mathematics.

9.4 Science

I suggest three processes that have initiated and reinforced the evolution of science.

First, the aptitude of curiosity which, I think, has been developed by its survival value and thus there has been a selection pressure for the enhancement of science.

Second, the disclosure of an explanation of a dazzling phenomenon may release endorphins which may boost continued efforts to find further explanations. A nice example

can be found in the myth of Archimedes.

King Heron had given Archimedes the task to examine if his crown was made of homogenous gold. When Archimedes took a bath, he came across the solution which now is known as Archimedes' principle. He then became so euphoric that he, according to Vitruvius, ran out into the street shouting "eureka" without even remembering to put on his clothes. Certainly, I think, Archimedes must have got a great portion of endorphins. Even if the myth isn't true, people obviously find it trustworthy thus supporting the general notion that endorphins may be released by science problems solving.

The third instance that has reinforced the evolution of science is sexual selection. I think that the aptitude of understanding difficult problems and of finding solutions to them gives a person high status and thus makes him/her sexually attractive. In this way, the person is encouraged to make further efforts along the same line.

Science is contra-intuitive. A typical example is found in Copernicus' suggestion of a heliocentric worldview. Actually, everyone has the immediate experience that the earth stands still and that the sun is moving. To defy this intuitive notion therefore requires a highly developed ability of abstract reasoning. Another example is found in Newton's theory of gravitation. Everyone has the intuitive experience that in order to bring a force to an object one has to apply a direct material contact. Therefore, Newton's conjecture that the Earth could affect the Moon with a force over the great distance was a highly contra-intuitive notion that initially caused a lot of hesitation to the very notion of gravity. As we know, Newton's theories gradually became accepted thus laying the ground for the all-encompassing scientific development of our culture. It must be observed, however, that neither Copernicus nor Newton scarcely were compelled by sexual drives.

Science, though it deals with reality, is a highly abstract enterprise. It can be traced back to ancient Greek culture and has after Copernicus' breakthrough been developed to unprecedented extension and complexity. The complexity of this evolutionary process has been enhanced by the use of mathematics, instruments, computers and other contraptions of high complexity.

9.5 Technology

The evolution of technology can be said to have been developed by the same mechanisms that we have discussed above in connection with the scientific evolution. Let us discuss an imagined situation in the dawn of technological evolution.

As studied by John Shea (2017), archeological findings of stone tools exhibit a continuous increase of complexity and efficiency. It seems plausible that the ability of the construction of stone tools already from its very emergence has been beneficial for survival of the individual as well as of his tribe. In this way there has been a selection pressure for enhanced efficiency of the shaping of stone tools.

However, I think that sexual selection has been in action as well. As Susan Blackmore (1999, Chapter 8) emphasizes, imitation and sexual selection are significant human features in the evolutionary process. Regarding the ability to construct stone tools, I think that a man who could make the best stone axes became the best hunter and the best warrior in the tribe. These features made this man sexually attractive. Young men understood this coupling and therefore tried to imitate and even improve the methods for stone axe construction that seemed to bring about such a success amongst women. Thus, I conclude that the evolution of stone tools to a significant degree has been accomplished by the aptitude of imitation and sexual selection and I think this conclusion can be generalized to many other innovative abilities during the evolution of our technological progress.

Technological achievements often happen in an outstretched progress. An illuminating example is found in the development of the car engine. We start by going back to the ancient Greek culture where Empedocles made experiment with water and air from which he concluded that vacuum cannot exist. This idea was challenged by Evangelista Torricelli who in 1643 preformed experiments with mercury that led him to the insight that nature's avoidance of vacuum is limited. This inspired Thomas Newcomen and James Watt during the latter part of the 1800th century to construct the first steam engines that came to initiate the Industrial Revolution. The next step was taken by Nicolaus Otto in eliminating the steam boiler by, so to speak, placing the fireplace inside the cylinder. In this way he constructed the first combustion engine which he in 1878 installed in a car. Since then, this motor has undergone continuous refinements while its main operating parts have remained the same.

All these steps of engine constructions are illustrations of a progressive development with successively increasing levels of complexity. This type of technological development is now further enhanced by information and digital technologies, the level of complexity of which far exceeds that achieved by mechanical designs. The unprecedented level of complexity of this development can now be seen as extended in extra-human devises in what is called Artificial Intelligence. Such contrivances contribute additional complexity to what already has been achieved by the human brain and by the mechanical and digital achievements.

10. Summary

The literature of complexity seems mostly to be focused on the task to find support of the very presence of complexity in the evolution of life and human culture. In the present paper I have suggested that the evolution of organic life as well as of human culture in their chief outlines can be characterized as a process of increasing complexity explained as a result of the mechanism of selection, which has been in action from the very the origin of life to the latest expressions of human culture. I have suggested that the mechanism of selection explains the ubiquitous increase of complexity because complexity is favored by selection in the reproductive processes of life and at the spreading of the multifarious human cultural manifestations.

I have argued that life on Earth is manifested in two main parts; the first of which is the emergence and evolution of life and animals; the second of which is the emergence of the human species including our cultural expressions. The reason why humanity occupies this exclusive position is that we have achieved a superior level of complexity in comparison with all other animals, first and foremost as a result of our ability of language.

However, in spite of the highly different characteristics of these two manifestations of evolution, I have argued that they are driven by one and the same chief mechanism, i.e. selection, of which I have discussed several different forms. Among these are adaptive natural selection, non-adaptive selection, sexual selection, and memetic selection.

In the human species, sexual selection has accomplished sexual ornaments, not only in the male but in both sexes, which is unique amongst all animals. Human sexuality has contributed to the superior level of complexity of our species.

As to the uniqueness of mankind, I have as a pivotal occurrence suggested our acquisition of language that to a large extent is instigated by our ability of imitation as well as by sexual selection. The strong selective pressure for language has, I propose, caused the exceptionally rapid growth of our brain and our high intelligence. The growth of our intelligence has in turn brought about many of our cultural, scientific and technological achievements all of which convey unprecedented levels of complexity.

I have referred to the selection mechanism of the meme as providing an important clue to the pervading spreading of religion over most human societies and the unintended result of Martin Luther´s introduction of literacy and schooling for the democratic development of Western culture.

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