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HUMAN EVOLUTION

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Since the writings of Charles Darwin, paleoanthropologists have taken seriously the fact of evolution and its ramifications for uderstanding and appreciating the origin and history of our own species. Fossil evidence from major sites in Africa and Asia substantiates the organic evolution of our bipedal ancestors during the last 4.2 million years. The earliest hominids emerged from fossil apelike forms. Subsequent hominid evolution was a long and complex process of ongoing speciations and extinctions from the diversified australopithecines of Africa, through *Homo habilis* and *Homo erectus*, to *Homo sapiens* of today. Present interpretations of human evolution vary among paleoanthropologists, but ongoing research promises to result in both the discovery of more empirical evidence and, consequently, a clearer model for the evolution of our fossil ancestors.

Introduction

Inspired by the scientific framework of organic evolution, paleoanthropologists continue to be very successful in discovering the diversified remains of fossil hominids at sites in eastern and southern Africa. This growing evidence represents the very long, branching and complex process of human emergence from Pliocene apelike forms, through protohominids and then hominids, to our present species.

The evolution of efficient bipedalism separated our earliest terrestrial ancestors from arboreal quadrupedal pongids; the adaptive and survival advantages of bipedal locomotion for the emerging hominids is still debatable. Plio-Pleistocene hominids (early australopithecines) were followed by *Homo habilis* with a Paleolithic culture of cores and flakes, then the migrations of *Homo erectus* with bifacial hand axes, and eventually the appearance of *Homo sapiens* with a modern cranial capacity, an advanced material culture, and increasing cognitive abilities in a social group (especially the use of symbolic language as articulate speech).

Darwin's influence

After waiting twenty years, the great naturalist Charles Darwin finally published *On the Origin of Species* (1859). This book argued for the mutability of species by

means of natural selection, i.e., organic evolution as a result of the survival of the fittest in the struggle for existence. Knowing how controversial his scientific theory of biological evolution would be for science, philosophy and theology, Darwin deliberately left out of this pivotal work a discussion on the origin and history of our own species. However, any critical reader could easily see that the Darwinian theory can be and should be extended to also include the evolution of the human animal from an apelike form in the remote past to *Homo sapiens sapiens* of today. In fact, after 1859, both Thomas Huxley in England and Ernst Haeckel in Germany were quick to lecture on and write about human evolution (although early fossil hominid evidence outside of Europe was lacking at that time).

Darwin's writings represent one long argument for organic evolution in terms of science and reason. Grounded in a mechanistic and materialistic interpretation of nature, his books maintain that natural selection is the basic principle to explain the evolution of all species throughout geological time. The fact that species are mutable challenged traditional science, philosophy and theology; it had been held since antiquity that plant and animal types are eternally fixed within a single hierarchy of static forms from minerals, through plants and animals, to the human being at the apex of this so-called great chain of being or ladder of nature. The Darwinian conceptual revolution of organic evolution in science gave priority to change over permanence; it also supported mechanism and materialism over Aristotelian teleology and essentialism, as well as discredited vitalism and challenged spiritualism.

Twelve years after the appearance of his *Origin* volume, Darwin published *The Descent of Man* (1871). In this work, he focused on human evolution. Darwin claimed that our species is closest to two African great apes (chimpanzee and gorilla) with which it shares a common fossil ancestor that would be found in Africa; although at that time, it was generally held by naturalists that Asia was the birthplace of humankind. Unfortunately, during Darwin's own life, no fossil hominid specimens older than the Neandertals of Europe had been found and the bonobo, the third great ape (or pongid) of Africa, was still unknown to science.

As had Huxley and Haeckel, Darwin also maintained that the difference between the human animal and the living pongids is merely one of degree rather than one of kind: there being no structure or function in our species that does not already exist to some extent in the great apes. Furthermore, Darwin held that our species is closer to the pongids than they are to the hylobates (gibbon and siamang); evidence from comparative studies in biochemistry, genetics, embryology, immunology, anatomy, physiology, psychology and behavior now support this scientific generalization.

Today, the discovery and examination of the bonobo, or Pygmy chimpanzee, in central Africa adds a fourth great ape species to the pongids (which include the African gorilla and the common chimpanzee, as well as the Asian orangutan). In fact, in terms of biology and behavior, *Homo sapiens* is very close indeed to both chim-

panzees. As a result, it becomes futile to draw a sharp line between the earliest hominid implement-making behavior and the making of tools or weapons by living bonobos and chimpanzees.

The idea that our own species evolved from an apelike ancestor did not settle well with the Victorian worldview. Nevertheless, naturalists could not ignore the growing facts in geology, paleontology, biogeography, botany and zoology that gave empirical support to the fact of organic evolution. Essentially, the bitter controversy surrounding Darwinism was due to the far-reaching implications and disquieting consequences that scientific evolution held for interpreting the place that the human animal occupies within the primate order and organic history. Evolution claims that our own species is a product of, dependent upon, and totally within dynamic nature. The writings of Huxley, Haeckel and Darwin himself inspired several naturalists to speculate seriously on human evolution and to begin searching for fossil hominids (first in Asia and then in Africa).

Major discoveries

The framework of evolution provided a new paradigm for understanding and appreciating our species in terms of science and reason. If primate evolution is true, then fossil hominid specimens should be found to substantiate the emergence of the human animal from a prehistoric apelike form that once existed outside of Europe millions of years ago.

Oddly enough, in his book *Arboreal Man* (1916), the comparative anatomist F. Wood Jones presented a "tarsoid hypothesis" to account for the origin of the human animal. He argued that our species had descended from an early tarsierlike form independent of the lines leading to the Old World monkeys and six apes. Modern physical anthropology now recognizes that the human animal is closest to the chimpanzees and bonobos. Of course, earlier evolutionists had recognized the glaring similarities between the pongids and our species in terms of general morphology.

Near the end of the nineteenth century, naturalists began to search for fossil jaws, teeth, crania, and other skeletal bones at hominid sites, first in Asia and then in Africa. Their impressive successes during the past 120 years clearly demonstrate the awesome power of scientific inquiry, particularly when it incorporates a team effort and a multidisciplinary approach in modern paleoanthropology. Furthermore, the shift from merely relative to more exacting (radiometric) dating techniques during this time has resulted in far more accurate models for and better interpretations of hominid evolution.

Inspired by the "missing link" hypothesis of Ernst Haeckel, the naturalist Eugene Dubois left Europe and went to Indonesia in order to search for a fossil apelike form ancestral to our species and the pongids. Erroneously, Haeckel had maintained that an ape-man without speech (*Pithecanthropus alalus*) had existed between fossil pongids and the present human animal. He further claimed that Asia

was the cradle of human evolution, speculating that a landmass he referred to as Lemuria (assumed to have once existed) was the geographical location where our species had its origin from such an ape-man species.

During the early 1890s, at the Trinil site on the island of Java, Dubois was fortunate enough to discover the fossil hominid bones of "*Pithecanthropus erectus*" (Java man). These remains are over 500,000 years old. This evidence suggested that Asia may have been the birthplace of hominids.

During the first two decades of the twentieth century, additional Neandertal and Cro-Magnon specimens were being found in Europe. However, none of this hominid evidence dated back earlier than about 200,000 years. Nevertheless, discoveries made of much earlier fossil hominid forms at sites in the Transvaal area of South Africa did substantiate Darwin's claim that this continent (not Asia) was the cradle of humankind.

Of special significance are the fossil hominids found at five sites in the Transvaal area of South Africa. In 1924, anatomist Raymond A. Dart analyzed a fossil juvenile skull from the Taung site; amazingly, it was over 1 million years old! Dart correctly interpreted this specimen as representing a hominid form that was clearly separated from the fossil apes of that time. Subsequently, discoveries were made of several adult individuals found at other sites in this area (Kromdraai, Swartkrans, Sterkfontein, and Makapansgat). These adult specimens clearly justified giving a hominid status to all this fossil evidence from the Transvaal sites.

Collectively referred to as the "southern apes" or australopithecines of South Africa (although they are hominids, not pongids), these specimens are from 3-1 million years old. They represent at least two different species: the large *Australopithecus robustus* and the small *Australopithecus africanus*. There is no conclusive evidence that either form made stone implements. Still, they were the earliest fossil hominids known to paleoanthropology before the middle of the twentieth century. However, it is now held that these two species represent side branches in hominid evolution that became extinct 1 million years ago, long before the most recent Ice Age.

Beginning in 1928, geopaleontological research in the Western Hills near Zhoukoudian, China, was directed first by Davidson Black and then by Franz Weidenreich; both were anatomists from the Cenozoic Laboratory of the Peking Union Medical College. Over several years, scientific excavations unearthed fossil hominid evidence referred to as "*Sinanthropus pekinensis*" (Peking man). These specimens are at least 350,000 years old. The geopaleontologist Pierre Teilhard de Chardin became famous for his research at and popularization of this important site that helped to establish the scientific fact of human evolution. Today both Java man and Peking man, as well as the hominid skeleton of a boy (specimen KNM-WT 15000) 1.6 million years old from Nariokotome on the western shore of Lake Turkana in central East Africa, are relegated to the *Homo erectus* phase of human evolution; a stage of hominid development that lasted

over 1.5 million years, between the earlier *Homo habilis* form and the later *Homo sapiens* species.

Darwin's idea that the earliest humans would be found in Africa greatly inspired the anthropologist Louis S.B. Leakey, who dedicated his entire career to searching for the first fossil hominid specimen to be discovered in central East Africa. Undaunted by his lack of success for three decades, Louis concentrated his research at Olduvai Gorge in the Gregory Rift Valley of Tanzania. Although he found fossil ape specimens, no hominid evidence was discovered during his 30-year search in this part of the world. Even so, Louis continued his quest along with his second wife Mary, an anthropologist specializing in the prehistoric archaeology of central East Africa.

In 1959, with bitter irony, it was Mary Leakey who found the first fossil hominid specimen in central East Africa: the cranium of *Zinjanthropus boisei* (as it was classified at that time), belonging to a 1.75 million-year-old robust hominid form found in the lowest rock strata at Olduvai Gorge. The "*Zinj*" skull was a major turning point in paleoanthropology because it inspired other physical anthropologists to concentrate their search for other similar hominids (if not even earlier forms) in central East Africa. Today, the "*Zinj*" specimen is classified as *Australopithecus boisei*, a brutish hominid form, with both large premolars and molars, that became extinct before the most recent Ice Age.

Just two years later, Louis himself found the skull of *Homo habilis* in the same rock strata at Olduvai Gorge; it is a far more hominid form than "*Zinj*" and is directly associated with the pebble culture of the Oldowan tradition, consisting of the earliest human-made stone implements of cores and flakes known at that time (although it is arbitrary when the designation 'human' may be first applied to the very long, branching and complex process of hominid evolution).

In 1972 at Koobi Fora on the eastern shore of Lake Turkana in northwestern Kenya, Richard Leakey discovered the famous *Homo habilis* skull 1470 dating back about 1.9 million years. Therefore, both at the Olduvai Gorge and Koobi Fora sites, the larger-brained *Homo habilis* is associated with the dawn of human-manufactured Paleolithic culture.

In 1974 at the Hadar site in the Afar Triangle of northern Ethiopia, Donald C. Johanson found the fossil hominid "Lucy" skeleton. This specimen was dated at being over 3 million years old. Although the skull and teeth of *afarensis* have apelike characteristics, the postcranial skeleton is truly hominid. An analysis of the postcranial bones revealed that "Lucy" stood erect and walked upright with a bipedal gait. Classified as *Australopithecus afarensis*, this remarkable discovery clearly demonstrated that bipedalism had been established in hominids before the end of the Pliocene epoch.

In 1978 at the Laetoli site south of Olduvai Gorge, Mary Leakey had the incredible good fortune to find three tracks of hominid footprints about 3.6 million years old. According to Johanson, these Laetoli tracks were made by *Australopithecus afarensis* (for him, the common ancestor of all later hominids). In 1995, these Pliocene footprints

were reexcavated and reexamined. Then, the three Laetoli tracks were carefully reburied in order to preserve this unique discovery for centuries to come.

In science, nothing succeeds like success. The more paleoanthropologists search for fossil hominids in central East Africa, the more evidence they find. Recent discoveries by Tim White and Meave Leakey have pushed back the beginning of hominid evolution to over 4.4 million years ago! These earliest bipedal hominid forms are represented by *Ardipithecus ramidus* (a side branch in hominid evolution found in Ethiopia) and the later *Australopithecus anamensis* from Kenya, a species ancestral to *Australopithecus afarensis*.

In 1999, fossil hominid evidence from the Bouri site south of Aramis in Ethiopia has been dated to be about 2.5 million years old. This latest discovery is designated *Australopithecus garhi* and is another illustration of Plio-Pleistocene hominid species diversity in Africa.

One generalization is clear: the very earliest hominid forms emerged in central East Africa long before later hominids, representing *Homo erectus*, migrated north into Europe and east into Asia. Consequently, both Charles Darwin and Louis Leakey are vindicated in light of the growing empirical evidence for the birth of our most remote bipedal ancestors in central East Africa. Of course, models and interpretations of hominid evolution vary among physical anthropologists. Remaining questions about the origin and emergence of humankind will be answered by the discovery of more fossil hominid evidence in Africa.

The pongid-hominid split

The simplistic three-stage-sequence fossil apes/hominid ancestors/*Homo sapiens* offered at the beginning of the twentieth century has been necessarily expanded to account for the ever-growing hominoid and hominid evidence as a result of ongoing research by paleoanthropologists, particularly since the discovery of the "*Zinj*" skull in 1959. In fact, both the diversity of hominids and the complexity of their evolution is far greater than was imagined in the middle of the twentieth century.

The Miocene hominoids represented a large, diversified group of apelike forms that survived and thrived for millions of years throughout the eastern hemisphere. Just several decades ago, fossil hominoid evidence suggested that the split between fossil apes and the earliest hominids had occurred before the end of the Miocene epoch at least 12 million years ago. However, upon careful reexamination of the fossil specimens, all these hominoids were found to be pongidlike rather than hominidlike (suggesting that the pongid-hominid split had occurred much later than was first thought to be the case). A reevaluation of the later Pliocene fossil hominoid evidence places the emergence of protohominids about 7-5 million years ago in Africa.

Early hominoid forms ranged from *Proconsul* of Rusinga Island in Africa and *Sivapithecus* of the Siwalik Hills in India and Pakistan (both from the Miocene ep-

och) to the later *Oreopithecus* of Europe and the huge Pleistocene fossil ape *Gigantopithecus* of India and China.

About 10 million years ago in central Turkey, the fruit-eating fossil ape *Ankarapithecus meteai* roamed the woodlands long before the pongid-hominid split. Although such forms were once numerous during the Miocene adaptive radiation of hominoid genera and species in Africa and Asia, these fossil apes were becoming extinct during the Plio-Pleistocene time. Insufficient evidence prevents determining which hominoid form is a definite common ancestor of later African fossil apes and the first protohominids.

The earliest known hominid, *Ardipithecus ramidus* of Ethiopia, lived about 4.4 million years ago. This form was followed by *Australopithecus anamensis* of Kenya about 4.2 million years ago, which was later replaced by the emergence of *Australopithecus afarensis* of central East Africa.

The incredible similarities between our own species and the great apes, particularly both the common chimpanzee (*Pan troglodytes*) and the Pygmy chimpanzee or bonobo (*Pan paniscus*), argue for a far more recent pongid-hominid split then was once maintained. With the serious consideration of comparative biochemistry and genetics, as well as molecular dating to determine the evolutionary relationships among different primate species, it became clear that protohominid evolution probably diverged from fossil apelike forms only about 7-5 million years ago. If this is true, then the common ancestor shared by apes and the human animal should be found somewhere in central East Africa, the fossil remains being only about 6 million years old.

The various fossil hominoid forms during the Plio-Pleistocene age reflect the diversified habitats of the central East African environment during that time. Through the mechanisms of genetic variation and natural selection (including sexual selection), hominoid populations in a variegated environment gave rise to the pongid-hominid split, which resulted in the apes remaining quadrupeds on the one hand and the emergence of quasi-bipedal protohominids on the other; with the latter forms leaving quadrupedal locomotion behind as they ventured out of the forests and jungles for a more and more terrestrial social life in the open woodlands and on the grassy savannahs.

There were probably numerous attempts at bipedalism. For whatever reason or reasons, there was an adaptive and survival, and therefore a reproductive, advantage to becoming more and more bipedal as the protohominids evolved into terrestrial hominids. Although a long, branching and complex process, the evolution of protohominids paved the way for the appearance of the earliest true hominid forms as bipeds over 4 million years ago, e.g., the species *ramidus* and *anamensis*.

Even though they stood erect and walked upright with a bipedal gait, the early hominid forms of central East Africa (including *afarensis* and *habilis*) probably returned to the security of the trees during the night in order to escape ground predators.

Human evolution

In modern physical anthropology, the *habilis-erectus-sapiens* sequence is now well documented in the fossil hominid record; although this history is far more complex than was once maintained. Furthermore, there is no common consensus concerning the taxonomy of the early hominids and no doubt additional species will be found. Nevertheless, for over 2 million years, human evolution shows an increase in the size and complexity of the brain, a reduction in the size of the face and teeth, and an ever-increasing reliance on cultural adaptations (especially symbolic language, manufactured stone technology and social patterns of cooperative behavior). Although speech, consciousness and behavior are not preserved in the fossil record, they may be inferred from osteological and archaeological remains.

Like other emerging groups of animals, the early hominids underwent adaptive radiation. To date, over 500 fossil hominid specimens have been found from sites in Africa. This diversity among the early and then later australopithecines resulted in many genera and species. No doubt, many other forms of early and later australopithecines will be found as paleoanthropologists continue searching for fossil evidence at sites ranging from 4.2-1 million years ago in Africa.

About 2.8 million years ago, a population of *Australopithecus africanus* inhabited subtropical woodlands in South Africa. These bipedal hominid individuals had a small brain, long arms and short legs; they may have coexisted with *Australopithecus afarensis*, with the probability that both species once shared a common ancestor. This hominid evidence suggests that perhaps the transition from *africanus* to *habilis* may have taken place in South Africa (rather than in central East Africa), followed by the *habilis* species migrating northward.

Within this diversity of australopithecines, it is the bigger-brained, implement-making and wider-ranging *Homo habilis* that was successful in terms of adapting, surviving and reproducing over 2 million years ago. Other hominid forms became extinct, e.g., *Australopithecus aethiopicus*, *Australopithecus africanus*, *Australopithecus boisei*, and *Australopithecus robustus*. Because of its superior brain and Paleolithic culture, *Homo habilis* not only survived but, more importantly, it gave rise to the next stage of hominid evolution, *Homo erectus*, about 2 million years ago. This transition was not sudden, for the *habilis* and *erectus* phases overlapped in central East Africa.

The emergence of *Homo erectus* from *Homo habilis* represented a major change both in the biological and sociocultural advances in hominid evolution. Compared to *habilis*, *erectus* was taller and had a larger brain. It even migrated both north into Europe and east into Asia, although populations of *erectus* remained in Africa. For almost 2 million years, *erectus* survived and thrived throughout the eastern hemisphere. Its stone culture consisted primarily of Acheulean bifacial hand axes along with cleavers and scrapers in Africa, and chopper/chopping implements in Asia. From an evolutionary viewpoint, *Homo erectus* represented a long and successful stasis in hominid biocultural evolution. Even so, recent fossil hominid evidence

suggests that the *erectus* stage of human evolution may actually represent a diversity of forms (perhaps even different species).

With the extinction of all other hominid genera, *Homo erectus* is directly ancestral to *Homo sapiens*. Before the emergence of our own species, the average hominid brain evolved slowly for about 2 million years; from about 630cc in *habilis* to about 900cc in *erectus*. Then, both the size and complexity of the hominid brain evolved faster, reaching an average of 1400cc in *sapiens* today. With the appearance of *Homo sapiens*, our human species manifested far greater self-consciousness along with the emergence of symbolic language as articulate speech (although a crude form of symbolic speech as protolanguage may be over 1 million years old).

About 400,000 years ago, with the extinction of *Homo erectus*, the archaic *Homo sapiens* form first appeared (this stage of hominid evolution probably emerged in Africa before spreading north into Europe and east into Asia). In South Africa about 120,000 years ago, an early member of our species left fossil footprints at Langebaan Lagoon and cultural remains (ashes, mussel shells and animal bones) in caves at Klasies River Mouth. This evidence suggests that South Africa may have been the birthplace of modern *Homo sapiens*, or a species anatomically like us.

The later *Homo sapiens neandertalensis* populations represent a complex and elusive phase of human evolution, showing great regional variation until about 35,000 years ago. They were hunters, gatherers and scavengers who occupied caves and used fire. More advanced both biologically and culturally, the classic Neandertal people had a modern cranial capacity and the far more sophisticated culture of the Mousterian tradition, including the deliberate burial of their dead with ritual (suggesting the emergence of magico-religious beliefs and practices). In some areas of the eastern hemisphere, the Neandertals were contemporary with the even more advanced Cro-Magnon people, with the two forms intermittently occupying the same sites. Apparently, the two subspecies seldom, if ever, mixed their gene pools. Any *neandertalensis-sapiens* overlap was relatively brief. For whatever reason or reasons, the Neandertals would eventually disappear, thereby setting the stage for the success of the Cro-Magnon people as *Homo sapiens sapiens* (early phase).

The Cro-Magnons had even greater self-consciousness and it was expressed in the creative explosion of tools, e.g., blades and burins, and works of art, e.g., stone sculptures and, in particular, the painted cave murals at Altamira in Spain and Lascaux in France. Surely, the Cro-Magnon people were far more sophisticated than the Neandertals in terms of thought and behavior. The Cro-Magnons built shelters and had articulate speech; perhaps their greater social intelligence and advanced symbolic language (rather than genetic makeup) separated them from the rapidly vanishing Neandertals. Moreover, the Cro-Magnon people are directly related to *Homo sapiens sapiens* (present phase), i.e., they were our immediate ancestors.

Following the most recent Ice Age, *Homo sapiens sapiens* has been enormously successful in adapting to different environments around the world as a result of the

evolution of culture, especially accelerating advances in science and technology. Yet, despite sociocultural diversity, our own species has remained a biological unit on this planet. At this present stage of hominid evolution, through genetic engineering, the human animal is becoming more and more capable of directing the further development of itself as well as the ongoing evolution of other plant and animal species. One may argue that our own species, as the bipedal ape or third chimpanzee, is becoming the cosmic primate. In fact, our self-imposed destiny may require adapting to habitats on other worlds.

Conclusion

At present, several different interpretations of human evolution are possible, e.g., there are conflicting phylogenetic models, depicting the relationship between our common hominid ancestor and later hominid forms, that are presented by Donald C. Johanson and Richard Leakey. One may even argue that each of the major phases of hominization first appeared in Africa. Yet, the earliest making of fire and the origin of symbolic language as articulate speech may always elude the paleoanthropologists. For the rigorous evolutionist, explaining the long and complex emergence of our species (strictly in terms of a naturalistic worldview) requires no appeal to a divine plan or predetermined direction or necessary end-goal.

Our species is not nailed to this planet, but it *is* tied to life on earth through genetic evolution. Likewise, the human animal is always subject to the threat of extinction, which remains a possibility in light of the fact that most of the billions of species that have inhabited this planet are now extinct. Ironically, the evolutionary success of our species in terms of sheer numbers may well be the cause of its future demise (in sharp contrast to our population explosion, the small wandering bands of our earliest bipedal ancestors had been successful for millions of years). And there is the ever-increasing possibility that our modern technology, which represents extraordinary progress from the manuports and eoliths of our remote human ancestors to the stealth jet and space shuttle of today, will in the future either destroy or supersede humankind as we know it. Or, in time, our own species may give rise to a new form of life.

In short, hominid evolution has been about a five-million-year journey from our earliest ancestral form in central East Africa to the self-reflective global species that it represents today. As a result of ongoing research in paleoanthropology, a much clearer and more complete picture of human evolution will emerge in light of the discovery and interpretation of additional fossils and artifacts. With the use of sophisticated computer simulations, future paleoanthropologists will provide a better understanding of and deeper appreciation for the emergence of our own species.

Hominid evolution has been a far more complex process than was thought just a few decades ago. The growing fossil evidence clearly documents the past exist-

ence of many hominid forms. Yet, only one species has been successful and this form represents the present biological unity of humankind.

About 3.6 million years separate the fossil hominid tracks at Laetoli from Neil Armstrong's footprints on the moon. Overcoming incredible odds and the threats of extinction, hominid evolution has been a remarkable success story. No doubt, in the distant future, our descendants will leave both their bipedal impressions and cultural achievements on the surfaces of remote planets.

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