East Side Story: The Origin of Humankind

The Rift Valley in Africa holds the secret to the divergence of hominids from the great apes and to the emergence of human beings

by Yves Coppens

Humans are creatures whose roots lie in the animals. Accordingly, we find ourselves at the tip of one of the branches of an immense tree of life, a tree that has been developing and growing ever more diverse over a period of four billion years. From an evolutionary standpoint, it is important to locate the place and the time that our branch separated from the rest of the tree. It is these questions that the present article attempts to answer. When, where and why did the branch that led to us, the genus *Homo,* diverge from the branch that led to our closest cousin, the genus *Pan,* or the chimpanzee? Because this parting of the ways seems to unfold several million years before *Homo,* properly speaking, was born, the issue of our precise origin also needs to be addressed. When, where and why did *Homo* appear in the bosom of a family, Hominidae, that was well planted in its ecosystem and well adapted to its environment?

I first realized in 1981 that it might be possible to find answers to these questions. The occasion was an international conference in Paris organized by UNESCO to celebrate the 100-year anniversary of the birth of Pierre Teilhard de Chardin. As an invited speaker, I gave a talk on the French paleontologist and philosopher's scientific work. Although this aspect of Teilhard's writing is often forgotten by biographers, who are essentially interested in his philosophical texts, he produced more than 250 scientific reports over the course of 40 years. His opus includes articles on the structural geology of Jersey, Somalia, Ethiopia and China; on the Paleocene and Eocene mammals of Europe; on the Tertiary and Quaternary mammals of the Far East; on the fossil men of China and Java; on the southern African australopithecines (a kind of prehuman, one that was already hominid, but not yet *Homo*); as well as on the Paleolithic and Neolithic tools of all those countries.

A member of the audience, whom I did not know at the time, came up to me after my talk and congratulated me very courteously, admitting that he had not known about this technical aspect of Father Teilhard's work. He asked me several questions about this science of evolution that I practiced and about its state of development. My visitor ended this short interview with a precise question: Is there at present an important issue that is still being debated in your field?

Yes, I responded, there is a problem of chronology, as is often the case in historical sciences. Biochemists, struck by the great molecular proximity between humans and chimpanzees, place the beginning of the divergence of these two groups some three million years ago. This discipline also assigns a strictly African origin to humanity. In contrast, the field of paleontology describes a divergence that dates as far back as 15 million years ago. Paleontologists also postulate a broad origin, that is, one radiating from both the Asian and the African tropics.

The gentleman seemed interested, thanked me and left. Several months later I received a letter of invitation to a conference in Rome that he proposed to hold in May 1982. My questioner had been none other than Carlos Chagas, president of the Papal Academy of Sciences! In search of subjects that would have both current interest and important philosophical implications, he had considered what I had said and had organized, under the aegis of his institution, a confrontation between paleontologists and biochemists.

That meeting did take place and, although discreet, its influence on scientific thought was considerable. Two significant facts, one paleontological and one biochemical, were presented to the participants. The first was the announcement by David Pilbeam, professor of paleontology at Harvard University, that his research group had discovered, in the Upper Miocene levels of the Potwar Plateau in Pakistan, the first known face of a ramapithecid. This face resembles an orangutan's much more closely than it does a chimpanzee's face. Pilbeam's data were particularly important because the ramapithecids had for many years been considered by some paleoanthropologists to be the first members of the human family.

The second fact presented was a statement by Jerold M. Lowenstein of the University of California at San Francisco that active proteins had been discovered in the dental material of a ramapithecid. He had determined that activity by injecting extract from the ramapithecid teeth into a rabbit, where it brought on the formation of antibodies. Lowenstein then told us of the indisputable reaction of these antibodies

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RIFT VALLEY cuts across eastern Africa from north to south, created by tectonic forces eight million years ago. The changing landscape and mountain boundaries divided an ancestor of ours into two groups. The western party thrived in forests and became our closest cousins, the chimpanzees. The eastern population evolved on the savanna and became human.

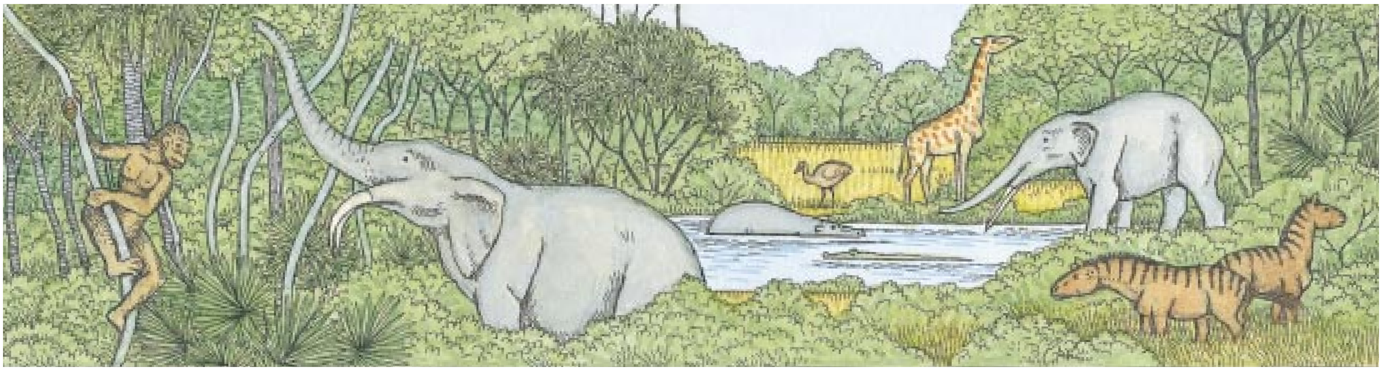
to the antigens of orangutans. This strong reaction made it clear that some of the ramapithecid proteins were still preserved and that the creature seemed related to orangutans.

Before the discovery of the ramapithecid face, scientists had procured only some of this genus's teeth and jaw fragments. Although these features were certainly interesting, it is necessary to know that all the bones of a skeleton do not carry information of equal value. These pieces were less significant than the orbit area and the nose and upper jaw region found in the new Pakistani piece. Paleontologists use such facial fossils to draw anatomical comparisons with similar or contemporary fossils. A simple comparison of the face of this ramapithecid, an orangutan and a chimpanzee clearly revealed the similarities between the ramapithecid and the orangutan.

Rather than comparing anatomical attributes, biochemists examine molecular details. They look at DNA, at the proteins and chromosomal maps of current species—elements that are not usually conserved in fossils. Their work helps paleontologists, who can then arrange species in order of complexity and compare their protein maps. The progression from simple to complex and the sequence that emerges reproduces, in some fashion, the evolution of creatures in the fossil record. In the case of the ramapithecid, however, biochemistry had made, as never before, a foray back in time by examining fossil proteins.

Circumstances had come together in such a way that we could finally put the ramapithecid in his place. This hominoid had been known to be Eurasiatic, and he remained so. Now that his relationship to the great ape of Asia, the orangutan, had been brought to light, the geographic picture became clear. Indeed, it made complete sense, as so often happens when one has found the solution to a problem. The origin of humanity, as the molecular biologists had suspected, appeared to be Africa, and Africa alone. The question of our family's place of birth seemed settled.

But the question of the date of this birth remained to be addressed. Several paleontologists present at this congress continued to defend the great antiquity of the hominids, whereas the molecular biologists extolled the extraordinary brevity of the independent part of our branch. The most generous of the paleontologists had arrived in Rome convinced of the 15-million-year history of our family. The most extreme of the molecular biologists were sure that three million years, at most, would measure the length of existence of the human family. Both sides came to the conclusion—made, of course, with only the most serious considerations possi-



The Omo River Sequence

LATE MIOCENE AROUND EIGHT MILLION YEARS AGO

ble—that seven and a half million years was a good span. I dubbed this conclusion "the prehistoric compromise."

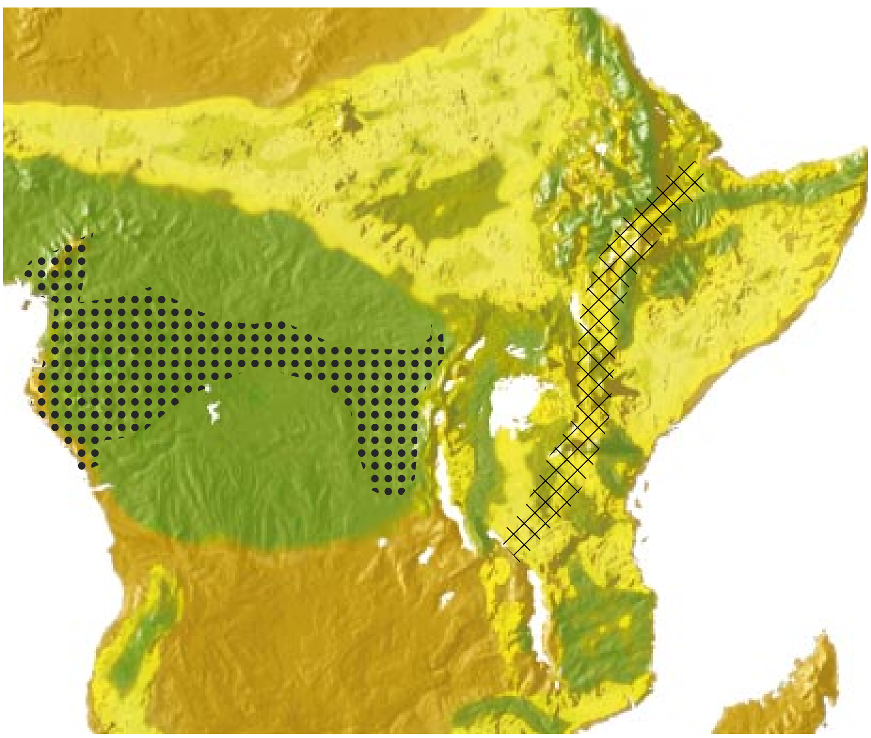
The two paleontological and biochemical announcements of the Rome meeting were not the only crucial items that came to light in the early 1980s. Another set of results further clarified our understanding of human origins. Twenty years of excavations in eastern Africa (between 1960 and 1980) had finally yielded a mass of information in which could be sought evolutionary sequences and patterns. This extensive material had not been looked at in such a way before because it takes time to study and identify fossils. Its implications were vast, particularly when coupled with the information from the ramapithecid and the newfound consensus on dates.

The entry of paleoanthropologists into eastern Africa was actually an ancient affair. In 1935 Louis Leakey's expedition to Olduvai Gorge in Tanzania discovered remains attributed to *Homo erectus.* In 1939 the German team of Ludwig Kohl-Larsen found fossils that were named *Praeanthropus africanus*—later considered to be *Australopithecus*—near Lake Garusi, an area also called Laetoli, in Tanzania. In 1955 another Olduvai expedition led by Leakey revealed a single australopithecine tooth. These modest discoveries, however, did not command much interest.

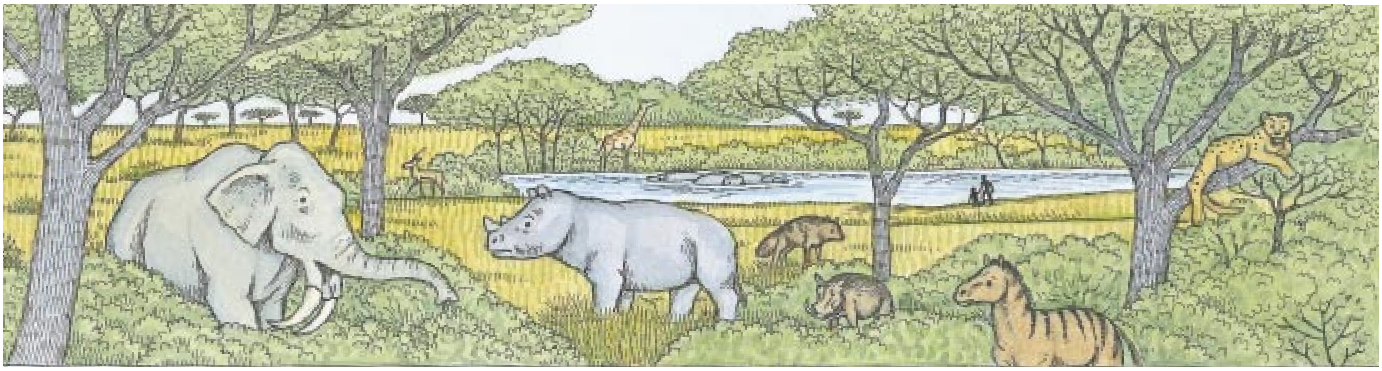
It was not until the 1960s that the world eagerly turned its attention to eastern Africa. In 1959 Mary Leakey found at Olduvai an australopithecine skull equipped with all its upper teeth. This skull could be absolutely dated to about two million years ago by the volcanic tuff below which it had been enveloped. The new hominid was named *Zinjanthropus;* it was a small-brained bipedal hominid species that went extinct about one million years ago. After that significant finding, expeditions started to arrive in abundance: a new team came each year for the first 12 years, and each one excavated for 10 or 20 seasons. Never before had such an effort been deployed by paleontologists or paleoanthropologists.

The results reflected the investment. Hundreds of thousands of fossils were discovered, of which about 2,000 were hominid remains. Yet, despite the constant work of preparation, analysis and identification of these fossils as they were unearthed, it is understandable that it was not until the 1980s that the first complete inventory of these thousands of finds was published. It is precisely this new information that, when added to the data received at the Rome conference, became essential to solving the mystery.

What emerged so clearly was that there was absolutely no sign of *Pan,* or one of its direct ancestors, in eastern Africa during the time of the australopithecines. Molecular biology, biochemistry and cytogenetics continued to demonstrate that humans and chimpanzees were molecularly extremely close, which meant, in evolutionary terms,



VEGETATION AND CLIMATE vary dramatically on either side of the Rift Valley: wet western woods (*dark green*) give way to eastern grasslands (*yellow*). Reflecting these ecological differences, which arose millions of years ago, chimpanzees are distributed only to the west (*stippling*), whereas hominid fossils are found only to the east (*cross-hatching*).



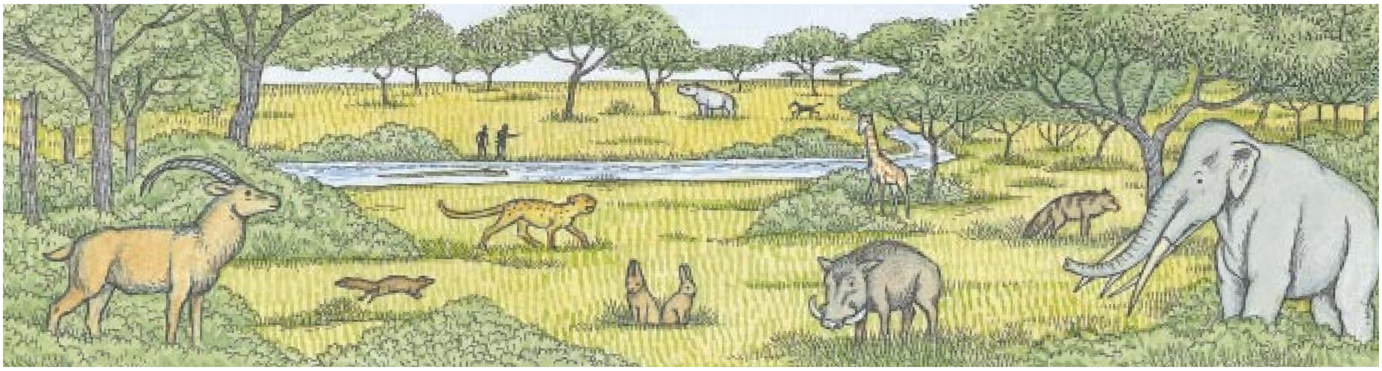
that they had shared a common ancestor not very far back in time, geologically speaking. And field-workers had just revealed that Hominidae, as of seven or eight million years ago, were present in Ethiopia, Kenya and Tanzania. But during the same period, this region had not seen the least sign of the family Panidae, no precursor of the chimpanzee and no precursor of the gorilla. Even though one cannot base a hypothesis on a lack of evidence, the striking absence of these Panidae where Hominidae were abundant represented a sufficient contrast to cause concern—all the more so because the 200,000 to 250,000 vertebrate fossils that had been collected constituted a statistical base with a certain authority.

I had been thinking about this puzzle during the conference in Rome. A quite simple explanation came to mind when I opened an atlas marking the distribution of vertebrates. The map devoted to chimpanzees and gorillas showed a significant group of territories, including all the large forested regions of tropical Africa, but stopped, almost without overflow, at the great furrow that cuts perpendicularly across the equator from north to south: the Rift Valley. All the hominid sites that dated to more than three million years ago were found, without exception, on the eastern side of this furrow. Only one solution could explain how, at one and the same time, Hominidae and Panidae were close in molecular terms but never side by side in the fossil record. Hominidae and Panidae had never been together.

I therefore suggested the following model. Before Hominidae and Panidae had separated, the Rift Valley did not constitute an irregularity sufficient to divide equatorial Africa. From the Atlantic to the Indian Ocean, the African continent constituted one homogeneous biogeographical province in which the common ancestors of the future Hominidae and Panidae lived. Then, about eight million years ago, a tectonic crisis arose that entailed two distinct movements: sinking produced the Rift Valley, and rising gave birth to the line of peaks forming the western rim of the valley.

The breach and the barrier obviously disturbed the circulation of air. The air masses of the west maintained, thanks to the Atlantic, a generous amount of precipitation. Those of the east, coming into collision with the barrier of the western rim of the Tibetan plateau, which also was rising, became organized into a seasonal system, today called the monsoon. Thus, the original extensive region was divided into two, each possessed of a different climate and vegetation. The west remained humid; the east became ever less so. The west kept its forests and its woodlands;

COMPARISON OF THREE HOMINOID SKULLS illustrates the proximity between two of the creatures. The ramapithecid (*center*) found in Pakistan resembles the great ape of Asia, the orangutan (*left*), much more closely than it does one of the African apes, the chimpanzee (*right*). Indeed, this very comparison led paleontologists to reject the Eurasiatic ramapithecids as close ancestors of humans and to focus on an African origin.



Crocodilus *Australopithecus* *Ceratotherium* *Giraffa* *Hyaena*
Hippotraginae *Enhydriodon* Machairodontinae *Lepus* *Nyanzachoerus* Gomphotheriidae

FIVE MILLION YEARS AGO **UPPER LOTHAGAMIAN (LOWER PLIOCENE)** 3.5 MILLION YEARS AGO

the east evolved into open savanna.

By force of circumstance, the population of the common ancestor of the Hominidae and the Panidae families also found itself divided. A large western population existed, as did a smaller eastern one. It is extremely tempting to imagine that we have here, quite simply, the reason for the divergence. The western descendants of these common ancestors pursued their adaptation to life in a humid, arboreal milieu: these are the Panidae. The eastern descendants of these same common ancestors, in contrast, invented a completely new repertoire in order to adapt to their new life in an open environment: these are the Hominidae.

This uncomplicated model has the advantage of explaining why Hominidae and Panidae are so close in a genetic sense and yet never together geographically. It also has the advantage of offering, by means of a situation that is at first tectonic and then ecological, a variant of the situation found on islands. Compared to complex solutions about the movements of Hominidae from the forest to the savanna or about the movements of Panidae from the savanna to the forest, the Rift Valley theory is quite straightforward.

It was only later, when I was reading the work of geophysicists, that I learned that the activity of the Rift Valley some eight million years ago was well known. Reading the studies of paleoclimatologists fortified me with the knowledge that the progressive desiccation of eastern Africa was also a well-known event, whose starting point had been placed at about eight million years ago. Finally, reading the declarations of paleontologists further reassured me, because they placed the emergence of eastern African animal life—a fauna labeled Ethiopian, to which the australopithecines belong—at about eight or 10 million years ago. Each discipline knew this date and in one way or another was familiar with the event or its consequences, but no interdisciplinary effort had brought them all into a synthesis. Adrian Kortlandt, a famous ethologist from the University of Amsterdam, had thought about such a possible scenario, but without any paleontological support, some years before.

The hypothesis lacked only a name. Three years later I was invited by the American Museum of Natural History in New York City to present the 55th James Arthur Lecture on the Evolution of the Human Brain. I also assumed a visiting professorship at the Mount Sinai School of Medicine of the City University of New York. The idea of giving this model a title that would be easy to remember and that would honor my hosts came to me then. I called it the East Side Story.

It is possible that the East Side Story has answered the first volley of questions: the when, where and why of our divergence from Panidae. Our phyletic branch, the one that now bears us, was marked off from the rest of the genealogical tree of living creatures eight million years ago in eastern Africa by reason of geographic isolation. The need for adaptation to the new habitat of the savanna, one that was drier and more bare than the preceding one, promoted further genetic divergence.

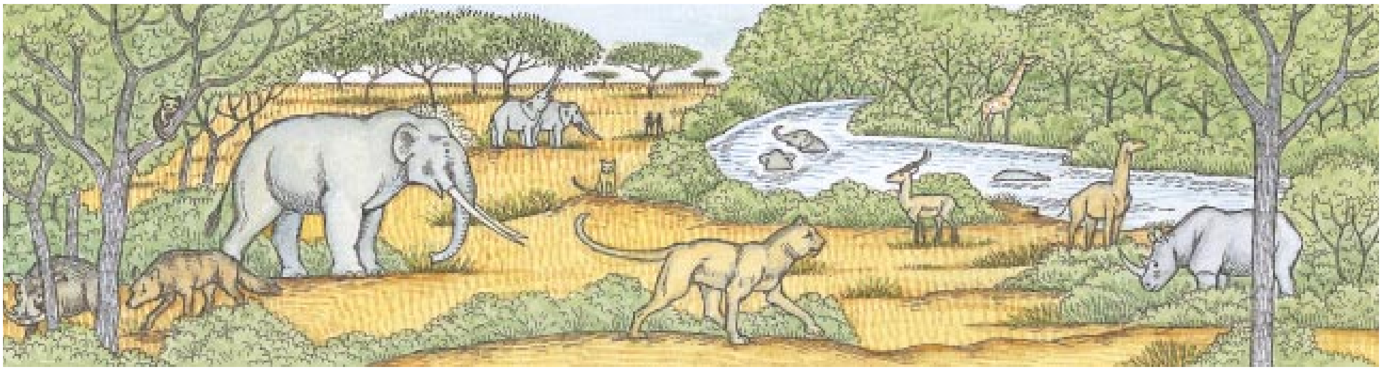
The second series of questions is more intricate: the when, where and why of the appearance of the genus *Homo* in the family Hominidae. The past eight million years during which our branch of the tree has grown have revealed themselves to be more complex than one might have imagined. The story begins with the diversification of a subfamily, the australopithecines. These creatures made very modest movements from eastern Africa to southern Africa. The story then continues from about three million years ago to today, with the emergence of another subfamily, the hominines. The hominines moved extensively, from eastern Africa across the entire planet. The last of the australopithecines coexisted for about two million years with the first of these hominines, which have only one genus, *Homo.*

The emergence of this hominine subfamily can be seen in a remarkable series of geologic beds and fossils found along the banks of the Omo River in Ethiopia. And, not surprisingly, because this is the second part of the East Side Story, the role of climate proves to be as powerful a force for change three million years ago as it did eight million years ago.

The Omo River tale began at the turn of this century, when a French geographic expedition proposed to cross Africa diagonally, from the Red Sea to the Atlantic. The Viscount du Bourg de Bozas directed the expedition. Having departed from Djibouti in 1901, the exploration was to end dramatically in the death of its leader from malaria on the banks of the Congo. The team nonetheless brought back from the journey, which followed the original itinerary, a fine harvest of fossils. Among the collection was a group of vertebrate remains gathered in what was then Abyssinia, on the eastern bank of the lower valley of the Omo River. The Omo lies on the eastern side of the Rift Valley.

Intrigued by this yield, which was described in two or three articles and in Émile Haug's geologic treatise in 1911, Camille Arambourg decided at the beginning of the 1930s to conduct a new expedition. Arambourg, future professor of paleontology at the National Museum of Natural History in Paris, reached the Omo and stayed eight months in 1932. He returned to Paris with four tons of vertebrate fossils.

The next major operation—the Omo



Research Expedition—was undertaken between 1967 and 1977. It was catalyzed, in part, by the bone rush of the 1960s and 1970s, described earlier, which had followed the 1959 find by Mary Leakey at Olduvai. A series of researchers conducted the 10-year Omo expedition in stages. In 1967 Arambourg and I worked on the site with Louis and Richard Leakey and Francis Clark Howell. Between 1968 and 1969 Richard Leakey left the expedition, and Arambourg, Howell and I continued the work. Finally, from 1970 until 1976, Howell and I dug there alone (Arambourg died in 1969).

From the very first expedition, the stratigraphy of this site was eminently visible, a superb column more than 1,000 meters deep. The fauna contained in these beds appeared to change so markedly as it progressed from base to summit that the site was obviously capable, even at mere glance, of telling a story. When dating by potassium-argon and by paleomagnetism finally became available, so that a chronological grid could be placed on this sequence, the history became clear.

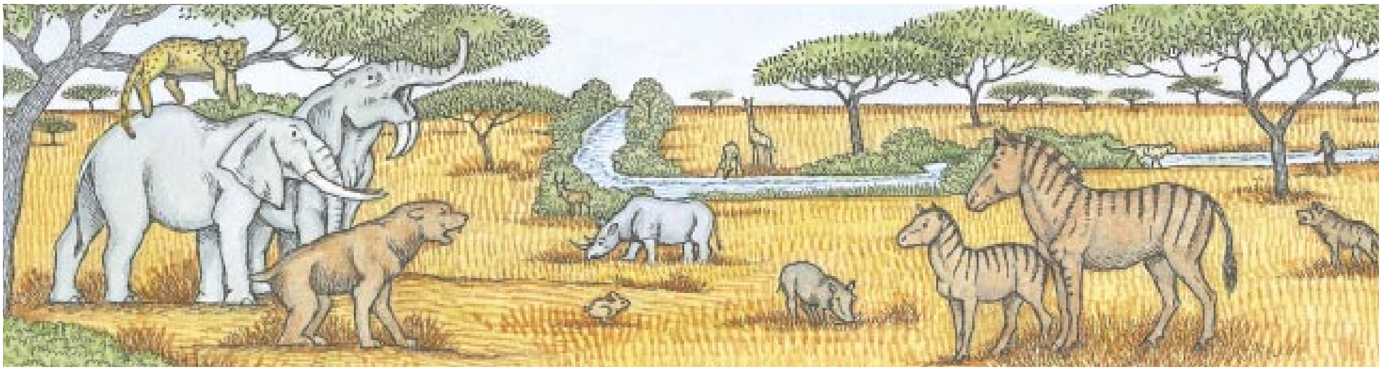
Starting four million years ago (the age of the oldest Omo level, the Mursi formation) and ending one million years ago (the age of the most recent level, the top of the Shungura formation), the climate had clearly changed from humid to distinctly less humid. As a consequence, the vegetation had evolved from plants adapted to humidity to those capable of thriving in a drier climate. The fauna had also changed from one suited to a brushwood assemblage to one characteristic of a grassy savanna. And the Hominidae, subject like the other vertebrates to these climate fluctuations, had changed from so-called gracile australopithecines to robust australopithecines and, ultimately, to humans.

In 1975 I informed the international paleontological community of this clear correlation between the evolution of the climate and the evolution of the hominines. I did so in a note to the *Proceedings of the Academy of Sciences* in Paris and in a communication to a congress in London at the Royal Geological Society. The reaction was very skeptical.

Of all the great eastern African paleontological sites, the strata of Omo were the only ones that could have permitted such observations. This site alone offered a continuous sedimentary column that ran from four million years ago to one million years ago. It is precisely between three and two million years ago, or to be very exact between 3.3 to 2.4 million years ago, that the whole earth cooled and that eastern Africa became dry. (Laetoli and Hadar were too old, Olduvai was too young and East Turkana presented a stratigraphic gap at that point, so they could not offer the same demonstration.) We know this fact through several other tests conducted in various regions of the world.

This climatic crisis appears clearly in the fauna and flora records of the Omo sequence. By indexing, both qualitatively and quantitatively, the animals and plants gathered in the various levels, we can interpret the differences that emerge from these species, with regard to changes in the environment.

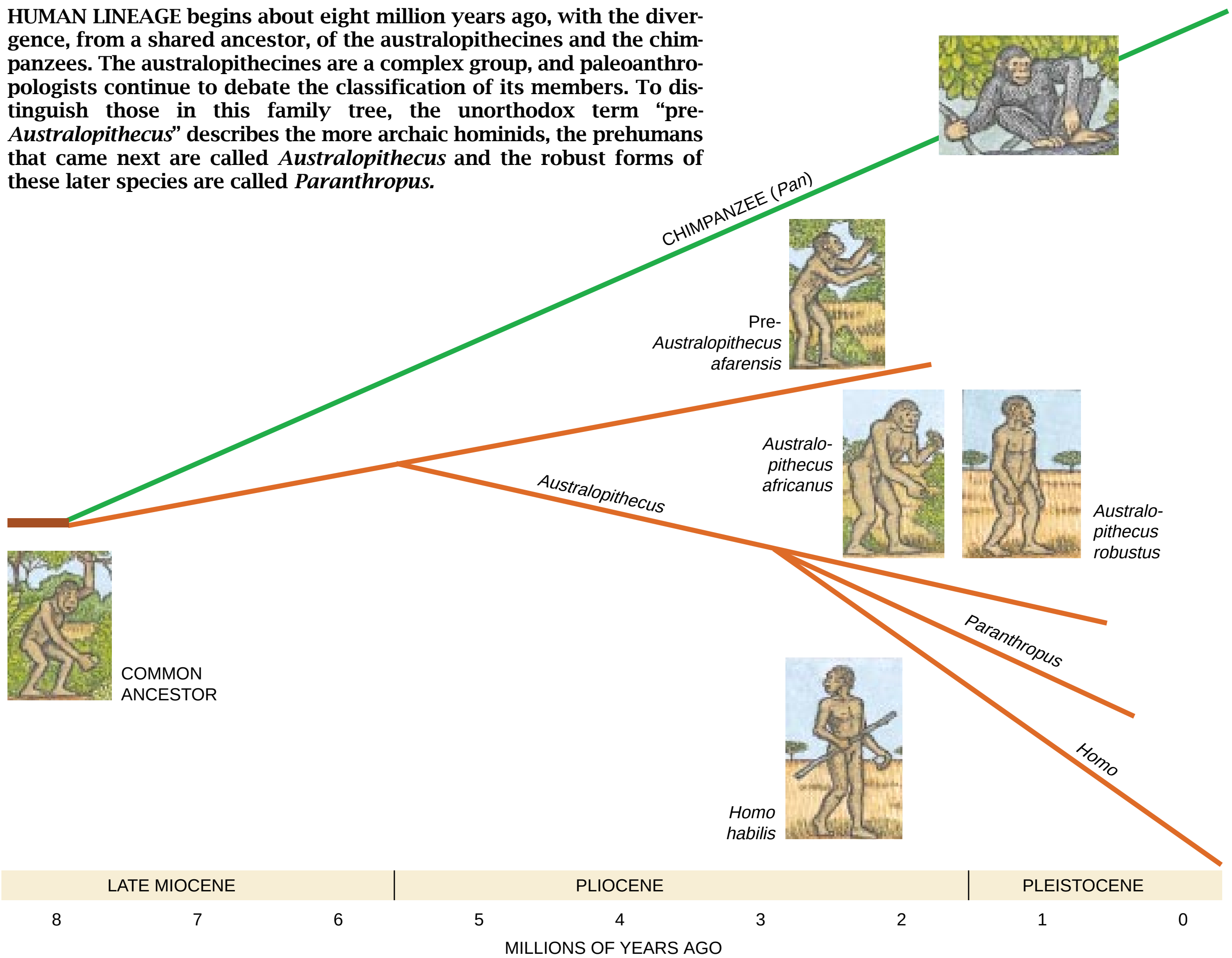
MARY AND LOUIS LEAKEY examine the *Zinjanthropus* skull and upper jaw at Olduvai Gorge in Tanzania in 1959. Their discovery of a hominid fossil at this site led to a bone rush: paleontologists flooded in, and hundreds of thousands of fossils were excavated in subsequent decades.

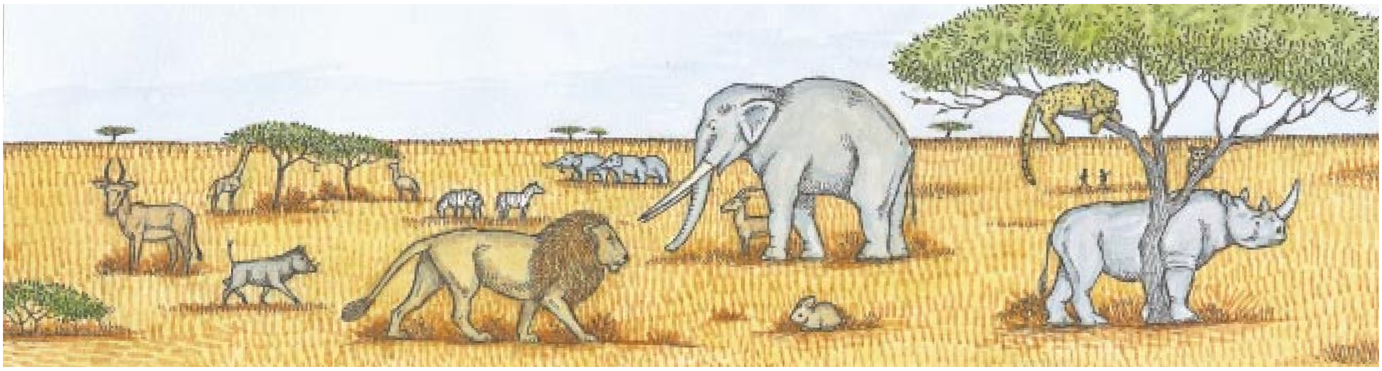


We know, for example, that the cheek teeth—that is, the premolars and molars—of herbivore vertebrates have a tendency to develop and become more complex when the diet becomes more grassy and less leafy. This change takes place because grass wears down the teeth more than leaves do. We know also that the locomotion of these same herbivores becomes more digitigrade in open habitats in which they are more vulnerable: one runs better on tiptoe than in boots. A certain number of anatomical features corresponding to very precise functions can also be good indicators: the tree-dwelling feet of some rodents or the feet of others that are adapted to digging. We use, with appropriate caution, of course, a method called actualist; in other words, we believe that the varieties of animals or plants we are considering acted then as they act today.

Many examples demonstrate this transition to a drier environment, and they are extraordinary in their agreement. As one moves from the older strata on

HUMAN LINEAGE begins about eight million years ago, with the divergence, from a shared ancestor, of the australopithecines and the chimpanzees. The australopithecines are a complex group, and paleoanthropologists continue to debate the classification of its members. To distinguish those in this family tree, the unorthodox term "pre-*Australopithecus*" describes the more archaic hominids, the prehumans that came next are called *Australopithecus* and the robust forms of these later species are called *Paranthropus.*





Giraffa Camelus Equus Deinotherium Elephas Panthera pardus Galago
Damaliscus Phacochoerus Panthera leo Kobus Lepus Homo Ceratotherium

1.8 MILLION YEARS AGO **PLEISTOCENE** ONE MILLION YEARS AGO

the bottom to the younger strata on the top, there is an increase in the hypsodonty—that is, in a tooth's height-to-width ratio—among Elephantidae (elephants close to the ones living in Asia today), Rhinocerotidae (specifically the white rhinoceros), *Hipparion* (ancestors of the horse), Hippopotamidae (precursors of the hippopotamus) and some pigs and antelopes. In other words, these groups exhibited the increasing complexity that we associate with a shift from a diet of leaves to a diet of grass. The Suidae, or precursors to swine, also show an increase in the number of cusps on their molars as they evolved.

On the lower strata are many antelopes—including Tragelaphinae and Reduncinae, which live among shrubs. All these creatures must have lived in an environment of wooded savanna close to water. On the top levels the true horse, *Equus,* appears, as do the high-toothed warthogs, *Phacochoerus* and *Stylochoerus.* We also see the development of the swift antelopes, *Megalotragus, Beatragus* and *Parmularius,* animals found on open grasslands.

On the bottom, three species of small *Galago,* or monkey, and the two Chiroptera, *Eidolon* and *Taphozous,* indicate a well-developed forest and a dense savanna. This conclusion is supported by the large number of Muridae rodents, such as *Mastomys,* as well as the rodents *Grammomys, Paraxerus, Thryonomys* and *Golunda.* At the top, the rodents *Aethomys, Thallomys, Coleura* and *Gerbillurus* in conjunction with *Jaculus* and *Heterocephalus,* the Chiroptera, and the *Lepus,* or hare, replace the previous inhabitants. All the later rodents inhabit dry savanna.

Pollen specimens on the bottom indicate 24 taxa of trees, whereas the top is characterized by 11. At the bottom, the ratio of pollens from trees to pollens from grasses equals 0.4. But at the top, it is less than 0.01. At the bottom, pollens from species that grow in humid conditions are abundant—they include *Celtis, Acalypha, Olea* and *Typha.* In the more recent strata, however, these pollens diminish considerably or even disappear from the record, whereas pollens from Myrica, a plant typical of dry climates, appear. The number of pollens transported by the wind, called allochtone pollens, dwindles from 21 percent at the bottom, where the forest edge is near the Omo River, to 2 percent at the top, where the Omo was low and the forest edge far away.

The story with the hominids is similar. They are clearly represented by *Australopithecus afarensis* on the lower strata. But the younger strata on the top reveal *A. aethiopicus, A. boisei* and *Homo habilis.* The oldest species of australopithecines, the graciles, are more ensconced in tree-filled habitats than are the more recent species, those called robust. As for humans, we are unquestionably a pure product of a certain aridity.

I called this climatic crisis "the (H)Omo event" using the simple play on words of Omo and *Homo,* because it permitted the emergence of humans—an event that affects us quite specifically—and because it was the Omo sequence that revealed it for the first time. Some years later the same data were reported from South Africa.

Thus, it appears strikingly clear that the history of the human family, like that of any other family of vertebrates, was born from one event, as it happens a tectonic one, and progressed under the pressure of another event, this one climatic.

These changes can be but quickly summarized here. Essentially, the first adaptation changed the structure of the brain but did not increase its volume, as suggested by the interpretation of endocasts, latex rubber casts of fossil skulls, done by Ralph L. Holloway of Columbia University. At the same time, the changes caused Hominidae to retain an upright stance as the most advantageous and to diversify the diet while keeping it essentially vegetarian. The second adaptation led in two directions: a strong physique and a narrow, specialized vegetarian diet for the large australopithecines and a large brain and a broad-ranging, opportunistic diet for humans.

Some hundreds of thousands of years later, it was the latter development that proved to be the more fruitful, and it is this one that prevailed. With a larger brain came a higher degree of reflection, a new curiosity. Accompanying the necessity of catching meat came greater mobility. For the first time in the history of the hominids, humanity spread out from its origin. And this mobility is the reason that in less than three million years, humanity has conquered this planet and begun the exploration of other worlds in the solar system.

FURTHER READING

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