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Early human biocultural evolution

350,000 generations of human history (approx. 7 million years) document a great geographical diversity of pre-human, early, and prehistoric humans, initially in Africa and beyond for circa the past 100,000 generations. Climate and environmental changes as well as changes in food resources were often the triggers for new developments.

Walking upright: the origin of hominins

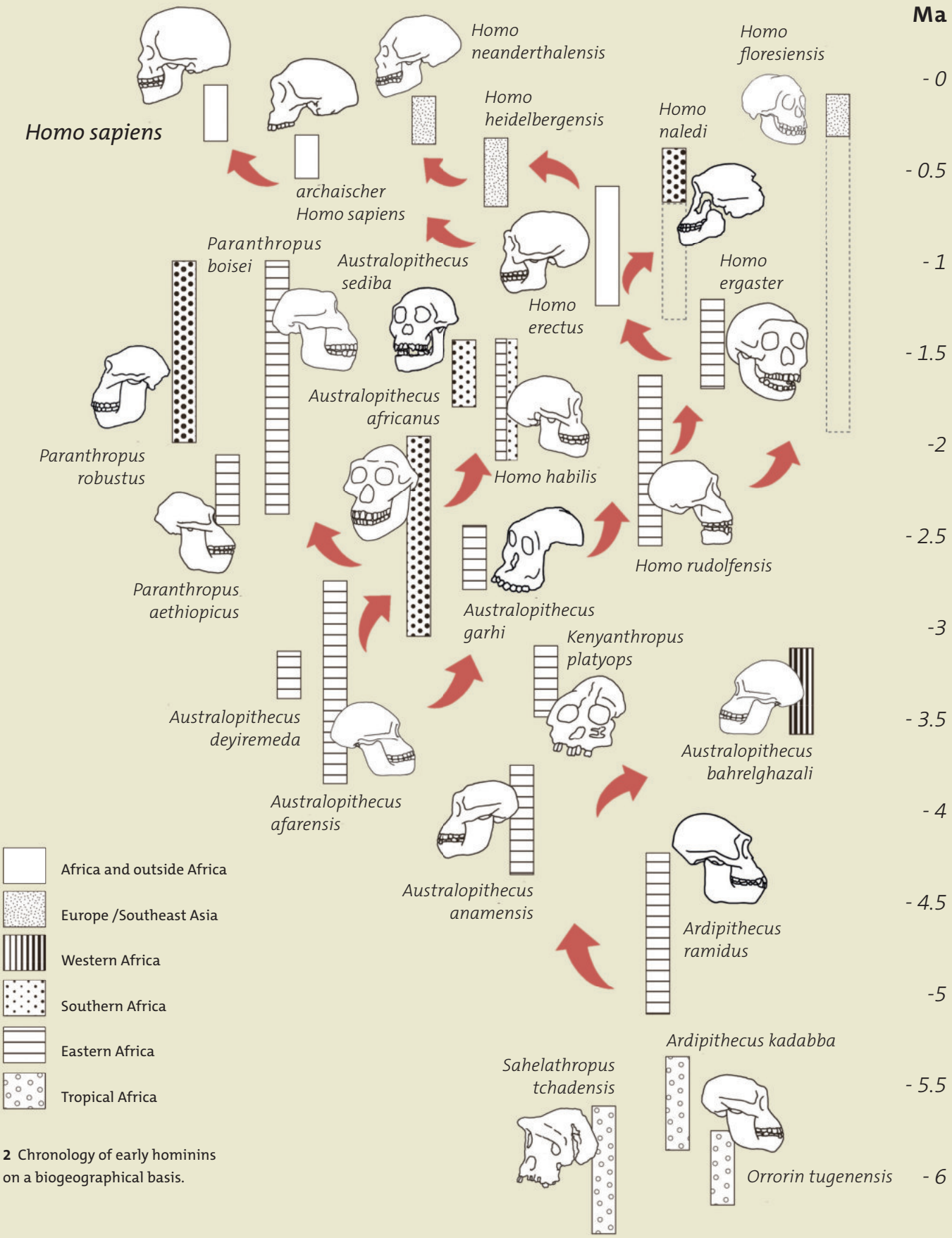
Great apes lived in the rainforests of tropical Africa, which stretched from the west to the east coast of the continent, for over 30 million years. Climbing, but not brachiation, was one of the common traits of modern great apes. Our ancestors never lived "in the trees", but were a four-legged species who could straighten up and probably also stand for a short period of time.

Due to global climate cooling since the Middle Miocene around 10 Ma (= million years ago), the tropical rainforest shrank, so that some great ape populations newly colonized the emerging African savannas. The fruit-rich food of the tropical rainforest was partially replaced by aquatic food. Since great apes cannot swim, they waded into the shallow water to gather food, which in the long term further stabilized the two-legged locomotion. The shore habitats of the savannah were thus the ideal breeding ground for bipedal walking.

As the savannas extended across more than 5 million km² it is unlikely that the bipedal walk developed only once. All finds from this period (Kenya, *Orrorin*, approx. 6 Ma, Ethiopia, *Ardipithecus*, approx. 5.8 Ma, and Chad, *Sahelanthropus*, approx. 7 Ma) show evidence for bipedal walking. The geographical variants of the original populations of the earliest hominins were intertwined along the borders of the shrinking tropical rainforest. The reduction in canine teeth is also an early feature of hominin origin. This suggests a changed social behavior in which social cognition and higher forms of cooperation were able to develop.

Fig. 2

1 To recover even the smallest bone fragments, archeologists sieve the sediment from a site in Malawi.



2 Chronology of early hominins on a biogeographical basis.

Pre-humans in eastern and western Africa

The oldest pre-human finds of the genus *Australopithecus* were discovered on the southeastern shore of Lake Turkana in Kenya (*Australopithecus anamensis*, approx. 4 Ma). All australopithecines had a brain no larger than that of chimpanzees, large molars, and thick enamel. The teeth and jaws were suitable for chewing hard and brittle food or for crushing small particles, such as nuts and other seeds, between their flat, broad molars.

Since neither physical nor cultural achievements provided effective defense, a pronounced cooperative social behavior took over the decisive protective function against predators. Australopithecine finds from Laetoli (Tanzania) and Hadar (Ethiopia) were jointly used as the basis for the description of *Australopithecus afarensis* (3.7–2.9 Ma). *Australopithecus afarensis* (for example "Lucy") weighed 30 to 50 kg and was about 1.20 m tall. The arms were relatively long, the legs very short compared to those of modern humans. The fully developed upright locomotion was therefore still quite strenuous. *Fig. 3*

The acquisition of food was probably relatively unspecialized: fruits, berries, nuts, seeds, saplings, buds, and mushrooms were available. Underground roots and tubers could be dug up. Small reptiles, fledglings, eggs, mollusks, insects, and small mammals living in the water and on the ground were also not spurned. Due to the seasonal change, *Australopithecus afarensis* is likely to have developed strategies to make the best possible use of the diverse food supply according to the availability in a seasonal habitat. *Fig. 4*

The pre-humans gradually achieved pan-African distribution, but always remained close to the broad riverbank habitats. *Australopithecus deyiremeda, Australopithecus garhi*, and *Kenyanthropus platyops* originated in eastern Africa. A subpopulation expanded into modern-day Chad *(Australopithecus bahrelghazali).*

Pre-humans in southern Africa

In periods of relatively warm climates around three and a half to three million years ago, pre-human populations also spread along coastal corridors into southern Africa. The first hominin discovery in Africa ("Taung Baby", 1925) led to the first description of the genus *Australopithecus*. The mouth region protrudes, the face is tilted slightly (prognathic). The forehead is flat, the bulge above the eye developed. The lateral cheekbones project powerfully, the jaw is robust, the chin is missing. A characteristic trait is a combination of a small cranium (approx. 450 cm^3) with a set of teeth in which the incisors and canines appear tiny, while the molars and premolars are almost twice as large as in modern humans.


Early hominins (pre- and proto-humans)
Homo ergaster/erectus (early humans)
Archaic Homo sapiens
Early modern Homo sapiens
Thigennif
Salé
Kebibat
Témara
Thomas Quarries
Sidi Abd el-Rahmane
Jebel Irhoud
Haua Fteah
Taramsa Hill
Koro Toro
Yayo
Toros Menalla
Buia
Woranso-Mille
Ledi Geraru
Hadar
Bodo
Singa
Gona
Maka
Aramis
Bouri
Nariokotome
Mélka Kunturé
Lomekwi
Konso Gardula
Lothagam
Omo
Kanapoi
Koobi Fora
Allia Bay
Baringo
Chemeron
Olorgesailie
Peninj
Ndutu
Olduvai Gorge
Laetoli
Makuyuni
Malema
Uraha
Kabwe
Malapa
Swartkrans
Gladysvale
Drimolen
Kromdraai
Sterkfontein
Rising Star
Makapansgat
Border Cave
Taung
Florisbad
Saldanha
Klasies River Mouth
Blombos Cave
Lakes in the African Rift Valley
1 Lake Turkana
2 Lake Albert
3 Lake Manyara
4 Lake Natron
5 Lake Eyasi
6 Lake Tanganyika
7 Lake Rukwa
8 Lake Malawi
Lake Chad
today
Lake Mega Chad (holocene)

Australopithecus africanus in southern Africa preferred habitats along the forest edge, often near rivers. There is no evidence for hunting behavior, therefore it is likely that only smaller animals or freshly torn game were eaten. Presumably, pre-humans drove away predators in a cooperative and targeted manner, for example by throwing stones. Pre-humans ate everything they could get their hands on in an opportunistic manner, with varying proportions of plants and meat according to the season. *Fig. 2*

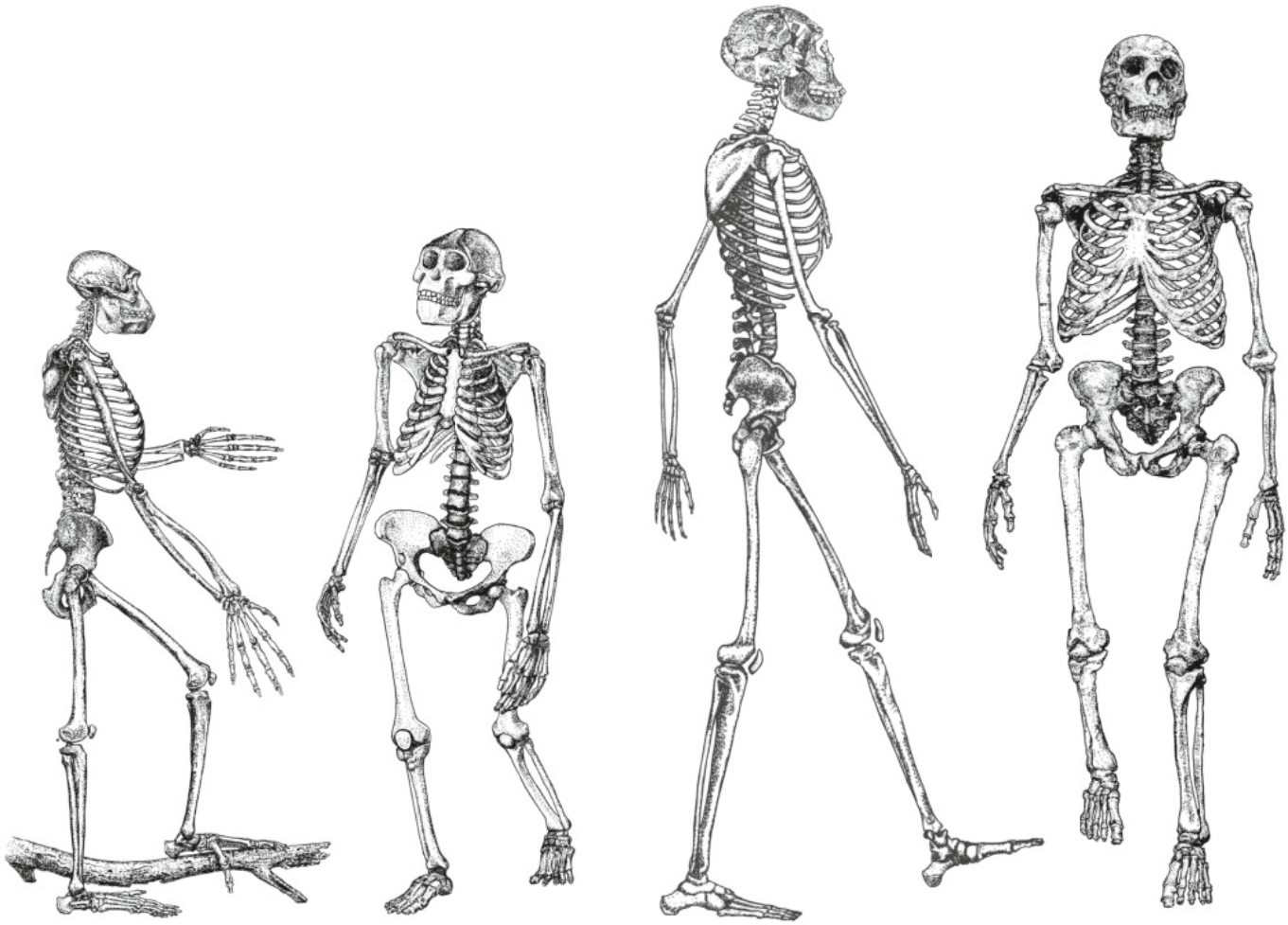
Climate change catalyst: expansion, evolution, culture

A phase of global cooling began around 2.8 million years ago. For around 15,000 generations, up to around 2.5 million years ago, pre-humans lived in increasingly extreme climatic and environmental conditions, which led to a profound change in the food base and a geographical shift in habitats. This resulted in passive expansions and evolutionary adaptations as well as the beginning of the biocultural evolution of the genus *Homo*.

Passive expansion: Some organisms retained their preference for seasonal changes by expanding towards the equator along with the shrinking biome (ecosystem). These "passive migrants" also included sub-populations of *Australopithecus africanus*, which spread north along corridors along the riverbanks. *Homo habilis* evolved due to its greater flexibility in behavior in the new living space.

Evolutionary adaptation: Some populations of *Australopithecus afarensis* in eastern Africa were able to digest the harder foodstuffs that were abundantly available in the open habitats, using their large molars. They developed wide facial bones and megadont (oversized) dentition. The zygomatic arches were strong and wide. The conspicuous formation of a sagittal crest on the top of the skull served as the attachment area for the greatly enlarged lateral masticatory muscles *(Musculus temporalis)*. Their megadont molars show that they chewed predominantly hard and coarse vegetable foods, such as seeds and hard plant fibers. The ability to break open hard shells could also have been beneficial when consuming aquatic food (such as mussels). The robust "nutcracker people" *aethiopicus, boisei,* and *robustus* are grouped in the genus *Paranthropus*. *Fig. 5*

4 Comparison of early hominin skeletons.



Reconstruction
Ardipithecus ramidus
Height: circa 1.20 m
Age: circa 4.4 million years

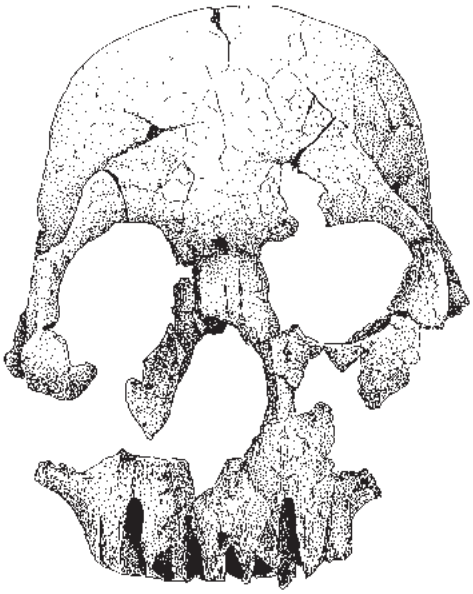
Reconstruction of "Lucy"
Australopithecus afarensis
Height: circa 1,20 m
Age: circa 2.9 million years

Early African
Homo erectus (Homo ergaster)
"Turkana Boy", skeleton KNM-WT 15000 from Nariokotome, West-Turkana, Kenya
Height: circa 1.70 m
Age: circa 1.7 million years

Homo neanderthalensis
Reconstruction of the skeleton, using La Ferrassie 1 (France) and Kebara 1 (Israel)
Height: circa 1.60 m
Age: circa 70,000–60,000 years

Paranthropus aethiopicus
(Black skull, KNM-WT 17000)

5 cm



Homo rudolfensis
(KNM-ER 1470)

5 Division and coexistence of new species in the hominin family tree for 2.5 million years.

Biocultural evolution: There was, however, an alternative to the hyper-robust chewing apparatus that was also suitable for chopping up increasingly harder food: the use of tools. Under the pressure of habitat changes over the past 2.8 million years, it was the hominins' capability of cultural behavior that gave birth to the genus *Homo*. The oldest prehistoric humans belong to the species *Homo rudolfensis*. By systematically using stones to crush the hard plant food, these prehistoric humans gained increasing independence from direct environmental influences. However, this inevitably led to a growing dependency on tools—a characteristic of humans to this day.

6 Expansions and important find sites of the genus *Homo* in Europe, Africa, and Asia.

EUROPE

Atapuerca: Gran Dolina
Skull fragment and Upper jaw
Homo antecessor
Age circa 800,000 years
Spain

Atapuerca: Sima de los Huesos
Skull 5
Homo heidelbergensis
Age circa 400,000 years
Spain

Mauer: Mauer 1
Lower jaw
Homo heidelbergensis
Age circa 600,000 years
Germany

Petralona: Skull
Homo erectus and *heidelbergensis*
Age circa 300,000 years
Greece

Arago: Arago 21
Skull
Homo erectus and *heidelbergensis*
Age circa 400,000 years
France

Steinheim:
Skull
Homo heidelbergensis and *steinheimensis*
Age circa 350,000 years
Germany

Gibraltar: Gibraltar 1
Skull
Homo neanderthalensis
Age circa 25,000 years
Great Britain

AFRICA and Levante

Uraha: UR 501
Lower jaw
Homo rudolfensis
Age circa 2.5 million years
Malawi

W-Turkana: KNM-WT 15000
Skeleton
Homo ergaster
Age circa 1.7 million years
Kenya

E-Turkana: KNM-ER 1470
Skull
Homo rudolfensis
Age circa 2 million years
Kenya

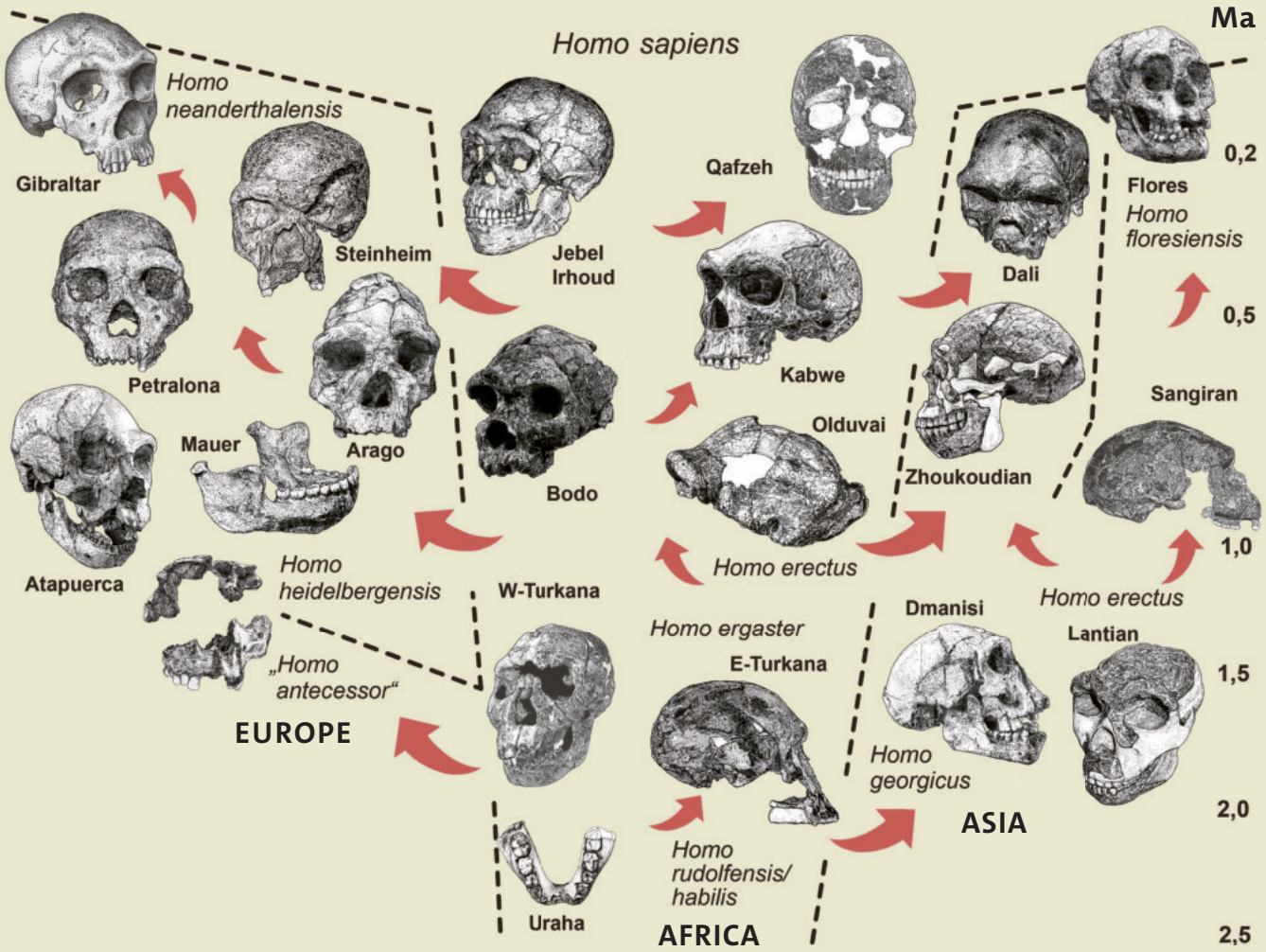
Olduvai: OH 9
Skull cap
Homo erectus
Age circa 1 million years
Tanzania

Bodo: Bodo cranium
Skull
archaic *Homo sapiens*
Age circa 600,000 years
Ethiopia

Kabwe: Broken Hill 1
Skull
archaic *Homo sapiens* and *Homo rhodesiensis*
Age circa 300,000 years
Zambia

Jebel Irhoud:
Virtual skull reconstruction
Homo sapiens
Age circa 300,000 years
Morocco

Qafzeh: Qafzeh IX
Skull
Homo sapiens
Age circa 95,000 years
Israel



ASIA

Lantian: Gongwangling
Skull
Reconstruction
Homo erectus
Age circa 2 million years
China

Dmanisi: D 2700 & D 2735
Skull and Lower jaw
Homo georgicus
Age circa 1.8 million years
Georgia

Sangiran: Sangiran 17
Skull
Homo erectus
Age not determinable
Indonesia

Zhkoudian:
Skull, Reconstruction
Sinanthropus pekinensis and
Homo erectus
Age circa 600,000 years
China

Dali: Dali skull
Skull
archaic *Homo sapiens*
Age circa 280,000 years
China

Flores: Liang Bua (LB) 1
Skull
Homo floresiensis
Age circa 50,000 years
Indonesia

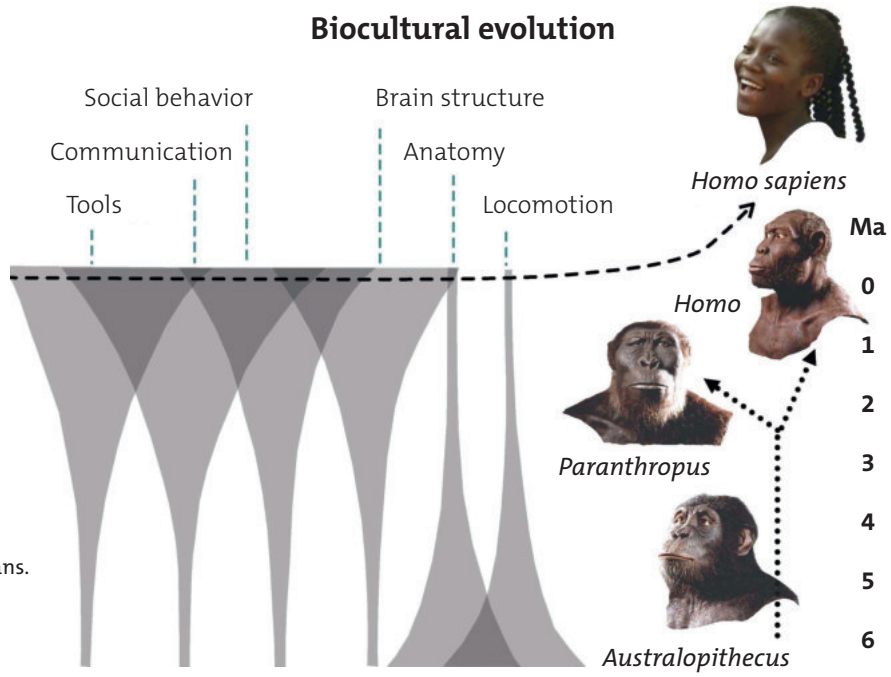
Early humans: *Homo erectus*

Fig. 3

About two million years ago in Africa, the development towards a stronger and larger skeleton and massive bone structure, the typical traits of *Homo erectus*, began. The oldest fossil remains, between 2 and 1.5 million years old, were described as *Homo ergaster.* The volume of the skull gradually increased, and the proportions of the cranium and facial skeleton changed. The point where the spinal column and spinal cord connect to the skull *(Foramen magnum)* moved further underneath the skull, the structure of the joint of the lower jaw changed, and the more rounded shape of the dental arch emerged. The massive bone structure shows that *Homo erectus* displayed great strength and endurance when carrying material and food. These early humans could run, as evidenced by the elongation of legs; loss of body hair and increase in sweat glands probably also developed during the *Homo erectus* phase.

The finger bones are elongated and no longer suitable for climbing. In contrast to the great apes' "power grip", which allowed them to clasp an object with their fingers and thumb, a "precision grip" is now possible. Due to the shorter fingers and the greater flexibility of the thumb, this is now opposable in such a way that the fingertips can touch each other. With more control, it is now possible to precisely manipulate objects held in one hand.

The earliest finds possess a brain volume of around 800 to 900 cm^3. The volume increased to around 900 to 1,000 cm^3 circa one million years ago, and more than 1,100 to 1,200 cm^3 half a million years ago. The more efficient brain improved the ability to store and process complex connections. There are no direct references to language among *Homo erectus*. Given the ability to produce tools that require a great deal of experience and knowledge to make, it can be assumed that verbal communication also increased. The increased demand for energy required by a larger brain necessitates an omnivorous lifestyle with a high proportion of meat. One way to efficiently digest plant foods is through the application of fire. The earliest evidence for the controlled use of fire was discovered in Koobi Fora, Kenya (approx. 1.5 Ma). The control of the fire is a technical and at the same time socially and proactively regulated task (see article "Fire" by Giemsch in this volume). We can assume a well-functioning social structure for *Homo erectus*.



7 Important evolutionary features in humans. The width of the pillars corresponds to the extent of the changes in the characteristics over the last 7 million years.

Earliest expansions 'Out of Africa'

Homo erectus was very familiar with the landscape and the availability of resources. This led to efficient use of seasonal resources and a greater radius of movement. Its ability to combine plant and meat resources gave it great flexibility long before the use of fire. The high tolerance towards variations in habitats led to the division into groups that lived further apart. River valleys allowed for a rapid spread. Expansions along the seacoast provided the opportunity to gather mollusks. Expansions of a few kilometers per generation led to the colonization of new habitats over a short geological period.

Fig. 6

Early humans left Africa for the first time around two million years ago, probably along routes through the Levant and the Arabian Peninsula. Evidence of the earliest settlements was found in China (2.1 Ma), Pakistan, and the Caucasus (Dmanisi, 1.8 Ma). Finds in Italy are 1.7 to 1.3 million years old, in Spain 1.4 to 1.2 million years. An increase of cultural abilities facilitated the expansion across habitat boundaries, such as into southeastern Asia (approx. 1.5 Ma) and the Philippines (approx. 700,000 years).

At least 500,000 years ago, *Homo erectus* was widespread in East and Southeast Asia as well as throughout Central and Southern Europe. While these geographical variants evolved into independent species (for example Neanderthals in Europe, Denisova people in Asia), in Africa around 400,000 years ago, a syn-

ergy effect of different factors of biological and cultural evolution, such as tool culture, communication, social behavior, brain structure, and body composition, led to the emergence of modern humans. The transfer of knowledge and cultural and genetic exchange were the decisive prerequisites for innovations and the worldwide spread of *Homo sapiens*. Therefore today's isolation of affluent regions – thought in many generations – will not be successful. Given global challenges such as serious changes in biodiversity and climate, only global networking can ensure our survival, as our long history has shown time and again.

Fig. 7

Further reading

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Australopithecus afarensis

Profile

Discovery

Ludwig Kohl-Larsen first discovered remains, jaw fragments and teeth, in 1938/39 in the Garusi Valley near Laetoli, Tanzania. It was not until 1979 that Donald Johanson, the discoverer of Lucy, and colleagues described a separate species *Australopithecus afarensis* based on finds from Laetoli and Ethiopia.

Sites

Tanzania: Laetoli.

Ethiopia: Hadar, Maka, Dikika, Aramis, Mount Galili.

Kenya: Turkwel River.

Finds

Left lower canine, incomplete skeleton ("Lucy"), juvenile skeleton from Dikika, and additional hand, foot, and extremity fragments, as well as the fossilized footsteps from Laetoli.

Age

3.76–2.92 million years.

Brain size

450–550 cm^3.

Characteristics

Australopithecus afarensis mainly lived in a so-called mosaic landscape (grassland with isolated trees and closed stands of bushes and trees on waterways and mountain valleys). They reached a size of approximately 1.20–1.40 m and weighed 20–50 kg. This weight corresponds to that of today's dwarf chimpanzees. Their diet was based primarily on fruits, leaves, plant pulp, seeds, and herbs. The angle of the knee joint suggests that they walked upright. The anatomy of the finger and toe bones, which are shorter than those of monkeys, are indicative of life on the ground.

Skull AL 333-105
from Hadar, Ethiopia

Facial reconstruction

Reconstruction
of "Lucy"