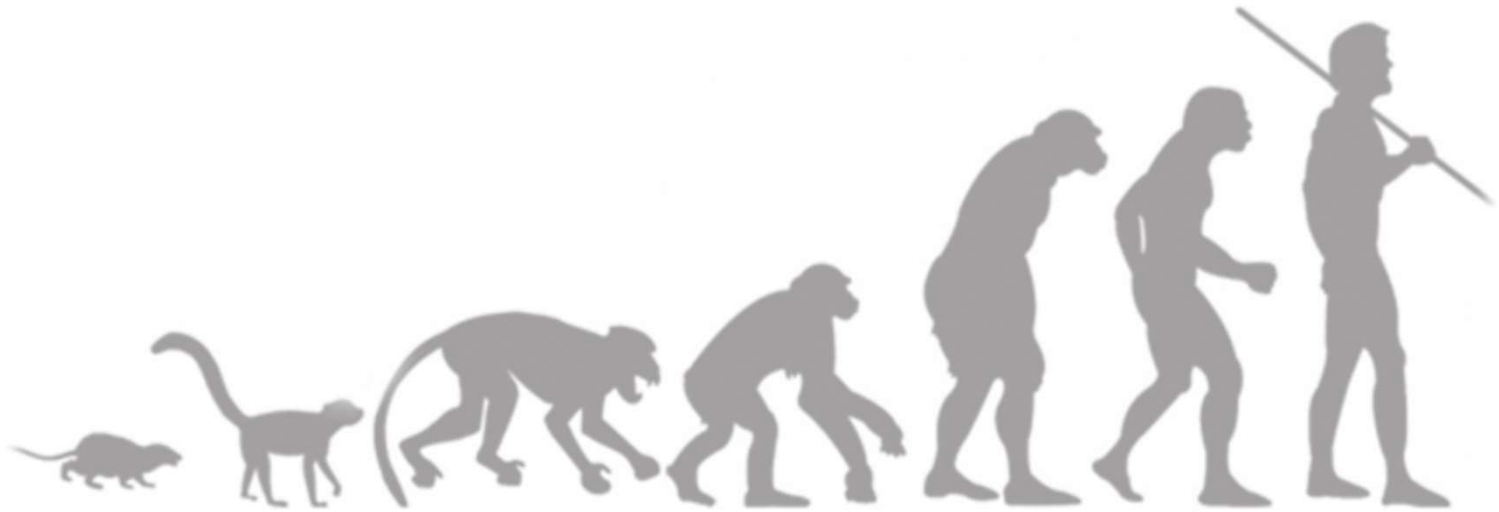
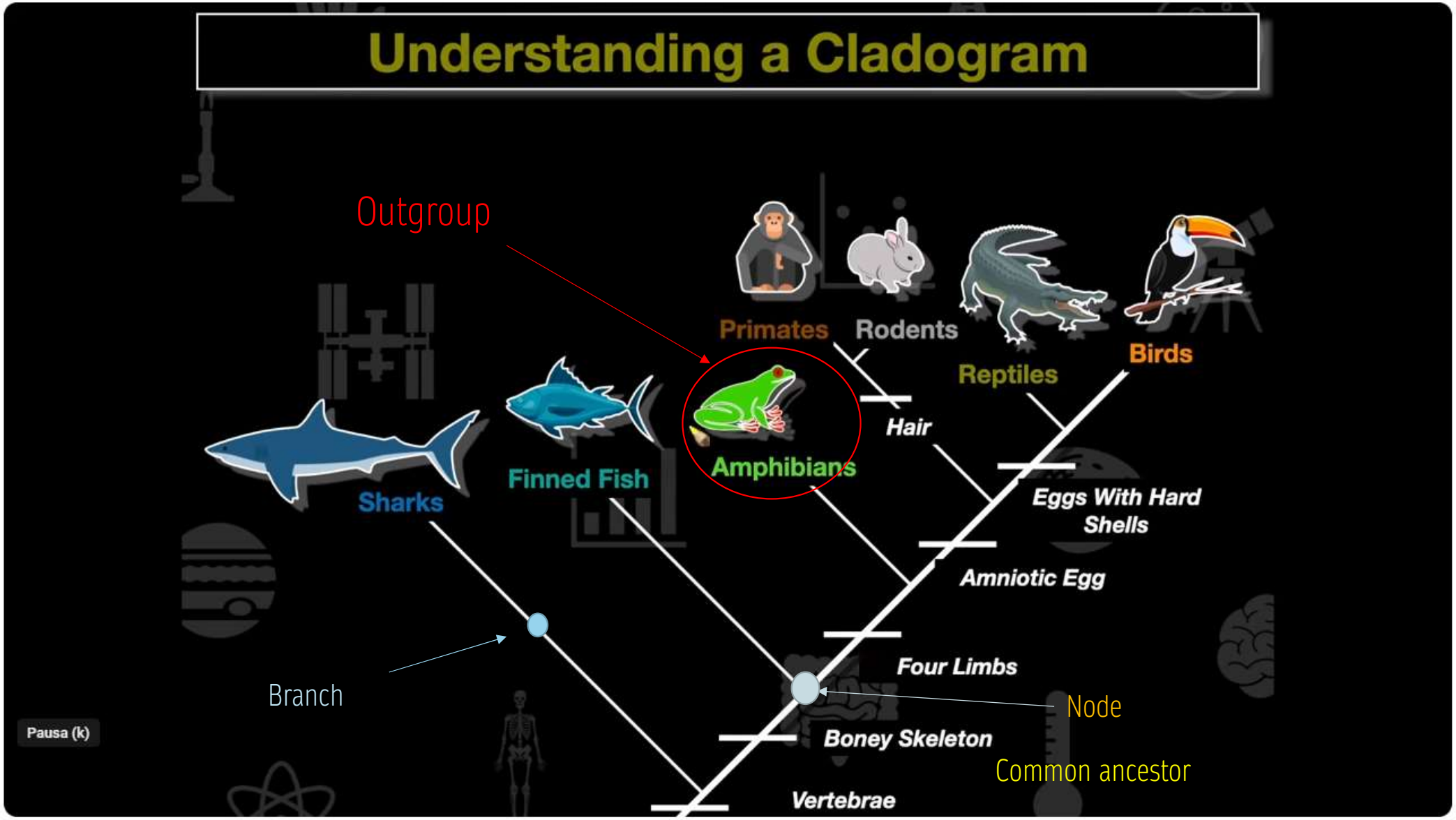
ZOOGEOGRAPHY



LESSON 21

1950: GERMAN TAXONOMIST WILLI HENNIG: THE CLADISTIC METHOD


Understanding a Cladogram
Outgroup
Primates
Rodents
Reptiles
Birds
Hair
Sharks
Finned Fish
Amphibians
Eggs With Hard Shells
Amniotic Egg
Four Limbs
Branch
Node
Boney Skeleton
Common ancestor
Vertebrae
Pausa (k)

Cladistics and parsimony

Concept Box 6.4

First of all, Hennig tried to identify a group of taxa that were all related to one another, sharing a common ancestor and including all its descendants. Such a lineage is known as a **clade**. He then treated the process of evolutionary change in this clade as a series of branching events, or 'dichotomies', at each of which a single group divides into two daughter groups. At each dichotomy, known as a *node*, one or more of the characteristics of the group changes from the original ancestral or **plesiomorphic** state into a derived or **apomorphic** state. The plesiomorphic characters are recognized by comparison with an *outgroup*, which is closely related to the lineage being studied but not a part of it. The evolutionary history of the group can then be portrayed as a branching **cladogram**. Thus, in Figure 6.9, characters a–g evolved after the divergence between group 1, which is the outgroup, and groups 2–5. They are therefore derived, or apomorphic, relative to the characters of group 1 (in which these characters have remained primitive, or plesiomorphic), but plesiomorphic for groups 2–5. Other new, apomorphic characters then evolved at different points within the evolutionary history of groups 2–6 and can therefore be used to analyse their patterns of relationship.

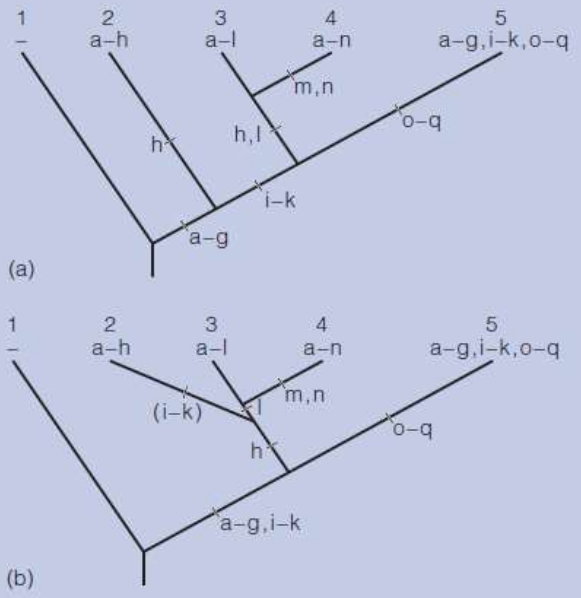


Figure 6.9 Cladogram of the relationships between five groups, using characteristics a to q. The positions at which characters were lost are shown in brackets.

In constructing a cladogram, the characters shown by the different taxa are listed, and the taxa are then arranged so that those that show a similar set of characters are placed in adjacent positions on the branching 'tree'. As far as possible, it is assumed that each apomorphic evolutionary event only occurred once in the history of each group of related taxa (a concept known as economy of hypothesis, or **parsimony**), and the taxa are arranged on the cladogram in such a way as to minimize the number of parallelisms. For example, in Figure 6.9 it is most parsimonious to believe that character h, which is absent in group 5, has evolved twice, because that involves the assumption of only that single additional evolutionary event (Figure 6.9a). The alternative is to transfer the origin of group 2 to near the base of groups 3–4, with the consequent need to assume that characters i–k had been lost in the evolution of group 2 (shown in brackets) – an assumption of three additional evolutionary events, instead of only one (Figure 6.9b).

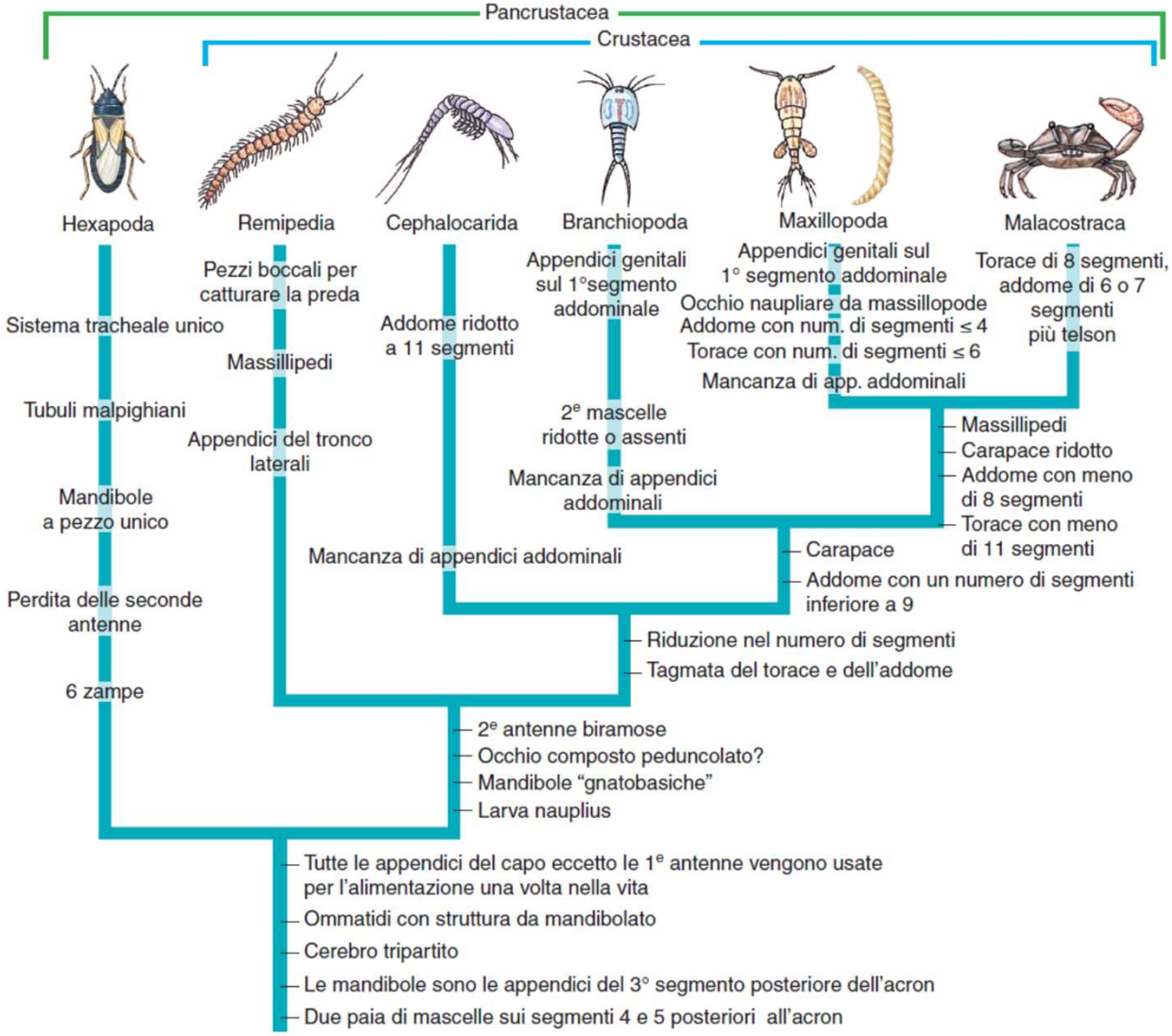
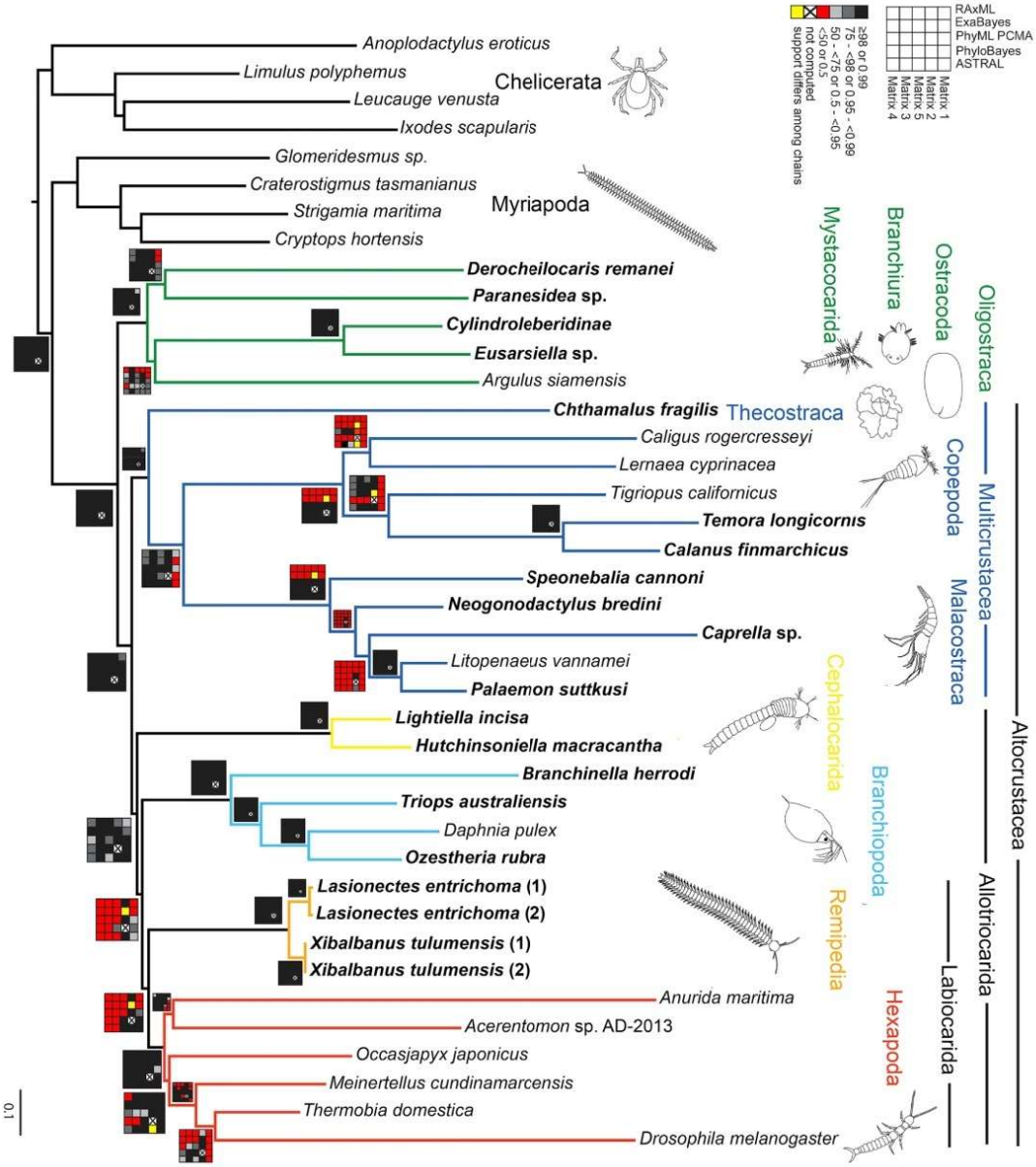


Figura 25.1 Cladogramma che mostra le ipotetiche relazioni tra gli esapodi e le diverse classi di crostacei. Gli esapodi e i crostacei formano un clado diagnosticato in base a numerose caratteristiche condivise. I caratteri seguiti da un punto di domanda potrebbero essere primitivi piuttosto che caratteristiche condivise derivate. L'acron è la regione anteriore del capo e non è contato come un segmento.


Anoplodactylus eroticus
Limulus polyphemus
Leucauge venusta
Ixodes scapularis
Chelicerata
Glomeridesmus sp.
Craterostigmus tasmanianus
Strigamia maritima
Cryptops hortensis
Myriapoda
Derocheilocaris remanei
Paranesidea sp.
Cylindroleberidinae
Eusarsiella sp.
Argulus siamensis
Chthamalus fragilis
Caligus rogercresseyi
Lernaea cyprinacea
Tigriopus californicus
Temora longicornis
Calanus finmarchicus
Speonebalia cannoni
Neogonodactylus bredini
Caprella sp.
Litopenaeus vannamei
Palaemon suttkusi
Lightiella incisa
Hutchinsoniella macracantha
Branchinella herrodi
Triops australiensis
Daphnia pulex
Ozestheria rubra
Lasionectes entrichoma (1)
Lasionectes entrichoma (2)
Xibalbanus tulumensis (1)
Xibalbanus tulumensis (2)
Anurida maritima
Acerentomon sp. AD-2013
Occasjapyx japonicus
Meinertellus cundinamarcensis
Thermobia domestica
Drosophila melanogaster
0.1
≥98 or 0.99
75 - <98 or 0.95 - <0.99
50 - <75 or 0.5 - <0.95
<50 or 0.5
not computed
support differs among chains
RAxML
ExaBayes
PhyML PCMA
PhyloBayes
ASTRAL
Matrix 1
Matrix 2
Matrix 5
Matrix 3
Matrix 4
Mystacocarida
Branchiura
Ostracoda
Thecostraca
Copepoda
Malacostraca
Cephalocarida
Branchiopoda
Remipedia
Hexapoda
Oligostraca
Multicrustacea
Allotriocarida
Labiocarida
Altocrustacea

- the periods of change took place in several lineages at about the same time suggests that they were the result of external events that affected all of them, rather than resulting from some inherent evolutionary mechanism

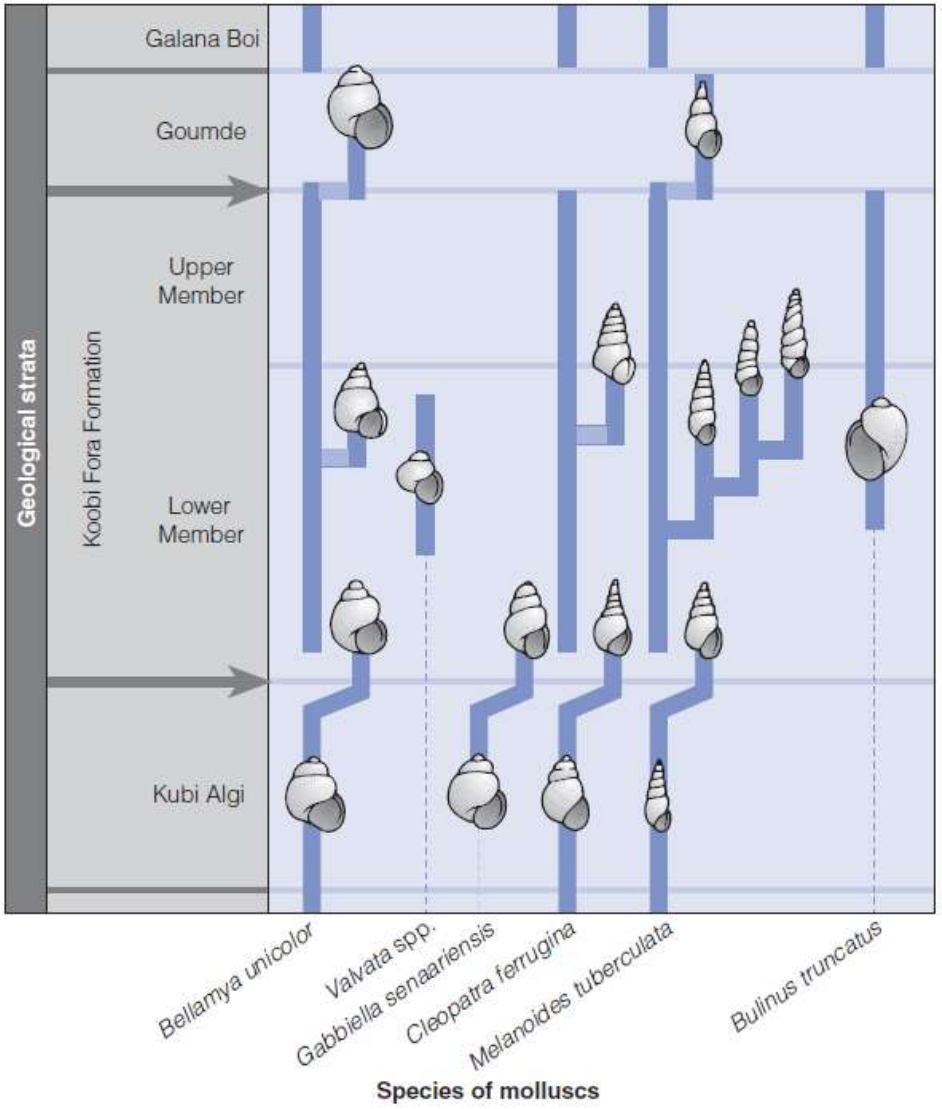
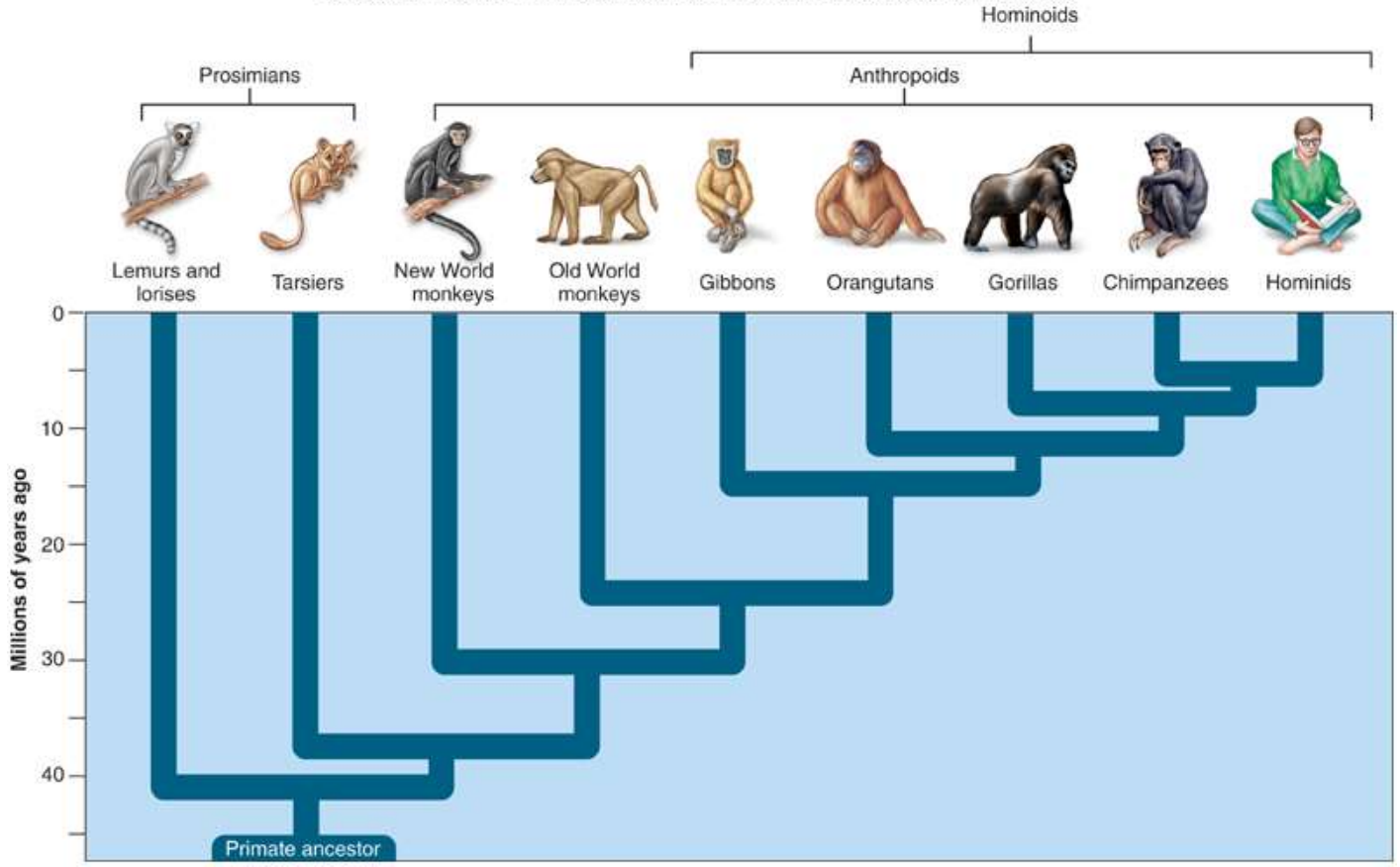
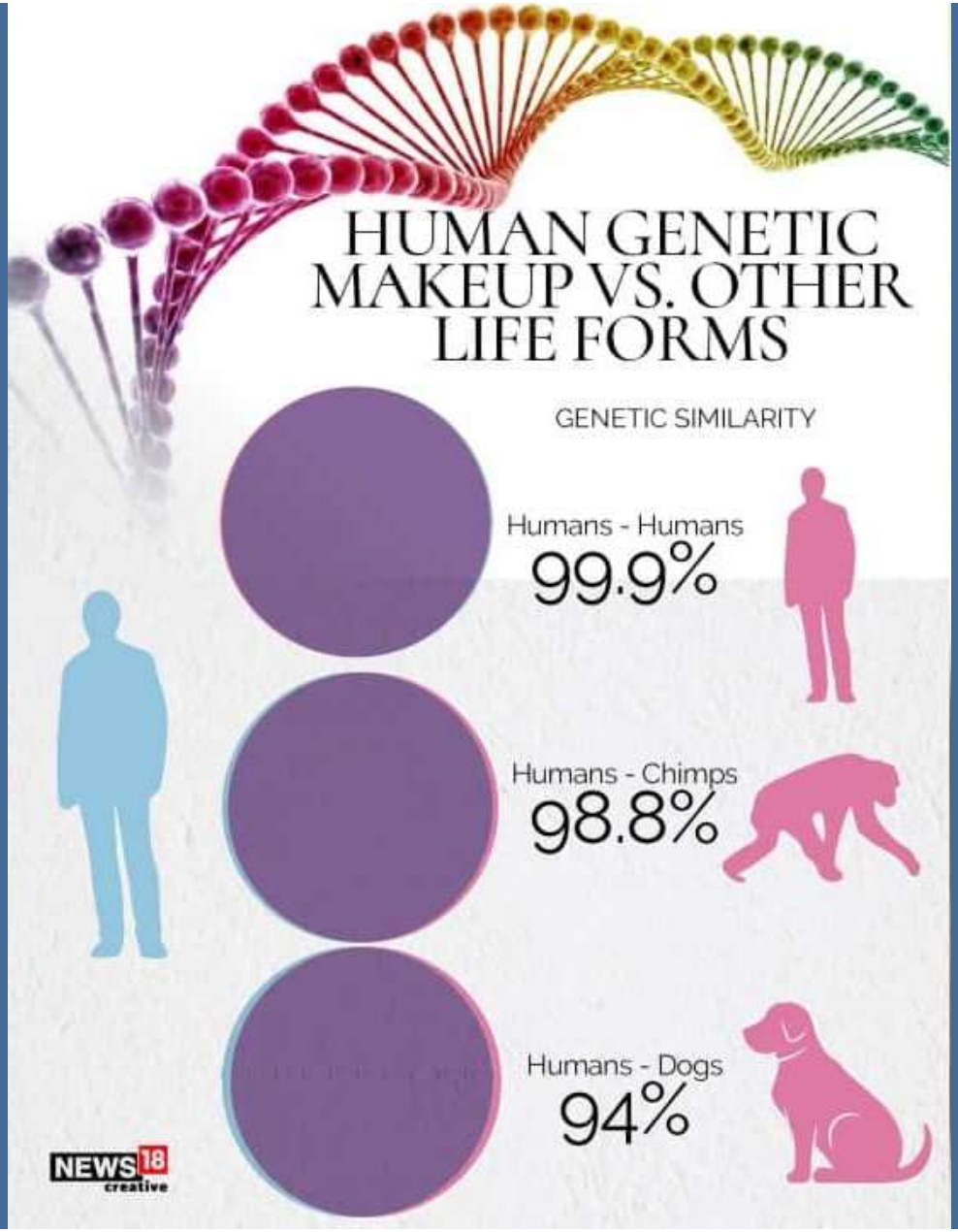


Figure 6.8 Evolutionary changes in fossil gastropod molluscs in northern Kenya. The arrows indicate the levels at which sudden evolutionary changes took place simultaneously in several different species. From Dowdeswell [23].



THE PRIMATES OF THE NEW WORLD AND THE OLD WORLD BECAME SEPARATED FROM EACH OTHER SOME 40 MILLION YEARS AGO (MYA)

the genetic similarity between humans and chimpanzees; almost 99% of human genetic makeup is shared with the chimpanzee, so their evolutionary divergence must have been relatively recent in geological terms.



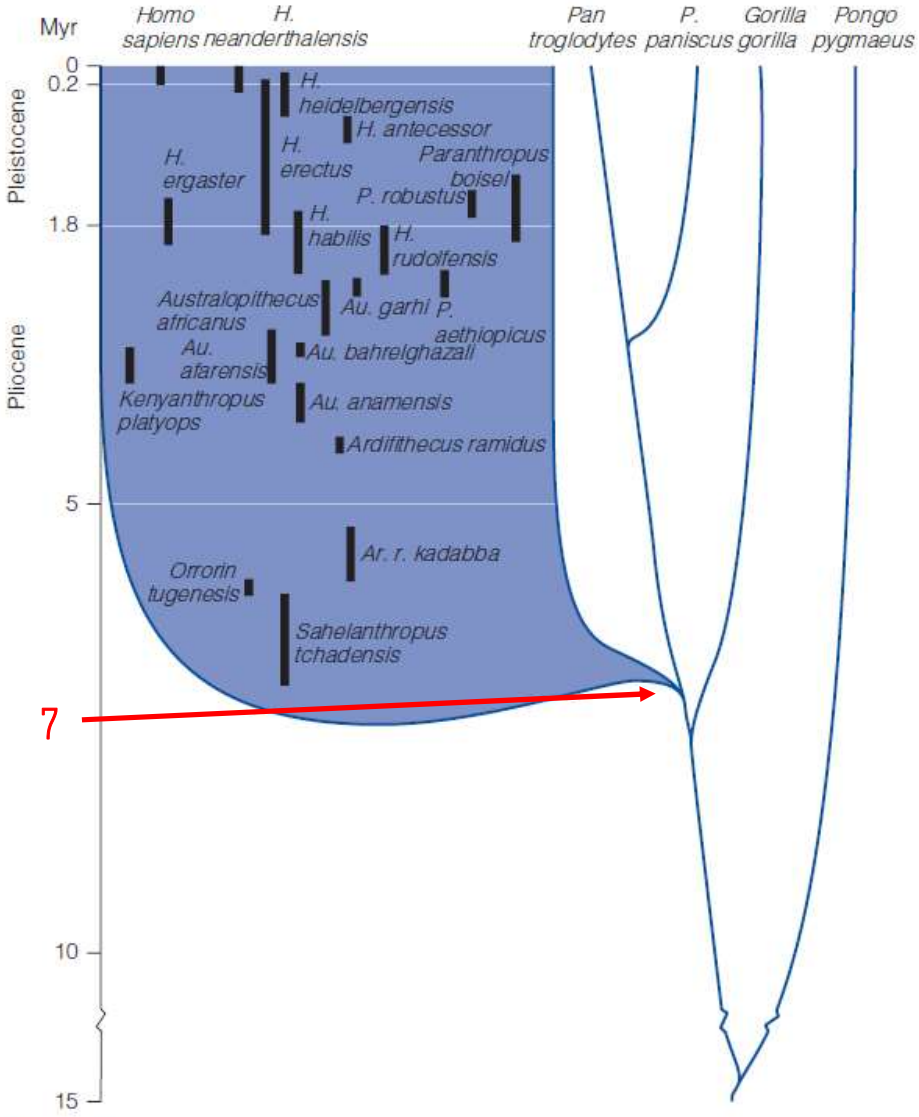


Figure 13.1 The relationships between the hominins and the great apes. From Carroll [4].

The separation of the human ancestral branch (the **hominins**) from the great apes (the two groups are known jointly as **hominids**) is thought to have taken place about 7 mya

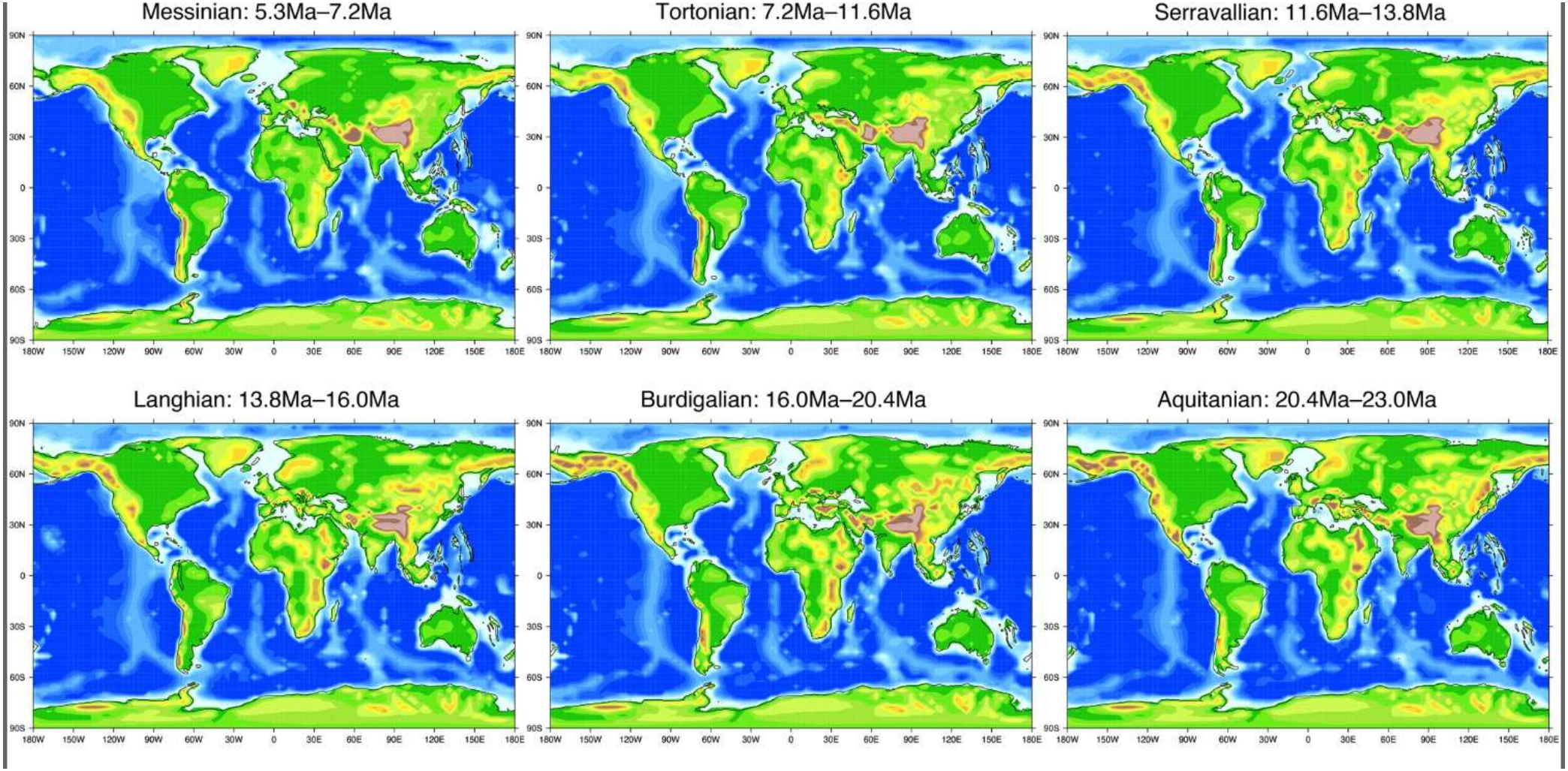
BIOGEOGRAPHY OF THE EARLY HOMINIDS

LACK OF FOSSILS

Trying to establish the biogeography of the early hominids, which lived during the Miocene over 5 mya, is extremely difficult because of the lack of fossils.

TO STUDY THE EVOLUTION OF ASSOCIATED ANIMALS

we can instead study the fossil record of other, larger and more common mammal groups, such as the hyaenids (hyenas) and the proboscideans (mammoths and elephants), which are often associated with hominids.


Messinian: 5.3Ma–7.2Ma
Tortonian: 7.2Ma–11.6Ma
Serravallian: 11.6Ma–13.8Ma
Langhian: 13.8Ma–16.0Ma
Burdigalian: 16.0Ma–20.4Ma
Aquitanian: 20.4Ma–23.0Ma
90N
60N
30N
0
30S
60S
90S
180W
150W
120W
90W
60W
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0
30E
60E
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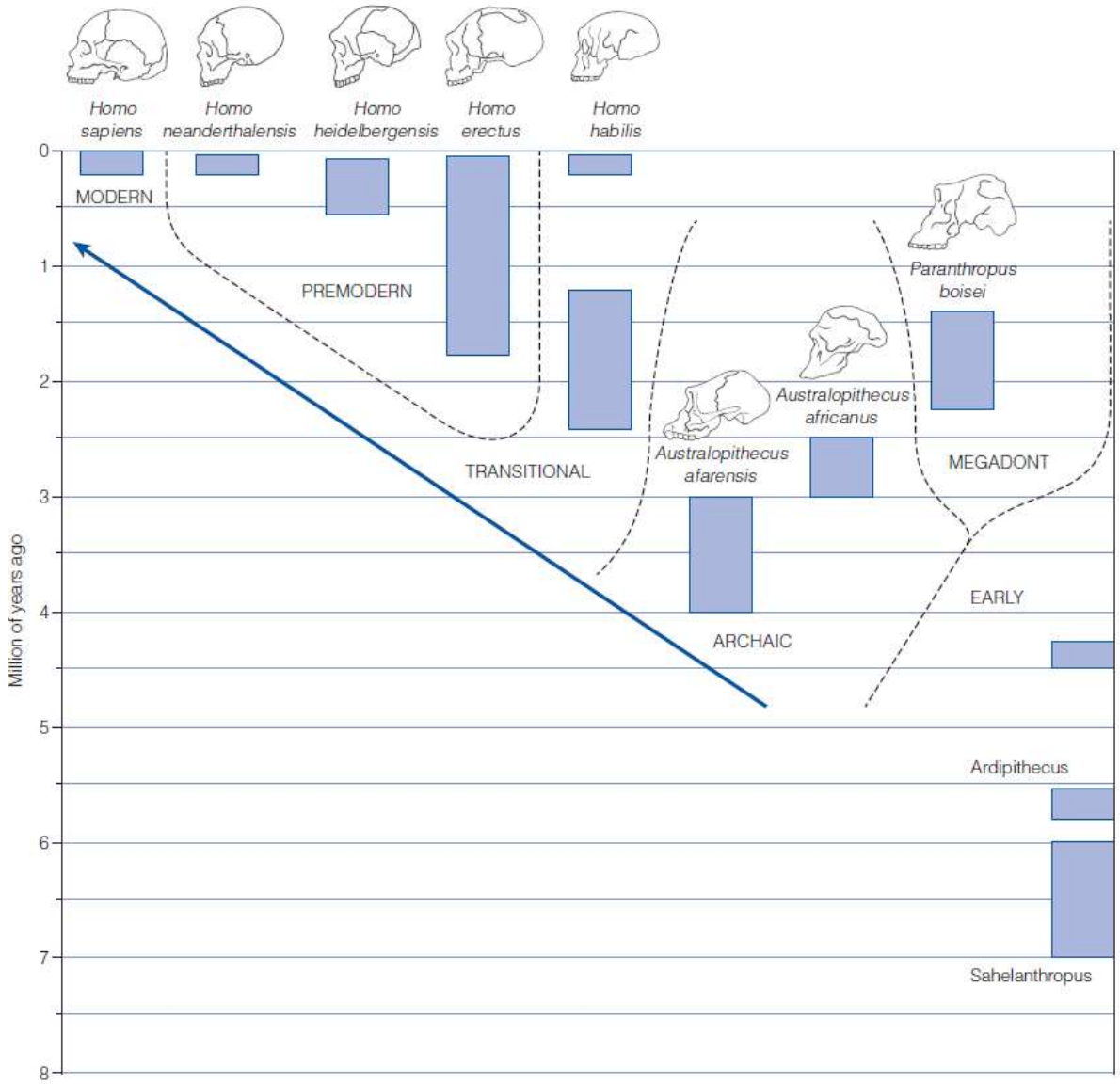

Figure 13.2 A scheme showing the possible interrelationships between hominins over the last 7 million years. Adapted from Wood and Lonergan [7].

A recent practical: six informal 'grades' rather than try to establish the detailed relationship of the different species.

- early,
- archaic,
- megadont ('large-toothed').
- transitional hominins,
- pre-modern *Homo,* and
- modern *Homo*

- In 2002, Michel B
  some lower jaws)

  Until then, most f
  Africa

  this set of fossils
  Chad, south of th

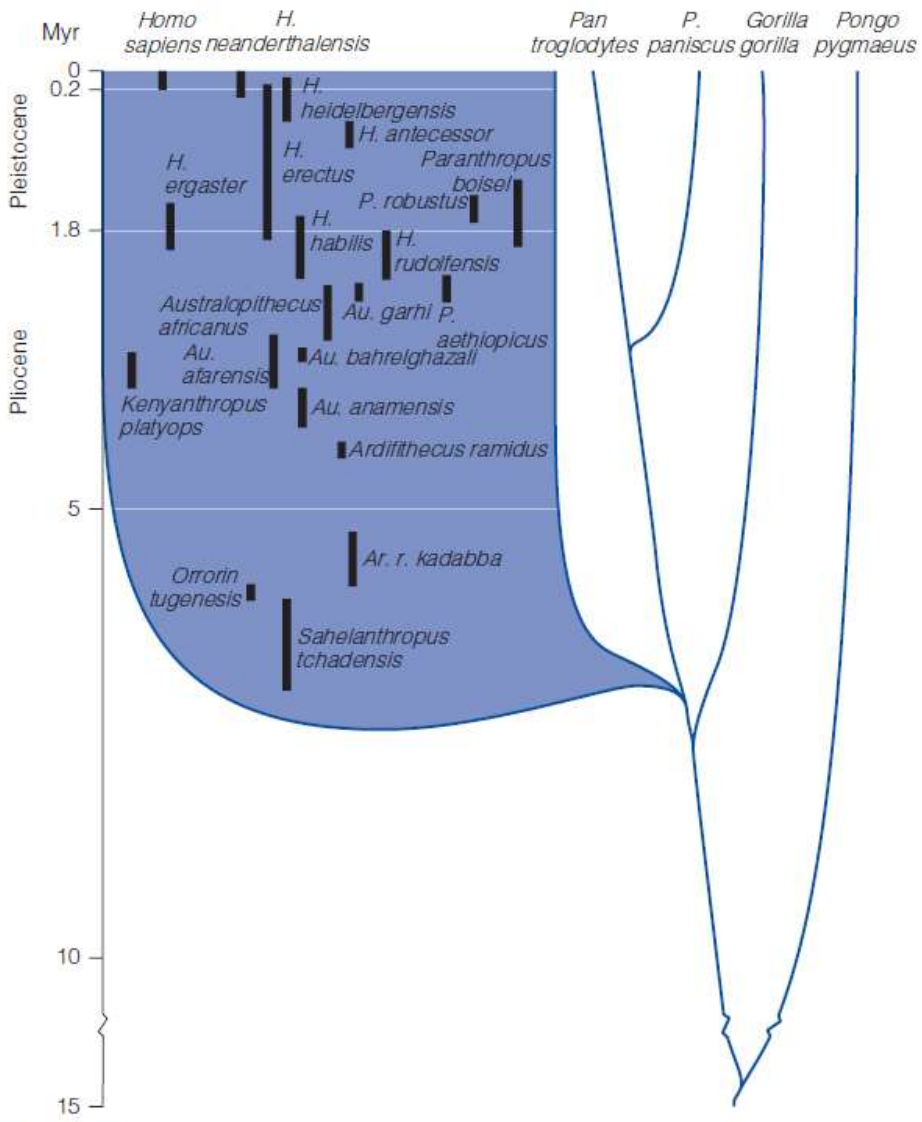

Figure 13.1 The relationships between the hominins and the great apes. From Carroll [4].

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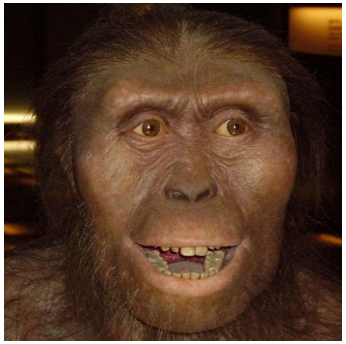
ARCHAIC HOMININS

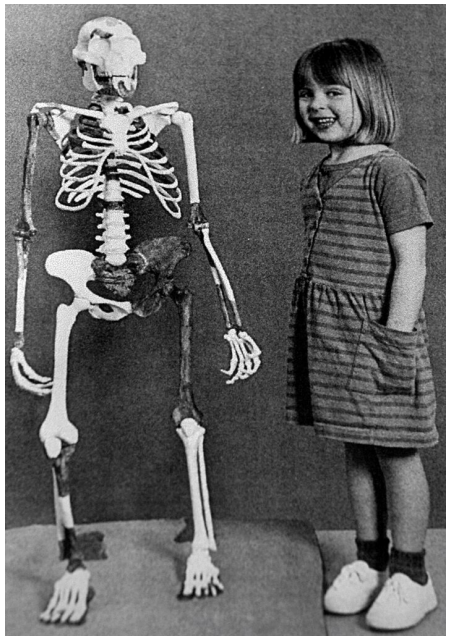
Australopithecus afarensis



- The fossil remains that succeeded *Sahelanthropus* are widely recorded from eastern and southern Africa; the earliest dated from around 4 mya.

The discovery of bipedal fossil human footprints in volcanic ash from Tanzania shows that they walked upright, on their hind legs, though their short legs suggest that they were not adapted to running.

The habitat in which they lived was open woodland and savanna, but very little is known of their precise way of life and the ecological niche they occupied.



MEGADONT HOMININS

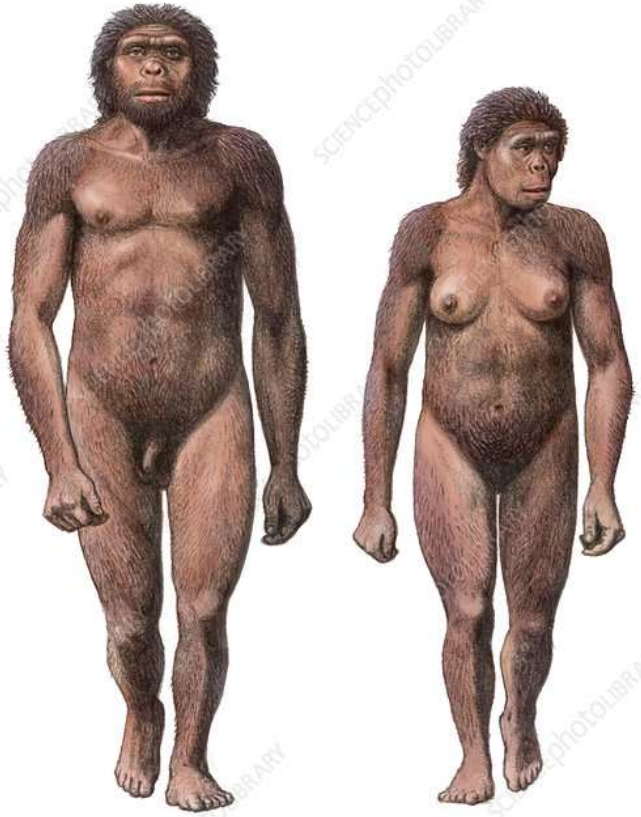
Paranthropus (ex Zinjanthropus)

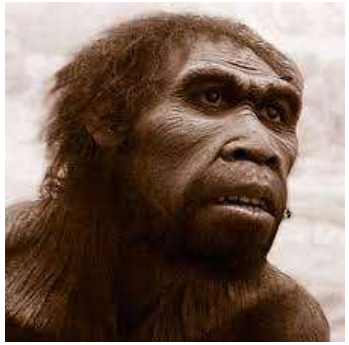
- A short-lived side-line of hominin evolution lived in East Africa 2.3–1.4 mya.
- Characterized by heavy, strong jaws and large molar teeth with a thick coating of enamel.
- The males of this genus were much larger than the females.
- They were adapted to feeding on large seeds, nuts and C4 grasses and sedges.

TRANSITIONAL HOMININS

Homo habilis

- This group includes *Homo habilis* (nearly 2 mya), it differs from *Australopithecus* for the upright posture and larger brain.
- However, the structure of its arms and hands suggests it was still quite adept at climbing, and its ankle has australopithecine characteristics.
- It belongs to the genus Homo, because it could make stone tools and, at the time at which it was discovered, it was assumed that this ability was confined to our own genus





PRE-MODERN HOMO

Homo ergaster, H. erectus

- *Homo ergaster* (1.9 mya) → direct descendent of *H. abilis*.
- H. erectus first species of our genus to be found far beyond Africa (1.7 mya, and had spread into eastern Asia by 100 000 years later)
- Some excavations in Java indicate that *H. erectus* may have survived in South-East Asia as late as the last Ice Age (50 000 years ago), in which case it would have overlapped with our own species in that area.

- By 1.5 mya, *H. erectus* had developed much more sophisticated stone tools, such as hand axes.
- The use of fire (as an aid in hunting).

Both the fauna and the flora of the grasslands must have been altered by this new phenomenon in the environment.

- between 600 000 and 100 000 years ago

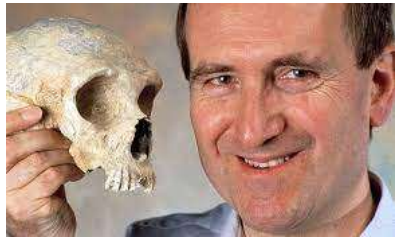
Homo heidelbergensis

Way of life: the discovery of hunting spears, buried in compressed peat deposits in north Germany 400k

hunting and butchering of animals using tools

H. heidelbergensis also reached Britain by about 500 000 years ago, although stone tools dating to about 900 000 years ago show that other hominins had reached the island even earlier.

POSSIBLE HYPOTHESIS BY BRITISH PALAEONTOLOGIST CHRIS STRINGER



Homo heidelbergensis

↓

Evolutionary split between 400 000 and 300 000 years ago

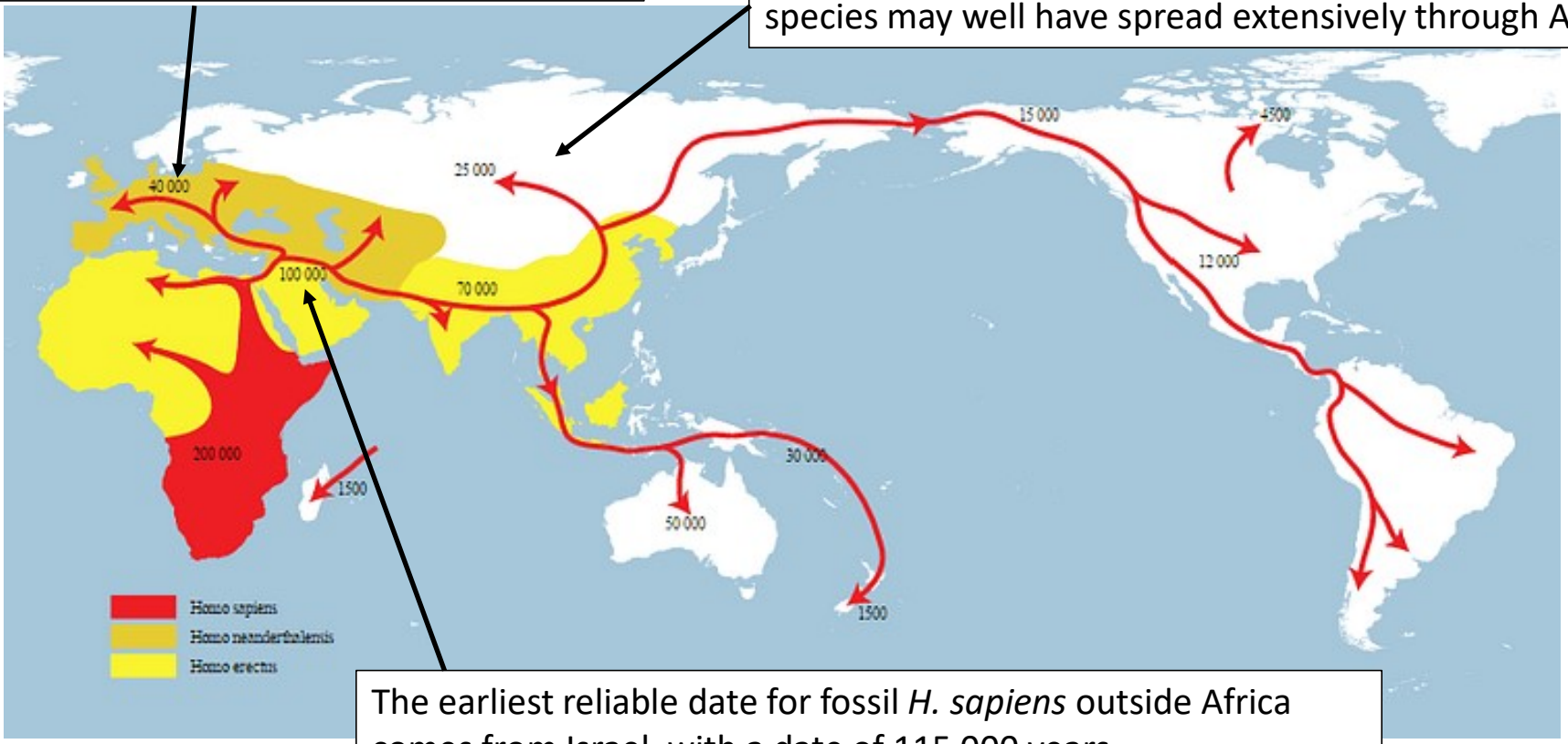
First evidence: *Homo neanderthalensis* about 200 000 years ago

Second evidence: *Homo sapiens* appearing later, (160 000-year-old) from Ethiopia

HUMAN MIGRATIONS

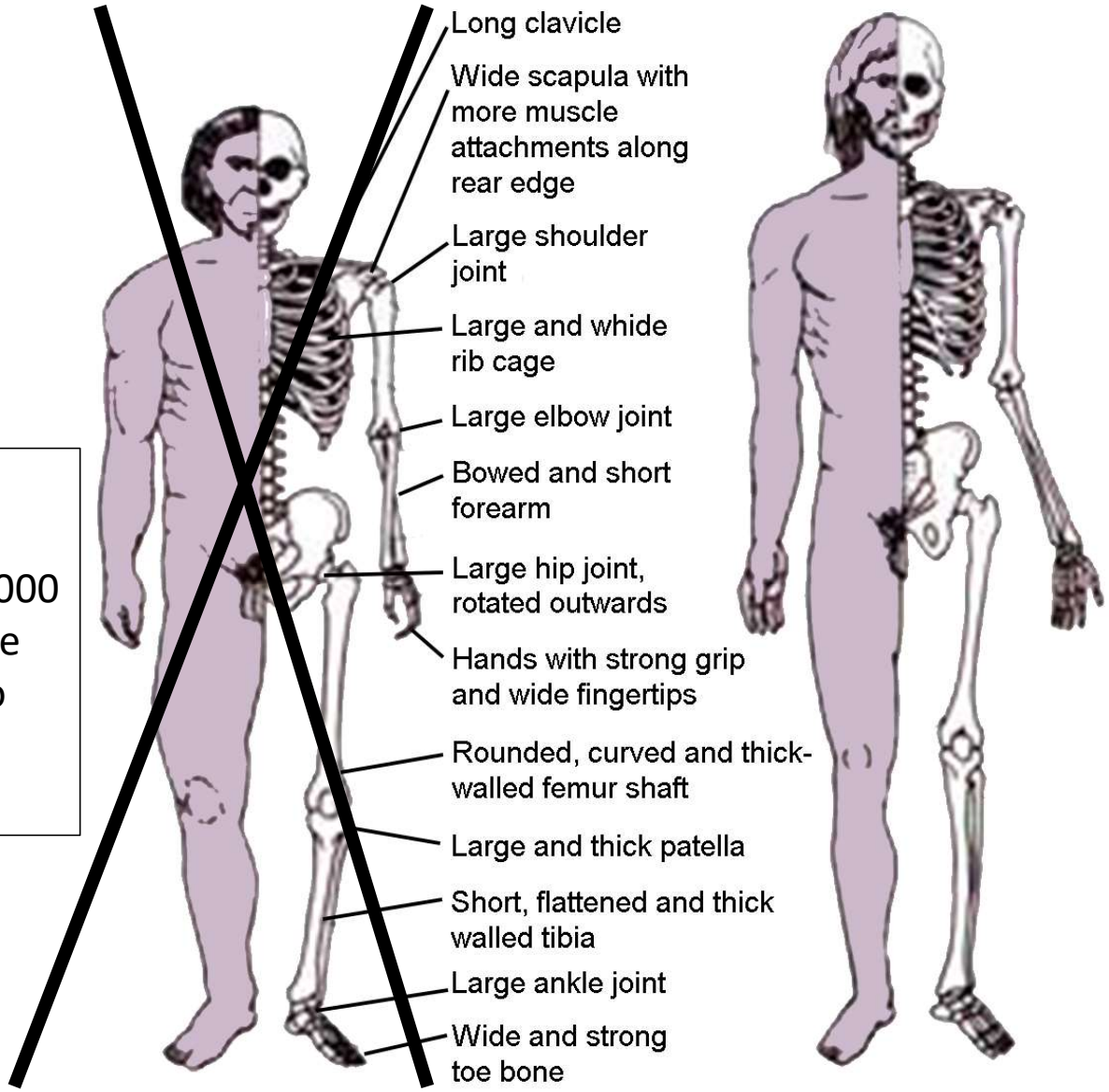
Neanderthals were the first of these two species to enter Europe, about 45 000 years ago

DNA from bones dating 38 000 years ago from Uzbekistan in Central Asia has Neanderthal affinities, suggesting that the species may well have spread extensively through Asia



The earliest reliable date for fossil *H. sapiens* outside Africa comes from Israel, with a date of 115 000 years.

Neanderthals disappeared from the fossil record about 28 000 years ago, though some would claim survival to 24 000 years ago in Gibraltar



NEANDERTHALS DISAPPEREANCE
(ROUGHLY 30K YRS AGO)

- Neanderthals disappeared coincides with a major expansion in global ice volume. This climatic change may have placed an additional strain on Neanderthal survival.

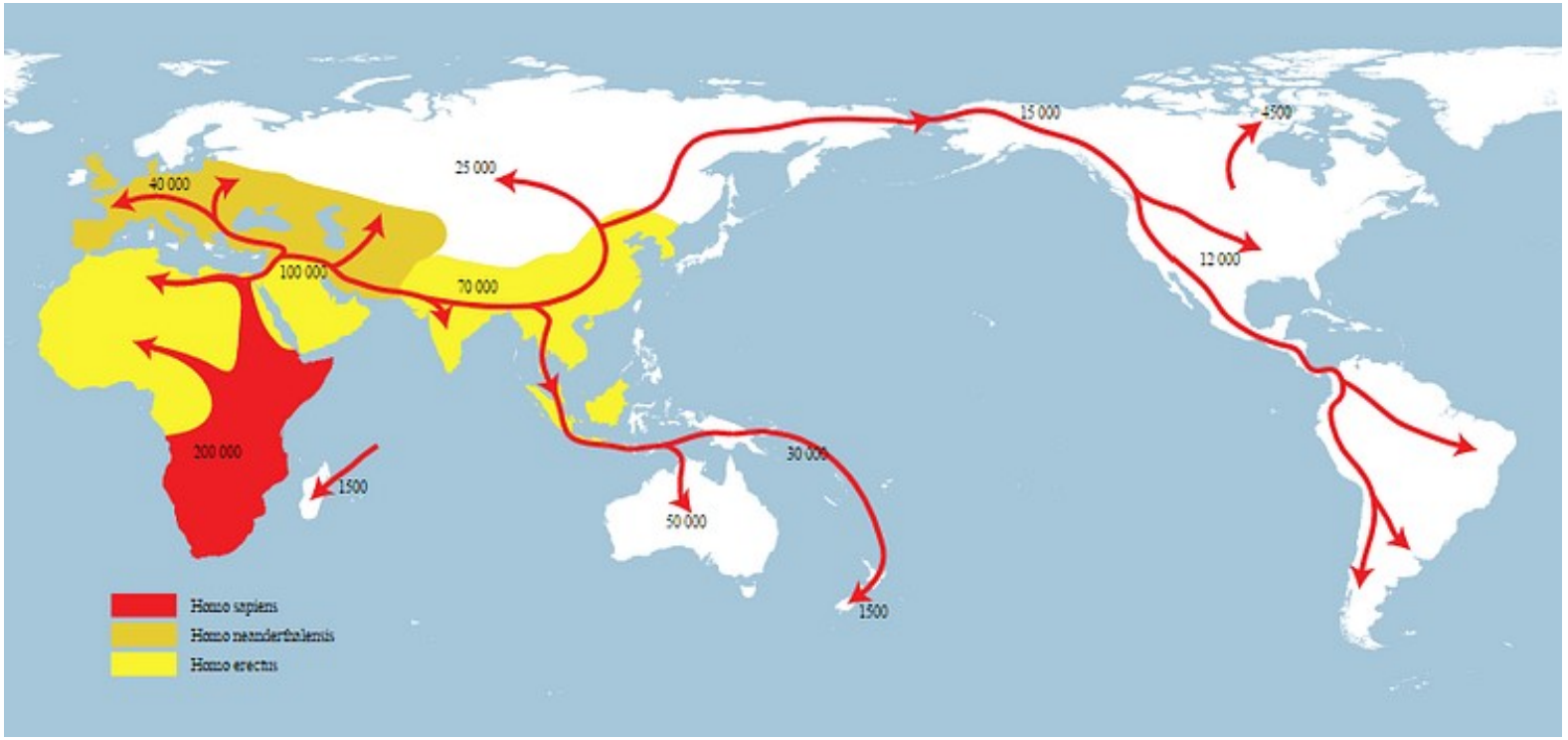
- However, only *Homo sapiens* remained in Europe at the beginning of the Holocene.

in 2003: a skeleton of an adult hominin only about 1 m tall was unearthed during the excavation of cave sediments dating back only 18 000 years on the island of Flores, Indonesia

Homo floresiensis

dwarf form of its genus, like many other examples of animals or reduced size living in islands, with their limited supplies of nourishment

MODERN HOMO



- Australia became populated by about 50 000 years ago
- Northern Europe and eastern Asia around 20 000 years ago (by the time the glaciation was at its peak)
- Only the Americas remained empty of our species

- Studies on human languages suggest that the colonization of the New World must have taken place before the major advance of the last glaciation about 22 000 years ago.

- three distinct groups of Native American languages

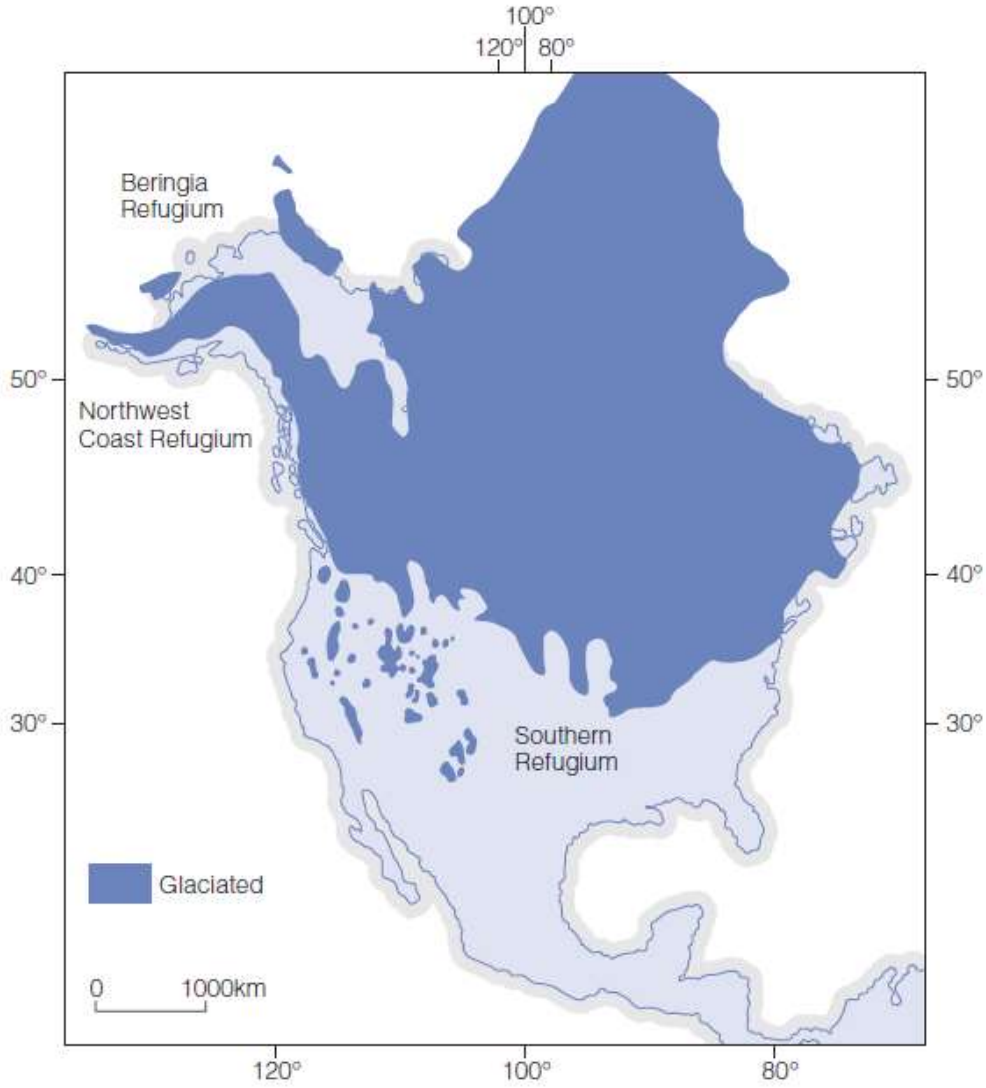


Figure 13.4 Maximum extent of the last (Wisconsin) glacial in North America, showing the three ice-free areas (refugia) which correspond to the language groups of Native Americans. From Rogers *et al.* [30].