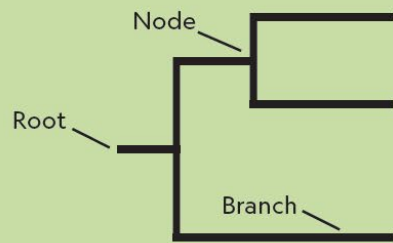


The evolution of us

Human evolution and speciation

Speciation in humans

- Phylogenetics of extant species
- Extinct species of Hominina (hominins) and where approx. they fit
- How they speciated – allopatry, founder effects?
- Examples of species on the Hominina lineage
- Ecological divergence, associated with savannah/open area living
- Brain size, technology
- Are we still evolving?
- Will we speciate?

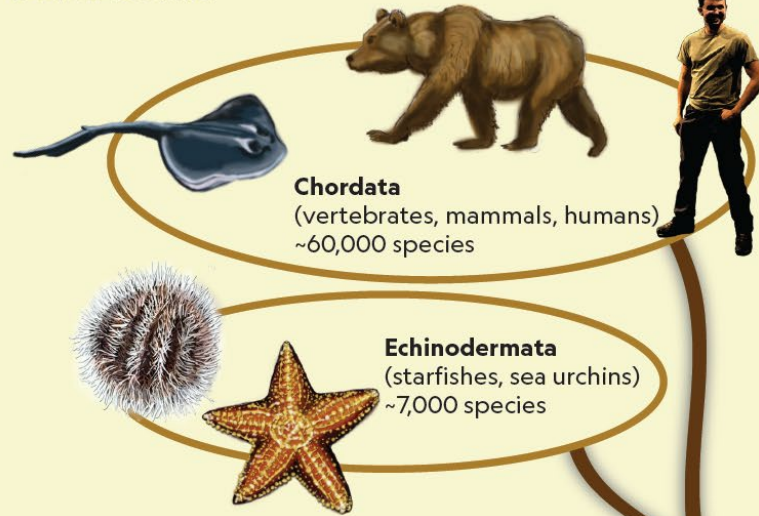


THE TREE OF LIFE

A phylogenetic tree shows the evolutionary relationships among different organisms. The branches of the tree show where genetic or physical similarities and differences between organisms begin or end.

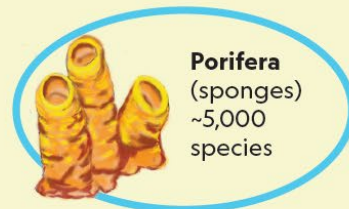
A phylogenetic tree is like a family tree. The root of the tree represents a distant ancestor of the species that appear at the ends of the branches. The branches separate at nodes, or points where ancestral lines split into new lines of evolution.

Deuterostomia

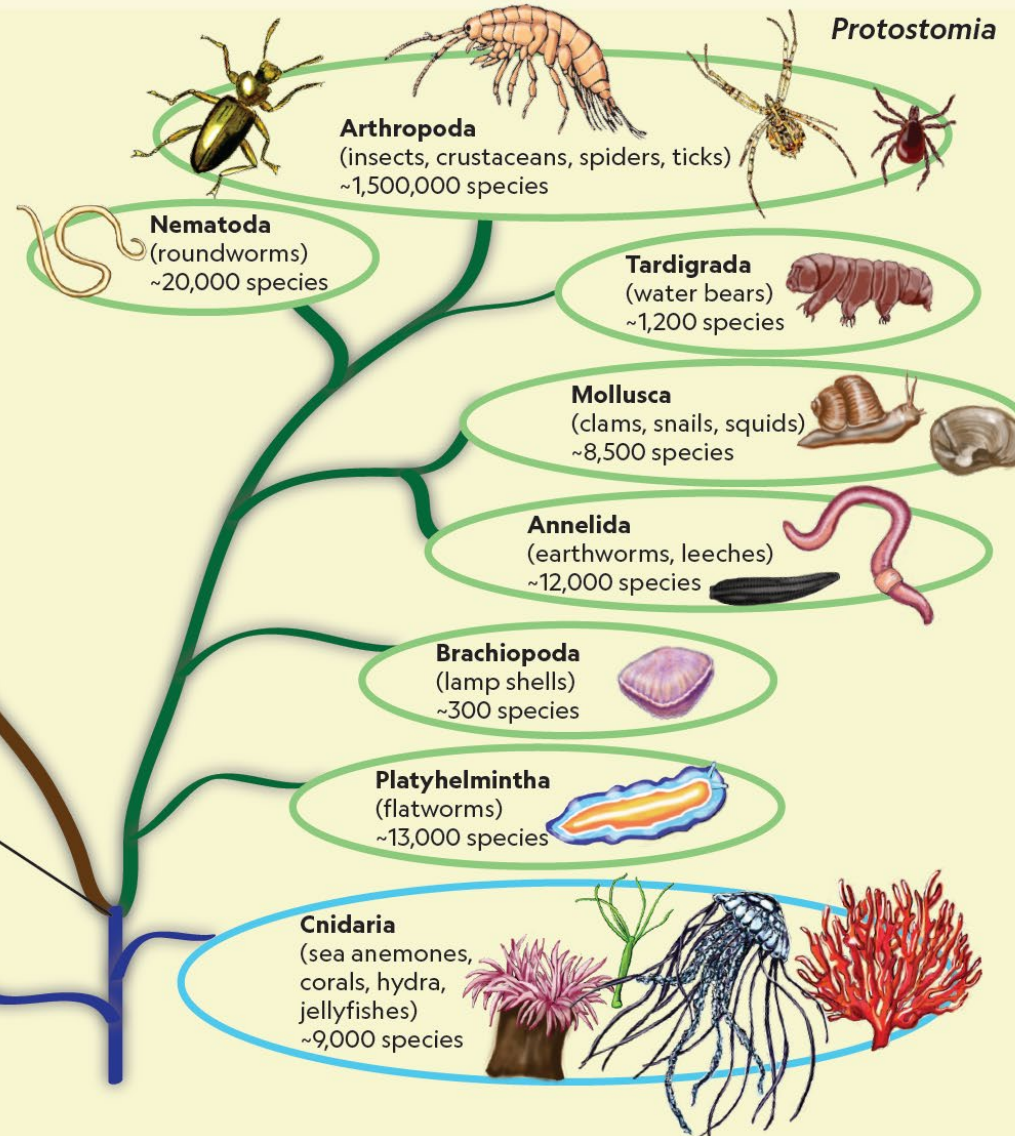


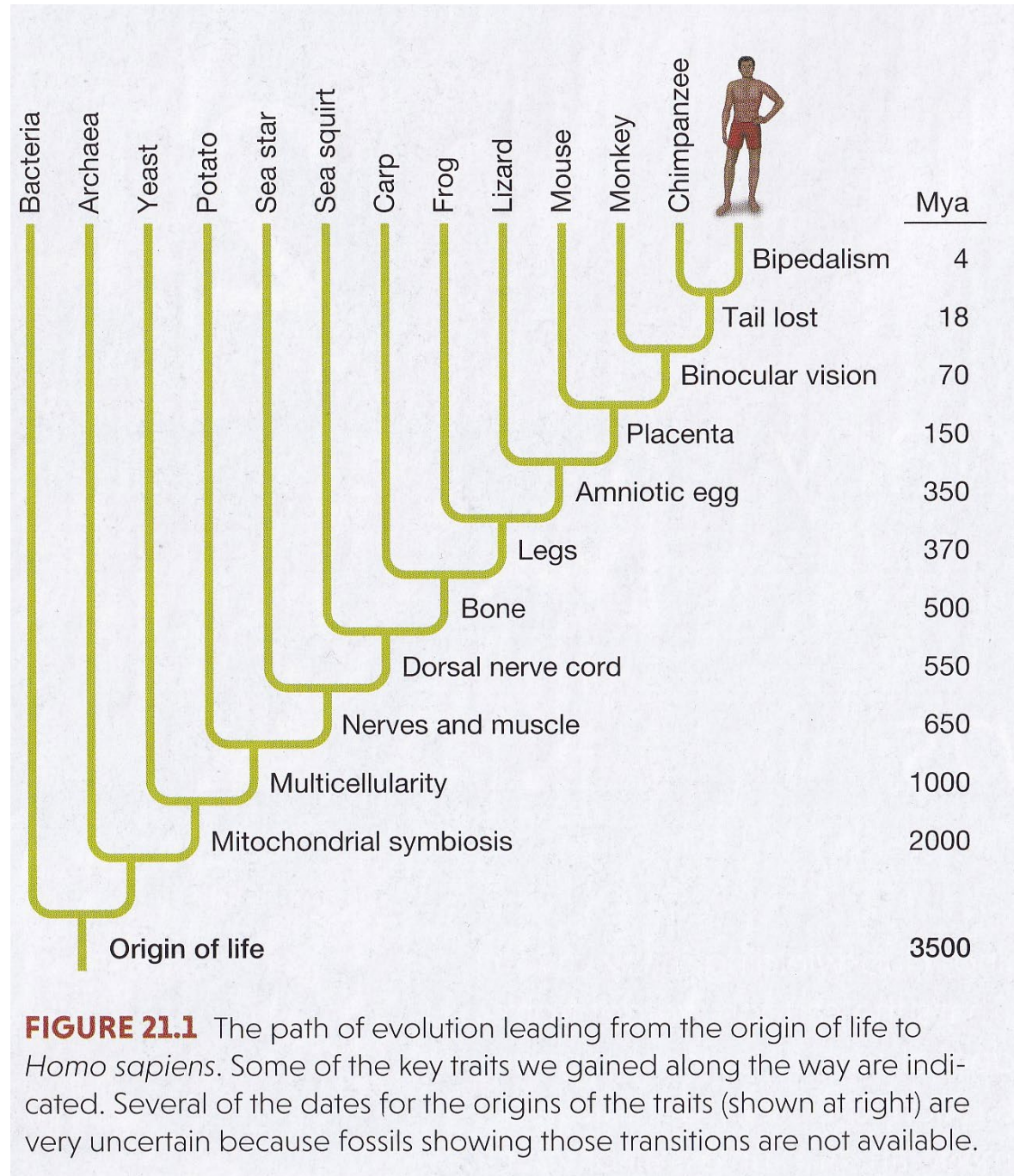
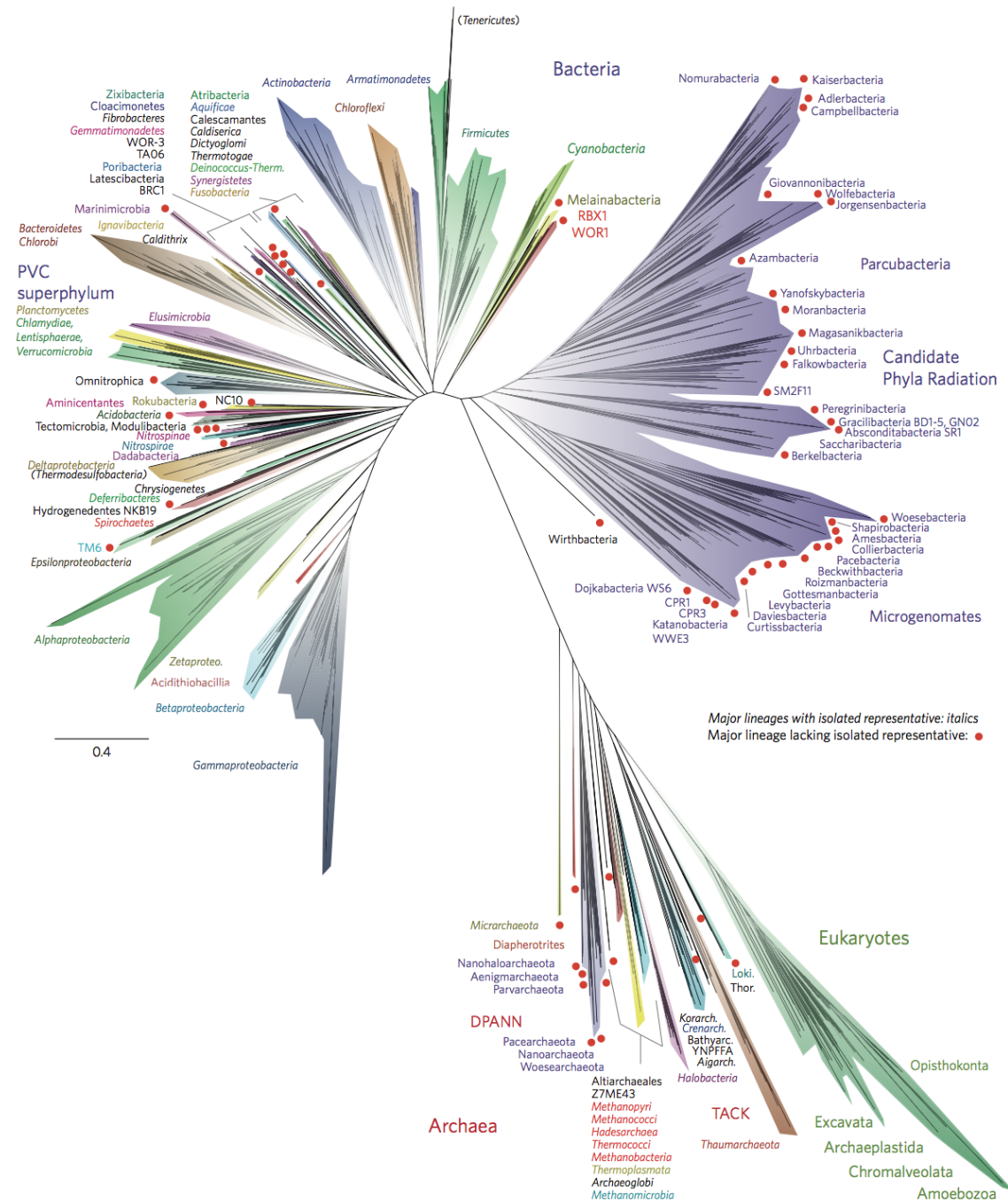
This tree of life shows the relationships among common groups of animals. The main branch in this tree, which separates the animals into two distinct groups, *Deuterostomia* and *Protostomia*, split about seven hundred million years ago. This tree shows how today's animal species have diverged over time from common ancestors.

~700 million
years ago



Protostomia





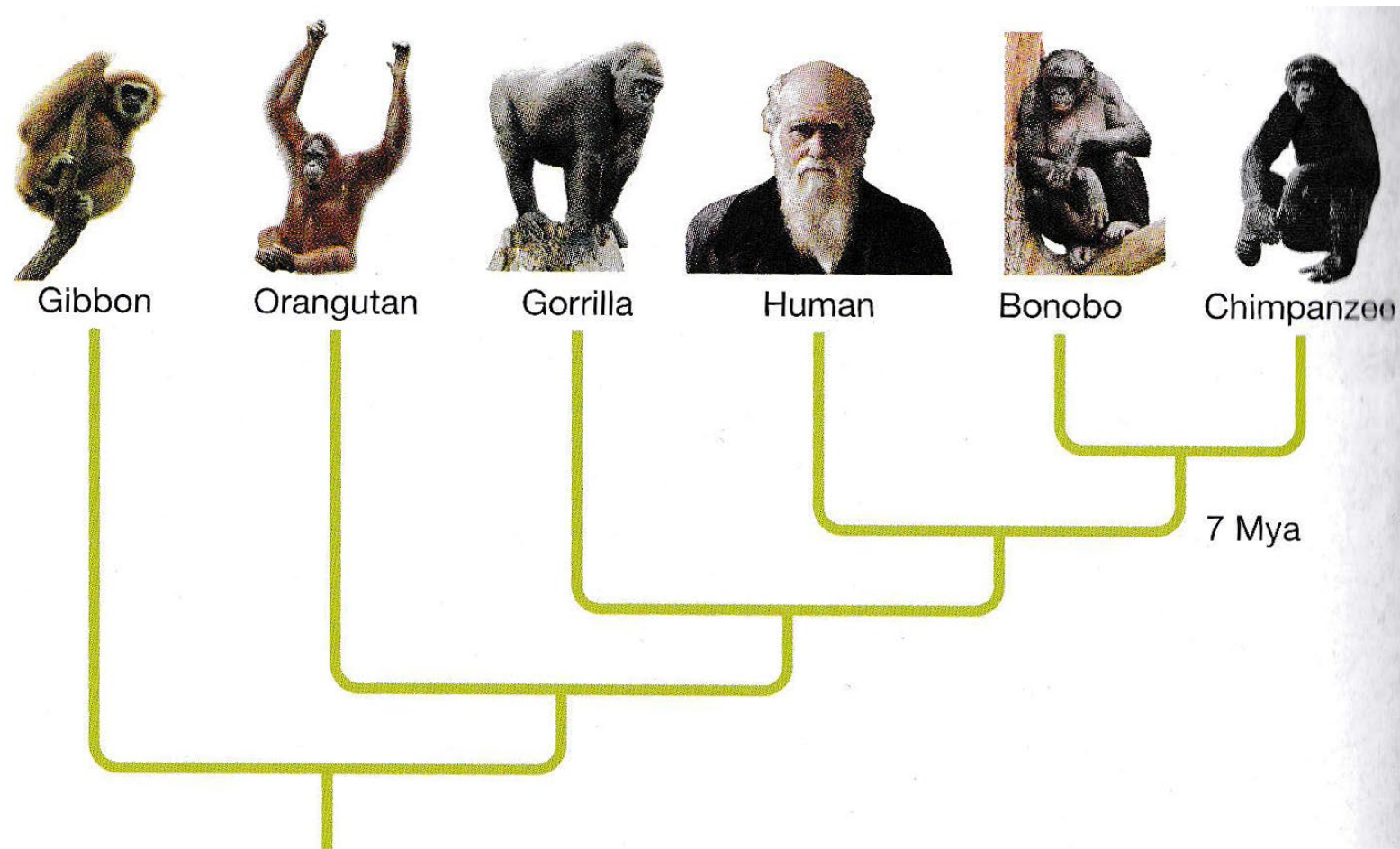
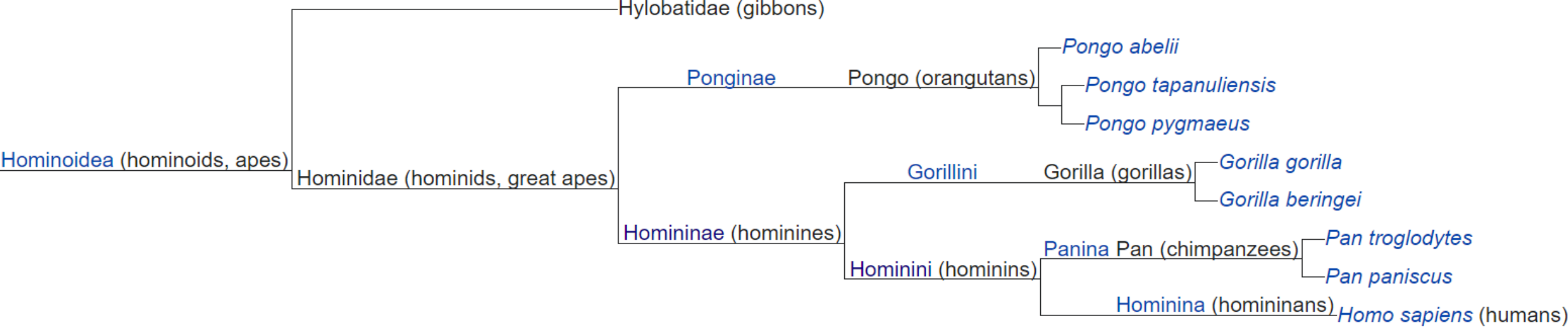
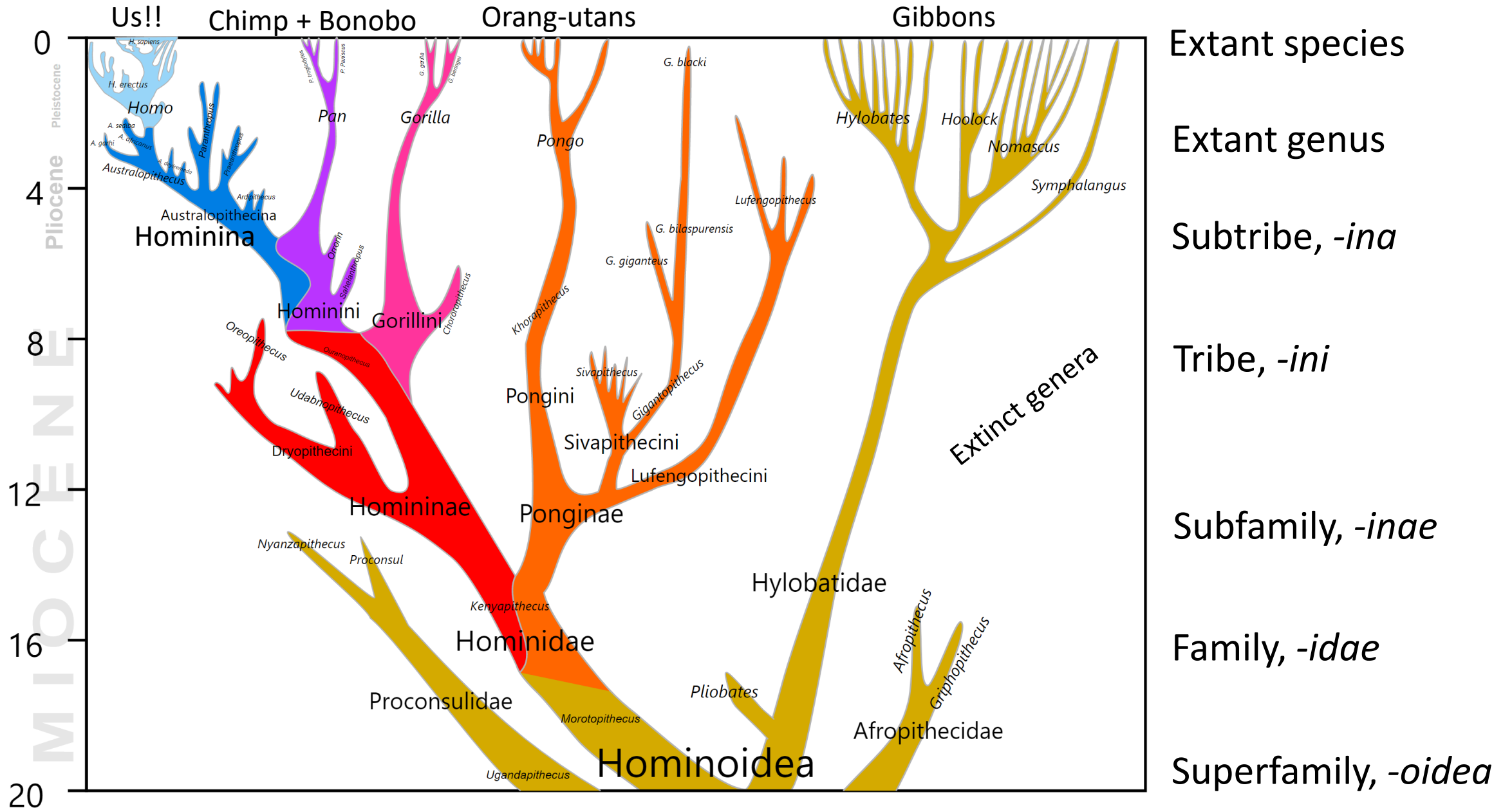


FIGURE 21.2 Phylogeny of some of the living apes, illustrated by the white-handed gibbon (*Hylobates lar*), orangutan (*Pongo pygmaeus*), western gorilla (*Gorilla gorilla*), human (*Homo sapiens*), bonobo (*Pan paniscus*), and chimpanzee (*Pan troglodytes*).



Human evolution relative to apes: the big picture

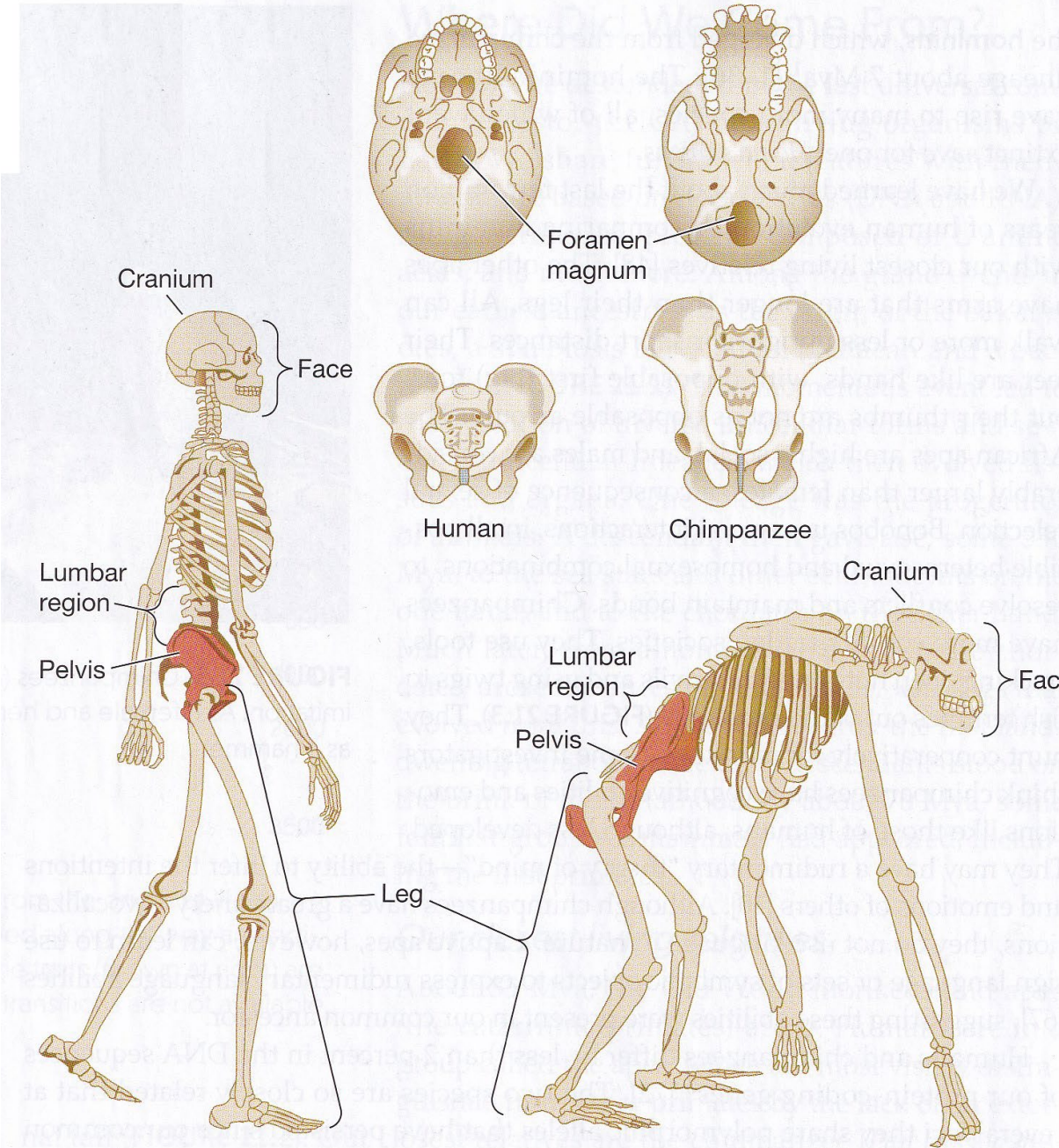


How do hominins (Hominini) differ?

Flat face, high forehead
Canines hardly differentiated

Opposable thumb

Big toe only for bipedalism



Foramen magnum for
vertical head versus
horizontal head

Hips for bipedal walking, as
opposed to climbing and
knuckle-walking

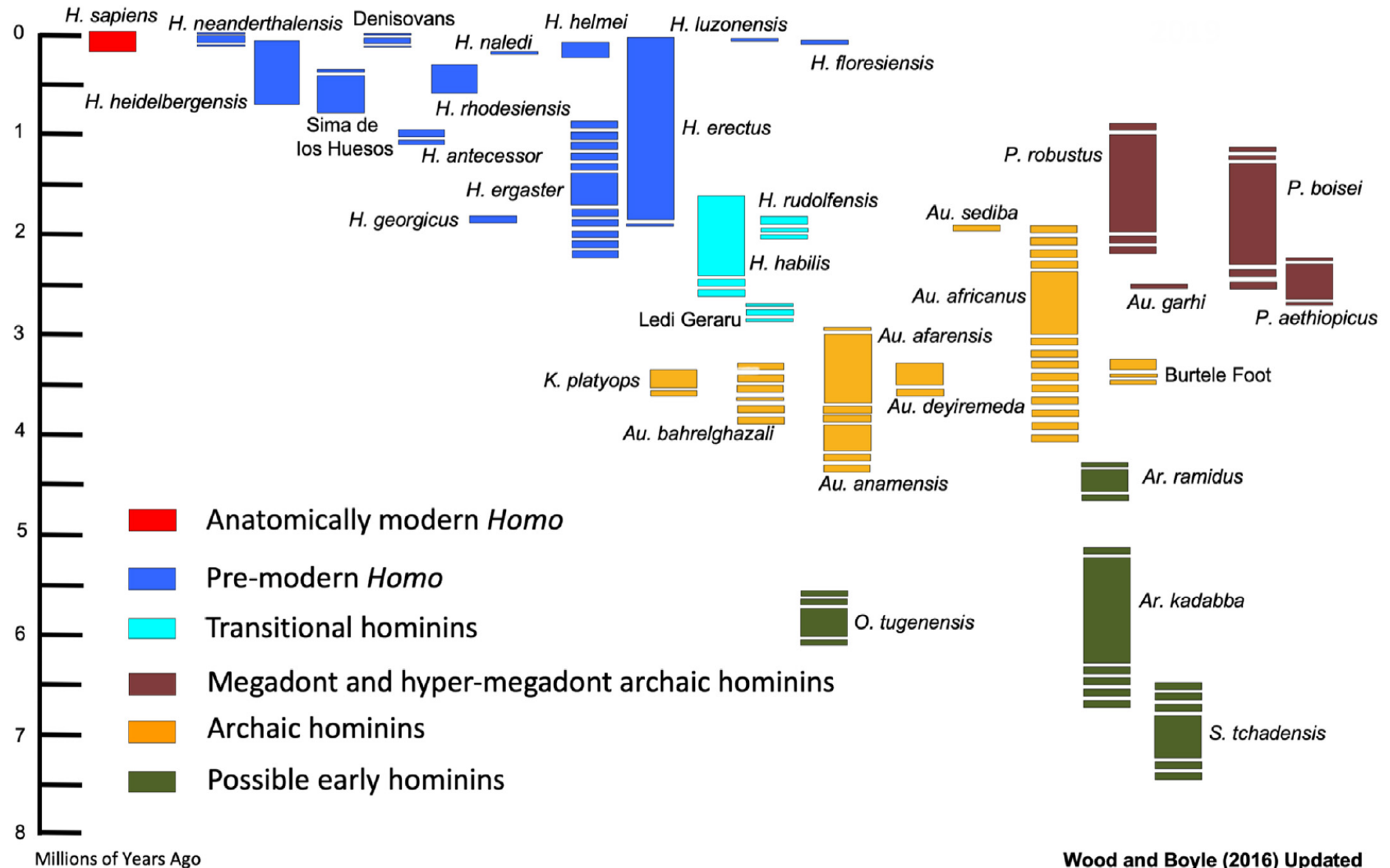
Prognathous, low forehead
Large canines

Not very opposable thumb

Opposable big toe

Hominin species according to a “splitter’s” taxonomy – with suspected presence dotted

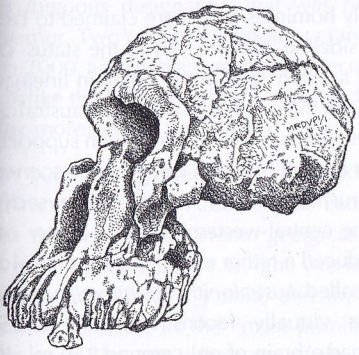
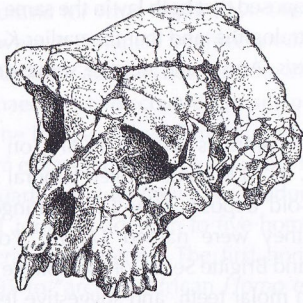
A lot of species?
Or just one?



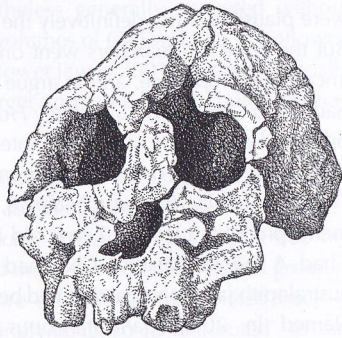
Classical questions about speciation:

- Was speciation allopatric, or sympatric?
- Punctuated equilibrium or gradual? Ian Tattersall believes in punc. eq. & allopatric speciation in small founder populations
- But it all looks rather gradual to me, from my non-palaeoanthropological background!
- It does seem clear that there were many species, often contemporaneous and sympatric (esp. Africa), on the hominin branch
- How about divergent adaptations between speciating entities
 - ... These are questions in which palaeoanthropologists are most interested
 - ... We'll get into them below!

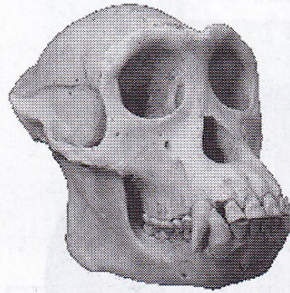
*Sahelanthropus
tchadensis* ~7Mya



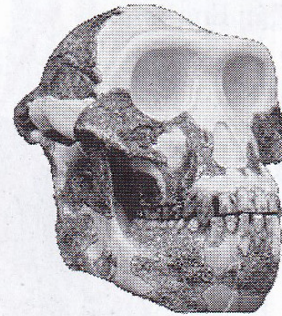
*Australopithecus
anamensis* ~4Mya



*Kenyanthropus
platyops* ~3.5 Mya



Chimpanzee



*Australopithecus
afarensis*



*Australopithecus
africanus*



Homo erectus

FIGURE 21.8 Skulls of a chimpanzee (*Pan troglodytes*) and three hominins. Note the chimpanzee's large canines, low forehead, prominent face, and brow ridge. The skull of *Australopithecus afarensis* shows several similarities with that of the chimpanzee. *A. africanus* had smaller canines and a higher forehead. *Homo erectus* had a more vertical face and rounded forehead. (From [41].)

(A)



(B)



Ardipithecus ramidus

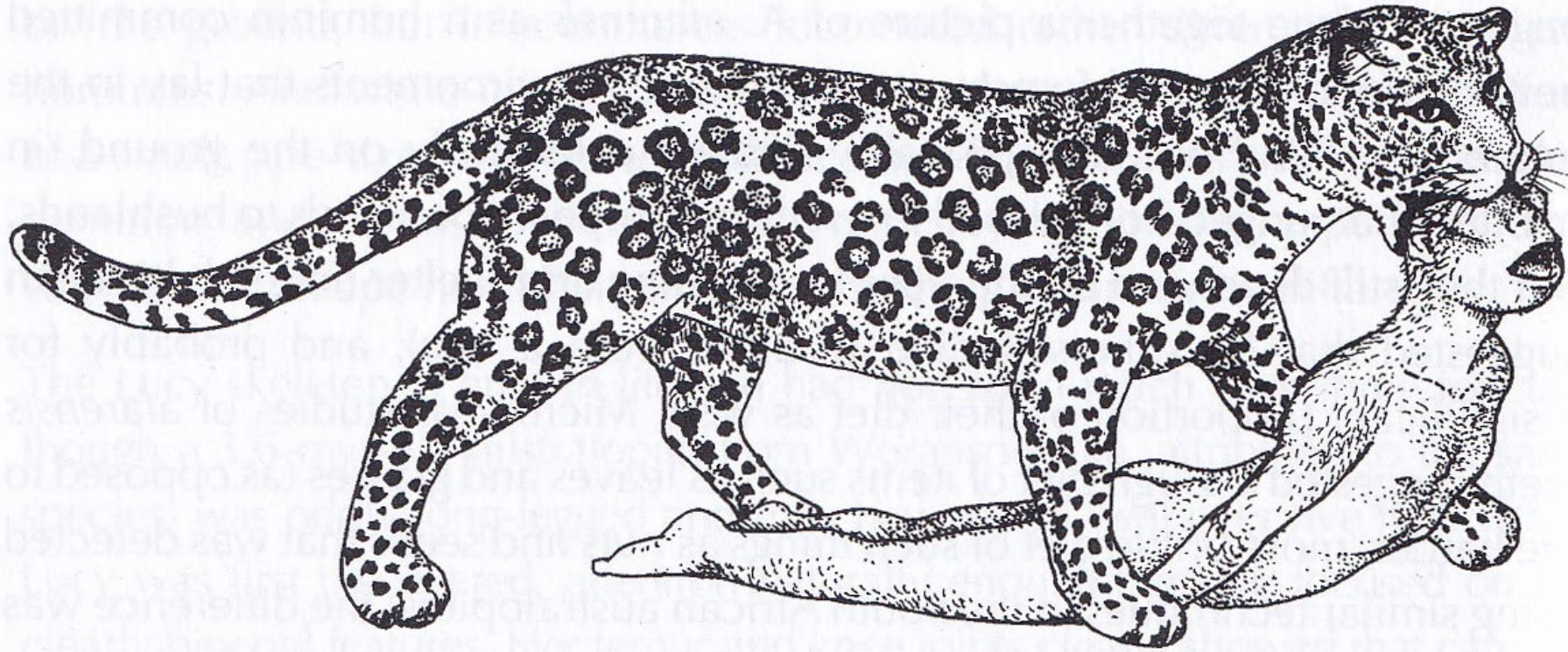


Figure 5.2 Artist's impression of a leopard dragging a *Paranthropus* cadaver. Based on a cranial fragment from Swartkrans, South Africa, that bears twin holes almost certainly made by leopard canine teeth.

How do
hominins
differ?



FIGURE 21.3 Chimpanzees (*Pan troglodytes*) learn how to use tools by imitation. As a female and her infant watch, a male cracks nuts using a rock as a hammer.

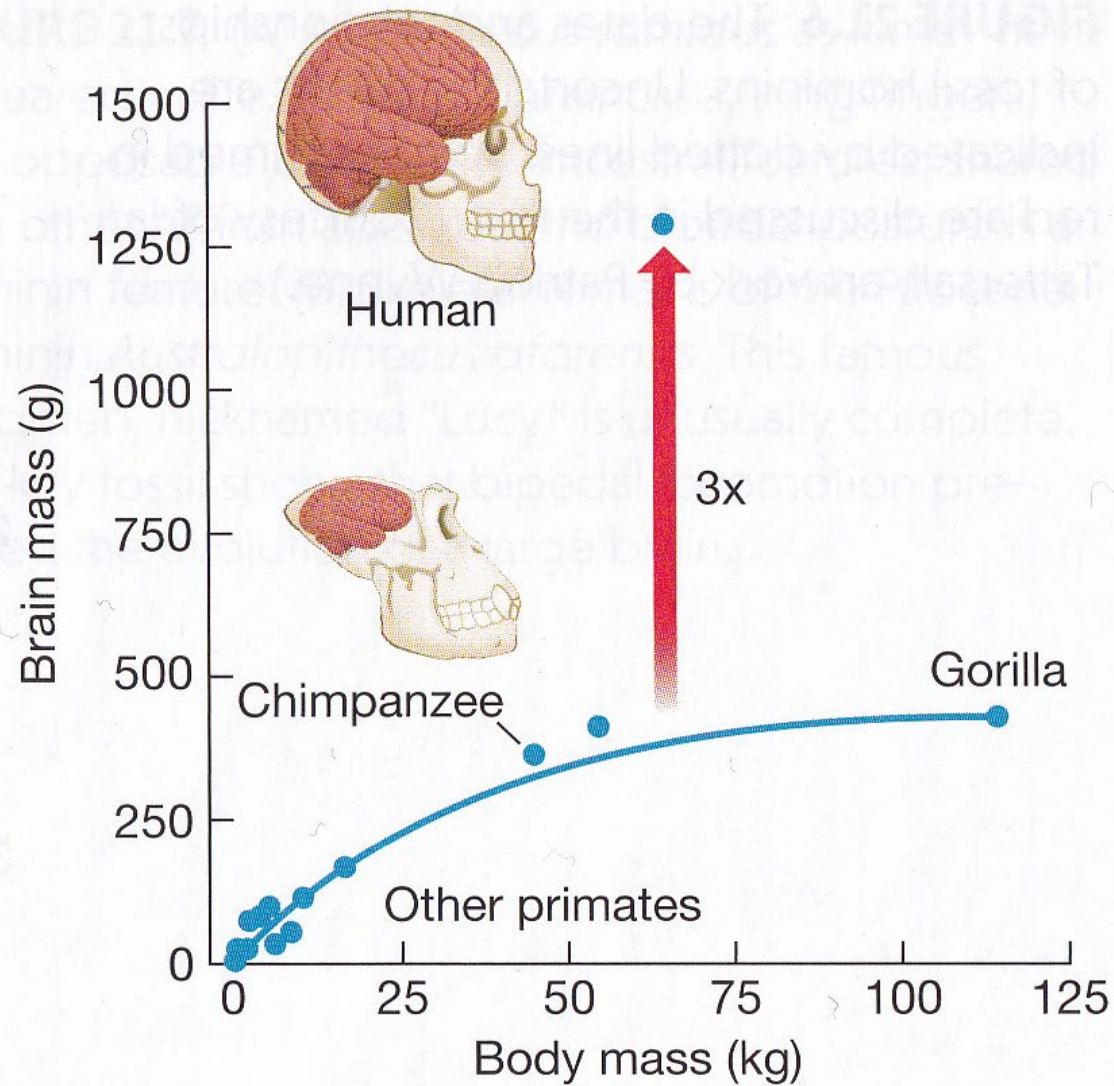


FIGURE 21.5 Plot of average brain mass against average body mass for primates. Relative to body mass, the human brain is three times larger than the average primate brain. (After [41].)

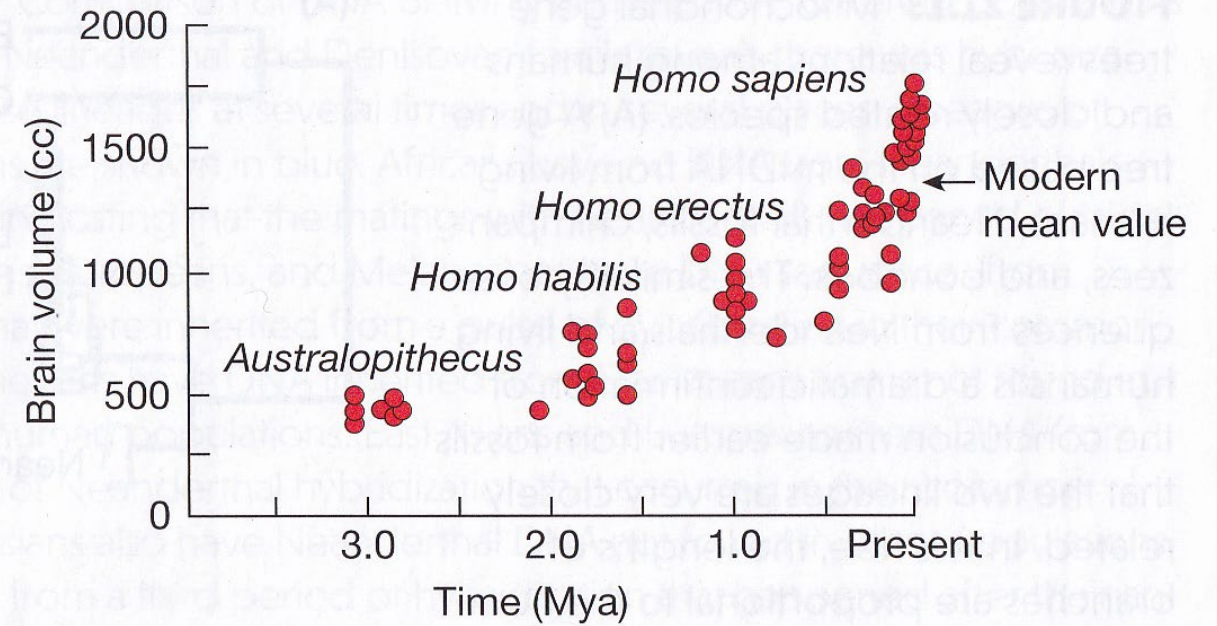


FIGURE 21.11 The brain volume of hominins has increased through time. This figure assigns specimens to *Homo habilis* and *H. erectus*, but some of those specimens are intermediate and cannot be classified with certainty. (After [34].)

How do hominins differ?

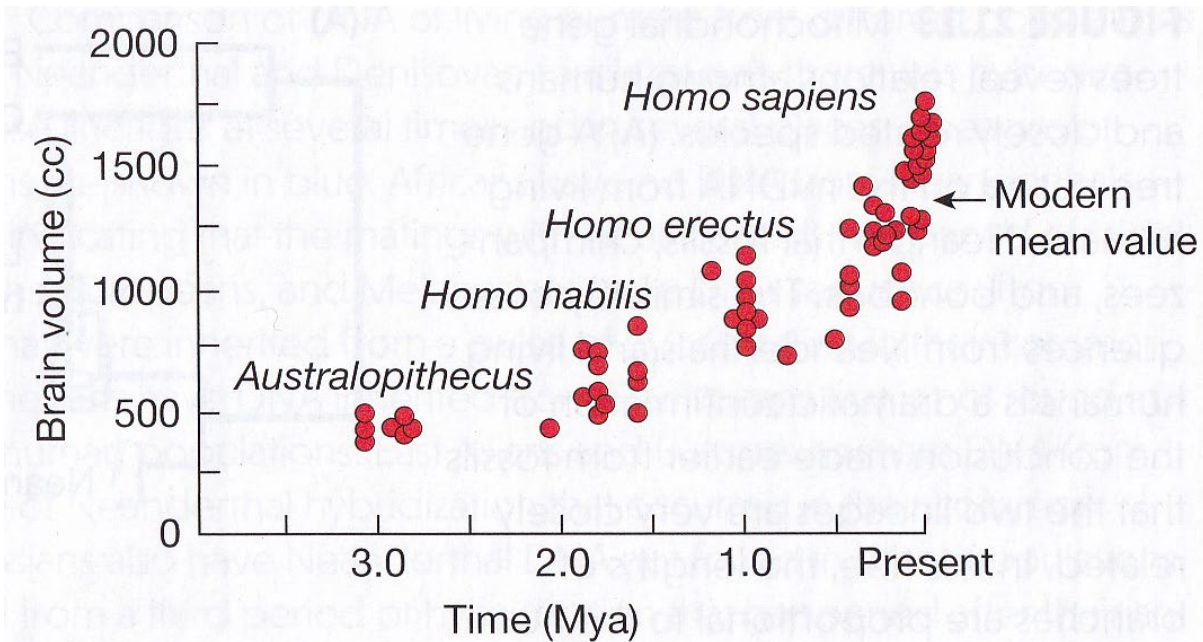


FIGURE 21.11 The brain volume of hominins has increased through time. This figure assigns specimens to *Homo habilis* and *H. erectus*, but some of those specimens are intermediate and cannot be classified with certainty. (After [34].)

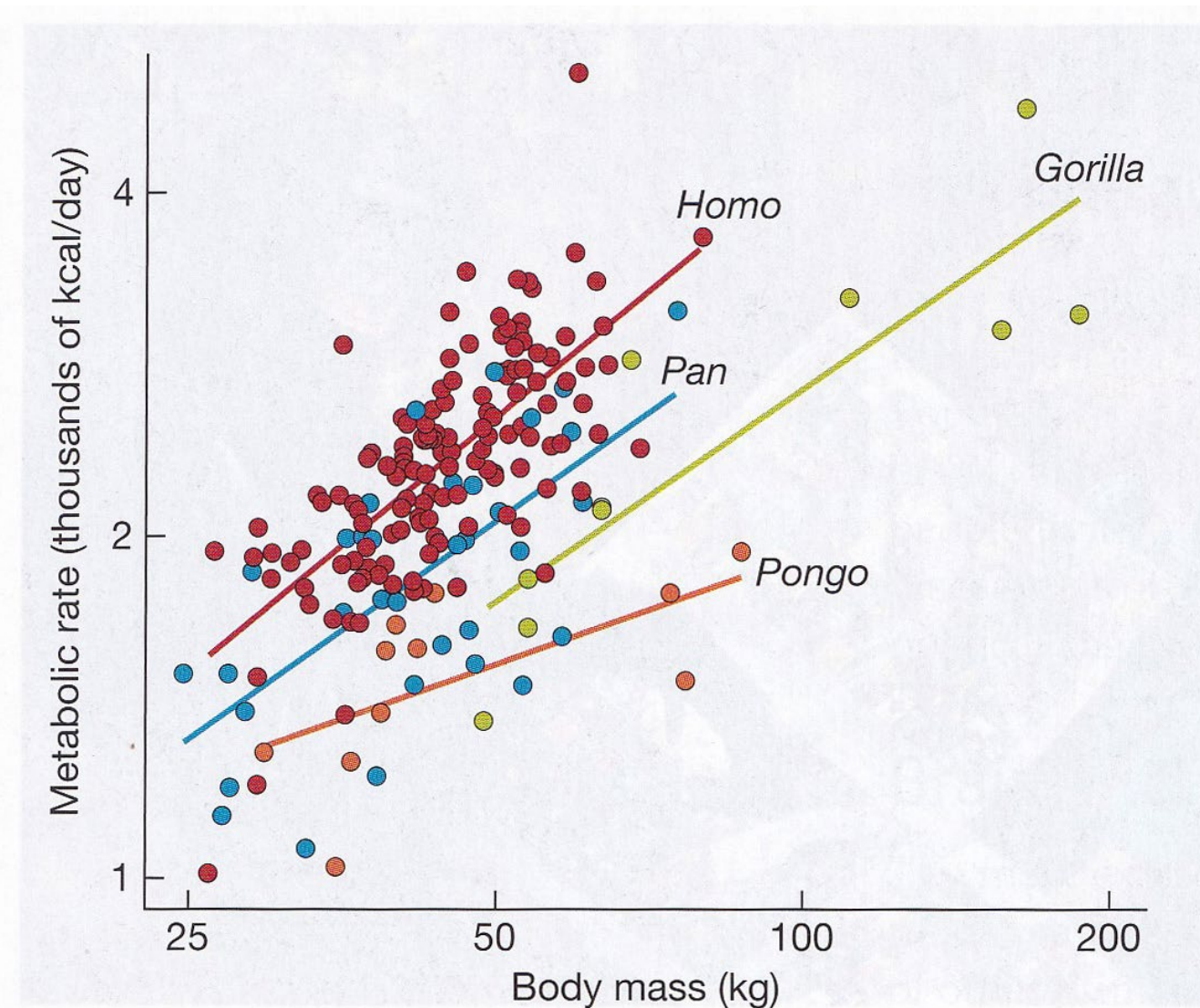
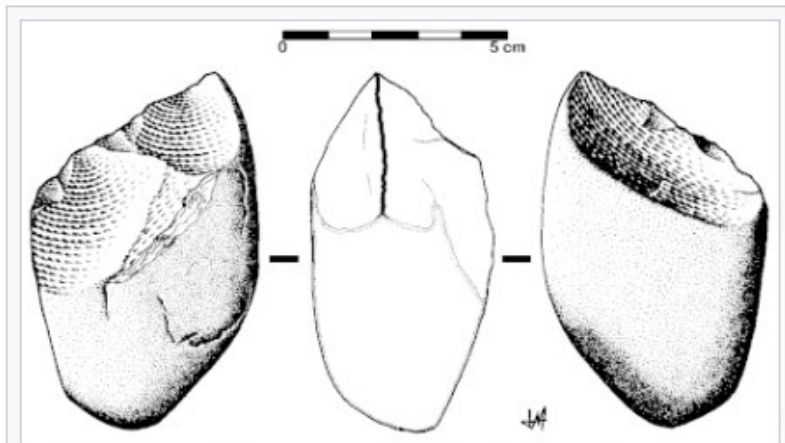


FIGURE 21.17 Humans have a higher metabolic rate relative to fat-free body mass than do chimpanzees (*Pan*), gorillas (*Gorilla*), and orangutans (*Pongo*). (After [58].)

Divergence of homins from “chimps”

- Reduced arboreality, forest -> savannah
- Upright stance, bipedalism, slow but good for open areas
- Evolution of foot, more opposable thumb
- Increased carnivory, shorter gut; from prey → predator
- Skin pigmentation, loss of body hair, sweat, endurance
- Increased group sizes, sociality
- Regular stone tool use, modification of tools (chipping stones)

Technology: stone tools

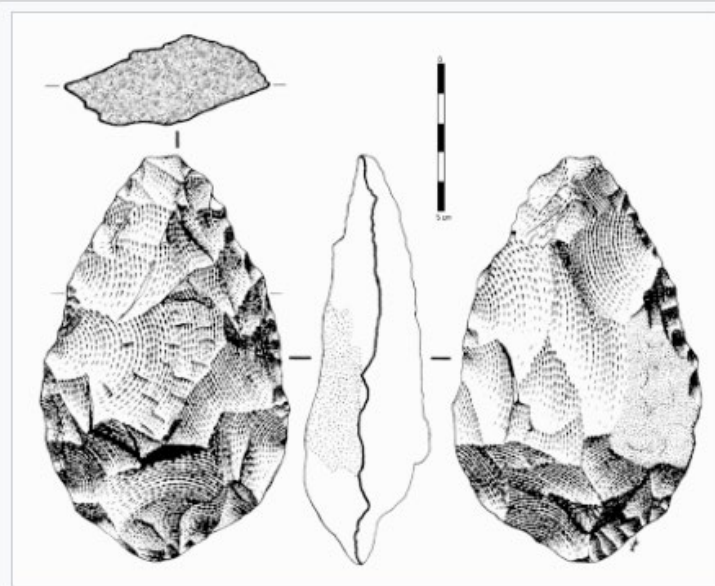


A typical Oldowan simple chopping-tool. This example is from the Duero Valley, [Valladolid](#).

Mode I, Oldowan (Olduvai gorge)

2.6 Mya

Australopithecines? Early *Homo*, to *Homo erectus* → out to Asia 1.8-1.6 Mya

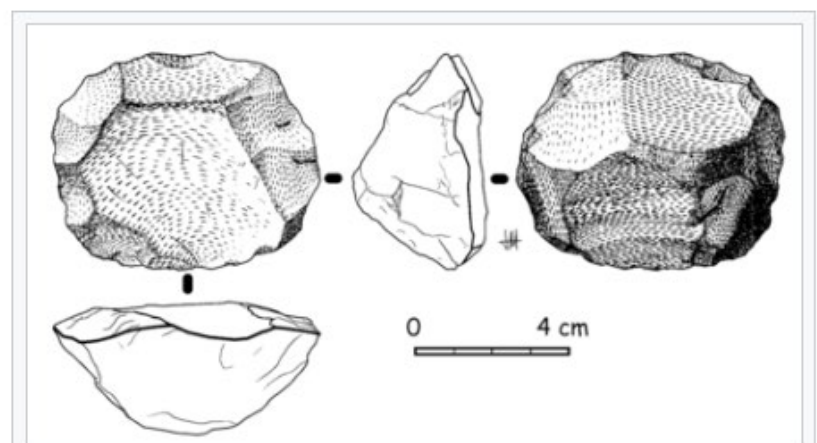


A typical Acheulean handaxe (from the Duero valley in Spain). The small flakes on the edge are from reworking.

Mode II, Acheulean (Saint-Acheul, France)

1.6-1.7 Mya Kenya & S. Africa

African *H. erectus*, *Homo ergaster*



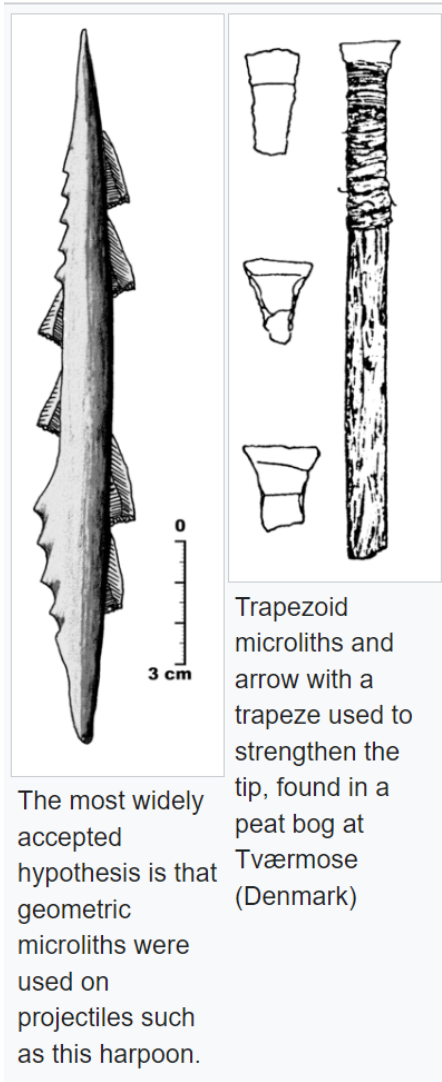
A tool made by the [Levallois technique](#). This example is from La Parrilla (Valladolid, Spain).

Mode III, Mousterian (Le Moustier, France)

300,000-40,000 BP

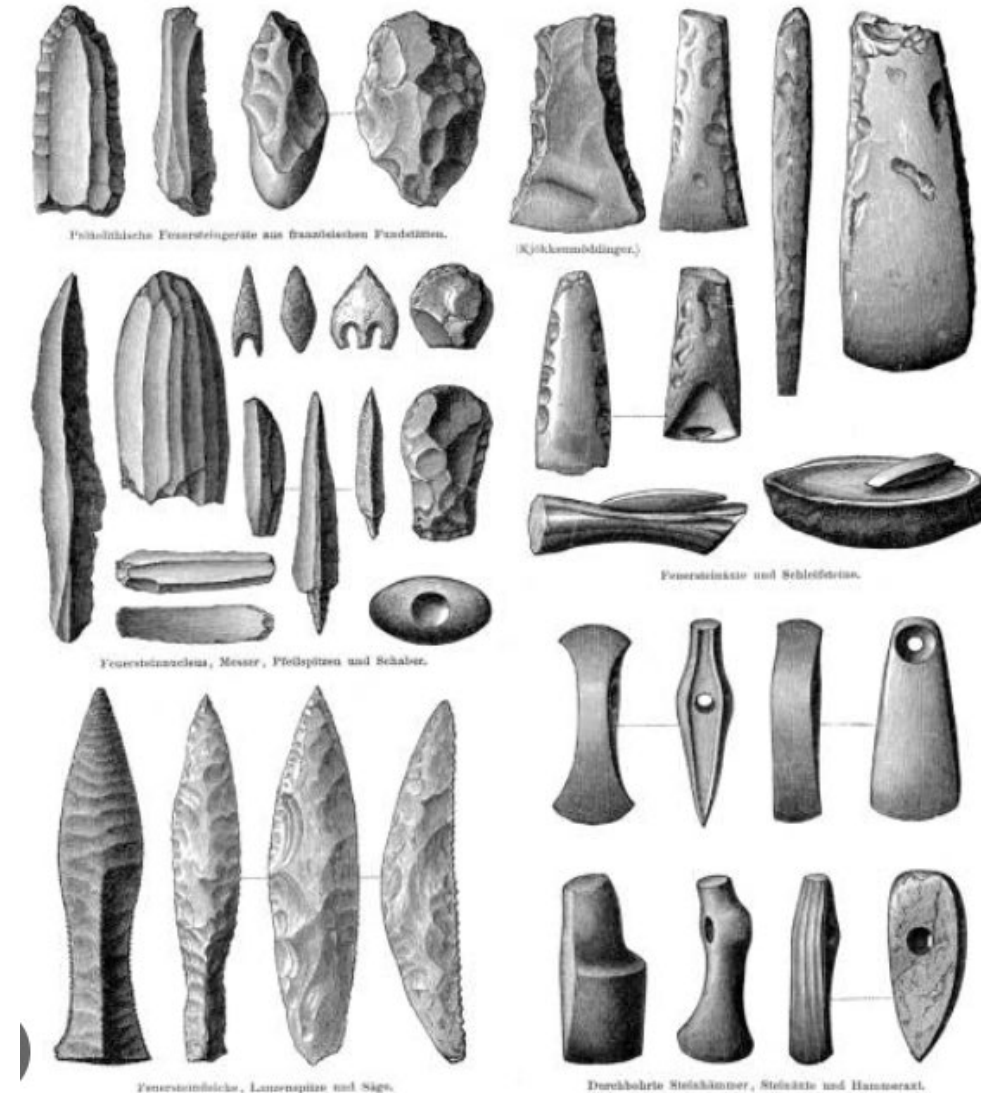
Use of flakes to make knife-like tools
Neanderthals and contemporaneous African species

Technology: advances in stone tools → Neolithic



“Microliths” attached to wood, Arrows, axes with hafts. Polished hand axes, etc.

40,000 – 17,000 BP
Worldwide



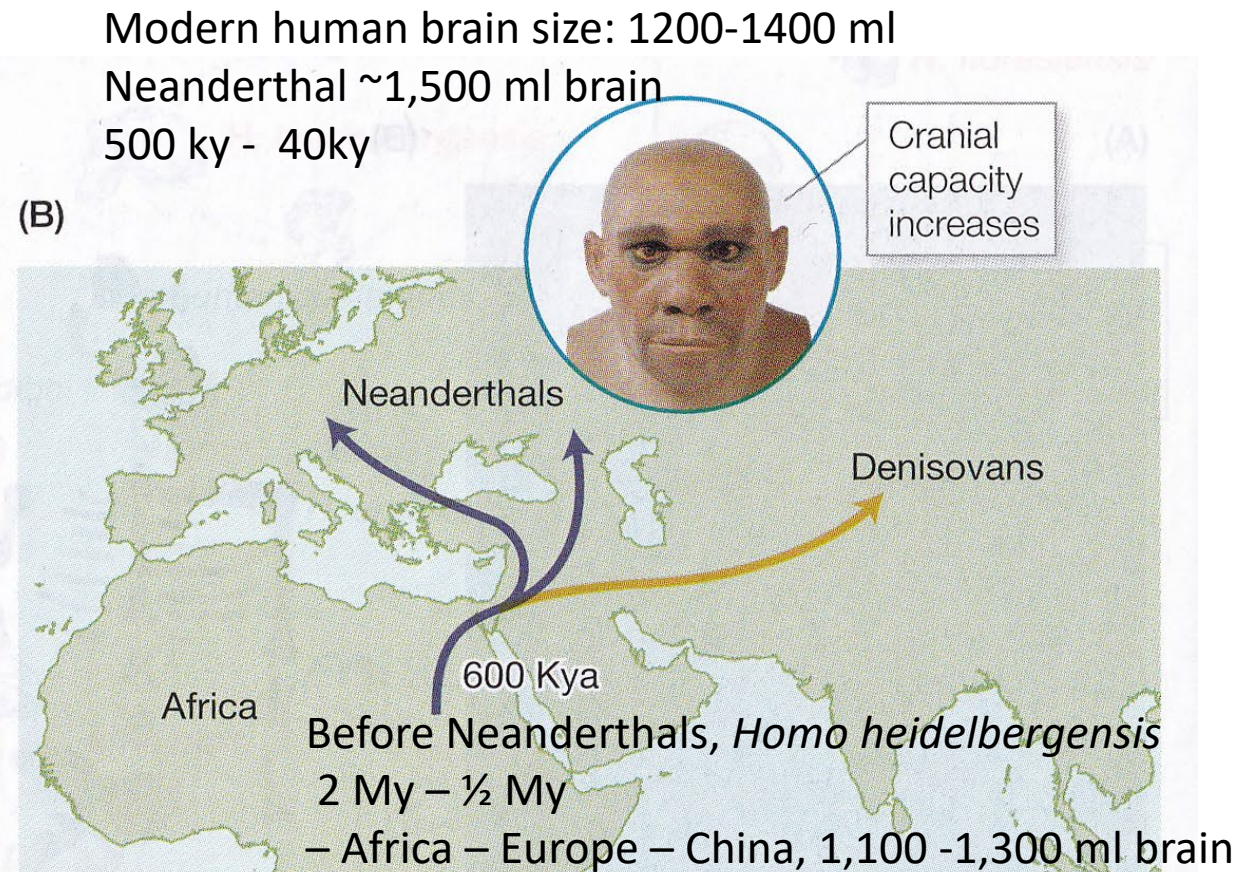
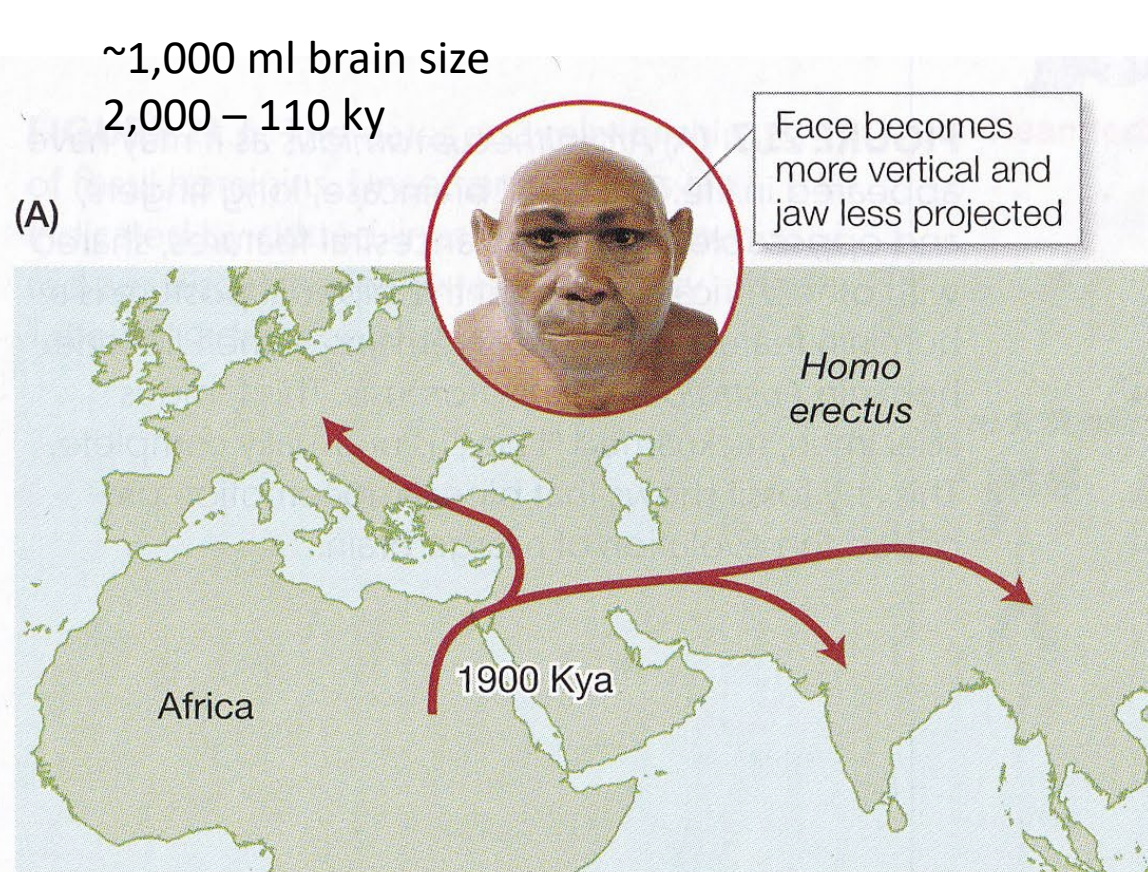


FIGURE 21.9 Before humans did so, other hominins spread out of Africa at least twice. (A) Starting about 1900 Kya, *H. erectus* spread to the Middle East, Europe, and Asia. It became extinct without contributing to human ancestry outside Africa. (B) The ancestor of Neanderthals (*H. heidelbergensis*) left Africa about 600 Kya. It spread into Europe and Asia, where it gave rise to the mysterious Denisovans. Later, both Neanderthals and Denisovans hybridized with humans outside Africa.

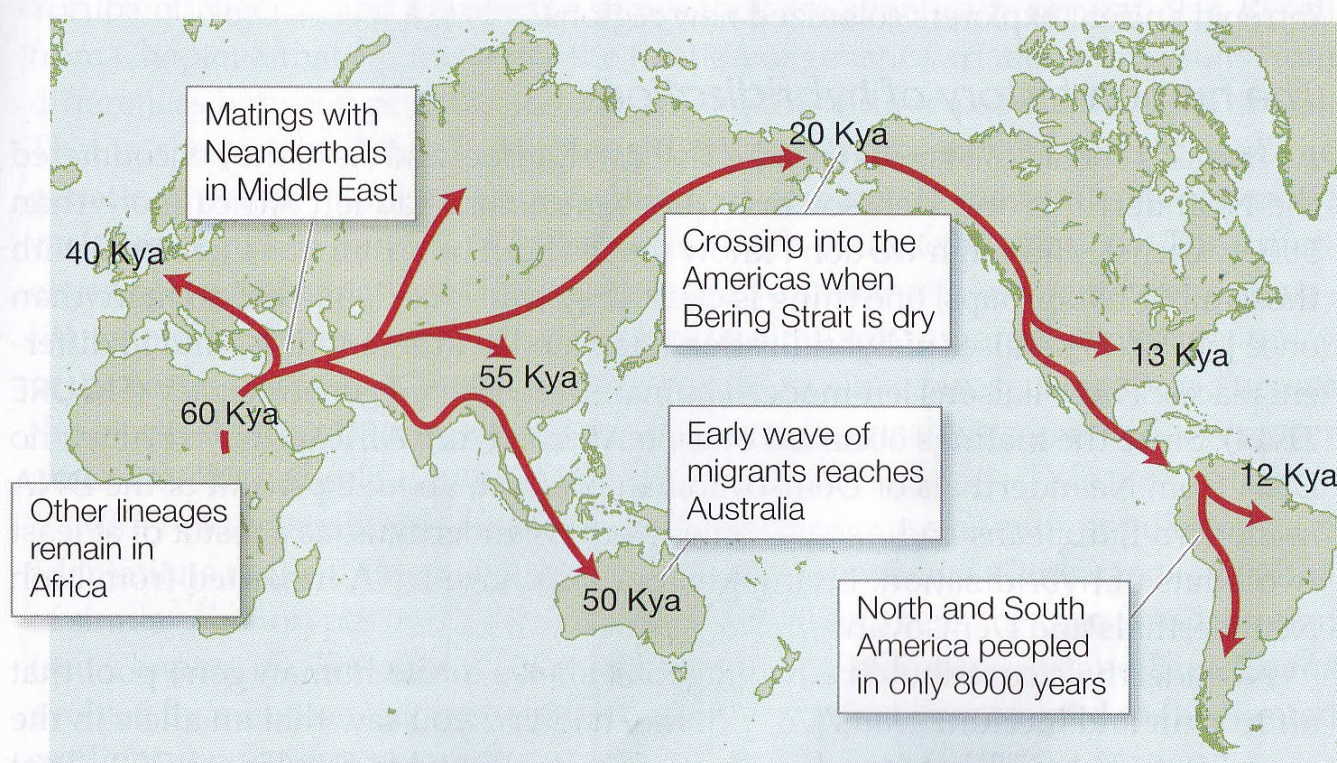


FIGURE 21.12 The colonization of Earth by humans. The arrows show paths of colonization, and the numbers show the times of arrival in years before present. Several of the paths and dates are not known with great certainty.

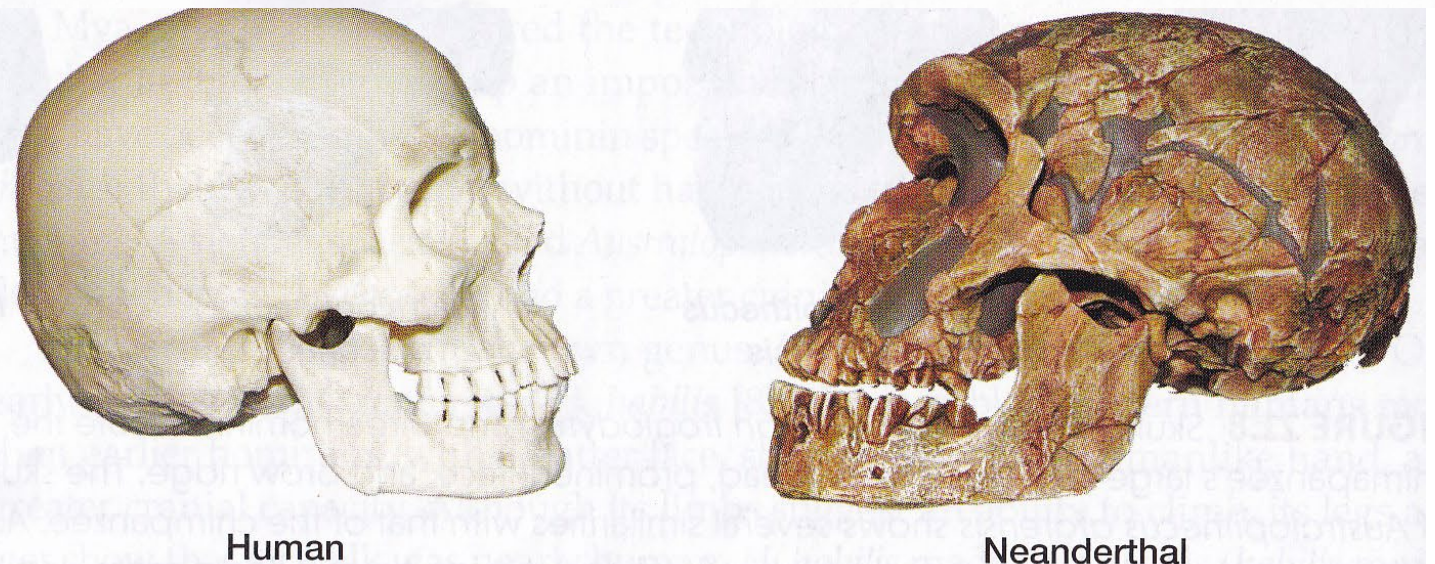


FIGURE 21.10 Skulls of a human from 28 Kya and a Neanderthal from 60 Kya. Neanderthals had an even bigger brain than living humans, but other features of their skull, such as the brow ridge, were more like those of other apes.

Neanderthals, Denisovans and modern humans; separate species?

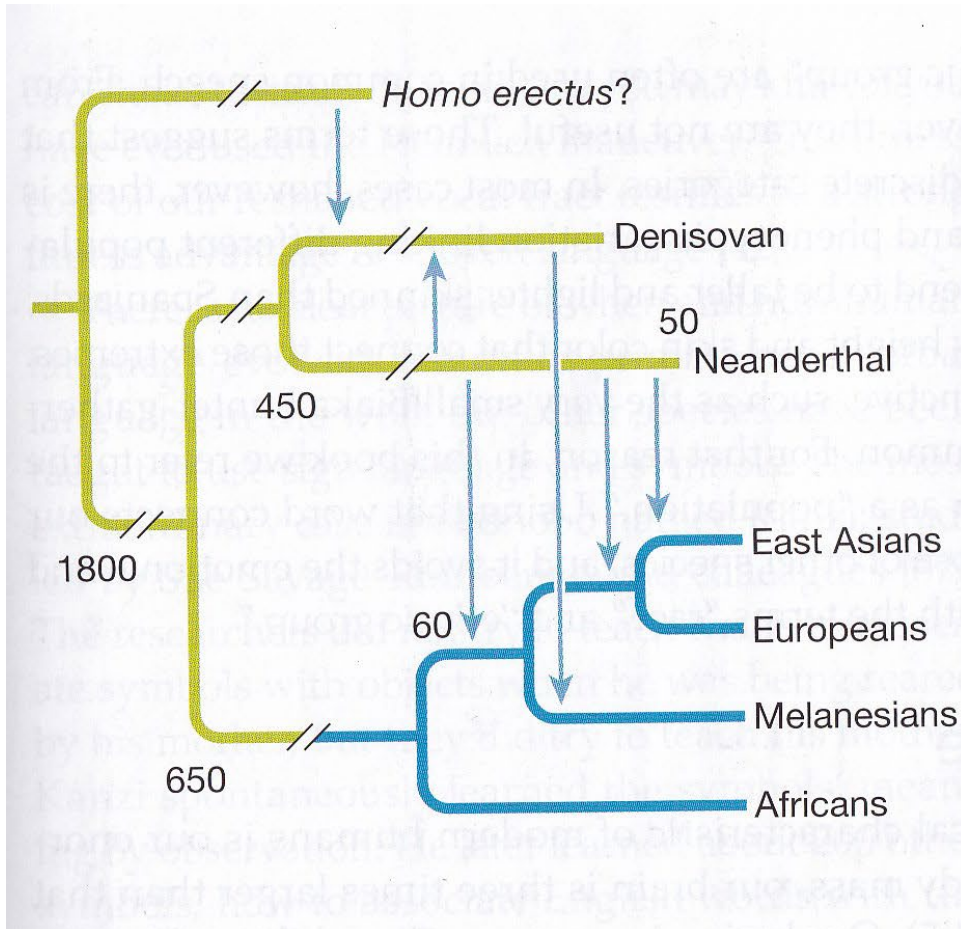
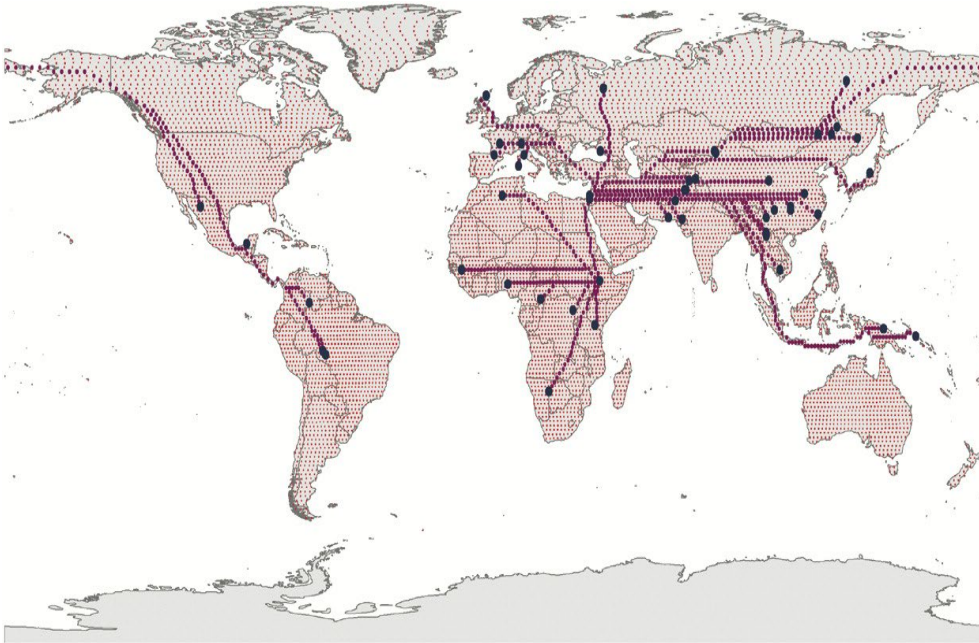
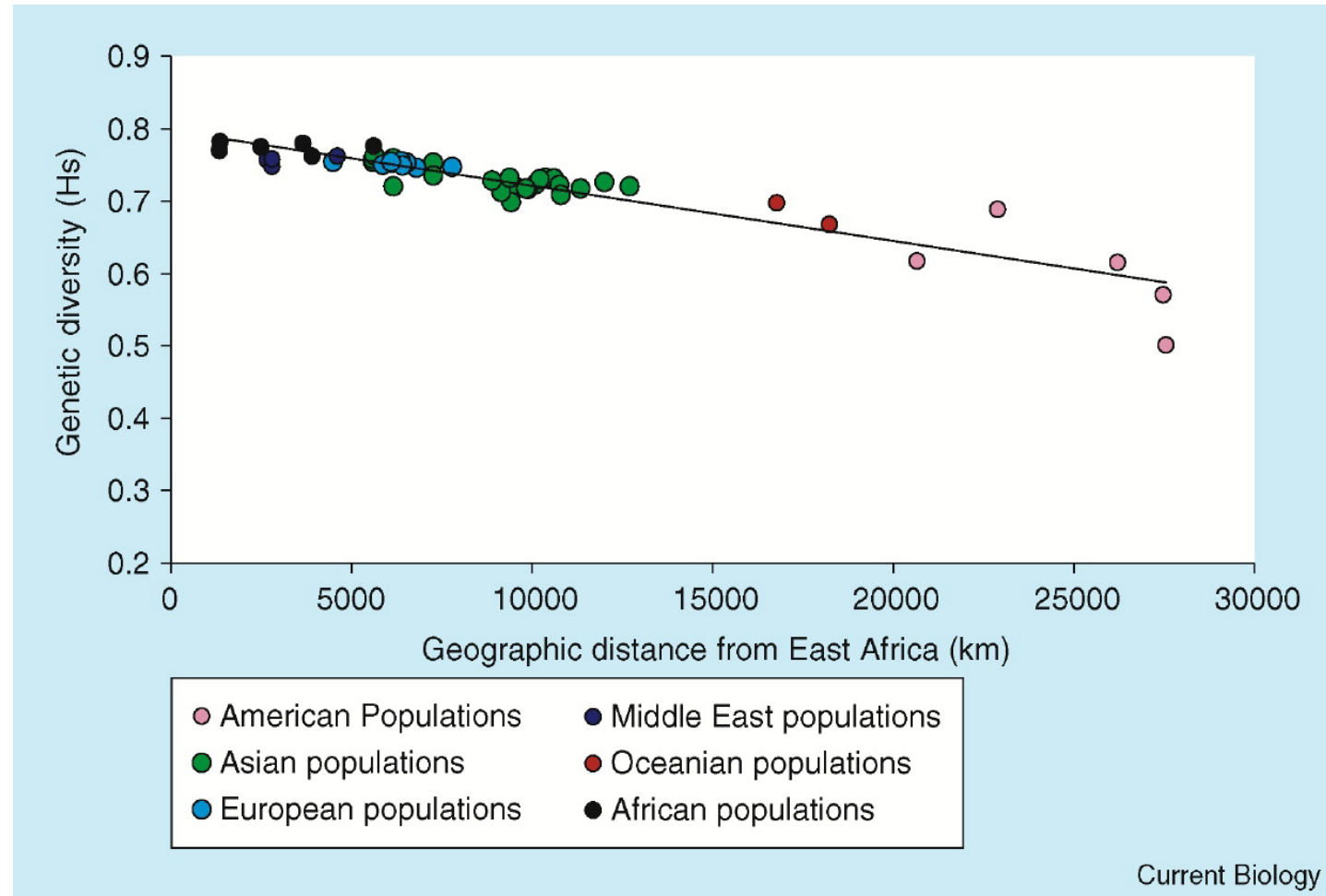


FIGURE 21.14 Comparison of DNA of living humans from different populations with DNA from Neanderthal and Denisovan fossils reveals there was hybridization among these lineages at several times and in several places. Lineages of modern humans are shown in blue. Africans have no DNA from Neanderthals or Denisovans, indicating that the matings with Neanderthals happened outside Africa. East Asians, Europeans, and Melanesians have DNA sequences from Neanderthals that were inherited from a pulse of hybridization in their common ancestor. Melanesians have DNA inherited from Denisovans that is not found in other modern human populations. East Asians and Europeans share DNA from a second pulse of Neanderthal hybridization that occurred in their common ancestor. East Asians also have Neanderthal DNA not found in other populations that is inherited from a third period of hybridization that happened after their ancestors diverged from European populations. Denisovan DNA shows evidence of much older hybridization with another species of hominin, possibly *Homo erectus*. The numbers show approximate dates of branch points in thousands of years ago. The breaks in the phylogeny indicate that the deeper branches are not shown to scale. The phylogeny is simplified, and the timing and number of hybridization events are not yet certain. (After [50, 61, 77].)

Genetic diversity – distance from origin in E. Africa

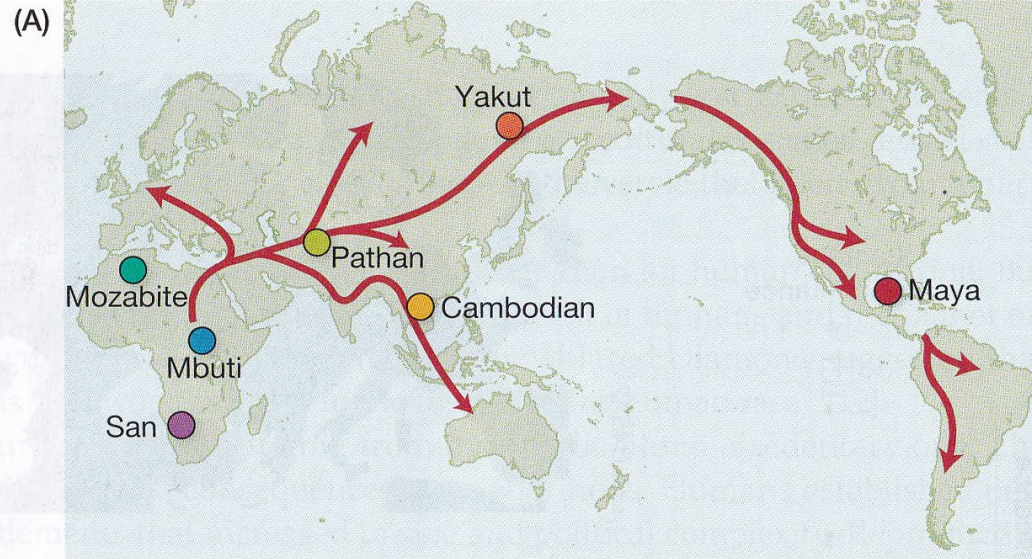


As expected due to genetic drift, the Out-of-Africa colonization led to reductions in genetic diversity. Here shown with microsatellite loci

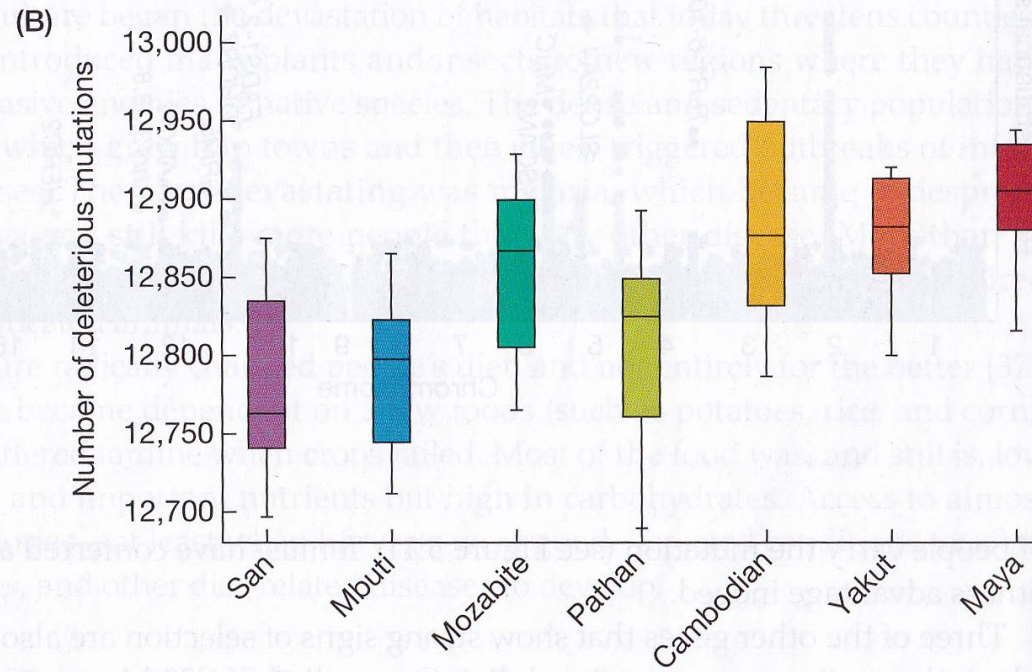


Current Biology

Prugnolle et al. 2005



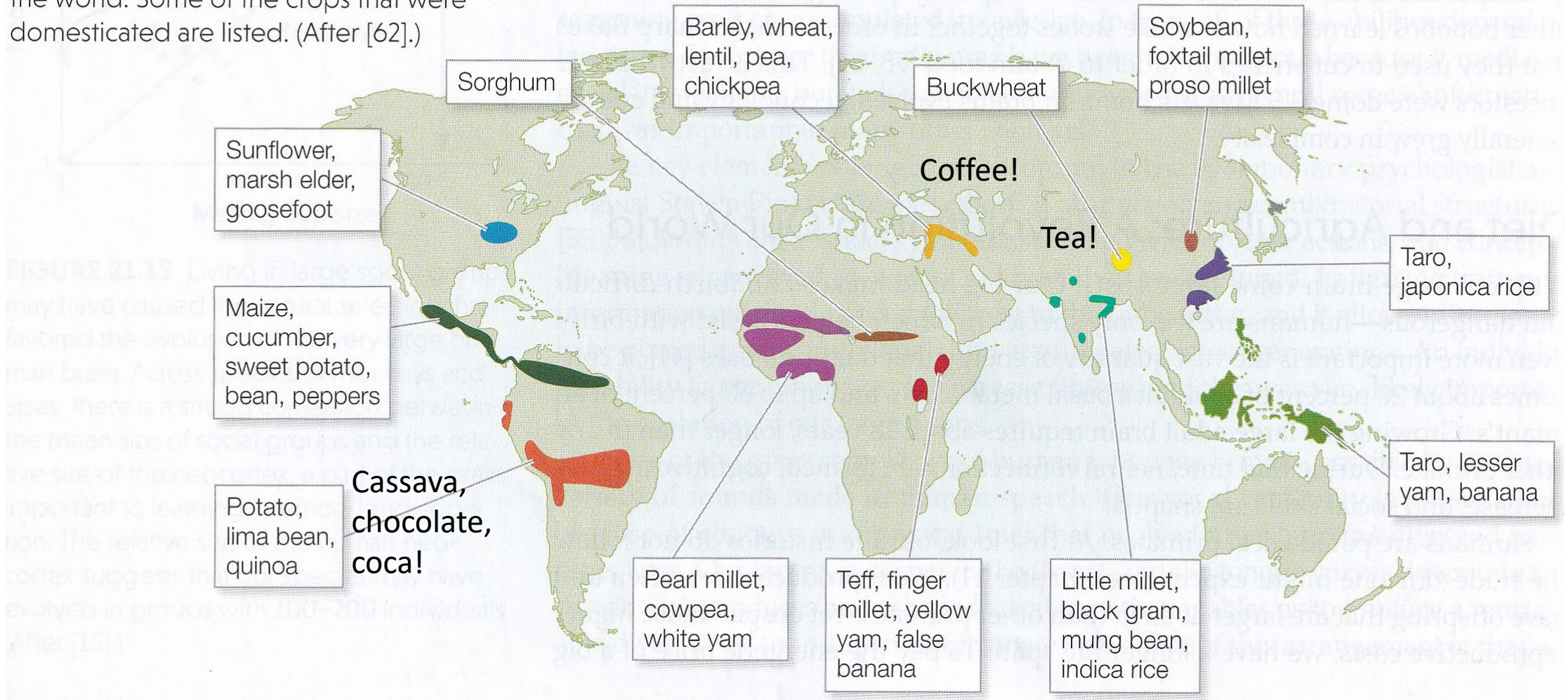
Deleterious mutations and genetic drift in human genomes



Deleterious variants were determined based on the ancestral variant being highly conserved in a phylogeny of mammals ("GERP" score). Phylogenetically conserved sites had lower heterozygosity in African populations, in spite of high heterozygosity of African populations for neutral loci.

Parallel invention of agriculture

FIGURE 21.18 Agriculture was invented independently at several places around the world. Some of the crops that were domesticated are listed. (After [62].)



Technology: pottery, copper, wheel, iron

Venus of Dolní
Věstonice
29,000-20,000
BCE

Long before
beginning of
agriculture!



Earliest known ceramics are the [Gravettian](#) figurines that date to 29,000 to 25,000 BC.

Pottery 29,000-20,000 BCE
Pre-neolithic
High temperature firing, 600-1600 deg. C



Shaping and smoothing [fire clay](#) to form a [bowl](#)

American pottery.
Almost certainly independent
9500 – 5000 BP
(Brazil, then Mesoamerica much
later)
No wheel, glazes or stoneware

African pottery.
Almost certainly independent
9400 BCE (Mali)

Technology: pottery, copper, wheel, iron



An early wheel made of a solid piece of wood

Pottery wheels 4700-4000 BCE
Wheeled vehicles 4000-3300 BCE



A figurine featuring the [New World's](#) independently invented wheel. Among the places where wheeled toys were found, [Mesoamerica](#) is the only one where the wheel was never put to practical use before the 16th century.

In the Americas, wheeled pull-toys are known from 1500 BCE, but no practical uses developed!

Symbolic behaviors

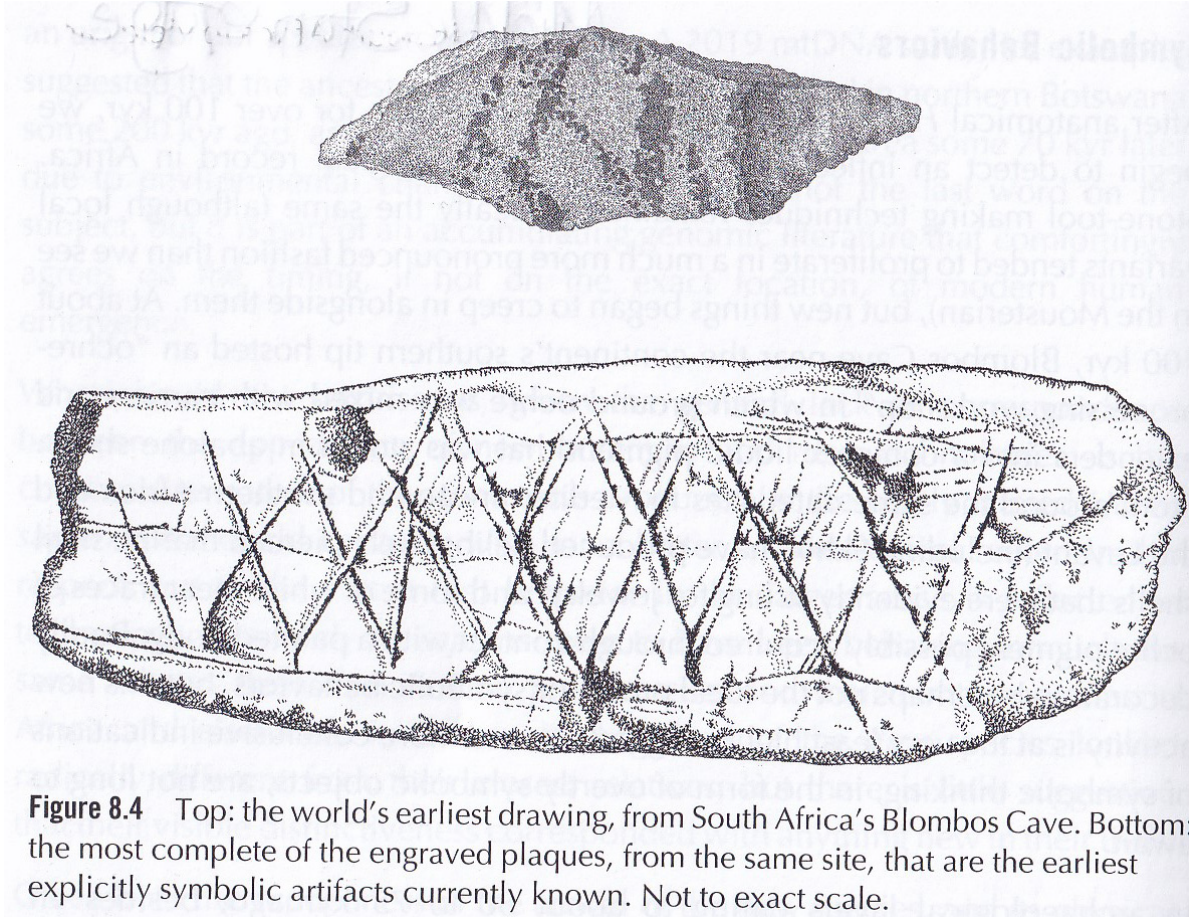


Figure 8.4 Top: the world's earliest drawing, from South Africa's Blombos Cave. Bottom: the most complete of the engraved plaques, from the same site, that are the earliest explicitly symbolic artifacts currently known. Not to exact scale.

100,000-75,000 BP Ochre processing, pierced shell
jewellery, first etched designs, art
Music!
Language? ~ Maybe 250,000 BP?



Figure 8.5 Black-and-white rendering of a now badly faded Upper Paleolithic (Magdalenian) polychrome image of two reindeer, from the cave of Font de Gaume, in western France. A female kneels before a large male, who is leaning forward and tenderly licking her brow. Undated, but likely about 14 kyr old.

(A)



(B)



FIGURE 21.23 Sophisticated culture in human societies began more than 50 Kya. The magnificent cave paintings found in France and Spain date from 30 to 10 Kya. This painting is from Lascaux, France. (B) The earliest flutes, made from the bones of bears, birds, and mammoths, are about 40 Ky old. These are from Hohle Fels cave in Germany.

Modern human “ecological isolation:” Technology

- Tools, hunting weapons
- Increased predatory activity – more meat eating (back to Australopiths)
- Fire, cooking
- Culture and language – huge societies, developed in parallel, Africa, Eurasia, the Americas
- Agriculture – potential for reduced meat-eating!
- Stone, Wood, Copper, Bronze, Iron working; now plastics etc. Buildings – protection from climate and predators
- Animal domestication, starting with dogs (probably traveled with early Americans across the Bering Straits)
- Guns, weapons of war
- The wheel, transportation, air travel, space etc.
- Writing, books, computers
(not in Inca Empire! They had *quipu*)
- Telecommunications & internet



An Inca *quipu*

Civilizations



Temple 7.0 The temple began as a modest structure in the 1300s, but as the Mexica, the ethnic group that came to rule the Aztec Empire, amassed wealth and territory, they enlarged the monument. By the time Spaniards arrived in 1519, Templo Mayor had undergone six major renovations, becoming a 10-story pyramid, with earlier structures nestled inside. This latest and greatest phase is the most poorly preserved: Only fragments of the floor remain because the Spanish razed the temple for materials to build their colonial city. DEA PICTURE LIBRARY/De Agostini/Getty Images



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Inca walls in Cusco, Peru

North America: Cahokia, nr. St. Louis



A Mississippian-era priest, in the 13th century, Cahokia metropolis, holding a ceremonial flint mace and severed sacrificial head

Cahokia Mounds State Historic Site



Monks Mound, the largest earthen structure at Cahokia (for scale, an adult is standing on top)



Artist's recreation of central Cahokia. Cahokia's east-west baseline transects the Woodhenge, Monk's Mound, and several other large mounds.

Use of energy resources: more “ecological isolation”



- Wood (fire)
- Agriculture and pastoralism
- Fossil fuels: coal – industrial revolution. Later, oil
- Nuclear fission
- Hydrogen
- Solar energy
- Nuclear fusion?

Buildings



Written by Eric Baldwin

January 14, 2020

[KPMB Architects](#) and [Suffolk](#) recently broke ground on Boston University's new Center for Computing and Data Sciences. The Center aims to be a striking new addition to Boston University's central campus and its first new major teaching center in a half-century. As the tallest building at Boston University, the 19-story, 350,000-square-foot structure will bring the institution's mathematics, statistics and computer science departments under one roof.

Have humans stopped evolving?

To be sure, there may have been an improvement of the brain without an enlargement of cranial capacity [over the last 100,000 years] but there is no real evidence of this. **Something must have happened to weaken the selective pressure drastically. We cannot escape the conclusion that man's evolution towards manness suddenly came to a halt.... The social structure of contemporary society no longer awards superiority with reproductive success.**

Ernst Mayr 1963

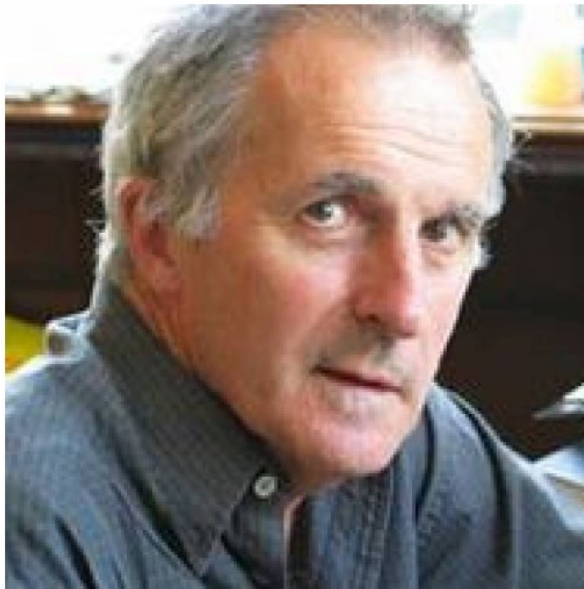
Have humans stopped evolving?

[UCL Home](#) » [UCL News](#) » Human evolution is over, says UCL academic

Human evolution is over, says UCL academic

7 October 2008

Human evolution has virtually come to a halt, according to Professor Steve Jones of UCL.



Speaking today at a UCL Lunch Hour Lecture in London, Professor Jones argues that human evolution has reached the end of the line

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@uclnews · 3h

Takeaway delivery riders who find work through apps are more likely to be in a serious collision than those employed directly by restaurants, find Prof Nicola Christie & Heather Ward @CTS_UCL @CEGE_UCL @UCLEngineering



ucl.ac.uk
Road collisions more likely for takeaway delivery riders working in

7

UCL News
@uclnews · 4h

In the UCL Lunch Hour Lecture today, Professor Jones outlines the three components that make up evolution: natural selection, mutation and random change.

"In ancient times half our children would have died by the age of twenty. Now, in the Western world, 98 per cent of them are surviving to the age of 21. Our life expectancy is now so good that eliminating all accidents and infectious diseases would only raise it by a further two years. Natural selection no longer has death as a handy tool."



David Attenborough

This article is more than 9 years old

Sir David Attenborough warns against large families and predicts things will only get worse

People should be persuaded against having large families, says the broadcaster and naturalist

James Meikle

Tue 10 Sep 2013 03.42 EDT



644

Have humans stopped evolving?

In 2000, the paleontologist Stephen Jay Gould famously declared that “there’s been no biological change in humans in 40,000 or 50,000 years,” suggesting that evolution in humans is imperceptibly slow or has perhaps stopped altogether.

The broadcaster and naturalist ... said he believed humans have stopped evolving physically and genetically because of birth control and abortion, but that cultural evolution is proceeding "with extraordinary swiftness".

"We stopped natural selection as soon as we started being able to rear 90-95% of our babies that are born. We are the only species to have put a halt to natural selection, of its own free will, as it were," he tells this week's Radio Times.

"Stopping natural selection is not as important, or depressing, as it might sound – because our evolution is now cultural ... We can inherit a knowledge of computers or television, electronics, aeroplanes and so on."

Natural selection on humans

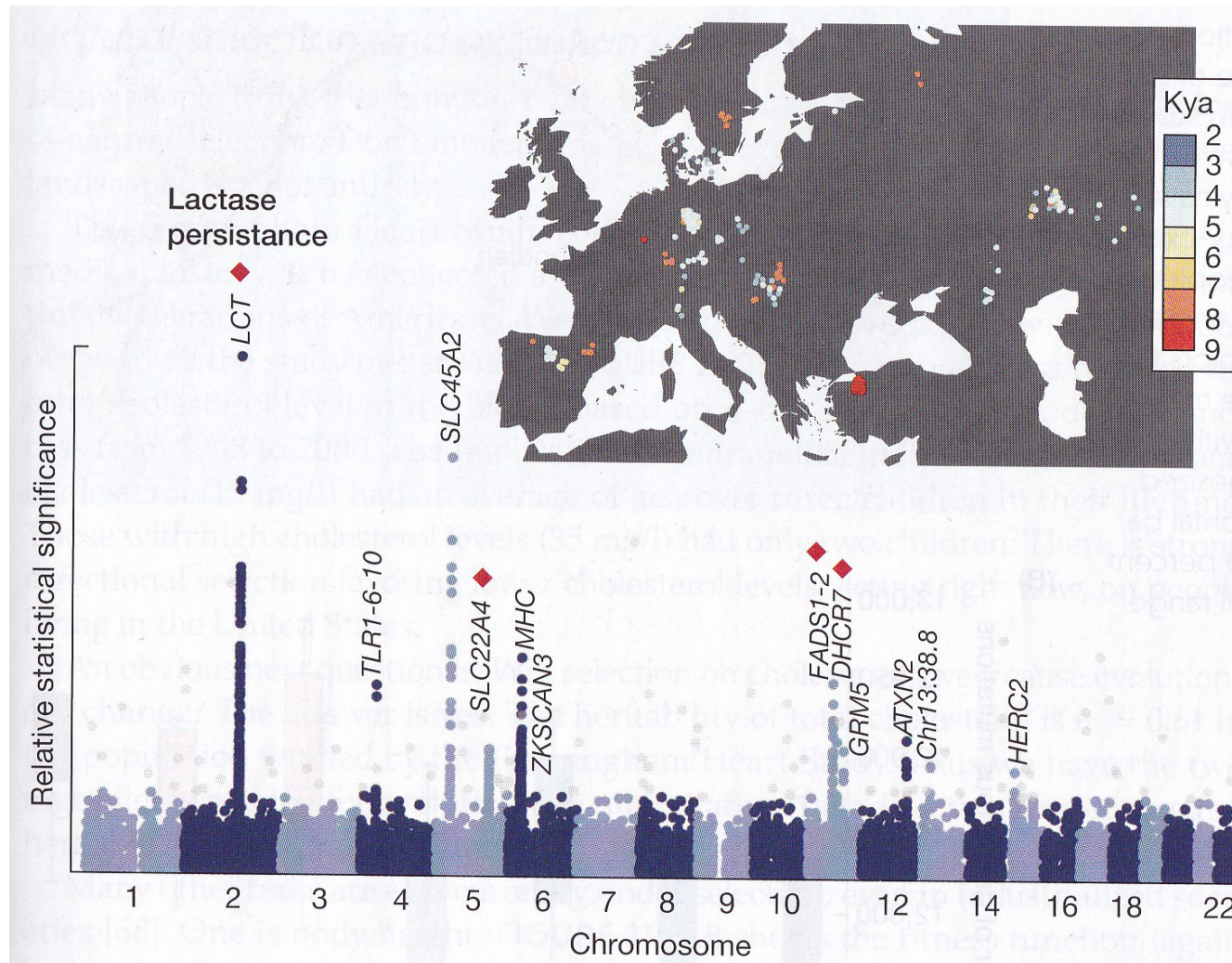


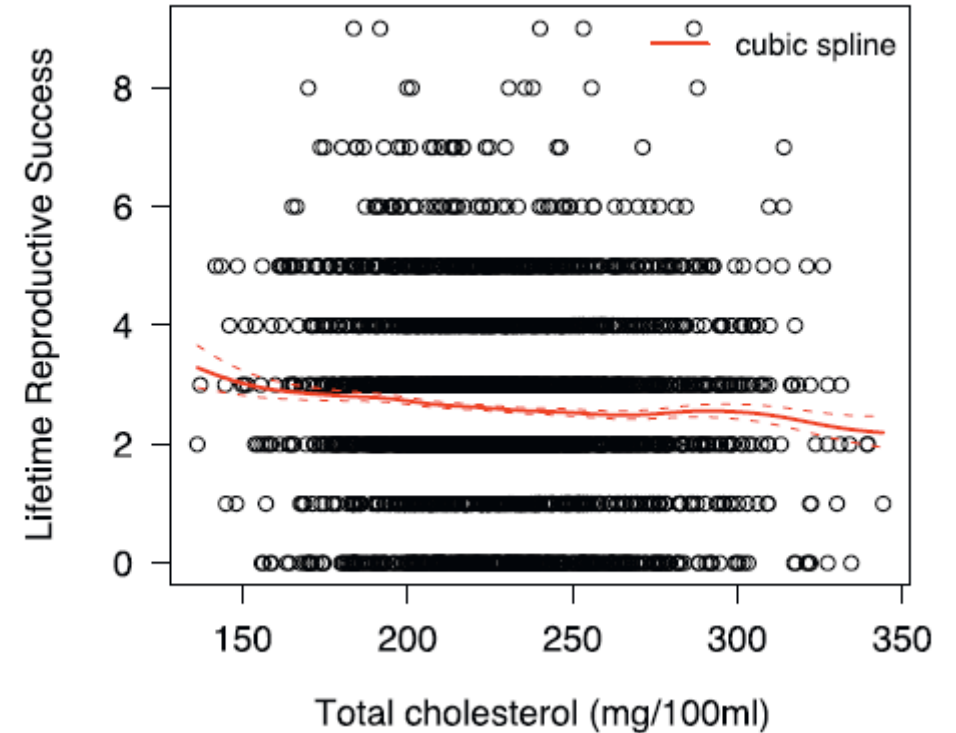
FIGURE 21.19 Twelve genes show strong signals of adaptive evolution in human populations in Europe and western Asia over the last 8500 years. Ancient DNA was collected at points shown on the map (inset). Comparison of single nucleotide polymorphisms in those samples with ones from modern humans living in the same locations pinpointed loci that evolved under positive selection. In the main panel, the genome is displayed from chromosome 1 to 22. The y-axis shows the strength of evidence for positive selection among more than 1 million single nucleotide polymorphisms. Four genes involved in adaptation to an agricultural diet are indicated by red diamonds. The strongest signal is for the mutation that causes lactase persistence, which allows adults to digest milk and other dairy products. It appeared in Europe just 4500 years ago. (After [46].)

Human evolution continues (quantitative traits)

The Framingham Heart Study (BU), followed cohorts since 1948.

By 2010 two complete generations (60 years) of women had been studied. Cholesterol levels expected to decline from 224 over last 60 years to 216 in next 10 generations. Also mean body weight and height expected to increase.

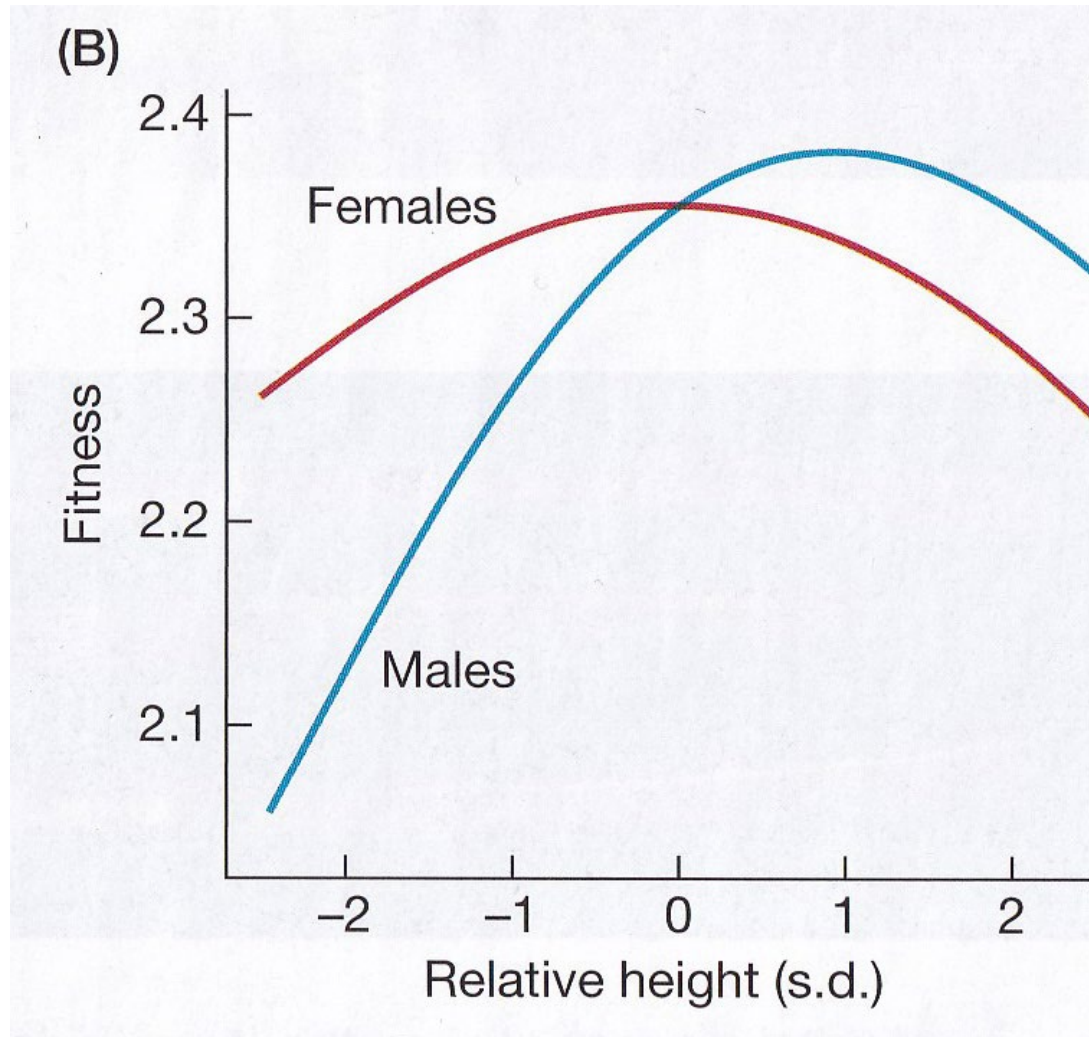
Heritable traits expected to change by 0.002 to 0.032 Haldanes (standard deviations per generation).



This is rapid, though slower than Darwin's finches and Trinidad guppies. Comparable to chinook salmon and Hawaiian mosquitofish

Byars et al. 2010

Selection on height in humans



Does natural selection favour taller stature among the tallest people on earth?

Stulp et al. 2015

It's the Dutch! (Not Finns as Futuyma & Kirkpatrick say it is).

Taller men and taller women are more fertile. However, they tend to pair up later, so the earlier pairing tends to outweigh the height advantage.

Human evolution and speciation

- No, humans have not stopped evolving. And this will continue.
- To some extent, we've escaped from our genes. We can conceive of actions in favour of the group (and against the interest of individuals or genes) being socially sensible and even enforced.
- But we haven't escaped entirely!
- Have we stopped speciating? Maybe!

References

I have taken many images and some of the ideas from:

Futuyma, D.J., & Kirkpatrick, M. 2017, 2023. Evolution. 4th & 5th editions. Sunderland, Mass., Sinauer Associates. Chapters 20,21.

Tattersall, I. 2022, Understanding Human Evolution. Cambridge, Cambridge University Press