MARK MASLIN

FOREWORD BY RICHARD LEAKEY

# THE CRADLE

# OF HUMANITY

How the changing landscape of Africa made us so smart

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# CONTENTS



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# LIST OF FIGURES



Copyrighted material

7. Records of hominin brain capacity and East African hominin diversity over the last five million years.

Based on figure 6 in Maslin, M.A., Brierley, C.M., Milner, A.M., Shultz, S., Trauth, M.H., and Wilson, K.E. 2014. East African climate pulses and early human evolution. Quaternary Science Reviews, 101: 1–17, CC-BY-SA-3.0 <https://creativecommons.org/licenses/by/3.0/>.

8. Summary of the hominin species covering the last five million years and major dispersal events.

Based on figure 4 in Maslin, M.A., Brierley, C.M., Milner, A.M., Shultz, S., Trauth, M.H., and Wilson, K.E. 2014. East African climate pulses and early human evolution. Quaternary Science Reviews, 101: 1–17, CC-BY-SA-3.0 <https://creativecommons.org/licenses/by/3.0>.

9. Illustration of the huge effect the latitudinal location of continents have on the Equator–Pole temperature gradient. The present-day northern and southern hemisphere temperature gradients are given as a comparison.

Based on figure 21 in Maslin, M. 2013. Climate: A Very Short Introduction, Oxford University Press, Oxford, by permission of Oxford University Press.

10. Illustration of the significant alteration of ocean currents with different ocean gateways within longitudinal continents.

Based on figure 23 in Maslin, M. 2013. Climate: A Very Short Introduction, Oxford University Press, Oxford, by permission of Oxford University Press.

11. The effect of changing ocean gateways on the location and intensity of deep ocean circulation.

Based on figure 24 in Maslin, M. 2013. Climate: A Very Short Introduction, Oxford University Press, Oxford, by permission of Oxford University Press.

12. Mountain rain-shadow.

Based on figure 25 in Maslin, M. 2013. Climate: A Very Short Introduction, Oxford University Press, Oxford, by permission of Oxford University Press.

13. The effects of mountains and plateaus on global rainfall.

Based on figure 26 in Maslin, M. 2013. Climate: A Very Short Introduction, Oxford University Press, Oxford, by permission of Oxford University Press.

14. The effects of plateaus and ice sheet on atmospheric circulation.

Based on figure 27 in Maslin, M. 2013. Climate: A Very Short Introduction, Oxford University Press, Oxford, by permission of Oxford University Press.

Copyrighted material

15. Long-term links between tectonics, sea level, climate, biodiversity, and extinctions.
Base on figure 29 in Maslin, M. 2013. Climate: A Very Short Introduction, Oxford University Press, Oxford, by permission of Oxford University Press.

16. Tectonic rifting and ocean formation.

17. Map of plate boundaries at the African Rift Valley triple junction.
Based on 'Map of East Africa', United States Geological Survey <https://en.wikipedia.org/wiki/African_Plate#/media/File:EAfrica.png>. Public Domain.

18. Explanation of horst-graben and half-graben geological formations.

19. Tectonic development of the East African Rift Valley system.
Adapted from figure 3.11 from Lewin, R. and Foley, R.A. © 2004. Principles of Human Evolution, John Wiley & Sons © by Blackwell Science Ltd.

20. Climatic effects of the development of the East African Rift Valley system.
Adapted from figure 3.11 from Lewin, R. and Foley, R.A. © 2004. Principles of Human Evolution, John Wiley & Sons © by Blackwell Science Ltd.

21. Influence of Tibetan uplift and the African Rift Valley on regional atmospheric circulation during Northern Hemisphere summer.

22. Vegetation effects of the development of the East African Rift Valley system.

23. Carbon isotope differences and relative abundance from different types of plants. The difference in carbon isotope signature between $C_3$ plants (mainly trees and shrubs) and $C_4$ plants (mainly tropical grasses) allows the reconstruction of palaeo-diet and thus the dominate vegetation on the landscape.
Based on figure 4 in Maslin, M.A. and Thomas, E. 2003. Balancing the deglacial global carbon budget: The hydrate factor. Quaternary Science Reviews 22(15–17): 1729–36, with permission from Elsevier.

24. Global temperatures through the Cenozoic.
Based on figure 30 in Maslin, M. 2013. Climate: A Very Short Introduction, Oxford University Press, Oxford, by permission of Oxford University Press.

Copyrighted material

25. Ocean gateways both today and during the Cretaceous.
    Based on figure 22 in Mark Maslin, M. 2013. Climate: A Very Short Introduction, Oxford University Press, Oxford, by permission of Oxford University Press.

26. Drying out, salt deposit formation, and reflooding of the Mediterranean Sea approximately 5 million years ago.
    Based on figure 31 in Maslin, M. 2013. Climate: A Very Short Introduction, Oxford University Press, Oxford, by permission of Oxford University Press.

27. Oxygen isotopes showing the step-like changes in global ice volume over the last 5 million years.
    Based on figure 32 in Maslin, M. 2013. Climate: A Very Short Introduction, Oxford University Press, Oxford, by permission of Oxford University Press.

28. Pacific Ocean during El Niño and normal periods.
    Based on figure 16 in Maslin, M. 2013. Climate: A Very Short Introduction, Oxford University Press, Oxford, by permission of Oxford University Press.

29. Orbital eccentricity, tilt, and precession.
    Based on figure 33 in Maslin, M. 2013. Climate: A Very Short Introduction, Oxford University Press, Oxford, by permission of Oxford University Press.

30. Long-term changes in the orbital parameters.

31. Insolation at 65°N compared with global sea level or global ice volume.
    Based on figure 34 in Maslin, M. 2013. Climate: A Very Short Introduction, Oxford University Press, Oxford, by permission of Oxford University Press.

32. East Africa, modern and palaeo lake location map.
    Adapted from original unpublished files for figure 1 in Junginger, A. and Trauth, M.H. 2013. Hydrological constraints of paleo-Lake Suguta in the Northern Kenya Rift during the African Humid Period (15–5 ka BP). *Global and Planetary Change* 111: 174–88, with permission from Elsevier and thanks to the authors.

33. East Africa north–south cross section with major modern and palaeo lakes shown.
    Adapted from original unpublished files for figure 1 in Junginger, A. and Trauth, M.H. 2013. Hydrological constraints of paleo-Lake Suguta in the Northern Kenya Rift during the African Humid Period (15–5 ka BP). *Global and Planetary Change* 111: 174–88, with permission from Elsevier and thanks to the authors.

34. Occurrence of shallow and deep lakes over 5 million years

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compared with the precessional orbital forcing.

Based on figure 6 in Maslin, M.A., Brierley, C.M., Milner, A.M., Shultz, S., Trauth, M.H., and Wilson, K.E. 2014. East African climate pulses and early human evolution. Quaternary Science Reviews, 101: 1–17, CC-BY-SA-3.0 <https://creativecommons.org/licenses/by/3.0>.

35. Age range of different dating methods using in the study of human evolution.

Adapted from figure 2 in Veldhuis, D., Kjærgaard, P.C., and Maslin, M. 2014. Human evolution: theories and progress, in Smith, C. (ed.) Encyclopedia of Global Archaeology, Springer, New York, pp. 3520–32. With permission of Springer.

36. Different modes of potential speciation with and without geographical or niche separation.

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37. Variability selection hypothesis of early human evolution.

Adapted from figure 2 in Potts, R. 1999. Variability selection in hominid evolution. Evolutionary Anthropology, 1999: 81–96. Permission of John Wiley and Sons. Evolutionary Anthropology: Issues, News, and Reviews © Wiley Periodicals, Inc.

38. Pulse climate variability framework.

Adapted from figure 3 in Maslin, M.A., Shultz, S., and Trauth, M. 2015. A synthesis of the theories and concepts of early human evolution. *Philosophical Transactions of the Royal Society B* 370 <http://dx.doi.org/10.1098/rstb.2014.0064>, CC-BY version 4.0 <https://creativecommons.org/licenses/by/4.0/>.

39. Relationship between growth and shrinkage of large lakes in the African Rift Valley. The bifurcation is caused by the evaporation from the lake making the surround region wetter and thus resilient to initial reductions of overall precipitation.

Adapted from figure 4 in Maslin, M.A., Shultz, S., and Trauth, M. 2015. A synthesis of the theories and concepts of early human evolution. *Philosophical Transactions of the Royal Society B* 370 <http://dx.doi.org/10.1098/rstb.2014.0064>, CC-BY version 4.0 <https://creativecommons.org/licenses/

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40. An interpretation of how the turnover pulse hypothesis could be placed within the pulsed climate variability framework.

Adapted from figure 5 in Maslin, M.A., Shultz, S., and Trauth, M. 2015. A synthesis of the theories and concepts of early human evolution. *Philosophical Transactions of the Royal Society B* 370 <http://dx.doi.org/10.1098/rstb.2014.0064>, CC-BY version 4.0 <https://creativecommons.org/licenses/by/4.0/>.

41. An interpretation of how the aridity hypothesis could be placed within the pulsed climate variability framework.

Adapted from figure 6 in Maslin, M.A., Shultz, S., and Trauth, M. 2015. A synthesis of the theories and concepts of early human evolution. *Philosophical Transactions of the Royal Society B* 370 <http://dx.doi.org/10.1098/rstb.2014.0064>, CC-BY version 4.0 <https://creativecommons.org/licenses/by/4.0/>.

42. An interpretation of how the allopatric speciation hypothesis could be placed within the pulsed climate variability framework.

Adapted from figure 9 in Maslin, M.A., Shultz, S., and Trauth, M. 2015. A synthesis of the theories and concepts of early human evolution. *Philosophical Transactions of the Royal Society B* 370 <http://dx.doi.org/10.1098/rstb.2014.0064>, CC-BY version 4.0 <https://creativecommons.org/licenses/by/4.0/>.

43. Estimated community size of different hominin species over the last four million years. Community size is estimated from converting cranial volumes to neocortex ratios which have a strong relation to group size in primates.

Based on figure 3.3 in Dunbar, R. 2014. Human Evolution: A Pelican Introduction, Penguin, London, p. 74. Reproduced by permission of Penguin Books Ltd.

44. Robin Dunbar’s circles of human relationships.

Adapted from original image by Robin Dunbar, with permission.

45. A ‘Midwife’s’ view of the birth canal in a chimpanzee, *A. afarensis*, and a modern human.

Based on figure 2a in Gruss, L.T. and Schmitt, D. 2015. The evolution of the human pelvis: changing adaptations to bipedalism, obstetrics and thermoregulation. Philosophical Transactions of the Royal Society B 370:

Copyrighted material

1663, adapted from Rosenberg, K. and Trevathan, W. 2002. Birth, obstetrics and human evolution. *BJOG* 109: 1199–206 (doi:10.1046/j.1471-0528.2002.00010.x) and Tague, R.G. and Lovejoy, O. 1986. The obstetric pelvis of A.L. 288–1 (Lucy). *Journal of Human Evolution* 15: 237–55 (doi:10.1016/S0047-2484(86)80052-5). With permission from The Royal Society.

46. Expensive brain hypothesis.

Adapted from figure 2 in Maslin, M.A., Shultz, S., and Trauth, M. 2015. A synthesis of the theories and concepts of early human evolution. *Philosophical Transactions of the Royal Society B* 370 <http://dx.doi.org/10.1098/rstb.2014.0064>, CC-BY version 4.0 <https://creativecommons.org/licenses/by/4.0/>.

47. Comparison of the great apes and humans relative body size and sexual organs.

Based on ‘Males, as females see them’, and ‘Females, as males see them’, in Diamond, J. 1992. The Rise and Fall of the Third Chimpanzee, Vintage, London, pp. 60–1. Created using data from table 3.3 in Dixson, A.F. 2012. Primate Sexuality, 2nd edition, Oxford University Press, Oxford (based on data from Harvey, P.H., Martin, R.D., and Clutton-Brock, T.H. 1987. Life histories in comparative perspective, in Smuts et al., (eds) Primate Societies, University of Chicago Press, Chicago pp. 181–96) and table 9.3. With permission from Oxford University Press.

48. Comparison of *Homo sapiens* skull morphology showing feminization that has occurred since the Middle Stone Age.

Based on unpublished diagrams by Robert L. Cieri, with permission.

49. Dispersal of *H. erectus, H. Neanderthalensis*, and *H. sapiens*.

Based on <https://en.wikipedia.org/wiki/Early_human_migrations> CC BY-SA 3.0 with additional data from Liu, W. et al. 2015. The earliest unequivocally modern humans in southern China. *Nature* 526: 696–9.

50. Relationship between *Homo sapiens* and *Homo erectus* reconstructed by Chris Stringer, based on the evidence we currently have from fossils and genetics.

Based on diagrams by Chris Stringer, with permission.

51. A history of interbreeding between early modern humans, Denisovans, and Neanderthals.

Figure 1 reprinted by permission from Macmillan Publishers Ltd: Callaway, E. Evidence mounts for interbreeding bonanza in ancient human species. Nature [website] 17 February 2016 <http://www.nature.com/news/evidence-mounts-for-interbreeding-bonanza-in-ancient-human-species-

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1.19394>.

## 52. Mass extinctions, land-use changes, and rising atmospheric greenhouse gas levels over the last 50,000 years.

Adapted from figure 1 in Lewis, S.L. and Maslin, M.A. 2015. A transparent framework for defining the Anthropocene Epoch. *The Anthropocene Review* 2(2): 128–46, doi: 10.1177/2053019615588792, which in turn was adapted, expanded, and scaled appropriately from Ruddiman, W.F., Ellis, E.C., Kaplan, J.O., and Fuller, D.Q. 2015. Defining the epoch we live in. *Science* 348: 38–9.

## 53. Shipping routes plotted from eighteenth- and nineteenth-century logs.

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# 1

# Introduction

Humans are rather weak when compared with many other animals. We are not particular fast and have no natural weapons. But we have become the world's apex predator and have taken over the planet. We *Homo sapiens* currently number nearly 7.5 billion and are set to rise to nearly 10 billion by the middle of this century. We have influenced almost every part of the Earth system and as a consequence are changing the global environmental and evolutionary trajectory of the Earth. We are also both inadvertently and on purpose changing our own evolution. Fundamental to our success is that we are very smart, both individually but more importantly collectively. But why did evolution favour the brainy ape? Because let face it there are lots of drawbacks to having a large brain. First every child tries to kill their mother, as it is difficult and dangerous to giving birth to offspring with such a large head. Second you need a large amount of food in order to keep the organ running, as big brains are energetically expensive. Third it frequently goes wrong. So the large brain must have given our ancestors a major advantage.

This book pieces together the evidence for human evolution by focusing on the major evolutionary changes that occurred in Africa that led our ancestors to walk upright and then to become progressively smarter. Without the unique combination of tectonics, global and local environmental changes, and celestial mechanics human evolution would never have occurred. In this introductory chapter I briefly review the origin of our planet to put our evolution in the context of all evolution on Earth. I then set out the ten

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transitions that have occurred on the way to humans becoming the new geological superpower. What I hope this book will show is that this human ascendancy was not inevitable but caused but a unique combination of factors. As the great evolutionary theorist Stephen J. Gould suggested, if we reran the tape of evolution again and again the chances of humans evolving is zero.

## In the beginning

To comprehend human existence and how we got here I believe we need to put our evolution into context. To do this we need to understand the origins of our planet and how life has evolved. So let us start right at the beginning of everything. The Universe, according to cosmologists, is 13.8 billion years old. It all started with the Big Bang, when all the matter in the Universe was created and blasted outwards. About 100,000 years after the creation of matter, its expansion allowed it to cool, so that negatively charged electrons were trapped by positively charged protons forming hydrogen gas. At this point there were no galaxies, no stars, no planets, and no life—only an expanding cloud of gas. Over time, this irregular cloud started to form clumps of matter. Gravity pulled on the gases within these clumps to form galaxies. Gravity within each galaxy pulled matter together to form billions and billions of stars.

Deep within each star the immense pressure resulting from gravity forces the hydrogen atoms to collide. These collisions occasionally lead to the creation of helium through the fusion of two hydrogen atoms and results in a huge release of energy. Stars thus burn hydrogen through nuclear fusion. As a star’s fuel is converted from hydrogen to helium, the helium starts to collide and its fusion creates carbon and oxygen. The carbon then burns to create oxygen, neon, sodium, and magnesium. This nuclear fusion or ‘cooking’ continues through the elements up to and including iron. These lighter elements are the main ones found in rocky planets and are often called the planet builders. Elements heavier than iron can only be created by neutron capture that involves adding energy. This only occurs in the ejecta of massive star, ten to twenty-five times the size of the Sun, when they finally explode. Large stars that have massive gravitational force have the most intense nuclear fires and are extremely bright but relatively short-lived. These stars produce all the elements and distribute them throughout galaxies through supernova explosions at the end of their cosmically short life. So we are all made of stardust. Though

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these massive stars create the building blocks for planets and life they themselves are not suitable for forming a habitable solar system. Smaller stars, like our Sun, have a smaller gravitational pressure and thus cook their hydrogen at a much slower rate and provide a more stable long-term environment to allow solar systems to develop. Our own Sun has already existed for 4.6 billion years, in 5 billion years time it will expand forming a Red Giant, and will continue expanding until it runs out of fuel in about 7.5 billion years time.

Our Solar System formed 4.568 billion years ago from the gravitational collapse of a giant interstellar gas cloud. The vast majority of the system's mass is in the Sun, with most of the remaining mass contained in Jupiter. There are four smaller inner or terrestrial planets—Mercury, Venus, Earth, and Mars. The four outer planets are giant planets. Then there is the asteroid belt, made up of numerous irregular shaped bodies and minor planets. The total mass of the asteroid belt is about 4 per cent that of the Moon, of which half is made up by the four largest asteroids. The two largest planets, Jupiter and Saturn, are gas giants, and are composed mainly of hydrogen and helium. It is the position and mass of Jupiter that has helped to create our relatively stable Solar System. It also influences the changing shape of the Earth's orbit around the Sun, and this has a profound effect on the Earth's climate. The two outermost planets, Uranus and Neptune, are ice giants, and are made of water, ammonia, and methane. Further out are rocky fragments, one of which is Pluto, which to my youngest daughter's dismay has been downgraded to a 'dwarf planet' or planetoid.

Central to the stability of the Earth is the Moon. The Moon formed about 4.53 billion years ago, some 30–50 million years after the origin of the Solar System. The prevailing hypothesis is that the Earth–Moon system formed as a result of a giant impact. A Mars-sized planet, which has been named Theia, hit the proto-Earth, increasing the mass of the Earth while blasting material into orbit around the proto-Earth, which accreted to form the Moon. The Moon is thus made of the lighter elements found in the surface of the proto-Earth. So the Moon does not have a metal core and its density is lighter than Earth's. The Moon acts as the Earth's gyroscope, so its axis of rotation in relation to the Sun has remained very similar for the last 4.5 billion years. As we will see later, the small wobbles of the axis of the rotation are enough to push the Earth into and out of the 'great ice ages'. About 100 million years after the formation of the Solar System the Earth degassed, creating an early atmosphere of nitrogen and carbon

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dioxide as well as significant amounts of water. The Earth overall has very low amounts of the essential volatiles such as water, carbon dioxide, and methane, which are essential for life. Only one molecule in 3 million on Earth is water, but through these early processes they have been concentrated at the surface. At about 4 billion years ago we have the first evidence of rock formation on Earth (Figure 1). Then, at about 3.5 billion years, we have the first evidence of life on Earth—and that is where our story really begins.

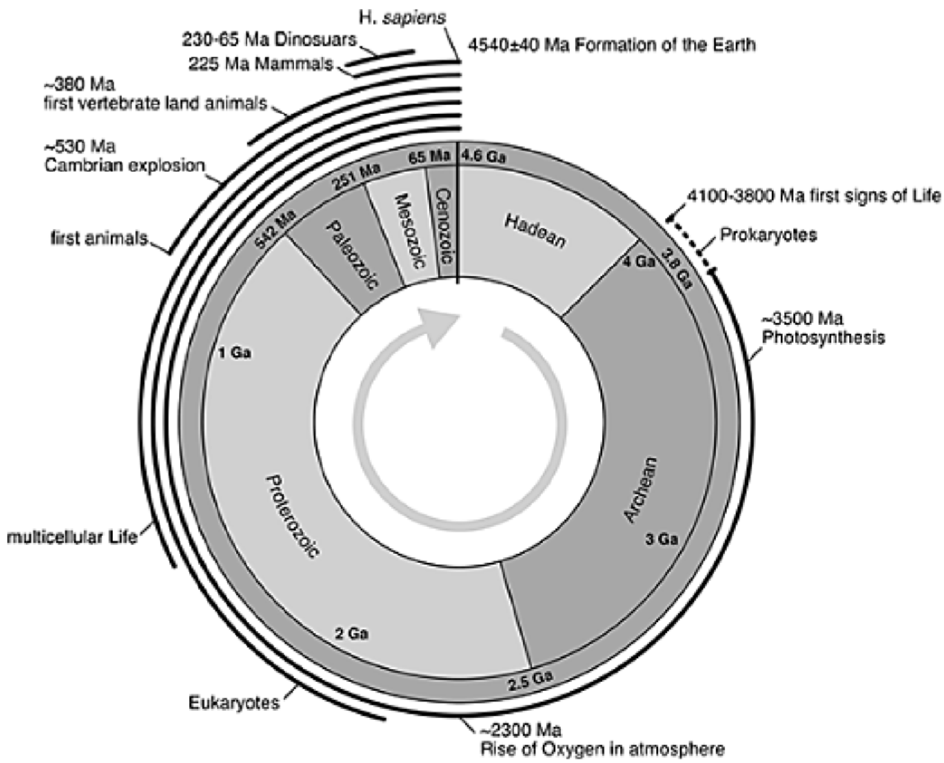


**FIGURE 1** Major biological events in the 4.6 billion years history of the Earth.

## Ten key steps in human evolution

The essential requirements to form a habitable planet seem to be a small long-lived star, a stable Solar System, and a planet at the right distance from the star so it is not too hot and not too cold and which also has enough water and carbon at the surface to support life. Once these elements were established then I think there are ten key transitions that occurred that inadvertently ended up with humans populating and dominating the whole planet. I summarize

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these below, and we will examine a number of them in more detail later.

### 1. *Origin of life*

Fossil evidence for life can be found as far back as 3.46 billion years ago in the form of preserved cellular structures in the Strelley Pool Formation in Western Australia. These are thought to be created by 'single-celled' bacterial communities that formed stromatolites and are still found today in the warm shallow seas in Shark Bay, Australia. Little seems to have happened during the following so-called 'boring' billion years until about 2.4 billion years ago, when a significant rise in atmospheric oxygen known as the Great Oxidation Event is recorded in the rocks. Until then, only simple, 'prokaryotic' organisms existed on Earth. The more complex 'eukaryotic' cells, with nuclei and other internal structures, emerged between 2.1 and 1.6 billion years ago from the merger of two types of prokaryotes, and these are the basis of almost all multicellular organisms.

### 2. *Origin of complex life*

The origin of animals is currently uncertain, but simple animals had probably evolved by about 600 million years ago. However, most of what were to become the major animal phyla we know today appear to have arisen during a period of rapid diversification known as the Cambrian Explosion, which began about 541 million years ago, the start of what is known as the Phanerozoic Eon, and lasted for over 40 million years. Some of the extraordinary forms that existed at this time are captured in the remarkably preserved fossil assemblages of the Burgess Shale (Rocky Mountains, Canada) and Chengjiang (Yunnan Province, China). This melting pot of evolution included one branch—the vertebrates—that evolved a backbone, and it is from these that we are descended.

### 3. *Evolution of mammals*

The unique features of mammals are milk-producing mammary glands in females, fur or hair, three bones in the inner ear which evolved from the reptilian jaw, and a neocortex (Figure 2). The neocortex is a region of the brain that controls higher functions such as sensory perception, generation of motor commands, spatial reasoning, and, in humans, conscious thought and language. The earliest mammals are thought to have emerged from mammal-like reptiles before the end of the Triassic Period, by about 225 million years ago.

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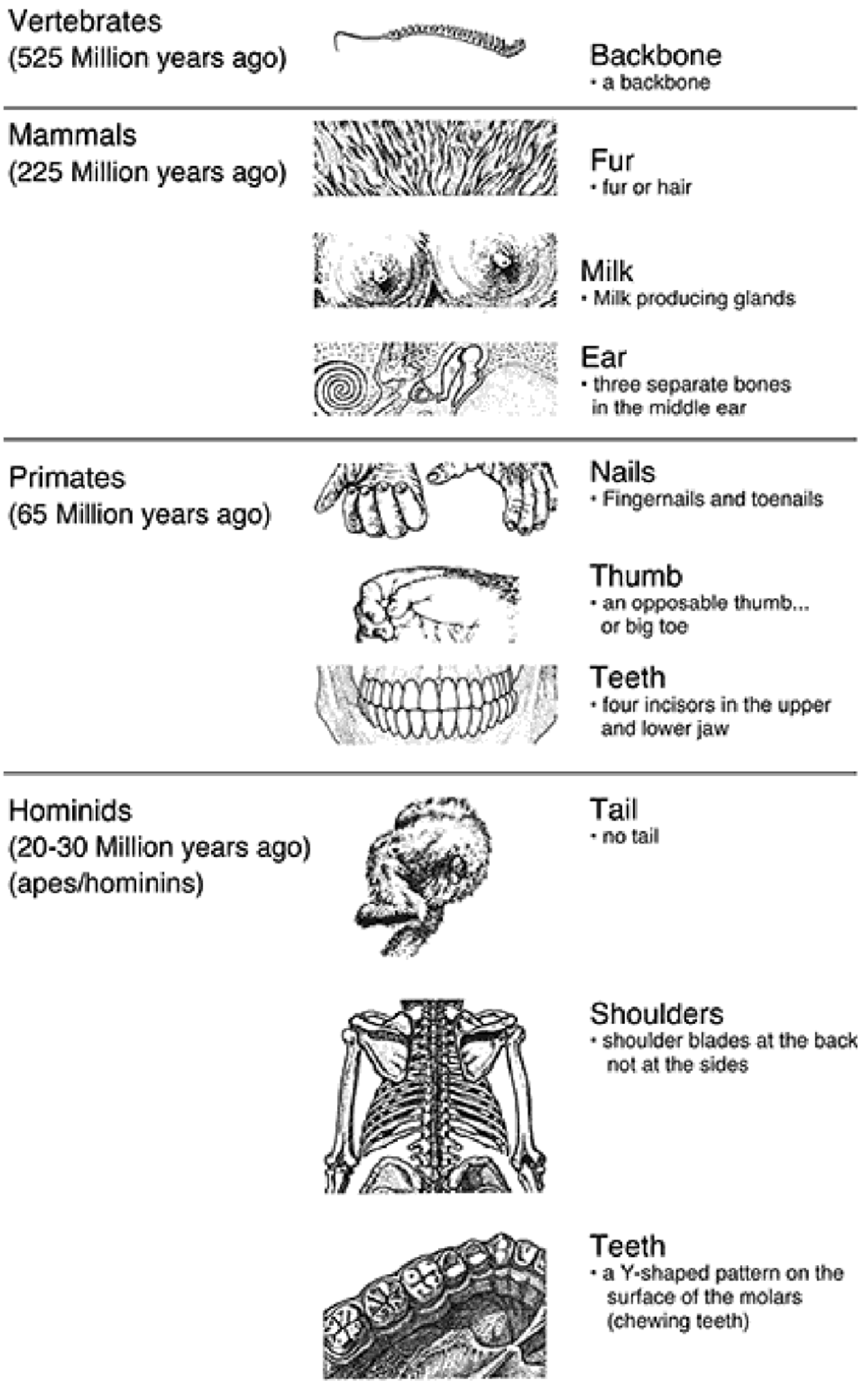


**FIGURE 2** Key morphological features that define hominids.

## 4. *Extinction of the dinosaurs*

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There have been several mass extinctions in Earth history, the most extreme of which was at the end of the Permian some 250 million years ago, which destroyed most of life on land and in the oceans. This has been referred to as the ‘mother of all extinctions’, but somehow life managed to survive and then diversify after this close call. The mass extinction most directly relevant to our story however is the Cretaceous–Tertiary extinction also called the ‘KT’ extinction for short. Around 66 million years ago, a major period of volcanism resulting in massive outpourings of lava, resulting in the Deccan Traps in India, compounded by the Chicxulub meteorite impact event in Central America, caused a mass extinction that killed off many species, including the non-avian dinosaurs. This extinction event was essential in the story of human evolution as it ended the 170 million-year domination of dinosaurs and allowed the evolution and proliferation of mammals, and the appearance of the first ancestors of primates.

## 5. *Evolution of social primates*

Ten million years after the extinction of the dinosaurs, during a period of super-global warming, the first fossil evidence for true primates and social monkeys begins to appear. Anthropoids or simians, a group that includes primates and monkeys (Table 1), began to live in larger groups, which meant that each animal had to negotiate complex webs of friendships, hierarchies, and rivalries. This is thought to have been a major driver of brain expansion later, in hominins.

**TABLE 1.** Common terminology used in human evolution and in this book

| | |
|---|---|
| **Anthropoids** | All primates (monkeys and great apes and their fossil ancestors), hominins, and humans |
| **Hominids** | All great apes (gorillas, orangutans, chimpanzees, bonobos, gibbons), hominins, and humans |
| **Hominins** | All our fossil ancestors (*Ardipithecus, Australopithecus, Homo*) |
| **Anatomically modern humans** | *Homo sapiens*, but without substantial evidence for our cultural accoutrements (art, burials, ornament, musical instruments) |
| **Humans** | Only modern humans, *Homo sapiens*, with clear evidence of cumulative culture |

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## 6. *Evolution of hominins*

The exact origins of hominins is disputed. However, the last common ancestor with chimpanzees is thought to have lived between 8 and 5 million years ago. Despite the relatively miniscule genetic difference between modern humans and chimpanzees, our evolutionary paths have been radically different since the split.

## 7. *Bipedalism*

Between 10 and 5 million years ago, hominins developed the ability to move efficiently on two legs. At the same time chimpanzees and gorillas became better at tree-climbing and developed knuckle-walking while on the ground. Bipedalism allowed our ancestors to spread out from East Africa into Northern and Southern Africa. Some of these bipedal hominins were already using stone tools by at least 3.3 million years ago.

## 8. *Brain expansion*

About 2 million years ago new hominin species appeared with brains up to 80 per cent larger than their ancestors, and for the first time they dispersed out of Africa. This large brain was accompanied by other sweeping changes to life history (shortened intervals between births, delayed child development), body size, the shape of the pelvis, and a shoulder morphology which allowed projectile use. These species show adaptations to long-distance running, ecological flexibility, and social behaviour, including food processing.

## 9. *Cumulative culture*

*Homo sapiens* emerged about 200,000 years ago in East Africa and dispersed into Eurasia. It is not until 100,000 years ago that there is evidence of creative thinking. From 50,000 years ago this becomes more consistent, with evidence of art, ornaments, and symbolic behaviour. These steadily increase in complexity and frequency and demonstrate that knowledge was being generated and passed on to the next generation. Culture was being accumulated and grew with every generation.

## 10. *Agriculture and industrial revolutions*

At the end of the last ice age, about 11,000 years ago, agriculture first appeared in South West Asia, South America, and northern China. It then appeared 6,000–7,000 years ago in southern China

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