The Emergence of Humans

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An Exploration of the Evolutionary Timeline

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Preface

Discoveries of fossils of our human ancestors have always been able to generate press and public interest and that interest has, if anything, increased in the early years of the twenty-first century. Human fossils are big news and those who discover them can acquire big reputations. Contrary to what we might expect, new discoveries are not filling in gaps in a well worked out history of the rise of humans. Some of the most recent discoveries have substantially changed the picture of our evolutionary past, a picture that we thought was becoming clearer. The discovery in 2003 of a possible new species of human from Flores in Indonesia, that was living as recently as 18 000 years ago looks set to alter many of our assumptions about the evolution of the human species. Not surprisingly, the discovery is controversial and it is interesting to see how the discovery of a new fossil often brings argument and dissent in its wake. The study of human fossils can often seem a more disputatious scientific discipline than most of the others, but in part this is because there is so much interest in the subject amongst non-specialists that the legitimate argument and debate that takes place in science is carried out in a more public arena. With a fossil record that is so sparse, firm answers to questions are often impossible and what evidence there is can be interpreted in different ways. This book is an introduction to the scientific study of human evolution.

We intend this book for undergraduate students who are studying human evolution as part of a Natural Sciences degree, or who might subsequently decide to specialize in Anthropology. We do not cover all the background information that would be needed for an Anthropology course, as our primary concern is to illuminate the *evolution* of human species. The book is based on an undergraduate course we have designed and taught, a course with a target

audience of first or second year equivalent undergraduates with some previous knowledge of biology. To help students with a limited biological background, we have included some basic information about evolution, genes and inheritance. Some detailed anatomical information is included in the book, but for more comprehensive information, reference to specialized Anthropology works would be necessary.

There are lots of instances recounted in this book where more than one interpretation of the evidence is possible. We have tried to steer an objective path through the conflicts and do justice to different views. For example, the number of known species of human is debated in the scientific literature, with the extreme ends of the distribution being 25 species and 4. Students need to be aware of the debate and the scale of the resulting uncertainty, but won't find in this book a definitive statement of what we believe to be the 'right' number. Inevitably in a few cases we have had to follow a particular view but have given our reasons for so doing.

We will travel along the timeline of human evolution, starting with the first primates. Then, from the point where the ancestral line leading to humans diverged from the chimp line, we shall follow the evolutionary history of humans up to the point where all other species had died out and only one species remained. In doing so, we hope to highlight some of the areas of uncertainty and show why such uncertainty exists.

About the structure of this book

This book is designed to be both used as a textbook by students in a taught course and to be studied by distance learners in courses where the book is the core of their learning. We have defined a set of learning outcomes for the

book and offer questions both in the text and at the end of chapters. The questions within the text provide an opportunity for students to pause and self-test their understanding. The questions at the end of the chapters are linked to the learning outcomes and enable students to test for themselves whether they are making progress in meeting particular outcomes.

Key references for each chapter are indicated by superscript numbers in the text and are listed in the further reading at the end of each chapter. These will enable students to follow up particular subjects dealt with in that chapter and include publications up to April 2009, when this text was completed. For ease of study, we have only included key citations within the text.

There are many techniques drawn from other disciplines that are available to those studying human evolution. Molecular biology, physics and genetics have all proved to have application in this field and an understanding of some techniques is necessary in understanding how evidence is obtained. Techniques are not covered in a separate section: rather each is introduced at the point in the text where it is first needed. For a comprehensive coverage of techniques students would need to refer to a more detailed text.

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Learning outcomes and key skills for the book

A Knowledge and understanding:	A1 Understand modern evolutionary theory and simple genetics, and use your knowledge to describe the emergence of humans. A2 Gain an overview of the evidence used for the interpretation of human evolution. A3 Interpret new evidence and intercalate it with established

	lines of evidence. A4 Recognize, and describe, the evolutionary significance of named fossils.
B Cognitive skills:	B1 Evaluate and use evidence, including data, to support theories and arguments. B2 Attempt to classify an appropriate range of Pleistocene hominins on the basis of similarities and differences. B3 Distinguish between a causal and a correlational relationship e.g. between assemblages of fossil hominin bones, animal bones and stone tools, which may be the result of taphonomy rather than hominin activity. B4 Interpret and draw evolutionary trees for primates. B5 Understand the use of models based on social structure of living primates for suggesting social structures for extinct hominins.
C Key skills :	C1 Monitor and check own progress using self assessment. C2 Identify a line of reasoning and main points of an argument and recognize opinion and bias. C3 Collate, summarize and interpret text and images from web resources. C4 Communicate using written material, tables, charts and diagrams.

Acknowledgements

This book was conceived after preparing a course at The Open University and we would particularly like to thank people involved with the course, especially Brian Richardson and Tracey Carlton. Our special thanks go to Becky Efthimiou (Life Sciences) who has provided administrative support at all the production stages. We are grateful to the University for permission to use drawn artwork from other courses.

In addition to the Open University collection of casts of key specimens, we have had access to casts in the Nottingham University collection and for this we are extremely grateful to Peter Davies who originally assembled the collection and Peter Whitworth for technical help. Sue Scarborough, also at Nottingham University, gave a lot of helpful advice to us in the early stages.

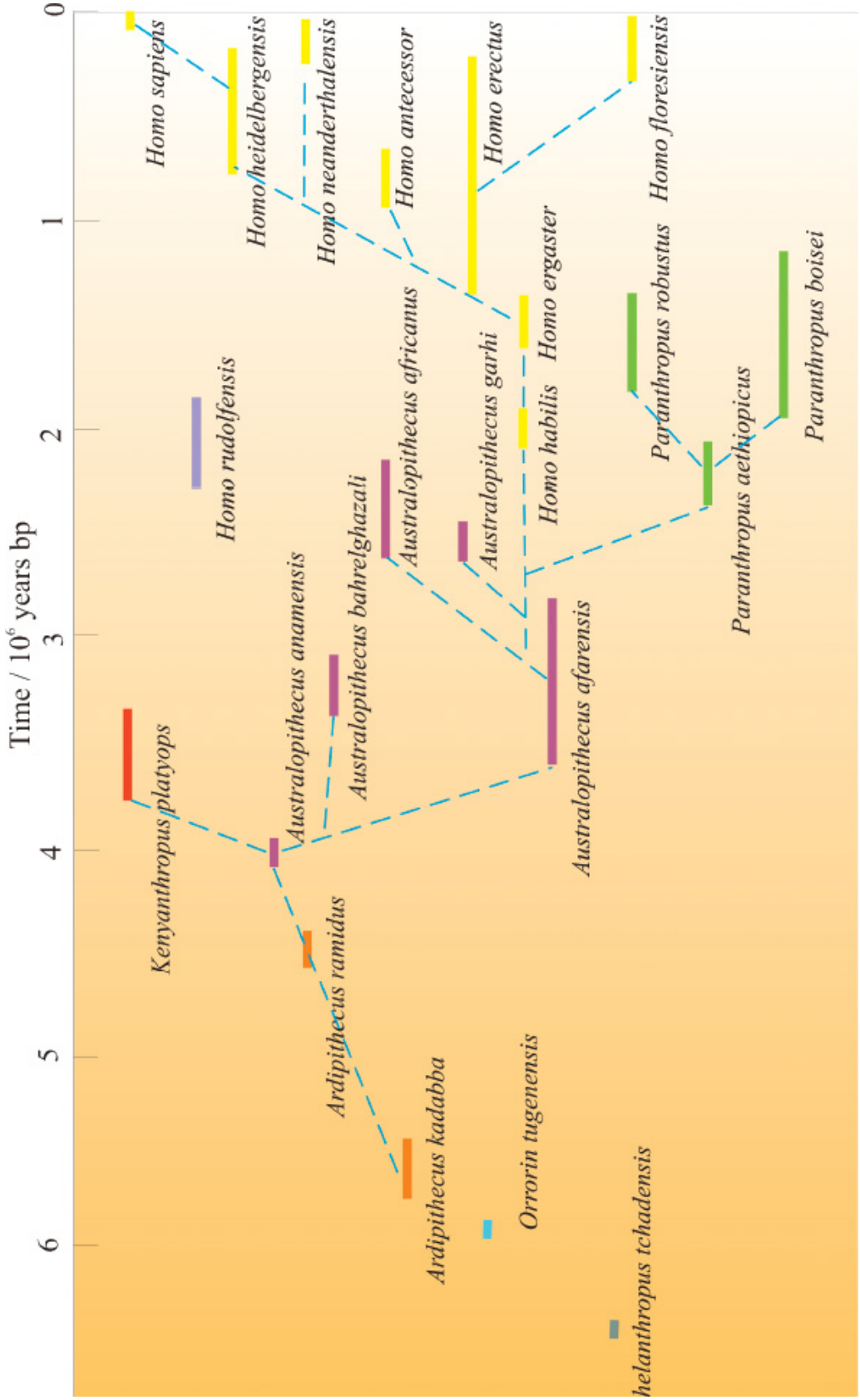
We would like to thank Richard Jurd (University of Essex) for reviewing and commenting on the first drafts and providing so many constructive comments. Erik Sieffert (University of Oxford and University Oxford Museum of Natural History) provided very detailed and invaluable comments, particularly on the Chapters on Primate and anthropoid origins and we are very grateful to him.

Special thanks are due to our patient editors at Wiley, Celia Carden, Robert Hambrook and especially Nicky McGirr who encouraged us to develop the book in the first place and has been so supportive during the writing, reviewing and production stages.

This book was started while one of us (DJR) was a visiting professor in the Centre for the Studies of Higher Education at Nagoya University as a guest of Professor Terumasa Ikeda.

Finally we both owe a huge debt to Peter Davies for his continuing support, advice and intellectual stimulation over

many years.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Homo floresiensis
Homo rudolfensis
Homo habilis
Homo ergaster
Paranthropus robustus
Paranthropus aethiopicus
Paranthropus boisei
Kenyanthropus platyops
Australopithecus anamensis
Australopithecus bahrelghazali
Australopithecus africanus
Australopithecus garhi
Australopithecus afarensis
Ardipithecus ramidus
Ardipithecus kadabba
Orrorin tugenensis
helanthropus tchadensis

Introduction to the Emergence of Humans

We are eminently curious and for some the biggest question in the world is – who are we and where did we come from. For many of us our ancestry is an ongoing fascination and perhaps there are very few of us who, if given the opportunity to learn more about our past, would profess no interest at all. We are the only animal, as far as we are aware, that can contemplate its own past. Why we should have this interest, and in some cases an overwhelming passion, for finding our ancestors and filling in our evolutionary tree, is not clear. Maybe we can feel more secure about our place in nature if we know how we reached it. What is clear, particularly from recent research, is that our place is not quite what we thought it was. There have been other human species in existence, some of them our recent contemporaries. We share a lot of our biology with our closest living relatives, the great apes, but recently with the completion of the mapping of the human genome we seem to be closer to them. Comparison of the chimp and human genome shows that there is an average substitution level of about 1.2% in single copy DNA, so the short-hand statement that we are 99% chimp isn't too far from the truth, at least as far as the base structure of our genome is concerned. However, other genetic differences between humans and chimps, for example in the number of copies of genes, are greater than 1%. The short-hand statement is sometimes rendered as '99% ape', but this is not really correct as we should be grouped with the apes ourselves, rather than placed in some special position in the evolutionary tree. In the past there were several species of human but now there is only one. There were many species of ape in the past too, but most are extinct and the outlook for the future of the remaining species is not good. Maybe

the human species will at some time in the future be the last ape?

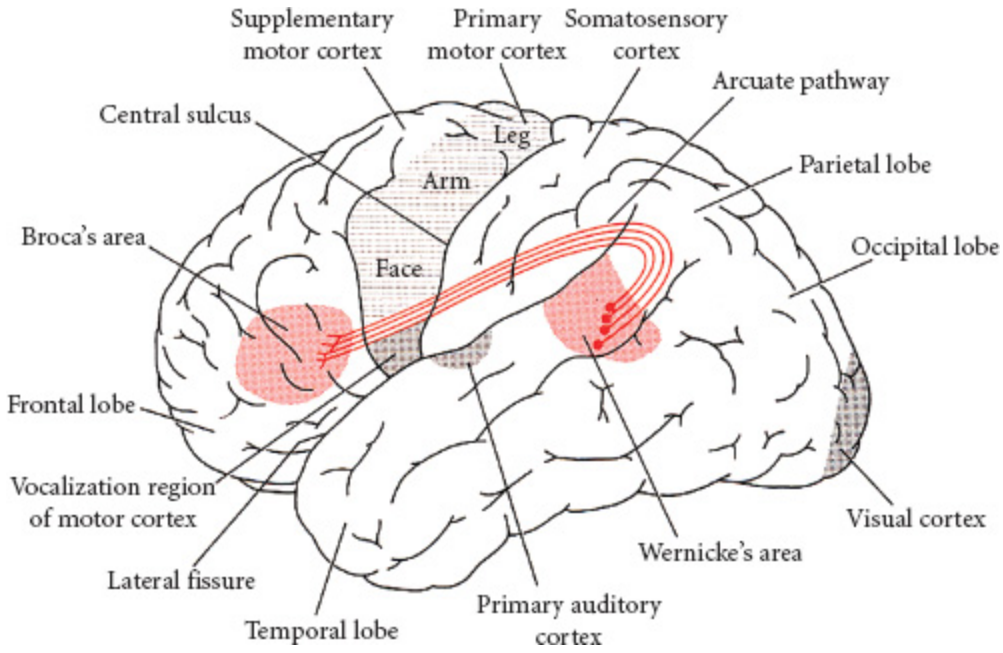
What is it that defines a human? It is likely that we would all feel able to answer that question to some degree by referring to our behaviour, our social structure, our intellectual capacity or our brains. Probably we would select the size of our brain as perhaps the defining feature. Maybe we would also add habitual bipedal locomotion, although it is becoming apparent that it isn't exclusively a human trait (see discussion of *Oreopithecus* in Section 5.5). Certainly there are a lot of aspects of our behaviour which do not seem to be unique to us, we share some basic features of our social structure with apes and our brain is similar to those of some primates, though larger at 1500 g – 2.1% of body mass. However, on its own, the size of the brain does not equate with, for example, intelligence. The elephant has a brain mass of around five times that of a human (7500 g), but of course has a larger body mass. As far as we can tell, it is not five times as intelligent as humans. Mice have a brain mass of 0.4 g but that equates to 3.2% of body mass, a greater proportion than in humans. So neither absolute nor relative mass is a good guide and although the human brain is larger, by volume, than a chimp brain, the brain of an extinct human species, *Homo neanderthalensis*, is 11% larger than ours.

We recognize that cognitive capacities in humans are much greater than in other animals and that this provides a clear distinction between us and our closest relatives, the other living great apes. Is this difference in capacity something that can be correlated with the comparative anatomy of the brains? Cognitive functions such as planning and organization are located in the frontal cortex of the brain and so we might expect that this area would be more highly developed in humans than in apes. In fact, this is not the case and both humans and apes share a large frontal

cortex, though one that is larger than that of gibbons or macaques. So if the difference does not lie in the cortex, could it be that another unique feature of humans, the production and recognition of speech, is reflected in the structure of the brain?

Two areas of the brain are associated with communication, **Broca's area** and **Wernicke's area** (Figure 0.1). Broca's area is associated with language and part of Wernicke's area, the **planum temporale**, with audible and visual communication. Although both hemispheres of the brain have these two areas, the size of each is asymmetrical with the left being larger than the right. When the homologous area has been examined in chimps, gorillas and bonobos using **MRI** (Magnetic Resonance Imaging) scans this same asymmetry is present. The asymmetry of the planum temporale is also present in chimps. So again, anatomical features of the human brain that might under-pin human distinctiveness are also present in at least some of the great apes.

Figure 0.1 The position of Broca's and Wernicke's areas in the human brain.
Source: Biology Brain and Behaviour Book 2. © The Open University.



Clearly there must be differences between the chimp and human brain, which studies in neuroanatomy and neurophysiology will eventually elucidate, but already it seems apparent that the greater cognitive capacities in humans result from changes within specialized areas rather than new and distinct areas of the brain.

There is a picture of human evolution that was clearly in the minds of earlier anthropologists and still persists in some minds today, despite the huge body of evidence to the contrary. That picture is of a species, *Homo sapiens*, that is the terminal member of a straight line heading back through time to an ape that represents our last link to other animals. The picture has within it some assumptions. The line from apes to humans is seen as a progression or advance. Since it is a linear progression, there has been a smooth transition between one evolutionary stage and the next and, behind this assumption, is the implication that there has only been one species of human around at any one time in that progression. This assumption also leads to the idea that humans occupy a special position in the natural world, distinct from all other animals. Using the word

progression implies that evolution has direction, moving towards a better or more complex state. However, evolution has not resulted in organisms becoming universally more complex. Taken as a whole, the biosphere has not become more and more advanced and complicated. The only way in which evolution can be perceived as having direction is in the fact that time has a direction. There is also an illusion of direction because evolution can build only on what already exists. So it might appear that evolution is a process of gradual improvement. Actually, since the pressures on an organism exerted by natural selection can change or even reverse with time, for example as climate changes, an apparent improvement might become detrimental subsequently. The important point to understand is that evolution has no goals and so an older idea that primate evolution was somehow preparing the way for the appearance of humans is incorrect. Although we have imposed a linear element on the story of human evolution by following a timeline, and hence also a line that follows climatic changes, the evolutionary tree of humans is a bushy one rather than a linear one, with a number of side branches.

1

The First Human Fossils

Just over 150 years ago there were no recognized fossils of ancestral human species and human remains that had been discovered were all attributed to our own species. When, in 1823, geologist and clergyman the Reverend William Buckland described the post-cranial skeleton of an anatomically modern, but undoubtedly ancient, human from Goat's Hole at Paviland on the Welsh Coast of the United Kingdom, it was possibly the first, and certainly the earliest, human fossil known at that time. That Buckland did not recognize it as such, preferring to believe that the skeleton was an intrusion into earlier, antediluvian deposits, was a reasonable conclusion when set against the intellectual background of the time.

Box 1.1 The Paviland find

Paviland cave is on the Gower Coast of Wales. On 27 and 28 December 1822 the tusk and part of the skull of an elephant were excavated from the cave by two local amateur geologists and a landowner. They also excavated many small bones and informed William Buckland, Professor of Geology at Oxford, of their finds. He visited the cave on 21 January 1823 and discovered parts of a human skeleton, together with some ivory rods and fragments of worked ivory. Worked flints were also found. The bones and the ivory were reddened by ochre. The skeleton became known as the Red Lady, although subsequently it was shown to be the skeleton of a male. Although Buckland was not inclined to regard the skeleton as dating to before the flood, it was associated with the bones of extinct mammals. Subsequent dating of the skeleton suggests an age of 24 000 years.

Worked flints and stones were well known before the nineteenth century and were recognized as being associated with human activities. However, during the first half of that century interest in the age of the tools was increasing. John Frere, a member of the Society of Antiquaries, is generally regarded as the first person to publish a description of tools with the conclusion that they came from a period much earlier than a time when humans were thought to have existed. This conclusion was based on the fact that worked flints that he found in a quarry at Hoxne in Suffolk were in an undisturbed layer of gravel below, and thus older, than some marine shells and bones of extinct mammals. In his letter to the Society in 1797, Frere wrote:

> The flints were evidently weapons of war, fabricated and used by a people who had not the use of metals. They lay in great numbers at the depth of about 12 feet in a stratified soil which was dug into for the purpose of raising clay for bricks. Under a foot and a half of vegetable earth was clay 7½; feet thick, and beneath this one foot of sand with shells, and under this 2 feet of gravel, in which the shaped flints were found generally at the rate of 5 or 6 in a square yard. In the sandy beds with shells were found the jawbone and teeth of an enormous unknown animal. The manner in which the flint weapons lay would lead to the persuasion that it was a place of their manufacture, and not of their accidental deposit (Lyell, 1863).

Further discoveries of tools were made, notably in the Somme Valley from 1841 by M. Boucher de Perthes, who described them as ‘antediluvian’ on the basis of the undisturbed strata that they came from being below some alluvial deposits which had been regarded as derived from the great flood. Bones from extinct mammals were also present. Following a visit by Charles Lyell and Joseph Prestwich to Abbeville and Amiens in 1859, they published

more information about the finds and their geological position and Lyell dealt extensively with the subject in his 1863 book, *The Antiquity of Man*. So by the time that Darwin's *On the Origin of Species* was published over 50 years of work on stone tools had shown the age of the human line to be much greater than had previously been thought. Against this background, human fossils could be set in context.

One of the first specimens of a human species other than *Homo sapiens* to be found was not recognized as such for several years. On 3 March 1848 Lieutenant Edmund Flint presented a skull to the Gibraltar Scientific Society. It had been exposed by an explosion during blasting at the Forbes Quarry in Gibraltar. Looking at it now (Figure 1.1) it is clear that it is a different species, but that is the advantage of hind-sight. At the time there was no expectation that other species of humans had existed and for the next 16 years it remained in obscurity.

In 1856 workmen at a lime quarry in the Neander valley on the river Düssel in Germany discovered part of a skull (Figure 1.2), and bones from the post-cranial skeleton of an unusual looking human. They showed the bones to an amateur naturalist who recognized them as a significant find and showed the bones to an anatomist. They jointly described the find the following year and concluded that the skeletal remains were of an individual of an ancient human race that was different from modern humans. This was a controversial view at the time and other explanations were advanced. For example, it was suggested that the remains were of a diseased human who suffered from rickets. However, despite the alternatives, the view of the authors of the publication prevailed and their description of the remains of what came to be known, in 1863, as *Homo neanderthalensis* marks the inauguration of the science of

palaeoanthropology, though that name was not applied to the science until the second half of the twentieth century.

Figure 1.1 The Gibraltar skull. (a) A cast of the specimen found in 1848 at Forbes Quarry in Gibraltar. (b) A reconstruction of the Forbes Quarry skull with a lower jaw from another specimen.

Figure 1.2 The Neander skull cap.
Reproduced by permission of the LVR-Landesmuseum Bonn.

Much later, in 1936, after a lot of debate, the **cranium** of a child that had been discovered in 1830 in Engis Cave near Liege in Belgium was also identified as belonging to a Neandertal. So just as the theory of evolution by natural selection was engaging science, fossil material was accumulating that would enable scientists to place humans in the evolutionary tree.

Charles Darwin did not include a treatment of humans in his first major work, *On the Origin of Species by Means of Natural Selection* (1859). In 1871 he published *The Descent of Man*, in which he dealt both with the genealogy of man and sexual selection. The book contains many fascinating insights, but for our interest in human evolution, there is one very striking section entitled 'On the Birthplace and Antiquity of Man'. In this section there is the following very prescient inference about the place where humans evolved:

> We are naturally led to enquire, where was the birthplace of man at that stage of descent when our progenitors diverged from the Catarhine[1] stock? The fact that they belonged to the stock clearly shows that they inhabited the Old World; but not Australia nor any oceanic island, as

we may infer from the laws of geographical distribution. In each great region of the world the living mammals are closely related to the extinct species of the same region. It is therefore probable that Africa was formerly inhabited by extinct apes closely allied to the gorilla and chimpanzee; and as these two species are now man's nearest allies, it is somewhat more probable that our early progenitors lived on the African continent than elsewhere (Darwin, 1874).

Box 1.2 The Gibraltar skull

The Gibraltar Scientific Society, whose members were mostly, if not exclusively, serving soldiers, met on 3 March 1848 in the Garrison Library on the Rock. The secretary was Lt Edmund Flint, RA and in the minutes of that meeting there is the following: 'Presented a Human Skull from Forbes Quarry, North Front, by the secretary'. With hindsight, we can see the importance of this meeting, but it was not recognized as such at the time and we do not know exactly how or where the skull was found. Lt Flint was later promoted to Captain. He died of apoplexy in 1857 (Rose and Stringer, 1997) and whatever details of the circumstances of the find that he knew died with him. The skull presumably remained in the care of the society until 1864, when the army officer who was governor of the military prison, included it in a consignment of fossils that he sent to George Busk at the Royal College of Surgeons in London in the summer of that year. Busk, working with Hugh Falconer (Vice President of the Royal Society), made the connection between the Gibraltar skull and the finding of the Neander fossils. Writing to J D Hooker in the evening on 1 September 1864 Charles Darwin wrote:

> Both Lyell & Falconer called on me & I was very glad to see them. F. brought me the wonderful Gibralter skull (Darwin, 1864).

So, by the time that Darwin completed *The Descent of Man*, he had certainly seen one significant human fossil. Comparison of the Neander remains with the Gibraltar skull in 1864 showed that they belonged to the same species. The skull still holds its position as one of the finest and most complete skulls of a Neandertal ever found. Perhaps if it's true importance had been recognized at the time of discovery, the Rock of Gibraltar, rather than the Neander river would have given it's name to the species we now know as *Homo neanderthalensis*.

So although such specimens of fossil humans as had been found by this time came from Europe, as also had fossils of