10

BECOMING HUMAN

In which we begin a fast-forward look at the human journey from tree-dwellers to moonwalkers and the potential expansion of Gaia into space.

Our evolutionary journey over the last 30 million years shows clearly our biological origin and that we are part of Gaia. Insignificant at first, we have made up for that in the last 500,000 years. Along our timeline we look for the characteristics that make us human: adaptability, tool use, intelligence – and empathy. These do not stand outside of biology but are part of it, supplemented by our own social evolutionary future.

It has already been remarked that being human is another way of being a fish. Not a flat, bottom-dwelling fish, but a goldfish, say. Everyone is familiar with a goldfish. It is an excellent swimmer, swimming with lateral flexures of a muscular body shaped like an aeroplane fuselage. It has pectoral and pelvic fins to provide steering and stability. Its gill slits allow a continuous respiratory flow over the gills as it moves forward, and its swim bladder gives it buoyancy so that it can 'hover' at different depths. This general design first appeared, in its basics, about 500 million years ago, and today, with a bit of pushing and pulling, it is a template that fits all animals with backbones (see Shubin 2008 for an excellent account of this process).

Goldfish and humans probably last shared an ancestor millions of years ago. Yet we still carry with us the signs that betray the fact that evolution, while often creating novelty, also tinkers with what has gone before. We are unmistakably fish-like. Our gill slits are gone, appearing only briefly during our development before becoming adjuncts to our immune system as tonsils. Instead, we breathe with an evolutionarily modified swim bladder, our lungs. Less efficient than gills, with their continuous flow, we have to breathe in and out through the same hole.

Our musculature and nervous system is segmented, based on the fish model. Our limbs are modified pectoral and pelvic fins. Our backbones, no longer horizontal, enable us to stand erect but are not well adapted to load bearing, as your first slipped disc will tell you. They do, however, free up our fins, so that notable fish, such as Leonardo da Vinci, could paint the Mona Lisa. It has been a long walk (swim?) to the Louvre!

The theme of this satirical poem, *Similar Cases* by Charlotte Gilman, illustrates the important truth of the opening paragraphs of this chapter. In evolution, a current state does not pre-empt a possible future state.

> Said the little Eohippus, 'I am going to be a horse!
> And on my middle finger-nails to run my earthly course!
> I'm going to have a flowing tail! I'm going to have a mane!
> I'm going to stand fourteen hands high on the psychozoic plain!'
> The Coryphodon was horrified, the Dinoceras was shocked;
> And they chased young Eohippus, but he skipped away and mocked.
> Then they laughed enormous laughter, and they groaned enormous groans.
> And they bade young Eohippus go view his father's bones.
> Said they, 'You always were as small and mean as now we see,
> And that's conclusive evidence that you're always going to be …'

Eohippus, the 'dawn horse' was the small ancestor of the modern horse. Other 'similar cases' dealt with, not very flatteringly, in this poem are those of the 'anthropoidal' ape and Neolithic man. Like *Eohippus*, humans started off small. Our ancestors were squirrel-sized tree-dwellers. But we eventually became atom splitters.

It has been a 40-million-year journey extending across three geological epochs: Palaeocene (66–57 million years ago), Eocene (57–34 million years) and Oligocene (34–23 million years). Some have christened our present era the Anthropocene, marking the influence of our species on the biosphere. As the previous epochs lasted an average of 15 million years and *Homo sapiens* is at the most only about 400,000 years old, this seems to exhibit a marked degree of anthropocentrism.

Charlotte Gilman's poem paints an amusing picture of the little *Eohippus* boasting about his future as a modern racing thoroughbred. The 'heavy aristocracy' of the time were slow, lumbering mammalian forms: *Coryphodon* was a swamp-dwelling vegetarian about the size of a rhinoceros, while *Dinoceras*, with a remarkable, large, lumpy skull, was a distant relative of the elephants. *Dinoceras* now rejoices in the large, lumpy name of *Uintatherium*, because its original fossils were found in the Uinta Mountains in Utah.

The percentage of oxygen in the Earth's atmosphere has varied over time. It reached a record peak of around 30 per cent about 300 million years ago. In the subsequent 100 million years, the oxygen concentration drifted downwards until, about 200 million years ago, it bottomed out at 15 per cent and then drifted higher to today's value of 21 per cent. During the good times of high oxygen levels, animals with high oxygen demands appeared. These included many small mammals and a large group of small dinosaurs, ancestors of today's birds (Ward and Kirschvink 2015). At the beginning of the Eocene, a mammalian revolution was just beginning.

Most of the modern orders of mammals, or, at least, their oldest known fossils, appeared in the early Eocene. They include the Artiodactyls, 'even-toed' ungulates that walk on their third and fourth toes. This large group includes all the deer and deer-like animals. They are also related to the whales that took to the sea about this time. In contrast, the Perissodactyls, the 'odd-toed' ungulate group, that walk on their middle toes, include the horses and their relatives. To quote again from the poetry of Charlotte Gilman that started this chapter:

> Said the little Eohippus 'I am going to be a horse!
> And on my middle finger-nails to run my earthly course!'

At the beginning of the Eocene, many of the newer mammals were much smaller than those left over from Palaeocene. Modern groups appearing at this time include the bats, the elephants, the rodents and our own ancestors, the primates.

It would be nice to think that primates originated in a gloriously unique ancestor; sadly, this is not the case. Modern studies suggest that the descendants of the earliest primate-like animal was an insectivore that led, on the one hand, to tree shrews, rodents and lagomorphs (Rabbit and his friends and relations) and on the other … to us. Imagine something like a squirrel with its grasping hands and feet. These first primate-like mammals are found as scarce and fragmentary fossils that are about 60 million years old. They appear to be adapted, like tree shrews, to a life in the trees in warm, moist climates. Being tree climbers, they had the first two essentials of arboreal life – good stereoscopic vision and grasping hands and feet that were adapted for gripping branches and would, much later, grip tools.

The fossils of our closer relations, the first true primates, appear about 55 million years ago in North America, Europe and Asia. With larger bodies and bigger brains, it has been suggested that, as brains devour oxygen, increasing brain size was also a response to the increasing levels of oxygen in the atmosphere. If so, it is an example of an important evolutionary innovation that owes its origin to the activities of all green plants and ancient cells, whose photosynthesis continues to produce oxygen as a waste product.

The extinction event that occurred around the beginning of the Eocene was relatively small compared with the great extinctions of previous epochs. It affected mainly marine animals, including the ancestors of modern whales. A cooling climate did the damage, perhaps due to a lot of volcanic activity or to a succession of meteor strikes. Before the extinction event, an archaic one-toed and two-toed ungulate fauna held sway. There were also rodents and some very ancient primates still at the 'tree shrew' level of evolution. The Smithsonian's Erin Wayman (2012) gives an excellent general account of five early primates.

After the crash, it turned out that the ancestors of the rhinoceroses, pigs, hippopotamuses and modern ruminants had made it through the bad times, together with the ancestors of modern rodents, dormice and hedgehogs. So too did primates, in the shape of the family that gave rise to modern tarsiers and the 'dawn monkey' (Beard 2004), weighing less than 200 g, which was discovered in China in the 1990s. Towards the end of the Eocene, our distant cousins, the New World monkeys, emerged, together with our probable ancestors, the flat-faced Old World monkeys. The primate-like mammals were thus insignificant during the changes in the terrestrial ecology immediately following the extinction event.

The ancestral 'almost-monkeys' began to resemble more modern primates as the Eocene unfolded. Brains and eyes increased in size, with an emphasis on binocular vision, and faces became even flatter. The hole in the skull through which the spinal cord joined the brain moved forward, allowing the skull to be held in a more vertical position. This suggests that they were beginning to hold their bodies erect while hopping and sitting, like modern lemurs, thus freeing their hands to tend infants and hold tools.

By the end of the Eocene, about 34 million years ago, many of these early mammals had themselves become extinct. It took a further 10 million years before the first recognisably apelike human ancestor appeared. And about 20 million years after that, in 1909, part of a fossil jaw was found.

To digress slightly, two criteria must be satisfied to obtain an accurate indication of the distribution and diversity of fossils. You must have a good idea of where to look and there must be a lot of searchers. These criteria were far from being satisfied until after the middle of the twentieth century. The hunt for fossil hominids that was conducted before World War II was remarkable, however, for the insightful individuals who followed their hunches. Eugene Dubois, Raymond Dart, Robert Broom and various members of the Leakey family stand out. The fact that they were successful testifies both to the quality of their hunches – and their great persistence.

Dubois's great discovery came in 1891 – inevitably, he thought of it as a missing link, but not in those words. Instead he described it as 'a species intermediate between humans and apes' and accordingly named it *Pithecanthropus erectus:* the upright half ape/half man. It was not, however, human. At the time, *Pithecanthropus* was a celebrated find, for finds of any sort were in such short supply. Piltdown Man, the name given to the doctored bits of skull and jaw that were 'found' in a quarry, was a famous fraud perpetrated about this time.

The jaw that was found in 1909, by an unnamed gold prospector in Kenya, was better fitted to the Victorian image of the 'missing link'. Twenty-two years later, in 1931, at Lake Victoria in Africa, Arthur Hopwood and Louis Leakey found fossils belonging to three individuals whose jaws were similar to the 1909 discovery. The find was given the name *Proconsul* by Hopwood in 1933, after a series of performing circus chimpanzees all named Consul. At the time it was considered to be the oldest hominoid fossil ever found, but now the view is that it belongs to a sister group. There are several related species known from the fossil record and they all share the shortened snout and grasping hands and feet. *Proconsul* probably went on all fours, as it had a backbone unsuited to bipedalism. It was obviously successful, as its fossils have been dated as recently as 10 million years ago. It is a strong candidate to be ancestor of other apes, if not our own line.

A visit to Olduvai Gorge in the Great Rift Valley of Africa is as awe-inspiring as one to Lake Mungo in Australia, Stonehenge in England or Chartres Cathedral in France for anyone who has a sense of the past. It is an otherwise unremarkable ravine in dry scrubland, scoured out by a stream that has run through it for thousands of years. Consequently, its exposed geology has made it a particularly rich fossil ground. Olduvai was the hunting ground of Louis and Mary Leakey and family. Not far away is Laetoli where Raymond Dart and Robert Broom were making many interesting discoveries. A list of fossils illustrating human evolution may be found on the Internet so it is not necessary to go into great detail here, especially as the various species have been subject to much revision.

It is clear that, since the time of the writing of *On the Origin of Species*, we are now far from a scarcity of intermediate forms in our ancestry. In fact, we have an embarrassment of riches, and with the riches comes confusion that is only now being sorted out. The fossils tend to fall in to four groups, one of which includes ourselves (Figure 17). The groups are: the ardipithecines, the earliest, followed by the australopithecines and then three species (so far) of paranthropines. Our own group, the *Homo* group, comprises everybody whose remains have been dated to the last million years. An excellent account of human evolution is to be found in Ayala and Cela-Condi (2017).

All of the great apes – and us – are now to be found in the superfamily Hominoidea (Figure 17). The superfamily is split into two families, the Hylobatidae, which includes all the gibbons, and the Hominidae. Nothing more needs to be said here about the four genera of gibbons, today found only in Madagascar.

The family Hominidae (our family) has been split into two subfamilies, the Ponginae and the Homininae. The Ponginae contains only the Orang-Utans. We therefore number ourselves among the living Homininae, an honour we share with the gorillas and the chimpanzees. The Homininae have been divided into two tribes. In the larger one, the Hominini, we find ourselves and our nearest neighbours, the chimpanzees, while the Gorillini contains only (you guessed it) the gorillas.

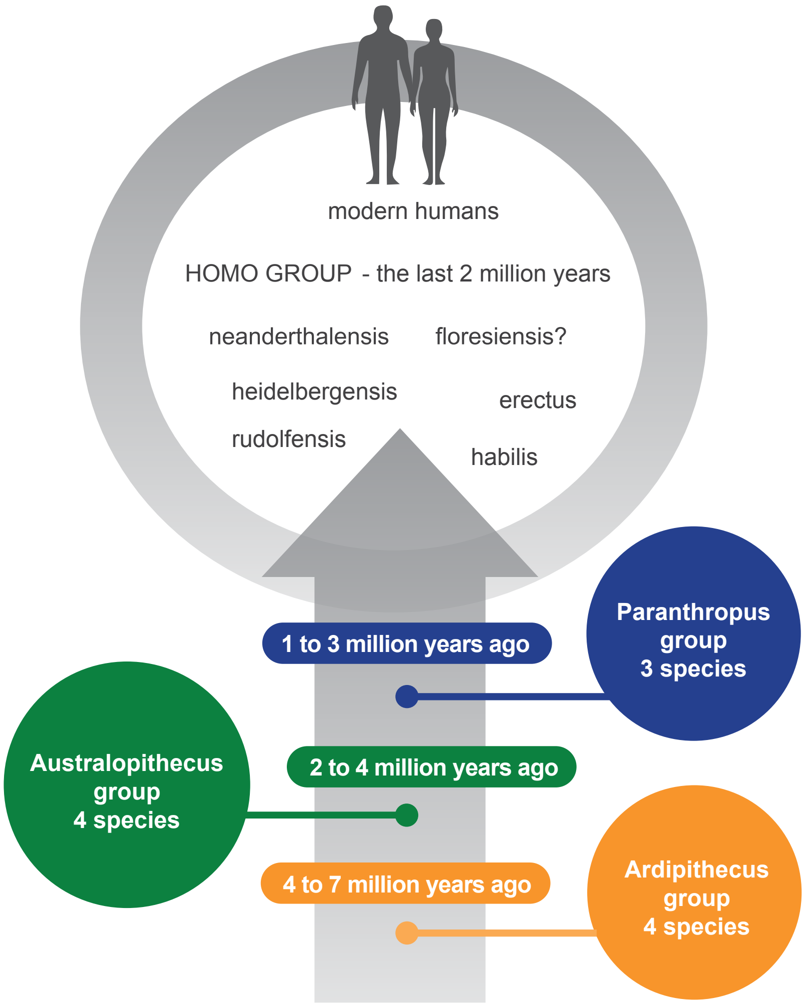

Figure 17. Modern humans and our ancestors.

Finally, within the Hominini, there are two living genera, *Homo* and *Pan*. *Homo* has one extant species – us, *sapiens,* while *Pan* contains two species. *Pan troglodytes* is the famous chimp of zoo tea parties who originates in the Congo. *Pan paniscus*, the bonobo, is a smaller chimp from further south. Bonobos are our nearest evolutionary relatives, with whom we share almost 99 per cent of our DNA. They are therefore of particular interest to us.

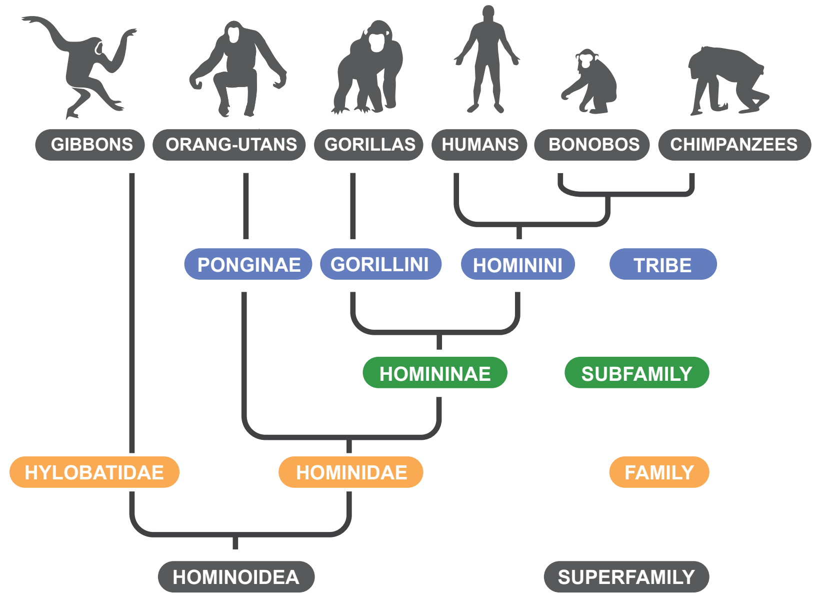

Figure 18. The Hominoidae superfamily.

Returning to the group to which we belong, now known as the Hominini, among the earliest members are *Homo rudolfensis*, known from three individuals, two of which were found in Turkana, in Kenya; and *Homo habilis*. Their fossils are about 2 million years old. *H. rudolfensis* had a brain volume above the upper end of the range for known *H. habilis* fossils. At the moment, these two are designated separate species but as 'one swallow does not a summer make', so one fossil, or even two, does not necessarily make a species. There remains a question mark over *Homo rudolfensis*.

To save an irritating proliferation of italics, in what follows, hominins will be referred to by their species or 'surnames' – as we might refer to Darwin or Huxley. Habilis was the 'handy man' and its (to avoid saying his or her!) fossils are known from east Africa. It was apparently brainier that the earlier hominins but was apelike in its prominent jaw and relatively long arms. It was named *habilis* as it was thought, at the time of its discovery, that it was the earliest maker of stone tools. It was a small hominin, not quite 1.5 metres tall and weighing about 30 kilograms. Since then, even earlier tools have been discovered, that have been made by … who knows?

About 1.5 million years ago, Erectus appears in the fossil record. Some authorities think that Erectus is not one but four species. In any event, its type was widely distributed in Africa, Georgia, China and Indonesia, and it was evidently a traveller – not as we might travel, to a specific destination or 'to boldly go where no hominin has gone before' – but little by little, generation by generation, as it extended its range. It was roughly the same size and proportions as modern humans. Significantly, there is fossil evidence that Erectus cared for its weak and its dead.

Erectus was a denizen of the savannahs, a way of life more conducive to movement on the ground, perhaps even to nomadism, than life in the trees. The larger body and longer legs made journeying for longer distances possible while the larger brain was equipped with an intelligence able to cope better with the vicissitudes of different environments and to make better tools. It has also been suggested that the Erectus diet included meat, which provided enough energy for the bigger brain and also permitted survival in temperate latitudes in winter, when food plants were dormant.

From the dates, almost everyone seems to agree that Erectus was gone about 400,000 years ago. It may be that its relict persisted for another 350,000 as the 'hobbit', Floresiensis, but the jury is still out on that one. Perhaps Floresiensis, imprisoned in the evolutionary hotbed of Flores Island, is a dwarf sister species of Habilis.

Anyway, everyone agrees that Floresiensis was a sideshow, but this is not the case for Heidelbergensis nor Neanderthalensis. These two hominins appear in the fossil record in the last million years. Heidelbergensis was the first to arrive, about 700,000 years ago while Neanderthalensis exists in the fossil record from 400,000 to 40,000 years ago and is with us today – in our DNA.

About 2 million years ago, Erectus, still in Africa, gave rise to the line that led to Heidelbergensis. This ancient Erectus stock continued in Africa, but around 700,000 years ago Heidelbergensis began moving to the Middle East and then westwards into Europe. They, or Neanderthals, were in France and Spain about 100,000 years ago. A group of humans, from Denisova in Siberia, are of great interest. They are not yet granted species status but named from a few remains found in a cave. One fossil find, a bone from a 13-year-old girl, is remarkable because analysis of DNA obtained from it shows her to be a hybrid produced by a mating between a Denisovan and a Neanderthal.

DNA analysis shows that modern humans, Neanderthals and Denisovans, had an ancestor in common about 600,000 years ago. Further evidence from mitochondrial DNA analysis suggests that the Denisovans were the result of an earlier migration out of Africa, distinct from the later out-of-Africa migrations associated with modern humans and Neanderthals, but also distinct from the earlier African exodus of Erectus.

In order to simplify discussion, it has been customary to divide our species into 'Archaic' and 'Anatomically Modern' humans; those forms are used here. Archaic humans have a greater physical resemblance to their heavier ancestors, and some argue that the latter represent subspecies of Sapiens – thus, *H. sapiens neanderthalensis* and *H. sapiens heidelbergensis* – or even separate species. Anatomically modern humans have lighter builds than their archaic ancestors and large brains that vary in size between populations and sexes but average 1300 mL.

Sapiens is first recorded in the fossil record in Morocco about 300,000 years ago. Remains have been found in Israel that are 100,000 years old, and slightly younger fossils have been discovered elsewhere in Eurasia. In contrast, the famous Cro-Magnon discovery provides earliest evidence of anatomically modern humans in Europe. The bones and the associated painted caves of Lascaux are only 30,000 years old. (For comparison, the skeletal remains from Lake Mungo in Australia are 40,000 years old.) Cro-Magnons were evidently strongly built. The high forehead had only slight brow ridges. The face was short and wide with a prominent jaw. The brain capacity was about 1600 mL, larger than most modern humans.

At some time during these journeys, they passed through a metaphysical barrier that Midgley (2004) marks as the transition from hominin to fully human: they learned to tell stories. Stories are really imagined futures. So are lies.

The whole of biology is beset with 'lies', with plants and animals pretending they are not there, or that they are something else, that they are dangerous, that they are poisonous, that they are fitter (in an evolutionary sense). In humans, children as young as two years old are capable of spontaneous lying and such behaviour increases dramatically by the time they are three. Children with better cognitive ability are capable of telling better lies (Evans and Lee 2014). As children develop, their ability to balance more than one 'reality' in their heads becomes easier.

Modern humans can thus visualise numerous possibilities, options that offer a large range of outcomes that vary from 'very good' to 'disastrous'. If you were to plot them as a normal distribution curve, you would get the 'disastrous' ones at one end and the 'brilliant' ones at the other. The hump in the middle would be occupied by the 'not too bad and not too good' – average, in fact. Setting aside those, like the winners of the Darwin Award, whose final disastrous choices remove them from the human gene pool, and Nobel Laureates at the other end, most people select from a range of 'imagined stories' whose outcomes are somewhere in the average hump. There are far more 'not so good' options than really good ones, and far more 'not so good' choosers than 'good' choosers. 'Not so good' outcomes, therefore, are more likely to be chosen, and to be tested either evolutionarily or socially. The sheer complexity of modern society created by billions of people has also created an enormous range of future options of the 'not so good but not disastrous' category.

The ability to tell good stories clearly has considerable survival value within human social systems. Sociologists Barthes and Duisit (1975) have argued that, despite the diversity in how it is told, there is only one human story: a villain and a hero searching for a treasure. This can even be applied to the evolutionary story. In an anthropologist's overview of evolutionary advances, say, a species is a hero if it brings the evolutionary journey closer to humans; a villain if it moves away from a hopeful extension (for example, the Neanderthals). The treasure is, of course, becoming human.

Ability to make choices about the future follows the same rules as other biological phenomena and conforms to a normal distribution curve. Those in the population who are able to make 'good' decisions will occupy one small tail, while the 'not so good' deciders will occupy the huge hump clustering around the mean. The other tail is occupied by the 'disastrous' choosers. Given that the population of Earth is 7 billion, the hump will comprise huge numbers of people, most of whom will be intelligent, and many of whom will be influential and may have an interest in promulgating 'not so good' scenarios.

A good leader, who understands their group's circumstances, will be able to extrapolate from them, see ways in which they might be improved and then impart that vision to others. Archaeological evidence suggests that hominins other than Sapiens had this ability.

Rendu et al. (2014) describe a Neanderthal burial at Chapelle-aux-Saint. It appears to have been a naturally formed trench that was modified in various ways to make it a suitable receptacle for the body. The authors concluded that these constitute convincing criteria for establishing purposeful burial. Studies of 28 human skeletons in Atapuerca in Spain suggest that Heidelbergs might have been the first hominins to bury their dead (Carbonell et al. 2006). Burying one's dead and using paints implies envisaging futures that are different from the real one or perhaps indicates respect and affection for the dead person. It may also reflect the recognition of a cause and effect relationship, with hygiene the main consideration – burial helps to prevent disease from a decaying corpse. The 'Midgley Point', the moment at which these practices arose in hominins, must predate this. Steven Mithen (2005) believes that both Neanderthals and Heidelbergs had acquired a pre-language system of communication. Red ochre, commonly used in painting and decoration, has been found at the Terra Amata excavations, recently dated at 230,000 years ago in the south of France, although no forms of art nor sophisticated artefacts other than stone tools have been uncovered.

Ergaster, an African form of Erectus, is thought to be the first hominid to vocalise, although the evidence on which this is based involves much supposition about airways and, to an inexpert reader, conveys little more than the possibility of modulated grunts. A better bet may be Heidelbergs and Neanderthals, who developed more sophisticated culture. The morphology of the outer and middle ears of these hominins suggests they had an auditory sensitivity similar to modern humans and very different from chimpanzees. According to Mithen, they were probably able to differentiate between many different sounds. Others have compared the structure of the vocal apparatus of five Heidelberg fossil individuals with modern humans and chimpanzees. Recently, a bonobo has learned to communicate, using geometric symbols representing words, without the arduous training required by the famous 'talking apes' of earlier studies.

These observations together suggest an origin for human speech about half a million years ago. Presumably, the ability to speak is a prerequisite for the telling of stories, so our capacity for mendacity has a considerable ancestry. The interesting question is whether it arrived before or after the development of an ethical sense to make it respectable.

On looking back, it seems inevitable that something like genus *Homo* would emerge. We see all about us trends that appear to point the way to bigger brains. Looking forward from 3 billion years ago, however, it is by no means obvious that the emergence of genus *Homo* was inevitable. Given our history, perhaps there is room for only one major intelligence per planet. Perhaps the qualities of intelligence and consciousness are such that an evolving planet only gets one shot at it at a time. There are some good understudies in other groups in our evolutionary bush waiting in the wings, although it might take them a few million years or more after we depart the stage.

> There was once a Neolithic Man, an enterprising wight,
> Who made his chopping implements unusually bright.
> Unusually clever he, unusually brave,
> And he drew delightful Mammoths on the borders of his cave.
> To his Neolithic neighbours, who were startled and surprised,
> Said he, 'My friends, in course of time, we shall be civilized!

This is the last we shall quote from the witty Charlotte Gilman, for at the end the poem turns dark and pessimistic!

It is time now to take a look at our own little taxonomic cluster, the Hominini. There are three of us left in it, the three chimpanzees, as our other *Homo* cousins have long departed.

The point in time at which *Homo* separated from the two chimpanzees is clouded because the extent of hybrid speciation is not known. Hybrid speciation occurs when two similar but not identical species successfully interbreed. It has not been thought to be a common occurrence, and conventional wisdom suggests that the offspring are usually sterile – think of mules and ligers. It has, however, obviously occurred in the evolution of modern humans since there are Neanderthal and, recent evidence suggests, Denisovan genes in the modern human genome.

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