THE BOOK OF HUMANS

THE STORY OF HOW WE BECAME US

ADAM RUTHERFORD

W&N
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ILLUSTRATIONS

By Alice Roberts

INTRODUCTION

'What a piece of work is a man!' marvels Hamlet, in awe at our specialness.

> How noble in reason! How infinite in faculty!
> In form, in moving, how express and admirable! In action how like an angel!
> In apprehension how like a god! The beauty of the world! The paragon of animals!

'The paragon of animals' is a lovely phrase. Hamlet exalts us as truly special, touching the divine, limitless in our thought. It's a prescient phrase too, as he raises us above other animals while acknowledging that we are one. Just over 250 years after William Shakespeare wrote those words, Charles Darwin irrefutably cemented humankind's classification as an animal – the slightest of twigs on a single, bewildering family tree that encompasses four billion years, a lot of twists and turns, and a billion species. All of those organisms – including us – are rooted in a single origin, with a common code that underwrites our existence. The molecules of life are universally shared, the mechanisms by which we got here the same: genes, DNA, proteins, metabolism, natural selection, evolution.

Hamlet then ponders the paradox at the heart of humankind:

What is this quintessence of dust?

We are special, but we are also merely matter. We are animals, yet we behave like gods. Darwin sounds a bit like Hamlet, declaring that we have 'god-like intellect', yet we cannot deny that man – and, to bring his language into the twenty-first century, woman – carries the 'indelible stamp of his lowly origin'.

This idea, that humans are special animals, is at the root of who we are. What are the faculties and actions that put us on a pedestal above our evolutionary cousins? What makes us animals, and what makes us their paragon? All organisms are necessarily unique, so that they can exist within and exploit their own unique environment. We certainly think of ourselves as pretty exceptional, but are we really more special than other animals?

Alongside Hamlet and Darwin comes a possible challenge to our ideas of human exceptionalism, from an arguably lesser piece of modern culture, the animated superhero film *The Incredibles*: 'Everyone is special . . . which is another way of saying that no one is.'

Humans *are* animals. Our DNA is no different from anything that has lived in the last 4,000 million years. The coding system employed within that DNA is no different either: the genetic code is universal as far as we know. The four coded letters that make up DNA (known as A, C, T and G) are the same in bacteria and bonobos, orchids, oaks, bedbugs, barnacles, triceratops, *Tyrannosaurus rex*, eagles, egrets, yeast, slime moulds and ceps. The way they are arranged in those organisms, and how they are translated into the protein molecules that enact the functions of a living being are all fundamentally the same

too. The fact that life is organised into discrete cells is also universal,[1] and these incalculably numerous cells harvest energy from the rest of the universe in a process common to all of them.

These principles are three of the four pillars of biology: universal genetics, cell theory, and chemiosmosis, which is a rather technical yet elegant word for the basic process of cellular metabolism – how cells draw energy from their surroundings, to be spent in the process of living. The fourth pillar is evolution by natural selection. Combined, these grand unifying theories coalesce to reveal something unarguable – that all life on Earth is related by common ancestry, and that includes us.

Evolution is slow, and the Earth has been host to life for the vast majority of our planet's existence. The timescales we talk about so casually in science are utterly baffling to comprehend. Even though we are a latecomer to life on Earth, our species is more than 3,000 centuries old. We have traversed that ocean of time largely unchanged. Physically, our bodies are not drastically different from *Homo sapiens* in Africa 200,000 years ago.[2] We were physically capable of speaking then as we do today, and our brains were not significantly different in size. Our genes have responded in small part to changes in the environment and diets as we migrated within and out of Africa, and genetic variants account for the minuscule percentage of DNA that spells out the differences between individuals, changes in the most superficial characteristics – skin colour, hair texture and a few others. But if you tidied up a *Homo sapiens* woman or man from 200,000 years ago, gave them a haircut and dressed them in twenty-first-century clothes, they would not look out of place in any city in the world today.

There's a conundrum in that stasis. Though we may not look different, humans did change, and profoundly. There's debate

about when this transition occurred, but by 45,000 years ago, something had happened. Many scientists think that it was a sudden change – sudden in evolutionary terms means hundreds of generations and dozens of centuries, rather than a thunderbolt. We don't quite have the language to relate to the timescales involved in such transitions. But what we can observe from the archaeological record is that we see the emergence and accumulation of a number of behaviours that are associated with modern humans, and there was a time before that where we see fewer or none of them. Given how long life has existed on Earth, this switch happened relatively in a heartbeat.

The transformation occurred not in our bodies or physiology or even in our DNA. What changed was culture. In scientific terms, culture refers broadly to the artefacts that are associated with a particular time and place. They include things like tools, blade technology, fishing gear, and use of pigment for decorative purposes or jewellery. The archaeological remains of a hearth show the ability to control fire, to cook, and maybe its position as a social hub. From material culture, we can infer behaviour. From fossils we can try to piece together what people looked like, but with archaeological evidence of the paraphernalia of our ancestors' lives, we can address what people *were like* in prehistory, and when they became like that.

By 40,000 years ago, we were designing decorative jewellery and musical instruments. Symbolism in our art was rife, and we were inventing new weapons and hunting technology. Within a few millennia, we had fostered dogs into our lives – tamed wolves that accompanied our search for food long before they became our pets.

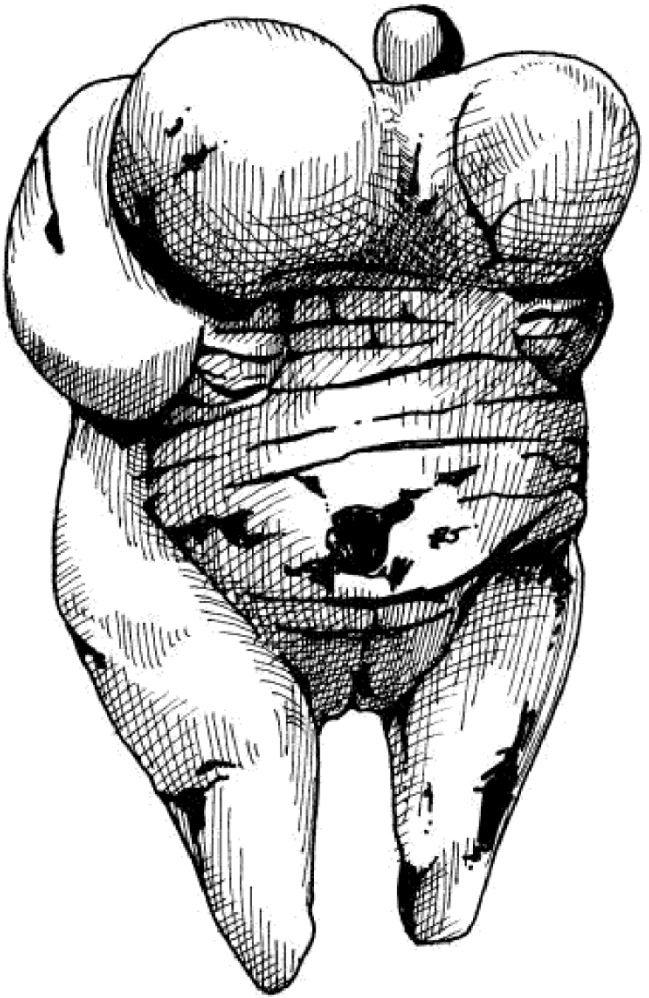
The concatenation of these behaviours is sometimes referred to as the Great Leap Forward, as we jumped into a state of intellectual sophistication that we see in ourselves today. Alternatively, it's a 'cognitive revolution', but I dislike the use of

that phrase to describe a process which was both continuous and probably lasted a few thousand years or more – real revolutions should be thunderbolts. Nevertheless, modern behaviour emerges permanently and quickly in several locations around the world. We began to carve complex figurines, both realistic and abstract, sculpted make-believe chimeras out of ivory, and we adorned cave walls with pictures of hunts, and of animals important to our lives. The earliest piece of figurative art by *Homo sapiens* that we know of is a 40,000-year-old twelve-inch statue of a lean man with the head of a lion. It was carved from a mammoth tusk during the last Ice Age.

Soon after that time we were making small statues of women. They are known today as Venus figurines. We don't know if there was a specific purpose to these dolls, though some researchers think they may have been fertility amulets, as their sexual anatomy is exaggerated: bosomy women with swollen labia, and often bizarrely small heads. Maybe they were just art for art's sake, or toys. Either way, to create such sculptures requires great skill and foresight, and a capacity for abstract thought. A lion-man is an imagined being. The Venus amulets are deliberate misrepresentations, abstractions of human bodies. These figures cannot exist in isolation either: artisan craft requires practice, and though today only a handful of these beautiful works of art remain, they must represent an iterative process, a lineage of skilled craftspeople.

Some of these types of traits pop up before the full transition to our modern behaviour, but they do so fleetingly, and then vanish from the archaeological record. *Homo sapiens* were not the only humans to have existed in the last 200,000 years, and not the only ones to have refined culture. *Homo neanderthalensis*, far from the brutes of popular lore, were simply people too. We are wrong to think of them as merely upright apes, living in dust with crude language and tools, all set

for extinction. Neanderthals showed clear signs of modern behaviour: they made jewellery, employed complex hunting techniques, used tools, had a control of fire, and made abstract art. We have to consider that they also were sophisticated in a way indistinguishable from our direct *Homo sapiens* ancestors, which undermines the uniqueness of our own forward leap. Though we have traditionally considered Neanderthals to be cousins to us, they were also ancestors: we now know that our lineage and theirs diverged more than half a million years ago, and both groups were isolated in time and space for almost all of that period. But our ancestors left Africa some 80,000 years ago, and were immigrants into Neanderthal territory. We reached Europe and central Asia, and around 50,000 years ago, we bred with them. Their bodies were different enough that they lie outside the range of human physical diversity as we see it today – a bit less chin, a bit more chest, heavy-set brows and robust faces. They weren't so different that we didn't have sex with them, women and men from both sides of the species fence, and together we had children. We know this because our genes are in their bones, and theirs are in our living cells. Most Europeans carry a small but significant percentage of DNA that was acquired from Neanderthals, and this blurs any hope of a clear boundary between two sets of people that we have declared separate species – that is, organisms that cannot produce fertile offspring. Though Neanderthal DNA is slowly being purged from our genomes for reasons that are not fully understood, humans today bear their living genetic heritage, as we do the genes of another type of human, the Denisovans, further to the east, and maybe others that are yet to be discovered but whose legacy sits within our DNA.



The Venus of Hohle Fels

When we first met, the Neanderthals and those other people were not long for this world, and by around 40,000 years ago, *Homo sapiens* had outlived the last of them. Whether the Neanderthals had undergone a full transition to the behavioural modernity as we saw in *Homo sapiens*, we do not know, and may never know, but the evidence is pointing towards those cavemen and women being much like ourselves in every way.

We lived and they died. We don't know what gave *Homo*

sapiens the edge over Neanderthals. All life is set for extinction over a long enough timescale: more than 97 per cent of species that have ever existed are already gone. The Neanderthals' tenure on Earth was much longer than we have racked up so far, and we are yet to firmly understand why their light was finally snuffed out 40,000 years ago. We don't think there were ever very many Neanderthals, which may have contributed to their demise. Maybe we outsmarted them. Maybe we brought with us diseases that we had lived with and earnt immunity to, but which were lethal to a virgin population. Maybe they simply petered out of existence. What we do know though is that around this time, the last type of human began to permanently and globally show signs of who we are today.

We certainly outbred all our nearest relatives. *Homo sapiens* went forth and multiplied very effectively. We're the dominant life form on Earth by many measures, if ranking matters to you (though bacteria outnumber us – you carry more bacterial cells than human ones – and are far more successful in terms of longevity. They have a four-billion-year lead on us, and no prospect of extinction). Today there are upwards of seven billion humans alive, more than at any time in history, and that number is still rising. Through our ingenuity, science and culture, we have eradicated many diseases, drastically reduced infant mortality, and extended lifespan by decades.

Hamlet marvels at our brilliance, as have scientists, philosophers and religions for millennia. But the progress of knowledge has chipped away at our specialness. Nicolaus Copernicus dragged us away from a world at the centre of the universe to one merely orbiting an ordinary star. Twentieth-century astrophysics revealed our solar system as an average one among billions in our galaxy, which itself is one of billions in the universe. We still

only know of one world that harbours life, but since 1997 when the first planets beyond our Sun's gravity were discovered, we have learnt of thousands in the heavenly firmament, and in April 2018 a new satellite was launched specifically to seek out strange new worlds. We're getting a good grip on the conditions required for chemistry to transition into biology, and for life to emerge from a sterile rock. The question of whether there is life beyond Earth has mutated: it would now be surprising if there *weren't* living things elsewhere in the universe. That is all still to come, and for now, we only know of life on Earth. But we might not be as unique as we once thought, and the more we learn the clearer that becomes.

On Earth, Charles Darwin began the process of inching us back into the natural world, and away from special creation. He showed that we are animals, evolved from other animals, and placed us firmly as a creature begotten not created. All of the incontrovertible molecular evidence of those pillars of biology was yet to come when he exposed the world to his big idea in 1859 in *On the Origin of Species*. He avoided including humans in that great work, but teased us that his mechanism of natural selection would soon shed light upon our own origins. In *The Descent of Man* in 1871, he applied his meticulous and foresightful brain to our genesis, and cast us as an animal evolved just like every organism in Earth's history. Mostly bald, you're an ape, descended from apes, your features and actions carved or winnowed by natural selection.

In that sense we are not special. We evolved with a biology indistinct from all life, and under the auspices of a mechanism that is similarly universal. But evolution also equipped us with a suite of cognitive powers that gave us, ironically, a sense of separateness from nature, because it allowed us to develop and refine our culture to a level of complexity well beyond any other species. It gave us a clear sense that we are special, and specially

created.

Yet many of the things once thought to be uniquely human are not. We have extended our reach so far beyond our grasp by utilising nature and inventing technology. But many animals also use tools. We have decoupled sex from reproduction, and almost always have sex for fun. Scientists are reluctant to admit the possibility of pleasure in animals, but even so, a huge proportion of sexual activity in animals does not and cannot result in reproduction. We are frequently a homosexual species. Once – and in many places to this day – homosexuality was decried as *contra naturam*, a crime against nature. In fact, sexual acts between members of the same sex abound in nature, in thousands of animals, and, for example, may well dominate male giraffe sexual encounters.

Our ability to communicate appears to trump all other animals, though maybe we just don't know what they're saying yet. I am writing this book and you are reading it, which is a degree of communication that has evolved far beyond any other level we have observed in any other species. Though that certainly makes us different, a mantis shrimp doesn't give two hoots about that. It can see in sixteen different wavelengths of light compared to our puny three,[3] which is rather more useful to them than all the culture and self-regard that we have mustered over the millennia.

Nevertheless, a book is a thing that typifies the gap between us and all other beasts. It is the sharing of information generated by thousands of others, almost none of whom I am closely related to. I have studied their ideas, and recorded them into a tool of almost unimaginable complexity, so that our minds might be enriched with this collection of stories that are new and hopefully interesting to anyone who cares to pick it up.

This is a book about the paradox of how we became us. It is an exploration of an evolution that bestowed enormous powers

of intellect on an otherwise average ape, to create tools, art, music, science and engineering. Through old bones and, nowadays, genetics, we know about the mechanics of our evolutionary journey through the eons (though there is so much still to discover), but we know far less about the development of our behaviour, of our minds, and of the way that we uniquely evolved into the cultural and social beings that we are today.

At the same time though, it is a book about animals, of which we are one. We're a self-centred species, and we find it hard not to see ourselves and our behaviours in other animals. Sometimes those characteristics do have a shared origin with our own. Often they do not. Regardless of their genesis, I am attempting to demystify our own behaviour by pointing to where else on Earth we see those traits, and trying to sort the things that are uniquely us, shared with close evolutionary cousins, or just things that look similar, but are in fact unrelated. I'll be examining the evolution of technology in humans – having mastered the crafting of stones, and sticks, and fire hundreds of thousands of years ago – and in the many other animals that also use tools. Evolutionary biologists love thinking about sex, and I'll be delving in, not only to try to understand how we decoupled sex in all its myriad forms from reproduction, but how the sex lives of animals are also a carnival of delights that are not always simply the direct manifestation of the biological imperative to create offspring. While this is a celebration of both us and the wondrous variation in nature, we are indubitably a creature capable of less than angelic behaviour, of creating horrible nightmares – violence, warfare, genocide, murder, rape. Are these different from the often horrifying behaviours that are part of the brutal natural world, the violence and sexual practices that don't get showcased on television documentaries? In the final part, I will be scrutinising the reasons behind the evolution of behavioural modernity – meaning the emergence of

people who are like us today. Our bodies became modern long before our minds did, which is a puzzle worth examining.

Biologists appraise the wonders of evolution, sometimes to understand ourselves, often to understand the grand scheme of life on Earth. This book is a glimpse of the epic meandering journey that every organism has made. After all, we are the only ones who can appreciate it.

What a piece of work we are!

The pillars of biology are firmly in place, installed over the last two centuries and tested over and over again. We have bound the principles of natural selection to genetics, in cells powered by chemistry. We have aligned these principles in history, to draw a picture of how life spread from such a simple beginning in the basement of the oceans to every inch of this planet. You might think that this means the study of life on Earth is pretty much done, and now we're just filling in the details. But science never sleeps, because there are always leviathan gaps in our knowledge. Most of nature remains unobserved, and it continues to utterly astound us with new discoveries every day, new species, and new traits in animals and other organisms that we simply have neither seen before nor perhaps even conceived of.

Some of the things described in the pages that follow were only discovered in 2018, the year I finished writing this book. That may mean details are scant, or have been seen only once or on a few occasions. It may mean these newly observed behaviours are outliers, truly unusual characteristics. Others might be generalisable to many species, or even all. Some may turn out to be not what we originally thought. For all the glorious documentaries that we see on television, most animals spend almost all of their lives unseen by human eyes, and live in environments that are inhospitable or alien to us. That is the

nature of science: seek and ye shall find. Studying these animals is important on its own terms, and may yet provide insight into our own condition.

Sometimes these behaviours appear to have a shared evolutionary origin with us. Others exist in non-human animals because they are clearly of great use in the struggle for existence, and have evolved many times over, just as insects, bats and birds all have wings but with little in common in their histories of acquiring flight. The philosopher Daniel Dennett calls these 'good tricks', meaning that they are characteristics of such benefit that they arise many times in history. Flight is a good trick, and has evolved repeatedly in distantly related creatures, but it has also evolved many times over within the same groups of creatures. Evolution can be efficient in that way: once there is a plan to make a particular trait, that plan can be deployed whenever desirable. Insect wings have come and gone dozens, maybe hundreds, of times in the last few hundred million years to suit survival in the local environment, though the genetic mechanism that underlies wings remains largely unchanged during this time. Flying is only useful when it's useful, and it's a costly activity, so can be discarded, and the genes filed away, when not needed, like a winter wardrobe.

There are plenty of potential pitfalls in studying our own evolution. Just as we must be careful about ascribing similarity of function with common origins, we must also be cautious about confusing our behaviour today with a presumption that that is why the behaviour emerged in the first place. There are many tempting myths about the origin of our bodies and behaviours that teeter near the edge of pseudoscience. Let me be clear on this: all life is evolved. But that doesn't necessarily mean that all behaviours are explained with the central idea of evolution, which is adaptation. Many behaviours, especially in us, are there as by-products of our evolved existence, and not

because they have specific functions that aid our survival. This fallacy is particularly prevalent in our sexual behaviours, which we will inspect in detail. We see familiar sexual behaviours in animals, some of which are associated with pleasure in us, and some with criminal violence. No matter how neat or appealing an explanation might be, science looks to facts and evidence, and an ability to test an idea to destruction.

Every evolutionary pathway is unique, and while all living beings are related, how each one came to be is a different story, with different pressures driving selection, and random changes in DNA providing the template from which variation, selection and evolutionary change can occur. Evolution is blind, mutation is random, selection is not.

Error and trial is a conservative process; radical biological change normally results in death. Some evolutionary developments are clearly so useful that they never truly go away. Vision is one example. Being able to see in the oceans clearly conferred a significant advantage for whatever life form first acquired vision, more than 540 million years ago – you can see things you wish to eat and move towards them, you can see things that wish to eat you and swim away. Once it had evolved, vision spread rapidly. Since then, the genetic programme for phototransduction – that is, converting light into sight – has remained virtually identical in all organisms that can see. In contrast, a crow with a bent stick wheedling out a fat grub from the bark on a tree is a skill that has evolved entirely independently of a chimpanzee doing exactly the same thing, and has little specific genetic underpinning in common. All abilities are evolved, which doesn't mean that they all have common roots. Unpicking and filtering the similarities and difference in behaviours that appear familiar to us is crucial in understanding our own evolution.

We have to separate out all of the attributes discussed in this

book, even though each is dependent on others. We cannot recreate the order or circumstances in which they appeared. Our brains expanded, our bodies changed, our skills sharpened and we socialised differently. We ignited sparks and lit fires, tilled the earth, crafted myths, created gods and commanded animals. The beginning of culture relied upon all of these things, powered by the flow of information and expertise. It was not an apple that gave us this knowledge – apples are a product of our own agricultural ingenuity. It was how we lived our lives. We began living in populations that grew to sizes where kin became communities, and tasks within communities fell to specialists – musicians, artists, craftspeople, hunters, cooks. In the transfer of the wisdom of these experts – in the interconnectedness of minds – modernity arose. Uniquely, we accumulate culture and teach it to others. We transmit information, not just via DNA down the generations, but in every direction, to people with whom we have no immediate biological ties. We log our knowledge and experiences, and share them. It is in the teaching of others, the shaping of culture, and the telling of stories, that we created ourselves.

Darwin, with typical prescience, suspected that this might be the case:

> Man alone is capable of progressive improvement. That he is capable of incomparably greater and more rapid improvement than is any other animal, admits of no dispute; and this is mainly due to his power of speaking and handing down his acquired knowledge.

Crucially, we are the only species to have held ourselves up to the light, to have asked, 'Am I special?' Paradoxically, the answer turned out to be both no and yes.

Over the eons, we have moved from being not particularly

special animals, to thinking ourselves uniquely created and distinct from the rest of the living world, to a sort of quantum state where we can occupy both positions at the same time. What follows is a compendium of that which unequivocally fixes us as animals, and simultaneously reveals how we are extraordinary.

[1] Viruses are normally and traditionally excused from this definition; arguments rage over whether viruses are living or not, though I vacillate between not caring and thinking that for all intents and useful purposes they display the characteristics of being alive. That they cannot reproduce themselves without the presence of a cellular living entity is, to my mind, not relevant. No organism has ever existed without dependence on another. The role of viruses in evolution cannot be understated and has been a major driver of the continuation of life for its entire duration, as is discussed later.

[2] The earliest *Homo sapiens* are found in Morocco and are around 300,000 years old, but these are sometimes referred to as archaic, rather than anatomically modern, humans, the oldest of which are more like 200,000 years old.

[3] Or four: we are beginning to think that some women are tetrachromats, meaning that they have photoreceptors that are optimised to detect four primary colours, rather than the standard trichromatic three. The new primary colour will be in the green range.

PART ONE

Humans and Other Animals

The data is not yet available, and studies that have been done so far have not drawn any strong conclusions or have been flawed in some way or other. Part of the discourse though is that we spend too much time on screens, when we should be doing more creative or cultural things or expressing ourselves without a reliance on technology. Of course, a paintbrush is a technological tool, as is a pencil, a sharpened stick or a particle accelerator. Very nearly nothing we do, artistic, creative or obviously scientific, could exist without technology underpinning it. Singing, dancing, even some forms of athletics and swimming, operate without direct reliance on an external technology, but as I watch my daughter tie her hair into a bun and spray it into place, clip her battered toenails and don her pointe shoes before ballet I can't help but think how we are an animal whose entire culture and existence is completely dependent on tools.

So, what is a tool? There are a few definitions. Here is one from a key textbook on animal behaviour:

> The external employment of an unattached or manipulable attached environmental object to alter more efficiently the form, position, or condition of another object, another organism, or the user itself, when the user holds and directly manipulates the tool during or prior to use and is responsible for the proper and effective orientation of the tool.

Which is wordy but covers most bases.[1] Some definitions make a distinction between use of a found object and a modified item, which qualifies it as technology. The key idea is that a tool is a thing external to the animal's body that is used to exert a physical action for the animal that extends its powers.

Tools are an inherent part of our culture. Sometimes we talk about cultural evolution in opposition to biological evolution,

the former being taught and passed down socially, the latter being encoded in our DNA. But the truth is that they are intrinsically linked, and a better way to think about it is as gene-culture co-evolution. Each drives the other, and cultural transmission of ideas and skills requires a biologically encoded ability to do so. Biology enables culture, culture changes biology.

Millions of years before the invention of the digital watch, we had an obligate technological culture. We have even specifically acknowledged our technological commitment in scientific nomenclature. One of our earliest genus cousins – probable ancestors – is named *Homo habilis*. Literally, this means 'handy man'. They were a people that lived between 2.1 and 1.5 million years ago in east Africa. There are a few specimens that have been classified as *habilis*, which generally have flatter faces than the earlier Australopithecines from around three million years ago, but still retain long arms and small heads – their brains were typically half the size of ours. To look at, *Homo habilis* would have been more ape-man than man-ape. They were probably the ancestors of the more gracile *Homo erectus*, though co-existed with them as well, maybe indicating that *Homo habilis* diverged within its own species group.

Their handy-man status is largely due to the discovery of specimens surrounded by evidence of lithic – that is, stone – technology. Some researchers suppose that the presence of tools represents the boundary between the genus *Homo* and what came before, meaning that humans are actually defined by tool use. The densest collections associated with *Homo habilis* come from the Olduvai Gorge in Tanzania, and this type of technology is referred to as the Oldowan tool set. There is a lot of technical jargon involved in describing this kit and how they were worked; 'lithic reduction' is one such term, which broadly means chipping a stone, often quartz, basalt or obsidian, to shape and sharpen. Many of the archaeological clues come in the form of lithic

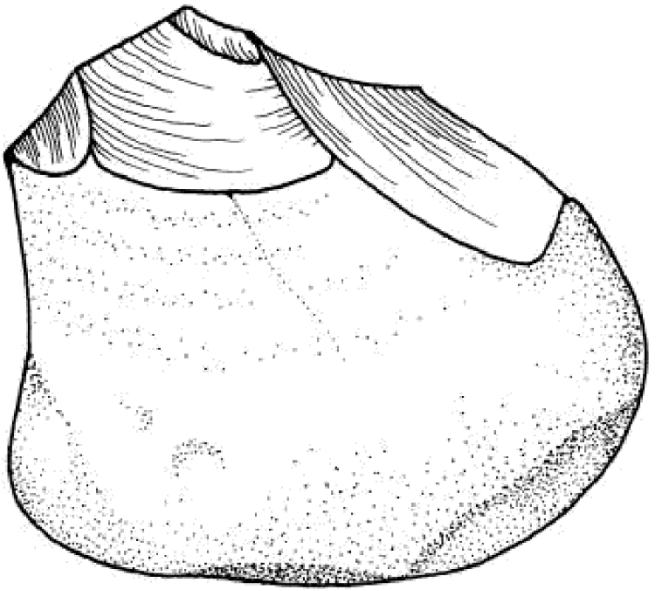
flakes – the detritus knapped from a raw stone into a tool, when the tool itself is lost in time. Obsidian[2] is an igneous rock – a type of volcanic glass, and a good choice for a cutting tool, as it forms edges so sharp that some surgeons use it today in preference to steel scalpels.

These actions imply a cognitive ability that enables selection of suitable stones, and a plan. You need a hammerstone and a platform, an anvil, on which to chip away at the raw material. Knapping is a deliberate and skilful activity, and the set required contains different tools. Some are heavy duty, such as the Oldowan chopper, which we think was used as an axe head. Others are lighter-duty tools – scrapers for removing meat from skins, chisel-edged stones called burins and other tools for engraving wood. Again, this variation in the overall set of tools presupposes a cognitive ability to distinguish appropriate tools for different actions.

Homo habilis is among the earliest members of the lineage that we have decided is human, and tool use is part of that definition. But this artificial boundary has not been borne out in scientific history; handy man wasn't the first to get handy. A thousand kilometres to the north of Olduvai is Lomekwi, on the western shore of Lake Turkana, another of the key areas in the nursery of early humans. This was the site of the discovery in 1998 of a specimen that has been designated *Kenyanthropus platyops*, roughly meaning 'flat-faced Kenyan man'.[3] It's a not-uncontroversial earlier great ape, that some have argued is morphologically similar enough to Australopithecus to suggest that it is not a separate species. I'm not sure it matters that much, as our taxonomic definitions are blurred at these arbitrary boundaries, and many assumptions must be made due to the specimens being few and far between – fragments from more than 300 Australopithecine individuals have been found, but only one *Kenyanthropus*.

In 2015, a wandering team of researchers from Stony Brook University in New York took a wrong turn in Lomekwi and stumbled into a site scattered on the surface with lithic detritus indicative of intentional tool-making. After excavating further, they found many other fragments and tools themselves. The dirt in which they were found could be accurately dated, which is not always easy, but in this case, was dependent on layers of volcanic ash, and the geological phenomenon of magnetic pole reversal.[4] The tools found are not quite as sophisticated as the Oldowan set, but are much older, probably 3.3 million years. In one case a lithic flake could be matched to the stone from which it was chipped. It is viscerally powerful: imagine an ape-like person sat right there, intentionally chipping at a rock with purpose in mind. Maybe he or she wasn't happy with how it split, discarded both halves, and moved onto something else. Or maybe it was chased away by a ravenous predator. There, the pieces lay undisturbed for more than three million years.

We don't know who it was who sat and carved those tools, though we do know that it was a creature that pre-dates the origin of the genus *Homo* – the humans – by maybe 700,000 years, and may well be the flat-faced Kenyans. The Oldowan tool set has now been found in key sites all over Africa where other significant evidence of human presence is known, including Koobi Fora on the east side of Lake Turkana in Kenya, and Swartkrans and Sterkfontein in South Africa. Further afield, these tools have been discovered in France, Bulgaria, Russia and Spain, and in July 2018, in south China – the oldest yet found outside Africa. The timescale over which this technology was used is huge, covering maybe more than a million years.



An Oldowan chopper

In our reading of the history of technology in humans, Oldowan tools in time are replaced with a new set consisting of more complicated kit. Thousands of miles from east Africa, St Acheul is a suburb of the northern French city of Amiens where, in 1859, a major haul of axe heads would come to define the most common industry in the whole of human history. They weren't the first of these discovered – in the late eighteenth century, similar examples were found in a Suffolk village near to the pleasant market town of Diss – but they are the type of specimens of what is now known as the Acheulian tool set.

Acheulian hand axes have been worked more precisely than their Oldowan ancestors. Typically, they are teardrop-shaped, chiselled into sharp points, and crafted into flattened blades, often on both sides. They are also larger, with a roughly 20cm cutting edge, compared to just 5cm in a typical Oldowan blade. They represent the fruit of a concerted cognitive ability to truly craft a tool, or a weapon, and require skilled hand–eye

and Asia. We see them slowly change in their anatomy, in species and in their global distribution, but the technology remains recognisable.

With the Lomekwi tools dated at 3.3 million years old, it's worth noting that these first technological people were already maybe four million years distant from the separation of our evolutionary branches and that of chimps, bonobos and other great apes. All of them also use tools today, which we will come to in a few pages. What we are unsure of is the continuity of cultural tool use. Humans accumulate knowledge and skills and transmit them through time, mostly without losing those acquired abilities. Generally, we don't have to invent the same technology over and over again. Have all the great apes used tools continuously since that divergence, or has tool use been forgotten and reinvented many times? This is unclear, and possibly unknowable, as there is little evidence of other great apes crafting stones, even if they did use wooden tools, which are not preserved well in the fossil record. With the advent of the basic Oldowan technology in ancestors that pre-date humans, but came after the split between those apes that would evolve to become us and those that would become gorillas, chimps and orangutans, we are witnessing an ability to deliberately manipulate external objects for specific purpose that exceeds any other animal – including all the other great apes – by a significant margin.

[1] *Animal Tool Behavior: The Use and Manufacture of Tools by Animals* by Robert W. Shumaker, Kristina R. Walkup and Benjamin B. Beck (Johns Hopkins University Press, 2011).

[2] Geologists have all the best names: obsidian is a rock formed when felsic lava rapidly cools on the edges of rhyolitic flows; that means it's rich in the silicate compounds feldspar and quartz.

[3] Historically, the word 'man' has been used to describe these species in common parlance, as in Neanderthal man, Cro Magnon Man, etc. It's a

casual usage that is annoying in that it fails to recognise 50 per cent of our species but it can be easily corrected by generally using 'human', as in humankind, which is an easy and inclusive fit. In this case though, 'human' specifically refers to the genus *Homo*, which *Kenyanthropus platyops* is not in, but *anthropus* implies human-ness, though in Greek it literally means 'man', so I'm not quite sure how to represent it here. It is a hominin, which includes both *Homo* – the humans – and Australopithecines, whose name roughly translates as 'southern ape-like things'.

[4] The magnetic poles are constantly moving and have flipped many times in our planet's history. We're not sure why and cannot predict when they will flip. The change happens over thousands of years, and no pattern has yet been discovered for the known times that magnetic north and south have reversed. But these reversals are recorded in microscopic fragments in rocks, and thus are useful for dating when the rocks were formed. The North Pole is currently moving south at a rate of about a few miles a year, though this is nothing to be worried about – it is too slow to have any noticeable effect on us, or the many migratory animals that have magnetoception and navigate using the Earth's natural polarity.

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