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INHERITING THE EARTH

Having established a zoological ancestry for humanity, countering the fundamental religious argument that we are unique and outside of nature, we follow the paths that humans have travelled out of Africa.

Originating in Africa, humanity undertook a series of migrations, spreading through Europe and Asia, finally arriving in Australia and the Americas. At some point a suite of evolutionary changes occurred that separated one line of hominins from their close relatives, with unforeseeable consequences.

Perhaps the need to accommodate to the rapid – from an evolutionary point of view – enlargement of their brains or to some other change in their environment, such as diet, our ancestors began to enter the world in an immature and defenceless condition. At another time and in another place, this could have been an evolutionary calamity, but it was accompanied by other changes to protect the newborn, including intense maternal care. A process of neoteny, not uncommon in evolution, had begun.

The change proved not to be the disaster it might have been. The babies had the potential to grow large brains, unhampered by premature hardening of the brain case. Early birthing also allowed a baby's head to fit better in the birth canal. The downside was that the hominins had to spend more time and effort in rearing their young successfully. We are now remarkable among animals for the years of work we put into our children.

It turned out in the end to be a great evolutionary success. The changes led eventually to all we take for granted in our human condition. Of course, one thing does not change in isolation. The need for prolonged child care created a selection pressure for greater cooperation within the family group to provide for and protect nursing mothers. And there were physical changes as well, developmental changes that once happened in utero that now happened in early childhood. These characteristics, once isolated from the environment, were exposed to it and subject to its influences.

Our ancestors, it seems, were the first hominins to show this form of evolution, called neoteny. It is essentially the retention of juvenile features into adulthood. It is a phenomenon that exposes persistent embryonic features to direct natural selection. Other primate species do not experience this as intrauterine development produces newborns with more advanced muscular development.

The idea that *Homo sapiens* is a neotenic chimpanzee is an idea of some antiquity. In 1929, a Dutch anatomist, Lodewijk Bolk, first drew up a list of the probable neotenic characteristics that we, as adults, display:

1. A rounded, bowl-shaped cranium to house a brain that will grow to about four times its volume at birth.
2. A juvenile face that lacks the brow ridges and the heavy jaw development that is characteristic of adult apes.
3. The spinal cord enters the skull at a point vertically underneath it and does not move towards the back during development, thus making an upright stance possible.
4. Late closure of skull sutures and persistence of cartilaginous bone ends (epiphyses) into early adulthood.
5. In women, the vaginal canal does not rotate backwards, as it does in chimpanzees, but remains directed forward.
6. A big toe that remains aligned with the other toes and does not rotate sideways and become opposable, like a thumb.

Compared with our simian cousins, our skeleton is under-developed at birth, with cranial sutures not yet joined, and uncalcified ends to the long bones which do not fuse together until puberty and a ‘straight’, rather than a grasping, big toe. An unfortunate legacy, a backbone better suited to walking on all fours than standing upright is still a human drawback today.

In women, the reproductive tract does not rotate rearwards, as in apes. Its more forward position facilitates face-to-face sexual and other communication. All this was accompanied by a period of intense social evolution that paved the way for collaborating communities. It must be said that this appealing concept is not without its critics. Shea (1989) considered the evidence, and concluded that there was a case, but it was 'relatively weak' (which might be interpreted as 'quite strong' depending on your point of view!).

So now, equipped with a bipedal posture made possible by longer legs and changes to the skull, combined with a Palaeolithic tool kit that included stone points, hand-held axes and fire-hardened spears, ancient humans were ready to leave Africa. Recent fossil evidence from Morocco suggests that archaic *Homo sapiens* were in north Africa as much as 300,000 years ago (Hublin et al. 2017). According to Groves (pers. comm.) 'modern' humans appeared first in Africa and began their migrations into Europe and Asia about 80,000 years BP (before present). Evidence for this comes from 'modern' human fossils found in the Middle East, suggesting the trip was made from the Horn of Africa to the Arabian Peninsula by rafts or by island-hopping, or even walking, when the sea level was about 70 metres lower than it is today.

This was a trip that other non-*sapiens* hominins had made much earlier. For example, the diminutive 'hobbit' had already drifted as far as Indonesia. Argue and colleagues (2017) conclude that the most likely origin for the 'hobbit' is from an early *Homo* lineage, such as *Homo erectus*, who wandered all over Africa, but also made it out of Africa and into Asia. Its most recent fossils in Asia are dated at 140,000 BP. The Neanderthals were in Europe and Asia 400,000 BP, and persisted until 40,000 BP, making them partly contemporaneous with modern humans. Cohabitation probably accounts for the Neanderthal genes we possess.

The fact that the date for the exodus from Africa of *Homo sapiens* is set around 80,000 years ago is consistent with the new estimates for human arrival in northern Australia. This is ample time for humans to have made the trip given the built-in error in the age estimates. The very recent discovery of polished stone axes dated to 65,000 BP, and other artefacts, such as the presence of red ochre for decoration and/or ritual purposes, suggests that modern humans – Aboriginals – were in Australia at least 10,000 years earlier than previously thought.

The first scanty suggestions of human abstract thought come from well before the last ice age. The carefully laid-out body of Mungo man in Australia, from 40,000 years ago, supports this. More recently, even clearer evidence of abstract thought is found in the cave paintings in Australia, France and Spain. The images are of animals and food sources, and other symbols of social custom. It has been suggested that these cave drawings were intended to increase the luck of the hunters, to show respect for others or to invoke help from spiritual beings. A stone figure of a plump woman, the 'Venus of Willendorf', carved 28,000 years ago, might have served all three purposes. The careful burial of a man, at about the same time, decorated with ochre strongly suggests that those who grieved had the concept of an afterlife.

Exciting recent finds in northern Australia carry implications for our understanding of the spread of humans around the globe, but also pose some more immediate questions (Clarkson et al. 2017). If humans have been in Australia for 65,000 years, why is there no evidence for their spread to the Lake Mungo region over the following 15,000 or so years? Perhaps the Lake Mungo people just took a long way round or the time gap is simply due to too few archaeologists searching too large an area.

If you go to Lake Mungo – now dry for several thousand years – and stand on the old lakebed, you can gaze up at the huge sand dunes on its eastern shore. You are now looking at the so-called 'Walls of China'. The dunes are called lunettes and they are on the move. The prevailing wind is picking them up, sand grain by sand grain, and shifting them further east. As the top of the dune drifts away it uncovers a few old and twisted long-dead trees, stone tools and old fireplaces, all that remains of an ancient Aboriginal community. As you stand there, you will experience a silence broken only by the soughing of the wind and the hissing of the sand. For a European it is a numinous experience, akin to standing in the nave of a great cathedral. A conservative estimate suggests that the site may have been occupied for 50,000 years.

There are two important discoveries of early humans at Mungo. Lake Mungo 1 includes the earliest evidence, 40,000 years old, of a cremation. The bones are those of a woman, who has now been returned to her people. A second skeleton, Lake Mungo 3, an unusually tall and slim man, had been buried on his back with his hands folded over his abdomen. Controversy surrounded his geological age, but it is now accepted that he was more or less contemporaneous with the cremated woman.

Good stone for the manufacture of tools is scarce in the area, and most of that worked by the Lake Mungo people has been imported from elsewhere. Points, knives, hand axes and grindstones have been recovered. The grindstones served the same purpose as the mortars and pestles used in kitchens of today: they are large and flat, with a circular, shallow bowl worn into one surface by the continuous pounding and grinding of seeds and other plant material with a rounded stone reserved for the purpose.

If you now journey from Lake Mungo, and travel just over 900 kilometres north-east as the crow flies, and 20,000 years forward from the time of the Lake Mungo people, you will find yourself in Carinda, New South Wales. Carinda, a small town of perhaps 200 people, is close to the important archaeological site of Cuddie Springs.

Cuddie Springs is the site of yet another of Australia's dry lakes, a basin about 3 kilometres wide. Fossils of all kinds of animals have accumulated there, animals that, in life, were attracted to the shrinking waters and then died there from various causes. The fossil-bearing strata are 3 metres thick. The bottom levels are dated at 50,000 years ago. Signs of human activity, as well as the bones of large animals (examples of some of the famed Australian megafauna), are found at about the 30,000-year horizon. This fact alone should persuade people that the Aboriginals had cohabited with megafauna without immediately bringing about their extinction.

There is, however, little doubt they caught these large marsupials – or took advantage of them being mired in the lake margins – and ate them. A worn stone core was found, still showing traces of fur and blood, suggesting it was used in butchering. Preliminary results of the analysis of DNA extracted from the megafaunal bones indicate that they were those of a giant kangaroo (*Macropus titan*) and an even larger *Diprotodon,* some species of which were rhinoceros sized. Even more interesting, a number of grindstones were found, with traces of plant tissue and starch granules on their surfaces. Nearby, charcoal suggests the presence of cooking fires. It seems likely that these people were among the first bakers in the world.

Now fast-forward to the year AD 1800 and the arrival of the European explorers. In his fascinating and award-winning book, Bruce Pascoe (2018) has collected and annotated eyewitness accounts of Aboriginal society by European explorers. For example, Major Thomas Mitchell, in Western Australia, wrote in 1839:

> the grass is pulled and piled in hayricks, so that the aspect of the desert was softened into the agreeable semblance of a hayfield … we found the ricks or haycocks …
>
> … dry heaps of this grass that has been pulled expressly for the purpose of gathering seed lay along our path for many miles …
>
> … the seed is made by the natives into a kind of paste or bread.

This surely goes beyond simple gathering. It is agrarian industry, its origins clearly of great antiquity. Pascoe goes on to provide evidence for the cultivation of yams and other food plants, for irrigation, of ancient fish-traps, of stone structures and of the benefits of the so-called 'firestick farming'. In one poignant story he tells of a proud settler demonstrating European methods by ploughing up and down a slope. The local people, however, were not having their precious soils, soils that they had been conserving for millennia, washed away by runoff and as soon as possible reorganised the area so the furrows ran parallel across the slope.

One settler disparaged these activities as 'the accidental semblance of gardening' and we may imagine that this particular view was conveniently extended to deny other agricultural activities. It is hard to see at this distance what would have convinced the settlers that the locals were acting with purpose gained from long experience.

Eva Jablonka and Marion Lamb (2014) describe 'evolution in four dimensions' – genetic (based on gene variation), epigenetic (based on environmental effects on development), behavioural (based on cultural change) and symbolic (based on communication and learning). Lake Mungo provides evidence for all four having been in place for human beings in Australia for at least 50,000 years.

The evidence collected throughout this time supports the thesis that cooperation is the mainspring of evolution. Genetic selection has led to human groups with similar physical characteristics creating communities. Belief systems, informal and formal, provided the glue that held the early communities together. A belief held in common, however badly based on reality, ensured that the community learned to act in concert against a perceived existential threat, whether it was imaginary, as in the case of a wrathful god, or real, in the form of an angry cave bear. The capacity for belief seems to be innate in humankind; it is as pointless to tell someone to stop believing, whether in transubstantiation or little green men from Mars, as to ask somebody to tell their pancreas to stop producing insulin.

Epigenetics, the idea that inheritable changes can be brought about by the environmental context, is a more recently respectable study. Farming to ensure a continuous supply of food is one such example. The discovery of a form of farming by Aboriginals may predate by millennia the similar discovery in the Middle East. In so doing, they modified the selection pressures that were originally present in the environment and provided new opportunities for epigenetic evolution. The interaction between humans and their environments is an effective form of niche improvement.

This, then, is the period for humans when the nature of evolutionary change entered a new dimension. Up to this point, the inheritable changes, on which Darwinian evolution depends, have depended on the modification of pre-existing genetic programs. With the development of social and cultural environments, *Homo sapiens sapiens* created a very different evolutionary milieu. It was one that was facilitated by language and all the forms of collaboration provided by a mutually cooperative society: as individuals living and working together, as communities with deep attachments to their land, and in structured organisations.

Everyone accepts that animals have 'behaviour'. At what point does complex behaviour become 'culture', with its sophisticated forms of expression, symbols and ritual? In the northern hemisphere, farming, a cultural phenomenon, is assumed to have started about 12,000 years ago in Mesopotamia, well after the recent Australian discoveries. However, culture does not arise fully-fledged. There must have been 'proto-farmers' attempting to improve their land, their evolutionary niche, by trial and error. Even in medieval times in Europe, farming theory was so rudimentary that often the most valuable thing a farmer could leave his son was a well-stocked dungheap. Without this important resource to replenish depleted farmland, the family was in danger of starving.

We are comfortable with the idea of animal behaviour, but can animals have culture? Animals can learn. Blue tits in Britain are famous for learning to open milk bottles to get at the cream (Aplin et al. 2013). It presumably started out with the birds' random explorations of a new environmental factor – the closed milk bottle – in their normal environment. In whatever way it came about, the lid was breached, the bird got the cream and this happy outcome reinforced the behaviour. Because the blue tit lives in family groups, the new skill, of opening bottles, was quickly learned by others in the group. Juvenile females proved more likely to learn the trick. Had this habit been allowed to persist, it is likely that evolutionary

changes would have occurred, perhaps to the birds' digestive physiology. Without the actual presence of the appropriate bottles, the birds had no means of passing it along to future generations. Sadly for the tits, the bottles were replaced by others with better seals. The new habit died out. It had been behavioural, tied to a very specific sort of bottle top, rather than culturally applicable to all bottle tops.

Consider now a group of Japanese macaque monkeys of Koshima Islet that has long been studied by behavioural scientists (Visalberghi and Fragaszy 1990). The monkeys live close to a warm spring. In winter these animals developed the habit of going swimming to keep warm, especially the mothers with their babies who thoroughly enjoyed frolicking in the water. One of these mothers was particularly clever. If fruit or vegetables were left on the sand for her, she would pick them up and take them to the water's edge and wash the sand off before eating them. Other female monkeys observed her doing it, and they all started washing the sand off their food before they ate. The young monkeys learned to do likewise, and this trick was added to the standard behaviour of the animals. It is interesting that the males did not learn to carry out either process, perhaps because they were less social than the females.

It is likely that there are many other monkey tricks that are potential precursors of human behaviour. Non-human primate archaeology is a new field that is providing insights into monkey behaviours that have respectable histories. Many monkeys use stones to crack nuts and they have favourite stones that they use as hammers and anvils. In so doing, they occasionally produce sharp-edged flakes that resemble the flake tools of early humans, although there is as yet no evidence that the monkeys use them in the way that early hominids did.

The next story is an example of learning as part of the acculturation of a human being. It is 1948. A 12-year-old boy is looking forward to an afternoon of 'stinks' in the chemistry laboratory at school. The schoolmaster in charge has promised that the experiment will be 'to burn metals in air'. The boy considers that this is both worth learning and fun. The society in which he lives confirms that it is worth learning because it is in the course notes. He takes his place at his workbench and watches as the chemistry teacher carries out the experiment, explaining as he goes along. Now, says the teacher, you do it. The teacher wanders around, giving advice and answering questions and under his watchful eye the boy carries out the experiment successfully.

The boy has learned a number of new skills in carrying out the experiment, skills that will come in handy in next week's lab session and, maybe, for a lifetime after. He writes the experiment up in a laboratory notebook to which he can refer if necessary and which, ideally, anyone else could use to repeat this experiment.

This process differs from the experience of the brainy macaque in a number of ways. First, inherited social conditions ensured that the laboratory, the teacher and the boy were all there at the same time. The boy and the schoolmaster could speak to each other, not only in the same language, but also using highly specialised terms of the science. The schoolboy had enjoyed a glimpse of a subculture of the main culture to which he belonged, the discipline of chemistry. In the language of his own boyish subculture, however, chemistry was 'stinks' and things excellent were 'trick super!' The laboratory itself spoke of a rapidly fading past subculture, with bottles labelled 'caustic potash', 'vitriol', 'blue vitriol' and 'hydrargyrum' (potassium hydroxide, sulphuric acid, copper sulphate and mercury).

The master had his own subculture, with the language of, fortunately, modern chemistry. He was there, not just to produce a single change of behaviour in the boy, but to play his part in educating a community. He was also a model for a technical performance and a prestigious member of their shared society. The whole process was designed to hand on the socialisation as well as the expertise. When the boy went home that night, he used the language of the main culture to explain to his parents what he had done at school and showed them the written symbols in his lab book. In a couple of decades or so he could have shown it to his own 12-year-old son, who would have understood it. This is cultural learning.

The transfer and acquisition of cultural learning provides an environment for inherited change totally different from that offered by the natural world. Darwin did acknowledge this in his treatise on the emotions although he didn't take it any further. Changes in thinking, use of language, standards of behaviour and values cannot be equated to genetic inheritance, although they can lead to evolutionary changes by contributing to the wellbeing and survival of a greater number of people than otherwise might have done so – an example of niche improvement.

The boy's story was drawn from the cultural context of one of the authors of this book in mid-twentieth-century lower-to-middle-class England. There are many different cultures, all offering different evolutionary

possibilities. Sadly, there is also the possibility of toxic cultures – the Stalinist purges, Nazism, the Pol Pot regime – but these fortunately have shown a tendency in the past not to survive for very long. There is a phrase, 'cultural memes', for words such as gene, sustainability, and learning that Dawkins and other writers argue are the cultural equivalent of genes (Heylighen 1998). Some memes, like some genes, have negative consequences.

The clever macaque may pass on her idea to other monkeys – monkey see, monkey do – especially her young ones. However, we must presume she cannot generalise and use her discovery in other contexts. Nor can she tease out the original principle from her empirical understanding of washing sand off her fruit – the idea of specific gravity, and that sand has a higher specific gravity than most fruit and will sink in water – because that requires the symbolic representation supplied by language. She may be no better off at thinking than the blue tits. Changes in human thinking have been variously described: by positivists as recombination of memes, by geneticists as evolutionary advances, by anthropologists as the 'golden bough', by the classicists as the great chain of being and by science fiction authors in as many forms as imagination can take.

Organic evolution was, in Darwin's time, a new way of thinking, and although he shattered the boundaries of Victorian thought, he was confined both by what he did know and what he could not know. We too are similarly constrained because we can only discuss evolution in terms of the ways of thinking of our own times.

The same is true for studies of evolution of the mind. Physical differences mark Neanderthal, Cro-Magnon and modern humans. Early palaeontologists could not resist the idea that the three represented an evolutionary sequence. This idea has now been discarded and they are understood to represent parallel evolutionary lines with a common ancestor. Even the supposition that the Neanderthals were less intelligent than modern humans, based on skull shape, has been dismissed. It is now generally accepted that *Homo sapiens* originated in Africa and different groups emerged from Africa at various times and spread across the world. As they travelled, each developed physical differences, in response to the environments in which they settled, that are still apparent today. In the modern era, movements of huge populations of travellers and asylum seekers are leading to intermarriage and a mingling of genetic information across a wider spectrum than ever before.

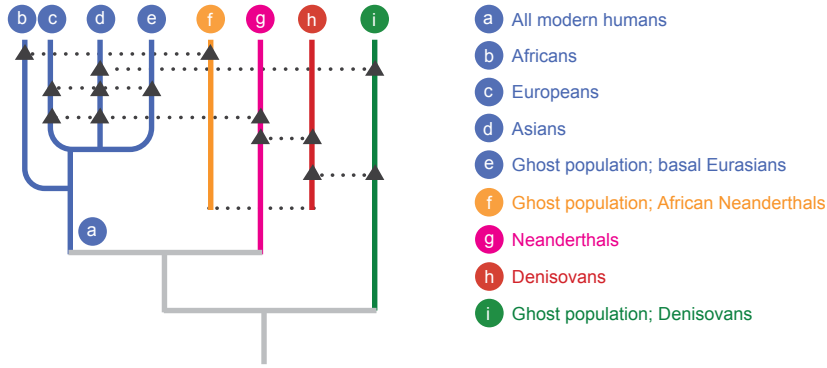

Figure 19. Ghosts in the DNA.

In spite of the differences, however, we are all one species if the standard definition – a group of individuals that actually or potentially interbreed in nature and produce fertile offspring – is accepted. Recent genetic analyses from fossil humans and from living humans belonging to defined groups, like Africans, Asians and Europeans, have suggested a human family 'tree' strongly reminiscent of an irregular network. A bone from the Denisova cave in Russia has yielded 'fossil' DNA. This young person is a perfect hybrid of Neanderthal and Denisovan; in other words they represent the immediate offspring of a mating between the two types of parents. Even more astonishing are the 'ghosts' in the DNA of various types of human.

A recent study, reported in *New Scientist* (Brahic 2018), describes the discovery of 'ghost' DNA from different sorts of humans (Figure 19). The 'ghosts' are of people who once formed coherent groups as distinctive as Neanderthals and Denisovans, but who are only known by their specific DNA and are unknown in the fossil record. In the figure, these 'ghosts' are indicated by dotted horizontal lines. Thus, modern humans (b) share DNA with a 'ghost' population of African Neanderthals (f), and so on. They are indeed true 'missing links' known only from samples of DNA. It says something about the inclusiveness of our ancestors. When two groups met, and each looked human to the other, they mated. Perhaps, like bonobos, copulation was used as a way of defusing potentially aggressive situations.

Language, spoken or written, is a principal driver of social evolution. Before there was written language there was an oral tradition. Modes of artistic representation had the same effect. The Pleistocene drawings of cattle in the Lascaux caves, the religious icons of the Renaissance,

the realistic paintings at the turn of the nineteenth century, impressionists at the turn of twentieth and the abstractions of this twenty-first century both record and shape the societies of their times. The cultural effects of change can reside in the very identity of a place. Change it, or move the people, and a culture and its individuals change dramatically. The same degree of change was observed with the advent of the electronic era, when, according to McLuhan (1967), the medium became the message.

Yet another avenue of change is in the educational transfer from one generation to another, as in our example of the schoolboy. Here there is a formal connection between evolutionary, environmental and social change. In the twentieth century, the 'jug and glass' concept of education was common, where knowledge is poured from a reservoir (a jug or a schoolteacher) into an empty glass in the form of a small boy or girl, until they are full and able to empty it out again in written form in an examination hall. Now that has given way to 'discovery learning', and the view of the world has changed. Research has become an investigation into physical environments and the chemical structure of the units of inheritance. This in turn allows human interventions that change the structure of the environment and so influence the evolutionary direction of the era.

The cultural setting shaped by social learning is always a complex construction of law, education, beliefs, resources, defences, health and landscape. The problems posed by any historical period can only be completely understood by the people living in it at the time. Oral history, poetry, theatre and creative literature have been brought in to help this process in the past, as now we depend on the cinema, television, the press and social media. We can, however, only build our ideas of the evolution of the mind through archaeological discoveries and historical analyses. It is often a very chancy business.

There is much evidence that the evolution of *Homo sapiens* has not stopped. At a recent conference (reported by Pennisi 2016), considerable variation was reported in human DNA of the last hundred years or so. For example, a 'smoker's gene' that makes some people more vulnerable than others to the effects of smoking has become less common in the population, presumably because of the increased early mortality of heavy smokers. At the same conference it was reported that in traits controlled not by a single gene but by hundreds of genes, there were many small

changes occurring. Among those are height, head circumference in infants and hip size in women. Many other changes were noted across the whole human genome.

Here are more examples of changes that affect human interrelationships that may bring about evolutionary change. Please keep in mind the statisticians' mantra that correlation is not causation! Similar variations with time in two separate sets of relationships do not necessarily mean that one is causing changes in another. One classic statistical joke is that, in our society, there is a positive correlation between the incomes of bishops and prostitutes. We must suppose that it is not that one has a direct influence on the other, but that both live in the same economic climate.

Late onset menstruation has been found to correlate with longer life. In Western society, however, menstruation is coming earlier and life expectancy is increasing rapidly. The incidence of pale skin, blond hair and blue eyes is correlated with a diet change. Perhaps the shift from fish and nuts to grain and meat with the onset of farming led to vitamin D deficiency and favoured those with paler skins. Mate selection in Africa is heavily influenced by the occurrence of steatopygia in women, the possession of large buttocks that evidently act as a fat store. This has survival value in a country that suffers regular famine. At the other end of the scale, the Western ideal of female body image reaches to the point of anorexia, even within members of the British royal family.

At the start of the fourteenth century, it is estimated that the world population was 450 million. By the end of the century it was down to perhaps 350 million, mainly due to the depredations of the plague. This is a stark reminder to us of the perils of being a species monoculture. People or potatoes, it is the same. If a lot of them grow together, they become vulnerable to disease (such as plague, *Yersinia,* or potato blight, *Phytophthora*), because of the ready availability of new individuals to infect. Famine caused by one organism (*Phytophthora*) affected the lives of a great proportion of the Irish population in the nineteenth century, displacing them from their homes and subjecting them to previously unexperienced social evolutionary pressures. A disease that has a low incidence in a sparse and scattered population can be disastrous in cities or cultivated fields of crops. The 1918 flu epidemic infected 500 million and may have killed 100 million of them. Young adults were susceptible and this, coming on top of the tragic Great War that killed a great many young men, left a generation of young women who had learned or had to

learn to be self-reliant without husbands. A door was slammed on *La Belle Époque* and Edwardian Britain, and a very different Europe went forward to fight World War II. Society and natural selection had conspired and the human world became as we see it today.

This is why the bird flus of recent years and other errant viruses such as Ebola are of such concern. The last had a fatality rate of 90 per cent when it emerged. Humans and virus were both under intense selection pressure. Resistance to Ebola does occur naturally in humans and fortunately the virus does not survive well outside its host. Resistant people are the ones who will repopulate the world in the event that the virus crosses its own Rubicon and becomes more resistant to external conditions and moves out of Africa.

A pandemic, such as the plague, thus has the power to bring about a radical change in society and, by so doing, change the course of history and of human evolution. (This text was written, by the way, before COVID-19 and its impact on our modern society.) In the fourteenth century, before the plague struck, the social order was that of feudalism, a pyramid-like structure in which the lord of a manor held his land on swearing loyalty to the local baron who in turn owed service to the monarch. The lord of the manor had yeomen farmers who owed him loyalty, and they in turn had serfs, effectively slaves, who worked the land, in return for a living for themselves and their families. In times of war everyone was expected to answer the call of the monarch or pay a fine. This system was sustained by the farm work of the lowest echelons and no serf or yeoman could change masters to go looking for a better position. The plague changed everything. Labour became scarce and whereas before a serf would have been returned to his lord if he started looking for work, now he was welcomed with open arms. With freedom of movement, feudalism collapsed, giving way to the agrarian revolution of the fifteenth century and eventually the Enlightenment.

By the beginning of the nineteenth century there were more humans on the move than ever before in history. The British, Spanish, French, German and Portuguese sought to build Empires. The result is that, in a country like Australia that encouraged immigration, over half the population now has a language other than English spoken at home. The diaspora of the Irish and the Chinese in the nineteenth century showed that people

were more mobile, with whole clans moving by boat, by roads and most recently by air. There has been a major mixing of genes, traditions of child-rearing, and social structures, from democracies to dictatorships.

At the time of writing this, the world is in the grip of a pandemic due to COVID-19, a disease caused by a new coronavirus. With 'social distancing' and 'lockdown' quarantine measures, habits of generations are being disrupted all over the world. There is much speculation that the world will never be the same again. At the very least, 'working at home' is likely to become more common; likewise with 'distance teaching'.

It is possible for every person to be influenced directly by the cultures of seven generations: those of their own, those of their parents and children, their grandparents and grandchildren, and their great-grandparents and great-grandchildren. As generations overlap, cultural communication can occur. As an example, one of us has memories of many songs of the Victorian Music Halls from his grandmother who learned them from her own mother. Similarly, it is likely that aspects of his own twentieth-century acculturation will be passed to his yet-to-be-born great-grandchildren.

Another instance of social selection, very different from what had gone before, occurred within the technical environments created by the Victorian Industrial Revolution. The great landowners seized on technology as a means to feather their own nests at the expense of the agricultural working class. They imposed a version of their existing aristocratic hierarchical society on the new culture that began to emerge. It was this elitist setting that nurtured the socially based reorientation of Darwin's work as 'survival of the fittest/wealthiest' almost as soon as the *Origin* was published. God was an Englishman and all was right with the world. To paraphrase Donald Horne (1970), only Englishmen with such a world view could sing of England in the words *of Land of Hope and Glory:*

> God, who made thee mighty,
> Make thee mightier yet!

At the same time, contemporary records show clearly that Darwin himself – and his defenders and myriad collaborators of all classes – were entirely aware of the collective thinking that led him to build his knowledge from all available sources and thereby pursue his idea of evolution by natural selection.

An even more surprising contributor to the evolutionary process is the influence of the digital revolution. This is so recent that we do not yet know the effects on populations or individuals, except that they are going to be massive. The designer of the first personal computer, and the first human–electronic partnership was Norbert Wiener (1988). He created the first human–electronic arm – only a few steps away from the science fiction cyborg. He described the personal computer as a prosthesis of the mind, somewhat like the electronic arm. Even more important, he predicted that, for the first time in the history of the planet, the global environment would be constructed by humans, and that evolutionary pressures would derive from that human-made context, a circular effect.

In his seminal book, Wiener points out that, as yet, there is no ethical system to guide us in this new world. Wikileaks, social media such as Facebook and Twitter, fake news and alternative facts are part of this story. Our understanding of evolution needs to encompass the complexity, and the essential contribution of a collective understanding to the genetic, epigenetic, cultural and symbolic dimensions of evolutionary change. Whereas in social animals, such as ants, symbols tend to be olfactory and tactile – where scent and touch have meaning – human symbols may be auditory, visual, tactile and, to a lesser extent, olfactory. Immensely complex combinations are possible, providing the glue for complex societies. A collective understanding of a collective process ought to create a better world for humans to live in. It is, potentially, niche improvement on a grand scale and, at best, will contribute to human survival, wherever on Earth humans find themselves. Societies may themselves form a culture and contain lesser cultures within. Roman civilisation, in its heyday, embraced people black, white and brindled, together with the gods of their choice.

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