



# Future evolution: How will humans change in the next 10,000 years?

BY NICHOLAS R. LONGRICH

Humanity is the unlikely result of 4 billion years of evolution. From self-replicating molecules in Archean seas, to eyeless fish in the Cambrian deep, to mammals scurrying from dinosaurs in the dark, and then, finally, improbably, ourselves – evolution shaped us.

Organisms reproduced imperfectly. Mistakes made when copying genes sometimes made them better fit to their environments, so those genes tended to get passed on. More reproduction followed, and more mistakes, the process repeating over billions of generations. Finally, Homo sapiens appeared. But we aren't the end of that story. Evolution won't stop with us, and we might even be evolving faster than ever.

It's hard to predict the future. The world will probably change in ways we can't imagine. But we can make educated guesses. Paradoxically, the best way to predict the future is probably looking back at the past, and assuming past trends will continue going forward. This suggests some surprising things about our future.

We will likely live longer and become taller, as well as more lightly built. We'll probably be less aggressive and more agreeable, but have smaller brains. A bit like a golden retriever, we'll be friendly and jolly, but maybe not that interesting. At least, that's one possible future. But to understand why I think that's likely, we need to look at biology.

The end of natural selection? Some scientists have argued that civilisation's rise ended natural selection. It's true that selective pressures that dominated in the past – predators, famine, plague, warfare – have mostly disappeared.

Starvation and famine were largely ended by high-yield crops, fertiliser and family planning. Violence and war are less common than ever, despite modern militaries with nuclear weapons, or maybe because of them. The lions, wolves and sabertoothed cats that hunted us in the dark are endangered or extinct. Plagues that killed millions – smallpox, Black Death, cholera – were tamed by vaccines, antibiotics, clean water.

But evolution didn't stop; other things just drive it now. Evolution isn't so much about survival of the fittest as reproduction of the fittest. Even if nature is less likely to murder us, we still need to find partners and raise children, so sexual selection now plays a bigger role in our evolution.

And if nature doesn't control our evolution anymore, the unnatural environment we've created – culture, technology, cities – produces new selective pressures very unlike those we faced in the ice age. We're poorly adapted to this modern world; it follows that we'll have to adapt.

And that process has already started. As our diets changed to include grains and dairy, we evolved genes to help us digest starch and milk. When dense cities created conditions for disease to spread, mutations for disease resistance spread too. And for some reason, our brains have got smaller. Unnatural environments create unnatural selection.

To predict where this goes, we'll look at our prehistory, studying trends over the past 6 million years of evolution. Some trends will continue, especially those that emerged in the past 10,000 years, after agriculture and civilisation were invented.

We're also facing new selective pressures, such as reduced mortality. Studying the past doesn't

help here, but we can see how other species responded to similar pressures. Evolution in domestic animals may be especially relevant – arguably we're becoming a kind of domesticated ape, but curiously, one domesticated by ourselves.

I'll use this approach to make some predictions, if not always with high confidence. That is, I'll speculate.

## Lifespan

Humans will almost certainly evolve to live longer – much longer. Life cycles evolve in response to mortality rates, how likely predators and other threats are to kill you. When mortality rates are high, animals must reproduce young, or might not reproduce at all. There's also no advantage to evolving mutations that prevent ageing or cancer – you won't live long enough to use them.

When mortality rates are low, the opposite is true. It's better to take your time reaching sexual maturity. It's also useful to have adaptations that extend lifespan, and fertility, giving you more time to reproduce. That's why animals with few predators – animals that live on islands or in the deep ocean, or are simply big – evolve longer lifespans. Greenland sharks, Galapagos tortoises and bowhead whales mature late, and can live for centuries.

Even before civilisation, people were unique among apes in having low mortality and long lives. Hunter-gatherers armed with spears and bows could defend against predators; food sharing prevented starvation. So, we evolved delayed sexual maturity, and long lifespans – up to 70 years.

Still, child mortality was high – approaching 50 percent or more by age 15. Average life expectancy was just 35 years. Even after the rise of civilisation, child mortality stayed high until the 19th century, while life expectancy went down – to 30 years – due to plagues and famines.

Then, in the past two centuries, better nutrition, medicine and hygiene reduced youth mortality to under 1 percent in most developed nations. Life expectancy soared to 70 years worldwide, and 80 in developed countries. These increases are due to improved health, not evolution – but they set the stage for evolution to extend our lifespan.

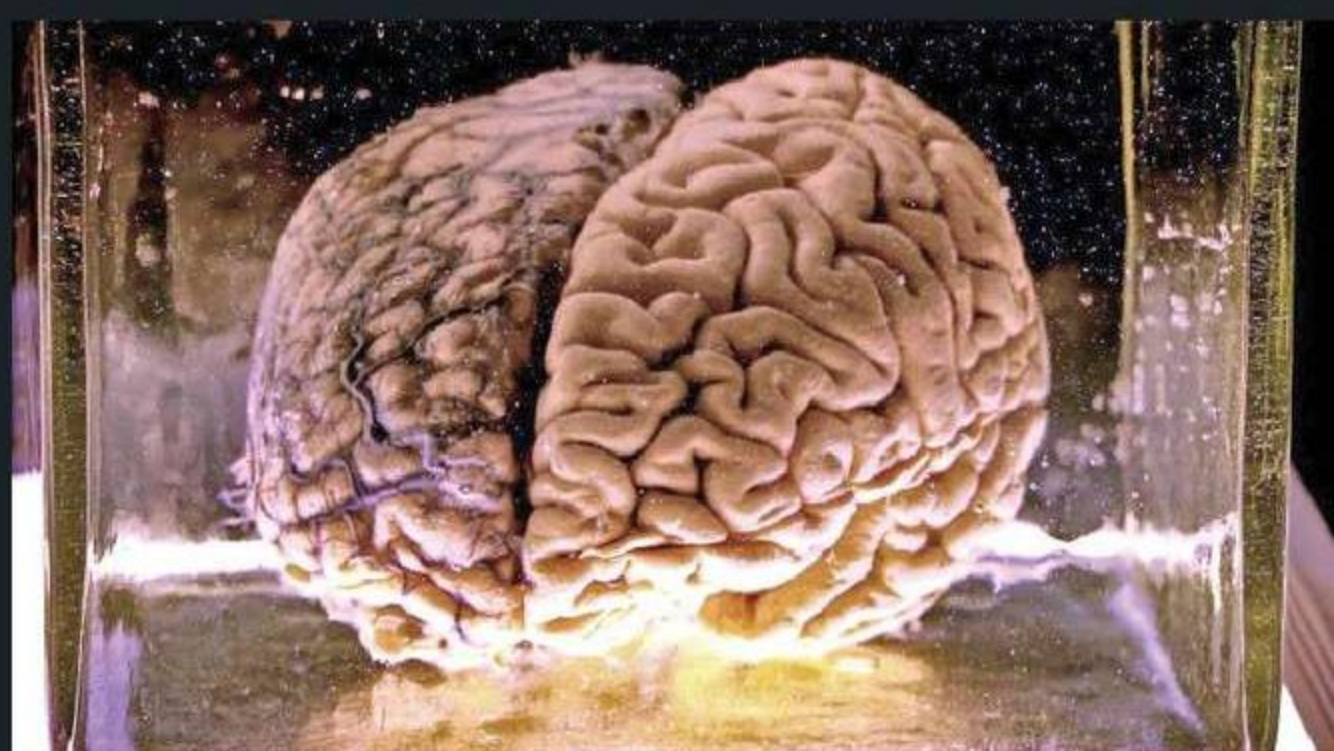
Now, there's little need to reproduce early. If anything, the years of training needed to be a doctor, CEO, or carpenter incentivise putting it off. And since our life expectancy has doubled, adaptations to prolong lifespan and child-bearing years are now advantageous. Given that more and more people live to 100 or even 110 years – the record being 122 years – there's reason to think our genes could evolve until the average person routinely lives 100 years or even more.

## Size, and strength

Animals often evolve larger size over time; it's a trend seen in tyrannosaurs, whales, horses and primates – including hominins.

Early hominins like Australopithecus afarensis and Homo habilis were small, four to five feet (120cm-150cm) tall. Later hominins – Homo erectus, Neanderthals, Homo sapiens – grew taller. We've continued to gain height in historic times, partly driven by improved nutrition, but genes seem to be evolving too.

Why we got big is unclear. In part, mortality may drive size evolution; growth takes time, so longer lives mean more time to grow. But human females also prefer tall males. So both lower mortality and



Our brains – and those of many other animals – are getting smaller. Sexual preferences will likely cause humans to get taller. Today, the tallest people in the world are in Europe, led by the Netherlands. Here, men average 183cm (6ft); women 170cm (5ft 6in). Someday, most people might be that tall, or taller.

As we've grown taller, we've become more gracile. Over the past 2 million years, our skeletons became more lightly built as we relied less on brute force, and more on tools and weapons. As farming forced us to settle down, our lives became more sedentary, so our bone density decreased. As we spend more time behind desks, keyboards and steering wheels, these trends will likely continue.

Humans have also reduced our muscles compared to other apes, especially in our upper bodies. That will probably continue. Our ancestors had to slaughter antelopes and dig roots; later they tilled and reaped in the fields. Modern jobs increasingly require working with people, words and code – they take brains, not muscle. Even for manual labourers – farmers, fisherman, lumberjacks – machinery such as tractors, hydraulics and chainsaws now shoulder a lot of the work. As physical strength becomes less necessary, our muscles will keep shrinking.

Our jaws and teeth also got smaller. Early, plant-eating hominins had huge molars and mandibles for grinding fibrous vegetables. As we shifted to meat, then started cooking food, jaws and teeth shrank. Modern processed food – chicken nuggets, Big Macs, cookie dough ice cream – needs even less chewing, so jaws will keep shrinking, and we'll likely lose our wisdom teeth.

## Beauty

After people left Africa 100,000 years ago, humanity's far-flung tribes became isolated by deserts, oceans, mountains, glaciers and sheer distance. In various parts of the world, different selective pressures – different climates, lifestyles and beauty standards – caused our appearance to evolve in different ways. Tribes evolved distinctive skin colour, eyes, hair and facial features.

With civilisation's rise and new technologies, these populations were linked again. Wars of conquest, empire building, colonisation and trade – including trade of other humans – all shifted populations, which interbred. Today, road, rail and aircraft link us too. Bushmen would walk 40 miles to find a partner; we'll go 4,000 miles. We're increasingly one, worldwide population – freely mixing. That will create a world of hybrids – light brown skinned, dark-haired, Afro-Euro-Australo-Americo-Asians, their skin colour and facial features tending toward a global average.

Sexual selection will further accelerate the evolution of our appearance. With most forms of natural selection no longer operating, mate choice will play a larger role. Humans might become more attractive, but more uniform in appearance. Globalised media may

also create more uniform standards of beauty, pushing all humans towards a single ideal. Sex differences, however, could be exaggerated if the ideal is masculine-looking men and feminine-looking women.

## Intelligence and personality

Last, our brains and minds, our most distinctively human feature, will evolve, perhaps dramatically. Over the past 6 million years, hominin brain size roughly tripled, suggesting selection for big brains driven by tool use, complex societies and language. It might seem inevitable that this trend will continue, but it probably won't.

Instead, our brains are getting smaller. In Europe, brain size peaked 10,000–20,000 years ago, just before we invented farming. Then, brains got smaller. Modern humans have brains smaller than our ancient predecessors, or even medieval people. It's unclear why. It could be that fat and protein were scarce once we shifted to farming, making it more costly to grow and maintain large brains. Brains are also energetically expensive – they burn around 20% of our daily calories. In agricultural societies with frequent famine, a big brain might be a liability.

Maybe hunter-gatherer life was demanding in ways farming isn't. In civilisation, you don't need to outwit lions and antelopes, or memorise every fruit tree and watering hole within 1,000 square miles. Making and using bows and spears also requires fine motor control, coordination, the ability to track animals and trajectories – maybe the parts of our brains used for those things got smaller when we stopped hunting.

Or maybe living in a large society of specialists demands less brainpower than living in a tribe of generalists. Stone-age people mastered many skills – hunting, tracking, foraging for plants, making herbal medicines and poisons, crafting tools, waging war, making music and magic. Modern humans perform fewer, more specialised roles as part of vast social networks, exploiting division of labour. In a civilisation, we specialise on a trade, then rely on others for everything else.

That being said, brain size isn't everything: elephants and orcas have bigger brains than us, and Einstein's brain was smaller than average. Neanderthals had brains comparable to ours, but more of the brain was devoted to sight and control of the body, suggesting less capacity for things like language and tool use. So how much the loss of brain mass affects overall intelligence is unclear. Maybe we lost certain abilities, while enhancing others that are more relevant to modern life. It's possible that we've maintained processing power by having fewer, smaller neurons. Still, I worry about what that missing 10 percent of my grey matter did.

Curiously, domestic animals

also evolved smaller brains. Sheep lost 24 percent of their brain mass after domestication; for cows, it's 26 percent; dogs, 30 percent. This raises an unsettling possibility. Maybe being more willing to passively go with the flow (perhaps even thinking less), like a domesticated animal, has been bred into us, like it was for them.

Our personalities must be evolving too. Hunter-gatherers' lives required aggression. They hunted large mammals, killed over partners and warred with neighbouring tribes. We get meat from a store, and turn to police and courts to settle disputes. If war hasn't disappeared, it now accounts for fewer deaths, relative to population, than at any time in history. Aggression, now a maladaptive trait, could be bred out.

Changing social patterns will also change personalities. Humans live in much larger groups than other apes, forming tribes of around 1,000 in hunter-gatherers. But in today's world people living in vast cities of millions. In the past, our relationships were necessarily few, and often lifelong. Now we inhabit seas of people, moving often for work, and in the process forming thousands of relationships, many fleeting and, increasingly, virtual. This world will push us to become more outgoing, open and tolerant. Yet navigating such vast social networks may also require we become more willing to adapt ourselves to them – to be more conformist.

Not everyone is psychologically well-adapted to this existence. Our instincts, desires and fears are largely those of stone-age ancestors, who found meaning in hunting and foraging for their families, warring with their neighbours and praying to ancestor-spirits in the dark. Modern society meets our material needs well, but is less able to meet the psychological needs of our primitive caveman brains.

Perhaps because of this, increasing numbers of people suffer from psychological issues such as loneliness, anxiety and depression. Many turn to alcohol and other substances to cope. Selection against vulnerability to these conditions might improve our mental health, and make us happier as a species. But that could come at a price. Many great geniuses had their demons; leaders like Abraham Lincoln and Winston Churchill fought with depression, as did scientists such as Isaac Newton and Charles Darwin, and artists like Herman Melville and Emily Dickinson. Some, like Virginia Woolf, Vincent Van Gogh and Kurt Cobain, took their own lives. Others – Billy Holliday, Jimi Hendrix and Jack Kerouac – were destroyed by substance abuse.

A disturbing thought is that troubled minds will be removed from the gene pool – but potentially at the cost of eliminating the sort of spark that created visionary leaders, great writers, artists and musicians. Future humans might be better adjusted – but less fun to party with and less likely to launch a scientific revolution – stable, happy and boring.

## New species?

There were once nine human species, now it's just us. But could new human species evolve? For that to happen, we'd need isolated populations subject to distinct selective pressures. Distance no longer isolates us, but reproductive isolation could theoretically be achieved by selective mating. If people were culturally segregated – marrying based on religion, class, caste, or even politics – distinct populations, even species, might evolve.

In The Time Machine, sci-fi nov-

elist H.G. Wells saw a future where class created distinct species. Upper classes evolved into the beautiful but useless Eloi, and the working classes become the ugly, subterranean Morlocks – who revolted and enslaved the Eloi.

In the past, religion and lifestyle have sometimes produced genetically distinct groups, as seen in for example Jewish and Gypsy populations. Today, politics also divides us – could it divide us genetically? Liberals now move to be near other liberals, and conservatives to be near conservatives; many on the left won't date Trump supporters and vice versa.

Could this create two species, with instinctively different views? Probably not. Still, to the extent culture divides us, it could drive evolution in different ways, in different people. If cultures become more diverse, this could maintain and increase human genetic diversity.

## Strange new possibilities

So far, I've mostly taken a historical perspective, looking back. But in some ways, the future might be radically unlike the past. Evolution itself has evolved.

One of the more extreme possibilities is directed evolution, where we actively control our species' evolution. We already breed ourselves when we choose partners with appearances and personalities we like. For thousands of years, hunter-gatherers arranged marriages, seeking good hunters for their daughters. Even where children chose partners, men were generally expected to seek approval of the bride's parents. Similar traditions survive elsewhere today. In other words, we breed our own children.

And going forward, we'll do this with far more knowledge of what we're doing, and more control over the genes of our progeny. We can already screen ourselves and embryos for genetic diseases. We could potentially choose embryos for desirable genes, as we do with crops. Direct editing of the DNA of a human embryo has been proven to be possible – but seems morally abhorrent, effectively turning children into subjects of medical experimentation. And yet, if such technologies were proven safe, I could imagine a future where you'd be a bad parent not to give your children the best genes possible.

Computers also provide an entirely new selective pressure. As more and more matches are made on smartphones, we are delegating decisions about what the next generation looks like to computer algorithms, who recommend our potential matches. Digital code now helps choose what genetic code passed on to future generations, just like it shapes what you stream or buy online. This might sound like dark science fiction, but it's already happening. Our genes are being curated by computer, just like our playlists. It's hard to know where this leads, but I wonder if it's entirely wise to turn over the future of our species to iPhones, the internet and the companies behind them.

Discussions of human evolution are usually backward looking, as if the greatest triumphs and challenges were in the distant past. But as technology and culture enter a period of accelerating change, our genes will too. Arguably, the most interesting parts of evolution aren't life's origins, dinosaurs, or Neanderthals, but what's happening right now, our present – and our future.

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