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The tamed ape: were humans the first animal to be domesticated?

Deep inside our genome are bits of DNA we share only with animals such as dogs and cattle. Our self-domestication may have been a pivotal moment in making us human

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By **Colin Barras**

FIRST came the dog, followed by sheep and goats. Then the floodgates opened: pigs, cows, cats, horses and a menagerie of birds and other beasts made the leap. Over the past 30,000 years or so, humans have domesticated all manner of species for food, hunting, transport, materials, to control pests and to keep as pets. But some say that before we domesticated any of them, we first had to domesticate ourselves.

Mooted by Darwin and even Aristotle, the idea of human domestication has since been just that: an idea. Now, for the first time, genetic comparisons between us and Neanderthals suggest that we really may be the puppy dogs to their feral wolves. Not only could this explain some long-standing mysteries – including why our brains are weirdly smaller than those of our Stone Age ancestors – some say it is the only way to make sense of certain quirks of human evolution.

One major insight into what happens when wild beasts are domesticated comes from a remarkable experiment that began in 1959, in Soviet Siberia. There, Dmitry Belyaev took relatively wild foxes from an Estonian fur farm and bred them. In each new litter, he chose the most cooperative animals and encouraged them to mate. Gradually, the foxes began to behave more and more like pets. But it wasn't just their behaviour that changed. The tamer foxes also looked different. Within 10 generations, white patches started to appear on their fur. A few generations later, their ears became floppier. Eventually the males' skulls shrank and began to look more like those of the females.

These were precisely the traits that Belyaev was looking for. He had noticed that many domesticated mammals – most of which weren't selectively bred, but gradually adapted to live alongside humans – have similarities. Rabbits, dogs and pigs often have patches of white hair and floppy ears, for instance, and their brains are generally smaller than those of their wild relatives. Over the years, the collection of physical traits associated with tameness has been extended to smaller teeth and shorter muzzles. Together, they are known as the domestication syndrome.

Wild abandon: in a Soviet experiment, foxes were bred to be less fearful and more like pets
Vincent J. Musi/National Geographic/Getty

Many creatures carry aspects of the domestication syndrome, including one notable species: our own. We too have relatively short faces, small teeth and no prominent brow ridges. Our relatively large brains are smaller than those of our Neanderthal cousins – something that has puzzled many an evolutionary biologist. And like many domesticated species, young humans are also receptive to learning from their peers for an unusually long time. Some of these similarities between humans and domesticated animals were noted early in the 20th century, but there was no follow-up. It was only after Belyaev publicised his experiments that a few evolutionary biologists once more began to consider the possibility that modern humans might be a domestic version of our extinct relatives and ancestors.

"Humans really may be the puppy dogs to Neanderthals' feral wolves"

On its own, Belyaev's work didn't provide the hard evidence needed to convince the wider community of human evolutionary biologists. "You can imagine people not liking the idea," says Cedric Boeckx at the Catalan Institute for Research and Advanced Studies in Barcelona. At best, many see it as an analogy, he says. In part, that's because

until recently there was no good explanation for why tameness was linked with a suite of physical traits. In the early 2000s, Susan Crockford, now at the University of Victoria in British Columbia, Canada, suggested the thyroid gland might be involved, but the idea didn't go very far.

That changed in 2014 when Richard Wrangham of Harvard University, Adam Wilkins, now at the Humboldt University of Berlin, and Tecumseh Fitch at the University of Vienna, made a connection. They pointed out one thing that unites the various parts of the body that are influenced by domestication: all derive from a tiny collection of stem cells in the developing embryo. The cluster of cells is called the neural crest. As the embryo develops in the uterus, and eventually forms a fetus, the cells of the neural crest are sent around the body to form different tissues, including ear cartilage, the dentin that makes teeth, and melanocyte cells that produce skin pigments.

Significantly, the neural crest also gives rise to the adrenal glands, which play a key role in fear and stress. Wrangham and his colleagues outlined a simple idea. During the initial stages of domestication of any animal – pigs, for instance – our ancestors began by selecting individuals that were less fearful of them, and less aggressive towards them. That made them easier to breed in captivity. Unwittingly, the tamers were selecting animals that had smaller, less active adrenal glands, a feature in turn linked to less active neural crest cells. Changes in the cartilage and other tissues derived from these cells were just inadvertent side effects. Crucially, the team predicted that dozens of genes with links to the neural crest should all change as a result of domestication. Domestic species should have distinct versions of these genes, not seen in their wild relatives.

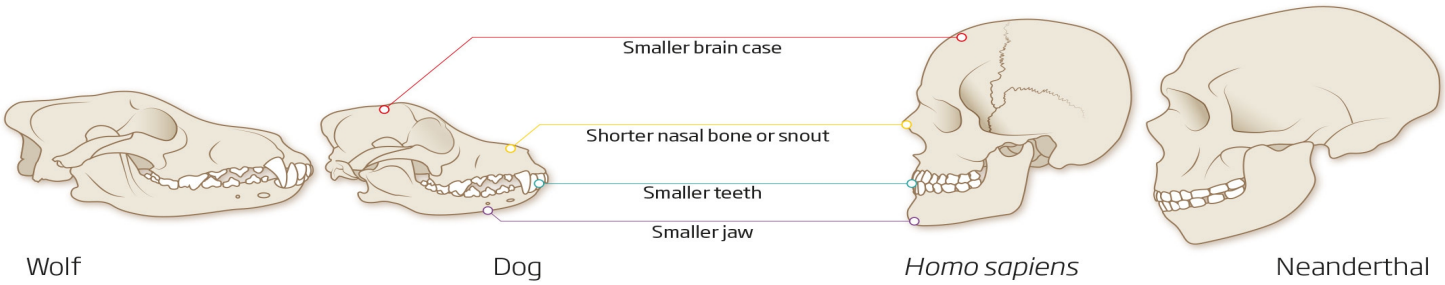
The idea, now known as the neural crest cell hypothesis quickly gained fans, including Boeckx. "Before they formulated [it], the idea of self-domestication was hard to test," he says. But with a genetic definition in place, it became possible to hunt for signs of it in species not normally considered domesticated – species like our own.

He and his colleagues looked at the genetic differences between modern humans and Neanderthals – the variations that, through the process of natural selection, caused our species to diverge. Remarkably, they discovered that many of the differences were linked

to the neural crest. What's more, the neural crest genes in several known domestic species were found to be distinct from those in their wild counterparts. In other words, some of the genetic differences that distinguish us from Neanderthals are the same as those that distinguish dogs from wolves and European cattle from European bison. This suggests there was an episode early in our evolution when our species underwent the same sort of domestication as these animals did. "The Boeckx result is totally cool," says Wrangham.

In your face

Compared with Neanderthals, modern humans have facial features that are more similar to those of a domesticated animal



There is a crucial difference, of course, between humans on one hand, and dogs and cattle, say, on the other. Most domestic animals were tamed by another species – us. So what tamed humans?

Evolution itself, says Boeckx. He and others distinguish between animals that are bred to be less aggressive, like horses, pigs and the Russian foxes, and ones that naturally evolve that way. Dogs, for instance, are thought by some to be partially self-domesticated. The idea is that some wolves were naturally bolder and less aggressive. They had an advantage because they could approach human settlements and dine on their leftovers. Only later did we selectively breed them and complete their domestication.

It is possible that being less aggressive and more cooperative was also an advantage for early humans, giving those with these traits a better chance of surviving and reproducing. Alternatively, researchers have argued that humans became less aggressive and more cooperative simply as a consequence of their large bodies and brains. Animals with these features typically show more self-control, so it is conceivable that our ancestors became less impulsive or quick to anger simply by virtue of their size. Sexual selection could also have played a role, with females finding less aggressive males more attractive, perhaps because they provided better care for their young. Wrangham and Brian Hare at Duke University in North Carolina have suggested that a similar process could explain why bonobos have evolved to be so much less violent than chimpanzees.

More work is needed to really pin down what ultimately drove self-domestication in humans, says Boeckx. He says the next step is to take lab animals and change some of the genes his team has identified, inserting the domestic versions in individuals that have the wild variants. If this produces offspring that look and act like a domestic species, but are otherwise unchanged, then we can be more confident that the genetic differences between Neanderthals and us really are down to self-domestication.

That said, several researchers are already convinced that this process can explain several important events in our evolutionary history, such as the evolution of language (see "Civil tongues"), and the explosion of culture during the Stone Age. The objects archaeologists have found suggest that it was only within the past 100,000 years that jewellery, musical instruments and other cultural artefacts became a common feature of human life, 200,000 years after *Homo sapiens* first appeared. "That's always been a puzzle," says Steven Churchill at Duke University.

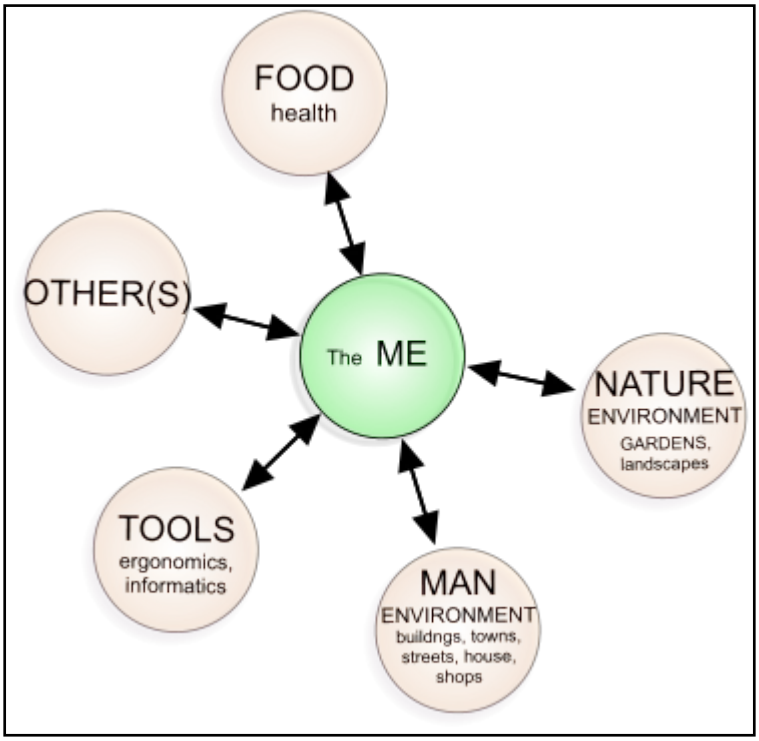
"Most domestic species were tamed by humans. So what tamed us?"

In 2014, he and his colleagues speculated that this delayed cultural revolution might have been linked to an intense pulse of human self-domestication 100,000 years ago. They argued that our species had the capacity to innovate from the start, but that our ancestors lacked the social networks for ideas to spread from group to group. Instead, knowledge and good ideas lived and died in the family group. Genetic and archaeological evidence suggests population densities began to rise around 100,000 years ago. Until that time, it may well have been beneficial for humans to be hostile towards strangers, perhaps to prevent others encroaching on their territories. But as people began to live more closely together, it would have been better to welcome them, say the researchers. Humans would have experienced an evolutionary selective pressure to be friendly and cooperative, potentially an episode of self-domestication.

The idea predicts that *H. sapiens* should have begun to show some physical features of domestication around the same time. The team looked at dozens of ancient human skulls and found that it was indeed around then that brow ridges and long, powerfully built faces

faded away to leave our species looking more feminine, just like Belyaev's foxes. "To operate in [a wide social network], I think you need overt signals that you're not going to behave aggressively," says Churchill's collaborator, Robert Franciscus at the University of Iowa. Smaller brow ridges and faces were probably just that, he says. It is a nice idea, but one that will need further work to explain away some contradictions. For instance, fossils show that several undomesticated mammals – bears, boars, even sea cows – also seem to have become more feminine over the past 100,000 years.

And so many researchers still need to be convinced that self-domestication – perhaps even successive pulses of self-domestication at different times – can explain profound mysteries of our evolutionary history. But advocates are undeterred. Wrangham is publishing a book on the subject later this year. Two millennia after Aristotle became the first person to compare people to domestic animals, the idea might be about to go mainstream.



Civil tongues

The capacity for language is one of our most enigmatic traits. Could domestication help explain it?

To understand how languages evolve, Simon Kirby at the University of Edinburgh, UK, and his colleagues ask volunteers to learn simple artificial languages using a computer program, then watch how they change as the volunteers learn from each other.

Initially, two people learn a "language" and use it to converse with each other. A second group of volunteers learns the language from those conversations; a third learns from the second generation, and so on. Under these conditions, the researchers found that their initial, essentially random made-up language evolves to become simpler and more structured, and thus a better vehicle to transmit meaning. "The structure of language comes essentially for free," says Kirby. The results suggest that cultural transmission played a role in the evolution of human language.

But if the process is so simple, why is it unique to humans? Kirby and his colleagues argue that we have two key skills: an ability to learn and imitate complex signals, and a sensitivity to signs that someone is trying to communicate. They searched the scientific literature for other species with the same skills and came across studies of songbirds. Many of them, such as the Bengalese finch, are excellent vocal learners. The search also highlighted dogs, which show an almost human-like ability to recognise communicative intent in gestures. Even chimps struggle to follow a pointing finger, yet dogs do this easily.

For Kirby, it was significant that both Bengalese finches and dogs are domestic species – especially when he came across the growing literature suggesting that we, too, are domesticated. "It was kind of spooky when I saw that," he says. He now believes that our self-domestication may have primed us to develop language.

"I agree that cultural evolution plays an important role [in language development] that has often been ignored," says Tecumseh Fitch at the University of Vienna, who studies the origin of language and has studied the evolution of domestication (see main story). But he wants to see more evidence before he is convinced self-domestication helped language evolve.

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