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Evolution and us

Some say it has stopped, others believe it's going faster than ever. So which is it, asks Kate Douglas

"ARE humans still evolving? In the vernacular sense of improving morally and intellectually — by cultural changes — I think so," says Steven Pinker. "In the biological sense of changes in the gene pool, it's impossible to say." If pressed to come off the fence, however, the Harvard-based evolutionary biologist knows where he stands. "People, including me, would rather believe that significant human biological evolution stopped between 50,000 and 100,000 years ago, before the races diverged, which would ensure that racial and ethnic groups are biologically equivalent," he says.

It's an understandable position given the political implications of being wrong. And in one important sense Pinker is absolutely spot on: it's very difficult, if not impossible, to observe human evolution in action. But saying it isn't happening is an increasingly difficult position to defend scientifically. Recent discoveries show that we must reject the idea that human evolution stopped dead 50,000 years ago or more. In fact, there is every reason to believe that it is going on right now.

Take the discovery last year by Bruce Lahn of the University of Chicago of two genes involved in brain development that emerged in recent human history and swept quickly through the population. One, a version of a gene called microcephalin, arose between

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14,000 and 60,000 years ago and is now carried by 70 per cent of people. The other, a variant of the ASPM gene, is as recent as 500 to 14,000 years old and is now carried by about a quarter of the global population.

No one yet knows the function of these genes, but Lahn's discoveries could be just the tip of the iceberg. With the publication of the chimpanzee genome (Nature, vol 437, p 69), geneticists are in a position to catalogue all the changes that have occurred in the human genome in the 7 million years or so since our species split from its closest relative. They will also be able to pinpoint when those mutations first arose — be it a few hundred or many million years ago — and what role they might have played in the evolution of our species.

The discovery of ongoing human evolution raises many questions, some of them uncomfortable. What if, for example, Pinker's fears are confirmed and racial groups turn out not to be biologically equivalent? Is natural selection still a driving force in humans, given that our survival is often less dependent on genes than on technology? To what extent might a changing genome lead to changes in attributes we value, such as intelligence? What might our species look like 1000 years from now? Contemporary human evolution may be a minefield, but it's a minefield that can no longer be ignored.

If asked whether we are still evolving, most experts would concur with Pinker: it depends what you mean by evolution. So, what are the options? In the loosest sense of the word, evolution is simply the change over time in a species' gene pool — all the genes in all the individuals alive at one time. In that sense, all species are evolving, even those that reproduce by cloning, because DNA inevitably changes over time through random mutation, and because some individuals of a species will have more offspring than others.

Beyond this, though, things get a bit more complicated. When considering how evolution might be happening, it is perhaps easier to think of a "gene boat" rather than a "gene pool" to represent all the genes present in the human population at the moment. Imagine this craft bobbing on a sea of all possible human genes, with the water under its hull representing the combination possessed by the species at any particular time. Left to its own devices, the boat drifts aimlessly. This is "genetic drift", where a species is changing randomly without any driving force from its environment.

Now imagine our boat has a sail, so that when the wind blows, it heads off with seeming purpose. That's like natural selection or sexual selection, in which an external force influences the direction taken by the gene boat. In the case of natural selection, the driving force is adaptation to a change in environmental conditions. For sexual selection, the force is exerted by other members of the species preferring to mate with individuals who possess desirable characteristics, which then become more prevalent.

Imagine now that the boat has a tiller and someone at the helm to steer it. This would be the equivalent of artificial selection similar to dog or plant breeding. The gene boat even encompasses artificial selection by genetic engineering. These are the possibilities, but to what extent is the evolution of our species being shaped by these various forces?

Genetic drift undoubtedly plays a role. Its scale is difficult to measure, however, given that drift produces no obvious trends in the way a species looks or behaves. Some experts argue that natural selection is diminishing in importance, and as it does genetic drift comes to the fore. It's a contentious suggestion, but even if they are correct, the aimlessness of drift makes it of limited interest.

Which takes us to natural selection. It's clear that the raw genetic material upon which selection could act is being generated all the time — the human genome is not immune from mutations, some of which could confer a selective advantage. But are there any selection pressures at work?

Steve Jones, a geneticist at University College London, has famously argued that natural selection is no longer important for humans. He points out that natural selection works by ensuring that individuals whose genes are best adapted to the prevailing environment are most likely to survive and reproduce. But, he says, in the developed world, survival no longer depends on genes. "Just 500 years ago — yesterday in evolutionary terms — a British baby had only a 50 per cent chance of making it to reproductive age. Now, the figure is around 99 per cent," Jones says. There is also a more level playing field in the reproduction game. "No longer, as in the Middle Ages, do a few rich men have many children while many of those in poverty are forced into the army or into monasteries," he says. Jones admits that measuring reproductive success, particularly for men, can be difficult, but he calculates that the changes in survival and reproduction rates have led to a decrease of around 70 per cent in the opportunity for natural selection to act today, compared with the time when our ancestors lived as peasant farmers.

That's not quite the "zero" natural selection that some reports of Jones's views have suggested. Even he accepts that genes can still make a difference to survival and reproduction. One obvious example is genes that confer resistance to emerging diseases. Some parts of Africa, for example, have seen an increase in the frequency of a gene called CCR5-32, which offers some protection against infection with HIV-1.

There are other, more puzzling examples. One form of the dopamine receptor gene DRD4 has become much more common over the past few thousand years. The rate of increase suggests the gene has been positively selected for, though it's not clear why: the variant is associated with attention deficit hyperactivity disorder.

So natural selection is still at work, and some evolutionary biologists believe it would come as no surprise to find many more examples. They point out that we live in an era of rapid technological progress, and hence a fast changing environment, exactly the conditions under which you'd expect natural selection to act. Technological change has clearly driven natural selection in the past. The invention of dairy herding, for example, selected for a gene that gives adults the ability to digest milk sugars. So why not now? It's not hard to dream up selection pressures that could be acting today. Caesarean sections, for example, could be selecting for genes that allow babies to grow bigger in the womb.

Some experts, including Pinker, argue that technological change doesn't necessarily drive natural selection. Once culture emerged, they say, it provided non-genetic means to adapt to change, such as more technology or culturally inherited changes in behaviour. Though that is true in many ways, it does not necessarily mean that evolution has stopped. Technology and medicine, by enabling almost everyone to have children, could be causing "reverse evolution" by preventing unfit genes from being purged from the gene pool. "Relaxed selection combined with a high mutation rate is probably causing gradual deterioration of many functions, especially disease defences," says Gregory Cochran, adjunct professor of anthropology at the University of Utah in Salt Lake City.

There are also plausible ways in which culture itself could be driving natural selection. This view has been expounded by Christopher Wills of the University of California, San Diego. In his book The Runaway Brain, he argues that there has been, and still is, positive

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feedback between our culture and our genes that led to the rapid evolution of the most characteristic human attribute, the mind. It began when the relatively advanced brains of our ancestors allowed them to succeed because of their wits rather than physical attributes. "Without a doubt, the most important selective pressures continue to be on brain function," says Wills.

This is one reason why Lahn's discovery of recent brain evolution has created such a stir. Lahn agrees with Wills that the defining feature of human evolution is that our minds have shaped our environment, which in turn has led to evolutionary changes in the way we think, and he is convinced it is continuing. Wills goes further, arguing that in the modern world nobody can do everything, so the advantage lies in being good at something that not many others can do well. "My prediction is that we are not simply getting smarter, we are selecting for more variability in our behaviours," he says. If he's right, that means our gene boat is getting bigger.

Lahn's discoveries have also given a boost to some controversial ideas. Last year, Cochran and his colleague Henry Harpending published a paper claiming that natural selection has increased the intelligence of Ashkenazi Jews in the past 1000 years (Journal of Biosocial Science, vol 37, p 1). Intelligence is notoriously difficult to measure, but this ethnic group scores between 12 and 15 points higher than average on IQ tests. Cochran and Harpending point out that from about AD 800 to 1700, Ashkenazim were forbidden to work in common trades and tended to make a living from more intellectual pursuits such as finance. The most successful had the most offspring and so there was natural selection for intelligence, argue the pair. They say they have genetic evidence to back them up, though the details have yet to be published.

Similarly, Lahn himself has found that the new microcephalin gene, which has been positively selected for and therefore appears to confer a useful trait, is relatively rare in sub-Saharan Africa, and the new form of ASPM is most prevalent in people from Europe and the Middle East, suggesting that both mutations originated in non-Africans after our ancestors migrated out of Africa. Lahn, though, has been keen to stress that both genes may still have arisen in Africa and that, anyway, having the genes may make brains "fitter" in certain environments, but doesn't necessarily mean they are "better".

Natural selection, however, isn't the only reason why a gene might become more prevalent. It's also possible that the driving force is sexual selection. Among the most prominent supporters of this idea is Geoffrey Miller of the University of New Mexico, Albuquerque, author of The Mating Mind. He believes that the rate of human evolution is accelerating, and that selection for sexually desirable traits is the driving force. "Our high rates of migration, outbreeding, and cross-ethnic mating are recombining our genes at unprecedented rates," he says.

What is more, the vast human population means that our gene boat is acquiring new mutations faster than ever. Miller also points out that people are far more likely to meet and have children with someone who is like them. "Assortative mating — for intelligence, personality traits, mental health, physical health, attractiveness — is getting ever more efficient through higher education, urbanisation, singles' ads, internet dating and speed dating," says Miller. Taken together, that is likely to mean that advantageous new mutations have a greater opportunity than ever to become fixed in the population.

Assortative mating is also promoted by contraception. And other reproductive technologies are probably exerting an influence on human evolution too. "Willingness to be a sperm or

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egg donor is being strongly favoured by current selection," says Miller. And if germ-line genetic engineering became commonplace, the effect would be much more profound. "I suspect," says Lahn, "that way before the next millennium, we will have figured out ways to manipulate our own genome, such that evolution will operate on a whole new set of rules that even Darwin did not envision." Miller agrees. "Within a few generations, market-based genetic technology will eclipse socio-sexual selection as the driving force in human evolution," he says.

Miller foresees a future in which parents try to eliminate traits that they personally find undesirable, but says it's impossible to predict how that will affect the human gene pool. There are, however, human characteristics that will probably always be seen as desirable, and are likely to be actively selected for by genetic technology. In 1000 years, Miller predicts, "people will be much more beautiful, intelligent, symmetrical, healthy and emotionally stable, due to 40 generations of genetic screening against harmful mutations". And if futurologists such as Ray Kurzweil are correct, our gene boat will also get some shiny new high-tech additions, as humans merge with technology to become cyborgs and biological evolution is rendered obsolete (New Scientist, 24 September 2005, p 32).

Our gene boat may even find new waters to sail on. "One way in which we could evolve in a truly spectacular fashion is if we colonise other planets," says Wills. "Those colonists — and the animals and plants that they take with them — will undergo dramatic evolutionary changes in the process of adapting to incredibly different conditions." It's possible that colonists would even become a separate species if there was no interbreeding with people on Earth.

All in all, it's hard not to conclude that humans are still evolving, probably quite rapidly. "All species are evolving, but at different rates — some so slowly that the term 'glacial' would comically miss the mark," says Daniel Dennett from Tufts University in Boston. "But I expect that Homo sapiens is evolving at a rather swift pace."

So where are we heading? Most experts agree that trying to predict the direction of evolution is a fruitless exercise. "Evolution is not really a predictive science," says Jones. Others point out that we may not like where we're heading. "Perhaps we will so befoul our planet," says Dennett, "that only an eccentric and hardy remnant of our species — which can survive on earthworms while living in underground burrows, for instance — will remain." Wherever we end up, it seems clear that the story of human evolution has only just started.

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By Kate Douglas
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