Human Culture, an Evolutionary Force

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Genes enabling lactose tolerance, which probably resulted in more surviving offspring, were detected in cultures like this Kenyan shepherd's.

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As with any other species, human populations are shaped by the usual forces of natural selection, like famine, disease or climate. A new force is now coming into focus. It is one with a surprising implication — that for the last 20,000 years or so, people have inadvertently been shaping their own evolution.

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The force is human culture, broadly defined as any learned behavior, including technology. The evidence of its activity is the more surprising because culture has long seemed to play just the opposite role. Biologists have seen it as a shield that protects people from the full force of other selective pressures, since clothes and shelter dull the bite of cold and farming helps build surpluses to ride out famine.

Because of this buffering action, culture was thought to have blunted the rate of human evolution, or even brought

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Maasai tribesman are among a culture with adult lactose tolerance.

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it to a halt, in the distant past. Many biologists are now seeing the role of culture in a quite different light.

Although it does shield people from other forces, culture itself seems to be a powerful force of natural selection. People adapt genetically to sustained cultural changes, like new diets. And this interaction works more quickly than other selective forces, "leading some practitioners to argue that gene-culture co-evolution could be the dominant mode of human evolution," Kevin N. Laland and colleagues wrote in the February issue of Nature Reviews Genetics. Dr. Laland is an evolutionary biologist at the University of St. Andrews in Scotland.

The idea that genes and culture co-evolve has been around for several decades but has started to win converts only recently. Two leading proponents, Robert Boyd of the University of California, Los Angeles, and Peter J. Richerson of the University of California, Davis, have argued for years that genes and culture were intertwined in shaping human evolution. "It wasn't like we were despised, just kind of ignored," Dr. Boyd said. But in the last few years, references by other scientists to their writings have "gone up hugely," he said.

The best evidence available to Dr. Boyd and Dr. Richerson for culture being a selective force was the lactose tolerance found in many northern Europeans. Most people switch off the gene that digests the lactose in milk shortly after they are weaned, but in northern Europeans — the descendants of an ancient cattle-rearing culture that emerged in the region some 6,000 years ago — the gene is kept switched on in adulthood.

Lactose tolerance is now well recognized as a case in which a cultural practice — drinking raw milk — has caused an evolutionary change in the human genome. Presumably the extra nutrition was of such great advantage that adults able to digest milk left more surviving offspring, and the genetic change swept through the population.

This instance of gene-culture interaction turns out to be far from unique. In the last few years, biologists have been able to scan the whole human genome for the signatures of genes undergoing selection. Such a signature is formed when one version of a gene becomes more common than other versions because its owners are leaving more surviving offspring. From the evidence of the scans, up to 10 percent of the genome — some 2,000 genes — shows signs of being under selective pressure.

These pressures are all recent, in evolutionary terms — most probably dating from around 10,000 to 20,000 years ago, in the view of Mark Stoneking, a geneticist at the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany. Biologists can infer the reason for these selective forces from the kinds of genes that are tagged by the genome scans. The roles of most of the 20,000 or so genes in the human genome are still poorly understood, but all can be assigned to broad categories of likely function depending on the physical structure of the protein they specify.

By this criterion, many of the genes under selection seem to be responding to conventional pressures. Some are involved in the immune system, and presumably became more common because of the protection they provided against disease. Genes that cause paler skin in Europeans or Asians are probably a response to geography and climate.

But other genes seem to have been favored because of cultural changes. These include many genes involved in diet and metabolism and presumably reflect the major shift in

diet that occurred in the transition from foraging to agriculture that started about 10,000 years ago.

Amylase is an enzyme in the saliva that breaks down starch. People who live in agrarian societies eat more starch and have extra copies of the amylase gene compared with people who live in societies that depend on hunting or fishing. Genetic changes that enable lactose tolerance have been detected not just in Europeans but also in three African pastoral societies. In each of the four cases, a different mutation is involved, but all have the same result — that of preventing the lactose-digesting gene from being switched off after weaning.

Many genes for taste and smell show signs of selective pressure, perhaps reflecting the change in foodstuffs as people moved from nomadic to sedentary existence. Another group under pressure is that of genes that affect the growth of bone. These could reflect the declining weight of the human skeleton that seems to have accompanied the switch to settled life, which started some 15,000 years ago.

A third group of selected genes affects brain function. The role of these genes is unknown, but they could have changed in response to the social transition as people moved from small hunter-gatherer groups a hundred strong to villages and towns inhabited by several thousand, Dr. Laland said. “It’s highly plausible that some of these changes are a response to aggregation, to living in larger communities,” he said.

Though the genome scans certainly suggest that many human genes have been shaped by cultural forces, the tests for selection are purely statistical, being based on measures of whether a gene has become more common. To verify that a gene has indeed been under selection, biologists need to perform other tests, like comparing the selected and unselected forms of the gene to see how they differ.

Dr. Stoneking and his colleagues have done this with three genes that score high in statistical tests of selection. One of the genes they looked at, called the EDAR gene, is known to be involved in controlling the growth of hair. A variant form of the EDAR gene is very common in East Asians and Native Americans, and is probably the reason that these populations have thicker hair than Europeans or Africans.

Still, it is not obvious why this variant of the EDAR gene was favored. Possibly thicker hair was in itself an advantage, retaining heat in Siberian climates. Or the trait could have become common through sexual selection, because people found it attractive in their partners.

A third possibility comes from the fact that the gene works by activating a gene regulator that controls the immune system as well as hair growth. So the gene could have been favored because it conferred protection against some disease, with thicker hair being swept along as a side effect. Or all three factors could have been at work. “It’s one of the cases we know most about, and yet there’s a lot we don’t know,” Dr. Stoneking said.

The case of the EDAR gene shows how cautious biologists have to be in interpreting the signals of selection seen in the genome scans. But it also points to the potential of the selective signals for bringing to light salient events in human prehistory as modern humans dispersed from the ancestral homeland in northeast Africa and adapted to novel environments. “That’s the ultimate goal,” Dr. Stoneking said. “I come from the anthropological perspective, and we want to know what the story is.”

With archaic humans, culture changed very slowly. The style of stone tools called the Oldowan appeared 2.5 million years ago and stayed unchanged for more than a million

years. The Acheulean stone tool kit that succeeded it lasted for 1.5 million years. But among behaviorally modern humans, those of the last 50,000 years, the tempo of cultural change has been far brisker. This raises the possibility that human evolution has been accelerating in the recent past under the impact of rapid shifts in culture.

Some biologists think this is a possibility, though one that awaits proof. The genome scans that test for selection have severe limitations. They cannot see the signatures of ancient selection, which get washed out by new mutations, so there is no base line by which to judge whether recent natural selection has been greater than in earlier times. There are also likely to be many false positives among the genes that seem favored.

But the scans also find it hard to detect weakly selected genes, so they may be picking up just a small fraction of the recent stresses on the genome. Mathematical models of gene-culture interaction suggest that this form of natural selection can be particularly rapid. Culture has become a force of natural selection, and if it should prove to be a major one, then human evolution may be accelerating as people adapt to pressures of their own creation.

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