The Tall and the Short of It

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Baffled by your future prospects? As a biological anthropologist, I have just one word of advice for you: plasticity. *Plasticity* refers to the ability of many organisms, including humans, to alter themselves—their behavior or even their biology—in response to changes in the environment. We tend to think that our bodies get locked into their final form by our genes, but in fact we alter our bodies as the conditions surrounding us shift, particularly as we grow during childhood. Plasticity is as much a product of evolution's fine-tuning as any particular gene, and it makes just as much evolutionary good sense. Rather than being able to adapt to a single environment, we can, thanks to plasticity, change our bodies to cope with a wide range of environments. Combined with the genes we inherit from our parents, plasticity accounts for what we are and what we can become.

Anthropologists began to think about human plasticity around the turn of the century, but the concept was first clearly defined in 1969 by Gabriel Lasker, a biological anthropologist at Wayne State University in Detroit. At that time scientists tended to consider only those adaptations that were built into the genetic makeup of a person and passed on automatically to the next generation. A classic example of this is the ability of adults in some human societies to drink milk. As children, we all produce an enzyme called lactase, which we need to break down the sugar lactose in our mother's milk. In many of us, however, the lactase gene slows down dramatically as we approach adolescence—probably as the result of another gene that regulates its activity. When that regulating gene turns down the production of lactase, we can no longer digest milk.

Lactose intolerance—which causes intestinal gas and diarrhea—affects between 70 and 90 percent of African Americans, Native Americans, Asians, and people who come from around the Mediterranean. But others, such as people of central and western European descent and the Fulani of West Africa, typically have no problem drinking milk as adults. That's because they are descended from societies with long histories of raising goats and cattle. Among these people there was a clear benefit to being able to drink milk, so natural selection gradually changed the regulation of their lactase gene, keeping it functioning throughout life.

That kind of adaptation takes many centuries to become established, but Lasker pointed out that there are two other kinds of adaptation in humans that need far less time to kick in. If people have to face a cold winter with little or no heat, for example, their metabolic rates rise over the course of a few weeks and they produce more body heat. When summer returns, the rates sink again.

Lasker's other mode of adaptation concerned the irreversible, lifelong modification of people as they develop—that is, their plasticity. Because we humans take so many years to grow to adulthood, and because we live in so many different environments, from forests to cities and from deserts to the Arctic, we are among the world's most variable species in our physical form and behavior. Indeed, we are one of the most plastic of all species.

In an age when DNA is king, it's worth considering why Americans are no longer the world's tallest people, and some Guatemalans no longer pygmies.

One of the most obvious manifestations of human malleability is our great range of height, and it is a subject I've made a special study of for the last 25 years. Consider these statistics: in 1850 Americans were the tallest people in the world, with American men averaging 5'6". Almost 150 years later, American men now average 5'8", but we have fallen in the standings and are now only the third tallest people in the world. In first place are the Dutch. Back in 1850 they averaged only 5'4"—the shortest men in Europe—but today they are a towering 5'10". (In these two groups, and just about everywhere else, women average about five inches less than men at all times.)

So what happened? Did all the short Dutch sail over to the United States? Did the Dutch back in Europe get an infusion of "tall genes"? Neither. In both America and the Netherlands life got better, but more so for the Dutch, and height increased as a result. We know this is true thanks in part to studies on how height is determined. It's the product of plasticity in our childhood and in our mothers' childhood as well. If a girl is undernourished and suffers poor health, the growth of her body, including her reproductive system, is usually reduced. With a shortage of raw materials, she can't build more cells to construct a bigger body; at the same time, she has to invest what materials she can get into repairing already existing cells and tissues from the damage caused by disease. Her shorter stature as an adult is the result of a compromise her body makes while growing up.

Such a woman can pass on her short stature to her child, but genes have nothing to do with it for either of them. If she becomes pregnant, her small reproductive system probably won't be able to supply a normal level of nutrients and oxygen to her fetus. This harsh environment reprograms the fetus to grow more slowly than it would if the woman was healthier, so she is more likely to give birth to a smaller baby. Low-birth-weight babies (weighing less than 5.5 pounds) tend to continue their prenatal program of slow growth through childhood. By the time they are teenagers, they are usually significantly shorter than people of normal birth weight. Some particularly striking evidence of this reprogramming comes from studies on monozygotic twins, which develop from a single fertilized egg cell and are therefore identical genetically. But in certain cases, monozygotic twins end up being nourished by unequal portions of the placenta. The twin with the smaller fraction of the placenta is often born with low birth weight, while the other one is normal. Follow-up studies show that this difference between the twins can last throughout their lives.

As such research suggests, we can use the average height of any group of people as a barometer of the health of their society. After the turn of the century both the United States and the Netherlands began to protect the health of their citizens by purifying drinking water, installing sewer systems, regulating the safety of food, and, most important, providing better health care and diets to children. The children responded to their changed environment by growing taller. But the differences in Dutch and American societies determined their differing heights today. The Dutch decided to provide public health benefits to all the public, including the poor. In the United States, meanwhile, improved health is enjoyed most by those who can afford it. The poor often lack adequate housing, sanitation, and health care. The difference in our two societies can be seen at birth: in 1990 only 4 percent of Dutch babies were born at low birth weight, compared with 7 percent in the United States. For white Americans the rate was 5.7 percent, and for black Americans the rate was a whopping 13.3 percent. The disparity between rich and poor in the United States carries through to adulthood: poor Americans are shorter than the better-off by about one inch. Thus, despite great affluence in the United States, our average height has fallen to third place.

People are often surprised when I tell them the Dutch are the tallest people in the world. Aren't they shrimps compared with the famously tall Tutsi (or "Watusi," as you probably first encountered them) of Central Africa? Actually, the supposed great height of the Tutsi is one of the most durable myths from the age of European exploration. Careful investigation reveals that today's Tutsi men average 5'7" and that they have maintained that average for more than 100 years. That means that back in the 1800s, when puny European men first met the Tutsi, the Europeans suffered strained necks from looking up all the time. The two-to-three-inch difference in average height back then could easily have turned into fantastic stories of African giants by European adventures and writers.

The Tutsi could be as tall or taller than the Dutch if equally good health care and diets were available in Rwanda and Burundi, where the Tutsi live. But poverty rules the lives of most African people, punctuated by warfare, which makes the conditions for growth during childhood even worse. And indeed, it turns out that the Tutsi and other Africans who migrate to Western Europe or North America at young ages end up taller than Africans remaining in Africa.

At the other end of the height spectrum, Pygmies tell a similar story. The shortest people in the world today are the Mbuti, the Efe, and other Pygmy peoples of Central Africa. Their average stature is almost 4'9" for adult men and 4'6" for women. Part of the reason Pygmies are short is indeed genetic: some evidently lack the genes for producing the growth-promoting hormones that course through other people's bodies, while others are genetically incapable of using these hormones to trigger the cascade of reactions that lead to growth. But another important reason for their small size is environmental. Pygmies living as hunter-gatherers in the forests of Central African countries appear to be undernourished, which further limits their growth. Pygmies who live on farms and ranches outside the forest are better fed than their hunter-gatherer relatives and are taller as well. Both genes and nutrition thus account for the size of Pygmies.

Peoples in other parts of the world have also been labeled pygmies, such as some groups in Southeast Asia and the Maya of Guatemala. Well-meaning explorers and scientists have often claimed that they are genetically short, but here we encounter another myth of height. A group of extremely short people in New Guinea, for example, turned out to eat a diet deficient in iodine and other essential nutrients. When they were supplied with cheap mineral and vitamin supplements, their supposedly genetic short stature vanished in their children, who grew to a more normal height.

Another way for these so-called pygmies to stop being pygmies is to immigrate to the United States. In my own research, I study the growth of two groups of Mayan children. One group lives in their homeland of Guatemala, and the other is a group of refugees living in the United States. The Maya in Guatemala live in the village of San Pedro, which has no safe source of drinking water. Most of the water is contaminated with fertilizers and pesticides used on nearby agricultural fields. Until recently, when a deep well was dug, the townspeople depended on an unreliable supply of water from rain-swollen streams. Most homes still lack running water and have only pit toilets. The parents of the Mayan children work mostly at clothing factories and are paid only a few dollars a day.

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I began working with the schoolchildren in this village in 1979, and my research shows that most of them eat only 80 percent of the food they need. Other research shows that almost 30 percent of the girls and 20 percent of the boys are deficient in iodine, that most of the children suffer from intestinal parasites, and that many have persistent ear and eye infections. As a consequence, their health is poor and their height reflects it: they average about three inches shorter than better-fed Guatemalan children.

The Mayan refugees I work with in the United States live in Los Angeles and in the rural agricultural community of Indiantown in central Florida. Although the adults work mostly in minimum-wage jobs, the children in these communities are generally better off than their counterparts in Guatemala. Most Maya arrived in the 1980s as refugees escaping a civil war as well as a political system that threatened them and their children. In the United States they found security and started new lives, and before long their children began growing faster and bigger. My data show that the average increase in height among the first generation of these immigrants was 2.2 inches, which means that these so-called pygmies have undergone one of the largest single-generation increases in height ever recorded. When people such as my own grandparents migrated from the poverty of rural life in Eastern Europe to the cities of the United States just after World War I, the increase in height of the next generation was only about one inch.

One reason for the rapid increase in stature is that in the United States the Maya have access to treated drinking water and to a reliable supply of food. Especially critical are school breakfast and lunch programs for children from low-income families, as well as public assistance programs such as the federal Woman, Infants, and Children (WIC) program and food stamps. That these programs improve health and growth is no secret. What is surprising is how fast they work. Mayan mothers in the United States tell me that even their babies are bigger and healthier than the babies they raised in Guatemala, and hospital statistics bear them out. These women must be enjoying a level of health so improved from that of their lives in Guatemala that their babies are growing faster in the womb. Of course, plasticity means that such changes are dependent on external conditions, and unfortunately the rising height—and health—of the Maya is in danger from political forces that are attempting to cut funding for food stamps and the WIC program. If that funding is cut, the negative impact on the lives of poor Americans, including the Mayan refugees, will be as dramatic as were the former positive effects.

Height is only the most obvious example of plasticity's power; there are others to be found everywhere you look. The Andes-dwelling Quechua people of Peru are well-adapted to their high-altitude homes. Their large, barrel-shaped chests house big lungs that inspire huge amounts of air with each breath, and they manage to survive on the lower pressure of oxygen they breathe with an unusually high level of red blood cells. Yet these secrets of mountain living are not hereditary. Instead the bodies of young Quechua adapt as they grow in their particular environment, just as those of European children do when they live at high altitudes.

Plasticity may also have a hand in determining our risks for developing a number of diseases. For example, scientists have long been searching for a cause for Parkinson's disease. Because Parkinson's tends to run in families, it is natural to think there is a genetic cause. But while a genetic mutation linked to some types of Parkinson's disease was reported in mid-1997, the gene accounts for only a fraction of people with the disease. Many more people with Parkinson's do not have the gene, and not all people with the mutated gene develop the disease.

Ralph Garruto, a medical researcher and biological anthropologist at the National Institutes of Health, is investigating the role of the environment and human plasticity not only in Parkinson's but in Lou Gehrig's disease as well. Garruto and his team traveled to the islands of Guam and New Guinea, where rates of both diseases are 50 to 100 times higher than in the United States. Among the native Chamorro people of Guam these diseases kill one person out of every five over the age of 25. The scientists found that both diseases are linked to a shortage of calcium in the diet. This shortage sets off a cascade of events that result in the digestive system's absorbing too much of the aluminum present in the diet. The aluminum wreaks havoc on various parts of the body, including the brain, where it destroys neurons and eventually causes paralysis and death.

The most amazing discovery made by Garruto's team is that up to 70 percent of the people they studied in Guam had some brain damage, but only 20 percent progressed all the way to Parkinson's or Lou Gehrig's disease. Genes and plasticity seem to be working hand in hand to produce these lower-than-expected rates of disease. There is a certain amount of genetic variation in the ability that all people have in coping with calcium shortages—some can function better than others. But thanks to plasticity, it's also possible for people's bodies to gradually develop ways to protect themselves against aluminum poisoning. Some people develop biochemical barriers to the aluminum they eat, while others develop ways to prevent the aluminum from reaching the brain.

An appreciation of plasticity may temper some of our fears about these diseases and even offer some hope. For if Parkinson's and Lou Gehrig's diseases can be prevented among the Chamorro by plasticity, then maybe medical researchers can figure out a way to produce the same sort of plastic changes in you and me. Maybe Lou Gehrig's disease and Parkinson's disease—as well as many other, including some cancers—aren't our genetic doom but a product of our development, just like variations in human height. And maybe their danger will in time prove as illusory as the notion that the Tutsi are giants, or the Maya pygmies—or Americans still the tallest of the tall.

Critical Thinking

1. What is meant by "plasticity" and why does it make "evolutionary good sense"?
2. What is "lactose intolerance" and why is this not an example of plasticity?
3. What are two other kinds of adaptation, pointed out by Lasker, that are examples of plasticity?
4. Why are humans among the most variable of species?
5. How have Americans and the Dutch changed in height since 1850 and why?

6. What happens to humans from the fetus to adulthood in a harsh environment, and why?
7. What do studies of monozygotic twins tell us about "reprogramming"?
8. What similarities and differences occurred in the United States and the Netherlands with regard to health care, and what has been the result?
9. Explain the "durable myth" of the Tutsi.
10. What has happened to the Tutsi and other Africans who have migrated to Western Europe or North America?
11. How do various Pygmy groups tell a similar story?
12. How do the Mayans of Guatemala contrast with those in the United States and why?
13. What has been surprising with regard to U.S. programs to improve health? What will happen if such funding is cut?
14. How do the Quechua illustrate plasticity and why?
15. What indications are there that Parkinson's and Lou Gherig's diseases exhibit plasticity?

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