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Are We Stuck?

Although we can argue about exactly how our ancestors from 50,000 years ago or more might have lived, it's undeniable that the time since people started living in settled groups larger than the size of a few extended families is extremely short. The ubiquitous clock metaphors for the history of the Earth have all of humanity shoved into the last few minutes, making agriculture and subsequent developments measurable only in nanoseconds. (In the Neanderthal Museum in Croatia, the time line of evolution is portrayed in a twenty-four-hour day, with "mankind's relations" appearing at just eight minutes before midnight.[1]) Even within the span of human evolution, the relative proportion of that period we have spent in agrarian settlements rather than as foragers or pastoralists is even more minuscule. And evolution is usually billed as a ponderous process, requiring thousands and thousands of generations before its effects are realized. It can seem logical, then, to assume that we have, as evolutionary psychologists and others are fond of stating, Stone Age genes ill suited to our Space Age lives and environment, and that we suffer the consequences. Or, as the Web page "Evolutionary Psychology: A Primer" puts it, "Our modern skulls house a stone age mind."[2]

Reasonable though this conclusion may seem, however, it is wrong, or at least it is correct only in such a broad sense as to be nearly useless. It is also often conflated with a different, though related, point, frequently made by paleo-diet proponents like Loren Cordain, that adopting agriculture sent humanity spinning down a starch-choked path of doom.[3] But in reality, we have two questions, both of which I will examine in this chapter. First, why, exactly, was this particular shift so momentous in the first place? In other words, what did agriculture do that was so revolutionary, and were all of the resulting changes bad? Second, given the consequences of humans giving up a less settled existence a mere handful of millennia ago, are we therefore stuck with the bodies—and minds—that we had before the transition to agriculture? Saying that agriculture and its concomitant changes to our diet and politics were bad for us, as Jared Diamond[4] and others do, isn't the same thing as saying we are trapped in an agriculture-induced cage—and an obese, sickly, socially stratified cage at that.

The curse or blessing—or both—of agriculture

Once the human species had spread out of Africa, people probably lived as hunter-gatherers in small groups until the rise of agriculture, which anthropologists Gregory Cochran and Henry Harpending call the Big Change.[5] No one denies that it was a major milestone, but several scientists go further and claim that it was the beginning of a downward spiral. In 1987, Jared Diamond, who later wrote such best-selling and influential books about the history of humans on Earth as *Guns, Germs, and Steel*, titled an article on the establishment of agriculture "The Worst Mistake in the History of the Human Race." In it he says, "With agriculture came the gross social and sexual inequality, the disease and despotism, that curse our existence."[6] An article in the British newspaper the *Telegraph* about Diamond's and others' work is similarly gloomily headlined "Is Farming the Root of All Evil?"[7]

Spencer Wells of the National Geographic Society goes even further: "Ultimately, nearly every single major disease affecting modern human populations—whether bacterial, viral, parasitic or noncommunicable—has its roots in the mismatch between our biology and the world we have created since the advent of agriculture."[8] And environmental writer and activist John Feeney pulls out all the stops with, "As hunter-gatherers, we blended gracefully into Earth's ecosystems. Then everything changed. Civilization is made possible by agriculture. Agriculture is unsustainable. If it weren't obvious already, you can see where this is going."[9]

The first point to clear up before we tackle all this pessimism is one of definition. Agriculture can be informally defined as growing one's crops and domesticating or at least keeping animals, rather than simply picking up what nature provides.[10] But anthropologists distinguish three kinds of such food production: horticulture, pastoralism, and intensive agriculture. People probably started out with horticulture, in which relatively unmodified crops are grown and cultivated with simple tools such as digging sticks. Modern-day horticultural societies include the Yanomami of South America, who combine growing manioc, taro, and some medicinal plants with foraging and hunting in the forest for the remainder of their food. Some horticulturalists today (and probably many in the past) spend part of their time as nomads, rather than living in permanent settlements. When they do form relatively sedentary groups, those groups are small, not likely to cluster in towns or cities.

Pastoralists, who rely on domesticated herds of animals that feed on natural pasture rather than on food provided by their keepers, have probably always been less common than crop-cultivating people, though even today a few groups, such as the Saami (known also as Lapps) of Scandinavia, who herd reindeer, persist. The animals are sometimes kept in one place for a few months at a time, as when the Saami keep female reindeer in corrals for milking during the summer. Although the reindeer, like other animals kept by pastoralists, provide the bulk of the Saami people's livelihood, the Saami and other pastoralists also trade with agricultural groups for other products, like plant foods.

Intensive agriculture is more like the form of growing food most often practiced today, though it is still seen in societies we would probably classify as "traditional," such as the rice-farming cultures of Southeast Asia. Fields are more permanent than those used by the horticulturalists, who may "slash and burn" the areas they cultivate, leaving them in between growing periods, sometimes for years, to regain nutrients in the soil. In contrast, intensive agricultural societies actively manage their fields with fertilizers and use them full-time. They also use more sophisticated tools, though these may simply be animal-drawn plows, not engine-powered cultivators. Crops are raised not only for eating by those who cultivate them, but for sale, which means that people can live in larger groups, with a division of labor between those who do the growing and those who buy or trade for the produce. That division of labor in turn means that resources—food itself or the means to purchase it—are not always divided equally, and society can become stratified.

Other than providing points of discussion to anthropologists, why do these distinctions matter? They matter because it is easier to accuse Monsanto-like agribusiness of causing widespread obesity and hypertension than it is to do the same thing to a few dozen people scrabbling in the ground for tubers using pointed sticks. And small-scale agriculture may have been around a great deal longer than people think; we are only now discovering that even the manly Neandertals had grain fragments between their teeth, and that early humans ground grains into flour, as I discuss in more detail in Chapter 5.

All of these gradations make it difficult to determine exactly when the woes associated with the shift to agriculture—increased levels of infectious diseases, reliance on one or a few food sources—first appeared. As archaeologist Tim Denham and his colleagues point out, "Early agriculture is not a demarcated 'all or nothing' lifestyle that can be clearly mapped across space and tracked through time."[11] As with all other processes in evolution, the move to a different way of obtaining food came about in fits and starts, with some human traits adapting well to the changes and others not so much. This irregular but realistic progression of events makes Cordain's contention that "the Paleo Diet is the one and only diet that ideally fits our genetic makeup. Just 500 generations ago—and for 2.5 million years before that—every human on Earth ate this way"[12] a little suspect.

This is not to deny the changes that took place as agriculture—intensive or otherwise—became established. Most obviously, the human diet changed to include and eventually depend on crops such as wheat, rice, and other grains, which meant that larger populations could be supported in one place. It also meant that the relative proportions of carbohydrates and proteins in the diet shifted toward the more reliable starches, though exactly how much is uncertain. Recent evidence from Neandertals and other fossils suggests, for example, that early humans may have eaten, and even processed, grain foods much earlier than had been supposed. Nevertheless, postagricultural diets not only relied more on carbohydrates, but were far less variable than the diets of hunter-gatherers. Estimates of the number of different kinds of plants eaten by many hunter-gatherer groups range from 50 to over 100, depending on the location of the population. Nowadays, in contrast, according to David Harris of the Institute of Archaeology at University College London, "a mere 30 crops account for 95% of plant-derived energy in the human food supply, over half of which is provided by maize, rice and wheat."[13]

Why might reducing the number of foods we eat be a bad thing? Eating a varied diet is not necessarily inherently virtuous, though certain micronutrients are probably best obtained from a variety of foods. But a varied set of crops does provide a cushion against some kinds of food shortages, in a not-putting-all-your-grains-in-one-basket way. The Irish potato famine, for example, came about because a fungal disease wiped out the potato crop that the peasants of Ireland relied on for most of their caloric needs. The disease, in turn, was able to have such devastating effects because almost all the potatoes had been selected to be genetically uniform, with the size, shape, and flavor that made them tasty and easy to grow. If one potato plant was susceptible, that meant they all were, and thus the entire crop could be decimated in one fell swoop. Reliance on just a few food plants makes us vulnerable to similar calamities, and it is an ongoing concern among scientists and farmers today. It is debatable, however, whether a return to a hunter-gatherer existence—even if feasible—is the best, or only, solution to this problem.

Working harder than a chimpanzee

One of the biggest bones of contention, so to speak, about hunter-gatherers versus agriculturalists is that the latter work too hard, in terms of both the time spent on subsistence and the intensity of the labor required, or at least they work harder than people who do not farm. Wells puts it this way: "As hunter-gatherers, we were a species that lived in much the same way as any other, relying on the whims of nature to provide us with our food and water."[14] And the whims of nature are presumably easier to cajole than the rocky soil or recalcitrant cattle of the farm. Agriculture, then, is sometimes seen as bad because it is just plain too difficult.

It is true that at least some hunter-gatherers spend less of their day "working," defined as engaging in activities necessary for subsistence, than do many farmers. Richard Lee's classic 1960s studies of the Kalahari desert people found that they needed two and a half days per week to collect enough food; adding activities such as toolmaking and other "housework" brought the total to an enviable forty-two hours per week.[15] Jared Diamond notes that the Hadza of Tanzania managed to keep their weekly work time down to fourteen hours or less.[16] Other estimates vary, and many of the calculations have been criticized by some anthropologists, who claim that the societies cited are not typical hunter-gatherers. But it seems reasonable to conclude that farmers, particularly those engaged in intensive agriculture, do indeed work harder than most foraging peoples.

The problem is that those foraging peoples are themselves still working pretty hard, at least compared to many other species. Anthropologist Hillard Kaplan and colleagues suggest that a hallmark of more modern humans was the ability to get hard-to-acquire foods.[17] They classify foods as *collected*, such as fruit; *extracted*, such as termites that are in protected underground nests or tubers that have to be dug from the ground; and *hunted*, which are foods such as deer or other prey that are caught or trapped.

Other primates, including chimpanzees, also eat foods that require some of the same kind of processing, and the chimps even hunt from time to time. But only humans focus on the extracted and hunted types rather than collecting what nature's whim provides. And we humans—even those in hunter-gatherer societies—need long years of training before we have the skills to net a fish or bring down an ungulate. Men of the Aché of South America, one of the best-studied contemporary foraging societies, do not peak in hunting ability, measured in the amount of meat collected per unit effort, until they are thirty-five years old. Collecting tubers is also no walk in the park; women of the Hiwi people of Venezuela become maximally efficient at foraging for roots between thirty-

five and forty-five years of age. Acquiring these skills takes time, and lots of it.[18]

We can draw two conclusions from these statistics. The obvious one is that hunting and gathering is more than lolling around waiting for grapes to fall into your mouth or meeting up with your mates for an occasional fun-filled hunting trip. It may not be the workweek of a Wall Street shark or a nineteenth-century sweatshop laborer, but it is not the idyllic life we might have imagined. Less obvious, though, is that the amount of time one spends making a living is a continuum among animals, humans included. Why do we have a paleofantasy about the ancestral hunter-gatherer, when our even earlier relations, the apes, spend even less time foraging? Should we be yearning for the days before tool use? And how do we balance time against effort? Is it better to mindlessly munch grass, which requires little effort but takes a lot of time to down, one determined mouthful after another, or to spend less of the day fashioning a complex fish trap that may yield no catch? Choosing agriculture as the point at which we all started to go downhill because we began to work too hard is simply not defensible.

Farming sickness

Irrespective of what they are eating, intensive agriculture allows more people to be supported in a society. Having larger groups of people around, and having them be more or less sedentary, has several consequences. As Wells and many other authors have noted, one of the clearly undesirable effects of agriculture is the proliferation of new diseases, both infectious and noninfectious. Here, then, we can point to an unmitigated downside to settling down and farming: infectious diseases, those caused by pathogenic organisms such as viruses and bacteria, were able to spread because when people are in one place, their waste tends to stay put as well.

For example, cholera outbreaks occur when bacteria from infected feces contaminate the water supply, which is a problem only if you keep going back to the same polluted source to wash and drink. The disease can't establish itself in a continually moving population, so hunter-gatherers would not have suffered from it. Similarly, the virus that causes measles requires a fresh set of victims to be maintained in a population, so even if a small band of humans was infected with it, the disease would eventually have died out. In more densely populated areas, however, measles and diseases like it can be perpetually recycled into newly vulnerable targets.

Farming usually also means domesticating animals, and those animals can harbor diseases of their own, many of which are unwittingly passed to their caretakers. Worms, fungi, bacteria, viruses—our pets and work animals can be infected with all of them, and all have been implicated in human diseases as well. Smallpox, influenza, and diphtheria are all thought to have originated in nonhuman animals. Although wild animals can be a source of disease for hunters, the risk is much lower simply because the animals are not in contact with humans for very long.

Noninfectious diseases that would have appeared in newly agricultural human societies include vitamin deficiency diseases such as pellagra or scurvy, simply because agriculturalists tend to have fewer kinds of food in their diet, as I mentioned earlier, and the chance of relying on one or a few foods that lack essential nutrients is high. The skeletons of ancient farmers are filled with evidence of tooth decay, iron deficiency anemia, and other disorders. Diamond notes that the Greek and Turkish skeletons from preagricultural sites averaged 5 feet 9 inches in height for men and 5 feet 5 inches for women, but after farming became established, people were much shorter—just 5 feet 3 inches and 5 feet, respectively, by about 5,000 years ago, probably because they were suffering from malnutrition. The teeth from skeletons of Egyptians who died 12,000 years ago, about 1,000 years after their people had shifted from

foraging to farming, were rife with signs of malnutrition in the enamel: a whopping 70 percent of them, up from 40 percent before agriculture became widespread.[19]

Then a funny thing happened on the way from the preagricultural Mediterranean to the giant farms of today: people, at least some of them, got healthier, presumably as we adapted to the new way of life and food became more evenly distributed. The collection of skeletons from Egypt also shows that by 4,000 years ago, height had returned to its preagricultural levels, and only 20 percent of the population had telltale signs of poor nutrition in their teeth. Those trying to make the point that agriculture is bad for our bodies generally use skeletal material from immediately after the shift to farming as evidence, but a more long-term view is starting to tell a different story. For example, Timothy Gage of the State University of New York at Albany examined long-term mortality records from around the world, along with the likeliest causes of death, and concluded that life span did not decrease, nor did many diseases increase, after agriculture. Some illnesses doubtless grew worse after humans settled down, but life has had its "nasty, brutish, and short" phases at many points throughout history.[20]

A deeper gene pool, with more unequal swimmers

Regardless of whether the people existing after agriculture were happier, healthier, or neither, it is undeniable that there were more of them. Agriculture both supports and requires more people to grow the crops that sustain them. Estimates vary, of course, but evidence points to an increase in the human population from 1–5 million people worldwide to a few hundred million once agriculture had become established. And a larger population doesn't just mean scaling everything up, like buying a bigger box of cereal for a larger family. It brings qualitative changes in the way people live.

For example, more people means more kinds of diseases, particularly when those people are sedentary. When those groups of people can also store food for long periods, the opportunity arises for sequestering that food, creating in turn a society with haves and have-nots. Many authors, including Diamond and Wells, have detailed the resulting social stratification, carrying with it increased division of labor and specialization, the growth of religion and government, and countless other marks of civilization, from architecture to money. Wells suggests that agriculture also fueled a change in human attitudes toward nature, from respect to a need for control, which in turn led to some of the planetary environmental problems of today.

Scientists and scholars ranging from the late Stephen Jay Gould to José Ortega y Gasset have lamented the supposed increase in warfare and violence as people moved from hunter-gatherer to settled life. The horrific large-scale violence we see today is sometimes attributed to the impersonal nature of warfare via airplanes and missiles, but the facts are hard to come by. Contemporary hunter-gatherers vary in the amount of warfare they exhibit, and as I pointed out in the previous chapter, because of modern influences on their behavior, any conclusions about our ancestors' violent predilections based on today's foraging peoples should be taken with a grain of salt.

Economist Samuel Bowles examined the percentage of adult mortality attributed to warfare from archaeological sites (where deaths from weapons can be determined using marks on the skeleton) and ethnographic records around the world dating from the nineteenth century, mainly before contact with modern industrialized society.[21] The data reveal a startling 14 percent of deaths from such violence, a much higher proportion than would be found in most societies today. Bowles goes on to suggest that

selection at the level of the group could have increased the frequency of altruistic genes in early humans, because groups with sacrificing members would have been better able to persist in the face of frequent attacks. Whether or not Bowles is correct, his findings do not support a pacifist history of early humans that became bloody only after people became farmers. Psychologist Steven Pinker argues that human society has, in fact, become much more peaceful of late.[22]

More people, however, also means more genes. Not more genes in each individual, but more genes overall, as a simple result of there being more humans on Earth. While a larger population has obvious drawbacks, including overcrowding and high demand on resources such as clean water, it also has a sometimes overlooked benefit: more fodder for natural selection to act on. Evolution requires mutations, small alterations in the genes, to do its work. Beneficial traits, whether those are air-breathing lungs instead of gills or the ability to throw a spear, depend on new genes or combinations of genes, and the ultimate source of new genetic material is random mutation. Think of mutations as lottery tickets: the vast majority of them are losers, but the only way to increase your chances of winning is to buy a larger number of entries. As Cochran and Harpending point out, once the human population began expanding at a rapid clip, "favorable mutations that had previously occurred every 100,000 years or so were now showing up every 400 years."[23] And such favorable mutations spread more quickly in larger populations. Hence, a bigger population can evolve faster. John Hawks and his colleagues calculated that in the last 50,000 years, nearly 3,000 new adaptive mutations arose in Europeans.[24]

What this means is that the population explosion after agriculture, despite its well-known drawbacks, also carried some important positive changes that may have been overlooked. Cochran and Harpending also believe that human intelligence increased dramatically once groups became larger, via the same more-tickets-in-the-lottery mechanism.[25] Adam Powell and colleagues at University College London suggest that group size, not necessarily related to the birth of agriculture but among early humans in general, was key to the uptick in cultural and technological complexity seen during the Upper Paleolithic in many parts of the world.[26] Tools, weapons, art, and ritual objects all became more complex, and evidence of long-distance trading emerges in the archaeological record.

Exactly when that increase happened differs around the world, with a more rapid transition in Europe and western Asia than in northeastern Asia and Siberia. Why the variation? Powell and colleagues believe that it is much easier to lose skills like toolmaking if a group is small and only a few individuals possess the crucial knowledge. One unfortunate accident, and the village elder who transmitted information about the best place to get stones for spear tips, or a more sophisticated method for drawing on cave walls, is gone, and with that person the skills he harbored. Larger groups, or frequent migration between populations, provide some insurance against those skills being lost forever.

It is important to keep in mind that neither the benefits of human population growth, such as the flowering of genetic potential or cultural complexity, nor the more dismal consequences of agriculture, were directed. Spencer Wells looks at the advent of farming as akin to humanity diving off a cliff. Humans, he says, "divorced themselves—and us—from millions of years of evolutionary history, charting a new course into the future without a map to guide them through the pitfalls that would appear over the subsequent ten millennia."[27] He rues the "unintended consequences" of the establishment of agriculture.

The problem is, all of evolution's consequences are unintended, and there are never any maps. Arguably, apes, by moving from trees to plains, made their world spin just as out of control as we did when we began to grow crops. Either way, no one was aiming anywhere. As I discussed in the previous chapter, all those cute cartoons showing fish anxiously, or ambitiously, gazing up the shore toward ever-more-bipedal animals that eventually tote briefcases and wear Prada are just that—cartoons. Evolution is continuous, but it is not goal-oriented. It is not as if we were on a predestined path toward enlightenment when agriculture suddenly threw a plow into the works and made us deviate into obesity and disease.

Mired in the Stone Age, or in the EEA, or somewhere

Whether agriculture was a boon or a burden, what about the idea that because our bodies and minds evolved during the millennia before agriculture came about, we are still hobbled by our ancient genes in a world that has changed beyond recognition from our days as hunter-gatherers? The notion of a mismatch between modern and ancestral humans can be seen everywhere from diet books detailing how cavemen ate to conjectures about why powerful male celebrities seek out young women. As the quotations at the start of this chapter illustrate, we often look to our evolutionary past to explain the woes of our apparently ill-adapted present.

This idea of being stuck in a world to which we are not adapted is perhaps most elaborated on by the evolutionary psychologists. Evolutionary psychology, a field that purports to explain human behavior using evolutionary principles, relies on a concept called the Environment of Evolutionary Adaptedness, or EEA. The original idea of the EEA was developed in the late 1960s and early 1970s by psychologist John Bowlby, who was interested in how children become attached to their parents and vice versa. The EEA was later used as a linchpin for examinations of adaptation in the human mind. As Leda Cosmides and John Tooby, some of the leaders in evolutionary psychology, put it:

> Our species lived as hunter-gatherers 1000 times longer than as anything else. The world that seems so familiar to you and me, a world with roads, schools, grocery stores, factories, farms, and nation-states, has lasted for only an eyeblink of time when compared to our entire evolutionary history. The computer age is only a little older than the typical college student, and the industrial revolution is a mere 200 years old. Agriculture first appeared on earth only 10,000 years ago, and it wasn't until about 5,000 years ago that as many as half of the human population engaged in farming rather than hunting and gathering. Natural selection is a slow process, and there just haven't been enough generations for it to design circuits that are well-adapted to our post-industrial life.[28]

The EEA is the environment in which a particular characteristic, like the eye, or a love of sweets, evolved. It is not simply equivalent to the African savanna of 100,000 years ago, or any other single place or time. But because the human species spent so much longer on that savanna than it has in Midtown Manhattan, the evolutionary psychologists surmise that we simply have not had enough time to adapt to the modern environment. Tooby and Cosmides claim, "The key to understanding how the modern mind works is to realize that its circuits were not designed to solve the day-to-day problems of a modern American—they were designed to solve the day-to-day problems of our hunter-gatherer ancestors."[29] Hence the Stone Age mind (or genes). More simply, Edward Hagen says that the EEA "is the environment to which a species is adapted."[30] Thus, all organisms have an EEA, from fish to bacteria to elephants.

Before going any further, let me point out that I see nothing wrong with trying to explain the psychology or behavior of humans using an evolutionary framework. I do, however, find that people have a hard time viewing themselves dispassionately, and when it comes to explaining our own behavior, we have a regrettable tendency to see what we want to see and rationalize what we already want to do. That often means that if we can think of a way in which a behavior, whether it is eating junk food or having an affair, might have been beneficial in an ancestral environment, we feel vindicated, or at least justified. It's different from "my genes made me do it," but the end result—that we are trapped, perhaps regrettably, in a web of behavior that we inherited from our ancestors—is the same. What I am arguing in this book is that such an approach misses the real lessons of evolution, not only because it is specious to suggest that our genes dictate infidelity, but because that trap does not exist.

Furthermore, appealing to the EEA doesn't help. First of all, let's look at those creaky old genes. What does it mean to say that our genes are old, but our environment new? Our genes come from our ancestors, who got them from their ancestors, and so on ad infinitum, or at least "ad Precambrian-um." Some of our genes are identical to those of worms, chickens, and even bacteria, while others arose much more recently. A gene crucial to sperm production, called *BOULE*, is found in virtually all sexually reproducing animals and is 600 million years old, far preceding, of course, the time when humans were on the African savanna, or were even mammals.

Genes change when mutation provides the raw material and then natural selection or other forces, such as individuals moving to a new place, or sheer random chance, act on that material. But they change piecemeal, in fits and starts, and the rest of the genome is dragged along higgledy-piggledy. Organisms don't get to shed their whole set of genes in one fell swoop, like a pair of ill-fitting trousers, even during major transitions like the shift from water to land—or from ape to human.

New molecular techniques are allowing scientists to pinpoint which genes are evolutionarily conserved—that is, essentially unchanged as different groups split off from each other in history—and which are more recent. While it is true that more recently separated groups, like humans and apes, share more genes than do distant relatives, like humans and carnations, that relationship does not mean that those shared genes arose at any particular point, in our hunter-gatherer past or elsewhere, and now cannot catch up. As anthropologists Beverly Strassmann and Robin Dunbar point out, "From a genetic standpoint, the Stone Age may have no greater significance than any other period of our evolutionary past."[31]

Which genes change is also important. Much has been made of the proverbial 98 percent genetic similarity between humans and chimpanzees (the actual percentage changes slightly depending on which expert you consult or what metric is used, with biologist Roy Britten recently suggesting that 95 percent is a more accurate figure[32]). But the add-'em-all-up approach is not likely to yield any insight into what genetic differences, whether small or large, really mean. Anthropologist Jonathan Marks points out that we share perhaps a third of our genes with daffodils. It all depends what scale of measurement you use. "So from the standpoint of a daffodil, humans and chimpanzees aren't even 99.4% identical, they're 100% identical. The only difference between them is that the chimpanzee would probably be the one eating the daffodil."[33] Without going so far as to argue for the rights of flowering bulbs, as people have done for chimps and other great apes, Marks notes that it is difficult to know what to make of the similarity free of context. But Loren Cordain says, "DNA evidence shows that genetically, humans have hardly changed at all (to be specific the human genome has changed less than 0.02 percent) in 40,000 years."[34] This purported lack of genetic progress is used to support Cordain's prescription of a hunter-gatherer diet, before agriculture came along with its newfangled ideas about growing grain and living in houses.

Setting aside whether we are in fact 2 percent, 1 percent, or 5 percent different from chimpanzees, or whether our genes really are less than 1 percent different from those of our Pleistocene ancestors, what that 5 percent or 0.08 percent contains is crucial.

The vaunted statistics are often obtained by counting up the differences in the components of DNA between two populations, or two species. Because these components occur in a pattern of chemicals called bases, we often speak of DNA sequences. But simply comparing sequences tells little about the function of the DNA. Rebecca Cann, a human geneticist and anthropologist at the University of Hawaii, is skeptical about extrapolating from DNA to meaningful difference. She points out that while "it is true that it is difficult to find coding sequence differences between two modern humans, it is not true that therefore the ones that do exist are unimportant. And we won't be able to tell this just looking at the 'parts list.'"[35]

In other words, if all you had was an alphabet, you could easily end up concluding that *Hamlet* and the script for an episode of *The Sopranos* were the same thing, since they use exactly the same letters. Perhaps that idea is a little far-fetched, but I trust the analogy is clear. And when it comes to genes, the "parts list" is woefully inadequate. The big question is not how many genes differ between ape and human, or between today's human and our ancestors of 50,000 years ago, but *which* genes differ. Changes in the fine biochemical structure of DNA happen over time, simply by chance. Other changes occur because of selection on human characteristics such as language ability. But as eminent evolutionary biologist Sean B. Carroll says, "How can we identify the 'smoking guns' of human genetic evolution from neutral ticks of the molecular evolutionary clock?"[36] Using the alphabet analogy, he means that we need tools to help us distinguish Shakespeare from soap opera in a way that shows the difference in content, not just a difference in the number of times the letter "a" or "b" is used.

Carroll and other geneticists are now focusing their attention on regulatory and developmental genes, the ones that direct the rest of the show and determine when in the early growth of an organism its genes are switched on or deactivated. Much of the genome contains noncoding DNA, or genetic material that does not produce proteins. These sections can direct other genes, or simply clutter up the chromosome like jars of rusty bolts in a garage. Their functions, and the rate at which they seem to have changed in comparison with other genes, are a hot area of research in evolutionary biology. What they do not tell us, however, is that our genes are so similar to those of other organisms, or to those of our ancestors, as to render us stuck in the past, or that the number of changes per se is a valuable yardstick. Carroll puts it this way: "The rate of trait evolution tells us nothing about the number of genes involved."[37] But the converse is also true: knowing how many genes have changed doesn't tell us about how fast a trait has become altered.

What's more, whether old or new, human genes are also far from uniform, even after all this time. Although we are more similar to each other than are the members of a group of chimpanzees, human beings are still remarkably genetically diverse. Some genes, such as those involved in lactose tolerance, are far more likely to be found in people whose ancestry comes from some parts of the world than in people originating from other parts. Even within groups, the most casual scrutiny shows genetic variation in traits ranging from ear shape to the ability to taste bitter compounds. Such genetic variation among individuals is the fodder for evolution because it provides a menu of options for natural selection. If the environment changes, one or another of those menu items might be suited for the new conditions. This means that we still have an ample supply of genes that can evolve, and we are not simply dragging around a set of genes that were best suited for the Pleistocene.

What about the other argument supporting the need to use our EEA—that we spent far longer as hunter-gatherers in small bands than as cubicle workers in an urban sea? It does stand to reason that longer periods of time give evolution more scope to work, and by that standard, 10,000 years doesn't provide as much of an opportunity as 100,000, or a million. But sheer time simply isn't the only relevant variable. My students often complain that if they had just had more time for an exam, or to write a term paper, they would have done better. More time means more opportunity to work for them too, or so the student frantically clutching a test paper after the bell goes off would have me believe. The sad truth, however, is that some of those students wouldn't get the correct answer, or write an A essay, if you gave them from now until doomsday, or the next geological epoch. Time matters, and of course if I allowed only fifteen minutes for students to write a five-page paper, I would get shoddy work from everyone. But time isn't the only thing that matters.

The same goes for evolution and our ability to adapt to a new environment, whether that is agriculture or life on land instead of water. Large changes take a long time. Olives don't become petunias in a few generations. But how long does it take for them to become bigger olives? We no longer have to satisfy ourselves with generalities like "the time since agriculture is too short." We can look for the answers. The length of time required for a change in genes to become common in a population is a question we can now at least partly answer with data, as I'll detail in the chapters that follow. In the meantime, while it is true that, as Tooby and Cosmides point out in the title of a 1990 paper, "The Past Explains the Present," the present has not stayed still.[38]

Genes, peaks, and mismatch

As an alternative to the EEA, prominent anthropologist Bill Irons suggested a modification: the Adaptively Relevant Environment.[39] The Adaptively Relevant Environment is a set of environmental features, such as the amount of rainfall or the abundance of snakes, that is important to a trait, such as having a fear of reptiles. In an environment brimming with cobras, those who shun snakes are at an advantage. If the environment becomes reptile-free, and people instead run screaming from garden hoses, telephone cables, and other wiggly cylindrical objects, the trait is no longer adaptive.

Irons' notion does not rest on life in a foraging society, and hence avoids what he calls "Pleistocentrism in which all human psychological adaptations are tightly tied to the conditions of Pleistocene foraging societies."[40] He sketches several human behaviors, including incest avoidance and striving for high status, and then analyzes them using the concept of an Adaptively Relevant Environment, arguing that the former evolved as a mechanism that avoids the deleterious effects of inbreeding when close relatives have children. The evolution of incest avoidance thus required "a social environment in which close kin, siblings, parent, and children are in intimate contact during the critical period of the first two or three years of a child's life, and in which intimate contact is rare between nonkin or distant kin when one or both parties are in the critical age range of newborn to three years."[41] This somewhat pedantic mouthful boils down to having an aversion to sex with those one is raised with from birth or thereabouts—a situation likely to have been common both in foraging societies and more recent ones. We therefore do not need to invoke a particular way of life as a reason for the behavior.

Irons also notes the difficulty of defining the precise environment in which any adaptation, whether dietary, psychological, or otherwise, occurred, since humans, and the other hominins before us, did so many different things in so many different places during the hundreds of thousands of years before agriculture. He also points out that many environmental changes occurred more recently than the end of the Pleistocene and do not seem to have hinged on the transition to agriculture.

I do not find any particular fault with Irons' concept, but I am not sure we need a new framework for understanding the evolution of human behavior in addition to the usual principles of evolutionary biology. Traits in organisms, human or not, evolve in a

particular environment, and although I agree with the evolutionary psychologists, and Irons, that understanding that environment helps us understand the adaptation, we may not need a brand-new dedicated term for it.

Perhaps it would be just as helpful to invoke a concept that has been in use by biologists in various forms since the 1930s, when the distinguished evolutionary biologist Sewall Wright imagined that populations and their genes could be viewed as if they were in a three-dimensional landscape, with hills and valleys.[42] The vertical axis, or height of the peaks, indicates the success or fitness of a group of genes. If a population on a mountaintop changes the composition of its genes, it is likely to move to a less successful point, and hence any small changes probably will be selected against. Conversely, a population in a valley is likely to improve with small changes. The entire fitness landscape may well contain peaks that are even higher than the one that a given population, even one on a mountain, is already on, but those peaks might have valleys between them. Hence, a population on a peak cannot move very easily to a higher one, whereas a population in a valley probably will get better no matter what direction it takes.

From the perspective of the EEA, the point is that we already have a way to think about inertia in evolution. Populations get "stuck," and it may be difficult for their gene frequencies to change without having their overall level of fitness—the degree to which they are suited to their environment—get worse before it gets better. But that is a different, and more nuanced, claim than the declaration that we arrived at the Pleistocene, or at a way of life with small hunter-gatherer bands, and will be unable to escape until millions of years pass.

This is not to argue that our modern lives are not sometimes, perhaps frequently, mismatched with our ancestral environment, or that we cannot use our past to inform our present. The evolutionary psychologists, among others, have reminded us that not all human behaviors are currently adaptive. It is extremely plausible, for example, that we crave sugar and not fiber because we evolved in an environment where ripe fruit was both nutritious and in short supply. Seeking it out meant gaining calories that in turn made it more likely the seeker would have enough nutrition to survive and reproduce, passing on his or her cravings. Nowadays, in a world full of processed sugar in everything from ketchup to Mars bars, this eagerness to consume sweets backfires, resulting in high rates of diabetes, obesity, and other woes.

Fiber is also good for us, yet we seem to lack that same enthusiasm for filling our diets with bran. Why wouldn't natural selection have instilled a drive to seek out high-fiber foods similar to the drive it instilled for sweet foods? The answer is simple: fiber was abundant in our ancestral environments, and no one had to do anything special to acquire it. People eating a diet similar to that eaten by hunter-gatherers can consume up to 100 grams of fiber per day, in contrast to the standard American intake of less than 20 grams, just because their food is all unprocessed. No one who craved the prehistoric equivalent of broccoli or bran muffins in the Pleistocene would have been at a particular advantage over those who did not.

Being mismatched, however, is different from being stuck. Instead of asking how we can overcome our Stone Age genes, let us ask which traits have changed quickly, which slowly, and how we can tell the difference.

3

Crickets, Sparrows, and Darwins—or, Evolution before Our Eyes

When we think about rapid change in a species, humans are often the first to come to mind, perhaps because we are so used to the idea that the modern world is very different from the one in which we evolved. But our anthropocentrism betrays us here, as it does in so many other places. Scientists are discovering more and more examples of evolution occurring in the span of just a handful of generations in animals large and small. What's more, some of those examples illustrate the practical implications of evolution, and why fishermen and farmers, not just scientists, should take heed of its findings.

My own firsthand experience with rapid evolution reminded me of taking our cat William with us in a U-Haul when my husband and I moved from New Mexico to Ohio. William was generally a stalwart and pragmatic animal, but like most cats, he greatly disliked riding in a vehicle, and he spent much of each day's trip howling in his crate, waiting for the horror to end. We would smuggle him into the motel room each evening, letting him out to use the litter box and eat. He would immediately dart under the bed, collect his nerves for an hour or so, and then emerge to go about his business.

This routine worked for the first two nights, but on the third we