THE SECRET OF OUR SUCCESS

How Culture Is Driving Human Evolution, Domesticating Our Species, and Making Us Smarter

JOSEPH HENRICH

PRINCETON UNIVERSITY PRESS
Princeton & Oxford

CHAPTER 1

A PUZZLING PRIMATE

You and I are members of a rather peculiar species, a puzzling primate.

Long before the origins of agriculture, the first cities, or industrial technologies, our ancestors spread across the globe, from the arid deserts of Australia to the cold steppe of Siberia, and came to inhabit most of the world's major land-based ecosystems—more environments than any other terrestrial mammal. Yet, puzzlingly, our kind are physically weak, slow, and not particularly good at climbing trees. Any adult chimp can readily overpower us, and any big cat can easily run us down, though we are oddly good at long-distance running and fast, accurate throwing. Our guts are particularly poor at detoxifying poisonous plants, yet most of us cannot readily distinguish the poisonous ones from the edible ones. We are dependent on eating cooked food, though we don't innately know how to make fire or cook. Compared to other mammals of our size and diet, our colons are too short, stomachs too small, and teeth too petite. Our infants are born fat and dangerously premature, with skulls that have not yet fused. Unlike other apes, females of our kind remain continuously sexually receptive throughout their monthly cycle and cease reproduction (menopause) long before they die. Perhaps most surprising of all is that despite our oversized brains, our kind are not that bright, at least not innately smart enough to explain the immense success of our species.

Perhaps you are skeptical about this last point?

Suppose we took you and forty-nine of your coworkers and pitted you in a game of Survivor against a troop of fifty capuchin monkeys from Costa Rica. We would parachute both primate teams into the remote tropical forests of central Africa. After two years, we would return and count the survivors on each team. The team with the most survivors wins. Of course, neither team would be permitted to bring any equipment: no matches, water containers, knives, shoes, eyeglasses, antibiotics, pots, guns, or rope. To be kind, we would allow the humans —but not the monkeys—to wear clothes. Both teams would thus face surviving for years in a novel forest environment with only their wits, and their teammates, to rely on.

Who would you bet on, the monkeys or you and your colleagues? Well, do you know how to make arrows, nets, and shelters? Do you know which plants or insects are toxic (many are) or how to detoxify them? Can you start a fire without matches or cook without a pot? Can you manufacture a fishhook? Do you know how to make natural adhesives? Which snakes are venomous? How will you protect yourself from predators at night? How will you get water? What is your knowledge of animal tracking?

Let's face it, chances are your human team would lose, and probably lose badly, to a bunch of monkeys, despite your team's swollen crania and ample hubris. If not for surviving as hunter-gatherers in Africa, the continent where our species evolved, what are our big brains for anyway? How did we manage to expand into all those diverse environments across the globe?

The secret of our species' success lies not in our raw, innate, intelligence or in any specialized mental abilities that fire up when we encounter the typical problems that repeatedly challenged our hunter-gatherer ancestors in the Pleistocene. Our ability to survive and thrive as hunter-gatherers, or anything else, across an immense range of global environments is not due to our individual brainpower applied to solving complex problems. As you will see in chapter 2, stripped of our culturally acquired mental skills and know-how, we are not so impressive when we go head-to-head in problem-solving tests against other apes, and we certainly are not impressive enough to account for the vast success of our species or for our much larger brains.[1]

In fact, we have seen various versions of the human half of our Survivor experiment many times, as hapless European explorers have struggled to survive, stranded in seemingly hostile environments, from the Canadian Arctic to the Gulf Coast of Texas. As chapter 3 shows, these cases usually end in the same way: either the explorers all die, or some of them are rescued by a local indigenous population, which has comfortably been living in this "hostile environment" for centuries or millennia.

Thus, the reason why your team would lose to the monkeys is that your species—unlike all others—has evolved an addiction to culture. By "culture" I mean the large body of practices, techniques, heuristics, tools, motivations, values, and beliefs that we all acquire while growing up, mostly by learning from other people. Your team's only hope is that you might bump into, and befriend, one of the groups of hunter-gatherers who live in the central African forests, like the Efe pygmies. These pygmy groups, despite their short stature, have been flourishing in these forests for a very long time because past generations have bequeathed to them an immense body of expertise, skills, and abilities that permit them to survive and thrive in the forest.

The key to understanding how humans evolved and why we are so different from other animals is to recognize that we are a *cultural species*. Probably over a million years ago, members of our evolutionary lineage began learning from each other in such a way that culture became cumulative. That is, hunting practices, tool-making skills, tracking know-how, and edible-plant knowledge began to improve and aggregate—by learning from others—so that one generation could build on and hone the skills and know-how gleaned from the previous generation. After several generations, this process produced a sufficiently large and complex toolkit of practices and techniques that individuals, relying only on their own ingenuity and personal experience, could not get anywhere close to figuring out over their lifetime. We will see myriad examples of such complex cultural packages, from Inuit snow houses, Fuegian arrows, and Fijian fish taboos to numerals, writing, and the abacus.

Once these useful skills and practices began to accumulate and improve over generations, natural selection had to favor individuals who were better cultural learners, who could more effectively tap in to and use the ever-expanding body of adaptive information available. The newly produced products of this cultural evolution, such as fire, cooking, cutting tools, clothing, simple gestural languages, throwing spears, and water containers, became the sources of the main selective pressures that genetically shaped our minds and bodies. This interaction between culture and genes, or what I'll call *culture-gene coevolution*, drove our species down a novel evolutionary pathway not observed elsewhere in nature, making us very different from other species—a new kind of animal.

However, recognizing that we are a cultural species only makes an evolutionary approach even more important. As you'll soon see in chapter 4, our capacities for learning from others are themselves finely honed products of natural selection. We are adaptive learners who, even as infants, carefully select when, what, and from whom to learn. Young learners all the way up to adults (even MBA students) automatically and unconsciously attend to and preferentially learn from others based on cues of prestige, success, skill, sex, and ethnicity. From other people we readily acquire tastes, motivations, beliefs, strategies, and our standards for reward and punishment. Culture evolves, often invisibly, as these selective attention and learning biases shape what each person attends to, remembers, and passes on. Nevertheless, these cultural learning abilities gave rise to an interaction between an accumulating body of cultural information and genetic evolution that has shaped, and continues to shape, our anatomy, physiology, and psychology.

Anatomically and physiologically, the escalating need to acquire this adaptive cultural information drove the rapid expansion of our brains, giving us the space to store and organize all this information, while creating the extended childhoods and long postmenopausal lives that give us the time to acquire all this know-how and the chance to pass it on. Along the way, we'll see that culture has left its marks all over our bodies, shaping the genetic evolution of our feet, legs, calves, hips, stomachs, ribs, fingers, ligaments, jaws, throats, teeth, eyes, tongues, and much more. It has also made us powerful throwers and long-distance runners who are otherwise physically weak and fat.

Psychologically, we have come to rely so heavily on the elaborate and complicated products of cultural evolution for our survival that we now often put greater faith in what we learn from our communities than in our own personal experiences or innate intuitions. Once we understand our reliance on cultural learning, and how cultural evolution's subtle selective processes can produce "solutions" that are smarter than we are, otherwise puzzling phenomena can be explained. Chapter 6 illustrates this point by tackling questions such as, Why do people in hot climates tend to use more spices and find them tastier? Why did aboriginal Americans commonly put burnt seashells or wood ash into their corn-meal? How could ancient divination rituals effectively implement game theoretic strategies to improve hunting returns?

The growing body of adaptive information available in the minds of other people also drove genetic evolution to create a second form of human status, called prestige, which now operates alongside the dominance status we inherited from our ape ancestors. Once we understand prestige, it will become clear why people unconsciously mimic more successful individuals in conversations; why star basketball players like LeBron James can sell car insurance; how someone can be famous for being famous (the Paris Hilton Effect); and, why the most prestigious participants should donate first at charity events but speak last in decision-making bodies, like the Supreme Court. The evolution of prestige came with new emotions, motivations, and bodily displays that are distinct from those associated with dominance.

Beyond status, culture transformed the environments faced by our genes by generating social norms. Norms influence a vast range of human action, including ancient and fundamentally important domains such as kin relations, mating, food sharing, parenting, and reciprocity. Over our evolutionary history, norm violations such as ignoring a food taboo, botching a ritual, or failing to give one's in-laws their due from one's hunting successes meant reputational damage, gossip, and a consequent loss of marriage opportunities and allies. Repeated norm violations sometimes provoked ostracism or even execution at the hands of one's community. Thus, cultural evolution initiated a process of *self-domestication*, driving genetic evolution to make us prosocial, docile, rule followers who expect a world governed by social norms monitored and enforced by communities.

Understanding the process of self-domestication will allow us to address many key questions. In chapters 9 to 11, we'll explore questions such as, How did rituals become so psychologically potent, capable of solidifying social bonds and fostering harmony in communities? How do marriage norms make better fathers and expand our family networks? Why is our automatic and intuitive response to stick to a social norm, even if that means paying a personal cost? Similarly, when and why does careful reflection cause greater selfishness? Why do people who wait for the "walk signal" at traffic lights also tend to be good cooperators? What was the psychological effect of World War II on America's Greatest Generation? Why do we prefer to interact with, and learn from, those who speak the same dialect as we do? How did our species become the most social of primates, capable of living in populations of millions, and at the same time, become the most nepotistic and warlike?

The secret of our species' success resides not in the power of our individual minds, but in the *collective brains* of our communities. Our collective brains arise from the synthesis of our cultural and social natures—from the fact that we readily learn from others (are *cultural*) and can, with the right norms, live in large and widely interconnected groups (are *social*). The striking technologies that characterize our species, from the kayaks and compound bows used by hunter-gatherers to the antibiotics and airplanes of the modern world, emerge not from singular geniuses but from the flow and recombination of ideas, practices, lucky errors, and chance insights among interconnected minds and across generations.

Thus, the three common explanations for our species' ecological success are (1) generalized intelligence or mental processing power, (2) specialized mental abilities evolved for survival in the hunter-gatherer environments of our evolutionary past, and/or (3) cooperative instincts or social intelligence that permit high levels of cooperation. All of these explanatory efforts are elements in building a more complete understanding of human nature. However, as I'll show, none of these approaches can explain our ecological dominance or our species' uniqueness without first recognizing the intense reliance we have on a large body of locally adaptive, culturally transmitted information that no single individual, or even group, is smart enough to figure out in a lifetime. To understand both human nature and our ecological dominance, we first need to explore how cultural evolution gives rise to complex repertoires of adaptive practices, beliefs, and motivations.

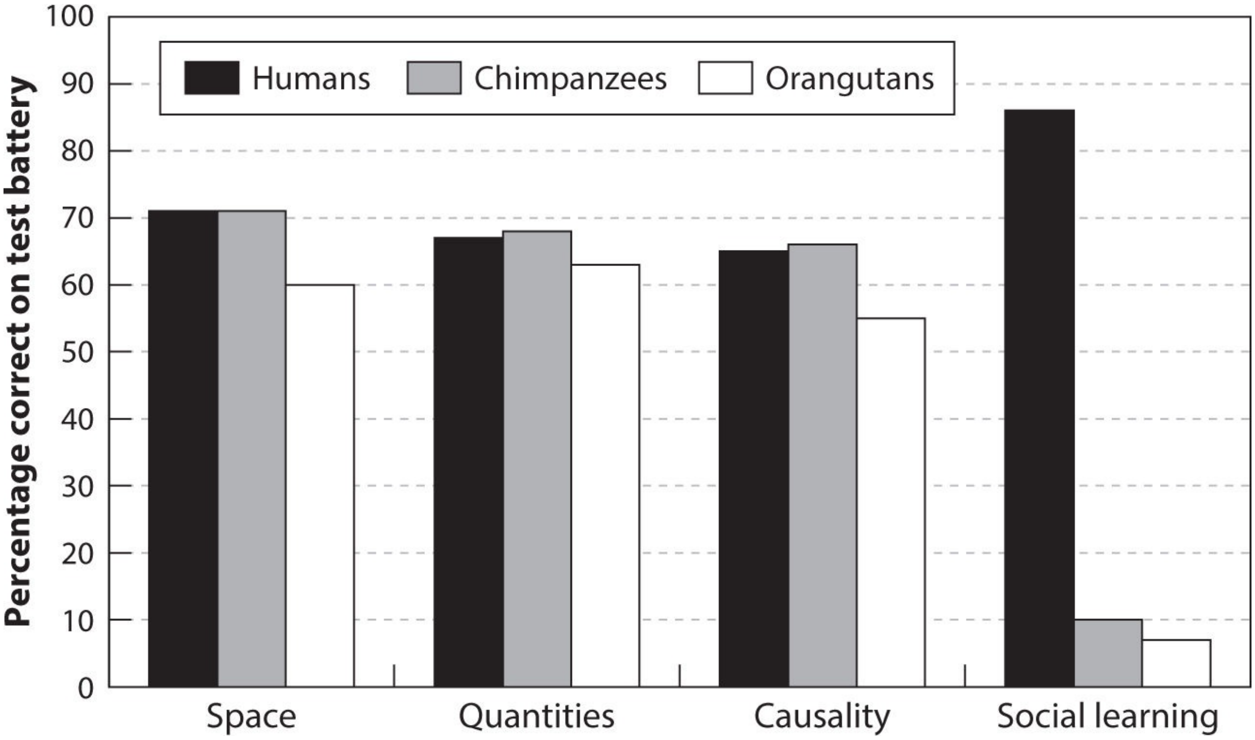
[redacted] put 106 chimpanzees, 105 German children, and 32 orangutans through a battery of 38 cognitive tests.[12] Their test battery can be broken down into subtests that capture abilities related to space, quantities, causality, and social learning. The space subtest includes tasks related to spatial memory and rotation in which participants have to recall the location of an object or track an object through a rotational movement. The quantities subtest measures participants' ability to assess relative amounts, or to account for additions and subtractions. The causality subtest assesses participants' abilities to use cues related to shape and sound to locate desirable things, as well as their ability to select a tool with the right properties to solve a problem (i.e., build a causal model). In the social learning subtest, participants are given opportunities to observe a demonstrator use a hard-to-discover technique to obtain a desirable object, such as extracting some food out of a narrow tube. Participants are then given the same task they just observed and can use what they just saw demonstrated to help them obtain the desired object.

Figure 2.2 is striking. On all the subtests of mental abilities, except social learning, there's essentially no difference between chimpanzees and two-and-a-half-year-old humans, despite the fact that the two-and-a-half-year-olds have much larger brains. Orangutans, who have slightly smaller brains than chimpanzees, do a bit worse, but not much worse. Even on the subtest that focused specifically on assessing the causal efficacy of tool properties (causal modeling), the toddlers got 71% correct, the chimps 61%, and the orangutans 63%. Meanwhile the chimps trounced the toddlers on tool use 74% to 23%.

By contrast, for the social learning subtest, the averages shown in figure 2.2 actually conceal the fact that most of the two-and-a-half-year-olds scored 100% on the test, whereas most of the apes scored 0%. Overall, these findings suggest that the only exceptional cognitive abilities possessed by young children in comparison to two other great apes relate to social learning, and not to space, quantities, or causality.

Crucially, if we gave this same battery to adult humans, they would blow the roof off the tests, performing at or near the ceiling (100% correct). This might lead you to think that the whole setup is unfair to the humans, because Esther, Mike, and their colleagues are comparing toddlers to older apes, who varied in ages from 3 to 21 years. Interestingly, however, older apes do not generally do better on these tests than younger apes—quite unlike humans. By age three, the cognitive performances of chimpanzees and orangutans—at least in these tasks—are about as good as they get.[13] Meanwhile, the young children will experience continuous, and eventually massive, improvements in their cognitive scores over at least the coming two decades of their lives. Just how good they will get will depend heavily on where, and with whom, they grow up.[14]

It's important to realize that chimpanzees and orangutans do have some social learning abilities, especially when compared to other animals, but when you have to design a test that is applicable to both apes and humans, the apes inevitably end up near the floor and the humans near the ceiling. In fact, we'll see later that when compared to other apes, humans are prolific, spontaneous, and automatic imitators, even willing to copy seemingly unnecessary or purely stylistic steps. When demonstrations include "extra" or "wasteful" steps, chimpanzee social learning emerges as superior to that of humans because we end up acquiring wasteful or inefficient elements whereas chimps filter these out.



CHAPTER 4

HOW TO MAKE A CULTURAL SPECIES

To understand why European explorers couldn't survive as hunter-gatherers while locals—even when stranded alone—could, we need to understand how populations generate cultural adaptations—the suites or packages of skills, beliefs, practices, motivations, and organizational forms that permit people to survive, and often thrive, in diverse and challenging environments. The process is—in some crucial sense—smarter than we are. Over generations, often outside of conscious awareness, individuals' choices, learned preferences, lucky mistakes, and occasional insights aggregate to produce cultural adaptations. These often-complex packages contain subtle and implicit insights that impress modern engineers and scientists (see chapter 7). We have glimpsed some of these cultural adaptations, from Inuit clothing to nardoo detoxification, and will study other such adaptations, ranging from food taboos that protect pregnant women from marine toxins to religious rituals that galvanize greater prosociality. Before getting to these, however, we need to build an understanding of cultural evolution, from the ground up, that can explain how it is that human populations end up with complexes of tools, tastes, and techniques that are honed to local environmental challenges.

This brings us to a central insight. Rather than opposing "cultural" with "evolutionary" or "biological" explanations, researchers have now developed a rich body of work showing how natural selection, acting on genes, has shaped our psychology in a manner that generates *nongenetic evolutionary processes* capable of producing complex cultural adaptations. Culture, and cultural evolution, are then a consequence of genetically evolved psychological adaptations for learning from other people. That is, natural selection favored genes for building brains with abilities to learn from others. These learning abilities, when operating in populations and over time, can give rise to subtly adaptive behavioral repertoires, including those related to fancy tools and large bodies of knowledge about plants and animals. These emergent products arose initially as unintended consequences of the interaction of learning minds in populations, over time. With this intellectual move, “cultural explanations” become but one type of “evolutionary explanation,” among a potential host of other noncultural explanations.

To see the power and pervasiveness of the use of success cues in cultural learning, consider the following experiment. MBA students participated in two different versions of an investment game. In the game, they had to allocate their money across three different investment options, labeled A, B, and C. They were told each investment's average monetary returns and its variation (sometimes you get more than average, other times, less). They were also told the relationships or correlations among the investments; for example, if investment A's value goes up, then B's value tends to go down. Participants could borrow money to invest. During each round of the game, each player would make his or her allocations and receive the returns. After each round, players could alter their investment allocations for the next round, and this went on for sixteen rounds. At the end of the game, each player's portfolio performance ranking relative to the other players heavily influenced their grade in the course, moving it up or down. If you know any MBAs, you'll know this is a serious incentive, and these players were thus strongly motivated to make the most money in the game.

The experimenters randomly assigned players to one of two different versions, or treatments. In one version, the MBAs made their decisions in isolation, receiving only the individual experience derived from their own choices over the sixteen rounds. The other version was identical except that the allocations chosen and performance rankings of all participants were posted between each round, using anonymous labels.

The difference in the results from each version surprised the economists who designed the experiment (though, admittedly, many economists are pretty easily surprised by human behavior[6]). Three patterns are striking. First, the MBAs didn't use the additional information available in the second treatment (with posted performances) in the complex and sophisticated way economic theory assumes. Instead, careful analysis shows that many participants were merely copying (“mimicking”) the investment allocations made by the top performers in the previous round. Second, the environment of this experiment is simple enough that one can actually calculate the profit-maximizing investment allocations. This optimal allocation can be compared with where participants actually ended up in round 16 for each of the two versions. Left only to their own individual experience, the MBAs ended up very far away from the optimal allocation—thus, poor overall performance. However, in the second treatment, when they mimicked each other’s investments, the group zeroed in on the optimal allocation by the end of the game. Here, the whole group made more money, which is interesting since there were no incentives for group performance, as grade assignments were all based on relative rankings. Finally, while opportunities to imitate each other had a dramatic effect on improving the overall group performance, it also led to some individual catastrophes. Sometimes top performers had taken large risks, which paid off in the short run—they got lucky. But their risky allocations, which often included massive borrowing, were copied by others. Since you can’t copy the luck along with the allocation choices, an inflated number of bankruptcies resulted as a side effect.[7]

The central finding of this experiment, that people are inclined to copy more successful others, has been repeatedly observed in an immense variety of domains, both in controlled laboratory conditions and in real-world patterns.[8] In experiments, undergraduates rely on *success-biased* learning when real money is on the line—when they are paid for correct answers or superior performance. In fact, the more challenging the problem or the greater the uncertainty, the more inclined people are to rely on cultural learning, as predicted by evolutionary models. This tells us something about *when* individuals will rely on cultural learning over their own direct experience or intuitions.[9]

Prestige

By observing whom others watch, listen to, defer to, hang-around, and imitate, learners can more effectively figure out from whom to learn. Using these “prestige cues” allows learners to take advantage of the fact that other people also are seeking, and have obtained, insights about who in the local community is likely to possess useful, adaptive information. Once people have identified a person as worthy of learning from, perhaps because they’ve learned about their success, they necessarily need to be around them, watching, listening, and eliciting information through interaction. Since they are trying to obtain information, learners defer to their chosen models in conversation, often giving them “the floor.” And, of course, learners automatically and unconsciously imitate their chosen models, including by matching their speech patterns (see chapter 8). Thus, we humans are sensitive to a set of ethological patterns (bodily postures or displays), including visual attention, “holding the floor,” deference in conversation, and vocal mimicry, as well as others. We use these prestige cues to help us rapidly zero in on whom to learn from. In essence, prestige cues represent a kind of second-order cultural learning in which we figure out who to learn from by inferring from the behavior of others who they think are worthy of learning from—that is, we culturally learn from whom to learn.

Despite the seeming ubiquity of this phenomenon in the real world, there is actually relatively little direct experimental evidence that people use prestige cues. There is an immense amount of indirect evidence that shows how the prestige of a person or source, such as a newspaper or celebrity, increases the persuasiveness of what they say or the tendency of people to remember what they say. This effect occurs even when the prestige of a person comes from a domain, like golf, that is far removed from the issue they are commenting on (like automobile quality). This provides some evidence, though it does not get at the specific cues that learners might actually use to guide them, aside from being told that someone is an “expert” or “the best.”[17]

To address this in our laboratory, Maciej Chudek, Sue Birch, and I tested this prestige idea more directly. Sue is a developmental psychologist and Maciej was my graduate student (he did all the real work). We had preschoolers watch a video in which they saw two different potential models use the same object in one of two different ways. In the video, two bystanders entered, looked at both models, and then preferentially watched one of them. The visual attention of the bystanders provided a "prestige cue" that seemingly marked one of the two potential models. Then, participants saw each model select one of two different types of unfamiliar foods and one of two differently colored beverages. They also saw each model use a toy in one of two distinct ways. After the video, the kids were permitted to select one of the two novel foods and one of the two colorful beverages. They could also use the toy any way they wanted. Children were 13 times more likely to use the toy in the same manner as the prestige-cued model compared to the other model. They were also about 4 times more likely to select the food or beverage preferred by the prestige-cued model. Based on questions asked at the end of the experiment, the children had no conscious or expressible awareness of the prestige cues or their effects. These experiments show that young children rapidly and unconsciously tune into the visual attention of others and use it to direct their cultural learning. We are prestige biased, as well as being skill and success biased.[18]

Chapter 8 expands on these ideas to explore how selective cultural learning drove the evolution of a second form of social status in humans called Prestige, which in our species resides alongside the Dominance status we inherited from our primate ancestors. We'll see why, for example, it is possible to become famous for being famous in the modern world.

The central argument in this book is that relatively early in our species' evolutionary history, perhaps around the origins of our genus (*Homo*) about 2 million years ago, we first crossed this evolutionary Rubicon, at which point cultural evolution became the *primary driver of our species' genetic evolution*. This interaction between cultural and genetic evolution generated a process that can be described as *autocatalytic*, meaning that it produces the fuel that propels it. Once cultural information began to accumulate and produce cultural adaptations, the main selection pressure on genes revolved around improving our psychological abilities to acquire, store, process, and organize the array of fitness-enhancing skills and practices that became increasingly available in the minds of the others in one's group. As genetic evolution improved our brains and abilities for learning from others, cultural evolution spontaneously generated more and better cultural adaptations, which kept the pressure on for brains that were better at acquiring and storing this cultural information. This process will continue until halted by an external constraint.

As the process continues over generations, the selection pressures only increase: the more culture accumulates, the greater the selection pressures on genes for making one an adept cultural learner with a bigger brain capable of harnessing the ever-upward-spiraling body of cultural information. Figure 5.1 illustrates the point. Consider the memory—or brain storage space—required by our six different generations. In Generation 0, at most you could invent one trait in your lifetime, so you only need brain space for one trait. However, by Generation 5, you'd better have storage space in your brain for T**, T2, and T3—and you'd best know how they fit together. The memory space demanded in Generation 5, if one wants any chance of outsurviving and outreproducing others in the population, has increased threefold in only six generations. If genes spread that expand the brains of Generation 6, the selection pressure for bigger and better brains won't abate because cultural evolution will continue to expand the size of the cultural repertoire—of the body of know-how one could learn, if one were sufficiently well equipped. This culture-gene coevolutionary ratchet made us human.

We've already seen some of the evidence that culture drove human evolution. In chapter 2, we saw that when toddlers competed against other apes in a variety of cognitive tasks, the only domain in which they kicked butt was social learning. Otherwise, for quantities, causality, and space, it was pretty much a tie. That's precisely what you'd expect if culture drove the expansion of our brains, honed our cognitive abilities, and modified our social motivations. In chapter 3, by accompanying various hapless explorers, we saw that our species ability to live as hunter-gatherers depends on acquiring the local cultural knowledge and skills. And in chapter 4 we explored how natural selection has shaped our psychology to allow us to selectively target and extract adaptive information from our social milieu.

Table 5.1. Examples of How Cultural Evolution and Its Products Have Shaped Human Genetic Evolution

Chapters covered	Culturally transmitted selection pressure	Coevolved genetic consequences	Other implications
2–5, 7–8, 12, 13, 16	*Cumulative culture* Accumulating body of cultural knowledge creates dependence	Specialized cultural learning abilities for selectively acquiring adaptive information from others	Selection pressure for greater sociality. Difficult childbirth, due to oversized heads
		Long childhoods and larger brains prepared for cultural learning and practice with extensive brain "wiring" over decades	Demands for more child care
5–7, 12, 16	*Food processing* Cooking, leaching, pounding, chopping	Increasing dependence on processed food, including cooked foods. Results in small teeth, gapes, mouths, colons, and stomachs; possible interest in fire during childhood	Frees energy for brain building and favors the sexual division of labor
5, 15, 16	*Persistence hunting* Tracking, water containers, and animal behavioral know-how	Distance running facilitated by springy arches, slow-twitch muscle fibers, shock-enforced joints, a nuchal ligament, and innervated eccrine sweat glands	Human lineage becomes high-level predator
5, 7	*Folkbiology* Increasing knowledge about plants and animals	Folk biological cognition: hierarchical taxonomies with essentialized categories, category-based induction, and taxonomic inheritance	Universal treelike taxonomies for categorizing the natural world

5, 12, 13, 15, 16	*Artifacts* Increasingly complex tools and weapons	Anatomical changes to hands, shoulders, and elbows. Direct cortical connections into spinal cord. Artifact cognition: functional stance	Greater manual dexterity and throwing abilities. Increased physical weakness
4, 5, 8, 12, 15, 16	*Wisdom of age* Opportunities to use and transmit culture gleaned over a lifetime	Changes in human life history: extended childhood, adolescence, and a longer postreproductive lifespan (menopause)	Cooperation in child investment and rearing
4, 7, 12, 13	*Complex adaptations* Pressure for high fidelity cultural learning	Sophisticated abilities to infer others' mental states—theory of mind, or mentalizing, and overimitation	Dualism: a preparedness to understand minds without bodies
4, 8	*Information resources* Variation in skill or know-how among individuals	Prestige status: suite of motivations, emotions, and ethological patterns that produce a second type of status	Prestige-based leadership and greater cooperation
9–11	*Social norms* Enforced by reputations and sanctions	Norm psychology: concerns with reputation, internalization of norms, prosocial biases, shame and anger at norm violators, cognitive abilities for detecting violations	Strengthens effect of intergroup competition on cultural evolution

11	*Ethnic groups* Culturally marked membership across social groups	Folksociology: in-group vs. out-group psychology that cues off phenotypic markers, which influence cultural learning and interaction	Tribal/ethnic groups, later nationalism and parochial religions
13	*Languages* Transmitted gestures and vocalizations	Changes in throat anatomy, audio processing, specialized brain regions, and tongue dexterity	Massive increase in the rate of cultural transmission
13	*Teaching* Opportunities to facilitate cultural transmission	Communicative or pedagogical adaptations: white sclera (whites of the eyes), eye contact, pedagogical inclinations, etc.	Higher-fidelity transmission and more rapid cultural evolution

Big Brains, Fast Evolution, and Slow Development

Compared to those of other animals, our brains are big, dense, and groovy. While we don’t have the biggest brains in the natural world—whales and elephants beat us—we do have the most cortical interconnections and the highest degree of cortical folding. Cortical folding produces that “crumpled wad of paper” (groovy) appearance that particularly characterizes human brains. But that’s just the beginning of our oddities. Our brains evolved from the size of a chimpanzee’s, at roughly 350 cm^3, to 1350 cm^3 in about 5 million years. Most of that expansion, from about 500 cm^3 upward, took place only in about the last 2 million years. That’s fast in genetic evolutionary terms.

This expansion was finally halted about 200,000 years ago, probably by the challenges of giving birth to babies with increasingly bulbous heads. In most species, the birth canal is larger than the newborn’s head, but not in humans. Infant skulls have to remain unfused in order to squeeze through the birth canal in a manner that isn’t seen in other species. It seems our brains only ceased expanding because we hit the stops set by our primate body plan; if babies’ heads got any bigger, they wouldn’t be able to squeeze out of mom at birth. Along the way, natural selection came up with numerous tricks to circumvent this *big-headed baby problem*, including intense cortical folding, high-density interconnections (which permit our brains to hold more information without getting bigger) and a rapid postbirth expansion. Specifically, newborn human brains continue expanding at the faster prebirth gestational rate for the first year, eventually tripling in size. By contrast, newborn primate brains grow more slowly after birth, eventually only doubling in size.[2]

After this initial growth spurt, our brains continue adding more connections for holding and processing information (new glial cells, axons, and synapses) over the next three decades of life and even beyond, especially in the neocortex. Consider our white matter and, specifically, the process of myelination. As vertebrate brains mature, their white matter increases as the (axonal) connections among neurons are gradually “burned in” and wrapped in a performance-enhancing coating of fat called myelin. This process of myelination makes brain regions more efficient, but less plastic and thus less susceptible to learning. To see how human brains are different, we can compare our myelination with that of our closest relatives, chimpanzees. For the cerebral cortex, figure 5.2[3] shows the fraction of myelination (as a percentage of the adult level) during three different developmental periods: (1) infancy, (2) childhood (called the “juvenile period” in primates), and (3) adolescence and young adulthood. Infant chimpanzees arrive in the world with 15% of their cortex already myelinized, whereas humans start with only 1.6% myelinized. For the neocortex, which has evolved more recently and is massive in humans, the percentages are 20% and 0%, respectively. During adolescence and young adulthood, humans still have only 65% of their eventual myelination complete, whereas chimpanzees are almost done, at 96%. These data suggest that, unlike chimpanzees, we continue substantial “wiring-up” into our third decade of life.

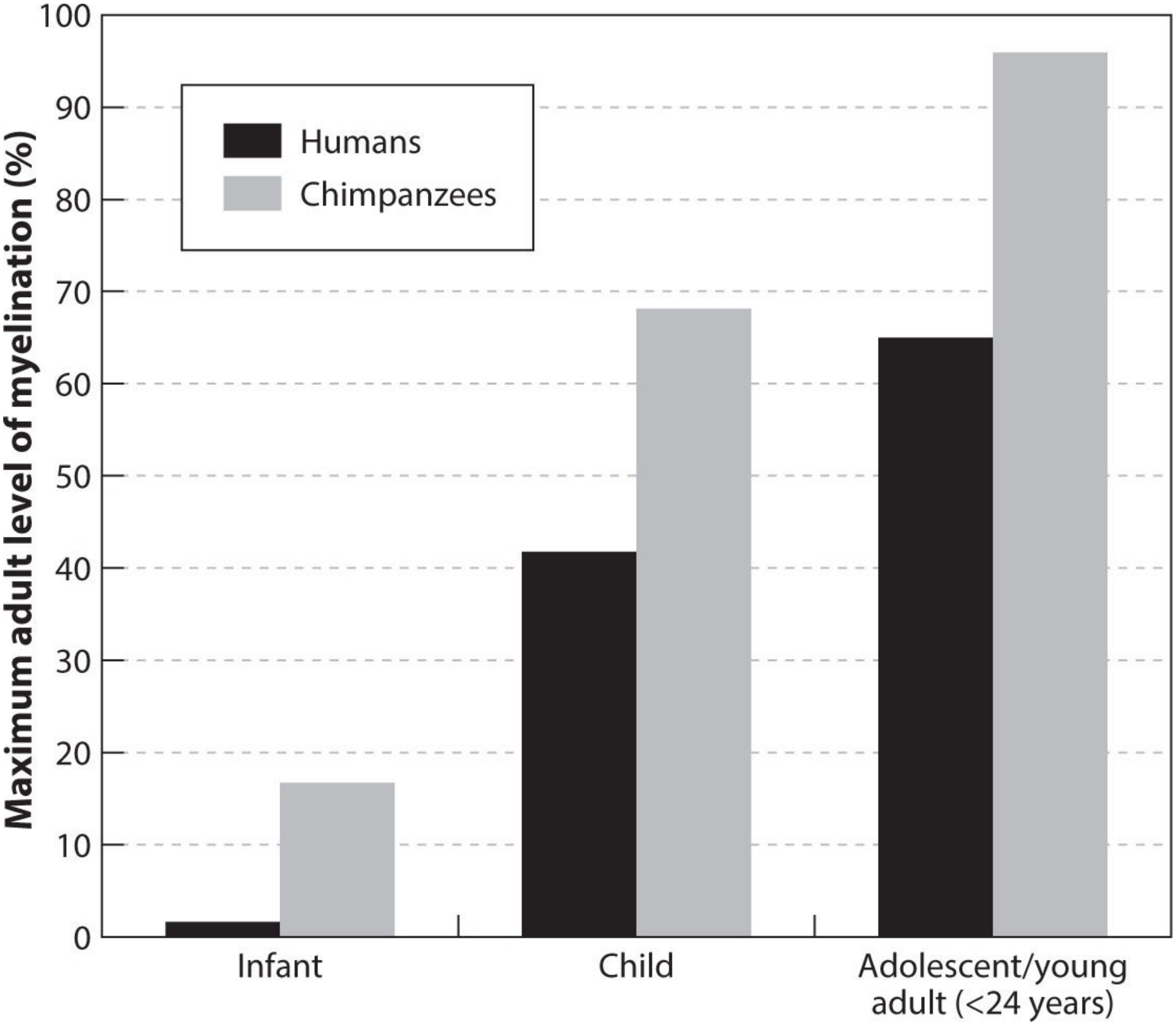


Figure 5.2. Myelination in chimpanzees and humans over development.

Human brain development is related to another unusual feature of our species, our extended childhoods and the emergence of that memorable period called adolescence. Compared to other primates, our gestational and infancy periods (birth to weaning) have shortened while our childhoods have extended and a uniquely human period of adolescence has emerged, prior to full maturity. Childhood is a period of intensive cultural learning, including playing and the practicing of adult roles and skills, during which time our brains reach nearly their adult size while our bodies remain small. Adolescence begins at sexual maturity, after which a growth spurt ensues. During this time, we engage in apprenticeships, as we hone the most complex of adult skills and areas of knowledge, as well as build relationships with peers and look for mates.[4]

The emergence of adolescence and young adulthood has likely been crucial over our evolutionary history, since in hunting and gathering populations, hunters do not produce enough calories to even feed themselves (let alone others) until around age 18 and won't reach their peak productivity until their late thirties. Interestingly, while hunters reach their peak strength and speed in their twenties, individual hunting success does not peak until around age 40, because success depends more on know-how and refined skills than on physical prowess. By contrast, chimpanzees—who also hunt and gather—can obtain enough calories to sustain themselves immediately after infancy ends, around age 5.[5] Consistent with our long period of wiring-up, this pattern and contrast with chimpanzees reveals the degree to which we humans are dependent on learning for our survival as foragers.

Our unusually big brains, with their slow neurological and behavioral development but rapid evolutionary expansion, is precisely what you'd expect if cumulative cultural evolution had become the driving selection pressure in the evolution of our species. Once cumulative cultural evolution began to produce cultural adaptations, like cooking and spears, individuals whose genes have endowed them with the brains and developmental processes that permit them to most effectively acquire, store, and organize cultural information will be the most likely to survive, find mates, and leave progeny. As each generation gets brains that are a little bigger and a little better at cultural learning, the body of adaptive know-how will rapidly expand to fill any available brain space. This process will shape the development of our brains, by keeping them maximally plastic and "programmed to receive," and our bodies, by keeping them small (and calorically inexpensive) until we've learned enough to survive. This culture-gene coevolutionary interaction creates an autocatalytic process such that no matter how big our brains get, there will always be much more cultural information in the world than any one of us can learn in a lifetime. The better our brains get at cultural learning, the faster adaptive cultural information accumulates, and the greater the pressure on brains to acquire and store this information.

This view also explains three puzzling facts about human infants. First, compared to other species, babies are altricial, meaning that they are weak, undermuscled, fat, and uncoordinated (sorry, babies, but it's true). By contrast, some mammals exit the womb ready to walk, and even primates rapidly figure out how to hang onto mom. Meanwhile, above the neck, human babies' brains are developmentally advanced at birth compared to those of other animals, having passed more of the mammalian neurological landmarks than other species. Fetuses are already acquiring aspects of language in the womb (see chapter 13), and babies arrive ready to engage in cultural learning. Before they can walk, feed themselves, or safely defecate, infants are selectively learning from others based on cues of competence and reliability (chapter 4) and can read others' intentions in order to copy their goals.[6] Third, despite being otherwise developmentally and cognitively advanced, babies' brains arrive highly plastic (unmyelinized) and continue to expand at their gestational rate. In short, while being otherwise nearly helpless, babies and toddlers are sophisticated cultural learning machines.

Natural selection has made us a cultural species by altering our development in ways that (1) slowed the growth of our bodies through a shortened infancy and extended childhood but added a growth spurt in adolescence, and (2) altered neurological development in complex ways that make our brain advanced at birth yet both highly expandable and enduringly plastic. As we go along, I will consider how our fast genetic evolution, big adult brains, slow bodily development, and gradual wiring-up are made possible only as part of a larger package of features that include the sexual division of labor, intensive parental investment in children, and the long postreproductive lives we associate with menopause. These features of our species will interact in crucial ways with cultural evolution.

Food Processing Externalizes Digestion

Compared to other primates, humans have an unusual digestive system. Starting at the top, our mouths, gapes, lips, and teeth are oddly small, and our lip muscles are weak. Our mouths are the size of a squirrel monkey's, a species that weighs less than three pounds. Chimpanzees can open their mouths twice as wide as we can and hold substantial amounts of food compressed between their lips and large teeth. We also have puny jaw muscles that reach up only to just below our ears. Other primates' jaw muscles stretch to the tops of their heads, where they sometimes even latch onto a bony central ridge. Our stomachs are small, having only a third of the surface area that we'd expect for a primate of our size, and our colons are too short, being only 60% of their expected mass. Our bodies are also poor at detoxifying wild foods. Overall, our guts—stomachs, small intestines, and colons—are much smaller than they ought to be for our overall body size. Compared to other primates, we lack a substantial amount of digestive power all the way down the line, from our mouth's (in)ability to breakdown food to our colon's capacity to process fiber. Interestingly, our small intestines are about the size they should be, an exception that we'll account for below.[7]

How can culture explain this strange physiological patterning in humans?

The answer is that our bodies, and in this case our digestive systems, have coevolved with culturally transmitted know-how related to food processing. People in every society process food using techniques that have accumulated over generations, including cooking, drying, pounding, grinding, leaching, chopping, marinating, smoking, and scraping. Of these, the oldest are probably chopping, scraping, and pounding with stone tools. Chopping, scraping, and pounding meat can go a long way, because they tenderize by slicing, dicing, and crushing the muscle fibers, partially replacing some of the functions of teeth, mouths, and jaws. Similarly, marinades initiate the chemical breakdown of foods. Acidic marinades, such as that used for the coastal South American dish ceviche, begin literally breaking down meat proteins before they reach your mouth, mimicking the approach taken by your stomach acid. And as we saw with nardoo, leaching is one of a host of techniques that hunter-gatherers have long used to process food and remove toxins.

Of all these techniques, cooking is probably the most important piece of cultural know-how that has shaped our digestive system. The primatologist Richard Wrangham has persuasively argued that cooking (and therefore fire) has played a crucial role in human evolution. Richard and his collaborators laid out how cooking, if done properly, does an immense amount of digestion for us. It softens and prepares both meat and plant foods for digestion. The *right* amount of heating tenderizes, detoxifies, and breaks down fibrous tubers and other plant foods. Heating also breaks down the proteins in meat, dramatically reducing the work for our stomach acid. Consequently, by contrast with meat-eating carnivores (e.g., lions), we do not often retain meat in our stomachs for hours, because it typically arrives partially digested by pounding, scraping, marinating, and cooking.

While all this food processing reduces the digestive workload of our mouths, stomachs, and colons, it does not alter the need to actually absorb the nutrients, which is why our small intestines are about the right size for a primate of our stature.

What is often underemphasized in this account is that food-processing techniques are primarily products of cultural evolution. Cooking, for example, is not something we instinctually know how to do, or even can easily figure out. If you don't believe me, go outside and make a fire without using any modern technology. Rub two sticks together, make a fire drill, find naturally occurring flint or quartz, etc. Put that big brain to work. Maybe some fire instincts designed by natural selection to solve this recurrent dilemma of our ancestral environments will kick in and guide you.

…

No luck? Unless you've had training—that is, received cultural transmission—it's very unlikely you were successful. Our bodies have been shaped by fire and cooking, but we have to learn from others how to make fire and cook. Making fire is so "unnatural" and technically difficult that some foraging populations have actually lost the ability to make fire. These include the Andaman Islanders (off the coast of Malaysia), Sirionó (Amazonia), Northern Aché, and perhaps Tasmanians. Now, to be clear, these populations couldn't have survived without fire; they retained fire but lost the ability to start new fires on demand. When one band's fire was inadvertently extinguished, say during a fierce storm, they had to head off to locate another band whose fire had not gone out (hopefully).[8] However, living in small and widely scattered groups in frosty Paleolithic Europe, the fires of our bigger-brained Neanderthal cousins probably sometimes went out and weren't to be reignited for thousands of years.[9] In chapter 12, we'll see how and why such important losses are not surprising.

It's likely that our species' reliance on fire began with the *control of fire*, perhaps obtained from naturally occurring sources. Nevertheless, just capturing, sustaining, and controlling fire requires some know-how. Keeping a fire going may sound easy, but you have to keep it going all the time, during rainstorms, high winds, and long journeys across rivers and through swamps. I learned something about this while living in the Peruvian Amazon among an indigenous group called the Matsigenka. After transporting what looked like a dead, charred log to her distant garden, I saw a Matsigenka woman breathe life back into a hidden ember using a combination of dried moss, which she brought with her, and thermal reflection from other logs. I was also embarrassed when another young Matsigenka woman, with the requisite infant slung at her side, stopped by my house in the village to rearrange my cooking fire. Her adjustments increased the heat, created a convenient spot for my pot, reduced the smoke (and my choking), and eliminated much of the need for my constant tending.[10]

Cooking is also difficult to learn through individual trial-and-error experience. For cooking to provide a digestive aid, it has to be done right. Bad cooking can actually make food harder to digest and increase its toxins. And what constitutes effective cooking depends on the type of food. With meat, doing the most obvious thing (to me) of placing pieces right in the flames can lead to a hard, charred outside and a raw interior—exactly what you don't want. Consequently, small-scale societies have complex repertoires of food-processing techniques that are specific to the food in question. For example, the best cooking technique for some foods involves wrapping them in leaves and burying them in the fire's ash for a long time (how long?). Meanwhile, many hunters eat the liver of their kill raw, on the spot. Livers, it turns out, are energy rich, soft, and delicious when eaten raw—except for those species in which eating the liver can be deadly (do you know which those are?).[11] Inuit hunters don't eat polar bear livers raw because they believe such livers are toxic (and they are correct, according to laboratory research on the question). The rest of the kill is typically butchered, sometimes pounded, possibly dried, and then cooked—though different parts of the kill are cooked in different ways.

The impact of this culturally transmitted know-how about fire and cooking has had such an impact on our species' genetic evolution that we are now, essentially, addicted to cooked food. Wrangham reviewed the literature on the ability of humans to survive by eating only raw foods. His review includes historical cases in which people had to survive without cooking, as well as studies of modern fads, such as the raw foods movement, The long and short of all this is that it's very difficult to survive for months without cooking. Raw-foodists are thin and often feel hungry. Their body fat drops so low that women often stop menstruating or menstruate only irregularly. This occurs despite the supermarket availability of a vast range of raw foods, the use of powerful processing technologies like blenders, and the consumption of some preprocessed foods. The upshot is that human foraging populations could never survive without cooking; meanwhile, apes do just fine without cooking, though they do love cooked foods.[12]

Our species' increasing dependence on fire and cooking over our evolutionary history may have also shaped our cultural learning psychology in ways that facilitated the acquisition of know-how about fire making. This is a kind of content bias in our cultural learning. The UCLA anthropologist, Dan Fessler, argues that during middle childhood (ages six to nine), humans go through a phase in which we are strongly attracted to learning about fire, by both observing others and manipulating it ourselves. In small-scale societies, where children are free to engage this curiosity, adolescents have both mastered fire and lost any further attraction to it. Interestingly, Fessler also argues that modern societies are unusual because so many children never get to satisfy their curiosity, so their fascination with fire stretches into the teen years and early adulthood.[13]

The influence of socially learned food-processing techniques on our genetic evolution probably occurred very gradually, perhaps beginning with the earliest stone tools. Such tools had likely begun to emerge by at least 3 million years ago (see chapter 15) and were probably used for processing meat—pounding, chopping, slicing, and dicing.[14] Drying meat or soaking plant foods may have emerged at any time, and probably repeatedly. By the emergence of the genus *Homo*, it's plausible that cooking began to be used sporadically but with increasing frequency, especially where large fibrous tubers or meat were relatively abundant.

Our repertoire of food-processing methods altered the genetic selection pressures on our digestive system by gradually supplanting some of its functions with cultural substitutes. Techniques such as cooking actually increase the energy available from foods and make them easier to digest and detoxify. This effect allowed natural selection to save substantial amounts of energy by reducing our gut tissue, the second most expensive tissue in our bodies (next to brain tissue), and our susceptibility to various diseases associated with gut tissue. The energy savings from the externalization of digestive functions by cultural evolution became one component in a suite of adjustments that permitted our species to build and run bigger and bigger brains.

How Tools Made Us Fat Wimps

Responding to posters that read “Wanted, athletic men to earn $5 per second by holding 85-pound ape’s shoulders to the floor,” beefy linebacker types would line up at *Noell’s Ark Gorilla Show*, part of a circus that travelled up and down the eastern seaboard of the United States from the 1940s to the 1970s. Inspired to impress the crowds at this star attraction, no man in thirty years ever lasted more than five seconds pinning down a juvenile chimpanzee. Moreover, the chimpanzees had to be seriously handicapped, as they wore “silence of the lambs” masks to prevent them from using their preferred weapon, their large canine teeth. Later, the show’s apes were forced to wear large gloves because a chimp named Snookie had rammed his thumbs up an opponent’s nose, tearing the man’s nostrils apart. The organizers of Noell’s Ark Gorilla Show were wise to use young chimps, because a full-grown male chimpanzee (150 lbs.) is quite capable of breaking a man’s back. The authorities did finally put an end to this spectacle, but it wasn’t clear whether they were concerned about the young apes or the brawny wrestlers who voluntarily entered the ring with them.[15]

How did we become such wimps?

It was culture. As cumulative cultural evolution generated increasingly effective tools and weapons, like blades, spears, axes, snares, spear-throwers, poisons, and clothing, natural selection responded to the changed environment generated by these cultural products by shaping our genes to make us weak. Manufactured from wood, flint, obsidian, bone, antler, and ivory, effective tools and weapons can replace big molars for breaking down seeds or fibrous plants and big canines, strong muscles, and dense bones for fighting and hunting.

To understand this, realize that big brains are energy hogs. Our brains use between a fifth and a quarter of the energy we take in each day, while the brains of other primates use between 8% and 10%. Other mammals use only 3% to 5%. Even worse, unlike muscles, you can't shut down a brain to save energy; it takes almost as much energy to sustain a resting brain as it does an active one. Our cultural knowledge about the natural world combined with our tools, including our food-processing techniques, allowed our ancestors to obtain a high-energy diet with much less time and effort than other species. This was crucial for brain expansion in our lineage. However, since brains need a constant supply of energy, periods of food scarcity—such as those initiated by floods, droughts, injuries, and disease—pose a serious threat to humans. To deal with this threat, natural selection needed to trim our body's energy budget and create a storehouse for times of scarcity. The emergence of tools and weapons allowed natural selection to trade expensive tissues for fat, which is cheaper to maintain and provides an energy-storage system crucial for sustaining big brains through periods of scarcity.[16] This is why infants, who devote 85% of their energy to brain building, are so fat—they need the energy buffer to sustain neurological development and optimize cultural learning.

So, if you are challenged to wrestle a chimpanzee, I recommend that you decline and instead suggest a contest based on (1) threading a needle (a sewing contest?), (2) fast-ball pitching or (3) long-distance running.[17] While natural selection traded strength for fat, increasingly complex tools and techniques drove another key genetic change: the human neocortex sends corticospinal connections deeper into the motor neurons, spinal cord, and brain stem than in other mammals. It is the depth of these connections—in part—that facilitates our fine dexterity for learned motor patterns (recall the plasticity of the neocortex mentioned above). In particular, these motor neurons directly innervate our hands, allowing us to thread a needle or throw accurately, as well as our tongues, jaws, and vocal cords, facilitating speech (see chapter 13). Improved motor control was favored once cumulative cultural evolution began delivering more and finer tools. Such tools also created genetic evolutionary pressures that shaped the anatomy of our hands, giving us wider fingertips, more muscular thumbs, and a "precision grip." Cultural evolution may also have produced packages for throwing, including techniques, artifacts (wooden spears and throwing clubs), and strategies, suitable for using projectiles in hunting, scavenging, raiding, or community policing. The emergence of these, along with the ability to learn to practice throwing by observing others, may have fostered some of the anatomical specializations in our shoulders and wrist, while at the same time explaining why many children are so keenly interested in throwing (more on this in chapter 15).[18]

Alongside these anatomical changes, our species' long history with complex tools has also likely shaped our learning psychology. We are cognitively primed to categorize "artifacts" (e.g., tools and weapons) as separate from all other things in the world, like rocks and animals. Unlike plants, animals, and other nonliving things like water, we think about function when we think about artifacts. For example, when young children ask about artifacts they ask "What's it for" or "What does it do?" instead of "What kind is it?" which is their initial query when seeing a novel plant or animal. This specialized thinking about artifacts, as opposed to thinking about other nonliving things, requires, first, that there be some complex artifacts with nonobvious, or *causally opaque*, functions in the world that one needs to learn about.[19] Cumulative cultural evolution will readily generate such cognitively opaque artifacts, a point I'll make in spades in chapter 7.

How Water Containers and Tracking Made Us Endurance Runners

Traditional hunters throughout the world have shown that we humans can run down antelopes, giraffes, deer, steenboks, zebras, waterbucks, and wildebeests. These pursuits often take three or more hours, but eventually the prey animal drops over, either from fatigue or heat exhaustion. With the exception of domesticated horses,[20] which we have artificially selected for endurance, our species' main competition for the mammalian endurance champion comes from some of the social carnivores, like African wild dogs, wolves, and hyenas, that also engage in persistence hunting and habitually run 6 to 13 miles (10 to 20 km) per day.

To beat these species, we only need to turn up the heat, literally, because these carnivores are much more susceptible to warmer temperatures than we are. In the tropics, dogs and hyenas can only hunt at dawn and dusk, when it's cooler. So, if you want to race your dog, plan a 25-kilometer race on a hot summer day. He'll conk out. And the hotter it is, the more you'll beat him by. Chimpanzees aren't even in our league in this domain.[21]

Comparisons of human anatomy and physiology with those of other mammals, including both living primates and hominins (our ancestor species and extinct relatives), reveal that natural selection has likely been at work shaping our bodies for serious distance running for over a million years. We have a full suite of specialized distance running adaptations, from toe to head. Here's a sampling:

- Our feet, unlike other apes, possess springy arches that store energy and absorb the shock of repeated impacts. This is provided that we learn proper form, and avoid landing on our heels.
- Our comparatively longer legs possess extended springlike tendons, including the crucial Achilles, that connect to short muscle fibers. This setup generates efficient power and provides us with the ability to increase speed by taking longer, energy-saving, strides.[22]
- Unlike animals built for speed, which possess mostly fast-twitch muscle fibers, frequent distance running can shift the balance in our legs upward from 50% slow-twitch muscle fibers to as high as 80%, yielding much greater aerobic capacity.
- The joints in our lower body are all reinforced to withstand the stresses of endurance running.
- To stabilize our trunk while running, our species sports a distinctively enlarged gluteus maximus, along with substantial muscles—the erector spinae—that run up our backbone.
- Coupled with our notably broad shoulders and short forearms, arm swinging creates a compensatory torque that balances us while running. And unlike other primates, the musculature in our upper back allows our head to twist independently from our torso.
- The nuchal ligament, connecting our heads and shoulders, secures and balances our skulls and brains against running-related shocks. Other running animals also have a nuchal ligament, but other primates do not.

Perhaps most impressive of all are our thermoregulatory adaptations—we are certainly the sweatiest species. Mammals must maintain their body temperature in a relatively narrow range, from roughly 36°C (96.8°F) to 38°C (100°F). The lethal core temperature of most mammals ranges from 42°C (107.6°F) to 44°C (111.2°F). Since running can generate a tenfold increase in heating, the inability of most mammals to run long distances arises from their inability to manage this heat buildup.

To overcome this adaptive challenge, natural selection favored the (1) nearly complete loss of hair, (2) proliferation of eccrine sweat glands, and (3) emergence of a "head-cooling" system. The idea here is that sweat coats and cools the skin through evaporation, which is fostered by the airflow generated by running. To appreciate what happened, note that sweat glands come in two varieties, apocrine and eccrine. At puberty, apocrine glands start producing a viscous pheromone-containing secretion, which is often processed by bacteria to create a strong aroma. These glands are confined to our armpits, nipples, and groin (guess what they are for?). By contrast, eccrine glands, which secrete clear salty water and some other electrolytes, can be found all over our bodies and are much more numerous on us than on other primates. The highest densities of these glands occur in the scalp and feet, the two locations most in need of cooling during running. Measured over body surfaces, no other animal can sweat faster than we do. Moreover, our eccrine glands are "smart glands," because they contain nerves that may permit centralized control from the brain (in other animals sweating is controlled locally). It was these innervated eccrine glands, and not the apocrine glands, that proliferated to cover our bodies during human evolution.

Because brains are particularly susceptible to overheating, natural selection also engineered a special *brain cooling system* in our ancestors. This system involves a network of veins that run near the surface of the skull, where they are first cooled by the ample sweat glands on the face and head. They then flow into the sinus cavities, where they absorb heat from the arteries responsible for transporting blood to the brain. This cooling system may be why humans, unlike so many mammals, can sustain core temperatures above the 44°C (111.2°F) limit.[23]

At this point, you might be thinking that all these features of our bodies are clearly adaptive, so why would I think that it was cultural evolution that created the conditions that led to the evolution of our species' running adaptations. To get at this point, let's look at three aspects of this adaptive design more closely. First, really putting our endurance abilities into action, where they give us the biggest survival advantage, requires running for hours in the heat of the day in the tropics. When our evaporative cooling system kicks into overdrive, a prime athlete will begin sweating out 1 to 2 liters per hour, with 3 liters being well within our bodies' capacity. This system can run, and keep us running, for many hours provided it doesn't run short of a critical ingredient—water. So, where's the genetically evolved water storage system or tank?

Horses, which as I mentioned can compete with us for distance, do have the ability to store large amounts of water. By contrast, not only are humans unable to consume and store large amounts of water, but we are actually relatively poor hydrators compared to other animals. While a donkey can drink 20 liters in 3 minutes, we top out at 2 liters in 10 minutes (camels do 100 liters in the same time). How can this crucial element be missing from our thermoregulatory system? Is our otherwise elegant running design fatally flawed?[24]

The answer is that cultural evolution supplied water containers and water-finding know-how. Among ethnographically known foraging populations, hunters carry water in gourds, skins, and ostrich eggs. Such containers are used in conjunction with detailed, local, culturally transmitted knowledge about where and how to locate water. In the Kalahari Desert of southern Africa, foragers use ostrich eggs as canteens (water containers), which keep the water refreshingly cool, or occasionally use the stomach sacs of small antelopes. They also use long reed straws to suck water from hollow tree trunks, where it collects, and they can readily locate water-bearing roots by spotting certain dry wispy vines. In Australia, hunter-gatherers created water containers using a technique that involved turning small mammals "inside-out" (see figure 5.3). Like the Kalahari foragers, they also used surface signs to locate hidden underground water sources. These techniques are nonobvious: recall that Burke and Wills became trapped along Coopers Creek for want of such know-how.

This reasoning suggests that the evolution of our fancy sweat-based thermoregulatory systems could take off only *after* cultural evolution generated the know-how for making water containers and locating water sources in diverse environments. The suite of adaptations that make us stunning endurance runners is actually part of a coevolutionary package into which culture delivered a critical ingredient, water.

Thinking and Learning about Plants and Animals

Over generations, cultural evolution generates a large, and potentially ever expanding, body of knowledge about plants and animals. This knowledge, as we saw with our lost European explorers, is crucial for survival. Given the criticality of this knowledge, we should expect humans to be equipped from a young age with psychological abilities and motivations to acquire, store, organize, extend (via inference), and retransmit this information. In fact, we humans have an impressive *folkbiological cognitive system* for dealing with information about plants and animals. Much research by anthropologists and psychologists, such as the dynamic duo of Scott Atran and Doug Medin, working in diverse human populations have shown that these cognitive systems have several interesting properties. Children rapidly organize information about plants and animals into (1) *essentialized categories* (e.g., “cobras” and “penguins”) embedded in (2) *hierarchical (treelike) taxonomies* that permit inferences using (3) *category-based induction* and (4) *taxonomic inheritance*.

These are fancy cognitive science terms for rather intuitive ideas. In using *essentialized categories*, learners implicitly assume that membership in a category (say, “cats”) results from some hidden essence deep inside that all members share. This essence cannot be removed by superficial changes to an individual. For example, suppose you operate on a cat and then paint it so that this individual now looks exactly like a skunk. Is it a cat or a skunk? Or, something new, like a “skat” or “cunk”? Children and adults will typically say that it is still a cat which currently looks like a skunk. By contrast, if a table is dismantled and reconstructed as a chair, no one thinks it’s still a table. It “is” what it “does.” Using *category-based induction* learners can readily extend information learned about one particular cat to all cats—if you see Felix go crazy over catnip, you readily infer that all cats will likely similarly respond to catnip. These essentialized categories are assembled, over development and cultural evolution, into increasingly complex hierarchical taxonomies, as shown in figure 5.4. With such taxonomies in mind, category-based induction allows people to use their knowledge of one category, say “chimpanzees,” to make inferences about other categories. The confidence one puts in these inferences depends on the relationship in one’s mental taxonomy. For example, knowing a fact about chimpanzees (e.g., that they nurse their infants), one can readily infer that wolf moms also probably nurse baby wolves, since both are types of mammals. The tree of relationships also allows us to use *taxonomic inheritance*: learners may find out that one of their higher-level categories, like “birds,” possesses particular traits, such as laying eggs or having hollow bones. When they encounter a new type of bird, say a robin, they can readily infer that it likely lays eggs and has hollow bones without explicitly learning these facts about robins.[29]

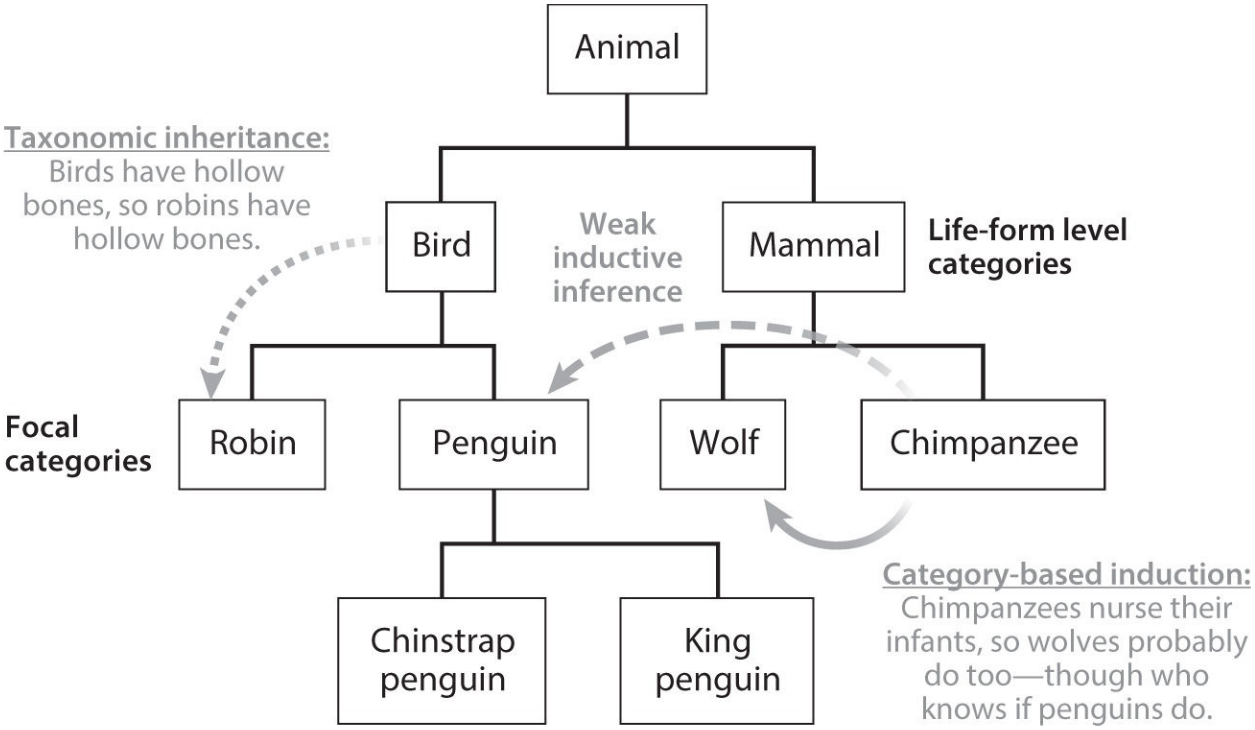


Figure 5.4. Diagram illustrating aspects of folkbiological thinking.

CHAPTER 6

WHY SOME PEOPLE HAVE BLUE EYES

If you create a global map of eye color but put aside the migrations of peoples in the last few hundred years, you will see that light eyes—blue and green—are common only in a region centered on the Baltic Sea in Northern Europe. Meanwhile, almost everyone else in the world has brown eyes, and there's good reason to believe that brown eyes were universal, or nearly so, prior to the emergence of this pattern of eye color. Here's the puzzle: why are light eyes distributed in this peculiar way?[1]

To understand this, we need first to consider how culture has shaped genes for skin color over the last 10 millennia. Much evidence now indicates that the shades of skin color found among different populations—from dark to light—across the globe represent a genetic adaptation to the intensity and frequency of exposure to ultraviolet light, including both UVA and UVB. Near the equator, where the sun is intense year-round, natural selection favors darker skin, as seen in populations near the equator in Africa, New Guinea, and Australia. This is because both UVA and UVB light can dismantle the folate present in our skin if not impeded or blocked by melanin. Folate is crucial during pregnancy, and inadequate levels can result in severe birth defects like spina bifida. This is why pregnant women are told by their physicians to take folic acid. In men, folate is important in sperm production. Preventing the loss of this reproductively valuable folate means adding protective melanin to our epidermis, which has the side effect of darkening our skin.[2]

The threat from intense UV light to our folate diminishes for populations farther from the equator. However, a new problem pops up, because darker skinned people face a potential vitamin D deficiency. Our bodies use UVB light to synthesize vitamin D. At higher latitudes, the protective melanin in dark skin can block too much of the UVB light and thereby inhibit the synthesis of vitamin D. This vitamin is important for the proper functioning of the brain, heart, pancreas, and immune system. If a person's diet lacks other significant sources of this vitamin, then having dark skin and living at high latitudes increases one's chances of experiencing a whole range of health problems, including, most notably, rickets. A terrible condition, especially in children, rickets causes muscle weakness, bone and skeletal deformities, bone fractures, and muscle spasms. Thus, living at high latitudes will often favor genes for lighter skin. Not surprising for a cultural species, many high-latitude populations of hunter-gatherers (above 50°–55° latitude), such as the Inuit, culturally evolved adaptive diets based on fish and marine animals, so the selection pressures on genes to reduce the melanin in their skin were not as potent as they would have been in populations lacking such resources. If these resources were to disappear from the diet of such northern populations, selection for light skin would intensify dramatically.

Among regions of the globe above 50°–55° latitude (e.g., much of Canada), the area around the Baltic Sea was almost unique in its ability to support early agriculture. Starting around 6000 years ago, a cultural package of cereal crops and agricultural know-how gradually spread from the south and was adapted to the Baltic ecology. Eventually, people became primarily dependent on farmed foods and lacked access to the fish and other vitamin-D-rich food sources that local hunter-gatherer populations had long enjoyed. As a consequence of this combination of living at high latitude and a lack of vitamin D, natural selection kicked in to favor genes for really light skin, so as to maximize whatever vitamin D could be synthesized using UVB light.

Natural selection would have operated on many different genes to favor very light skin among cereal-eating Baltic peoples, because there are many genetic routes to reduce melanin in our skin. One of those genes is called *HERC2* which is located on chromosome 15. *HERC2* inhibits, or suppresses, the production of a protein by a nearby gene called *OCA2*. Suppression of the synthesis of this protein, which occurs through a long and complicated set of biochemical pathways, results in less melanin in people's skin. However, unlike other genes that influence skin color at other places in those pathways, *HERC2* usually causes light eyes because it also reduces the melanin in irises. Blue and green eyes, then, are a side effect of natural selection favoring genes for lighter skin among cereal-dependent populations living at high latitudes. If cultural evolution hadn't produced agriculture, and specifically techniques and technologies suitable for higher latitudes, then there would be no blue or green eyes.[3] In all likelihood then, this genetic variant only started spreading within the last six millennia, after agriculture arrived in the Baltic region.

The point of this example is this: cultural evolution can shape our environments, and consequently, it can drive genetic evolution. In cases of recent culture-gene coevolution, in which the relevant genes have not spread to replace all or most competing genetic variants, we can isolate the causes and effects and sometimes even finger the specific genes being favored. This is important because some researchers have argued that culture could never be strong enough for long enough to drive genetic evolution. Recently, however, new mathematical models and mounting evidence from the human genome provide a clear, if only preliminary, answer. Not only has culture driven specific genes to high frequency in some populations in the last ten millennia, but in fact, sometimes cultural evolution can create selection pressures *more* powerful than seen elsewhere in nature. Sometimes, culture catalyzes and drives more rapid genetic evolution.

To be clear, this book is about how culture drove genetic evolution during the emergence of our species. It's about human nature, *not about the genetic differences among current populations* in our species now. However, I'm going to use the fact that culture-gene coevolution continues today, with many culture-gene interactions still in progress in our species, to illustrate the power of culture to shape the genome. Aside from this chapter, I'll only occasionally be able to link specific genes to the culture-gene coevolutionary processes described. This is for several reasons. First, many of the coevolutionary processes I'm focused on are "completed," such that the traits under selection don't vary across our species. This means that we can't exploit the variation among

[redacted]

Culture-Gene Revolutions

These cases of culture-driven genetic evolution are three of the best documented examples we have, though there's every reason to suspect that they represent only the tip of an iceberg. The evolutionary biologist Kevin Laland and his collaborators have already fingered over 100 genes that have likely been under selection, based on analyses of the genome, and have at least plausible cultural origins. These genes influence an immense spectrum of traits ranging from dry earwax and malaria resistance to skeletal development and the digestion of plant toxins.[13] What these cases illustrate for our purposes is as follows:

1. Culture can exert a powerful force on genes, driving genetic evolution. Gene-culture packages emerge and spread rapidly, as with milk-drinking, blue eyes, and booze avoidance.
2. In fact, the selection pressures created by culture can be among the most powerful observed in nature, and broad genetic sweeps can occur in tens of thousands of years. Culture-gene coevolution can be remarkably fast.
3. We can point to specific genes on particular chromosomes, and sometimes even know which molecular base changed. Once-hypothetical genes have now been pinpointed.
4. Once cultural evolution creates the selection pressures, natural selection often manages to find and favor several different genetic variants to address the challenge.
5. However, sometimes cultural evolution can sap the strength of selection, as we saw for populations who rapidly developed

cheese-and yogurt-making technology.

One concern with the above examples is that all stem from the emergence of food production—from agriculture and animal domestication. Perhaps this major revolution in human history is a unique event from which we cannot draw general conclusions? To the contrary, my view is that the agricultural revolution just happens to be the best-timed revolution in order for us to detect its causes and effects in our genome. The industrial revolution is too recent, and the revolutions that preceded food production are much older and thus harder to study. Nevertheless, there's every reason to suspect that there was a cooking-and-fire revolution, a projectile-weapons revolution, and a spoken-language revolution, among many others. And as you will see in later chapters, technologically driven revolutions are probably underpinned by revolutions in forms of social organization or institutions. The agricultural revolution is just the one in the temporal sweet spot for today's science.

To see something of this, consider that chimpanzees have two copies of the *AMY1* gene, but humans have, on average, six copies. The gene codes for a protein—amylase—found in saliva that helps break down starch. The extra copies mean that humans, on average, end up having six to eight times more amylase in their saliva than chimpanzees. All other things equal, this means we are better at starch processing than chimps. So, after you beat that chimp in a marathon, you should challenge him to a potato-digesting contest.

Human populations, however, vary in the number of *AMY1* copies they have. Populations who have long been dependent on eating high-starch diets have between 6.5 and 7 copies, on average. The Hadza, African hunter-gatherers who live in savannah woodlands and rely on starchy roots and tubers, have the most, at almost 7 copies, on average, and some Hadza have as many as 15 copies. European-Americans and Japanese are not far behind, at 6.8 and 6.6 copies. By contrast, populations long dependent on low-starch diets have copy counts around 5.5. These include other African hunter-gathers who live in the tropical forest of the Congo basin and herders in both Africa and central Asia, who depend primarily on some combination of meat, blood, fish, fruit, insects, seeds, and honey.[14]

These differences are likely part of a long and meandering evolutionary story and emerged as our ancestors shifted to a heavy reliance on underground roots and tubers over a million years ago. However, just how much populations have depended on starch since then has been influenced by a combination of ecology and cultural evolution, including the practices, preferences, technologies, and know-how of different populations. As we see from the examples above, groups can live relatively close by, in similar ecologies, but still maintain different numbers of *AMY1* genes because they operate with different economic packages.

There is also evidence that culturally prescribed forms of social organization can shape our genome. This is important since some have argued that the forms of social organization created by cultural evolution are too weak or unstable to affect our genes. One important aspect of human social organization is what anthropologists call *postmarital residence*. In many human societies, especially until recently, local norms specified that a newly married couple went to live either with the husband's family or with the wife's family. The first is called *patrilocal residence*, and the second, *matrilocal residence*. Working in three patrilocal and three matrilocal farming populations in Northern Thailand, Hiroki Oota and his colleagues examined the variation in people's mitochondrial DNA and Y chromosomes. Both sons and daughters get their mitochondrial DNA from mom, and only mom. Sons get their Y chromosomes from dad, whereas daughters don't get Y chromosomes at all. If social organization is stable enough to influence the genome, than patrilocal communities should have relatively low variation in their Y chromosomes compared to mitochondrial DNA because sons always stick with their fathers. Similarly, because daughters stick with their mothers, matrilocal communities should show the opposite pattern, low variation in mitochondrial DNA and higher variation in Y chromosomes. This is precisely what Oota's team found, showing that culturally evolved social norms can shape the genome.[15]

Overall, cultural evolution can, and has, powerfully shaped the human genome in a variety of important ways. As we saw in chapter 5, this culture-gene coevolutionary interaction goes well back into our species' history, where culturally transmitted know-how about fire, water containers, tracking, and projectiles were some of the key selection pressures favoring aspects of our anatomy and physiology. Moving forward, I'll begin to focus on how culture created selection pressures on genes that influence our psychology and sociality. In chapter 7, we'll take another step by going deeper into the subtle and nuanced ways cultural evolution can build adaptations without the culture-bearers themselves having any idea what's going on.

Genes and Races

Before moving on, it's worth highlighting a point about genes and race. Anthropologists have long argued that race is not a biological concept. What we mean by this is that the racial categories developed historically by Europeans—such as Caucasian, Negroid, and Mongoloid—do not convey or contain much, if any, useful genetic information, aside from capturing something of the migration patterns of ancient peoples.[16] Detailed studies of the genome, including the research highlighted above, has only served to further underline this point. As we saw, skin-color genes are heavily influenced by a combination of UV radiation and diet, because they effect vitamin D and folate. This means that people in New Guinea and Africa are both very dark skinned despite being from opposite ends of our species' family tree. And very light-skinned Europeans are evolutionarily recent, being mostly a product of agriculture at high latitudes. Other genes have quite different distributions for distinct reasons. For example, we saw that lactase persistent genes are common among indigenous populations in Britain and some African groups, exist at moderate frequencies among Eastern Europeans and Middle Easterners, and remain at low frequencies in other African groups and many Asian populations. Similarly, amylase genes are more common among Japanese, European-Americans, and Tanzanian foragers but less common among Congo forgers and herders in both Tanzania and Central Asia. What does race tell us about these genetic differences?

Nothing. Traditional racial categories just don't tell us anything about this important variation. In fact, the processes I've described above actually make classical racial categories even less informative, since they operate in diverse and nonconcordant ways *within* races to make local groups less similar (e.g., lactase persistent and nonpersistent

Africans) while at the same time making different continental races more similar (e.g., amylase genes in Japanese and Americans). The current evidence indicates that natural selection operates in diverse ways on scales much smaller than races and simultaneously on different continents.

Moreover, figures 6.1 and 6.2 show that even using *categories*, racial or otherwise, often distorts the picture. The genetic distributions on these maps vary continuously, so it's best to forget about discrete boundaries. Overall, traditional racial categories capture only about 7% of the total genetic variation in our species, which reveals that races are nothing like the subspecies found in chimpanzees.[17] Given our global distribution and range of environments, our species genetic variation is actually rather limited. Of course, this is not surprising when you realize that in addition to sometimes driving genetic evolution, cultural evolution can also inhibit genetic responses by more rapidly generating cultural adaptations of the kind discussed in chapter 7.[18]

Why Put Ash in the Corn Mix?

One morning in 1998, when I was living in rural southern Chile and working with the indigenous Mapuche, I arrived at my friend Fonso's farmhouse to find him preparing what he called *mote*, a traditional Mapuche corn dish. He showed me how you have to scoop fresh ash out of the wood stove and put it into the corn mix for soaking, before heating it. I thought that was curious, so I asked him why he mixed the wood ash in with the corn. His answer was, "It's our custom." And a wise custom it is.

In the Americas before 1500 CE, corn was the stable crop for many farming societies. However, relying heavily on corn presents some tricky nutritional issues. A diet based on corn can leave one short on niacin (vitamin B3). Failure to get enough niacin results in a disease called pellagra, a horrible condition characterized by diarrhea, lesions, hair loss, tongue inflammation, insomnia, dementia, and then death. There is actually niacin in corn, but it's chemically bound and cannot be freed by normal cooking. To release this niacin, populations throughout the New World culturally evolved practices that introduced an alkali (a base) into their corn preparations. In some places, the alkali came from burning seashells (generating calcium hydroxide) or the ash of certain kinds of wood. Elsewhere, there were natural sources of lye (providing potassium hydroxide). Mixing the alkali into the recipe in the right way chemically releases the otherwise unavailable niacin in the corn, which stops pellagra in its tracks, and allowed corn-based agricultural populations to grow and spread.[10]

Perhaps mixing nonfood substances, like wood ash or burned seashells, with foods during cooking is easy for a big-brained ape like us to figure out?

History, again, provides us with a natural experiment, because corn was brought from the New World to Europe after 1500. By 1735, some populations in Italy and Spain had already become reliant on cornmeal as a staple, and pellagra had emerged. The condition was theorized to be a form of leprosy or somehow caused by spoiled corn. Pellagra spread across Europe with this new staple crop into Romania and Russia but remained confined mostly to poor populations, who relied on it almost exclusively through the winter—making pellagra the "springtime disease." Experiments were done, and laws were passed to address the problem, by prohibiting the sale of spoiled or moldy corn. This did little to reduce pellagra, since spoilage is not the issue—the Europeans developed the wrong causal model.[11]

Later, pellagra also emerged in the southern United States during the late nineteenth and early twentieth century and spread in epidemic fashion until the 1940s. Millions died, because poor people and institutions, including prisons, sanitariums, and orphanages, had come to rely heavily on diets of cornmeal and molasses. Despite alarms raised by the Surgeon General, special commissions, medical conferences, and private donations to find a cure, the plague raged on for thirty years.

One man, Dr. Joseph Goldberger, investigated orphanages, performed controlled experiments on prisoners, and had begun to construct the right causal model by 1915. However, at the time, the medical community was convinced that pellagra must be an infectious disease, so Goldberger was ineffective and his ideas thought “absurd.” Goldberger even injected his wife and friends with blood from people suffering from pellagra to demonstrate the noninfectious nature of the condition. These studies were dismissed by asserting that Goldberger’s staff must have been “constitutionally resistant” to the disease.[12]

Thus, not only did people—Europeans and Americans in this case—not figure out the right causal model, but they actively resisted it when it was presented to them by Goldberger. Instead, they preferred to hold firmly to the wrong causal model, probably because the right model was rather less intuitive. Spoiled food and contamination were, and are, relatively “easy to think” about with regard to food compared to the concept of chemical reactions initiated by the introduction of nonfoods, like burnt seashells, into culinary recipes. Cultural evolution had produced a rather nonintuitive fix for the pellagra challenge.

Note, if you are educated and Western, you might be thinking that my numerous examples of toxic plants and animals are merely special cases, because you might be under the impression that few plants need detoxification and that nature’s bounty is pure and safe. For many Westerners, “it’s natural” seems to mean “it’s good.” This view is wrong and comes from shopping in supermarkets and living in landscaped environments. Plants evolved toxins to deter animals, fungi, and bacteria from eating them. The list of “natural” foods that need processing to detoxify them goes on and on. Early potatoes were toxic, and the Andean peoples ate clay to neutralize the toxin. Even beans can be toxic without processing. In California, many hunter-gatherer populations relied on acorns, which, similar to manioc, require a labor intensive, multiday leaching process. Many small-scale societies have similarly exploited hardy, tropical plants called cycads for food. But cycads contain a nerve toxin. If not properly processed, they can cause neurological symptoms, paralysis, and death. Numerous societies, including hunter-gatherers, have culturally evolved an immense range of detoxification techniques for cycads.[13] By contrast with our species, other animals have far superior abilities to detoxify plants. Humans, however, lost these genetic adaptations and evolved a dependence on cultural know-how, just to eat.

Figure 11.1. An experimental subject wagging his finger at Max the puppet, who is violating the rules for this context.

As in the small-scale societies seen in earlier chapters, the social world faced by our Paleolithic ancestors would have been increasingly shaped by the emergence of an immense variety of norms, and by the selective spread of specific norms packaged in institutions, that fostered success in intergroup competition. From the gene's-eye view, survival and reproduction would have increasingly depended on the abilities of one's bearer (the individual) to acquire and navigate a social landscape governed by culturally transmitted local rules—those appropriate to whatever group a particular gene happened to find itself in. Typically, in small-scale societies, as in many communities, the sanctioning of norm violators begins with gossip and public criticism, often through joking by specific relatives (as with Kula), and then intensifies to damage marital prospects and reduce access to trading and exchange partners. If violators are still not brought into line, matters may escalate to ostracism or physical violence (e.g., beatings) and occasionally culminate in coordinated group executions.[2] In parallel with how wolves were domesticated into dogs by killing those that wouldn't obey and refused to be trained, human communities domesticated their members.[3]

In research in the villages of Yasawa Island, my team and I have studied how norms are maintained. When someone, for example, repeatedly fails to contribute to village feasts or community labor, or violates food or incest taboos, the person's reputation suffers. A Yasawan's reputation is like a shield that protects them from exploitation or harm by others, often from those who harbor old jealousies or past grievances. Violating norms, especially repeatedly, causes this reputational shield to drop and creates an opening for others to exploit the norm violator with relative impunity. Norm violators have their property (e.g., plates, matches, tools) stolen and destroyed while they are away fishing or visiting relatives in other villages; or they have their crops stolen and gardens burned at night. Despite the small size of these communities, the perpetrators of these actions often remain anonymous and get direct benefits in the form of stolen food and tools as well as the advantages of bringing down a competitor or dispensing revenge for past grievances. Despite their selfish motivations, these actions sustain social norms, including cooperative ones, because—crucially—perpetrators can only get away with such actions when they target a norm violator, a person with his reputational shield down. Were they to do this to someone with a good reputation, the perpetrator would himself become a norm violator and damage his or her reputation, thereby opening themselves up to gossip, thefts and property damage. This system, which Yasawans themselves can't explicitly lay out, thereby *harnesses* past grievances, jealousies, and plain old self-interest to sustain social norms, including cooperative norms like contributing to village feasts.[4] Thus, individuals who fail to learn the correct local norms, can't control themselves, or repeatedly make mistaken violations are eventually driven from the village after having been relentlessly targeted for exploitation.

Over our evolutionary history, the sanctions for norm violations and the rewards for norm compliance have driven a process of self domestication that has endowed our species with a *norm psychology* that has several components. First, to more effectively acquire the local norms, humans intuitively assume that the social world is rule governed, even if they don't yet know the rules. The violation of these rules could and should have negative consequences. This outcome means that the behavior of others can be interpreted as being influenced by social rules. This also means that, at a young age, we readily develop cognitive abilities and motivations for spotting norm violations and avoiding or exploiting norm violators, as well as for monitoring and maintaining our own reputations.[5] Second, when we learn norms we, at least partially, *internalize* them as goals in themselves. This internalization helps us navigate the social world more effectively and avoid temptations to break the rules to obtain immediate benefits. In some situations, internalizations may provide a quick and efficient heuristic that saves the cost of running the mental calculations that consider all the potential short- and long-term benefits and probabilistic penalties of an action; instead we simply follow the rule and abide by the norm. This means that our automatic and unreflective responses come to match the normatively required ones. Other times, internalized preferences may merely provide an additional motivation that goes into our calculations.[6]

It's Automatic

Internalized social norms help guide us through complex social environments, allowing people to automatically—without conscious reflection or complex mental calculations of the reputational consequences—do the "right thing" (i.e., comply with local norms). This can be seen in how people respond in the Public Goods Game. The structure of this game captures the logic of real-life situations, like recycling, giving blood, paying taxes, and defending the community, in which the group does best if everyone cooperates but the individual does best if he or she acts selfishly while everyone else cooperates. In this classic cooperative dilemma, individuals are placed into groups with three strangers for a single interaction. Each person gets $4 to start. Without knowing what others will do, they have to contribute between 0 and $4 to a common project. Whatever enters the project is doubled and then distributed equally among all four group members, regardless of what they contributed.

To highlight the cooperative dilemma, consider that the group gets the highest payoff if everyone contributes all four of their dollars to the common project (4 × $4 = $16). This money doubles to $32 and is distributed equally so that everyone goes home with $8 (twice what each started with). However, every individual does best if they keep their $4 and free ride on those who contribute to the common project. For example, if three people contribute $4 and one free rider contributes nothing to the common project, then the three contributors go home with $6 each, and the free rider goes home with $10—his initial $4 plus the $6 he got from the common project. If three people free ride and only one person contributes his entire $4, then the free riders go home with $6 each while the contributor gets only $2. Thus, those aiming to maximize their payoff should contribute zero. However, most educated Westerners agree that—if asked—players *should* contribute all the money to the common project. Among the typical experimental subjects (undergraduates), the average contributions are commonly between 40% and 60%, with many people contributing either 100% (cooperators) or 0% (free riders).[13]

To examine whether high contributions in the Public Goods Game, and prosocial choices in other such games, result from automatic norm following, David Rand and his colleagues examined the relationship between the time people spent making their contribution decisions and the size of their contributions. Figure 11.2 shows one of Dave's findings: the more rapidly participants made their decision, the higher their contribution was to the common pool—that is, quick, gut responses were more cooperative.[14]

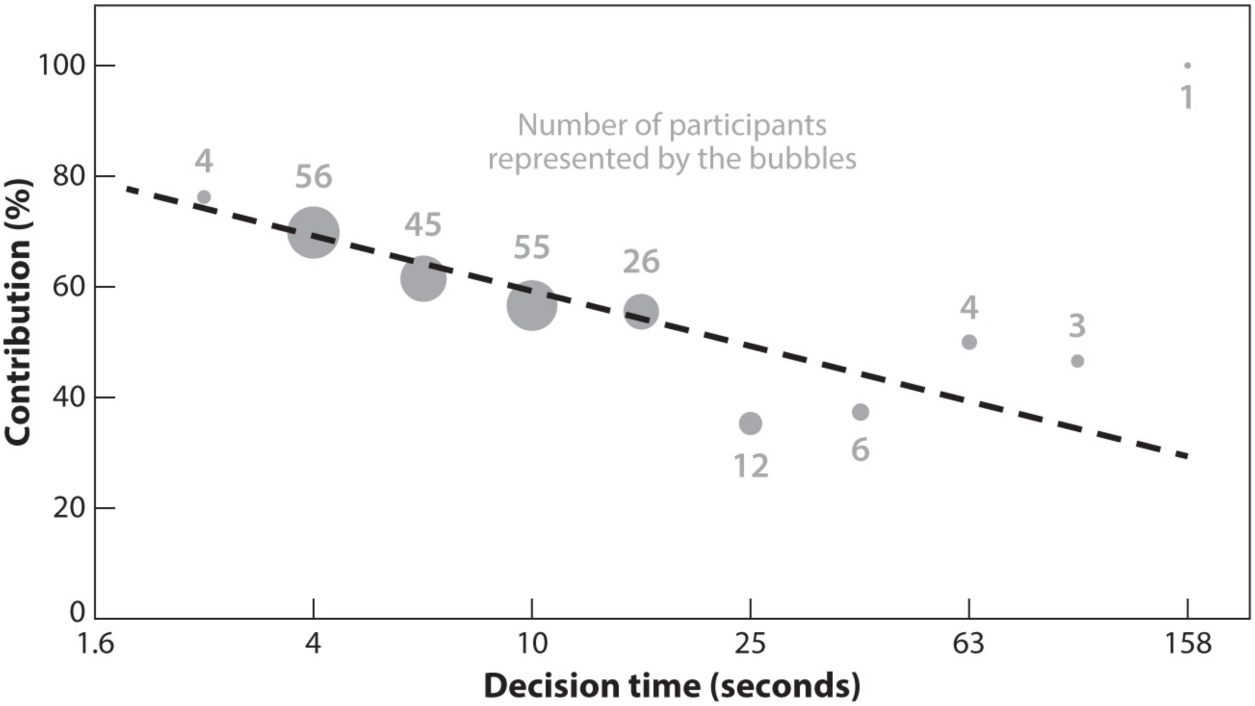


Figure 11.2. Plot showing that the longer people took to decide what to do, the less they cooperative they were.

As both Adam Smith and Friedrich Hayek argued long before Erik and me, it’s our automatic norm following—not our self-interest or our cool rational calculation of future consequences—that often makes us do the “right thing” and allows our societies to work. This means that how well a society functions depends on its package of social norms.

And in the Brain

The effects of internalizing norms can be seen in our brains when economic games are combined with tools from neuroscience. When people cooperate, give to charity, or punish norm violators in locally prescribed ways, the “rewards circuits” in their brains fire up. Some of these are the same circuits that fire when people are rewarded with money or food, yet in these costly social contexts, the circuits are firing despite the fact that individuals are actually losing money.[17] Neurologically speaking, people “like” to comply with norms and punish norm violators.

Using these brain-imaging tools, it’s instructive to consider what people’s brains do when we decide to break a social norm. Consider lying. Neurologically, lying requires most people, though presumably not lawyers or car salesmen (just kidding), to override their automatic or unreflective reactions by engaging those brain regions responsible for cognitive control and abstract reasoning. That is, violating a social norm requires mental effort and “higher” cognition.[18] Most Westerners, for example, have to override an internalized norm to lie to strangers in many contexts. Note, of course, that intentionally not telling the truth isn’t always a norm violation, such as with “white lies.” And in many places it’s considered totally fine—if not encouraged—to lie to strangers or foreigners to benefit oneself or one’s family (no “over-ride” needed).

Why would natural selection have built us to be norm internalizers? Broadly speaking, internalizing motivations helps us to more effectively and efficiently navigate our social world, a world in which some of the most frequent and dangerous pitfalls involve violating norms. Such motivations may help us avoid short-term temptations, reduce cognitive or attentional loads, or more persuasively communicate our true social commitments to others. The logic here parallels that which we encountered in chapter 7, where I explained how cultural learning could overcome an innate aversion to chili peppers and other spices in order to reduce the dangers of meat-borne pathogens. Reinterpreting the pain as pleasure helps individuals navigate the ecological landscape by solving an adaptive problem (meat-borne pathogens) without us even being aware of it. Analogously, internalizing norms as tastes helps us more easily and intuitively navigate the social landscape.

Why Spotting Potential Norm Violations Is Easy

In addition to the internalization of social norms, culture-gene coevolution has honed our cognitive abilities, motivations and emotions in various ways, including ways that permit us to effectively manage our reputations. On the cognitive side, both children and adults are more skilled at solving logic problems when the latter are contextualized as norm violations. This helps us avoid committing norm violations ourselves and pick out other norm violators, whom we might be required to punish, avoid, or ostracize (and even be rewarded for doing so). As we saw in Fiji, spotting norm violators results in opportunities to justifiably steal their crops or take revenge for past grievances.

To understand these abilities, consider this experiment with three-and four-ear-olds: the children hear one of two stories and then have to solve a logic problem. In both stories, they are told about some mice that go out to play in the evening. Some of these mice tend to squeak while playing, which attracts the neighborhood cat, who comes and tries to catch them. In one version, the children hear a *descriptive claim*, which states that all squeaky mice stay in the house in the evening. In the other version, they are told about a *social norm* prescribing that all squeaky mice *must* stay in the house. Now for the test. The children are placed in front of the mouse house, with ten yellow rubber mice inside the house. They are also shown that "squeaky" and "quiet" mice can only be distinguished by squeezing the mice and listening for a squeak. Then, evening arrives at the mouse house, and four mice leave the house to play in the backyard. Depending on which version of the story they heard, children were tasked either with (1) checking to see if the descriptive claim was true or (2) locating norm violators. The answer is the same in both cases: you have to check all the mice in the backyard, not in the house. Checking the mice in the house tells you little, since quiet mice might be in the house in either case, and you don't know how many of each kind of mice there are. When checking for norm violations, most three- and four-year-olds decided to check the mice in the backyard. However, when verifying the descriptive statement, most of the children did not think to check the backyard mice.[19] This suggests that setting up the task to cue norm psychology made the children better at solving the logic problem.

This self-domestication process has also tinkered with our feelings and emotional displays to better navigate a world governed by social norms. Primate emotions related to shame and pride have been retrofitted to apply to social norms. Shame in humans evolved (genetically) from a primate "proto-shame," the package of feelings and bodily displays that we see in primates when individuals demonstrate or signal their subordinate status to a dominant group member. The shame and proto-shame display in both humans and primates involves slumped shoulders, downcast gaze, crouching, and a diminutive body posture—the idea seems to be to look small and unimposing. However, as the anthropologist Dan Fessler has persuasively argued, shame in humans emerges when someone violates a social norm or delivers a substandard performance as well as in status hierarchies (see chapter 8). Norm violators display shame to their communities for communicative reasons that parallel those that drive subordinates to display shame in the presence of more dominant animals. In both cases, the shame display reaf-firms their acceptance of the local social order. In the context of norm violations, the ashamed is effectively saying to the community, “Yes, I know I violated a norm, and should be admonished for it; but please don’t be too harsh on me.”[20]

The size of the group and the social interconnectedness among these individuals plays a crucial role in this process. The most obvious way that the size of a group can matter is that more minds can generate more lucky errors, novel recombinations, chance insights, and intentional improvements. To see this in starkest terms, consider how group size influences the chance of coming up with an invention, say using feathers to fletch an arrow. Suppose any one individual operating alone will only figure out—by luck or effort—"arrow fletching" once in one thousand lifetimes. The chance that at least one person in a group of 10 people will figure out fletching in their lifetimes is then 1%. So, on average, a group of 10 persons will take 100 generations to come up with this invention (2,500 years). In a group of 100 people, at least 1 person will devise it 10% of the time in one lifetime. Consequently, on average, it will take 11 generations for the group to figure this out (275 years). For 1000 people, there's a 63% chance they will get it in 1 generation, and on average, they will figure it out in 1.6 generations (40 years). If you can unite 10,000 minds, you will have fletching in 1 generation (well, technically, a 99.995% chance). So, bigger groups have the potential for more rapid cumulative cultural evolution, especially since these effects further compound when you consider that many inventions require combining several elements, so their rate of emergence depends on the slowest element.

This, of course, assumes that the members of this group are sufficiently socially interconnected to other members of the group so that their improvements can rapidly spread through the group. The bigger the group, the more implausible this assumption is. To see the importance of this sociality, imagine that every person is a social island who keeps any insights he has secret from all others. What happens?

Well, not much. Some individuals will make slightly better tools, but then they will die and their improvements will go with them. No fancy tools will emerge. And the size of the group doesn't matter. This is the case for most animals.

Thus, along with group size, the degree of social interconnectedness is very powerful in generating cumulative cultural evolution, even more powerful than individual smarts. Consider two very large prehuman populations, the *Geniuses* and the *Butterflies*. Suppose the Geniuses will devise an invention once in 10 lifetimes. The Butterflies are much dumber, only devising the same invention once in 1000 lifetimes. So, this means that the Geniuses are 100 times smarter than the Butterflies. However, the Geniuses are not very social and have only 1 friend they can learn from. The Butterflies have 10 friends, making them 10 times more social. Now, everyone in both populations tries to obtain an invention, both by figuring it out for themselves and by learning from friends. Suppose learning from friends is difficult: if a friend has it, a learner only learns it half the time. After everyone has done their own individual learning and tried to learn from their friends, do you think the innovation will be more common among the Geniuses or the Butterflies?

Well, among the Geniuses a bit fewer than 1 out of 5 individuals (18%) will end up with the invention. Half of those Geniuses will have figured it out all by themselves. Meanwhile, 99.9% of Butterflies will have the innovation, but only 0.1% will have figured it out by themselves. Keep in mind that the Geniuses were 100 times smarter than the Butterflies whereas the Butterflies were only 10 times more social. Bottom line: if you want to have cool technology, it's better to be social than smart.

Now, suppose the invention mentioned above is the bow and arrow, and the Butterflies and the Geniuses come into conflict over territory. Who would win, the smarter group or the more social one? It's unclear, but the Butterflies would have a good chance since they would all be armed with bows and arrows, but only 18% of the Geniuses would.[3]

This cultural evolutionary process may also shape the *learnability* of the know-how and skills related to tools, technology, and practices. Over generations, the details, techniques, and protocols that go into producing complex technologies should—all other things being equal—tend to simplify in ways that make them easier to learn and more intuitive. This propensity suggests that larger and more interconnected populations not only will have a larger variety of more sophisticated tools and technologies, but also that they will have more learnable techniques for producing them.

As our species self-domesticated and we became increasingly social, our collective brains would have expanded, making possible greater technological sophistication and larger bodies of know-how. However, remember that our species' ability to live in large groups, well beyond residential populations, still depends heavily on social norms. Under the influence of intergroup competition, social norms that effectively maintain internal harmony in ever larger groups would have spread. Institutions that expand social groups and help forge broad alliances, through kin ties, naming practices, affinal ties, spousal exchange, and rituals, would have expanded our collective brains, making them better able to culturally evolve and sustain more-complex bodies of cultural know-how, including more sophisticated tools and weapons.

Further, by shaping both the incentives in our social world and our motivations, culture causes us to train our brains in particular ways. In some societies, this involves learning to read, tracking gender or status differences, or using fractions. In other societies, it involves spotting and identifying animal tracks, seeing clearly underwater, or recognizing individual cows within large herds. As part of this process, cultural evolution sometimes constructs what amount to mental prostheses that augment our brains and cognitive abilities, like the physical and mental abaci that permit children to make mental calculations faster than calculators (see chapter 12).

CHAPTER 15

WHEN WE CROSSED THE RUBICON

The crucial event in the history of our species involved crossing the threshold into a regime of cumulative cultural evolution, which has driven human genetic evolution ever since. This is the process that made us uniquely human, but I have not said much about when our lineage made the crossing. When did our ancestors first begin to possess bodies of know-how or tools of sufficient complexity that no single individual could have invented it from scratch on his or her own in one lifetime?

Well, first, there's no reason to suspect it was a singular moment or event. Instead, our lineage probably danced around the starting line for a long time. One group would cross the threshold and begin to very slowly accumulate cultural know-how, only to have those cultural products lost when the group was broken up or decimated by environmental shifts, diseases, or conflicts with nearby groups. Setbacks would also result from migrations to new environments or environmental changes, because any emerging cultural adaptations might not fit the new circumstances or the relevant materials or resources might not be available. For example, groups might learn to control—but not start—fires for cooking. Once they move away from their natural fire sources and their fires go out in a rainstorm, that's it, no more fire. Or a little cumulative cultural evolution might create a nice stone chopper made from a certain kind of volcanic rock, but once the group migrated to a new region, perhaps driven there by climatic shifts, they'd lose access to that type of rock and eventually forget how to make those choppers. With low-quality imitative abilities, error-prone copying, social intolerance, and little or no teaching, accumulating and sustaining cultural adaptations would have been very delicate in the early days. So, when were these early days?

[redacted] the signature of cumulative cultural evolution seems to emerge at certain times and places. For example, between the Golan Heights and the Galilee mountains (Israel) on the shores of an ancient lake, the site of Gesher Benot Ya'aqov has yielded rich insights into the life of one society around 750,000 years ago. The extensive remains indicate the existence and persistence of hearths and areas for both stone-tool manufacturing and food processing. The inhabitants controlled fire and made a variety of stone tools, including hand axes, cleavers, blades, knives, awls, scrapers, and choppers. Made from flint, basalt, and limestone, tool manufacture was done on-site, often from giant slabs carried in from a distant quarry by a team. Some of the basalt slabs have notches, indicating the use of levers as part of the quarrying process. The basalt is of the highest quality and well quarried, suggesting that someone had a storehouse of know-how on the topic.[24]

The group's diet was diverse and also would have required extensive local knowledge. The stone tools were used to process the carcasses of elephants, deer, gazelles, and rhinos as well as boars and rodents. The cut marks left on deer bones are not much different from the same marks made hundreds of thousands of years later by late Paleolithic hunters. The inhabitants of Gesher Benot Ya'aqov also, somehow, obtained freshwater crabs, turtles, reptiles, and at least nine types of fish, including carp, sardines, and catfish. Some of these fish were big, longer than a meter. On top of this, there were seeds, acorns, olives, grapes, nuts, water chestnuts, and various other fruits. This bounty included the submerged prickly water lily, which grows well away from shore. It also appears that they were cracking nuts open and roasting acorns to remove their shells and perhaps reduce the bitter tannins. They may even have made "popcorn" by roasting the seeds from the prickly water lily, as has been done for thousands of years in India and China.

Clearly, cumulative cultural evolution is up and running at this point, generating more know-how than you, me, or our lost European Explorers could have ginned up in a lifetime. If you aren't sure, go quarry some high-quality basalt slabs (you'll need a lever, I think), make a beautiful hand axe with full symmetry (remember to make that antler or bone hammer first), bring down an elephant (trust your Paleolithic instincts?), butcher the carcass (use the hand axe), make a fire or find naturally occurring flame, and then whip up a raft to paddle out and pick some prickly water lily (you can spot this plant, right?). Then, enjoy the elephant steaks and "popcorn."

Of course, this is not to imply that these ancient humans were like us, but merely that they had crossed the Rubicon and embarked on a genetic evolutionary trajectory that was primarily driven by culture and its products.

If you have any remaining skepticism that the cumulative cultural evolutionary threshold has been crossed by this point, in the next 300,000 years after the activities at Gesher Benot Ya'aqov, *Homo erectus* changed sufficiently, including a brain expansion to 1200 cm^3, to justify a new species name, *Homo heidelbergensis*. This period revealed the first evidence of projectile weapons, including wooden throwing spears with stone points, and the emergence of a variety of techniques for producing stone blades. These techniques are consistent within sites or populations but did vary between populations. Distinct tool traditions and composite tools that exploited natural glues weren't far behind. *Heidelbergensis* also appears to have had ears calibrated like humans to speech sounds, unlike other apes, which suggests that a culturally evolved spoken communicative repertoire had been hammering away at our genes (see chapter 13).[25] Now, many of these bits of know-how and technologies seem to drop in and out of the record and don't make a sustained an enduring appearance until the last 100,000 years. But this is just what you'd expect in a species dependent on a collective brain that was subject to shifting environments, intergroup competition, and challenging ecologies that constrained group size and fractured the social ties between bands.

The upshot of all this is that, based on current evidence, Australopiths probably began to aggregate cultural information more intensively than any other living ape (except us), but that no particular tool or element of know-how was more sophisticated than an individual could invent in his or her lifetime. However, taken together, these aggregations may have at certain times and places been more than any one individual could have figured out. These populations, however, likely stood on the precipice of true cumulative cultural evolution, with slow advances and common retreats. This aggregation of cultural know-how drove the evolution of Early Homo, expanding his brain and reducing his teeth and jaws. By 1.8 million years ago, however, the threshold had probably been crossed, and cumulative cultural evolutionary products were driving the genetic evolution of our genus, shaping our feet, legs, guts, teeth, and brains. Albeit slow by later standards, toolkits improved and techniques were added gradually, though of course, cultural losses and technological setbacks continued, and would continue into the modern world. By 750,000 years ago at Gesher Benot Ya'aqov, there’s little doubt that we are dealing with a cultural species who hunts large game, catches big fish, maintains hearths, cooks, manufactures complex tools, cooperates in moving giant slabs, and gathers and processes diverse plants.

The bottom line: cumulative cultural evolution is old in our species’ lineage, dating back at least hundreds of thousands of years, but probably millions of years. Now, let’s explore why it was our lineage that crossed the Rubicon.

CHAPTER 17

A NEW KIND OF ANIMAL

The case I've presented in this book suggests that humans are undergoing what biologists call a *major transition*. Such transitions occur when less complex forms of life combine in some way to give rise to more complex forms. Examples include the transition from independently replicating molecules to replicating packages called chromosomes or, the transition from different kinds of simple cells to more complex cells in which these once-distinct simple cell types came to perform critical functions and become entirely mutually interdependent, such as the nucleus and mitochondria in our own cells. Our species' dependence on cumulative culture for survival, on living in cooperative groups, on alloparenting and a division of labor and information, and on our communicative repertoires mean that humans have begun to satisfy all the requirements for a major biological transition. Thus, we are literally the beginnings of a new kind of animal.[1]

By contrast, the wrong way to understand humans is to think that we are just a really smart, though somewhat less hairy, chimpanzee. This view is surprisingly common.

It’s not just that these older approaches fail to consider some minor influences of culture on biology or some recent and rare feedback loops showing how cultural practices, like drinking cow’s milk, have shaped genetic changes; these now outdated evolutionary views fail to recognize that the *central force* driving human genetic evolution for hundreds of thousands of years, or longer, has been cultural evolution. The consequences of this run deep and wide (see table 5.1):

- Many aspects of our physiology and anatomy make sense only as genetically evolved responses to selective pressures created by the cultural evolution of things like fire, cooking, cutting tools, projectile weapons, water containers, artifacts, tracking know-how, and communicative repertoires. Among our numerous features, these help explain our small teeth, short colons, shrunken stomachs, poor plant-detoxification abilities, accurate throwing capabilities, nuchal ligaments (head stabilizer for running), numerous eccrine sweat glands, long postreproductive lives, lowered larynxes, dexterous tongues, whitened sclera, and enlarged brains (see chapters 5 and 13).
- Many of our cognitive abilities and biases make sense only as genetically evolved adaptations to the presence of valuable cultural information (chapters 4, 5, and 7). These evolved mechanisms include our well-honed cultural learning abilities, “over-imitative” tendencies, and folkbiological capacities for organizing and enriching what we learn about plants and animals, among many others.
- Much of our species’ status psychology, including our deferential motivations, patterns of mimicry and imitation, facets of pride, cooperative tendencies, and bodily displays, appear to be genetically evolved adaptations to a world in which valuable cultural information was unevenly distributed across the minds of other members of our social groups (chapter 8).
- Our social psychology appears designed for navigating a world with social rules and reputations, where learning and complying with these rules is paramount and where different groups possess quite different norms (chapters 9–11). We internalize costly norms as goals in themselves, usually via cultural learning, and are

> particularly good at spotting norm violators, even when those violations have nothing to do with cooperation. To make sure we learn the best norms for our own groups and avoid the dangers of miscoordinating with others, we preferentially use marker traits like dialect and language to distinguish potential models and then preferentially target our cultural learning and social interactions toward those who share our marker traits.

My point is that trying to understand the evolution of human anatomy, physiology, and psychology without considering culture-gene coevolution would be like studying the evolution of fish while ignoring the fact that fish live, and evolved, underwater.[4]

Once we understand humans as a cultural species, the toolbox for designing new organizations, policies, and institutions begins to look quite different. Here are eight insights drawn from this book.

1. Humans are adaptive cultural learners who acquire ideas, beliefs, values, social norms, motivations, and worldviews from others in their communities. To focus our cultural learning, we use cues of prestige, success, sex, dialect, and ethnicity, among others, and especially attend to particular domains, such as those involving food, sex, danger, and norm violations. We do this especially under uncertainty, time pressure, and stress. If you doubt the power of cultural learning, remember the celebrity copycat suicides in chapter 4.
2. However, we aren't suckers. To adopt costly practices or nonintuitive beliefs, such as eating a strange food or believing in life after death, we demand Credibility Enhancing Displays (CREDs). Our models must endure costs, such as extreme pain or big financial hits, that demonstrate their deep commitment to their expressed beliefs or practices. CREDs can turn pain into pleasure and make martyrs into the most powerful of cultural transmitters.
3. Humans are status seekers and are strongly influenced by prestige. But what's highly flexible is which behaviors or actions lead to high prestige. People will grant others great prestige for being fierce warriors or gentle nuns. Remember Saint Ambrose, who convinced rich Romans in late antiquity that they had to give their wealth to the poor. Only by giving generously would they prove themselves worthy of the kingdom of heaven. Of course, before Ambrose began this campaign, he gave away most of his substantial wealth (a CRED).
4. The social norms we acquire often come with internalized motivations and ways of viewing the world (guiding our attention and memory), as well as with standards for judging and punishing others. People's preferences and motivations are not fixed, and a well-designed program or policy can change what people find desirable, automatic, and intuitive.
5. Social norms are especially strong and enduring when they hook into our innate psychology. For example, social norms for fairness toward foreigners will be much harder to spread and sustain than those that demand mothers care for their children. Throughout this book, I've discussed norms that have locked into various

innate aspects of our psychology, including our favoritism toward close kin, aversion to incest, preference for reciprocity, readiness to avoid meat, and desire for pair-bonding. As we saw, rituals have also evolved culturally to powerfully tap many innate aspects of our psychology.

6. Innovation depends on the expansion of our collective brains, which themselves depend on the ability of social norms, institutions, and the psychologies they create to encourage people to freely generate, share, and recombine novel ideas, beliefs, insights, and practices.
7. Different societies possess quite different social norms, institutions, languages, and technologies, and consequently they possess different ways of reasoning, mental heuristics, motivations, and emotional reactions. The imposition of new formal institutions, imported from elsewhere, on populations often create mismatches. The result is that such imposed formal institutions will work rather differently, and perhaps not at all.
8. Humans are bad at intentionally designing effective institutions and organizations, though I'm hoping that as we get deeper insights into human nature and cultural evolution this can improve. Until then, we should take a page from cultural evolution's playbook and design "variation and selection systems" that will allow alternative institutions or organizational forms to compete. We can dump the losers, keep the winners, and hopefully gain some general insights during the process.

To move forward in our quest to better understand human life, we need to embrace a new kind of evolutionary science, one that focuses on the rich interaction and coevolution of psychology, culture, biology, history, and genes. This scientific road is largely untraveled, and no doubt many obstacles and pitfalls lie ahead, but it promises an exciting journey into unexplored intellectual territories, as we seek to understand a new kind of animal.