CHAPTER 1

ON HUMAN NATURE

How would you describe yourself? If you had to list some personality traits, say for a dating website or a job application, what words would you use? Do you consider yourself shy or outgoing? Are you cautious or reckless? Anxious or carefree? Are you creative, artistic, adventurous, stubborn, impulsive, sensitive, brave, mischievous, kind, imaginative, selfish, irresponsible, conscientious? People clearly differ in such traits and in many other aspects of their psychology—such as intelligence and sexual preference, for example. All of these things feed into making us *who we are*.

The question is, how do we get that way? This has been a subject of endless debate for literally thousands of years, with various prominent thinkers, from Aristotle and Plato to Pinker and Chomsky, lining up to argue for either innate differences between people or for everyone starting out with a blank slate and our psychology being shaped by experience alone. In the past century, the tradition of Freudian psychology popularized the idea that our psychological dispositions could be traced to formative childhood experiences. In many areas of modern academic sociology and psychology this belief is still widespread, though it has been extended to include cultural and environmental factors more broadly as important determinants of our characters.

But these fields have been fighting a rearguard action in recent years, against an onslaught from genetics and neuroscience, which have provided strong evidence that such traits have at least some basis in our innate biology. To some, this is a controversial position, perhaps even a morally offensive one. But really it fits with our common experience that, at some level, people just are the way they are—that they're just made that way. Certainly, any parent with more than one child will know that they start out different from each other, in many important ways that are unrelated to parenting.

This notion of innate traits is often equated with the influences of genes—indeed, "innate" and "genetic" are often used interchangeably. This idea is captured in common phrases such as "the apple doesn't fall far from the tree," or "he didn't lick it off the stones." These sayings reflect the widespread belief that many of our psychological traits are not determined solely by our upbringing but really are, to some extent at least, "in our DNA."

How that could be is the subject of this book. How could our individual natures be encoded in our genomes? What is the nature of that information and how is it expressed? That is, in a sense, just a different version of this question: How is human nature, generally, encoded in the human genome? If there is a program for making a human being with typical human nature, then our individual natures may simply be variations on that theme. In the same way, the human genome contains a program for making a being about so tall, but *individual humans* are taller or shorter than that due to variation in the programs encoded in their respective genomes. We will see that the existence of such variation is not only plausible—it is inevitable.

BEING HUMAN

If we think about human nature generally, then we should ask, first, whether it even exists. Are there really typical characteristics that are inherent in each of us that make humans different from other animals? This question has exercised philosophers for millennia and continues to today, partly because it can be framed in many different ways. By human nature, do we mean expressed behaviors that are unique to humans and not seen in other animals? Do we mean ones that are completely universal across all members of the species? Or ones that are innate and instinctive and not dependent at all on maturation or experience? If those are the bars that are set, then not much gets over them.

But if instead we define human nature as a set of behavioral *capacities* or *tendencies* that are typical of our species, some of which may nevertheless be shared with other animals, and which may be expressed either innately or require maturation or experience to develop, then the list is long and much less contentious. Humans *tend to* walk upright, be active during the day, live in social groups, form relatively stable pair-bonds, rely on vision more than other senses, eat different kinds of food, and so on. A zoologist studying humans would say they are bipedal, diurnal, gregarious, monogamous, visual, and omnivorous—all of these traits are shared by some other species, but that overall profile characterizes humans.

And humans have *capacities* for highly dexterous movements, tool use, language, humor, problem solving, abstract thought, and so on. Many of those capacities are present to some degree in other animals, but they are vastly more developed in humans. The actual behaviors may only emerge with maturation and many depend to some extent on learning and experience, but the capacities themselves are inherent. Indeed, even our capacity to learn from experience is itself an innate trait. Though our intellect separates us from other animals—by enabling the development of language and culture, which shape all of our behaviors—our underlying nature is a product of evolution, the same as for any other species.

Simply put, humans have those species-general tendencies and capacities because they have human DNA. If we had chimp DNA or tiger DNA or aardvark DNA, we would behave like chimps or tigers or aardvarks. The essential nature of these different species is encoded in their genomes. Somehow, in the molecules of DNA in a fertilized egg from any of these species is a code or program of development that will produce an organism with its species-typical nature. Most importantly, that entails the specification of how the brain develops in such a way that wires in these behavioral tendencies and capacities. Human nature, thus defined, is encoded in our genomes and wired into our brains in just the same way.

This is not a metaphor. The different natures of these species arise from concrete differences in some physical properties of their brains. Differences in overall size, structural organization, connections between brain regions, layout of microcircuits, complement of cell types, neurochemistry, gene expression, and many other parameters all contribute in varied ways to the range of behavioral tendencies and capacities that characterize each species. It's all wired in there somehow. Human nature thus need not be merely an abstract philosophical topic—it is scientifically tractable. We can look, experimentally, at the details of how our species-typical properties are mediated in neural circuitry. And we can seek to uncover the nature of the genetic program that specifies the relevant parameters of these circuits.

THE WORD MADE FLESH

To understand this genetic program, it is crucial to appreciate the way in which information is encoded in our genomes and how it gets expressed. It is not like a blueprint, where a given part of the genome contains the specifications of a corresponding part of the organism. There is not, in any normal sense of the word, a representation of the final organism contained within the DNA. Just as there is no preformed homunculus curled up inside the fertilized egg, there is no simulacrum of the organism strung out along its chromosomes. What is actually encoded is a *program*—a series of developmental algorithms or operations, mediated by mindless biochemical machines, that, when carried out faithfully, will result in the emergence of a human being.

This is not a reductionist view. The DNA doesn't do any of this by itself. The information in the genome has to be decoded by a cell (the fertilized egg, in the first place), which also contains important components required to kick the whole process off. And, of course, the organism has to have an environment in which to develop, and variation in environmental factors can also affect the outcome. Indeed, one of the most important capacities encoded in the genetic program is the ability of the resultant organism to respond to the environment.

Moreover, while the information to make any given organism and to keep it organized in that way is written in its genome, there is a web of causation that extends far beyond the physical sequence of its DNA. Its genome reflects the life histories of all its ancestors and the environments in which they lived. It has the particular sequence it has because individuals carrying those specific genetic variants survived and passed on their genes, while individuals with other genetic variants did not. A full map of what causes an organism to be the way it is and behave the way it does thus extends out into the world and over vast periods of time.

However, what we are after in this book is not a full understanding of how such systems work—how all those genetically encoded components interact to produce a human being with human nature. It is something subtly but crucially different—how *variation* in the genetic program causes *variation* in the outcome. Really, that's what we've been talking about when we've been comparing different species. The *differences* between our genomes and those of chimps or tigers or aardvarks are responsible for the *differences* in our respective natures.

INDIVIDUAL DIFFERENCES

The same can be said for differences *within* species. There is extensive genetic variation across the individuals in every species. Every time the DNA is copied to make a sperm or egg cell, some errors creep in. If these new mutations don't immediately kill the resultant organism or prevent it from reproducing then they can spread through the population in subsequent generations. This leads to a buildup of genetic variation, which is the basis for variation in all kinds of traits—most obviously physical ones like height or facial morphology. (Conversely, shared profiles of genetic variants are the basis for familial *similarities* in such traits.) Some of those genetic variants affect the program of brain development or brain function in ways that contribute to differences in behavioral tendencies or capacities.

We know this is the case because we can successfully *breed for* behavioral traits in animals. When wolves were tamed, for example, or when other animals were domesticated, early humans selected animals that were less fearful, less aggressive, more docile, more submissive—perhaps the ones that came nearest to the fire or that allowed humans to approach the closest without running away. If the reason that some were tamer was the genetic differences between them, and if those ones who hung around and tagged along with human groups then mated together, this would over time enrich for genetic variants predisposing to those traits. On the other hand, if the variation was not at least partly genetic in origin then breeding together tame individuals would not increase tameness in the next generation—the trait would not be passed on.

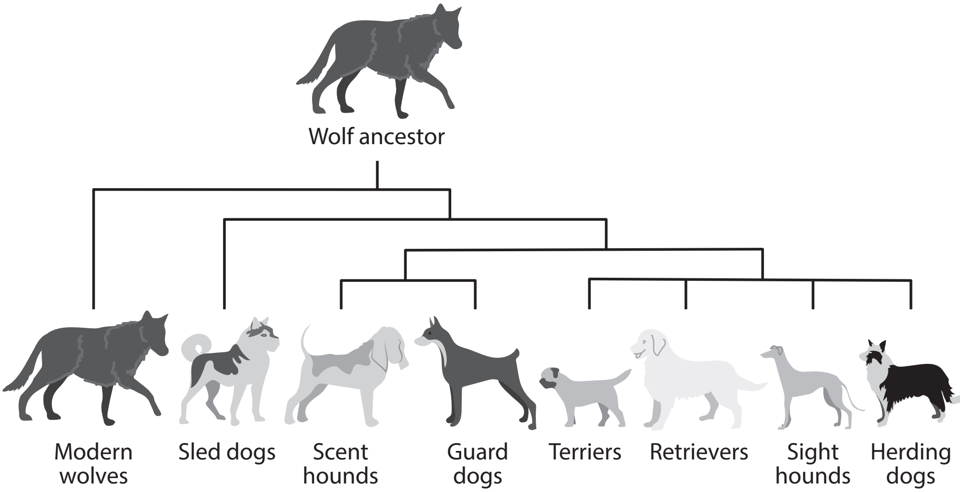

Figure 1.1 Selection of dog breeds for diverse behavioral traits.

Well, we know how that turned out—with modern dogs that have a nature very distinct from their lupine ancestors. And that process has been played out over and over again in the creation of modern dog breeds (see figure 1.1). These breeds were selected in many cases for behavioral traits, according to the functions that humans wanted them to perform. Terriers, pointers, retrievers, herders, trackers, sled dogs, guard dogs, lapdogs—all show distinct profiles of traits like affection, vigilance, aggression, playfulness, activity, obedience, dominance, loyalty, and many others. All these traits are thus demonstrably subject to genetic variation. The details of *how* genetic differences influence them remain largely mysterious, but the fact that they do is incontrovertible.

And the same is true in humans, as we will see in subsequent chapters. The empirical evidence for this is every bit as strong as it is in dogs. Even just at a theoretical level, this is what we should expect, based on the geneticist's version of Murphy's Law: anything that can vary will. The fact that our nature *as a species* is encoded in the human genome has an inevitable consequence: the natures of individual humans will differ due to differences in that genetic program. It is not a question of whether or not it does—it must. There is simply no way for natural selection to prevent that from happening.

BECOMING A PERSON

Just showing that a trait is genetic does not mean that there are genes "for that trait." Behavior arises from the function of the whole brain—with a few exceptions it is very far removed from the molecular functions of specific genes. In fact, many of the genetic variants that influence behavior do so very indirectly, through effects on how the brain develops.

This was dramatically highlighted by the results of a long-running experiment in Russia to tame foxes. Over 30 generations or more, scientists have been selecting foxes on one simple criterion—which ones allowed humans to get closest. The tamest foxes were allowed to breed together and the process repeated again in the next generation, and the next, and so on. The results have been truly remarkable—the foxes did indeed end up much more tame, but it is how that came about that is most interesting.

While they selected only for behavior, the foxes' appearance also changed in the process. They started to look more like dogs—with floppier ears and shorter snouts, for example—even the coat color changed. The morphological changes fit with the idea that what was really being selected for was retention of juvenile characteristics. Young foxes are tamer than older ones, so selecting for genetic differences that affected the extent of maturation could indirectly increase tameness, while simultaneously altering morphology to make them look more like pups.

This highlights a really important point. Just because you can select for a trait like tameness does not mean that the underlying genetic variation is affecting *genes for tameness*. The effect on tameness is both indirect and nonspecific, in that other traits were also affected. Though their identities are not yet known, the genes affected are presumably involved in development and maturation somehow.

The same kind of relationship holds in us. As we will see, the genetic variants that affect most psychological traits do so in indirect and nonspecific ways—we should not think of these as "genes for intelligence" or "genes for extraversion" or "genes for autism." It is mainly genetic variation affecting brain development that underlies innate differences in psychological traits. We are different from each other in large part because of the way our brains get wired before we are born.

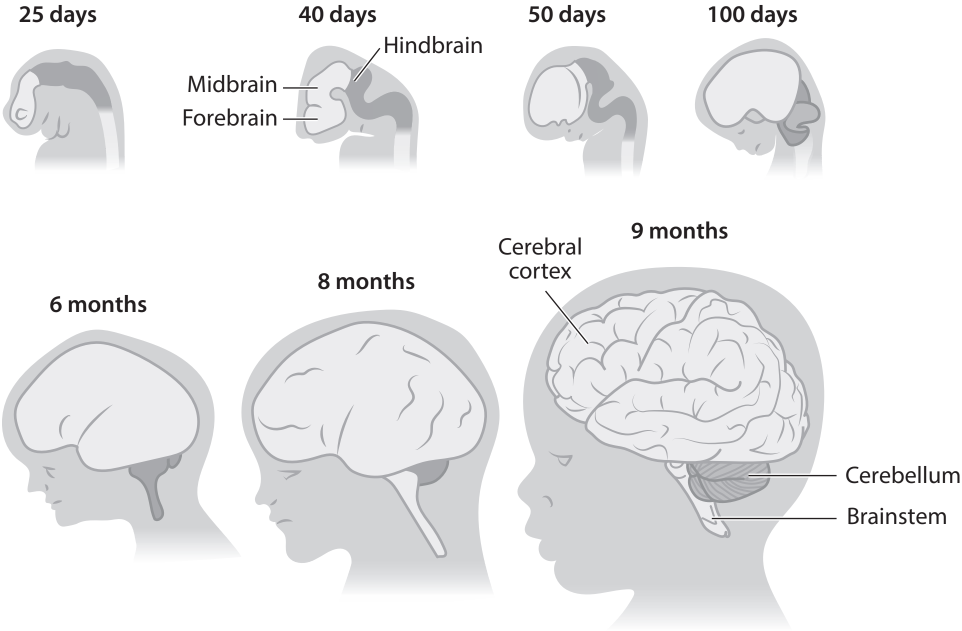

Figure 1.2 Human embryonic and fetal brain development. (Modified from B. Kolb and B. D. Fantie, "Development of the Child's Brain and Behavior," in *Handbook of Clinical Child Neuropsychology (Critical Issues in Neuropsychology)*, 3rd ed., ed. C. R. Reynolds and E. Fletcher-Janzen (New York: Springer, 2008), 19–46.)

But this is only half the story. Genetic variation is only one source of differences in how our brains get wired. The processes of development themselves introduce another crucial source of variation—one that is often overlooked. The genome does not encode a person. It encodes a program to make a human being. That potential can only be realized through the processes of development (see figure 1.2). Those processes of development are noisy, in engineering terms. They display significant levels of randomness, at a molecular level. This creates strong limits on how precisely the outcome can be controlled.

Thus, even if the genetic instructions are identical between two people, *the outcome will still differ*. Just as the faces of identical twins differ somewhat, so does the physical structure of their brains, especially at the cellular level. The progressive nature of development means that this inherent variability can have very substantial effects on the outcome, and, along with genetic differences, be a major contributor to differences in people's psychological makeup.

In sum, the way our individual brains get wired depends not just on our genetic makeup, but also on how the program of development happens to play out. This is a key point. It means that even if the variation in many of our traits is only partly genetic, this does not necessarily imply that the rest of the variation is environmental in origin or attributable to nurture—much of it may be developmental. Variation in our individual behavioral tendencies and capacities may thus be *even more innate* than genetic effects alone would suggest.

A LOOK AHEAD

This book is split into two main sections. In the first, I present a conceptual overview of the origins of innate differences in human faculties. We will start by looking at the evidence from twin and adoption studies of genetic effects on human psychological traits, brain anatomy, and brain function. These studies can begin to dissociate the effects of nature and nurture as contributors to variation across the population. They aim to explain not what makes individuals the way they are but what makes people different from each other. Because they are often misconstrued, we will look carefully at what the findings mean and what they don't mean.

We will then look in more detail at genetic variation, where it comes from and the kinds of effects it can have. We will examine how differences in the DNA sequence ultimately impact the kinds of traits we are interested in—often, as discussed above, through effects on development. We will look in depth at the mechanisms underlying the self-assembly of the brain's circuitry to see how it is affected by variation in the genetic instructions. And we will consider just how noisy and inherently variable those developmental processes can be. In the end, I hope to have convinced you that both genetic and developmental variation contribute to innate differences in people's natures.

In the final chapter of the first section we will look at the role of nurture in shaping people's psyches. The human brain continues to mature and develop over decades, and our brains are literally shaped by the experiences we have over that period. It is common to view "nurture" as being in opposition to nature, such that the environment or our experiences act as a great leveler, to smooth over innate differences between people or counteract innate traits in individuals. I will describe an alternative model: that the environments and experiences we each have and the way our brains react to them are largely *driven by our innate traits*. Due to the self-organizing nature of the processes involved, the effects of experience therefore typically act to *amplify* rather than counteract innate differences.

With that broad framework in place, we will then examine a number of specific domains of human psychology in the second section. These include personality, perception, intelligence, and sexuality. These diverse traits affect our lives in different ways and genetic variation that influences them is therefore treated very differently by natural selection. As a result, their underlying genetic architecture—the types and number and frequency of mutations that contribute to them—can be quite different. Much of the variation in these traits is developmental in origin—the circuits underlying these functions work differently in part at least because they were put together differently. This means that random variation in developmental processes, in addition to genetic variation, also makes an important—sometimes crucial—contribution to innate differences in these faculties.

We will also look at the genetics of common neurodevelopmental disorders, such as autism, epilepsy, and schizophrenia. There has been great progress in recent years in dissecting the genetics of these conditions, with results that are fundamentally changing the way we think about them. Genetic studies clearly show that each of these labels really refers to a large collection of distinct genetic conditions. Moreover, while these disorders have long been thought to be distinct, the genetic findings reveal the opposite—these are all possible manifestations of mutations in the same genes, which impair any of a broad range of processes in neural development.

The final chapter will consider the social, ethical, and philosophical implications of the framework I've described. If people really have large innate differences in the way their brains and minds work, what does that mean for education and employment policies? What does it mean for free will and legal responsibility? Does it necessarily imply that our traits are fixed and immutable? What are the prospects for genetic prediction of psychological traits? What limits does developmental variation place on such predictions? And, finally, how does this view of the inherent diversity of our minds and our subjective experiences influence our understanding of the human condition?