1 What makes humans special?

Between two and three million years ago, a small creature hardly larger than a pygmy chimpanzee but with a much larger brain relative to its body weight began a remarkable journey. The initial part of that journey didn't involve much by today's standards, merely the ability to scavenge and possibly chase-hunt the creatures of the sub-Saharan African savannahs, to make some rather modest stone-flaked tools for that purpose, and eventually to migrate over the African and possibly the Eurasian land mass. This little creature, arguably our first unequivocally human ancestor, was known as *Homo habilis* ("domestic" man). How the modest abilities of this first human emerged and were transformed into the prodigious human achievements and civilization that exist today is arguably the most important scientific mystery of all. The solution to this mystery will not only help to explain where and why we evolved as we did – it will additionally shed light on how we may continue to evolve in the future.

But, first, some basic questions must be asked, including: what is human nature and what is the basis of it? How much of human nature is related to our genes? Is human nature related to the size and shape or lateralization of our brain? How did human nature evolve? Although our hairless skin and elongated body make our appearance quite different from our primate cousins, it is not our anatomy but our unique brain and behavior that most people consider special. Typical behaviors considered uniquely human include propositional (grammatical) language, mathematics, advanced tool use, art, music, religion, and judging the intent of others. However, outside of religion, which has yet to be documented in any other extant species, at least one other – and, in some cases, several – advanced species have been shown to possess one or more of the above traits. For example, dolphins understand and can use simple grammar in their contact with humans (Herman, 1986) and probably use even more sophisticated grammar in their own ultrasonic communications. Certain avian species such as parrots can count up to ten (Pepperberg, 1990) and, like apes, use mathematical concepts such

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as similarity and transitivity (Lock and Colombo, 1996). Orangutans display highly advanced tool use, including the preparation of tools for use in procuring food (van Schaik, 2006). As regards music and art, singing is a highly developed and plastic form of communication in songbirds (Prather and Mooney, 2004), apes have proven to be adept musical instrumentalists in their drumming (Fitch, 2006), and elephants and chimpanzees have been known to create realistic and abstract paintings.[1] Finally, chimpanzees (but not monkeys) are able to determine the mental states of others and to engage in mirror self-recognition (Lock and Colombo, 1996), attributes normally considered part of a general mental capability known as the "theory of mind" (see later chapters).

What mostly defines humans, then, is not a unique ability to engage in a particular behavior but rather *the way in which we perform it*. Three features of human behavior are particularly salient: its context-independence, its generativity, and its degree of abstraction. Context-independent cognition, emphasized in the comparative analysis of Lock and Colombo (1996), refers to the ability to perform mental operations on new and different types of information in different settings. The behavior of chimpanzees may be viewed as much more contextually dependent than that of humans because it differs considerably depending on whether they are in the wild or in captivity; in the wild, for example, chimpanzees are relatively more likely to use tools but less likely to use symbols (Lock and Colombo, 1996). Generativity refers to the incredible amount of and variety of human cognitive output – whether it be in the tens of thousands of words in a typical language's lexicon, the almost limitless varieties of song and paintings, or the incredible technological progress that has continued largely unabated from the end of the Middle Stone Age to the present. Finally, the abstract nature of human cognition, similar to what Bickerton (1995) has referred to as "off-line" thinking and what Suddendorf and Corballis (1997) term "mental time travel," strikingly sets humans apart from all other species, which engage largely in the present. While some species can use symbols, only humans can create abstract ones like numbers, words, and religious icons, and it is difficult to conceive of even such advanced creatures as chimpanzees and dolphins as going beyond a simple emotional concept of death or the fulfillment of a current motivationally driven state to such spatially and temporally distant religious concepts as heaven and eternity. Indeed, apes spend the vast majority of their waking lives in immediate, nearby activities (eating and grooming) (see Bortz, 1985; Whiten, 1990), and even Neanderthals

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[1] In fact, three paintings by a chimpanzee named Congo sold for 12,000 British pounds (over $20,000 US) in 2005 (http://news.bbc.co.uk/2/hi/entertainment/4109664.stm).

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appear to have been more constrained in their spatial and temporal mental spheres (Wynn and Coolidge, 2004).

There are two major features that characterize all of the advanced cognitive skills in humans:

1. they all appear to have first emerged between 50,000 and 80,000 years ago, first in Africa and later in Europe and elsewhere; and
2. the context-independent, generative, and abstract expressions of these skills require high levels of a critical neurotransmitter in the brain known as dopamine.

Hence, the emergence of intellectually modern humans around 80,000 years ago arguably represented the beginning of what I will refer to as the "dopaminergic mind." How that mind depends on dopamine, how it came to evolutionary fruition, and the dangers its continued evolution pose for the denizens of industrialized societies in particular will all be discussed in later chapters of this book. First, however, I attempt to refute commonly held explanations (myths) of how human nature evolved. The first myth is that the evolution of human intelligence was primarily a product of genetic selection, while the second is that the specific size, shape, or lateralization of our brain is critical for us to be considered human.

1.1 Myths concerning the origins of human behavior

1.1.1 Was human intelligence genetically selected?

There are many reasons to believe that the origin of advanced human behavior was at least partly controlled by genetic evolution. For one, estimates of the heritability of intelligence, based largely on twin studies that compare the concordance (similarity) of identical twins (which share the same genome) to fraternal twins (which only share the same genetic makeup as regular siblings), are around 0.50 (see Dickens and Flynn, 2001). There are also genetic differences between chimpanzees and modern humans on the order of about 1.2 percent (Carroll, 2003), which in principle could allow for selection for particular genes that may have helped produce the intellectual capabilities of modern humans. Certainly, advanced intelligence should help members of a species survive and reproduce, which according to Darwinian mechanisms should allow that trait to be passed on genetically to offspring. Indeed, it is highly likely that some genetic changes at least indirectly helped to advance human intelligence, although I will argue in Chapter 5 that most of these were probably associated with an overall physiological adaptation that occurred with the dawn of *Homo habilis*.

There are more compelling reasons, though, to believe that *advanced human intellectual abilities are not primarily due to genetic selection*. First of all, genetic expression and transmission have been documented to be modifiable at many levels by a wide variety of influences (especially maternal) that can themselves be passed to offspring in a mode known as "epigenetic inheritance" (Harper, 2005). Indeed, there are ongoing major increases in intelligence (Dickens and Flynn, 2001) and various clinical disorders (Previc, 2007) in the industrialized societies that are occurring despite stable or even opposing genetic influences. For example, the prevalence of autism, characterized by severely deficient social and communication skills, is dramatically increasing despite the fact that most individuals with autism never marry and thereby pass on their genes (see Chapter 4). Second, heritability estimates for intelligence and many other normal and abnormal traits may be overblown because fraternal twins do not share as similar a prenatal environment (a major source of epigenetic inheritance) as most identical twins due to the lack of a shared blood supply (Prescott *et al.*, 1999) and because of the greater similarity of rearing in identical twins (Mandler, 2001). Third, dramatic changes in physiology, anatomy, and behavior are believed to occur when the timing of gene expression is affected by disturbances in key regulatory or hormonal centers such as the thyroid (Crockford, 2002; McNamara, 1995). Fourth, anatomical findings (McDougall *et al.*, 2005) and genetic clock data (Cann *et al.*, 1987; Hammer, 1995; Templeton, 2002; von Haeseler *et al.*, 1996) clearly place the most recent ancestor common to all modern humans at around 200,000 years,[2] yet there is little or no evidence of art, music, religion, beads, bone tools, fishing, mining, or any other advanced human endeavors until more than 100,000 years later (McBrearty and Brooks, 2000; Mellars, 2006; Shea, 2003). One hundred thousand years may not seem like a large amount of time, in that it only constitutes about 5 percent of the total time elapsed from the appearance of *Homo habilis*, but it is more than *ten times longer* than from the dawn of the most ancient civilization to the present. Finally, there is no convincing evidence that genetic factors have played any role whatsoever in one of the most striking of all human features – the functional lateralization of the brain (Previc, 1991).

Although it still remains to be determined exactly how many genes humans actually have, the current best estimate is around 20,000–25,000. Given the 1.2 percent genetic divergence between chimpanzees (our genetically closest living relative) and modern humans, there would first

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[2] Genetic clock estimates can be derived from the rates of mutation of various types of DNA (mitochondrial, y-chromosomal, etc.) and the known variations among extant human populations.

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appear to be a sufficient amount of discrepant genetic material to account for neurobehavioral differences between us and our nearest primate relation. However, the vast majority of our genome appears to be non-functional "junk" DNA and most of the remaining DNA is involved in gene regulation, with only a tiny percentage of the total DNA (<1.5 percent) actually used in transcribing the amino acid sequences that create proteins (Carroll, 2003). The "coded" sections of the human genome also appear to show less variation between humans and apes than the "non-coded" sections (Carroll, 2003; Mandel, 1996), and much of that difference relates to genes for the protein-intensive olfactory system.[3] In fact, there is no evidence that any proteins, receptors, neurotransmitters, or other components of our basic neural machinery do not exist in chimpanzees (Rakic, 1996). Rather, most of the different genetic sequencing between chimpanzees and humans is in regulatory sections of the genome that affect gene expression (Carroll, 2003), presumably including those that affect brain and body development conjointly. As but one example, there are many genes that affect calcium production, which in turn helps regulate skeletal growth as well as the production of key brain transmitters (see Previc, 1999). Also, there are many genes that can affect the thyroid gland, which has an important influence on body metabolism, body growth, brain activity, and brain size and is arguably a major force for speciation during evolution (Crockford, 2002) and one of the few endocrine structures known to have altered its function during human evolution (Gagneux *et al.*, 2001; Previc, 2002). It is likely, therefore, that changes in regulatory-gene activity and other factors that influence gene expression played some role in the evolution of humans, most probably in its earliest stages (see Chapter 5).[4]

To say that there may have been some influences on gene regulation in humans during the course of our evolution is more defensible than the notion that *specific genes or sets of genes determine advanced human capabilities*. Rarely does a single gene or small set of genes affect a major brain or non-brain disease, and higher cognitive capacities involve even more genes (Carroll, 2003). For example, the combined variance

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[3] The olfactory system of humans, for example, is believed to express ~500 receptor genes (Ressler *et al.*, 1994), which is much less than other mammalian species that rely on olfaction to a greater extent.

[4] It has recently been claimed that the general mutation rate of genes related to brain growth has increased in humans relative to other primates faster than genes controlling general cellular function (Dorus *et al.*, 2004), but the significance of this preliminary finding is unclear because it is not known whether the genes in question are specific to brain growth as opposed to body growth in general. Indeed, body height correlates with intelligence by roughly the same amount as brain size, and both relationships are subject to environmental influences (Nagoshi and Johnson, 1987; Schoenemann *et al.*, 2000).

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accounted for by several key genes known to contribute to intelligence and to various clinical disorders in humans is less than 10 percent (Comings *et al.*, 1996). The polygenic nature of higher cognition is not surprising when one considers the many cognitive skills – discussed in much greater detail by Previc (1999) and in Chapter 3 – that are required for listening to, comprehending, and responding appropriately to a simple sentence such as “Build it and they will come.” First, a motor system must recreate in our own minds what is being said; second, an incredibly rapid auditory processor must decode a multitude of acoustic transients and phonemes; third, a capability for abstraction serves to link the spoken words to their correct meaning; fourth, working memory is required to keep the first clause of the sentence in mind as we await the final one; fifth, cognitive flexibility is needed to realize that, after hearing the second part of the sentence, the first part isn’t about construction but expresses a more profound thought; sixth, an ability to judge speaker intent aids in further recognizing that this sentence as spoken by a particular individual (e.g. a philosopher) is not about construction; and finally, there must be an ability to assemble and correctly sequence a collection of phonemes that provides a spoken response that we (or any other individual) may have never uttered before. Despite all of this, some researchers such as Pinker and Bloom (1990) have postulated that a single gene or small set of genes may have mutated to create specific language capabilities (e.g. grammar) only found in humans. Indeed, there was great excitement among the scientific world that a “grammar gene” had been identified in a small English family of supposedly grammar-deficient individuals (Gopnik, 1990), who were later shown to have a mutation of a gene known as “Foxp2” (Lai *et al.*, 2001). There eventually turned out to be several major problems with this finding, however. The first was that the affected family members did not have a selective loss of grammar but rather exhibited many other language problems as well as severe speech articulation difficulties, an inability to carry out simple facial gestures (like winking), behavioral disorders such as autism, and even nonlinguistic cognitive deficits (their average *nonverbal* intelligence quotient was found to be only eighty-six, or fourteen points below their unaffected relatives) (Vargha-Khadem *et al.*, 1995). Moreover, the Foxp2 gene mutation turns out not to be associated with the deficits exhibited by most individuals with specific language impairments (Newbury *et al.*, 2002), nor does the human Foxp2 gene resemble that of other species (e.g. avians and dolphins) who possess advanced vocal communication skills (Webb and Zhang, 2005). The final factor mitigating the importance of the Foxp2 gene in human linguistic evolution comes from a recent DNA finding in

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Neanderthals, from whom the ancestors of modern humans diverged nearly 400,000 years ago. At least one of the two major variants of the modern human Foxp2 gene relative to that of chimpanzees was once thought to have occurred as recently as 10,000 years ago (Enard *et al.*, 2002), or long after the emergence of the common human genome. However, an analysis of the DNA of Neanderthals shows that they, too, possessed both modern human Foxp2 variants (Krause *et al.*, 2007), which indicates that these variants must be at least 400,000 years old given the estimated date of divergence of the Neanderthal and modern human lineages (Chapter 5).

Another phenomenon tied to the evolution of humans is the lateralization of the human brain for advanced cognitive functions. Two of the most well-known manifestations of cerebral lateralization are the overwhelming and universal preponderance of right-handedness in humans – about 85–90 percent of individuals in Western societies exhibit some form of right motor dominance – and the greater likelihood of suffering serious speech and language deficits (known as aphasias) following damage to the left hemisphere in adulthood.[5] Although brain lateralization of some sort or another is common in the animal world, the degree of functional lateralization of the human brain is remarkable compared to that of other mammalian brains and especially that of the chimpanzee. Indeed, one of the great triumphs of modern neuroscience was the demonstration, mainly through studies of "split-brain" patients in which the connections between the hemispheres were severed to relieve epilepsy (Gazzaniga, 2005), that the left and right hemispheres of most humans not only differ in their linguistic capabilities but also possess very different personalities (the left is more active, controlling, and emotionally detached while the right is more earthy and emotional) and intellects (the left is more analytical, abstract, and future-oriented while the right one is more concrete, better at judging emotional and mental states, and better at visual manipulations, especially 3-D geometrical ones in body space). Indeed, the cognitive and personality differences between the left and right hemispheres of most humans are greater than between almost any two humans, and the specialized functions of the left hemisphere arguably render it almost as dissimilar to those of the right hemisphere as human intellectual functions in general differ from chimpanzees.[6]

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[5] It is generally accepted that about 90–95 percent of right-handers and about 70 percent of left-handers possess left-hemispheric dominance for speech (see Previc, 1991).

[6] Indeed, Gazzaniga (1983) has even gone so far as to describe the cognitive skills of an isolated right hemisphere as "vastly inferior to the cognitive skills of a chimpanzee" (p. 536).

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Although many theorists such as Annett (1985) and Crow (2000) have posited that left-hemispheric language dominance is largely determined by a single gene – and despite evidence that, at least in some species, the overall direction of body asymmetry is subject to genetic influences (Ruiz-Lozano *et al.*, 2000) – the evidence is strongly against a genetic explanation for brain lateralization in humans. First, the likelihood of one member of a twin pair having the same hand dominance as the other is no greater for identical than for fraternal twins (Reiss *et al.*, 1999),[7] and speech dominance for monozygotic twin pairs shows a similarly weak concordance (Jancke and Steinmetz, 1994). Second, neither handedness nor speech lateralization (see Tanaka *et al.*, 1999; Woods, 1986) appears to be related to the genetically influenced asymmetrical position of the major body organs such as the heart, which, in any case, is the same in humans as in chimpanzees. Third, there does not appear to be any evolutionary advantage conferred by the typical pattern of left-hemispheric dominance for handedness, as left-handers and right-handers on average do not differ in academic or athletic achievement or any other personality variables (see Hardyck *et al.*, 1976; Peters *et al.*, 2006; Previc, 1991), although there may be very slight deficits for some individuals with ambiguous dominance (Peters *et al.*, 2006).[8] Fourth, the development of cerebral lateralization is heavily dependent on both cultural and prenatal factors. As an example of cultural factors, aphasia following left-hemispheric damage was very uncommon a few centuries ago in Europe when the vast majority of adults were illiterate and not exposed to the left–right reading and writing of Western languages, and right-handedness remains much less prevalent in existing illiterate populations (see Previc, 1991). As an example of prenatal factors, handedness and other forms of motoric lateralization are greatly reduced in otherwise normal infants born before the beginning of the third trimester and are affected by fetal positioning in the final trimester, which may be crucial as a source of early

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[7] Although a greater concordance between identical twins usually (but not always) implies at least some genetic influence, the absence of a greater identical-twin concordance almost certainly rules out such an influence. In a meta-analysis by Sicotte *et al.* (1999), which did not include the Reiss *et al.* 1999 study, a significantly greater percentage of dizygotic twins was found to be discordant for handedness, but this difference averaged across twenty-eight studies was less than 2 percent (21.03 percent for monozygotic twins versus 22.97 percent for dizygotic twins) and can be easily accountable by the different child-rearing of the two twin types.

[8] Nonright-handedness does appear to be slightly more associated with both extreme giftedness and mental retardation, for largely nongenetic reasons (see Previc, 1996), but handedness certainly does not predict intelligence in the vast majority of humans (Hardyck *et al.*, 1976).

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asymmetrical motion experience in bipedal humans (Previc, 1991). Indeed, the entire edifice of human laterality may be based primarily on primordial prenatal (i.e. nongenetic) factors (Previc, 1991).

Finally, the notion that language and language-linked brain lateralization are determined genetically is contradicted by the nature of human language as a very robust behavior that does not depend on a particular sensory modality (e.g. hearing) or motor system (e.g. speech). For example, individuals who cannot speak or move their hands can communicate with their feet, and those who cannot hear or see can use their hands to receive messages. Humans have invented languages dependent on speech sounds but also on manual signs, tactile signals, fundamental (musical) frequencies, visual icons, clicks, whistles, and probably other signals as well, all demanding many of the same skills described above for speech comprehension and production. Moreover, the mechanisms of language have expropriated the same systems used in more basic motor functions such as chewing, hand movements and eye movements, the latter two of which accompany linguistic thought (Kelso and Tuller, 1984; Kingston, 1990; McGuigan, 1966; Previc *et al.*, 2005). And, the fact that speech is housed mostly in the left hemisphere of humans certainly doesn't imply a causal (or more specifically, a genetic) linkage because the loss in early life of the left hemisphere does not affect subsequent language ability in any measurable way (see next section). Indeed, a pure "language" gene/protein would have to be a strange one in that it would have to:

1. affect language at a superordinate level, independent of any particular sensorimotor modality;
2. affect one hemisphere more than another, even though the lateralization process does not appear to be under genetic control and even though language proceeds just fine in the absence of the originally favored hemisphere; and
3. affect no other sensorimotor or cognitive systems, even though these other systems are closely tied to language processing and output and are, in some case, necessary for language to occur.

Needless to say, no pure language gene has been found or is likely to ever be found.

In summary, a direct, major role of direct genetic selection in language and other higher-order cognitive functions is unlikely. This is consistent with the fact that *all major intellectual advances during human evolution proceeded in sub-Saharan Africa* (McBrearty and Brooks, 2000; Previc, 1999), even though ancestral humans had populated wide swaths of Africa, Europe, and Asia nearly two million years ago. If cognitive ability

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and not physiological and dietary adaptations – which occurred mostly in sub-Saharan Africa, for reasons to be discussed in Chapter 5 – was the major trait genetically selected for, then why were the other regions of the world in which cognitive ability would have also proven beneficial unable to rival sub-Saharan Africa as the cradle of human evolution?

1.1.2 Did our larger brains make us more intelligent?

The second "myth" concerning human evolution – that we got smarter mainly because our brains got bigger – remains very popular, even among researchers in the field. Yet, there are even more powerful arguments against this view than against the genetic selection theory. After all, elephants by far have bigger brains than anyone else in the animal kingdom, yet most would not be considered intellectual giants; conversely, birds have very small brains (hence, the derogatory term "bird-brain"), but we now realize that some bird species (e.g. parrots) actually possess relatively advanced cognitive capacities, such as language, arithmetic, and reasoning skills (Pepperberg, 1990).

Accordingly, most brain scientists accept that a better measure than brain size for predicting intelligence is brain-to-body weight; using this measure, humans fare very well, along with other creatures that we might consider intelligent (chimpanzees, dolphins, parrots). However, there are problems even with this measure, because the lowly tree shrew – a small, energetic creature that was an early ancestor of primates such as monkeys but is hardly noted for its intellectual prowess – ranks above all others in brain-body ratio (Henneberg, 1998). Moreover, the correlation between brain/body size and intelligence in humans has generally been shown to be very modest, with a typical coefficient that is barely more than the correlation between height and intelligence (~0.3) (see Previc, 1999). Since no researchers have claimed that height is *causally* related to intelligence, there is no reason to assume that the equally modest relationship between brain size and intelligence is also causally related. Moreover, when examining the relationship between brain size and intelligence *within* families to control for dietary and other environmental differences that differ among families, the correlation becomes essentially random (Schoenemann *et al.*, 2000). Indeed, there are even among humans of normal body sizes great variations in brain size, ranging normally from 1,000 cc to over 1,500 cc, and some of the most brilliant minds throughout history have actually had estimated brain sizes toward the low end of that range. The Nobel prize-winning novelist Anatole France had a brain size of only 1,000 g – about the same as the human ancestor *Homo erectus*, who lived over a million years