CHAPTER 1

FOOD, SEX, and DEATH: What Biology Can (and Can't) Tell Us about Ourselves

From: The Intelligible Self.

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"Who am I?"

Throughout history, we humans have concocted innumerable answers to this question: we are the handiwork of divine intention, the product of our social class, the outgrowth of a repressed libido, the magical amalgamation of cosmic forces . . . the list goes on. By themselves, none of these descriptions is necessarily right or wrong; rather, each is merely a tool, a human-created mechanism of self-understanding. And, as with any tool, each of these conceptions has its own uses. Just as a hammer is good for driving nails but not much help for cutting wood, so religious concepts, for example, are useful for quelling our existential anxieties but they are not very helpful for explaining why we have language, why boys like toy guns more than girls, why the poor might oppose a progressive income tax, or many other puzzles of human nature.

In this book, I also use a tool of human understanding -- evolutionary biology. This does not, in itself, invalidate any of these other approaches nor does it deny the importance of culture or environment in human development (as we'll see in Chapter 2). But, as a tool of self-understanding, evolutionary biology offers an unique perspective on who we are by analyzing the functions of our genes, brain structures, and psychological traits.

But as a tool of self-understanding, evolutionary biology is also problematic because we still don't yet know how exactly our constituent parts function. The human brain and genome are incredibly complex physical systems and our knowledge of them is incomplete. We know little about which parts of our psychology originate in our genes or how such traits evolved. It remains exceedingly difficult to differentiate which parts of our minds come from just our biology, which parts come from our environments, and which parts come from a combination of the two.

This is partly why we see so many misguided uses of evolution to explain our actions. Why do women prefer pink and like to gossip? It's in their genes! Why are men more likely to rape than women? They evolved to be lustful and violent! Why are some people liberal? They're born that way! The problem with these and many other biological accounts of human behavior is that they are usually just-so stories, explanations for some modern trends that rely on some imagined evolutionary past. Any exceptions to the statistical trend (and, in statistics, there are always exceptions) are then explained with elaborating stories. In the end, evolution too-often becomes an unfalsifiable catch-all explanation that justifies whatever behavior its employer wants to excuse.

The fact is that almost none of our modern behaviors have a simple biological source. We inhabit very complex cultures that fundamentally define how we behave. Our ancestors did not evolve specific traits to make us join unions, vote Republican, support gun control, or protest for "fair trade." Yet, at the same time, all of our behaviors involve psychological elements that *were* biological adaptations at one point in time. And when it comes to a lot of human behaviors, these innate elements often have enormous influence. If we want to use biology to answer the question of "Who am I?" we need to try and identify what these elements are and how they evolved. Only then can we begin to identify where the boundaries between biology and environment end and where they intersect.

The key to using biology to understanding ourselves is to first appreciate the evolutionary logic of animal psychology. It is easy to forget that human psychology didn't suddenly materialize with the emergence of homo sapiens or that humanity is not the inevitable or necessary culmination of a deliberate evolutionary process. Our brains and psychology are simply a particular and accidental elaboration of evolutionary processes that have been occurring for hundreds of millions of years. These brain systems constitute what I call a "primordial ideology," a system for guiding animal behavior according to the central values of self-preservation and reproduction, or what we can commonly call Food, Sex, and Death. If we look at human nature relative to the larger demands of Food, Sex, and Death, we can discern the contours of this "primordial ideology" and identify where our biological roots lie. So, before proceeding any further, let us quickly review what evolutionary account of ourselves needs to look like.

The Siren Song of Evolution Theory

For anyone looking to explain human nature, evolutionary theory is both highly alluring and frustratingly problematic. It is alluring because it offers the promise of a powerful and parsimonious explanation of our existence that originates in our very physicality. Contrast this with three other popular explanations of human nature: Marxism, psychoanalytic theory, and religion. These latter explanations are notorious for being subjectively interpreted, capriciously applied, and generally un-falsifiable. Evolutionary biology, in contrast, can generate precise and falsifiable hypotheses about human behavior rooted in genetic variation, hormonal fluctuation, and brain function. From the biological perspective, human nature originates in the linkages among specific gene variations and particular neurological and hormonal processes. And unlike with false consciousness, the superego, or God, these are all potentially observable phenomena. Any behaviors that do not come from this gene-brain-behavior matrix can be thought of as "learned" and attributed to the person's environment (although more on this in a moment). Evolutionary theory thus offers the tantalizing possibility of replacing vague and ephemeral interpretations of human behavior with the crisp predictability of biomechanics.

Evolutionary biology remains problematic because we still know relatively little about these biomechanics, how they evolved, or how they interact with their environments. Consider the human genome. Yes, scientists have mapped the human genome, demarcated the roughly 20,000 plus genes that are responsible for who we are, and begun to discover the phenotypes (i.e., the physical and behavioral traits) that these genes code for. And, by many accounts, genes look like a good foundation on which to build a biological description of the human experience. It is common these days to hear about the discovery of genes that "make us fat," or "make us happy," or even "make us conservative."

But such simplifications do a great disservice to both gene science and our current understanding of how genes work. Despite all of the monumental breakthroughs in genetic research, we still have a very incomplete picture of the relationship between genes and their corresponding phenotypic traits. Very few of our physical or behavioral traits come from a single gene and most require multiple genes acting in specific combinations.[1] In fact, some, like aggression, may involve thousands of genes.[2] Nor is there a direct one-to-one correspondence between genes and most animal behaviors; rather, most traits are the result of many genes working in tandem.[3]

Indeed, the more that we discover about genes, the more complex the relationship between genes and their traits appears to be. For example, gene expression is often controlled by seemingly dormant sections of the genome, sometimes even by genes on other chromosomes.[4] And many gene expressions also are highly sensitive to environmental triggers. Even basic traits like height and baldness arise not just from our genes but also from the interaction between genes and their surroundings.[5] The chances that you'll be bald or tall are not just determined by your genes but by the ways your genes respond to signals from your environment. Or, as anthropologists Peter Richerson and Robert Boyd aptly describe, *"genes are like a recipe, but one in which the ingredients, cooking temperature, and so on are set by the environment."* Some traits, like our body size or language competency, are highly sensitive to environmental differences; other traits, like having two eyes or five fingers are not.[6] In other words, lots of genes are responsible for lots of different traits under many different circumstances.

Similar complexities apply to neuroscience. Once again, we often hear stories about how certain parts of our brains “light up” when we think of anything from hamburgers to Hillary Clinton or about hormones that make us fall in love or make us more interested in the world.[7] But despite the compelling visual evidence from fMRI images, neuroscience is still a very young discipline and our knowledge of brain function is incomplete. Although we know that certain regions of the brain correspond to certain mental functions and that different neurotransmitters have distinct effects on our behavior, we still don’t know the full relationship between our brain regions, neural connections, hormones, and our psychology. Brains are incredibly complex entities containing over *one hundred billion* neurons; these neurons are then connected to thousands of other neurons meaning the brain is “wired together” in nearly innumerably different ways.[8] These connections, in turn, are influenced by scores of different neurotransmitters and hormones. We simply don’t yet know how all the brain’s cells and regions function or which genes are responsible for our brain’s development.

Even more vexing is the fact that our brains are not intransigent machines but living, growing tissues that change over time. The human brain is a remarkably plastic organ—it continually restructures itself in relation to its environment. At this very moment, your neurons are establishing new patterns of connection while older connections decay. This degeneration and connectivity starts at birth. In the first ten years of life, it is estimated that the human brain pairs away roughly half of its neurons.[9] This long growth trajectory makes a huge impact on later adult brain configuration: brains that are brought up learning Chinese end up being "wired differently" than brains brought up learning English, just as brains brought up in an environment of love and nurturance are "wired differently" than brains raised in an environment of trauma or neglect.[10] Thus, even when we observe brain activity, we are only getting a partial and suggestive picture of brain function.

And because we can’t yet specify the relationship between our genes, hormones, and our neurological functions, we can't yet specify our own psychology. This presents us with a major problem in trying to connect biology and human nature. For if we can’t specify the linkages between genes and brain function or know exactly how certain neural processes make us behave, then most of what we call a "psychological trait" is really a subjective interpretation of only those behaviors that we actually can observe. And, at this point, our powers of observation are very limited. Consequently, any part of human psychology that we describe as "innate" must be understood relative to our own culturally determined interpretations. Both the behaviors we observe and the means by which we observe them are determined by our particular cultural milieu.

This specter of cultural relativism haunts even the simplest assertions about human nature. Say, for example, we want to answer the seemingly straightforward question of whether some people are "born happier" than others. Although this question seems innocent enough, it is actually fraught with at least three highly questionable assumptions:

1) There is a universal, innate human trait of happiness;

2) That happiness is categorically distinguishable from other emotional states like sadness, anger, or even bliss and joy;

3) That happiness has some specific genetic and neurological underpinnings.

In reality, we don't know if happiness is a specific psychological trait or merely a notion particular to our culture--how I experience or understand "happiness" may be quite different than someone in Burma, Botswana, or ancient Babylon, particularly if their language does not have an equivalent term.[11] As we pull the threads on this line of inquiry further, we begin to realize that many psychological traits that we take for granted are only those feelings, thoughts, or behaviors for which we have descriptive terms (something I'll discuss in more detail in Chapter 3).

This same problem plagues all accounts of human nature. Consider, for example, the quest to discover human "universals," those behaviors and traits that exist across every human culture. Several scholars have tackled this Herculean task and each offers his own taxonomy: psychologist Paul Ekman identifies seven universal emotions, anthropologist Alan Fiske claims there are "four basic models of social relations," psychologist Shalom Schwartz suggests "ten universal human values," and anthropologist Donald Brown offers an even longer list of universal behaviors that includes everything from self-conception to shelter seeking.[12]

Immediately, however, we can see many problems with this enterprise. First, these lists are incommensurate—some activities and traits appears on some but not others. Second, they also have the problem of cultural bias—who knows how much our lists of human universals come from only identifying those traits that we want to see? But, most importantly, these lists don't explain *why* certain human traits are universal and why others are not. If we want to claim something in human nature is innate, we need to identify both its biological source and its underlying purpose. In other words, if we want to explain why Inuit, Italians, and Indonesians all worship gods and value trade, then we need to do more than just recognize them as universal human behaviors, we need to identify where they come from and how they evolved.

It is on these grounds that some scholars are suspicious of even the very *concept* of human nature. Humans are, after all, an extremely cultured species. Not only do most of our behaviors occur in specific cultural contexts, but the very way we understand the world is fundamentally defined by our words, concepts, and language. For all its efforts at "objective" theories, hypotheses, and evidence, science itself is a cultural construct. Thus not only is our thinking shaped by our culture, but *our thinking about our thinking* is also culturally determined. These indisputable facts lead some critics to question our motives for trying to identify an innate nature and to accuse this entire enterprise as being a manifestation of some type of latent neo-liberal, heterosexist political agenda.[13]

I do not agree. Yes, science is a cultural construct but it is also a dynamic knowledge system that is partially aware of its own cultural circumstance and is constantly challenging it. Science is a belief system of perpetual conflict and change. Moreover, few people actually think that we are *solely* the products of our culture or environment and most will acknowledge some role of our biology in our behavior. If we want to understand ourselves, then it behooves us to try to identify where those biological parameters lie. And even if our knowledge of genes and brain structures is incomplete, we now know enough to begin putting forth some testable hypotheses.

But because we are dealing with extremely complex systems, we need to have a general map telling us where to look. So before we start sifting through the billions of elements that comprise the human brain system and genome, let us look at what theories of biology might tell us about human nature.

Back to Evolutionary Biology

Evolutionary biology is based on an elegantly simple premise: life is the consequence of a relentless genetic algorithm. All life forms, from the smallest bacteria to the largest blue whale, emerge from a specific set of genes. Whether or not a gene is able to replicate itself depends on how well its phenotypic expressions (i.e., the physical and behavioral traits it codes for) perform in their environments. Those traits that better help the gene replicate itself will, simply by virtue of mathematics, be more likely to be passed on. As organisms reproduce, mutations in their genome create new types of traits and, if they promote survival and reproduction, they too will spread. Moreover, as organisms evolve, they will fundamentally change their adaptive environment, creating new evolutionary pressures, what biologists call Niche Construction Theory. This dynamic process of mutation, adaptive selection, and ecological re-equilibrium is at the core of neo-Darwinian evolutionary theory and the basis for the diversity of all life.

Within this brief (and overly simplistic) description of evolution lies an idea whose profundity is often hard for us to grasp: we are merely instruments that allow our genes to replicate themselves. Everything we think, feel, or wonder about originates in a biological system of genetic replication. We are, to put it crudely, the puppets of our genome. This humbling fact is something most of us find hard to accept. It is not how we like to think about ourselves. After all, we are intentional beings with free will! We are the authors of our own life story! We also project these egoistic concerns on other animals. Elephants and bees are interesting not simply because of their trunks or wings, but because their social behavior seems so reminiscent of our own. Surely they must also act with some kind of conscious volition.

But with biology, it's not trunks, wings, or free will that directly inform the evolutionary process, it's genes. From a biological perspective, all visible life forms are just the expression of latent, genetic codes. All that we see, value, and puzzle over in our natural world is the outcome of a massive, microscopic process of genetic replication. This includes human existence as well. While we are consumed with the importance of our identity and individuality, biologically these are rather extraneous traits. From a biological perspective, everything we do ultimately boils down to our genetic substrata. To paraphrase biologist Richard Dawkins: All life forms, from the simplest bacterium to the most sophisticated human being, is simply a gene's way of making another gene.[14]

I will consider some of the more profound implications of this fact later, but for now, let us consider what it means for describing human nature. If we want to depict any human behavior or psychological trait as innate, we must ultimately determine how it provides a specific reproductive benefit for our genes. And this, it turns out, is actually a very difficult thing to do. Partly this is because it is hard to identify why or how any particular trait enhances an organism's reproductive fitness. And partly this is because many traits may not provide any reproductive benefits at all and simply get passed through genetic drift.

Consider, for example, the giraffe's neck. It seems relatively self-evident that a giraffe's long neck evolved because it helps giraffes reach vegetation high in trees. But, we don't know this for sure. Perhaps a giraffe's neck was like a peacock's feather and evolved simply as a mechanism to demonstrate male genetic fitness?[15] If the latter is the case, then we could say the nutritional benefits that accompany a long neck are no more than a fortuitous by-product. More importantly, we would also be mistaken in assuming that a modern giraffe's eating behavior is the reason for its longer neck – a long neck may help further a giraffe's genome if it makes a giraffe "sexy" just as much as if it helps it eat better. Or maybe longer necks are neither beneficial nor costly for giraffes but simply exist through accident and genetic drift?[16]

Which leads us to the challenge of human psychology—if we want to identify which parts of our psychology are innate, we need to determine which parts of our psychology are genetically determined. This means trying to identify which parts of our psychology are directly beneficial for reproducing our genome, which parts are accidental beneficial, and which parts might simply exist by virtue of random circumstance. This, in turn, means we need to specify our psychological traits and then identify when and why they might have evolved.

Over the past thirty years, one of the most forceful efforts to do this has come from a group of scholars operating in the field of evolutionary psychology. Although this group is diverse and not always consensual, they have offered a dazzling array of hypotheses about the biological origins of everything from religion to morality. Not surprisingly, their efforts have also generated a great deal of controversy and criticism.

Although evolutionary psychology encompasses a wide range of disparate views, its practitioners generally share some key assumptions about the human mind. Rather than view the human mind as a general-purpose learning machine, evolutionary psychologists assert that the brain evolved as a hierarchical system of numerous, specialized adaptations selected for specific environmental problems.[17] In their terms, the mind is a complicated information processor comprised of specific "modules" that evolved to perform particular functions. Like the subroutines of a computer program, each of these mental "modules" is devoted to a specific psychological task. Examples of such "modules" include our innate fear of snakes or heights, a baby's ability to recognize faces, our language competency, certain aspects of our moral decision-making, and even our tendency to overestimate our own driving ability.

In speculating about when these mental modules evolved, most evolutionary psychologists focus on the Pleistocene, the time period between 4 million and 10,000 years ago. This period is when our hominid ancestors evolved away from other great apes and developed so many of the characteristics that differentiate us today, such as the use of language, symbolic reasoning, theory of mind, and general intelligence. As two of the pioneers in this field, Leda Cosmides and John Tooby, summarize:

> "*Our species lived as hunter-gatherers 1,000 times longer than as anything else. The key to understanding how the modern mind works is to realize that its circuits were not designed to solve the day-to-day problems of a modern American -- they were designed to solve the day-to-day problems of our hunter-gatherer ancestors.*"

In other words, we are basically "cavemen" sheathed in a thin veneer of modern culture; the logic of much of our behavior can only be understood relative to the distant light of the past 4 million years.

With this model of mental modularity and a focus on the Pleistocene, evolutionary psychologists have concocted a trove of interesting and provocative theories about human nature. Perhaps, the most notable of these deal with human sexuality. Evolutionary psychologists deduce that, because females bear most of the costly reproductive burdens in our species and males bear very few, men and women evolved different psychologies of desire.[18] For example, because it is in a male's genetic interest to inseminate any potentially fertile female, some evolutionary psychologists hypothesize that men evolved "mental modules" that make them easily aroused by youthfulness, a slim body shape, or any other visible markers of fecundity.[19] Females have more limited opportunities to pass on their genes and are greatly incapacitated by motherhood. Thus women evolved modules that make them value male partners who might provide support for them and their children or at least who seem to carry good genes.[20] These differences supposedly explain many contemporary sexual behaviors: if we want to know why pornography is overwhelmingly consumed by men, why men masturbate more than women, why women rate wealthier men as better looking, and why youthfulness confers beauty, we can find the answers in those mental modules that evolved to optimize reproduction.

Such explanations, however, are not without their own problems. First, it is not clear how much of human behavior is driven by specific "modules," whether the "modules" they suppose even exist, or where such modules may reside in the brain.[21] Although evolutionary psychologists offer many compelling hypotheses, most of their hypotheses about specific modules remain untested.[22] The human brain is made of highly specialized regions but neuroscientists have yet to identify the specific types of modules that most evolutionary psychologists speculate about.[23]

This touches on a much larger problem in understanding the biology of human nature: human behavior involves a lot of extremely complex genetic and neurological processes. Right now, your brain is utilizing *tens of millions* of neurons just to read these words. So imagine how many neural systems must be involved in doing something more exciting, like watching pornography or seducing a potential mate. We still don't know how much of human behavior is delimited by specific "modules," how these "modules" are constituted, and how much is accomplished through more plastic general thinking or learned capacities. Evolution tends to select simpler rather than more complex solutions to survival problems. In many cases, it might have been more efficient for our brains to evolve a more generalized capacity for learning about different situations rather than anticipating every contingency with a specific cognitive program.[24] This is especially the case with humans who have managed to settle over diverse range of environments and are highly social beings. More than most creatures, humans exhibit a lot of mental plasticity—we are extraordinarily adaptable and this flexibility comes from our ability to learn and adjust to a wide variety of habitats.

Moreover, the differences between innate traits and learned behaviors are often not clear. A good example of this is with our fear of snakes. Evolutionary psychologists have deduced that our ancestors evolved a mental "module" that makes us afraid of snakes.[25] The logic behind this deduction is pretty sound: poisonous snakes inhabit much of the planet and learning that a snake is dangerous is generally catastrophic. So it is not surprising that many animals have aversion to snakes, that people can quickly pick out snake shapes from a busy picture, or that snake fears are one of the most commonly related phobias.[26] But not all people or animals are afraid of snakes. Instead, many people and animals seem *primed to learn* a fear of snakes.

The proclivity for learning some kinds of information was demonstrated in an interesting set of experiments. Researchers showed lab-reared monkeys who were not afraid of snakes two sets of videos.[27] In the first video, the naïve monkeys saw images of another monkey reacting to a snake with fear; in the second video, they saw another monkey being afraid of a flower. Monkeys who watched the first video quickly emulated what they saw--they too became afraid of snakes. But monkeys who watched the second video did not develop a fear of flowers. Some kinds of traits, it appears, are easier to teach than others. The same type of differential learning occurs in humans as well. Children have a much easier time learning to speak than to write and, as any parent will attest, its much easier to teach a toddler to exchange a toy that to share one.

Most importantly, this research shows how difficult it is to specify a mental module about a complex social behavior. All animals show diversity in their phenotypic traits and the same applies to our psychology. Some phobias may be innate, some may be learned, and some may be more easily learnable than others. These distinctions are especially difficult to make in a highly social species like ours that spends such a long time maturing into adulthood.

Because most evolutionary psychologists have not yet theorized about the biological parameters that underlie these mental "modules," nearly all of their hypotheses are vulnerable to the charge of being Panglossian "just-so" stories i.e., explanations that assume a particular behavior evolved because of the benefit it seems to provide today. For example, some evolutionary psychologists claim that Playboy centerfold models all look a certain way because human males have evolved a "module" that makes them attuned to a certain hip-to-waist ratio.[28] But if sexual taste is rooted in reproductive imperatives, then how can we account for homosexuality, sado-masochism, or other forms of sexuality that seem to defy any evolutionary logic? Or how might we account for the fact that Playboy models themselves have changed so much over the past 60 years? Or why pin-up models have different body shapes across different cultures? Since, biologically speaking, sex is relatively cheap for men, it is hard to see what physical traits in a potential mate would constrain their desire or why they would be particular in whom they would try to inseminate.[29] More importantly, most human activities are culturally determined and it is highly unlikely that any particular social behavior will result from a single biological imperative.[30] In looking to find the adaptations in so many human behaviors, evolutionary psychologists often run the risk of positing biological explanations where none should exist.

If biology is to have any role in explaining human behavior, then we'll need to have a more nuanced and sophisticated understanding of neural functioning. Which brings me to the central point of this chapter. The problem with evolutionary psychology is not necessarily with the idea of mental modularity. Few would doubt that brains and neural systems are built of various subcomponents dedicated to specific tasks, and these systems are partly the product of evolution. Rather, the biggest problem with much evolutionary psychology is with its preoccupation for trying to locate the adaptive logic of modern behaviors and to locate it specifically in the

Pleistocene. And, in this, they are in good company. Whether depicting us as "the image of God," "a rational man," or "man, the tool maker," nearly all descriptions of human nature inevitably concentrate on human distinctiveness. When evolutionary psychologists hypothesize about "modules" behind modern behaviors or use the Pleistocene as the "environment of evolutionary adaptedness," they join a long list of efforts that characterize human nature from a decidedly anthropocentric perspective.

But, from a biological standpoint, this fixation with our own distinctiveness is myopic. Our species didn't evolve from scratch during the Pleistocene, it evolved as simply yet another incarnation in a menagerie of animals going back well over 500 million years. Our ancestors may have lived 1,000 times longer as hunter-gathers than as modern humans, but they lived *100,000 times* longer as pre-human animals than as hunter-gatherers. Human nature does not simply consist of those elements that differentiate us from other species; instead, it consists *mostly* of elements we share with other species.

When we view nature from an anthropocentric perspective, we risk misinterpreting the evolution of our own psychology. Let me give a brief example. Compared to all other species, humans display extraordinarily high levels of altruism towards non-kin. No other animal will sacrifice itself the way we do for non-relatives. Many evolutionary psychologists explain altruism as an evolved adaptation to the problem of human cooperation. As hominids evolved during the Pleistocene, they grew dependent on living in large groups and the cohesion of these groups depended on evolving pro-social psychological traits, like altruism. To put it crudely, hominids evolved a mental "module" of altruism to facilitate living together.[31]

But if we step back and examine the biology of altruism, we find that altruism partly arises from hormonal and neurological processes that all mammals share. Humans have an extraordinary capacity for altruism because they are extremely susceptible to feeling empathy with others. And we are extremely susceptible to feeling empathy because human children, like most primate offspring, need extraordinarily high levels of care and nurturance.[32] In other words, the reason why we are altruistic is not simply because our hominid ancestors evolved some "altruism module" two million years ago, but because our more ancient mammalian ancestors evolved a neurological sensitivity to oxytocin, vasopressin, and other hormones that increase empathy towards our offspring.[33] In the case of our species, these tendencies spill over into our feelings for our non-kin, but this may be simply because our children require so much more care. Rather than evolving an "altruistic module" during the Pleistocene, it is quite likely that our ancestors' higher levels of empathy towards their off-spring made it possible for them to develop norms of altruism.

This same type of interpretive danger holds with any evolutionary explanation of contemporary human behavior. Like the example of the giraffe's neck, we can't simply assume that our psychology is rooted in a particular biological function just because it exists today or across all cultures. Evolution is filled with traits that are maladaptive or simply exist from genetic drift. Modern life is so culturally ensconced that it is extremely difficult to differentiate where environments end and biology begins. We will have a lot more confidence in our deductions, if we start by not looking a humans but looking instead at those psychological traits that we share with other animals.

This idea arises from a central concept within evolutionary theory: biological evolution occurs in a cumulative, piecemeal fashion. Excepting the first form of life, no species comes into existence with entirely brand new genes; instead it evolves from derivations of pre-existing genetic codes. All animals descend from a common ancestor and their derivations arise largely from incremental, piecemeal elaborations of this first genome. Apart from these small mutations, the central genetic building blocks remain the same. This fact is why we share such an astonishingly high percentage of our DNA with flies, frogs, and tapeworms. It is also why so many parts of our bodies, such as our backs, hips, and knee joints, are prone to malfunction as we age. Our ancestors only recently evolved bi-pedalism and our poorly configured lower bodies only make sense as stop-gap derivations from a long line of quadruped ancestors. Our current physical incarnation is but the latest shard emerging from a complex process of mutation and elaboration that is driven by chance and circumstance.

In fact, the *ad hoc* nature of evolution is probably nowhere more evident than in the human brain. It is common for us to describe the brain as a single organ but, in reality, the human brain is more of a mishmash of different component parts that evolved to perform different functions. As I'll describe in a moment, these different brain regions not only evolved at different times, they also evolved to be highly interconnected with each other. For example, the thoughts generated in the neo-cortex are inexorably linked to autonomic processes in the brain stem, e.g., think about an ex-lover and your heart rate rises. While we often hear of the brain described as a living computer, it is actually more like a series of computers wired together. To continue with this analogy, some parts of our brain, such as the brain stem, are old and relatively weak in "processing power" (e.g., an Atari 64). Other parts of our brain, like the prefrontal cortex, are more recent evolutions and have much more computational capacity (e.g., a Cray Titan Supercomputer). Nevertheless, all of these parts are fundamentally interconnected, and our overall brain performance is contingent on their interactions. As the anthropologist Melvin Konner artfully describes, our brains are like a Cray Titan supercomputer that must route many basic functions back through a primitive Atari 64 (p.142). Before we marvel at the power of our own enlarged neo-cortex, we should be aware that our neo-cortex still depends on working with the more "primitive" or ancient parts of our brains.

In short, if we want to identify the biological sources of human nature, we need to first identify when and why these different brain regions evolved. Of course, this doesn't mean we should completely disregard human distinctiveness – the unique capacities of the human mind are also important for understanding our innate nature. But before we can identify the evolution of those uniquely human traits, we need to go back further in time and understand human nature relative to its evolutionary context. And the best place to start is with the evolution of the brain.

Why do We Have Brains?

As biological phenomena, human brains are something of a curiosity. In themselves, our brains don't directly digest our food, carry us from predators, or attract our mates. Our larger brains make our births extraordinarily difficult – one of the consequences of our ancestors evolving both bipedalism and larger brains was that we have to be born before we're fully developed and that birthing us puts our mothers at extraordinary risk. And, physiologically, our brains are also very expensive to maintain: although they comprise less than five percent of our body weight they consume 20 percent of our blood oxygen and 70 percent of our blood sugars. If we really want to understand how biology shapes human nature, then the first puzzle we need to solve is why we have these costly, burdensome brains at all.

Interestingly, the answer begins with how we eat. You may not realize it but your capacity to feel joy, contemplate the mysteries of the universe, or add two plus two fundamentally is defined by how you feed yourself. Let me explain. All living organisms can be distinguished by how they get the energy they need to survive. Bacteria absorb energy from other chemical compounds, plants and algae get their energy through photosynthesizing sunlight, and animals get theirs by ingesting other organisms. These differences, in turn, partly explain why bacteria, plants, and animals evolved the different types of physical structures we see today. Because most plants exist on passively absorbed solar energy, water, and carbon dioxide, they have evolved physical traits to obtain these elements, like leaves and roots. More importantly, because sunlight is both abundant and basically the same wherever one goes, plants don't need to move to get their daily energy needs. This is partly why plants never evolved calorically expensive features like muscles, skeletons, or other mechanisms of propulsion.

Animals, on the other hand, have to get their food by ingesting other living creatures and this type of "eating" put them on a distinct evolutionary trajectory. Trace along the animal evolutionary tree and you find organisms that evolved from very simple, plant-like creatures into the highly complex animals we see today. It is likely that the very first animal was nearly indistinguishable from a plant. This tiny, sponge-like creature, made up of a relatively small number of interconnected cells, didn't move about or have muscles, skeletons, or neurons.[34] The major factor that really differentiated it from a plant was that it ingested other living organisms instead of photosynthesizing sunlight.

But it was an animal and, as such, it faced a big problem: it existed completely at the mercy of its immediate environment. If local food sources suddenly relocated to just a few inches away, it would perish. Given that the oceans still hold plenty of sponges, it is clear that immobility is not a complete disaster for an animal. Yet it is also easy to appreciate the tremendous advantage conferred to those later animals that evolved a way of getting around—now they could go to where the food is rather than wait for the food to come to them.

Unfortunately for the first itinerant animal, simply moving wouldn't greatly improve its life-chances, because it would just trade the mercy of the local environment for the mercy of random chance encounters with food – moving alone doesn't do you much good if you don't know where you're going. As these early animals evolved ways of propulsion, they also evolved mechanisms that could sense their surroundings and communicate to themselves what they sensed; indeed, the sensory mechanisms probably evolved first.[35] Nevertheless, movement basically necessitated special cells that could sense the environment, signal what they sensed to other cells, and prompt the organism to act appropriately. These were the cellular forerunners of our own neurons.

INSERT Text Box 1 (WHAT IS A NEURON)

In short, eating other creatures put pressure on animals to evolve movement and sensory perception: if you're an animal that moves you need neurons; if you're an animal that stays put, you don't. This interrelationship between movement and neural development is well illustrated with a subphylum of animals known as Tunicates, also known as sea sprites. These animals are distinctive because they have a few neural cells during their mobile youth and then consume these cells when, in adulthood, they become sessile.[36] In popular terms, once sea sprites become settled in one place, they "eat their own brains!" But, more importantly, they also demonstrate how much neural development and mobility are fundamentally linked—if you don't move, you don't need complicated and calorically expensive mechanisms to sense the world.

In these early neural systems, we find the foundations of human nature. As animals developed ways to sense their surroundings, they also needed to evolve ways to manage this new information and determine an optimal response. To do this, animals evolved mental faculties both to evaluate information and to initiate appropriate actions. They not only need to distinguish food from mates and mates from predators but all of these from rocks, water, or other inanimate objects. Once they perceive a salient cue, they must then initiate the right behavior: an animal doesn't want to run away from a food source, to mate with a predator, nor eat a sexual partner (unless, of course, she has already copulated). In short, they started to evolve a psychology. As we'll see in Chapters 3 and 4, what becomes the basis for our own minds actually begins with the neurological mechanisms our ancestors evolved to appraise the world and choose the right response.

INSERT Illustration 1.1 (ANIMAL TREE OF LIFE)

A good way to understand this is to look at some of the major branches in the animal family tree. The first that is important for human nature occurs between radial animals with primitive neural networks, like jellyfish, and bilateral creatures, like worms, that have a distinct front and back. In the latter group, this new physical orientation gave rise to a new form of neural organization: a central nervous system.[37] Although the exact evolution of the centralized nervous system is unclear, it is likely that it developed in an ancestor we share with modern flatworms. Interestingly, it also accompanied the evolution of a head and mouth. These early flatworms were the first species to exhibit an oral cavity, asymmetric body structure (i.e., a "head"), and a centralized nervous system. This suggests that these early flatworms found advantage in communicating the proximity of food sources to a specialized organ that absorbed the food and to muscle cells that would propel their movement in a particular direction.[38] It's also humbling to realize the first "brain" came from an ancestor who resembled an intestinal parasite.

This is also a good point to recognize a second key element in the evolution of animal psychology: hormones. Although many of the same chemicals in hormones can be found in single-celled organisms, the real story of hormones, as far as we're concerned, takes off in multi-cellular animals. As early organisms were evolving greater structural complexity, they needed to obtain information not only about their environments, but also about themselves. This increased need for "self-awareness" is a by-product of their cellular specialization. A single-celled organism is a relatively autonomous creature – it has a limited range of interactions with its environment and it determines its energy needs in a rather simple way. However, once an organism becomes multi-cellular, it needs its constituent parts to communicate and work in concert. If one cell is getting lots of energy and the other cell isn't, the latter will deteriorate and the whole organism will perish. As animals grew more complex and their cells more specialized, they needed to find a means of inter-cellular communication.[39]

And one of the ways they did this was with hormones. In vertebrates, hormones do everything from triggering muscular development to the production of eggs and sperm. But, most importantly for our purposes, hormones also direct animal behavior. One of the most important ways they do this is in maintaining energy balance, a process called homeostasis (an idea we'll examine in more detail in Chapter 3). Hormones not only signal our brains when we're hungry, when we need rest, or when we need cooling, they also trigger emotional states that motivate us to eat, sleep, or jump in a pool. So when we talk about the biology of human behavior, we shouldn't limit ourselves simply to neurons and brains; hormones are important too.

Anyway, back to the flatworms. Once our bilateral ancestors acquired fronts and backs, they also began evolving more complex ways of moving, eating, and mating. They started evolving distinct body segments, digestive cavities, circulatory systems, organs and limbs.[40] With their more complex ways of getting about, these animals also began evolving more elaborate sense mechanisms, such as eyes and antennae. All of these physical developments, in turn, required a more sophisticated psychology. After all, if an animal suddenly evolves limbs, it also needs to evolve neural mechanisms to coordinate its legs moving together. If its neighbor suddenly evolves sharp teeth or a tail, this same animal will experience strong pressures favoring any mutations that provide appropriate responses. As one traces back through animal evolution, one sees the same pattern: as animals become more physically multifaceted they also evolved a wider behavioral repertoire, developing more specialized ways of hunting, attracting mates, and fleeing from predators who themselves are evolving. They also evolved more elaborate neural structures.[41] This, in turn, places ecological pressure on other species who must either evolve ways of surviving or perish. Thus in the archeological record, we see that animals progress relatively quickly from a bilateral form to greater complexity and, with this, the neural structures, hormones, and basic psychological processes like reflexes, coordination, sensation, sexual drive, and hunger that are essential elements within human behavior.

The next period of note comes with the evolution of vertebrates, somewhere around 500 million years ago. This moment also brings a basic brain structure that is still evident in us today. Although its different parts were independently elaborated or shrunk in various species, nearly all sharks, fish, amphibians, reptiles, birds, and animals retain the same, basic tripartite brain organization.[42] In the early stages of human embryonic development, one can see quite glaring references to this ancestral brain—a six-week-old human embryo has a brain structure that is not terribly dissimilar from a crocodile or a frog.[43] This similarity in brain structure occurs because, despite the tremendous physical differences between eels, eagles, and elephants, they all share similar core physical functions that are regulated by analogous brain regions. These also comprise the same building blocks of human psychology. To see what these are, let us quickly review the role of each of these brain structures.

First is the hindbrain (formally called the Rhombencephalon). This region controls basic autonomic body functions, such as heart-rate, breathing, and digestion. In most vertebrates, it is actually comprised of numerous sub-parts, including the medulla oblongata, cerebellum, and pons. Each of these organs, in turn, has very specialized tasks. The medulla oblongata coordinates reflexes and perspiration, the cerbellum enables gross motor control, and the pons relays information on autonomic functions ranging from sleep to digestion. As I mentioned earlier, in humans and other mammals, these areas also integrate with many higher order brain functions. The pons, for example, relays nerve impulses for both chewing and a variety of facial expressions while the cerebellum is important for language and vocal communication, thus they are still very involved in our most sophisticated psychological behaviors.[44]

INSERT Illustration 1.2 (VERTEBRATE TRIPARTITE BRAIN)

Second is the midbrain (or mesencephalon). This region generally functions to process visual and auditory information in non-mammals. In mammals, this area is comparatively small because these functions later shifted to other parts of the forebrain. Yet it still retains some essential functions, especially in coordinating eye movements and in the production of dopamine, an essential neuro-transmitter. Much of how we learn, think, and remember is contingent upon the chemicals released from this brain region.[45]

Third is the forebrain (or proscencephalon), which itself is divided into many other parts. For example, the thalamus regulates sleep and sensory information; the hypothalamus help regulate hormones, hunger, and other autonomic functions. The biggest part of the forebrain is the one most familiar to us and includes the parts when we typically think of the brain. This includes the cortices and the limbic system, the parts primarily responsible for more complex psychological functions including sensory processing, emotions, and deliberative thought. These are the brain parts that are highly developed in mammals and especially our species and will be the focus of much of our later attention.[46]

Viewed in this light, we can appreciate both how ancient our basic brain organization is and how much of our own brain processes we share, not simply with other mammals, but also with reptiles, birds, and fishes. As we'll see in later chapters, even our most "human" characteristics actually involve brain regions and processes that existed well before the dinosaurs. The same ancient brain regions that generate pain and pleasure, allow for learning and memory, and enable complex foraging, hunting and mating in our vertebrate ancestors are also involved when we feel guilt, appreciate Mozart, or contemplate infinity.

Of course, this is not to imply, however, that all animal brains are the same. Fish, reptiles, birds, and mammals also have some fundamentally different elaborations of this basic tripartite brain structure. And many that are the most important for human nature are the changes that come with mammals, about 200 million years ago.

The Brains of Mammals

There are many traits that differentiate mammals in their evolution away from other vertebrates, but two that probably had the biggest impact were hair and mammary glands. How did hair affect the evolution of a brain? The answer is likely to be found in what hair allows: endothermia. Hair enables mammals to maintain a more constant body temperature, which proved to be quite advantageous for our ancestors' survival. For not only did hair allow them to survive great climatic shifts, it allowed them to become nocturnal.[47] While many reptiles and dinosaurs were immobilized by cooler night temperatures, our hairy, endothermic ancestors could now venture out and forage with fewer reptiles that were trying to eat them. Hunting at night, however, also put pressure on our hairy ancestors to evolve a different psychology. For if you're hunting in the dark, you'll be at a much greater advantage if you can smell, see, and hear more clearly. Nocturnal foraging partly explains why our mammalian ancestors evolved larger olfactory lobes and middle ears and a larger forebrain as well.[48]

Mammals are also distinguished by their mammary glands. This too had profound psychological consequences, for nursing put mammals on more socially interdependent evolutionary trajectory. Although mammals are not the only animals to either secret milky substances or to heavily invest in newborns, few other vertebrates exhibit the type of intimate nurturance so common in mammals. This heightened nurturance is possibly related to the enlarged brain that was necessary for nocturnal feeding.[49] As mammals developed bigger forebrains to help them forage at night, they had to change how they took care of their young. Remember brains are expensive and time-consuming tissues to develop. If your children have a larger brain, they are going to need more energy and guidance in their youth. This, in turn, demanded the evolution of some particular psychological functions associated with nurturance: caring, sensitivity, separation distress, and general sociability.[50] The same hormones and neurotransmitters that promote bonding between human parents and children today are rooted in ancient chemicals that evolved in our earliest milk-feeding ancestors.[51]

The connection between nurturance and sociability then leads us to one of the most important facts regarding mammals and brain development: the more sociable the mammal, the larger its brain (or more specifically its forebrain) tends to be. This correlation between forebrain size and sociability is a little counter-intuitive. We tend to associate brain size with intelligence; animals have bigger brains because it makes them smarter, no? Actually brain mass is not a great predictor of intelligence. Larger animals have bigger brains than smaller ones because of their greater body surface, which requires more sensory processing, not because of their greater intelligence. If we compare mammals by their *relative* forebrain size (or what scientists call an encephalization quotient or EQ), we see a wide range of scores and that these scores don't always predict intelligence. For example, those clever mice and rats only have a measly .5 EQ, about the same as an ox. Camels or walruses, animals not generally renown for their intelligence, have a much larger EQ of 1.2.[52]

Humans have an EQ between 7.4 and 7.8, but our greater EQ did not evolve to give our minds greater computational power. Instead, our brains are probably bigger because we are more social. Our greater intelligence is most likely the by-product of our greater sociability rather than a biological adaptation in itself. Across the animal kingdom, it is the social animals that have the largest EQs. The same holds among groups of primates – humans have a larger EQ than chimpanzees, gorillas, or baboons because we live in larger social groups. This relationship even holds among individual humans. Anthropologist Robin Dunbar, the pioneer of this research, has also found that the size of a person's orbital prefrontal cortex is correlated with the size of their social network: more sociable people tend to have bigger front parts of their brain.[53]

As an interesting aside, Dunbar has estimated that the current size of the human neo-cortex allows us to have stable relationships, on average, with about 150 other people ("e.g. Dunbar's number").[54] This is the number of social relationships our brains seem capable of keeping track of. Most organic social groups (foraging tribes, army groups, communes, church parishes, etc.) tend to destabilize when they get much bigger than 150 and often then split up into smaller subunits. Back when people had address books, most had an average of 150 entries just as most have about 150 meaningful social contacts.[55]

This, however, begs the question of why our brains capped at 150? Although no one knows for sure, it probably has something to do with early ecologies and the limits of human mobility. If we assume that the average forager could roam about 14 miles over rough terrain in a day, then early people could move in a seven-mile radius from their base camps. Since most sub-Saharan African ecosystems can support about one person per square mile, an area within a seven-mile radius could thus sustain about 150 people. Granted, this speculation is based on some pretty heroic assumptions about mobility and ecology, but it would seem consistent with Dunbar's number.

Nevertheless, the important point to consider is that much of our current brain size and psychology has evolved to meet the particular cognitive and social demands of our mammalian ancestors. They evolved larger forebrains not only to help them nocturnally forage and avoid predation, but to facilitate greater social connections. In the animal world, this social psychology is most fully evident in our primate cousins, especially gorillas and chimpanzees. As we'll see in later chapters, they value reciprocity, distinguish between in-groups and out-groups, punish cheaters, and have a high degree of concern about status and reputation. These same social behaviors are evident in most human political behaviors as well and arise from some of the same evolutionary sources.

This is also an opportune moment to address one of the most common misconceptions about evolution and human nature: that our terrific biological complexity is a sign of our biological superiority. This is an easy mistake to make. After all, it seems intuitive that a more complex animal is somehow a better one, i.e., a human is a superior creature to a frog which is, in turn, superior to a sponge. We have, after all, taken ourselves out of the food chain, so a little self-congratulation may seem appropriate. Thus it is understandable if we think humans represent the apex of some evolutionary trajectory.

Nature, however, makes no such distinctions. Evolution is simply based on genetic replication and superiority is only defined by the ability to survive and reproduce. The fact that simple organisms like bacteria, sponges and jellyfish have endured numerous global cataclysms and climatic upheavals for hundreds of millions of years is a much stronger testament to their biological preeminence. In fact, simplicity may often be an optimal survival strategy—numerous species have evolved by becoming more simple rather than more complex. Thus rather than think of ourselves as some logical end to evolution or as being superior to other animals because of our great brains, it is worth recognizing that, biologically speaking, we're still new kids on the block who have yet to prove our metal.

More importantly, we also need to be cognizant that our psychological complexity comes with its own costs. Like any machine, organisms with more distinct parts require more energy and are more vulnerable to malfunction. A sponge may be a simple creature, but it gets along pretty easily. It doesn't have the organs, muscles, or neural cells of a reptile, bird, or mammal, but its caloric demands are a fraction of these other creatures. Sponges are also incredibly tough. Cut most animals in half and they'll perish, but put a sponge through a sieve and it will eventually piece itself back together. Complicated animals have more "moving parts" and are thus more vulnerable to breakdown. The same goes with one's psychology. Our elaborate psychology leaves us incredibly vulnerable to mental malfunction: much of the neurosis, depression, and anxiety that is so rife in human society is the by-product of our intricate psychology. Complexity comes with its own costs.

Thus as we ponder the evolution of human nature, it is worth remembering that our brains are simply the physical expression of particular adaptive circumstances and that they may no longer be properly adaptive to our circumstances. Brains evolved to help our ancestors find food and brains then evolved greater complexity as our ancestors themselves became more physically multifaceted. But remarkable as our brains are, they are not any more exceptional as a biological adaptation than a bee's wings or an elephant's trunk. Just as plants evolved leaves and some bacteria evolved cilia, animals evolved brains in response to very particular needs of how they eat, mate, and live. Human brains are simply a particularly elaborate expression of a set of tissues that nearly every animal has. Ironically, the very complexity of our brain and brain functions also creates a distinctive set of challenges to us as a species. Whether by gross psychological dislocation, human-induced nuclear conflagration, or environmental degradation, it is entirely possible that our great, complex brains end up dooming us to misery, if not extinction. Now that's a cheery thought.

Primordial and Modern Ideologies

From this very brief description of animal evolution, we can begin to see how various brain regions and hormones evolved to serve animals needs for survival and reproduction. Once our ancestors started moving, they started evolving a brain and psychology to help them eat, mate, and survive. And once our mammalian ancestors evolved hair and mammary glands, they evolved even more specific psychological functions related to cognitive capacity and sociability. Cumulatively, these brain regions and psychological functions comprise what I term a "primordial ideology."

Now it may seem strange to say animals have an ideology, "primordial" or otherwise. Ideologies are typically understood as cultural constructs and something particular to our species. But if we understand an ideology as simply a means of translating a set of core values into a predictable array of actions and behaviors, then an ideology is something that all animals have. The core value of any organism is in replicating its genome, or more specifically, finding energy (FOOD), reproducing (SEX), and avoiding destruction (DEATH). An organism's "primordial ideology" is comprised of the biological mechanisms that further these values; in animals, this includes their brains, hormones, and the psychological processes that direct their behavior. Just as human ideologies translate general values, like global justice or individual freedom, into specific behavioral mandates, so too does primordial ideology translate the demands of genetic reproduction, i.e., food, sex, and death, into specific physical and psychological traits.

Now if we were looking to understand the behavior of any other animal, we could basically stop here. All I've done with this idea of a "primordial ideology" is to crudely re-characterize how most ethnologists and biologists understand the evolution of animal brains and behavior. But the reason I purposely use a term like "primordial ideology" is that provides us a good conceptual point in differentiating between innate and cultural influences on human nature. The part of our brains and psychology that we share with other animals, our "primordial ideology," is the part we can confidently describe as innate. Once we begin exploring things like human emotion (Chapter 3) or cognition (Chapter 4), we'll see that much of how we think and feel is based upon neurological elements that were in place long before our hominid ancestors started walking upright. Most important, much that of what is bizarre or irrational in our lives arises not from our cultural imperatives but from our biological ones.

But before we explore this "primordial ideology" in more detail, we'll need to address a more complicated wrinkle that comes with our species: we are the first animals to challenge and rewrite our own primordial ideology. Not only has our species evolved tools, language, and other cultural mechanisms that shape the way we live, our species' genes coevolved with this cultural devices to produce a very distinctive kind of animal. Although our "primordial ideology" shares much with other species, it also has some unique characteristics as well. To better understand these, we'll need to look more closely at the distinctive aspects of human evolution, which we'll take up in Chapter 2.

[1] Plomin R, Owen MJ, McGuffin P. The genetic basis of complex human behaviors. Science. 1994;264:1733–1739.

[2] Zwarts, L., M. M. Magwire, M. A. Carbone, M. Versteven, L. Herteleer, R. R. H. Anholt, P. Callaerts, and T. F. C. Mackay. 2011. "Complex Genetic Architecture of Drosophila Aggressive Behavior." Proceedings of the National Academy of Sciences USA 108 (41): 17070–75.

[3] Pierce, Benjamin. Genetics: a Conceptual Approach.

[4] J Neurobiol. 2003 Jan;54(1):4-45.**Genetic and environmental influences on human psychological differences.**Bouchard TJ Jr, McGue M.

[5] Eur J Clin Nutr. 1999 Dec;53(12):938-45. Association of maternal short stature with stunting in Mexican children: common genes vs common environment. Hernández-Díaz S, Peterson KE, Dixit S, Hernández B, Parra S, Barquera S, Sepúlveda J, Rivera JA.

[6] Boyd and Richerson, Not by Genes Alone. p. 9.

[7] http://www.nytimes.com/2007/11/11/opinion/11freedman.html?pagewanted=all. Kaplan JT, Freedman J, Iacoboni M. (2007). Us versus them: Political attitudes and party affiliation influence neural response to faces of presidential candidates. *Neuropsychologia* 45:55-64.

[8] Gazzaniga, Ivry, and Mangun. Cognitive Neuroscience.

[9] Andersen SL (2003). "Trajectories of brain development: point of vulnerability or window of opportunity?". *Neurosci Biobehav Rev.* **27** (1–2): 3–18.

[10] Tang, Zhang, Chen et al. 2007. Arithmetic processing in the brain shaped by cultures.

[11] Argyle, Michael. 2001. The Psychology of Happiness.

[12] Paul Ekman, Emotions Revealed; Shalmon Schwartz ; Donald Brown Human Universals; Alan Fiske, Structures of Social Life

[13] Susan McKinnon, Neoliberal Genetics; Marshall Sahlins, the Western Illusion of Human Nature.

[14] Dawkins, the Selfish Gene.

[15] Simmons and Scheepers 1996 "winning by a neck"

[16] Gould, Stephen J. The Tallest Tale.

[17] Buss, David. 1995. Evolutionary Psychology.

[18] See Barkow, et al. Adapted Mind.

[19] Wilson, Glenn. 1992. The Great Sex Divide.

[20] Abramson, Paul and Steven Pinkerton (eds) Sexual Nature/Sexual Culture.

[21] See Fodor, Jerry. The Mind Doesn't Work That Way.

22 Buller, David. Adapting Minds.

23 Gerrans, Philip. "The theory of mind module in evolutionary psychology." *Biology and Philosophy* 17.3 (2002): 305-321.

24 See Buller, D. for an excellent discussion.

25 Sperber, Dan. "In defense of massive modularity." *Language, brain and cognitive development: Essays in honor of Jacques Mehler* 47 (2001).

26 Ohman, A., Flykt, A., & Esteves, F. (in press). Emotion drives attention: Detecting the snake in the grass. *Journal of Experimental Psychology: General.*

27 Ohman and Minetka, 2003. O¨ hman, A., & Mineka, S. (2003). The malicious serpent: Snakes as a prototypical stimulus for an evolved module of fear. *Current Directions in Psychological Science, 12,* 5-9. doi:10.1111/1467-8721.01211

28 Singh, Devendra. "Adaptive significance of female physical attractiveness: role of waist-to-hip ratio." *Journal of personality and social psychology* 65.2 (1993): 293.

29 Unless sexual activity is socially costly, a topic we'll discuss in Chapter X.

30 Freese, Jeremy, and Sheri Meland. "Seven tenths incorrect: Heterogeneity and change in the waist-to-hip ratios of Playboy centerfold models and Miss America pageant winners." *Journal of Sex Research* 39.2 (2002): 133-138.

31 Sober and Wilson 19XX.

32 Hrdy, Sarah Blaffer. *Mothers and others*. Belknap Press, 2009.

33 Churchland, Patricia S. *Braintrust: What neuroscience tells us about morality*. Princeton University Press, 2011.

34 http://news.discovery.com/animals/dinosaurs/namibia-sponge-fossils-worlds-first-animals-study-120207.htm

35 Nieuwenhuys, R. 2002. "Dueterostome Brians: Synopsis and Commentary" Brain Research Bulletin 57:257-270.

36 http://www.britannica.com/EBchecked/topic/609172/tunicate/49487/Nervous-system-and-organs-of-sensation

37 Bear, M. et al. 1996. Neuroscience: Exploring the Brain.

38 DeSalle, Rob and Ian Tattersall. 2011. The Brain. New Haven: Yale University Press.

39 Finch, Caleb E., and Michael R. Rose. "Hormones and the physiological architecture of life history evolution." *Quarterly Review of Biology* (1995): 1-52.

40 Cowen, R. (1995) *History of Life* (2nd edition); Blackwell Scientific Publications.

41 Ibid.

[42] Wada, Hiroshi, et al. "Tripartite organization of the ancestral chordate brain and the antiquity of placodes: insights from ascidian Pax-2/5/8, Hox and Otx genes." *Development* 125.6 (1998): 1113-1122.

[43] Roth, Gerhard. 2013. The Long Evolution of Brains and Minds. Springer.

[44] Ibid.

[45] Ibid.

[46] Ibid.

[47] Ruben, John. "The evolution of endothermy in mammals and birds: from physiology to fossils." *Annual Review of Physiology* 57.1 (1995): 69-95.

[48] Kemp, T. S. "The origin of mammalian endothermy: a paradigm for the evolution of complex biological structure." *Zoological Journal of the Linnean Society* 147.4 (2006): 473-488.Jerison, H. J. "More on why birds and mammals have big brains." *The American Naturalist* 105.942 (1971): 185-189.

[49] Hofman, Michel A. "Evolution of brain size in neonatal and adult placental mammals: a theoretical approach." *Journal of theoretical biology* 105.2 (1983): 317-332.

[50] Panksepp, Jaak and Lucy Biven. 2011. The Archaeology of Mind. Norton.

[51] Churchland.

[52] Figures accumulated in Roth from numerous other sources.

[53] Dunbar, Robin IM. "The social brain meets neuroimaging." *Trends in cognitive sciences* 16.2 (2012): 101-102.

[54] Dunbar, Robin, and Robin Ian MacDonald Dunbar. *Grooming, gossip and the evolution of language*. Harvard University Press, 1998.

[55] Dunbar, R. I. M. "Social cognition on the Internet: testing constraints on social network size." *Philosophical Transactions of the Royal Society B: Biological Sciences* 367.1599 (2012): 2192-2201.