Chapter 3
The Last Wall to Fall

In 1755, Samuel JOHNSON wrote that his dictionary should not be expected to "change sublunary nature, and clear the world at once from folly, vanity, and affectation: 'Few people today are familiar with the lovely word sublunary, literally "below the moon." It alludes to the ancient belief in a strict division be- tween the pristine, lawful, unchanging cosmos above and our grubby, chaotic, fickle Earth below. The division was already obsolete when Johnson used the word: Newton had shown that the same force that pulled an apple toward the ground kept the moon in its celestial orbit.

Newton's theory that a single set of laws governed the motions of all objects in the universe was the first event in one of the great developments in human understanding: the unification of knowledge, which the biologist E. 0. Wilson has termed consilience. Newton's breaching of the wall between the terrestrial and the celestial was followed by a collapse of the once equally firm (and now equally forgotten) wall between the creative past and the static present. That happened when Charles Lyell showed that the Earth was sculpted in the past by forces we see today (such as earthquakes and erosion) acting over immense spans of time.

The living and nonliving, too, no longer occupy different realms. In 1628 William Harvey showed that the human body is a machine that runs by hydraulics and other mechanical principles. In 1828 Friedrich Wohler showed that the stuff of life is not a magical, pulsating gel but ordinary compounds following the laws of chemistry. Charles Darwin showed how the astonishing diversity of life and its ubiquitous signs of design could arise from the physical process of natural selection among replicators. Gregor Mendel, and then James Watson and Francis Crick, showed how replication itself could be understood in physical terms.

The unification of our understanding of life with our understanding of matter and energy was the greatest scientific achievement of the second half of the twentieth century. One of its many consequences was to pull the rug out from under social scientists like Kroeber and Lowie who had invoked the "sound scientific method" of placing the living and nonliving in parallel universes. We now know that cells did not always come from other cells and that the emergence of life did not create a second world where before there was just one. Cells evolved from simpler replicating molecules, a nonliving part of the physical world, and may be understood as collections of molecular machinery - fantastically complicated machinery, of course, but machinery nonetheless.

This leaves one wall standing in the landscape of knowledge, the one that twentieth-century social scientists guarded so jealously. It divides matter from mind, the material from the spiritual, the physical from the mental, biology from culture, nature from society, and the sciences from the social sciences, humanities, and arts. The division was built into each of the doctrines of the official theory: the blank slate given by biology versus the contents inscribed by experience and culture, the nobility of the savage in the state of nature versus the corruption of social institutions, the machine following inescapable laws versus the ghost that is free to choose and to improve the human condition.

But this wall, too, is falling. New ideas from four frontiers of knowledge - the sciences of mind, brain, genes, and evolution - are breaching the wall with a new understanding of human nature. In this chapter I will show how they are filling in the blank slate, declassing the noble savage, and exorcising the ghost in the machine. In the following chapter I will show that this new conception of human nature, connected to biology from below, can in turn be connected to the humanities and social sciences above. That new conception can give the phenomena of culture their due without segregating them into a parallel universe.

THE FIRST BRIDGE between biology and culture is the science of mind, cognitive science. The concept of mind has been perplexing for as long as people have reflected on their thoughts and feelings. The very idea has spawned paradoxes, superstitions, and bizarre theories in every period and culture. One can almost sympathize with the behaviorists and social constructionists of the first half of the twentieth century, who looked on minds as enigmas or conceptual traps that were best avoided in favor of overt behavior or the traits of a culture.

But beginning in the 1950s with the cognitive revolution, all that changed. It is now possible to make sense of mental processes and even to study them in the lab. And with a firmer grasp on the concept of mind, we can see that many tenets of the Blank Slate that once seemed appealing are now unnecessary or even incoherent. Here are **five ideas from the cognitive revolution** that have revamped how we think and talk about minds.

The first idea: The mental world can be grounded in the physical world by the concepts of *information*, *computation*, and *feedback*. A great divide between mind and matter has always seemed natural because behavior appears to have a different kind of trigger than other physical events: Ordinary events have causes, it seems, but human behavior has reasons. I once participated in a BBC television debate on whether "science can explain human behavior." Arguing against the resolution was a philosopher who asked how we might explain why someone was put in jail. Say it was for inciting racial hatred. The intention, the hatred, and even the prison, she said, cannot be described in the language of physics. There is simply no way to define "hatred" or "jail" in terms of the movements of particles. Explanations of behavior are like narratives, she argued, couched in the intentions of actors - a plane completely separate from natural science. Or take a simpler example. How might we explain why Rex just walked over to the phone? We would not say that phone-shaped stimuli caused Rex's limbs to swing in certain arcs. Rather, we might say that he wanted to speak to his friend Cecile and knew that Cecile was home. No explanation has as much predictive power as that one. If Rex was no longer on speaking terms with Cecile, or if he remembered that Cecile was out bowling that night, his body would not have risen off the couch.

For millennia the gap between physical events, on the one hand, and meaning, content, ideas, reasons, and intentions, on the other, seemed to cleave the universe in two. How can something as ethereal as "inciting hatred" or "wanting to speak to Cecile" actually cause matter to move in space? But the cognitive revolution unified the world of ideas with the world of matter using a powerful new theory: that mental life can be explained in terms of information, computation, and feedback. Beliefs and memories are collections of in-formation-like facts in a database, but residing in patterns of activity and structure in the brain. Thinking and planning are systematic transformations of these patterns, like the operation of a computer program. Wanting and trying are feedback loops, like the principle behind a thermostat: they receive in- formation about the discrepancy between a goal and the current state of the world, and then they execute operations that tend to reduce the difference. The mind is connected to the world by the sense organs, which transduce physical energy into data structures in the brain, and by motor programs, by which the brain controls the muscles.

This general idea may be called the computational theory of mind. It is not the same as the "computer metaphor" of the mind, the suggestion that the mind literally works like a human-made database, computer program, or thermostat. It says only that we can explain minds and human-made information processors using some of the same principles. It is just like other cases in which the natural world and human engineering overlap. A physiologist might invoke the same laws of optics to explain how the eye works and how a camera works without implying that the eye is like a camera in every detail.

The computational theory of mind does more than explain the existence of knowing, thinking, and trying without invoking a ghost in the machine (though that would be enough of a feat). It also explains how those processes can be intelligent - how rationality can emerge from a mindless physical process. If a sequence of transformations of information stored in a hunk of matter (such as brain tissue or silicon) mirrors a sequence of deductions that obey the laws of logic, probability, or cause and effect in the world, they will generate correct predictions about the world. And making correct predictions in pursuit of a goal is a pretty good definition of "intelligence".

Of course there is no new thing under the sun, and the computational theory of mind was foreshadowed by Hobbes when he described mental activity as tiny motions and wrote that "reasoning is but reckoning." Three and a half centuries later, science has caught up to his vision. Perception, memory, imagery, reasoning, decision making, language, and motor control are being studied in the lab and successfully modeled as computational paraphernalia such as rules, strings, matrices, pointers, lists, files, trees, arrays, loops, propositions, and networks. For example, cognitive psychologists are studying the graphics system in the head and thereby explaining how people "see" the solution to a problem in a mental image. They are studying the web of concepts in long- term memory and explaining why some facts are easier to recall than others. They are studying the processor and memory used by the language system to learn why some sentences are a pleasure to read and others a difficult slog.

And if the proof is in the computing, then the sister field of artificial intelligence is confirming that ordinary matter can perform feats that were supposedly performable by mental stuff alone. In the 1950s computers were already being called "electronic brains" because they could calculate sums, organize data, and prove theorems. Soon they could correct spelling, set type, solve equations, and simulate experts on restricted topics such as picking stocks and diagnosing diseases. For decades we psychologists preserved human bragging rights by telling our classes that no computer could read text, decipher speech, or recognize faces, but these boasts are obsolete. Today software that can recognize printed letters and spoken words comes packaged with home computers. Rudimentary programs that understand or translate sentences are available in many search engines and Help programs, and they are steadily improving. Face-recognition systems have advanced to the point that civil libertarians are concerned about possible abuse when they are used with security cameras in public places.

Human chauvinists can still write off these low-level feats. Sure, they say, the input and output processing can be fobbed off onto computational modules, but you still need a human user with the capacity for judgment, reflection, and creativity. But according to the computational theory of mind, these capacities are themselves forms of information processing and can be implemented in a computational system. In 1997 an IBM computer called Deep Blue defeated the world chess champion Garry Kasparov, and unlike its predecessors, it did not just evaluate trillions of moves by brute force but was fitted with strategies that intelligently responded to patterns in the game. Newsweek called the match "The Brain's Last Stand!' Kasparov called the outcome "the end of mankind."

You might still object that chess is an artificial world with discrete moves and a clear winner, perfectly suited to the rule-crunching of a computer. People, on the other hand, live in a messy world offering unlimited moves and nebulous goals. Surely this requires human creativity and intuition - which is why everyone knows that computers will never compose a symphony, write a story, or paint a picture. But everyone may be wrong. Recent artificial intelligence systems have written credible short stories, composed convincing Mozart-like symphonies, drawn appealing pictures of people and landscapes, and conceived clever ideas for advertisements.

None of this is to say that the brain works like a digital computer, that artificial intelligence will ever duplicate the human mind, or that computers are conscious in the sense of having first-person subjective experience. But it does suggest that reasoning, intelligence, imagination, and creativity are forms of information processing, a well-understood physical process. Cognitive science, with the help of the computational theory of mind, has exorcised at least one ghost from the machine.

A second idea: **The mind cannot be a blank slate, because blank slates don't do anything.** As long as people had only the haziest concept of what a mind was or how it might work, the metaphor of a blank slate inscribed by the environment did not seem too outrageous. But as soon as one starts to think seriously about what kind of computation enables a system to see, think, speak, and plan, the problem with blank slates becomes all too obvious: they don't do anything. The inscriptions will sit there forever unless something notices patterns in them, combines them with patterns learned at other times, uses the combinations to scribble new thoughts onto the slate, and reads the results to guide behavior toward goals. Locke recognized this problem and alluded to something called "the understanding' which looked at the inscriptions on the white paper and carried out the recognizing, reflecting, and associating. But of course explaining how the mind understands by invoking something called "the understanding" is circular.

This argument against the Blank Slate was stated pithily by Gottfried Wilhelm Leibniz (1646-1716) in a reply to Locke. Leibniz repeated the empiricist motto "There is nothing in the intellect that was not first in the senses:' then added, "except the intellect itself": Something in the mind must be innate, if it is only the mechanisms that do the learning. Something has to see a world of objects rather than a kaleidoscope of shimmering pixels. Something has to infer the content of a sentence rather than parrot back the exact wording.

Something has to interpret other people's behavior as their attempts to achieve goals rather than as trajectories of jerking arms and legs.

In the spirit of Locke, one could attribute these feats to an abstract noun-perhaps not to "the understanding" but to "learning," "intelligence;' "plasticity;' or "adaptiveness." But as Leibniz remarked, to do so is to "[save appearances] by fabricating faculties or occult qualities, . . . and fancying them to be like little demons or imps which can without ado perform whatever is wanted, as though pocket watches told the time by a certain horological faculty without needing wheels, or as though mills crushed grain by a fractive faculty without needing anything in the way of millstones:' 9 Leibniz, like Hobbes (who had influenced him), was ahead of his time in recognizing that intelligence is a form of information processing and needs complex machinery to carry it out. As we now know, computers don't understand speech or recognize text as they roll off the assembly line; someone has to install the right software first. The same is likely to be true of the far more demanding performance of the human being. Cognitive modelers have found that mundane challenges like walking around furniture, understanding a sentence, recalling a fact, or guessing someone's intentions are formidable engineering problems that are at or beyond the frontiers of artificial intelligence. The suggestion that they can be solved by a lump of Silly Putty that is passively molded by something called "culture" just doesn't cut the mustard.

This is not to say that cognitive scientists have put the nature-nurture debate completely behind them; they are still spread out along a continuum of opinion on how much standard equipment comes with the human mind. At one end are the philosopher Jerry Fodor, who has suggested that all concepts might be innate (even "doorknob" and "tweezers"), and the linguist Noam Chomsky, who believes that the word " learning" is misleading and we should say that children "grow" language instead. At the other end are the connectionists, including Rumelhart, McClelland, Jeffrey Elman, and Elizabeth Bates, who build relatively simple computer models and train the living daylights out of them. Fans locate the first extreme, which originated at the Massachusetts Institute of Technology, at the East Pole, the mythical place from which all directions are west. They locate the second extreme, which originated at the University of California, San Diego, at the West Pole, the mythical place from which all directions are east. (The names were suggested by Fodor during an MIT seminar at which he was fulminating against a "West Coast theorist" and someone pointed out that the theorist worked at Yale, which is, technically, on the East Coast.)

But here is why the East Pole-West Pole debate is different from the ones that preoccupied philosophers for millennia: neither side believes in the Blank Slate. Everyone acknowledges that there can be no learning without innate circuitry to do the learning. In their West Pole manifesto Rethinking Innateness, Bates and Elman and their coauthors cheerfully concede this point: "No learning rule can be entirely devoid of theoretical content nor can the tabula ever be completely rasa. They explain:

> There is a widespread belief that connectionist models (and modelers) are committed to an extreme form of empiricism; and that any form of innate knowledge is to be avoided like the plague....We obviously do not subscribe to this point of view....There are good reasons to believe that some kinds of prior constraints [on learning models] are necessary. In fact, all connectionist models necessarily make some assumptions which must be regarded as constituting innate constraints.

The disagreements between the two poles, though significant, are over the details: how many innate learning networks there are, and how specifically engineered they are for particular jobs. (We will explore some of these disagreements in Chapter 5.)

A third idea: An infinite range of behavior can be generated by finite combinatorial programs in the mind. Cognitive science has undermined the Blank Slate and the Ghost in the Machine in another way. People can be forgiven for scoffing at the suggestion that human behavior is "in the genes" or "a product of evolution" in the senses familiar from the animal world. Human acts are not selected from a repertoire of knee-jerk reactions like a fish attacking a red spot or a hen sitting on eggs. Instead, people may worship goddesses, auction kitsch on the Internet, play air guitar, fast to atone for past sins, build forts out of lawn chairs, and so on, seemingly without limit. A glance at National Geographic shows that even the strangest acts in our own culture do not exhaust what our species is capable of. If anything goes, one might think, then perhaps we are Silly Putty, or unconstrained agents, after all.

But that impression has been made obsolete by the computational approach to the mind, which was barely conceivable in the era in which the Blank Slate arose. The clearest example is the Chomskyan revolution in language. Language is the epitome of creative and variable behavior. Most utterances are brand-new combinations of words, never before uttered in the history of humankind. We are nothing like Tickle Me Elmo dolls who have a fixed list of verbal responses hard-wired in. But, Chomsky pointed out, for all its open-endedness language is not a free-for-all; it obeys rules and patterns. An English speaker can utter unprecedented strings of words such as *Every day new universes come into existence*, or *He likes his toast with cream cheese and ketchup*, or *My car has been eaten by wolverines*. But no one would say *Car my been eaten has wolverines by* or most of the other possible orderings of English words. Something in the head must be capable of generating not just any combinations of words but highly systematic ones.

That something is a kind of software, a generative grammar that can crank out new arrangements of words. A battery of rules such as "An English sentence contains a subject and a predicate; A predicate contains a verb, an object, and a complement," and "The subject of eat is the eater" can explain the boundless creativity of a human talker. With a few thousand nouns that can fill the subject slot and a few thousand verbs that can fill the predicate slot, one al- ready has several million ways to open a sentence. The possible combinations quickly multiply out to unimaginably large numbers. Indeed, the repertoire of sentences is theoretically infinite, because the rules of language use a trick called recursion. A recursive rule allows a phrase to contain an example of it- self, as in She thinks that he thinks that they think that he knows and so on, ad infinitum. And if the number of sentences is infinite, the number of possible thoughts and intentions is infinite too, because virtually every sentence ex- presses a different thought or intention. The combinatorial grammar for language meshes with other combinatorial programs in the head for thoughts and intentions. A fixed collection of machinery in the mind can generate an infinite range of behavior by the muscles.

Once one starts to think about mental software instead of physical behavior, the radical differences among human cultures become far smaller, and that leads to a **fourth new idea**: **Universal mental mechanisms can underlie superficial variation across cultures**. Again, we can use language as a paradigm case of the open-endedness of behavior. Humans speak some six thousand mutually unintelligible languages. Nonetheless, the grammatical programs in their minds differ far less than the actual speech coming out of their mouths. We have known for a long time that all human languages can convey the same kinds of ideas. The Bible has been translated into hundreds of non-Western languages, and during World War II the U.S. Marine Corps conveyed secret messages across the Pacific by having Navajo Indians translate them to and from their native language. The fact that any language can be used to convey any proposition, from theological parables to military directives, suggests that all languages are cut from the same cloth.

Chomsky proposed that the generative grammars of individual languages are variations on a single pattern, which he called Universal Grammar. For example, in English the verb comes before the object (drink beer) and the preposition comes before the noun phrase (from the bottle). In Japanese the object comes before the verb (beer drink) and the noun phrase comes before the preposition, or, more accurately, the postposition (the bottle from). But it is a significant discovery that both languages have verbs, objects, and pre- or post-positions to start with, as opposed to having the countless other conceivable kinds of apparatus that could power a communication system. And it is even more significant that unrelated languages build their phrases by assembling a head (such as a verb or preposition) and a complement (such as a noun phrase) and assigning a consistent order to the two. In English the head comes first; in Japanese the head comes last. But everything else about the structure of phrases in the two languages is pretty much the same. And so it goes with phrase after phrase and language after language. The common kinds of heads and complements can be ordered in 128 logically possible ways, but 95 percent of the world's languages use one of two: either the English ordering or its mirror image the Japanese ordering. A simple way to capture this uniformity is to say that all languages have the same grammar except for a parameter or switch that can be flipped to either the "head-first" or "head-last" setting. The linguist Mark Baker has recently summarized about a dozen of these parameters, which succinctly capture most of the known variation among the languages of the world.

Distilling the variation from the universal patterns is not just a way to tidy up a set of messy data. It can also provide clues about the innate circuitry that makes learning possible. If the universal part of a rule is embodied in the neural circuitry that guides babies when they first learn language, it could explain how children learn language so easily and uniformly and without the benefit of instruction. Rather than treating the sound coming out of Mom's mouth as just an interesting noise to mimic verbatim or to slice and dice in arbitrary ways, the baby listens for heads and complements, pays attention to how they are ordered, and builds a grammatical system consistent with that ordering.

This idea can make sense of other kinds of variability across cultures. Many anthropologists sympathetic to social constructionism have claimed that emotions familiar to us, like anger, are absent from some cultures. (A few anthropologists say there are cultures with no emotions at all!) For example, Catherine Lutz wrote that the Ifaluk (a Micronesian people) do not experience our "anger" but instead undergo an experience they call *song*. Song is a state of dudgeon triggered by a moral infraction such as breaking a taboo or acting in a cocky manner. It licenses one to shun, frown at, threaten, or gossip about the offender, though not to attack him physically. The target of song experiences another emotion allegedly unknown to Westerners: *metagu*, a state of dread that impels him to appease the *song*ful one by apologizing, paying a fine, or offering a gift.

The philosophers Ron Mallon and Stephen Stich, inspired by Chomsky and other cognitive scientists, point out that the issue of whether to call Ifaluk song and Western anger the same emotion or different emotions is a quibble about the meaning of emotion words: whether they should be defined in terms of surface behavior or underlying mental computation. If an emotion is defined by behavior, then emotions certainly do differ across cultures. The Ifaluk react emotionally to a woman working in the taro gardens while menstruating or to a man entering a birthing house, and we do not. We react emotionally to someone shouting a racial epithet or raising the middle finger, but as far as we know, the Ifaluk do not. But if an emotion is defined by mental mechanisms - what psychologists like Paul Ekman and Richard Lazarus call "affect programs" or "if-then formulas" (note the computational vocabulary) - we and the Ifaluk are not so different after all. We might all be equipped with a program that responds to an affront to our interests or our dignity with an unpleasant burning feeling that motivates us to punish or to exact compensation. But what counts as an affront, whether we feel it is permissible to glower in a particular setting, and what kinds of retribution we think we are entitled to, depend on our culture. The stimuli and responses may differ, but the mental states are the same, whether or not they are perfectly labeled by words in our language.

And as in the case of language, without some innate mechanism for mental computation, there would be no way to learn the parts of a culture that do have to be learned. It is no coincidence that the situations that provoke *song* among the Ifaluk include violating a taboo, being lazy or disrespectful, and refusing to share, but do not include respecting a taboo, being kind and deferential, and standing on one's head. The Ifaluk construe the first three as similar because they evoke the same affect program - they are perceived as affronts. That makes it easier to learn that they call for the same reaction and makes it more likely that those three would be lumped together as the acceptable triggers for a single emotion.

The moral, then, is that familiar categories of behavior - marriage customs, food taboos, folk superstitions, and so on - certainly do vary across cultures and have to be learned, but the deeper mechanisms of mental computation that generate them may be universal and innate. People may dress differently, but they may all strive to flaunt their status via their appearance. They may respect the rights of the members of their clan exclusively or they may extend that respect to everyone in their tribe, nation-state, or species, but all divide the world into an in-group and an out-group. They may differ in which outcomes they attribute to the intentions of conscious beings, some allowing only that artifacts are deliberately crafted, others believing that illnesses come from magical spells cast by enemies, still others believing that the entire world was brought into being by a creator. But all of them explain certain events by invoking the existence of entities with minds that strive to bring about goals. The behaviorists got it backwards: it is the mind, not behavior that is lawful.

A **fifth** idea: **The mind is a complex system composed of many interacting parts.** The psychologists who study emotions in different cultures have made another important discovery. Candid facial expressions appear to be the same everywhere, but people in some cultures learn to keep a poker face in polite company. A simple explanation is that the affect programs fire up facial expressions in the same way in all people, but a separate system of "display rules" governs when they can be shown.

The difference between these two mechanisms underscores another insight of the cognitive revolution. Before the revolution, commentators invoked enormous black boxes such as "the intellect" or "the understanding;' and they made sweeping pronouncements about human nature, such as that we are essentially noble or essentially nasty. But we now know that the mind is not a homogeneous orb invested with unitary powers or across-the-board traits. The mind is modular, with many parts cooperating to generate a train of thought or an organized action. It has distinct information-processing systems for filtering out distractions, learning skills, controlling the body, remembering facts, holding information temporarily, and storing and executing rules. Cutting across these data – processing systems are mental faculties (sometimes called multiple intelligences) dedicated to different kinds of content, such as language, number, space, tools, and living things. Cognitive scientists at the East Pole suspect that the content-based modules are differentiated largely by the genes; those at the West Pole suspect they begin as small innate biases in attention and then coagulate out of statistical patterns in the sensory input. But those at both poles agree that the brain is not a uniform meatloaf. Still another layer of information-processing systems can be found in the affect programs, that is, the systems for motivation and emotion.

The upshot is that an urge or habit coming out of one module can be translated into behavior in different ways – or suppressed altogether - by some other module. To take a simple example, cognitive psychologists believe that a module called the "habit system" underlies our tendency to produce certain responses habitually, such as responding to a printed word by pronouncing it silently. But another module, called the "supervisory attention system;' can override it and focus on the information relevant to a stated problem, such as naming the color of the ink the word is printed in, or thinking up an action that goes with the word. More generally, the interplay of mental systems can explain how people can entertain revenge fantasies that they never act on, or can commit adultery only in their hearts. In this way the theory of human nature coming out of the cognitive revolution has more in common with the Judea-Christian theory of human nature, and with the psychoanalytic theory proposed by Sigmund Freud, than with behaviorism, social constructionism, and other versions of the Blank Slate. Behavior is not just emitted or elicited, nor does it come directly out of culture or society. It comes from an internal struggle among mental modules with differing agendas and goals.

The idea from the cognitive revolution that the mind is a system of universal, generative computational modules obliterates the way that debates on human nature have been framed for centuries. It is now simply misguided to ask whether humans are flexible or programmed, whether behavior is universal or varies across cultures, whether acts are learned or innate, whether we are essentially good or essentially evil. Humans behave flexibly because they are programmed: their minds are packed with combinatorial software that can generate an unlimited set of thoughts and behavior. Behavior may vary across cultures, but the design of the mental programs that generate it need not vary. Intelligent behavior is learned successfully because we have innate systems that do the learning. And all people may have good and evil motives, but not everyone may translate them into behavior in the same way.

THE SECOND BRIDGE between mind and matter is neuroscience, especially cognitive neuroscience, the study of how cognition and emotion are implemented in the brain. Francis Crick wrote a book about the brain called The Astonishing Hypothesis, alluding to the idea that all our thoughts and feelings, joys and aches, dreams and wishes consist in the physiological activity of the brain. Jaded neuroscientists, who take the idea for granted, snickered at the title, but Crick was right: the hypothesis is astonishing to most people the first time they stop to ponder it. Who cannot sympathize with the imprisoned Dmitri Karamazov as he tries to make sense of what he has just learned from a visiting academic?

> Imagine: inside, in the nerves, in the head- that is, these nerves are there in the brain ... (damn them!) there are sort of little tails, the little tails of those nerves, and as soon as they begin quivering ... that is, you see, I look at something with my eyes and then they begin quivering, those little tails ... and when they quiver, then an image appears ... it doesn't appear at once, but an instant, a second, passes ... and then something like a moment appears; that is, not a moment--devil take the moment!-but an image; that is, an object, or an action, damn it! That's why I see and then think, because of those tails, not at all because I've got a soul, and that I am some sort of image and likeness. All that is nonsense! Rakitin explained it all to me yesterday, brother, and it simply bowled me over. It's magnificent, Alyosha, this science! A new man's arising - that I understand. . . . And yet, I am sorry to lose God!

Dostoevsky's prescience is itself astonishing, because in 1880 only the rudiments of neural functioning were understood, and a reasonable person could have doubted that all experience arises from quivering nerve tails. But no longer. One can say that the information-processing activity of the brain causes the mind, or one can say that it is the mind, but in either case the evidence is overwhelming that every aspect of our mental lives depends entirely on physiological events in the tissues of the brain.

When a surgeon sends an electrical current into the brain, the person can have a vivid, lifelike experience. When chemicals seep into the brain, they can alter the person's perception, mood, personality, and reasoning. When a patch of brain tissue dies, a part of the mind can disappear: a neurological patient may lose the ability to name tools, recognize faces, anticipate the outcome of his behavior, empathize with others, or keep in mind a region of space or of his own body. (Descartes was thus wrong when he said that "the mind is entirely indivisible" and concluded that it must be completely different from the body.) Every emotion and thought gives off physical signals, and the new technologies for detecting them are so accurate that they can literally read a person's mind and tell a cognitive neuroscientist whether the person is imagining a face or a place. Neuroscientists can knock a gene out of a mouse (a gene also found in humans) and prevent the mouse from learning, or insert extra copies and make the mouse learn faster. Under the microscope, brain tissue shows a staggering complexity - a hundred billion neurons connected by a hundred trillion synapses - that is commensurate with the staggering complexity of human thought and experience. Neural network modelers have begun to show how the building blocks of mental computation, such as storing and retrieving a pattern, can be implemented in neural circuitry. And when the brain dies, the person goes out of existence. Despite concerted efforts by Alfred Russel Wallace and other Victorian scientists, it is apparently not possible to communicate with the dead.

Educated people, of course, know that perception, cognition, language, and emotion are rooted in the brain. But it is still tempting to think of the brain as it was shown in old educational cartoons, as a control panel with gauges and levers operated by a user - the self, the soul, the ghost, the person, the "me." But cognitive neuroscience is showing that the self, too, is just another network of brain systems.

The first hint came from Phineas Gage, the nineteenth-century railroad worker familiar to generations of psychology students. Gage was using a yard- long spike to tamp explosive powder into a hole in a rock when a spark ignited the powder and sent the spike into his cheekbone, through his brain, and out the top of his skull. Phineas survived with his perception, memory, language, and motor functions intact. But in the famous understatement of a co-worker, "Gage was no longer Gage." A piece of iron had literally turned him into a different person, from courteous, responsible, and ambitious to rude, unreliable, and shiftless. It did this by impaling his ventromedial prefrontal cortex, the region of the brain above the eyes now known to be involved in reasoning about other people. Together with other areas of the prefrontal lobes and the limbic system (the seat of the emotions), it anticipates the consequences of one's actions and selects behavior consonant with one's goals.

Cognitive neuroscientists have not only exorcised the ghost but have shown that the brain does not even have a part that does exactly what the ghost is supposed to do: review all the facts and make a decision for the rest of the brain to carry out. Each of us feels that there is a single "I" in control. But that is an illusion that the brain works hard to produce, like the impression that our visual fields are rich in detail from edge to edge. In fact, we are blind to detail outside the fixation point. We quickly move our eyes to whatever looks interesting, and that fools us into thinking that the detail was there all along.) The brain does have supervisory systems in the prefrontal lobes and anterior cingulate cortex, which can push the buttons of behavior and override habits and urges. But those systems are gadgets with specific quirks and limitations; they are not implementations of the rational free agent traditionally identified with the soul or the self.

One of the most dramatic demonstrations of the illusion of the unified self comes from the neuroscientists Michael Gazzaniga and Roger Sperry, who showed that when surgeons cut the corpus callosum joining the cerebral hemispheres, they literally cut the self in two, and each hemisphere can exercise free will without the other one's advice or consent. Even more disconcertingly, the left hemisphere constantly weaves a coherent but false account of the behavior chosen without its knowledge by the right. For example, if an experimenter flashes the command "WALK" to the right hemisphere (by keeping it in the part of the visual field that only the right hemisphere can see), the person will comply with the request and begin to walk out of the room. But when the person (specifically, the person's left hemisphere) is asked why he just got up, he will say, in all sincerity, "To get a Coke"- rather than "I don't really know" or "The urge just came over me" or "You've been testing me for years since I had the surgery, and sometimes you get me to do things but I don't know exactly what you asked me to do." Similarly, if the patient's left hemi - sphere is shown a chicken and his right hemisphere is shown a snowfall, and both hemispheres have to select a picture that goes with what they see (each using a different hand), the left hemisphere picks a claw (correctly) and the right picks a shovel (also correctly). But when the left hemisphere is asked why the whole person made those choices, it blithely says, "Oh, that's simple. The chicken claw goes with the chicken, and you need a shovel to clean out the chicken shed."

The spooky part is that we have no reason to think that the baloney- generator in the patient's left hemisphere is behaving any differently from ours as we make sense of the inclinations emanating from the rest of our brains. The conscious mind-the self or soul-is a spin doctor, not the commander in chief. Sigmund Freud immodestly wrote that "humanity has in the course of time had to endure from the hands of science three great outrages upon its naive self-love": the discovery that our world is not the center of the celestial spheres but rather a speck in a vast universe, the discovery that we were not specially created but instead descended from animals, and the discovery that often our conscious minds do not control how we act but merely tell us a story about our actions. He was right about the cumulative impact, but it was cognitive neuroscience rather than psychoanalysis that conclusively delivered the third blow.

Cognitive neuroscience is undermining not just the Ghost in the Machine but also the Noble Savage. Damage to the frontal lobes does not only dull the person or subtract from his behavioral repertoire but can unleash aggressive attacks. That happens because the damaged lobes no longer serve as inhibitory brakes on parts of the limbic system, particularly a circuit that links the amygdala to the hypothalamus via a pathway called the *stria* terminalis. Connections between the frontal lobe in each hemisphere and the limbic system provide a lever by which a person's knowledge and goals can override other mechanisms, and among those mechanisms appears to be one designed to generate behavior that harms other people.

Nor is the physical structure of the brain a blank slate. In the mid-nineteenth century the neurologist Paul Broca discovered that the folds and wrinkles of the cerebral cortex do not squiggle randomly like fingerprints but have a recognizable geometry. Indeed, the arrangement is so consistent from brain to brain that each fold and wrinkle can be given a name. Since that time neuroscientists have discovered that the gross anatomy of the brain -the sizes, shapes, and connectivity of its lobes and nuclei, and the basic plan of the cerebral cortex - is largely shaped by the genes in normal prenatal development. So is the quantity of gray matter in the different regions of the brains of different people, including the regions that underlie language and reasoning.

This innate geometry and cabling can have real consequences for thinking, feeling, and behavior. As we shall see in a later chapter, babies who suffer damage to particular areas of the brain often grow up with permanent deficits in particular mental faculties. And people born with variations on the typical plan have variations in the way their minds work. According to a recent study of the brains of identical and fraternal twins, differences in the amount of gray matter in the frontal lobes are not only genetically influenced, but are significantly correlated with differences in intelligence. A study of Albert Einstein's brain revealed that he had large, unusually shaped inferior parietal lobules, which participate in spatial reasoning and intuitions about number. Gay men are likely to have a smaller third interstitial nucleus in the anterior hypothalamus, a nucleus known to have a role in sex differences. And convicted murderers and other violent, antisocial people are likely to have a smaller and less active prefrontal cortex, the part of the brain that governs decision making and inhibits impulses. These gross features of the brain are almost certainly not sculpted by information coming in from the senses, which implies that differences in intelligence, scientific genius, sexual orientation, and impulsive violence are not entirely learned.

Indeed, until recently, the innateness of brain structure was an embarrassment for neuroscience. The brain could not possibly be wired by the genes down to the last synapse, because there isn't nearly enough information in the genome to do so. And we know that people learn throughout their lives, and the products of that learning have to be stored in the brain somehow. Unless you believe in a ghost in the machine, everything a person learns has to affect some part of the brain; more accurately, learning is a change in some part of the brain. But it was difficult to find the features of the brain that reflected those changes amid all that innate structure. Becoming stronger in math or motor coordination or visual discrimination does not bulk up the brain the way becoming stronger at weightlifting bulks up the muscles.

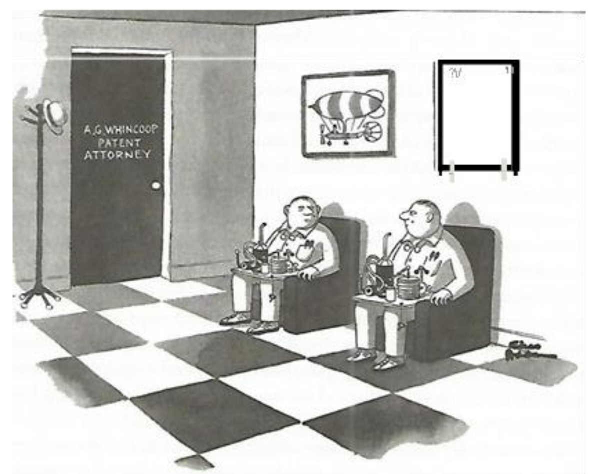
Now, at last, neuroscience is beginning to catch up with psychology by dis- covering changes in the brain that underlie learning. As we shall see, the boundaries between swatches of cortex devoted to different body parts, talents, and even physical senses can be adjusted by learning and practice. Some neuroscientists are so excited by these discoveries that they are trying to push the pendulum in the other direction, emphasizing the plasticity of the cerebral cortex. But for reasons that I will review in Chapter 5, most neuroscientists believe that these changes take place within a matrix of genetically organized structure. There is much we don't understand about how the brain is laid out in development, but we know that it is not indefinitely malleable by experience.

THE THIRD BRIDGE between the biological and the mental is behavioral genetics, the study of how genes affect behavior. All the potential for thinking, learning, and feeling that distinguishes humans from other animals lies in the information contained in the DNA of the fertilized ovum. This is most obvious when we compare species. Chimpanzees brought up in a human home do not speak, think, or act like people, and that is because of the information in the ten megabytes of DNA that differ between us. Even the two species of chimpanzee s, common chimps and bonobos, which differ in just a few tenths of one percent of their genomes, part company in their behavior, as zookeepers first discovered when they inadvertently mixed the two. Common chimps are among the most aggressive mammals known to zoology, bonobos among the most peaceable; in common chimps the males dominate the females, in bonobos the females have the upper hand; common chimps have sex for procreation, bonobos for recreation. Small differences in the genes can lead to large differences in behavior. They can affect the size and shape of the different parts of the brain, their wiring, and the nanotechnology that releases, binds, and recycles hormones and neurotransmitters.

The importance of genes in organizing the normal brain is underscored by the many ways in which nonstandard genes can give rise to nonstandard minds. When I was an undergraduate an exam question in Abnormal Psychology asked, "What is the best predictor that a person will become schizophrenic?"

The answer was, "Having an identical twin who is schizophrenic." At the time it was a trick question, because the reigning theories of schizophrenia pointed to societal stress, schizophrenogenic mothers, double binds, and other life experiences (none of which turned out to have much, if any, importance); hardly anyone thought about genes as a possible cause. But even then the evidence was there: schizophrenia is highly concordant within pairs of identical twins, who share all their DNA and most of their environment, but far less concordant within pairs of fraternal twins, who share only half their DNA (of the DNA that varies in the population) and most of their environment. The trick question could be asked - and would have the same answer - for virtually every cognitive and emotional disorder or difference ever observed. Autism, dyslexia, language delay, language impairment, learning disability, left-handedness, major depressions, bipolar illness, obsessive-compulsive disorder, sexual orientation, and many other conditions run in families, are more concordant in identical than in fraternal twins, are better predicted by people's biological relatives than by their adoptive relatives, and are poorly predicted by any measurable feature of the environment.

Genes not only push us toward exceptional conditions of mental functioning but scatter us within the normal range, producing much of the variation in ability and temperament that we notice in the people around us. The famous Chas Addams cartoon from The New Yorker is only a slight exaggeration:



Separated at birth, the Mallifert twim meet

Identical twins think and feel in such similar ways that they sometimes suspect they are linked by telepathy. When separated at birth and reunited as adults, they say they feel they have known each other all their lives. Testing confirms that identical twins, whether separated at birth or not, are eerily alike (though far from identical) in just about any trait one can measure. They are similar in verbal, mathematical, and general intelligence, in their degree of life satisfaction, and in personality traits such as introversion, agreeableness, neuroticism, conscientiousness, and openness to experience. They have similar attitudes toward controversial issues such as the death penalty, religion, and modem music. They resemble each other not just in paper-and-pencil tests but in consequential behavior such as gambling, divorcing, committing crimes, getting into accidents, and watching television. And they boast dozens of shared idiosyncrasies such as giggling incessantly, giving interminable answers to simple questions, dipping buttered toast in coffee, and - in the case of Abigail van Buren and Ann Landers - writing indistinguishable syndicated advice columns. The crags and valleys of their electroencephalograms (brain-waves) are as alike as those of a single person recorded on two occasions, and the wrinkles of their brains and distribution of gray matter across cortical areas are also similar.

The effects of differences in genes on differences in minds can be measured, and the same rough estimate - substantially greater than zero, but substantially less than 100 percent - pops out of the data no matter what measuring stick is used. Identical twins are far more similar than fraternal twins, whether they are raised apart or together; identical twins raised apart are highly similar; biological siblings, whether raised together or apart, are far more similar than adoptive siblings. Many of these conclusions come from massive studies in Scandinavian countries where governments keep huge databases on their citizens, and they employ the best-validated measuring instruments known to psychology. Skeptics have offered alternative explanations that try to push the effects of the genes to zero - they suggest that identical twins separated at birth may have been placed in similar adoptive homes, that they may have contacted each other before being tested, that they look alike and hence may have been treated alike, and that they shared a womb in addition to their genes. But as we shall see in the chapter on children, these explanations have all been tested and rejected. Recently a new kind of evidence may be piled on the heap. "Virtual twins" are the mirror image of identical twins raised apart: they are unrelated siblings, one or both adopted, who are raised together from infancy. Though they are the same age and are growing up in the same family, the psychologist Nancy Segal found that their IQ scores are barely correlated. One father in the study said that despite efforts to treat them alike, the virtual twins are "like night and day:'

Twinning and adoption are natural experiments that offer strong indirect evidence that differences in minds can come from differences in genes. Recently geneticists have pinpointed some of the genes that can cause the differences. A single wayward nucleotide in a gene called FO XP2 causes a hereditary disorder in speech and language. A gene on the same chromosome, LIM- kinasel, produces a protein found in growing neurons that helps install the faculty of spatial cognition: when the gene is deleted, the person has normal intelligence but cannot assemble objects, arrange blocks, or copy shapes. One version of the gene IGF2R is associated with high general intelligence, ac- counting for as many as four IQ points and two percent of the variation in intelligence among normal individuals. If you have a longer than average version of the D4DR dopamine receptor gene, you are more likely to be a thrill seeker, the kind of person who jumps out of airplanes, clambers up frozen waterfalls, or has sex with strangers. If you have a shorter version of a stretch of DNA that inhibits the serotonin transporter gene on chromosome 17, you are more likely to be neurotic and anxious, the kind of person who can barely function at social gatherings for fear of offending someone or acting like a fool.

Single genes with large consequences are the most dramatic examples of the effects of genes on the mind, but they are not the most representative examples. Most psychological traits are the product of many genes with small effects that are modulated by the presence of other genes, rather than the product of a single gene with a large effect that shows up come what may. That is why studies of identical twins (two people who share all their genes) consistently show powerful genetic effects on a trait even when the search for a single gene for that trait is unsuccessful.

In 2001 the complete sequence of the human genome was published, and with it came a powerful new ability to identify genes and their products, including those that are active in the brain. In the coming decade, geneticists will identify genes that differentiate us from chimpanzees, infer which of them were subject to natural selection during the millions of years our ancestors evolved into humans, identify which combinations are associated with nor- mal, abnormal, and exceptional mental abilities, and begin to trace the chain of causation in fetal development by which genes shape the brain systems that let us learn, feel, and act.

People sometimes fear that if the genes affect the mind at all they must determine it in every detail. That is wrong, for two reasons. The first is that most effects of genes are probabilistic. If one identical twin has a trait, there is usually no more than an even chance that the other will have it, despite their having a complete genome in common. Behavioral geneticists estimate that only about half of the variation in most psychological traits within a given environment correlates with the genes. In the chapter on children, we will explore what this means and where the other half of the variation comes from.

The second reason that genes aren't everything is that their effects can vary depending on the environment. A simple example may be found in any genetics textbook. While different strains of corn grown in a single field will vary in height because of their genes, a single strain of corn grown in different fields - one arid, the other irrigated - will vary in height because of the environment. A human example comes from Woody Allen. Though his fame, fortune, and ability to attract beautiful women may depend on having genes that enhance a sense of humor, in Stardust Memories he explains to an envious childhood friend that there is a crucial environmental factor as well: "We live in a society that puts a big value on jokes....If I had been an Apache Indian, those guys didn't need comedians, so I'd be out of work."

The meaning of findings in behavioral genetics for our understanding of human nature has to be worked out for each case. An aberrant gene that causes a disorder shows that the standard version of the gene is necessary to have a normal human mind. But what the standard version does is not immediately obvious. If a gear with a broken tooth goes clunk on every turn, we do not conclude that the tooth in its intact form was a clunk-suppressor. And so a gene that disrupts a mental ability need not be a defective version of a gene that is "for" that ability. It may produce a toxin that interferes with normal brain development, or it may leave a chink in the immune system that allows a pathogen to infect the brain, or it may make the person look stupid or sinister and thereby affect how other people react to him. In the past, geneticists couldn't rule out the boring possibilities (the ones that don't involve brain function directly), and skeptics intimated that all genetic effects might be boring, merely warping or defacing a blank slate rather than being an ineffective version of a gene that helps to give structure to a complex brain. But increasingly researchers are able to tie genes to the brain.

A promising example is the FOXP2 gene, associated with a speech and language disorder in a large family. The aberrant nucleotide has been found in every impaired member of the family (and in one unrelated person with the same syndrome), but it was not found in any of the unimpaired members, nor was it found in 364 chromosomes from unrelated normal people. The gene belongs to a family of genes for transcription factors - proteins that turn on other genes - that are known to play important roles in embryogenesis. The mutation disrupts the part of the protein that latches onto a particular region of DNA, the key step in turning on the right gene at the right time. The gene appears to be strongly active in fetal brain tissue, and a closely related version found in mice is active in the developing cerebral cortex. These are signs, according to the authors of the study, that the normal version of the gene triggers a cascade of events that help organize a part of the developing brain.

The meaning of genetic variation among normal individuals (as opposed to genetic defects that cause a disorder) also has to be thought through with care. An innate difference among people is not the same thing as an innate human nature that is universal across the species. Documenting the ways that people vary will not directly reveal the workings of human nature, any more than documenting the ways that automobiles vary will directly reveal how car engines work. Nonetheless, genetic variation certainly has implications for human nature. If there are many ways for a mind to vary genetically, the mind must have many genetically influenced parts and attributes that make the variation possible. Also, any modern conception of human nature that is rooted in biology (as opposed to traditional conceptions of human nature that are rooted in philosophy, religion, or common sense) must predict that the faculties making up human nature show quantitative variation, even if their fundamental design (how they work) is universal. Natural selection depends on genetic variation, and though it reduces that variation as it shapes organisms over the generations, it never uses it up completely.

Whatever their exact interpretation turns out to be, the findings of behavioral genetics are highly damaging to the Blank Slate and its companion doctrines. The slate cannot be blank if different genes can make it more or less smart, articulate, adventurous, shy, happy, conscientious, neurotic, open, introverted, giggly, spatially challenged, or likely to dip buttered toast in coffee. For genes to affect the mind in all these ways, the mind must have many parts and features for the genes to affect. Similarly, if the mutation or deletion of a gene can target a cognitive ability as specific as spatial construction or a personality trait as specific as sensation-seeking, that trait may be a distinct component of a complex psyche.

Moreover, many of the traits affected by genes are far from noble. Psychologists have discovered that our personalities differ in five major ways: we are to varying degrees introverted or extroverted, neurotic or stable, incurious or open to experience, agreeable or antagonistic, and conscientious or undirected. Most of the 18,000 adjectives for personality traits in an unabridged dictionary can be tied to one of these five dimensions, including such sins and flaws as being aimless, careless, conforming, impatient, narrow, rude, self-pitying, selfish, suspicious, uncooperative, and undependable. All five of the major personality dimensions are heritable, with perhaps 40 to 50 percent of the variation in a typical population tied to differences in their genes. The unfortunate wretch who is introverted, neurotic, narrow, selfish, and undependable is probably that way in part because of his genes, and so, most likely, are the rest of us who have tendencies in any of those directions as compared with our fellows.

It's not just unpleasant temperaments that are partly heritable, but actual behavior with real consequences. Study after study has shown that a willingness to commit antisocial acts, including lying, stealing, starting fights, and destroying property, is partly heritable (though like all heritable traits it is exercised more in some environments than in others). People who commit truly heinous acts, such as bilking elderly people out of their life savings, raping a succession of women, or shooting convenience store clerks lying on the floor during a robbery, are often diagnosed with "psychopathy" or "antisocial personality disorder.” Most psychopaths showed signs of malice from the time they were children. They bullied smaller children, tortured animals, lied habitually, and were incapable of empathy or remorse, often despite normal family backgrounds and the best efforts of their distraught parents. Most experts on psychopathy believe that it comes from a genetic predisposition, though in some cases it may come from early brain damage. In either case genetics and neuroscience are showing that a heart of darkness cannot always be blamed on parents or society.

And the genes, even if they by no means seal our fate, don't sit easily with the intuition that we are ghosts in machines either. Imagine that you are agonizing over a choice-which career to pursue, whether to get married, how to vote, what to wear that day. You have finally staggered to a decision when the phone rings. It is the identical twin you never knew you had. During the joyous conversation it comes out that she has just chosen a similar career, has decided to get married at around the same time, plans to cast her vote for the same presidential candidate, and is wearing a shirt of the same color-just as the behavioral geneticists who tracked you down would have bet. How much discretion did the "you" making the choices actually have if the outcome could have been predicted in advance, at least probabilistically, based on events that took place in your mother's Fallopian tubes decades ago?

THE FOURTH BRIDGE from biology to culture is evolutionary psychology, the study of the phylogenetic history and adaptive functions of the mind. It holds out the hope of understanding the design or purpose of the mind - not in some mystical or teleological sense, but in the sense of the simulacrum of engineering that pervades the natural world. We see these signs of engineering everywhere: in eyes that seem designed to form images, in hearts that seem de- signed to pump blood, in wings that seem designed to lift birds in flight.

Darwin showed, of course, that the illusion of design in the natural world can be explained by natural selection. Certainly an eye is too well engineered to have arisen by chance. No wart or tumor or product of a big mutation could be lucky enough to have a lens, an iris, a retina, tear ducts, and so on, all perfectly arranged to form an image. Nor is the eye a masterpiece of engineering literally fashioned by a cosmic designer who created human s in his own image. The human eye is uncannily similar to the eyes of other organisms and has quirky vestiges of extinct ancestors, such as a retina that appears to have been installed backwards. Today's organs are replicas of organs in our ancestors whose design worked better than the alternatives, thereby enabling them to become our ancestors. Natural selection is the only physical process we know of that can simulate engineering, because it is the only process, in which how well something works can play a causal role in how it came to be.

Evolution is central to the understanding of life, including human life. Like all living things, we are outcomes of natural selection; we got here because we inherited traits that allowed our ancestors to survive, find mates, and re- produce. This momentous fact explains our deepest strivings: why having a thankless child is sharper than a serpent's tooth, why it is a truth universally acknowledged that a single man in possession of a good fortune must be in want of a wife, why we do not go gentle into that good night but rage, rage against the dying of the light.

Evolution is central to understanding ourselves because signs of design in human beings do not stop at the heart or the eye. For all its exquisite engineering, an eye is useless without a brain. Its output is not the meaningless patterns of a screen saver, but raw material for circuitry that computes a representation of the external world. That representation feeds other circuits that make sense of the world by imputing causes to events and placing them in categories that allow useful predictions. And that sense-making, in turn, works in the service of motives such as hunger, fear, love, curiosity, and the pursuit of status and esteem. As I mentioned, abilities that seem effortless to us - categorizing events, deducing cause and effect, and pursuing conflicting goals-are major challenges in designing an intelligent system, ones that robot designers strive, still unsuccessfully, to duplicate.

So signs of engineering in the human mind go all the way up, and that is why psychology has always been evolutionary. Cognitive and emotional faculties have always been recognized as nonrandom, complex, and useful, and that means they must be products either of divine design or of natural selection. But until recently evolution was seldom explicitly invoked within psychology, because with many topics, folk intuitions about what is adaptive are good enough to make headway. You don't need an evolutionary biologist to tell you that depth perception keeps an animal from falling off cliffs and bumping into trees, that thirst keeps it from drying out or that it's better to remember what works and what doesn't than to be an amnesiac.

But with other aspects of our mental life, particularly in the social realm, the function of a faculty is not so easy to guess. Natural selection favors organisms that are good at reproducing in some environment. When the environment consists of rocks, grass, and snakes, it's fairly obvious which strategies work and which ones don't. But when the relevant environment consists of other members of the species evolving their own strategies, it is not so obvious. In the game of evolution, is it better to be monogamous or polygamous? Gentle or aggressive? Cooperative or selfish? Indulgent with children or stern with them? Optimistic, pragmatic, or pessimistic?

For questions like these, hunches are unhelpful, and that is why evolutionary biology has increasingly been brought into psychology. Evolutionary biologists tell us that it is a mistake to think of anything conducive to people's well-being-group cohesion, the avoidance of violence, monogamous pair bonding, aesthetic pleasure, self-esteem-as an "adaptation." What is "adaptive" in everyday life is not necessarily an "adaptation" in the technical sense of being a trait that was favored by natural selection in a species' evolutionary history. Natural selection is the morally indifferent process in which the most effective replicators outreproduce the alternatives and come to prevail in a population. The selected genes will therefore be the "selfish" ones, in Richard Dawkins's metaphor-more accurately, the megalomaniacal ones, those that make the most copies of themselves. An adaptation is anything brought about by the genes that helps them fulfill this metaphorical obsession, whether or not it also fulfills human aspirations. And this is a strikingly different conception from our everyday intuitions about what our faculties were designed for.

The megalomania of the genes does not mean that benevolence and co- operation cannot evolve, any more than the law of gravity proves that flight cannot evolve. It means only that benevolence, like flight, is a special state of affairs in need of an explanation, not something that just happens. It can evolve only in particular circumstances and has to be supported by a suite of cognitive and emotional faculties. Thus benevolence (and other social motives) must be dragged into the spotlight rather than treated as part of the furniture. In the sociobiological revolution of the 1970s, evolutionary biologists replaced the fuzzy feeling that organisms evolve to serve the greater good with deductions of what kinds of motives are likely to evolve when organisms interact with offspring, mates, siblings, friends, strangers, and adversaries.

When the predictions were combined with some basic facts about the hunter-gatherer lifestyle in which humans evolved, parts of the psyche that were previously inscrutable turned out to have a rationale as legible as those for depth perception and the regulation of thirst. An eye for beauty, for example, locks onto faces that show signs of heal1h and fertility-just as one would predict if it had evolved to help the beholder find the fittest mate. The emotions of sympathy, gratitude, guilt, and anger allow people to benefit from co- operation without being exploited by liars and cheats. A reputation for toughness and a thirst for revenge were the best defense against aggression in a world in which one could not call 911 to summon the police. Children ac- quire spoken language instinctively but written language only by the sweat of their brow, because spoken language has been a feature of human life for tens or hundreds of millennia whereas written language is a recent and slow-spreading invention.

None of this means that people literally strive to replicate their genes. If that's how the mind worked, men would line up outside sperm banks and women would pay to have their eggs harvested and given away to infertile couples. It means only that inherited systems for learning, thinking, and feeling have a design that would have led, on average, to enhanced survival and reproduction in the environment in which our ancestors evolved. People enjoy eating, and in a world without junk food, that l d them to nourish themselves, even if the nutritional content of the food never entered their minds. People love sex and love children, and in a world without contraception, that was enough for the genes to take care of themselves.

The difference between the mechanisms that impel organisms to behave in real time and the mechanisms that shaped the design of the organism over evolutionary time is important enough to merit some jargon. A proximate cause of behavior is the mechanism that pushes behavior buttons in real time, such as the hunger and lust that impel people to eat and have sex. An ultimate cause is the adaptive rationale that led the proximate cause to evolve, such as the need for nutrition and reproduction that gave us the drives of hunger and lust. The distinction between proximate and ultimate causation is indispensable in understanding ourselves because it determines the answer to every question of the form "Why did that person act as he did?" To take a simple example, ultimately people crave sex in order to reproduce (because the ultimate cause of sex is reproduction), but proximately they may do everything they can not to reproduce (because the proximate cause of sex is pleasure).

The difference between proximate and ultimate goals is another kind of proof that we are not blank slates. Whenever people strive for obvious rewards like health and happiness, which make sense both proximately and ultimately, one could plausibly suppose that the mind is equipped only with a desire to be happy and healthy and a cause-and-effect calculus that helps them get what they want. But people often have desires that subvert their proximate well- being, desires that they cannot articulate and that they (and their society) may try unsuccessfully to extirpate. They may covet their neighbor's spouse, eat themselves into an early grave, explode over minor slights, fail to love their stepchildren, rev up their bodies in response to a stress or that they cannot fight or flee, exhaust themselves keeping up with the Joneses or climbing the corporate ladder, and prefer a sexy and dangerous partner to a plain but dependable one. These personally puzzling drives have a transparent evolutionary rationale, and they suggest that the mind is packed with cravings shaped by natural selection, not with a generic desire for personal well-being.

Evolutionary psychology also explains why the slate is not blank. The mind was forged in Darwinian competition, and an inert medium would have been outperformed by rivals outfitted with high technology - with acute perceptual systems, savvy problem-solvers, cunning strategists, and sensitive feedback circuits. Worse still, if our minds were truly malleable they would be easily manipulated by our rivals, who could mold or condition us into serving their needs rather than our own. A malleable mind would quickly be selected out.

Researchers in the human sciences have begun to flesh out the hypothesis that the mind evolved with a universal complex design. Some anthropologists have returned to an ethnographic record that used to trumpet differences among cultures and have found an astonishingly detailed set of aptitudes and tastes that all cultures have in common. This shared way of thinking, feeling, and living makes us look like a single tribe, which the anthropologist Donald Brown has called the Universal People, after Chomsky's Universal Grammar. Hundreds of traits, from fear of snakes to logical operators, from romantic love to humorous insults, from poetry to food taboos, from exchange of goods to mourning the dead, can be found in every society ever documented. It's not that every universal behavior directly reflects a universal component of human nature - many arise from an interplay between universal properties of the mind, universal properties of the body, and universal properties of the world. Nonetheless, the sheer richness and detail in the rendering of the Universal People comes as a shock to any intuition that the mind is a blank slate or that cultures can vary without limit, and there is something on the list to refute almost any theory growing out of those intuitions. Nothing can substitute for seeing Brown's list in full; it is reproduced, with his permission, as an appendix (seep. 435).

The idea that natural selection has endowed humans with a universal complex mind has received support from other quarters. Child psychologists no longer believe that the world of an infant is a blooming, buzzing confusion, because they have found signs of the basic categories of mind (such as those for objects, people, and tools) in young babies. Archaeologists and paleontologists have found that prehistoric humans were not brutish troglodytes but exercised their minds with art, ritual, trade, violence, cooperation, technology, and symbols. And primatologists have shown that our hairy relatives are not like lab rats waiting to be conditioned but are outfitted with many complex faculties that used to be considered uniquely human, including concepts, a spatial sense, tool use, jealousy, parental love, reciprocity, peacemaking, and differences between the sexes.

With so many mental abilities appearing in all human cultures, in children before they have acquired culture, and in creatures that have little or no culture, the mind no longer looks like a formless lump pounded into shape by culture.

But it is the doctrine of the Noble Savage that has been most mercilessly debunked by the new evolutionary thinking. A thoroughly noble anything is an unlikely product of natural selection, because in the competition among genes for representation in the next generation, noble guys tend to finish last. Conflicts of interest are ubiquitous among living things, since two animals cannot both eat the same fish or monopolize the same mate. To the extent that social motives are adaptations that maximize copies of the genes that produced them, they should be designed to prevail in such conflicts, and one way to prevail is to neutralize the competition. As William James put it, just a bit too flamboyantly, "We, the lineal representatives of the successful enactors of one scene of slaughter after another, must, whatever more pacific virtues we may also possess, still carry about with us, ready at any moment to burst into flame, the smoldering and sinister traits of character by means of which they lived through so many massacres, harming others, but themselves unharmed."

From Rousseau to the Thanksgiving editorialist of Chapter 1, many intellectuals have embraced the image of peaceable, egalitarian, and ecology-loving natives. But in the past two decades anthropologists have gathered data on life and death in pre-state societies rather than accepting the warm and fuzzy stereotypes. What did they find? In a nutshell: Hobbes was right, Rousseau was wrong.

To begin with, the stories of tribes out there somewhere who have never heard of violence turn out to be urban legends. Margaret Mead's descriptions of peace-loving New Guineans and sexually nonchalant Samoans were based on perfunctory research and turned out to be almost perversely wrong. As the anthropologist Derek Freeman later documented, Samoans may beat or kill their daughters if they are not virgins on their wedding night, a young man who cannot woo a virgin may rape one to extort her into eloping, and the family of a cuckolded husband may attack and kill the adulterer. The Kung San of the Kalahari Desert had been described by Elizabeth Marshall Thomas as "the harmless people" in a book with that title. But as soon as anthropologists camped out long enough to accumulate data, they discovered that the Kung San have a murder rate higher than that of American inner cities. They learned as well that a group of the San had recently avenged a murder by sneaking into the killer's group and executing every man, woman, and child as they slept. But at least the Kung San exist. In the early 197Os the New York Times Magazine reported the discovery of the "gentle Tasaday" of the Philippine rainforest, a people with no words for conflict, violence, or weapons. The Tasaday turned out to be local farmers dressed in leaves for a photo opportunity so that cronies of Ferdinand Marcos could set aside their "homeland" as a preserve and enjoy exclusive mineral and logging rights.

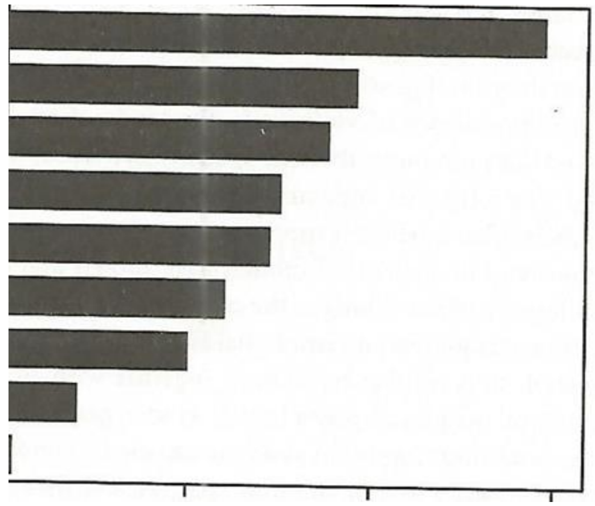
Anthropologists and historians have also been counting bodies. Many intellectuals tout the small numbers of battlefield casualties in pre-state societies as evidence that primitive warfare is largely ritualistic. They do not notice that two deaths in a band of fifty people is the equivalent of ten million deaths in a country the size of the United States. The archaeologist Lawrence Keeley has summarized the proportion of male deaths caused by war in a number of societies for which data are available:

Percentage of male deaths caused by warfare

Jivaro Yanomamo (Shamatari)
MaeEnga

Dugum Dani

Murngin Yanomamo (Namowei)
Huli Gebusi
US and Europe 20th C.



0 20 40 60
Male deaths (%)

The first eight bars, which range from almost 10 percent to almost 60 percent, come from indigenous peoples in South America and New Guinea. The nearly invisible bar at the bottom represents the United States and Europe in the twentieth century and includes the statistics from two world wars. Moreover, Keeley and others have noted that native peoples are dead serious when they carry out warfare. Many of them make weapons as damaging as their technology permits, exterminate their enemies when they can get away with it, and enhance the experience by torturing captives, cutting off trophies, and feasting on enemy flesh.

Counting societies instead of bodies leads to equally grim figures. In 1978 the anthropologist Carol Ember calculated that 90 percent of hunter-gatherer societies are known to engage in warfare, and 64 percent wage war at least once every two years. Even the 90 percent figure may be an underestimate, because anthropologists often cannot study a tribe long enough to measure outbreaks that occur every decade or so (imagine an anthropologist studying the peaceful Europeans between 1918 and 1938). In 1972, another anthropologist, W. T. Divale, investigated 99 groups of hunter-gatherers from 37 cultures, and found that 68 were at war at the time, 20 had been at war five to twenty-five years before, and all the others reported warfare in the more distant past. Based on these and other ethnographic surveys, Donald Brown includes conflict, rape, revenge, jealousy, dominance, and male coalitional violence as human universals.

It is, of course, understandable that people are squeamish about acknowledging the violence of pre-state societies. For centuries the stereotype of the savage savage was used as a pretext to wipe out indigenous peoples and steal their lands. But surely it is unnecessary to paint a false picture of a people as peaceable and ecologically conscientious in order to condemn the great crimes against them, as if genocide were wrong only when the victims are nice guys.

The prevalence of violence in the kinds of environments in which we evolved does not mean that our species has a death wish, an innate thirst for blood, or a territorial imperative. There are good evolutionary reasons for the members of an intelligent species to try to live in peace. Many computer simulations and mathematical models have shown that cooperation pays off in evolutionary terms as long as the cooperators have brains with the right combination of cognitive and emotional faculties. Thus, while conflict is a human universal, so is conflict resolution. Together with all their nasty and brutish motives, all peoples display a host of kinder, gentler ones: a sense of morality, justice, and community, an ability to anticipate consequences when choosing how to act, and a love of children, spouses, and friends. Whether a group of people will engage in violence or work for peace depends on which set of motives is engaged, a topic I will pursue at length in later chapters.

Not everyone will be comforted by such reassurances, though, because they eat away at the third cherished assumption of modern intellectual life. Love, will, and conscience are in the traditional job description for the soul and have always been placed in opposition to mere "biological" functions. If those faculties are "biological" too - that is, evolutionary adaptations implemented in the circuitry of the brain - then the ghost is left with even less to do and might as well be pensioned off for good.