JOHN TEMPLETON FOUNDATION
SUPPORTING SCIENCE~INVESTING IN THE BIG QUESTIONS

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Does evolution explain human nature?

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The John Templeton Foundation serves as a philanthropic catalyst for research on what scientists and philosophers call the Big Questions. We support work at the world's top universities in such fields as theoretical physics, cosmology, evolutionary biology, cognitive science, and social science relating to love, forgiveness, creativity, purpose, and the nature and origin of religious belief. We encourage informed, open-minded dialogue between scientists and theologians as they apply themselves to the most profound issues in their particular disciplines. And we seek to stimulate new thinking about wealth creation in the developing world, character education in schools and universities, and programs for cultivating the talents of gifted children.

The Big Question posed in these pages celebrates the bicentenary of the birth of Charles Darwin, the founding genius of modern biology. We have focused on the long-standing debate over how well the theory of evolution can explain human nature—a subject of heated contention in Darwin's day as in our own. An important new aspect of the discussion, as many of our essayists emphasize, is the transformation that evolutionary theory itself has undergone in recent decades. Researchers have concluded that natural selection helps to explain the development of a range of human emotions, behaviors, and capacities—and not just the stereotypically "selfish" ones. Evolutionary theory has become a powerful tool in trying to understand such traits as altruism, cooperation, religious belief, and moral commitment. But is it sufficient for a full understanding of these human qualities? And does evolutionary theory illuminate such intractably difficult subjects as human consciousness, free will, and spirituality?

This booklet neatly embodies the approach that we take to the Big Questions across all of the Foundation's areas of interest. The contributors are distinguished scientists and scholars, they address a perennial

and much-disputed subject, and they bring to bear—in civil, elegant prose—a range of different perspectives. By assembling this "conversation" and inviting the public to join in, we intend to spark a discussion that transcends the familiar positions usually found in such debates. We aim to turn discourse on the Big Questions in a more thoughtful, considered direction. It is our hope that this booklet will be a lasting resource for students, teachers, parents, political leaders, scientists, clergy, and anyone else engaged with the great issues of human nature and purpose. Additional copies of the booklet can be ordered by writing to bigquestions@templeton.org.

Four previous conversations on Big Questions at the core of the Foundation's mandate may also be of interest to readers. They can be found online at the following addresses:

Does the universe have a purpose?
www.templeton.org/purpose

Will money solve Africa's development problems?
www.templeton.org/africa

Does science make belief in God obsolete?
www.templeton.org/belief

Does the free market corrode moral character?
www.templeton.org/market

Frans de Waal

Obviously, says the monkey.

Frans de Waal is C.H. Candler Professor of Psychology at Emory University and conducts research at the Yerkes National Primate Research Center. His popular books include Chimpanzee Politics, Our Inner Ape, *and* The Age of Empathy, *which will be published this fall.*

Human nature simply cannot be understood in isolation from the rest of nature. This evolutionary approach is already difficult for many people to accept, but it is likely to generate even more resistance once its implications are fully grasped. After all, the idea that we descend from long-armed, hairy creatures is only half the message of evolutionary theory. The other half is continuity with all other life forms. We are animals not only in body but also in mind. This idea may prove harder to swallow.

We are so convinced that humans are the only intelligent life on earth that we search for other intelligent beings in distant galaxies. We also never seem to run out of claims about what sets us apart, even though scientific progress forces us to adjust these claims every couple of years. That is why we do not hear any more that only humans make tools, imitate each other, have culture, think ahead, are self-aware, or adopt another's point of view. It is the rare claim of human uniqueness that holds up for more than a decade.

If we look at our species without letting ourselves be blinded by the technological advances of the last few millennia, we see a creature of flesh and blood with a brain that, albeit three times larger than that of a chimpanzee, does not contain any new parts. Our intellect may be superior, but we have no basic wants or needs that cannot also be observed in our close relatives. I interact daily with chimpanzees and bonobos, which are known as anthropoids precisely because of their human-like characteristics. Like us, they strive for power, enjoy sex, want security and affection, kill over territory, and value trust and cooperation. Yes, we use cell phones and fly airplanes, but our psychological make-up remains that of a social primate.

To explain human behavior as a "mere" product of evolution, however, is often seen as insulting and a threat to morality, as if such a view would absolve us from the obligation to lead virtuous lives. The geneticist Francis Collins sees the "moral law" as proof that God exists. Conversely, I have heard people echo Dostoevsky's Ivan Karamazov, exclaiming that "If there is no God, I am free to rape my neighbor!"

Perhaps it is just me, but I am wary of anyone whose belief system is the only thing standing between them and repulsive behavior. Why not assume that our humanity, including the self-control needed to form a livable society, is built into us? Does anyone truly believe that our ancestors lacked rules of right and wrong before they had religion? Did they never assist others in need or complain about an unfair share? Human morality must be quite a bit older than religion and civilization. It may, in fact, be older than humanity itself. Other primates live in highly structured cooperative groups in which rules and inhibitions apply and mutual aid is a daily occurrence.

Even without claiming other primates as moral beings, it is not hard to recognize the pillars of morality in their behavior. These are summed up in our golden rule, which transcends the world's cultures and religions. "Do unto others as you would have them do unto you" brings together empathy (attention to the feelings of others) and reciprocity (if others follow the same rule, you will be treated well, too). Human morality could not exist without empathy and reciprocity, tendencies that have been found in our fellow primates.

After one chimpanzee has been attacked by another, for example, a bystander will go over to gently embrace the victim until he or she stops yelping. The tendency to console is so strong that Nadia Kohts, a Russian scientist who raised a juvenile chimpanzee a century ago, said that when her charge escaped to the roof of the house, there was only one way to get him down. Holding out food would not do the trick; the only way would be for her to sit down and sob, as if she were in pain. The young ape would rush down from the roof to put his arm around her. The empathy of our closest evolutionary relatives exceeds even their desire for bananas.

Reciprocity, on the other hand, is visible when chimpanzees share food specifically with those who have recently groomed them or supported them in power struggles. Sex is often part of the mix. Wild males have been observed to take great risks raiding papaya plantations, returning to share the delicious fruit with fertile females in exchange for copulation. Chimps know how to strike a deal.

We never seem to doubt that there is continuity between humans and other animals with respect to negative behavior, but we prefer to claim noble traits exclusively for ourselves.

Our primate relatives also exhibit pro-social tendencies and a sense of fairness. In experiments, chimpanzees voluntarily open a door to give a companion access to food, and capuchin monkeys seek rewards for others even if they themselves gain nothing from it. Perhaps helping others is self-rewarding in the same way that humans feel good doing good. In other studies, primates will happily perform a task for cucumber slices until they see others being rewarded with grapes, which taste so much better. They become agitated, throw down their measly cucumbers, and go on strike. A perfectly fine vegetable has become unpalatable! I think of their reaction whenever I hear criticism of the extravagant bonuses on Wall Street.

These primates show hints of a moral order, and yet most people still prefer to view nature as "red in tooth and claw." We never seem to doubt that there is continuity between humans and other animals with respect to negative behavior—when humans maim and kill each other, we are quick to call them "animals"—but we prefer to claim noble traits exclusively for ourselves. When it comes to the study of human nature, this is a losing strategy, however, because it excludes about half of our background. Short of appealing to divine intervention as an explanation, this more attractive half is also the product of evolution, a view now increasingly supported by animal research.

This insight hardly subtracts from human dignity. To the contrary, what could be more dignified than primates who use their natural gifts to build a humane society?

Simon Conway Morris

Except where it matters.

Simon Conway Morris is a professor of evolutionary paleobiology at the University of Cambridge and a Fellow of St. John's College. Elected to the Royal Society in 1990, he is the author, most recently, of Life's Solution: Inevitable Humans in a Lonely Universe.

As I write this essay, my fingers hold a pen and my eyes scan the page—fingers that have evolved from fins, eyes that have developed from little more than pigmented spots. We may walk tall, but we cast a long evolutionary shadow. At the same time, my ears are distracted by bird-song from the yard outside. But why should I bother to waste my time listening to the birds? Why, indeed, should I be interested if three separate families of birds—songbirds, parrots, and hummingbirds—all evolved song independently, and why should I care that the manner in which some birds learn to sing is strikingly similar to the way that language emerges from babble in children?

The answer is that I am naturally curious and also that I appreciate beauty. The evolution of bird-song is not only a striking example of evolutionary convergence—that is, of unrelated organisms arriving at very much the same biological solution—but it has a much wider importance. It is an indication that at least some outcomes of the Darwinian process are more likely than others and, in some cases perhaps, are actually inevitable. The capacity for song points to even more striking similarities between birds and mammals in terms of overall cognitive capacity, not least with respect to play and the manufacture of tools. All

of these developments have occurred independently and by the process of evolution.

So why quibble with the standard Darwinian formulation? Is it not obvious that the roots of human behavior and cultural sophistication lie in the rich loam of our evolutionary past? We are but a hair's breadth from our animal cousins. Such is evident in terms of their cognitive world (which many believe encompasses, at least in apes and some birds, a theory of mind), their capacity for self-recognition in mirrors, and the glimmerings among them not just of culture and its transmission but of crafted tools and even traits of personality. So what is the problem?

At one level, there is none. It would be strange if my fingers and eyes were to have an evolutionary origin but not my capacity to speak, to empathize, and even to deal with simple abstractions like numbers. And yet, though we may be just a hair's breadth away from a chimp—not to mention a crow, a dolphin, an elephant, and even an octopus—we humans are still utterly and stupendously different. A seamless extrapolation from one species to another? That is what Darwin proposed, but pinning down how the glaring gaps—most obviously, language—were actually bridged remains almost entirely obscure.

Should we look, then, to human exceptionalism, to a freak mutation that suddenly propelled us into new worlds? It is possible, of course, but there is not a shred of evidence for it. Could it just be an illusion? Perhaps we think we are different, but the animals themselves know better. Is that credible? Not really. So profound is the gulf between us and the chimps that they might as well live in the Andromeda galaxy. Have you seen a chimp make a fire, let alone go to the library?

The late David Stove, an Australian philosopher, wrote a wonderful book entitled *Darwinian Fairytales*. How dare anybody use a word like "fairytale" in the same breath as the venerated Darwin? (See how the cage housing the ultra-Darwinists rocks and shudders, the occupants hurling themselves against the bars with cries of outrage.) But Stove was emphatically not a creationist or even a theist, let alone a Christian. And he had no quarrel with evolution. For him, the question was not

where we came from but who we are now. In a piercing critique, he dismantled the Darwinian pieties purporting to show why we are so extraordinarily altruistic (not to mention our love of animals), demolished the absurdities of genetic determinism, exploded the naiveties of sociobiology, and laid waste the myth that we are "just another species."

But how did we come to be so different, in fact, so very odd? I would propose a radical alternative. We live in a world riddled with symbols and symbolic expression—a place where people kill for principle or engage in reckless altruism, where thousands cheer their teams while others choose monastic isolation. Our societies buzz with chatter, friendship, and laughter, but they are also haunted by terrible, reflective silences, echoing back through history for hundreds of years.

The world of myth is not just a set of superior fairy stories but rather an attempt to use language to describe our cosmic engagement. Is all this striving after ultimate meaning a massive delusion?

Somehow we have intuited the ineffable, matters that defy precise description but still resonate at the deepest levels. The world of myth is not just a set of superior fairy stories but rather an attempt to use language to describe our cosmic engagement. Is all this striving after ultimate meaning a massive delusion, a gigantic wish-fulfillment? Is this what happens when the brain gets too big: the puzzled and frightened ape stumbles across comprehension and just as suddenly realizes that his existence is entirely meaningless? Could our symbol-rich world be of interest only to a pitiless nihilist? I do not think so.

Suppose that the moral structure, the ethical voice, the heart-wrenching aesthetic, the haunting intuition that certain places are holy, the endless yearning for a world made good are not the fantasies of a deracinated ape but rather are signposts to deep realities in which our destiny may be involved. Suppose that evolution is like a search engine, always seeking the best solution. From this perspective, it is hardly surprising that scattered across the evolutionary landscape, among the

grunts and howls, the dawning intelligence and the scarcely articulated emotions, we do indeed see the flickerings of ourselves.

The real question of how we came to be who we are does not revolve around a process of creeping Darwinian emergence, whereby the various components drifted together into a human whole with distinctive and (let us be honest) very odd powers all of its own. Rather it is a true story of discovery, of first detecting and then entering and finally enjoying entirely new worlds that were waiting for us all the time. We could not have arrived where we are except by evolution, and this is where we need to be. As rational creatures we now not only know evolution but we know how to transcend it.

Lynn Margulis

Quite well.

Lynn Margulis is Distinguished University Professor in the Department of Geosciences at the University of Massachusetts-Amherst and, currently, the Eastman Professor at Balliol College, Oxford. A member of the National Academy of Sciences, she is the author of, among other books, Acquiring Genomes *and* Dazzle Gradually *(both with Dorion Sagan).*

Ever since Bishop Wilberforce asked, in a debate with Thomas Huxley, whether it was from his grandmother or grandfather that he claimed descent from a monkey, the sufficiency of evolutionary theory to explain humanity's spiritual and moral qualities has been in question. Then, as now, the evolution of humans was a touchy subject, and after the publication of *On the Origin of Species*, Darwin devoted a separate work, *The Descent of Man*, to untangling how evolutionary understanding could be applied to humans and their special traits.

Since his account of "descent with modification" leaned heavily on natural selection of the *individual*, Darwin wondered how moral behaviors — which focus on others — evolved. When lying, cheating, manipulation, greed, and other less than admirable qualities seemed to benefit those individuals who practiced them, how could their opposites evolve? Pointing out that he "who was ready to sacrifice his life … would often leave no offspring to inherit his noble nature," Darwin pondered how members of a tribe became endowed with moral attributes.

His simple answers still apply. One who aids his fellows commonly receives aid in return. Darwin called this a "low motive" because it is

self-regarding. So-called reciprocal altruism — I'll carry your baby if you take my son on the hunt tomorrow at dawn — is operative in species whose members are capable of recognizing each others' faces. More important is the praise we love and the blame we dread, instincts that help bind tribe members who work together. Reciprocal acts of kindness and aid underlie families, tribes, and religious groups; they ensure survival and reproduction as "naturally selected" perpetuating, living entities.

Our human sort of mutual care, along with the strong feeling of life we have in the presence of sexual partners, family, friends, colleagues, classmates, and fellow citizens (in short, in the company of meaningful others), necessitates frequent communication: symbols, language, music, teaching, learning, etc. Do these activities fundamentally distinguish us from the non-human life forms with whom we share the planet and upon whom we depend for our survival? I doubt it.

This may sound inadequate to true believers in human uniqueness, especially on religious grounds. But religion serves an obvious evolutionary function: it identifies, unifies, and preserves adherents. Admonitions to desist from the seven deadly sins inhibit behaviors that threaten group solidarity and survival. Greed, for example, privileges the individual in seasons of limited resources. Lust — the biblical coveting of the neighbor's wife (in its male-centered perspective) — interferes with ideals for the nurture of healthy children and effective warriors. Prohibiting sloth enhances productive work intrinsic to survival and reproduction of the social unit. Anger, perhaps useful in battle, destroys family and other social relationships. Envy and pride promote individual interests above those of the larger social unit. The survival value of prohibiting sin seems obvious.

By contrast, "love thy neighbor," interpreted from an evolutionary point of view, is an algorithm for social connectedness. The touted virtues of chastity, moderation, compassion, diligence, patience, moral commitment, and humility provide touchstones for effective group action. The intellectual historian Karen Armstrong, a former nun and the author of books on Christianity, Judaism, and Islam, argues that compassion is the crucial

link among the major religions. The golden rule of Jesus, Confucius, and others is that we should not do to others what we would not want them to do to us. Is this not a clear precept for the evolutionary perpetuation of specific cohesive groups in familiar habitats?

On a crowded planet, there has always been a premium on effective togetherness. Our moral nature reflects rather than conflicts with nature.

We differ from other species in that fewer rules of social behavior are communicated only by shout, groan, touch, and facial expression and more by verbal explication. But all tend to maintain and perpetuate unity of the pack, gaggle, or herd. We people share a linguistic version of the universal tendency toward socio-ecological wisdom measurable in life forms at every level. After my collaborative scientific work for over a half century to detail the genetics, microscopy, and biochemistry of cells that adhere in their lives together, I consider the neo-Darwinist overemphasis on competition among selfish individuals —who supposedly perpetuate their genes as if they were robots— to be a Victorian caricature. Disease microbes that kill all their victims perish themselves as a result of their aggression.

I disagree with neo-Darwinist zoologists who assert that the accumulation of random genetic mutations is the major source of evolutionary novelty. More important is symbiogenesis, the evolution of new species from the coming together of members of different species. Symbiogenesis is the behavioral, physiological, and genetic fusion of different kinds of being; it leads to the evolution of chimeric new ones. One example is of originally pathogenic bacteria that invaded and killed many amoebae in the University of Tennessee laboratory of Kwang Jeon in the 1970s. He selected survivors, and eventually different amoebae with new species characteristics appeared among them. These had retained 40,000 bacteria in each amoeba!

A new type of fruit fly evolved after it acquired an insect-loving bacterium that prevented it from successfully mating with its old partners. Indeed,

the only documented cases of the "origin of species" in real time involve not selfish genes but "selfless" mergers of different forms. Chemical and genetic evidence suggests that even mitochondria, bodies inside all of our cells that suffocate without oxygen, came from ancient mergers, truces between oxygen-respiring bacteria and the nearly poisoned cells of other kinds of microscopic beings. The mergers, naturally selected, survived to thrive and spread across the planet.

Gifted with large brains that permit us great neurological processing power, we humans plan further into the future. We recognize more of our own kind with whom, now via global communication, we establish relationships of identity and trust. But on a crowded planet, there has always been a premium on effective togetherness. Our moral nature reflects rather than conflicts with nature.

Free will may also be nature-deep. Large single-celled forams choose from brightly colored sand grains the correct ones with which to make shells. Aware of shape and color, they make choices and reproduce their kind. Awareness in some form has been naturally selected for at least 550 million years. For me, our spirituality and moral nature help perpetuate our living communities, just as similar attributes aided previous living communities whose evolution is chronicled in the fossil record.

Photo credit: Mariana Cook.

Francis Collins

Not entirely.

Francis Collins is a physician and geneticist noted for his leadership in directing the Human Genome Project. He is the author of The Language of God *and the founder and president of the BioLogos Foundation (www.biologos.org), which seeks to promote harmony between science and faith.*

The evidence in support of Darwin's theory of evolution is overwhelming. In my own field of genomics, the digital record of the long history of life on this planet—a complex and awesome story of gradual change in DNA acted upon by natural selection—provides incontrovertible proof of descent from a common ancestor. As the noted geneticist and evolutionary theorist Theodosius Dobzhansky wrote several decades ago, "Nothing in biology makes sense except in the light of evolution." And that includes humankind.

But Dobzhansky believed in God. And so do I.

Regrettably, much of the current culture in the United States sees evolution as an affront to belief in God. But the 40 percent of working scientists who are believers have a different view. Most of us are theistic evolutionists. We see evolution as God's method for creation—and what an elegant method it is! Put another way, we see life (bios) as the consequence of God's Word (the Logos). Thus, I like to refer to theistic evolution as "biologos."

Scientists who share my view do not see evolution as incompatible with the Bible, and we are puzzled and distressed that so many modern-day Christians insist on an ultra-literal reading of Genesis, when thoughtful believers down through the centuries have concluded that this story of God's plan for creation was never intended to be read as a scientific textbook. We see science as the way to understand the awesome nature of God's creation and as a powerful method for answering the "how" questions about our universe. But we also see that science is powerless to answer the fundamental "why" questions, such as "Why is there something instead of nothing?," "Why am I here?," and "Why should good and evil matter?"

Let's focus on this last question. One of the most notable characteristics of humanity, across centuries, cultures, and geographic locations, is a universal grasp of the concept of right and wrong and an inner voice that calls us to do the right thing. This is often referred to as the moral law. We may not always agree on what behaviors are right (which is heavily influenced by culture), but we generally agree that we should try to do good and avoid evil. When we break the moral law (which we do frequently, if we are honest with ourselves), we make excuses, only further demonstrating that we feel bound by the moral law in our dealings with others.

Evolutionary arguments, which ultimately depend on reproductive fitness as the overarching goal, may explain some parts of this human urge toward altruism, especially if self-sacrificing acts are done on behalf of relatives or those from whom you might expect some future reciprocal benefit. But evolutionary models universally predict the need for reflexive hostility to outside groups, and we humans do not seem to have gotten that memo. We especially admire cases in which individuals make sacrifices for strangers or members of outside groups: think of Mother Teresa, or Oskar Schindler, or the Good Samaritan.

We should be skeptical of those who dismiss these acts of radical altruism as some sort of evolutionary misfiring. And if these noble acts are frankly a scandal to reproductive fitness, might they instead point in a different direction—toward a holy, loving, and caring God, who instilled the moral law in each of us as a sign of our special nature and as a call to relationship with the Almighty?

Do not get me wrong. I am not arguing that the existence of the moral law somehow proves God's existence. Such proofs cannot be provided by the study of nature. And there is an inherent danger in arguing that the moral law points to some sort of supernatural intervention in the early days of human history; this has the flavor of a "God of the gaps" argument. After all, much still remains to be understood about evolution's influence on human nature. But even if radically altruistic human acts can ultimately be explained on the basis of evolutionary mechanisms, this would do nothing to exclude God's hand. For if God chose the process of evolution in the beginning to create humans in *imago Dei*, it would also be perfectly reasonable for God to have used this same process to instill knowledge of the moral law.

A deeper question raised by this debate is the fundamental nature of good and evil. Does morality actually have any foundation? To be consistent, a committed atheist, who argues that evolution can fully account for all aspects of human nature, must also argue that the human urge toward altruism, including its most radical and self-sacrificial forms, is a purely evolutionary artifact. This forces the conclusion that the concepts of good and evil have no real foundation, and that we have been hoodwinked by evolution into thinking that morality provides meaningful standards of judgment. Yet few atheists seem willing to own up to this disturbing and depressing consequence of their worldview. On the contrary, the most aggressive of them seem quite comfortable pointing to the evil they see religion as having inspired. Isn't that rather inconsistent?

I was once an atheist myself, and so I understand the temptation to fall into a completely materialistic view of human nature. But seeing all of humanity's nobler attributes through the constricted lens of atheism and materialism ultimately leads to philosophical impoverishment and even to the necessity of giving up concepts of benevolence and justice. I found that a whole world of interesting questions opened up for me once I accepted the possibility of a spiritual aspect to humanity.

Geoffrey Miller

More fully by the day.

Geoffrey Miller is an evolutionary psychologist at the University of New Mexico. He is the author of The Mating Mind: How Sexual Choice Shaped the Evolution of Human Nature *and* Spent: Sex, Evolution, and Consumer Behavior.

In the last two decades, evolutionary psychology has cast new light on ever more facets of human nature. And contrary to popular critiques of the field, it has done so in ways that are ever more intellectually thrilling, morally enlightening, spiritually satisfying, and socially progressive. What we mean by "evolution" and "human nature" continues to develop through mutual interaction, like the passions of a whispering couple in a close-embrace tango.

During the 1990s, biologists developed a whole new toolbox of ideas about the nature of evolution, including theories based on life history, multi-level selection, strong reciprocity, good-genes sexual selection, and costly signalling. These terms may be unfamiliar to non-specialists, but they represent a revolution in Darwinian theory and have proven their value again and again in understanding aspects of human nature that defy simplistic "survival of the fittest" reasoning.

Likewise, our understanding of human nature has been growing exponentially through work in evolutionary psychology, evolutionary anthropology, human evolutionary genetics, and primate behavior. Our model is no longer a tattered old treasure map of a few basic instincts (hunger, fear, lust) but a topographically detailed Google Earth panorama across a whole continent of familiar capacities (romantic love, moral

commitment, self-deprecating humor, conspicuous charity, and many more). New theories have led researchers to acknowledge new aspects of human nature, and recognizing previously overlooked aspects of human nature has promoted new progress in evolutionary theory.

My own research has been inspired mostly by good-genes sexual selection theory (the idea that animals choose their partners based on cues about genetic quality) and costly-signalling theory (the idea that only animals in good condition can afford seemingly pointless displays like extravagant plumage). These theories have proved enormously useful in understanding a range of human behaviors that have seemed to have no clear survival payoffs, like music, dance, art, humor, verbal creativity, conspicuous consumption, and altruism.

Consider a few examples of new empirical discoveries from research I have done with various collaborators:

* Gil Greengross and I showed that women are more attracted to men who use self-deprecating rather than other-deprecating humor during courtship (but only if the men are fairly high in social status). This is consistent with the costly-signalling idea that self-mockery is a virtue that only the successful can afford.

* Martie Haselton and I showed that women at peak fertility, just before ovulation, show a stronger preference for creativity as opposed to wealth in potential mates. This supports the idea that creativity is an indicator of "good genes" rather than of potential as a "good provider."

* Vladas Griskevicius, several colleagues, and I showed that if men are put in a romantic mood rather than a neutral mood, they are more likely to spend money on conspicuous luxuries, whereas women spend more time on conspicuous charity, such that each sex is signalling a trait (social status or kindness) that is relatively more desired by the other sex.

Each new finding like this illustrates how new evolutionary theories can lead to discoveries that were never predicted by the standard "blank slate" view of human behavior.

Still, evolutionary psychologists must guard against complacency. We should not imagine that we have discovered every important facet of human nature, or that evolutionary theory as it exists circa 2009 has told us everything we need to know about the selection pressures that have shaped human nature.

Consider just one new development in biology: the whole new world of RNA, which may help explain the unique behavioral flexibility of the human brain. The "central dogma" of genetics since the 1950s was that DNA is transcribed into RNA, which is translated into proteins, which generate all the adaptive complexity of organic life. Thus, only the DNA sequences that code for proteins are important, and only evolutionary changes in protein-coding DNA are worth analyzing. When journalists report that humans have "only" some 25,000 genes—just a few more than the 20,000 of the *C. elegans* worm—they are referring to these protein-coding genes.

This "central dogma" has guided the Human Genome Project, the HapMap project, and even the genome-wide association studies that dominate the human genetics journals these days. But the idea has been decisively overturned in the last decade by new discoveries about the diversity of RNA that is transcribed from DNA but that is not, in turn, translated into proteins. Most of this "non-coding" RNA seems to constitute a genomic regulatory system of vast complexity—a system that determines the expression of different protein-coding genes in different cell types, tissues, and organs at different times during development and in response to different environmental changes. The human genome has a vastly more complex RNA system than *C. elegans*.

The molecular biologist John Mattick and others have argued that the evolution of this RNA system was crucial for three great innovations in life on earth: the emergence of the eukaryotic cell, the Cambrian explosion of multi-cellular life, and the complexity of the human brain. In this view, humans differ from other great apes not so much at the level of protein evolution but at the level of the RNA regulatory system that orchestrates the spatio-temporal patterning of gene expression and protein function. The inherited DNA that is translated into this RNA

regulatory system does not just determine "innate instincts" or "hard-wired" behaviors; it also orchestrates dynamic changes in brain function and behavior under different circumstances.

Indeed, it seems likely that RNA is crucial in all sorts of behavioral flexibility that humans have, from feeling different moods (elation, love, depression, ambition) to laying down new memories, to super-charging our creativity, humor, and altruism when we are courting a new mate. All of this may be mediated by complex changes in gene expression throughout the brain, over time scales ranging from hours to decades. We are realizing that our genes do not just determine the blueprint for an infant's brain; they are working actively throughout our lives, governed by this vast RNA regulatory system, giving us degrees of behavioral creativity and flexibility that it will take us decades to understand.

In short, evolution explains human nature very well indeed, but we are far from finished in the grand project of naturalizing human consciousness.

Joan Roughgarden

Not yet…

Joan Roughgarden is professor of biology at Stanford University. Her books include Evolution's Rainbow: Diversity, Gender, and Sexuality in Nature and People *and* The Genial Gene: Deconstructing Darwinian Selfishness.

and almost surely never. Although human nature, like biological nature generally, results from a continuing process of evolution, the question before us is whether present-day evolutionary science explains human nature. Does it explain our religious beliefs and moral commitments as convincingly as it explains our more prosaic traits like, say, why we have four arms and legs instead of six? Obviously not. Evolutionary science has much more work to do before it can explain our more abstract traits. But how much more?

Religious beliefs, moral commitments, consciousness, and the free will to do right and wrong emerge in a social context. These traits are not properties of an individual like the ability to hear high notes or to taste bitter flavors. Social behavior develops as individuals acquire experience with one another. It is a system of traits that forms when individuals interact. A white-crowned sparrow learns its song by listening to others as it grows up. Unlike its vocal chords, a bird's song is a collective property belonging to its group.

What makes social behavior hard to understand is that interaction takes place *during* development rather than after it. By contrast, consider some socially important physical traits, like green or gray skin color in frogs. These traits are formed not during social interaction but *prior* to it. In wet

years, with green moss on the trees, green frogs are more camouflaged and are able to fight longer for space than gray frogs before seeking cover from predators, whereas in dry years, gray frogs are able to defend their territory longer. The competitive balance point between green and gray frogs changes from year to year, depending on the year's rainfall, favoring green frogs in wet years and gray frogs in dry years. At each year's balance point, the frogs occupy all of the living space according to a color ratio such that a newly arriving frog of either color has no advantage over another frog. Thus, the colors influence the outcome of territorial interactions, but the colors themselves are not generated by those interactions.

The competitive balance between socially important traits was studied by the late John Maynard Smith, a theoretical biologist who introduced mathematical game theory into evolutionary biology. Maynard Smith applied his analysis to the evolution of social behavior among competing individuals, assuming that their behavioral inclinations or "strategies" were already formed prior to their interaction. He famously discussed the evolutionary outcome of competition between "altruists" who interact with "selfish" individuals, as though the traits of altruism and selfishness were permanent characteristics of the actors, just as green or gray body coloration might be for a frog.

But in most social behavior, how an organism acts, whether it behaves altruistically or selfishly, depends in large part on its experience with others while maturing. Moreover, the Maynard Smith approach stipulates that behavioral interactions are inherently competitive because he considered their outcome to be a competitive balance point.

To go beyond the limitations of Maynard Smith's model, my students and I have introduced the idea of "social selection." Our approach decomposes the evolutionary theory of social behavior into two levels or "tiers." The "lower" tier analyzes the development of behavioral actions using game-theory techniques but without Maynard Smith's assumption of inherently competitive behavior; we employ criteria for both cooperative and competitive endpoints. The "higher" tier analyzes the evolution of behavioral tendencies using population-genetic techniques.

With this approach, we have been able to show, for instance, that sexual conflict is not inevitable in the relationship between males and females in nature, as some evolutionary biologists claim, and we have demonstrated that some forms of sexual intimacy may be interpreted as mechanisms to enable friendship and teamwork among animals. All in all, our research suggests that the "selfish-gene" metaphor for evolution is misleading and inaccurate.

Still, the question remains whether evolutionary science, even after these and other improvements take root, will ever explain features of human behavior such as spirituality, morality, consciousness, free will, and so forth. But why stop there? Will evolutionary science ever explain most of the features of any species?

This question forces us to confront our own modest place in nature. The natural world is infinite, and even if the aggregate number of people who have ever lived were scientists working 24/7 on evolutionary research, their aggregate effort would be finite, leaving a still infinite set of evolutionary mysteries. Do we know why the chameleon evolved to catch bugs with its tongue instead of sneaking up and pouncing on them? No. Will we ever? Probably not. Do we know why and how humans have come to possess a sense of morality? Not yet. Will we ever? Almost surely not.

Scientific research requires the expenditure of scarce time and money, and for most people, the value of discovering the origins of our moral sense is dwarfed by the health benefits of curing cancer or the environmental benefits of conserving tropical forests. Questions about the evolution of morality seem destined to linger indefinitely on some back burner.

There is nothing inappropriate about asking how we evolved our sense of morality or any other aspect of human nature. Indeed, I believe that investigating how evolution occurs is a sacred calling and that our appreciation for every aspect of human life is enriched by an evolutionary perspective. But some parts of this enterprise are more practical than others—and also are far more likely to succeed.

Martin Nowak

In part.

Martin Nowak is professor of biology and mathematics at Harvard University, where he directs the Program for Evolutionary Dynamics. He is the author of over 300 scientific publications and two books, Virus Dynamics *(with Robert May) and* Evolutionary Dynamics: Exploring the Equations of Life.

I am deeply fascinated by evolution, and I wish to expand the boundaries of the evolutionary explanation as far as possible. Yet I do not think that all aspects of human nature can be explained by evolution. The question is subtle, and the answer depends on how we choose to define "human nature."

I like to think of human nature as a collection of thoughts, feelings, and actions that humans experience or perform. Language, for example, is a fundamental aspect of human nature. A child growing up in an environment of speakers develops a language faculty. The thoughts and ideas that are expressed in the languages of the world are all part of human nature. Similarly, we like to listen to music and perform it. A few of us compose music. Music is part of human nature. There is also something very intuitive about numbers and geometric objects, and the ability to do some basic math seems to be part of human nature.

Yet the great theorems of mathematics are statements of an eternal truth that comes from another world, a world that seems to be entirely independent of the particular trajectory that biological evolution has taken on earth. The great symphonies of Beethoven and Mahler capture glimpses of a beauty that is absolute and everlasting. Beyond the temporal, materialistic world there is an unchanging reality.

My position is very simple. Evolution has led to a human brain that can gain access to a Platonic world of forms and ideas. This world is eternal and not the product of evolution, but it does affect human nature deeply. Therefore evolution cannot possibly explain all aspects of human nature.

What is evolution? Evolution occurs whenever there is a population of reproducing individuals. Reproduction at different rates leads to natural selection. Mistakes during reproduction lead to mutation. Mutation and natural selection are two fundamental "forces" of evolution.

Reproduction can be genetic or cultural. The former gives rise to genetic evolution, which has molded life on earth over the last four billion years. The latter is the most decisive factor shaping human society. Humans with language invented a mechanism for nearly unlimited cultural evolution. New ideas and behaviors can spread rapidly by learning, teaching, and imitation. Cultural evolution allows rapid innovation and is responsible for the dramatic changes that have occurred on this planet in the last few millennia.

Sadly, humans do not use their evolved traits only for good ends. They wage wars of destruction. They fight each other, and they destroy the environment that is essential for their survival. Despite all of this, a flame of love is burning inside us that cannot be extinguished.

I am fascinated by questions concerning the evolution of cooperation and altruistic behavior. Natural selection is based on competition between individuals. It introduces conflict. Cooperation means that one individual pays a cost for another individual to receive a benefit. Cooperation is opposed by natural selection unless specific mechanisms are in place.

For humans, the fundamental mechanisms encouraging cooperation are direct and indirect reciprocity. Direct reciprocity is based on repeated interactions between the same two individuals: my behavior toward you depends on what you have done to me. Indirect reciprocity is based on repeated interactions in a group: my behavior toward you also depends on what you have done to others. Cooperation among humans is related to altruistic behavior. Loving others and trying to help them are important aspects of human nature.

Cooperation is, in my opinion, another fundamental "force" of evolution. Cooperation is needed for construction. Whenever evolution moves to higher levels of organization, cooperation is involved. The emergence of multi-cellular organisms, for example, requires cooperation among cells. And human language would not have evolved without sustained cooperation among potential speakers and hearers.

There is a fascinating additional problem concerning our present understanding of evolution. Evolution is a search process. Populations of reproducing individuals "search" for short-term solutions, such as adaptations to a new environment or modifications of a social system. But the search process has to operate within a given space of possibilities. This "search space" ultimately determines what can evolve. For example, evolution can find intelligent life, if it is part of the search space, but it cannot construct the possibility of intelligent life. For science to fully "explain" intelligent life (or other fundamental properties of living systems), we need not only a theory of evolutionary dynamics but also a theory describing how the fundamental laws of nature span the search space.

As a scientist, I could adopt the narrow position that I am exclusively interested in those aspects of human nature that can be analyzed by scientific methods. This is a valuable and useful perspective, and it will continue to generate much scientific progress. But in my Faustian search for truth, I realize that science does not give a complete analysis of human existence. We are all confronted by questions concerning the mystery and purpose of life, which cannot be answered by natural science alone.

I subscribe to the ideas of what Leibniz called "perennial philosophy": there is an unchanging reality beneath the world of change; this reality is also at the core of every human existence; and the purpose of life is to discover this reality. In the context of my own Christian faith, the fundamental aspect of human nature is our relationship with God and our participation in God's love and eternity. This particular aspect of human nature is also not a product of evolution.

Photo credit: Erik Jacobs.

Robert Wright

Yes.

Robert Wright is the author of The Moral Animal: Why We Are the Way We Are *and* Nonzero: The Logic of Human Destiny. *His new book,* The Evolution of God, *will be published in June.*

Two centuries after the birth of Darwin, the Darwinian explanation of human nature is essentially complete. We now know why people everywhere—notwithstanding differences of culture and context—experience the same basic emotions, the same kinds of hopes and fears, even the same distortions of perception and cognition.

Ever since Darwin published *On the Origin of Species* in 1859, it has been clear that natural selection could explain the more obviously animal parts of human nature. Things like hunger and lust are no-brainers: genes that encourage you to ingest nutrients and have sex do better in the Darwinian marketplace than genes that counsel starvation and abstinence. Nor is it any great mystery how humans came to be socially competitive. High social status brings improved access to mates, so genes that fuel the pursuit of status fare well.

Much subtler legacies of evolution have come to light in recent decades as the modern science of evolutionary psychology has emerged. Not just animal appetites and drives, but fine-grained tendencies of emotion and cognition can now be ascribed with some confidence to natural selection. For example, genes inclining us to lower the social status of rivals by spreading unflattering gossip or harsh moral appraisals would be favored by natural selection. And, of course, the most effective propagandist is

someone who believes the propaganda, so our everyday moral evaluations of people may be skewed by our genes.

Maybe the biggest accomplishment of post-Darwin Darwinians has come in explaining the mushy side of human nature: compassion, empathy, and so on. These emotions make obvious Darwinian sense only when they are directed toward those endearing little vehicles of genetic transmission known as offspring. But what about when they are directed toward collateral kin — siblings, cousins — or even non-kin? Over the past half-century, two theories — the theory of kin selection and the theory of reciprocal altruism, respectively — have answered these questions.

The theory of reciprocal altruism has also illuminated several other big parcels of the emotional landscape — gratitude, obligation, forgiveness, and righteous indignation. Even the sense of justice — the intuition that it is "right" for good deeds to be rewarded and for bad deeds to be punished — now makes sense as a product of natural selection.

The evolutionary roots of human nature have not been "proved" in the sense that theorems are proved, and they are not as firmly corroborated as, say, the first law of thermodynamics. But they grow increasingly plausible as more psychological experiments are done from a Darwinian angle, more evolutionary dynamics are modeled by computer, and the biochemical links between genes and behavior become clearer. One chemical alone — oxytocin — has been implicated in maternal bonding, romantic bonding, and the trust that undergirds friendship.

None of this is to say that no puzzles remain or that there are no disagreements among Darwinians. Spats between "group selectionists" and "individual selectionists," though often overstated and in some cases merely semantic, do sometimes have real consequences. Still, this infighting results from a *surplus* of serviceable Darwinian theories, not a shortage. There can no longer be reasonable doubt that the emotions and inclinations that people everywhere share are the legacy of natural selection. Darwin's theory has illuminated and explained the fundamental unity of human experience.

Many people find it depressing that some of our noblest impulses are reducible to genetic self-interest — and, worse, that this self-interest can subtly corrupt our moral evaluations and our conduct. As it happens, the fact that they find this depressing is itself explicable in Darwinian terms. Natural selection has inclined us to present ourselves as public-spirited and even selfless, and in the service of that goal we are inclined to convince ourselves that we really *are* public-spirited and even selfless. In other words, we naturally consider ourselves noble, not just "noble."

Maybe the biggest accomplishment of post-Darwin Darwinians has come in explaining the mushy side of human nature: compassion, empathy, and so on.

But this points to the sense in which the Darwinian explanation of human nature is *not* depressing. If we are naturally inclined to overestimate our goodness, then a theory that exposes us to a truer view of ourselves has the potential to inspire self-improvement. What should depress us is how much time we spend deluding ourselves about our goodness, not the fact that we now have a chance to escape delusion and make amends.

Another dubious source of Darwinian depression is the idea that an evolutionary explanation of human nature leaves us with no great awe-inspiring mysteries about the human condition. Actually, Darwinism, while solving the mystery of human nature per se, has revealed deeper mysteries that it has no hope of solving.

For example: how on earth did the universe wind up generating an algorithm (natural selection) that turns an imperative of utter selfishness at the genetic level into altruism at the individual level? An algorithm this elegant is at least as awe-inspiring as more direct means of creating humanity and other species. Charles Kingsley, an Anglican clergyman and a naturalist, wrote in a letter to Darwin, "I have gradually learnt to see that it is just as noble a conception of Deity, to believe that He created primal forms capable of self-development into all forms needful

pro tempore and *pro loco*, as to believe that He required a fresh act of intervention to supply the *lacunas* which he himself had made. I question whether the former be not the loftier thought."

Finally, there is the mystery of consciousness. I have said that natural selection readily explains emotions like compassion and indignation. Strictly speaking, it does not. It explains the behaviors with which compassion and indignation are correlated and the neural programs that govern those behaviors. Why these behaviors and this neural governance should have emotional correlates—why there is subjective experience *at all*—is actually a mystery. Only a few Darwinian thinkers, such as Steven Pinker and the late John Maynard Smith, have appreciated this problem. Daniel Dennett and others deny the mystery, but in doing so, they sometimes veer perilously close to denying the existence of consciousness itself.

Subjective experience, of course, is what gives life meaning. A planet full of robots that have no interior life but behave and speak as we do is not a planet worth caring about. If none of these robots can feel pain, what is wrong with smashing them? If none can feel joy—or anything else—what is good about "life" on this planet?

What Darwinism tells us is how natural selection gave human life its distinctively rich texture of meaning. Darwinism can also give us guidance as we try to better ourselves and make that meaning richer still. What Darwinism does not tell us is why there is meaning at all.

Francisco J. Ayala

Only up to a point.

Francisco J. Ayala is University Professor and Donald Bren Professor of Biological Sciences at the University of California, Irvine. A former president of the American Association for the Advancement of Science and a winner of the National Medal of Science, he is the author of Darwin's Gift to Science and Religion.

Evolution explains human origins. We know that humans share recent ancestors with the apes. Our lineage separates from that of the chimpanzees, our closest living relatives, six or seven million years ago. Scientists call members of this lineage "hominins." The first fossil of a hominin was discovered on the island of Java in 1894, twelve years after the death of Charles Darwin, who had predicted that such remains would eventually be found. That hominin belonged to the species *Homo erectus* and lived more than a million years ago.

Over the past century, thousands of other hominin fossils have been discovered. The oldest of these belong to species quite different from modern humans, classified with exotic names that usually refer to where they were unearthed. *Sahelanthropus tchadensis*, found in Chad in Central Africa, lived between six and seven million years ago. *Australopithecus afarensis*, found in the Afar region of East Africa, lived between three and four million years ago. And *Homo heidelbergensis*, first found in Germany, lived between 500,000 and one million years ago.

For several million years, hominins had a small brain, similar to that of a chimpanzee and weighing about one pound. Brain size started to increase about two million years ago, with the species *Homo habilis*, the first of the hominins to make stone tools. It seems likely that smarter individuals with somewhat larger brains would have been able to make

better tools, which was advantageous for hunting, fighting, and so on. As a result, smarter individuals would have left behind more descendants. Gradually, over the last two million years, brain size tripled, reaching about three pounds in the average modern human.

Evolution also allows us to trace the origin and migration of human populations. Modern humans evolved in tropical and subtropical Africa about 150,000 years ago. They colonized much of Africa and parts of Asia and Europe starting about 100,000 years ago, and America about 15,000 years ago. As one would expect from so recent a diaspora (recent, that is, on the evolutionary scale), humans from different parts of the world are genetically quite similar, despite their conspicuous differences in skin color, body configuration, hair, and other traits that help us to distinguish people from different parts of the world.

Over the past decade, evolutionary geneticists have started to decipher the genomes of humans and chimps. Surprisingly, in the genome regions shared by the two species, nearly 99 percent of the DNA is identical. But we also have discovered distinctive human features. Genes active in the development of the brain, for instance, have changed more in the human lineage than in the chimp lineage, and so has the gene called FOXP2, which relates to speech. In fact, researchers have identified 585 genes that have evolved faster in humans than in chimps. But there is still much that we do not know about what makes us so different from apes. Fortunately, we have been searching in earnest only for a decade, and discoveries will continue to accumulate.

Evolutionary neurobiology has made similar advances. We now know a great deal about which parts of the brain have become more differentiated in humans than in apes, and what functions they play in memory, speech, hand articulation, and so on. Much has been learned as well about how light, sound, temperature, resistance, and other impressions are transmitted to the brain by our sense organs. Still, despite all this progress, the field remains in its infancy. Those questions that matter the most to us remain shrouded in mystery: how physical phenomena (the chemical and electric signals by which neurons communicate) become feelings, sensations, concepts, and all the other elements of consciousness, and how the

mind, a reality whose properties include free will and self-awareness, emerges from the diversity of these experiences.

Science is a way of knowing, but it is not the only way. Evolution tells us much, but certainly not everything, about human experience and the human predicament.

Humans also have opened up a new mode of evolution: adaptation by technological manipulation and culture. We have developed the capacity to modify hostile environments according to the needs of our genes. The discovery of fire and the fabrication of clothing and shelter have allowed us to spread from the warm tropical and subtropical regions of the Old World, to which we are biologically adapted, to most of the Earth. Humans did not wait until genes evolved that would provide anatomical protection against cold temperatures by means of fur or hair. Nor have we bided our time in expectation of wings or gills: we have conquered the air and seas with artfully designed contrivances. It is the human brain (or rather, the human mind) that has made humankind the most successful—by most meaningful standards—of living species.

But culture includes much more than adaptation to the environment and much more than science and technology. Culture includes art and literature; history and political organizations; economic and legal systems; philosophy, ethics, and religion. These all-important components of human nature transcend evolutionary biology and every other science. Science has nothing decisive to say about values, whether economic, aesthetic, or moral; nothing to say about the meaning of life and its purpose; and nothing to say about religious beliefs—except, of course, in those cases when these values and activities transcend their proper scope and make demonstrably false assertions about the natural world.

Science is a way of knowing, but it is not the only way. Evolution tells us much, but certainly not everything, about human experience and the human predicament. In *The Myth of Sisyphus*, Albert Camus asserted

that we learn more about ourselves and the world from a relaxed evening gazing at the starry heavens and taking in the scent of grass than from science's reductive ways. This may be literary exaggeration, but there can be no doubt that we learn about human nature by reading Shakespeare's *King Lear*, contemplating the self-portraits of Rembrandt, and listening to Tchaikovsky's *Symphonie Pathétique*. We humans judge our actions toward others according to systems of morality, and we derive meaning and purpose from religious beliefs. Evolution may explain our capacity to hold these principles and beliefs, but it does not explain the principles and beliefs themselves.

Eva Jablonka

Yes, but…

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we have to qualify what we mean by "human nature," by "explain," and by "evolution."

If, like Aristotle, we see "human nature" as something that depends on a basic animal nature, which in turn depends on a nature that is common to all living things, then the answer to the question is long and complicated. It has to include the evolution of the goal-directed, teleological systems underlying the origin of life and the acquisition of a mentality that endows every animal with a will, as well as the evolution of the unique aspects of the human mind. An answer would amount to re-writing Aristotle's *De Anima* using a 21st-century evolutionary framework.

But I think that the question being asked is a more modest one, highlighting the uniqueness of human nature as compared, for example, with the nature of our evolutionarily close relative, the chimpanzee. Many people are ready to accept that evolution explains chimpanzee nature, but not that it explains human nature. They assume that at some definite point in evolutionary history, God intervened and endowed the human lineage with something that has set humankind apart from all other animals. So let us consider these more limited questions: Is there a line of demarcation between humans and chimpanzees that makes humans very

different? And can we explain human nature as a product of an evolutionary process, without miracles? I believe that the answer to both questions is "yes."

Much has been written about how humans are unique or special, but I favor the philosopher Ernst Cassirer's views on the matter. He maintained that what sets us apart is symbolic systems, most notably, our capacity to think and communicate using language. This, he argued, is the foundation of our rationality and religiosity and for creating long-term goals and abstract concepts like justice and truth, which organize human psychology and social life. Cassirer is right, I believe — but none of this changes the fact that our capacity to use symbols is a product of evolution. Describing the evolution of this capacity is an incredibly difficult task, because it has complex and multiple social, cognitive, and emotional bases. But during the last fifteen years great progress has been made in understanding it, especially with regard to our linguistic capacity. Although we are only at the beginning of this great intellectual journey, the framework for explaining the origins and evolution of symbolic systems is now in place.

At this point I also must qualify what I mean by "explain," in particular, how an evolutionary account can be said to be explanatory. If we can describe the biological basis for the appearance of a new trait in a population, describe how and why it spreads, and how, over time, it becomes increasingly more sophisticated, we may claim to have provided an evolutionary explanation of this trait. Evolutionary biologists recognize that at present there are only partial evolutionary descriptions of most complex behavioral traits. Evolution explains cooperation among ants, for instance, but we are still far from being able to give a full causal account of how cooperation is instantiated in the biology of ants and of how every aspect of such cooperation has evolved. The situation is similar but even more difficult with respect to the human ability to use language and other symbols. But the question is tractable and answerable within an evolutionary framework.

Here I must qualify yet another term, "evolution." The evolutionary framework that we need to use in this case is much wider than the one to which we are accustomed. The great evolutionary biologist Theodosius

Dobzhansky famously defined evolution as "change in the genetic constitution of populations over time," but this definition is too narrow and, therefore, misleading. We have to think about more than genes. My colleague Marion Lamb and I have suggested that evolution should be redefined as the "set of processes that lead to changes in the nature and frequency of heritable types in populations over time." Heritable types include: genotypes, types of transmissible epigenetic (that is, developmentally acquired) variations, types of socially learned animal behavior, and types of symbol-based transmitted information.

With humans, the transmission of information via symbols has resulted in a very rich cultural evolution. This transmission is of major importance not only for our cultural history but also for our genetic evolution. Under the appropriate ecological and social conditions, even a crude ability to communicate using symbols, similar to that seen in trained chimpanzees, can trigger greatly accelerated genetic evolution of the capacity to use symbolic systems. This, in turn, will lead to more elaborate symbol-based cultural evolution, which will favor further genetic changes, and so on. Recognizing this positive feedback loop between genetic and cultural evolution may help us to understand how human language evolved and how other cognitive and emotional features specific to humans — artistic ability, rationality, religiosity — emerged and became consolidated during our evolutionary history.

The original question therefore needs to be rephrased in a clumsier but less ambiguous way: Can an expanded evolutionary framework account for the specifically human features that set us apart from chimpanzees and that most of us recognize as constituting human nature? The answer is "yes." Indeed, I believe that we can answer this question affirmatively even if we are committed to the more ambitious Aristotelian concept of human nature, which includes not only the nature of much simpler animals endowed with wills but the nature of life itself. There is historical continuity among the different "natures" that culminate in human nature. Giving a fuller account of the continuous evolution of these goal-directed systems is one of the great scientific challenges of this century.

Jeffrey Schloss

Totally, for a Martian.

Jeffrey Schloss is distinguished professor and chair of biology at Westmont College. He is the co-editor of several books on evolutionary themes, including The Believing Primate: Scientific, Philosophical, and Theological Perspectives on the Origin of Religion *(with Michael Murray).*

Humans bear the stamp of a fascinating evolutionary past, and theories elucidating our biological origins immensely enrich our understanding of what it is to be human. But, no, evolution does not "explain human nature." In fact, the power of evolutionary theory to illuminate our humanity derives importantly both from what it is able to penetrate and from what remains opaque to it.

So what does evolutionary theory explain well? For starters, it provides one-stop shopping for many of the universal or nearly universal features of our species. It presents compelling accounts of our intense need to give and receive parental and social care; of our wide-ranging emotions and the ability to recognize them facially; of our shared cognitive biases, phobias, and desires; and of our capacities to form lifelong social attachments and aversions, to fall in love, and to envision not just the future but also other minds, including supernatural minds.

Evolutionary analysis also helps us to understand why human groups are structured around kinship and reciprocity, why they are monogamous or polygamous but rarely polyandrous, why they are averse to incest, reliant on the division of labor, and universally inclined to punish violations of fairness, to accumulate and transmit extra-genetic information, and to

cooperate on a scale far beyond that of any other species on the planet. For all of these varied but crucial features of humanity, evolution provides a single, empirically assessable account in terms of a principle — natural selection — that also explains the features of other living organisms. Evolution locates human nature securely within the confines of nature itself.

Though many of the attributes that I have listed above are universal among humans, not all of them are. Evolutionary theory helps us to understand this too, by reformulating biological notions of "human nature" in terms of central tendencies rather than inevitabilities. It navigates between naïve assertions of organically unconstrained cultural relativism, on the one hand, and fixed and universal biological nativism, on the other. The upshot of explaining the statistically normal while eschewing the normative is that evolution cannot provide counsel for what humans should be (work done by traditional concepts of human nature from Aristotle on) and only posits accounts of how humans came to be what we are.

It turns out, though, that even this more modest goal is not fully attained by evolutionary theory. In the first place, evolution is absolutely necessary but not sufficient for explaining just the most straightforward aspects of an organism. Bat wings, for example, only make sense as evolved derivations of mammalian forelimbs. But to understand them fully also requires concepts outside of evolution, like the principles of aerodynamics and gravity. Evolution is a search engine that combs possibility space, but to explain what it comes up with, we need to understand both the engine and the space. Like a Shakespearian play, the evolutionary drama is determined not only by the playwright (in this case, natural selection, a very dumb author) but also by the constraints of an Elizabethan theater company. To understand the human and our place in nature, we must understand the budget and the bounties of the world that made humans possible.

In addition, when it comes to the most distinctive aspects of humanity — language, morality, religious belief, altruism, even our capacity for science itself — we do not yet have complete or even agreed-upon

evolutionary explanations. This does not signal a need to give up on evolutionary accounts. Indeed, there has been a recent flowering of promising proposals for each of these qualities. Among the alternative evolutionary explanations are theories based on sexual selection, cooperative adaptation, dominance displays, group-level function, and traits as byproducts. All of these contending accounts are consistent with the process of genetic selection that operates in other species.

What can we learn about the nature of being human from an account that in principle could be developed by an alien intelligence without access to human interiority or any interest in humanity's most enduring questions?

But how do we engage the thorny issue of why our species so often makes choices that do not maximize or even contribute to our reproductive fitness? One possibility is the idea of "memes" (that is, transmitted units of cultural information), which may involve a distinctly human and non-genetic form of evolution. Since being proposed by Richard Dawkins to explain behaviors that "we alone on earth" exhibit, the idea has been criticized by some as too vague, too dualistic, too culturally reductionistic, or too assertive of human uniqueness. Whatever the precise character of the mechanism, however, one thing seems clear: genetic selection has sprouted an organism whose behavior is not fully reducible to genetic selection.

The very existence of these fascinating debates constitutes an instructive example of how evolution illuminates the distinctively human by what it is both able and not yet able to explain. This does not mean that we will not close the gap. But science does not give credit for future understanding. At present, evolution does not explain these important aspects of humanity.

Even if we achieve a fully adequate evolutionary account of things like morality, religious belief, love, and sentience (perhaps the most difficult question of all), it still would not tell us what these things *are* or what it is to experience them as humans. This is not a deficiency of evolutionary theory. To the contrary, it is a limitation directly related to its potency as an empirical science. But not all questions that we humans ask about ourselves are scientific ones.

On my bookshelf, I have an extensive collection of classic (and often conflicting) volumes on evolution and human nature. It is uncanny how many of them begin with the same affirmation of the objective nature of their approach: their accounts, they suggest, are of just the sort that Martian biologists or intelligent visitors from another planet would develop. Several even claim that all of humanity's own ideas about our nature prior to evolutionary theory are "worthless" and that we would be better off to "ignore them completely." Indeed, one of the most prominent accounts — Richard Dawkins again — asserts that, if extraterrestrial intellects were to visit earth, it is unlikely they would be interested in music or religion, and Shakespeare might "mean nothing," but they would revere Darwin, whose ideas "really matter in the universe."

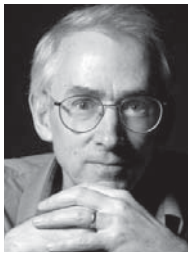
Given biology's rejection of disembodied Cartesian rationality and our understanding of how reason is deeply intertwined with emotions and values, the Darwin versus Shakespeare dichotomy is probably just plain wrong. Nor is much gained by invoking a sort of interplanetary argument from authority: "E.T. believes me — so should you!" But the real problem with so starkly objective an approach is what is left out. What can we learn about the nature of being human from an account that in principle could be developed by an alien intelligence without access to human interiority or any interest in humanity's most enduring questions?

Pretty much everything a Martian scientist might want to know.

Does evolution explain human nature? No. Does it enrich our understanding of the human? Most profoundly. But so does Shakespeare.

David Sloan Wilson

Yes and no.



David Sloan Wilson directs EvoS, Binghamton University's evolutionary studies program and the hub of a nationwide consortium. His latest book is Evolution for Everyone: How Darwin's Theory Can Change the Way We Think About Our Lives.

When we say that a species has a "nature," we are referring to its evolved properties. For a lactose-digesting bacteria, digesting lactose is part of its "nature." If we turn it into a new genetic strain unable to digest lactose, we will have changed its "nature." Similarly, domesticated animals have different "natures" from their wild ancestors.

My simple formula equating "nature" with evolved properties might seem boring at first, until we realize that there is more to evolution than *genetic* evolution. Genes are only one mechanism of inheritance. Some immunological, psychological, and cultural processes also count as evolutionary. They too rely on the open-ended variation and selective retention of traits, but they are based on non-genetic inheritance mechanisms.

People and cultures shaped by these fast-paced evolutionary processes no longer have the same "nature," any more than two bacterial strains that have diverged by genetic evolution. In this fashion, my simple and seemingly boring formula can be understood to say that humanity as a whole does not have a single "nature." Instead, each and every person and culture has its own "nature."

This is not just idle word play. We are only beginning to appreciate the fact that human cultural diversity is fundamentally like biological

diversity. Humanity is more like a multi-species ecosystem than a single biological species. A culture, like a species, has a historical phylogeny (that is, a sequence of events in its evolutionary trajectory) and is adapted to its local environment. The body of knowledge that members of Arctic cultures must learn and transmit to survive in their harsh environment is mind-boggling when understood in detail—and very different from the equally extensive body of knowledge that members of desert cultures must master. In what sense do they have the same "nature," any more than a polar bear and a camel?

This is equally true of modern cultural diversity. Only a few decades ago, American psychologists confidently assumed that their studies of college students revealed a universal human nature. Economists treated individual utility maximization as a grand explanatory principle. Moral philosophers assumed that their own intuition was representative of everyone's intuition. The failure of these grand generalizations has been a humbling experience. As the social psychologist Richard Nisbett put it, "Psychologists who choose not to do cross-cultural psychology may have chosen to be ethnographers instead." Or, in the immortal words of George Bernard Shaw, "Forgive him, for he is a savage and believes that the customs of his tribe are the laws of nature."

But this is not the whole story. Only *some* immunological, psychological, and cultural processes qualify as evolutionary in their own right. Immunologists distinguish between the "innate" and "adaptive" components of the immune system. The innate component consists of fixed responses to invading organisms, such as the ability of macrophages to recognize and engulf bacteria based on their surface properties, recruit other macrophages to wound sites, and so on. These highly sophisticated responses developed through genetic evolution, but they are not open-ended evolutionary processes. They are species-typical, in contrast to the unique suite of antibodies that evolves in every individual, thanks to the adaptive (that is, open-ended evolutionary) component of the immune system.

In addition, the adaptive component of the immune system requires an elaborate architecture that is genetically innate and therefore part of the "nature" of our species. Species-typical mechanisms create the

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diversity of antibodies, distribute them throughout the body, cause those that successfully bind to antigens to reproduce, keep them around for a long period of time as a "memory," and so on. The neurobiologist and evolutionist William H. Calvin coined the term "Darwin machine" to describe any fast-paced process of evolution built by the slow-paced process of genetic evolution. Darwin machines must include a genetically evolved architecture (the "machine") if open-ended evolutionary processes are to achieve biologically adaptive outcomes.

What holds for the immune system also holds for psychological and cultural processes. For example, immediate threats to a person result in automatic psychological defense responses analogous to macrophages rushing to a wound site. These responses are highly adaptive products of genetic evolution, but they are not open-ended evolutionary processes in their own right. Calling them part of our "nature" should be uncontroversial. In addition, our open-ended behavioral flexibility, as individuals and as cultures, requires a genetically evolved architecture no less than the immune system. A more poetic metaphor than a "Darwin machine" is a musical instrument. It can produce an infinite number of songs but also has a single "nature."

Why do we ask questions about human nature in the first place? Many people are interested primarily in human *potential*, our capacity as individuals and societies to change for the better. For some, saying that we have a nature is threatening because it seems to deny our capacity for change, raising the specter of genetic determinism. For others, saying that we have a nature is enticing because it promises the same kind of understanding for humanity that evolutionary theory currently offers for the rest of life.

Answering "yes and no" to the question offers the best of both worlds. We do not have a single nature as a species because we are actively evolving, thanks to the rapid processes of evolution that employ non-genetic inheritance mechanisms. Yet, a sophisticated knowledge of evolution is required to understand both our genetically evolved nature and our capacity for change. Indeed, just because we have a capacity for change does not mean that we will necessarily change for the *better*. Evolution frequently results in outcomes that are highly undesirable for long-term human welfare. If we want to change for the better as individuals and societies, we must learn how to manage fast-paced evolutionary processes to take us where we want to go. Might this be possible in the foreseeable future? The answer to that question is "yes."