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Steven Pinker

Why nature & nurture won't go away

When Richard Mulcaster referred in 1581 to "that treasure . . . bestowed on them by nature, to be bettered in them by nurture," he gave the world a euphonious name for an opposition that has been debated ever since. People's beliefs about the relative importance of heredity and environment affect their opinions on an astonishing range of topics. Do adolescents engage in violence because of the way their parents treated them early in life? Are people inherently aggressive and selfish, calling for a market economy and a strong police, or could they become peaceable and cooperative, allowing the state to wither and a spontaneous socialism to blossom? Is there a universal aesthetic that allows great art to transcend time and place, or are people's tastes determined by their era and culture? With so much seemingly at stake in so many fields, it is no surprise that debates over nature and nurture evoke more rancor than just about any issue in the world of ideas.

During much of the twentieth century, a common position in this debate was to deny that human nature existed at all – to aver, with José Ortega y Gasset, that "Man has no nature; what he has is history." The doctrine that the mind is a blank slate was not only a cornerstone of behaviorism in psychology and social constructionism in the social sciences, but also extended widely into mainstream intellectual life.[1]

Part of the blank slate's appeal came from the realization that many differences among people in different classes and ethnic groups that formerly were

Steven Pinker, Johnstone Family Professor in the department of psychology at Harvard University, conducts research on language and cognition. A Fellow of the American Academy since 1998, he is the author of six books, including "How the Mind Works" (1997), "The Language Instinct" (2000), and "The Blank Slate" (2002).

1 Carl N. Degler, *In Search of Human Nature: The Decline and Revival of Darwinism in American Social Thought* (New York: Oxford University Press, 1991); Steven Pinker, *The Blank Slate: The Modern Denial of Human Nature* (New York: Viking, 2002); Robin Fox, *The Search for Society: Quest for a Biosocial Science and Morality* (New Brunswick, N.J.: Rutgers University Press, 1989); Eric M. Gander, *On Our Minds: How Evolutionary Psychology Is Reshaping the Nature-Versus-Nurture Debate* (Baltimore: Johns Hopkins University Press, 2003); John Tooby and Leda Cosmides, "The Psychological Foundations of Culture," in *The Adapted Mind: Evolutionary Psychology and the Generation of Culture*, ed. Jerome H. Barkow, Leda Cosmides, and John Tooby (New York: Oxford University Press, 1992).

thought to reflect innate disparities in talent or temperament could vanish through immigration, social mobility, and cultural change. But another part of its appeal was political and moral. If nothing in the mind is innate, then differences among races, sexes, and classes can never be innate, making the blank slate the ultimate safeguard against racism, sexism, and class prejudice. Also, the doctrine ruled out the possibility that ignoble traits such as greed, prejudice, and aggression spring from human nature, and thus held out the hope of unlimited social progress.

Though human nature has been debated for as long as people have pondered their condition, it was inevitable that the debate would be transformed by the recent efflorescence of the sciences of mind, brain, genes, and evolution. One outcome has been to make the doctrine of the blank slate untenable.[2] No one, of course, can deny the importance of learning and culture in all aspects of human life. But cognitive science has shown that there must be complex innate mechanisms for learning and culture to be possible in the first place. Evolutionary psychology has documented hundreds of universals that cut across the world's cultures, and has shown that many psychological traits (such as our taste for fatty foods, social status, and risky sexual liaisons) are better adapted to the evolutionary demands of an ancestral environment than to the actual demands of the current environment. Developmental psychology has shown that infants have a precocious grasp of objects, intentions, numbers, faces, tools, and language. Behavioral genetics has shown that temperament emerges early in life and remains fairly constant throughout the life span, that much of the variation among people within a culture comes from differences in genes, and that in some cases particular genes can be tied to aspects of cognition, language, and personality. Neuroscience has shown that the genome contains a rich tool kit of growth factors, axon guidance molecules, and cell adhesion molecules that help structure the brain during development, as well as mechanisms of plasticity that make learning possible.

These discoveries not only have shown that the innate organization of the brain cannot be ignored, but have also helped to reframe our very conception of nature and nurture.

Nature and nurture, of course, are not alternatives. Learning itself must be accomplished by innate circuitry, and what is innate is not a set of rigid instructions for behavior but rather programs that take in information from the senses and give rise to new thoughts and actions. Language is a paradigm case: though particular languages such as Japanese and Yoruba are not innate, the capacity to acquire languages is a uniquely human talent. And once acquired, a language is not a fixed list of sentences, but a combinatorial algorithm allowing an infinite number of new thoughts to be expressed.

Moreover, because the mind is a complex system composed of many interacting parts, it makes no sense to ask whether humans are selfish or generous or nasty or noble across the board. Rather, they are driven by competing motives elicited in different circumstances. And

2 Pinker, *The Blank Slate*; Gary F. Marcus, *The Birth of the Mind: How a Tiny Number of Genes Creates the Complexities of Human Thought* (New York: Basic Books, 2004); Matt Ridley, *Nature Via Nurture: Genes, Experience, and What Makes Us Human* (London: Fourth Estate, 2003); Robert Plomin, Michael J. Owen, and Peter McGuffin, "The Genetic Basis of Complex Human Behaviors," *Science* 264 (1994): 1733–1739.

if genes affect behavior, it is not by tugging on the muscles directly, but by their intricate effects on the circuitry of a growing brain.

Finally, questions of what people innately have in common must be distinguished from questions of how races, sexes, or individuals innately differ. Evolutionary biology gives reasons to believe that there are systematic species-wide universals, circumscribed ways in which the sexes differ, random quantitative variation among individuals, and few if any differences among races and ethnic groups.[3]

This reframing of human nature also offers a rational way to address the political and moral fears of human nature.[4] Political equality, for example, does not hinge on a dogma that people are innately indistinguishable, but on a commitment to treat them as individuals in spheres such as education and the criminal justice system. Social progress does not require that the mind be free of ignoble motives, only that it have other motives (such as the emotion of empathy and cognitive faculties that can learn from history) that can counteract them.

By now most scientists reject both the nineteenth-century doctrine that biology is destiny and the twentieth-century doctrine that the mind is a blank slate. At the same time, many express a discomfort with any attempt to characterize the innate organization that the mind does have (even in service of a better understanding of learning). Instead, there is a widespread desire that the whole issue would somehow just go away. A common position on nature and nurture among contemporary scientists can be summarized as follows:

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> No one today believes that the mind is a blank slate; to refute such a belief is to tip over a straw man. All behavior is the product of an inextricable interaction between heredity and environment during development, so the answer to all nature-nurture questions is "some of each." If people only recognized this truism, the political recriminations could be avoided. Moreover, modern biology has made the very distinction between nature and nurture obsolete. Since a given set of genes can have different effects in different environments, there may always be an environment in which a supposed effect of the genes can be reversed or canceled; therefore the genes impose no significant constraints on behavior. Indeed, genes are expressed in response to environmental signals, so it is meaningless to try to distinguish genes and environments; doing so only gets in the way of productive research.

The attitude is often marked by words like 'interactionist,' 'developmentalist,' 'dialectic,' 'constructivist,' and 'epigenetic,' and is typically accompanied by a diagram with the labels 'genes,' 'behavior,' 'prenatal environment,' 'biochemical environment,' 'family environment,' 'school environment,' 'cultural environment,' and 'socioeconomic environment,' and arrows pointing from every label to every other label.

This doctrine, which I will call holistic interactionism, has considerable appeal. It is based on some unexceptionable points, such as that nature and nurture are not mutually exclusive, that genes cannot cause behavior directly, and that the direction of causation can go both

3 John Tooby and Leda Cosmides, "On the Universality of Human Nature and the Uniqueness of the Individual: The Role of Genetics and Adaptation," *Journal of Personality* 58 (1990): 17 – 67.

4 Pinker, *The Blank Slate*.

ways (for example, school can make you smarter, and smart people are most engaged by schooling). It has a veneer of moderation, of conceptual sophistication, and of biological up-to-dateness. And as John Tooby and Leda Cosmides have put it, it promises "safe conduct across the politicized minefield of modern academic life."[5]

But the very things that make holistic interactionism so appealing should also make us wary of it. No matter how complex an interaction is, it can be understood only by identifying the components and how they interact. Holistic interactionism can stand in the way of such understanding by dismissing any attempt to disentangle heredity and environment as uncouth. As Dan Dennett has satirized the attitude: "Surely 'everyone knows' that the nature-nurture debate was resolved long ago, and neither side wins since everything-is-a-mixture-of-both-and-it's-all-very-complicated, so let's think of something else, right?"

In the following pages I will analyze the tenets of holistic interactionism and show that they are not as reasonable or as obvious as they first appear.

"No one believes in the extreme nurture position that the mind is a blank slate." Whether or not this is true among scientists, it is far from true in the rest of intellectual life. The prominent anthropologist Ashley Montagu, summing up a common understanding in twentieth-century social science, wrote in 1973 that "With the exception of the instinctoid reactions in infants to sudden withdrawals of support and to sudden loud noises, the human being is entirely instinctless....Man is man because he has no instincts, because everything he is and has become he has learned...from his culture, from the man-made part of the environment, from other human beings."[6] Postmodernism and social constructionism, which dominate many of the humanities, vigorously assert that human emotions, conceptual categories, and patterns of behavior (such as those characterizing men and women or homosexuals and heterosexuals) are social constructions. Even many humanists who are not postmodernists insist biology can provide no insight into human mind and behavior. The critic Louis Menand, for instance, recently wrote that "every aspect of life has a biological foundation in exactly the same sense, which is that unless it was biologically possible it wouldn't exist. After that, it's up for grabs."[7]

Nor is a belief in the blank slate absent among prominent scientists. Richard Lewontin, Leon Kamin, and Steven Rose, in a book entitled *Not in Our Genes*, asserted that "the only sensible thing to say about human nature is that it is 'in' that nature to construct its own history."[8] Stephen Jay Gould wrote that the "brain [is] capable of a full range of behaviors and predisposed to none."[9] Anne Fausto-Sterling expressed a common view of the origin of sex differences: "The key biological fact is that boys and girls have different genitalia,

5 Tooby and Cosmides, "The Psychological Foundations of Culture."

6 Ashley Montagu, ed., *Man and Aggression*, 2nd ed. (New York: Oxford University Press, 1973).

7 Louis Menand, "What Comes Naturally," *The New Yorker*, 25 November 2002.

8 R. C. Lewontin, Steven Rose, and Leon J. Kamin, *Not in Our Genes: Biology, Ideology, and Human Nature* (New York: Pantheon Books, 1984).

9 Stephen Jay Gould, "Biological Potential vs. Biological Determinism," in *Ever Since Darwin: Reflections in Natural History*, ed. Stephen Jay Gould (New York: Norton, 1977).

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and it is this biological difference that leads adults to interact differently with different babies whom we conveniently color-code in pink or blue to make it unnecessary to go peering into their diapers for information about gender."[10]

These opinions spill into research and policy. Much of the scientific consensus on parenting, for example, is based on studies that find a correlation between the behavior of parents and the behavior of children. Parents who spank have children who are more violent; authoritative parents (neither too permissive nor too punitive) have well-behaved children; parents who talk more to their children have children with better language skills. Virtually everyone concludes that the behavior of the parent causes the outcomes in the child. The possibility that the correlations may arise from shared genes is usually not even mentioned, let alone tested.[11]

Other examples abound. Many scientific organizations have endorsed the slogan "violence is learned behavior," and even biologically oriented scientists tend to treat violence as a public health problem like malnutrition or infectious disease. Unmentioned is the possibility that the strategic use of violence could have been selected for in human evolution, as it has been in the evolution of other primate species.[12] Gender differences in the professions, such as that the proportion of mechanical engineers who are women is less than 50 percent, are attributed entirely to prejudice and hidden barriers. The possibility that, on average, women might be less interested than men in people-free pursuits is similarly unspeakable.[13] The point is not that we know that evolution or genetics are relevant to explaining these phenomena, but that the very possibility is often treated as an unmentionable taboo rather than as a testable hypothesis.

"For every question about nature and nurture, the correct answer is 'some of each.'" Not true. Why do people in England speak English and people in Japan speak Japanese? The 'reasonable compromise' would be that the people in England have genes that make it easier to learn English and the people in Japan have genes that make it easier to learn Japanese, but that both groups must be exposed to a language to acquire it at all. This compromise is, of course, not reasonable but false, as we see when children exposed to a given language acquire it equally quickly regardless of their racial ancestry. Though people may be genetically predisposed to learn language, they are not genetically predisposed, even in part, to learn a particular language; the explanation for why people in different countries speak differently is 100 percent environmental.

Sometimes the opposite extreme turns out to be correct. Psychiatrists commonly used to blame psychopathology on mothers. Autism was caused by 'refrigerator mothers' who did not emotionally engage their children, schizophrenia by mothers who put their children in double binds. Today we know that autism

10 Anne Fausto-Sterling, *Myths of Gender: Biological Theories About Women and Men* (New York: Basic Books, 1985).

11 David C. Rowe, *The Limits of Family Influence: Genes, Experience, and Behavior* (New York: Guilford Press, 1994); Judith Rich Harris, *The Nurture Assumption: Why Children Turn Out the Way They Do* (New York: Free Press, 1998).

12 Martin Daly and Margo Wilson, *Homicide* (New York: A. de Gruyter, 1988).

13 David Lubinski and Camilla Benbow, "Gender Differences in Abilities and Preferences Among the Gifted: Implications for the Math-Science Pipeline," *Current Directions in Psychological Science* 1 (1992): 61 – 66.

and schizophrenia are highly heritable, and though they are not completely determined by genes, the other plausible contributors (such as toxins, pathogens, and developmental accidents) have nothing to do with how parents treat their children. Mothers don't deserve some of the blame if their children have these disorders, as a nature-nurture compromise would imply. They deserve none of it.

"If people recognized that every aspect of behavior involves a combination of nature and nurture, the political disputes would evaporate." Certainly many psychologists strive for an innocuous middle ground. Consider this quotation:

> If the reader is now convinced that either the genetic or environmental explanation has won out to the exclusion of the other, we have not done a sufficiently good job of presenting one side or the other. It seems highly likely to us that both genes and environment have something to do with this issue.

This appears to be a reasonable interactionist compromise that could not possibly incite controversy. But in fact it comes from one of the most incendiary books of the 1990s, Herrnstein and Murray's *The Bell Curve*. In this passage, Herrnstein and Murray summed up their argument that the difference in average IQ scores between American blacks and American whites has both genetic and environmental causes. A "some-of-each" position did not protect them from accusations of racism and comparisons to Nazis. Nor, of course, did it establish their position was correct: as with the language a person speaks, the black-white average IQ gap could be 100 percent environmental. The point is that in this and many other domains of psychology, the possibility that heredity has any explanatory role at all is still inflammatory.

"The effects of genes depend crucially on the environment, so heredity imposes no constraints on behavior." Two examples are commonly used to illustrate the point: different strains of corn may grow to different heights when equally irrigated, but a plant from the taller strain might end up shorter if it is deprived of water; and children with phenylketonuria (PKU), an inherited disorder resulting in retardation, can end up normal if given a diet low in the amino acid phenylalanine.

There is an aspect of this statement that indeed is worth stressing. Genes do not determine behavior like the roll of a player piano. Environmental interventions – from education and psychotherapy to historical changes in attitudes and political systems – can significantly affect human affairs. Also worth stressing is that genes and environments may interact in the statistician's sense, namely, that the effects of one can be exposed, multiplied, or reversed by the effects of the other, rather than merely summed with them. Two recent studies have identified single genes that are respectively associated with violence and depression, but have also shown that their effects are manifested only with particular histories of stressful experience.[14]

At the same time, it is misleading to invoke environment dependence to deny

14 Avshalom Caspi, Karen Sugden, Terrie E. Moffitt, Alan Taylor, and Ian W. Craig, "Influence of Life Stress on Depression: Moderation by a Polymorphism in the 5-HTT Gene," *Science* (2003): 386–389; Avshalom Caspi, Joseph McClay, Terrie E. Moffitt, Jonathan Mill, Judy Martin, and Ian W. Craig, "Evidence that the Cycle of Violence in Maltreated Children Depends on Genotype," *Science* 297 (2002): 727–742.

the importance of understanding the effects of genes. To begin with, it is simply not true that any gene can have any effect in some environment, with the implication that we can always design an environment to produce whatever outcome we value. Though some genetic effects may be nullified in certain environments, not all of them are: studies that measure both genetic and environmental similarity (such as adoption designs, where correlations with adoptive and biological parents can be compared) show numerous main effects of personality, intelligence, and behavior across a range of environmental variation. This is true even for the poster child of environmental mitigation, PKU. Though a low-phenylalanine diet does prevent severe mental retardation, it does not, as is ubiquitously claimed, render the person 'perfectly normal.' PKU children have mean IQs in the 80s and 90s and are impaired in tasks that depend on the prefrontal region of the cerebral cortex.[15]

Also, the mere existence of *some* environment that can reverse the expected effects of genes is almost meaningless. Just because extreme environments can disrupt a trait does not mean that the ordinary range of environments will modulate that trait, nor does it mean that the environment can explain the nature of the trait. Though unirrigated corn plants may shrivel, they won't grow arbitrarily high when given ever-increasing amounts of water. Nor does their dependence on water explain why they bear ears of corn as opposed to tomatoes or pinecones. Chinese foot-binding is an environmental manipulation that can radically affect the shape of the foot, but it would be misleading to deny that the anatomy of the human foot is in an important sense specified by the genes, or to attribute it in equal parts to heredity and environment. The point is not merely rhetorical. The fact that kittens' visual systems show abnormalities when their eyelids are sewn shut in a critical period of development does not imply (as was believed in the 1990s) that playing Mozart to babies or hanging colorful mobiles in their cribs will increase their intelligence.[16]

In short, the existence of environmental mitigations doesn't make the effects of the genes inconsequential. On the contrary, the genes specify what kinds of environmental manipulations will have what kinds of effects and with what costs. This is true at every level, from the expression of the genes themselves (as I will discuss below) to large-scale attempts at social change. The totalitarian Marxist states of the twentieth century often succeeded at modifying behavior, but at the cost of massive coercion, owing in part to mistaken assumptions about how easily human motives would respond to changed circumstances.[17]

Conversely, many kinds of genuine social progress succeeded by engaging specific aspects of human nature. Peter Singer observes that normal humans in

15 Adele Diamond, "A Model System for Studying the Role of Dopamine in the Prefrontal Cortex During Early Development in Humans: Early and Continuously Treated Phenylketonuria," in *Handbook of Developmental Cognitive Neuroscience*, ed. Charles A. Nelson and Monica Luciana (Cambridge, Mass.: MIT Press, 2001).

16 John T. Bruer, *The Myth of the First Three Years: A New Understanding of Early Brain Development and Lifelong Learning* (New York: Free Press, 1999).

17 Jonathan Glover, *Humanity: A Moral History of the Twentieth Century* (London: J. Cape, 1999); Peter Singer, *A Darwinian Left: Politics, Evolution, and Cooperation* (London: Weidenfeld & Nicolson, 1999).

all societies manifest a sense of sympathy: an ability to treat the interests of others as comparable to their own.[18] Unfortunately, the size of the moral circle in which sympathy is extended is a free parameter. By default, people sympathize only with members of their own family, clan, or village, and treat anyone outside this circle as less than human. But under certain circumstances the circle can expand to other clans, tribes, races, or even species. An important way to understand moral progress, then, is to specify the triggers that prompt people to expand or contract their moral circles. It has been argued that the circle may be expanded to include people to whom one is bound by networks of reciprocal trade and interdependence,[19] and that it may be contracted to exclude people who are seen in degrading circumstances.[20] In each case, an understanding of nonobvious aspects of human nature reveals possible levers for humane social change.

"Genes are affected by their environments, and learning requires the expression of genes, so the nature-nurture distinction is meaningless." It is, of course, in the very nature of genes that they are not turned on all the time but are expressed and regulated by a variety of signals. These signals in turn may be triggered by a variety of inputs, including temperature, hormones, the molecular environment, and neural activity.[21] Among the environmentally sensitive gene-expression effects are those that make learning itself possible. Skills and memories are stored as physical changes at the synapse, and these changes require the expression of genes in response to patterns of neural activity.

These causal chains do not, however, render the nature-nurture distinction obsolete. What they do is force us to rethink the casual equation of 'nature' with genes and of 'nurture' with everything beyond the genes. Biologists have noted that the word 'gene' accumulated several meanings during the twentieth century.[22] These include a unit of heredity, a specification of a part, a cause of a disease, a template for protein synthesis, a trigger of development, and a target of natural selection.

It is misleading, then, to equate the prescientific concept of human nature with 'the genes' and leave it at that, with the implication that environment-dependent gene activity proves that human nature is indefinitely modifiable by experience. Human nature is related to genes in terms of units of heredity, development, and evolution, particularly those units that exert a systematic and lasting effect on the wiring and chemistry of the brain. This is distinct from the most common use of the term 'gene' in molecular biology, namely, in reference to stretches of DNA that code for a

18 Peter Singer, *The Expanding Circle: Ethics and Sociobiology* (New York: Farrar, Straus & Giroux, 1981).

19 Robert Wright, *NonZero: The Logic of Human Destiny* (New York: Pantheon Books, 2000).

20 Glover, *Humanity*; Philip G. Zimbardo, Christina Maslach, and Craig Haney, "Reflections on the Stanford Prison Experiment: Genesis, Transformations, Consequences," in *Obedience to Authority: Current Perspectives on the Milgram Paradigm*, ed. Thomas Blass (Mahwah, N.J.: Lawrence Erlbaum Associates, 2000).

21 Marcus, *The Birth of the Mind*; Ridley, *Nature Via Nurture*.

22 Ridley, *Nature Via Nurture*; Richard Dawkins, *The Extended Phenotype: The Gene as the Unit of Selection* (San Francisco: W. H. Freeman & Company, 1982); Seymour Benzer, "The Elementary Units of Heredity," in *A Symposium on the Chemical Basis of Heredity*, ed. William D. McElroy and Bentley Glass (Baltimore: Johns Hopkins Press, 1957).

protein. Some aspects of human nature may be specified in information carriers other than protein templates, including the cytoplasm, noncoding regions of the genome that affect gene expression, properties of genes other than their sequence (such as how they are imprinted), and cross-generationally consistent aspects of the maternal environment that the genome has been shaped by natural selection to expect. Conversely, many genes direct the synthesis of proteins necessary for everyday metabolic function (such as wound repair, digestion, and memory formation) without embodying the traditional notion of human nature.

The various concepts of 'environment,' too, have to be refined. In most nature-nurture debates, 'environment' refers in practice to aspects of the world that make up the perceptual input to the person and over which other humans have some control. This encompasses, for example, parental rewards and punishments, early enrichment, role models, education, laws, peer influence, culture, and social attitudes. It is misleading to blur 'environment' in the sense of the psychologically salient environment of the person with 'environment' in the sense of the chemical milieu of a chromosome or cell, especially when that milieu itself consists of the products of other genes and thus corresponds more closely to the traditional notion of heredity. There are still other senses of 'environment,' such as nutrition and environmental toxins; the point is not that one sense is primary, but that one should seek to distinguish each sense and characterize its effects precisely.

A final reason that the environment dependence of the genes does not vitiate the concept of human nature is that an environment can affect the organism in very different ways. Some aspects of the perceptual environment are instructive in the sense that their effects are predictable by the information contained in the input. Given a child who is equipped to learn words in the first place, the content of her vocabulary is predictable from the words spoken to her. Given an adult equipped to understand contingencies, the spot where he will park his car will depend on where the No Parking signs are posted. But other aspects of the environment, namely, those that affect the genes directly rather than affecting the brain through the senses, trigger genetically specified if-then contingencies that do not preserve information in the trigger itself. Such contingencies are pervasive in biological development, where many genes produce transcription factors and other molecules that set off cascades of expression of other genes. A good example is the Pax6 gene, which produces a protein that triggers the expression of twenty-five hundred other genes, resulting in the formation of the eye. Highly specific genetic responses can also occur when the organism interacts with its social environment, as when a change of social status in a male cichlid fish triggers the expression of more than fifty genes, which in turn alter its size, aggressiveness, and stress response.[23] These are reminders both that innate organization cannot be equated with a lack of sensitivity to the environment, and that responses to the environment are often not specified by the stimulus but by the nature of the organism.

"Framing problems in terms of nature and nurture prevents us from understanding human development and mak-

23 Russell Fernald, "How Does Behavior Change the Brain? Multiple Methods to Answer Old Questions," *Integrative Comparative Biology* 43 (2003): 771–779.

ing new discoveries." On the contrary, some of the most provocative discoveries in twentieth-century psychology would have been impossible if there had not been a concerted effort to distinguish nature and nurture in human development.

For many decades psychologists have looked for the causes of individual differences in cognitive ability (as measured by IQ tests, school and job performance, and indices of brain activity) and in personality (as measured by questionnaires, ratings, psychiatric evaluations, and tallies of behavior such as divorce and crime). The conventional wisdom has been that such traits are strongly influenced by parenting practices and role models. But recall that this belief is based on flawed correlational studies that compare parents and children but forget to control for genetic relatedness.

Behavioral geneticists have remedied those flaws with studies of twins and adoptees, and have discovered that in fact virtually all behavioral traits are partly (though never completely) heritable.[24] That is, some of the variation among individual people within a culture must be attributed to differences in their genes. The conclusion follows from repeated discoveries that identical twins reared apart (who share their genes but not their family environment) are highly similar; that ordinary identical twins (who share their environment and all their genes) are more similar than fraternal twins (who share their environment but only half their variable genes); and that biological siblings (who share their environment and half their variable genes) are more similar than adoptive siblings (who share their environment but none of their variable genes). These studies have been replicated in large samples from several countries, and have ruled out the most common alternative explanations (such as selective placement of identical twins in similar adoptive homes). Of course, concrete behavioral traits that patently depend on content provided by the home or culture – which language one speaks, which religion one practices, which political party one supports – are not heritable at all. But traits that reflect the underlying talents and temperaments – how proficient with language a person is, how religious, how liberal or conservative – *are* partially heritable. So genes play a role in making people different from their neighbors, and their environments play an equally important role.

At this point it is tempting to conclude that people are shaped both by genes and by family upbringing: how their parents treated them and what kind of home they grew up in. But the conclusion is unwarranted. Behavioral genetics allows one to distinguish two very different ways in which people's environments might affect them. The *shared* environment is what impinges on a person and his or her siblings alike: their parents, home life, and neighborhood. The *unique* environment is everything else: anything that happens to a person that does not necessarily happen to that person's siblings.

Remarkably, most studies of intelligence, personality, and behavior turn up few or no effects of the shared environment – often to the surprise of the researchers themselves, who thought it was obvious that nongenetic variation

24 Plomin, Owen, and McGuffin, "The Genetic Basis of Complex Human Behaviors"; Eric Turkheimer, "Three Laws of Behavior Genetics and What They Mean," *Current Directions in Psychological Science* 9 (5) (2000): 160 – 164; Thomas J. Bouchard, Jr., "Genetic and Environmental Influences on Intelligence and Special Mental Abilities," *Human Biology* 70 (1998): 257 – 259.

had to come from the family.[25] First, adult siblings are about equally correlated whether they grew up together or apart. Second, adoptive siblings, when tested as adults, are generally no more similar than two people from the same culture chosen at random. And third, identical twins are no more similar than one would expect from the effects of their shared genes. Setting aside cases of extreme neglect or abuse, whatever experiences siblings share by growing up in the same home in a given culture make little or no difference to the kind of people they turn into. Specific skills like reading and playing a musical instrument, of course, can be imparted by parents, and parents obviously affect their children's happiness and the quality of family life. But they don't seem to determine their children's intellects, tastes, and personalities in the long run.

The discovery that the shared family environment has little to no lasting effect on personality and intelligence comes as a shock to the traditional wisdom that "as the twig is bent, so grows the branch." It casts doubt on forms of psychotherapy that seek the roots of an adult's dysfunction in the family environment, on theories that attribute adolescents' alcoholism, smoking, and delinquency to how they were treated in early childhood, and on the philosophy of parenting experts that parental micromanagement is the key to a well-adjusted child. The findings are so counterintuitive that one might doubt the behavioral genetic research that led to them, but they are corroborated by other data.[26] Children of immigrants end up with the language, accent, and mores of their peers, not of their parents. Wide variations in child-rearing practices – day-care versus stay-at-home mothers, single versus multiple caregivers, same-sex versus different-sex parents – have little lasting effect when other variables are controlled. Birth order and only-child status also have few effects on behavior outside the home.[27] And an extensive study testing the possibility that children might be shaped by *unique* aspects of how their parents treat them (as opposed to ways in which parents treat all their children alike) showed that differences in parenting within a family are effects, not causes, of differences among the children.[28]

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The discovery of the limits of family influence is not just a debunking exercise, but opens up important new questions. The finding that much of the variance in personality, intelligence, and behavior comes neither from the genes nor from the family environment raises the question of where it does come from. Judith Rich Harris has argued that the phenomena known as socialization – acquiring the skills and values needed to thrive in a given culture – take place in the peer group rather than the family.

25 Rowe, *The Limits of Family Influence*; Harris, *The Nurture Assumption*; Turkheimer, "Three Laws of Behavior Genetics"; Robert Plomin and Denise Daniels, "Why Are Children in the Same Family So Different from One Another?" *Behavioral and Brain Sciences* 10 (1987): 1 – 60.

26 Harris, *The Nurture Assumption*.

27 Ibid.; Judith Rich Harris, "Context-Specific Learning, Personality, and Birth Order," *Current Directions in Psychological Science* 9 (2000): 174 – 177; Jeremy Freese, Brian Powell, and Lala Carr Steelman, "Rebel Without a Cause or Effect: Birth Order and Social Attitudes," *American Sociological Review* 64 (1999): 207 – 231.

28 David Reiss, Jenae M. Neiderhiser, E. Mavis Hetherington, and Robert Plomin, *The Relationship Code: Deciphering Genetic and Social Influences on Adolescent Development* (Cambridge, Mass.: Harvard University Press, 2000).

Though children are not prewired with cultural skills, they also are not indiscriminately shaped by their environment. One aspect of human nature directs children to figure out what is valued in their peer group – the social milieu in which they will eventually compete for status and mates – rather than to surrender to their parents' attempts to shape them.

Acknowledging this feature of human nature in turn raises questions about how the relevant environments, in this case peer cultures, arise and perpetuate themselves. Does a peer culture trickle down from adult culture? Does it originate from high-status individuals or groups and then proliferate along peer networks? Does it emerge haphazardly in different forms, some of which entrench themselves when they reach a tipping point of popularity?

A revised understanding of how children socialize themselves has practical implications as well. Teen alcoholism and smoking might be better addressed by understanding how these activities become status symbols in peer groups than by urging parents to talk more to their adolescents (as current advertisements, sponsored by beer and tobacco companies, insist). A major determinant of success in school might be whether classes fission into peer groups with different status criteria, in particular whether success in school is treated as admirable or as a sign of selling out.[29]

The development of personality – a person's emotional and behavioral idiosyncrasies – poses a set of puzzles distinct from those raised by the process of socialization. Identical twins growing up in the same home share their genes, their parents, their siblings, their peer groups, and their culture. Though they are highly similar, they are far from indistinguishable: by most measures, correlations in their traits are in the neighborhood of 0.5. Peer influence cannot explain the differences, because identical twins largely share their peer groups. Instead, the unexplained variance in personality throws a spotlight on the role of sheer chance in development: random differences in prenatal blood supply and exposure to toxins, pathogens, hormones, and antibodies; random differences in the growth or adhesion of axons in the developing brain; random events in experience; random differences in how a stochastically functioning brain reacts to the same events in experience. Both popular and scientific explanations of behavior, accustomed to invoking genes, parents, and society, seldom acknowledge the enormous role that unpredictable factors must play in the development of an individual.

If chance in development is to explain the less-than-perfect similarity of identical twins, it also highlights an interesting property of development in general. One can imagine a developmental process in which millions of small chance events cancel one another out, leaving no difference in the resulting organism. One can imagine a different process in which a chance event could disrupt development entirely. Neither of these happens to identical twins. Their differences are detectable both in psychological testing and in everyday life, yet both are (usually) healthy human beings. The development of organisms must use complex feedback loops rather than prespecified blueprints. Random events can divert the trajectories of growth, but the trajectories are confined within an envelope of functioning designs for the species.

These profound questions are not about nature versus nurture. They are about nurture versus nurture: about

29 Harris, *The Nurture Assumption*.

what, precisely, are the nongenetic causes of personality and intelligence. But the puzzles would never have come to light if researchers had not first taken measures to factor out the influence of nature, by showing that correlations between parents and children cannot glibly be attributed to parenting but might be attributable to shared genes. That was the first step that led them to measure the possible effects of parenting empirically, rather than simply assuming that parents had to be all-powerful. The everything-affects-everything diagram turns out to be not sophisticated but dogmatic. The arrows emanating from 'parents,' 'siblings,' and 'the home' are testable hypotheses, not obvious truisms, and the tests might surprise us both by the arrows that shouldn't be there and by the labels and arrows we may have forgotten.

The human brain has been called the most complex object in the known universe. No doubt hypotheses that pit nature against nurture as a dichotomy or that correlate genes or environment with behavior without looking at the intervening brain will turn out to be simplistic or wrong. But that complexity does not mean we should fuzz up the issues by saying that it's all just too complicated to think about, or that some hypotheses should be treated a priori as obviously true, obviously false, or too dangerous to mention. As with inflation, cancer, and global warming, we have no choice but to try to disentangle the multiple causes.[30]

30 The writing of this paper was supported by NIH Grant HD-18381. I thank Helena Cronin, Jonathan Haidt, Judith Rich Harris, and Matt Ridley for comments on an earlier draft.

Richard Rorty

Philosophy-envy

When philosophers like Ortega y Gasset say that we humans have a history rather than a nature, they are not suggesting that we are blank slates. They do not doubt that biologists will eventually pin down the genetic factor in autism, homosexuality, perfect pitch, lightning calculation, and many other traits and abilities that differentiate some humans from others. Nor do they doubt that, back in the days when our species was evolving its way into existence on the African savannas, certain genes were weeded out and others preserved. They can cheerfully agree with scientists like Steven Pinker that the latter genes account for various sorts of behavior common to all human beings, regardless of acculturation.

What these philosophers doubt is that either factoring out the role of genes in making us different from one another, or tracing what we have in common back to the evolutionary needs of our ancestors, will give us anything appropriately labeled 'a theory of human nature.' For such theories are supposed to be normative – to provide guidance. They should tell us what to do with ourselves. They should explain why some lives are better for human beings than other lives, and why some societies are superior to others. A theory of human nature should tell us what sort of people we ought to become.

Philosophical and religious theories of human nature flourished because they stayed clear of empirical details. They took no chances of being disconfirmed by events. Plato's and Aristotle's theories about the parts of the soul were of this sort, and so were Christianity's theory that we are all children of a loving God, Kant's theory that we are phenomenal creatures under noumenal command, and Hobbes's and Freud's naturalizing stories about the origins of sociality and of morality. Despite their lack of predictive power and empirical disconfirmability, such theories were very useful – not because they were accurate accounts of what human beings, deep down, really and truly are, but because they suggested perils to avoid and ideals to serve. They marketed helpful moral

Richard Rorty, a Fellow of the American Academy since 1983, is professor of comparative literature and philosophy at Stanford University, as well as a regular contributor to "The Nation" and "Dissent." His books include "Philosophy and the Mirror of Nature" (1979), "Contingency, Irony, and Solidarity" (1989), and, most recently, "Philosophy and Social Hope" (1999).

and political advice in fancy, disposable, packaging.

Steven Pinker is trying to recycle this packaging, wrapping it around a miscellany of empirical facts rather than around a vision of the good life or of the good society. But it is hard to see how a composite, or a synthesis, of the various empirical disciplines that now call themselves cognitive sciences could serve the purposes that religion and philosophy once served. The claim that what the philosophers did a priori and badly can now be done a posteriori and well by cognitive scientists will remain empty rhetoric until its adherents are willing to stick their necks out. To make good on the promise of the term 'a scientific theory of human nature' they would have to start offering advice about how we might become, individually or collectively, better people. Then they would have to spell out the inferences that had led them from particular empirical discoveries about our genes or our brains to these particular practical recommendations.

E. O. Wilson, Pinker, and others who think that biology and cognitive science can take over at least part of the cultural role of philosophy are reluctant to start down this path. They remember the fate of the eugenics movement – of claims to have 'proved scientifically' that interracial marriage, or increased immigration, would produce cultural degeneration. Recalling this obnoxious predecessor makes them leery of betting the prestige of their disciplines on the outcome of practical recommendations. Instead, they just repeat over and over again that as we learn more and more about our genes and our brains, we shall gain a better understanding of what we essentially are.

But for historicist philosophers like Ortega there is nothing we essentially are. There are many lessons to be learned from history, but no super-lesson to be learned from science, or religion, or philosophy. The unfortunate idea that philosophy could detect the difference between nature and convention – between what is essential to being a human being and what is merely a product of historical circumstance – was passed on from Greek philosophy to the Enlightenment. There it reappeared, in a version that would have disgusted Plato, in Rousseau. But in the last two centuries the notion that beneath all cultural overlays there lurks something called human nature, and that knowledge of this thing will provide valuable moral or political guidance, has fallen into deserved disrepute.

Dewey was right to mock Plato's and Aristotle's claims that the contemplative life was the one that best utilized our distinctively human abilities. Such claims, he said, were merely ways in which these philosophers patted themselves on the back. Ever since Herder, the Rousseauvian claim that the aim of sociopolitical change should be to bring us back to uncorrupted nature has been rejected by thinkers impressed by the extent, and the value, of cultural variation. The idea, shared by Plato and Rousseau, that there is such a thing as *the* good life for man has gradually been replaced by the conviction that there are *many* equally valuable human lives. This change has resulted in our present conviction that the best sociopolitical setup is one in which individuals are free to live whichever of these lives they choose – to make themselves up as they go along, without asking what they were somehow 'meant' to become. It has also resulted in religion and philosophy being nudged aside by history, literature, and the arts as sources of edification and of ideals.

Carl Degler's *In Search of Human Nature: The Decline and Revival of Darwinism in American Social Thought* tells the story of the biologists' attempts to move onto some of the turf from which the philosophers have been withdrawing. Darwinism revealed previously unsuspected continuities between humans and brutes, and these made it seem plausible that further biological research could tell us something morally significant. In a chapter called "Why Did Culture Triumph?" Degler explains how the overweening pretensions of the eugenicists, and the futile attempt to stem the tide of feminism by appeals to biological facts about the differing 'natures' of men and women, helped to discredit this suggestion. Then, in a chapter called "Biology Redivivus," he describes how sociobiologists and their allies have been trying to push the pendulum back in the other direction.

Degler ends his book on an ecumenical note, endorsing what Pinker calls holistic interactionism. But many of his readers will conclude that the moral of the story he tells is that "nature or nurture?" was never a very good question. Darwin did make a tremendous difference to the way we think about ourselves, because he discredited religious and philosophical accounts of a gap between the truly human and immaterial part of us and the merely animal and material part. But nothing Darwin taught us blurs the distinction between what we can learn from the results of biological and psychological experiments and what we can only learn from history – the record of past intellectual and social experiments.

Pinker is right that the nature vs. nurture debate will not go away as long as the question is raised in respect to some very particular type of human behavior – autism, for example. But at more abstract levels, such debates are vacuous. They are rhetorical exchanges occasioned by academic turf wars. The question "Is our humanity a biological or a cultural matter?" is as sterile as "Are our actions determined or do we have free will?" No concrete result in genetics, or physics, or any other empirical discipline will help us answer either bad question. We will go right on deliberating about what to do, and holding each other responsible for actions, even if we become convinced that every thought we have, and every move we make, will have been predicted by an omniscient neurologist. We will go right on experimenting with new lifestyles, new ideas, and new social institutions, even if we become convinced that, deep down, everything somehow depends on our genetic makeup. Discussion of the nature-nurture question, like discussion of the problem of free will, has no pragmatic import.

Pinker says, correctly, that there is a "widespread desire that the whole [nature-nurture] issue would somehow just go away" and an equally widespread suspicion that to refute a belief in the blank slate is "to tip over a straw man." Readers of Degler will be disposed to share both that desire and that suspicion. Pinker hopes to change their minds by tipping over other straw men: "postmodernism and social constructionism, which dominate many of the humanities." But it is hard to think of any humanist – even the most far-out Foucauldian – who would endorse the view, implausibly attributed by Pinker to Louis Menand, that "biology can provide no insight into human mind and behavior." What Foucault, Menand, and Ortega doubt is that insights provided by biology will ever help us decide which individual and social ideals to strive for.

Pinker thinks that science may succeed where philosophy has failed. To make his case, however, he has to treat platitudes as gee-whiz scientific discoveries. He says, for example, that "cognitive science has shown that there must be complex innate mechanisms for learning and culture to be possible." Who ever doubted there were? We already knew, before cognitive science came along, that you cannot teach young nonhuman animals to do things that you can teach young humans to do. We figured out a long time ago that if an organism had one kind of brain we could teach it to talk, and that if it had another kind we could not. Yet Pinker writes as if people like Menand were committed to denying evident facts such as these.

Again, Pinker cites recent suggestions that the circle of organisms that are objects of our moral concern "may be expanded to include people to whom one is bound by networks of reciprocal trade and interdependence, and . . . contracted to exclude people who are seen in degrading circumstances." But we did not need recent scientific research to tell us about these "possible levers for humane social change." The relevance of interdependence to the way we treat foreign traders, and of degradation to the way we treat prisoners of war, is hardly news. People have been recommending trade and intermarriage as a way of achieving wider community for a long time now. For an equally long time, they have been suggesting that we stop degrading people in order to have an excuse for oppressing them. But Pinker describes facts familiar to Homer and Herodotus as exhibiting "nonobvious aspects of human nature."

It is likely that further discoveries about how our brains work will give us a lot of useful ideas about how to change human behavior. But suppose that nanotechnology eventually enables us to trace the transmission of electrical charges from axon to axon within the living brain, and to correlate such processes with minute variations in behavior. Suppose that we become able to modify a person's behavioral dispositions, in pretty much any way we like, just by tweaking her brain cells. How will this ability help us figure out what sort of behavior to encourage and what sort to discourage – to know how human beings should live? Yet that sort of help is just what philosophical theories of human nature claimed to provide.

Pinker says at various places in *The Blank Slate* that everybody has and needs a theory of human nature, and that empirical scientific inquiry is likely to give us a better theory than either uninformed common sense or a priori philosophizing. But it is not clear that we have or need anything of the sort. Every human being has convictions about what matters more and what matters less, and thus about what counts as a good human life. But such convictions need not – and should not – take the form of a theory of human nature, or a theory of anything else. Our convictions about what really matters are constantly modified by new experiences – moving from a village to a city or from one country to another, meeting new people, and reading new books. The idea that we deduce them, or should deduce them, from a theory is a Platonist fantasy that the West has gradually outgrown.

The books that change our moral and political convictions include sacred scriptures, philosophical treatises, intellectual and sociopolitical histories, epic poems, novels, political manifestoes, and writings of many other sorts. But scientific treatises have become increasingly irrelevant to this process of change.

This is because, ever since Galileo, natural science has won its autonomy and its richly deserved prestige by telling us how things work, rather than, as Aristotle hoped to do, telling us about their intrinsic natures.

Post-Galilean science does not tell us what is really real or really important. It has no metaphysical or moral implications. Instead, it enables us to do things that we had not previously been able to do. When it became empirical and experimental, it lost both its metaphysical pretensions and the ability to set new ends for human beings to strive for. It gained the ability to provide new means. Most scientists are content with this trade-off. But every so often a scientist like Pinker tries to have it both ways, and to suggest that science can provide empirical evidence to show that some ends are preferable to others.

Whereas physics-envy is a neurosis found among those whose disciplines are accused of being soft, philosophy-envy is found among those who pride themselves on the hardness of their disciplines. The latter think that their superior rigor qualifies them to take over the roles previously played by philosophers and other sorts of humanists – roles such as critic of culture, moral guide, guardian of rationality, and prophet of the new utopia. Humanists, such scientists argue, only have opinions, but scientists have knowledge. Why not, they ask us, stop your ears against culture-babble (which is all you are going to get from those frivolous postmodernists and irresponsible social constructionists) and get your self-image from the people who know what human beings really, truly, objectively, enduringly, transculturally are?

Those who succumb to such urgings are subjected to bait-and-switch tactics. They think they will learn whether to be more like Antigone than like Ismene, or more like Martha than like Mary, or more like Spinoza than like Baudelaire, or more like Lenin than like FDR, or more like Ivan Karamazov than like Alyosha. They want to know whether they should throw themselves into campaigns for world government, or against gay marriage, or for a global minimum wage, or against the inheritance tax. They hope for the sort of guidance that idealistic freshmen still think their teachers may be able to provide. When they take courses in cognitive science, however, this is not what they get. They get a better understanding of how their brains work, but no help in figuring out what sort of people to be or what causes to fight for.

This sense that they have been subjected to bait-and-switch tactics often also afflicts freshmen who sign up for philosophy courses because they have been turned on by Marx, Camus, Kierkegaard, Nietzsche, or Heidegger. They imagine that if they take a course in what are advertised as 'the core areas of philosophy' – metaphysics and epistemology – they will be better able to answer the questions these authors raised. But what they get in such courses is, typically, a discussion of the place of such things as knowledge, meaning, and value in a world made up of elementary particles. Many would-be students of philosophy are unable to see why they need have views on that topic – why they need a metaphysics.

It was because Ortega found such topics profitless that he wrote polemical essays like the one from which Pinker quotes ("History as a System," in Ortega's *Toward a Philosophy of History*). There he said:

> all the naturalist studies on man's body and soul put together have not been of the slightest use in throwing light on any of our most strictly human feelings, on what each individual calls his own life, that life which, intermingling with others, forms societies, that in their turn, persisting, make up human destiny. The prodigious achievement of natural science in the direction of the knowledge of things contrasts brutally with the collapse of this same natural science when faced with the strictly human element.

Ortega insisted that increasing knowledge of how things such as the human brain and the human genome work will never help us figure out how to envisage ourselves and what to do with ourselves. Pinker thinks that he was wrong. But only a few pages of *The Blank Slate* grapple directly with this issue. Among those that do, the most salient are the ones in which Pinker argues that scientific discoveries give us reason to adopt what he calls "The Tragic Vision" rather than "The Utopian Vision" of human life – to take a dim view of the capacity of human beings to change themselves into new and better sorts of people.

In order to show that our choice between these two visions should be made by reference to science rather than to history, Pinker has to claim, cryptically, that "parts of these visions" consist of "general claims about how the mind works." But that is just what historicist philosophers like Ortega doubt. They think that the contest between these two visions will be unaffected even if the brain turns out to work in some weird way that contemporary science has not yet envisaged, or if new fossil evidence shows that the current story about the evolution of our species is all wrong. Debates about what to do with ourselves, they say, swing as free from disagreements about the nature of neurons or about where we came from as they do from controversies about the nature of quarks or about the timing of the big bang.[1]

The issue Pinker has with Ortega, and with most philosophers outside the so-called analytic tradition, has nothing to do with blank slates. It is about whether the conversations among humanists about alternative self-images and alternative ideals would be improved if the participants knew more about what is going on in biology and cognitive science. Pinker argues that men and women with moral and political concerns have always relied upon theories of human nature, and that empirically based theories are now available. But Ortega would reply that for the last few hundred years we have learned to substitute historical narrative and utopian speculation for such theories.

This historicist turn does, however, owe a great deal to one particular scientist: Darwin. Darwin helped us stop thinking of ourselves as an animal body in which something extra, and specifically human, has been inserted – a mysterious ingredient whose nature poses philosophical problems. His critics said that he had reduced us to the level of the beasts, but in fact he let us see imaginative daring as a causal force comparable to genetic mutation. He reinforced the historicism of Herder and Hegel by letting us see cultural evolution as on a par with biological evolution – as equally capable of creating something radically new and better. He helped poets like Tennyson and Whitman, and thinkers like Nietzsche, H. G. Wells, George Bernard Shaw, and John Dewey, to dream of

1 For more on this point, see my "The Brain as Hardware, Culture as Software," *Inquiry* 47 (3) (June 2004): 219 – 235.

utopias in which human beings had become as wonderfully different from us as we are from the Neanderthals. The dreams of socialists, feminists, and others have produced profound changes in Western social life, and may lead to vast changes in the life of the species as a whole. Nothing that natural science tells us should discourage us from dreaming further dreams.

Richard Wrangham

Killer species

Human social behavior varies so much that our plasticity can sometimes seem infinite. But human variation has obvious limits when we compare ourselves with our primate relatives. Napoleon may have claimed that he always had to give in to his wife, the Empress Josephine, but there are no human societies that follow the lemur pattern of all males invariably subordinating themselves to all females. Nor do women anywhere entice all their male counterparts in their community to mate with them every month, as female chimpanzees do. Just as other species have their particular social tendencies, in other words, so does ours. Features characteristic of human society include social communities composed of individuals who associate at will, multilevel ties among communities, mothers forming mating bonds, coalitions of males fighting over territory, and so on.

That all humans share some characteristic social tendencies may be unremarkable in comparison with other species, but it provides valuable insight into behavioral evolution. In this essay I will focus on a few features we share with our closest ape relatives, but that are otherwise found rarely. In particular, we share the tendency for coalitions of related males to cooperate in defending a shared territory; and we kill our enemies. These are unusual patterns in other primates, so the question is why they should be prominent in humans and our close kin.

One hypothesis is phylogenetic inertia, the nonadaptive retention of an ancestral trait. Phylogenetic inertia is a possibility whenever closely related species behave alike. For example, horses and zebras both live in groups of unrelated females and single stallions within larger herds. Breeding wolves and coyotes live as isolated monogamous pairs aided by nonbreeding helpers. Male hornbills of many different species imprison their mating partners in a secluded breeding hole. There are many such examples of social systems corre-

Richard Wrangham, professor of biological anthropology at Harvard University, has studied chimpanzees in Gombe (with Jane Goodall) and in Kibale, as well as vervet monkeys and gelada baboons. His book "Demonic Males: Apes and the Origins of Human Violence" (1996) popularized ideas he developed in research focused on the influence of ecology on the evolution of primate social behavior. He has been a Fellow of the American Academy since 1993.

lated with phylogeny, and in theory these could result from species failing to adapt their behavior to new circumstance.

However attractive the notion of phylogenetic inertia might seem, it suffers from the problem of explaining why adaptive changes in social behavior should be constrained. The hypothesis of adaptive socioecology is therefore a strong a priori alternative to phylogenetic inertia. Adaptive socioecology posits that a similar lifestyle is the key to similar behavior among closely related species, whether it be grass-eating for horses and zebras, den-living for wolves and coyotes, or a shortage of suitable nesting holes for different species of hornbills. Adaptive socioecology rests on the notion that social systems can change rapidly in response to a novel ecology.

Baboons offer a particularly tidy example of adaptive socioecology, because even within a single species genetically based differences in psychology have evolved in apparent response to a specific ecological change. East Africa's olive baboons live in lush grasslands where the abundance of food permits large, cooperative groups of female kin that aid each other in competition against other females. Too large to be monopolized by a single male, a group generally includes ten or more unrelated males that join as adolescents. Female olive baboons respond to the plethora of males by mating widely within the group, thereby garnering protection for their offspring from the numerous possible fathers. A rich food supply thus promotes large, multimale groups of promiscuous and kinbonded females.

Hamadryas baboons, by contrast, occupy semideserts in northeast Africa and Arabia. They resemble olive baboons closely, being only marginally smaller, with somewhat more colorful males. In their dry habitat, food is so sparse that in bad seasons the large groups fragment by day in search of forage. But females can't survive without a defending male, so each stays in a small subgroup with a single male, to whom she becomes faithfully bonded and whom she allows to herd her when other males are near. To prevent other males from stealing their females when the subgroups reunite at sleeping sites, males form defensive alliances with each other. A poor food supply thus leads to small families of acquiescent female hamadryas attached to a network of bonded males.

The contrasting baboon social patterns conform to the respective ecological pressures. These differences could in theory emerge merely as the baboons' developmental response to their immediate environments, but there is evidence of strong genetic influence. Thus even after many generations in captivity, baboons of the two subspecies form the same kinds of social groups as their wild ancestors. The same differentiation is dramatically echoed among naturally occurring hybrids in Ethiopia, for which physical features and behavior are correlated. Females that look more like olive baboons, for example, strongly resist male efforts to herd them. By contrast, those that look more like hamadryas readily accept a male's herding. Differences in serotonin levels between males of the two subspecies of baboons conform to the different patterns of aggression.

Olive and hamadryas baboons differentiated from each other around three hundred thousand years ago. Even without any notable anatomical evolution, therefore, three hundred thousand years and a changed ecology are enough for radical adaptation in social behavior, including patterns of grouping, kin relations, and feeding competition.

Why, then, should humans be in the least similar to our cousin apes? Chimpanzees and bonobos are separated from humans not only by five to six million years, but by enormous changes in ecology and ability, including raw biological differences in diet, locomotion, and sexuality, as well as by the refined influences of language and culture. Against this background, significant social similarities with our cousin apes are puzzling. While phylogenetic inertia is an explanation of last resort, adaptive socioecology is at first glance improbable. As we will see, however, hidden ecological similarities suggest that contrary to the apparent differences between humans and other apes, our shared social features derive from parallel ecological pressures.

Though human hunter-gatherers (also called foragers) offer the most appropriate comparison with other species, their lifestyle and social relations differ about as much from those of our cousin apes as any other people's. Foragers dig for roots and collect fruits, hunt large game, cook their food, construct simple housing, and defend themselves with spears or other weapons. They tend to occupy temporary camps for several weeks at a time, housing a group of perhaps twenty to forty people, and they relocate these camps when the women find it hard to get enough food within a reasonable day's walk. The members of a camp are part of a larger social community that might include a few hundred or even a thousand or more people. At certain times of the year this community gathers for a few days, when feasts and ceremonies allow social relationships to be re-formed across the wider network of the tribe. And as is true for every other human society, cultural rules pervade life among such communities. None of this is very ape-like.

Chimpanzees and bonobos are the species of apes that are closest to humans. Both are quadrupedal, forest-living fruit-eaters that climb for most of their food, sleep in trees exposed to the rain, and use only the simplest tools (some populations use none). Their communities are limited to the set of individuals that live sufficiently close that they might meet by chance. These communities are formed around a core of related males, and there are no bonds among mates.

Yet different as humans and these apes are, all three species live in social communities with no fixed associations of individuals other than those between mothers and their dependent offspring – a rare trait in the context of most other primates. Accordingly, during the day, individuals of these species can decide for themselves where to go. In practice, among hunter-gatherers most women forage every day in the company of other women from their temporary camp, much as most male chimpanzees spend the day in the company of chosen allies. But in both cases, there are options. A woman might choose to make a tryst, stay in the camp, or walk alone. A male chimpanzee might equally well opt to travel alone for hours or days at a time.

Such individual choice within a defined social network occurs in only one other group of primates: the atelines, South American monkeys distantly related to apes. In addition to community organization, those species share a second rare similarity with humans, chimpanzees, and bonobos: their males form coalitions to defend territory.

There are other ways in which the atelines (spider monkeys, woolly monkeys, and muriqui) are the most ape-like group of monkeys: their large size relative to other South American monkeys, relatively efficient travel, mobile shoulders, and diet of ripe fruit and soft leaves. It has therefore been suggested that resemblances between the social behavior of atelines and that of the apes have resulted from parallel adaptations for harvesting ripe fruit, a resource that induces intense feeding competition, independent travel, and territorial defense.[1] In line with this suggestion, the protean grouping patterns of humans may be similarly derived from an evolutionary commitment to high-quality foods.

Whatever its precise cause, the combination of social communities with small and frequently changing subgroups appears to be an important precondition for one of the most striking similarities between humans and any other primates: the territorial aggression observed in humans and chimpanzees alike.

Warfare is often defined in a way that suggests it is unique to humans, for instance, as an interaction involving culturally sanctioned plans or weapons or organized fighting between large groups. But of course the behavior that underlies human warfare is not unique, as the chimpanzee case makes clear.

Most encounters between chimpanzee communities involve males. There can be as many as thirty-five males in a community, but the average is ten to twelve, and most parties (temporary subgroups) have about half that number. Interactions with neighboring communities are never friendly and are often dangerous.

But even so, males sometimes seek out opportunities to engage with neighbors. They routinely conduct border patrols and may penetrate beyond the zone of relative safety, looking carefully as they go. Sometimes they climb a tree and face the neighboring range, as if listening for rivals. Occasionally they make deep invasions.

Most encounters that result from these behaviors happen by chance when nearby parties surprise each other at close range – a few hundred yards, say. Calls from strangers prompt immediate tension. Sometimes the listeners briefly freeze, but more often they let out a volley of shouts and quickly move. If they are numerous, they advance. If not, they retreat toward the heart of their territory.[2]

But when they meet at close range and the numbers of males on each side are similar they're more likely to stand their ground. Typically, chimpanzees in the battleground hurtle unpredictably through the brush, pausing after each rush to look and listen tensely around, often standing bipedal with one hand on a small tree. For them one decision might be a matter of success or death. Their pauses allow them to gauge who's where, to find an ally, or to see uncertainty in the enemy. After a stop, alone or in a small tight group of two or three, they charge off on a new run across the battle area. Occasionally one of them gets hit by a passing rusher, but mostly the chimpanzees from each community charge backwards and forwards from safe spots as each side tries to frighten the other into retreat. The air is thick

1 Colin A. Chapman, Richard Wrangham, and Lauren J. Chapman, "Ecological Constraints on Group Size: An Analysis of Spider Monkey and Chimpanzee Subgroups," *Behavioral Ecology and Sociobiology* 36 (1995): 59 – 70.

2 Michael L. Wilson, Marc D. Hauser, and Richard W. Wrangham, "Does Participation in Intergroup Conflict Depend on Numerical Assessment, Range Location, or Rank for Wild Chimpanzees?" *Animal Behaviour* 61 (2001): 1203 – 1216, describe playback experiments showing that when a call is heard from a single stranger, chimpanzees move forward only if there are at least three males in the listening party, and that otherwise they retreat.

with screams and emotion. It's hard to tell exactly what's happening; it's difficult even to identify the males in the melee of speed and power and fully erected hair. Their screams and barks can go on with hardly a pause for forty-five minutes.

In the end, the party with fewer males generally retreats. The result can be important. For several weeks, the losing community tends to avoid an area that would otherwise have provided access to a preferred food; this could mean the difference between a few weeks of eating from a rich fruit crop, and being forced onto a poor diet that causes delayed response and threatens infant survival.

Of more immediate importance, these battles sometimes lead to a lone participant being caught by several of his rivals. The result tends to be remarkably lopsided. While the aggressors are unlikely even to be scratched, the victim may be killed on the spot, or bruised, bitten, and torn so badly that he survives for only a few days or weeks. The same result can follow from border patrols or deep invasions. Overwhelming numbers mean the attackers are safe. Several males each hold a hand or foot of the rival. The immobilized victim can then be damaged at will.

Observations from five study sites now allow the first rough estimates of death rates from intergroup killing among chimpanzees. Between 1963 (when we have Jane Goodall's first demographic data from Gombe) and 2002, a total of about 145 data-years of observation were logged across the five long-term sites. During that time, forty-six intercommunity kills were observed or suspected. Thirty-one involved members of the study communities (twenty-four adult males, one adult female, six infants). When the number of chimpanzees in each community is taken into account, these figures yield a median death rate from intergroup aggression of 140 per 100,000, which rises to 356 per 100,000 if we include suspected cases in addition to those observed or confidently inferred.[3]

The chimpanzee data resemble death rates from war among traditional subsistence societies. Thus, based on a worldwide compilation by Lawrence Keeley, Michael Wilson and I have assembled demographic data for thirty-two politically independent peoples. These include twelve hunter-gatherer and twenty gardening or farming cultures. For hunter-gatherers, annual war death rates averaged 165 per 100,000, about the same as the intergroup killing rate for chimpanzees. For the subsistence farmers, the toll rose to a startling 595 per 100,000, somewhat above the upper estimate for chimpanzees (356 per 100,000).[4] The sampled cultures range from relatively peaceful people such as the Semai of Malaysia to the famously dangerous Dani of New Guinea, among whom at least 28 percent of men's deaths, and 2 percent of women's, occurred in war.[5] Understanding why there is such a range is an important challenge for the future. For the moment, however, we can conclude that

3 Rates are calculated from data presented in Michael L. Wilson and Richard W. Wrangham, "Intergroup Relations in Chimpanzees," *Annual Review of Anthropology* 32 (2003): 363 – 392. For adult males as a separate class, the equivalent rates are between 0.38 and 1.30 percent per year.

4 Lawrence H. Keeley, *War Before Civilization* (New York: Oxford University Press, 1996).

5 Karl G. Heider, *The Dugum Dani: A Papuan Culture in the Highlands of West New Guinea* (Chicago: Aldine Publishing Company, 1970), 128, recorded for Dani living in the Grand Valley of Balim River in the central highlands of western New Guinea.

death rates from intergroup aggression among small independent communities are broadly similar for humans and chimpanzees.

Shockingly, death rates in the modern era tend to be lower even when periods of major war are included. During the twentieth century, for example, Germany, Russia, and Japan each experienced rates of war deaths that were less than half the average hunter-gatherer rate. The contrast reflects a difference in the practice of war between prestate and state societies. In prestate societies all men are warriors, and all women are vulnerable. In state societies, by contrast, fewer people are directly exposed to violence (even though civilians and children often suffer worse casualties than the military) because armies fight on behalf of the larger group.[6]

There's only one other mammal whose intergroup killing has been observed frequently enough to have been calculated. The discovery would have been a surprise to Konrad Lorenz, a founding father of ethology. Lorenz thought wolves would not kill wolves, because he saw captive dominants treating helpless subordinates in a kindly manner. So he argued that wolves must have been selected for inhibition. He was right in one sense: within social groups, wolves normally control their emotions well. But Lorenz didn't know about wolves in the wild, where food is scarce and every group is surrounded by its neighbors.

Wolves of neighboring groups don't hold back. David Mech and his colleagues studied packs in the glacial uplands of Alaska's Denali National Park, an area they considered to be free of human influences. Based on twenty-two killings in at least seventeen packs, they estimated that 39 to 65 percent of adult wolves were killed by other packs. We can expect variation in such rates across populations, but at least in Minnesota a similar figure emerged: 43 percent of wolves not killed by humans were killed by other wolves.[7]

These data were presented as percentages of deaths from violence, rather than as an annual death rate. Human data have sometimes been compiled in the same way, and show that only the most extreme of human cultures match the killing rate of wolves. The highest human death rate from violence has been recorded in eastern Ecuador, where anthropologist James Yost and colleagues collected data on causes of death for Waorani horticulturalists living in dispersed villages of less than a hundred people. Based on 551 deaths, they found that homicide took the lives of 49 percent of women and 64 percent of men, close to the figure for Denali wolves.[8]

Other prestate societies show slightly lower figures. More such data have been collected from highland New Guinea than from any other part of the world, because many of the people living there continued to practice local war until recently. These people include the Tauna

6 Death rates in the twentieth century were presented by Keeley, *War Before Civilization*. Carolyn Nordstrom, "Deadly Myths of Aggression," *Aggressive Behavior* 24 (1998): 147–159.

7 L. David Mech, Layne G. Adams, Thomas J. Meier, John W. Burch, and Bruce W. Dale, *The Wolves of Denali* (Minneapolis: University of Minnesota Press, 1998).

8 James A. Yost and Patricia M. Kelley, "Shotguns, Blowguns, and Spears: The Analysis of Technological Efficiency," in Raymond B. Hames and William T. Vickers, eds., *Adaptive Responses of Native Amazonians* (New York: Academic Press, 1983), 189–224. The recorded deaths include an unrecorded proportion of killings within villages, so these figures do not correspond exactly to the wolf data.

Awa, with 16 percent of women and 30 percent of men (of 206 deaths) dying from homicide; the Usurufa, with 12 percent of women and 32 percent of men (of 514 deaths); the Mae Enga, with maybe 2 to 3 percent of women and 35 percent of men (of 261 deaths); and the Huli, with 1 percent of women and 20 percent of men (of 769 deaths).

For hunter-gatherers, fewer data are available, but the picture is as expected from the annual kill rate. Homicides occur, but at lower rates than among horticultural farmers.[9] There are the Aché of Paraguay, among whom homicide has been responsible for the deaths of 14 percent of women and 15 percent of men (of 115 deaths); the Hiwi of Venezuela, with 17 percent of women and 14 percent of men (of 124 deaths); and the Agta of the Philippines, with 3 percent of women and 14 percent of men (of 78 deaths).

The point about these figures isn't to claim any particular numerical averages. It's merely to say that with chimpanzees, wolves, and humans the big picture is consistent: in typical populations of these three species, it can be mortally dangerous to meet the neighbors.

That's why they all have war zones.

War zones are the border areas where territories abut, danger lurks, and parties rarely go. Low rates of foraging mean that war zones can become lands of plenty – rich in tempting resources.

The Upper Missouri War Zone, a corridor five hundred kilometers long and two hundred forty kilometers wide, was a focal area for the intertribal aggression of numerous indigenous groups, including the Nez Perce, Crow, and Shoshone. Lewis and Clark described the presence there of "immence [sic] quantities of buffalo in every direction";[10] the herbivores benefited from the low human predation pressure resulting from the dangers of hunting in these contested ranges. So the feared war zone became a game sink. Territorial tension sometimes works the same way today. The Demilitarized Zone (DMZ) separating North and South Korea is so empty of people that it has particularly high biodiversity, and supports large populations of rare and endangered species extinct on the rest of the Korean peninsula. (Conservationists should be worried about the prospect of peace. When peace came to the Upper Missouri War Zone, prey animals were hunted to extinction.)

War zones occurred among hunter-gatherers also. Anthropologist Bion Griffin reports, for example, that the Agta of the Philippines knew where the danger lay. "Hunters are especially aware of the chance of illegal trespassers and assume that they may be bent on raiding," Griffin writes. "In the remotest forest hunting zones, where hunters from more than one dialect group may range, precautions are taken and one would seldom hunt alone."[11]

In Australia, expeditions outside the core of the territory were likewise viewed as dangerous: "The red ochre gathering expeditions . . . were normally all-male parties, and although cordial relationships between groups were

9 Bruce M. Knauft, "Violence and Sociality in Human Evolution," *Current Anthropology* 32 (1991): 391 – 428, has stressed the evidence that rates of war are higher among horticulturalists than among hunter-gatherers.

10 Paul S. Martin and Christine R. Szuter, "War Zones and Game Sinks in Lewis and Clark's West," *Conservation Biology* 13 (1999): 36 – 45.

11 P. Bion Griffin, "Forager Resource and Land Use in the Humid Tropics: The Agta of Northeastern Luzon, the Philippines," in Carmel Schrire, ed., *Past and Present in Hunter-Gatherer Studies* (New York: Academic Press, 1984), 106.

sought, fighting appears to have been a common hazard faced by traveling parties. One entire party, with the exception of one man, is recorded as having been ambushed and killed in about 1870, whilst in about 1874 all but one of a group of 30 men were 'entombed in the excavations.'"[12]

Among chimpanzees, evidence of a game sink in war zones comes from the group size of their favorite prey species, red colobus monkeys. Groups averaged 46 percent smaller in the core of the territory than in the border area, according to primatologist Craig Stanford. He attributed the difference to the lower hunting pressure in the border areas, where chimpanzees feared to go.

Meanwhile, David Mech describes how except during periods of extreme food shortage, the threat of encountering hostile neighbors keeps packs of wolves out of border areas. White-tailed deer therefore occur at particularly high density in the zones of wolf-pack territorial overlap. Mech believes that these war-zone populations of deer are critical for the long-term relationship between predator and prey, since they provide the stock for recolonizing the over-hunted areas in the core of the wolf territories. Wolf war zones, in other words, provide conservation areas rather in the style of the Korean DMZ.

It's not the abutment of territories that makes a war zone. Redtail monkeys in Kibale also live within territories, but they do not kill members of neighboring communities and they do not avoid the territorial borders. They use the territory fully, right up to the border, and merely defend their ranges with chases when they meet neighbors. What makes a war zone is not a territory, but the risk of being victimized at its edge.

War zones also aren't known among bonobos, or, for that matter, among most primates or most mammals or most animals. In the great majority of species, territorial encounters involve display, chases, and occasional grappling, but not outright killing. There are only a select few species whose territorial boundaries are places of death and avoidance. The question is why this selection should include chimpanzees, wolves, and humans.

A strong evolutionary rationale for killing derives from the harsh logic of natural selection. Every homicide shifts the power balance in favor of the killers. So the killers have an increased chance of outnumbering their opponents in future territorial battles, and therefore of winning them. Bigger territories mean more food, and therefore more babies.

This unpleasant formula implies that killing is favored by two conditions. It pays whenever resource competition is intense, and whenever killing can be carried out at low risk to the aggressors.

All animals face resource competition. In the wild, for example, female chimpanzees lose weight during poor seasons and are often so short of food that they must wait for an abundant fruiting season before they can conceive. All hunter-gatherer populations show similar evidence of intermittent food scarcity, such as reduced growth during poor seasons.

Persistent food shortages suggest that a larger territory will always pay, and long-term data from Gombe confirm it. During two decades the territory of the Kasekela chimpanzee community varied in size. Shifts in the balance of power with neighboring communities may

12 The quotation is from R. G. Kimber, "Hunter-Gatherer Demography: The Recent Past in Central Australia," in Betty Meehan and Neville White, eds., *Hunter-Gatherer Demography Past and Present* (Sydney: University of Sydney Press, 1990), 160 – 170.

have been responsible for these oscillations. When the territory was small, the chimpanzees had inadequate food. Individuals lost body weight and tended to travel in the small parties typical of periods of low food supply. Females then had long intervals between births, and offspring survival was low. When the territory was larger, everything changed. Male efforts at expanding the territory led to gains for both sexes. With a better food supply, all adults gained weight, females reproduced faster, and the young survived better.[13]

The Gombe study nicely shows the importance of a larger territory. But it doesn't show anything special about the killer species. Any territory-holding group can be expected to fare better if its neighbors' power declines, allowing its territory to expand. By the same process seen in Gombe, a group of any species that gets a larger territory can be expected to have improved food and better reproduction. This principle should apply as much to bonobos and redtail monkeys as to chimpanzees, wolves, and humans. But bonobos and monkeys don't kill.

So resource competition is a necessary condition for war-zone killing, but it's not enough on its own. The second condition is the sufficient one. Killing must be cheap.

The special feature of the killer species is that when parties from neighboring territories meet, there is sometimes an imbalance of power so great that one party can kill a victim without any significant risk of any of them getting hurt themselves. For chimpanzees and wolves, the imbalances of power come entirely from their protean grouping patterns. For hunter-gatherers, the same applies, but there is an extra twist from human inventiveness. For modern humans, imbalances of power come not only from being able to form a larger subgroup than the enemy's, but also from striking the first lethal blow – such as by throwing a spear, flaming a hut, or flying an airplane into a building.

Among chimpanzees, the most likely victims of homicide are adults found alone or immediately abandoned by their friends after being cornered by members of a hostile community. Among wolves, the evidence is less direct, but 90 percent of kills in Denali occurred in winter. At that time, the probability of a lone individual meeting a party of at least three other wolves is forty times higher than in the summer.

Support for the supposed importance of power imbalances comes from the species that don't kill. Bonobos and monkeys live in relatively stable groups, with individuals rarely in parties so small that they might be overwhelmed by neighbors. Those species have diets that allow parties the luxury of permanent association.

But among humans, power imbalances are routine in intercommunity conflict, and the predominant tactic of war for small-scale societies is unambiguous. It's hit-and-run or ambush. Anthropologist A. R. Radcliffe-Brown recorded the attitude of the Andaman Islanders, hunter-gatherers living east of India. "The whole art of fighting," he wrote, "was to come upon your enemies by surprise, kill one or two of them and then retreat . . . . They would not venture to attack the enemy's camp unless they were certain of taking it by surprise . . . . If they met with any serious resistance or lost one of their own number, they

13 Jennifer M. Williams, Anne E. Pusey, John V. Carlis, B. P. Farm, and Jane Goodall, "Female Competition and Male Territorial Behavior Influence Female Chimpanzees' Ranging Patterns," *Animal Behaviour* 63 (2002): 347–360.

would immediately retire. Though the aim of the attacking party was to kill the men, it often happened that women or children were killed."[14]

Similar tactics have been described for hunter-gatherers around the world. In Australia, Walbiri men who surprised enemy camps were said to have killed or driven off the enemy males, and to have carried away any women they could find. In the Arctic, by contrast, raiders would normally kill everyone, though they might spare young girls. Raids typically involved fifteen to twenty men, and could take ten days to complete.[15]

That hunter-gatherers would have raided each other may seem surprising in view of the reputation of forager societies like the Kalahari Bushmen for living peacefully. Scrutiny of early records of contact with hunter-gatherers, however, shows widespread evidence of primitive violence, even in the Kalahari. And material culture supports the picture. Archaeologist Steven LeBlanc has recently drawn attention to the shields of Eskimos that attest to the occurrence of battles. Australian Aborigines also had shields as well as weapons used exclusively for warfare, such as a hooked boomerang and a heavy spear. Both in the Arctic and in Australia there is clear historical evidence for a combination of raids and battles.[16]

The principle that underlies the mayhem is simple, then. When the killing is cheap, kill. In any particular instance it may or may not lead to a bigger territory, but from the perspective of natural selection, the specific case is less important than the average benefit. The integrating effect of selective pressures on emotional systems requires only that killing should lead to benefits sufficiently often. Just as the first male fig wasp that emerges from pupation will immediately attempt to kill any other males he finds in the same fig, so the defenders of territory benefit by taking advantage of opportunity. The killers don't have to think through the logic. They may think of their action as revenge, or placating the gods, or a rite of manhood – or they may not think about it at all. They may do it because it's exciting, as seems the case for chimpanzees. The rationale doesn't matter to natural selection.[17]

What matters, it seems, is that in future battles the neighbors will have one less warrior. So those who killed will become a little more powerful as a result.

Why, then, do humans, chimpanzees, and wolves share the unusual practice of deliberately and frequently killing neighbors? In each species the violence makes sense. Protean grouping patterns allow individuals to attack only when they have overwhelming power. Such tactical success allows them to kill safely and cheaply, and thereby win a likely increase in resources over the succeeding months or years. Killing thus emerges as a consequence of having territories, dispersed groups, and unpredictable power relations. These driving variables, in turn, appear to result from ecological adaptations, whether to a scattered fruit supply or to the challenges of hunting

14 A. R. Radcliffe-Brown, *The Andaman Islanders: A Study in Social Anthropology* (Cambridge: Cambridge University Press, 1948), 85.

15 Azar Gat, "The Human Motivational Complex: Evolutionary Theory and the Causes of Hunter-Gatherer Fighting, Part I: Primary Somatic and Reproductive Causes," *Anthropological Quarterly* 73 (2000): 20–34.

16 Steven A. LeBlanc, *Constant Battles* (New York: St. Martin's Press, 2003).

17 Klaus Reinhold, "Influence of Male Relatedness on Lethal Combat in Fig Wasps: A Theoretical Analysis," *Proceedings of the Royal Society of London* B 270 (2003): 1171–1175.

vertebrate prey. The implication is that because of our particular evolutionary ecology, natural selection has favored in the brains of humans, chimpanzees, and wolves a tendency to take advantage of opportunities to kill enemies.

This doesn't condemn us to be violent in general. Indeed, within our communities humans are markedly less violent than most other primates, and in some ways humans are specially peaceful. Nor does it mean that intergroup aggression is inevitable: rather, it predicts little violence when power is balanced between neighboring communities. Nor, again, does it mean that gang attacks on members of other tribes or religions or clubs or countries are necessarily adaptive: in evolutionary terms, they may or may not be. Nor does it mean that women are incapable of violence, or are inherently less aggressive than men: it suggests instead why the circumstances that favor aggression are not identical for men and women.

What it does imply, however, is that selection has favored a human tendency to identify enemies, draw moral divides, and exploit weaknesses pitilessly across boundaries. As a result, our species remains specially predisposed to certain types of violent emotion. That selection operated in the context of a hunter-gatherer world that has all but disappeared. But if its legacy is that we are biologically prepared by natural selection to be killers, an understanding of the neural basis of intergroup violence should be a research priority.

perhaps such impotence is an inevitable result of poetry's inability to find convincing collective voices that might make revolutionary sentiments less wistful and less dogged by irony.

Lynn Margulis

on syphilis & Nietzsche's madness: spirochetes awake!

In the foothills of the Italian Alps, in a snow-draped piazza in Turin on January 3, 1889, a driver was flogging his horse when a man flung his arms around the poor beast's neck, his tears soaking its mane. The horse's savior was the German philosopher Friedrich Wilhelm Nietzsche (1844 – 1900). His landlord later found him collapsed in the square and brought him back to his room, where Nietzsche spent the night writing a flurry of bizarre postcards. As soon as his friend and colleague Jacob Burck-

Lynn Margulis is Distinguished University Professor in the department of geosciences at the University of Massachusetts, Amherst. A Fellow of the American Academy since 1998, she is the author of "Symbiosis in Cell Evolution: Microbial Communities in the Archean and Proterozoic Eons" (2nd ed., 1993) and "Symbiotic Planet: A New Look at Evolution" (1998). She coauthored "Early Life: Evolution on the Precambrian Earth" (2002) with Michael F. Dolan and "Acquiring Genomes: A Theory of the Origin of the Species" (2002) with Dorion Sagan.

hardt received a crazed letter, he convinced his close friend Peter Gast to go and accompany Nietzsche on his return to Basel. Much of the rest of the century, the last eleven years of his life, Nietzsche spent in incoherent madness, crouching in corners and drinking his urine. The most productive year of his career had been immediately prior to the psychotic break. After it, he wrote no more philosophy. Deborah Hayden, in her recent book *Pox: Genius, Madness, and the Mysteries of Syphilis* (2003), summed up the famous incident:

> The story of Nietzsche's sudden plummet from the most advanced thought of his time to raving dementia is often told as if there were a razor's edge demarcation between sanity and tertiary syphilis, as if on 3 January armies of spirochetes woke suddenly from decades of slumber and attacked the brain, instead of the biological reality that paresis is a gradual process presaged over many years.

Hayden's case to prove that Nietzsche indeed suffered all his adult life from syphilis is as strong as any posthumous medical history can be. He was diagnosed at a time when clinical familiarity with the disease abounded. Detailed evidence shows that he passed through each of the three stages: the chancre of primary syphilis immediately after infection; the terrible pox, fever, and pain of secondary syphilis that emerges months or years later; and the dreaded third: paresis. 'Paresis,' like the word 'syphilis' itself, refers to a syndrome. An acronym, its mnemonic is: *p*ersonality disturbances; *a*ffect abnormalities; *r*eflex hyperactivity; *e*ye abnormalities; *s*ensorium changes; *i*ntellectual impairment; and *s*lurred speech. Paresis often begins with a dramatic delusional episode, but in the following months and years dementia alternates with periods of such clarity that there seems to have been a cure.

Syphilis & Nietzsche's madness: spirochetes awake!

Infection by the spirochete of syphilis – declared eradicated in the mid-twentieth century – still prevails, I believe. The efficacy of early treatment with penicillin, improved hygiene, condom use, and attitudes that lead the afflicted to seek help for venereal disease conspire to bolster the common myth that syphilis has disappeared. We are deceived; many people suffer from syphilis called by other names.

Syphilis symptoms are caused by venereal infection with a spirochete bacterium called *Treponema pallidum*. The treponeme family of spirochetes consists of tiny corkscrew-shaped bacteria, all of which swim and grow in animal tissue. The bacterial flagella are encased within an outer membrane. Spirochetes, like other 'gram negative' bacteria, all have two cell membranes with a space between them. In this periplasmic space between the inner and outer membranes the flagella rotate. Smaller spirochetes such as the syphilis treponeme have only one or two such flagella, whereas some giant spirochetes have more than three hundred. The efficient screw-wise motion into genital and other tissue requires this flagellar arrangement.

Treponema pallidum is one freak among a huge diversity. The vast majority of spirochetes live peacefully in mud, swamps, and waterlogged soils all over the world. Benign, 'free-living' spirochete relatives of *Treponema pallidum* are everywhere. They thrive where food is plentiful: lakeshores rich in decaying vegetation, marine animal carcasses, hot sulfurous springs, intestines of wood-eating termites and cockroaches, and the human mouth. Most kinds are poisoned by oxygen, from which they swim away to avoid. Very few cause illness, yet ticks infected with the *Borrelia* *burgdorferi* spirochete of Lyme disease can induce serious arthritis and other enduring symptoms. Another spirochete nearly indistinguishable from the Lyme disease *Borrelia* is a healthy symbiont in the intestines of termites. A treponeme similar to that of syphilis is associated with the tropical eye disease yaws. Leptospirosis, a systemic and sometimes fatal infection found usually in fishermen, is due to spirochetes that are carried in the kidney tubules of rats that urinate into nearby water. The fishermen acquire *Leptospira* spirochetes from fishhook cuts and other skin lesions. And, of course, there is syphilis.

Nietzsche's letters from 1867 until his breakdown provide a vivid account of the suffering of secondary syphilis. He complains of the pain, skin sores, weakness, and loss of vision that typify the repertoire of the disease. In his last year, his letters give evidence of euphoria. His published works show the grandeur and inspiration that tertiary syphilis sometimes brings to brilliant and disciplined creative minds by removing inhibition as brain tissue is destroyed. When Nietzsche wrote in *Thus Spoke Zarathustra* (1884), "Die Erde, sagte Er, hat eine Haut; und diese Haut hat Krankheiten. Eine diese Krankheit heist zum Beispiel: 'Mensch'" (translated as "The Earth, he says, has a skin, and this skin has a sickness. One of these sicknesses is called 'man,'" or as "The Earth is a beautiful place but it has a pox called man"), what terrible insight Nietzsche must have had into the devastating horror of pox!

Multiple sources indicate that he was treated for syphilis in 1867 at age twenty-three. Seeking medical treatment for eye inflammation, a frequent syphilitic symptom, he consulted Dr. Otto Eiser, who reported not only Nietzsche's penile lesions, but that he had engaged in sexual relations several times on doctor's orders! Years later, in 1889, when Nietzsche broke down and was taken to the clinic of a paresis expert, he was admitted with the diagnosis "1866. *Syphilit. Infect.*"

In 1888 Nietzsche's productivity was, by any standard, extraordinary. He completed his philosophical project: *Twilight of the Idols*, *The Antichrist*, *Ecce Homo*, and *The Case of Wagner*. The style of these works is apocalyptic, prophetic, incendiary, and megalomaniacal, leading many scholars to claim the excesses of these works were due to incipient paresis. Now, after more than half a millennium of the study of syphilis and more than a century after Nietzsche's breakdown, our research suggests that the philosopher really did plummet abruptly into madness; armies of spirochetes *did* awaken suddenly from decades of slumber, and literally began to eat his brain.

Many claim syphilis was known in Europe prior to the return of Columbus; but as Hayden describes and I agree, it is more likely the insidious venereal infection was a new gift of the Americas to the people of Europe. Columbus and his crew returned to Spain with a novel set of symptoms that soon spread to Naples and France. From that year, 1493, the disease was described in detail, first by the physician who treated Columbus and his men, Dr. Ruiz Diaz de Isla. Diaz reported, "And since the Admiral Don Cristobal Colon had relations and congress with the inhabitants . . . and since it is contagious, it spread." Eventually it affected the waterfront prostitutes of Barcelona. Diaz, in work published in 1539, wrote that infected sailors were accepted into the army that Charles of France brought to besiege Naples in 1495 and into the forces that Ferdinand of Spain employed to defend Naples. Ferdinand's army alone is estimated to have had five hundred prostitutes among its camp followers. Soon after the victorious entry of Charles's army, the Great Pox of Naples erupted. His multinational mercenaries brought infection back to every European country. Charles himself returned to France infected. By the next year, the disease spread across the continent, puzzling physicians with its novelty.

Within the early decades of the contagion, in cities across Europe physicians reported that between 5 and 20 percent of the population suffered. Variously named at first, it came to be called *morbus gallicus*, the French malady. Charles's army was blamed for its introduction to Naples – perhaps rightly. Physicians who published work on it in the *lingua franca* of Latin soon after the great outbreak of 1495 drew international attention. Girolamo Fracastoro, in 1530, wrote a verse treatise on the disease entitled *Syphilus sive Morbus Gallicus*, in which the eponymous protagonist, a shepherd, is the first to bear the disease, as a punishment for impiety. The name stuck.

Syphilis has been surprisingly well documented since its outbreak in the closing years of the fifteenth century, as microbiologist and sociologist of science Ludwik Fleck (1896 – 1961) wrote in his masterpiece *Genesis and Development of a Scientific Fact*. From the sixteenth through the end of the nineteenth century, the prevalence and peculiarities of syphilis inspired a wide range of literature, from scientific arcana to torrid novels. Meanwhile, the cause of the disease was avidly sought. Then in 1905 Erich Hoffmann sent a genital chancre specimen to German microscopist Fritz Schaudinn, who confirmed the etiology. He aptly called the lively, translucent, thin, corkscrew-shaped bacterium he observed "thin, pale thread": *Treponema pallidum*. In 1913 Udo J. Wile found *Treponema pallidum* spirochetes in the brains of patients that manifested tertiary syphilis symptoms. (The best recent photo I've seen of spirochetes in the frontal cortex of a paresis patient, figure 8-14 in W. E. Farrar's *Atlas of Infections of the Nervous System*, is at too low a magnification to see round-body details. See the inside back cover and page 125 below.)

Syphilis & Nietzsche's madness: spirochetes awake!

Syphilis has gained attention again because of its disputed relationship to AIDS. Today, although physicians rarely record cases of tertiary syphilis, the earlier two stages of the disease seem on the rise. AIDS patients who have a past record of syphilis that was apparently cured by antibiotics succumb again to the disease. "Syphilis in patients infected with HIV is often more malignant with a greater disposition for neurological relapses following treatment," says Dr. Russell Johnson of the University of Minnesota Medical School, a world expert on the Lyme disease spirochete. Dr. Peter Duesberg, discoverer of the retrovirus, rejects exclusive focus on HIV as the cause of AIDS in his excellent book *Inventing the AIDS Virus*. He questions the common assumption that, as a contagious virus, HIV is even the main cause of the lesions, tumors, rashes, arthritis, weakness, pneumonia, and other severities that accompany immunosuppression. Such symptoms, including the presence in tissue of both the HIV antibody and of the virus itself, may, as in other opportunistic infections, be the consequence, not the cause, of AIDS. I suspect that many of the symptoms in the immunosuppressed sufferers correlate both with the tenacity of the syphilis treponeme and the sexual and other behaviors of the patient.

Joan McKenna, a physiologist with a thermodynamic orientation, writes:

> Because spirochetes can be harbored in any tissue for decades and can move from latency to reproductive stages,

their survival in any host and despite any known therapy is nearly certain . . . . [We also] know that unknown factors will activate the microorganism [*Treponema pallidum*] from latency into an aggressive infection . . . .

She goes on to remark about the relation between syphilis and AIDS: "No symptoms show up in AIDS that have not historically shown up with syphilis and the history of these populations [where AIDS is rampant] includes a high incidence of syphilis."

Clinical confusions (misdiagnoses, anomalous symptoms, conflated multiple infections) have abounded since the early centuries of syphilology. Yet many studies confirm the variety and severity of symptoms attributable to the *Treponema pallidum* spirochete. The malady remains idiosyncratic in its course, with variability in the timing of the stages, and in the absence of any reliable test or single diagnostic. Still, the evidence suggests that the virulence and severity of the disease have diminished dramatically since the initial violent pox outbreak. This behavior is expected of pathogens in first exposure to naive populations. Syphilis in Europe showed the same pattern as measles and smallpox did when Europeans first introduced them to the Americas. As early as the first few decades that followed the Pox of Naples, subsequent generations of Europeans were more resistant. Pathogenic microbes maximize not by rapid lethality, but by transforming into a chronic disease that lasts a lifetime and subtly affects behavior in the stricken animal.

Since the late nineteenth century, the Wassermann blood test has often been touted as the best diagnostic test for syphilis. The fear of syphilis transmission was so common that the Wassermann test was, and often still is, legally mandated in many places, required prior to marriage. However, as shown by Fleck and others, the Wassermann reagent does not measure the presence of *Treponema pallidum*. It indicates, and not even 100 percent of the time, the exposure of a patient to unspecified infectious bacteria: a positive Wassermann test shows only that a person makes antibodies against certain blood-borne bacteria that may include the syphilis treponeme. Furthermore, this test in known syphilitics in advanced stages of the syndrome often converts to negative.

To preclude mother-to-infant transmission of syphilis during parturition, drops of silver nitrate, thought to suppress the syphilitic spirochete, were placed in the eyes of most newborns. This practice occurs in some regions even now, and even when blood tests for syphilis in the mother are negative. These irrational practices measure residual fear of the contagion of syphilis.

In the beginning of the twentieth century, arsphenamine, an arsenic-based remedy, was said to improve the health of syphilitic patients. Often it made people sicker. After 1943 came the 'miracle drug': the claim was that a single or a few massive doses of penicillin cured the body permanently of the dreaded treponeme. After hefty antibiotic treatment in newly detected cases, the insidious corkscrews disappeared. Whereas the apparent remains of 'dead' spirochetes – tiny, shiny round bodies – might sometimes be found in tissue, the moving treponeme was declared gone. J. Pillot, the French researcher after whom the beautiful large spirochete *Pillotina* was named, 'proved' that the round-body remnants of the lively corkscrew are dead. The confusion comes from the fact that – penicillin or not – during the long latent phases of the disease after the primary chancre, moving corkscrew treponemes are not seen anyway. Many years and studies later we can say that whether or not any treponemes are visible in the patient, penicillin (except when given in an appropriate dose very early in the course of the disease) is not an effective and permanent cure.

Yet some physicians still insist that penicillin and strong immune systems definitively eliminate this disease; others claim that treponemes 'hide' in tissues where antibiotics are inaccessible. Some speculate that tertiary syphilis occurs when the syphilis treponemes finally manage to spread, after decades of invisible stealth, and penetrate the blood-brain barrier. Alas, most physicians and syphilis scholars (and scientists such as I) simply don't know the relationship between *Treponema pallidum*, syphilis symptoms, the immune response, the HIV virus, secondary infection, sexual behavior, and the putative cures.

Finally, in 1998, the description of the entire genome of *Treponema pallidum*, one of the smallest bacterial genomes known, with about nine hundred genes in total, was published. Two other spirochete genomes are known: *Borrelia burgdorferi*, with some eleven hundred genes, and *Leptospira*, with nearly five thousand genes. Spirochetes like *Leptospira*, which are capable of life outside the body of animals, have at least five times as many genes as the syphilis treponeme. The leptospires all by themselves internally produce all their necessary components (proteins, lipids, vitamins, etc.), whereas *Treponema pallidum* does very little by itself; it survives only on the nourishment of rich human tissue. For this reason, it is likely that the syphilis treponeme lost four-fifths of its genes as it became an obligate parasite.

To identify any bacterium, the microbiologist needs to separate it and grow it by itself, that is, in isolation. Despite the specific genome knowledge of the single treponeme strain investigated, however, the routine growth of any *Treponema pallidum* in isolation (outside the warm, nutritious mammalian body) has not been achieved. Whether in organic mud or changing human tissue, these spirochetes depend utterly on their immediate environment. Unfortunately, moreover, no one has ever been able to induce round bodies of *Treponema pallidum* to form in isolation in a test tube, or to test these round bodies in isolation for their ability to resume growth.

My students and colleagues and I are not experts on any disease bacteria, nor on illnesses where symptoms are associated with visible spirochetes. We have been living closely with spirochetes for very different reasons. Our interest is in the possible role these wily bacteria played in the evolution of larger forms of life. Attempts to reconstruct the evolutionary history of the nucleated cell, the kind that divides by mitosis, have led us to study harmless spirochetes.

I suspect that the mitotic cell of animals, plants, and all other nucleated organisms (algae, water molds, ciliates, slime molds, fungi, and some fifty other groups included in the Protoctista kingdom) share a common spirochete ancestor. I believe that with much help from colleagues and students, we will soon be able to show that certain free-swimming spirochetes contributed their lithe, snaky, sneaky bodies to become both the ubiquitous mitotic apparatus and the familiar cilia of all cells that make such 'moving hairs.' Our lab work, coupled with that of other scientists, reveals that certain spirochetes when threatened by death can and do form immobile, shiny round bodies. Furthermore, these round bodies can hide and wait until conditions become favorable enough for growth to resume.

Note by Lynn Margulis

Since 1977, a group of scientists and students has been traveling to Laguna Figueroa (called Lake Mormona by Anglophones) near San Quintin, Baja California Norte, Mexico, to study microbial mats. These communities of organisms resemble ancient ones that left fossils in rocks. They are the best evidence we have of Earth's oldest life-forms. Many times we have brought microbial mat samples back to our lab and left these bottles of brightly colored mud on the windowsill, where photosynthetic bacteria powered the community. On several occasions the bottles were assiduously ignored through semesters of classes and meetings. From time to time, we took tiny samples and placed them in test tubes under conditions favorable for growth. Various kinds of spirochetes did begin to swim and grow; we suspect they emerged from round bodies after the samples were put into fresh, clean, abundant liquid food. Spirochetes, mostly unidentified, persisted in hiding in these bottles and jars for at least ten years.

Today we study another microbial-community sample, collected by Tom Teal in 1990 at Eel Pond in Woods Hole, Massachusetts. It is in our lab at the University of Massachusetts, Amherst in a forty-liter glass jar. To it we add only 'rain' (distilled water), but with sunlight as the energy source an abundance of life still thrives. Long after no typical spirochetes were seen in the sample, we added bits of either wet or dry mud to food and water known to support the activities of spirochetes, swimming and growing. In a very few samples, within about a week, armies of spirochetes awoke from at least months of slumber.

We have observed and filmed spirochetes in samples from all over the world rounding up to form inactive bodies. Continuation of work on spirochetes led to our collaboration with Spanish colleagues at the delta of the Ebro River. Professors Ricardo Guerrero and Isabel Esteve had begun a strong research project. One stake, a stick in the mud labeled #1 UAB, marks a site on a microbial mat that somehow seems exceptional. Many fascinating organisms were taken from that place, but none as interesting as the large spirochetes we named *Spirosymplokos deltaeiberi*. Whenever these easy-to-see spirochetes are confronted with harsh conditions – such as liquid that does not support their growth, water that is too acidic, sugars that they cannot digest, a temperature that is too high – they make round, dormant bodies much like those that Pillot and nearly all his successors argue are dead.

The spheres of *Spirosymplokos deltaeiberi* we studied look just like the round bodies published by Norwegian microbiologists Oystein and Sverre-Henning Brorson. (They call them cysts.) The Brorsons showed that under unfavorable conditions the *Borrelia burgdorferi* spirochetes of Lyme disease make round bodies. After weeks of dormancy, of no growth and no sensitivity to antibiotics and other chemical insults, these round bodies revive. At high magnification they look just like those of *Spirosymplokos deltaeiberi*, only smaller. The *Borrelia burgdorferi* round bodies convert to form swimming spirochetes all at once and begin to grow easily as soon as they are placed into proper liquid food at the correct temperature and salt concentration.

The Brorsons confirmed what we suspected: spirochete round bodies, like the spheres of *Spirosymplokos deltaeiberi*, are fully alive. Either mixed with other mud organisms or growing by themselves in isolation, just supply them with what they need to grow and within minutes they revert into swimming, active, feeding, corkscrew spirochetes. Armies of them awake from months of slumber. Our work with Guerrero on *Spirosymplokos deltaeiberi*, coupled with our reading of the literature (especially several studies by the Brorsons), leads us to emphasize an ancient secret of spirochete success: persistence via round bodies.

Syphilis & Nietzsche's madness: spirochetes awake!

Nietzsche's brain on January 3, 1889 experienced a transformation like that of the microbial mat sample transferred into new fresh food. Our interpretation is that the spirochetes transformed from dormant round bodies into the swimming corkscrews in a very short time. Deborah Hayden, however, is also correct. Nietzsche was inoculated in his early twenties, and his long-standing condition was confirmed both by the physician's diagnostic on the medical record ("*Syphilit. Infect.*") and, at his autopsy, by pox scars on his private parts. The dormant spirochetes had been hiding out in his tissues for over thirty years. But on January 3, 1889 in Turin, armies of revived spirochetes munched on his brain tissue. The consequence was the descent of Nietzsche the genius into Nietzsche the madman in less than one day.*

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