Pages 10-35 in Kelly Bulkeley, ed., *Soul, Psyche, Brain: New Directions in the Study of Religion and Brain-Mind Science.* New York: Palgrave Macmilian, 2005.

CHAPTER ONE

Genes, Brains, Minds: The Human Complex

HOLMES ROLSTON III

Earth is the planet where the most complex creativity of which we are aware has taken place; and on this Earth, the most complex creative thing known to us is the human mind. John Maynard Smith and Eörs Szathmáry analyze "the major transitions in evolution" with the resulting complexity, asking, "how and why this complexity has increased in the course of evolution." "Our thesis is that the increase has depended on a small number of major transitions in the way in which genetic information is transmitted between generations." Critical innovations have included "the origin of the genetic code itself," "the origin of eukaryotes from prokaryotes," "meiotic sex," "multicellular life," "animal societies," and especially "the emergence of human language with a universal grammar and unlimited semantic representation," this last innovation making possible human culture (1995, pp. 3, 14).

Maynard Smith, the dean of theoretical biologists, finds that each of these innovative levels is surprising, not scientifically predictable on the basis of the biological precedents. He and his colleague are deeply impressed with the cybernetic and, eventually, cognitive character of what has taken place in natural history, expressed so strikingly in the human mind. What makes the critical difference in evolutionary history is increase in the information possibility space, which is not something inherent in the precursor materials, nor in the evolutionary system, nor something for which biology has an evident explanation, although all these events, when they happen, are retrospectively interpretable in biological categories—at least all except perhaps culture are. The biological explanation is modestly incomplete, recognizing the importance of the genesis of new information channels.

Since we humans find ourselves at the apex of these complex events, it becomes us? as far as we can, to figure out what to make of ourselves, both who we are and where we are. We proceed with an analysis of nature and culture, adapted versus adaptable minds, genes making human brains, human minds making brains, and the spirited human self and our self-transcendence, At such levels of complexity, we will often be in "over our heads"; but one conclusion is inescapable: what is in our heads is as startling as anything else yet known in the universe. We will be left wondering how far what is going on in our heads is a key, at cosmological and metaphysical levels, to what is going on over our heads.

Nature and Culture

Both "nature" and "culture" have multiple layers of meaning. If one is a metaphysical naturalist, nature is all that there is, and so all things in culture—computers, artificial limbs, or presidential elections—are natural. Nature has no contrast class. At another level, however, culture contrasts with nature; and we need to be adequately discriminating about the real differences between them. Animals, much less plants, do not form cumulative transmissible cultures. Information in wild nature travels intergenerationally largely on genes; information in human culture travels neurally as persons are educated into transmissible cultures.

The determinants of animal and plant behavior are never anthropological, political, economic, technological, scientific, philosophical, ethical, or religious. The intellectual and social heritage of past generations, lived out in the present, re-formed and transmitted to the next generation, is regularly decisive in culture. Culture, by Margaret Mead's account, is "the systematic body of learned behavior which is transmitted from parents to children" (1989, p. 11).[1] Culture, according to Edward B. Tyler's classic definition, is "that complex whole which includes knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of society" (1903, p. 1).

Animal ethologists have complained that such accounts of culture are too anthropocentric (indeed chauvinistic!) and need to be more inclusive of animals (de Waal, 1999). Partly because of new animal behaviors observed, but mostly by enlarging (or, if you like, shrinking) the definition, it has become fashionable to claim that animals have culture. Robert Boyd and Peter J. Richerson revise the definition: "Culture is information capable of affecting individuals' phenotypes which they acquire from other conspecifics by teaching or imitation" (1985, p, 33). The addition of "imitation" greatly expands and simultaneously dilutes what counts as culture. By this account, there is culture when apes "ape" each other, but also culture in horses and dogs, beavers, rats—wherever animals imitate the behaviors of parents and conspecifics. Geese, with a genetic tendency to migrate, learn the route by following others; warblers, with a tendency to sing, learn to sing better when they hear others. Whales and dolphins communicate by copying the noises they hear from others; this vocal imitation constitutes culture at sea (Rendell and Whitehead 2001).

But with culture extending from people to warblers, it has become a nondiscriminating category for the concerns we wish to analyze here.

One finds widespread animal cultures by lowering the standards of evidence. Critical to a more discriminating analysis is the difference between mind-mind interactions, sharing ideas, pervasive in human cultures, and not mere behavioral imitation, copying what another does, which is widespread among animals, that can acquire information. If we are going to call what warblers and geese do culture, then we will need to invent another word "super-culture"—to describe what humans do, which is indeed "super" to these animal capacities.

Opening an anthology on *Chimpanzee Cultures,* Wrangham et al. doubt, interestingly, whether there is much of such a thing: "Cultural transmission among chimpanzees is, at best, inefficient, and possibly absent" (1994, p. 2). There is scant and in some cases negative evidence for active imitation or teaching of the likeliest features to be transmitted, such as tool-using techniques. Chimpanzees clearly influence each other's behavior, and seem to intend to do that; they copy the behavior of others. Chimps do seem to know when another chimp has seen something (e.g. where food is). But they do not differentiate between those who know and those who do not when they communicate with other chimps. The chimp world is local. In terms of acquired information, if a chimp doesn't see it (or hear, taste, smell it), he doesn't know it. If a brother chimp departs and disperses to another troop for a year and then returns, he does not remember and recognize (re-cognize) his brother; they take their family and troop cues from whoever is nearby and do not have the concept of "brother."

There is no clear evidence that chimps attribute mental states to others. They seem, conclude these authors, "restricted to private conceptual worlds." In the technical vocabulary, the chimps have little or no "theory of mind"; they do not know of other minds' being there with whom they might communicate to learn what they know. Without some concept of teaching, of ideas' moving from mind to mind, from parent to child, from teacher to pupil, a cumulative transmissible culture is impossible. Humans learn what they realize others know; they employ these ideas and resulting behaviors; they test and modify them, and, in turn, teach others what they know, including the next generation. So human cultures cumulate, but with animals there is no such cultural "ratchet" effect.

In a lead article in *Behavioral and Brain Sciences,* Michael Tomasello, Ann Gale Kruger, and Hiliary Horn Ratner pinpoint this difference:

> Simply put, human beings learn from one another in ways that nonhuman animals do not.... Human beings are able to learn from one another in this way because they have very powerful, perhaps uniquely powerful forms of social cognition. Human beings understand and take the perspective of others in a manner and to a degree that allows them to participate more intimately than nonhuman animals in the knowledge and skills of conspecifics." (1993, p. 495)

Bennett G. Galef, Jr. concludes: "As far as is known, no nonhuman animal teaches" (1992, p. 161).

We can better dissect nature, culture, and cumulative transmissible cultures with degrees of intentionality (Dennett 1987). Animals are variously socialized, and become what they become due to interactions with their surroundings, which include the groups in which they live. But there is little or no evidence of any higher-order intentionality, even among primates that are highly social. Organisms with zero-order intentionality have no beliefs or desires at all. Animals, such as vervet monkeys, intend to change the behavior of other animals—this represents first-order intentionality. Second-order intentionality would involve intent to change the mind, as distinguished from the behavior (though perhaps the behavior as well), of another animal, that is, to teach by passing ideas from mind to mind. Third-order intentionality involves knowledge that another, a teacher, intends to change one's mind. Human language is in this sense recursive; animal communication is not. Primates do not seem to realize that there are minds in others to teach, although they often imitate each other's behavior, as when adults are imitated by their offspring.

In this higher-order sense of communication, conclude Dorothy L. Cheney and Robert M. Seyfarth, "signaler and recipient take into account each others' states of mind. By this criterion, it is highly doubtful that *any* animal signals could ever be described as truly communicative" (1990, pp. 142-143). They continue:

> It is far from clear whether any nonhuman primates ever communicate with the intent to inform in the sense that they recognize that they have information that others do not possess … There is as yet little evidence of any higher-order intentionality among nonhuman species … Teaching would seem to demand some ability to attribute states of mind to others … Even in the most well documented cases, however, active instruction by adults seem to be absent ... The social environment in most primate species is probably too simple to require higher-order intentionality. (pp. 209, 223, 252)

David Premack finds that humans are quite unique in their capacity to teach: "Teaching, which is strictly human, reverses the flow of information found in imitation. Unlike imitation, in which the novice observes the expert, the teacher observes the novice—and not only observes, but also judges and modifies" (2004, p. 318). In due course, in human societies, the pupil likewise judges and modifies what the teacher teaches. In such recursive loops, cumulative transmissible cultures can be endlessly generated and regenerated.

Cumulative transmissible cultures are made possible by the distinctive human capacities for language. Language "comes naturally" to us, in the sense that humans everywhere have it. The child picks up speech during normal development with marvelous rapidity; language acquisition is only more or less intentional. The mind of a child is innately prepared for such learning (Chomsky 1986). Human language, when it comes, is elevated remarkably above anything known in nonhuman nature. The capacities for symbolization, abstraction, vocabulary development, teaching, literary expression, argument are quite advanced; they do not come naturally as an inheritance from other primates, whatever may otherwise be our genetic similarity with them. Though language comes naturally to humans, what is learned has been culturally transmitted; the specific language and content of childhood education is that of an acquired, nongenetic culture. The development, transmission, and criticism of culture depends on this capacity for language.

In a major recent study to determine whether animals have language, the authors Hauser et al. conclude: "It seems relatively clear, after nearly a century of intensive research on animal communication, that no species other than humans has a comparable capacity to recombine meaningful units into an unlimited variety of larger structures, each differing systemically in meaning" (2002, p. 1576). The primate communication "system apparently never takes on the open-ended generative properties of human language" *(p.* 1577).

After 30 years of study of communication in mountain gorillas, the researchers Harcourt and Stewart conclude:

> Gorilla close-calls [those made within the group] are very far from being language-like, they seem to be of the order of complexity of threat displays, as indeed do chimpanzee calls. That simplicity raises the question of why apes, popularly considered more intelligent than monkeys, have apparently a simpler mode of communication, in the sense that they apparently do not label the environment by association of specific calls with specific contexts … We have no answer for the contrast. (2001, pp. 257-258)

Cheney and Seyfarth (1990) found that vervet monkeys give different alarm signals for snakes, leopards, and eagles; other monkeys hear these alarms and take cover appropriately to differing predators. Hence, it seemed that the calling monkey intended to refer and communicate its knowledge to others. But the most recent evidence raises doubt about whether the seeming "callers" intend to inform. Rather, these differing noises appear to be spontaneous response grunts in alarm, although other monkeys can learn from such grunts and respond appropriately to the predator that is present. Such signals cannot "be considered as precursors for, or homologs of, human words. "There is no evidence that calling is intentional in the sense of taking into account what other individuals believe or want" (Hauser et al. 2002, p. l576),

What is missing in the primates is precisely what makes a human cumulative transmissible culture possible. The central idea is that acquired knowledge and behavior is learned and transmitted from person to person, by one generation teaching another and ideas passing from mind to mind, in large part through the medium of language, with such knowledge and behavior resulting in a greatly rebuilt, or cultured, environment. Humans have genes, of course; but humans live under what Boyd and Richerson call "a dual inheritance system" (1985; Durham 1991). They live both in nature and in culture. Discovery of the nature and origins of human language, making possible this emergence of culture, is quite possibly "the hardest problem in science" (Christiansen and Kirby 2003, p. 1).

Adapted versus Adaptable Minds

In nature, in the lives of animals, the microscopic determinants are coded in the genes, but the macroscopic determinants are found in the ecological niches these animals inhabit, in their need to cope, to survive, as this has been honed by natural selection. We next need to place the mind, which makes culture possible, in an evolutionary context. Mind is at once a survival tool in both nature and in culture. But this evolutionary past, while necessary for explaining our mental powers, may not be sufficient for a complete explanation.

Biologists distinguish between proximate and ultimate explanations (Mayr 1988, p. 28). Why does a plant turn toward light? Cells on the darker side of a stem elongate faster than cells on the brighter side because of an asymmetric distribution of auxin moving down from the shoot tip. But the ultimate explanation is that, over evolutionary time, in the competition for sunlight, there were suitable mutations, and such phototropism increases photosynthesis. Analogously, in the developing infant, genes produce a brain, which sponsors a mind. But the developing infant also inherits a long evolutionary past. The results of this ancient history are delivered biologically at birth to (all normal) members of *Homo sapiens.* These past evolutionary events (phylogenesis) are recapitulated (more or less) and generate a contemporary brain (ontogenesis), sponsoring a mind. What was achieved in millions of years (even billions if one includes all the biochemistries) is, via DNA suitably emplaced in a zygote in the womb, coded and copied, reenacted in the few natal/childhood months and years.

Therefore, whatever the proximate explanations about how an infant develops a brain and a mind, a more comprehensive explanatory framework is the evolutionary success; brains must have been good for something. Fish have fins, birds have wings, humans have brains—all for adaptive success. Fish must swim, birds must fly, and humans must be cultured. That seems obviously what the distinctive human brain is for. The infant, coming of age, needs to inherit a long cultural past. But there is a vital disanalogy. The information fish need to swim is in their genes, inborn and with some cutting and splicing of this information in the developing embryo; likewise with the birds who fly. The cultural information the infant needs, however, is not in his or her genes. It must be acquired by cultural learning. The previously solitary mind is able to import the acquired knowledge of others and to export its own acquired knowledge. So minds become ideationally webworked where previously only bodies were genetically and ecosystemically webworked.

One might first think that genes and culture coevolve, and on some scales that can seem reasonable. Humans have lived in cultures for perhaps a million years, during which time they have reproduced across thousands of generations. There is every reason to expect that over these millennia, those humans who do best culturally will do best reproductively also, and vice versa that a genotype will be selected to produce a culturally congenial phenotype.

As cultures become more fluid and complex, however, any tight coevolutionary connections become problematic. The genes need to produce a keen, critical, open mind, which can evaluate cultural options for their functional usefulness and for their contribution to a meaningful life. The direction of selection in humans, as evidenced by their enormous potential for diverse cultures, would then select for an unspecialized intellect with open educable capacity—from those of the Neanderthals to our high-tech computer age—all of which require intelligence in various roles.

When we try to map the evolution of the brain onto the mind's acquisition of cultures, we immediately confront a time-joint problem. Evolution proceeds slowly over geologic timescales; cultural changes can be quite rapid, especially in these modern times. The result is something like linking a horse and buggy with a jet plane. Information transfer in culture can be several orders of magnitude faster and overleap genetic lines. There is a radically accelerated transmission speed. Evolving genes shift in ecosystemic webs and this takes centuries and millennia. Passing ideas around takes minutes, hours, days, though these ideas do accumulate over millennia. The shift is something like that from snail mail delivered on horseback to e-mail on the Internet. The best strategy for slow-paced genes that need to succeed in fast-paced culture is not to build a relatively inflexible mind whose pace and preferences are genetically biased toward one culture or another, since these biases could misdirect persons in the rapidly shifting vicissitudes of culture. Rather, the genes will need to build a flexible mind, which can make preferences independently of any genetic/cultural biases.

When there emerges a later-evolved method of communication at the neural past the genetic level, the genes will subsequently need to develop so as to favor *teachability* above all. What will get selected is not so much specific gene traits coevolving lockstep with matching cultural behaviors as open teachability, which is to say that the genes will have to abandon tight control of behavior and cast their luck with launching a human organism whose behavior results from an education beyond their control. As more and more knowledge is loaded into the tradition (fire-building, agriculture, writing, weaponry, industrial processes, ethical codes, electronic technology, legal history), the genome selected will be the set that is maximally instructive by the increasingly knowledgeable tradition. This will require that the genes produce a flexible and open intellect, which is generalized and unspecialized, able to accommodate lots of learning and to do so speedily, able to adopt behaviors that are functional in, or conform to, whatever cultures they find themselves in. Perhaps the owners of these genes may choose another culture and migrate there. Perhaps soldiers or traders from a variant culture will invade their territory and force their culture upon them.

Theodosius Dobzhansky, a principal founder of modern genetics, reached this conclusion: "A genetically fixed capacity to acquire only a certain culture, or only a certain role within a culture, would however be perilous; cultures and roles change too rapidly … Human genes insure that a culture can be acquired, they do not ordain which particular culture this will be" (1963, p. 146). Boyd and Richerson, wondering whether genetics might bias our cultural dispositions in our dual inheritance system, conclude: "Genetic differentiation between human populations for determinants of biases is unlikely" (1985, pp. 284-285). It is better to be able to learn any of the myriad human languages than to be genetically dispositioned to learn French, better to eat a cosmopolitan fare than to like only Italian food, better to be able to use any of the various cultural ideas than to be genetically inclined to use only Polynesian-originated ones.

Intelligence, based on neurology, allows an organism to make an appropriate, rapid response to an environmental opportunity or threat, protecting it against the necessity of making slower, less reversible responses at the genetic level. If the genes supply intelligence in sufficient amounts, they need not themselves be closely tuned to directing behavior that can track environmental changes; they turn this over to the general intelligence they have created,

But, reply the evolutionary psychologists, this idea of a "global learning capacity" can be exaggerated. The genes do not build a *tabula rasa* mind; humans do need behavioral dispositions of some kinds, such as to fear snakes or spiders, to seek mates, to avoid incest, to protect their children, to reciprocate for mutual benefits, to obey parents, or follow leaders. Every earthbound culture must provide for persons to be washed, sheltered, go to the toilet, mate, and so on. Every culture must express and control the human emotions—love, fear, joy, grief, guilt, anxiety—and allow artistic, musical, religious expression, protect property and privacy, and provide for various activities to which they are "by nature" inclined. Perhaps humans could be genetically disposed toward religious beliefs or ethical practices, because of cultural group selection; those in such cultures prosper (Wilson 1978). So a genetic bias toward ideas useful in various cultures can be expected, and welcomed.

This account of evolutionary psychology can become too restrictive, however, with the claim that humans have more of an evolutionary adapted mind than a culturally adaptable one. John Tooby and Leda Cosmides, denying any all-purpose mind, claim that humans have what they call an "adapted mind," The mind is made up of "a complex pluralism of mechanisms," "a bag of tricks ," a set of "complex adaptations" that, over our evolutionary history, have promoted survival. "What is special about the human mind is not that it gave up 'instinct* in order to become flexible, but that it proliferated 'instincts'—that is, content-specific problem-solving specializations" (1992, pp. 61, 69, 113). "These evolved psychological mechanisms are adaptations, constructed by natural selection over evolutionary time" (Cosmides et al, 1992, p. 5). These form a set of behavioral subroutines, selected for coping in culture, by which humans maximize their offspring. The human mind is "an integrated bundle of complex mechanisms *(adaptations* " (Symons 1992, p. 138). The mind is, says Cosmides, more like a Swiss army knife, tools for this and that, rather than a general purpose learning device.

Humans have needed teachability; but they have also needed channeled reaction patterns. The adapted mind evolved a complex of behavior-disposition "modules," "Darwinian algorithms," each dedicated to task-specific functions in one or the other dimension of life, such as picking mates, or helping family, or obeying parents, or being suspicious of strangers, or dealing with noncooperators by ostracizing them, or preferring savannah-type landscapes. In picking mates, for example, men are disposed to select younger women, likely to be fertile. Women are disposed to select men of social status, likely to be good providers (Buss 1989; Buss et al. 1990; Symons 1992). Further, these dispositions to behavior, still present in any contemporary culture, are those that meant survival in a Pleistocene environment (such as fear of strangers, or desiring many children); and this may mean that they are neither optimal nor altogether desirable dispositions in a modern environment (where people may need to cooperate with strangers, have fewer children, and live in cities) (Cosmides et al. 1992, p. 5).

The human mind is indeed complex, and various subroutines to which we are genetically programmed (e.g., caring for children, obeying parents, and even ostracizing noncooperators or being suspicious of strangers) may indeed be convenient shortcuts to survival—reliable modes of operating whether or not we have reflected rationally over these behaviors. It seems plausible that humans are disposed to see colors in certain ways, or to like sweets and fats, or use nouns and verbs in our languages. Some more or less "automatic" behavior is desirable. It is hardly surprising that males look for females likely to be good mothers (able to bear children and care for them) and females look for males likely to be good fathers (able and likely to provide resources and care about the family). It would be surprising if evolution had selected any other dispositions.

It is also possible that selective forces in earlier cultures (for men with strength enough to hunt or plow) differ from those of later cultures (for persons who can read, write, and do arithmetic). We should probably not assume, however, that there was some one kind of Pleistocene environment, either in the various kinds of landscapes on which humans lived or in the various cultures that they developed. The Pleistocene environment too demanded multiple skills, and an adaptable mind that could integrate them well. Many of the successful behaviors (recognizing faces, planning for tomorrow, being resolute in difficult times, cooperating with others, learning from mistakes, using appropriate caution, controlling jealousy, or lust, or forgiving others) were just as relevant then as they are now. There is much evidence, for example, that humans now taken as infants out of aboriginal cultures can do quite well when educated into a modern European culture.

The mind is not overly compartmentalized, because behaviors interconnect. Behavioral and genetic psychologists are fond of speaking of mental "mechanisms," and any machine-like function, working instinctively, diminishes the cognitive reflection required. But if women are prone to choose men of status, that requires considerable capacity to make judgments about what counts as status—economically, politically, religiously. They will have to judge which one from among their suitors, often still relatively young, is most likely to attain it in the decades of their child rearing. If men are to be good providers, that requires judgments about cooperation, and if one is operating in a barter or market culture, judgments will be needed about trading with strangers, or ostracizing merchants who renege on their promises. Men need to judge potential mates not just on their likely fertility, but also on whether they too are likely to be good providers, able and willing to care for offspring, and to educate them successfully into their culture, until these offspring reach childbearing age.

Any such articulated behavioral mode needs to be figured back into a more generalized intelligence (Sterelny 1995). Genetically programmed algorithms seem unlikely for the detail of such decisions under changing cultural conditions. Such decisions are difficult even for well-educated persons; they may require insight into character and evaluation based on intuition, additionally to conscious, explicit calculations; decisions at this level take considerable capacity for judgment, not simply mental mechanisms. The strongest finding by far in the cross-cultural study of mate preference is that both sexes from cultures around the globe consistently agree on the most promising characteristics they look for in a mate: kindness, understanding, and intelligence (Buss 1989, p. 13; Buss et al 1990, pp. 18-20). Capacities to select such a mate are perhaps somewhat "instinctive," but they are unlikely to be an adaptive mechanism isolated from general intelligence and moral sensitivity,

Apparently, the mind is not so compartmentalized that humans—modern ones who read this literature at least—cannot make a critical appraisal of what behavioral subroutines they do inherit by genetic disposition, and choose, if they wish, to offset these "Stone Age" dispositions in their evolutionary psychology. Cosmides and Tooby are doing just that—if we may be permitted an *ad hominem* argument. They themselves illustrate that the human mind is more than a patchwork of naturally selected response routines when they call for "conceptual integration'* of the diverse academic disciplines studying humans, their behavior, and their minds. These include "evolutionary biology, cognitive science, behavioral ecology, psychology, hunter-gatherer studies, social anthropology, biological anthropology, primatology, and neurobiology" among others (Cosmides et al 1992, pp. 4, 23-24).

These are not disciplines in which one becomes an expert by behavioral mechanisms in a Swiss-army-knife mind adapted for Pleistocene environment.

At least they and their readers must have quite broadly analytical and synoptic minds.[3] The mind is fully capable of evaluating any such behavioral modules, and of recommending appropriate education so as to reshape these dispositions in result. These psychologists seem to be quite able to re-adapt by critical thought their own adapted minds; nor is there any reason to think that they and their colleagues in evolutionary psychology are alone in this capacity. Neuroscientist Beatriz Luna and her colleagues (2004) have found that the brain switches from relying heavily on local regions in childhood to more distributive and collaborative interactions among distant brain regions on becoming an adult.

All sorts of cultures demand all sorts of capacities and skills, and nearly all humans have sufficiently rich talents to find a niche in their culture. If so, there might not be any differential selection pressures when cultural patterns differ across place and time. On statistical average, different human populations in different cultures might not be detectably different genetically so far as their capacities for either culture in general or this or that culture are involved. S. L. Washburn, surveying the archaeological record, concludes "that there has been no important change in human abilities in the last 30,000 years" (1978, p. 57). If so, then all the changes are technological, historical, political, religious, or some other form of cultural change,

In present human populations, it seems that a baby taken from any race on Earth, appropriately reared, can receive almost any sort of general education. This does not mean that any baby can become a mathematician, or a musician, or a professional basketball player. But different babies can be found in any particular race who can do all these things well, and any normal baby can learn enough of these things to function more or less normally in any culture. Geneticists find that the vastest part of human variation is not across races or continents but within local populations (Lewontin 1972, p. 397; 1982).

Culture is quite a diverse affair, and it might be culture that reinforces genetic disposition for some practices (incest avoidance), but not for others (learning nuclear physics), with interaction sometimes and independence at other times. Whether or not adults have enzymes for digesting fresh milk will determine their pastoral practices. But, the differences, say, between the Druids of ancient Britain and the Maoists in modern China, would be non-genetic and have to be sought in the historical courses peculiar to these cumulative transmissible cultures. Such cultures catch their member humans up into an ongoing tradition, give them their identity, and radically differentiate persons historically, even though Druids and Chinese have a biochemistry and a biological nature largely held in common (though there can be differences in skin color or in blood groups).

Genes Making Human Brains

Genes make such varied cultures possible by making up each human brain with one trillion neurons, each with hundreds and sometimes thousands of possible synaptic connections, providing virtually endless opportunities for encoding ideas. These hookups code cumulative cultural discoveries and transmit them in new networks of information transfer (language and books, and, more recently, telephones, television, and the Internet). When this has gone on for a hundred thousand years and more, one can expect some startling outcomes. In fact, we have recently experienced such a star-ding outcome: we humans have decoded our own genome. That simultaneously impresses us with the marvel of these genes that encode and transmit millennia of evolutionary discoveries, and the still greater marvel of the powers of the brain that the genes make, which can decode its own genome.

To the marvelous discoveries in genetics we now have to add equally stunning progress in the neurosciences, again simultaneously impressing us with the powers of the brain. We humans are beginning to decode our own brains. Neuroscience is, at present, less accomplished than genetic biosciences; and this is to be expected since its focus is orders of magnitude more complex than is the genome. What we do not know vastly exceeds what we know. Neuroscientists and psychologists face a conceptual problem, since scientists are using their brains to understand their brains, and while we can well suppose that the brain might understand itself in part and in outline, can any logical system transcend itself exhaustively to critique its own structures?

All other sciences study a simpler other, while in psychological science and neuroscience, mind tackles itself. That may imply limits to the possibility of a human science. We may run afoul of a limit to our resolving power, namely, that a system of great complexity can perhaps not be wholly understood, predicted, or controlled either by itself or by some observer of the same type and complexity. Meanwhile, what we do know leaves us impressed, and puzzled.

Here we find some "cognitive dissonance." The information in the human genome is quite impressive. If the DNA in the myriad cells of the human body were uncoiled and stretched out end to end, that microscopically slender thread would reach to the sun and back over half a dozen times.[4] But this is far too little information with which to build a functioning human brain. The number of neurons and their possible connections is far more vast than the number of genes coding for the neural system, and so it is impossible for the genes to specify all the needed neural connections. We already knew that when we thought the human genome would contain 100,000 genes, but a further recent surprise is the finding that we humans do not have as many genes as we thought, only some 25,000. Humans have 100 trillion cells in their body, one trillion in their brains, but only half again as many genes as the roundworm, with a body of 959 cells of which 302 are its "brain" (Venter et al. 2001; Wade 2001).

Nevertheless, there is this enormous amount of information in human genes, and the genes in the fetus and the womb seem to have learned how to generate, by repeated algorithms, a dynamic and open-ended neural network, which, in due course, makes itself. Brain-forming genes do not specify some product with stereotyped function; rather, by splicing and re-splicing, cutting and shuffling, the brain genes proliferate cascading neurons with almost endless possibilities of organization, depending on how they synaptically connect themselves up. Genes create the instruments, but the orchestration is cerebral. Our fewer genes does not mean that we have less intelligence than before; rather, it means that the secret of our advanced information lies somewhere else, resulting from genetic flexibility that opens up cerebral capacity. In generating the human brain, Barry J. Dickson concludes: "The ultimate challenge, after all, is to find out how a comparatively small number of guidance molecules generate such astonishingly complex patterns of neuronal wiring" (2002, p. 1963). Richard Lewontin puts it this way:

> Our DNA is a powerful influence on our anatomies and physiologies. In particular, it makes possible the complex brain that characterizes human beings. But having made that brain possible, the genes have made possible human nature, a social nature whose limitations and possible shapes we do not know except insofar as we know what human consciousness has already made possible ... History far transcends any narrow limitations that are claimed for either the power of the genes or the power of the environment to circumscribe us ... The genes, in making possible the development of human consciousness, have surrendered their power both to determine the individual and its environment. They have been replaced by an entirely new level of causation, that of social interaction with its own laws and its own nature. (1991, p. 123)

The genes outdo themselves.

Theodosius Dobzhansky, realizing that genes underdetermine culture, had already anticipated this. Culture takes on a life of its own.

> Human genes have accomplished what no other genes succeeded in doing. They formed the biological basis for a superorganic culture, which proved to be the most powerful method of adaptation to the environment ever developed by any species … The development of culture shows regularities *sui generis*, not found in biological nature, just as biological phenomena are subject to biological laws which are different from, without being contrary to, the laws of inorganic nature. (1956, pp. 121-122)

Animal brains are already impressive. According to an estimate, in a cubic millimeter (about a pinhead) of mouse cortex, there are 450 meters of dendrites and 1-2 kilometers of axons; each neuron can synapse on thousands of others (Braitenberg and Schüz 1998). But this cognitive development has come to a striking expression point in the hominid lines leading to *Homo sapiens*, going from about 300 to 1,400 cubic centimeters of cranial capacity in a few million years. The human brain has a cortex 3,000 times larger than that of the mouse. The genes keep building a bigger and bigger brain. E. O. Wilson, Harvard sociobiologist, emphasizes: "No organ in the history of life has grown faster" (1978, p. 87). The connecting fibers in a human brain, when extended, can wrap around the Earth 40 times. This line seems "headed *for* more head," so to speak.

Generally, in body structures such as blood or liver, humans and chimpanzees are 95-98 percent identical in their genomic DNA sequences and the resulting proteins, but this is not true of their brains. "Changes in protein and gene expression have been particularly pronounced in the human brain. Striking differences exist in morphology and cognitive abilities between humans and their closest evolutionary relatives, the chimpanzees." So conclude a team of molecular biologists and evolutionary anthropologists from the Max-Planck Institutes in Germany (Enard et al. 2002). The puzzle is how so little genetic difference can make such an enormous brainpower difference. "This is one of the major questions that those of us interested in our own biology would like to ask. What does that 1.5% difference look like?" asks Francis Collins, director of the National Human Genome Research Institute (in Gibbons 1998). Some threshold seems to have been crossed, a trans-genetic crossing, a quantum leap, a change of state of order of magnitude similar to that when life once originated, or when previously instinctively stereotyped organisms gained the capacity to acquire new, nongenetic information during their lifetimes.

Biologists sometimes make claims like this based on the 95-98 percent protein identity: "DNA evidence provides an objective non-anthropocentric view of the place of humans in evolution. We humans appear as only slightly remodeled chimpanzee-like apes" (Wildman et al 2003, p. 7181). But humans have over three times the brain size of chimps, so that 3 percent, or whatever, in protein structures makes 300 percent bigger brains. Cognitively, we are not 3 percent but 300 percent different (Marks 2002, p. 23). A few percent different may be the way we humans appear from the perspective of DNA but appearances are often deceiving; when you compare Einstein with a chimp, it does not appear that Einstein is only slightly remodeled; nor do we wonder whether an atomic bomb built with his theory that $E = me^2$ is a slightly remodeled ant-fishing stick.

An information explosion gets pinpointed in humans, an event otherwise unknown, but undoubtedly present in us. Perhaps only one line leads to persons, but in that line, at least, the steady growth of cranial capacity makes it difficult to think that intelligence is not being selected for and conserved when it is achieved. This know-how for building bigger brains is genetically coded, of course, but here genetic history transcends itself and passes over into something else. Chimps do not attempt to construct persuasive arguments. I am not a chimp because I do. You are not a chimp either, because you are reading this book and looking for such arguments. Such arguments require language with its advanced conceptual and symbolic powers enabling abstraction, analysis, evaluation, which is present in humans but unprecedented in animals. "All the odd elaborations of human life, socially and individually, including the heights of imagination, the depths of depravity, moral abstraction, and a sense of God, depend on this *symbolic coding of the nonvisible* (Potts 2004, p. 263). In that capacity, humans are not a few percent different; they differ by a thousand orders of magnitude.

The human brain is of such complexity that descriptive numbers are astronomical and difficult to fathom.[6] A typical estimate is 10^{12} neurons, each with several thousand synapses (possibly tens of thousands), a flexible neural network, more complex by far than anything eke known in the universe. Each neuron can "talk" to many others. This network can be formed and reformed, making possible virtually endless mental activity (Braitenberg and Schüz 1998). The result of such combinatorial explosion is that the 1,500 cubic centimeters of a human brain is capable of forming more possible thoughts than there are atoms in the universe (Hanagan 1992, p. 37). Compare how many sentences can be composed rearranging the 26 letters of the English alphabet. The most startling phenomenon yet found in the universe is right behind the eyes we are looking with. We noted earlier a marvelous information in genetic nature; but now, in the human brain, the combinatorial cybernetic explosion is recompounded.

Genes repeatedly make animal brains. But does evolution repeatedly produce this ideational intelligence characteristic of humans? Increasing diversity and complexity appear repeatedly in evolutionary history. In the animal world, eyes evolved many different times, and similarly with muscles, with organs of hearing, taste, smell. Legs, fins, and wings evolved several times. Genetically based skills are widely distributed and shared. Much of this increased complexity depends on neural development, allowing, from the skin in, centered identity and integrated control of animal life, and, from the skin out, cognitive powers for information perception and processing important for survival. On the one hand, such mental powers evidently have survival value; on the other, most species (plants, insects, crustaceans) survive quite well with little intelligence and develop no more over the millennia.

So one cannot claim that all animals, much less organisms in general, evolve steadily toward higher intelligence. Only some do. But perhaps it is highly likely that some will. Christian de Duve, a Nobel laureate, concludes that neural power, where it luckily arises, has such "decisive selective advantage" that there is high probability of its increase:

> The direction leading toward polyneuronal circuit formation is likely to be specially privileged in this respect, so great are the advantages linked with it. Let something like a neuron once emerge, and neuronal networks of increasing complexity are almost bound to arise. The drive toward larger brains and, therefore, toward more consciousness, intelligence, and communication ability dominates the animal limb of the tree of life on Earth. (1995, p. 297)

Perhaps that is so with certain kinds of intelligence, but still it is rather surprising that of the 5-10 million species on Earth at present, of the perhaps 5-10 billion species that have come and gone over evolutionary time, only one has reached self-conscious personality sufficient to build cumulative transmissible cultures. Ernst Mayr, despite finding other kinds of progress undeniable in the evolutionary record, reflects on the evolution of intelligence with conclusions opposite from those of de Duve:

> We know that the particular kind of life (system of macromolecules) that exists on Earth can produce intelligence … We can now ask what was the probability of this system producing intelligence (remembering that the same system was able to produce eyes no less than 40 times). We have two large super-kingdoms of life on Earth, the prokaryote evolutionary lines each of which could lead theoretically to intelligence. In actual fact none of the thousands of lines among the prokaryotes came anywhere near it.
>
> There are 4 kingdoms among the eukaryotes, each again with thousands or ten thousands of evolutionary lineages. But in three of these kingdoms, the protists, fungi, and plants, no trace of intelligence evolved. This leaves the kingdom of Animalia to which we belong. It consists of about 25 major branches, the so-called phyla, indeed if we include extinct phyla, more than 30 of them. Again, only one of them developed real intelligence, the chordates. There are numerous Classes in the chordates. I would guess more than 50 of them, but only one of them (the mammals) developed real intelligence, as in Man. The mammals consist of 20-odd orders, only one of them, the primates, acquiring intelligence, and among the well over 100 species of primates only one, Man, has the kind of intelligence that would permit [the development of advanced culture]. Hence, in contrast to eyes, an evolution of intelligence is not probable. (Quoted in Barrow and Tipler 1986, pp. 132-133)

Repeatedly, Mayr concludes: "An evolutionist is impressed by the incredible improbability of intelligent life ever to have evolved" (1988, p. 69; 1994). Mind of the human kind is unusual, even on this unusual Earth.

What is surprising in humans is not so much that they have intelligence generically, for many other animals have specific forms of a generic intelligence; nor is it that humans have intelligence with subjectivity, for there are precursors of this too in the primates. The surprise is that this intelligence becomes reflectively self-conscious and builds cumulative transmissible cultures. *Homo sapiens,* as we have named ourselves, is the "wise" species, and some of this is "wisdom" programmed into our genes, universal to all. Still, the specific reference largely denotes the wisdom achieved during human historical careers, and passed on culturally to generations to come. The wisdom peculiar to humans lies in the powers of their self-conscious minds and builds in their cumulatively transmissible cultures,

J. Craig Venter and over 200 coauthors, reporting on the completion of the Celera Genomics version of the human genome project, caution in their concluding paragraph:

> In organisms with complex nervous systems, neither gene number, neuron number, nor number of cell types correlates in any meaningful manner with even simplistic measures of structural or behavioral complexity … Between humans and chimpanzees, the gene number, gene structures and functions, chromosomal and genomic organizations, and cell types and neuroanatomies are almost indistinguishable, yet the development modifications that predisposed human lineages to cortical expansion and development of the larynx, giving rise to language culminated in a massive singularity that by even the simplest of criteria made humans more complex in a behavioral sense …
>
> There are two fallacies to be avoided: determinism, the idea that all characteristics of the person are "hard-wired" by the genome; and reductionism, the view that with complete knowledge of the human genome sequence, it is only a matter of time before our understanding of gene functions and interactions will provide a complete causal description of the human variability. The real challenge of human biology, beyond the task of finding out how genes orchestrate the construction and maintenance of the miraculous mechanism of our bodies, will lie ahead as we seek to explain how our minds have come to organize thoughts sufficiently well to investigate our own existence. (2001, pp. 1347-1348)

Human Minds Making Brains

Genes make the kind of human brains that facilitate an open mind possible. But when that happens, these processes can also work the other way around. Minds employ and reshape their brains to facilitate their chosen ideologies and lifestyles. Our ideas and practices configure and reconfigure our own sponsoring brain structures. Michael Merzenich, a neuroscientist, reports his increasing appreciation of "what is the most remarkable quality of our brain: its capacity to develop and to specialize its own processing machinery, to shape its own abilities, and to enable, through hard brainwork, its own achievements" (Merzenich 2001, p. 418).

In the vocabulary of neuroscience, we have "mutable maps" in our cortical representations, formed and re-formed by our deliberated changes in thinking and resulting behaviors. For example, with the decision to play a violin well and resolute practice, string musicians alter the structural configuration of their brains to facilitate the differential use of left and right arms—fingering the strings with one and drawing the bow with the other (Elbert et al. 1995). Likewise, musicians enhance their hearing sensitivity to tones, enlarging the relevant auditory cortex by 25 percent compared with nonmusicians (Pantev et al. 1998).

So our minds shape our brains. The authors of a leading neuroscience text conclude: "The amount of cortex devoted to the fingers of the left hand is greatly enlarged in string musicians. It is likely that this is an exaggerated version of a continuous mapping process that goes on in everyone's brain as their life experiences vary" (Bear et al. 2001, p. 418). With the decision to become a taxi driver in London, and long experience driving about in the city, drivers likewise alter their brain structures, devoting more space to navigation-related skills than non-taxi drivers have. "There is a capacity for local plastic change in the structure of the healthy adult human brain in response to environmental demands" (Maguire et al. 2000, p. 4398). Similarly, researchers have found that "the structure of the human brain is altered by the experience of acquiring a second language" (Mechelli et al, 2004), or by learning to juggle (Draganski et al. 2004).

One can say that finding differing locations in the brain where differing kinds of mental activities takes place is evidence for the physical basis of our mental activities. This is true. But another way to interpret the same evidence is that our mental decisions to become a violin player, taxi driver, or learn a second language reallocate brain locations to new functions in support of these decisions. Violin players, taxi drivers, jugglers use highly localized areas of their brains. But other skills, such as gaining a higher education, are more pervasively distributed. We have no apparatus to measure such more global synaptic changes, but every reason to think they are there.

This brain is as open as it is wired up; the self we become is registered by its synaptic configurations, which is to say that the information from personal experience, both explicit and implicit, goes to pattern the brain. The informing of the mind, our psychological experiences, reconfigure brain process, and there are no known limits to this global flexibility and interactivity. This is what philosophers call "top down" causation (an emergent phenomenon reshaping and controlling its precedents), as contrasted with "bottom up" causation (precedent, simpler causes fully determinative of more complex outcomes). Quantitative genetic differences add into qualitative differences in capacity, an emerging cognitive possibility that exceeds previous evolutionary achievements.

So the genes-producing-brains-producing-behavior model, always too simplistic, has now been quite replaced by a dual model, where genes produce neural networks with open possibilities, and the awakening person dynamically self-organizes a brain interactively with complex environmental influences in both nature and culture. Dean Hamer (2002) models the alternatives as shown in figure 1.1.

Indeed, strange though it may seem at first, and despite the astronomical numbers of neurons in the adult brain, in the early generation of the brain

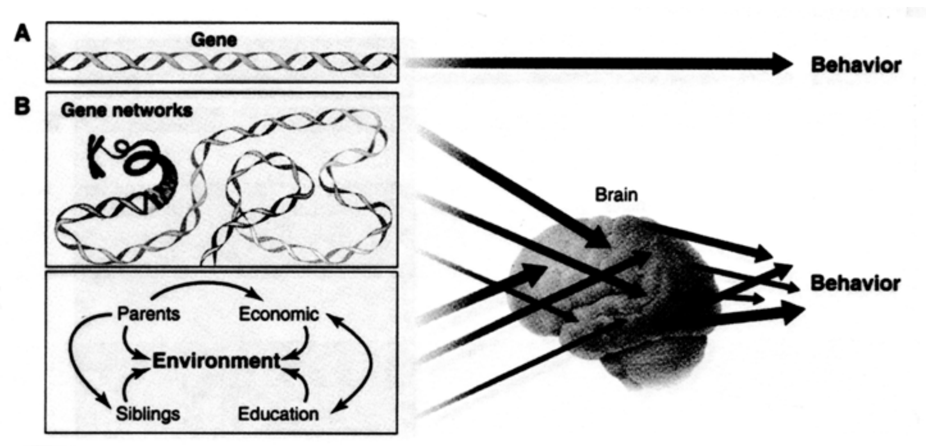

Figure 1.1 Two views of behavior genetics. (A) A simplified model underlying much behavior genetics research envisages a direct linear relationship between individual genes and behavior. (B) The reality is likely to be far more complex with gene networks and multiple environmental factors impacting brain development and function, which, in turn, will influence behavior. From Dean Hamer, "Rethinking Behavioral Genetics," *Science* 298 (October 4, 2002), 71-72.

during the first years of life, there are made far more neurons than the maturing brain needs. The awakening mind organizes itself by pruning away neurons that it is not using, as well as by facilitating new synaptic connections that it comes to need to support its developing lifestyle (Bear et al. 2001, Chapter 22, especially pp. 719-722). Neuroscientists may speak of the "death" of such brain cells. A more comprehensive perspective interprets this as further evidence of the excessively huge possibility of space open to the developing brain, its potential freedom and openness, coupled with the reduction of such possibilities required when some possibilities and not others are actualized.

In philosophical circles (more than among neuroscientists), it is currently fashionable to envision the brain as a kind of computer. The computational mind is the model for much cognitive science. But there is an important disanalogy with computers. Christof Koch and Gilles Laurent caution us about this:

> Software and hardware, which can be easily separated in a computer, are completely interwoven in brains … Brains wire themselves up during development as well as during adult life, by modifying, updating, replacing connections, and even in some circuits by generating new neurons. While brains do indeed perform something akin to information processing, they differ profoundly from any existing computer in the scale of their intrinsic structural and dynamic complexity (1999, p. 98)

Computers, of course, do not have minds with which to reconfigure themselves. Minds, everyone knows, can do some computing.

In evolutionary history, with the coming of humans, there appears the genesis of ideas; and in culture thereafter, ideas are perennially generated and regenerated. This phenomenon too has to be incorporated into any unified worldview. But only in the human world does consciousness become recompounded though the compounding of transmissible cultures; that is the peculiar genius of the human "spirit." Superposed on biology, we become, so to speak, "free spirits," not free from either the worlds of nature or culture, but free in those environments. That humans are embodied spirits, bodies with self-reflective psychological experience, capable of thinking about themselves and what they can and ought to do is really beyond dispute. The act of disputing it, verifies it.

Humans must mate, their genes degenerate unless they outbreed; and so, perhaps, biology shapes marriage customs, or what humans think about incest. But consider what educated people think about polygamy, or abortion, or birth control—or disarmament, or evolutionary theory—all done on circuits in the brains that the genes have made possible. What is happening when a developed nation sends food to those underfed in a developing nation? Such beliefs and events are the results of decisions, perhaps individual, perhaps corporate, but it no longer seems plausible to hold that the principal determinant is something basically biological, such as producing more offspring in the next generation, or that the decision is only the resultant of some complex of basically instinctive, adaptive behavioral subroutines, more or less stereotyped by the genetics. Culture relaxes the pressures of natural selection, and the genetically constructed but experientially completed mind opens up new levels of freedom

Spirited Self and Self-Transcendence

What is really exciting is that human intelligence is now "spirited" an ego with felt, self-reflective psychological inwardness. In the most organized structure in the universe, so far as is known, molecules, trillions of them, spin around in this astronomically complex webwork and generate the unified, centrally focused experience of mind. For this process, neuroscience can as yet scarcely imagine a theory. A multiple net of billions of neurons objectively supports one unified mental subject—a singular center of experience. Synapses, neurotransmitters, axon growth—all these can be and must be viewed as objects from the "outside" when neuroscience studies them, But what we also know, immediately, is that these events have "insides" to them, subjective experience. There is "somebody there."

The self-actualizing and self-organizing characteristic of all living organisms now in humans doubles back on itself in this reflexive animal with the qualitative emergence of what the Germans call "Geist," what existentialists call "Existenz," what philosophers and theologians often call spirit. (Like nature and culture, spirit too has multiple layers of meaning.) This sense of the existential self, the Cartesian "I think, therefore I am," which is present in all normal persons, remains at once our central certainty and the great unknown. An object, the brained body, becomes a spirited subject. A team of neuroscientists (Bear et al) concludes: "It is difficult to study the brain without developing a sense of awe about how well it works." They also concede: "Exactly how the parallel streams of sensory data are melded into perception images, and ideas remains the Holy Grail of neuroscience" (2001, pp. 434, 740).

We must further recompound this complexity when we look forward in the directions in which contemporary evolutionary biology, molecular biology, neuroscience, and psychology are all pointing. In nature, once there were two metaphysical fundamentals: matter and energy. The physicists reduced these two to one: matter-energy; the biologists afterward discovered that there are still two metaphysical fundamentals: matter-energy and information. At the start of the cybernetic age, Herbert Wiener insisted: "Information is information, not matter or energy" (1948, p. 155). What is already spectacular in biology on Earth, differing from the physics and chemistry of the stars, is an information explosion. Biological information is actively agential, self-actualizing. Only on Earth (so far as we yet know) can anything be learned, and the first secret of such animated life is genetic coding of an organismic self enabling coping in an environment.

But there are multiple orders of magnitude change with the coming of humans. This cybernetic or cognitive tendency does not "reduce" well; rather, it tends to "expand." This seems especially true when nature goes on information searches, and generates human brains with almost unlimited searching capacity. Yes, the evolutionary cognitive trajectory continues, but the past is not a good guide to what the future holds when there is this discontinuous "massive singularity" (Venter, 2001) at the coining of the human brain. Perhaps the most we can conclude is that the secret of such creativity lies in new domains of information searched and gained, in new information possibilities opening up. If so, the kind of ultimate destiny we now must envision, and perhaps also the kind of ultimate explanation needed, can as plausibly be said to be mind-like as mindless mechanicity. In this sense, the evolutionary, the genetic, the neurological, and the psychological sciences suggest that we inhabit a "spiritual" universe. We can wonder if there is a "Logos" in, with, and under the logic of such nature.

Alone among the other species on Earth, *Homo sapiens* is cognitively remarkable for being a spirited self and for self-transcendence. We humans are at once "spirited selves," enjoying our incarnation in flesh and blood, empowered for survival by our brain/minds, defending our personal selves, and yet transcending ourselves and our local concerns. *Homo sapiens* is the only part of the world free to orient itself with a view of the whole. That makes us, if you like, free spirits; it also makes us self-transcending spirits.

Consider this self-transcendence first in the sciences—and now it is revealing to look beyond genetics and neuroscience, beyond the sciences where we study ourselves. Physics and astronomy are within our scientific cultures, and yet with these disciplines, we transcend our cultures. With our instrumented intelligences and constructed theories, we now know of phenomena at structural levels from quarks to quasars. We measure distances from picometers to the extent of the visible universe in light years, across 40 orders of magnitude. We measure the strengths of the four major binding forces in nature (gravity, electromagnetism, the strong and weak nuclear forces), again across 40 orders of magnitude. We measure time at ranges across 34 orders of magnitude, from attoseconds to the billions-of-years age of the universe. Nature gave us our mind-sponsoring brains; nature gave us our hands. Nature did not give us radiotelescopes with which to "see" pulsars, or relativity theory with which to compute time dilation. These come from human genius cumulated in our transmissible cultures (though we do not forget that nature supplies these marvelous processes analyzed by radiotelemetry and relativity theory).

These extremes are beyond our embodied experience. No one experiences a light year or a picosecond. But they are not beyond our comprehension entirely; else, we could not use such concepts so effectively in science. The instrumentation is a construction (radio telescopes and mathematics), a cultural invention, a "social construct," if you must. But precisely this construction enables us dramatically to extend our native ranges of perception. The construction disembodies us. It distances us from our embodiment. No one has an everyday "picture" of a quark or a pulsar. But we have good theory about why nothing can be "seen" at such ranges in the ordinary sense of see, which requires light in the wavelength range of 400-700 nanometers, with quarks and pulsars far outside that range. We can ask whether a molecule is too small to be colored, or whether an electron, in its superposition states, is so radically different as to have no position, no "place" in the native range sense, but only a probabilistic location.

Owing to their linguistic abilities, humans have enormous powers of symbolic thought and abstraction, of extrapolation and theory construction, of hypothesis testing and paradigm evaluation. We often attempt understanding by analogy. Metaphor makes initial contact, and then we critique the imagery with counter-imagery, with more precision in analysis, with measurement, further imagination. We may decide to prefer the account that mathematics suggests, even if this seems counterintuitive to analogies drawn from native range experience (as in quantum mechanics). Science involves a long history of breaking up commonsense understandings with more sophisticated ones. We greatly extrapolate and radically transform any such originating metaphor. We get loose enough from our positions and places to consider other time-space scales. Our bodies with our perceptions, our brains with their concepts, which are figured out on synaptic circuits, and our spirited selves expand our location and build up overviews of the global and astronomical whole, ranging from subatomic levels through organismic, evolutionary, and ecosystemic levels.

That transcends startpoint location enabling us to reach standpoint location greater than ourselves. No animal, humans included, knows everything going on at all levels, quarks to cosmos ("the God's eye view").

Some animals, sometimes humans, know little of what is going on at any level; they have only functional behaviors, genetically coded or behaviorally acquired, that work, more or less, for survival. They have, we might say, limited know-how and no know-that. But humans can sometimes enjoy an epistemic genius transcending their own sector, and take an overview (Earth seen from space, the planet's hydrologic cycles), or take in particulars outside their embodiment (sonar in bats, low-frequency elephant communication).

Humans find themselves uniquely emplaced on a unique planet—in their world—cognitively and critically, as no other species is. Our bodily incarnation embeds us in this biospheric community; we are Earthlings. Our mental genius, our spirited self, enables us to rise to transcending overview. Eugene P. Wigner, a mathematical physicist, calls the mathematical facility humans have achieved a "miracle in itself" and comments, "Certainly it is hard to believe that our reasoning power was brought, by Darwin's process of natural selection, to the perfection which it seems to possess" (1960, p. 3).

Max Delbruck, the father of molecular genetics and a Nobel laureate, finds deeply puzzling the fact that human rationality has evolved out of natural history, selected for better survival in the jungle, for producing more offspring, yet providing an exodus by which we transcend our origins to probe the depths of the universe:

> Evolutionary thinking … suggests, in fact it demands, that our concrete mental operations are indeed adaptations to the mode of life in which we had to compete for survival a long, long time before science. As such we are saddled with them, just as we are with our organs of locomotion and our eyes and ears. But in science we can transcend them, as electronics transcends our sense organs.
>
> Why, then, do the formal operations of the mind carry us so much further? Were those abilities not also matters of biological evolution? If they, too, evolved to let us get along in the cave, how can it be that they permit us to obtain deep insights into cosmology, elementary particles, molecular genetics, number theory? To this question I have no answer. (1978, p. 353; cf. 1986, p. 280).

Science is rooted in human nature, employs biologically evolved perceptual and conceptual faculties, and is a social construct; but, for all that, it sometimes flowers to discover objective truths—such as the relativity theory or the atomic table—which are true universally, that is, all over our universe.

If human capacities in the sciences are so startling, what does this suggest for human capacities in the arts, in ethics, in religion? On the one hand, these too evolved in the jungle and helped us survive, and, like science, continue to do so. But here too we may well transcend our local selves, our local presence, by multiple orders of magnitude. We humans live on Earth; the spiritual formation required must be of earthly use and globally inclusive. Beyond that, it does not follow that nothing universally true can appear in human morality because it emerges while humans are in residence on Earth.

Some insights in our human moral systems may be transhuman. Keep promises. Tell the truth. Do not steal. Respect property. There is nothing particularly earthbound about "Do to others as you would have them do to you." Love your enemies; do good to those who hate you. Such commandments may be imperatives on other planets where there are no humans, but rather where alien species of moral agents inhabit inertial reference frames that have no contact with ours. Wherever there are moral agents living in a culture that has been elevated above natural selection, one can hope that there is love, justice, and freedom, although we cannot specify what content these activities will take in their forms of life. The miracle of the mind is as much its capacity for seeking righteousness as its capacity for figuring mathematics. Nothing known in genetics or neuroscience prevents our claiming that humans are spirited selves who can transcend themselves in their spiritual life.

Once critics might have said that mind is rare, and drawn the conclusion that mind is an epiphenomenon, a freakish accident, that reveals nothing about the nature of nature or about forces superintending or transcending nature. But scientists now realize that anomalous events can be quite revelatory of deep-down truths. Scientists look for places where some phenomenon in nature has come to an unusually intense expression in order to study it more carefully there. Our human minds are a phenomenon of that intense kind. If so, what we humans have cognitively become, and what we morally ought to be, our trajectory, reveal a great deal more than our origins in the matter out of which we were launched and have been assembled. Perhaps after all, this primate rising from the dust of the Earth, on becoming so remarkably spiritually informed, bears the image of God.

Notes

1. For 164 definitions of culture, see Kroeber and Kluckhohn, 1963.
2. Cosmides once started a lecture by holding up a Swiss army knife as a model of the mind. This was at a joint meeting of the Royal Society of London and the British Academy, April 4-6, 1995, London and the proceedings titled "Evolution of Social Behavior Patterns in Primates and Man" published were in a volume by Runciman et al (1996).
3. As Cosmides must have believed while speaking at a joint meeting of the Royal Society of London, dealing with the sciences, and the British Academy, dealing with arts, asking the cross-disciplinary arts-sciences audience to evaluate the model of a Swiss-army-knife mind.
4. Estimated from data in Orten and Neuhaus (1982, pp, 8,154).
5. Some early humans had slightly larger brains than modern humans, though a smaller brain to body ratio, but modern brains are more convoluted and complex. Brain size is only an approximate index of intelligence; some individuals with quite small brains have been fully human.
6. Nor are the estimates always consistent; they can differ by an order of magnitude, partly owing to their astronomical nature, partly due to our ignorance of neuroscience.

References

Barrow, J. D. and Tipler, F. J. 1986. *The Anthrophic Cosmological Principle.* New York: Qxford University Press.

Bear, M. F., Connors, B. W., and Paradiso, M.A. 2001. *Neuroscience: Exploring the Brain,* 2nd ed. Baltimore: Lippincott Williams and Wilkins.

Boyd, R. and Richerson, P. J. 1985. *Culture and the Evolutionary Process.* Chicago: University of Chicago Press.

Braitenberg, V. and Schüz, A. 1998. *Cortex: Statistics and Geometry of Neuronal Connectivity,* 2nd ed. New York: Springer.

Buss, D. 1989. Sex differences in human mate preferences: evolutionary hypotheses tested in 37 cultures. *Behavioral and Brain Sciences,* 12,1-49.

Buss, D, et al 1990. International preferences in selecting mates: a study of 37 cultures. *Journal of Cross-Cultural Psychology,* 21, 5-47.

Cheney, D. L. and Seyfarth, R. M. 1990. *How Monkeys See the World.* Chicago: University of Chicago Press.

Chomsky, N. 1986. *Knowledge of Language: Its Nature, Origin, and Use.* New York: Praeger Scientific.

Christiansen, M.H. and Kirby, S. 2003. Language evolution: the hardest problem in science?, in M.H, Christiansen and S. Kirby (eds.), *Language Evolution.* New York Oxford University Press, pp. 1-15.

Cosmides, L., Tooby, J., and Barkow, J. H. 1992. Introduction: evolutionary psychology and conceptual integration, in Jerome H. Barkow, Leda Cosmides, and John Tooby (eds.), *The Adapted Mind: Evolutionary Psychology and the Generation of Culture.* New York: Oxford University Press, pp. 3-15.

de Duve, Christian, 1995. *Vital Dust: Life as a Comic Imperative,* New York: Basic Books.

Delbrück, M. 1978. Mind from Matter? *American Scholar,* 47,339-353.

--------. 1986. *Mind from Matter; An Essay on Evolutionary Epistemology.* Palo Alto, CA: Blackwell Scientific.

Dennett, D. G. 1987. *The Intentional Stance,* Cambridge, MA: The MIT Press.

de Waal, F. B. M. 1999. Cultural primatology comes of age. *Nature* 399 (June 17), 635-636.

Dickson, B.J. 2002. Molecular mechanisms of axon guidance. *Science,* 298,1959-1964.

Dobzhansky, T. 1956. *The Biological Basis of Human Freedom.* New York: Columbia University Press.

Dobzhansky, T. 1963. Anthropology and the natural sciences: the problem of human evolution. *Current Anthropology, 4,* 138, 146-148.

Draganski, B., Gaser, C., Busch, V., Schuierer, G., Bogdahn, U., and May, A. 2004. Changes in grey mat ter induced by training. *Nature,* 427 (January 22), 311-312.

Durham, W.H. 1991. *Coevolution: Genes, Culture, and Human Diversity.* Stanford, CA: Stanford University Press.

Elbert, T., Pantev, C., Wienbruch, C., Rockstroh, B., and Taub, E. 1995. Increased cortical representation of the fingers of the left hand in string players. *Science,* 270 (October 13), 305-307.

Enard, W. et al 2002. Intra- and interspecific variation in primate gene expression patterns. *Science,* 296 (April 12), 340-343.

Flanagan, 0. 1992. *Consciousness Reconsidered.* Cambridge, MA: The MIT Press.

Galef, B.G., Jr. 1992. The question of animal culture. *Human Nature,* 3 (no. 2), 157-178.

Gibbons, A. 1998. Which of our genes make us human? *Science,* 281 (September 4), 1432-1434.

Hamer, D. 2002. Rethinking behavior genetics. *Science,* 298 (October 4), 71-72.

Harcourt, A.H. and Stewart, K. J. 2001. Vocal relationships of wild mountain gorillas, in Martha M. Robbins, Pascale Sicotte, and Kelly J. Stewart (eds.), *Mountain Gorillas: Three Decades of Research at Karisoke.* Cambridge: Cambridge University Press, pp. 241-262.

Hauser, M. D., Chomsky, N., and Fitch, W. T. 2002. *The* faculty of language: What is it, who has it, and how did it evolve? *Science,* 298 (November 22), 1569-1579.

Koch, C. and Laurent, G. 1999. Complexity and the nervous system. *Science,* 284 (April 2), 96-98.

Kroeber, A. L. and Kluckhohn, C. 1963. *Culture: A Critical Review of Concepts and Definitions.* New York: Vintage Books, Random House.

Lewontin, R.C. 1972. The apportionment of human diversity. *Evolutionary Biology,* 6,381-398

——. 1982. *Human Diversity.* San Francisco: W. H. Freeman.

——. 1991. *Biology as Ideology: The Doctrine of DNA.* New York: HarperCollins Publishers.

Luna, B., Krista E. Carver, Trinity A. Urban, Nicole A. Lazar, and John A. Sweeney. 2004. Maturation of cognitive processes from late childhood to adulthood. *Child Development,* 75, 1357-1372.

Maguire, E.A. et al 2000. Navigation-related structural change in the hippocampi of taxi drivers. *Proceedings of the NationalAcademy of Sciences,* USA, 97 (no. 8), 4398-4403.

Marks, J. 2002. *What It Means to be 98% Chimpanzee: Apes, People, and their Genes.* Berkeley: University of California Press.

Maynard Smith, J. and Szathmáry, E. 1995. *The Major Transitions in Evolution.* New York: W. H. Freeman.

Mayr, E. 1988. *Toward a New Philosophy of Biology.* Cambridge, MA: Harvard University Press.

——. 1994. Does it pay to acquire high intelligence? *Perspectives in Biology and Medicine,* 37, 337-338.

Mead, M. 1959, 1989. Preface, in Ruth Benedict, *Patterns of Culture*. Boston: Houston Mifflin, pp. xi-xiv.

Mechelli, A. et al. 2004. Structural plasticity in the bilingual brain. *Nature,* 431 (October 14), 757.

Merzenich, M. 2001. The power of mutable maps, box essay, p. 418, in Bear, Connors, and Paradiso,

Orten, J.M. and Neuhaus, O.W. 1982. *Human Biochemistry,* 10th ed. St. Louis: C.V. Mosby Co.

Pantev, C., Qostenveld, R., Engellien, A., Ross, B., Roberts, L. E., and Hokc, M. 1998. Increased auditory cortical representation in musicians. *Nature,* 392 (April 23), 811-814.

Potts, R. 2004. Sociality and the concept of culture in human origins, in Robert W. Sussman and Audrey R. Chapman (eds.), *The Origins and Nature of Sociality,* New York: Aldine de Gruyter, pp. 249-269.

Premack, D. 2004. Is language the key to human intelligence?. *Science,* 303 (January 16), 318-320.

Rendell, L. and Whitehead, H. 2001. Culture in whales and dolphins. *Behavioral and Brain Sciences,* 24, 309-382.

Runciman, W.G., Maynard Smith, J., and Dunbar, R.I.M. 1996, *Evolution of Social Behaviour Patterns in Primates and Man.* Oxford: Oxford University Press.

Sterelny, K. 1995. The adapted mind. *Biology and Philosophy,* 10, 365-380.

Symons, D. 1992. On the use and misuse of Darwinism in the study of human behavior, in Jerome H. Barkow, Leda Cosmides, and John Tooby (eds.), *The Adapted Mind: Evolutionary Psychology and the Generation of Culture.* New York: Oxford University Press, pp. 137-159.

Tomasello, M., Kruger, A. C., and Ratner, H. H. 1993. Cultural learning. *Behavioral and Brain Sciences,* 16, 495-552.

Tooby, J. and Cosmides, L. 1992. The psychological foundations of culture, in Jerome H. Barkow, Leda Cosmides, and John Tooby (eds.), *The Adapted Mind: Evolutionary Psychology and the Generation of Culture.* New York: Oxford University Press, pp. 19-136.

Tylor, E. B. 1903. *Primitive Cultures,* 4th ed., 2 vols. London: John Murray.

Venter, J. C. et al 2001. The sequence of the human genome. *Science,* 291 (February 16), 1304-1351.

Wade, N. 2001. Genome's riddle: few genes, much complexity. *New York Times* (February 13), D1, D4.

Washburn, S. L. 1978. Animal behavior and social anthropology, in Michael S. Gregory, Anita Silvers, and Diane Sutch (eds.), *Sociobiology and Human Nature.* San Francisco: Jossey-Bass Publishers, pp. 53-74.

Wiener, N. 1948. *Cybernetics,* New York: John Wiley.

Wigner, E. P. 1960. The unreasonable effectiveness of mathematics in the natural sciences, *Communications on Pure and Applied Mathematics,* 13, 1-14.

Wildman, D. E., Uddin, M., Liu, G., Grossman, L. I., and Goodman, M. 2003. Implications of natural selection in shaping 99.4% nonsynonymous DNA identity between humans and chimpanzees: enlarging genus Homo. *Proceedings of the National Academy of Sciences,* USA, 100, 7181-7188.

Wilson, **D. S.** 2002. *Darwin's Cathedral: Evolution, Religion, and the Nature of Society.* Chicago: University of Chicago Press.

Wilson, E.O., 1978. *On Human Nature.* Cambridge, MA: Harvard University Press.

Wrangham, R.W., McGrew, W.C., de Waal, F. B. M., and Heltne, P. G. (eds.) 1994, *Chimpanzee Cultures,* Cambridge, MA: Harvard University Press.