

EVOLUTION: ITS RELIGIOUS IMPLICATIONS

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Perhaps I'm hopelessly brainwashed by evolutionist doctrine, but I don't think Phillip Johnson makes much of a case against the theory of evolution in the few portions of his book and article that I've just read, respectively, *Darwin on Trial* and "The Religion of the Blind Watchmaker." Johnson himself seems to grant the possibility of evolution by arguing that such a process could only have been directed by God from beginning to end. Indeed, evolution might have happened, he concedes, but only by means of God's omnipotence. Hard-core amateur evolutionists--myself included--don't bother trying to refute such a thesis, for if a god has played nothing more than a final role, there is no way to prove it one way or another. The notion of such a god remains, like most the rest of religion, what old-fashioned positivists have argued is a matter of "pseudo-statement" entirely dependent on belief as opposed to observable fact.

What facts may be adduced to prove God's role? Try submitting a grant proposal in physics, astronomy, geology, biology, archaeology, or physical anthropology to prove the existence of a god, and see how far it gets you. And rightly so. As the astronomer Laplace once argued, God's existence wasn't essential in the universe he [Laplace] was proposing. Nor, in fact, is a divine being essential to the theory of evolution. Of course God may be construed as a final cause additional to everything else. All except God would need to be confirmed by hard data, and then, if one wishes, contrary to Ockham's razor (or law of parsimony), one more ingredient would be added on a new and more inclusive scale to augment the story told--a potentially superfluous ingredient--God himself. But this becomes entirely a matter of personal belief rather than theory supported by scientific evidence.

So how could life begin in a godless universe? The only ingredients that seems needed, really, are nitrogen, the right assortment of inorganic carbon compounds, and an abundance of water, the latter mostly limited to temperatures between zero and one hundred degrees centigrade. As Johnson grudgingly acknowledges, the famous 1952 Miller-Urey experiments established that an electric charge such as lightning could have produced in the primordial atmosphere, or ooze, the simple amino acids that provide probably the most basic building blocks of life. What happened between such an event maybe 3.9 billion years ago and the advent of blue algae nobody can entirely explain, but it took almost two billion years for the eukaryotic cell to evolve with a nucleus and its magic ingredient, DNA, which probably originated in an RNA "world," and, before that, an "iron-sulphur" world as described today by Wächtershäuser and others.

Wächtershäuser's theory of the origin of life, perhaps the most promising explanation available today, shifts the site at which life began to a subterranean region a mile or two below the surface of the earth. Here there is both sufficient heat and pressure to produce carbon adhesions to iron-sulfide surfaces, such that these adhesions acquire a surface of their own within which a primitive version of metabolism occurs that feeds on the chemical properties of the

adjacent iron sulfide surface. Evolution proceeds from there first within a pre-RNA world, then within an RNA world, and finally, billions of years later, within a DNA world. No oxygen is involved in the earliest stages, and temperatures are at approximately 2,000 F, well above water's boiling point. These prebiotic phenomena begin as autotrophs that devour inorganic materials, converting them to perform an organic function. It has also been proposed that many are probably transported to the earth's surface as archaea by the white-hot magma that is ejected into the ocean through hydrothermal vents located in deep-sea rifts produced by continental drift. And in fact a "submarine snow" of archaea is to be found in the presence of the magma that is spewed into the ocean from these rifts.¹ In contrast to the creation of life told in Genesis, this entire explanation can be tested on an empirical basis, and with the expectation that much of it might turn out to be false, or excessively simplistic. But perhaps not, and the theory provides a useful step--perhaps a major breakthrough--in ascertaining what actually happened when life began. So what role did a god (or gods) play in what happened? Some kind of a remote godhead might have been involved, but it could also have happened without supernatural intervention--just one more accident of the physical universe that ultimately led to the existence of human intelligence.

But this was a very major step. Once the eukaryotic cell had established itself as coded by DNA, all the more advanced forms of life could evolve through mutation and genetic drift steered by natural selection, i.e., the destruction of less effective individuals and species relative to environmental circumstances. It seems everything biological accordingly derives from eukaryotic DNA, and our entire family tree may be "mapped"--such, for example, that grass and fungi may be identified as distant cousins of mammals, of primates, and therefore of Newton, Einstein, and most all the rest of us. And some species are very close cousins--much closer than we realize. It has been estimated that not more than a 1 % genetic difference as coded by DNA exists between man and the chimpanzee.² Whatever the exact amount, this difference is smaller than between a chimpanzee and gorilla, and it seems to have resulted from gene flow and evolutionary drift punctuated by relatively few genetic mutations--according to Gribbin & Cherfas as few as six, according to Goodman as few as eight. Incredibly, these half dozen mutations played a major roles in differentiating humans and chimpanzees, which otherwise share 6 billion ATCG DNA segments within the cell's nucleus. Between 5 and 10 million years ago (according to the recent theory of Sarich and Wilson, as few as 4.5 million years ago), our ancestors diverged from their primate cousins, but any good recombinant geneticist a couple decades from now will probably be able to patch together our respective DNA identities, producing artificial people with monkey genes and artificial monkeys with human genes. And I'm sure it will be done.

So what's so special about the human being? Why do we enjoy such an important status in God's eye--"chosen" creatures more punishable and/or rewardable by God, for instance, than any of the rest of his animal kingdom? In fact, our role in the universe is very marginal. Try this for arithmetic: if, for the sake of argument, the average size of the human being is less than three cubic feet, the current population of the world, around 5.3 billion people, displaces at most 16 billion cubic feet of dirt (or water, or sky). And if the total human population of the world since the very beginning is not more than double our present population (we are reproducing that fast!), this means that everybody in the world since the celebrated Lucy 3.5 million years ago would displace not more than 33 billion cubic feet of dirt (water, or sky)--seemingly quite a bit.

But how much of a cubic mile would this fill? The dimensions of a cubic mile are in the neighborhood of 147 billion cubic feet, more than four times the displacement of our total human population! In other words, if a hole were dug 1,200 feet deep and a mile square, it would be big enough to contain all of humanity, all the way back to Lucy.

Contrast this quarter of a cubic mile with the incredible size of the universe. There are over two hundred billion stars in the Milky Way alone (our own private galaxy). Countless millions of galaxies like the Milky Way fill up bigger clusters, and, in turn, countless millions of clusters fill up even bigger super-clusters. We can only speculate how many of these super-clusters exist, or whether they, too, belong to bigger and even more inclusive groupings within the universe itself. And for all we know, the big bang that spawned this infinitude of constellations exists only as one spark among an infinitude of such sparks (or bangs), each of them exploding, then cooling as its energy converts to mass in its own shower of super-clusters, clusters, and galaxies. Of course the big bang we are still 2which does not even begin to acknowledge this immensity, to say nothing of the DNA miracle and everything known today in the various scientific disciplines. The anthropomorphic hubris of such a notion frankly astonishes me. Whose watchmaker god, blind or otherwise, would toss together this much matter that hardly matters to support an infinitesimally tiny speck of organic aspiration (the quarter cubic mile mentioned above) that does? And once having done so, why would such a god so totally neglect to tell how he did it to his “chosen” people in the opening chapter of their Bible dedicated to this information. Analogies, that’s all that was told, some say, but, if so, God even got the sequence wrong in spinning his analogies.

And what does God tell of the universe’s final destruction. According to Christ (Matthew, 25.31-45), Judgment Day occurs whereby the blessed are separated from the damned by God, with Christ at his side. How so incredibly anthropomorphic compared to the actual scenario now envisaged by cosmologists. It seems the “big bang” occurred some 12 to 15 billion years ago and can be expected to terminate with some kind of a “big crunch” perhaps 65 billion years from now. The Big Bang was entirely an explosion of energy, and in contrast, it seems, the Big Crunch will entirely culminate with mass (or matter) the stuff of Black Holes, existence’s final stage of manifestation. The sun and all the rest of the stars meanwhile function as machines that consume themselves converting energy to mass according to their own principle of evolution, so much bigger than that of life on earth. Their first stage in “massification” consists of the conversion of hydrogen to helium, followed by the conversion of helium to carbon and heavier elements--finally the heaviest of all, for example iron, which now provides the core of the earth. Then stars die, either through explosion or collapse--as is probably the case for the sun, which isn’t big enough to explode. Somehow the explosion of stars produces the stuff that composes planets, but all such “stuff” culminates by being sucked into black holes that become bigger and more powerful the more they consume until nothing else is left. Today astronomers are confident that at least one black hole exists in the Milky War, and that might be all that is necessary. If others exist, according to Stephen Hawking, the bigger ones consume the smaller. All ends in mass, so the entirety of nature can be interpreted as consisting of stages and plateaus in the cosmic advance from pure energy to pure mass, whereupon the universe has devoured itself. How much mass compared to the energy it absorbs? Very little, as exemplified by the atomic bomb produced by splitting an atom, also as explained by Einstein’s famous equation, $e =$

mc^2 . If c is the speed of light, the ratio between mass and energy is 186,000 per second times itself, enough to suggest that a very big “big bang” culminates in a relatively tiny black hole.

Will people be around to observe this outcome, for example in the presence of God and Christ on their respective thrones? Not a chance. Now almost five billion years old, the sun can be expected to exist roughly another three and a half billion years. In its final stages of collapse before becoming a white dwarf star, it will first become too cold, then too hot (its expanded diameter perhaps reaching the earth’s orbit), and then again too cold to support life on earth. But there are earlier threats. Within another couple million years, the Milky Way stands a strong chance of colliding with the Andromeda Galaxy, when lots of stars can be expected to collide. There is also the excellent possibility much earlier yet that humanity’s misuse of its environment might culminate in the total destruction of humanity either through disease or warfare within the next several centuries.

So how did we come by our unique and precious souls as opposed to the limited cortical activity of the animal kingdom? The Bible suggests we were created from mud, i.e., dust watered by heavy rainfall, but Anaximander’s explanation five centuries before Christ seems more likely, that we have evolved from lower animals. Why, then, such amazing differences between people and animals lower in the food chain. I would argue that the difference to be explained is no less quantifiable than astronomy, but relevant to brain capacity. The human brain comprises an electrical circuit of 100 billion neurons wired by axons and dendrites linked by an average of 10,000 synapses per neuron. All of these electronic tendrils function to play a role in the performance of conscious thought as a biological computer for steering us through life as effectively as possible. We may only guess, for example, how many hundred million brain cells discharge or not for Christ’s most relevant question why God had forsaken him. Perhaps most of these cells, perhaps only a few, but sheer quantity seems essential to the adequacy of the idea. In other words, at least compared to animals, soul = I.Q., for we’ve got lots more of it than the rest of the animal kingdom.³ Why? Bigger brain size--more brain cells to fire or not fire on an either-or basis in their microscopically intricate circuitry.

Granted, scientists have found not much more than a 30% correlation between I.Q. and the total brain mass, but based strictly on lobe surface comparisons (which average more or less 1.5 square meters), the correlation is undoubtedly higher, and based on the all but impenetrable thicket of dendrites within these surfaces, if and when these may be quantified, the correlation, I am confident, would be most significant indeed.⁴ And certain portions of this thicket would probably be more important than others. So the denser this thicket where it matters, for example regarding spatial awareness or the ability to dance, the more profound our souls! I realize that such figures as Einstein and the late Duke of Windsor possessed abnormally small brains, but if their brains could have been microscopically dissected, I am confident that a high positive correlation would have linked their intelligence with the relative size of their brains, whether measured by their grey mass, dendrite number, lobe surfaces, or total electrical output (i.e., their cumulative neural action potential frequencies). Or perhaps by all of these in combination. Somehow, somewhere, improved cognitive performance in both people and animals derives from increased magnitude in the size, shape and function of the brain. In comparisons among people this correlation might seem arguable, but in comparisons between people and other

primates, or mammals, or less advanced creatures (insects, for example), the correlation is undeniable.

Of course two other variables must also be calculated: (a) brain size alone (favorable to men), and (b) brain size proportional to body size (favorable to women). Whales and elephants, for example, have bigger brains than people on an absolute basis, but their brains are smaller relative to their body sizes. On the other hand, certain tiny birds, for example the hummingbird, have bigger brains relative to their body sizes compared to people, but their brains are too small in size alone to accommodate much intelligence. And it seems porpoises have brains roughly as big as ours in both categories, but not in the region of the neo-cortex. So the neo-cortex is apparently where it's at--the soul, I.Q., or whatever you want to call it. Lots of neo-cortex wired by neurons and well thicketed by dendrites: lots of soul.

How did the human neo-cortex ever get so big? It seems by accident. Some kind of a god might have played a role, but once again the entire process seems to have happened without supernatural intervention. When dinosaurs became extinct 65 million years ago, smaller hairy nocturnal species suddenly flourished, including mouse-like tree shrews that evolved into monkeys. As monkeys grew bigger (because body size has certain advantages in the survival game), they could no longer run along the tops of branches but needed to swing beneath, becoming perhaps 15 million years ago the so-called brachiators. These in turn evolved into the even bigger semi-arboreal species, including gorillas, chimpanzees, and our pre-hominid ancestors, all of whom could take advantage of the opposable thumb that had once been useful for swinging. And of these ex-brachiators it was only our ancestors, the pre-hominids, who completely descended from the trees, stood erect, and became bipedal (or "terrestrial"), walking on their hind legs, thus altogether liberating their hands at the cost of fast locomotion.

This singular advance to bipedalism--shared by no other living creature--took place approximately 3.7 million years ago, and for perhaps the next million years our prehistoric ancestors walked on their hind legs without much of a brain (perhaps 500 cc). But then a marvelous thing happened, and it happened very suddenly as compared to the total history of life on earth. In the next couple million years the human brain almost tripled its size at what seems to have been almost a cancerous speed--supposedly the fastest evolutionary development in the entire history of life on our planet. No other animal organ is known to have evolved more rapidly than the human brain! Freakishly, our ancestors' brains grew to maybe 1,350 cc., big enough to accommodate the eductive skills we associate with human intelligence as opposed to the brute intelligence of animals.

How could the brain grow so fast? Very probably because of the unique and accidental advantages of bipedalism. Only people and birds walk on their hind legs, but birds (cousins of the dinosaur) developed wings instead of hands very soon in their evolution, so most of their biology has been devoted to flight instead of the benefits of neck-top dendritic circuitry. As a result, we homo sapiens are the only creatures adapted to walking continuously on our hind legs with our heads located directly above our legs, with hands instead of paws or feathers at the end of our forelegs, and with enormous brains to guide the use of these limbs. It is universally accepted today among physical anthropologists that bipedalism preceded the enlargement of the human brain; what I think will eventually be recognized is that bipedalism not only preceded this

growth, but played a role of singular importance in causing it. Here can be listed some of the potentially important advantages of bipedalism for the development of the brain in our hominid ancestors:

1. Fully liberated by bipedalism, hands benefitted those the most who best figured out how to use them. Intelligent hominids with hands possessed an enormous advantage at the expense of their dull-witted cousins. Clothes became possible, and tools and weapons. Also, social cooperation became easier. People could work together--they could push and pull together and pass things back and forth.
2. Because of mankind's erect posture, the vocal tract seems to have been modified to produce a bigger variety of sounds beneficial to those who could best organize them in language, thus more easily participating in cooperative endeavors.⁵
3. The olfactory centers of the brain atrophied because bipedalism lifted mankind's noses too high off the ground to be of much use, creating more space in the skull for the development of the neo-cortex. Also, the visual centers of the brain could be emphasized, since increased height and binocular vision gave the eyes a more important role.
4. As a result of walking on two legs instead of four, adjustments could occur in the pelvis of the female, making possible a bigger birth canal, as proposed by Owen Lovejoy, for the passage of infants with bigger heads.
5. An infant's brain could continue to grow after its birth since its skull did not need to be as thick and strong at birth. Why? Partly because neck muscles could be smaller in supporting a head directly above the body instead of hanging in front of it; also partly because the jaw bone and its muscles could be smaller, since the hands could serve both to cook and tear food, thus reducing the need for heavy chewing. The diminished leverage of both the neck and jaw muscles attached to the skull could only have helped in permitting an open suture at the top of the skull in new-born infants, the fontanel ("soft spot") that within five years or so lets the brain expand to four times its size after birth.
6. Babies could be born at an earlier stage in the growth of their brains, when they were much more helpless, because of the more effective care by parents with both hands and a higher I.Q. ⁶

Quantitatively, how do all these changes benefit the human brain as compared to those of chimpanzees and gorillas? As compared to a new-born chimp's brain, which must be two-fifths its adult size, the new-born human brain can begin only one quarter its adult size, then grow to approximately 1,350 grams (from 3 to 4 pounds), more or less 1/50 of its body size. In contrast, the adult chimpanzee's brain is limited to 400 grams, 1/150 of its body size, and the adult gorilla's brain is limited to 540 grams, 1/500 of its body size. In other words, the human brain ends up more than three times the size of the chimpanzee brain and more than twice size of the gorilla brain. Proportional to its total body size, it benefits from a brain/body ratio three times as much as for chimpanzees and almost ten times as much as for gorillas.

Needless to say, bipedalism's six potential benefits for brain growth listed above are of variable importance, and some are more clearly demonstrable than others. The use of hands, for example, has been of obvious benefit, while the importance of pelvic changes and the relationship of the fontanel to jaw and neck muscles remains highly speculative. Nevertheless, the overall impact of these six accidental evolutionary benefits continues to be of major importance.

But what about social evolution? Didn't this play a role in the growth of human intelligence? Undoubtedly it did, and its impact should also be taken into account. However, the study of the group behavior of chimpanzees and gorillas indicates that human socialization probably thrived at a primitive level well before both bipedalism and the evolution of the brain, and archaeological evidence indicates that the major advances in socialization we emphasize today began well after the brain ceased its rapid growth between 50 and 100 thousand years ago, near the beginning of the Würm (or Wisconsin) Ice Age. It might even be suggested that advanced socialization eventually capped the evolutionary growth of the brain through the establishment of social institutions that have significantly impeded the dynamics of natural selection that had once benefited individuals with bigger and better brains to a much greater extent.

What I am suggesting here is that bipedalism set the stage for increased brain capacity, that increased brain capacity permitted an augmentation of intelligence, and, at least until the end of the most recent ice age, that intelligence and increased brain capacity have since reinforced each other in human evolution through feedback whereby each of these benefits encouraged the development of the other. Bigger and more intricate brains have accommodated higher intelligence, and higher intelligence has rewarded the possession of bigger and more intricate brains. If the Neanderthal brain (bigger than ours) did not favor the neocortex, its displacement was adequate for the necessary adjustments to occur. And they did. So just by walking on their hind legs, our ancestors have sprouted gigantic and maximally functional brains proportional to their bodies--as might very likely happen, I suspect, for dogs and cats, too, if they could grow hands instead of claws and maintain their verticality for at least a couple million years. After which, they would likewise sport high I.Q.s and all the moods and uncertainties that add up to soul.

What I am finally suggesting, of course, is that the spectacular evolution of the human brain happened by blind chance, not because an anthropomorphic god benevolently steered the tree shrew to monkeyhood, then brachiation, bipedalism, and finally the possession of the remarkable neo-cortex we can take for granted today. Of course one cannot altogether discount the possibility that a personal god might have bestowed his special grace on our quarter of a cubic mile of the universe without at all disclosing his identity except through sheer belief among the faithful. For no doubt about it--an all-powerful god can, if he pleases, hide his role well enough to elude scientific verification, yet be jealously insistent that we all believe in his presumably magnanimous existence. Such a clever and demanding trickster might in fact reign in our universe, as suggested by Descartes on a hypothetical basis when he suggested the concept of god as being nothing more than a Malicious Demon. But I don't know why such a God would bother doing this sort of thing. Nor can I vest any belief in such a creature. To me the very idea

of such a figure seems preposterous, perhaps mildly (even dangerously) paranoid. If in fact he does exist, somebody should try to bring him to his senses.

"But without some kind of a god, sane or insane," the believer asks, "who could have created the universe and launched the evolution of mankind?" To which one replies by asking, "Who, then, first launched such an all powerful god?" And when the believer replies that the god he believes in always existed, one answers that it is even easier to attribute this immortal status to the physical universe itself devoid of any godhead, if in fact a universe bigger than the one we know--call it a cosmos inclusive of countless universes. "But who imposed order on the universe and gave us a purpose in life?" the believer persists, to which one replies with the question, "Who, then, granted your god this special capacity to bestow order and purposefulness" in a realm so much bigger than himself as explained by the Bible?" And when the believer replies, as explained by St. Anselm's Ontological Proof, that God is necessarily the very biggest and most powerful entity of all, whatever size this might consist of, one replies that such a principle may likewise be attributed to the universe itself devoid of godhead since the very beginning. How? No problem at all if creation is traced from the bottom up rather than the top down. Its metaphor would consist of flux and stasis as opposed to patriarchal edict. As the big bang's energy converts into mass that ultimately dissolves and voids itself by means of Black Holes and proton decay (something's conversion to nothing), flow congeals into a proliferation of structures with amazing complexity based on relatively simple physical laws.

Think of how a water drop crystalizes as a snowflake, or, better yet, how an almost frozen stretch of rapids in a brook during winter becomes a magnificent cascade of emerald pools held by ice dams with stalagmite and stalagmite overlaps, funnels and flow surfaces. Such an ice palace can be admired for its unique and intricate aesthetic harmony, yet calculated based on just a few principles of slope, velocity, temperature threshold, etc. In much the same fashion sub-atomic "logic" differentially replicates itself at the level of molecules, and this logic in turn differentially replicates itself in molecular superstructures a tiny portion of which evolved into carbon compounds, the eukaryotic cell (with its double-helixed DNA instructions) and then into all the eukaryotic-derivative organisms inclusive of humanity as stirred by our dendritic brain-ridden use of logic, the biggest, craziest and most extravagant of all. From the very first instant in the creation of the universe the entire process has been evolutionary, and the latest stage ironically boils down to the evolution of DNA based on the survivability of the individuals its code produces. Thus our intentionality as a mental equivalent to physical and biological inertia, thus the final value of evolution as an explanation of human potential and the universe itself in its transition from energy to mass--thus, also, our gods, myths, and fantasies that made sense two thousand years ago, and thus our absurd confidence that we possess a soul that transcends the universe in which we live.

So the argument persists. For in fact all the proofs of god's role are readily answered, as summarized in the eight articles in the Encyclopedia of Philosophy listed under the seemingly affirmative entry, "God, Arguments for the Existence of." Yes, a god might indeed exist as an agent of human destiny, but there is no rational argument to demonstrate his influence that cannot be effectively disputed. For the evidence seems indisputable. God did not create man; rather, the physical universe created man by the process of evolution, and man invented the concept of God to suggest that something akin to human intelligence created the universe. Such

incredible egotism! God's role, if he exists (and he might), is entirely elusive--somewhere out there hiding behind a cloud--a very special cloud that I, for one, choose not to believe in. If soul = I.Q., I consider religious belief (soul's effort to assert its unique identity impervious to nature) to consist of tired I.Q., timid I.Q., I.Q. that ought to know better. All this is blasphemy, I realize. But to me the oppressively simplistic belief system of organized religion seems no less blasphemous at the expense of human intelligence since early Greek philosophy, when Thales and his successors first risked proposing an explanation of the universe at odds with received popular orthodoxy. Science and secular philosophy have since brought us a long way--we can do better today than the notion of an intrusive personal god.

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Footnotes

1. Peter Ward and Donald Brownlee's *Rare Earth: Why Complex Life is Uncommon in the Universe* (Copernicus, 2000), provides in its first chapter a useful popular explanation of possibilities in this direction without reference to Wächtershäuser's theory. For the latter, see Günter Wächtershäuser, "Groundworks for an Evolutionary Biochemistry: the Iron-Sulphur World," *Prog. Biophys. molec. Bio.*, vol. 58 (1992), pp. 181, 185-86; and George D. Cody, et al., "Primordial Carbonylated Iron-Sulfur Compounds and the Synthesis of Pyruvate," *Science*, vol. 289 (August, 2000), pp. 1337-40, as well as Wächtershäuser's response in the same issue, "Life as We Don't know It," pp. 1307-8. Also consult Nicholas Wade's news account of the breakthrough in *The New York Times* on August 25, 2000, p. A17.
2. According to Morris Goodman of Wayne State University, it is as much as a 1.6% difference. See also John Gribbin & Jeremy Cherfas, *The Monkey Puzzle: Reshaping the Evolutionary Tree--A Major Scientific Revision of the Theory of Human Origins and Development* (New York: Pantheon, 1982), p. 15. Morris Goodman is quoted in *The Washington Post Weekly* of May 15, 1990.
3. More accurately, soul = mental capacity as measured by I.Q. For both emphasis and brevity's sake I shall hereafter be describing this capacity as I.Q.
4. L. Van Valen, "Brain size and intelligence in man," *American Journal of Physical Anthropology*. 1974, 40, 417-23.
5. Research on how bipedalism influenced human speech is thoroughly summarized in Elaine Jayne's unpublished paper, "On the Speech of Neanderthal Man: A Reconstruction of his Vocal Tract," written under the supervision of Dr. Robert Sundick.
6. See Donald Johanson and Maitland Edy's *Lucy: The Beginning of Mankind* (New York: Simon and Schuster, 1981), p. 325.