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Article

A Proposed Model for the Evolutionary Creation of Human Beings: From the Image of God to the Origin of Sin

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The qualities usually considered for the imago Dei *– reason, righteousness, relationship, and rule – are interactive and are scientifically measurable. Human uniqueness is a matter of prosociality, recursive consciousness, and plastic neural development. Our brains are genetically designed to be the products and the producers of culture. A model of positive feedback between high-fidelity cultural transmission and the genetic selection for neural plasticity provides a good model of how God produced those unique features. Fossil, genetic, and archaeological evidences indicate how this pattern of human uniqueness developed in Africa during the period of 400,000 to 100,000 years ago. The above model concerning how humans are unique, and how we evolved to be unique, provides insights into theological issues concerning the appearance of the image – and how we became and remain sinners.*

The scriptures are clear. God has made us in his image, different from all the other species of the earth. The data from science are clear. We are the products of a long history of evolutionary adaptation and change, coming from unremarkable animal ancestors. Is there any way to embrace both of these statements as true? Some advocates for each position state that such a rapprochement is impossible, a treacherous Trojan horse seeking the destruction of either sound theology or good science. My thesis is that this is a category mistake, that the two propositions, in fact, illuminate each other dramatically.

What Is the Image of God (or *imago Dei*)?

To show that coordination is possible, we must insure that both sides of the debate are talking about the same thing. Clearly humans *are* unique – after all, we are the ones debating our own uniqueness, not chimps or dolphins. *Homo sapiens* obviously shows a long list of unique qualities (abstract reason, representational art, complex linguistic structure, religious belief, accumulated knowledge, cultural diversity) unequalled by any other species on Earth. But which differences are significant? What is the meaning of the *imago Dei*, and will the methods of science be able to discern it?

Theologically speaking, although God's eternal decrees are considered the source of uniqueness for all creatures, human uniqueness is due to a specific unique decree – no other species was made in God's image. Further, as theologian B. B. Warfield said, design does not rule out natural cause; rather, causal chains in nature are produced by design.[1] Thus both theology and science may legitimately look in the creation for physical evidence of that uniqueness.

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Of course, for insights on the planned essence of things, theology prefers to use the scriptures. A verbal communication from the creator/designer can give inside information on the designer's intent.

> So God created man in his own image, in the image of God created he him; male and female he created them. God blessed them and said to them, "Be fruitful and increase in number; fill the earth and subdue it. Rule over … every living creature … I give you every seed-bearing plant … for food." (Gen. 1:27–30)
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> The LORD God formed man from the dust of the ground and breathed into his nostrils the breath of life, and man became a living being … and put him into the Garden of Eden to work it and to take care of it. (Gen. 2:7,15)
>
> Cursed is the ground because of you; through painful toil you will eat of it … Until you return to the ground, since from it you were taken; for dust you are and to dust you will return. (Gen. 3:17b,19b)

On the one hand, the scriptures say that humans, in common with other animals, are made of dust (the same material), are given the same food (green plants), and are commanded to increase and fill the earth (same commands). On the other hand, in distinction from other animals, humans, as God's image, are appointed (under God) to rule over the animals and the earth (fleshed out as instructions to care for God's garden, by extension perhaps to extend the order of the garden over the earth). Thus one important dimension of how humans were to image God was a unique commission to act as God's "executive assistants," his representatives to govern the earth.[2] But ecosystem governance (an ecological role) is not the only meaning that has been proposed for the *imago Dei*.

Theological discussion has long contrasted the "structural" aspects of the image—what humans are—and the "functional" aspects—what humans (are supposed to) do.[3] The most familiar structural aspect is "reason," the idea that the human "rational soul" mirrors the mind of God and allows humans to understand God and the world that he made. Thus, humans can communicate with, companion with, and worship their Maker in a unique way. This view was especially meaningful to theologians such as Augustine and Aquinas, who were influenced by the Greek concept of eternal reason.[4] The image as reason has been held more recently by evangelical scholars Carl F. H. Henry and Gordon Clark.

> The image must be reason or intellect. Christ is the image of God because he is God's Logos or Wisdom. This Logos enlightens every man that comes into the world. Man must be rational to have fellowship with God.[5]

This differs from the preeminent Enlightenment understanding of "omni-competent" human reason. Human reason is necessarily either a limited, finite reflection of the rationality of the infinite Creator or a limited, finite product of nonrational nature. And although powerful, if human rationality was damaged by a Fall, it is driven to rationalization rather than to clear insight. The Enlightenment idea that human reason can be "the measure of all things" was a "cut root" conviction derived from forgotten Platonist and Christian assumptions. It has become increasing clear that the Enlightenment vision was illusion. Human reason forms an "image" of the world from our experience; it is not prior to and above reality. Some still accept human rationality as ultimately valid through a "blind faith" in the capacity of irrational physical processes to produce true reason, but the more reasonable materialist view would be that human reason is an evolved mechanism, functionally honed (and thus limited) by its pragmatic usefulness in achieving survival and gaining mates. Still, the nature of human cognition remains a primary parameter of "true humanity." The interesting question currently being raised in anthropology is, what sort of cognition is critical for being human? Is it primarily our understanding of physical reality or of social realities and relationships?

A second structural understanding of the *imago Dei* is "righteousness," human behavior which reflects God's holy character in thought, word, and deed. This was the concept favored by the Reformers Calvin and Luther. The essence of humanness is thus morality, the inward knowledge or perception of truly correct behavior, the "law of God in the heart." Only humans can choose to obey or disobey these inward commands, for only humans are fully conscious of their own selfhood. The doctrine of the Fall describes the defacement of this moral image, although not its complete destruction. "Fallen man" still knows righteousness and still does moral reasoning. However, he freely rejects right actions, refuses to perceive or to accept the evidence for God, and uses his rational faculties to support his rebellious actions.

> For although they knew God, they neither glorified him as God nor gave thanks to him, but their think-

> ing [reason] became futile and their foolish hearts were darkened [perception]. (Rom. 1:21)

In current anthropological studies, the equivalent questions are about unique human prosocial behaviors—cooperation, altruism, selfishness—the nature of morality. A great deal of effort and debate has gone into developing models which can explain our innate impulses toward "helping" behaviors in terms of the essentially "selfish" logic of natural selection, and into more recent alternative models which assume that some form of "group" selection has produced significant human prosociality.[6]

But, of course, the definition of "morality" is hotly debated. For instance, social psychologist Jonathan Haidt points out that modern theorists tend to limit moral questions to two individualized issues—harm versus care, and fairness with justice. In contrast, traditional societies consider three other parameters of equally valid moral questions—in-group loyalty, authority and respect, purity and sanctity—values which bind and stabilize groups. Haidt points out that modern moral theorists often view such group binding issues as dangerous and primitive[7]—but such issues certainly are part of what it means to behave as a full human. In any case, the behaviors which theology calls "righteous" are indeed available for data collection and theory production.

The idea of group "binding principles" leads to a third concept of the *imago Dei*, "human relationships." Humanity is to mirror the triune God in forming relationships—with God, between husband and wife, with other humans (human society), and with the rest of the creation. "So God created man in his own image, in the image of God he created him; male and female he created them" (Gen. 1:27). For Karl Barth, the image consisted in the human capacity for relationship, and cannot be fully expressed in a solitary life. We reason or rationalize, we show altruism or selfishness, within community.[8] G.C. Berkouwer states,

> The preservation of humanness has often been interpreted as the preservation of understanding and will, but actually it manifests itself in a much deeper and more important way in the various sorts of relations between man and fellow man.[9]

In evolutionary anthropology as well, questions about the nature of human relationships lead to questions concerning the structure of human societies. Are there animal models comparable to human groups (think ants, crows, apes, or elephants)? Is the structure of human social bonds detectable in taxa of fossil hominins?

To return to the functional concept of the *imago Dei* as office, the issue is human dominion over the earth, the task that God gave humanity at its inception.

> You made him a little lower than God and crowned him with glory and honor. You made him ruler over the works of your hands; you put everything under his feet. (Ps. 8:4,5)

Reason (cognition), morality, and social relationship "describe" humanity—one can investigate their qualities. The concept of office provides a purpose for those qualities: it implies that the social, emotional, intellectual, and physical qualities of humanity were given to equip us to govern the earth (under God), to further develop God's purposes for the creation, and to mirror the kingly activity of God.

Can observation measure office? If one is looking for "dominion," the fingerprint of true humanness would be our significant—and unique—impact on the ecosystem. The Pleistocene over-kill debate reflects that awareness, as does the impact of agriculture and our current ecological crisis. Clear cultural impact? Yes! The extension of the garden? Hardly!

> For the creation was subjected to frustration, not by its own choice, but by the will of the one who subjected it, in hope that the creation itself will be liberated from its bondage to decay and brought into the glorious freedom of the children of God. (Rom. 8:20,21)

The full realization of the image is therefore seen only in the incarnation, in Jesus Christ himself, the unblemished image of God and the Restorer of the whole creation order.

All the qualities suggested above for the *imago Dei* are obviously characteristic of humanity—all reflect aspects of the eternal decree of God. Unique human qualities are realizations (abet, sometimes badly distorted) of facets of the image. And these characteristic qualities of *Homo sapiens* can be investigated by science. But can they be explained as products of some unique selective pressures acting on our ancestors, molding them into efficient survivors? Is there a reasonable evolutionary model for this? And would such an explanation exclude the hand of God?

What Makes *Homo sapiens* Truly Unique?

True, humans have specific features which we consider important identifiers. But are these features actually measurably unique in humans? That is, if there are unique aspects of the Image, can we quantify them? Are we really all that different from other socially intelligent species? Obviously, some people do not think so—witness the lawsuits advancing the human rights of chimpanzees!

But it seems so obvious that humans are unique. No other species writes poetry, builds ships, will die for an idea, makes maps, envisions a deity, and so forth. Yet many of the characteristics we typically consider distinctively human have been identified in some form in other animal species. Crows and chimpanzees make tools. Dolphins have personal identifying whistles—"names." Elephants, and perhaps crows, seem to mourn their dead. Chimpanzees, elephants, and dolphins pass information between generations—a parallel to human culture. Apes, dogs, and parrots can learn human words for objects or actions. Chimp troops are described as engaging in "war" with their neighbors. So, are our vaunted (or abhorred) human characteristics simply upgrades of the preexisting behavioral software found in other species? Not necessarily. The current best models state that although humans do share cognitive processes found in other species, they transcend them.

To start with a quick overview, Kim Hill et al., in explaining human success, point out unique human physiological, behavioral, cognitive, and emotive traits.[10] They emphasize the critical role played by cumulative adaptive cultural change, pointing out its dependence on social learning. Social learning, they argue, depends on certain behavioral proclivities, cognitive capabilities, and emotional mechanisms which are unique to humans. So, how then do humans differ from chimpanzees?

Consider cognitive capacities: Esther Herrmann et al. compared the performance of young humans (2.5 years), chimps (mean age, 10 years), and orangutans (mean age, 6 years) on an array of different aspects of cognition. In tasks involved with the physical world (spatial, quantity, and causality), human toddlers and chimps scored about the same (but better than orangutans). However, when causality was broken down into the physical use of tools versus the mental understanding of underlying causes, the chimps scored better with tool use, whereas humans showed better causal understanding.[11] In contrast, in social tasks (communication, theory of mind, and social learning), humans were distinctly superior, though chimps were again better than orangutans. Human toddlers were particularly better at social learning, that is, in following demonstrated solutions to problems. Humans, it seems, have significantly greater—possibly unique—social-cognitive skills for communicating information.

Differences in understanding physical causality were further illuminated in a study by Jonas Langer that compared cognitive development in two monkey species, chimpanzees, and humans.[12] The study split logico-mathematical (LM) knowledge (classification and numerical cognition) from physical (real world) knowledge. All species started "physical" learning immediately, but there were wide differences in the developmental pattern and pace of LM knowledge. Neither species of monkey started LM development until after physical learning was complete. Humans started LM development immediately, simultaneously with physical learning. Further, human LM development continued longer, developed more rapidly, became far more complex, and ended later than in monkeys. LM development in chimps was intermediate—initiated well after physical learning had begun, and intermediate in length, speed, complexity, and end point. So, human logico-cognitive development completely overlaps the developing understanding of the physical world and the developing knowledge of the human social world as well. This overlap is a key to understanding human uniqueness.

If the most accomplished nonhuman animals are the chimpanzees and other great apes, it is not by much. A number of other highly social species such as whales, elephants, corvids, and parrots have comparable cognitive skills. Such animals variously learn the behavior of objects in their environment—they develop a usable form of observable "folk physics." Many can make simple tools. Animals must learn to detect "agency"; objects with self-initiating behavior are usually living objects. Their survival depends on the ability to make behavioral predictions from those observations. Some higher primates can perceive quantities up to four items, or evaluate ratios from a larger total. Most animals know their spacial location and home territory.[13] And a few species of animals such as chimps and dolphins can observe

the behavior of their peers well enough to emulate their outcomes, producing a simple form of "cultural" transmission.[14]

But no nonhuman animal has been shown to understand invisible causal forces such as gravity.[15] Likewise, although chimpanzees can predict behavior from observed patterns, there is no definitive evidence that they can attribute invisible mental states, such as intentions or knowledge, to another individual.[16] Chimpanzees may trace another's line of sight to find an object of regard, but they do not look back to their guide. Thus, they work in a dyadic relationship: I and you both see the object, but on our own. In contrast, humans glance back and forth to the guiding eye, forming a triadic relationship with their guide. I see the object, I join you in thinking about the object, and I think about how you are thinking of the object.[17]

Animals certainly communicate, but none has even the beginning of a recursively structured language. Although apes and a few other species can identify the numerosity of up to four objects, they cannot intuit the abstract system behind integer addition. Animals learn to run mazes; they cannot learn to read maps.[18] Although many species such as food-caching scrub jays have very efficient specialized memory systems, not even chimpanzees have been shown to retain episodic memories for more than a few seconds.[19] Apes and other animals use specialized neural modules to derive and update patterns from incoming sensory streams. This perceptual processing is specific to sensory domains, concrete (tied to physical objects), fast acting, automatic, and limited.[20]

Of course, such domain-specific neural modules are also active in human infants and continue to be active throughout adult life. What makes humans cognitively unique is the progressive development of a second, overlying neural integration system—notably involving the parietal lobes and the cerebellum. This integrative activity is closely tied to the default network, one of the unique systems associated with human specific areas of the parietal lobes, for example, the supramarginal and angular gyri.[21] Human thought is characterized by a controlled switching of the brain's conceptual focus between the task-focused attention of the central executive network (primarily the frontal and prefrontal cortex) and the defocused attention of the default network (primarily the parietal lobe, but also the cerebellum).[22] Thus, new combinations of ideas can be generated and tested (the default network connects widely; processes social information; enhances creativity; produces self-awareness, time travels, and daydreams; and is likely unique to modern humans).

This secondary level derives abstract information from the patterns produced by the primary systems—recursive rules and hierarchical structures. It links those patterns together, forming the core of logical cognition.[23] Processed through this system of secondary integration, the expected behavior of physical systems and tool skills becomes theoretical laws and technical reasoning. Numeric perceptions become mathematical deductions and theorems. Perceptions of location are transformed into symbolic representations of space, namely, into maps by age 3,[24] and then further expanded into measures of abstract reasoning, and emotional and relational distances.[25] The prediction of peer behavior becomes the prediction of their mental states, termed "mind-reading" or theory of mind (TOM). (Face reading is well underway by four months[26]). Emulation becomes directed, corrected imitation—in other words, deliberate and expected instruction. The internal logic of all of these disparate areas becomes encoded into symbols and language which allow the structured sharing/recombination of information between different centers in the brain and the sharing of those "abstract" patterns with other intelligences.[27]

This capacity for integrated global mindedness allows humans to become aware of their own mental state, producing consciousness as we know it. Human consciousness is not simply being aware of the environment and one's body, or acting on that awareness. It is the perception of one's own personal awareness. Gerald Edelman identified two levels of cognition: the primary consciousness of our situation (which we share with animals), and the secondary consciousness of our primary awareness (which we do not share).[28] In his view, the human cerebral cortex is unique in that the majority of its neural input is reentrant rather than sensory. Sensory input, he suggests, produces primary consciousness, the "remembered present." Reentrant input produces secondary consciousness, an awareness of our own mental activity which requires semantic capacities or language for its "perception." It becomes a new form of memory, the awareness of self—past, present, and future—in the remembered present.

Such internal discussion or metacognition combines the abstractions emerging from the local integrative systems, including the cerebellum which is tied to *all* the perceptual and motor areas of the cerebral cortex.[29] Since it overlays and combines abstract patterns, secondary consciousness allows internal feedback, conceptual changes, cognitive leaps, and conceptual fusion. For instance, human episodic memory can be fused into mental time travel, facilitating retrospective planning for the future.[30] Or, learned patterns can feed back into the perceptual and motor areas of the cortex, guiding and altering both perceptions and motion.[31] And most remarkably, as the brain develops, new integrative centers can be constructed, for example, the "new" center for visual word recognition. There is no significant evidence of this sort of plastic capacity in any other species.[32]

In humans and other species, the primary sensory integrative systems stimulate a drive for information about the physical and social environment. But, in fact, rather than waiting for sensory input, the human senses are evaluating the sensory predictions being made by the limbic system without sensory input.[33] Likewise, the secondary integrative systems unique to humans also hunger for information—information about abstract system structures, a drive which requires the development of complex representative language. Language allows us to pass our patterns of abstract knowledge directly between brain centers and between generations.[34]

And human language is unique. Chet Sherwood et al. summarize the following unique features from a number of studies: (1) It is independent of modality—the same information can be encoded vocally, by gesture, by writing, and so forth. (2) It is voluntary and independent of circumstance—anything can be talked about at any time. (3) It shows domain independence. Anything can be tied to anything—any object can have any property that imagination allows. (4) It is independent of action. Anything can be talked about without implying some necessary action. (5) It uses the shared meanings of arbitrary symbols. (6) It shows plurality of programming: phonemes→morphemes→sentences, et cetera. (7) It has a nested, hierarchical, recursive structure in which meaning depends on syntax.[35] No animal communication system has any of these features. Human language is not just communication; it is the structural backbone of logical cognition.

To return to chimpanzees, female chimpanzees do provide opportunities for their offspring to watch techniques, but they do not recognize the "needs of the student." They do not correct errors, nor do they attribute the concepts of "knowledgeable" or "ignorant" to individuals. This difference in "teaching technique" is also reflected in the "student response"—chimps and human children do not respond in the same way to instruction.[36] Chimps ignore extraneous actions; human children copy such actions in detail. Chimps learn how to accomplish their goals; humans learn how actions should be done correctly.[37] No nonhuman animal—not even a chimp—has been shown to directly copy (imitate) the specific actions of another. Animals learn by repeated experience, by the observation of outcomes, and thus by emulation. Humans learn by imitation, by repeated observations of process, and by imitation of the means. This implies different motives and expectations for teaching: apes see models as competitors; humans see them as helpers. Humans teach both children and other adults; chimps do not. Further, animals do not learn to copy altruistic behavior, but children do—and children assign "rightness" to observed actions, giving technique a moral shading. The human response to teaching is central to human uniqueness.

Consider the implications for accumulating cultural transmission. All humans, adult or child, voraciously seek social connections and shared information. As we individually systematize the patterns of the world, we project, simulate, elaborate, design, and plan—together. This level of societal linking and thinking is true of no other species.[38] No other species cooperates via shared intentionality.[39] As part of that drive for social connections, in adolescence we even create our sense of personal identity from the socially reflected perceptions of ourselves.[40] And our species is prosocial—uniquely (although imperfectly) altruistic, with an impulse to help and share resources even with strangers, a characteristic seen even in infants.[41] These altruistic impulses are tied to moral perceptions and cognition. When faced with a moral question, different pathways in our brain evaluate and balance our own good versus the good of the other. The "good of the other" is being evaluated by the humanly unique social intelligence areas such as the temporal-parietal junction.[42] And, among other unique conclusions we humans draw about reality, we often uniformly decide during early childhood

that God and/or ghosts exist, we instinctively perceive agency and purpose in the world, and we are cognitively ready to understand "the divine." And this we link as support to our moral judgments.[43] In contrast, agnosticism or atheism must usually be learned from directed instruction.

Unique Genetics Acting in Neural Development Make Us What We Are

Humans are essentially (necessarily) born "prematurely," before the brain has begun to mature, a process which will continue into young adulthood. For humans, knowledge about the physical environment, logico-mathematical reasoning, and social understanding are all developing simultaneously during that early period when the human brain is still in a prolonged process of shaping its neural networks. This allows flexible interactions between all categories of thought, and it actually shapes the early wiring of the brain itself (the "connectome"). It gives a "heuristic logic of experimentation" to human mental/brain formation. This means that each human brain is uniquely shaped in its very structure by its social and physical environment. Each human being is therefore a product of his or her culture, and each person becomes a maker of culture (Joseph Henrich's "cultural brain hypothesis").[44]

And the pattern of neural development in modern humans is indeed dramatically different, unique. Modern human brains balloon into a globular shape during the first few months after birth, due especially to the expansion of the parietal lobe and cerebellum, producing the distinctive rounded shape of the "modern" cranium and face.[45] This growth trajectory does not occur in the chimp, nor did it occur in archaic hominines such as the Neanderthals.[46] But after that early expansion, human neural maturation slows down. Chimpanzees reach 75% of their adult brain size by nine months, Neanderthals reached 75% at fifteen months, but modern humans take thirty months.[47] And it takes another twenty years to mature our neural circuitry. This synaptic rewiring is an extremely energy-intensive task—it uses up to 44% of our metabolic expenditure during childhood, puts the growth of the body on hold for years, and continues through adolescence.[48] Delayed synaptic maturation allows increased experience-dependent neural plasticity.

The extensive cortical rewiring which happens during human development interconnects specialized cortical areas, producing higher networks of complexity.[49] Thus, delayed synaptic maturation is a critical key to understanding the flexible nature of human intelligence, language, and culture.[50] Tomoko Sakai et al. conclude that such delayed synaptic maturation, coupled together with increased human brain volume, allows the rapid refitting of the prefrontal regions with reciprocal connections to posterior regions during infancy. These long connections, they propose, allow increasing levels of human social complexity to literally reshape the patterns of neural connectivity of the growing brain, thus giving the unique human cognition its character.[51]

So, the unique behavioral observations are supported by unique neural and genetic characteristics. Even more significant than the dramatic size of the human brain is the higher degree of neural integration. There are significantly higher levels of white matter at all structural levels. Humans' neurons have an order of magnitude more neural connections than those of chimps, longer axons with more branches, more junctions on the dendrites, and dramatically delayed synaptic maturation (increased neural reorganization).[52] Individual sections of the human cortex have more complex "wiring" (local modularization), and those distant sites are far more heavily interconnected with long fiber tracts than they are in an ape's brain.[53] Further, some cortical centers are unique in humans, particularly those involved with speech, fine-motor learning, and the default network.[54]

As for the genetic evidence, the unique character of the human mind is not due to a "magic genetic bullet." There are not just a few major alterations, not just the injection of a "new" set of genes—although some new loci have been identified. Rather, based on differences with the chimpanzee genome, human neural development depends on the wholesale alteration of the control sequences of the majority of the genes acting in the brain.[55] More than one hundred neural loci show signs of high selection, and most are upregulated and delayed in expression. Humans' neural loci also have higher levels of alternate gene splicing (hence producing a more diverse array of proteins) and altered neural epigenetic markers. Most of these differences are in loci controlling neural development. Much of this variation has been

generated by transposon-driven mutation (ALUs—or jumping genes). As to how this pattern evolved, it seems obvious to point to a selective regime favoring neural complexity. But that is an empty description. The real question for evolution would be, what circumstances would produce such a regime?

First though, what insights do the above descriptions of human uniqueness yield to a Christian understanding of humanity? Biologically speaking, the two most distinguishing features of human function are our unique levels of societal integration and of cerebral integration. We possess automatic information acquisition mechanisms in multiple areas. We do language-based personal extrapolation and scenario building in multiple areas from that information. We are unique because of our social intelligence. We deliberately guide each other's cognitive development; we share our thoughts. We are driven to link with each other at the most profound levels. Our need to connect, as driven by language, generates social learning, mind reading (theory of mind), morality, religion, music, art, and even consciousness itself. And that vision of humanity is brilliantly illuminated by the doctrinal paradigm of the *imago Dei*. Based on that doctrine, the data is precisely what we would expect from a careful, scientific evaluation of the human race.

We need not change our background principles; God has made us in his image. The scientific data clearly illuminates the nature of the *imago Dei*. The long discussions of reason, righteousness, relationship, and rule—or culture, character, community, and commission—are matched by the scientific analyses of human uniqueness. The rational capability of the human mind is a product of a myriad of genetic alterations to neural loci. Questions of morality and community are considered key elements of the functional purpose human rationality played in our survival. The extended plasticity of human neural development and the recursive nature of human language have allowed the growth and retention of culture. These qualities have given us the power—for better or worse—of shaping our environment and of dominion. But finding that the abstract maps of theology and science match does not invalidate either one. After all, what else would one expect in a world in which God used evolution to create creatures in his own image? But, how did he do it? What were his methods? Can science speak to that?

What Would These Insights about Human Uniqueness Mean for a Model of Our Origins?

Obviously, if God has been creating us though a long-term evolutionary process, we could look for his actions over millions of years. However, the more interesting question may be the production of the distinguishing qualities listed above—prosociality, secondary consciousness, neural plasticity, social learning, and so forth.

Kim Sterelny has proposed an intriguing model he terms "the evolved apprentice," a theory of cognitive and social evolution based on ecological cooperation, sociocultural learning, and environmental scaffolding.[56] In this model, the pressures of a difficult and changing environment and of rising population numbers intensified the need for shared planning and coordinated hunting and provisioning. These social needs demanded increasingly complex cognitive work, which pushed the process of cultural (social) learning from simple imitation to structured learning environments. Sterelny suggests that the resulting incremental development of deliberately prepared environments for learning techniques produced an increasingly high bandwidth of intergenerational information flow. This, in turn, created positive feedback loops for greater ability to do complex cognition—feedback between social parameters and genetic parameters. Thus, the ancient environmental demand for "vigilant cooperation" and division of labor drove an ever expanding need for the transmission of expertise in both physical crafts and social interaction.

Transmitting expertise requires task decomposition, an ordered process of skill acquisition, the choice of good exemplars, and expert structured and supervised teaching. It also implies the loss of critical information if the knowledge of an expert "instructor" is lost. This would result in the partial reversals and spotty appearance of technology characteristic of the ethnographic and archaeological record.

The apprentice model also fits with more than "tech" instruction; it applies as well to social skills such as "mind reading," language, and religion and obviously, to such areas as symbol use, music, and art. As a result, humans are information hungry on multiple levels—including technology, language, social navigation, bargaining, and planning. In many ways, we

are more a collectively intelligent species than a society of cognitive-rugged individualists.

Similar models of increasing social interaction and prosociality are also proposed by Hill et al.[57] They too attribute adaptive human cumulative cultural change to social learning, namely, to stored information passed on by processes requiring complex symbolic communication. They also point to increasing nonkin cooperation or prosociality in allowing specialization in the flow of resources, services, information, and alliances; and to communal emotional binding through developing concepts of morality, fairness, justice, anger, guilt, religion, et cetera. They too tie their model to dual inheritance theory—social learning occurs through mechanisms shaped by evolution (genome changes), but the genome is altered by social means which favor certain genes, that is, by positive feedback. The strength of the selection force generated by such social learning depends on the complexity of the cultural information to transmit. Thus, evidence for the growth of cumulative culture is indicated by "traits" which require multiple innovative steps unlikely to be "invented" in one generation. Language and social norms are evolving information systems; techniques, regulations, ID signals, and language are necessary cognitive offshoots.

Likewise, Michael Tomasello's "shared intentionality hypothesis" locates human uniqueness in the development of joint attention and shared conventions.[58] Shared attention seems to be a human exclusive. The social interactions of ape "society" are competitive; communications are imperatives. Humans are far more cooperative, as reflected in human communication. Tomasello traces development from individual intentionality and directive communication (ape individuals) to shared intentionality and cooperative communication (hominine dyads) and on to collective intentionality and conventional communication (human groups). Environmental changes drove the need for more coordinated behavior. In order to survive, humans had to develop the ability to view the world from multiple social perspectives, to draw socially recursive inferences, and to evaluate their own thinking vis-à-vis normative group standards. Thus for humans, shared conceptions become reified, that is, socially created "objects" such as money become viewed as objective features of the world. This makes sense only if humans can conceive of the existence of a group-minded perspective, a universal point of view, thus presumably an objective agent-neutral external authority. This assumption of an objective perspective, Tomasello says, is the source of cultural institutions, linguistic conventions, recursive/rational reasoning, social norms, self-governance, and presumably, the concept of God.

In the proposed model, dietary stress produced by significant changes in the environment, at some point, altered the selection pressures on an ancestral hominine population.[59] Effective survival required higher levels of cooperation for care of the young and for food provisioning, which would include more complex technological skills and more cooperation in hunting and food sharing. Those individuals with the genes for higher cognitive and communicative skills, and the emotional willingness to cooperate, would prosper, relatively speaking. Likewise, as the population was selected for those skills, the social environment would be altered, increasing the importance of those skills, and in turn, intensifying the selection pressure for them. At the same time, the high levels of physiological stress would potentiate the release of new genetic diversity by processes such as de-inhibiting the transcription of ALUs and other retrotransposons. These new genetic variants, particularly at control sites, would be rapidly sorted out (selected) by the increasing need for further neural plasticity and the integrative power needed to prosper in an intensifying social regime.

This model does not necessarily require gradual change. The production of neurogenetic mutations leading to the increasing plasticity and integrative power of the brain would be gradual, but their accumulation would speed up exponentially with the increasing selective power of a complex accumulative culture. The functional nature of individual brains would depend increasingly on the cultural transmission system rather than on genetic determinants. Language development doubtless was crucial. Ian Tattersall, rather controversially, attributes modern culture to an abrupt "invention" of complex recursive language at approximately 100,000 years ago[60]—which is part of an ongoing debate.[61] There are counterintuitive effects, however, to increasing the plasticity of neural systems and the bandwidth of information transmission.

Increasing the "bandwidth" of information transmission by the creation of multiple parallel neural circuits could have both stabilizing and destabilizing effects—vis-à-vis innovation. A parallel effect occurs

in cellular information systems: as parallel information pathways increase, response time becomes inflected, that is, moves closer and closer to a threshold effect. In a cultural sense, as the effectiveness of "apprentice learning" increased, the amount of cultural variation between generations would decrease, producing more cultural stability. On the other hand, when an effective innovation does appear, it can spread with increasing rapidity through the population. Think hunter-gatherers with cell phones! In this way, innovations could become culturally "locked in" and alter the selective pressures on the genome, becoming, in some sense, fixed. Further, outliers (immigrants) to such a "stabilized" population are easily assimilated without altering the culture. We see effects similar to this as populations mix today.

The "assimilation effect" is enhanced by our reactions to easily available information, what Timur Kuran and Cass Sunstein term "the availability cascade."[62] Our drive to connect our minds and to fit into our social norm, and our hunger for information and systematizing, lead us to accept the ideas which we hear the most—often without going through the work of verification. "If it can be recalled, it must be important," so the noisiest or latest or simplest ideas are favored. And we choose to act based on what we deduce others must know and on how they are acting—hence, a cascade of opinion or action sweeps through a population with possible long-lasting effects. The implication is that major irreversible transformations in human society are possible. Further, such social alterations can make changes at the genetic level. The mechanisms are there. We know some physical changes of that sort did happen with agricultural developments, for instance, lighter skeletons and enhanced abilities to digest milk or starch.[63]

But, Did It Happen? Is There Evidence for Such a Pattern?

Can the development of the unique human cognitive traits be identified through the patterns in the archaeological record? The evidence indicates that although archaic hominine populations did possess significant cultural abilities, they did not demonstrate the level of cognitive ability which was expressed early, and fairly abruptly, in the culture of developing modern humans. The use of complex technologies, and especially the use of symbols, is tied to the recursive nature of modern cognition, and developed as a property of the African lineage which produced modern humans.

It is well known that there is a sequence in the paleoarchaeological record of tool making from simple to complex. Assuming a start at the level of living chimpanzees who make simple tools to smash nuts, dig tubers, fish for termites, and kill small animals, we are looking for evidence of new techniques requiring increased cognitive ability.[64] The archaeological record clearly centers in Africa. The standard model recognizes five stages or modes of ancient stone tool making: pebble, biface, core, blade, and microlith.[65] Dwight Read and Sander van der Leeuw have proposed a correlating conceptual schema of seven cognitive advances.[66]

In Read and van der Leeuw's schema, two stages are already present in chimps and presumably in our common ancestor. Chimps recognize (1) an object's attribute and use repeated actions, for example, using a rock to break a nut. They also can (2) impose a foreign attribute on an object, for example, shaping a grass stem for termite fishing. The third stage, rock flaking, was possibly an advance of the Australopithecines. It adds the controlled repetition of a two-handed strike of a rock balanced on a larger stone. Not even Kanzi, the bonobo, has been able to develop that skill.[67] This recently reported pre-Oldowanian tool type, termed "the Lomekwain," was produced in east Africa around 3.3 million years ago. The specific tool-making agent is debated.[68]

In the fourth cognitive stage, Mode 1 tool making, the Oldowan chopper or pebble tool (2.8 million years ago) added the cognitive dimension of the edge as a specific part of a rock and requires controlled iterative action—multiple flaking.[69] The fifth stage or Mode 2 is the Acheulean hand axe. This stage implies the two-dimensional concept of a closed curve: as the edge meets itself, it generates an object with two surfaces. Hand axes appear in Africa around 1.5 million years ago and are associated with *Homo erectus*. After 500,000 years ago, these axes began to show some regional variation as hominines exited Africa.

Mode 3 or the Mousterian (cognitive stage 6) used the Levallois technique (prepared blanks) and refocused on the chip. From the blank, a large flake could be struck and retouched into various forms, and the core reused—thus producing an "algorithm" of

repeated return to a planned form.[70] There is good evidence of such core and flake/blade technique developing between 500,000 and 280,000 years ago at Kathu Pan, south Africa; at the Kapthurin Formation, Kenya; and in Tabun and Qesem Caves, Israel.[71] In Africa, such Mousterian technology replaced the hand axe and was the technology of the first anatomically modern human populations. The technique also reached Europe around 250,000 years ago; the Neanderthals, until they disappeared, used a mix of Acheulean and Mousterian techniques.

This period seems to be a significant point of adaptive departure. The disappearance of elephants in the Levant around 400,000 years ago may have forced an adaptive shift to smaller, more diverse, and agile prey with both anatomical and cultural implications.[72] Around 300,000 years ago, a variety of cultural shifts appear in this region: Acheulo-Yabrudian flint-knapping, habitual fire use and organized hearth building, and home-site meat processing and sharing at Qesem and Tabun Caves.[73]

In Mode 4 tool making (blade/core), long prismatic blades are struck in such a fashion that each blade prepares the surface of the core for the next blade strike. The blades were, in turn, shaped into a wide variety of tools. Thus, cognitive stage 7 uses a three-dimensional concept of intersecting planes which requires recursive planning. Both the present and future blades are simultaneously envisioned. Mode 4 appears in Africa around 200,000 years ago with a lot of regional variation. It reached Europe with the modern human invasion 40,000+ years ago.

Mode 5 tools are the microliths, very small blades used as inserts in compound tools. The manufacture of multicomponent tools requires holding a large number of variables in mind, and learning techniques of complex assembly. Their earliest appearance may be at Pinnacle Point cave in South Africa, around 165,000 years ago, made by fully modern people. After that, there was the spotty appearance across Africa of advanced techniques which in Europe would be considered Neolithic—microliths, cooked silicate, carved bone harpoons, bone spear and arrow points, small backed blades (one side blunted), tanged elements, and complex adhesives (ocher and acacia gum) used to make complex tools.[74]

In summary, changing styles of tool manufacture—and of social interaction—indicate that significant changes in cognition were accumulating in the ancestors of modern humans, especially after 300,000 years ago. Long periods of cultural stasis were "punctuated" by short periods of cultural innovation, a pattern which paralleled patterns of changes in skeletal morphology. Tool making per se does not seem to provide a clear marker for "a beginning" of modern cognition. However, the pattern of increasing cultural acceleration, particularly after 250,000 years ago, and the fixation of new levels of complexity after 100,000 years ago, are as predicted by the gene/culture positive feedback model.

Of course, tools are not the only sorts of things which modern humans make; we also make ornaments and engage in symbolic acts.[75] An artefact made without "practical" application indicates symbolic thought, namely, a recursive connection between multiple cognitive domains—parallel to the linguistic representation of classes of objects and actions. The appearance of paintings and statuettes in Europe and Asia after 40,000 years ago is well known.[76] However, there are significant earlier indications of such modes of thought in Africa. For instance, strings of beads made from marine bivalves and snail shells (*Nassarius* sp.) made 80,000 years ago have been found in Blombas and Sibudu caves in South Africa, and possibly as early as 120,000 years ago at Skhul and Qafzeh caves in Israel, and at the Oued Djebbana shelter in Morocco.[77] The beads were matched by color and size or coated in red ochre.[78] Perhaps they were tribal identifiers. Their presence in sites far from the sea (in the north) suggests a trade network. Other examples of "symbolic" artefacts include cross-hatched ochre blocks and decorated ostrich egg shells.[79] Such artefacts, the use of grave goods and other mortuary practices, and the use of ochre as pigment indicate a significant use of symbolic activities. The possible use of ochre on the skin may date back to 250,000 years ago at the Kapthurin and Olorgesailie formations in Kenya, and possibly at some European Neanderthal sites. It is not clear if it was used to produce a mastic, to enhance body features in some fashion, or to send an agreed-on signal—only the latter being a symbolic use.

So, was this sort of cultural development occurring in all the large-brained hominine lineages, or was there something unique occurring in the lineage which showed modern morphology? Neanderthals were equally large brained, but apparently they were genetically and culturally isolated for at least 650,000

years from the lineage which developed into "moderns" in Africa. (The Sima de los Huesos people of Spain of 430,000 years ago are now understood as early Neanderthals.[80]) But were the Neanderthals also culturally progressive? As noted, Neanderthals used a mixed set of Mode 2 and 3 techniques—both Acheulean and Mousterian. Although there is some evidence of cultural movement in Europe prior to 250,000 years ago, Mode 3 was clearly first developed in Africa. A mixed Mode 3/Mode 4 techocomplex, termed "the Châtelperronian," did emerge around 42,000 years ago in France. Although made by Neanderthals, it was rooted in Mode 3 techniques and seems likely to have been triggered by the early arrival of modern humans using Mode 4 artefacts (in the Middle East by 48,000 years ago, and then on into Europe). The cultural development of Modes 4 and 5 was apparently unique to the developing modernity of the African lineages.[81]

The site where the earliest modern behavioral adaptations seem most evident is the South African coast (at Pyramid Point) during the previous glacial maxima (165,000 years ago). At that time, Africa was broadly inhospitable due to widespread drought, causing a Pan-African population collapse. The southern coast acted as refuge, and it potentiated the development of the systematic use of coastal resources. Curtis Marean comments, "The origin of this coastal adaptation marks a transformative point for the hominin lineage in Africa."[82] He notes that before this point the human adaptive systems were based on highly mobile, low-density, and egalitarian populations. In contrast, typical coastal social developments resemble agricultural groups with "reduced mobility, larger group size, population packing, smaller territories, complex technologies, increased economic and social differentiation," and with more gifting and exchange, boundary defense, and group conflict.[83] Such neighbor-group conflict has been suggested as a driver for prosocial altruism.[84] Survival required learning to exploit the tubers (fynbos) of the coastal vegetation and understanding the movement of the tides to effectively harvest shell fish. It also pushed the survivors to develop complex material processing (cooking silicate and mastic, knapping small blades for composite tools) and later, symbolic objects.[85]

A related plausible driver for cultural development is demography, the idea that the level of cultural expression reflects changes in population density.[86] Both genetic and paleoclimatic analyses suggest that the appearance and disappearance of "advanced" behaviors such as those of Still Bay and Howiesons Poort correspond to sharp changes in climate which triggered changes in human population density.[87] Technologies appeared during periods when high population densities could have stimulated the formation of integrated networks of tribes, and when the population collapsed, isolating the tribes, the technology disappeared.[88] So, an improving environment can trigger a population increase, and increased density supports cultural innovation. In turn, when a population collapses, its cultural attributes become much less complex, possibly due to the loss of "expert" teachers before they can pass on their information, as suggested by Sterelny.[89] The period from 190,000 BC to 130,000 BC was a sustained glacial period. Although there were anatomically modern people in Africa, little advance was seen. Between 130,000 BC and 80,000 BC (an interglacial), new techniques and the use of beads appear in a number of areas.[90] The oscillation of interstadials between 80,000 BC and 30,000 BC saw innovations come and go in South Africa, but the basic technology involving the ochre gums (mastics) continued through the period.[91] In the same vein, the immigration of people into very difficult environments such as Australia seems to be accompanied by a loss of technology.[92]

What Do the Fossils and the Genes Tell Us?

Can these patterns of cultural change be tied to changes in the fossil record? The obvious tie of cognition to the brain has led to the assumption that brain size (or relative brain size) is the key datum which defines modern cognitive abilities. Modern skulls and delayed developmental trajectories appeared in Africa roughly around 200,000 years ago. But what leads up to that?

The most functionally significant comparison between brain sizes is the encephalization quotient (EQ), the expected brain size given the size of the body.[93] Modern chimpanzees have about the same EQ (about 2.45) as did the early australopithecines. The later species, *A. africanus* (a possible human ancestor), had an estimated EQ of 2.7. Robust australopithecines had EQs around 3.1.[94] It is not possible to tell if the australopithecines show derived changes in relative cerebral proportions. In terms of artefacts which show altered cognition, the earliest stone tools

(Lomekwian) are dated at 3.3 million years ago, which predates the earliest *Homo* fossils.

Brain sizes—and EQs—rose in an irregular fashion in genus *Homo*. *Homo habilis* had an EQ of around 3.4 and a brain of 630 cc. Early African *Homo ergaster* was larger, with a brain of 825 cc. but about the same EQ (3.3). Later *Homo erectus* (circa 500,000 years ago), found in Eurasia, with larger skulls and bodies, have an average brain size of 973 cc and an EQ of around 4.3. *Homo heidelbergensis* (600,000 years ago) with a brain of 1200 cc (within the modern size range) still has an EQ of only 4.3. *Homo neanderthalensis* originated around 250,000 years ago; they had very large brains (around 1420 cc, modern size) and thick, cold-adapted bodies. Their EQs were around 4.9. The early modern people such as the Cro-Magnons had the largest brains at 1490 cc, with an EQ of 5.45. Recent modern populations are smaller—our brains average about 1360 cc, with EQs of around 5.33.

So, the EQ did jump with the appearance of genus *Homo*, but it increased only slightly over the next million years. Modern-sized brains appeared a half-million years ago, but as they are matched by bigger body size, the EQ did not rise much. The brains of anatomically modern people were equally large, but since their bodies were smaller, they had a higher EQ. The altered shape of their skulls probably reflects functional changes signalled by globularization. In contrast, the large brains of the Neanderthals were produced by extending the archaic trajectory of neural growth. Such differences in the increases in specific brain areas would be expected to be driven by selection for the enhancement of particular functions—the unique functions in modern human brains vis-à-vis the chimp brain clearly are reflected in differences in their cerebral structures. The developing cranium forms around the developing brain; therefore, changes in cerebral function should produce changes in the shape of the developing brain and in the shape of the skull. The most parsimonious explanation for such changes is a functional alteration in the relative volumes of the various cerebral lobes driven by selection.[95]

One recent suggestion for differences in mental function between Neanderthals and moderns is that Neanderthals had an advanced "modular" system of "expert" performance, essentially an enhanced "executive" control system based in the frontal lobes using long-term memory, but that they lacked the working memory capacity of modern humans.[96] Working memory capacity is needed to hold a diverse amount of "other" information. Thus the "default" system which particularly uses unique areas of the parietal lobes to recursively and creatively compare patterns might not have been available for the Neanderthals—possibly they did not "daydream" of impossible connections.[97]

One aspect of the fossil record which would be particularly interesting to match with cultural development is the period in which modern skull morphology was developing—between 400,000 and 150,000 years ago in Africa. Unfortunately, the fossils which might provide that evidence are pretty sparse. There are Kabwe (300,000?), Guombe (270,000), Florisbad (250,000), Eliye Springs (250,000), Omo I and II (195,000), Herto (160,000), Jebel Irhoud (160,000), Singa (135,000), Ngaloba (120,000), Qafzeh (100,000), and Skhul (90,000). These few specimens have variable degrees of modern and archaic features. The data indicate that over this period the human population was highly diverse—more so than at any other period—and thus probably was divided into isolated bands and widely dispersed.[98] Subdivided populations of this sort undergo fairly rapid local evolution. It is a pattern which potentiates both local drift and group selection, enhancing social recognition and binding mechanisms and increasing prosocial adaptation.

The genetic evidences (for this model) which demonstrate the unique qualities of the human genome vis-à-vis neural function have been extensively documented previously, including known differences between the Neanderthal genome and the modern version.[99] A more recent study by Hang Zhou et al. documented the time that certain loci were under strong selection.[100] They identified six loci involved in brain development which were under strong selection between 200,000 and 50,000 years ago. The loci are involved in synaptic hyperconnectivity, augmented neuronal metabolic activities, and functional plasticity—results which correlate well with a model of culturally driven selection causing increased neuronal plasticity during that period.

The other piece of genetic evidence which seems relevant is the pattern of genetic relationships between human populations. It is clear that our species originated in Africa, that the oldest distinct lineages were in the south, and that our ancestors went through a

period of reduced population around 150,000 years ago. These patterns are robustly supported by multiple studies.[101] The most likely model is that all modern humans are descended from a part ("tribe") of a dispersed subdivided population at around the time modern cultural motifs seem to have become consolidated. That particular population would have provided the largest part of our genetic (and cultural) ancestry, with occasional smaller contributions from isolated groups.

The clearest data showing the effect of such "contribution" is the admixture of Neanderthal genes into the genome of non-African modern humans. Perhaps twenty percent of the Neanderthal genome is scattered throughout Eurasian populations, but very few remaining loci seem to have any significant effects, good or bad—mainly, some immune variants and a gene which allows the people of the Himalayan Mountains to function at high altitudes.[102] Most Neanderthal loci were apparently selected out, presumably because they interfered with normal functions of the modern genome and depressed their owners' survival. The loss of these genes is likely due to the powerful positive feedback between complex cultural transmission and plastic neural genetics.

In summary, I have proposed that the gradual (but rapid) accumulation of genetic changes supporting social and general cognitive intelligence was driven by selection for effective group-coordinated activity. The product of that selection was the broadly integrated and developmentally plastic modern human brain, as reorganized during its genetically prolonged period of enculturation. Thus, the gradually selective accumulation of human potential was functionally stabilized by the increasingly intensive cultural programming of adolescent neural rewiring. Such social and cognitive selective pressures, acting through a "high-band" intergenerational instructional system, became locked in and reliably transmitted increasingly complex adaptive cultural information (the ratchet effect). This produced increasing cultural stability, punctuated by sudden functional changes triggered by alterations in climates, ecosystems, and the resulting demographics, leading to significant innovations in multiple areas. Such sociogenetic fixation would be enhanced by the isolation provided by tribal barriers and would also act to absorb and enculturate outliers. The system of positive feedback between culture, brain, and genes seems to have begun in earnest between 400,000 and 300,000 years ago, becoming progressively intensified and effective and reaching a probable climax of modern levels of function around 100,000 years ago in the South African coastal population. Genetic and cultural evidence indicates that this population was the one which became the genetic and cultural core of *Homo sapiens*.

Theological Implications of This Model of Human Origins

Humans are indeed unique: they show the qualities of the *imago Dei*. But the model proposed for human creation implies that those features developed gradually, especially the genetically driven delay in neurological development which extends the period of neurological plasticity of the modern brain. This may mean that the appearance of the image was gradual, spread over hundreds of thousands of years (under God's providential governance of the process). But not necessarily. John Walton has argued that creation in scripture is primarily about being made functional.[103] That concept gives a handle to understand a "punctuated" model of gradual human creation. Even if the genetic substratum is "prepared," it does not automatically produce a functionally modern brain. It requires particular cultural nurturing during infanthood and childhood to establish the "modern" form of the synaptic array. Since a child's cultural "Weltbild" is a product of the adult brains around it, the realization of a "modern" brain is not possible unless those adult brains are also "modernized."

So, how could a tribal group be made "functional"? A point of sudden appearance of the image might have been produced by the impact of a threshold event in cultural transmission. This could happen due to the profoundly culturally driven (re)shaping of the cerebrum which takes place during early development. It is, after all, those culturally driven qualities which make humanity unique. Such a transformation would not necessarily leave a detectable physical trail in the form of transformed skulls or altered genetic loci. But would such an event take an extended theophany, or perhaps a miracle of neural transformation to make Adam (or a group) truly unique, to jump the gap to full humanness?

A possible model of the giving of the image might indeed include a divine "initiating" act, one in which God interacted "culturally" with developing human

children to alter the shape of their brains' operating systems, producing a self-replicating system of cultural integration. If that was what happened, it would, in fact, be transmissible to other children who were not part of the initial group, just as children moved to a new cultural milieu pick up the local mindset, although it remains forever "foreign" to their parents.

Recall that the gradual selective accumulation of human cultural and mental potential was functionally stabilized by the increasingly intense cultural programming of adolescent neural wiring. Also, note that the most intense environmental and social crisis point for humanity was at the previous glacial maxima, as witnessed by the population bottleneck. At that time, our ancestors were a relatively localized population under intense environmental pressure, a situation potentiating significant cultural change (or maturation, if you will). This situation had both social and genetic implications. Socially, it made a cultural threshold transition more likely. Genetically, it would increase the selective intensity on neurally active loci, and it might even cause further release of ALU transcripts, for instance, increasing available genetic variability.

If God acted at this point in time in a "divine acculturation" mode directed toward cultural maturation, the process went awry. The event could have begun with the isolated human population. It had the neuro-genetic potential for modern function, but it was locked into premodern psycho-cultural complex by the power of the apprentice effect. Divine revelatory activity programed a new cultural operating system into the brain(s) of one (or a few) humans—divine enculturation. I see no reason why this could not imply the extended presence of God "raising/apprenticing" Adam (or his tribe). However, I also do not know how one would rule out this change occurring over multiple generations. In any case, it did not go well.

How Does This Model Apply to the Question of "Original Sin"?

First, it would be well to consider the growth of a moral sense in our ancestors. Many socially aware animals seem to have a sort of "morality" in the sense of a perception and evaluation of fairness directed to themselves, their young—and for some species—their mates and community members. Standard models of "fitness" require that organisms seek their own "good" (personal survival) and their offspring's good (genetic survival). But a full moral sense requires a recursive theory of mind, the mental capacity to not only recognize the other as a "self," but also to see one's own self as an equivalent "self" in the mind of the other—and then to put one's personal "good" against another's "good," and make a choice.[104]

But how did humanity reach the point to be able to choose to so honor the altruistic impulse? For a self-aware species to become a highly coordinated social entity, it must develop something beyond the intelligent competition of the chimpanzee. The question is, what is needed? Chimpanzees (our "next of kin") are intelligent and socially complex. Thus, much of their behavior troubles us—infanticide, murder, and war have all been attributed to them. But though chimps can hold grudges, there is no evidence that they feel shame or guilt. They can coordinate activities, but there is little evidence that they have altruistic impulses. They communicate imperatives, not gossip. What is missing? One key is probably the level of their theory of mind, or mind reading.

It is clear from numerous experiments that chimps can detect from observation what other chimps are observing and anticipate what they probably will do. It is not clear that they are attributing mental states to those other chimps, forming explanations of why they are acting in a particular fashion. In such cases, humans would be "mind reading," but a simple reaction to the observed state or action will explain the chimpanzees' responses—and that is, of course, the simplest explanation.[105] Thus, when they kill, they are "innocent killers." But the ability to do advanced mind reading, to correctly attribute mental states to another intelligence, potentially allows a society to move beyond the "innocent killer" stage.

If the ability to know the other's mind is coupled with an instinctive desire to advance the other's good, a moral choice is presented. In such a moral choice of action, there must be a clear understanding of the good of the other as well as the good of one's self, and they must be seen as equivalent goods. As previously discussed, these evaluations are being done in part at the temporoparietal junction.[106] To choose to "do unto others what you would have them do unto you" requires that sort of mental balancing evaluation. And humans universally are aware of this as

"right"—the principles of the golden rule and loving one's neighbor as oneself are recognized as "good" in all cultures. But though understood, this rosy picture is seldom realized. Rather, we frequently make things worse.

What is the source of the moral insight that the other's good should come first? As long as no exterior command is given to which one is called to react, moral choices are still a balancing of internal drives—the demands of conscience (obeying it will make me feel good) versus other personal desires (beating your head in will make me feel good). Of course, chimps will "command" each other, but when one knows that the source of a demand is a person like yourself—seeking their own "good," the command loses credibility. In fact, we *must* work through this during adolescence to become healthy adults. An imperative to act in the face of exterior force does not translate into an imperative to act due to internal directives, but only to a strategic choice between personal goods. If the sin of Eden was rebellion, the desire to place oneself above God, then the source of the command has become transcendent. Thus God's commands will be objective, outside oneself, the same for all. When that becomes true, the "altruistic impulse" becomes preeminent.

We are intended to hear and heed our inner voice, but I do not think that it could have been just the urging of conscience which made us sinners—even that high level of conscience which requires recursive theory of mind (TOM). In the end, that is still myself talking, and I cannot be sure that the voice in my head is the voice of God. My conscience may be intended to be the image of God's character, but it is not the direct voice of God—it is, in fact, largely influenced by my cultural experience, and we are quite skilled at creating warning signals in our own conscience and in others. Perhaps the first sin was the "Chief" who claimed to speak with the voice of God in his pronouncements and commands!

Thus, the developed ability to do advanced mind reading, to correctly attribute mental states to another intelligence, is also necessary to truly do evil. In a sufficiently advanced, socially aware mind, an act which is of personal benefit but harms another generates both an internal awareness of how the actor feels, and also how the person acted on feels. The decision to do an evil act such as knifing a man for his money is accompanied by a predictive TOM scenario in which a (normal) actor "feels" the outcome for the victim. In both the decision and the act, one feels the personal "good" achieved—and equally, the personal "evil" suffered. No animal apparently has the capacity for such perception of the other, and therefore no animal can truly choose "evil."

In primitive members of genus *Homo*, a full empathy coupled to a complete simulation of another's state of mind was unlikely—that processing takes place in a section of the parietal lobes which is uniquely expanded in the modern human cerebrum. As Michael Graziano suggested, the high level of TOM ability in modern humans may be what produces full consciousness—we become aware not only of what is happening in others' minds, but also, recursively, of what is happening in our own.[107] The Neanderthals probably lacked that modern capacity to balance moral issues. Presumably they were able to make moral judgments for the "community's good," but their archaic morphology indicates that they lacked the modern level of recursive thinking. It seems unlikely that they could say to themselves—and realize that they were making the choice—"I ought to do A, but I want to do B, and I can choose between A and B."

In the suggested model for modern human origins, the feedback between the selection pressures for cooperative behaviors and the supporting genetic capabilities for neural plasticity brought our ancestors to a critical state. The pressure of social selection had made the "law of God" in the heart (instinctive prosocial empathetic altruism) more visible, more poignant, and more clearly in conflict with the necessary survivalist focus on self-love and personal good. But as yet, there was no way to resolve the dilemma, no sure way to judge situations and resolve the tension. In fact, we still are likely to decide that our feelings of "universal" altruism (or "affection for impartial justice" as John Hare puts it) are only the product of those having power over us, that we have been programmed into them by others seeking their own benefit.[108] What was needed to turn altruism into morality was the law—God had to validate our insights. But the law makes sin possible.

Clearly, there is no consensus concerning the meaning of "the Fall." Tensions between theological models and scientific models reflect tensions within both disciplines. What has been proposed as the nature of the Fall? What resolutions might make

sense, assuming neither science nor theology is to be rejected? Shall we view the Fall as a metaphor for retained primitive nature—basically, a lack of altruism—a failure of that evolutionary process which produced prosociability in the human race? Can a universal human sin nature have been produced as a gradual, incremental "fall" with "social compound interest"? Might it be that with increasing internal demands for altruistic acts, there can be increasing pressure (temptation) to not obey due to a clearer prediction of the personal costs?

Or, could universal sinfulness have grown to cover the human race as a spread of rebellion from a seeded event, rather like the spread of crystallization in a super-saturated liquid? Perhaps such a spread would be the expected outcome of producing a highly prosocial species with a culturally induced moral programming of the neural pathways. Would that model allow for the possibility of sudden dramatic change in moral type, an "Eden event" due to new input which caused a threshold event? And if so, would such an event need to be caused by a direct alteration of genes—or of the neural state—or could it be induced through a complex social event, as "literally" described in Genesis?

The sin of the garden must be viewed within the context of the narrative of the garden. Eden was the garden of God, not the garden of humans. The fruit is God's. Adam and Eve are placed within it as caretakers. Humanity's dominion is a promised future, not a present reality, even then. The decision to eat the fruit was to take control of the garden, to set its agenda. The tree of the knowledge of good and evil was able to make one wise (crafty). "To make one wise" is to focus on practical outcomes. Here the "good" equals what works, "evil" equals what does not work, and thus wisdom means choosing actions which are effective in reaching one's goals. The "wisdom" derived by eating is the choice itself. The choice to disobey was the rejection of God as the source of wisdom, the rejection of God's goals and methods. Humankind was now to envision their own goals, choose their own methods, and make their own judgments of rightness. God's "good" was thereby effectively ignored, or even declared "evil." And that means that the growing power of the image of God, which was being given to humanity, was warped into an image of self. Adam bears sons in his own warped image. And all of us are shaped into humanity by our enculturating tribe. If Adam (or his tribe) provided that initial model, we are all humans made in Adam's sinful image. His rebellion is the initiating sin, inherited sin, original sin, and my personal sin.

T. A. Noble has provided a summary list of ten theological definitions of original sin:

1. It is universal—everyone sins;
2. Fallenness—the state of being fallen (decay);
3. The original act as the root of sin;
4. Original guilt—Adam's guilt passed on to us;
5. A disease which we inherit;
6. Hereditary sinfulness;
7. Inner bent disposition—our desires and passions;
8. Propagation by sexual desire (Augustine's idea);
9. The flesh—the power of self-centeredness; and
10. Corporate sin—human solidarity and domination by the system.[109]

Will the proposed model speak to these? I think that it does.

My preferred model proposes that humanity had reached a point of development with the potential to understand God's plan to unite the world, to be inducted into his created role as God's agent, and to be commissioned to direct the process of making "all things one" under God. At that point, God acted (suddenly—by a theophany, or via a threshold effect). Choosing a particular individual or a group, God communicated and clarified his goals. Perhaps he acted by intensively socializing a growing child, by showing the nature of love, by teaching the gift of language, or by equipping with the concept of effective agency in the service of the garden kingdom. In any case, I do not think that it was business as usual. Humanity was being ordained as the intended "priest-kings" to further extend the "sacred space" of the garden as the home of God, and he would dwell among them.[110]

But they rebelled. In my opinion, the first sinning must have occurred among individuals capable of a mature moral choice, but yet innocent in that they had not yet been faced with such a choice. God gave them the chance to grow up—a choice to make. They matured by making the choice, but they matured wrongly, warped, broken—they "learned disobedience." The chance to mature into God's true image was lost. Human rejection of God's authority altered the direction of the "new" cultural program from

altruistic dominance back to egoistic dominance. It inserted a "sin acquisition drive" into the pattern. Evil experienced becomes domesticated, justified, an accepted act. One develops a taste for it. Further, evil experienced due to another's act gives rise to evil in the one who was injured. Evil experienced is projected back on the perpetrator—or on others in his stead—by recursive scenario building. The evil imagination itself contaminates the social mind, and leads, in turn, to additional acts producing deliberate harm.

The resulting warped "modernized" pattern of culture completely and rapidly displaced the premodern cultural complex which existed—possibly at the time of the demographic bottleneck, circa 150,000 years ago. All of us as "Adam's" cultural descendants are necessarily egoistic, with that impulse dominant over our altruistic impulses, in part, because the culture which nurtures and apprentices us determines the shape of the neural programming which makes us human. That cultural alteration likely also altered the selection pressures on epigenetic and genetic loci, increasing the power and malignancy of the fallen pattern (think of the tricky character of pit bulls). For instance, a culture based on class dominance versus an egalitarian culture will select for different genes which assist survival in those different situations. We thus have a "fallen" form of culture reinforced with selected genes (and epigenetic settings). This is not a matter of "sin inherited in the genes." Nevertheless, some genetic differences are indeed likely to weaken or strengthen personal altruism or egoism. For instance, there are known genetic differences in the response of children to abuse and known genetic differences in the degree of felt empathy. An example is sociopathy, the inability to feel empathy, which seems to have a 56% genetic contribution.[111] The genes involved are undoubtedly widely distributed and produce some of the "normal" spectrum of human behavior—and they very well might be selected for in particular cultures. There is some evidence that they make one a better CEO!

We are born as sinners because we can only become human by being nurtured by humans—who are all sinners. Adam's sin is and was therefore indeed our sin—for Adam's sin is embedded in those who make us human, and they can only make us after their image. Adam's rebellion has come down to us generation after generation—culturally transmitted, neurologically inevitable. We seek sin as we do all the other aspects of culture—freely, nay ravenously, from our birth. We instinctively acquire its principles, creatively build sinful scenarios, and become "educated" into the besetting sins of our local culture. That cultural sin is part of our corporate identity as "sons of Adam and daughters of Eve." And these parts of the pattern do fit and explain the theologians' several paradigms for original sin. We need a Savior!

What about physical death? Clearly creatures have died from the beginning of Earth's history. In whatever way one wishes to interpret the biblical text, death is biologically necessary and a spiritual mystery. So let me speculate a bit. Note that in the Eden narrative, eternal life is "literally" offered—not guaranteed. Why else would there need to be a "Tree of Life"? Henri Blocher suggests the following way to untie the knot.[112] Without the law, sin cannot be made the object of judgment. He suggests that Adam's (or Adam's tribe's) sin makes possible the imputation, the judicial treatment, of all human sin. Without that rebellion, there is no basis to judge human actions. Adam directly disobeyed the command—thus all human sinning against the law in the heart is shown to be true sin, a reflection of the rebellion in Eden. This judgment therefore brings universal condemnation and death, for if God sees us in Adam, we are identified with him—seen through the covenant of creation. In this way, all human sin can be viewed as part of—grafted onto—the broken command and sin of Genesis 3. Perhaps then there would be no need for sin to "spread" over the world. And possibly, that is the reason that sins prior to Adam can be judged. If Adam was raised and placed in a "purified" environment and still sinned, it illuminates the true heart of humans. Moses's law did not have to be there for sin to be judged, but it increased the efficiency of judgment. However, it is God's demands, which he built into our hearts—even if that building took 300,000 years—which condemn us.

As the good taste of the fruit in Eden was accompanied by the dawning awareness of evil, so began the sorrow of breaking trust with the loving Father God. Having broken faith with God, easy dominion in the earth was taken away. The *imago Dei* was warped and twisted. We do not see humans playing the role described in Psalm 8. Rather, we see humanity destroying the earth, and we long for the return of Jesus who will make all things new and who will restore the vision born—and aborted—in Eden. ✺

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Notes

[1]B. B. Warfield, "Review of *Darwinism Today* by Vernon L. Kellogg," *Princeton Theological Review* 6 (1908): 640–50.

[2]J. Richard Middleton, *The Liberating Image: The* Imago Dei *in Genesis 1* (Grand Rapids, MI: Brazos Press, 2005).

[3]Anthony A. Hoekema, *Created in God's Image* (Grand Rapids, MI: Wm. B. Eerdmans, 1986).

[4]Thomas Aquinas, *Summa Theologica* (New York: Benzinger Brothers, 1947), 1:15.

[5]Gordon Clark, "Image of God," in *Baker's Dictionary of Christian Ethics*, ed. Carl F.H. Henry (Grand Rapids, MI: Baker Book House, 1973), 312–13.

[6]Kim Hill, Michael Barton, and A. Magdalena Hurtado, "The Emergence of Human Uniqueness: Characters underlying Behavioral Modernity," *Evolutionary Anthropology: Issues, News, and Reviews* 18, no. 5 (2009): 187–200.

[7]Jonathan Haidt, "The New Synthesis in Moral Psychology," *Science* 316, no. 5827 (2007): 998–1002.

[8]Karl Barth, *The Doctrine of Creation*, in *Church Dogmatics* III/I, ed. G. Bromiley and T. F. Torrance (Edinburgh: T&T Clark, 1958), 186.

[9]G. C. Berkouwer, *Man: The Image of God* (Grand Rapids, MI: Wm. B. Eerdmans, 1962), 179.

[10]Hill, Barton, and Hurtado, "The Emergence of Human Uniqueness."

[11]Esther Herrmann et al., "Humans Have Evolved Specialized Skills of Social Cognition: The Cultural Intelligence Hypothesis," *Science* 317, no. 5843 (2007): 1360–66.

[12]Jonas Langer, "The Heterochronic Evolution of Primate Cognitive Development," *Biological Theory* 1, no. 1 (2006): 41–43.

[13]Chet C. Sherwood, Francys Subiaul, and Tadeusz W. Zawidzki, "A Natural History of the Human Mind: Tracing Evolutionary Changes in Brain and Cognition," *Journal of Anatomy* 212, no. 4 (2008): 426–54; and Derek C. Penn, Keith Holyoak, and Daniel J. Povinelli, "Darwin's Mistake: Explaining the Discontinuity between Human and Nonhuman Minds," *Behavioral and Brain Sciences* 31, no. 2 (2008): 109–30.

[14]Andrew Whiten et al., "Emulation, Imitation, Over-Imitation and the Scope of Culture for Child and Chimpanzee," *Philosophical Transactions of the Royal Society B* 364 (2009): 2417–28.

[15]Penn, Holyoak, and Povinelli, "Darwin's Mistake."

[16]Derek C. Penn and Daniel J. Povinelli, "The Comparative Delusion: The 'Behavioristic'/'Mentalistic' Dichotomy in Comparative Theory of Mind Research," chap. 3 in *Agency and Joint Attention*, ed. J. Metcalfe and H. S. Terrace (New York: Oxford University Press, 2013), 62–81.

[17]Sherwood, Subiaul, and Zawidzki, "A Natural History of the Human Mind."

[18]Penn, Holyoak, and Povinelli, "Darwin's Mistake."

[19]Johan Lind, Magnus Enquist, and Stefano Ghirlanda, "Animal Memory: A Review of Delayed Matching-to-Sample Data," *Behavioural Processes* 117 (2015): 52–58.

[20]Penn, Holyoak, and Povinelli, "Darwin's Mistake."

[21]Vilayanur S. Ramachandran, *The Tell-Tale Brain: A Neuroscientist's Quest for What Makes Us Human* (New York: W.W. Norton, 2012).

[22]Courtney Chrusch and Liane Gabora, "A Tentative Role for FOXP2 in the Evolution of Dual Processing Modes and Generative Abilities," *Proceedings of the 36nd Annual Meeting of the Cognitive Science Society* (Houston, TX: Cognitive Science Society, 2014), 499–504, https://people.ok.ubc.ca/lgabora/papers/conf_papers/Chrusch-Gabora-CogSci2014.pdf; and Manish Saggar et al., "Pictionary-Based fMRI Paradigm to Study the Neural Correlates of Spontaneous Improvisation and Figural Creativity," *Scientific Reports* 5, no. 10894 (2015), http://www.nature.com/articles/srep10894, doi:10.1038/srep10894.

[23]Penn, Holyoak and Povinelli, "Darwin's Mistake"; and Gerald M. Edelman, *Wider Than the Sky: The Phenomenal Gift of Consciousness* (New Haven, CT: Yale University Press, 2005).

[24]Penn, Holyoak, and Povinelli, "Darwin's Mistake."

[25]Carolyn Parkinson and Thalia Wheatley, "Old Cortex, New Contexts: Re-purposing Spatial Perception for Social Cognition," *Frontiers in Human Neuroscience* 7, article 645 (2013), http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3792395/.

[26]Adélaïde de Heering and Bruno Rossion, "Rapid Categorization of Natural Face Images in the Infant Right Hemisphere," *eLife* 4 (2015): e06564, http://psych.mcmaster.ca/Adelaide_de_Heering/Adelaide_de_Heering/Publications_files/eLife.pdf, doi:10.7554/eLife.06564.

[27]Kim Sterelny, *The Evolved Apprentice: How Evolution Made Humans Unique* (Cambridge, MA: MIT Press, 2012); Ian Tattersall, "An Evolutionary Context for the Emergence of Language," *Language Science* 46, Part B (2014): 199–206; Thomas Suddendorf, *The Gap: The Science of What Separates Us from Other Animals* (New York: Basic Books, 2013).

[28]Edelman, *Wider Than the Sky*.

[29]Douglass Godwin, Robert L. Barry, and René Marois, "Breakdown of the Brain's Functional Network Modularity with Awareness," *Proceedings of the National Academy of Sciences of the USA* 112, no. 12 (2015): 3799–3804; Yin T. Kelly et al., "Attributing Awareness to Oneself and to Others," *Proceedings of the National Academy of Sciences of the USA* 111, no. 13 (2014): 5012–17; Randy L. Buckner, "The Cerebellum and Cognitive Function: 25 Years of Insight from Anatomy and Neuroimaging," *Neuron* 80, no. 3 (2013): 807–15.

[30]Lind, Enquist, and Ghirlanda, "Animal Memory"; Suddendorf, *The Gap*.

[31]Lauren L. Emberson, John E. Richards, and Richard N. Aslin, "Top-Down Modulation in the Infant Brain: Learning-Induced Expectations Rapidly Affect the Sensory Cortex at 6 Months," *Proceedings of the National Academy of Sciences of the USA* 112, no. 31 (2015): 9585–90.

[32]Stanislas Dehaene and Laurent Cohen, "Cultural Recycling of Cortical Maps," *Neuron* 56, no. 2 (2007): 384–98.

[33]Lisa Feldman Barrett and W. Kyle Simmons, "Interoceptive Predictions in the Brain," *Nature Reviews Neuroscience* 16 (2015): 419–29.

[34]Suddendorf, *The Gap*; Tattersall, "An Evolutionary Context for the Emergence of Language."

[35]Sherwood, Subiaul, and Zawidzki, "A Natural History of the Human Mind."

[36]M. Tomasello and E. Herrmann, "Ape and Human Cognition: What's the Difference?," *Current Directions in Psychological Research* 19, no. 1 (2010): 3–8; and Derek E.

Lyons, Andrew G. Young, and Frank C. Keil, "The Hidden Structure of Overimitation," *Proceedings of the National Academy of Sciences of the USA* 104, no. 50 (2007): 19751–56.

[37]Mark Nielsen, "The Imitative Behaviour of Children and Chimpanzees: A Window on the Transmission of Cultural Traditions," *Revue de primatologie* 1 (2009), http://primatologie.revues.org/254; Whiten et al., "Emulation, Imitation, Over-Imitation and the Scope of Culture for Child and Chimpanzee."

[38]Suddendorf, *The Gap*; Yvonne Rekers, Daniel B. M. Haun, and Michael Tomasello, "Children, but Not Chimpanzees, Prefer to Collaborate," *Current Biology* 21, no. 20 (2011): 1756–58.

[39]Michael Tomasello, *A Natural History of Human Thinking* (Cambridge, MA: Harvard University Press, 2014).

[40]Matthew Lieberman, *Social: Why Our Brains Are Wired to Connect* (New York: Crown Publishers, 2013).

[41]Michael S. Gazzaniga, *The Ethical Brain: The Science of Our Moral Dilemmas* (New York: Dana Press, 2005); Haidt, "The New Synthesis in Moral Psychology."

[42]Petra Michl et al., "Neurobiological Underpinnings of Shame and Guilt: A Pilot fMRI Study," *Social Cognitive and Affective Neuroscience* 9, no. 2 (2014): 150–57; Marco Zanon et al., "Brain Activity and Prosocial Behavior in a Simulated Life-Threatening Situation," *NeuroImage* 98 (2014): 134–46; Amitai Shenhav and Joshua D. Greene, "Integrative Moral Judgment—Dissociating the Roles of the Amygdala and Ventromedial Prefrontal Cortex," *The Journal of Neuroscience* 34, no. 13 (2014): 4741–49; Cendri A. Hutcherson, Benjamin Bushong, and Antonio Rangel, "A Neurocomputational Model of Altruistic Choice and Its Implications," *Neuron* 87, no. 2 (2015): 451–62.

[43]Justin Barrett, *Born Believers: The Science of Children's Religious Belief* (New York: Atria Books, 2012).

[44]See Joseph Henrich's "cultural brain hypothesis" in his paper, "A Cultural Species—How Culture Drove Human Evolution: A Multi-disciplinary Framework for Understanding Culture, Cognition and Behavior," *Psychological Science Agenda* (2011), http://www.apa.org/science/about/psa/2011/11/human-evolution.aspx.

[45]Cedric Boeckx and Antonio Benítez-Burraco, "The Shape of the Human Language-Ready Brain," *Frontiers in Psychology* 5, Article 282 (2014), doi:10.3389/fpsyg.2014.00282.

[46]Emiliano Bruner, Giorgio Manzi, and Juan Luis Arsuaga, "Encephalization and Allometric Trajectories in the Genus *Homo*: Evidence from the Neandertal and Modern Lineages," *Proceedings of the National Academy of Sciences of the USA* 100, no. 26 (2003): 5335–40; Philipp Gunz et al., "Brain Development after Birth Differs between Neanderthals and Modern Humans," *Current Biology* 20, no. 21 (2010): R921–22; and Jean-Jacques Hublin, Simon Neubauer, and Philipp Gunz, "Brain Ontogeny and Life History in Pleistocene Hominins," *Philosophical Transactions of the Royal Society B* 370, no. 1663 (2015), doi:10.1098/rstb.2014.0062.

[47]Tanya Smith et al., "Rapid Dental Development in a Middle Paleolithic Belgian Neanderthal," *Proceedings of the National Academy of Sciences of the USA* 104, no. 51 (2007): 20220–25; Sherwood, Subiaul, and Zawidzki, "A Natural History of the Human Mind."

[48]Christopher Kuzawa et al., "Metabolic Costs and Evolutionary Implications of Human Brain Development," *Proceedings of the National Academy of Sciences of the USA* 111, no. 36 (2014): 13010–15; John R. Skoyles, "Human Metabolic Adaptations and Prolonged Expensive Neurodevelopment: A Review," *Nature Precedings* (2008), http://precedings.nature.com/documents/1856/version/2; Emily L. Dennis et al., "Development of Brain Structural Connectivity between Ages 12 and 30: A 4-Tesla Diffusion Imaging Study in 439 Adolescents and Adults," *NeuroImage* 64 (2013): 671–84, doi:10.1016/j.neuroimage.2012.09.004.

[49]Kaustubh Supekar, Mark Musen, and Vinod Menon, "Development of Large-Scale Functional Brain Networks in Children," *PLoS Biology* 7, no. 7 (2009): e1000157, http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2705656/.

[50]Xiling Liu et al., "Extension of Cortical Synaptic Development Distinguishes Humans from Chimpanzees and Macaques," *Genome Research* 22, no. 4 (2012): 611–22; Mehmet Somel et al., "MicroRNA-Driven Developmental Remodeling in the Brain Distinguishes Humans from Other Primates," *PLoS Biology* 9, no. 12 (2011): e1001214; Chan-Ying Zheng et al., "MAGUKs, Synaptic Development, and Synaptic Plasticity," *Neuroscientist* 17, no. 5 (2011): 493–512.

[51]Tomoko Sakai et al., "Differential Prefrontal White Matter Development in Chimpanzees and Humans," *Current Biology* 21, no. 16 (2011): 1397–1402.

[52]Lori Marino, "Absolute Brain Size—Did We Throw the Baby Out with the Bathwater?," *Proceedings of the National Academy of Sciences of the USA* 103, no. 37 (2006): 13563–64; Sakai, "Differential Prefrontal White Matter Development in Chimpanzees and Humans"; Muhammad A. Spocter et al., "Neuropil Distribution in the Cerebral Cortex Differs between Humans and Chimpanzees," *Journal of Comparative Neurology* 520, no. 13 (2012): 2917–29.

[53]Sakai et al., "Differential Prefrontal White Matter Development in Chimpanzees and Humans."

[54]Ramachandran, *The Tell-Tale Brain*.

[55]David L. Wilcox, "Our Genetic Prehistory: Did the Genes Make Us Human?," *Perspectives on Science and Christian Faith* 66, no. 2 (2014): 83–94; David L. Wilcox, "Genetic Insights for Human Origins in Africa and for Later Neanderthal Contact," *Perspectives on Science and Christian Faith* 66, no. 3 (2014): 140–152; Stephen K. Reilly et al., "Evolutionary Changes in Promoter and Enhancer Activity during Human Corticogenesis," *Science* 347, no. 6226 (2015): 1155–57; Aida Gómez-Robles et al., "Relaxed Genetic Control of Cortical Organization in Human Brains Compared with Chimpanzees," *Proceedings of the National Academy of Sciences of the USA* 112, no. 48 (2015): 14799–804, doi:10.1073/pnas.1512646112.

[56]Sterelny, *The Evolved Apprentice*.

[57]Hill, Barton, and Hurtado, "The Emergence of Human Uniqueness."

[58]Tomasello, *A Natural History of Human Thinking*.

[59]Miki Ben-Dor et al., "Man the Fat Hunter: The Demise of *Homo erectus* and the Emergence of a New Hominin Lineage in the Middle Pleistocene (ca. 400 kyr) Levant," *PLoS One* 6, no. 12 (2011): e28689; Marlize Lombard, "Hunting and Hunting Technologies as Proxy for Teaching and Learning during the Stone Age of Southern Africa," *Cambridge Archaeological Journal* (forthcoming); Christopher Boehm, *Moral Origins: The Evolution of Virtue, Altruism, and Shame* (New York: Basic Books, 2012); Andrew Whiten and David Erdal, "The Human Socio-Cognitive Niche and Its Evolutionary Origins," *Philosophical Transactions of the Royal Society B* 367, no. 1599 (2012): 2119–29.

[60]Tattersall, "An Evolutionary Context for the Emergence of Language."

[61]Johan J. Bolhuis et al., "How Could Language Have Evolved?," *PLoS Biology* 12, no. 8 (2014): e1001934,

doi:10.1371/journal.pbio.1001934; Philip Lieberman, "Language Did Not Spring Forth 100,000 Years Ago," *PLoS Biology* 13, no. 2 (2015), e1002064, doi:10.1371/journal.pbio.1002064; Johan J. Bolhuis et al., "Language: UG or Not to Be, That Is the Question," *PLoS Biology* 13, no. 2 (2015): e1002063, doi:10.1371/journal.pbio.1002063.

[62]Timur Kuran and Cass R. Sunstein, "Availability Cascades and Risk Regulation," *Stanford Law Review* 51, no. 4 (1999): 683–768.

[63]Edward Hollox, "Evolutionary Genetics: Genetics of Lactase Persistence—Fresh Lessons in the History of Milk Drinking," *European Journal of Human Genetics* 13 (2005): 267–69, doi:10.1038/sj.ejhg.5201297; George H. Perry et al., "Diet and the Evolution of Human Amylase Gene Copy Number Variation," *Nature Genetics* 39, no. 10 (2007): 1256–60, doi:10.1038/ng2123.

[64]Itai Roffman et al., "Stone Tool Production and Utilization by Bonobo-Chimpanzees (*Pan paniscus*)," *Proceedings of the National Academy of Sciences of the USA* 109, no. 36 (2012): 14500–503.

[65]Grahame Clark, *World Prehistory: A New Outline*, 2nd ed. (Cambridge, UK: Cambridge University Press, 1969), 31; Robert Foley and Marta Mirazón Lahr, "Mode 3 Technologies and the Evolution of Modern Humans," *Cambridge Archeological Journal* 7, no. 1 (1997): 3–36, doi:10.1017/S0959774300001451.

[66]Dwight Read and Sander van der Leeuw, "Biology Is Only Part of the Story," *Philosophical Transactions of the Royal Society B* 363, no. 1499 (2008): 1959–68, doi:10.1098/rstb.2008.0002.

[67]Nicholas Toth and Kathy Schick, "The Oldowan: The Tool Making of Early Hominins and Chimpanzees Compared," *Annual Review of Anthropology* 38 (2009): 289–305, doi:10.1146/annurev-anthro-091908-164521.

[68]Sonia Harmand et al., "3.3-Million-Year-Old Stone Tools from Lomekwi 3, West Turkana, Kenya," *Nature* 521, no. 7552 (2015): 310–15.

[69]Toth and Schick, "The Oldowan."

[70]Read and van der Leeuw, "Biology Is Only Part of the Story."

[71]Alan L. Deino and Sally McBrearty, "$^{40}Ar/^{39}Ar$ Dating of the Kapthurin Formation, Baringo, Kenya," *Journal of Human Evolution* 42, no. 1–2 (2002): 185–210; Jayne Wilkins and Michael Chazan, "Blade Production ~500 Thousand Years Ago at Kathu Pan 1, South Africa: Support for a Multiple Origins Hypothesis for Early Middle Pleistocene Blade Technologies," *Journal of Archaeological Science* 39, no. 6 (2012): 1883–1900; Ron Shimelmitz et al., "Predetermined Flake Production at the Lower/Middle Paleolithic Boundary: Yabrudian Scraper-Blank Technology," *PLoS One* 9 no. 9 (2014): e106293, doi:10.1371/journal.pone.0106293.

[72]Ben-Dor et al., "Man the Fat Hunter."

[73]Ron Shimelmitz et al., "'Fire At Will': The Emergence of Habitual Fire Use 350,000 Years Ago," *Journal of Human Evolution* 77 (2014): 196–203; Mary C. Stiner, Avi Gopher, and Ran Barkai, "Hearth-Side Socioeconomics, Hunting and Paleoecology during the Late Lower Paleolithic at Qesem Cave, Israel," *Journal of Human Evolution* 60, no. 2 (2011): 213–33; R. Shahack-Gross et al., "Evidence for the Repeated Use of a Central Hearth at Middle Pleistocene (300 ky ago) Qesem Cave, Israel," *Journal of Archaeological Science* 44 (April 2014): 12–21.

[74]Lyn Wadley, Tamaryn Hodgskiss, and Michael Grant, "Implications for Complex Cognition from the Hafting of Tools with Compound Adhesives in the Middle Stone Age, South Africa," *Proceedings of the National Academy of Sciences of the USA* 106, no. 24 (2009): 9590–94, doi:10.1073/pnas.0900957106; Lombard, "Hunting and Hunting Technologies as Proxy for Teaching and Learning during the Stone Age of Southern Africa"; C. O'Driscoll, "Zooarchaeological Evidence for Projectile Technology in the African Middle Stone Age," *Australian Archaeology* 76 (2013): 98; Sylvain Soriano et al., "The Still Bay and Howiesons Poort at Sibudu and Blombos: Understanding Middle Stone Age Technologies," *PLoS One* 10, no. 7 (2015), doi:10.1371/journal.pone.0131127.

[75]Paul Mellars, "Neanderthal Symbolism and Ornament Manufacture: The Bursting of a Bubble?," *Proceedings of the National Academy of Sciences of the USA* 107, no. 47 (2010): 20147–48, doi:10.1073/pnas.1014588107.

[76]Compare Maxime Aubert et al., "Pleistocene Cave Art from Sulawesi, Indonesia," *Nature* 514, no. 7521 (2014): 223–27; Paul S. C. Taçon et al., "The Global Implications of the Early Surviving Rock Art of Greater Southeast Asia," *Antiquity* 88, no. 342 (2014): 105.

[77]R. N. E. Barton et al., "OSL Dating of the Aterian Levels at Dar es-Soltan I (Rabat, Morocco) and Implications for the Dispersal of Modern *Homo sapiens*," *Quaternary Science Reviews* 28, no. 19–20 (2009): 1914–31.

[78]Marian Vanhaeren et al., "Middle Paleolithic Shell Beads in Israel and Algeria," *Science* 312, no. 5781 (2006): 1785–88; Abdeljalil Bouzouggar et al., "82,000-Year-Old Shell Beads from North Africa and Implications for the Origins of Modern Human Behavior," *Proceedings of the National Academy of Sciences of the USA* 104, no. 24 (2007): 9964–69, doi:10.1073/pnas.0703877104; Francesco d'Errico et al., "Additional Evidence on the Use of Personal Ornaments in the Middle Paleolithic of North Africa," *Proceedings of the National Academy of Sciences of the USA* 106, no. 38 (2009): 16051–56, doi:10.1073/pnas.0903532106; Daniella E. Bar-Yosef Mayer, Bernard Vandermeersch, and Ofer Bar-Yosef, "Shells and Ochre in Middle Paleolithic Qafzeh Cave, Israel: Indications for Modern Behavior," *Journal of Human Evolution* 56, no. 3 (2009): 307–14, doi:10.1016/j.jhevol.2008.10.005.

[79]Pierre-Jean Texier et al., "A Howiesons Poort Tradition of Engraving Ostrich Eggshell Containers Dated to 60,000 Years Ago at Diepkloof Rock Shelter, South Africa," *Proceedings of the National Academy of Sciences of the USA* 107, no. 14 (2010): 6180–85, doi:10.1073/pnas.0913047107.

[80]Nohemi Sala et al., "Lethal Interpersonal Violence in the Middle Pleistocene," *PLoS One* 10, no. 5 (2015), doi:10.1371/journal.pone.0126589; Ann Gibbons, "Humanity's Long, Lonely Road," *Science* 349, no. 6254 (2015): 1270, doi:10.1126/science.349.6254.1270-a.

[81]Karen Ruebens et al., "On the Local Mousterian Origin of the Châtelperronian: Integrating Typo-Technological, Chronostratigraphic and Contextual Data," *Journal of Human Evolution* 86 (2015): 55–91.

[82]Curtis Marean et al., "The Origins and Significance of Coastal Resource Use in Africa and Western Eurasia," *Journal of Human Evolution* 77 (2014): 17–40, doi:10.1016/j.jhevol.2014.02.025.

[83]Curtis Marean et al., "Early Human Use of Marine Resources and Pigment in South Africa during the Middle Pleistocene," *Nature* 449 (2007): 905–908, doi:10.1038/nature06204.

[84]Sergey Gavrilets, "Collective Action and the Collaborative Brain," *Journal of the Royal Society Interface* 11 (2014), doi:10.1098/rsif.2014.1067.

[85]Marean et al., "Early Human Use of Marine Resources and Pigment in South Africa during the Middle Pleistocene"; Curtis W. Marean, "An Evolutionary Anthropological Perspective on Modern Human Origins," *Annual Review of Anthropology* 44 (2015): 533–56, doi:10.1146/annurev-anthro-102313-025954; Marean et al., "The Origins and Significance of Coastal Resource Use in Africa and Western Eurasia."

[86]A. Powell, S. Shennan, and M.G. Thomas, "Late Pleistocene Demography and the Appearance of Modern Human Behavior," *Science* 324, no. 5932 (2009): 1298–301.

[87]G.S. McCall and J.T. Thomas, "Still Bay and Howiesons Poort Foraging Strategies: Recent Research and Models of Culture Change," *African Archaeological Review* 29, no. 1 (2012): 7–50; Zenobia Jacobs and Richard G. Roberts, "Human History Written in Stone and Blood," *American Scientist* 97, no. 4 (2009): 302–309; Martin Ziegler et al., "Development of Middle Stone Age Innovation Linked to Rapid Climate Change," *Nature Communications* 4, Article number: 1905 (2013), doi:10.1038/ncomms2897.

[88]Powell, Shennan, and Thomas, "Late Pleistocene Demography and the Appearance of Modern Human Behavior"; Jacobs and Roberts, "Human History Written in Stone and Blood."

[89]Sterelny, *The Evolved Apprentice*.

[90]Bar-Yosef Mayer, Vandermeersch, and Bar-Yosef, "Shells and Ochre in Middle Paleolithic Qafzeh Cave, Israel."

[91]Lombard, "Hunting and Hunting Technologies as Proxy for Teaching and Learning during the Stone Age of Southern Africa"; Jacobs and Roberts, "Human History Written in Stone and Blood."

[92]Paul Mellars et al., "Genetic and Archaeological Perspectives on the Initial Modern Human Colonization of Southern Asia," *Proceedings of the National Academy of Sciences of the USA* 110, no. 26 (2013): 10699–704.

[93]Robert C. McCarthy et al., "Encephalization in Pleistocene *Homo* Revisited," Poster presented at the 81st Annual Meeting of the American Association of Physical Anthropologists, 2012.

[94]Ibid.

[95]Emiliano Bruner, "Morphological Differences in the Parietal Lobes within the Human Genus: A Neurofunctional Perspective," *Current Anthropology* 51, no. S1 (2010): S77–S88; Daniel E. Lieberman, B. M. McBratney, and G. Krovitz, "The Evolution and Development of Cranial Form in *Homo sapiens*," *Proceedings of the National Academy of Sciences of the United States* 99, no. 3 (2002): 1134–39; Daniel Lieberman, "Speculations about the Selective Basis for Modern Human Craniofacial Form," *Evolutionary Anthropology* 17, no. 1 (2008): 55–68; Boeckx and Benítez-Burraco, "The Shape of the Human Language-Ready Brain."

[96]Thomas Wynn and Frederick L. Coolidge, "The Implications of the Working Memory Model for the Evolution of Modern Cognition," *International Journal of Evolutionary Biology* 2011, Article ID 741357 (2011), doi:10.4061/2011/741357.

[97]Thomas Wynn and Frederick L. Coolidge, *How to Think Like a Neanderthal* (New York: Oxford University Press, 2013); Read and van der Leeuw, "Biology Is Only Part of the Story"; Robert P. Spunt, Meghan L. Meyer, and Matthew D. Lieberman, "The Default Mode of Human Brain Function Primes the Intentional Stance," *Journal of Cognitive Neuroscience* 27, no. 6 (2015): 1116–24.

[98]Christopher Stringer, *Lone Survivors: How We Came to Be the Only Humans on Earth* (New York: Time Books, 2012); Philipp Gunz et al., "Early Modern Human Diversity Suggests Subdivided Population Structure and a Complex Out-of-Africa Scenario," *Proceedings of the National Academy of Sciences of the USA* 106, no. 15 (2009): 6094–98, doi:10.1073/pnas.0808160106.

[99]Wilcox, "Our Genetic Prehistory: Did the Genes Make Us Human?"; Wilcox, "Genetic Insights for Human Origins in Africa and for Later Neanderthal Contact"; Matthias Meyer et al., "A High-Coverage Genome Sequence from an Archaic Denisovan Individual," *Science* 338, no. 6104 (2012): 222–26; Liu et al., "Extension of Cortical Synaptic Development Distinguishes Humans from Chimpanzees and Macaques."

[100]Hang Zhou et al., "A Chronological Atlas of Natural Selection in the Human Genome during the Past Half-Million Years," *bioRxiv beta*, Cold Spring Harbor Laboratory (2015), doi:10.1101/018929.

[101]Wilcox, "Our Genetic Prehistory: Did the Genes Make Us Human?"; Wilcox, "Genetic Insights for Human Origins in Africa and for Later Neanderthal Contact"; Eva K. F. Chan et al., "Revised Timeline and Distribution of the Earliest Diverged Human Maternal Lineages in Southern Africa," *PLoS One* 10, no. 3 (2015): e0121223, doi:10.1371/journal.pone.0121223.

[102]Wilcox, "Our Genetic Prehistory: Did the Genes Make Us Human?"; Wilcox, "Genetic Insights for Human Origins in Africa and for Later Neanderthal Contact"; Ewen Callaway, "Neanderthals Had Outsize Effect on Human Biology," *Nature* 523, 7562 (2015): 512–13; Benjamin Vernot and Joshua M. Akey, "Resurrecting Surviving Neandertal Lineages from Modern Human Genomes," *Science* 343, no. 6174 (2014): 1017–21; Sriram Sankararaman et al., "The Genomic Landscape of Neanderthal Ancestry in Present-Day Humans," *Nature* 507, no. 7492 (2014): 354–57.

[103]John H. Walton, *The Lost World of Adam and Eve: Genesis 2–3 and the Human Origins Debate* (Downers Grove, IL: InterVarsity Press, 2015).

[104]John Hare, "Is There an Evolutionary Foundation for Human Morality?," chap. 9 in *Evolution and Ethics: Human Morality in Biological and Religious Perspective*, ed. Philip Clayton and Jeffrey Schoss (Grand Rapids, MI: Eerdmans, 2004), 187–203.

[105]Penn, Holyoak, and Povinelli, "Darwin's Mistake"; Penn and Povinelli, "The Comparative Delusion."

[106]Hutcherson, Bushong, and Rangel, "A Neurocomputational Model of Altruistic Choice and Its Implications."

[107]Michael S.A. Graziano and Sabine Kastner, "Human Consciousness and Its Relationship to Social Neuroscience: A Novel Hypothesis," *Cognitive Neuroscience* 2, no. 2 (2011): 98–113.

[108]Hare, "Is There an Evolutionary Foundation for Human Morality?"

[109]T. A. Noble, "Original Sin and the Fall: Definitions and a Proposal," in *Darwin, Creation and the Fall: Theological Challenges*, ed. R. J. Berry and T. A. Noble (Nottingham, UK: Apollos, 2009), 99–112.

[110]Walton, *The Lost World of Adam and Eve*.

[111]Christopher J. Ferguson, "Genetic Contributions to Antisocial Personality and Behavior: A Meta-analytic Review from an Evolutionary Perspective," *The Journal of Social Psychology* 150, no. 2 (2010): 160–80.

[112]Henri Blocher, *Original Sin: Illuminating*.

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