Article


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Updating Human Origins

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In 2016 I proposed an "evolutionary" model of human creation and the Fall based on a divinely directed "explosive" growth of social cognition and "hypersocial" behavior in coastal South Africa.[1] *But science never stands still, and a variety of more recent studies raise questions for the model. This article reviews some of that new data, and evaluates their implications. These challenges include (1) increased evidence of multiple gene flows between archaic hominines and the* Homo sapiens *lineage; (2) skeletal evidence that cerebral modernization occurred over 400,000 years in Africa within species* Homo sapiens; *(3) paleoarcheological evidence of gradually increasing technical and social complexity over the same period; and (4) indications that those advances were dispersed and Pan African. In light of these evidences, is a localized transforming event still possible? I suggest here that it is.*

A contrast is often drawn between the "timeless truths" of theology and the "changing theories" of science. In one sense, such a distinction may seem to have some justification. Biblical theology is intended to be founded on a stable, static database—the scriptures—whereas scientific theorizing seeks to explain a changing, ever-growing mass of physical data. But reality is more complex than that. Science does not invent data, it discovers them. And biblical theologies obviously can and do draw quite different doctrinal formulations from the same scriptural "data." In the same way, scientific disciplines also frequently propose quite different theories to explain the same data. As humans, our world views, shaping principles, and paradigms necessarily enter in as we form models of reality (for even scientists and theologians are human).[2]

As Christians, we frequently argue that we must allow our theological understandings to inform our scientific paradigms; this makes sense if God is the source of both the Word and the world. Conversely, as scientists we frequently argue that we must allow our scientific understandings to inform our theological paradigms; this also makes sense if God is the source of both the world and the Word. When theology and science are both forming explanatory models of some of the same things, such as the nature of humanity, integrating these quests may leave honest thinkers feeling as if they are wrestling with an angel. What makes it more difficult is that the collection of data by science never stops. And since all theories are human models of reality, when God's reality clips you over the ear with new data, you have to rethink. That duty applies to both the scientist and the theologian.

Few areas of study are more fraught with important implications for both theology and science than human origins. A number of important research results have been published during the last two or three years bearing on that subject, potentially calling for alterations in integrative models. These data involve, variously, multiple genetic studies, improved site dating, new skeletal and cultural finds, and new analyses of old data. Here I intend, first, to outline some of the new genetic data and tie it into a coherent pattern. Then I will examine how nongenetic data fit into that pattern. Finally, I will

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evaluate the implications of the resulting patterns of data for an "African Eden" event.

Tracing Your Ancestors—Building Genetic Trees

The explosive development of ancient DNA sequencing technologies has provided surprising insights into the pattern of modern human origins, including our relationship with our "archaic" cousins, the Neanderthals. As an overview, the DNA extracted from Neanderthal skeletal materials and the DNA from both ancient and living modern humans indicate that the lineage of the Eurasian Neanderthals and the lineage which gave rise to modern humans are two branches rising from a common ancestral population. That population lived sometime between 400 to 700 thousand years ago. There is some debate over the location of that ancestral population, but the general consensus is Africa. Thus, the Neanderthals (and the related Denisovans) are descended from an early African emigration, whereas modern humans are descended from the populations which stayed in Africa.

To review the evidence from living human genomes, multiple analyses of thousands of human Y chromosomes, mtDNAs, and whole genomes have shown that by far the deepest variations (or, longest branches) in the DNA of both living and ancient (think, Cro-Magnon) "modern" humans are within Africa.[3] In a comparison of whole genome sequences drawn from several thousand South African individuals, Carina Schlebusch and colleagues conclude that this divergence in nuclear DNA sequences was established between African populations more than 260 Ka (260 thousand years ago).[4] In contrast, the genomes of all non-African populations branch from one particular African lineage at about 80 Ka to 60 Ka. Thus, all non-Africans form a single "minor" branch of a particular East African lineage. Supporting an African origin, the most recent common ancestor (MRCA) of living human mtDNAs is currently placed in Africa at around 170 Ka, and the MRCA of human Y chromosomes in Africa at around 250 Ka.[5]

Two archaic Eurasian hominin populations, the Neanderthals and the Denisovans, also lived recently enough to yield high quality sequences of their mtDNA, Y chromosome, and nuclear DNA. The divergence of their nuclear DNA indicates that the Neanderthals and the Denisovans were closely related, and that both were equally genetically distant from all modern humans. Based on the divergence between their nuclear DNAs and the nuclear DNA of modern humans (and the accepted mutation rate—which produces the divergences in DNA sequences), the archaic lineages shared a common ancestor with modern humans 700 Ka to 600 Ka.[6]

Limited cross-breeding between archaic and modern humans apparently took place, but at a much later date. A bit more than 2% of the nuclear DNA in all non-African human populations matches Neanderthal sequences more closely than modern sequences. And likewise, Austronesian genomes contain a few sequences which match Denisovan DNA. In addition, the sequenced Denisovan individual of the Altai Mountains had some Neanderthal DNA, and possibly admixture from a still more ancient lineage (i.e., *Homo erectus*).[7]

As the total number of genomes sequenced from all three lineages continues to climb, the precision of genealogy building increases. For instance, the "mitochondrial Eve" (MRCA) calculation of modern human mtDNAs indicates around 170 thousand years of divergence within modern humans. A similar MRCA calculation based on known Neanderthal mtDNAs shows roughly the same amount of divergence within that population.[8] But here there comes a mystery—how are these two "populations" of mtDNAs related to each other? The divergence between the known Denisovan mtDNAs and the mtDNAs of modern humans is consistent with the nuclear evidence: it indicates a common maternal ancestor at around 700 Ka. But with the Neanderthals, there is an anomaly: the divergence between all the reported Neanderthal mtDNAs and those of modern humans indicates a separation of "only" about 400,000 years.[9] How can the mtDNA distance be 300,000 years less than the nuclear DNA distance?

This anomaly has been resolved through DNA extracted from the pre-Neanderthal hominins of 430 Ka from the Sima de los Huesos (Pit of Bones) in Spain. The initial genetic study isolated their mtDNA and found that it was closer to Denisovan mtDNA than to the mtDNA either of Neanderthals or of modern humans.[10] Since the Denisovans had previously been found only in Asia, finding a related population in Spain was puzzling. However, a more recent study was able to extract their nuclear DNA, and that placed the Sima de los Huesos hominins securely within the ancestral Neanderthal lineage. Their nuclear DNA clustered with the high quality nuclear DNA of the Altai Neanderthal (Siberia).[11]

So, what happened to the mtDNA of all the other Neanderthals? It seems that the original Neanderthal mtDNAs were replaced by mitochondria which came, by interbreeding, from a population related to the hominine line which had stayed in Africa (the line which would give rise to modern humans). The timing of this mtDNA replacement was further clarified by a study which isolated mtDNA from the HST Neanderthal (Hohlenstein–Stadel Cave, Germany).[12] The HST mtDNA diverged from all other Neanderthal mtDNAs (except Sima de los Huesos) prior to 270 Ka. In addition, Neanderthal mtDNAs diverged from modern human mtDNAs at about 400 Ka. Thus, individuals from our ancestral African lineage must have interbred with a group of Neanderthals sometime between 400 Ka and 270 Ka. As a result, their "African line" mtDNAs displaced the original Neanderthal mtDNAs. Keep in mind that small isolated groups like Neanderthals are subject to periodic depletion and replacement, and thus they rapidly and randomly lose genetic variation. This allows rare alleles (or mitochondrial strains) to become established. In this case, it allowed "African" lineage mtDNAs to become established in the Neanderthal population.

Neanderthal mtDNA is not the only indication of early gene flow (emigration) out of Africa. Martin Kuhlwilm and colleagues report that the Altai (Siberian) high resolution Neanderthal nuclear genome shows inclusions from a "modern" human population which apparently left Africa around 200 Ka (based on sequence divergence), which is about the time of the common root for living African populations.[13] Thus, this is a later "African" emigration than the earlier replacement of Neanderthal mtDNAs. Kay Prüfer and colleagues report the same pattern of inclusions in the more recent Vindija (Croatian) genome, and conclude that this "modern" human admixture occurred before 145 Ka to 130 Ka.[14] In contrast, Mateja Hajdinjak and colleagues report that there is no evidence of any "recent" gene flow from modern humans in five more-recent (49 Ka–39 Ka) Neanderthal genomes sampled over a wide area. This is surprising given their temporal overlap with invading modern humans who *did* have Neanderthal inserts.[15]

Were such early "ghost" lineages of *Homo sapiens* ancestral to any living populations? A "ghost" lineage refers to a population which is inferred to have existed, but has left no physical evidence. Studies of the DNA haplotypes of living populations outside Africa are consistent with a single major "out of Africa" dispersal event between 80 Ka and 60 Ka.[16] But, Melanesian populations may have retained some evidence of such early "ghostly" emigrants. Luca Pagini and colleagues report that an anomalous 2% of the DNA in Papua New Guinea (PNG) genomes show unusually short haplotypes which match ancient African alleles.[17] They date them as diverging from ancestral African sequences at around 200 Ka. This was in addition to the Neanderthal and Denisovan inserts in Melanesian genomes. They conclude that 2% of the PNG genome reflects an early emigration from Africa which occurred a bit before 200 Ka. Supporting evidence for such an early migration of modern humans is a report of *Homo sapiens* teeth in Fuyan Cave, Daoxian, China, at 120 Ka—80 Ka.[18] If valid, that relic "modern" population was presumably swamped by the arrival of the later major wave. The majority of the Eurasian genome show longer haplotypes, and hence, they are derived from a later exit from Africa at around 65 Ka. The PNG genome anomaly is also reported by Anna-Sapfo Malaspinas and colleagues, but they postulate a more complex scenario, with an earlier majority African exit (around 127 Ka), ghost lineages with early gene flows back to Africa, multiple bottlenecks, and a separate gene flow to Austronesia.[19]

The greater than 2% Neanderthal sequences in the genomes of all living non-African populations were apparently acquired about 60 Ka during the exit from Africa. The man from Ust-Ishim in Siberia, who lived 45,000 years ago, showed Neanderthal input from about 10,000 years earlier.[20] The contributing Neanderthal population branched from the line of the Vindija and Mezmaiskaya Neanderthals prior to 100 Ka.[21] In addition to the Neanderthal inputs, both Melanesians and South Asians are reported to have Denisovan sequences coming from two different source populations that contribute perhaps as much as 5% to Melanesian genomes.[22] In contrast to Eurasian lineages, Prüfer and colleagues confirm that no Neanderthal alleles are present in African populations, although there may be limited "recent" admixtures from archaic populations within Africa.[23] Multiple groups of hominins exited Africa for the north, but there was apparently no significant gene flow back to Africa.

So, there are several indications of "modern" human gene flow to the Neanderthals, Neanderthal and Denisovan gene flow to modern humans, and gene flow from both Neanderthals and some other very ancient hominin population into the Denisovans. In each case, the admixture is only a few percent. No fully hybrid populations/genomes have been discovered. Such hybrid populations would be a reasonable expectation at the limits of the modern human expansion from Africa. There is evidence in modern humans of strong selection against most, but not all, Neanderthal alleles, particularly those active in neural tissues.[24] And, there are also evidences of the sort of small chromosomal rearrangements which interfere with stable hybrid formation.[25] These data are consistent with the hypothesis that the African lineage and the two archaic Eurasian lineages were developing post-zygotic (and probably pre-zygotic) barriers—they were on the way to becoming good species. Ajit Varki postulates that such an F1 pre-zygotic barrier would likely be due to cognitive factors, of which more later.[26]

Species formation has been reported for many other pairs of species separated by glacial maxima, such as fire-bellied toads and nightingales. During the last 600,000 years, there have been at least four full glacial cycles. The path between central Africa and Eurasia is only intermittently open due to the appearance and disappearance of extreme deserts in North Africa and the Arabian Peninsula. The door is shut for primitive hunter-gatherers both, at minimum, during warm periods such as the present, and, at maximum, during glaciation. A very comprehensive evaluation of the timing of open paths indicates that African emigrants—assuming a start in Central Africa at 125 Ka—should have arrived in South Asia and in Europe by 60 Ka, and possibly as early as 80 Ka.[27] By extension, earlier pulses of emigration from Africa should have been possible every 100,000 years or so. In between, African and Eurasian lineages would have been isolated, becoming more genetically incompatible.

The data suggest the following series of events. Skeletal evidence indicates that around 1.5 million years ago a population of early *Homo erectus* left Africa and spread across Eurasia. But, the only genetic evidence we have of their presence is some admixture in the Denisovian genome. A larger-brained population (*Homo heidelbergensis?*) emigrated 700 Ka to 600 Ka from Africa, and spread thinly across Eurasia. This was a bottleneck or founder event—the eastern and western populations were separated, becoming the Denisovans and the Neanderthals. After that, it is hard to be sure how many times "African" emigrants added "African" genes to the archaic northern lineages. Clearly, sometime between 413 Ka and 268 Ka, such an African immigrant group interbred with a small Neanderthal clan, and subsequent genetic drift replaced the Neanderthals' mtDNAs, but not much of their nuclear DNA. That clan became quite successful—after all, the African clan's DNA is all which has been detected in Neanderthals. A likely time point for that interbreeding would be around 340 Ka following a particularly long glacial period (Riss). Such an extended glaciation would have reduced Neanderthal population density, increasing the possibility of genetic drift.

But then, when were modern humans established outside Africa? Nuclear admixtures in the Altai Neanderthal and in the PNG genomes suggest a second "early modern" group left Africa before 200 Ka, and could have arrived in South Asia by 120 Ka.[28] Some physical evidence is consistent with such a very early arrival of modern humans in China.[29] On the way, that population might have fused with an existing Denisovan population, and it was possibly decimated by the climate effects of the Toba eruption in 70 Ka. If the Vindija Neanderthals have some modern human genes, possibly some of these early migrants could have also made their way westward. However, the definitive movement out of Africa does seem to have been between 90 Ka and 80 Ka, arriving in south Asia (Sumatra and Australia) before 65 Ka.[30] That population could then have enveloped remnants of earlier migrations.

Modern humans may also have gotten as far west as Spain by 80 Ka.[31] Though there is not yet skeletal evidence of that presence, the report of early cave painting is suggestive.[32] It is also interesting that the oldest modern human genomes from Europe included mtDNA haplogroup M, although later European populations (from genomes dating from after the glacial maximum) did not.[33] M is the major haplogroup found in South Asia and Australia.

Finding it in the earliest settlement of Europe suggests that it comes from the same early emigrant population. And, of course, both eastern and western emigrants picked up some Neanderthal genes on their way.

Your Brain Shapes Your Skull

Laying out a genetic tree which covers more than half a million years means that significant amounts of adaptive evolution can take place during such a vast time span. The ancestral population which split between Eurasia and Africa 600,000+ years ago was by no means either modern human or Neanderthal. Both lineages would show discernable changes. The question is, what was the significance of those changes? In both cases, the skeletal evidence is sparse and scattered. The best evidence of the developing Neanderthal lineage is the skeletal material at Sima de Los Huesos, dated at 430 Ka. Juan Arsuaga and colleagues report that their crania were intermediate in volume (1232 cc) between *Homo erectus* and the Neanderthals, and show derived Neanderthal traits in the facial skeleton and anterior cranial vault.[34] Also notably, they report that the lateral cranial walls are parallel rather than convergent (*Homo erectus*), rounded (Neanderthal), or divergent with marked parietal bosses (*Homo sapiens*). The significance of these parietal differences will become clear in the next paragraphs.

The best Middle Stone Age evidence from Africa is the skeletal material at Jebel Irhoud in Morocco, re-dated to an early 315 Ka.[35] This large-brained (1425 cc) population had facial, mandibular, and dental morphology that closely links them with modern *Homo sapiens.* But, in contrast to their modern facial skeletons, the Jebel Irhoud skulls had an elongated (archaic) braincase (cranium).[36]

The globular braincase of modern humans is due to a unique neural expansion which occurs in the perinatal period—before the first tooth eruption. Modern newborns have an elongated brain, the same shape as did Neanderthal infants, but a similar globularizing expansion did not occur in Neanderthals. Cranial globularization is due to the rapid enlargement of the parietal area and the cerebellum.[37] The parietal bulging is most likely due to a unique enlargement of deep parietal areas, notably the precuneus. Neanderthal brain growth followed a different developmental trajectory: the neural growth which produced their large brains was allometric to the archaic pattern typical of *Homo erectus*. The elongated Neanderthal cranium had significant enlargements in the visual cortex (in the occipital lobe) and in the motor/premotor cortex.[38]

Simon Neubauer and colleagues analyzed the patterns of endocranial shape in *Homo erectus,* in the Neanderthals, and in ancient *Homo sapiens* skulls from several periods, beginning with Jebel Irhoud.[39] They found that the crania of the Jebel Irhoud hominins (315 Ka) lie on the archaic trajectory between *Homo erectus* and the Neanderthals. Five later *Homo sapiens* skulls dated 200 Ka to 100 Ka, for example, Qafzeh 6, 9 and Omo 2 were intermediate between the Jebel Irhoud specimens and modern *Homo sapiens* crania. Somewhat later "ancient" skulls such as Cro-Magnon 1, 3 or Oberkassel 1, 2 lie within the modern distribution.

The distribution of "modernization" in *Homo sapiens*—in the Levant, and in North, East, and South Africa (Hofmeyr skull)—indicates that this was a Pan-African evolutionary phenomenon.[40] African populations were changing on a different trajectory than Eurasian hominines. The modern globular cranium was completely established at some point between 100 Ka and 35 Ka. Neubauer and colleagues point out that since the shape of the brain determines the shape of the cranium, the altered cranial/brain shape indicates an alteration of brain function within the *Homo sapiens* line. Of course, the functional significance of those changes is the critical question. Significantly, the areas which are enlarged in the modern human brain are crucial for what it means to be human.

The expansion of the precuneus (part of the superior parietal lobule) is significant because it is a central node for the default network, and possibly the center of consciousness. The precuneus has the highest level of energy use in the brain during consciousness. This high energy expenditure is especially true at "rest," that is, daydreaming, when the default network is most active. The precuneus also does mapping of all sorts—from visual to social, acts as "the mind's eye" on environmental stimuli, and is implicated in task initiation. It is inactive in sleep or anesthesia, and less active in an individual engaged in outwardly goal-oriented activity. It is involved in episodic memory and planning, in self-representation and self-consciousness, and in theory of mind (the attribution of emotion and intention toward others). Thus it is central to social judgment and empathy. In summary, the precuneus is a critical center for social cognition as well as other cognitive specializations.[41]

It may be surprising that the cerebellum is also uniquely enlarged in modern humans. For the first three months of life, it is the fastest-growing part of the brain, doubling in size. In contrast, the Neanderthal cerebellum was relatively small, "overgrown" by a larger cerebrum.[42] The key datum is that although the human cerebellum does indeed coordinate movement, most of it maps through bidirectional feedback to areas of the association cortex rather than to the motor cortex. Presumably, it is refining the activities of areas such as the executive control network and the default network.[43] Thus, the cerebellum enhances the power of cognitive and emotive functions such as working memory, language processing, social and affective cognition, and mapping functions.[44] In support, there is a considerable amount of clinical evidence that cerebellar pathology is associated with cognitive and psychiatric illness.[45]

A significant number of genes have been found which are unique to modern humans, genes which affect neural development.[46] The idea that the morphological differences are genetically driven is also supported by an evaluation of the effects of Neanderthal alleles in modern humans. Having a higher percentage of Neanderthal alleles is associated with Neanderthal-like alterations in the shape of the skull in the parietal and occipital regions, and by alterations in the primary visual cortex and the intraparietal sulcus.[47] Some specific Neanderthal alleles are also implicated in neurological disorders and depression.[48]

These genetic effects on the shape of the cranium are also intriguing given the reports of certain Middle Stone Age skulls in China with a mixture of characteristics—expanded parietals with an archaic face, for instance—implying possible cross-breeding of early modern human migrants and local archaic populations.[49] Or, the earlier Dali skull (260 Ka) which seems to have the same morphological pattern as the skulls at Jebel Irhoud—a relatively modern face with an archaic cranium.[50]

The question is, when did the process of change begin? Note another modern characteristic of the Jebel Irhoud hominins: based on their rate of tooth development, they had the extended developmental pattern of modern humans. In comparison, Neanderthal development was about 20% more rapid than the modern pattern, *Homo erectus* was still faster, and the Australopithecines, faster still.[51] Slowing physical and neurological development is significant—it leaves more time for reorganizing the brain, thus more time to train/socialize the young.[52]

If the *Homo sapiens* line has been moving steadily toward cranial globularity for the last 300,000 years, there must be a causative mechanism. Cranial alterations due to progressive enlargement of particular areas of the brain such as the precuneus and the cerebellum—areas central to theory of mind, self-consciousness, language, the default system, and others—must be due to particular continuing adaptive pressures which depend on those functions. These abilities are central in the evolved apprentice model or the hypersocial learning model.[53] Advanced cognition,[54] social complexity, group size, empathy, complex learning through instruction—all of these are tied to those particular cerebral modules which are larger in modern humans.

Kim Sterelny's "evolved apprentice model" links cognitive and social evolution through ecological cooperation, sociocultural learning, and environmental scaffolding. Difficult environments and increased population density require shared planning and coordinated provisioning. This puts value on increasingly complex cognitive work, which requires structured learning/teaching. As the required flow of information between generations increases, a positive feedback loop is produced, selecting for genetic variants which increase the cognitive capacity needed to handle increasingly complex technical and social skills.[55]

Kim Hill and colleagues likewise suggest a parallel "hypersocial" model of increasing social interaction and prosociality. 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 non-kin cooperation (prosociality), allowing the flow of resources and information in non-kin alliances and promoting communal emotional bonds, such as concepts of morality, justice, guilt, and religion. They also work with a dual inheritance theory—social learning is enhanced by evolution (genomic changes), but the genome is altered through social means as they favor certain genes, producing a positive selective feedback loop. The strength of the selection is proportional to the complexity of the information which must be transmitted.[56]

Logically, therefore, the force driving selection for these neural/genetic alterations would be natural selection for socially enhanced learning. Further, this pressure must have been active throughout the period of change. And indeed, the developmental delay of the Jebel Irhoud people (archaic cranium or not) indicates that they were already under selection for increased social learning. The evolving apprentice model postulates positive feedback—increased capacity provides more complex content to transmit, which selects for increased capacity to learn it, which in turn increases the possible complexity to transmit. Thus, transmitted culture becomes increasingly complex and more important, and the capacity to work collectively in larger, extended groups becomes more critical. Further, as time passes, the process speeds up—logically, it would still be operative today.[57]

If the *Homo sapiens* lineage was being driven by the need to teach by instruction, and by the need to process increasingly larger and complex social interactions (both leading to parietal enlargement), what was driving selection in the Neanderthal lineage? Of course, we cannot really be sure, but we can speculate based on which areas were enlarged in the Neanderthal brain. Neubauer's analysis of cranial change in the Neanderthals indicates enlargement of both primary and secondary visual cortexes, and motor cortexes, resulting in visual pattern recognition and the learned selection of appropriate motions for various situations.[58] Verbal instruction, the evaluation and correction of student efforts, and the coordination of groups—which are so typical of modern human socialization—would be greatly handicapped if language and theory of mind were significantly less effective. Remember how culture is transmitted in chimpanzees and other species—by observation and imitation only. Perhaps Neanderthal neural evolution was specifically driven by an increasingly "technological" complexity; but, without the instructor paying much attention to how well the "student observer" was doing, it produced the critical need to make increasingly careful observations and to store very detailed technique as muscle memory. We will never really know. We know only that the neural areas critical to modern human instruction were apparently not selectively important for the Neanderthals.

Sticks and Stones—Dawn in the Rift Valley

Unfortunately, it is not possible to go back and run fMRIs on ancient/archaic hominins. The usual substitute is the evaluation of artifacts and other archeological evidences. In Africa, the appearance of Oldowan cobbles dates back to 3.2 million years ago, shortly before the appearance of genus *Homo*. Bifaces (Acheulean culture or Mode 2 tool making) appeared about 1.7 million years ago, in conjunction with *Homo erectus* in Kenya and South Africa.[59] However, the hominins which first entered Eurasia 1.5 million years ago brought with them only the Oldowan industry. The Acheulean did not spread through Eurasia until around 700 Ka to 600 Ka, around the time that the ancestors of the Neanderthals and Denisovans arrived there. The relationship of changes in tool-making technique to changing cognitive requirements is outlined in greater detail elsewhere.[60]

Mode 3 tool making—blade and core—developed in Africa from Mode 2 sometime between 550 Ka and 320 Ka. There is evidence of blade making and scattered ocher use at Kathu Pan in South Africa at 500 Ka (early Fauresmith industry).[61] There are also recent reports of complex tool making by 320 Ka at a minimum, as well as long-distance material transport and pigment manufacture in the Olorgesailie Basin of Kenya.[62] Richard Potts and colleagues point out that the Acheulean in the region had begun to show marked selectivity and extended collection distance by 615 Ka, which they attribute to the need to adapt to rapidly oscillating climates and environments. Alan Deino and colleagues note that the culture was late Acheulean until 499 Ka, beyond which point erosion removed evidence. When the sequence resumes at 320 Ka, it lacks Acheulean elements. Similar Middle Stone Age techniques were characteristic at Jebel Irhoud at the same era (the Aterian), and they are found at scattered sites across South Africa.[63]

In the Levant, Israel Hershkovitz and colleagues' report of a 180-Ka-old *Homo sapiens* jaw at Misliya Cave (near Skhul Cave) on Mt. Carmel, or Huw Groucutt and colleagues' report of an 88-Ka-old modern human digit in the Nefud desert of Saudia Arabia, are not surprising.[64] Qesem Cave in Israel, from 420 Ka to 200 Ka, shows evidence of the organized use of space around central hearths, flint recycling, early blade production, social hunting, and meat-sharing.[65] Teeth from this site resemble those of the people of Skhul and Qafzeh Caves, with some archaic features.[66] Also from Qesem comes the report of a sort of "flint-knapping school" area where unskilled individuals were being coached by the more skilled.[67] Thus, the postulated selection mechanism of "social learning" was already well established there and available to drive cerebral evolution toward the modern form.

Middle Stone Age techniques, termed Mousterian or Levalloisian, were common in Eurasia only after 160 Ka. And, they were displaced after 40 Ka by Mode 4 technology (Aurignacian). However, there are spotty earlier appearances, for instance, Nor Geghi in Armenia, a well-dated site (335 Ka–325 Ka) which contains both bifacial tools and Levallois flakes.[68] The time and place of this find is interesting. It would be about right for the particular "African intrusion" which replaced the mtDNA of the Neanderthals—the early "Out of Africa" migration which perhaps made it to China (Dali skull). The immigrants would have had "more advanced" technology, and if the genes can flow, so can ideas. Likewise, if another early "Out of Africa" migration happened around 200 Ka, it would have contributed a few loci to Neanderthal nuclear DNA and perhaps made it as far as New Guinea—that emigration would also correlate with the rather sudden appearance of Mousterian culture in Europe. Both technologies were developed in Africa long before they appeared in Eurasia.

So, from before 300 Ka to 40 Ka, there was a gradual, but diverse, increase in technical complexity in tool making across Africa. Early Middle Stone Age techniques gave way to more-uniform Levallois core and chip and, in turn, to soft hammer and pressure flaking.[69] Diets diversified—mollusks were being harvested by 164 Ka. "Symbolic" acts such as shell collecting (110 Ka), ochre processing (164 Ka), shell beads (90 Ka–70 Ka), and engraved bone and ochre (100 Ka–60 Ka) first appeared locally but sporadically, and then appeared widely and typically. After 65 Ka, complex skills needing verbal instruction, such as microliths, bone-projectile points, atlatls, bows, heat-treated mastics, poisons, long-distance exchange, and tidal coast foraging, became progressively more common. Particularly notable are early African cultures which used processes typical of the European "late stone age," but tens of thousands of years earlier. For example, the Semliki River carved bone harpoons (90 Ka), the Still Bay heat-treated silcrete bifacial points (82 Ka–70 Ka) or the Howiesons Poort microlith composite tools (60 Ka–50 Ka) are found scattered across multiple sites. The skills used are developments from previous local techniques. Broadly, this is the expected cultural pattern if an increased need for the social learning of complex skills was driving selective changes in brain structures to support such learning.[70]

Clearly related to these changes in African paleotechnology, and presumably African neurological complexity, is the recently proposed concept of *Homo sapiens* as a "general specialist."[71] The authors suggest that humans are not a "specialist" species like the Panda, locked into a single ecological niche. Nor are we a "generalist" species with a broad and varying niche using multiple resources like a raccoon. They suggest, in fact, that all hominin species prior to late *Homo sapiens* were indeed "generalists" tied to a mixed forest/grassland habitat using multiple resources. Sometime during the period discussed in the previous paragraph, *Homo sapiens* developed the ability to become specific specialists for very different habitats and resources, allowing the penetration of difficult environments such as extreme deserts, high montane regions, rain forests, arctic regions, and tidal coast. They attribute this new capability to the ability to accumulate and pass on large amounts of specific cultural knowledge applicable to specific environments—that is, the evolving apprentice model—and thus, to outcompete archaic competitors.

Was There a Bottleneck?

The evidence of widespread (Pan-African) Middle Stone Age artifacts and modernizing skulls after 300 Ka does not seem to support a bottleneck, nor does Eleanor Scerri's descriptions of isolated communities and cultures along North African rivers and across the continent after 100 Ka.[72] She argues that the prehistoric African "*Homo sapiens* clade" was highly structured, being morphologically, culturally, and genetically diverse due to "shifting and fractured habitat zones." What then of Curtis Marean's suggestion that there was a localized intensification of the selective process for both technical and social complexity sometime before 100 Ka?[73] He proposed that during MIS 7 (the previous glacial maximum), when Africa became hyperdry, the south coastal areas acted as a refuge. Intensive coastal harvesting began around 160 Ka, in the middle of MIS 7, on the South African coast, and gradually spread westward.[74] He suggested that the drought increased population pressure in the coastal refuge areas, increased the dependence on dense (coastal) resources, increased the importance of hypersocial (nonrelative) behavior and social learning, and increased the need for mastering cognitively difficult techniques, for example, reading the moon's phases to predict the low tides. These forces produced increasing selective pressure for alleles which would increase neural flexibility, complexity, and plasticity. This could be considered the first appearance of the above-mentioned "generalist-specialist" adaption.

What is the physical evidence of climate change? Across the African continent, MIS 7 (190 Ka–130 Ka) was a significantly more prolonged and severe dry period than was the most recent glacial maximum (MIS 2). The deep lakes of Africa—Malawi (in the South), Tanganyika (in the East), and Bosumtwi (in the West)—almost disappeared in MIS 7, but they remained filled during MIS 2.[75] Likewise, the Sahara Desert reached its maximum extent. The lake studies document a major shift to more-humid, stable weather conditions following 70 Ka. It follows that during MIS 7, local populations across the continent would have disappeared or been dramatically reduced. When the rains returned, those relic populations would have been largely replaced, swamped by the descendants of the larger populations from the coastal refuges—a population expansion which Christopher Scholz and colleagues also tie to the major wave of emigration out of Africa.[76]

Effectively, the climate of MIS 7 would have created a genetic bottleneck. It could have been somewhat sparing of nuclear diversity if diverse populations were driven together into the coastal refuges, but would have significantly reduced haploid (mtDNA, Y chromosome) diversity. The mtDNA diversity of the late Neanderthals are instructive in comparison. The African-derived mtDNA of the Neanderthals showed divergence from before 316 Ka to 219 Ka, whereas modern human mtDNA diverges from 170 Ka to 124 Ka.[77] The establishment of the "new" Neanderthal mtDNA strain is best explained as a founder effect which followed a Neanderthal population bottleneck. If African populations had remained roughly stable and dispersed from 320 Ka to the present, one would expect far greater diversity in the African (modern) lineages, that is, an older MRCA, than that of the Neanderthal mtDNAs. The same logic applies to the MRCAs of modern human nuclear and Y-chromosome diversity.

Further, modern human DNA diversity is also much lower than that of either species of chimpanzee, again supporting some sort of unique human bottleneck.[78] If the modernization following 320 Ka was a Pan-African process occurring in diverse isolated local tribes, the effective human population would have been far greater than that of either species of *Pan*, and it therefore should have generated deeper (older) MRCA values. A significant population reduction during MIS 7 (after 190 Ka), with refugee populations flooding coastal refuges, could explain both why nuclear markers for an ancient bottleneck are difficult to find, and why human mtDNA and Y-chromosome distances are so unexpectedly short.[79] In addition, structured populations with varying degrees and timings for gene flow between isolated demes can produce a wide variety of trees of descent. These can suggest quite different demographic histories depending on their complex histories.[80]

Significance and Conclusions

What is significant in the new data? The amount of Neanderthal/modern human contact was considerable, occurred in multiple episodes, and although there was significant infertility, some gene flow did occur in both directions. However, it is clear that the point of population divergence between Neanderthal and modern human lineages was not the significant point of "origin" for modern humanization—that modernity developed gradually in scattered locations across Africa *within* species *Homo sapiens*. Although the earliest recognizable *Homo sapiens* at Jebel Irhoud were not completely functionally modern—presumably their modern-sized brains did not yet function exactly as ours do—yet they were already moving toward modernity. If the final touches for modern neural functioning came under pressure on the South African coastal plains, relict populations in other parts of Africa (and possibly in South Asia) would not yet have had the complete sets of neurally significant modern alleles. However, they could have acquired them as the climate eased and as they were enveloped by the expanding coastal populations—but within limits. Ajit Varki argues that the cognitive effects of the modern genetic complex would itself have limited hybridization.[81]

In a previous paper, I postulated a rapid, localized "modernizing" event during a period when the human race was much reduced, and concentrated in a particular locale.[82] And I proposed that event, perhaps, as the time and place for the full realization (and defacement) of the image of God in human beings. To summarize the logic of that proposal, the discussion of the *imago Dei* typically revolves around the issues of human reason, relationships, righteousness, and rule. These issues correspond closely to several of the central issues paleoanthropology has proposed for modern human origins—complex cognition, hypersociability, and ecological dominance. These diagnostic characteristics are based on a level of neurogenetic plasticity unique to modern humans. The evolutionary development of these qualities can be plausibly explained by positive feedback between social/cultural needs for increasing information flow and neurogenetic mutations increasing developmental plasticity. If human neural configurations are produced by increasing intense intergenerational enculturation, then the possibility exists for an abrupt inflection point—an event which established a modern "neural operating system" in some local community. This could have unstoppably transformed humanity both down through the generations, and laterally between communities.[83] Thus, such an event could be a point of contact with the science for theologians seeking an "Eden" event to explain the human dilemma.

So, does the new data falsify that proposal? Not necessarily. It is true that a Pan-African process of modernization reaching back 400,000 years does not at first glance lead to a focal area for the "completion" for human creation.[84] However, if the data about MIS 7 are correct, a Pan-African modernization process would have been interrupted, or perhaps compressed locally, by the extended MIS 7 Pan-African hyperdrought. The diverse populations reaching the coastal refuges, and then interbreeding, would have been under intensified purifying pressure for cognitive power, and thus would have been pushed toward the postulated threshold "phase transition" into modern function.[85] The altered cultural package—and the supporting genetics—of these coastal survivors could then have enveloped outlying remnant populations with both the blessing and the curse, the image of God and the breaking of the image. Rather than challenging my proposal, I think the new data may be supportive. That is not to say, however, that I am sure that I am correct. I have managed to be wrong about these sorts of things before. The collection of new data is intense—let's see where that puts us in ten years.

And certainly, there are questions which my model does not answer, questions which the new data does not clarify. For instance, what was the spiritual status of all the premodern hominine "peoples" such as the Neanderthals—or the "African lineage people" of Jebel Irhoud and Qesem Cave? Perhaps we had better leave them all in the hands of God. As Job learned, not all questions are answered—at least not yet. ✧

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