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SPECULATIONS AS TO CLIMATE CHANGE AND ECOLOGICAL STRESS ON HUMAN EVOLUTION

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Introduction

The question of how climate change may or may not have affected the evolution of the human species is a provocative question in and of itself. The evolutionary principles of Charles Darwin take into consideration the issue of the environment, but his focus is mostly on how our species evolved gradually through millions of years of natural selection. Modern science has shown us that the evolutionary process is somewhat more complex; science has not discarded Darwin, far from it, but his work is in the constant process of modification or evolution. In some respects the debate is much older than Darwin and his predecessors as scientists and philosophers have debated whether or not catastrophic occurrences or "acts of God," have played a role in the development of our species, or in life in general. There can be little doubt today, that factors from outside our climate as well as our ecosystem can greatly affect our planet. A meteor traveling anywhere from 30-70 kilometers per second hit the Yucatan Peninsula some 65 million years ago, "plunging the surface of the Earth into a total darkness for several months," and very likely "caused the extinction of the dinosaurs, and half of all other life forms on the planet." (W. Alvarez,) In fact it is almost impossible to conceive the evolution of mammals without this event. Still we must ask, as catastrophic as it was, may it merely be illustrative of a process that has been ongoing since the formation of life on our planet; as changes in climate and the ecological stress involved in this happening have worked to shape human existence, as well as the existence of all life. Since our focus however is on the evolution of man, we will look more to recent events in our history, a mere 2-4 million years ago, and the dawn of the species *Homo*. In doing this we will take a lens to the East African roots of our ancestors for the purpose and see if the Global Climate played a role in their evolution. Here again, we have a statement which is provocative in that it begs the question of whether or not our ancestors evolved because of their environment, or our species was fortunate enough to have already been genetically capable of handling the ecological stresses that it was met with. Perhaps both factors work together in this effort? I do not hope to answer these questions, only to discuss some of the relevant data on the topic and perhaps bring a little more light to some of the issues at hand. In doing this I hope to show also the relevance of trans-disciplinary work in the area of science, particularly in the area of Anthropology, which by its nature requires one to look outside a narrow sphere, and into the great primordial soup.

Discussion

Modern Humans or Homo sapiens are part of the "genus Homo (Man) is a subdivision of the hominid family, and probably split away from the australopithecines (southern apes) around 3 million years ago." (J. Aitchinson, Pg 51) However, it is not enough to discuss this process as if it occurred in a vacuum. Instead we will need to look to some of the environmental factors that would have most certainly played a role in shaping our early ancestors. In fact, it would seem almost silly today to say that our environment does not at the very least play a significant role in our modern existence as Franz Boas showed how the cephalic shape of an ethnic group can change in one generation through factors such as diet. Although this plays more into what we might call "secular evolution," it should not be considered a stretch to speculate or even hypothesize, that major environmental changes could permanently alter our biology or even our genetic makeup. For this reason can ask ourselves what, if any, were these changes, and furthermore could there be significant events in during our history that may have "pushed" our species into the relatively privileged position in which it enjoys today." Clearly we can't examine every event, however, let us look to our origins to see how anthropologists have grappled with the question, and to some of the theories that have been posed in this process.

One view suggests that we were living in Africa when a "catastrophic event" or series of events occurred, perhaps a series of earthquakes which created the Great Rift Valley in Eastern Africa. This "Great Rift," in turn separated "the wet forests of west Africa from the relatively dry grasslands of east Africa." (Pg 55) This view and a number of views similar to this has been called that savanna hypothesis, and was first postulated by Dart in 1925.(R. Bobe, & A. Behrenmeyer, Pg 400) and is was later coined as the "East Side Story" by the French paleoanthropologist Yves Coppens. (J. Hawks, 3http://www.johnhawks.net/weblog/).

This theory postulates that as the rift valley sank, and many of our early ancestors "were stranded in the relatively dry east, where in they were forced to adapt or die." (J. Aitchinson, Pg 55) In doing this they may have had to "broadened their diet" maybe by scavenging for food that included meat, and this lead to a "better nourished brain" which lead to a "greater degree of social organization, and an increase in brain size." (Pg 55) There appears to be some solid evidence of this story as where geologists and earth scientists have concluded that during the "early Pliocene differed from that of the Miocene primarily by the appearance of a cooling and drying trend across Africa, which is within the same time period where we see the emergence of early Homo. (J. Hawks, 3http://www.johnhawks.net/weblog/) Additionally it may be very "likely that these climatic changes led to a decrease in the forest cover of large parts of the African continent, and that "some of the climatic conditions of the early Pliocene were indirect effects of tectonic activity on the African continent." (J. Hawk)

For many years, this theory seemed to hold a significant amount of weight, as fossil evidence of early Homo was discovered within the dry region of the East. However more recent discoveries (what time) have cast doubt on this theory, as similar remains have been found to the west of this region. John Hawks of the University of Wisconsin points out that although early hominids were highly preserved in the East African rift context, they may not have actually originated there. He expounds further by stating that "recently, discoveries to the west of the rift, including those at Bahr el Ghazal and Toros-Menalla in Chad, have pointed to the possibility that hominids existed in Central and West Africa as well." If this is true then it "may be that the formation of the rift and the consequent changes in East African climate actually had little or nothing to do with hominid origins." (J. Hawk) If this is the case, then the *savanna hypothesis* or the "East Side Story" could be "completely incorrect," as stated by Professor Hawks of the University of Wisconsin. Although, the hypothesis still has its adherents only they are somewhat more conservative in how far they will push its postulations.

Rene Bobe and Anna Behrensmeyer of the Smithsonian Institute address the issue of climate change and its relationship to human evolution in their joint paper entitled, *The expansion of grassland ecosystems in Africa in relation to mammalian evolution and the origin of the genus Homo.* In this work, Bobe and Behrensmeyer discuss the "relationship between climatic change and human evolution, […] in terms of three major hypotheses." (R. Bobe and A. Behrensmeyer, Pg 399) These hypotheses are, "the long held savanna hypotheses" and its variations, one of which we have already touched on already, in addition to two other hypotheses which are related to our discussion. These are, the *turnover pulse hypothesis*, and the *variability selection hypothesis*. Before discussing the later two hypotheses, we will touch again on the savanna hypothesis, because Bobe and Behrensmeyer do not completely discount it in terms of theoretical merit. Additionally, it appears to be a foundational theory in which a number of other hypotheses have been built on.

In this work, Bobe and Behrensmeyer, touch on how the *savanna hypothesis* held that "*vast open country with the occasional wooded belts and a relative scarcity of water, together with fierce and bitter mammalian competition,* […] provided the ecological context for the divergence of humans from apes." (Pg 400) Bobe and Behrensmeyer are also aware that there is evidence to suggest that "early hominids may have inhabited rather closed, forested environments." (Pg 400) However, they do not completely discount the savanna hypothesis, but instead work from the premise that grasslands played an important role "in the early evolution of Homo," although they believe that this singular approach is far too simple to completely explain "the divergence of hominids from apes."(Pg 416).

They next move into an explanation of *the turnover pulse hypothesis* which has gained many followers in more recent times. This hypothesis is also related to *the savanna hypothesis* in that it holds close to the notion that the expansion of savanna grasslands is linked to human evolution. This hypothesis which was first proposed by (Elizabeth) Vrba in 1985, is even more ambitious than the *savanna hypothesis* in that it postulates "that the expansion of the savanna grasslands are tied not only to important events in human evolution, but also to major pulses of faunal turnover in many mammal taxa over wide geographical scales," (Pg 400) and global climate change to the "emergence of the hominin genera Homo and Paranthropus," […] with these changes expressed by increasing aridity in Africa." (Pg 400) To do this Vrba "studied both living and fossilized remains of both living and fossilized remains of antelopes, hoping to trace a pattern of evolutionary change over a 10 million year period." What she found was: *"rapid periods of radiation, where the species diverged into a number of new forms, the original forms eventually being replaced. The nature of the adaptations (altered teeth structures, for example) indicated they were precipitated by climatic changes resulting in differing food sources. Vrba hypothesized that, if climate is the primary factor in speciation and extinction, then other species should exhibit radical change at the same periods in history. Preliminary evidence suggests that this is the case. Such turnovers, then, pulse¸ through the food chain, affecting all living things."*

(Vrbahttp://www.galafilm.com/turnoverpulsehypothesis.html)(Shortened here)

In regards to this *hypothesis,* Bobe and Behrensmeyer concede that there is "much evidence that supports the hypothesis of broad climatic change in the late Pliocene, (e.g. Shackleton et al., 1984; Kennett, 1995), with these changes expressed by increasing aridity in Africa (e.g., Burkle, 1995; deMenocal, 1995; Dupont and Leroy, 1995)." (R. Bobe and A. Behrensmeyer, Pg 400) Additionally, there does seem to be a correlation between the "emergence of the genus *Homo* in the Pliocene of East Africa [which] does appear to be broadly correlated in time with the advent of major global and regional climatic changes." (Pg 400) However, Bobe and Behrensmeyer believe that this evolutionary phenomenon may even be far more complex and "increasing variability, rather than the trend toward more open (i.e. grassland) and arid conditions in Africa." (Pg 400) This in turn would lead us to view the "appearance of Homo" as being "associated in time with a transition toward a complex mosaic of habitats that included savanna grasslands, and also a range of woodlands and bushland habitats." (Pg 415)

To address the questions or gaps that Rene Bobe and Anna Behrensmeyer, felt were very much a part of *the savanna hypothesis* and the *turnover pulse hypothesis,* the two scholars proposed the *variability selection hypothesis.* This hypothesis is somewhat more multidimensional in its approach in that it "emphasizes the importance of fluctuation climates and environments, rather than any single trend, in shaping human adaptations and evolution." (Pg 400) Without being able to site all their data in its entirety, I will borrow from pertinent facts from the text in an effort to extrapolate what I believe are some of their key points.

Instead of looking at merely the expansion of grasslands or the adaptability of our early ancestors as to a drier and less forested environment, or to all mammalians to an overall change in climate and environment; they try to be more specific. To elucidate some of their work I would like to restate some of their main points and then compare them the other hypotheses that have been discussed.

One of their first conclusions they make in support of the *variability selection hypothesis* is quite basic in that they state that "there were profound faunal and environmental changes in the Turkana Basin during the interval from 4to 1Ma." They elaborate on this point by stating that during this interval, there were not only "significant shifts in the most common types of mammals, episodes of high faunal turnover, and an increase in the number and abundance of species that show adaptability." (Pp 415-416) This first point is essentially a statistical reinforcement of the previous two hypotheses, namely the *savanna* and its more expansive version, the *turnover pulse.* This is true because the data they provide is fundamental restatement of the *turnover pulse* which also proposes massive shifts in mammalian occurred in that time period of climatic change and a drier climate.

Bobe and Behrensmeyer clearly narrow their focus on the next statement by focusing specifically on the emergence of Paranthropus and Homo.

In regards to this effort, they state: *"Paranthropus and Homos appear to have originated in the Turkana Basin in separate immigration events associated with episodes of high turnover at 2.8-2.6 Ma, while the appearance of H. erectus is coupled with a major episode of turnover and grassland expansion after 2 Ma.and grasslands expansion after 2 Ma. Thus, there were multiple events that successively led to the appearance of Paranthropus, early Homo and H. erectus."*(Pg.416)

Additionally they go further, and state that the results of their data "show evidence of large- scale shifts in the fauna beginning at 2.5 Ma, during the time that Homo and lithic artifacts that first appear in the Turkana Basin, (Take this line out/- Lead into Variability Selection Hypotheses) lending to support the variability selection hypothesis (Potts, 1996a, 1998a), which emphasizes large-scale shifts (variability) in climate and environments occupied by earlier hominins rather than overall change toward drier and more open habitats." (Pg 416) However, even if what they are saying is true, is this so different from the *turnover pulse hypothesis?* Let's return to this hypothesis as has been articulated on the Smithsonian Museum website.

Hominin evolution over the last 5 Ma of the Pliocene-Pleistocene was punctuated by dramatic changes in species morphology, innovation, and diversity centered near 2.8 Ma, 1.7 Ma, and ca. 1 Ma [Kimbel, 1995; Vrba, 1995; Vrba et al., 1989; Wood, 1992]. Significant changes in the evolution of East African antelopes [Vrba, 1995; Vrba et al., 1989] and micromammals [Wesselman, 1985] are evidently synchronous with some of these hominin speciations, suggesting broad changes in African faunal compositions at specific times during the Pliocene-Pleistocene, although the amplitudes of these speciation events have been debated [Behrensmeyer et al., 1997]. (http:// www.nmh.si.edu/anthro./humanorigins/ha/qt/qtvr.html.)

If we examine Bobe and Behrensmeyer's conclusions, to the basic articulation of the *turnover pulse hypothesis* it is hard to see the difference. Although to give the benefit of the doubt, they may be more specific. Rene Bobe and Anna Behrensmeyer do state that there was the "appearance" of Paranthropus and Homo, after a "major faunal turnover" where as Homo Erectus "appeared" after "a major episode of faunal and a grassland expansion." (R. Bobe, and A. Behrenmeyer, Pg 400) This makes their argument a little more varied. However I do not believe that it makes much of a theoretical difference, particularly since both the *savanna hypothesis* and the *turnover pulse hypothesis* emphasize the importance of grassland expansion brought about by an increased aridity in climate. I believe what we find in this instance, is not so much a new idea but an expansion of a previous one. However this becomes somewhat of a semantic issue as new theories are built on the "remains of previous postulates." Still, I am not in a position to be critical of their data per say, I can only comment on what appears to be pertinent.

Nevertheless, what is central to all these hypotheses and the respective data is that climate and environmental factors had to play a role in our evolutionary development. We have so few other alternatives to explain our material existence. Granted, much of the evidence that connects climate change to evolution is somewhat circumstantial; meaning, a change in the temperature coincides with an increase in faunal remains. Although, we can not step out of our material existence and beyond time and space to see our cosmos in a vacuum, and in fact, no science can. This does not mean that we are left without reasonable explanations for natural phenomenon. There is a fair degree of understanding in answering how various species adapt to their environment, from the beak size of a particular type of the Galapagos finch, to varying degrees of skin pigmentation among Homo sapiens. Of course even if we are to grant these hypotheses considerable weight, we are still left with the circular argument that often plagues the sciences; in our case we might always ask the question, did the change in climate lead to an increase in brain size, or had the brain evolved to a point where it could handle the sparser, somewhat less hospitable settings?

Should we look somewhere else for our answer? Should we take note that the faunal remains strongly suggest an affirmation of the theory of *Punctuated Equilibrium*? Punctuated Equilibrium, a theory made famous by the late Jay Gould, tries to reconcile two ideas that seem both mutually exclusive as well as scientifically sound. The first idea is that of gradual evolutionary change as is mandated by strict Darwinism. To this effect there is a considerable amount of evidence, particularly in terms of micro-evolutionary data, that this is the case. Conversely, there is also a substantial amount of data which indicates that our evolutionary existence owes much too outside influences such as comets and climate which leads to evolutionary jumps of sorts. *Punctuated Equilibrium* attempts to reconcile these potentially conflicting ideas, by stating that evolution, as "not fluent but proceeding in steps," with "periods of rapid changes with the origin of a new species alternating with those of long evolutionary stasis." (Z. Smahel, Pg 5) Is Gould's answer to this question adequate for our purposes? Are there other scientific explanations which can better explain our somewhat paradoxical origins?

Maybe we should reexamine the question? Perhaps the issue is not so paradoxical at all? In regards to whether or not evolution was static or punctuated, Zbynek Smahel instead asks whether or not the question is even relevant. He states:

"Evolution was primarily dependant upon ecological changes, some taking place slowly, others Rapidly, followed by a change in the species, and even the periods of statis were not completely free from any evolution. Micro-evolutionary changes were under way, depending upon environmental influences. Evolution has been a combination of quicker and slower, major or minor changes in time." (Z. Smahel, Pg.6)

In fact, this critique is quite sound, however one must still contend with the multitude of the theoretical frameworks on the involving clime and time and its influence on our formation. With these questions in mind should "one must choose," to borrow a phrase used by the late Clifford Geertz. In the case of Dr. Smahel somewhat of a preference has been expressed on the issue, as elaborated on in his work. However his "synergetic" approach begs the question, is the evolutionary theory practiced today even Darwinian, or have we changed or evolved to such an extent that we are no longer different in degree but in kind? Charles Darwin was not privy to the post Francis Crick and James Watson world of the Double Helix and the extraordinary complexity of the cell. The cell in the time of Darwin was not understood as the virtually incomprehensibly complex organism that we know it to be today. Furthermore, although environment played a role in |Darwinian theory in terms of the amount of stress placed on the species to adapt, there was still the assumption that fossils would be found later, anticipating that they would be gradual in illustrating how life metamorphoses from one genus to the next.

There were no crashing meteors in Darwin's gradualism. Smahel's premises leading to the synergetic conclusion articulated above speaks volumes in this respect, and is worth examining. Smahel gives us perhaps the two central ones

The two arguments are as follows. Firstly: *"According to one hypothesis, the evolutionary step (speciation) is induced by ecological stress which prompts mutations and the selectively suitable changes are then gradually spread throughout the gene pool of a population."* (Smahel Pg. 5)

This point of view fits in well in summarizing the *savanna hypothesis*, the *turnover pulse hypothesis*, as well as the *variability selection hypothesis* in that it places ecological stress at the forefront of evolution.

The second argument is founded on an opposing idea which again I will quote directly.

"A contrary idea which is based on the observation that mutations occur spontaneously at a certain speed, and that many of them are selectively neutral (being neither advantageous nor disadvantageous for their carriers)". (Smahel Pg.5)

Without restating the entire argument, he furthermore states that within this theoretical framework, genetic drift, (accidental breeding) as well as the founder effect, in addition to inbreeding in a "population of a particular of a particular species will contain multiplied neutral mutations, some of which can bring selective advantage to their carriers under changed ecological circumstances." (Pg.5) As we can see, "contrary" viewpoint is essentially borrowing from Hegel in that it could be said to "flip" the opposing argument "on its head." Instead of ecological stress prompting mutations, mutations make adaptability possible in a changed environment.

Conclusion

There is an ancient myth that the world was balanced on the back of a giant tortoise. Steven Hawkins makes light of this remark in his famous book, *A Brief History of Time,* when the question was posed to someone who believed this myth, they replied something to the effect of "turtles all the way down." Sometimes I feel that scientific endeavors are of this nature; just when we have figured out the nature of one turtle that we believe carries on its shoulders the "weight of the world," there is a more dynamic turtle underneath that turtle waiting to be discovered. In the world of Biological Anthropology the great *savanna myth* ruled the plains of scientific thought regarding how a change in climate, perhaps brought on by a series of volcanic activities, or increased aridity, which lead to the expansion of the East African grasslands and the adaptation of our kind to that changed environment. Our story on the other hand, is may very well be like a Mosaic "of habitats that included savanna grasslands, and also a range of woodlands and bushland habitats." (R. Bobe & A. Behrensmeyer, Pg 415) Moreover, more recent data strives to expand this Mosaic, as researched continue to try to digest more information on the topic.

Anna Behrensmeyer writes: *The biggest challenge involves how to relate different types and scales of paleoclimatic evidence between the marine and terrestrial realms. Marine-core records show that a cooler, drier, and more variable global climate regime began about 3.0 million years ago (Ma), gradually intensifying into northern continental glacial cycles by 1.0 Ma (10–12). The climate shift between ~3.0 and 2.5 Ma thus marks the onset of Northern Hemisphere glaciation (10–13), and this coincides generally with the timing of the origin of the genus Homo [reviewed in (8, 14)] (see the figure). Fluctuations in continent-derived dust and biomarkers in the marine record indicate that climate shifts recorded in the oceans affected the land as well (12, 15).* (A. Behrensmeyer, Pg 476)

Clearly there are more turtles beneath this one, no one knows how many. Moreover, even if we are to view the final turtle in this endeavor, there still awaits the rabbit of genetics; which is not be sleeping in this race, and instead randomly mutates without too much regard for clime and time A more expansive and detailed view of this phenomenon is expressed in the *turnover pulse hypothesis,* and maybe in the *variable selection hypothesis* which delves into the faunal remains of mammalian in general to extend and elaborate the point, however these explanations give us only a more detailed theoretical framework from what was there before. The synergetic approach advocated by Professor Smahel, which explains evolution in terms of "ecological stress" prompting "mutations" while at the same time favoring others may be sound, as is the argument that evolution is both a "combination of quicker and slower, major or minor changes in time. (Z. Smahel, Pg.5) Still, sometimes these issues which work together must be stripped from one another and pushed on an individual basis to see how far they reach. In the case of our discussion, changes in climate and the ecological stress placed on our predecessors may have been the "evolutionary step" (P.Blaha, C.Susanne, & E. Rebato, Pg 19) that had taken us form Australopithecus Afarensis and beyond, but how far that step extends is yet to be determined.

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