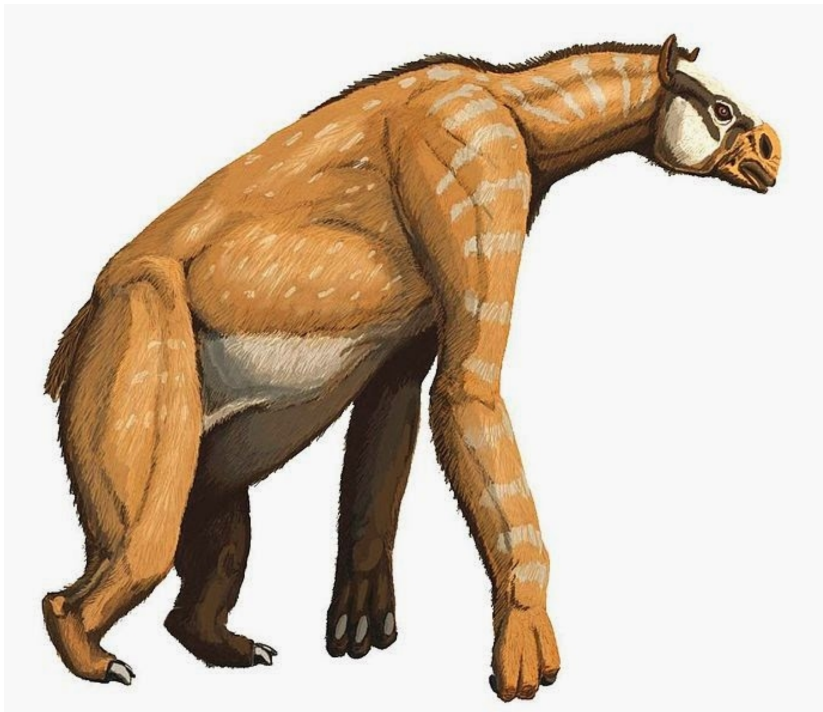
(First posted on TheQuodlibetarian.)

What follows is a thought experiment. I have imagined it in rather specific detail, not because the specifics are important, but because I think they help focus the question. The most general objection that could be made to the specifics is that they are not imaginative *enough,* but that is intentional; I'll explain below.

Anisodon Sapiens



(The above picture courtesy of Wikipedia and Dmitri Chel__. This is A. grande.*)*

Let us imagine that 36 million years ago a species emerges in the chalicothere family: *Anisodon sapiens.* Like the other chalicotheres, they are large knuckle-walking herbivores. They browse mainly on tree leaves and insects in the lush Eocene forests of central North America, reaching up to pull the branches down and strip them, using very dextrous claws. *A. sapiens* are somewhat smaller than many of the other chalicotheres, and they tend to focus on forest edges where the trees are shorter and there is more undergrowth. They live in small herds for protection, and use vocalizations to warn each other of threats. The males have a mating-ritual combat behavior, similar to wrestling, which they use to establish dominance: it is often but not always fatal for the losers. For hundreds of thousands of years, their total population is fairly stable at about 50,000.

Between 36 and 34 mya, several new features develop in *A. sapiens.* Physiologically, they develop larger brains and more complex neural architecture. This becomes slowly visible in behavioral changes that are passed on semiotically rather than genetically. *A. sapiens* frequently break branches while browsing, and some of them learn to use these broken branches as crooks to bend down higher branches that would otherwise be out of reach. The use of crooks spreads through the population, as does a rudimentary skill set for making ideally shaped crooks. Crooks are also used in the dominance wrestling matches, and (when used victoriously) are given names, as if they were individuals. Other namings occur to communicate abstract concepts; these rapidly expand to create languages with recursive grammar. A variety of basic technologies using wood, stone, and plant fibers appear; some of these technologies allow exogenous communication such as territorial boundary markers.

By 34.3 mya, several core groups of *A. sapiens* are simultaneously experimenting with leagues of multiple family groups, and with a variety of techniques for "farming" the undergrowth advantageously, including the management of forest fires and eventually the control of fire. Certain caterpillar and beetle species that *A. sapiens* used to eat incidentally are now being cultivated in downed trees. The populations in these core groups begin to expand, and they soon have alliances containing thousands of individuals with elaborate social hierarchies. Males who might in the past have died from wrestling injuries are now castrated and kept as workers, often at high status levels. These central leagues are so powerful that the outlying groups of *A. sapiens* begin to migrate outwards to avoid conflict with them. With the development of rafts, the migration eventually spreads across almost the entire globe.

About 34.121 mya, a cascade of technological innovations occurrs almost simultaneously in four populations of *A. sapiens*—along the two major rivers draining North America (A and B), along the north-eastern coast of North America (C), and along the Eastern coast of Asia (D). Despite minor variations in focus and speed, each of these cascades involves very complex political structures, written language, agricultural techniques relying on the domestication of multiple species, and and the exploitation of first copper and gold, and then iron, tin, and related alloys. The civilizations quickly rise to population figures in the millions, and are so behaviorally distinct from the outlying populations that they barely recognize them as members of the same species.

These *A. sapiens* civilizations are all gifted at mathematics and theoretical physics, often to a degree that outstrips their engineering ability by several generations. They expend enormous resources building astronomical observatories, metallurgical laboratories, and academic centers. By 34.115 mya, they develop electrical energy, first using carbon-fuel generation, almost immediately supplanted by nuclear fission. They develop power grids based largely on broadcast energy relays rather than long-distance cables, and experiment unsuccesfully with orbital sattelites as relay nodes, even landing on the moon for this purpose. These technologies generate enormous amounts of ozone, which create a complex sequence of climactic effects.

During this period, the A civilization has politically annexed B, while D has fallen behind in technology to the point that it is simply a series of vassal cultures to A and C. Most of the coastal regions remain fairly technologically primitive, although they become enmeshed in the politics of A, C, and D. The global powers are stressed by rapid climate change. Droughts, famines, and extreme weather events occur more frequently, against a more gradual backdrop of planetary cooling.

At this point, a viral infection related to orf begins to attack *A. sapiens*. It infects the skin folds between the hooves and claws, working in tandem with commonly occuring *Fusobacterium* species to devastate the flesh, rapidly causing necrosis. Mortality rates reach high as as 40% in some areas. The pseudo-orf virus can persist in the soil and on organic surfaces for months, causing chains of re-infection among aid workers and scavengers.

For some years, the pandemic is confined to the outlying, less affluent regions, and it is not in the immediate political interest of A or C to address the problem, while D lacks the resources. Even in these marginal areas, pseudo-orf has differential social effects. It is much more devastating in localities where there is high social cohesion and mutual aid. In more marginal and chaotic communities, infected individuals are simply abandoned, the overall survival rates are higher. This situation creates a series of subcultural patterns that strongly reject population centers, and indeed any sort of communalism. A large body of ideological content emerges arguing that communal enterprises are unwise or wicked: the more radical versions of this discourse ostensibly reject concepts like family and language, though in practice their adherents are not nearly as deviant as their ideology would suggest.

As pseudo-orf and its cultural shock wave begins to affect the treaty leagues of D, a number of large-scale wars break out. When the C homeland begins to be exposed, they adopt a policy of creating a defensive perimeter using cobalt bombs, while using thermobaric weapons on alleged infection sites. Opposition movements within C accuse the government of targeting dissidents with these policies; they ally with A, and the tension culminates in a nuclear exchange between A and C. 46 of the 100 largest *A. sapiens* cities are annihilated, and the central govenments of both major leagues are effectively destroyed. A religious group that is committed to “purifying the world” creates an artifically enhanced strain of the pseudo-orf virus and releases it, with further devastating consequences.

Efforts to rebuild are hampered by ongoing environmental issues related to climate change. Industrial maintenance in D becomes difficult, and populations gradually decline. Constant recurrence of both the wildtype and artificial virus reinforce the subcultures that reject communal habitation, and large numbers of survivors return to the semi-nomadic existence of their remote ancestors.

Over the next thirty thousand years, the remaining cities are depopulated to such an extent that their maintenance becomes completely impossible. Runaway climate change obviates most of the major forms of agriculture, and there is not enough social infrastructure left to adapt new methodologies. Eye and bladder parasites that were previously held in abeyance by medical technology become pandemic. Iron-smelting technology is retained in theory among secret societies, but lost in practice. During this period, there are several dozen “renaissance” societies that establish cities and advanced industry over relatively small regions, but none of them last more than 1200 years, or exceed the technological zenith of the A and C civilizations.

By 34.084 mya, the population of *A. Sapiens* has dropped to 25,000, and there are no more political units larger than the triple-family-group. By 33.984 mya, the last of the *A. Sapiens* are dead.

The Question

This story, as I've said, is unimaginative. I have cast the chalicotheres as human beings, more or less, but that is only one of many behavioral patterns that we might be forced to recognize as intelligent. We can certainly imagine versions of intelligence that do not involve covering the planet in chromium steel and nylon. For instance, it has been rather popular in the last fifty years to think of the cetaceans as our equals in intelligence, despite their lack of technology.

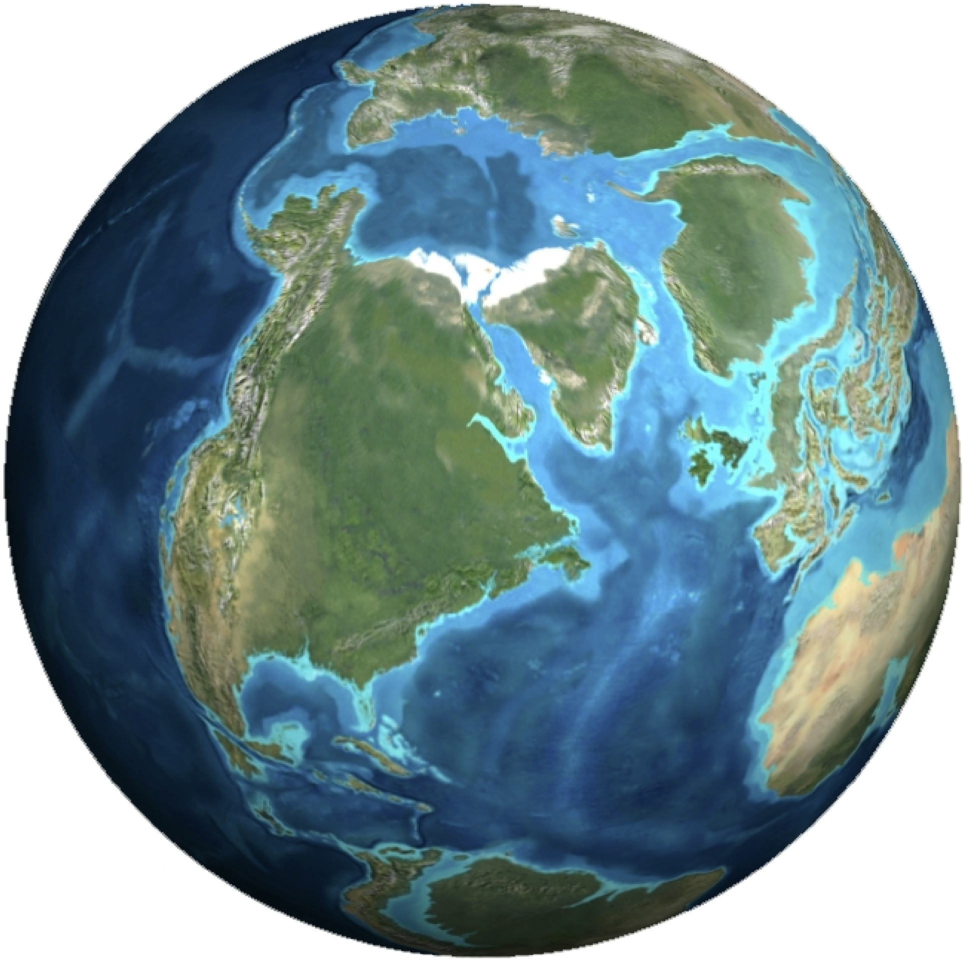
Following Clarke, I'm not especially sanguine about this claim. “Intelligence” is a purposefully vague word, but surely it has something to do with the ability to rapidly, radically, and repeatedly change one's behavior, and there is good reason to think that cetaceans can't do that, despite their very complex cognitive abilities. Clarke has pointed to beachings as an obvious failure in this regard; I would add that there are only two cases of whales directly attacking whaling vessels, and no examples of it happening in either an organized or first-strike fashion. I've heard arguments for why this intransigence is *further* evidence of cetecean's advanced intelligence (or pacifism?), but these seem to me ever-more precious. No matter: let us grant there may be beehives or turtles with human-level intelligence, who express it only via poetry and philosophy. Yes, fine, I love it. But I am not concerned with them here. I am interested in what Mumford called “technics”; the use of intelligence to radically alter the surrounding environment in one's own favor. That is what we humans do, and that is what, in the preceding thought experiment, the chalicotheres did, long ago.

The question then is: *would we know?* Would there be any evidence left today?

I think there as an instictive tendency to answer our question in the affirmative. And part of this, surely, is egoism. I have depicted *A. sapiens* as being more or less like human beings. Humans, we feel quite sure, will survive until the end of the universe, or at least leave an indelible mark of our presence. In a roundabout way, it follow that no other species on earth could ever have attained our level of intelligence, because *if they had,* they would either still be running the place, or we would still be gazing awestruck at their monumental ruins.

Such considerations, however, tread over our ignorance of the time scales involved. We simply have no context for imagining what 33 million years of rot and rust looks like. My idea of an utterly ancient structure is the great pyramid of Cheops, which is a mere 4,600 years old or so. Significantly, it has already lost about 5% of its original height, and it is perhaps equally significant that we don't notice that, because in some sense we see it as eternal. But here we are discussing artifacts *seven thousand times older* than the pyramids: there is no way to intuitively understand what that means; we need to think about in point-by-point detail.

The Aftermath



(*The map above, by the inimitable paleocartographer, [Ron Blakely](), shows the Eocene slightly before the days of* A. sapiens.*)*

Ocean levels

The *A. sapiens* civilizations existed at a time of relatively high ocean levels, so the majority of their sites are not submerged in today's oceans. The exception to this is C, which was largely on a landmass that is currently submerged due to glacial isostatic adjustment. Nevertheless, sea level fluctuations in the million or so years after the decline of *A. sapiens* would have inundated all of their coastal cities for long periods of time. The most destructive effects would not have been the complete inundations, but the periods during which coastal cities were between the tidelines. Daily wave and tidal action, salt water, prolific attacks by marine organisms and storm surges—it would all be quite enough to quickly reduce even the most splendid industrial centers to a smooth beach.

Earthquakes

In the interval we are discussing, there must have been about 300,000 earthquakes larger than 10 Exajoules, which is to say, as large as any earthquake in human history, or larger. Any excavated structures (mine-shafts, quarries, foundations) would have collapsed and filled in.

Any elevated structures (buildings) would also have collapsed. This latter point may, however, actually be protective for artifacts in the cores of the resulting piles.

Mountain Decay

All the world's major mountain systems are in a constant process of decay. The Rockies, for instance, have lost some 2000 meters worth of material since the days of *A. sapiens*. Any sites that were on top of those slopes would have have been broken up and transported away by landslides and erosion. The same process also damages and buries sites across a very much larger area, though again, artifacts buried under debris flows may be preserved from weathering effects to some extent by that fact.

Vulcanism

Several regions that might have otherwise been relatively stable were affected by vulcanism in this time frame. The Basin-and-Range Disturbance in the American Southwest, which lasted millions of years, included constant volcanic eruptions and ash flows. The La Garita eruption in Colorado, 26.3 mya, is one of the largest known eruptions in earth's history, blowing 1,200 cubic miles of stone and lava across most of the middle of the continent. Volcanic ejecta can burn and/or bury artifacts, but the larger issue is that blankets of volcanic ash (which cover much larger areas) often interact with water to chemically attack artifacts.

Surface Damage

Any *A. sapiens* sites that remained on the planet's surface (or spent any considerable amount of time in the upper few meters of regolith) would have suffered a level of corrosion which is impossible to imagine based on human historical experience. Consider that all the most extreme planetary events in human history would have happened some 7000 times in this time frame, plus many events far more extreme than anything we've ever seen. Volcanoes, wildfires, meteor impacts, tsunamis, mudslides, avalanches, storms of locusts, whatever. The higher temperatures in the Eocene would probably have contributed to hurricane and tornado activity on a much larger scale than humans are familiar with today; *A. sapiens* structures would be designed to cope with this, but after long-term abandonment, those design features would certainly fail.

All the organic materials would be rapidly burned, dissolved, metabolized, and/or photolyzed. Plant roots, lichen, fungi, and other organisms would mechanically and chemically attack everything. Ash from volcanoes and wildfires would chemically corrode everything on the surface, while windblown particles would scour it to a degree that is comparable to being placed in an industrial sandblaster. Moreover, *all* parts of the planet are subject to freeze-thaw cycles during portions of this time frame, cracking most solids and making them more available to other types of attack. The upshot of this is that the only materials that have any real chance of surviving on the surface are certain metals, glass, and vitreous ceramics. But the prognosis is not good even for them.

To put this in perspective, stainless steel is one of the most durable materials that humans create in large quantities. When exposed to water, it experiences pitting in the range of about 0.02 to 0.2 mils per year. While this is negligible across industrial time scales, it corresponds to a removal of at least 20 inches of solid steel every million years. With that in mind, it should be clear that mere structural steel of the sort used to build skyscrapers and bridges is totally ephemeral on the surface.

Glass and high-fire ceramics may also survive for millions of years, but they are both friable. They would slowly break apart to size scales where they become available to wind saltation, and they they can rapidly be “sandblasted” into much smaller size scales, indistinguishable from any other silicate dust.

Perhaps the most significant effect of this is that, although the *A. sapiens* colonized the entire planet, across most of that range they had relatively low technology and low population density. In these areas—which are probably some 90% of the landmass—there is virtually no possibility of any artifact surviving whatsoever.

Glaciation

In relatively recent geologic history, every inch of land in Northern Europe and Northern North America has been repeatedly glaciated, grinding and crushing any remains into gravel. The dynamics of glacial retreat generally mean that this gravel is plowed down into the regolith, further reducing the odds that any fragmentary artifacts would remain on the surface.

Surface Scavenging

The most likely artifacts of the *A. sapiens* to survive to the human era on the surface are fragments of relatively inert material. The major contenders are gold, glass, or stainless steel. Any such artifacts found on or near the surface would probably be encountered by early humans, who are apt to re-work them into new artifacts. This poses a challenge to later human archaeologists: if a gold ornament is discovered in a tomb from 2000 BC, there is no way to tell if it is made of native gold or from a 33-million-year-old gold artifact. Similarly, we attribute many ancient steel artifacts to meteoric iron, but it would be hard to distinguish this from the relicts of *A. sapiens* steel.

Finally, it is plausible that *A. sapiens* artifacts might be recorded by science, but viewed either as a hoax, or as an “anomoly” along the lines of Forteana or Dankineana. The typical fate of the latter category is that established science reaches for the first plausible explanation that will make the crackpots shut up.

Subsurface Extraction
There are better odds for *A. sapiens* artifacts to survive underground, in loess, pumice, debris flows, or similar deposits that act as a preservative. If such deposits are near the (modern) surface, it is statistically likely that they have been exposed at some point in the past, and subjected to surface weathering. If they are deeper, however, we are only likely to encounter such deposits by mining or quarrying. Both these techniques are highly destructive: new material is often dynamited, transported, and mechanically pulverized before any human being actually lays eyes on it.

In the (quite primitive) mine that I once worked in, I'd estimate that we would have had about one chance in a thousand to notice an obvious artifact the size of the Venus de Milo during a given detonation-and-clearance cycle. In a modern coal mine with remote-control continuous mining machines, the odds are precisely zero: we could dig through the Parthenon and it would just show up as low-grade coal.

Nuclear Waste

If *A. sapiens* discarded nuclear waste in the oceans, it would have long since dissolved. If they stored it on the surface, it would have surely been broken up by geological forces and entered the water table. This is especially significant for Iodine-129, which has longest half-life of any common fission product, making it the most identifiable—but is extremely mobile in water.

If, however, *A. sapiens* took the care to place their nuclear waste in deep, geologically stable bedrock, then some of it will have survived to the present in a recognizable format. True, it will not be very radioactive, or even all that metallic, and there are naturally ocurring nuclear reactors (such as the Oklo site) that might look somewhat similar. But if the site was chosen for stability, and survived for 33 million years, it might well preserve contextual clues that would help us identify the slag as ancient nuclear waste. On the other hand, a deep-borehole site in stable bedrock (with the access shaft inevitably collapsed) would be almost impossible to locate by chance. And since only a handful of these sites, at best, would exist on the whole of the planet, the odds of finding one would be fairly close to nil—unless humans tried to store nuclear waste at the same site, for the same reason.

Planet-Wide Systems

If someone were doing fly-bys of the earth every quarter million years or so, looking for signs of intelligent life, they would need a way to evaluate whether or not a technologically sophisticated species had appeared and then vanished in between their visits. The cheapest approach to this would probably not be archaeology, but rather ecology and climatology. After all, at the apex of the *A. sapiens* civilization, they and their domestic and commensal species must have represented a vastly disproportionate ammount of the land animal biomass for their respective sizes, a fact which would have left a signature for a long time thereafter: perhaps a million years? Again, the *A. sapiens* technologies contributed to a planet-wide climactic shift. Both of these things are also true of modern humans.

It might well be possible to use these signatures in real-time to detect intelligent life: climactic patterns, for instance, are probably our best bet for remotely detecting intelligence on planets in other star systems. (*Pace* a few thousand sci-fi stories, it will certainly be impossible to do so by scanning radio signals.) These planet-wide signatures, however, must surely regress rapidly into the chaotic noise of the systems involved. There have been three major extinction events since the *A. sapiens,* and enormous fluctuations in the climate. It would be quite impossible for us, today, to work back through all of those dynamics and find a smoking gun.

The fossil record is not much more helpful. There are 148 extant specimens of *chalicotheriidae,* most of them very incomplete, spanning about 55 million years and twelve genera. This comparison is inexact, because in the story above, we would expect *A. sapiens* to exist in large numbers for their size, as humans do today. But it is still indicative of the scales involved that across the entire family, we have only one set of bones every 370 thousand years.

Orbital Decay

All of the *A. sapiens'* low-orbiting satellites would be knocked out by atmospheric drag within a few decades of ground control failure, if that. Their satellites in very high orbits would still be subject to mascon disturbances, and their orbits would decay much more slowly, but likely none of them would survive more than 10,000 years. On re-entry, the satellites would either burn up completely in the atmosphere, or be reduced to lightweight fragments that would readily disintegrate on the surface.

Lunar artifacts

If the *A. sapiens* landed any exploratory probes on the moon, those relics would be in a much better state of preservation than anything we could hope to find on earth. But our odds of finding them would be very low. Because of the energy costs required to get them there, such artifacts would presumably be fairly small, and humans have not yet surveyed the lunar surface in great detail. Moreover, moon dust accumulates at a rate of about one micrometer a year. That's not much, but it still means we should expect to find *A. sapiens* artifacts buried under about 100 feet of dust. Even if they aren't, the dust is electrostatically "sticky", and apt to coat any artifacts, making them very hard to detect photographically. So even if *A. sapiens* had colonized the moon by building underground or low-surface structures, we could not expect to have found those sites yet.

Reflections

When I've posed this thought experiment to people in general terms, the nearly universal reaction is "well, we would find *something."* And even after going through all the mechanics, even after convincing myself that *A. sapiens* could have written "KILROY WAS HERE" in bright red on the moon in Comic Sans 12 trillion, and we'd have no way to see it today....I still have this intuitive sense that we'd find *something*.

Whether or not its correct, I think we can chalk up this response to several distinct factors. I've mentioned our difficulty in intuitively understanding time spans on this scale. But there is also the matter of ego. *A. sapiens,* after all, are modelled on humanity. We humans like to believe that we will last forever, or at least be remembered forever. Even in our post-apocalyptic fantasies, we have the statue of liberty sticking out of the beach, or some other immortal marker that we passed this way. It is a deep affront to our ego to think that a species of our technical ability could come and go and leave no lasting trace.

There is a quick way to gauge how very emotional and arbitrary this reaction is. Perhaps we feel certain that an industrial megalopolis on the order of the American or Chinese East Coast in 2014 could not simply *vanish* in 33 million years. Fine. Then what is the time frame in which it could? 66 million, which takes us to the last days of the dinosaurs? Half a billion? If all these numbers sound about the same to us, and we're sure that *something* would have survived in each case, we are not really engaging the reality of the question.

I hope that I've poured some doubt on those self-assurances. Even if we cannot accept the idea that a civilization equivalent to the US in 2014 could be obliterated, I think the mechanisms above make it quite clear than a Classical Athens or a Medieval China would have leave no trace after a few million decades.

This point has bearing on a larger question: how many times has human-like intelligence arisen on earth, and why? I say "human-like" because we can imagine a species whose intelligence was demonstrably greater than ours, but chose not to manipulate their environment in lasting ways. Perhaps the blue whales have solved all the great math problems and spend their days composing inscrutably brilliant poems. I doubt it, actually: it seems to me that whatever we mean by "intelligence" ultimately implies the ability to radically and rapidly change behaviors in the face of crisis. Whales don't seem to have that, as beachings (and the absence of a coordinated response to whaling) suggests. But no matter. I'm quite happy to imagine that there have been plenty of intelligent species in the math-and-poems-but-no-tools variety. I am not, for the purposes of this essay, interested in them, which is why I envision *A. sapiens* as a stand-in for human beings.

The usual narrative of evolutionary history would suggest that the primate genus *homo* arrived at the math-poems-fire-and-spaceships version of intelligence quite uniquely. But why would this be? The apparent prerequisites (tool use, communication, social behavior) appear in dozens of species across multiple families, including some unlikely contenders like octopi and squid. A number of genera of birds and mammals demonstrate all three of these patterns, and apparently have done so for millions of years. More controversially, it is plausible that a number of dinosaur species were social and/or communicative.

Given this range of precursors, why did no previous genus develop guns-and-pokemon intelligence? Someone had to be first, of course, but this narrative suggests that many species sat just outside the threshhold of a radically adaptative pattern, and never stepped through. Yet in that same time span, many different species independently developed venoms and toxins, fins and wings. Are we to believe that having poison glands in your skin is a vastly better strategy than tool use?

There are several ways to answer to that question, and the *A. sapiens* thought experiment is simply meant to give us the first:

[1] Other species may have developed human-like intelligence (more than once?), and subsequently become extinct, leaving no traces that we have detected.

[2] Human-like intelligence is not generally adaptive. Whenever species in the past drifted towards it, they were selected against. (Perhaps because of social conflict or other inefficient uses of resources.)

[3] Human-like intelligence is only adaptive in a very unusual set of circumstances, which happened to occur 1-2 mya for the genus *homo*. (But what were those circumstances, precisely?)

It would be hard to say which of these alternatives is most thought-provoking. But all of them suggest, in different ways, a certain hubris to our species' claims of intellectual superiority and uniqueness.