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SIXTY-EIGHTH
JAMES ARTHUR LECTURE ON
THE EVOLUTION OF THE HUMAN BRAIN
1998

THE ORIGIN OF THE HUMAN CAPACITY

IAN TATTERSALL

AMERICAN MUSEUM OF NATURAL HISTORY
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Frederick Tilney, *The Brain in Relation to Behavior*; March 15, 1932

C. Judson Herrick, *Brains as Instruments of Biological Values*; April 6, 1933

D. M. S. Watson, *The Story of Fossil Brains from Fish to Man*; April 24, 1934

C. U. Ariens Kappers, *Structural Principles in the Nervous System; The Development of the Forebrain in Animals and Prehistoric Human Races*; April 25, 1935

Samuel T. Orton, *The Language Area of the Human Brain and Some of Its Disorders*; May 15, 1936

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- Niles Eldredge, *Mind Over Matter: The Evolving Place of Humans in Nature*; April 11, 1994
- Este Armstrong, *Expansion and Stasis in Human Brain Evolution: Analyses of the Limbic System, Cortex and Brain Shape*; April 17, 1995
- *Matt Cartmill, *Do Horses Gallop in their Sleep? Consciousness, Evolution, and the Problem of Animal Minds*; April 30, 1996
- John Morrison, *The Human Cerebral Cortex: Exceptional Capabilities and Unique Vulnerability*; April 8, 1997
- *Ian Tattersall, *The Origin of the Human Capacity*; March 24, 1998

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James Anthony

JAMES ARTHUR

1842-1930

Born in Ireland and brought up in Glasgow, Scotland, James Arthur came to New York in 1871. Trained in mechanics and gear-cutting, he pursued a career in the manufacture and repair of machinery, during the course of which he founded a number of successful businesses and received patents on a variety of mechanical devices. His mechanical interests evolved early into a lifelong passion for horology, the science of measuring time, and he both made some remarkable clocks and assembled an important collection of old and rare timepieces.

Early in this century James Arthur became associated with the American Museum of Natural History, and began to expand his interest in time to evolutionary time, and his interest in mechanisms to that most precise and delicate mechanism of them all, the human brain. The ultimate expression of his fascination with evolution and the brain was James Arthur's bequest to the American Museum permitting the establishment of the James Arthur Lectures on the Evolution of the Human Brain. The first James Arthur Lecture was delivered on March 15, 1932, two years after Mr. Arthur's death, and the series has since continued annually, without interruption.

THE ORIGIN OF THE HUMAN CAPACITY

Just what is it, that strange quality of our consciousness that sets us off from all other living organisms—and which, as importantly, makes us *feel* so entirely different from them all, even those to whom we know ourselves to be quite closely related? And, whatever it is, how and when did we acquire it? While these questions come close to being unanswerable except in the broadest of terms, they beg to be asked; for they encapsulate the most basic and profound of all the many mysteries posed by our strange and (occasionally) wonderful selves. It is thus natural that they should have been raised—in a variety of different ways and from an equally large number of perspectives—by several earlier James Arthur lecturers on *The Evolution of the Human Brain*.

My talk today is no exception, and I have even borrowed part of my title from one of my distinguished predecessors as a James Arthur lecturer, Alexander Marshack, who coined the term “the human capacity” to denote this elusive quality that makes humans so distinctive. In his lecture, Marshack (1985) explored the origins of the human capacity in the context of the Ice Age art and symbolism that are its most dramatic early expression. Today I would like to cast my net a little wider, looking at the evidence for the emergence of what we might call cognitive novelties throughout the hominid fossil and archaeological records, and asking whether it is possible to discern any consistent pattern among them. More precisely, I shall ask whether the final step to becoming fully human—the acquisition of the human capacity—was an abrupt or a gradual event, and whether it simply represented the culmination of earlier trends in human evolution, or was an unprecedented, emergent event that could not have been predicted from what went before. And I shall also inquire into possible causes or at least correlates of this fateful step. Before I begin to do this, however, it’s necessary to digress for a moment to look briefly at the evolutionary process itself, because the way in which we view this process profoundly affects the manner in which we interpret its manifold results.

Evolution: Expectations from Theory

This may sound odd coming from a lecturer on the evolution of the human brain, but I'll say it anyway. One of the greatest impediments to a rational interpretation of the human fossil record has been the fact that, over the long haul, there has been an undeniable tendency among hominids toward increasing brain size. We'll look later at the details; it's sufficient for the present to note that this "trend" has distracted attention away from diversity in the hominid fossil record, and toward continuity—thereby reinforcing the notion, prevalent from paleoanthropology's earliest days, that our evolutionary history has been one of a slow, singleminded progress from primitiveness to perfection. This transformational bias has proven very congenial to adaptationist paleoanthropologists concerned with projecting the origins of *Homo sapiens* as far back in time as possible; but the terminology and the mindsets it has fostered are in my view totally inimical to the proper understanding of many important facets of human evolution. And of none of the many aspects of the human story is this truer than it is of the origin of the human capacity.

Strangely, perhaps, the first evolutionary biologist to hint at this last point was one of the fathers of the theory of evolution by natural selection, Alfred Russel Wallace. While his elder contemporary Charles Darwin had no doubts whatever that generation-by-generation natural selection fully explained all aspects of human emergence, Wallace, ironically the staunchest advocate of natural selection in all other contexts, simply could not see how this process could have brought into existence the extraordinary consciousness of human beings. "Darwinian theory," he wrote, "shows us how man's body may have developed from that of a lower form under the law of natural selection; but it also teaches us that we possess intellectual and moral faculties which could not have been so developed, but must have had another origin." (Wallace, 1889). Wallace attempted to find this other origin by embracing Spiritualism, a movement that had initially developed in direct opposition to the "materialism" of which evolutionary thought was widely believed to be an excellent example, but which rapidly became rampant with

fraud and fakery—which the totally guileless Wallace, as thoroughly decent a human being as ever existed, was ill-equipped to perceive. Wallace's gullibility in this matter greatly annoyed Darwin, and led to a rift between the two men that never completely healed.

The irony, of course, is that both Wallace and Darwin were right. The problem is one of levels of analysis. No reasonable scientist doubts the central role played by natural selection in the evolutionary process, normally at the level of the local population (Tattersall, 1994). But, equally, it is evident that natural selection *per se* cannot be responsible for the *emergence* of the evolutionary novelties which it acts to promote or eliminate. A wholly different set of mechanisms, acting at the genomic and developmental levels, comes into play here, and at least potentially these mechanisms are totally independent of those that enter into the selective process. Darwin was certainly correct in surmising that natural selection played a crucial role in establishing enlarged and rewired brains in certain local populations of our ancestors (presumably on the basis of substantial rather than marginal advantages conferred by the resulting behaviors, for the brain, as Bob Martin [1983] pointed out in his James Arthur lecture several years ago, is metabolically a very expensive luxury). But Wallace was equally accurate in his belief that natural selection could not have created human consciousness—that it could not in itself have produced the reformed or enlarged structures that are responsible for the human capacity, and that it was to favor once they had come into existence. For every organismic attribute has to exist *before* it can acquire an identifiable function. In this very limited sense all successful evolutionary novelties must necessarily arise as exaptations (Gould and Vrba, 1982): features that appear in one context (in this case, independently of adaptation) before being co-opted by selection in another.

But the emergence of novelties and their fixation in local populations via natural selection is not the whole evolutionary story. Local populations are reproductively compatible with other populations of their species, and their unique characteristics are at risk of loss through intermixing and reabsorption at any time. Discrete historical identity is only conferred on populations by the very poorly understood event of speciation: an event caused by a process (or,

more accurately, by any one of a variety of processes) that has no necessary relationship to genetic/morphological change under the guiding hand of natural selection. Among mammals, speciation appears to require complete—or at least effective—physical separation of populations (see, for example, the discussion by Mayr, 1966); but, once such separation has occurred and speciation has intervened, the resulting sister species will compete rather than interbreed should environmental circumstances change and place them in contact once more. Habitat change of this kind will normally involve upheavals in whole faunas rather than in the lives of individual species, placing each population in a complex new competitive situation. In such circumstances winnowing effects will take place among species that are analogous to the winnowing of individuals under natural selection that occurs within local populations.

I have, I hope, said enough to persuade you that evolution is a complex process into which many influences enter that are entirely random with respect to excellence of adaptation (see discussion in Tattersall, 1998). Environments fluctuate, adaptations become irrelevant, disasters befall. Yet discourse on the subject of human cognitive evolution has, almost without exception, proceeded as if increasing brain sizes and “intelligence” were simply matters of inexorable improvement under the benign influence of natural selection. We have big brains; we take their advantageousness for granted; and we thus tend to see a certain inevitability in our having become the way we are. Yet a moment’s thought is sufficient to indicate how implausible it is that bigger and better brains or improved brain structures evolved in this tranquil and linear fashion, most especially in the highly unsettled ecogeographic conditions of the past few million years. The fact that brain enlargement, at least, has been a fairly consistent if irregular theme throughout the last couple of million years or more of hominid evolution does, of course, suggest that on balance, and on average, larger brains have conferred advantage; but we should bear in mind that the trend we perceive is almost certainly not a simple within-species phenomenon, smarter individuals surviving and reproducing more successfully, generation by generation, in an inexorable process of improvement over the eons. Instead, as Gould and Eldredge (1993) empha-

sized, trends such as this are most plausibly due to the effects of interspecies competition, a process presumably enhanced in our own case by the complex ecogeographic effects of the "Ice Ages," almost exactly the period within which we have seen hominid brain size mushroom.

There is another factor, too, one having to do with systematic analysis rather than with notions of evolution per se. Drawing a straight line between two points is easy; indeed, two points are the definition of a straight line. And the fewer points you choose to deal with, the more likely all are to fall close to the same straight line. The tendency in paleoanthropology (for reasons that there is no time to discuss here, but see Tattersall, 1995a), has been toward the minimization of the number of points, i.e. species, recognized over the course of human evolution; and this peculiar paleoanthropological perception has reinforced the notion of linearity in our evolution. Indeed, some paleoanthropologists (see Wolpoff et al., 1993), while having had to abandon the "single-species hypothesis" for Hominidae as a whole, still recognize no more than two successive species in the entire history of the genus *Homo*. However, an alternative (and, to me, both theoretically and empirically much more persuasive) interpretation of the human fossil record reveals a much greater systematic complexity (fig. 1).

Putting together the notions of the episodic nature of innovation in human evolution, and of greater taxic diversity than usually recognized in the fossil record, I had planned to plot brain sizes vs. time in the context of a realistic number of taxa. I was thwarted, however, when I realized two things. First, I was totally unsure how to sort the human fossil record into what I would regard as a reasonable number of taxa (my colleague Jeffrey Schwartz and I are currently engaged in an attempt to do this, but it will take some time). For, despite the huge morphological diversity that the human fossil record evidently contains, little has been done either to describe it properly at the requisite level of detail, or to evaluate it in the appropriate terms. The result of this legacy of linear thought is that many of the fossil human crania for which brain sizes have been accurately estimated actually exist in a taxonomic limbo—in which they will remain at least until the human fossil record is

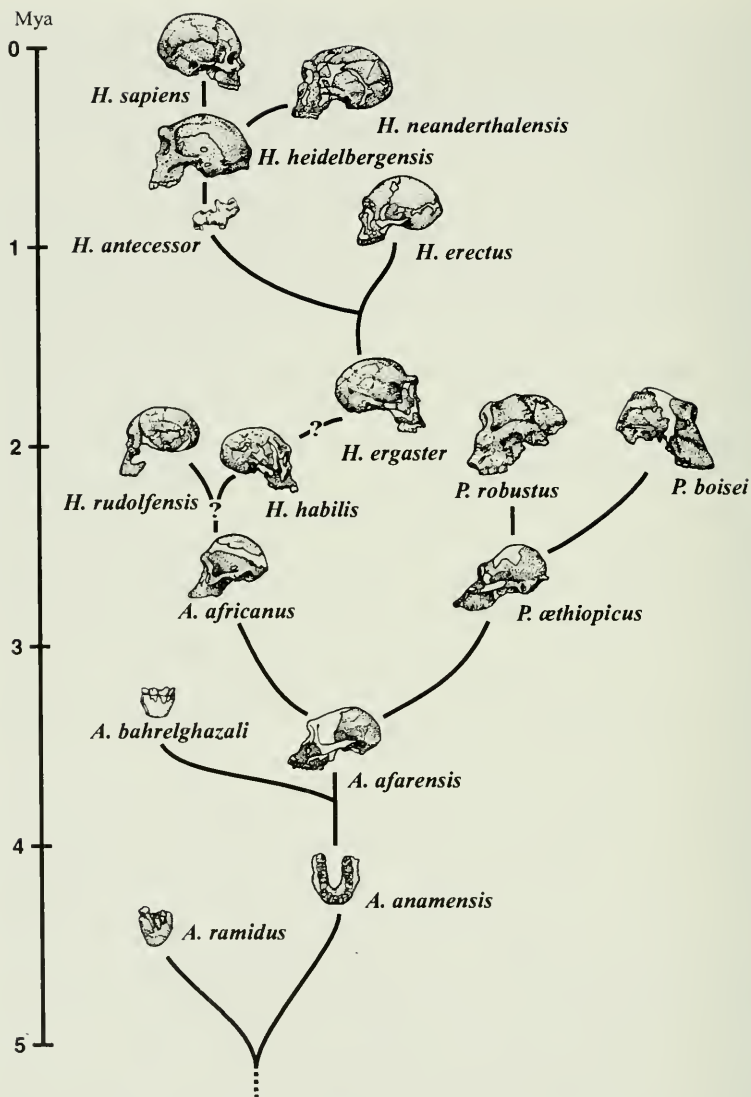


Fig. 1. An evolutionary tree of the hominid family, incorporating all those species currently recognized by many (if not all) paleoanthropologists. The true picture is undoubtedly more complex than this.

emptied of “wastebasket” taxa. Second, far too many of these same fossils are of debatable age, or are dated only to within the broadest of time zones. Given these considerations, it is obviously premature to attempt to determine the actual pattern of hominid brain size increase with time, although the overall tendency to enlargement (at least among those fossils conventionally assigned to genus *Homo*) is clearly there.

However all this may be, when evaluated by the criteria routinely applied to all other organisms, the fairly substantial fossil record of hominid evolution robustly declares that the human story has been vastly more eventful than the linear model suggests (Tattersall, 1986). This is no story of straight-line progression; rather, it is one of diversification, with numerous speciations and extinctions right from the very first fossil intimations of our family. If there is consistency in this almost 5 million-year-long story, it is not to be found in a slow and steady grind but rather in the consistency of repeated evolutionary experimentation, both successful and otherwise. Bearing this in mind, let’s look briefly at the human fossil and archaeological records with the aim of identifying major innovations whose accretionary history may help us to determine the pattern of modification in human evolution.

Innovations in Human Evolution

The earliest evidence we have of creatures who were exclusively our ancestors, and not those of apes as well, comes from sites in Kenya and Ethiopia dating to the period between about 4.4 and 3.9 million years (myr) ago. The most convincing of these fossils have been allocated to the species *Australopithecus anamensis*, a form represented as yet only by a few fragments which include a couple of fairly decent jaws and part of a shin bone (M. Leakey et al., 1995). Despite a few differences in detail, the jaws and teeth look comfortably similar to those of the next-in-line species *Australopithecus afarensis*, known from sites in Ethiopia and Tanzania that date in the 3.8 to 3.0 myr range. And, tellingly, the shin bone shows unmistakable signs of uprightness in the part that contributes to the

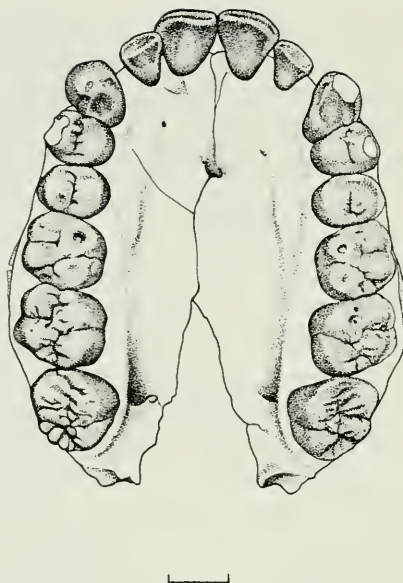


Fig. 2. Upper dentition of *Australopithecus afarensis* (AL 400-1a) from Hadar, Ethiopia. About 3.4 myr old. Scale is 1 cm.

knee joint. Humans were up and walking on their hind legs by about 4.2 million years ago.

This is not something we can tell with any certainty from evidence so far reported for the earliest claimant of all to hominid (human-family) status: an equally fragmentary form from Ethiopia that rejoices in the name of *Ardipithecus ramidus* (White et al. 1994). Much less like later hominids than *A. anamensis* is, the main importance of *A. ramidus* is to remind us that from the very beginning, hominid history has been one of evolutionary experimentation, for it represents at best a side branch on the human evolutionary tree. *Homo sapiens* is the exception, rather than the rule, in being the lone hominid on Earth. It is useful to keep this in mind as we look at the human fossil record since, while there is something inherently linear in any form of story-telling, linearity is not in fact a strong signal in human phylogeny.

Australopithecus afarensis (fig. 2) is the first well-documented hominid known, including in its ranks such stars as "Lucy," who



Fig. 3. Reconstruction of the cranium of *Australopithecus afarensis*, assembled from fragments of several individuals. Scale is 1 cm.

consists of much of a 3.2 myr old skeleton, and the members of the “First Family,” fragmentary bones of a group of at least 13 individuals who may have perished together about 3.4 myr ago. Beyond these Ethiopian fossils, it seems most likely that the famous 3.5 myr old footprint trails of Laetoli, in Tanzania, were also made by members of this species, whose upright-walking behavior has thereby literally been fossilized. This unique insight into the locomotion of *A. afarensis* is confirmed by examination of the fossils themselves, but such scrutiny also reveals that these rather small-bodied creatures did not walk upright quite as we do (e.g., Johanson and Edgar, 1996). Descendants of tree-living ancestors, they retained a variety of features that would have helped them to exploit their ancestral habitat even as they moved more freely beyond it than ever before. This have-it-both-ways adaptation made the early hominids neither as agile in the trees as apes are, nor as efficient on the ground as we are; but it served them well, remaining essentially unaltered for over 2 million years, even as new hominid species came and went. Over this period early hominids seem to have been largely confined to the forest fringes, where true forest grades into grassy woodland; and indeed, 4 million years ago, true Serengeti-style savannas lay very far in the future, even as increased seasonality and climatic drying steadily shrank the African forests.

“Why bipedalism?” is a complicated and as yet incompletely resolved story for which there is no time here. However, it’s im-

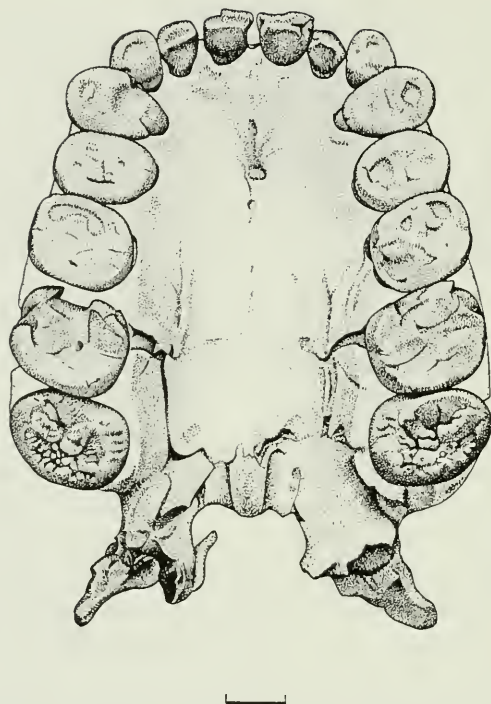


Fig. 4. Upper dentition of *Paranthropus boisei* (OH 5) from Olduvai Gorge, Tanzania. About 1.8 myr old. Scale is 1 cm.

portant to note that, bipedalism aside, there is very little to indicate that the early hominids were functionally hominid in other respects. True, we see some typically hominid innovations very early on, such as both absolute size reduction of the canine teeth, and the elimination of the canine size differential between the sexes that is typical of the great apes. But these early hominids still had apelike cranial proportions, with large, projecting faces hafted onto small braincases (which housed brains little, if any, larger than those of apes, even if body size is factored in: fig. 3). And indeed, there is a strong tendency among paleoanthropologists today to refer to these ancestral early hominids as "bipedal apes."

In the period between 4 and 2 myr ago these creatures flourished widely in Africa, giving rise to several species in two major lineages

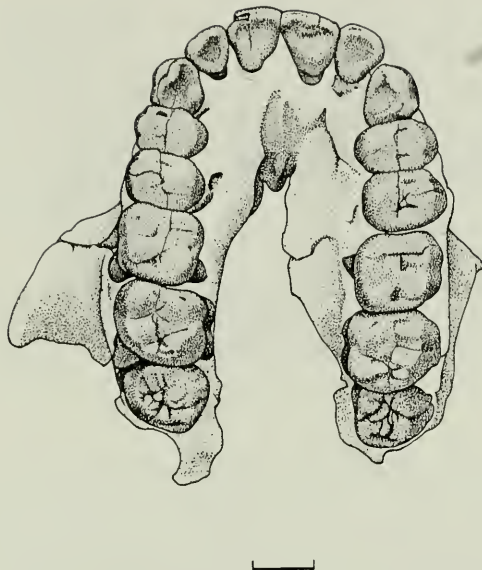


Fig. 5. Upper dentition of a "gracile" australopith, *Australopithecus africanus* (Sts 52a), from Sterkfontein Member 4, South Africa. About 2.5 myr old. Scale is 1 cm.

that are often dubbed "robust" versus "gracile." The robust forms differentiated before about 2.6 myr ago and typically showing huge cheek teeth—molars and premolars—in contrast to tiny front teeth—incisors and canines—(fig. 4) are widely thought to have specialized in exploiting the tough roots and tubers of the grasslands, though there is little direct evidence for this. The "gracile" forms (fig. 5), on the other hand, are believed to have hewed to a more opportunistic, omnivorous diet. Significantly, though, it's clear that each lineage made its own evolutionary experiments, each spinning off separate species or species groups in southern and eastern Africa (and presumably elsewhere in the continent, did we but have the fossil evidence to show it; the lone such fossil comes from Chad).

Presumably it was one such experiment within the gracile lineage that gave rise to the first members of the genus *Homo*. The earliest widely recognized species of *Homo*, *H. habilis* ("handy man") was described in 1964 from Olduvai Gorge in Tanzania (L. Leakey et al., 1964). The handful of fossils (e.g., fig. 6) on which this new



Fig. 6. Upper dentition of OH 13, one of the fragments from Olduvai Gorge assigned to *Homo habilis*. About 1.6–1.5 myr old. Scale is 1 cm.

species was based was ascribed to our own genus largely because it was plausibly associated with the crude stone tools found in the lowest layers of the Gorge, and because there were indications of a brain vault a bit bigger than that typical for the early hominids—even if there were not a lot of other identifiable physical differences. Since then the plot has thickened, and a variety of fragmentary “early *Homo*” fossils have been identified in eastern Africa in the period between about 2.5 and 2.0 myr ago, just as have several sites yielding early stone tools. We have yet to obtain a firm association between such tools and hominid(s) who made them; more than one species may well have been involved. But it is a fair bet that the first stone toolmaker was physically of fairly archaic body build and possessed of a brain not a lot bigger than you might expect of an ape of his or her body size. And if so, we have here a good example of a theme we find consistently throughout the hominid record: behavioral innovations do not tend to be associated with new kinds of humans. If you think about it, this makes considerable sense, for a new technology must be invented by an individual who cannot differ



Fig. 7. Oldowan tools, representative of the earliest stone implements yet known, dating back as far as about 2.5 myr. These tools consisted of sharp flakes (center and right) struck from small cobbles (left), which might themselves also have been used as tools. Scale is 5 cm.

too much from his or her own parents or offspring. Innovations arise *within* species, for there's no place else for them to do so.

Still, whatever the first toolmaker looked like, the tools themselves mark a major cognitive leap forward among hominids. They allowed the exploitation of a new source of protein—animal carcasses—that had previously been largely off-limits to tiny defenseless foragers who would have had to yield to most competitors for such resources. These early stone tools (fig. 7) were crude—simple sharp flakes knocked off larger stone “cores”—but highly effective: experimental archaeologists have butchered entire elephants using them. What's more, it takes considerable insight, well beyond what any ape has achieved, even with intensive coaching (Toth et al., 1993), to strike a cobble with another at precisely the angle necessary to detach a sharp flake. Further yet, we know that the earliest *Homo* anticipated needing the tools they would make, for we have evidence that they carried suitable stones around with them for long distances before making them into tools as needed (see review by Schick and Toth, 1993). With the invention of stone tools, we have the first unequivocal evidence that hominids had moved cognitively well beyond the ape league, whatever they looked like.

At about 1.8 myr ago we find the first fossils of the earliest member of genus *Homo* to have had a body size and build essentially comparable to our own, which makes one wonder whether it should not be with such creatures that we should really begin to recognize

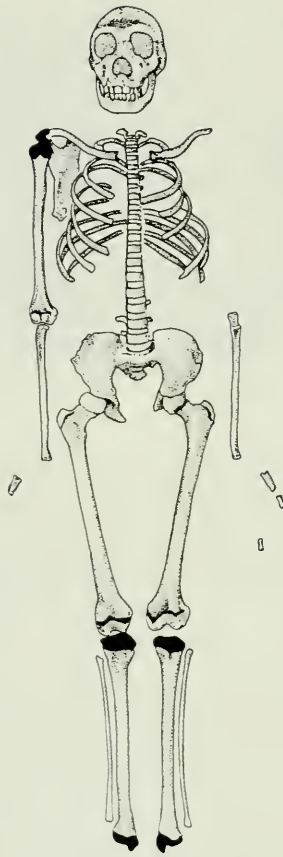


Fig. 8. The "Turkana Boy" (KNM-WT 15000) from Nariokotome, West Turkana, Kenya. This remarkably preserved adolescent skeleton of a probable *Homo ergaster* is about 1.6 myr old.

the genus *Homo*. Known as *Homo ergaster*, this new form is best represented by the miraculously complete "Turkana Boy" skeleton from northern Kenya (Walker and Leakey, 1993). The remains of a 5 foot 3 inch youngster who died at the age of nine and would have topped 6 feet had he lived to maturity, this skeleton (fig. 8) tells us that the people who lived by Lake Turkana 1.6 myr ago were long-limbed and slender, built, like the people of the area today, for life out in the hot, arid, open savanna, far from the shelter of the forest.



Fig. 9. Skull of an adult *Homo ergaster* (KNM-ER 3733), from Koobi Fora, East Turkana, Kenya. Scale is 1 cm.

And it seems that once emancipation from the forest had thus been achieved, the way was open for ancient humans to indulge their wanderlust. New dates suggest that humans had not only exited Africa but had reached all the way to eastern Asia almost immediately after achieving modern body form (see review in Tattersall, 1997).

Still, while the Boy and his relatives had larger brains than any of their predecessors, these were not a lot more than half the size of ours today. What's more, while the face of *Homo ergaster* is substantially reduced compared to those of australopiths, it still juts out in front of the braincase and is equipped with modestly large teeth (fig. 9). There are incipient signs of the flexion of the cranial base that signals the presence of a vocal tract capable of producing the sounds associated with articulate speech; but speech and hence language are belied by the narrowness of the thoracic vertebral canal that carries the innervation of the thoracic musculature. The Boy apparently lacked the fine control of the musculature which produces the moving air column that we modulate to generate speech (McLarnon, 1993).

For all the innovations borne by *Homo ergaster*, we have to wait over a quarter of a million years after its first appearance before we encounter the next technological innovation. The Boy and his kin made stone tools that were for the most part indistinguishable from



Fig. 10. An Acheulean handaxe from St-Acheul, France. Probably about 350 kyr old, although implements of the same design in Africa go back to around 1.5 myr ago. Scale is 1 cm.

those their predecessors had made for almost a million years, and it is not until about 1.5 myr ago that we begin to find a significantly new kind of tool. This is the “Acheulean” handaxe (fig. 10), an implement consciously and symmetrically fashioned on both sides to a deliberate shape. For the first time, toolmakers were making tools to a “mental template” held in their minds, rather than simply going after an attribute—a cutting edge (see Schick and Toth, 1993). Yet another cognitive advance. But we know little if anything about how this innovation affected the lifestyles of the toolmakers. These hominids presumably lived in small, mobile groups that moved consistently around a landscape shared with a variety of other hominid species. Most likely they gained the greater part of their sustenance from plant materials or scavenged animal carcasses; few archaeologists today would argue that they were accomplished hunters of anything other than small animals.

After about 1.4 myr ago the paleoanthropological focus shifts out of Africa, if only for reasons of geological sampling. We find the

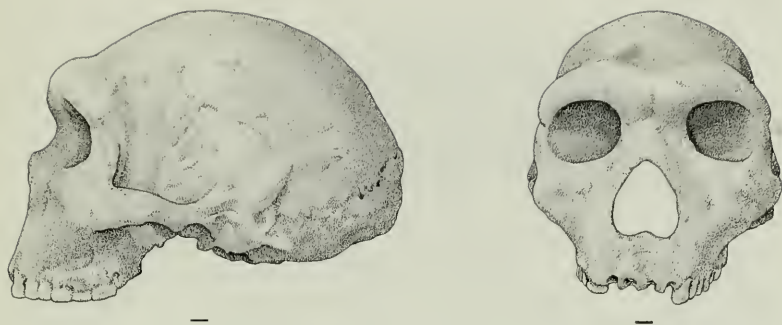


Fig. 11. Cranium of *Homo heidelbergensis* from Petralona, Greece. Age is uncertain, but possibly around 250 kyr. Scale is 1 cm.

famous *Homo erectus* in eastern Asia perhaps as much as 1.8 myr ago (and perhaps as recently as 40 thousand years (kyr) ago: Swisher et al., 1994, 1996); and recently a new hominid species, *Homo antecessor*, has been named from an 800 kyr old site in Spain (Bermudez de Castro et al., 1997). Once humans had left Africa, new species were evidently spawned in different parts of the world, exactly as one might expect, though what was going on in Africa itself at around this time remains rather obscure. By about 600 kyr, however, we find evidence in Africa of a new hominid species, *Homo heidelbergensis*, at the site of Bodo, in Ethiopia; and also, after about 500 kyr ago, at sites in Europe (fig. 11). This new species boasted a brain within the modern size range, though well below the *Homo sapiens* average (1100–1200 ml, vs. ca. 1350 ml); and it possessed flexion of the basicranium to a degree that suggests the ability to produce the sounds necessary for articulate speech (Laitman, 1988). Curiously, at the European sites there is, in early stages at least, a conspicuous absence of handaxe technology, stone tool kits remaining rather crude. It's almost certainly significant that we have found nothing that is convincingly a symbolic artifact in association with *Homo heidelbergensis*; but it is in the time range of this species, about 400 kyr ago, that we find the first evidence of simple structures and hearths, both substantial technological advances (fig. 12). Again, though, we have to wait for some time, until ca. 300–200

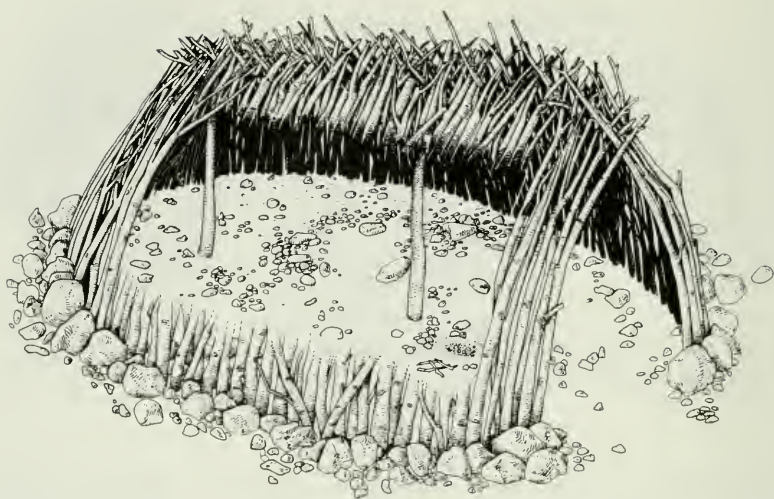


Fig. 12. Reconstruction of one of the 400 kyr-old shelters at Terra Amata, France. The cutout shows the scattering of cobbles and bones in the interior, and on the right is seen the emplacement of a shallow hearth.

kyr ago (dating is hazy) to find a significant innovation in stone toolmaking techniques.

This innovation was the “prepared-core” tool, whereby a stone core was carefully shaped until a single blow could detach a flake that required little modification to become a finished implement (fig. 13). The overwhelming advantage of this technique was to provide a virtually continuous cutting edge around most of the periphery of the implement. Once more, where the prepared-core tool was invented, and by whom, remains uncertain; but what is undeniable is that the best-documented and quite probably the most accomplished practitioners of the technique were the Neanderthals, *Homo neanderthalensis*. It seems likely that both the Neanderthals and our own *Homo sapiens* were ultimately derived from *Homo heidelbergensis* (or some species like it, but lacking the capacious sinus spaces in the skull that are such a striking feature of *Homo heidelbergensis*). The Neanderthals were an indigenous European and western Asian development from that ancestor, while *Homo sapiens* arose in Africa or nearby (and *Homo erectus* ploughed its own evolutionary furrow in Asia).

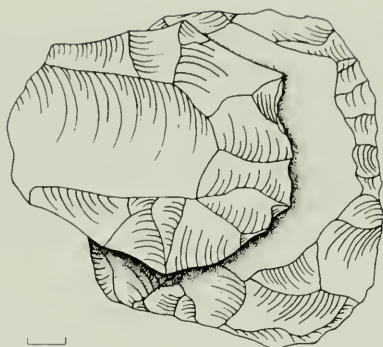


Fig. 13. A prepared-core tool, with a single large flake detached from a preshaped core. Tools such as this begin to be found at around 300–200 kyr ago. Scale is 1 cm.

The Neanderthals, quite abundantly known at sites from the Atlantic to Uzbekistan, and from Wales to Gibraltar and the Levant, were hominids with brains as large as our own (see review by Tattersall, 1995b). Those brains were, however, housed in differently shaped skulls, with long, low braincases and faces that protruded in the midline and that swept back toward the sides (fig. 14). These distinctive hominids emerged around 200 kyr ago and crafted stone tools beautifully but, as the French archaeologist Francois Bordes once remarked, “stupidly.” By this he meant that the productions of the Neanderthals, skillful as they were (we would be hard put to match their craftsmanship) were rather monotonous, in the sense that



Fig. 14. Cranium of a well-preserved adult Neanderthal from La Ferrassie, France (MH La Ferrassie 1). Probably around 70 kyr old. Scale is 1 cm.

there was a sameness to them over the whole vast expanse of time and space these people inhabited. This stands in stark contrast to the spirit of innovation and inventiveness that suffused the productions of the modern humans who entered Europe around 40 kyr ago, displacing the Neanderthals in the process (see below).

Interestingly, some Japanese investigators (Ohnuma et al., 1997) have recently carried out an elegant experiment in which two groups of college students were taught to make “Levallois points,” a tool type favored by many Neanderthal groups. One group was taught by direct nonverbal demonstration, while the other was also given verbal explanations. Significantly, there was no difference in performance between the two groups, either in quality of product or in speed of learning!

The Neanderthals lived in a period of oscillating climates, sometimes extremely severe, and occupied a huge area as a rather homogeneous group. Exactly how sophisticated they were as hunters is not entirely clear, although many believe that in most places, at least, they probably only hunted smallish mammals, scavenging the remains of larger ones. In most cases their living places seem to have been rather haphazardly organized, unlike those of modern people. It’s been suggested that, like their predecessors, Neanderthals were “foragers,” opportunistically availing themselves of food sources they encountered while roaming around the landscape (see Binford, 1981). This contrasts with modern hunters and gatherers, who are (or were) “collectors,” carefully monitoring the resources around them and planning their exploitation.

One Neanderthal propensity that may bespeak a profound aspect of humanity is the burial of the dead—something that these hominids practiced at least occasionally, and simply. Burial might, of course, have been no more than a convenient way of disposing of a particularly unpleasant form of clutter, and the Neanderthal preference for placing the corpse in a flexed posture might have resulted simply from the desire to dig the smallest pit possible. But it’s hard to avoid the impression that the act of burial conveys some form of empathy with the deceased. Whether it implies more than that is less certain. Spiritual awareness in all early modern human societies is marked by the inclusion of grave goods with the deceased: objects

that might be useful in the afterlife. Nothing of this kind is found in Neanderthal graves, in which any found objects are invariably the kind of thing found lying naturally on cave floors and that could well have been kicked in accidentally (Stringer and Gamble, 1993). In one intriguing case, at Iraq's Shanidar cave, a Neanderthal grave was found to be unusually rich in the pollen of spring flowers (Leroi-Gourhan, 1968). Perhaps the deceased was laid to rest on a bed of flowers; but there are, equally, other ways in which the pollen could have found its way into the grave. More suggestive at Shanidar was the skeleton of an aged individual who had suffered, maybe since birth, from a withered arm. This individual must have enjoyed the consistent support of his group over his long lifetime, for he could not have survived on his own (Trinkaus, 1983). In this observation there are, surely, strong echoes of human sensibility.

In the Levant we find evidence for anatomically modern people at almost 100 kyr ago, and Neanderthal remains at a mere 40 kyr ago. *Homo neanderthalensis* and *Homo sapiens* thus shared this region in some way for at least 60 kyr. How they did so is uncertain, although very interestingly the two species shared a virtually identical stoneworking technology (see Bar-Yosef, 1993). Functionally, at least, we have little reason to suspect any cognitive difference between them in this period. It is surely significant, though, that the last recorded Neanderthal occurrence in this region comes only a few millennia after the appearance (Marks, 1983) of an "Upper Paleolithic" stoneworking technology similar to (although distinct from) that of the earliest *Homo sapiens* who invaded Europe at about 40 kyr ago. These hominids were the Cro-Magnons (fig. 15), the people who, in not much more than 10 millennia, entirely eliminated the Neanderthals from the vast area they had inhabited—whether by conflict or by competition is not known. These invading moderns brought with them (from where, exactly, is uncertain) abundant evidence of the entire cognitive panoply that characterizes humans worldwide today. Not only did these new people make tools—in a dazzling variety—out of new materials such as bone and antler, in addition to stone, but from the very beginning they showed abundant evidence of symbolic behavior.

The record of the Cro-Magnons is truly extraordinary (see review



Fig. 15. Cranium of the "old man" from Cro-Magnon, France (MH Cro-Magnon 1). About 30 kyr old. Scale is 1 cm.

by Tattersall, 1998). Over 30,000 years ago they had begun to leave extraordinary art on the walls of caves. Bone flutes of complex sound capability announce the advent of music. Markings on bone plaques clearly represent systems of notation, perhaps even lunar calendars. Some of the most beautifully observed and crafted sculptures ever made date from this time (e.g., fig. 16). Technology became more complex; by 26 kyr bone needles announce the invention of tailoring, and at this same time ceramic technology was devised,



Fig. 16. Sculpture of a young woman's head, in mammoth ivory, from Brassempouy, France. Probably around 25 kyr old. Scale is 1 cm.

figurines being baked in simple but remarkably effective kilns. Hunting became more complex, and fish and bird bones show up for the first time in food refuse. The list of Cro-Magnon achievements could go on and on, but the point is already evident: these people were most profoundly us, and possessed of a sensibility then totally unprecedented in human history. As we have seen, innovation in human evolution, technological as well as anatomical, had previously been sporadic, and it is fair to say that with only a couple of exceptions (the first bipeds and the first toolmakers), new kinds of hominids had essentially done what their predecessors did, if a little bit better. With the emergence of behaviorally modern *Homo sapiens*, however, a totally unprecedented entity was on the scene. This hominid is not simply an extrapolation of earlier trends in human evolution.

The Human Capacity

So what happened? As I've noted, essentially this issue was the cause of the deepest disagreement that ever fissured the relationship between Charles Darwin and Alfred Russel Wallace, Darwin firmly believing that natural selection was the unambiguous explanation of human consciousness, while Wallace simply couldn't see how this could be so. And as I've also said, it seems to me that both men were right, in different ways. Consciousness is the product of our brains, which are in turn the product of a long evolutionary history. But the properties of the modern human brain are quite clearly emergent, the result of a chance coincidence of acquisitions. For, while natural selection plays an essential role in the evolutionary process, it is not a creative force; it has to act on variations that come into existence spontaneously. Nothing arises *for* anything, and natural selection can only work on variations presented to it. We must thus conclude that the immediate ancestor of modern humans possessed a brain that had, for whatever reason, evolved to a point where a single developmental change, or genetically related group of changes, was sufficient to create a structure with an entirely new potential.

But this is probably not the whole story. Recall that the earliest

humans who looked exactly like us behaved, as far as can be told, pretty much like Neanderthals, for upward of 50 kyr. These humans had brains that were externally like our own, but that evidently did not function in the way that the Cro-Magnons' did in later times. What happened? Did the earliest anatomically modern and the earliest behaviorally modern humans represent separate but skeletally identical species, the latter eventually replacing the former? This scenario seems inherently improbable, since any such dramatic Old World-wide replacement would have had to have taken place in an implausibly short window of time; and there is, in any event, no direct evidence for it. The only evident (and as we've seen, in terms of evolutionary mechanisms far from unusual) alternative is that the potential for the unique human capacity was born with our species *Homo sapiens* as a byproduct of some other change, and that it lay fallow, as it were, until unleashed by a cultural (rather than biological) stimulus. This capacity, once declenched, would then have spread quite easily by cultural contact among populations that already possessed the latent ability to acquire it.

What might that releasing stimulus have been? Like many others, I am almost sure that it was the invention of language. We must bear in mind here that by the time *Homo sapiens* came on the scene the peripheral equipment that allows articulate speech had been around for several hundred thousand years, having emerged initially for other purposes entirely. The archaeological record is but a dim record of the full panoply of behaviors of any early hominid, but if it shows us anything at all it is the starkness of the contrast between the torrential outpouring of symbolic behaviors by the Cro-Magnons and the essentially symbol-free behaviors of their predecessors. The fundamental innovation that we see with the Cro-Magnons, underwriting all their varied achievements, is that of symbolic thought, with which language is virtually synonymous. Like thought, language involves forming and manipulating symbols in the mind, and our capacity for symbolic reasoning is virtually inconceivable in its absence. Imagination and creativity are part of the same process, for only when we create mental symbols can we combine them in new ways and ask "What if?" Nonverbal intuitive reasoning can, of course, take one a long way (recall the toolmaking experiment); and

indeed, we can probably look upon the considerable achievements of the Neanderthals as the ultimate example of what intuition can do; but it is almost certainly symbolic thought that, above all, differentiates us from them—and from every other hominid, indeed every other organism, that has ever existed. For it is surely symbolic reasoning that makes consciousness as we know it possible, given that only by symbolically recreating the world in our minds can we objectify not only ourselves but our own positions in that world.

The strong signal from the behavior record, then, is that our acquisition of the human capacity was a recent, and emergent, happening. Much as paleoanthropologists like to think of our evolution as a linear affair, a gradual progress from primitiveness to perfection, this received wisdom is clearly in error. We are not simply the inevitable result of a remorseless process of fine-tuning over the eons, any more than we are the summit of creation. For all of our remarkable—and recently acquired—cognitive attributes, we are but one of numerous evolutionary experiments spawned by our diverse family Hominidae. Yes, there has been an overall trend within Hominidae toward an increase in relative brain size over the past 2 million years or so, suggesting that there is something about being hominid (or at least a member of *Homo*) that predisposes to this trend. And yes, it is unquestionably the unique cognitive features resulting from our own particular experiment that account for the fact that we are the lone hominid in the world today, as for so much else. But we risk deceiving ourselves if we try to link such observations too closely. The archaeological record of human behavioral evolution shows clearly that the human capacity, whatever the neural mechanisms and cultural stimuli underlying it, is the end result of a long and untidy history of sporadic accretion. More significantly, however, it powerfully suggests that the final acquisition of this remarkable capacity was not simply a gradual extrapolation of what had gone before. Instead, this event of events was a sudden and emergent one—whose roots, perhaps ironically, were firmly embedded in the prosaic evolutionary phenomenon of exaptation.

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