

# From Ape to Man: The Phenomenal Growth of Cranial Capacity and Culture

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What could have triggered the rapid and unprecedented expansion of brain capacity in the course of the evolution of man from one of the ape species? The development of language and associated thinking process is a strong possibility; a few other surprising activities also appear to be good candidates to have acted as the trigger.

Most of us, who are not creationists, have wondered at some time or the other, what direction evolution will take in the future. What are the selection pressures at present, and what are the consequences likely to be? In order to make an intelligent guess, it may be worthwhile to look at the course of evolution over the past few million years leading to the present-day human beings.

Several million years ago, certain species of apes evolved into what were to become two distinct, erect, bipedal creatures – *Australopithecus africanus* and *Australopithecus robustus*. By about one million years ago the former had developed into the earliest known human species, while the latter had become extinct. This ‘advanced Australopithecus’ was followed by *Homo erectus* (about 500,000 years ago), which then led to the Neanderthal man (80,000 to 30,000 years ago) and the Cro-Magnon (35,000 B.C.). From fossil data, there is clear circumstantial evidence pointing to a connection between the growth in size of the human brain and the development of language and culture. It is also quite certain that this growth of the brain occurred astonishingly rapidly; this probably represents the fastest advance recorded for any complex organ in the entire history of life [1]. From chimpanzee to *Homo sapiens* the evolution of the skull shows two main characteristics: the brain gets bigger and the face smaller. The brain size seems to have approximately doubled every 1.5

## Keywords

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million years – from about 300 to 500 ml in the chimpanzee to about 1200 to 1500 ml in the Neanderthal.

The evolution of language and culture during this period has been reviewed by a leading paleoanthropologist [2]. Apes lack speech centers in their brains; so, although attempts have been made to teach them to talk, they are unable to repeat more than a word or two, and even this cannot be classified as ‘communication’. The frontal region of the brain of *Homo erectus* lacked the complex lobes of modern man. Although it is extremely risky to draw inferences about function from shape, one can hazard the guess that the powers of speech of *Homo erectus*, and his ability to conceptualize were inferior to ours; he might have been able to think, but possibly not very complicated thoughts. The Neanderthlers probably spoke a crude language. Evidence from their burial sites indicates that they believed in some kind of life after death; death itself was probably regarded as a kind of sleep, since corpses were carefully arranged in sleep-like positions. Very likely, they had felt the first primitive stirrings of religion. The advent of the Cro-Magnon marked the establishment of the present model of *Homo sapiens*. “The Cro-Magnon produced a culture that, in variety and elegance, far outstripped anything that Neanderthal man had aspired to.” The cave sites in France (e.g. at Lascaux) bear witness to his artistic ability.

What was the mechanism that triggered this unique and rapid enlargement of the brain? How can one explain the fact that among a set of African ape species such as chimpanzees endowed with modest brains, just one species suddenly raced ahead of the others?

Darwin himself believed that the principle of natural selection could also account for the development of mental capacities. But Wallace (the co-discoverer of the principle of natural selection) disagreed with this view. He was convinced that once language and culture entered the scene, human evolution became Lamarckian [3]. The accumulated wisdom of the parent was passed on to the offspring. These progeny would consequently be much

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wiser than the offspring of illiterates. But there is a flaw in this argument, since the transfer of knowledge and culture could occur from any source, not necessarily only the parent.

It is obvious that two different mechanisms must have operated in tandem – the normal Darwinian selection along with another evolutionary process based on intelligence and culture. Dawkins, the brilliant neo-Darwinian biologist, has clearly summarized the basic principles of Darwinism in genetic terms [1]. Those genes that exist in many copies in the population of a particular species are obviously the ones that are good at surviving and, by inference, good at making copies. It follows that these genes are good at surviving in an environment consisting of other genes that are typically found in that species. The genes of any species become selected to be good at cooperating with each other. It is important to note that it is *not the genes of any given individual that cooperate together*; for all we know, they might never have encountered one another earlier in that particular combination. It is the genes of the species at large that cooperate. What are passed on in successive generations are the genes that tend to be good at forming favorable combinations with other genes that the gene pool of the species has to offer.

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Similar to the gene, which is the basic unit of inheritance, Dawkins has coined the term 'meme' to denote the unit of cultural inheritance [1, 4]. The meme can consist of a good idea, a tune, a piece of poetry, or even a crass jingle. It replicates itself by imitation or copying, thus jumping from one brain to another. Memes can form a meme pool similar to the gene pool of a species. The evolution of intelligence and culture in humans is dependent on the successful transmittance of the memes from one generation to the next. Cultural evolution involves selection of memes for their ability to cooperate with other memes. Cooperativity amongst memes leads to the evolution of culture; great ideas in philosophy, brilliant insights in mathematics or superbly conceived tunes of music owe their existence to such cooperativity. The pre-existence of certain memes in the mind can make it become receptive to certain other memes; thus the



foundation for a tradition gets laid. Based on this hypothesis, culture can be regarded as a cooperative cartel of memes.

According to Dawkins, these two selection processes – one based on genes, and the other on memes – acting together can lead to the rapid enlargement of the brain. During evolution, memes are selected for their ability to spread themselves by imitation or copying; genes are selected for their ability to make individuals that are good at spreading memes. The co-evolution of genes and memes is responsible for the spectacular development of human language, art, science, mathematics and philosophy.

To return to the unprecedented rapid expansion of the brain: there must have been a self-feeding process superposed on this co-evolution – a sort of feedback loop [1]. A possible scenario could have been the following: The honing of a particular skill might have required a slight increase in the brain capacity. This initial slight increase might have enabled the brain to launch on a completely new activity (the ‘trigger’). This new activity, in turn, might have led to a change in the environment, thus making the brain size subject to natural selection – large-brained individuals having more children than smaller-brained ones. (Dawkins notes that this does not seem to be happening today, although it must have happened during our ancestral past.)

Implicit in the above discussion is the assumption that it was the development of language and the faculty of communication that acted as the trigger for unleashing the spiral of co-evolution. This, of course, is extremely likely. The evolution of language must have certainly altered the selection pressure dramatically. There would have been natural selection in favor of individuals genetically equipped to exploit the benefits of oral communication. The brain could certainly have grown in size in response to the demanding needs of linguistic developments and creative thought processes. Karl Popper, the brilliant twentieth century philosopher, has added a further crucial detail to this theory [5]. There is no doubt that the descriptive function of human language has played a significant role in the development of the

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brain; this is only one aspect of the evolutionary process, proceeding by the usual Darwinian selection. The second method replaces natural selection by conscious critical rejection; this is probably the route by which cultural evolution has taken place. Popper emphasizes that this is also Darwinian, but in place of natural selection, we ourselves assume responsibility for driving this evolution by exercising our critical faculty – discarding ideas or hypotheses, which do not meet the requisite standards. Of course, critical thinking is also an offshoot of the development of linguistic skills.

Dawkins has pointed out [1] that apart from the development of human language, there are also a couple of other activities, which might have acted as the trigger for the sudden spurt in the brain capacity of humans. The first one surprisingly, is ‘map-reading’! For the hunter, it is but a short step from reading patterns of pug marks and footprints on the ground to drawing a crude map of the movements of the prey, or indicating the flow of a river by taking a stick and drawing lines on the dust. A further advance might have been creating the likeness of a whole animal. Such representational art implies an awareness that something can be made to stand for something else, and that this may assist thought or communication. It is quite possible therefore that the drawing and reading of maps were the activities that boosted our ancestors beyond the critical threshold, which the other species of apes failed to transcend.

Another candidate for this is the act of throwing a projectile to fell a prey. How does the nervous system achieve the feat of releasing the projectile at exactly the right moment? Anyone who has attempted to throw a boomerang (as I have) would realize what an extraordinary coordination of muscles this calls for. Such ballistic achievements make special computational demands on the brain, which is probably not equipped to respond with the necessary speed. (Even an ordinary PC can carry out more than  $10^6$  operations per second, whereas the typical firing rate for a neuron in the brain is in the region of only a 100 spikes per second [6]. But the brain compensates somewhat by



parallel processing). Perhaps the act of throwing is programmed in the brain as a list of individual muscle twitch commands in the correct sequence. If so, then obviously the continuous refining of the technique of throwing projectiles would demand an expansion of the brain capacity and would thus qualify to be the trigger [1].

There is another mystery associated with the rapid increase of cranial capacity from the ape to the modern man. The two related developments – increase of brain size and the expression of mental capacity in terms of artistic or scientific talent – do not seem to be in phase. The anthropological evidence cited earlier [2] clearly shows that the brain attained its present size long before it was called upon to exercise its full potential. The intricate neuronal connections, which the Cro-Magnon's brain presumably possessed, were vastly in excess of anything he might have needed, to cope with his environment. He had 'potential intelligence' which found no use. What was the evolutionary survival value of such a brain, which was capable of great ranges of conceptual thought or of artistic imagination? The principle of natural selection can only explain the emergence of actual abilities; it cannot explain the appearance of potential ability.

Conventional Darwinians would explain that general intelligence evolved so that one can communicate, hunt game, collect food, etc; once this intelligence was in place, the excess capacity could be used for all sorts of other mental activities such as solving mathematical problems or composing music. A more convincing explanation offered by the distinguished neuroscientist Ramachandran [3] is that the brain probably had to become big for some adaptive reason – throwing spears, map-reading or just talking. The simplest way to achieve this enlargement was perhaps by increasing the production of growth-related hormones. But such a hormone-based growth cannot be selective; it cannot be restricted to certain specific parts of the brain. There would inevitably have been a general enlargement of the entire brain, including those areas that deal with math-

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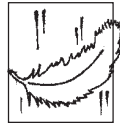
ematical ability or artistic expression. Thus intellectual powers and artistic impulses could have arisen as a bonus to the normal process of selection. (Does the brain function as a whole, or are the different parts of the brain highly specialized for mental capacities? The modular and holistic points of view may not be mutually exclusive. From his own experience, Ramachandran tends to believe that enhancement in mathematical ability is associated with an increase in size of the angular gyrus).

That brings us back to the question raised at the beginning: what is the future direction of evolution likely to be? Size-wise, we are assured that there has been no further enlargement of the cranium after the Neanderthal man [3]. But it would be extremely arrogant on our part to imagine that the present-day human being represents the ultimate in his ability to utilize the mental power available to us. It is quite conceivable that latent mental powers may be expressed in the future, without the need for any further enlargement of the cranial capacity.

### Suggested Reading

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Historians will have to face the fact that natural selection determined the evolution of cultures in the same manner as it did that of species.

– Konrad Zacharias Lorenz

