Primate and Hominid Evolution

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Often the question is posed to scientists, why do we need paleontology and paleoanthropology, why are we compelled to study the bones of creatures so long dead our minds can barely comprehend how long ago they lived? Why? Is it simply to satisfy the desire of the ever curious scientist; to discover and enhance knowledge for its own sake. I do not think so, I feel the reason for these explorations runs a much deeper course through the human soul. These scientists are trying to explain a question that has been confronted by of men of religion from the dawn of time, the question that the great philosophers strove to answer, and now it serves as the focal point for research conducted by scientists in fields as diverse as astronomy and molecular biology. This question is the cornerstone in our interpretation of self, yet in all our insatiable curiosity we have not yet definitively answered "Where do we come from".

Every religion and every great philosophy in some way attempts to address this question. These scientists are now simply the descendants of the authors of the Biblical Scriptures and Hindu Upanishads, the kin of Plato and Aristotle. We search these ancient bones to find out where we came from and, perhaps if we are lucky, where we are going.

There are as many views on our creation as there are religions in the world. What I will discuss, however, will be limited to the post medieval traditional Western Judeo-Christian beliefs because they are what has had the greatest impact on the development of modern science, and hence evolutionary theory. From the time of the Renaissance the Catholic Church held the belief that the Earth
was formed exactly as we know it now on October 29, at 9:30 in the morning in the year 4004 B.C., a remarkably precise calculation arrived at by Bishop Ussher of Ireland in 1664 by a careful examination of the Old Testament Scriptures.\(^1\) All fossil discoveries were attributed to be victims of the Biblical "Great Deluge".

In the Renaissance and the years following many great revelations were made, and traditional theories were challenged and destroyed. Copernicus showed that the Earth was not the center of the Universe, Sir Issac Newton brought us gravity and an explanation of the Laws of Motion, and French Anatomist George Cuvier and the earliest Paleontologists broke the belief in Divine Creation at 4004 B.C.

By the end of the Eighteenth Century it was becoming increasingly apparent that there were errors in the 4004 Theory. The Geologists were constantly confronting Biblical scholars with questions they could not adequately answer, how could rocks be metamorphosed by the pressure and temperature of mountain building then eroded flat in just 5000 years, and how could fossil bearing sediment be thousands of feet thick in places,\(^2\) the volume of water it would take to deposit that much sediment at one time is simply a physical impossibility on Earth. Then by the beginning of the Nineteenth Century George Cuvier had combed Europe’s fossil beds and managed to assemble the bones of several species of animals which were unlike anything then living. These fossils of animals he described as "extinct" were used by scientists to show the


\(^2\) Lane 5.
obvious discrepancies in the Biblical stories of the Creation and the Great Deluge.

The mid Nineteenth Century saw the rise of the single most important man and theory to ever cross the stage of evolutionary thought. Charles Darwin and his book *On the Origin of Species by Means of Natural Selection* brought forth the theory of Natural Selection, which is still the foundation for all of today's evolutionary science (even though Darwin generally receives sole credit for this theory fellow Englishmen Alfred Russel Wallace came up with the same idea at the same time). In 1859 when Darwin first introduced his theory of Natural Selection it was a ground breaking event which seemed to threaten the very pillars of Christianity. It is this theory of Natural Selection and Evolution that is the cornerstone around which all of our modern evolutionary theory is built, this was what gave rise to physical anthropology and paleontology. It was from here that scientists from virtually every field started converging to help answer the question of our creation.

The post Darwin era is generally described as the "Modern" era in Biological Anthropology. In the early years no single figure dominated the field, instead several men shared the spotlight with their ever increasing cache of fossils.

One event in early modern biological Anthropology did seize worldwide attention however, the finding of the "Missing Link" in a gravel pit in Piltdown, England. The "Piltdown Man", as it was called combined a skull that appeared almost exactly anatomically identical

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to a modern human's and a jaw that was very similar to a great ape's. It was hailed as the connection between men and the apes, and shown as proof of Darwin's Theories. While there was still some skepticism of the authenticity of the fossil, virtually all the important scientists of the time supported this intermediate link between *Pongidea* and *Homo*. Unfortunately it took 40 years for the skeptics to prove the Piltdown Man a hoax, it was not until 1953 when Kenneth Oakley had perfected the radioactive flourine dating technique that he was able to show that the skull was thousands of years older than the jaw.4

Perhaps the true beginning of modern Biological Anthropology came in November of 1924 when Raymond Dart discovered the first *Australopithecine* cranium in a limestone block brought to him from the Taung quarry in South Africa.5 He found fragments of a very tiny cranium and a nearly complete mandible of which he wrote the following description in *Nature*:

"The orbits are not in any sense detached from the forehead, which rises steadily from their margins in a fashion amazingly human. The interorbital width is very small (13 mm) and the ethmoids and not blown out laterally as in modern Africa anthropoids . . . The molars, zygomatic arches, maxillae, and mandible all betray a delicate humanoid character."6

Raymond Dart had truly made an amazing discovery, he named this find *Amphipithecus africanus* (literally, Southern ape of Africa),

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6Lewin 49.
affectionately referring to the actual fossil as the "Taung Child". However, when Dart sent out his initial report on the find to the British Journal Nature a scant forty days after the find it was received with a mix of skepticism and rejection by the anthropological community. Dart's estimations that the creature was a precursor of humans based on evidence of an upright walking posture (the position of the foramen magnum indicates bipediality), small canine teeth, and a brain case which he estimated would have been 450 cc at maturity (slightly larger than a modern Gorilla), and his approximate age of one million years was simply too much for the Anthropological world to handle, especially in light of the Piltdown find and the common, but unsubstantiated, theory that man arose in Asia.

Dart's mistake lay in two areas: his rapid publication of his findings and that he failed to check the paper with a respected member of the field, considered wise practice if one wished to publish a paper with the implications that this one obviously had. While eventually his theories were validated as true, the initial reaction was scornful. Sir Arthur Keith, a former President of the Anthropological Institute and the leading Anthropological figure of the day stated "At most it represents a genus in the chimpanzee or gorilla group . . . The Taung ape is much too late in the scale of time to have any effect on man's ancestry.\(^7\) and condemnation from a man

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\(^8\)Johanson and Edey 45.
of Sir Keith's stature meant the same would follow from the rest of the community.

It would not be until the end of Raymond Dart's life that he and the Taung find would received the respect and acclaim they each deserved. In his later years he would become a respected member of the Anthropological community and would even be affectionately dubbed "Uncle Ray" by his colleagues.9 This first Australopithecine find set the stage for Robert Broom and his Robust Australopithecine finds in South Africa as well as the work of Louis and Mary Leakey, perhaps the two most important physical Anthropologists ever, and their work has now been built upon by their son Richard and his rival, nemesis, and occasional friend Donald Johanson, the two most influential men in the field today.

When we look at primate and hominid evolution the number of pertinent species, theories and evolutionary trees are overwhelming, what I will try to discuss are the key players and mainstream theories in primate, hominoids, and human evolution.

Primate like animals first appear to have evolved at the end of the Cretaceous period, roughly 65 million years ago. These animals were small, nocturnal, aboreal creatures, probably very closely resembling the modern tree shrew. Very few fossils of these animals exist, however, recently, teeth and jaw fragments of an animal dubbed Purgatorius have been recovered from Cretaceous and Paleocene deposits in the Western United States.10 These fossils,

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9Milner 107.
10Relethford 278.
while not conclusive, are the closest thing yet found to our first definitive primate ancestor.

The Eocene epoch (58 to 37 million years ago) saw not only the first true primate but also an adaptive radiation of the family. The major evolutionary adaptations that would separate the primates from the primate-like mammals were occurring; the development of the bony eye orbit (post orbital bar) is first seen in *Smioldectes*,11 development of prehensile hands and feet for grasping, a generalized skeleton adapted for an arboreal existence, teeth that were growing closer together, and enlarging brain cases. There were five families and 57 genera of the early prosimian like creatures during the Eocene Period, many of these became extinct, others evolved into today's modern prosimians, the lemurs, loris and tarsiers, and still others evolved into the anthropoids, the higher primates.12

The earliest known anthropoid dates from the late Eocene, called *Amphipithecus* is known only from fossil teeth and fragments of the jaw. While there is no post-cranial skeleton intact the cusp pattern and shape of the molars as well as the mandible structure13 do seem to indicate that this is very probably the first of the higher primates.14

From the end of the Eocene into the Oligocene (37 to 24 million years ago) the higher primates (which at the time roughly resembled present day monkeys) radiated again, filling the ecological niches

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12 Relethford 279.
14 Relethford 279.
that the prosimians had held. One of the most interesting and controversial of all the primates of that period is the genus *Aegyptopithecus*. For years it was thought that this was the link between monkeys and apes, based on the molar cusp pattern. *Aegyptopithecus* has the Y-5 pattern common to all apes and hominids, while all monkeys have a bilophodont (four cusp) pattern. However, it has recently been discovered that the Y-5 is the more primitive characteristic and the bilophodont is a secondary, or derived characteristic,\textsuperscript{15} therefore negating evidence that *Aegyptopithecus* is an early ape, now it is simply grouped into the primate lineage before the monkey ape split.

The next important step in primate development came in the form of the *Dryopithecines* (also refered to as *Proconsulid*) Family, specifically the genus *Proconsul*. Living between 23 and 17 million years ago *Proconsul* had numerous ape characteristics while still retaining several monkey-like features. It had no tail, as well as shoulders that were rotated toward the back of the body (as opposed to the side as in monkeys), a Y-5 cusp pattern, 2-1-2-3 dentition, and thin tooth enamel, all characteristic features of extant African apes, however, *Proconsul* had monkey-like leg to arm length ratio (50-50) as well as simian hands and arms.\textsuperscript{16} Due to these similarities it is commonly felt by most, but certainly not all, of the Anthropological community that this was the monkey-ape link and a crucial part of our evolutionary heritage.

\textsuperscript{15}Relethford 282.
\textsuperscript{16}Relethford 287.
The next important link in the Primate family tree is the genus *Sivapithecus* (the genus in which all *Ramapithecines* are now placed), which spanned across Africa into Europe and Central and Southeast Asia from 17 to 8 million years ago. Possibly a direct descendant of a branch of *Proconsuls*, *Sivapithecus* represents possibly the next step forward on the evolutionary ladder. In the 1960's it was felt that the *Sivapithecines* were almost certainly ancestral to humans either before or after the hominid-great ape split. Some scientists went as far as to place *Sivapithecines* in with the hominids.\textsuperscript{17} However due to recent molecular research and fossil finds this opinion is rapidly changing. Analysis of the protein Albumin led Vincent Sarich and Allan Wilson, biochemists at the University of California, Berkeley to place the hominid-ape split at 5 million years, making *Sivapithecus* far too old to be a hominid.\textsuperscript{18} Additionally, recent *Sivapithecine* skeleton finds have allowed scientists to discern a very close relationship between the fossils and extant orangutans. This means that they, in the words of paleontologist Roger Lewin, are "... disqualified from being a hominid, because humans are more closely tied to the chimpanzee and the gorilla than they are to the orangutan."\textsuperscript{19}

While this recent evidence decreases the importance of the *Sivapithecines* they are still crucial to our understanding of our ancestral line before the Pongid-Homo split. These very well may be our great-great-grandfathers, but due to the incomplete nature of

\textsuperscript{17}Relethford 295.  
\textsuperscript{19}Lewin 116.
the fossil record we can clearly discern if Sivapithecus is a shared ancestor with the orangutan's or simply a distant, non-ancestral cousin.

After Sivapithecus there is conspicuous hole in the fossil record, appropriately named the hominid gap. For roughly ten million years (from 14 until 4 m.y. ago) the fossil record is essentially nonexistent for hominoids, the ancestral primates seem to "drop out" of existence. Very few specimens of any type of ape are known to have existed in this interval, however the *Dryopithecine* family is relatively well represented. For years the prevailing theory was that these *Dryopithecines* (in particular *Ramapithecus*) were the bridge over the gap, but in light of the aforementioned evidence, this theory has been essentially discarded, and the hunt for the much romanticized "Missing Link" resumed.\(^{20}\)

The next significant step in ape-Homo evolution comes at the end of this "gap", where it appears that the human ancestral line splits off from the pongids. It is in rocks from this time interval (four to five million years ago) that the first *Australopithecine* skeletal fragments have been found. These fossil fragments represent the first emergence of the hominids, the family to which *Homo sapiens* belongs. First discovered by Raymond Dart, extensive further research has lead to numerous fossil finds, including the stunning "Lucy" skeleton found by David Johanson in Hadar, Ethiopia. A forty percent complete $s$ skeleton, Lucy clearly demonstrates a bipedal, upright posture as well as an enlarged brain case (400 c.c.),

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\(^{20}\)Milner 16.
significant evolutionary steps away from the apes.\textsuperscript{21} These fossils, as well as others discovered by Mary Leakey at Laetoli, Tanzania, have been dated to around 3.75 million years ago, clearly show the split between the ancestral great apes and the ancestral hominids had certainly happened by then.

In recent years there have been several fossil hominid finds which had pushed the split further back in time. The oldest conclusive find has been of fragments of a mandible, a molar crown and two molar roots from the Lothagam Hill site in Kenya. These fossils, which have been conclusively shown to be from a \textit{Australopithecus afarensis}, have been positively dated to 5.5 to 5.0 million years ago. However, disputed fossils have been dated as far back as as 12 to 9 million years ago.\textsuperscript{22}

The evolutionary history of the apes becomes increasingly skewed at this time. In the past there were several theories that were in the mainstream of Anthropological thought, however, in light of the large number of hominid finds these theories have been shown to be erroneous. The only clear evolutionary relationship is between the Asian Sivapithecus and the modern orangutan, the other hominoids, the gorilla, chimpanzee, and gibbon, have very myopic histories. In all likelihood fossil evidence of these primates has simply not been found yet.\textsuperscript{23}

The recent technological breakthroughs in genetic technology have allowed new and more accurate analysis techniques to be used

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\textsuperscript{21}Relethford 303.
\textsuperscript{23}Stein and Rowe 394.
to determine the closeness of our genetic link with the primates. The previously mentioned work of Sarich and Wilson, in which they determine the closeness of relation by the reaction of one species immune system when injected with another species proteins, was the first step made with the new technology. They were able to determine that humans, chimpanzees and gorillas were more closely related than initially thought and the Asian orangutans and gibbons were more distant relatives. This has lead to many zoologists regrouping the primate family tree placing humans, chimpanzees, and gorillas in one family, orangutans in one, and gibbons in yet another. Using the data obtained in their study Sarich and Wilson were able to hypothesize that humans and chimpanzees split off only five million years ago. This flew in the face of popular convention, which believed the split to be around fifteen to twenty million years. However, molecular analysis by Cronin (1983) and later by Gingerich (1985) has roughly confirmed Sarich and Wilson's conclusions, Cronin putting the split at five million years and Gingerich at nine million.

The study of amino acid sequences has also improved our understanding of our link with the apes. This type of analysis is more accurate than Sarich and Wilson's immunological studies because it actually reconstructs the genetic material and allows it to be analyzed. Amino acid sequence substitution provides us with the minimum number of changes necessary on DNA to differentiate two

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24 Stein and Rowe 332.
species. Through this technique it has been found that human and chimpanzee polypeptides (complex proteins) are 99% identical.\textsuperscript{26}

The most accurate of all the analyzation techniques is DNA hybridization. This is when the DNA double helix is split and combined with a strand of DNA from another organism. Because every species has a different series of nitrogenous bases, the strands do not completely match up, however, the closer the genetic tie between two species the closer the match will be, and, therefore the molecule will be more stable. The amount of stability can be determined by slowly raising the temperature of the DNA. The higher the temperature at which the DNA differentiates into two strands the closer the genetic match.\textsuperscript{27} Analysis of this sort has led to the conclusion that the DNA differentiation between humans and chimpanzees is 1.2% roughly that between horses and zebras.

Another interesting line of research not directly related to the study of the great apes in mitochondrial DNA (mtDNA) analysis. Unlike normal cell DNA, half of which comes from the male gamete and half of which comes from the female gamete, the mtDNA comes entirely from the female gamete. Because of this the genes are not mixed in each successive generation and the genetic lineage can easily be traced. In 1987 Rebecca Cann analyzed the mtDNA of 147 women of different nationalities, using this data and assuming a constant rate of random mutation of the DNA. She concluded that the

\textsuperscript{26}Stein and Rowe 311.
\textsuperscript{27}Stein and Rowe 333.
mtDNA in all humans stems from a single female human ancestor who lived in Africa between 140,000 and 290,000 years ago.\textsuperscript{28}

Recent studies by Hedges and colleagues and Templeton (1992) have shown that the method for reconstructing family trees using this method is incorrect. This, along with questions about the sample populations, has jeopardized the validity of mtDNA, and little stock is now placed in the so called "Eve" hypothesis.\textsuperscript{29}

The study of our long lost ancestors and our cousins, the apes, is far from over. Just now are we starting to understand exactly how closely we are linked to them. Our research into our mutual past should help heighten our knowledge of our own survival as well as aiding the conservation and preservation of the remaining extant apes.

There are great gaps in the fossil record which need to be filled in, and only through the diligence of Anthropologists, and a good deal of luck, will we ever fill in those gaps. As we slowly start to unravel these clues of our past we will find that not only will we have a better understanding of who we are but also where we will be in the future.

\textsuperscript{28}Relothford (2nd Edition) 391.
\textsuperscript{29}Relothford (2nd edition) 392.
Bibliography:


