The Theory of Evolution - Stephen Segall

[audio of talk Pt I; http://nadineloveshenry.com/chapala/ft/audio/2017-03-15.mp3]

Charles Darwin published his great theory in his famous and controversial book, “The Origin of the Species” in 1859 following various expeditions, including his famous voyage on the HMS Beagle to the Galapagos Islands off the coast of Ecuador.

A thorough definition of biological evolution might be:

Evolution is the change allele frequency in a population - the genetic composition of that population - over successive generations, often resulting in the development of new species due to offspring varying from their parents as a result of random mutation and gene recombination, coupled with the heritability of these new genes, as well as the differential survival and reproductive success of individuals competing for scarce resources including as food, shelter, and mates, while avoiding predation and leaving viable offspring because of these physical differences, a process called natural selection.

Biological evolution is thought to have occurred over deep time, ever since the advent of the first replicator, which is thought to be or to have generated the last common ancestor (LCA) of the entire tree of life, which fact accounts for the commonalities in all species.

Evolution has been observed, and so can be called a fact. The fact of evolution is distinct from the theory of evolution, which accounts for it by suggesting a mechanism. Scientific theories can never be proven, just shown to be useful. To be scientific, however, an idea needs to be falsifiable, that is, if it is incorrect, there has to be at least the potential of demonstrating that. Finding a stratum of rabbit fossils deposited where they don’t belong - say, in a pre-Cambrian layer - would contradict the theory and threaten it if the findings couldn’t be explained by a geological process that brought the rabbit fossils deeper than they had formerly been and somehow mixed them with trilobites. Finding a 100 million year old modern human would have similar consequences.

Important features of the theory are that biological evolution occurs in populations, not individuals, and across generations, not within lifetimes.

Another is that the process is blind and unguided. This is often mistakenly called random, but that is incorrect. The selection process is directed toward ever more successful populations. The mutations are random, and environmental changes, which cause an acceleration of the rate of evolution, are not directed, but natural selection will not randomly change polar bears from white to black, whereas it would predictably cause a population of black bears whose habitat became perpetually snowy to become white.

Another feature of evolution is what is called punctuated equilibrium, which describes how evolution proceeds in fits and starts - rapidly when conditions are changing, and more slowly when conditions are more stable.

The definition of a species can be problematic. The usual one is that if two healthy, fertile organisms cannot produce fertile offspring, they are not of the same species. That’s obviously not an adequate definition for bacteria, which don’t mate, but rather divide.

And though we are descended from other species - perhaps Homo erectus was our immediate ancestor - there was never a first human or a last Homo erectus.

A clade is a collection of living and extinct organism that all descended from a single common ancestor through a series of splits in populations. Thus, the four genuses of extant great apes, Pongo, or the orangutans, Gorilla, Pan, or the chimps and bonobos, and Homo or man, and all their ancestors leading back to a single species of ancestral great ape, form a clade containing several others in a nested hierarchy.

Types of evidence for evolution

We'll begin with the kind of evidence available to Darwin

[1] Fossil evidence - Darwin had seen extinct transitional forms document change in traits through time. For example, Darwin found the larger fossils of extinct sloths in the same region as present-day sloths.

Since Darwin's time, many more transitional forms have been uncovered such as Tiktaalic, an extinct fish-amphibian intermediate, Archeopteryx, an extinct dinosaur bird intermediate, and multiple hominan fossils of extinct forms leading to man.

We have also examined much of the geologic column, and find the fossils stratified, older ones being deeper and more recent forms above them, including more complex forms not found in deeper strata.

[2] Vestigial features in animals - These include tiny, useless leg bones in whales, dolphins, and some snakes, and unused eyes in blind cave fish. Darwin was the first to describe and interpret these traits.

[3] Biogeographical data. Darwin observed the variation in the Galapagos finches, especially their beaks, that varied according to island and food source. Darwin reasoned that they shared a common ancestor, and had transformed over time to optimally exploit their local food sources.

He was also aware of how the marsupials of Australia seemed to have the forms and behaviors of the placental mammals, and surmised that these two groups of animals evolved to fill corresponding niches.

Today, we can add ring species, such as the salamanders of California's central San Joaquin valley that gradually transform as they migrate around some natural barrier. Neighboring variants are still able to mate, but eventually, as the ring closes, the variants on the two ends cannot reproduce and are therefore considered separate species.

Likewise with the Larus gulls of the arctic, who don't get further north than a certain latitude, and created a similar pattern around the northernmost circle available to them – neighbors are variants that can breed, but by the time the ring was closed, it was now two different species of gulls meeting.

[4] Structural homologies - Darwin pointed out that if all mammals descended from a common ancestor, and if that ancestor had a limb with the same basic arrangement, then it would be logical to observe that its descendants had a modified form of the same arrangement. Darwin was aware that the same bones in the same relative positions occur in primate hands, bat wings, bird wings, which suggested common descent.

[5] Comparative embryology - Darwin was not only aware of the vestigial bones in some adult forms, but their more pronounced appearance in their embryos such as legs on dolphin and snake embryos, and tails and gill folds on human embryos. Today, man has a vestigial tailbone, the coccyx, but as an embryo, he has a full tail.

Based on all of those observations, Darwin suggested that all life descended from a common ancestor in the manner described in the definition of evolution.

Since that time, we have accumulated other kinds of data not available to Darwin.

[6] Evolution has been reproduced in the lab and documented in nature such as fruit flies that have lost the ability to interbreed and became two new species, multiple species of the house mouse unique to the Faeroe Islands occurring within 250 years of introduction of a founder species to the islands, and five new species of cichlid fishes forming in a single lake within 4,000 years of introduction of a parent species.

[7] Genetic evidence - chromosome homologies, common genes, “junk” DNA including endogenous retroviruses, a common genetic code, molecular clock evidence in the DNA which timeline corresponds with fossils and radiometric dating data, and human chromosome 2.

[8] Molecular evidence - common biological pathways such as the (Krebs cycle), common A, B, O blood typing and the Rh factor, the insulin molecule, and the proteins responsible for color vision (same as those found in Old World primates but absent in New World primates and from all other mammals.

[9] Bacteriology, virology, immunology, pest-control - the way that bacteria evolve in response to antibiotics, viruses evolve to require new vaccines, and assorted vermin develop resistance to pesticides.

[10] Nested hierarchies in the anatomy, biochemistry, and genetics of living things. We can think of these as nested boxes. Consider a large box containing two or more smaller boxes, each containing two or more even smaller boxes, and so on, until we reach the smallest boxes, each containing an object similar to the object in the adjacent box, and less similar than what is contained in the smallest boxes in the adjacent next to smallest box. The tree of life is organized that way.

Species are the smallest boxes. Similar species are grouped as a genus, the next larger box, and so on up the largest boxes, the various kindoms such as plants, animals, and fungi.Taxonomic groups fit neatly and completely inside other taxonomic groups. All monkeys are mammals, and all mammals are vertebrates. Likewise, all dolphins are also mammals, and thus also vertebrates. But all penguins are birds, and also vertebrates, but not mammals. This is what evolution predicts. The same relationships are seen in the eznymes and other proteins of living things, and in the DNA. Two kinds of monkeys will have more similar chemistry and genetics than a monkey and a dolphin.

[10] The predictive power of the theory and the ability to use it productively in areas such as medicine and agriculture.

At this time, the evidence for evolution is so robust that there can be no other naturalistic explanation for it. If the theory had to be tossed out, all that is left is that a deceptive intelligent designer seeded the earth with fossils in strata and arranged the DNA of all living things to make it appear that evolution had occurred.

“Consilience” is the word used to refer to multiple independent avenues all pointing to the same conclusion. That is, when multiple sources of evidence are in agreement, the conclusion can be very strong even when none of the individual sources of evidence is significantly so on its own.

For example, it should not matter whether one measures the distance between two points by satellite imaging, by laser rangefinding, or using a yardstick. In all three cases, the answer should be approximately the same. And if that happens, we can be confident in that answer. Evolutionary theory enjoys that status.

The evolutionary path leading from the first cell to primates

Let’s do a quick review of evolution leading from the first life to the various primates.

Like all life on earth, man is thought to have descended according to the mechanism proposed by Charles Darwin from a common ancestor that lived billions of years ago. Life was on earth by 3.8 billion years ago, when the earth was about 750 million years old.

It was the simplest possible cell, or biological replicator - unicellular, marine life forms that after a very long delay, on the order of 2 billion more years, evolved into eukaryotic cells, which are more complex cells containing a nucleus and other membrane bound organelles such as chloroplasts, mitochondria, endoplasmic reticulum, and the Golgi apparatus. These then developed sexual reproduction about 1.2 billion years ago.

Then, by about 600 million years ago, multicellular life appeared, and what is called the Cambrian explosion followed about 60 million years thereafter - a period in which multiple life forms visible to the naked eye appeared in the oceans that now appear only in the fossil records.

These were initially radially symmetric life forms like sponges and jellyfish, but evolved into bilaterally symmetric creatures like trilobites with heads and tails about 550 mya, followed by wormlike creatures, and then to fishlike creatures about 500 mya that acquired backbones and eventually left the sea about 360 mya ago. Plants and insects already had done that.

From there, amphibians arose (360 mya), followed by reptiles (300 mya), and then about 200 mya, the earliest mammals, including the insectivores that survived the asteroidal impact of 65 million years ago that eliminated the dinosaurs. This opened new niches for these surviving mammals, and the primates evolved from the insectivores to exploit arboreal niches.

Intermediate forms connecting these classes have been uncovered such as Tiktaalik, half fish and half amphibian, and Archeopteryx, half dinosaur and half bird.

A word on nomenclature

The classification of living things is called **taxonomy**.The naming system tries to capture the treelike relationship of the various species. Species are grouped together according to various commonalities. Two similar species will fall into the same genus, for example. Originally, similar genuses were grouped into families, families into orders, orders into classes, classes into phyla, and phyla into kingdoms.

Unfortunately, many more subdivision, or **taxons**, have been added. Orders have suborders, suborders have infraorders, infraorders are divided into parvorders, parvorders divide into super families, then families, then subfamilies, then tribes, then subtribes, and finally back to genus and species and then subspecies.

These are all given Latin names as well as their anglicized variants. Thus, we belong to Kingdom Animalia, Phylum Chordata, Subphylum Vertebrata, Class Mammalia, and order Primates, be we say that we are animals, vertebrates, chordates, mammals and primates.

Once we get down to the superfamily of apes, the words all start to look alike, both the Latin and anglicized forms. We belong to the superfamily of apes called Hominoidea, or the hominoids. Remove the lesser apes, and we are left with our great ape family Hominidae, or the hominids.

Remove the orangutan line and what remains is our subfamily Homininae, or the hominines (gorillas,chimps and man). Remove the gorillas and we have tribe Hominini, or the hominins (chimps and man). Remove the chimp branch leaving only the line leading to man, and we have subtribe Hominina, or the hominans.

This is an area that has been in a state of relatively rapid flux as new information accrued over the last several decades. Older sources use other classification schemata lending to some confusion. The shifting classifiaction and nomenclature seems to be stablizing, but recently, the line that separated from the chimp line, once called hominids, have gone from being called hominins to hominans.

The evolution of the primates up to man

The first primates appeared 50-55 mya, 10-15 million years after the asteroidal impact that led to the extinction of the dinosaurs and the end of the Mesozoic era, and which ushered in the age of the mammals.

The Eocene epoch of the Cenozoic era began about 56 mya, when the oxygen levels in the atmosphere increased considerably, along with a rise in global temperatures (9-16° F / 5-9° C higher) and sea level (330 ft / 100m), changes which facilitated a relatively rapid explosion of placental mammals including the first primates.

The earliest member of what became order Primates, or the primates, was a species descended from what was formerly called order Insectivora, probably a creature like a treeshrew.

Primates are characterized by having more forward facing eyes with stereoscopic vision in bony sockets, highly flexible limbs and fingers with five moveable digits per hand, flat nails on their fingers and toes rather than claws or hooves, opposable thumbs, a diminished sense of smell, as well as collar bones and enlarged cerebral cortices.

Prosimians

The earliest primates, the prosimians, had relatively long, pointed snouts, wet noses, and whiskers. Modern wet-nosed prosimians include lemurs (Madagascar), lorises (Southeast Asia), and galagos (or “bush babies” in Africa).

Eventually, a dry-nosed prosimian like the modern tarsier split from the wet-nosed prosimians forming **suborder Haplorrhini**, the dry nosed primates.

Eocene prosimians were more widely distributed then than now. They lived in North America, Europe, Africa, and Asia. It was during this epoch that they reached what would become the island of Madagascar, where they flourish up to modern times.

The great diversity and widespread geographical distribution of Eocene prosimians was probably a consequence of the fact that they did not have competition from monkeys and apes, since these latter more advanced primates had not yet evolved.

Prosimians are all nocturnal except the lemurs of Madagascar. And unlike higher primates, they almost all possess a tapetum lucidem reflective surface inside their eyes.

Monkeys

From the prosimians came the monkeys, the first simians, also called anthropoids, comprising **infraorder Simiiformes**. They first appeared about 45 mya. Compared to the prosimians, monkeys have flatter faces (shorter, less foxlike snouts), fewer teeth, dryer noses, larger brains, even more forward looking eyes, and smaller and less mobile outer ears. Having better vision and less olfaction due to shorter snouts suggests that these first monkeys were probably more diurnal than their prosimian ancestors.

Like prosimians, they tend to run along branch tops rather than swing from branch to branch like the apes that would come later.

Monkeys are broadly classified as either Old World monkeys, which are found in Africa and Asia, and the New World monkeys of Central and South America. Apart from one genus of New World monkeys, they are all diurnal.

Due to the relative paucity of Oligocene prosimians in the fossil record, it is believed that the monkeys out-competed and replaced them in most environments at that time. This idea is reinforced by the fact that modern prosimians either live in locations where monkeys and apes are absent, or they are normally active only at nighttime when most of the larger, more intelligent primates are sleeping.

New World monkeys, or the **platyrrhine** ("flat-nosed") monkeys**,** who first appeared about 30 mya, have a flatter nose with their nostrils further separated than their Old World counterparts, three premolars and two molars, a short thumb aligned with the rest of the fingers and a muscular prehensile tail that is used for balancing and grasping. Their forelimbs are more mobile and flexible than a ground dwelling tetrapod like a dog or bear, but they cannot straighten their elbows completely, and they have restricted movement of the forearm and wrist.

Typical examples are the marmosets, capuchin monkeys, spider monkeys, squirrel monkeys, and howler monkeys. Think of the self-portrait of Frida Kahlo amidst four black spider monkeys, or an organ grinder with a capuchin monkey on a leash.

When we exclude the New World monkeys, we are left with the Old World monkeys and their ape descendents - Old World simians - called **parvorder Catarrhini**.

Old World monkeys, or **catarrhine** ("downward-nosed") monkeys, from which all apes including human beings descended, have a narrow downward pointing nose, two premolars and three molars, and a short partially opposable thumb. They often have ischial callosities (hard calloused patches on their rear ends).

Although many Old World monkeys are small like the New World monkeys, this group also includes large monkeys such as mandrills, baboons, and macaques that might be mistaken for apes.

Apes

Once we exclude the Old World monkeys, we are left with the superfamily of apes, whose first representatives split from the Old World monkeys about 22-24 mya during the Miocene epoch. Proconsul, 21-14 mya, is an intermediate monkey-ape transitional form. During this epoch, prosimian and monkey fossils are rarer, whereas ape fossils become commoner. Dryopithecus is a very early ape.

Altogether, the apes comprise **superfamily Hominoidea**, or the **hominoids**. All are diurnal.

Apes include the gibbons and siamangs, together known as the lesser apes, or **family Hylobatidae** - the hylobatids - and the orangutans, gorillas, chimps (and bonobos), and man collectively known as the great apes, or **family Hominidae**, also called the **hominids**.

Compared to monkeys, apes are larger, have a broader rib cage, are more muscular, have bigger brains with more convoluted cortices, have color vision, lack cheek pouches, have a fused frontal bone, have more narrow noses with downward pointing nostrils, have molars with five cusps rather than four, a different shoulder anatomy adapted for swinging through the trees - or brachiating - rather than crawling above their branches.

Their shoulders and wrists are more flexible than those of monkeys, they have longer and stronger upper limbs with elbows that can straighten but relatively shorter lower limbs, no tail, an appendix - monkeys lack these – and on the ground, they are knuckle walking quadrupeds. Apes are more dependent on learned behavior as opposed to instinct than monkeys or any other lower taxon.

Compared to the great apes, the lesser apes comprise four genera (genuses) and 16 species of gibbons including the siamang. They are shorter and have relatively longer arms to body height than the great apes. The lesser and great apes began to diverge about 20.4 mya

Great apes

The existing great apes comprise 4 genera:

- Pongo - the orangutans (4 Bornean species and 1 Sumatran)
- Gorilla – the gorillas (2 Western species and 2 Eastern)
- Pan - the chimps (1 species with 4 subspecies) and bonobos (1 species)
- Homo - man

The great apes began separating from one another when the last common ancestor of the gorillas, chimps, bonobo, and man split from the orangutan line to form two subfamilies about 15.7-21 mya, one the ancestor of orangutans, or the **pongids**, the other the ancestor of what would become the gorillas, chimps, bonobos, and man called **subfamily Homininae**, or the **hominines**.

The chimp's, bonobo's and man's last common ancestor split from the line leading to modern gorilla about 9 mya to form **tribe Hominini**, sometimes called **hominins**.

The line that split from the chimp-human last common ancestor and led to man is called **subtribe Hominina**, until recently also called the hominins, but now increasingly being called the **hominans**.

We have hominan ancestors, but no other living ape does. Estimates for when the hominin tribe split into chimp and human subtribes vary widely, from about 6.3-13 mya. Eight mya is a commonly cited figure.

Geology strikes again

Something very interesting happened over geological time that is considered key in the history of the evolution of man. We have already considered how the asteroidal impact that divided the Mesozoic and Cenozoic eras opened up niches for the small, surviving mammals and how the increases in atmospheric oxygen and temperature powered the radiation of primates in the Eocene epoch of the Cenozoic era. Now let's see look at the geological change that forced man's ancestors down from the trees.

There had been a gap between the continents of North and South America through which the waters of the Atlantic and Pacific Oceans flowed freely. Drifting tectonic plates, volcanic island building activity due to the Pacific plate subducting below the Caribbean plate, and accumulating sediments began creating the Isthmus of Panama beginning about 12 million years ago and ending about 3-4 mya.

The formation of the Isthmus of Panama had an enormous impact on Earth's climate and terrestrial environments, an effect that had a fateful impact on man's arboreal ancestors. By shutting down the flow of water between what is now the Pacific ocean and the Caribbean sea in the Atlantic, currents in both oceans were rerouted, creating among other things, what we call the Atlantic Gulf Stream, a swift warm current ranging from the Gulf of Mexico around the tip of Florida, up the eastern North American coast to Newfoundland, and across the Atlantic to the Old World. These oceanic changes had global atmospheric consequences as well. Western Europe became warmer, and parts of Africa that had been jungle (rain forest) slowly became the relatively treeless savannas we see there today.

Some species that were highly specialized for life in the trees went extinct, but some that were able to adapt survived, including our ape ancestors. The transition was rapid in geologic terms, but not in the terms of lifetimes of successive generations of our forebears. Continents just don't move that fast. Exposing apes to increasingly more treeless environments powered the environmental changes that led to the evolution of man, who is very different from his ape cousins of both then and today. Changes in environment accelerate evolution.

Over uncounted generations, ape-men came down from the trees, stood up, grew taller, became more gracile, grew bigger brains, developed more articulate hands, lost most of their body hair, learned to hunt and eat meat, tamed fire, made tools, acquired language, migrated across continents, formed complex societies and eventually developed complex cultures capable of sailing, agriculture, and domesticating animals. These are many of the features that distinguish man from his arboreal, brachiating cousins and ancestors.

Just how this transition occurred is still being worked out. Many species of hominan fossils have been found, some with familiar names like Australopithecus afarensis, Homo erectus, and the Homo sapiens neanderthalis.

Today we have multiple species of hominan fossils, and the task before the scientists is to determine in what order these changes occurred in our ancestors, which fossils are ancestral, and which represent failed branches from our family tree that went extinct. Kenyanthropus and Paranthropus, for example, probably represent the latter, whereas it is thought that Australopithicus afarensis, Homo habilis, Homo erectus, and Homo heidelbergensis were ancestral forms, although this has been extremely difficult to establish.

Let's look at that transition a little more closely.

The road to humanity

It was originally thought that the bigger brains that characterize modern man were the first major change in our ancestors, and that bipedalism and changes in diet and dentition, for example, came later.

You've undoubtedly heard of the hoax called the **Piltdown man**, where somebody treated and planted fragments of the teeth and skulls of chimps, orangutans, and medieval humans together to be uncovered. This "missing link" was deceptively fashioned to appear to be a big-brained, quadrupedal ape.

A skull can tell us whether the creature that had it walked on all fours or upright according to the location of the foramen magnum, the hole through which the fibers of the spinal cord enter and leave the brain and skull.

In a quadruped, the foramen magnum is located in the occipital part of the brain, or the posterior aspect of the skull. In an animal that stands upright, it is on the inferior aspect of the skull.

Piltdown man was created with a large cranial capacity - closer to the 1300-1400 cc of a human being than the 300-400 cc of a chimp - and an occipital foramen magnum.

The hoax was exposed before it was proven that bipedalism preceded big brains, but the truth of that was evident in **Australopithecus afarensis**, whose first discovered member was a fairly complete female found by Don Johansen in 1974 and nicknamed Lucy.

Lucy is closer to a chimp in stature and dimensions than a modern man, but has her foramen magnum under her skull, which cranial capacity was about 450 cc.

She also had reduced canine teeth and smaller molars than arboreal apes suggesting that our ancestors' diet was changing before bigger brains formed. This is interesting because if Lucy lived on the ground, her tribe was probably already hunting and eating meat with their smallish, lower ape-sized brains.

Lucy's kind are thought to have walked the earth 3.0-3.9 million years ago, about the time of the formation of the Isthmus of Panama. Was she an ancestor that gradually evolved into a more modern ancestor, or was she part of a branch from our ancestors that went extinct? We don't know, but it is suspected that if she wasn't an ancestor, something very similar from which she could have branched was.

Lucy is the earliest obligate bipedal hominan known, by which is meant that she was an animal that traveled exclusively on two feet.

Before Lucy, about 4.4 mya, another hominan called **Ardipithecus** (-pithecus means ape) lived in the African woodlands, not the savanna. Although this creature walked upright on the ground, it still had prehensile toes for navigating the trees where it spent most of its day. This may have been the era in which apes were still principally arboreal vegetarians, but were experiencing a thinning of their woodlands, beginning to spend more time on the ground, and pressured by circumstances to change their diets.

Hominan skull evolution

Let's discuss the evolution of the skull in the hominan line. We've already considered the change in the location of the foramen magnum associated with bipedalism, and alluded

to changes in dentition associated with the change in diet, which included smaller teeth, changes in the cusps of the molars, less enamel, and more vertically angled teeth rather than the forward angled teeth of leaf, fruit, young shoot, and nut eating arboreal apes.

Associated with these changes were those that reflected the reduced facial musculature that accompanied the acquisition of an omnivorous diet. We lost the muzzle of our forebears and acquired flatter faces, as well as a chin, and a smaller, more parabolic mandible, or jaw.

The sagittal crest, a bony prominence at the top of the skull like a mohawk which anchored the origins of powerful jaw muscules, disappeared. The temporal fossae - the depressions on the side of the upper skull above the ears - become shallower as jaw musculature diminishes. The shape and size of the zygoma. or cheekbones diminishes as does the size of the hole in them through which jaw muscles pass on the way to the mandible. The nuchal ridge in the lower back of the skull, the occipital region, to which neck musculature attaches also becomes smaller.

Other changes include the larger calvarium, or skullcap, to accommodate the bigger brains, a higher forehead, changes in the size of the ear holes, the nose becomes pointier, and the brow ridges gradually disappear.

Other skeletal differences

Also, modern man is taller than his ancestors, the shoulder and clavicle (or collar bone) change in size, shape, orientation, and mobility to reflect the absence of any need to swing through branches, his arms are relatively shorter compared to his overall size and hang closer to his side, his thumb is relatively longer, his palms smaller with a broken palmar crease, his chest is less robust and more slender, his legs relatively longer and thinner with the knees oriented forward and closer together, and the pelvis oriented differently to reflect bipedalism, as well as having a larger central opening to reflect a need to birth bigger-brained babies.

The feet change from flat to arched, and the foot goes from being a lower hand with a divergent hallux - or big toe - capable of grasping, to the modern human foot, where the toes are used for maintaining balance instead and are rather inarticulate. They can't be used for much else.

Genus Homo arises

Eventually, the genus Homo appears with the advent of **Homo habilis** about 1.5-2.3 mya, the late Pleistocene. This guy is the earliest creature to be called Homo - a controversial designation. Nobody is clear on what the definition of Homo is, and why some early forms should be included in this genus, but not ones preceding it. There is no clear demarcation.

Although he was a meat eater and may have been the first to cook his food, Homo habilis was probably still pretty furry, albeit less so than Lucy and modern apes, and appears to have lived in woodlands rather than the open savanna.

His brain was about half the size of a modern human (about 650 cc), he was short statured - about 4' 3" – and had disproportionately long arms relative to modern humans - all apelike characteristics.

Nevertheless, his remains have been found with primitive stone tools, hence his name “handy man” and inclusion in genus Homo.

A 2.8 million year old jawbone fragment found in 2013 is thought to be intermediate between Australopithecus and Homo habilis.

Homo ergaster, who appears at about 1.5-1.8 mya, was taller and more slender, probably the first mostly hairless hominan, probably had complex social behavior since babies that would eventually have bigger brains were being born to females with relatively smaller and more narrower pelvises, meaning that these infants needed to be born more prematurely and required more care and support for the caregiver.

Homo ergaster is perhaps the first to leave Africa, although the same is said about Homo erectus. There is also dispute whether these two should be grouped together as a single species.

Compared to the other extant great apes, humans grow much longer hair on their heads and lower faces, and can go bald. Was this true of Homo ergaster? We don’t know.

Hairlessness is an interesting topic. It’s associated with the appearance of sweat glands and sweating, which is how man siphons of excess body heat when exerting himself. Hairy and furry creatures, including those our ancestors hunted, don’t sweat. They pant when overheated.

This adaptation led to the advent of what is called persistence hunting. Panting quadrupedal animals can sprint quite rapidly, but only for relatively short distances before having to stop to pant - something they can’t do while sprinting.

Hominan hunters, though much slower, had much greater endurance and could eventually run their prey into exhaustion for the kill through a combination of jogging and speed walking.

Wikipedia describes persistence hunting as "a hunting technique in which hunters, who may be slower than their prey over short distances, use a combination of running, walking, and tracking to pursue prey until it is exhausted. A persistence hunter must be able to run a long distance over an extended period of time."

Next is **Homo erectus**, who was around before Homo ergaster (oldest fossils 1.9 mya), but seems to have survived until relatively recently (most recent fossils 70,000 ya). Turkana boy discovered by the Leaky’s in Africa in 1984, Peking man, and Java man discovered by Eugene Dubois in 1891 were all Homo erectus.

These hominans were likely the first to migrate out of Africa (around 1.8 mya). They have been found throughout Eurasia in such remote areas as Georgia, Turkey, India, Sri Lanka, China, Vietnam, and Indonesia. They had bigger brains, were tool users (hand axes), were perhaps the first to build shelters, use fire, and make sea voyages (hence Java man on the island of Java).

He still had brow ridges and a bit of a muzzle, as well as a broad nose and relatively long arms. His cranial capacity ranged from 850 - 1100 cc, he stood about 5’ 10”, and was more slender than his ancestors

Homo heidelbergensis lived about 200,000 - 600,000 years ago, used obsidian spears, possibly buried their dead, and are thought to have had primitive linguistic skills based on the anatomy of their necks, which suggest vocal chords.

The defining feature of hominans since Australopithecus afarensis, Lucy, is that they are habitually bipedal, meaning not that they are capable of walking on two legs, but that it is their habit to do so. It is not incorrect to define man as the bipedal ape, although he is also the naked ape and the ape with language. Other differences are relative

Essentially humans can be described as the Apes that walk on two legs. The features of hominans ultimately relate to their bipedal lifestyle.

Homo sapiens neanderthalensis lived about 200,000-28,000 years ago. He produced art, definitely buried his dead, had a larger nose than ours, was more robust, stood about 5'5", and had a modern human's cranial capacity (1400 cc) cranial capacity.

Homo sapiens sapiens (Cro-Magnon) was able to successfully mate with the Neanderthals, but with difficulty, especially when the Neanderthal was the male and the fetus was male due to mutations in the Neanderthal Y-chromosome that would elicit an immune response in the mother. Modern non-Africans have Neanderthal DNA suggesting that Neanderthal arose in Europe following a migration out of Africa by a precursor that became Neanderthal there.

Arguments against evolution

There are no credible counterarguments against evolution. It is a theory that unifies multiple types of evidence under an explanatory mechanism that is plausible and accounts for observed evolution, is falsifiable, makes predictions about what can and cannot be found that have never been falsified, and has had practical application in such areas as agriculture and medicine. It works, and it has no competition. Creationism does none of those things.

Objections are virtually all going to come from the subset of theists that are creationists - people promoting a religious agenda that they feel is contradicted by the Theory of Evolution.

It should be noted that most Christians accept evolution as fact:

[1] Baylor University, the largest Baptist University in the world has stated: "Evolution, a foundational principle of modern biology, is supported by overwhelming scientific evidence and is accepted by the vast majority of scientists. Because it is fundamental to the understanding of modern biology, the faculty in the Biology Department at Baylor University, Waco, TX, teach evolution throughout the biology curriculum. We are in accordance with the American Association for Advancement of Science's statement on evolution. We are a science department, so we do not teach alternative hypotheses or philosophically deduced theories that cannot be tested rigorously."

[2] The Vatican claims Darwin's theory of evolution is compatible with Christianity http://www.telegraph.co.uk/news/religion/4588289/The-Vatican-claims-Darwins-theory-of-evolution-is-compatible-with-Christianity.html ; Pope John Paul Paul II said, "new scientific knowledge has led us to the conclusion that the theory of evolution is no longer a mere hypothesis."

[3] The United Methodist Church : "THEREFORE BE IT RESOLVED that the General Conference of the United Methodist Church go on record as opposing the introduction of any faith-based theories such as Creationism or Intelligent Design into the science curriculum of our public schools." http://idexposed.wordpress.com/2008/05/19/united-methodist-church-evolution-and-intelligent-design/

[4] The Church of England, 2009:"Charles Darwin: 200 years from your birth, the Church of England owes you an apology for misunderstanding you and, by getting our first reaction wrong, encouraging others to misunderstand you still. We try to practise the old virtues of 'faith seeking understanding' and hope that makes some amends."

[5] In the main atrium in Notre Dame's new Jordan Hall of Science, there is a plaque that reads: "Nothing in biology makes sense except in the light of evolution."

[6] Here are more Christians rejecting ID as pseudoscience: http://en.wikipedia.org/wiki/Intelligent_design#Reaction_from_other_creationist_groups

Nevertheless, this science is under attack by a remnant. These are some of the commonest objections:

- "Macroevolution has never been observed. Sure, organisms can adapt to their environments in small ways, so-called microevolution, but have never been seen to transform into other kinds of animals." Irrelevant. We don't expect to see new families of animals arise over decades or centuries.

  Furthermore, science is the explanation for what HAS been observed, accounting for it, unifying the observations, suggesting mechanisms, making testable predictions, and by useful applications of the knowledge – not what hasn't been seen.

- "Evolution cannot account for why butterflies metamorphose, how the two genders arose, and this is a big problem for evolutionists."

  Problems for scientists to solve are not problems in the sense that phrase implies – problems that threaten the theory's viability.

  This is similar to the what-we-don't-see argument – what we don't know.

  Arguments that focus on what is not known yet, or what hasn't been found yet - so-called god of the gaps arguments - imply that if either A or B is true, and you can't prove or explain A, B must be true – an informal fallacy called an argument from ignorance.

  For example, we are commonly told by critics of the theory that the hominan fossil record cannot show lineage. We can't prove that any given creature descended from any other from examining its bones. However true that is, it is immaterial. Why would we need to do that for the theory of evolution to be correct? Yes, it is very difficult to determine which hominans are our ancestors, and which diverged from our line of descent from a common ancestral ape to generate cousin species.

  But the absence of that knowledge is not a weakness of the theory. We knew less fifty years ago, and we will know more in fifty years. Our level of knowledge is never an argument against the validity of the theory.

  What is important is what we DO have and know, including some things predicted by the theory, but not by creationism. The theory predicts that we will find older forms that are less human looking in deeper strata, and more recent forms that are more manlike and in younger strata, which is what has been found. Creationism cannot account for that, but it makes perfect sense from an evolutionary standpoint.

- “Man cannot have descended from a common ancestral great ape because all of the other apes have 24 pairs of chromosomes, and man but 23, implying the loss of a whole chromosome, which would be fatal” http://www.darwinconspiracy.com/ Human chromosome-2 was formed by an end to end-fusion of two ancestral ape chromosomes sometime after man split from the chimps and bonobos. This is known not only by the banding patterns of the two ape and one human chromosome, but also by the presence of two centromeres flanking central telomeric code in human chromosome 2.

- “If man evolved from apes, why are there still apes, and if evolution is correct, why are there creatures that have been stable for tens of millions of years.”

  This represents a misunderstanding of the process. The first question can be answered by analogy - If Americans derived from the British, why are there still Brits? The second is answered by understanding that if a population is well adapted to a particular niche in a stable habitat, mutations are much less likely to be beneficial than when habitats are changing. Nevertheless, these populations are evolving

- “Evolution is only a theory that cannot be proven.”

  Theories are the highest order of scientific knowledge, above individual facts and observations, and scientific laws. We don’t prove them. We demonstrate that are valid by confirming their predictions and their practical application.

- “Living things are irreducibly complex. They could not have formed by gradual increment because partial change would not be selected for. Remove a heart or a liver and death ensues.”

  That’s not evidence of irreducible complexity. Were it possible to reverse the growth and development process and go from adult to zygote, we would be seeing cells removed just as they were added with life maintained at all stages as it was coming in the other direction.

  Another common irreducible complexity claim is that you cannot remove any part of an eye and have it work. That’s roughly the same argument as the one above, and is also irrelevant. The evolution of the eye is well understood and its description is easy to find.

- Arguments from incredulity, a type of logical fallacy, which basically say in one form or another that someone just can’t believe it, or can’t see how it can happen - in this case, evolution.

  These most commomly are arguments from complexity: “It’s just too complex to have arisen naturally.” But complexity is not an argument for intelligence. Complexity can arise incrementally in naturalisitic processes.

  Here are two examples. In the second, the writer simply declares the theory impossible and adds an irreducible complexity assertion regarding the evolution of wings, also :

  [1] From Thomas Nagel....His 2012 book Mind and Cosmos: Why the Materialist Neo-Darwinian Conception of Nature Is Almost Certainly False, he elaborates his critiques of Darwinism: “It is prima facie highly implausible that life as we know it is the result of a sequence of physical accidents together with the mechanism of natural selection. We are expected [by mainstream biologists] to abandon this naïve response [critiquing standard materialist explanations of life’s origins], not in favor of an alternative that is really a schema for explanation, supported by

example. What is lacking, to my knowledge, is a credible argument that the story has a nonnegligible probability of being true."

[2] Jerry Fodor.....Natural selection "cannot be the mechanism that generates the historical taxonomy of species," he writes, for "the theory of natural selection is internally flawed…there's a crack in the foundations. Random mutation and natural selection alone are unable to find the extremely rare DNA sequences that yield solutions to complex biological problems.....the challenge for gradualist adaptationism is to explain how mutations capable of producing full wings can have accumulated silently over a long evolutionary time in the absence of any adaptive advantage."

- "The evolutionary scientists cannot be trusted. Remember the Piltdown man hoax." That was not evidence that science cannot be trusted. It was the opposite. It was evidence that a man could perpetrate a plasible hoax, and that science is self-correcting.

  Or, "Besides, even the honest ones keep changing their minds. How can we call evolution true if the scientists can't stick to one story?" This is a misunderstanding of how science works, and the different between core concepts like natural selectionand common descent, which are not controverial or changing, and cutting edge science, such as whether Homo habilis should be reclassified as an australopithecine, which is less well established and expected to go through multiple incarnations for years befire consensus is reached.

- "Evolution violates the 2nd Law of Thermodynamics, which states that nature proceeds to states of greater disorder, or higher entropy." Evolution does not violate thermodynamics any more than a zygote developing into an infant and then an adult or an acorn becoming an oak does. http://www.icr.org/article/does-entropy-contradict-evolution/

- "Radiocarbon dating is unreliable" http://www.icr.org/carbon-14 This is also untrue if one knows the limits of its application and proper technique to avoid contamination of specimens. The technique is based on the idea that mother isotopes radioactively decay into daughter isotopes, often of a different element, in a predictable way that is a function of time, or the half-life of the mother isotope. Various pairs of mother-daughter isotopes have been found, and their characteristic half-lives are known, which vary from thousands of years to millions. It becomes important to use the right isotope pair for the purpose. Carbon-14 decays to carbon-12, but the process is essentially complete after 50-100,000 years. Thus one cannot date dinosaur tissue this way. Potassium-40 decays to Argon-40 with a half-life of over a billion years, so wouldn't be useful for dating something under 100,000 years.

- "There are no transitional fossils between man and ape." They're all either human or ape. That is incorrect. The hominan fossil series can be ordered from older, more primitive forms to mere recent and more human-like forms. Several creationists were asked to judge six skulls as ape or human and couldn't agree whether any was human or ape. From http://www.talkorigins.org/faqs/homs/compare.html "As this table shows, although creationists are adamant that none of these are transitional and all are either apes or humans, they are not able to agree on which are which."

- Mutations cannot add information, they merely result in a degradation of the gene pool. That's simply untrue. Mutations change the genetic code. If code is considered information, then information can be added.

- Statistical arguments: The odds of all of the amino acids in a single protein coming together in exactly the right order are as astronomical as a tornado assembling a 747 jet from junkyard scrap (Hoyle's fallacy). This ignores the incremental change characteristic of evolution, and that biological systems are different from jets in that they can transform incrementally over generations as long as each step is compatible with life and selected for instead of against.

- "Survival of the fittest is tautological. They survive because they're fittest and they're fittest because they survive." Survival of the fittest is not the theory. It's a euphemism for the idea that the individuals that can get the most copies of their DNA into the population will alter the relative allelic frequencies of the population's gene pool more than others. It's not really about surviving, but reproducing. Surviving by being the fastest, strongest, or best camouflaged is not enough. One must compete successfully for mates, which of course requires surviving into and through reproductive age.

- "Darwin himself recognized that the fossil record was inadequate." Darwin did recognize that we needed to uncover more transitional forms, but neither he nor we, nor anybody in between sees this as a problem.

Here are three typical consecutive comments by critics of the theory frequently read at https://answers.yahoo.com/question/index?qid=20080421021810AAH3obx :

[1] "Evolution is the hypothesis that animals can change into different kinds of animals by means of natural selection working on genetic mutations. These alleged mutations need to add genetic information. However no such genetic mutation has ever been observed. Mutations are information neutral or lossy. 'But evolution is too slow to see' protest the evolutionists. Well then it's not observable and not worthy of being even called a theory. In any case, time is the enemy - mutations are resulting in the degradation of the gene pool - that is observable Darwin also used the fossil record. Actually they do not show evidence for evolution. Darwin admitted this himself as being one of the major problems with his theory. He expected that many more fossils would be found that would support his idea of common descent."

[2] "There is as yet not one piece of supporting data for the theory of evolution to be validated...not one piece for ANY species on this planet...much of the supposed "evidence" consists of speculation and assumption...then there are the outright frauds...it remains as a theory ONLY...this is the ONLY fact regarding the theory of evolution of species."

[3] "Superficial, circumstantial evidence...which is all Evolution has"

APPENDIX I - **Human taxonomy**

- **Domain Eukaryota** – cells with well formed organelles
- Unikonta (unranked)
- Opisthokonta (unranked)
- **Kingdom Animalia**
- Subkingdom Eumetazoa
- Superphylum Deuterostomia
- **Phylum Chordata**
- **Subphylum Vertebrata**
- Infraphylum Gnathostomata
- Amniota (unranked)
- Synapsida (unranked)
- **Class Mammalia**
- Subclass Theriiformes
- Infraclass Eutheria
- Magnorder Boreoeutheria
- Superorder Euarchontoglires

- Primatomorpha (unranked)

- **Order Primates**
- Suborder Haplorrhini - (dry-nosed primates) tarsiers and anthropoids
- Infraorder Simiformes (simians/anthropoids) - monkeys (old and new world), apes and man
- Parvorder/Taxon Catarrhini - old world monkeys apes
- Superfamily Hominoidea (hominoids) - apes (includes lesser apes such as gibbons and siamangs)
- **Family Hominidae** (hominids) - great apes
- Subfamily Homininae (hominines) - gorillas, chimps/bonobos, and man
- Tribe Hominini (hominan?) - Pan and the hominins
- Subtribe Hominina (hominins) - Ardipithecus, Australopithecus, Kenyanthropus, Paranthropus, Homo
- **Genus Homo**
- **species sapiens**

http://humanorigins.si.edu/evidence/human-evolution-timeline-interactive

APPENDIX II - Primate taxonomy

Order: PRIMATES -> Suborder STREPSIRRHINI: non-tarsier prosimians (wet-nosed primates: lemurs, lorises, pottos, galagos)
|
Suborder: HAPLORRHINI (dry-nosed primates): tarsiers and anthropoids -> Infraorder TARSIIFORMES: tarsiers (dry-nosed prosimians)
|
Infraorder: SIMIIFORMES monkeys, apes and man (simians/anthropoids)-> (Taxon/Parvorder PLATYRHINI) NewWorld monkeys
|
Taxon/Parvorder: CATARRHINI : Old World simians/anthropoids (apes and Old World monkeys)-> Superfamily CERCOPITHECOIDEA: Old World monkeys
|
Superfamily HOMINOIDEA ("hominoids") the apes -> lesser apes (Family HYLOBATIDAE) Gibbons Genus Hylobates
|
Family HOMINIDAE ("hominids") great apes -> (Subfamily PONGINAE) Orangutans
|
Subfamily HOMININAE ("hominines") Gorilla, Pan and Homo -> Tribe GORILLINI
|
Tribe HOMININI ("homin..?") Pan (chimps, bonobos) and Homo -> Subtribe PANINA
|
Subtribe HOMININA ("hominins") Homo and Australopithecoids -> Austrlopithecoids (Australopithecus, Ardipithicus, Paranthropus)
|
Genus Homo

APPENDIX III - observable and testable evidence of human evolution

Observable
http://media.npr.org/assets/news/2010/03/22/skulls_wide-26add557279907968771ff3bc02b43fe168dc483-s6-c30.jpg

http://3.bp.blogspot.com/-shnmf8OB04U/TpMH8rBulZI/AAAAAAAABgg/KNTh6na47w4/s1600/hs.gif
http://4.bp.blogspot.com/_BisAUOY9kFU/TS47ZqXEHqI/AAAAAAAAACM/c3U6y61es48/s1600/skulls.jpg
https://en.wikipedia.org/wiki/Hominidae#/media/File:Fossil_hominids.jpg

Testable (and replicated)
https://www.sciencedaily.com/releases/2009/01/090120144508.htm
http://www.pnas.org/content/112/51/15696
https://pandasthumb.org/archives/2006/09/fun-with-homini.html

APPENDIX IV - Differences between monkeys, and apes including man

http://askjohnmackay.com/man-apes-and-monkeys-what-are-the-differences/

APES AND HUMANS

Posture and Locomotion

Humans are uniquely designed for upright stance and bipedal movement. Although apes can walk on two legs for a short time they are really quadrupeds on the ground and brachiators (arm swingers) in trees. Gorillas live mainly on the ground but can climb larger trees. Features essential for man's upright stance and walking are:

1. Relatively long legs compared with the trunk with the centre of gravity in the pelvis, just in front of the sacrum.

2. An S-shaped curved spine so that the head and trunk are balanced over the centre of gravity. This combined with the outward facing shoulder means the arms rest beside the trunk.

3. A wide curved pelvis providing large attachment sites for strong abductor and rotator muscles needed to raise the pelvis and swing the legs under it. A large hip joint with its mechanical axis in front of the line of gravity. This means that the most stable position for the hip is full extension, i.e. upright.

4. A large, forward facing knee joint, aligned under the hip joint with its mechanical axis behind the line of gravity. This means that the most stable position for the knee is also full extension, i.e. upright.

5. A plantigrade foot, i.e. heel and toes both on the ground, with a large heel, and the foot bones arranged in lengthways and side-to-side arches. This distributes the body weight evenly between the heel and toes and provides some elastic recoil when walking.

6. A large first toe ("big toe") tightly bound to and aligned with the other toes, with the toes being short and straight.

Apes have none of these essential features. Apes have short legs, a long trunk and long arms (longer than their legs) with their centre of gravity high in the trunk. This makes them top heavy and unstable without using their arms for support. Their spines lack any convex forward curves needed to balance the head and upper body over the centre of gravity. The head and arms tend to swing forward. Their knees and feet are turned outwards and their hip and knee joints are aligned so that they bend with gravity.

Although apes have a plantigrade foot, it is not arched, and the big toe is separate from the other toes, like a thumb. Their toes are long and curved.

There is no functional half-way combination of apes' quadruped stance and human bipedal stance. The semi-stooped posture depicted in evolutionary drawings is hopelessly unstable and would require enormous expenditure of muscle energy to maintain it. Humans can stand upright with very little muscle contraction required because their bones are joints are arranged in a balanced way around a vertical line through their centre of gravity.

Arms

Human arms and hands are designed for manipulating objects. The shoulder girdle holds the arms beside the trunk and is capable of a large range of movement. The shoulder joint is very flexible and not designed to hold the body weight. The hands have long, straight fingers and a large straight thumb that can oppose the tips of all the fingers.

Ape arms are large and strong and designed for weight bearing. The clavicle (collar bone) slopes upwards so that the shoulders are beside the lower jaw.

Apes' hands are quite good at manipulating objects but must share the load in locomotion. Apes have large hands with long, strong curved fingers used for knuckle walking. Their thumb is short and cannot completely oppose all the fingers.

Hair

Humans have short, sparse hair all over their bodies but it varies between individuals, racial groups and between males and females. Humans have hair on their heads that grows to be over a metre long if not cut. Males of most races have long hair on the lower half of the face if this is not shaved. Male pattern baldness affects the scalp hair of some males but not facial hair. Human hair is believed to be a vestigial leftover from when we were hairy apes. However human hair has several functions and shows evidence of design. For more details see the Question: Why is the human body covered in hair?

Apes have short, dense hair all over their bodies except for their faces where it is thin and sparse. Apes do not have beards or suffer from baldness.

Teeth and Jaws

Humans and apes both 32 teeth with the same combination of different functional types – incisors, canines, premolars and molars. However, ape and human jaws are different shapes. Human jaws have parabolic shape and the teeth and jaws are much smaller than any ape's. The canines of humans are the same height above the gums as the other teeth.

Ape jaws are rectangular and have large prominent canines. In general apes are vegetarian, living on fruit, leaves and young shoots. Humans have a chin. Apes do not.

Face

Human faces are vertical in profile due to the large cranium and small jaws. Human noses are narrow and project downwards.

Ape profiles slope backwards due to the large jaws and small cranium. Ape noses are relatively wide and flat.

Nervous System

A chimpanzee cranial capacity averages about 400 cubic cm whilst human cranial capacity averages around 1350cm. There is quite a deal of variation in humans and brain size does not indicate intelligence level. Bipedal gait (two legged walking) and manipulative hands can only work if the muscles are controlled by the nervous system. The control of posture and gait involves built in circuits in all regions of the nervous system. These automatically work for upright stance. Babies do not progress from crawling to bipedal gait by copying adults. The circuits are built in. They merely have to wait for sufficient strength to develop in the legs, and for their nerve fibres to be covered with the insulating layer needed to conduct rapid electrical signals.

The largest difference in brains of apes and humans is in the cerebral cortex. This is part of the brain that control conscious awareness and understanding, conscious control of movements and learning and memory. In humans this includes language, numeracy, artistic and craft skills, judgement and forward planning. These functions take up most of cerebral cortex in humans. Apes are capable of learning and memory and communication but not in the same way as humans.

Speech and Communication

Apes can communicate with vocalisation and gestures, including facial expressions. They can also be taught to recognise symbols and use them to communicate. However, they do not have the nervous system control needed for speech and writing. All attempts to teach apes to speak have failed.

In humans speech is controlled by two large sections of cerebral cortex in the parietal and frontal lobes. These have many connections with other parts of the cortex and with each other. Apes do not have these specialised functional areas or the extensive connections. The ability to speak is built into human brains. Children acquire, rather than mimic, the language they are exposed to as infants, i.e. the potential to speak any language is hard wired into the brain. The child's brain takes in, analyses and re-synthesises the language it hears. There is evidence that numeracy and an appreciation of music is also "hard wired" into the brain in a similar way.

The muscle control needed for speech is very complex and comes built into the human brain. Speech involves precision control of breathing muscles as well as the face, tongue and larynx. This does not exist in apes, neither does the precision control of the arms and hand required for writing and drawing.

Can apes be taught to be human?

Chimpanzees and gorillas live in social groups and show complex social behaviour, but attempts to integrate them into human society have failed. The chimps you see doing clever things in TV programmes and films are juveniles, usually less than eight years old. Juvenile chimps are quick to learn, and are amenable to human handling, but an adult chimpanzee is a large and dangerous animal. Adult chimps are far stronger than humans even though they are of similar size.

All apes are essentially wild animals, and although they can be kept in captivity they cannot be integrated into human society. Man and Ape are actually so different they are truly unrelated, which is exactly what you would expect given that God declares He made man separate from all the other creature on the sixth day of creation. (Gen 1:26-31).

MONKEYS AND APES

Many people confuse monkeys and apes.

Monkeys include a large number of species that have “monkey” in their name, e.g. rhesus monkey, patas monkey, langur monkey, but also include baboons, mandrills, macaques and marmosets. They are quadrupeds with a tail. Monkeys are classified into two groups – New World and Old World monkeys. These terms refer to their geographical location in the wild.

New World monkeys live in Central and South America, Old World monkeys in Africa and Asia. There are also some anatomical and behavioural differences. New World monkeys have a flat nose with wide apart nostrils, three premolars and two molars, a short thumb aligned with rest of the fingers and a muscular prehensile tail. Old World monkeys have a narrow downward pointing nose, two premolars and three molars and a short partially opposable thumb. Their tails vary in size and muscularity, and they often have ischial callosities (hard callused patches on their rear ends). Most monkeys live in forests although some Old World monkeys live in savannah and semi-arid environments.

Apes include chimpanzees, gorillas, gibbons and orang-utans. They have long, strong upper limbs, short lower limbs and no tail.

How different are monkeys and apes?

The main differences between monkeys and apes are in their locomotor systems, i.e. bones, muscles and joints. Although monkeys and apes both live in trees, they move about them very differently. Monkeys move about like other quadrupeds. They have a long muscular body and use their tails for balance. New World monkeys use their prehensile tail to help move about and support their body weight in trees. Monkeys’ forelimbs are a more mobile than those of a ground dwelling quadruped, e.g. a dog, but they do not swing on them like apes. Their shoulders are small and narrow. They cannot straighten their elbows completely, and have restricted movement of the forearm and wrist.

Apes have large, flexible shoulders, elbows that can fully straighten and a large range of movement in the wrists and forearms. To move quickly through trees they brachiate – swing from branch to branch, easily supporting their body weight on their arms. On the ground apes are knuckle walkers – supporting their weight on the backs of their curled fingers.

Their molar teeth are different. Monkey molars have four cusps, ape molars have five.

Monkeys do not have an appendix, but apes do

APPENDIX V - Extinct hominans

Subtribe Hominina

- *Ardipithecus*
    - *Ardipithecus ramidus*
    - *Ardipithecus kadabba*
- *Kenyanthropus* (placement debated)
    - *Kenyanthropus platyops*
- *Praeanthropus*
    - *Praeanthropus bahrelghazali*
    - *Praeanthropus anamensis*

        - *Praeanthropus afarensis*
    - *Australopithecus*
        - *Australopithecus africanus*
        - *Australopithecus garhi*
        - *Australopithecus sediba*
        - *Australopithecus deyiremeda*
    - *Paranthropus*
        - *Paranthropus aethiopicus*
        - *Paranthropus robustus*
        - *Paranthropus boisei*
    - *Homo* – immediate ancestors of modern humans
        - *Homo gautengensis*
        - *Homo rudolfensis*
        - *Homo naledi*
        - *Homo habilis*
        - *Homo floresiensis*
        - *Homo erectus*
        - *Homo ergaster*
        - *Homo antecessor*
        - *Homo heidelbergensis*
        - *Homo cepranensis*
        - *Homo helmei*
        - *Homo palaeojavanicus*
        - *Homo tsaichangensis*
        - Denisovans (scientific name has not yet been assigned)
        - *Homo neanderthalensis*
        - *Homo rhodesiensis*
        - *Homo sapiens*
            - *Homo sapiens idaltu*
            - *Archaic Homo sapiens* (Cro-Magnon)
            - Red Deer Cave people (scientific name has not yet been assigned; perhaps a race of modern humans or a hybrid[20] of modern humans and Denisovans[21])

APPENDIX VI – The extant great apes

- **Family Hominidae**: humans and other great apes; extinct genera and species excluded
    - Subfamily Ponginae
        - Tribe Pongini
            - Genus *Pongo*

- Bornean orangutan, *Pongo pygmaeus*
  - *Pongo pygmaeus pygmaeus*
  - *Pongo pygmaeus morio*
  - *Pongo pygmaeus wurmbii*
- Sumatran orangutan, *Pongo abelii*

- Subfamily Homininae
  - Tribe Gorillini
    - Genus *Gorilla*
      - Western gorilla, *Gorilla gorilla*
        - Western lowland gorilla, *Gorilla gorilla gorilla*
        - Cross River gorilla, *Gorilla gorilla diehli*
      - Eastern gorilla, *Gorilla beringei*
        - Mountain gorilla, *Gorilla beringei beringei*
        - Eastern lowland gorilla, *Gorilla beringei graueri*
  - Tribe Hominini
    - Subtribe Panina
      - Genus *Pan*
        - Chimpanzee (common chimpanzee), *Pan troglodytes*
          - Central chimpanzee, *Pan troglodytes troglodytes*
          - Western chimpanzee, *Pan troglodytes verus*
          - Nigeria-Cameroon chimpanzee, *Pan troglodytes ellioti*
          - Eastern chimpanzee, *Pan troglodytes schweinfurthii*
        - Bonobo (pygmy chimpanzee), *Pan paniscus*
    - Subtribe Hominina
      - Genus *Homo*
        - Human, *Homo sapiens*
          - Anatomically modern human, *Homo sapiens sapiens*

APPENDIX VII – Timeline of human evolution

• for the last 3.6 billion years, simple cells (prokaryotes);
• for the last 3.4 billion years, cyanobacteria performing photosynthesis;
• for the last 2 billion years, complex cells (eukaryotes);
• for the last 1.2 billion years, eukaryotes which sexually reproduce
• for the last 1 billion years, multicellular life;
• for the last 600 million years, simple animals;
• for the last 550 million years, bilaterians, water life forms with a front and a back;
• for the last 500 million years, fish and proto-amphibians;

• for the last 475 million years, land plants;
• for the last 400 million years, insects and seeds;
• for the last 360 million years, amphibians;
• for the last 300 million years, reptiles;
• for the last 200 million years, mammals;
• for the last 150 million years, birds;
• for the last 130 million years, flowers;
• for the last 60 million years, the primates,
• for the last 20 million years, the family Hominidae (great apes);
• for the last 2.5 million years, the genus Homo (including humans and their predecessors);
• for the last 200,000 years, anatomically modern humans."

APPENDIX VIII – The Cenozoic Era (from the extinction of the dinosaurs until now)

Paleogene	**66-23.0 mya (period)**	
•Paleocene	66 – 56 mya (epoch)	
•Eocene	56 – 33.9 mya	
•Oligocene	33.9 – 23 mya	
Neogene	**23.0 – 2.58 mya**	
•Miocene	23- 5.3 mya	Late Miocene 7 - 5.3 mya
•Pliocene	5.3 – 2.58 mya	
Quaternary	**2.58 mya – present**	
•Pleistocene	2.58 – 0.0117 mya	Lower Paleolithic 2.58 – 0.3 mya Middle Paleolithic 300 -50 kya Upper Paleolithic 50 – 10 kya
•Holocene	0.0117 mya – present	Mesolithic / Neolithic: 10 - 5 kya

GEOLOGIC TIME http://www.palaeos.com/Timescale/timescale.html

Eon	Era	Period	begin - end (Mya)
Phanerozoic Eon	**Cenozoic Era**	**Neogene**	**23.0 - 0.00**
		Paleogene	**65.5 - 23.0**

	Mesozoic Era	**Cretaceous**	**146 - 65.5**
		Jurassic	**200 - 146**
		Triassic	**251 - 200**
	Paleozoic Era	**Permian**	**299 - 251**
		Carboniferous	**359 - 299**
		Devonian	**416 - 359**
		Silurian	**444 - 416**
		Ordovician	**488 - 444**
		Cambrian	**542 - 488**
Proterozoic	**Neoproterozoic**		**1000 - 542**
	Mesoproterozoic		**1600 - 1000**
	Paleoproterozoic		**2500 - 1600**
Archean	**Neoarchean**		**2800 - 2500**
	Mesoarchean		**3200 - 2800**
	Paleoarchean		**3600 - 3200**
	Eoarchean		**3800 - 3600**
Hadean	**Early Imbrian**		**3850 - 3800**
	Nectarian		**3950 - 3850**
	Basin Groups		**4150 - 3950**
	Cryptic		**- 4150**

APPENDIX IX – human anatomical changes