Origin of Man
Core course: ZOOL3014
B.Sc. (Hons'): VIth Semester

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Origin of Human

Origin of man is one of the most puzzling phenomena of nature

The fossil records in the case of other animals doubtlessly reveal their ancestry, human fossil records are scanty and full of gaps

Man appears to have evolved through natural selection from ape-like creatures that migrated from forests to grasslands and lived as group hunters

Before Darwin

The word *homo*, in Latin was given by Carolus Linnaeus in his classification system

The word "human" is from the Latin *humanus*, the adjectival form of *homo*

The Latin "homo" derives from the Indo-European root **dhghem*, or "earth"

Linnaeus and other scientists of his time also considered the great apes to be the closest relatives of humans due to morphological and anatomical similarities

Darwin

The possibility of linking humans with earlier apes by descent only became clear after 1859 with the publication of Charles Darwin's *On the Origin of Species*

This argued for the idea of the evolution of new species from earlier ones. Darwin's book did not address the question of human evolution, saying only that "Light will be thrown on the origin of man and his history“

The first debates about the nature of human evolution arose between Thomas Huxley and Richard Owen

Huxley argued for human evolution from apes by illustrating many of the similarities and differences between humans and apes in his 1863 book *Evidence as to Man's Place in Nature*

However, many of Darwin's early supporters (such as Alfred Russel Wallace and Charles Lyell) did not agree that the origin of the mental capacities and the moral sensibilities of humans could be explained by natural selection

Darwin applied the theory of evolution and sexual selection to humans when he published *The Descent of Man* in 1871

Fossil Records of human phylogeny

Explosive primate radiation took place in the early part of Coenozoic era, in Palaeocene and Eocene epochs

Primitive monkeys and primitive anthropoid apes made their appearance in the Oligocene epoch, about 35 million years ago, thus setting the stage for further hominid evolution

However, fossil records depicting human evolution are incomplete and fragmented and do not give a clear linear picture of human phylogeny

First fossils

Despite the 1891 discovery by Eugène Dubois of what is now called *Homo erectus* at Trinil, Java, it was only in the 1920s when such fossils were discovered in Africa, that intermediate species began to accumulate

In 1925 Raymond Dart described *Australopithecus africanus*

The type specimen was the Taung Child, an Australopithecine infant which was discovered in a cave

The child's remains were a remarkably well-preserved tiny skull and an endocranial cast of the brain

Although the brain was small (410 cm^3), its shape was rounded, unlike that of chimpanzees and gorillas, and more like a modern human brain

Also, the specimen showed short canine teeth, and the position of the foramen magnum was evidence of bipedal locomotion

All of these traits convinced Dart that the Taung baby was a bipedal human ancestor, a transitional form between apes and humans

The East African Fossils

During the 1960s and 1970s hundreds of fossils were found, particularly in East Africa in the regions of the Olduvai gorge and Lake Turkana

The driving force in the east African researches was the Leakey family, with Louis Leakey and his wife Mary Leakey, and later their son Richard and daughter in-law Meave being among the most successful fossil hunters and palaeoanthropologists

From the fossil beds of Olduvai and Lake Turkana they amassed fossils of australopithecines, early *Homo*, and even *Homo erectus*

These finds cemented Africa as the cradle of human kind

In the 1980s Ethiopia emerged as the new hot spot of palaeoanthropology as "Lucy"

Lucy was the most complete fossil member of the species *Australopithecus afarensis*

***It* was found by Don Johanson in Hadar in the desertic Middle Awash region of northern Ethiopia**

This area would be the location of many new hominin fossils particularly those uncovered by the teams of Tim White in the 1990s, such as *Ardipithecus ramidus*

Evidence from the fossil record

There is little fossil evidence for the divergence of the gorilla, chimpanzee and hominin lineages

The earliest fossils that have been proposed as members of the hominin lineage are-

Sahelanthropus tchadensis **dating from 7 million years ago,**
Orrorin tugenensis **dating from 5.7 million years ago and**
Ardipithecus kadabba **dating to 5.6 million years ago**

Each of these have been argued to be a bipedal ancestor of later hominins, but in each cases the claims have been contested

It is also possible that either of these species are ancestors of another branch of African apes, or that they represent a shared ancestor between hominins and other apes

From these early species the australopithecines arose around 4 million years ago diverged into robust (also called *Paranthropus*) and gracile branches, one of which (possibly *A. garhi*) probably went on to become ancestors of the genus *Homo*

The australopithecine species that are best represented in the fossil record is Australopithecus afarensis with more than a hundred fossil individuals represented, found from Northern Ethiopia (such as the famous "Lucy"), to Kenya, and South Africa

Fossils of robust australopithecines such as *A. robustus* (or alternatively *Paranthropus robustus*) and *A./P. boisei* are particularly abundant in South Africa at sites such as Kromdraai and Swartkrans, and around Lake Turkana in Kenya

Homo

The earliest members of the genus *Homo* are *Homo habilis* which evolved around 2.3 million years ago

***Homo habilis* is the first species for which we have positive evidence of use of stone tools**

They developed the oldowan lithic technology, named after the Olduvai gorge where the first specimens were found

Some scientists consider *Homo rudolfensis*, a larger bodied group of fossils with similar morphology to the original *H. habilis* fossils to be a separate species while others consider them to be part of *H. habilis* - simply representing species internal variation, or perhaps even sexual dimorphism

The brains of these early hominins were about the same size as that of a chimpanzee, and their main adaptation was bipedalism as an adaptation to terrestrial living

During the next million years a process of encephalization began, and with the arrival of *Homo erectus* in the fossil record, cranial capacity had doubled

***Homo erectus* were the first of the hominina to leave Africa, and these species spread through Africa, Asia, and Europe between1.3 to 1.8 million years ago**

One population of *H. erectus*, also sometimes classified as a separate species *Homo ergaster*, stayed in Africa and evolved into *Homo sapiens*

It is believed that these species were the first to use fire and complex tools

The earliest transitional fossils between *H. ergaster/erectus* and *Archaic H. sapiens* are from Africa such as *Homo rhodesiensis*, but seemingly transitional forms are also found at Dmanisi, Georgia

These descendants of African *H.erectus* spread through Eurasia from ca. 500,000 years ago evolving into *H. antecessor*, *H. heidelbergensis* and *H. neanderthalensis*

The earliest fossils of anatomically modern humans are from the Middle Paleolithic, about 200,000 years ago such as the Omo remains of Ethiopia, later fossils from Skhul in Israel and Southern Europe begin around 90,000 years ago

As modern humans spread out from Africa they encountered other hominins such as *Homo neanderthalensis* and the so-called Denisovans, who may have evolved from populations of *Homo erectus* that had left Africa already around 2 million years ago

The nature of interaction between early humans and these sister species has been a long standing source of controversy, the question being whether humans replaced these earlier species or whether they were in fact similar enough to interbreed, in which case these earlier populations may have contributed genetic material to modern humans

This migration out of Africa is estimated to have begun about 70,000 years BC and modern humans subsequently spread globally, replacing earlier hominins either through competition or hybridization

They inhabited Eurasia and Oceania by 40,000 years BC, and the Americas by at least 14,500 years BC

The Molecular evidence

Mitochondrial DNA is inherited maternally through the cytoplasm of the egg which contains about 100,000 mitochondria (sperm contains insignificant amount of mtDNA, only about 50), and is not subjected to the same selection pressure as the nuclear DNA

The rate of mutation in mtDNA is ten times faster than nuclear DNA and is constant and hence can be measured to reveal a relationship between two species that emerged from common ancestor

Cann et al. (1987) analyzed 144 mtDNA samples from human groups of different origin and estimated the age of common ancestor as 150,000-290,000 years

Linda Vigilant et al. (1991) studied mitochondrial DNA of 189 people from different regions

Their direct maternal ancestry was found to converge to a single female in Africa called “mitochondrial Eve” that lived between 1,66,000 and 2,49,000 years ago

Data on amino acid residues indicates that chimpanzee and gorilla are genealogically closer to man than to other apes

The fusion of acrocentric chromosomes, which is called Robertsonian translocation, has perhaps taken place, which reduced the number of chromosomes from 48 in apes to 46 in man

Such chromosomal rearrangements and also pericentric and paracentric inversions alter the metabolic pathways and thus produce reproductive isolation

Molecular analysis to reveal human origin and dispersal

Progress in DNA sequencing, specifically mitochondrial DNA (mtDNA) and then Y-chromosome DNA advanced the understanding of human origins

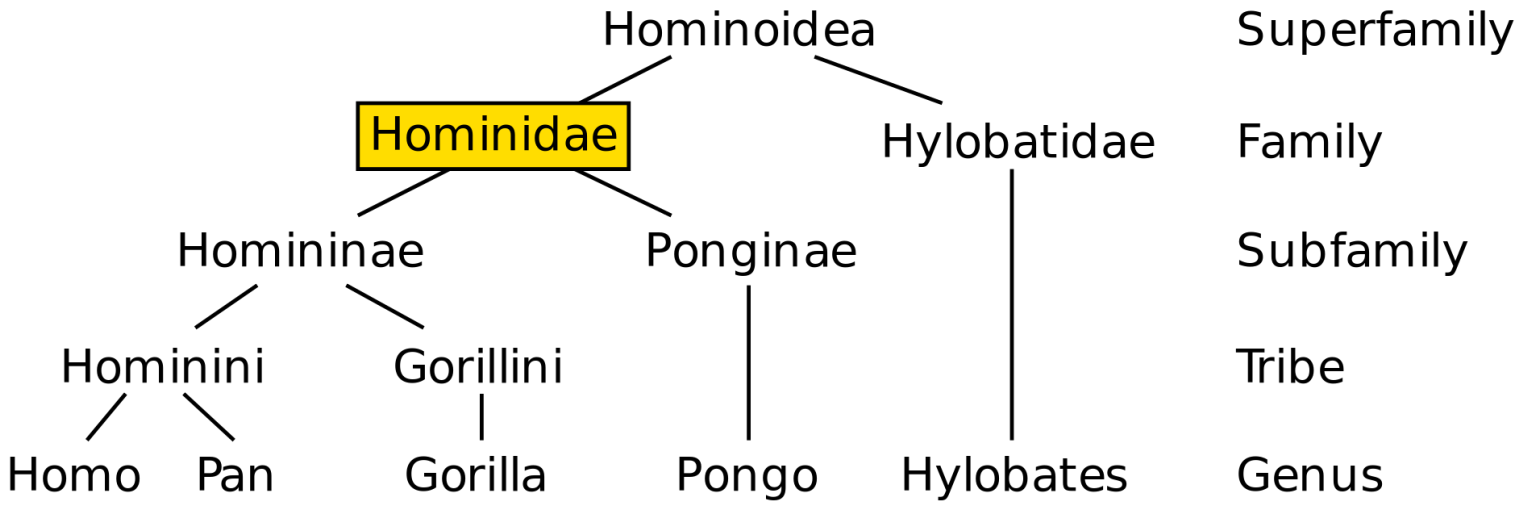
Sequencing mtDNA and Y-DNA sampled from a wide range of indigenous populations revealed ancestral information relating to both male and female genetic heritage

Aligned in genetic tree differences were interpreted as supportive of a recent single origin

Analyses have shown a greater diversity of DNA patterns throughout Africa, consistent with the idea that Africa is the ancestral home of mitochondrial Eve and Y-chromosomal Adam

Evidence from Molecular Biology

The closest living relatives of humans are gorillas (genus *Gorilla*) and chimpanzees (Genus *Pan*). With the sequencing of both the human and chimpanzee genome, current estimates of the similarity between their DNA sequences range between 95% and 99%



Family tree showing the extant hominoids: humans (genus *Homo*), chimpanzees and bonobos (genus *Pan*), gorillas (genus *Gorilla*), orangutans (genus *Pongo*), and gibbons (four genera of the family Hylobatidae: *Hylobates*,*Hoolock*, *Nomascus*, and *Symphalangus*). All except gibbons are hominids

By using the molecular clock which estimates the time required for the number of divergent mutations to accumulate between two lineages, the approximate date for the split between lineages can be calculated

The gibbons (*hylobatidae*) and orangutans (genus *Pongo*) were the first groups to split
from the line leading to the humans, then gorillas followed by the chimpanzees and bonobos

The splitting date between human and chimpanzee lineages is placed around 4-8 million years ago during the late Miocene epoch

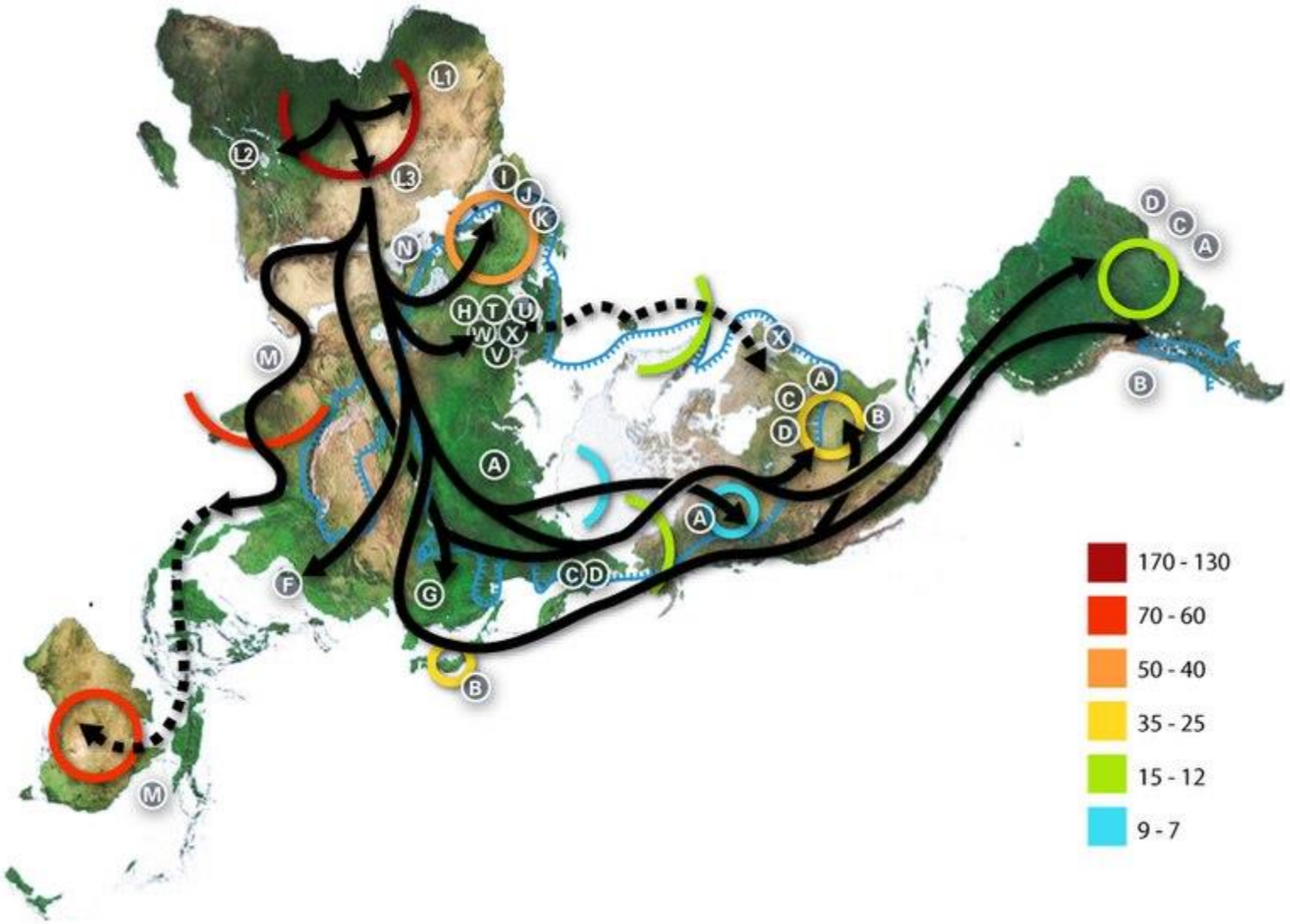
Genetic evidence

Whether there was any gene flow between early modern humans and Neanderthals, to enhance our understanding of the early human migration patterns and splitting dates

By comparing the parts of the genome that are not under natural selection and which therefore accumulate mutations at a fairly steady rate, it is possible to reconstruct a genetic tree incorporating the entire human species since the last shared ancestor.

Each time a certain mutation (Single nucleotide polymorphism) appears in an individual and is passed on to his or her descendants a haplogroup is formed including all of the descendants of the individual who will also carry that mutation

By comparing mitochondrial DNA which is inherited only from the mother, geneticists have concluded that the last female common ancestor whose genetic marker is found in all modern humans, the so-called mitochondrial Eve, must have lived around 200,000 years ago



A global mapping model of human migration, based from divergence of the mitochondrial DNA (which indicates the matrilineage). Timescale (ka) indicated by colours

The Genetic revolution

The genetic revolution in studies of human evolution started when Vincent Sarich and Allan Wilson measured the strength of immunological cross-reactions of blood serum albumin between pairs of creatures, including humans and African apes (chimpanzees and gorillas)

The strength of the reaction could be expressed numerically as an immunological distance, which was in turn proportional to the number of amino acid differences between homologous proteins in different species

By constructing a calibration curve of the ID of species' pairs with known divergence times in the fossil record, the data could be used as a molecular clock to estimate the times of divergence of pairs with poorer or unknown fossil records

In their seminal paper in 1967 in *Science*, Sarich and Wilson estimated the divergence time of humans and apes as four to five million years ago, at a time when standard interpretations of the fossil record gave this divergence as at least 10 to as much as 30 million years

Subsequent fossil discoveries, notably Lucy, and reinterpretation of older fossil materials, notably Ramapithecus, showed the younger estimates to be correct and validated the albumin method

Application of the molecular clock principle revolutionized the study of molecular evolution

Human dispersal

Anthropologists in the 1980s were divided regarding some details of reproductive barriers and migratory dispersals of the *Homo* genus

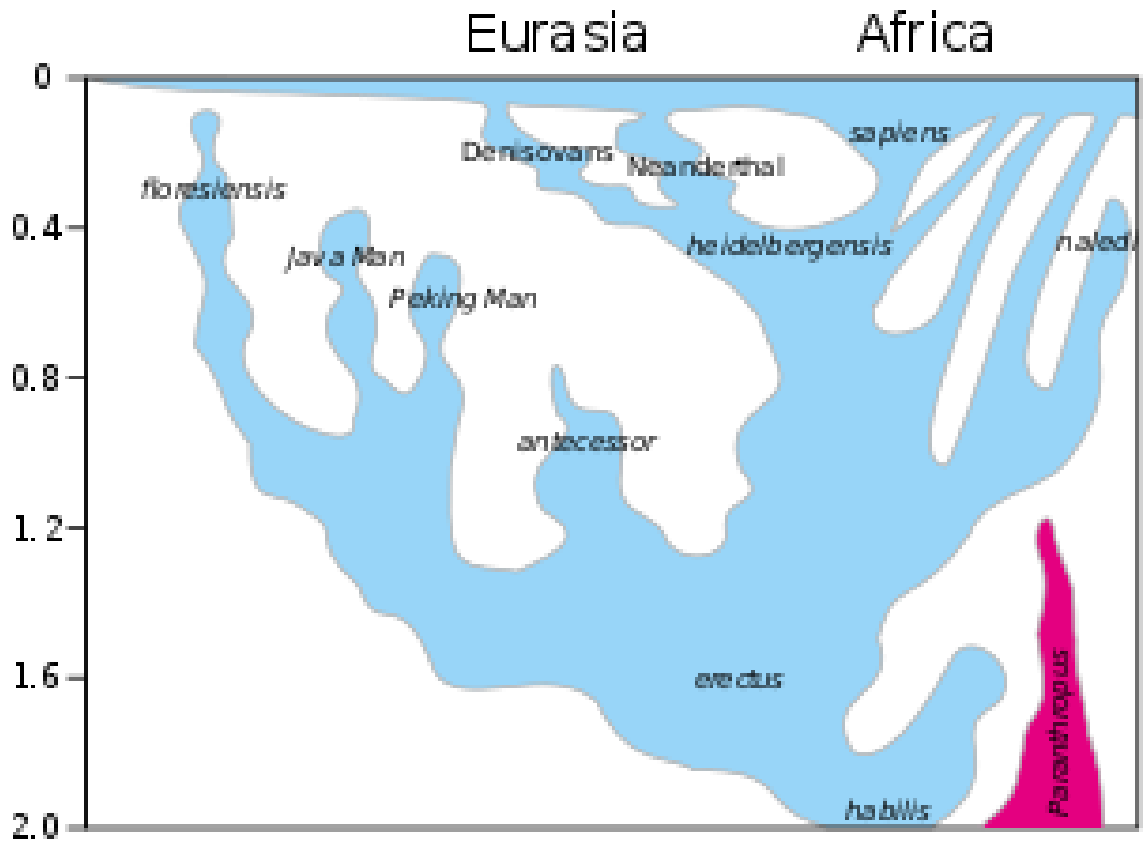
Subsequently, genetics has been used to investigate and resolve these issues

Out-of-Africa model

Proposed that modern *H. sapiens* speciated in Africa recently (approx. 200,000 years ago) and their subsequent migration through Eurasia resulted in complete replacement of other *Homo* species

This model has been developed by Chris Stringer and Peter Andrews

Gained support from research using female mitochondrial DNA (mtDNA) and the male Y chromosome



A model of the evolution of the genus *Homo* over the last 2 million years (vertical axis)
The rapid "Out of Africa" expansion of *H. sapiens* is indicated at the top of the diagram, with admixture indicated with Neanderthals, Denisovans, and unspecified archaic African hominins
Late survival of robust australopithecines (*Paranthropus*) alongside *Homo* until 1.2 Mya is indicated in purple

After analysing genealogy trees constructed using 133 types of mtDNA, researchers concluded that all were descended from a female African progenitor, dubbed Mitochondrial Eve

Out of Africa is also supported by the fact that mitochondrial genetic diversity is highest among African populations

Multiregional hypothesis

By Milford H. Wolpoff proposed that *Homo* genus contained only a single interconnected population like it does today (not separate species), and that its evolution took place worldwide continuously over the last couple million years

There are still differing theories on whether there was a single exodus or several

Multiple dispersal model (Southern Dispersal theory)

Supported by genetic, linguistic and archaeological evidence

In this theory, there was a coastal dispersal of modern humans from the Horn of Africa around 70,000 years ago

This group helped to populate Southeast Asia and Oceania, explaining the discovery of early human sites in these areas much earlier than those in the Levant

The multiple dispersal model is contradicted by studies indicating that the populations of Eurasia and the populations of Southeast Asia and Oceania are all descended from the same mitochondrial DNA lineages, which support a single migration out of Africa that gave rise to all non-African populations

A second wave of humans dispersed across the Sinai peninsula into Asia, resulting in the bulk of human population for Eurasia

This second group possessed a more sophisticated tool technology and was less dependent on coastal food sources than the original group

Much of the evidence for the first group's expansion would have been destroyed by the rising sea levels at the end of each glacial maximum

African genetic diversity

A study by Sarah Tishkoff, found the San people had the greatest genetic diversity among the 113 distinct populations sampled, making them one of 14 "ancestral population clusters"

The research also located the origin of modern human migration in south-western Africa, near the coastal border of Namibia and Angola

Studies of haplogroups in Y-chromosomal DNA and mitochondrial DNA have largely supported a recent African origin. Evidence from autosomal DNA also predominantly supports a Recent African origin

However evidence for archaic admixture in modern humans had been suggested by some studies. Recent sequencing of Neanderthal and Denisovan genomes shows that some admixture occurred

Modern humans outside Africa have 2-4% Neanderthal alleles in their genome, and some Melanesians have an additional 4-6% of Denisovan alleles

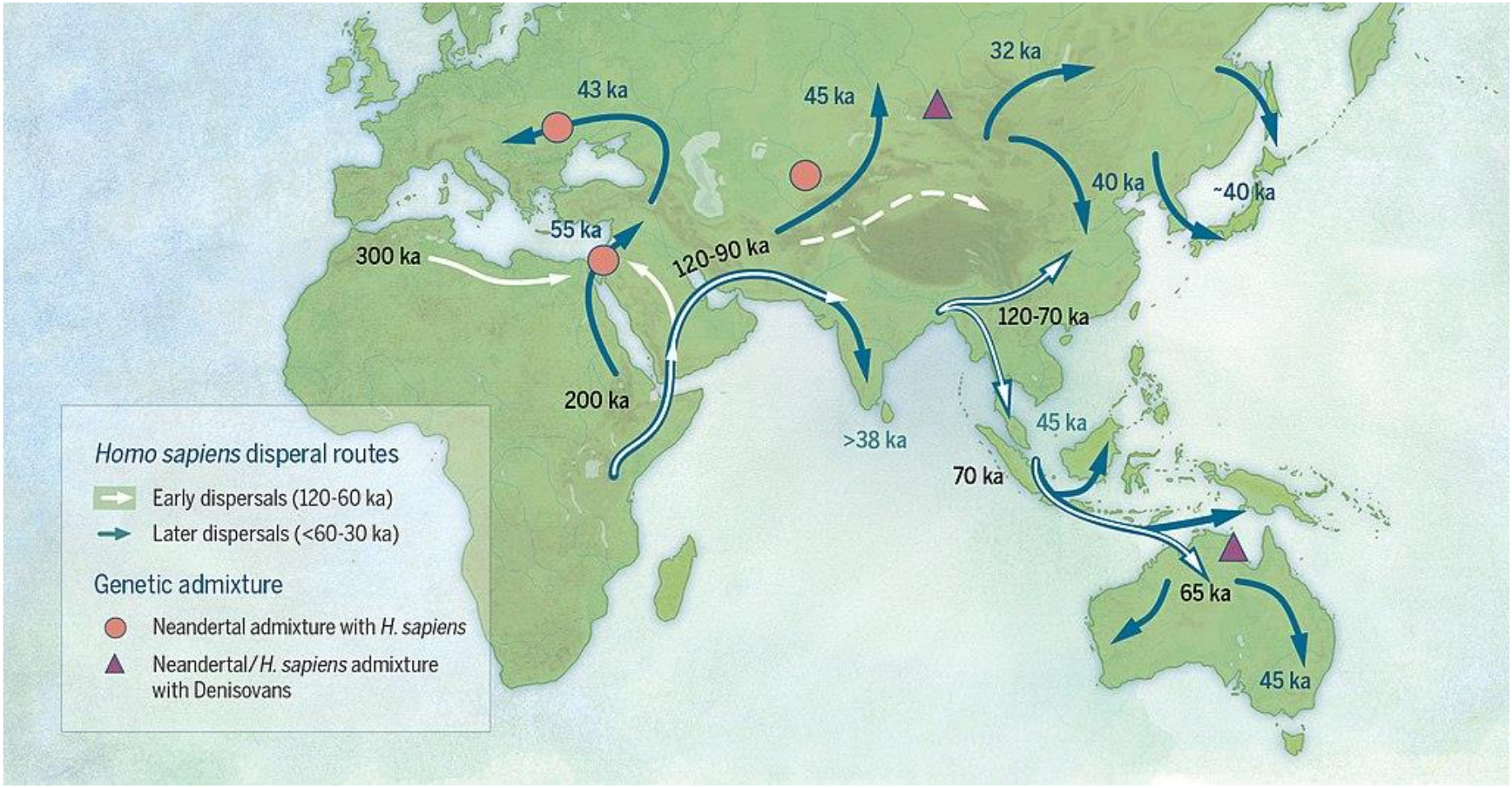
These new results do not contradict the Out of Africa model, except in its strictest interpretation

After recovery from a genetic bottleneck that might be due to the Toba supervolcano catastrophe, a fairly small group left Africa and briefly interbred with Neanderthals, probably in the middle-east or even North Africa before their departure

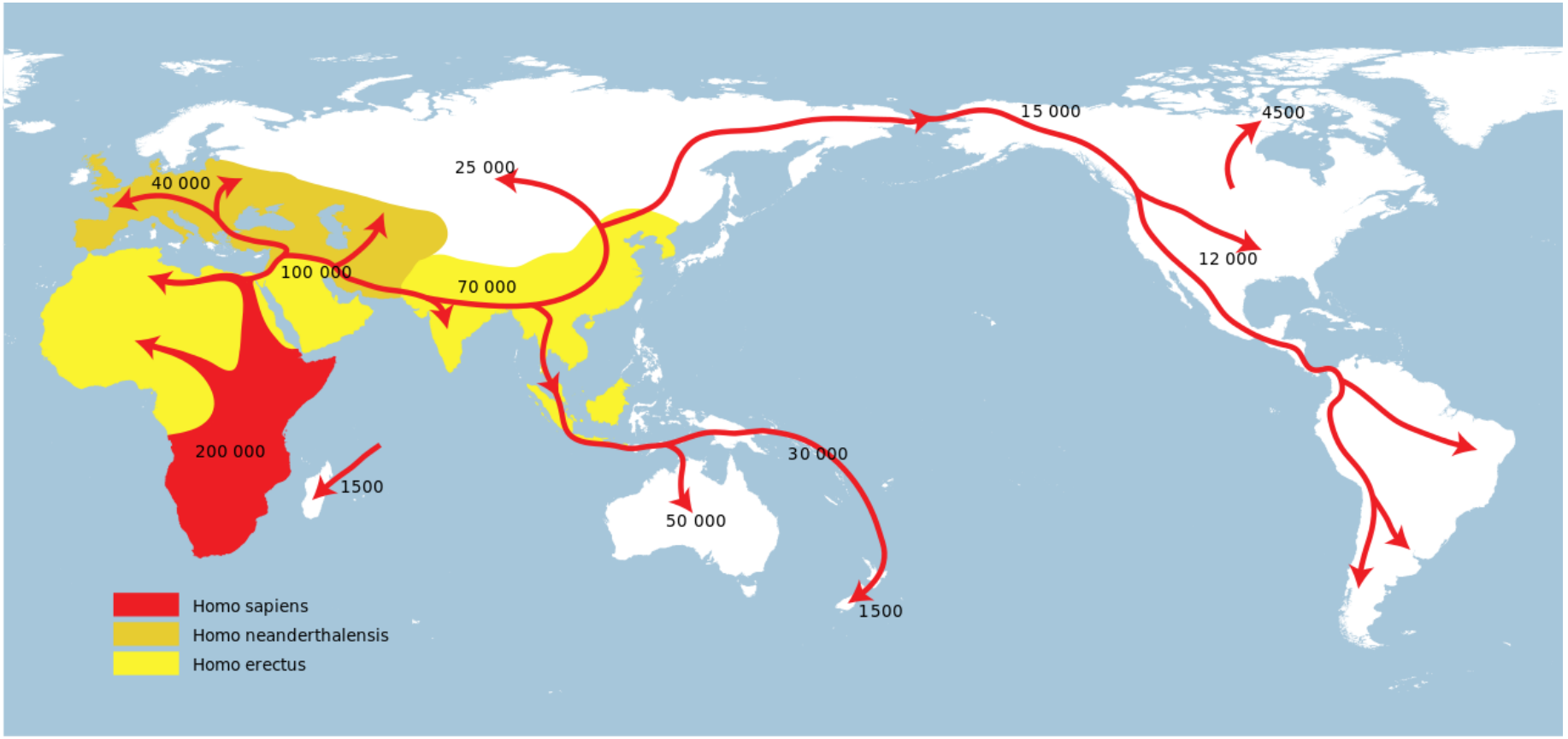
Their still predominantly-African descendants spread to populate the world

A fraction in turn interbred with Denisovans, probably in south-east Asia, before populating Melanesia

HLA haplotypes of Neanderthal and Denisova origin have been identified in modern Eurasian and Oceanian populations



Known *H. sapiens* migration routes in the Pleistocene



A map of [early human migrations]

Single origin versus multiple origin of man

Molecular evidence seems to support the African origin of humans and then their migration to other continents to develop racial differences

All non-African mitochondrial DNA sequences are only variants of the African sequence, and African populations possess the maximum mtDNA variability suggesting their ancient character

A study by Hammer and co-workers of Y-chromosome of more than 1500 individuals from all continents also points to the African origin of man

Human populations all over the world are basically similar in anatomy and genetic composition and hence must have had a single origin in Africa

Multiple origin hypothesis or multiregional proposal, on the other hand, suggests that all human populations in different continents evolved in parallel over long periods from *Homo erectus*

Hominids migrated out of Africa much earlier than the subsequent origin of modern man about 100,000 years ago in different geographic regions of the world

Fossils from the Chinese and Australian regions show continuous and independent progression from the *Homo erectus* stage to the present

Human ancestors were highly mobile creatures and hence constantly exchanged genes between populations to break the reproductive isolation and keep genetic variability to the minimum

Factors that influenced human evolution

Both Miocene and Pliocene were dry periods of great stress, when sea level went down by about 200 meters and northern and southern hemispheres had huge ice caps

There are indications that fragmentation of dense tropical forests in east Africa initiated the evolution of bipedal hominids from the arboreal apes

The dry period of a few million years put a lot of pressure on the animals living in the shrinking forests and forced them to migrate and adapt to the open grasslands

The evolution of horse, camel, giraffe, and elephant was also triggered by the same factors

Some groups of apes that were omnivorous and semiterrestrial, faced with intense competition in the forests, started migrating to grasslands

Community living evolved to defend themselves in groups and also to hunt large animals in groups

As the hands were engaged in handling arms and food, they had to walk and run on two legs, giving rise to bipedalism, resulting in the elongation and strengthening of legs

Standing upright in the tropical savannas could also have given them the advantage of scanning horizons for predators as well as potential prey, exposed less of body surface to the perpendicular sun rays and more to the horizontal cooling winds, and freed the hands for carrying stones, sticks, food or infants

Manipulation of objects by hand put a lot of pressure on brain, leading to its enlargement and increased intelligence

As these migrants continued to live in grasslands and perfected their bipedal locomotion and use of hand for more complex jobs, their brain increased in size and capacity

Later, they started living in caves for protection and probably developed a language for communication

***Australopithecus* was such a creature, which lived socially in caves, made stone tools and hunted animals**

Eating cooked food led to the reduction of canines, shortening of jaw and simplification of teeth

Human evolution is an example of specialization in brain's ability, achieved due to manipulative skills of hands, strategic group hunting and communication in social groups

Cultural and social evolution of man

Modern humans, being highly social, learn from their experiences, share these experiences with the others and modify their behaviour based on constant learning

Unlike other animals, they are also capable of modifying their environment to suit their needs and keep considerable control over it

An important difference between the genetic exchanges and cultural exchanges is that the former can take place between parents and offspring while the latter can take place among the unrelated individuals

Therefore, while the biological traits are transmitted *vertically* within the lineages, cultural traits are transmitted both *vertically* and *horizontally* within lineages or among the unrelated individuals

Cultural evolution is therefore much faster than the genetic evolution

While the cultural evolution follows Lamarckian mode of inheritance, the biological evolution is driven by natural selection in which information is transmitted through DNA and the mechanisms of heredity

Cultural evolution is independent of genetic system and can take place without making any change in the genes