

# Human evolution

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# Framework of the lecture

1. How to study human evolution – overview of methods
2. Primates and their major characteristics
3. Human as a primate - place in evolutionary tree, classification and timescale

Hominins – humans and their close extinct and extant relatives

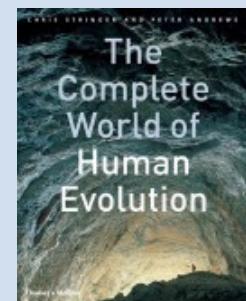
- fossils;
- main characteristics of hominin lineage;
- environmental, social and genetic factors behind these characteristics
- Anatomically Modern Human (AMH)

## Additional material:

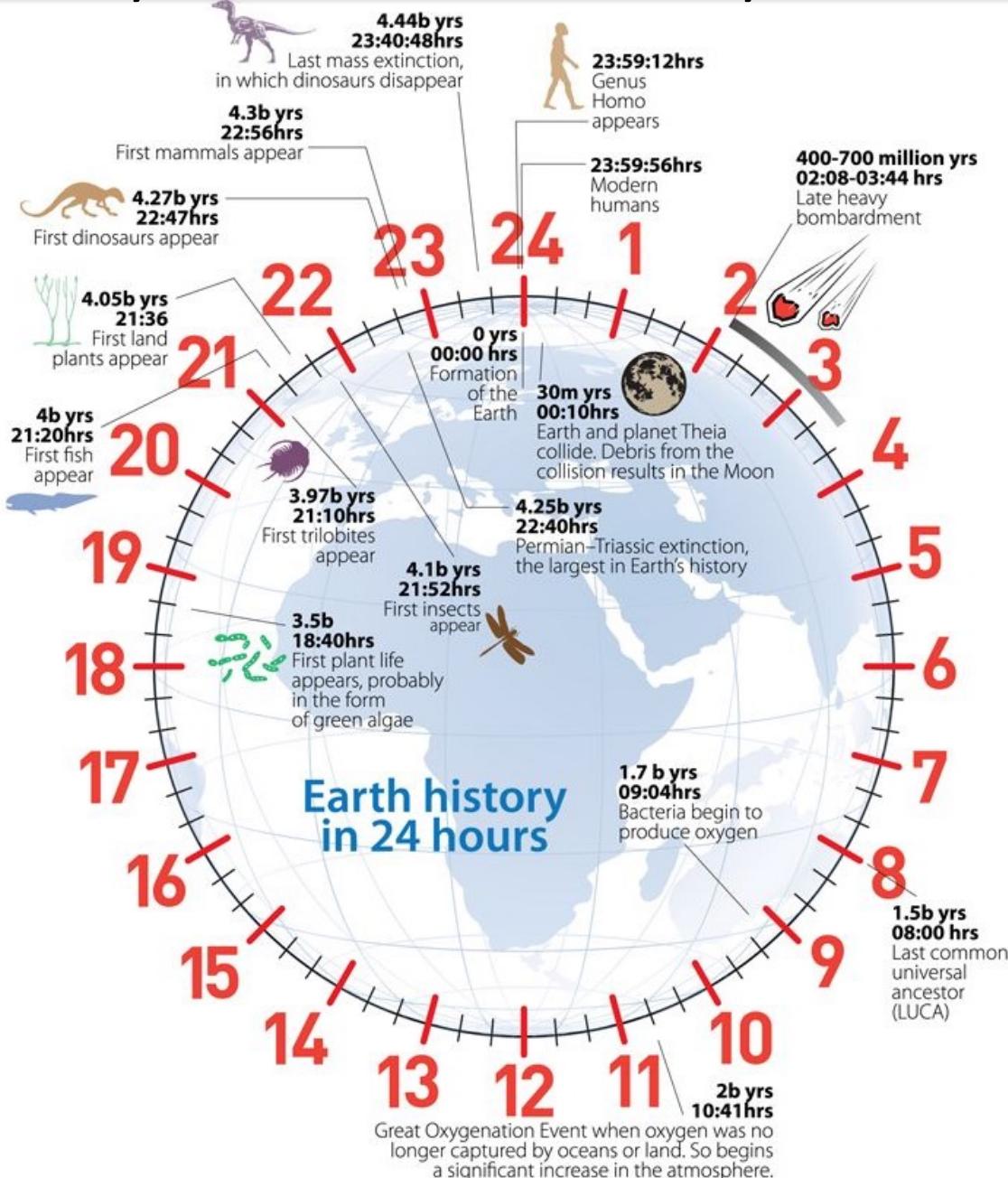
**Stringer ja Andrews 2005** The Complete World of Human Evolution.

**Jobling, Hollox, Hurles, Kivisild, Tyler-Smith 2014** Human evolutionary Genetics

**Bergstrom and Dugatkin 2016** Evolution



# History of Earth – 4.5 billion years within 24 h - model



*Homo sapiens* is a very young species in an evolutionary scale

CAROLI LINNÆI

EQUITIS DE STELLA POLARI,  
ARCHIATRI REGII, MED. & BOTAN. PROFESS. UPSAL.;  
ACAD. UPSAL. HOLMENS. PETROPOL. BEROL. IMPER.  
LOND. MONSPEL. TOLOS. FLORENT. SOC.

SYSTEMA  
NATURÆ

PER

REGNA TRIA NATURÆ,

SECUNDUM

CLASSES, ORDINES,  
GENERA, SPECIES,

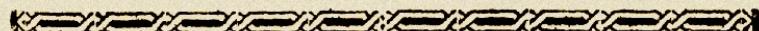
CUM

CHARACTERIBUS, DIFFERENTIIS.  
SYNONYMIS, LOCIS.

TOMUS I.

—<sup>10</sup>  
EDITIO DECIMA, REFORMATA.

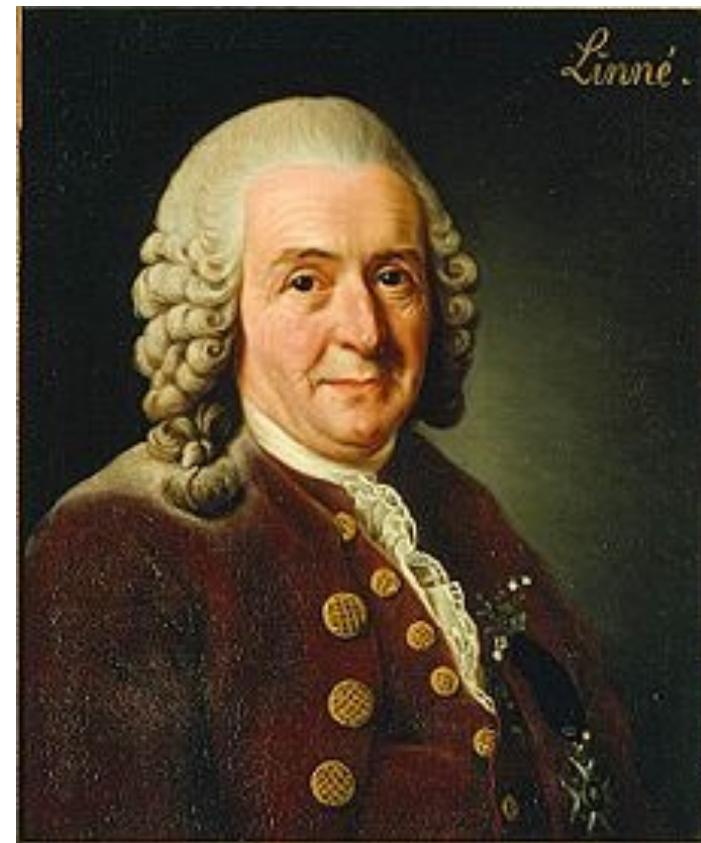
—  
Cum Privilegio S:æ R:æ M:tis Svecicæ.



HOLMIAE,

IMPENSIS DIRECT. LAURENTII SALVII,  
1758.

Carl Linne (1707 – 1778)

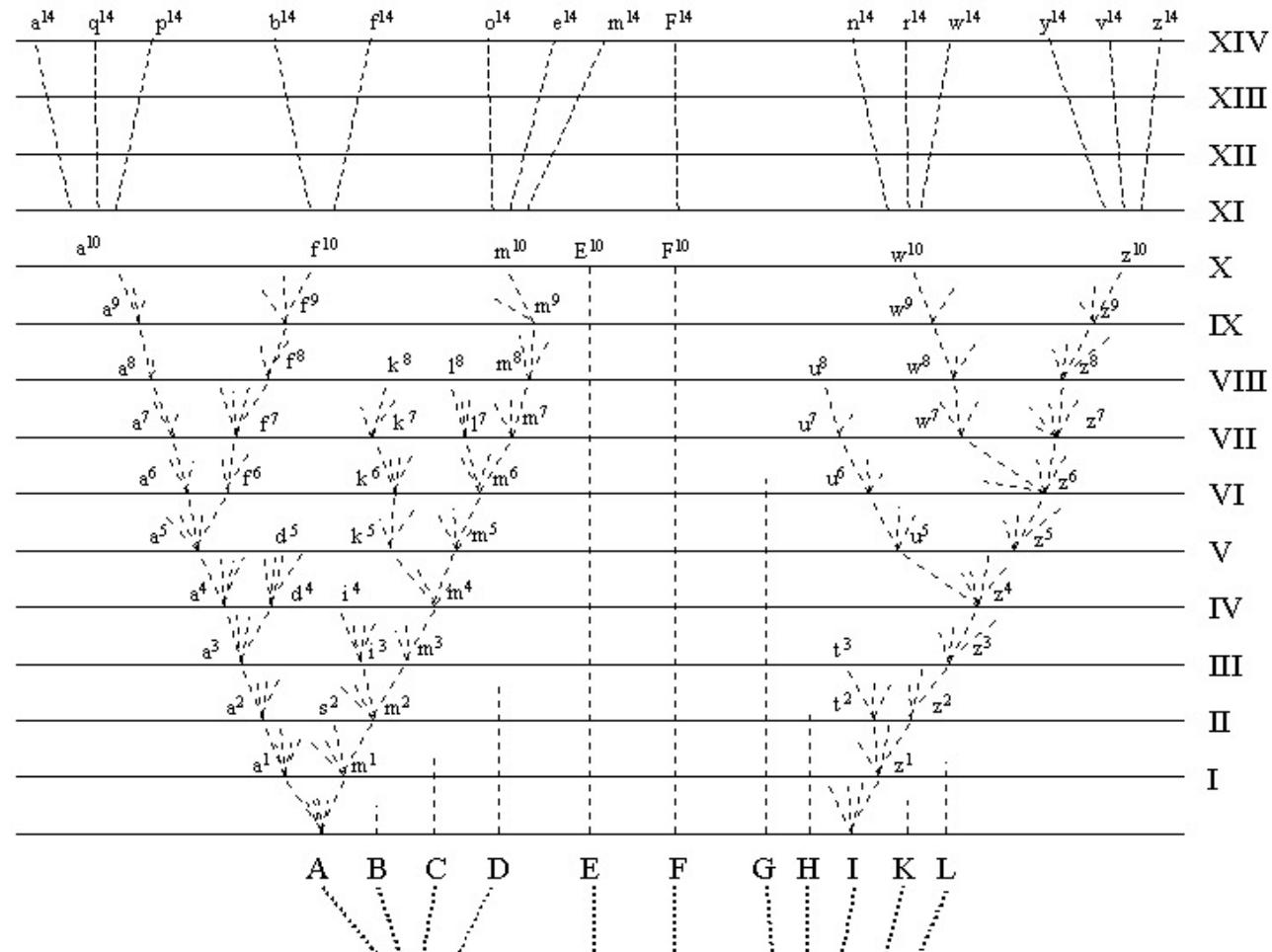
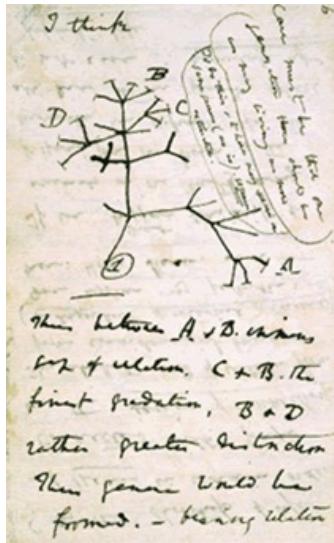


Classified ca 4400 animal  
(*Homo sapiens*) and  
ca 7700 plant species

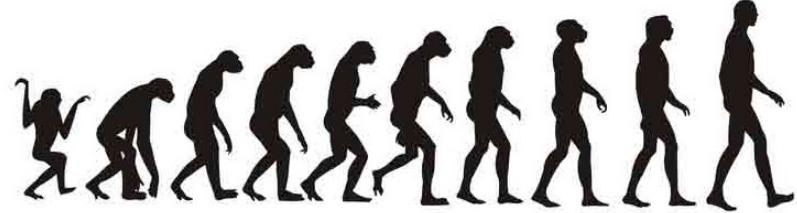
# Tree of life – consists of both living and extinct organisms who all have a common ancestor

Ch. Darwin

“The Origin of Species”  
(1859)



Natural system – important is not the taxonomical comfort, but real associations between organisms through descent – **cladistics**

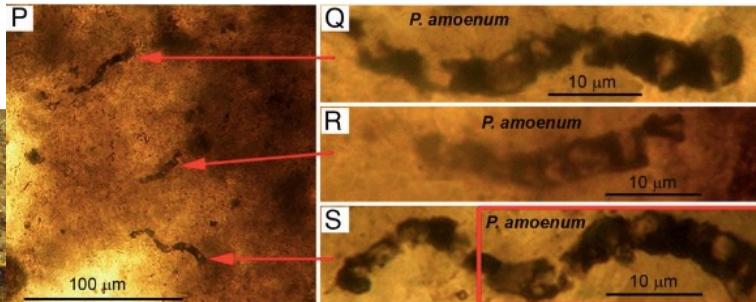
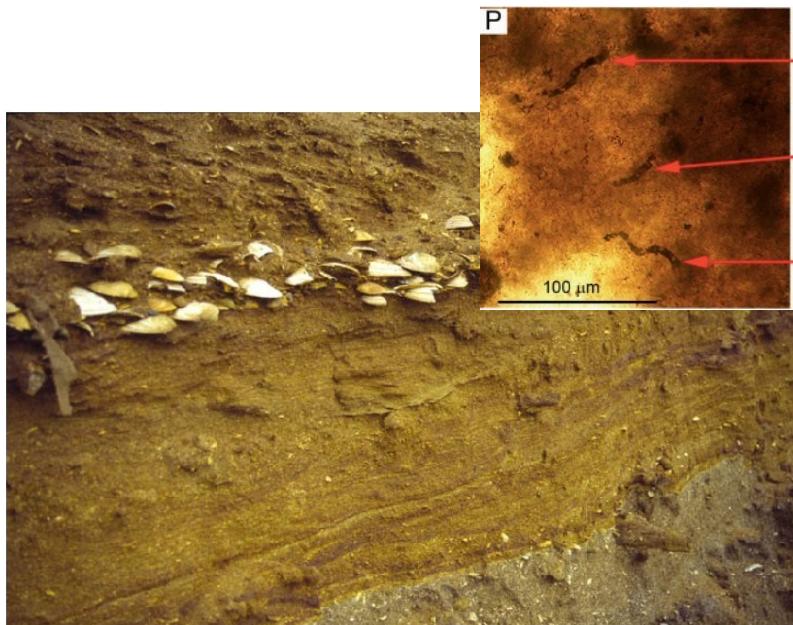


## How to study human evolution:

- Fossilized evidences;
- Archaeological evidences;
- Molecular genetics – modern and ancient DNA studies (the origin of *H. sapiens* and its demographic history);
- Comparative studies with closest living organisms of human – great apes – genetic, morphological, physiological, behavioural etc. features.

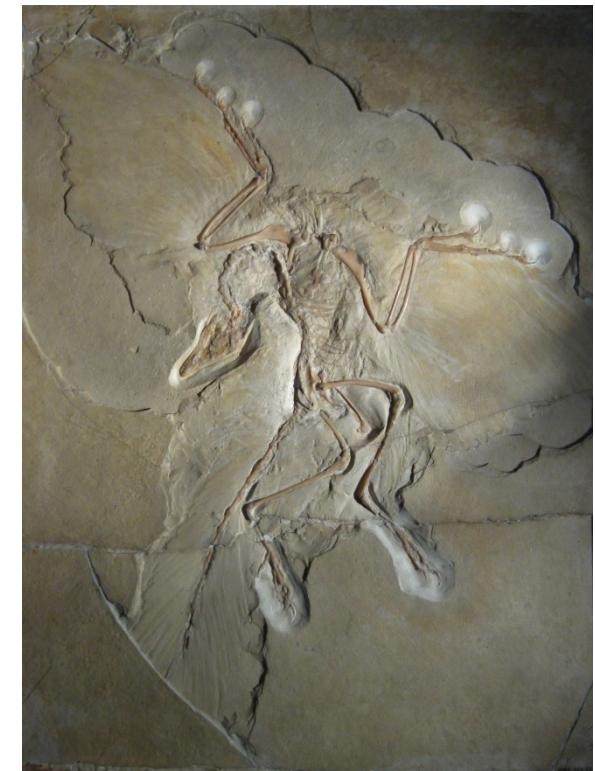
# Fossilized evidences of evolution

Mya = Million years ago; kya = thousand (kilo) years ago



3,46 GA -  
oldest cellular  
fossil - archaea  
(Schopf et al.  
2018, PNAS)

*Sparnodus sp.* 50 Mya



- Fossils are the best but also a very scarce source of evidence of evolution; „Street-light effect“ and problems with „missing link“;
- The younger the fossils are the more they resemble modern organisms;
- There are lots of gaps, but also some surprisingly well covered periods of evolutionary lineages:
- How to classify new findings? New species?  
Variation within already defined groups?

*Archaeopteryx sp.* 150 Mya

# Archaeological evidences - tools

Until 2015 – the oldest tools of **Oldowan culture** – **2.6 Mya** (Ethiopia), associated with the dawn of *Homo* family (*H. habilis* – „handy“ man)

Now – **3.3 Mya** – several thousands of years earlier findings, no fossils found, already at the time before *Homo*

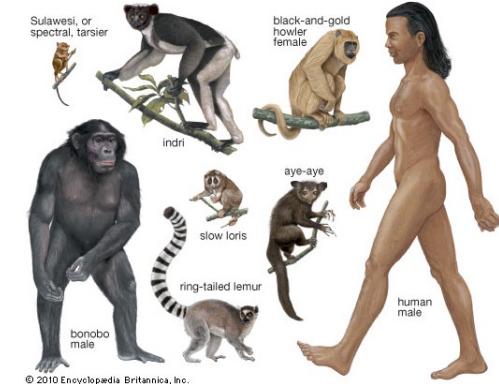
Lake Turkana , Kenia, 2011



Lomekwi 3



# Primates



- Primates are a sub-group of mammals (>200 species);
- This group contains all of the species commonly related to lemurs, monkeys and apes, including humans;
- The oldest primates appeared 60-80 Mya and were probably small arboreal frugi- and folivorous mammals, who lived in tropical and sub-tropical areas;
- The oldest fossils of primates are ca 60 My old

# Earliest primate fossils are from Paleogene

[www.stratigraphy.com](http://www.stratigraphy.com)

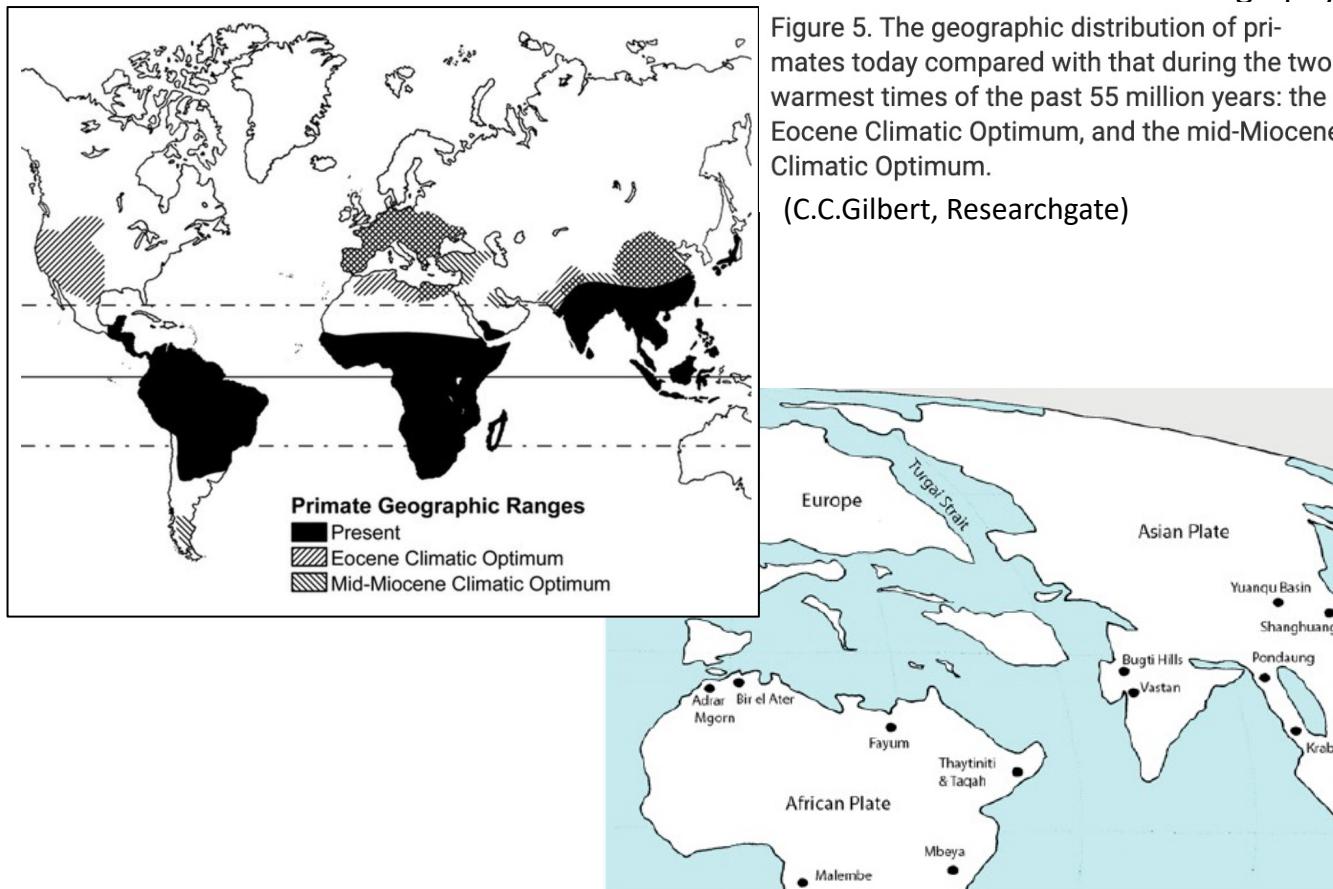


Fig. 1. Map showing localities containing Paleogene anthropoids. Coastlines and continental positions represent roughly the situation in the early Eocene to early Oligocene. Modified from refs. 8 and 119 with a more northerly position of India.

Williams *et al.* 2010, PNAS

**Climate got warmer – wide spread of tropical forests and primates in Eocene**

Eonothem / Eon	Era	System / Period	Series / Epoch	numerical age (Ma)
			Holocene	present
			Pleistocene	0.0117
				0.126
				0.781
			Pliocene	1.806
				2.588
				3.600
			Miocene	5.333
				7.246
				11.62
				13.82
				15.97
			Oligocene	20.44
				23.03
				28.1
Cenozoic	Neogene			33.9
				38.0
				41.3
			Eocene	47.8
				56.0
				59.2
Phanerozoic	Paleogene			61.6
				66.0

# Primates – major characteristics

1. **Prehensile** (holding, grabbing) **hands and feet** (opposable thumbs and big toes);
2. **Nails** on digits instead of claws (higher sensitivity, important for social interactions);
3. **Flexible** shoulder and hip joints (clavicle);
4. **Big brains** compared to their **body mass** (eye-hand coordination „+“, olfactory region „-“);
5. **Forward facing eyes**, which allow **stereoscopic vision**;
6. **Long gestation and slow post-birth development**
7. **Longer life-span** - prolongation of all phases of postnatal life

loris and lemurs	20 years
chimp	40 years
human	80 years

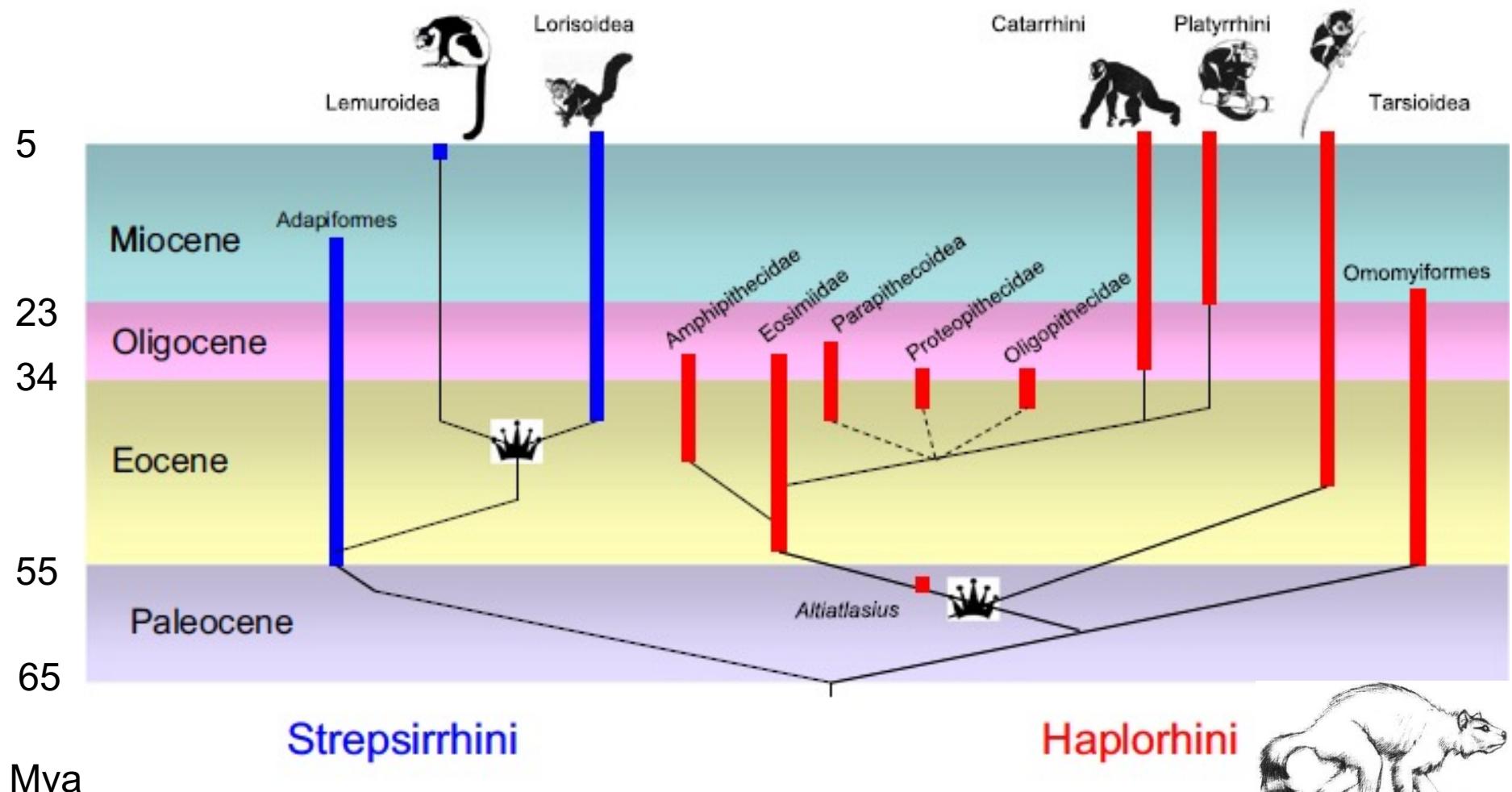


# Major groups of primates

## New perspectives on anthropoid origins

PNAS | March 16, 2010 | vol. 107 | no. 11 | 4797–4804

Blythe A. Williams<sup>a,1</sup>, Richard F. Kay<sup>a</sup>, and E. Christopher Kirk<sup>b</sup>



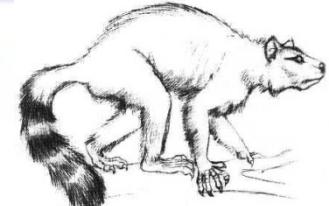
### Strepsirrhini

First branches to diverge from Anthropoid lineage were **loris** and **lemurs**, then **tarsiers**

### Haplorrhini

#### *Altiatlasius*

one of the oldest known primates in Anthropoid lineage, Maroko, Paleocene(60 Mya).



# Major branches of primates

- *Strepsirrhini* – “wet-nosed” primates

- lemurs of Madagascar
- “bushbabies” of Africa
- lorises of India and Southeast Asia



- *Haplorhini* – “dry-nosed” primates

- tarsiers
- Old World monkeys and apes (inc. humans)
  - Catarrhini* (“down-nosed”)
  - New World monkeys *Platyrrhini* (“flat-nosed”)

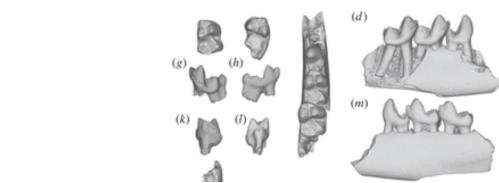


# Primates

## Early primates

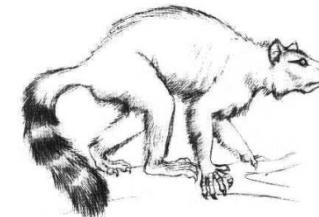
***Purgatorius***      **65 Mya**

Montana, 1965 – primate



***Altiatlasius koulchii***      **60 Mya**

Maroko, 1990 - one of the oldest fossils in Anthropoid lineage



***Darwinius masillae***      **47 Mya**

Germany, 2009 -  
mixed features of lemurs and monkeys  
*Adapiformes*



# Fossils of hominoids (apes) - Miocene

Earliest (ca 20 Mya) hominoid fossils are found from Africa.

**Proconsul**      **23-25 Mya**

Kenia 1909

?

**Afropithecus**    **16-18 Mya**

Kenia 1986

predecessors of great apes?

**Kenyapithecus** **14 Mya**

Kenia 1981



*Proconsul*

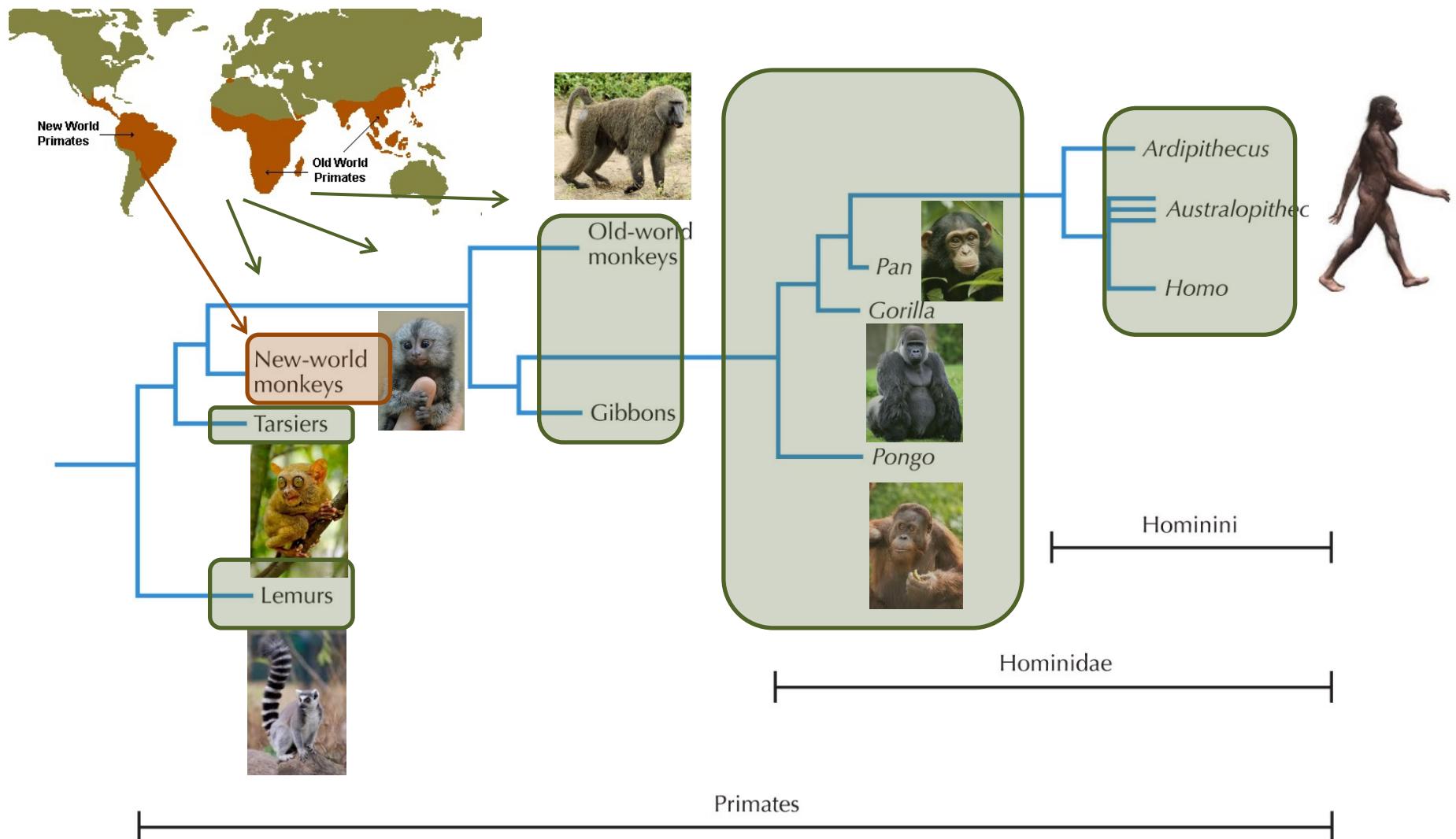
**15 Mya** land bridge between Africa and Europe. *Kenyapithecus* – first out-of-Africa traveller among hominoids?

**13-7 Mya** – very scarce of African fossils

Close relatives in **10-12 Mya** Europe:

*Dryopithecus*, *Graecopithecus*, *Oreopithecus*

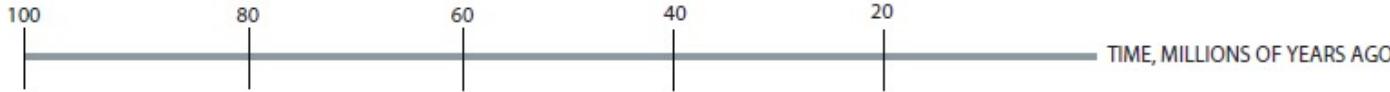
# Phylogeny of modern primates



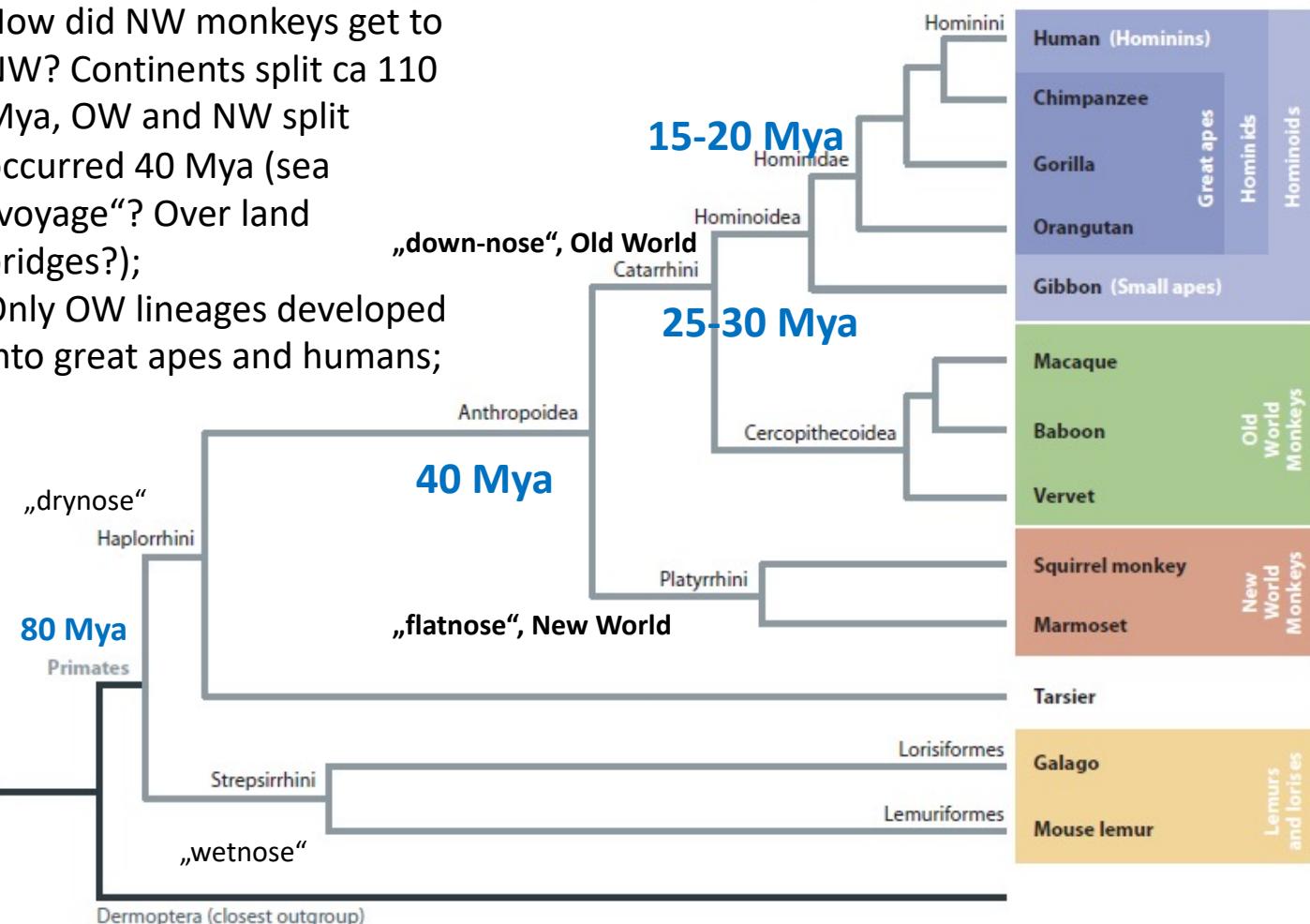
**FIGURE 25.1.** Organization of the order Primates. This tree represents only the branching order among the lineages. The lengths of the branches are not meaningful.

Barton et al. 2007

# Phylogeny of modern primates



- How did NW monkeys get to NW? Continents split ca 110 Mya, OW and NW split occurred 40 Mya (sea „voyage“? Over land bridges?);
- Only OW lineages developed into great apes and humans;



## Hominins



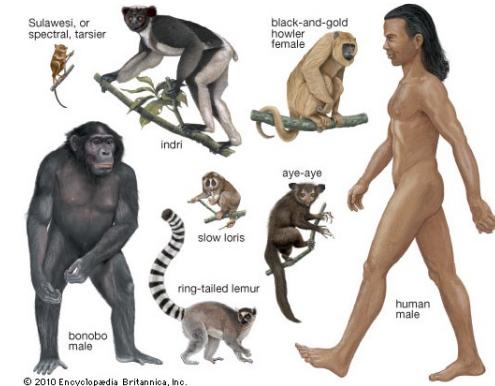
the Eocene period, statistical modeling of species preservation [data from Tavaré S et al. (2002) *Nature* 416, 726] suggests the last common ancestor of primates may have lived more than 80 MYA, a date that agrees well with genetic data.

**Figure 7.3: A phylogeny of extant primate groups.**

The phylogeny is shown for species that have undergone complete genome sequencing. The branching order is shown on a time-scale inferred from molecular data [data from Perelman P et al. (2011) *PLoS Genet.* 7, e10001342]. While the oldest known fossil primates date to

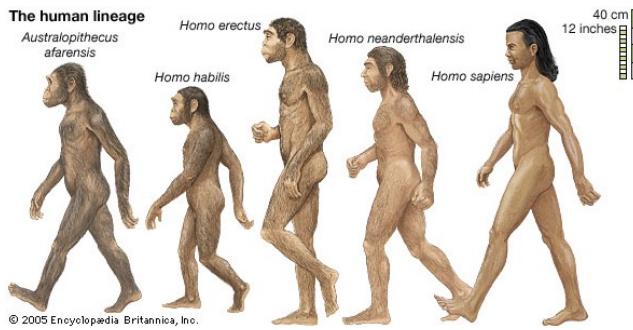
# Primates

## Major evolutionary events



- 40 Mya – split between Old (*Catarrhini*) and New World (*Platyrrhini*) primates;
- 25-30 Mya – split between Hominoids (human, great apes, gibbons) and Old World monkeys;
- 15-20 Mya – split of great apes (and human) from gibbons;
- 5-7 Mya – split between chimpanzee and hominin lineages

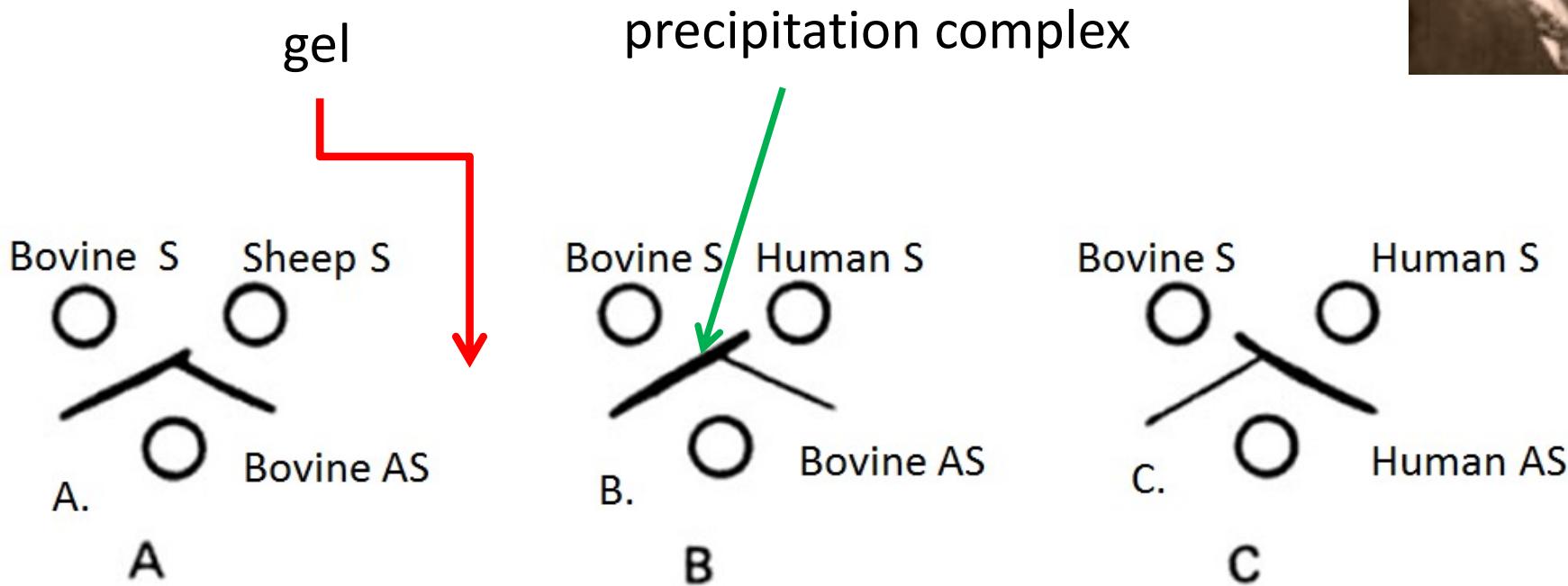
# Hominins



- Hominins – primate lineages that led to humans but not to the other great apes;
- There were several co-existing parallel lineages of hominins
- The only living hominin species today is *Homo sapiens*
- Our closest living relative is chimpanzee
- The split between the lineages of hominins and chimpanzees occurred 5-7 Mya

# Humans and their living relatives

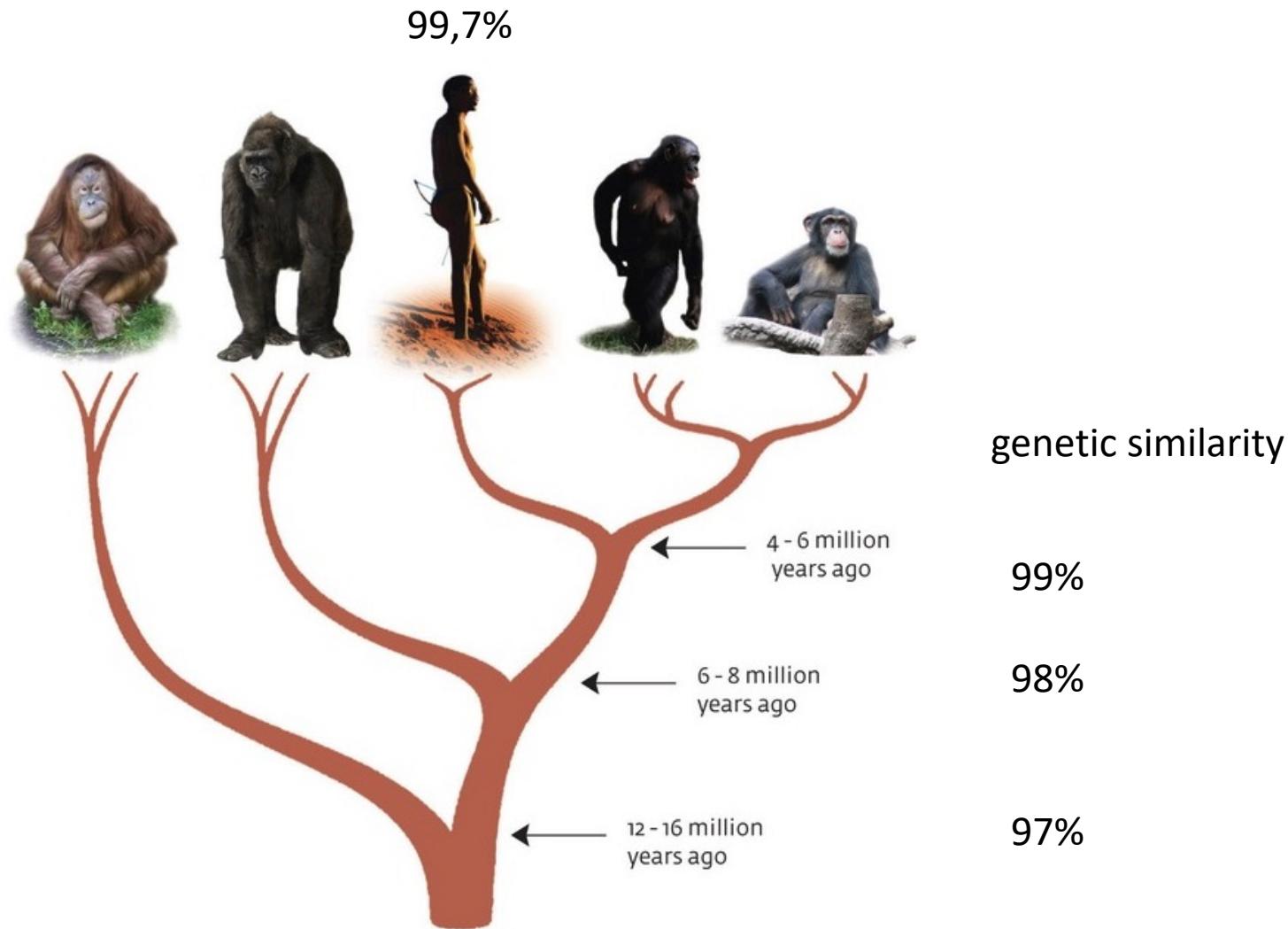
Immunoprecipitation test of blood serum-antisera (George Faulkner Nuttall, 1904!)



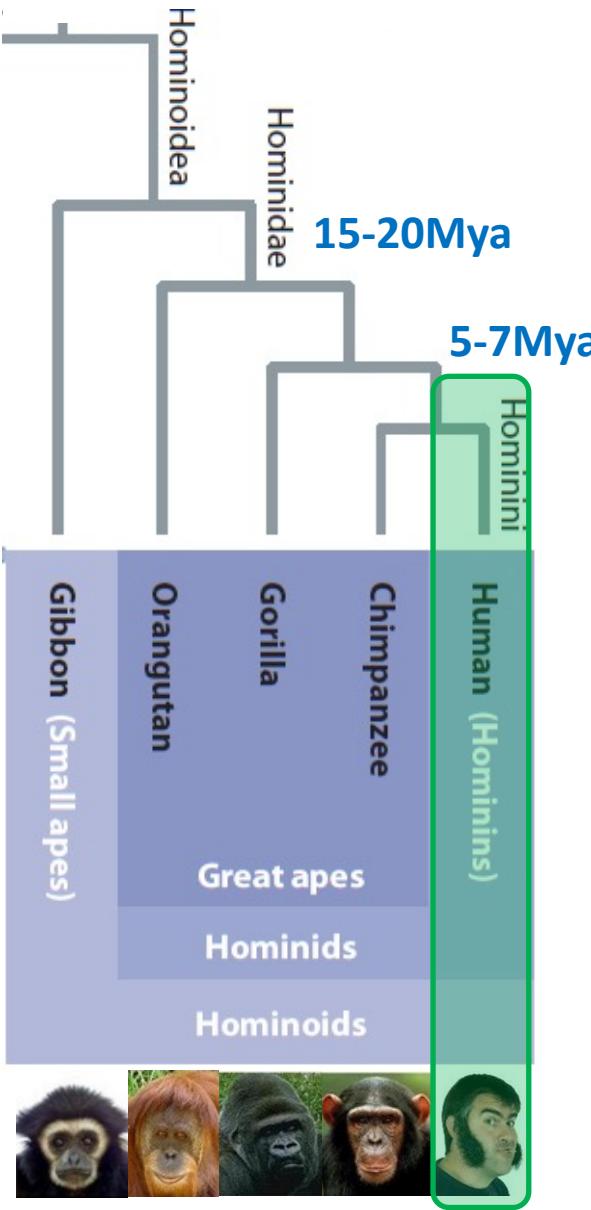
The more similar are the proteins (closer relationship), the stronger is the reaction! s – serum (blood plasma); AS – antiserum, serum containing antibodies against blood plasma components

With similar test he showed that closest to human are the apes, then Old World monkeys and then New World monkeys – this was **one of the first experiments to show the close phylogenetic relationships of human with other primates**

# Phylogeny of humans and apes



# Homininization – major characteristics of hominins



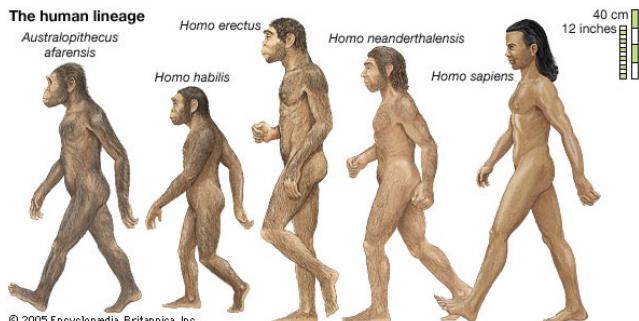
1. Prefer **bipodal** locomotion. *Homo* is **obligatory**, all other hominins were **facultative** bipedals;
2. Spinal cord curves keep weight centered above the pelvis;
3. Pelvis is broad and has a bowl shape;
4. Toe bones are short and broad, big toe is not diverged, heel strikes first;
5. Head is centered on the spine (*foramen magnum*);
6. Muscles are adapted to bipedality;
7. The proportion of legs grows;
8. **Brain size** grows rapidly compared to **body size starting from *H. erectus***;
9. „Neoteny“ - adult individual resembles juvenile (young) individuals of other primates – slowdown of postnatal morphological dev.;
10. Loss of body hair.

# Hominins(*Hominini*) – primate lineages that led to humans

Oldest fossils of hominin lineages have been found from Africa - **7 Mya**

Family ***Homo*** and our extinct relatives:

- ***Homo***
- ***Paranthropus***
- ***Australopithecus***
- ***Ardipithecus***
- ***Orrorin***
- ***Sahelantropus***

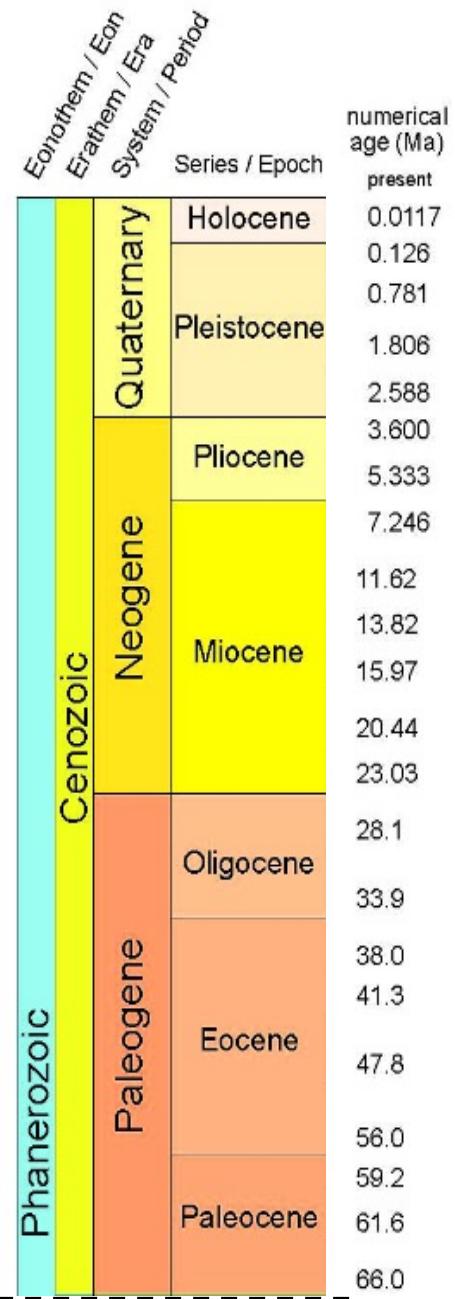


Quaternary - Anthropocene

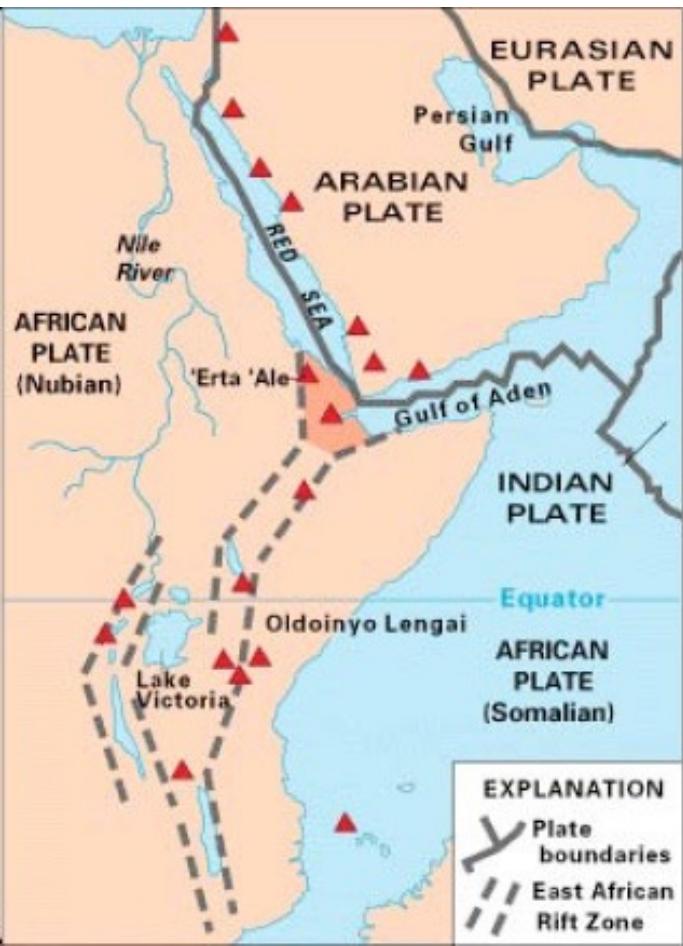
time

[www.stratigraphy.com](http://www.stratigraphy.com)

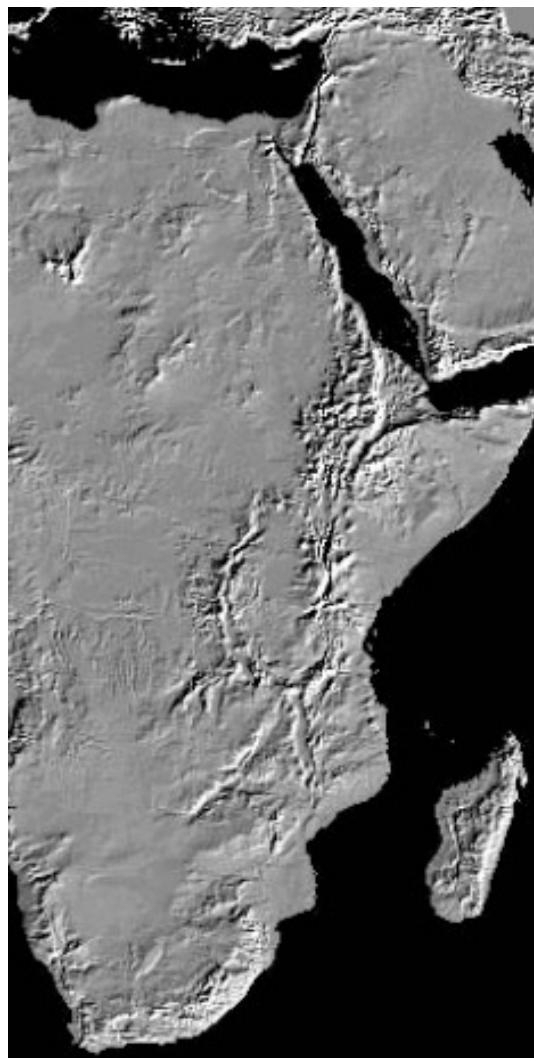
First primates



# East-African Rift (EAR) valley – very rich for fossils



EAR valley



Started to develop ca 25 Mya in East Africa, during which also the formation of the Red Sea started.

African continental plate will separate into two parts in the middle of rift area. There are lots of volcanoes (▲).

EAR extends from the Near East (Jordan River) to Mozambique (Indian Ocean) and is altogether 6400 km long.

5-7 Mya – formation of lakes and savannas, climate gets drier

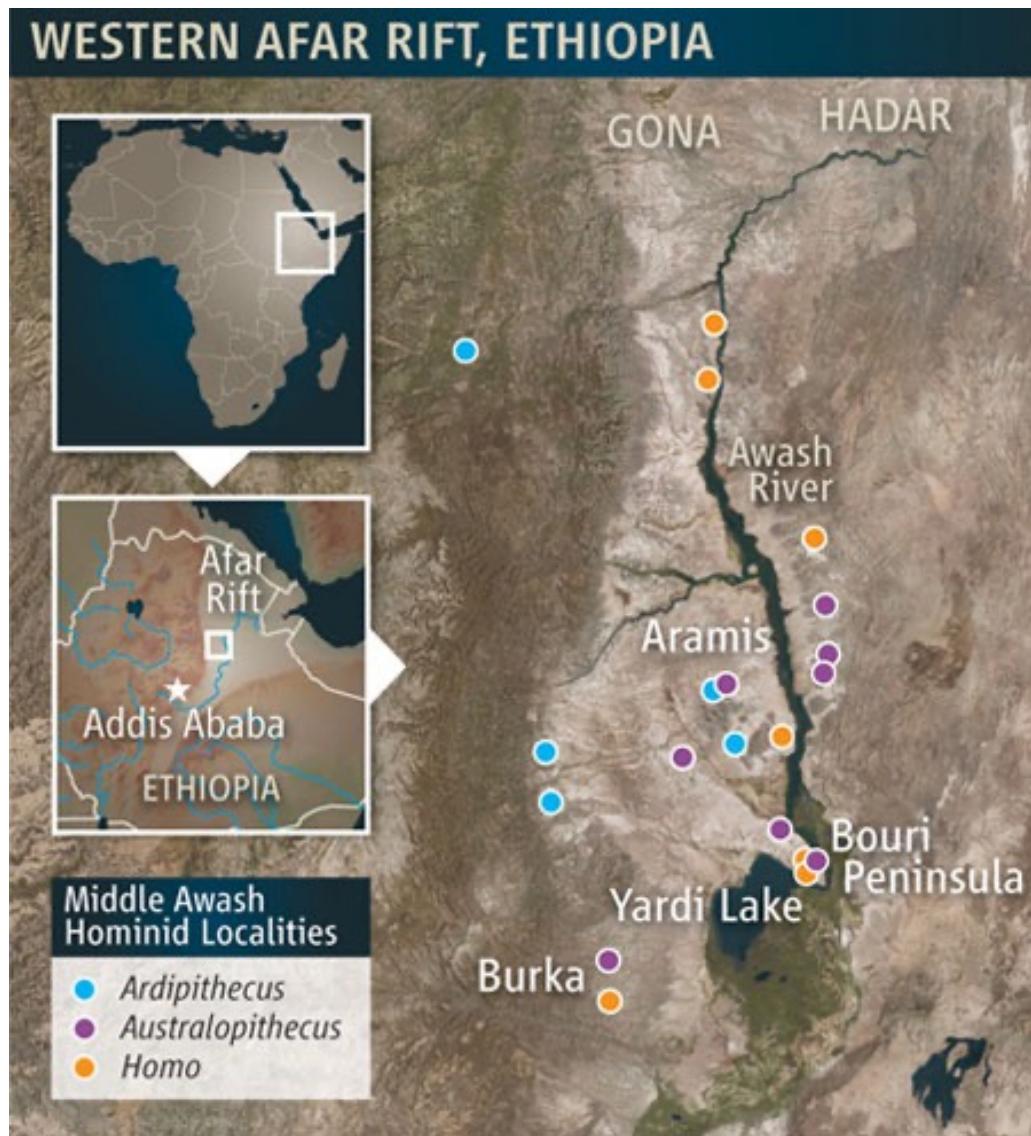
# East-African Rift (EAR) valley – very rich for fossils

Especially rich for **hominin fossils** is the contact area of three continental plates in **Ethiopia**.

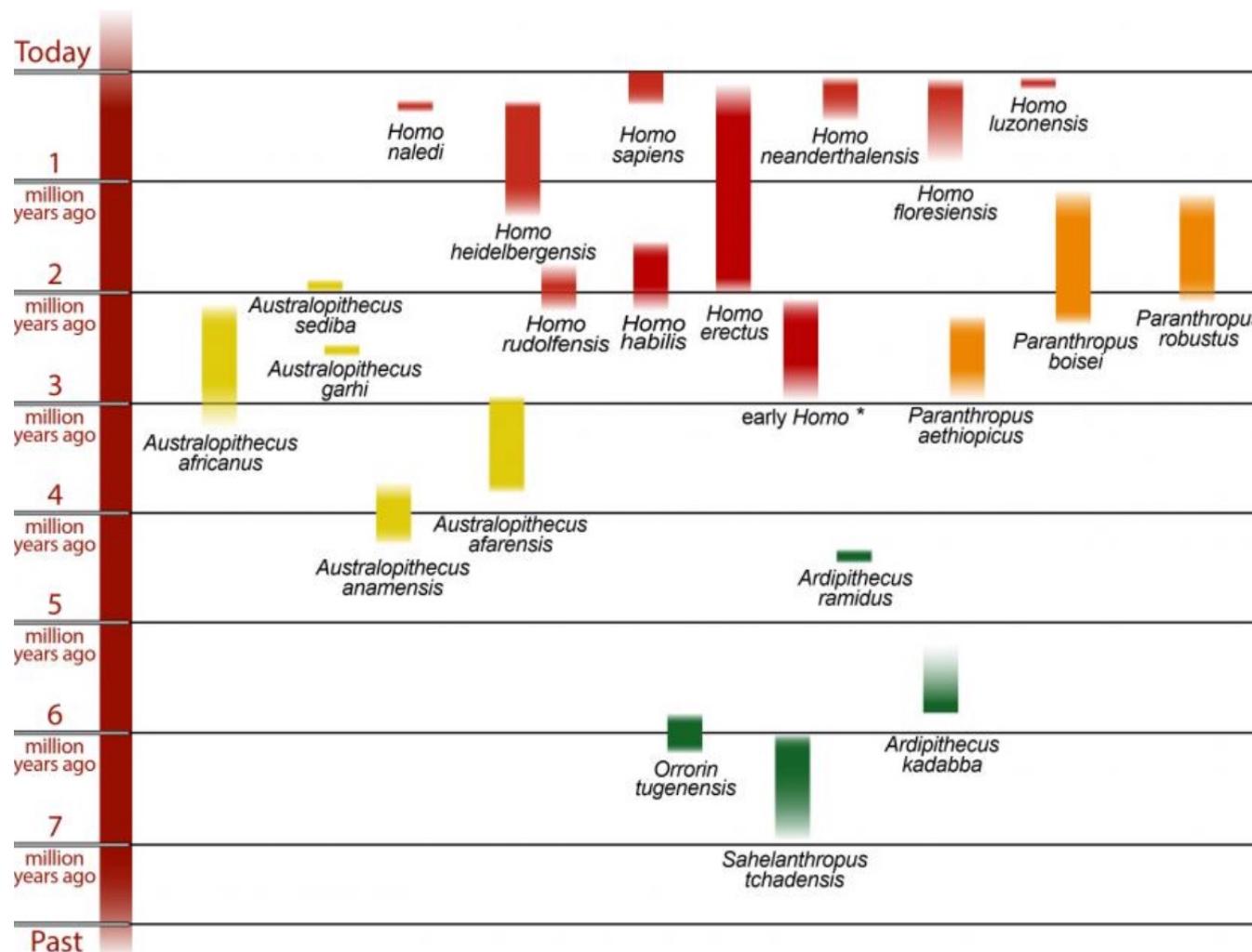
- **Ardipithecus** 5,8...4,5 Mya
- **Australopitecus** 3,2 Mya “Lucy”
- **Homo** 2,8 Mya ...

There are both early *Homo* (2,8 Mya) as well as *H.sapiens* fossils.

Geologically very good area to study – volcanic layers can be well dated (Hadar) to see the temporal background for found hominin fossils.



# Hominin fossils and their classification



\* This time bar refers to a group of fossils not yet identified to a particular species because they are not complete enough to be given a species name. They are, though, the oldest fossils currently identified as belonging to our genus. Together, they are usually called "Early *Homo*". These fossils include the 2.80-2.75 million-year-old mandible from Ledi-Geraru, Ethiopia (LD 350-1), and the 2.36 million-year-old maxilla from Hadar, Ethiopia (A.L. 666-1), among others. The earliest evidence of our genus has drawn such scientific and public interest<sup>1</sup> that we include this group of fossils in the graphic.

<sup>1</sup> <http://science.sciencemag.org/content/345/6192/1236828>

# Fossilized hominins – I - Miocene

East Africa ca **7 Mya** – first hominins (?).

This group is a subject of disputes – are these predecessors of humans or great apes.

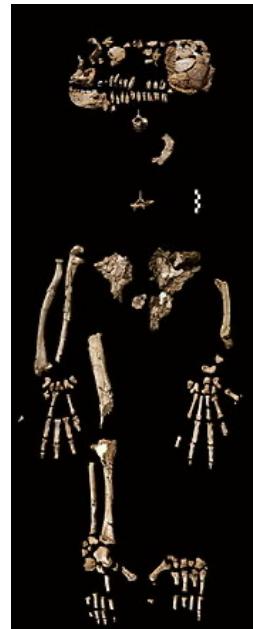
***Sahelanthropus tchadensis*** 7 Mya

Chad, 2001, „Toumai“ („hope of life“), skull, brain size 350cm<sup>3</sup>



***Orrorin tugenensis*** 6 Mya

Tugen Hills, Kenia, 2000, „Millenium Man“, femur (13 fossils) – bipedalism?



***Ardipithecus ramidus*** 4,5 Mya

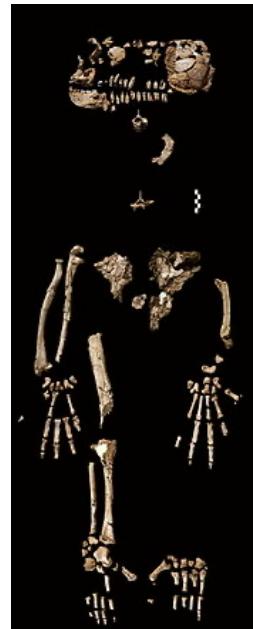
Ethiopia, 1994 (36 fossils) – bipedalism?

Brain size 300-350cm<sup>3</sup>



***A. kaddaba*** 5,6 Mya

Ethiopia, 1997 (11 fossils)



# Fossilized hominins – II – Plio-/Pleistocene „gracile“ australopithecines (southern apes)

Regression of canins (fangs) and shortening of jaws

## *Australopithecus anamensis* 4 Mya

Kenia, Turkana 1998



## *A. afarensis*

Ethiopia, 1972 „Lucy“  
(brain size 400-500 cm<sup>3</sup>)

3,8-2,9 Mya



Above is a mandible and upper tibia of *Australopithecus anamensis*. The tibia shows the articulation surface of the knee joint expanded front to back as in a biped.

3,2 Mya



Cranium of *Australopithecus afarensis*

## *A. africanus*

3-2,4 Mya

*A. afarensis*



*A. africanus*

## *A. sediba* 1,9 Mya

South Africa

### - sexual dimorphism

Females 1m, 35 kg

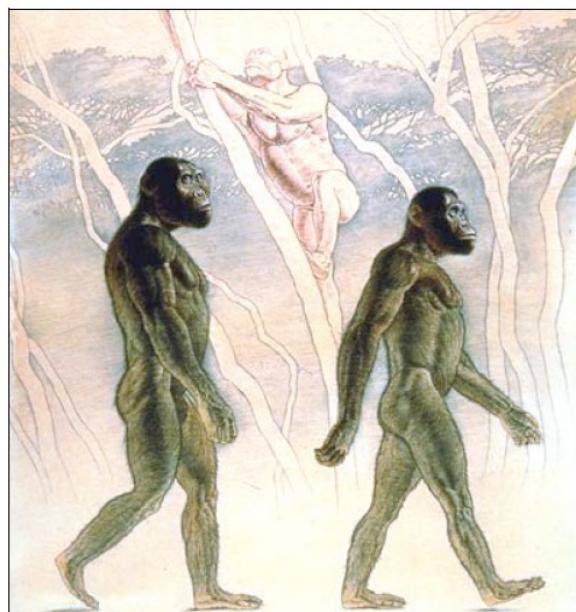
Males 1,5m, 70 kg

### - clearly bipedal

Laetoli footprints, 3,5 Mya

Tansania

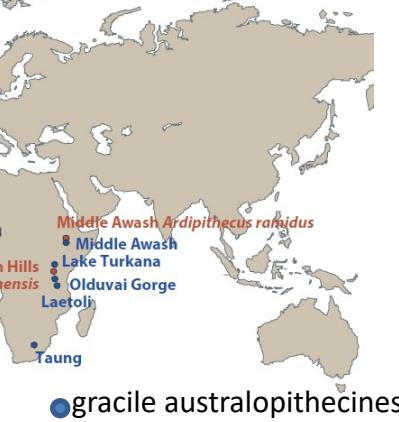
### - use of tools?



*Australopithecus afarensis* was ~ 1 to 1.5 meters tall (3 to 4.5 feet).



„Lucy“



# Fossilized hominins – III – Pleistocene

robust australopithecines e. *Paranthropus* are sometimes classified separately from other australopithecines

***Paranthropus***      2,5 – 1,2 Mya

Ethiopia, Tansania, Kenia etc.

The skulls of *Paranthropus* are more „robust” than those of gracile australopithecines – with gorilla-like sagittal cranial crest and very strong teeth .



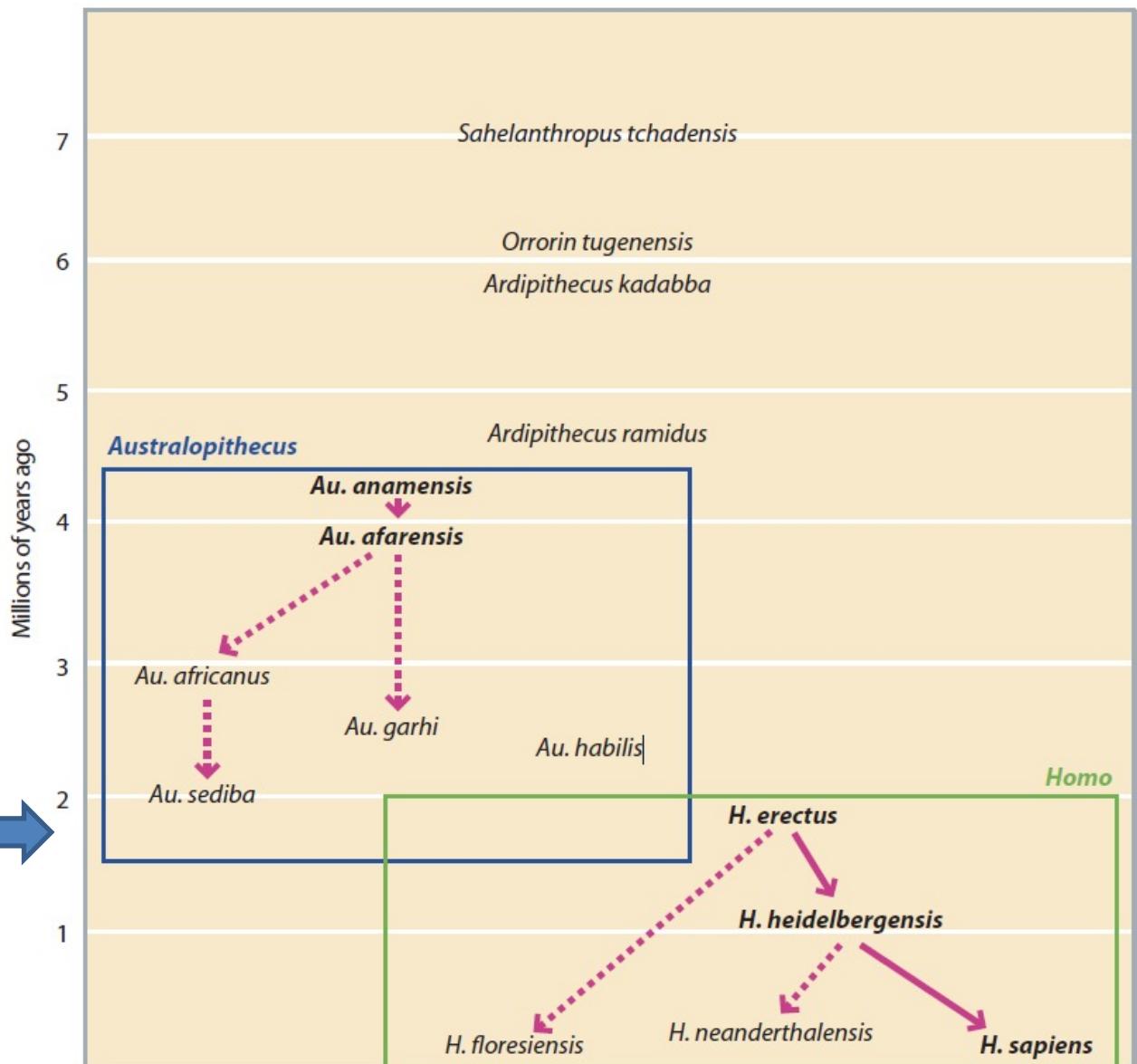
Remains of *Paranthropus boisei* (above), one of the later robust species, have

Robust australopithecines lived at the same time with early *Homo* (*H. habilis*, *H. ergaster*), but they belonged to the lineage branching off from ours. At the same time *H. ergaster* expanded out of Africa (1,8 Mya).

# Possible relationships of fossilized hominins

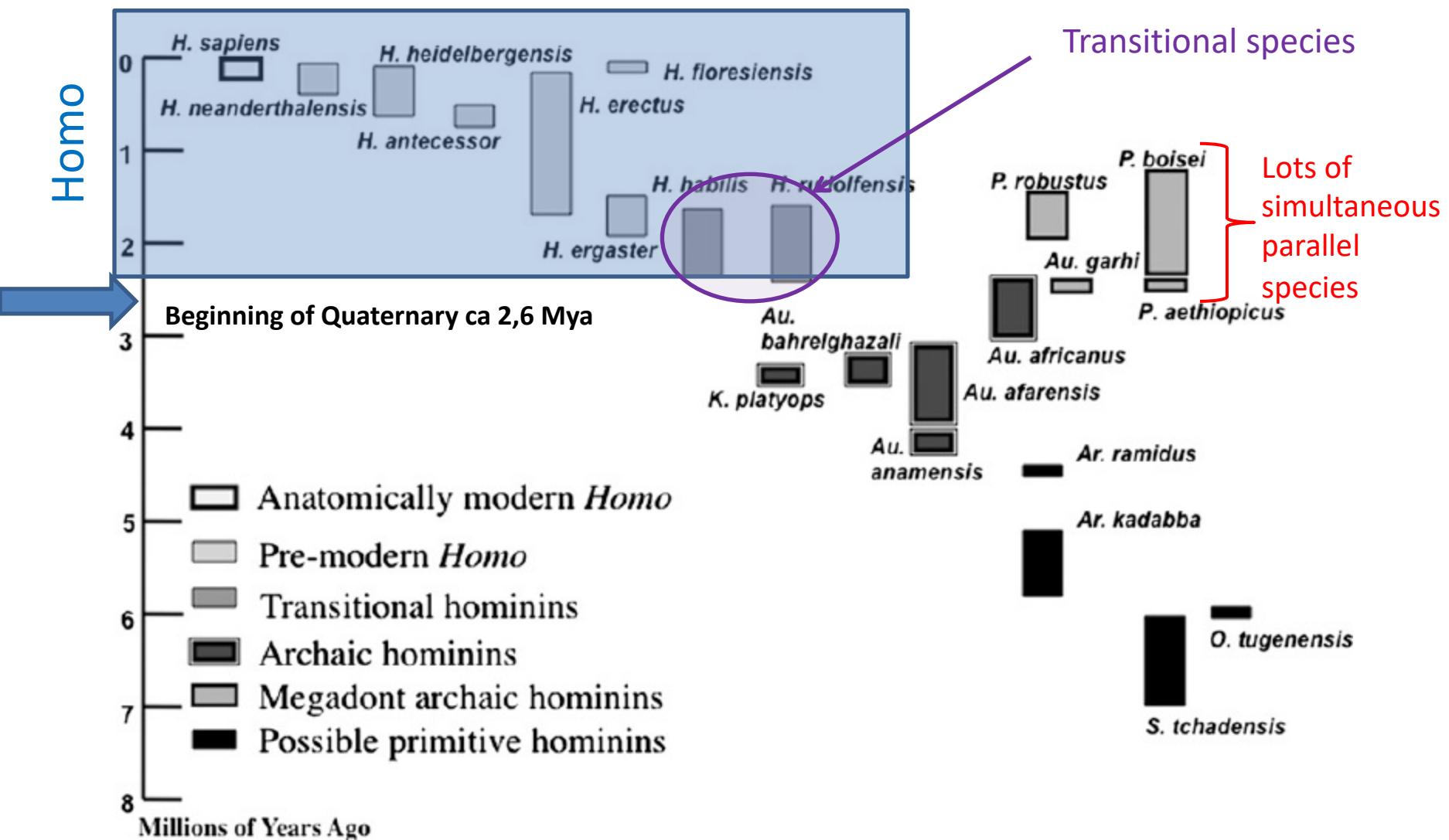
**Figure 9.4: Relationships of fossil hominin species, indicating plausible human ancestors.**

Species relationships are shown by red arrows, solid when on the human ancestral line; species in bold are likely human ancestors. Note the uncertainty about the relationships and human line affinities of the early hominins, and the uncertainty about which later australopithecine is ancestral to *Homo*. Compare with Figure 9.1.



# Hominin fossils and their classification

## Hominin grades - speciose taxonomy

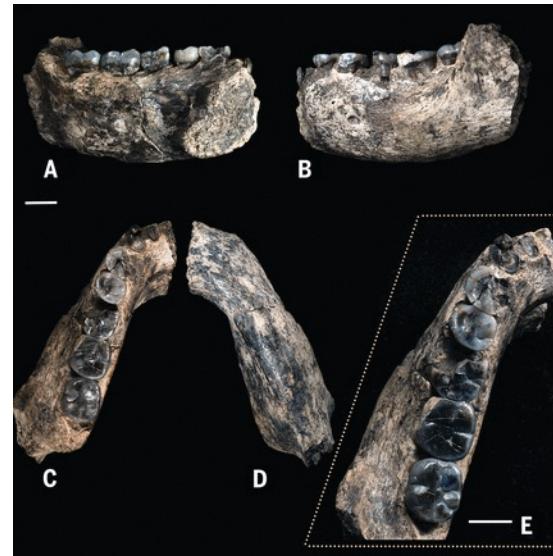


# Fossilized hominins

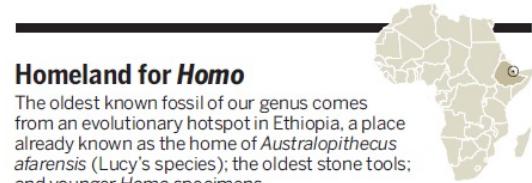
Recent finding – *Homo*  
Ethiopia, Afar

Villmoare *et al.* 2015 *Science*

2,8 Mya



- pushed the age of *Homo* family ca 400 000 y backward;
- transitional fossil, some morphological traits are similar to *A. afarensis*;
- *Homo* overlapping time-wise with australopithecines?



# Fossilized hominins – latest news

## *Homo naledi*

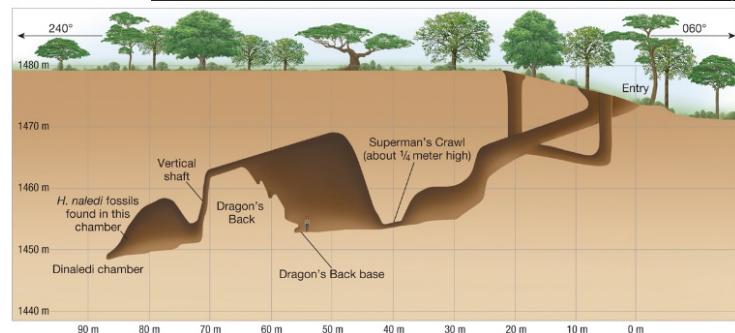
South Africa, Gauteng

Berger *et al.* 2015

15 skeletons in Dinaledi cave of Rising Sun cave system



- New member of *Homo* family;
- Transitional morphological traits, very small scull (465-610 cm<sup>3</sup>);
- Only 236 – 335 000 years old – parallel to *H. sapiens* – big diversity of hominins in Africa



# Homo family



*H. habilis* (Tansania)

*H. rudolfensis* (Kenia)

*H. erectus*

*H. heidelbergensis*

*H. floresiensis*

*H. neanderthalensis*

*H. sapiens*

2,4-1,4 Mya

1,9 Mya

*H. erectus*

*H. ergaster (Africa)*

*H. erectus (Asia)*

1,9-1,0 Mya

1,8 Mya – 200 kya

First clear *Homo* member and also a first hominin who expanded out of Africa!

*H.sapiens*

*H. antecessor (Europe)*  
*H. heidelbergensis (Europe, West Asia)=*  
*= H. rhodesiensis (Africa)*  
*H. neanderthalensis*

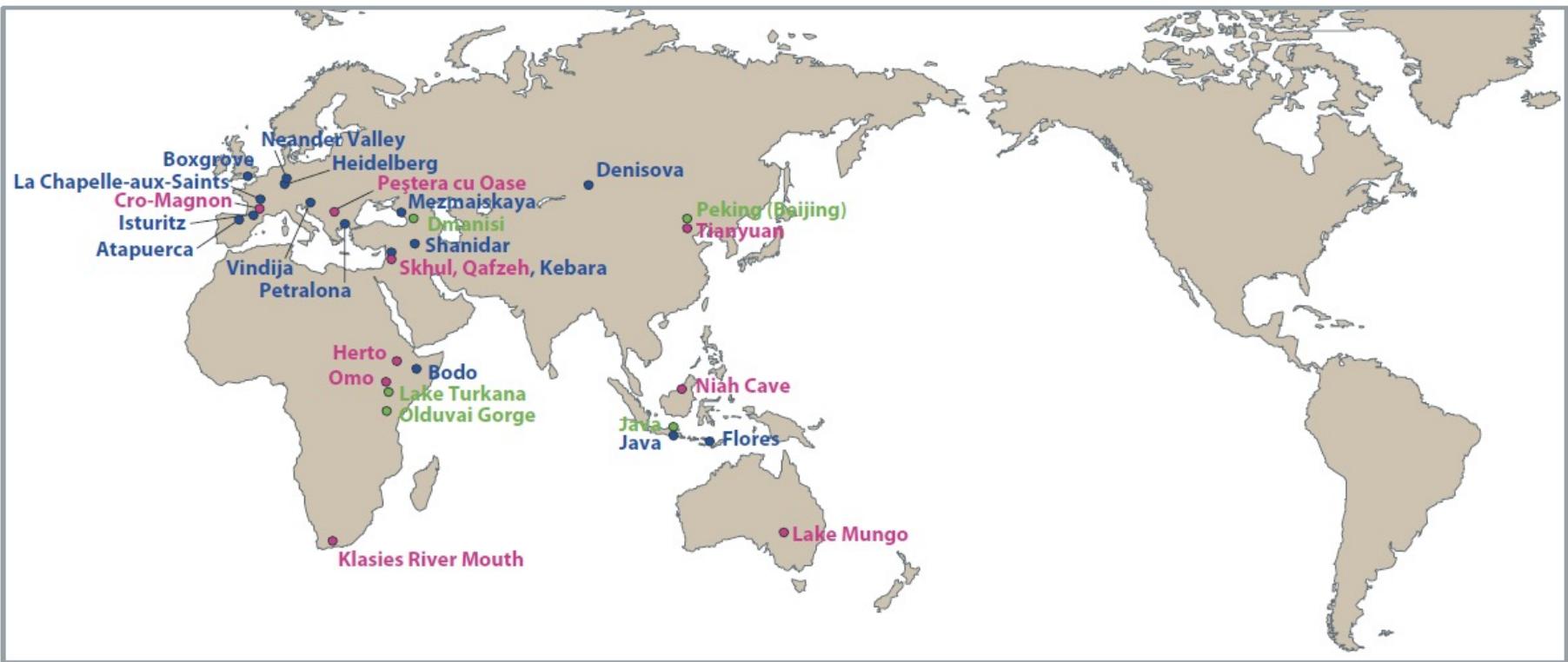
1,2 Mya – 600 kya  
600 – 300 kya

400 – 40 kya  
195 - ... kya

*Denisova human*  
*H. floresiensis*

(finding ca 50 - 160 kya old)  
60-100 kya

# The oldest findings of fossils of *Homo* family



**Figure 9.6:** Sites of *Homo* fossils.

Early sites (1.9–1.6 MYA) are shown in green, later sites (800–12 KYA) for species other than *H. sapiens* in blue, and *H. sapiens* in red. These sites

are spread throughout much of the world, illustrating the extensive spread of *Homo* compared with earlier hominins (Figure 9.2).

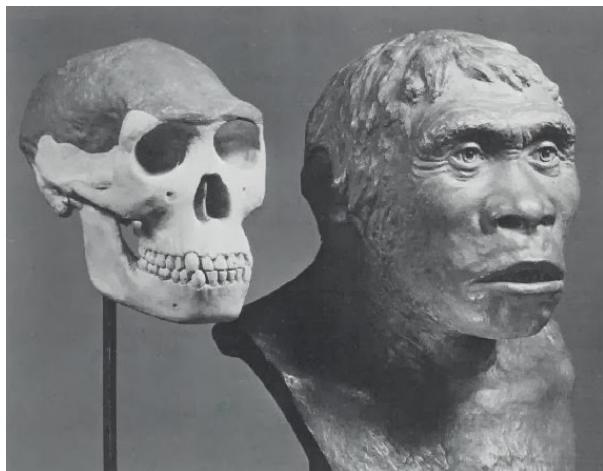
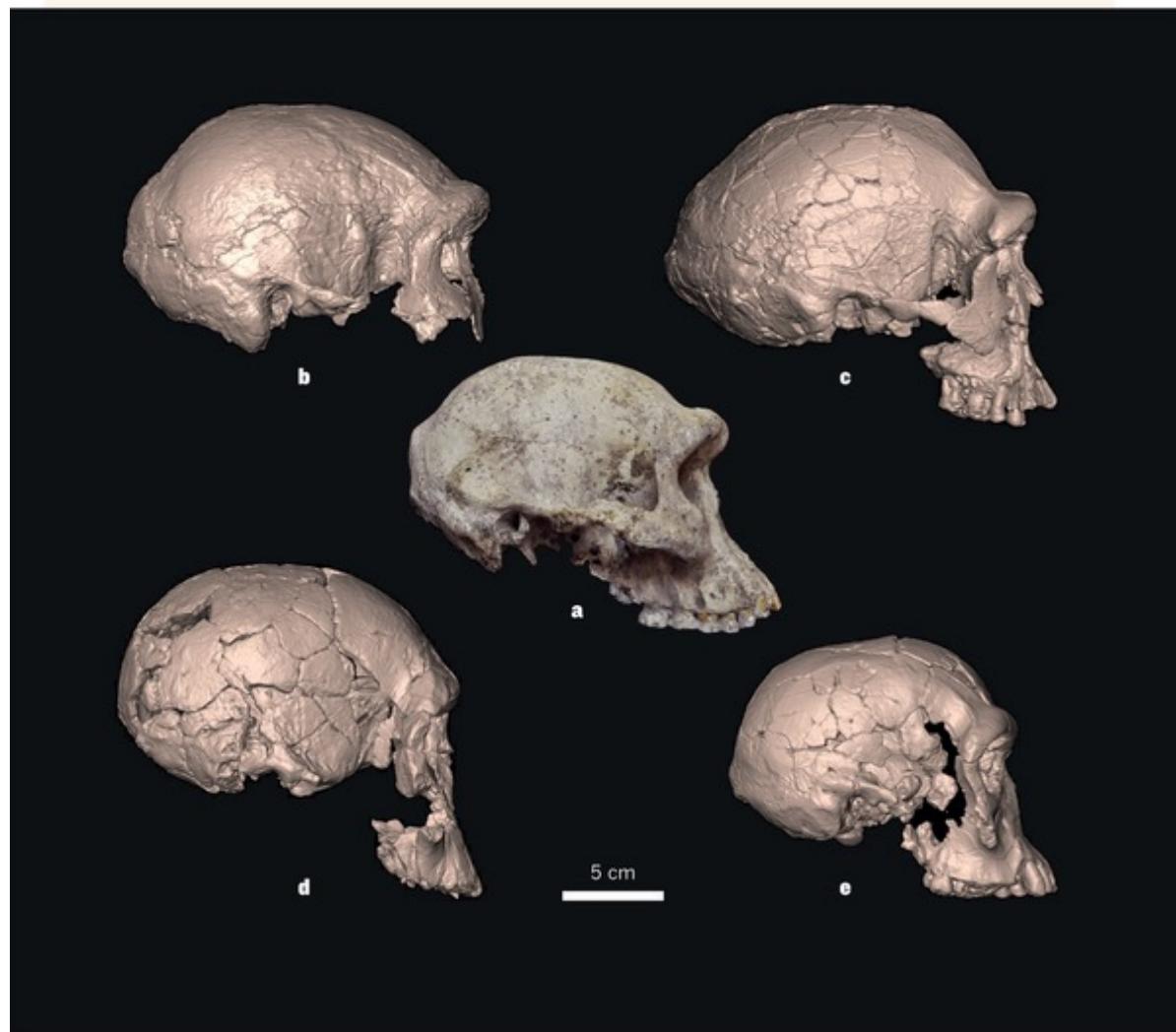
*H. erectus* was a first hominin who travelled out of Africa

First fossil found from outside Africa – Dmanisi, Georgia 1,8 Mya

# *Homo* family

Early representatives of  
*Homo*

- a. *H. erectus* from Georgia  
(very diverse set of 5 sculls);
- b-c. *H. erectus* Kenia;
- d. *H. rudolfensis*
- e. *H. habilis*,



Java fossils are dated to 1,7 Mya – 135 kya – very long period  
Altogether – *H. erectus* has been once around for a much longer period than *H. sapiens*

**Eugene Dubois 1887** – Java Man, *Pithecanthropus erectus* – first expedition with an aim to find a „missing link“ between human and apes

# *Homo* family



Acheulean Handaxe  
**Acheulian culture**  
1,2 Mya - 200 kya

## *Homo ergaster*

(African *H. erectus*) 1,5 Mya

### **Nariokotome (or Turkana) boy**

Kenia, 1984, one of the best preserved hominin skeletons

(Ca 10 y old, as a grown-up - 1,65 cm ja ca 50 kg, brain size 900 cm<sup>3</sup>)

1) *Homo erectus* was adapted to dry savanna climate – **slim body with long legs** allowing to be a good hunter in a treeless landscape;

2) with *H. erectus* started a **rapid growth of brain size** (900 – 1200 cm<sup>3</sup>);

3) were the first to **lose their thick body-hair**;

4) 800 000 ya started **actively to use fire**.



*Homo erectus* (*ergaster*) from Nariokotome, West Turkana, Kenya

# *Homo* in Europe

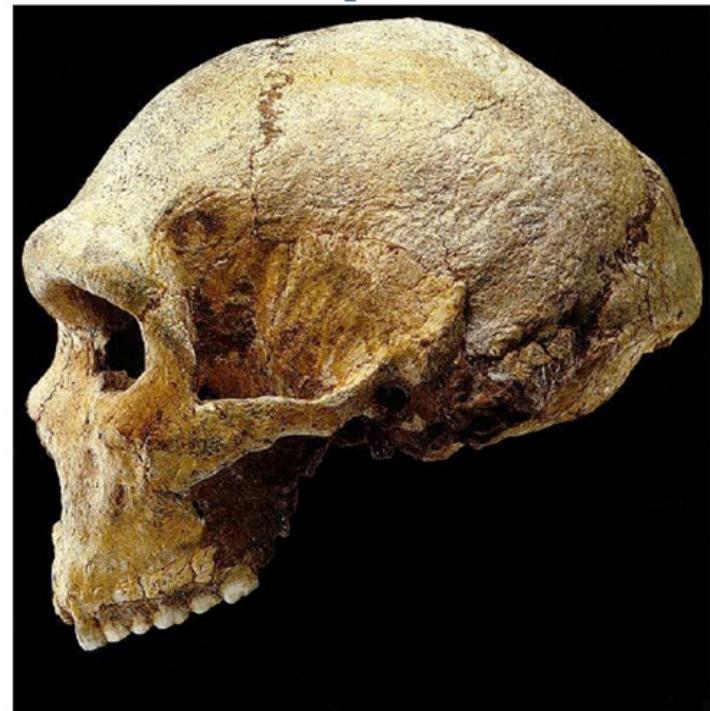
*H. antecessor* 1,2 Mya - 600 kya

*H. heidelbergensis* 600 - 300 kya

These two are often classified as *H. heidelbergensis* – predecessor of *H. sapiens* and *H. neanderthalensis*

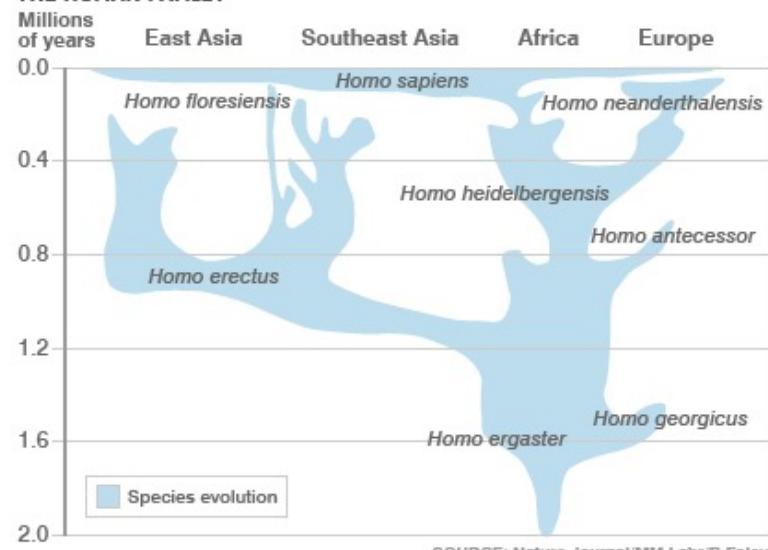
Main findings are from Europe and Africa (there named as *H. rhodesiensis*), has arisen probably in Africa

**Sima de los Huesos** - oldest *Homo* who has been studied with the help of ancient DNA.



Cranium of *Homo heidelbergensis* from Petralona, Greece

## THE HUMAN FAMILY



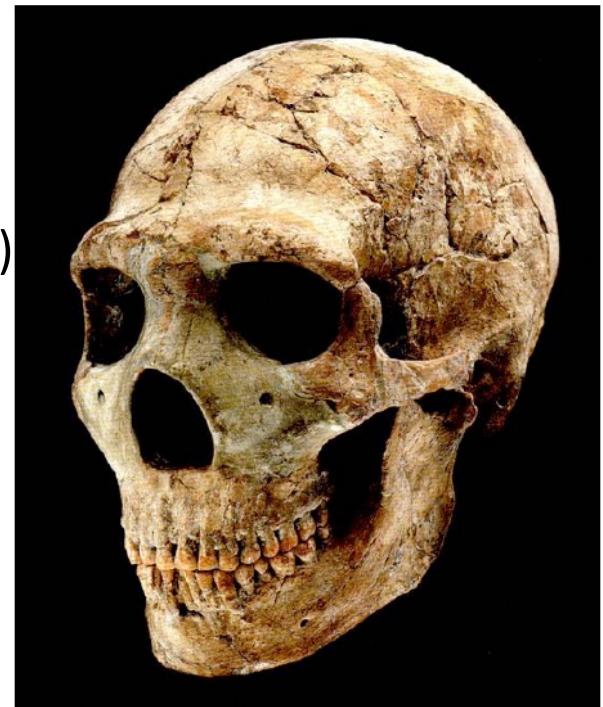
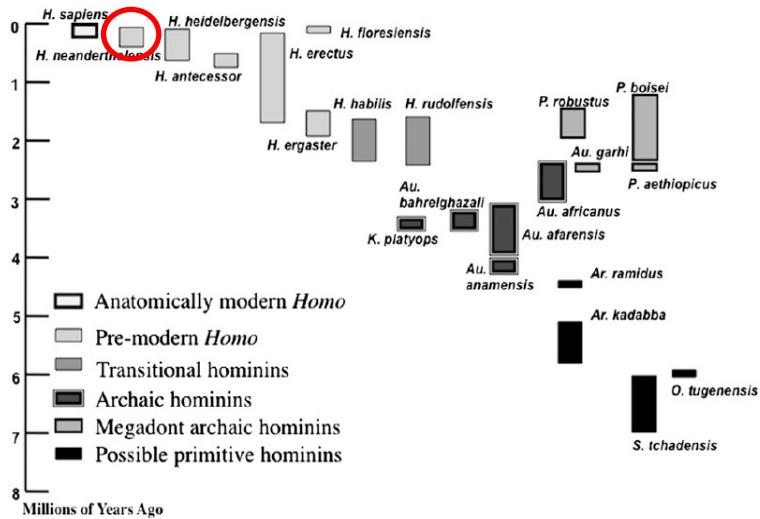
# *Homo* in Europe

## *Homo neanderthalensis*

ca 400 - 40 kya (NB! At the same time with *H. sapiens*!)

Evolved in Europe (brain size 1300-1600 cm<sup>3</sup>).

### Hominin grades - speciose taxonomy



*Homo neanderthalensis* from Amud Cave, Israel

(Photograph by David L. Brill)

Feldhofer from Neander valley in Germany  
40 000 ya  
Vindija (1,3x), Mezmaiskaya (0,5x) and Altai (52x) are well-known because of aDNA studies

- robust build, strong muscles;
- males 164-168 cm, females 152-156 cm;
- adapted to cold climate;
- big brains;
- symbolic thinking (burial customs and language, toolmaking)

**Mousterian** culture  
300-30 kya Europe



# Spread map of *Homo neanderthalensis*



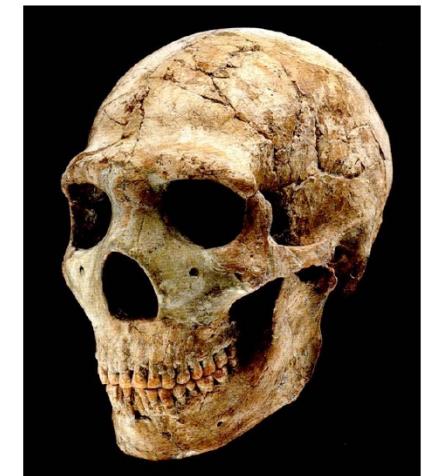
*Wikipedia*

# *Homo* in Europe

## *Homo neanderthalensis*

ca 400 - 40 kya (NB! ca 10 kya with *H. sapiens*!)

5 new neanderthal genomes (39 – 47 000 ya), 1-3x coverage

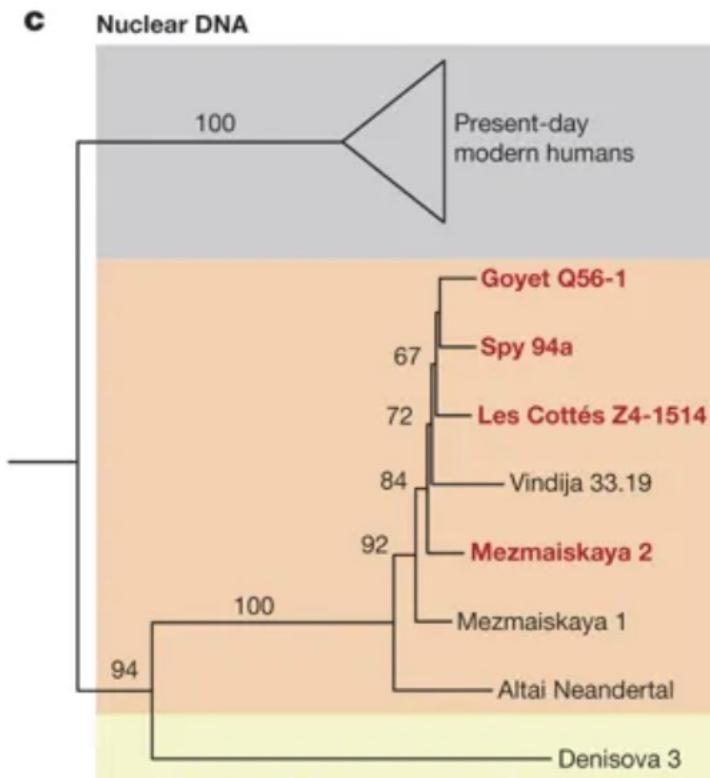


*Homo neanderthalensis* from Amud Cave, Israel

(Photograph by David L. Brill)



Hajdinjak et al. 2018, *Nature*



# *Homo neanderthalensis*

## Why did they die out?



- Genomic studies have shown that at least in the “last period” their population was **small and homogenous**, with very limited genetic variation – not flexible to changes;
- **climatic changes** during the last Ice Age might have put too much pressure on their small population (not only cold but dry climate, rapid change of ecosystem?);
- **violent conflict** between neanderthals and *H. sapiens*?
  - not many evidences;
- **competitor for food** and other resources – *H. sapiens* was more plastic?

# *Homo neanderthalensis* – latest news about their 50 kya diet

- **Dental plaque** from four Neanderthals from three sites of Europe were studied for aDNA;
- Neanderthal from Belgium consumed **woolly rhinoceros** and **wild sheep**;
- Neanderthal from El Sidrón in Spain ate **pine nuts, moss and mushrooms**;
- Poplar(*Populus*) containing active ingredient in **aspirin** (salicylic acid) and an **antibiotic mould** (*Penicillium*) were found in one sample – **self-medication and use of painkillers?**



Poplar (*Populus*)



Fungus (*Penicillium*)

Weyrich *et al.* 2017 *Science*



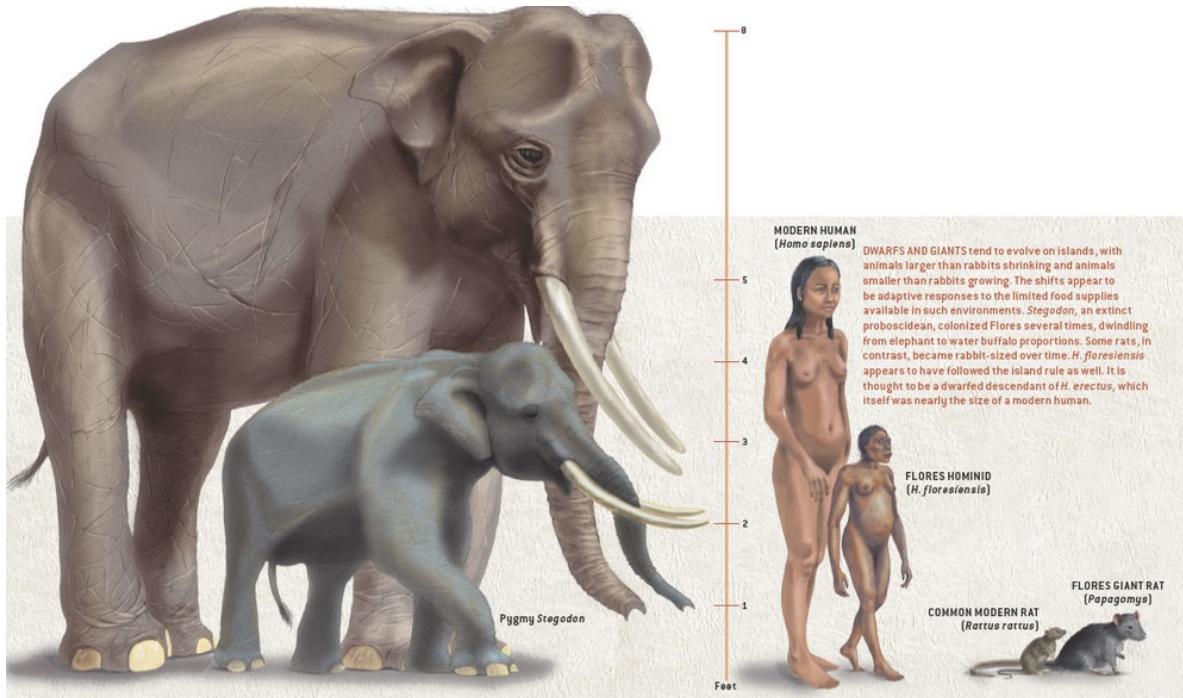
Dental plaque or *calculus*

# Ca dozen years ago *Homo floresiensis* was discovered in Indonesia

60 - 100 000 ya;



- „The Hobbit“ or „Flo“ from Flores Island (2004);
- length - 110 cm, brain size 400 cm<sup>3</sup>;
- contemporaneous with *H. sapiens*;
- phylogenetic relationship with other hominins unclear:
  - a) descendants of *H. erectus*?;
  - b) dwarf variant of *H. sapiens* ? or *erectus*?  
(microcephaly?);
- no aDNA available so far.



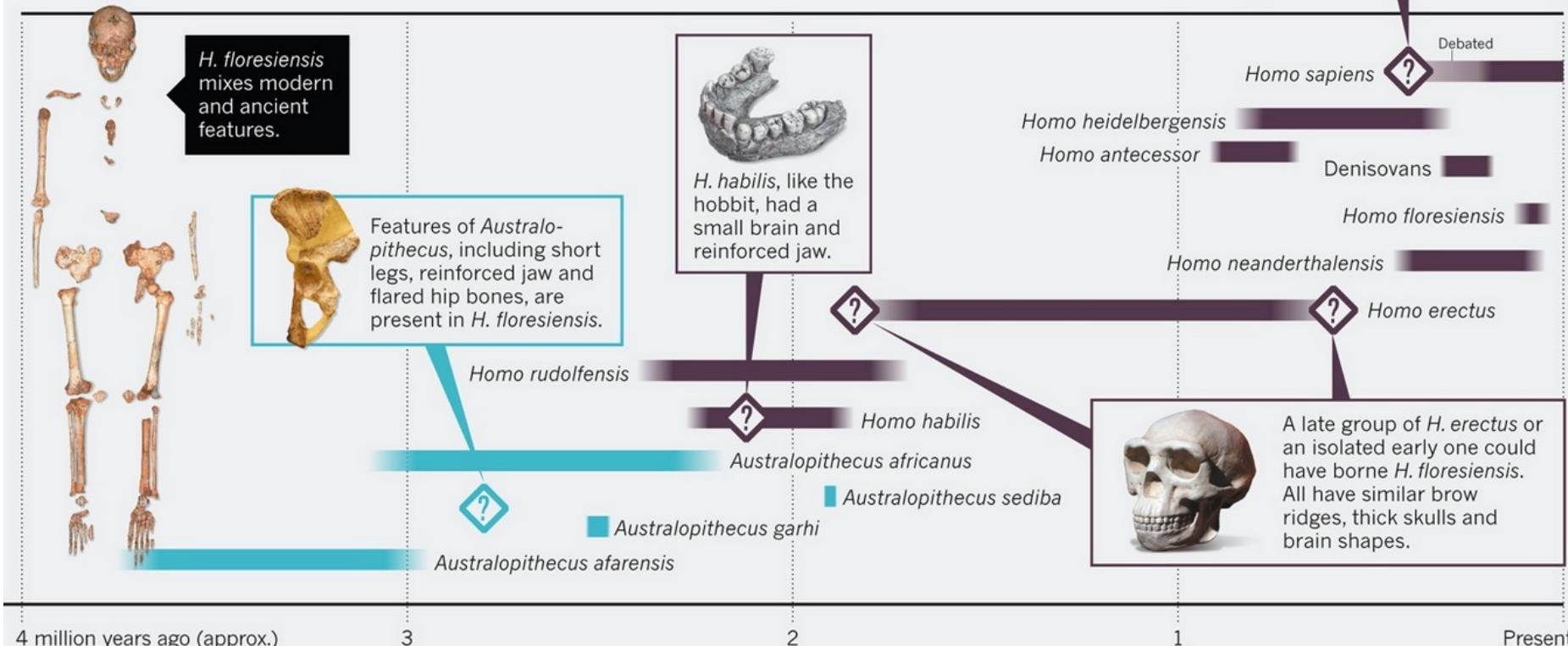
Ca dozen years ago *Homo floresiensis* was discovered in Indonesia

- Morphologically a mixture of modern and ancient hominin traits

## WHERE DOES THE HOBBIT BELONG?

More than a decade after scientists unearthed a startling tiny skull, debate rages over which branch of the human tree bore *Homo floresiensis*.

Some argue that the small hobbit bones resemble an abnormal, dwarfed *H. sapiens*.



# Denisova human

(preliminary name: *Homo sp. Altai* or *Homo sapiens ssp. Denisova*)

- discovered 2010 from **Denisova Cave** (together with bones of Neanderthals and *H. sapiens*) in **Altai Mountains, Siberia**;
- all what is known about Denisovan human comes from genomic studies of ancient DNA, skeletal remains are extremely scarce (bone fragments, some teeth, mandibula)



„X-woman“



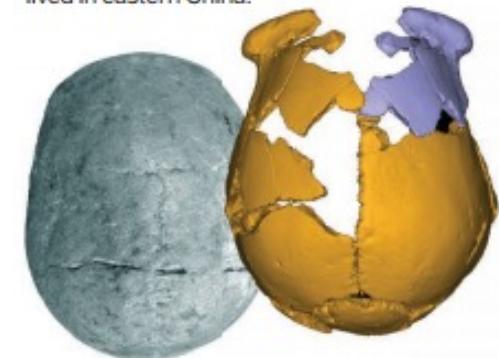
Chen et al. 2019 – new discovery - mandibula 160 kya

100-130 000 ya Denisova ?

1800 cm<sup>3</sup> (!)

## Mystery skull takes shape

Fossil fragments (yellow) were put together with their mirror-image pieces (purple) to visualize the skull of an archaic human who lived in eastern China.



Gibbons 2017 *Science*

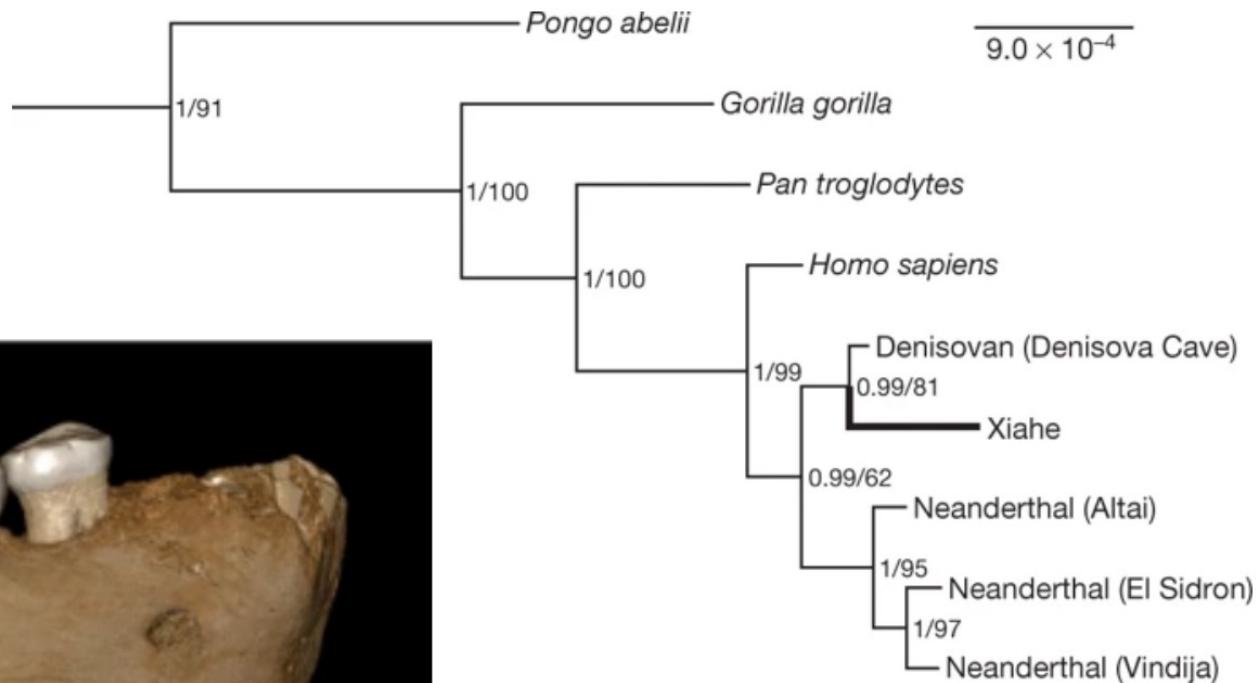
# Denisova human

(preliminary name: *Homo sp. Altai* or *Homo sapiens ssp. Denisova*)

Ancient DNA – 1 000 000 ya – mammoth from permafrost

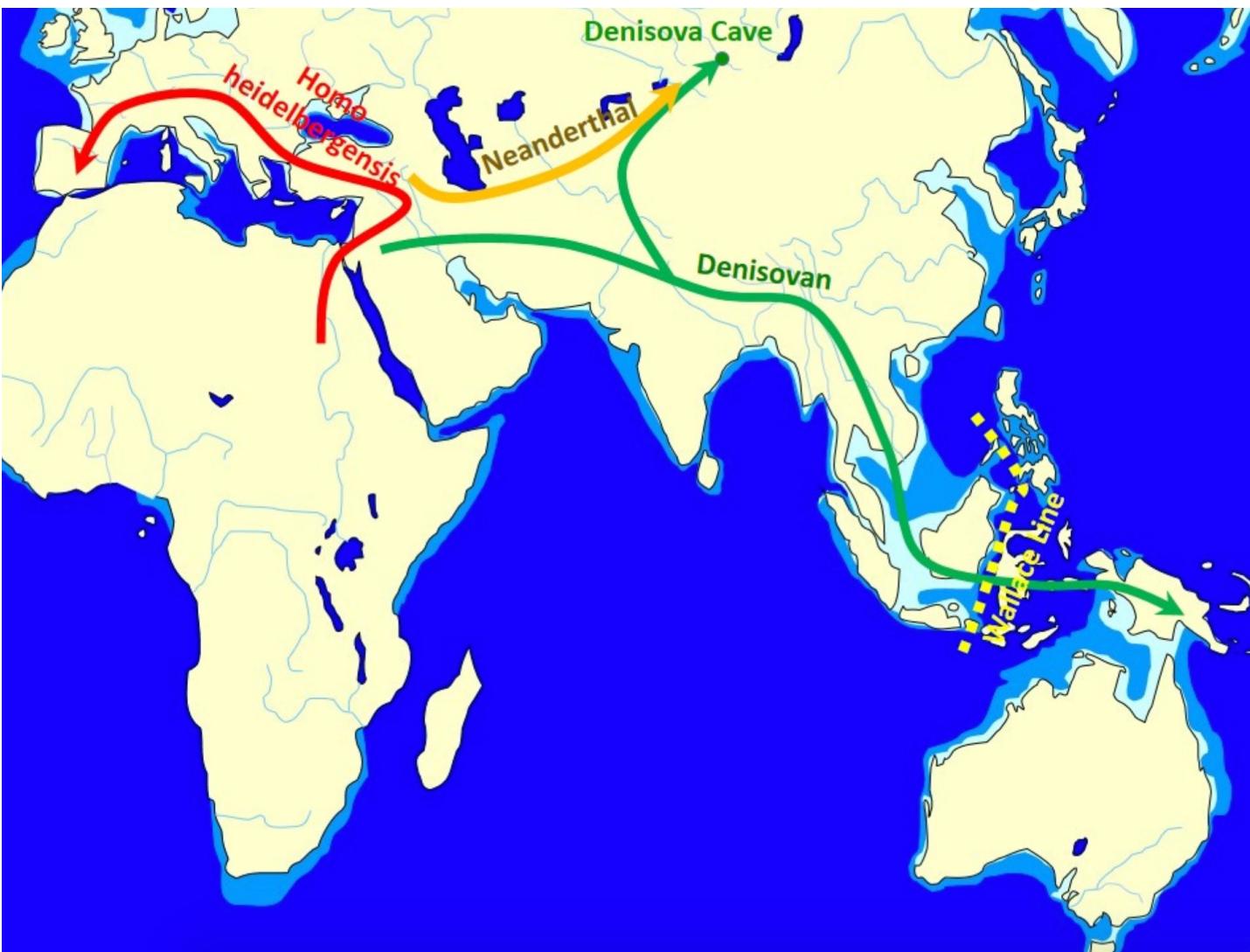
Ancient proteins – 3.8 Mya – ostrich eggshell

**Fig. 2: Phylogenetic position of the Xiahe proteome within Hominidae.**



Chen et al. 2019 – new discovery - mandibula 160 kya in China

# Geographical spread of hominins

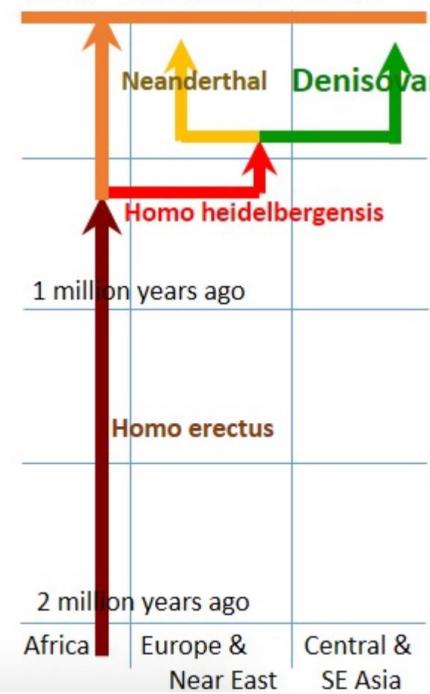


Key

Maximum Sea Level  
during the Ice Age



Today – modern Homo sapiens



# Earliest findings of *Homo sapiens* fossils

**TABLE 9.2:**  
**THE OLDEST ANATOMICALLY MODERN HUMAN FOSSILS FROM DIFFERENT REGIONS OF THE WORLD**

Continent	Location	Remains	Date (KYA)	Reference
Africa	Omo-Kibish, Ethiopia	Omo I skull	195	McDougall I et al. (2005) <i>Nature</i> 433, 733.
Africa	Herto, Ethiopia	three crania	154–160	White TD et al. (2003) <i>Nature</i> 423, 742.
Africa	Klasies River Mouth, South Africa	multiple fragments	90–120	Royer D et al. (2009) <i>Am. J. Phys. Anthropol.</i> 140, 312.
Middle East	Qafzeh and Skhul, Israel	multiple, >30 individuals	90–130	Grün R et al. (2005) <i>J. Hum. Evol.</i> 49, 316.
East Asia	Niah Cave, Borneo	cranium and leg bones	34–46	Barker G et al. (2007) <i>J. Hum. Evol.</i> 52, 243.
East Asia	Tianyuan Cave near Beijing, China	partial skeleton including mandible	39–42	Shang H et al. (2007) <i>Proc. Natl Acad. Sci. USA</i> 104, 6573.
Australia	Lake Mungo	Lake Mungo 3	40 ± 2	Bowler J et al. (2003) <i>Nature</i> 421, 837.
Europe	Grotta del Cavallo	two molars	43–45	Benazzi S et al. (2011) <i>Nature</i> 479, 525.

Jobling *et al.* 2014

Africa      Jebel Irhoud, Morocco (some archaic traits) 315      Hublin et al (2017) *Nature*

Africa      Florisbad, South-Africa (archaic *H. sapiens*) 300

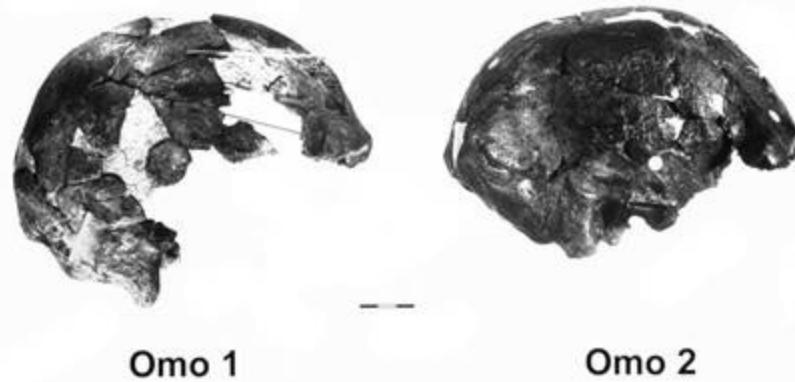
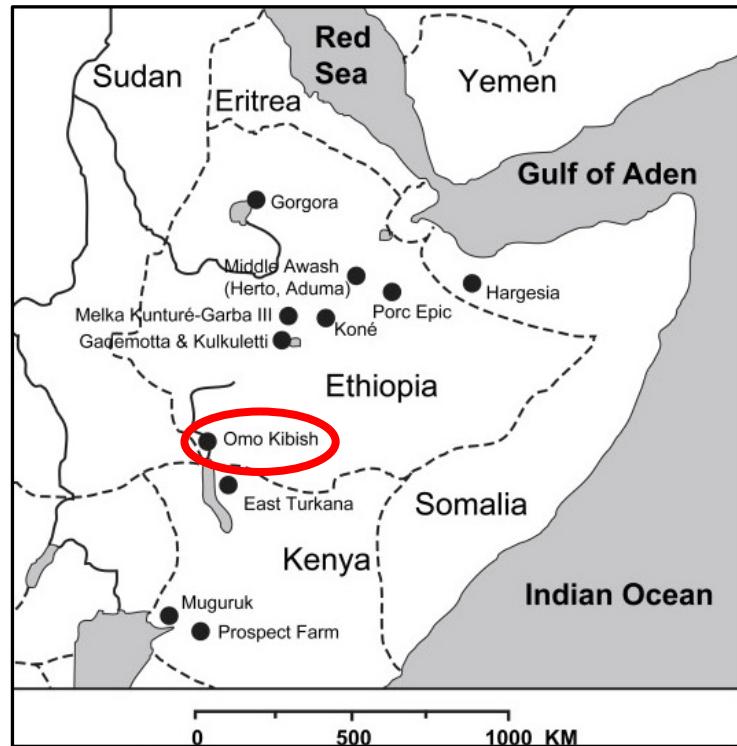
East Asia      Daoxian, **China**      47 teeth      80-120      Liu *et al.* (2015) *Nature*

# Findings of *Homo sapiens* fossils – East Africa

AMH –Anatomically Modern Human

Omo-1 195 000 +/- 5000 aastat.

Ethiopia, Kibish Formation,  
1967/2005 – found/updated dating



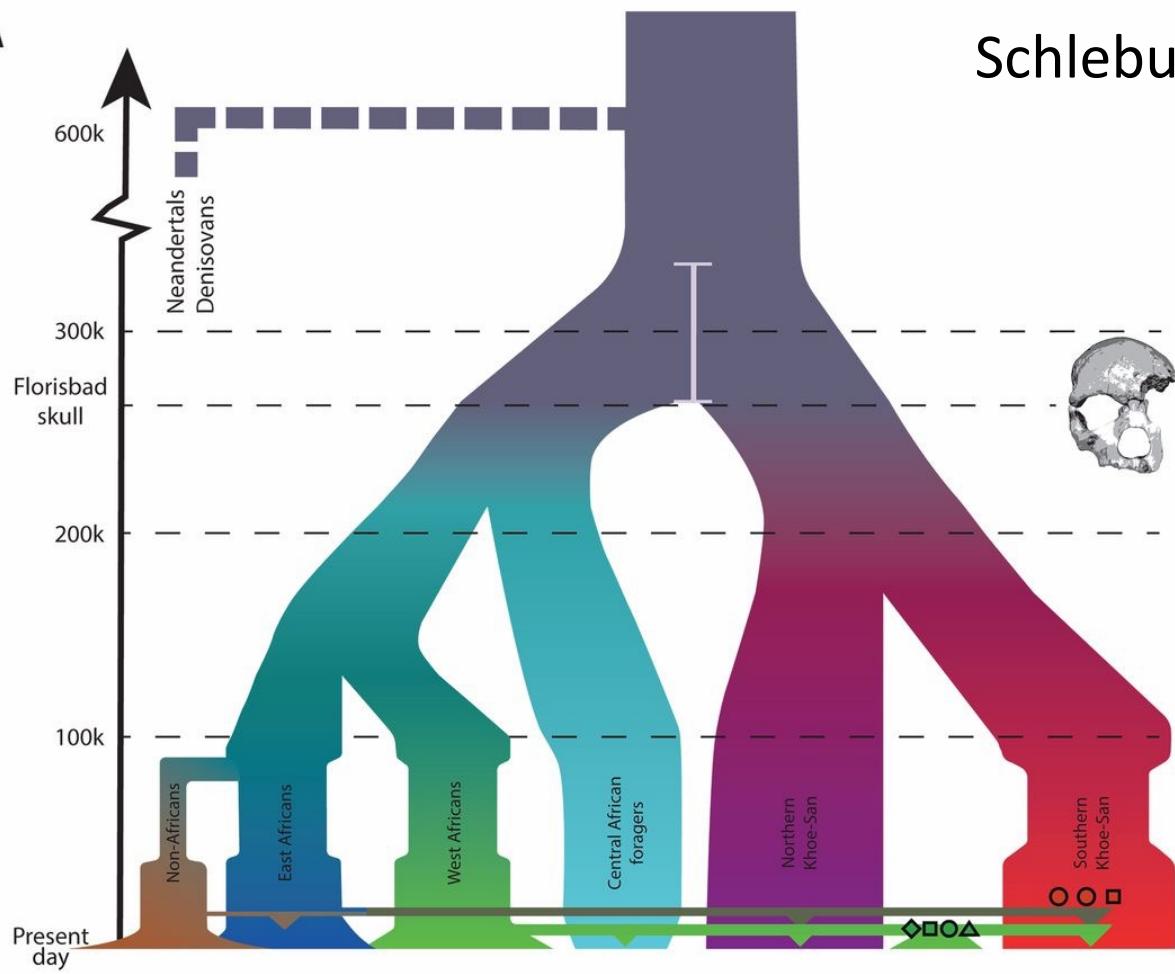
Omo 1

Omo 2



# *Homo sapiens* fossils – old findings also outside Africa

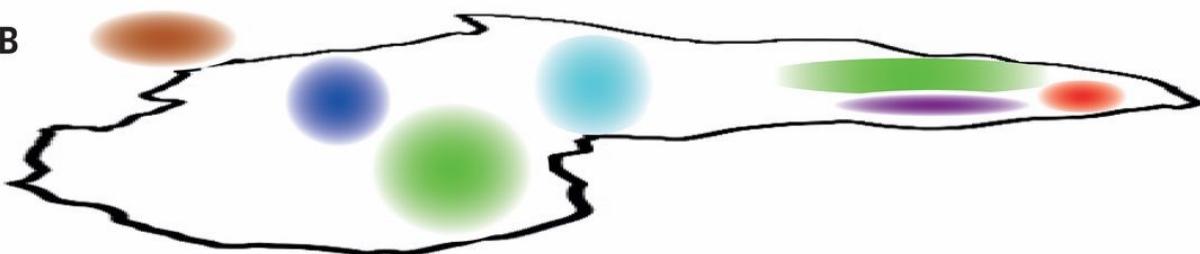


**A**

Schlebusch jt. (2017) *Nature*

3 genomes from 2000 ya  
Stone Age hunters-gatherers (San) – (1 from those 13x coverage);

4 genomes 300 – 500 ya  
farmers (Bantu)

**B****C**

Split method	Human-Neandertal (Nean-BBayA)	Human-Neandertal (Nean-San)	Human-Neandertal (Nean-Dinka)	Deep Human (Dinka-BBayA)	Deep Human (Dinka-San)	Deep Human (Mandenka-BBayA)	Deep Human (Mandenka-San)	NKSP-SKSP (San-BBayA)	Out of AFR (Dinka-Sardinian)
G-PhoCS	545 ± 9	534 ± 8	535 ± 9	336 ± 7	282 ± 7	356 ± 7	298 ± 7	185 ± 6	115 ± 6
TT-method	660 ± 33	639 ± 26	632 ± 28	265 ± 5	255 ± 5	256 ± 6	261 ± 5	156 ± 5	76 ± 6

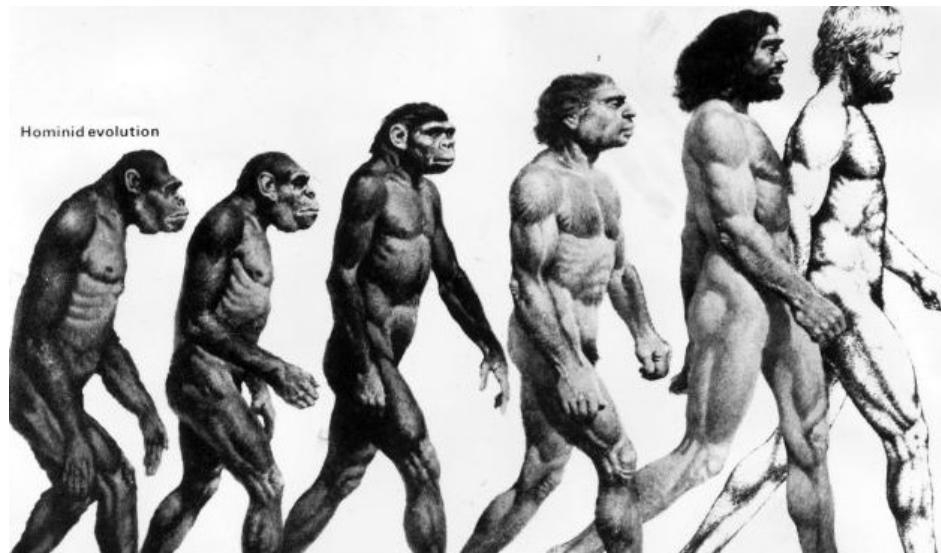
Diversification of modern human population occurred in Africa 260 – 300 000 ya (much deeper time estimate than was proposed before, earlier than the first finds of “fully” modern AMH fossils).

At that time the transition to middle stone age happened in sub-Saharan Africa

# Morphological and behavioural changes in hominin lineage

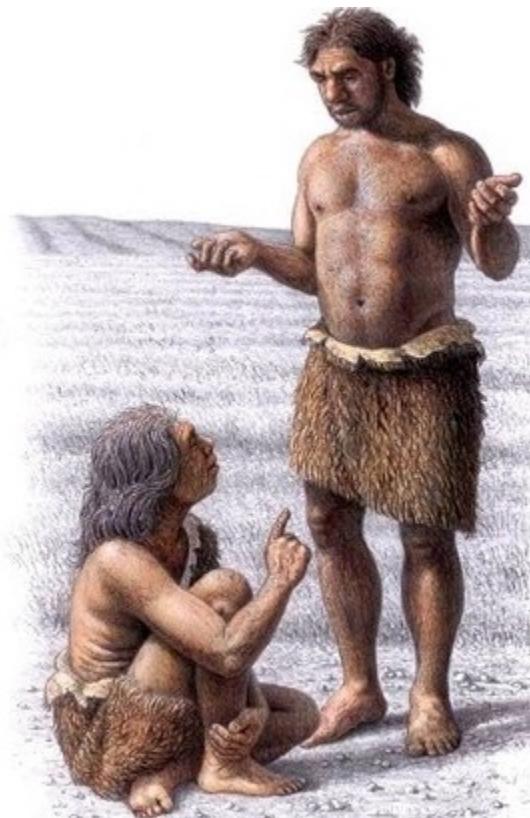
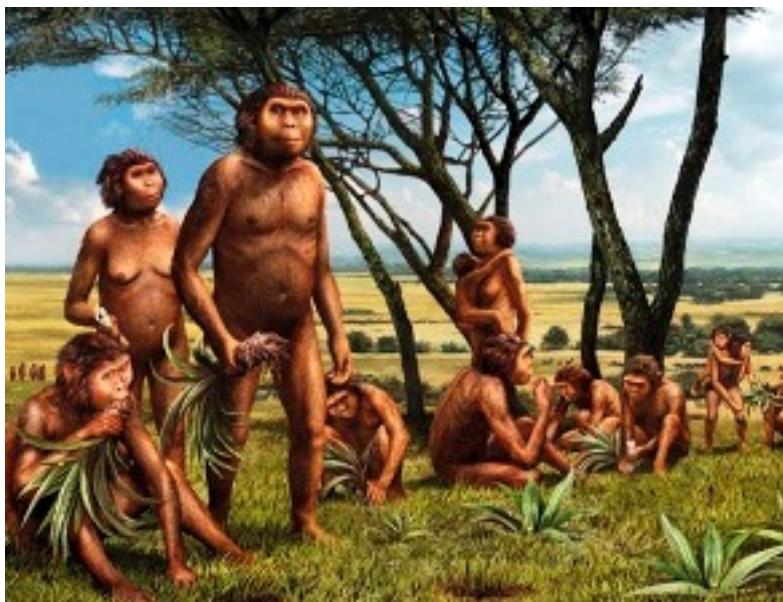
- **bipedalism;**
- rapid **growth of brain size** compared to body size (encephalization);
- use of tools, fire and cooked-food;
- changes in individual life-histories (prolonged childhood);
- hand preference;
- loss of body hair;
- language;
- *and many more...*

Genetic background of those changes is not yet well understood



# What has influenced hominin evolution?

- Environmental factors
- Social factors



# Comparison of biotopes of great apes, australopithecines and members of *Homo* family – environmental factors in human evolution.

## Gorillas and chimpanzees

– inhabitants of rain-forests;

**Australopithecines** - gallery forests on the riverbanks, savanna;

***H. habilis*** - savanna;

***H. erectus* and *sapiens*** – could live also in warm temperate climate

**Climate cooled and dried – formation of savanna biotope**

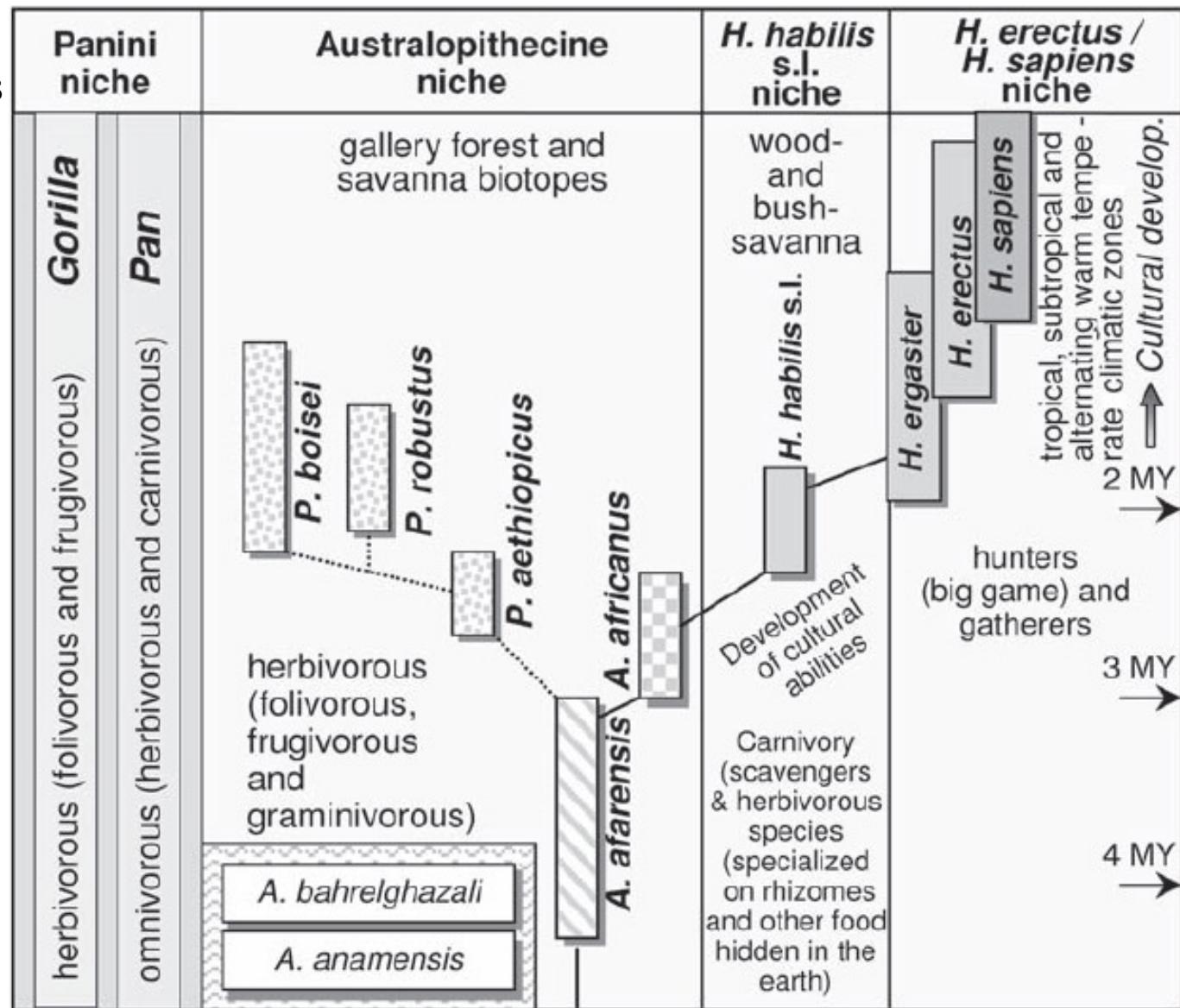


Figure 6.30 Model of niche separation (from Henke and Rothe 1998).

# Bipedalism

One of the factors of impact : climatic changes in East Africa 4-5 MAT – new niches (savanna), food sources



## Cost of bi- and quadrupedal walking

Net cost of transport for chimpanzee quadrupedal walking, chimpanzee bipedal walking and human walking

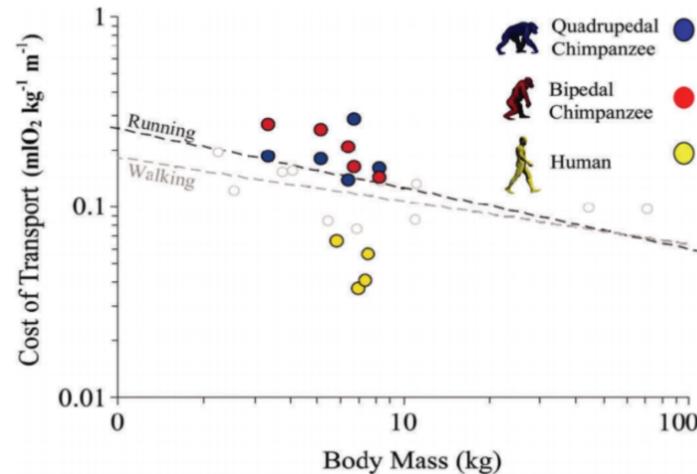


Fig 5:  
Comparison of the net cost of transport ( $\text{ml of O}_2 \text{ kg}^{-1} \text{ m}^{-1}$ ) for chimpanzee quadrupedal walking (blue), chimpanzee bipedal walking (red), and human walking (yellow).

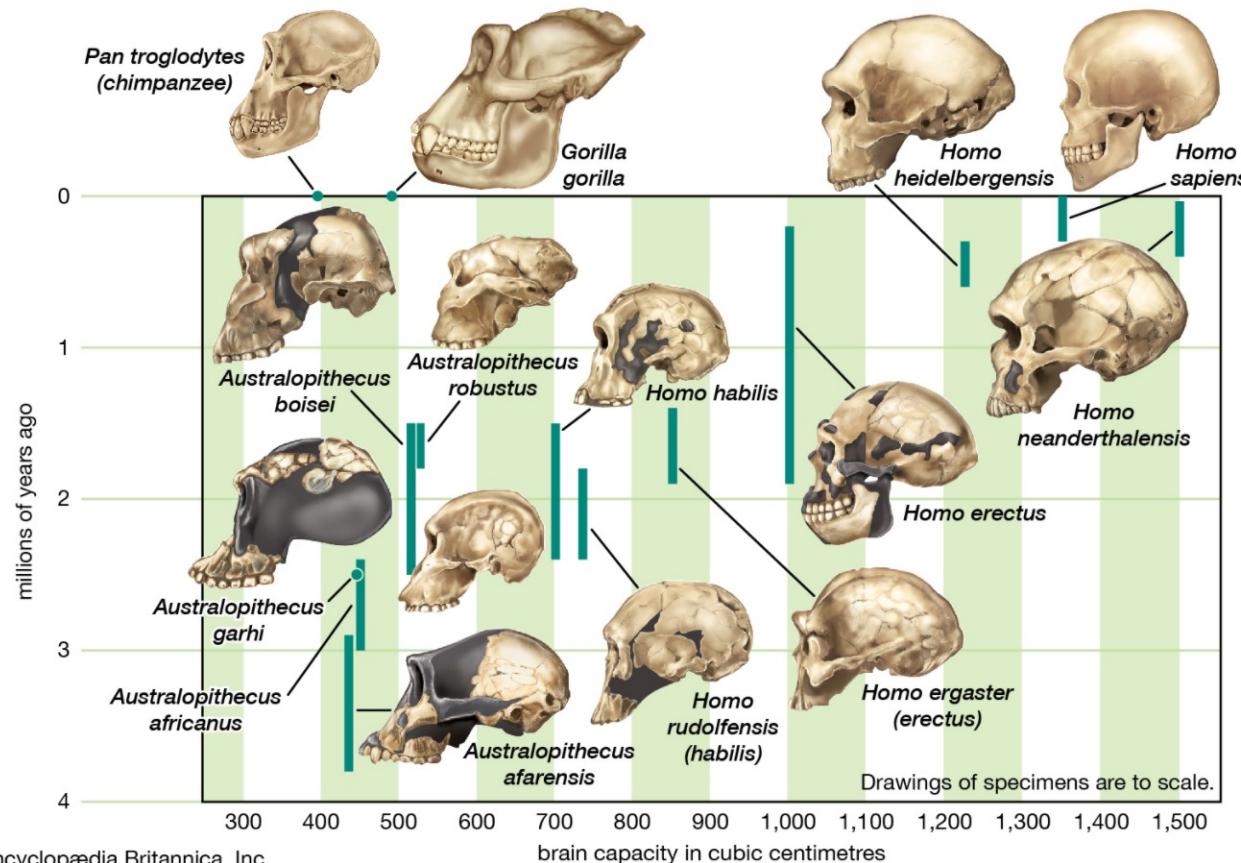
Dashed lines indicate trendlines for running and walking in birds and mammals. The running trendline is for 65 terrestrial species. Walking data (open symbols) were collected from the literature.

Sockol M. D et al  
PNAS 2007; 104: 12265–12269

## Other factors:

- better thermoregulation, ability to get food in a hot climate, body is less exposed to sunlight
- better view – good for avoiding predators
- better abilities for transporting things (food, tools, children)

# Brain size change – hominins' lineage



© Encyclopædia Britannica, Inc.

## Rapid brain size growth – 1,9...1,7 Mya, *H. erectus*.

Brain size growth and bipedalism are not directly related – bipedality in hominin lineage appeared at least **6 Mya** and continued in australopithecines, but their brain size was still comparable to this of chimpanzees – ca 400cm<sup>3</sup>. Think also, for example, about *H. naledi*!

# Brain size compared to body weight

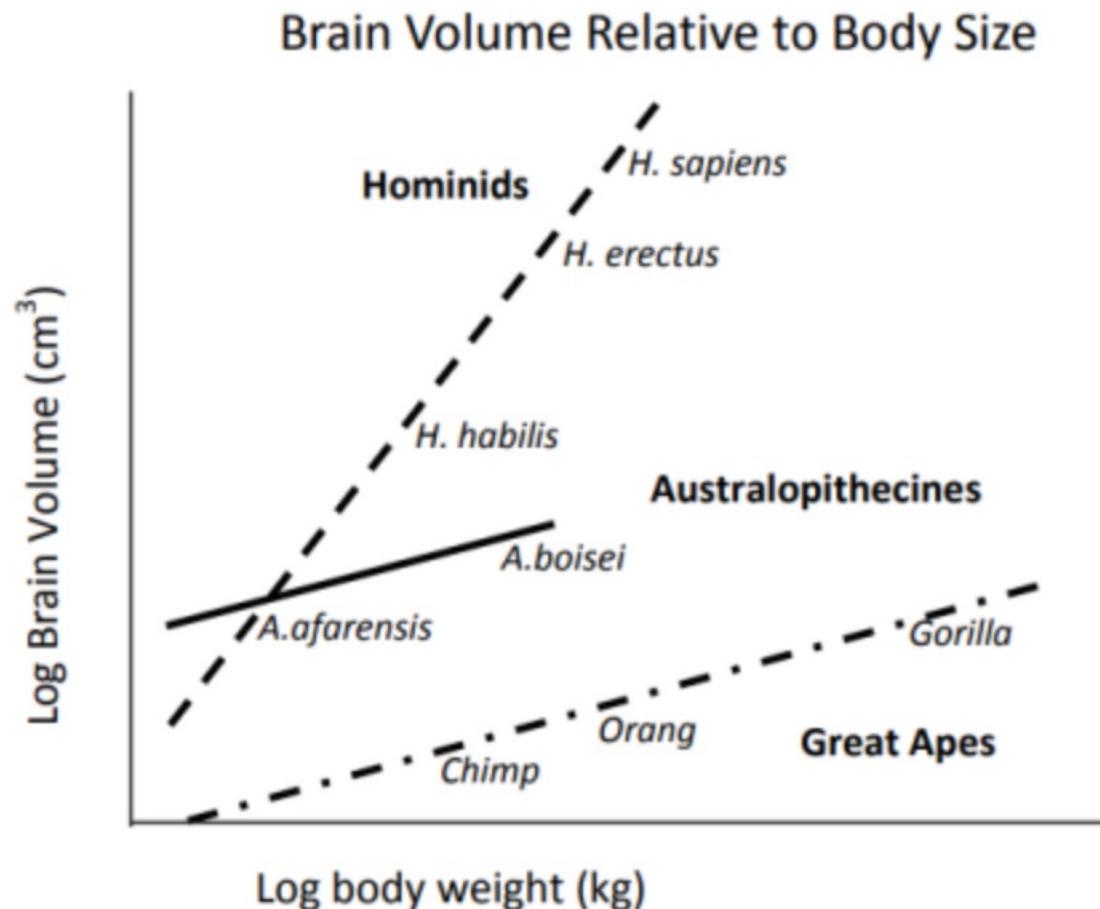


Fig 6. Change in brain volume relative to body size, calculated from fossil skull dimensions.  
Redrawn from Bonner J.T., Why Size Matters. Princeton University Press 2006

# Some hypotheses behind the success of *Homo* family

## 1) Wranghami (2009): **Cooking-hypothesis**

Cooked food – easier intake of calories, different microbioma, less pathogens



**Figure 1:** Noodles dating to 4000 YA in China.

## 2) Bingham (2001): **“Remote-killing”-hypothesis**



**Human Evolution and Human History:  
A Complete Theory**

PAUL M. BINGHAM

400 kya **wooden spear** from Germany (Schöningen);  
**Bow** is much later – 9 000 ya from Denmark, but arrowheads are from >70 kya, from Africa

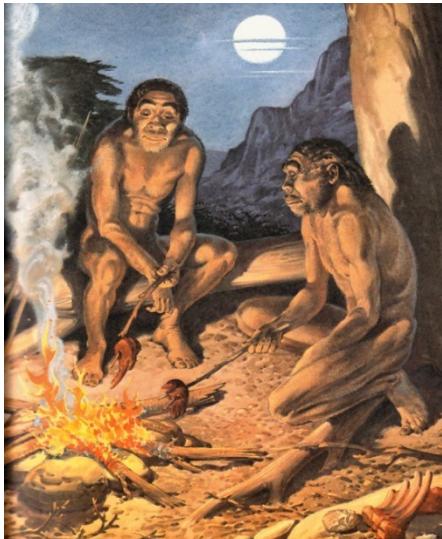
Both of these might have been important for development of **collaboration, language** and **larger brain** for early *Homo*.

# Brain size - associations between shift to cooked food and growth of brain size

According to one hypothesis (Fonseca-Azevedo and Herculano-Houzel, 2012) the growth of brain size (number of neurons) compared to body size has **metabolic constraints** – big brains need more energy, but the time spent for getting food for needed calories per day is limited



Great apes – the largest primates – have relatively small brains  
But humans?



Hominins might have overcome these constraints by starting to cook the food – the calories from cooked food can be more easily obtained

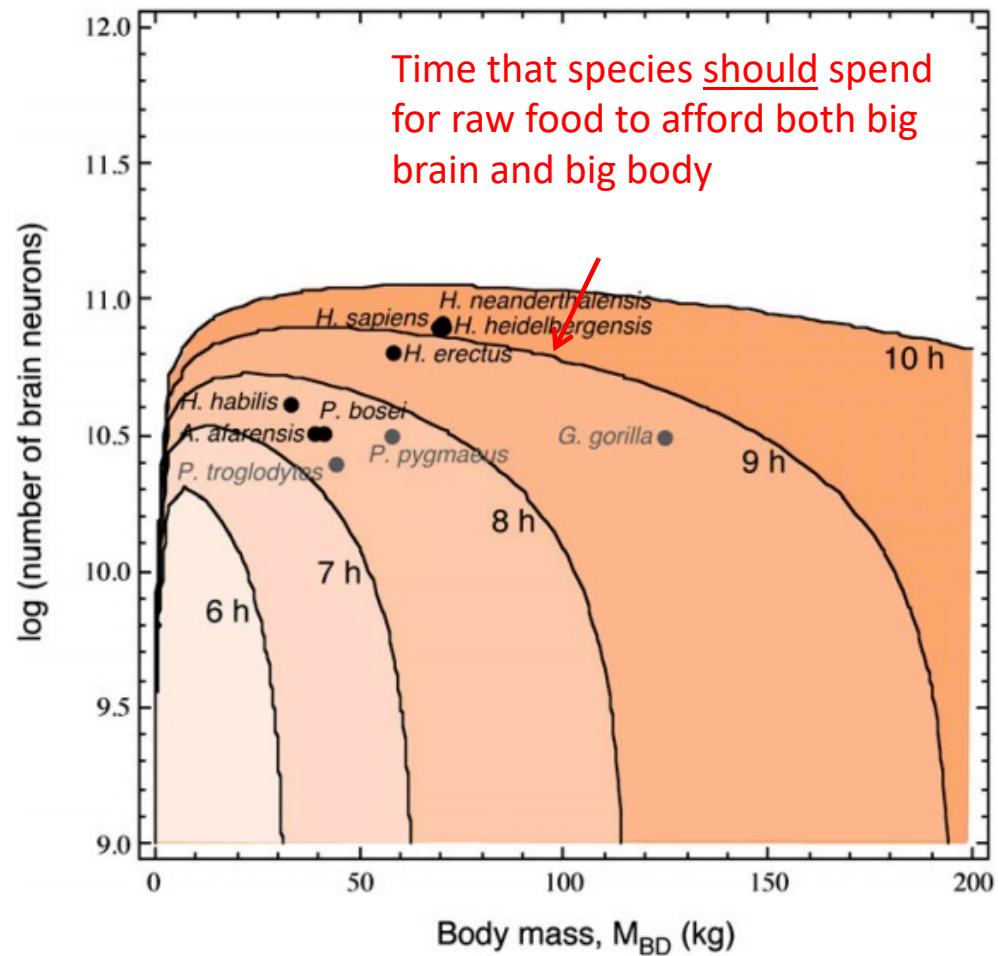
*H. erectus* - big brains and active use of fire 800 kya

# Brain size - associations between shift to cooked food and growth of brain size

In real life we do not spend most of the time for feeding

**Selection acting pro cooking?**

... lots of time left for social activities!



**Fig. 5.** Required daily feeding time for hominin and great ape species to afford combinations of  $M_{BD}$  and total number of brain neurons. Notice that *H. heidelbergensis*, *H. neanderthalensis*, and *H. sapiens* fall well over the viability curve for 8 h/d of feeding if they had a raw foods diet similar to extant nonhuman primates.

# Arhaeological evidences for firemaking by hominins

Archeological site	Date (MYA)	Country	Kind of evidence			Association	Classification	References
Yuanmou	1,7	China	C	BB?		None	VWE	James, 1989
Koobi Fora	1,55	Kenya	BL?			None	VWE	James, 1989
Koobi Fora	1,4	Kenya	RA	BL?		None	VWE	James, 1989
Chesowanja	1,4	Kenya	BC			None	VWE	James, 1989
Swartkrans	1,2	South Africa		BB		not clear	WE	Brain and Sellen, 1988
Wonderwerk Cave	1	South Africa	A	BB	T	not clear	WE	Berna et al., 2012
Gesher Benot Yaakov	0,79	Israel	H	T		Clear	SE	Oldest reliable Alperson-Millett et al., 2009
Zhoukoudian	0,5	China	BD	BL		None	VWE	Weiner et al., 1998
Atapuerca	0,6	Spain	H	T	HB	Clear	SE	Arsuaga et al., 1993
Zhoukoudian	0,45	China	H	BB	BF	not clear	WE	Wu, 1999
Schöningen	0,4	Germany	A	C	FHW	BF	clear	Thieme, 1997
Qesem Cave	0,38	Israel	H	BB	BF	HB	T	Karkanas et al., 2007
Bajondillo	0,15	Spain	H	BF	BB	HB	T	Cortés-Sánchez et al., 2011
Bolomar	0,13	Spain	H	BF	T	HB	clear	Blasco, 2008

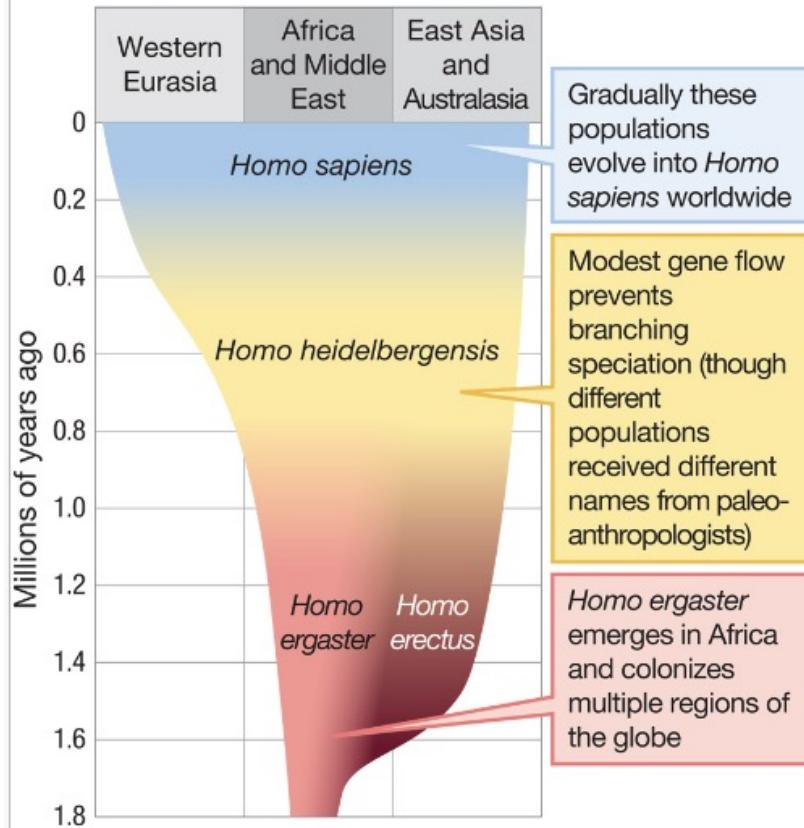
SE, strong evidence; WE, weak evidence; VWE, very weak evidence; NE, non-existent evidence; FHW, fire-hardened wood; BB, burned bones; BS, burned shells; BF, burned food; FR, fire-cracked rock; BL, burned lithics; H, hearth; C, charcoal; BD, burned deposit; BC, baked clay; A, ashes; RA, reddened area; HB, human bones; T, tools.

Cornelio jt. 2016 Frontiers in NS

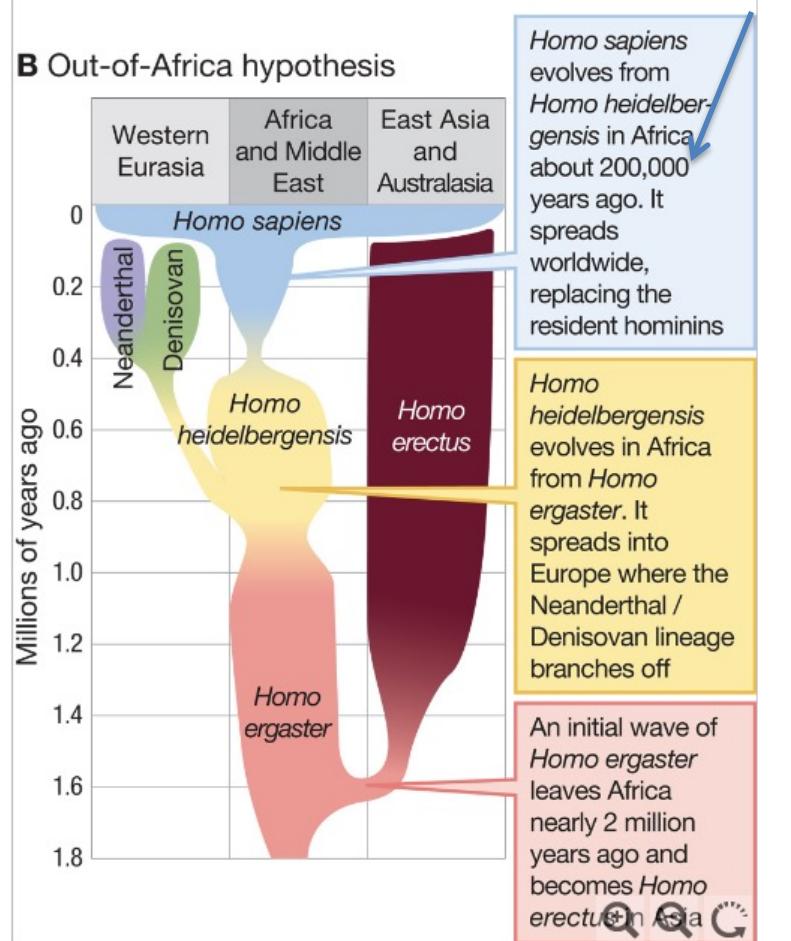
***H. erectus*** was probably the first one to use fire actively – 800 000 ya.  
 Today, cooked food is obligatory for our species.

# Two hypotheses of the origin and early migration of *H.sapiens*

## A Multiregional hypothesis

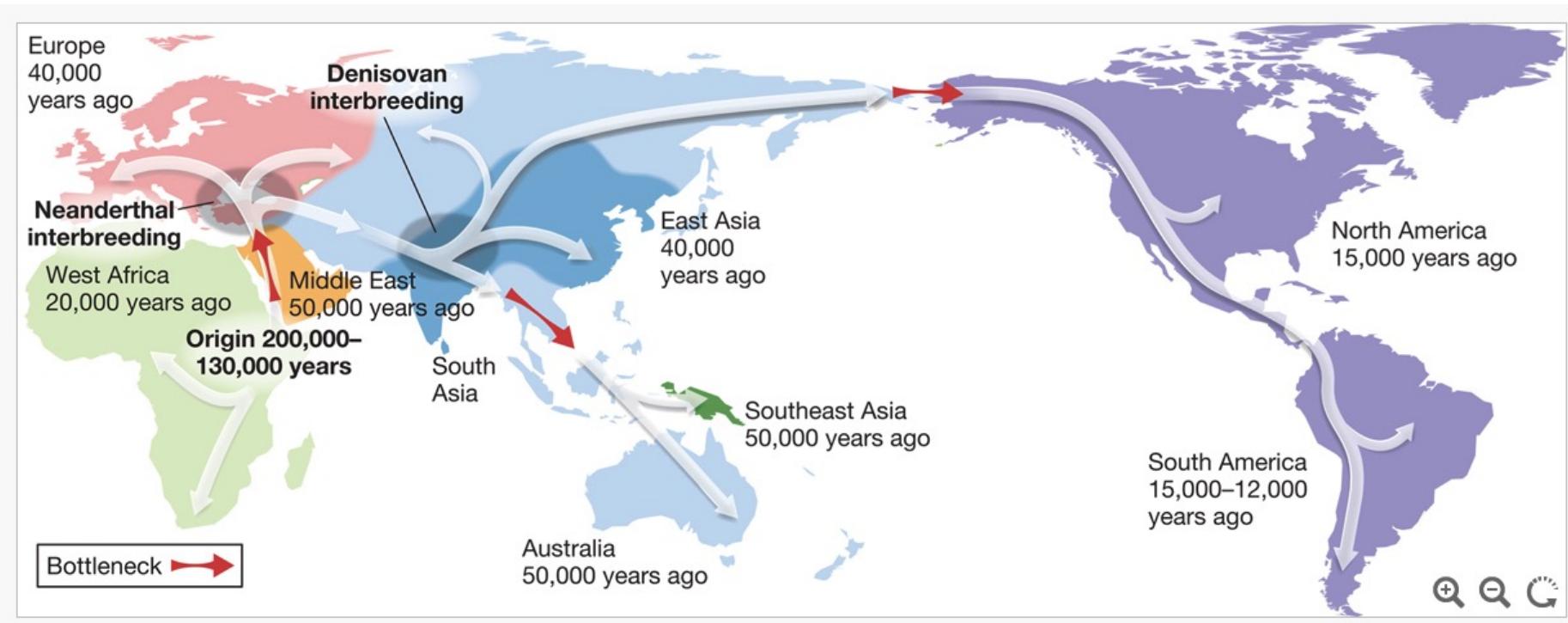


## B Out-of-Africa hypothesis



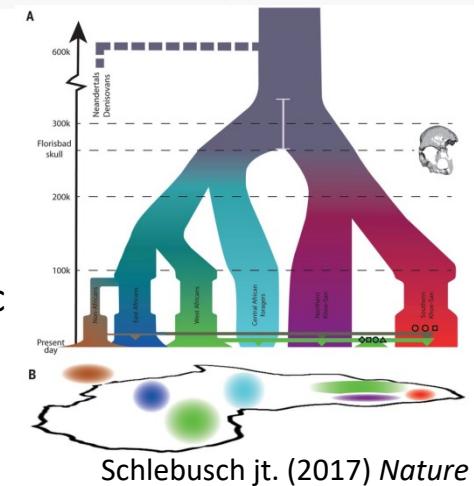
Bergstrom and Dugatkin 2016

# Expansion of *H. sapiensi*

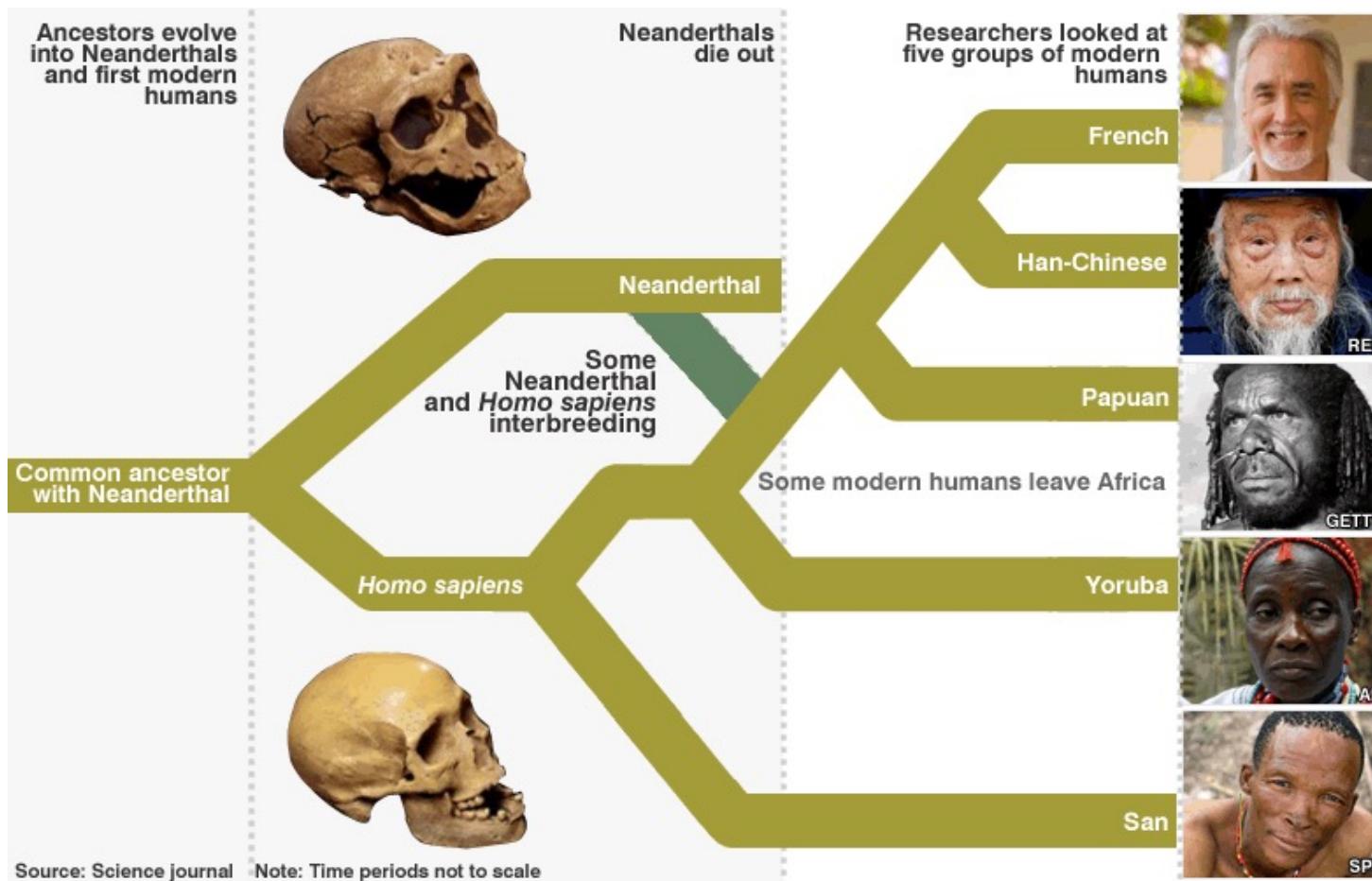


Bergstrom and Dugatkin 2016

- The „age“ of AMH ca 300 000 y;
- Major out-of-Africa migration took place < 70 000 ya, there has been also at least one other earlier migration ca 120 000 ya, but the genetic heritage of this is only very small (2% among Papuans);
- The spread of AMH corresponds to the dispersal model

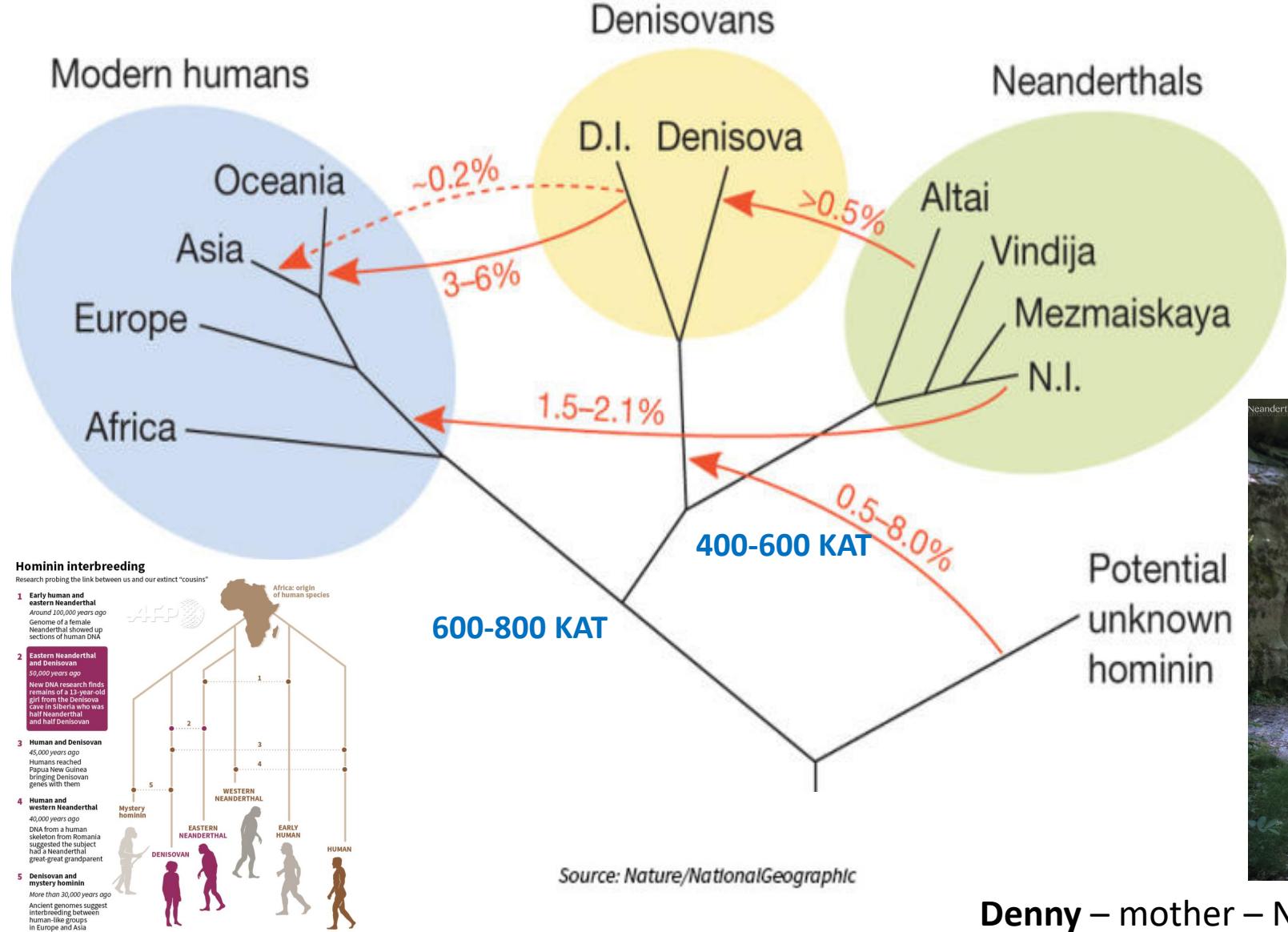


# Did AMH, neanderthals and Denisovan humans admix?



AMH has a small but detectable genetic heritage from Neanderthals (ca 1-3 %).  
The traces of Neanderthal introgression can be found from all modern humans, except from those of Sub-Saharan Africa – it occurred after the out-of-Africa migration.

# Did AMH, neanderthals and Denisovan humans admix?

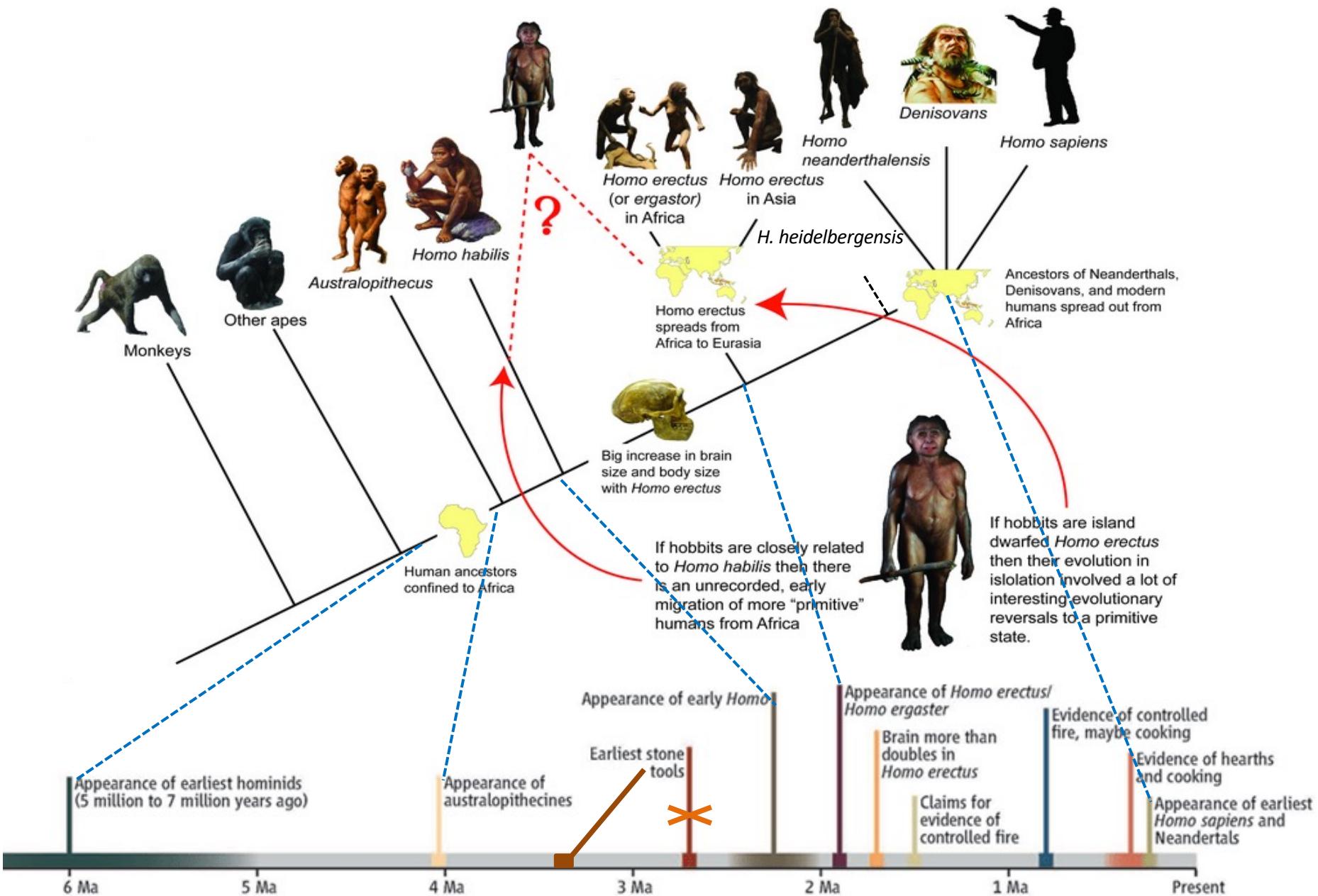


**Denny** – mother – Neanderthal  
and father Denisovan – F1 hybrid

Slon jt. 2018 *Nature*

All three groups have been admixed with each other

# Hominins phylogeny and major events in their lineage :



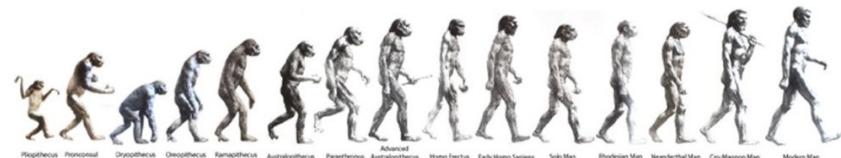
# Summary

Human evolution can be studied with the help of :

- fossils and archaeological evidences;
- comparative genetics and ancient DNA

7-5 Mya

First hominins in Africa



Cooler and drier climate, spread of savannas and open landscapes

6-4 Mya

Bipedalism

3,3 Mya

First tools found (Australopithecines?)

1,8 Mya

start of rapid growth of brain (*H. erectus*)

1,8 Mya

several expansions of *H. erectus* out-of-Africa

0,8 Mya

active use of fire by *H. erectus*

300 Kya - ...

*Homo sapiens*

There have been lots of parallel lineages of hominins, for today only one member of *Homo* family - ***Homo sapiens*** - has survived.

The area of human evolution is a very dynamic field and a subject of hot debates in very many topics, every year brings new evidences and hypotheses that help us to better understand our origins