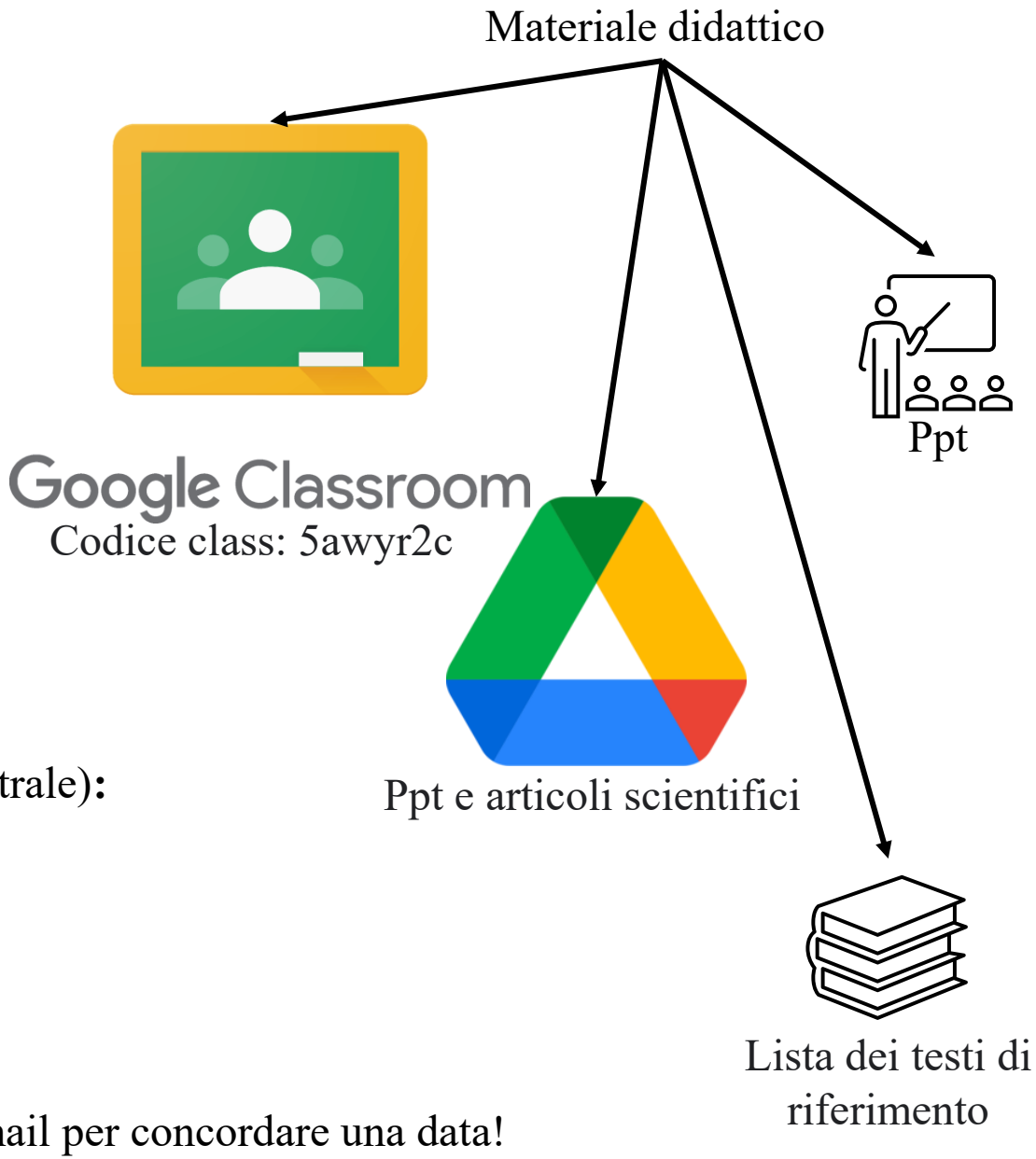
The first hominins part 1

Julie Arnaud
Julie.arnaud@unife.it

Contenuti del corso:

- Lezione introduttive (Prof. ssa Arzarello e Prof. Sala)
- Metodologie di studio in Paleoantropologia
- Primi ominini parte 1 (dal *Sahelanthropus* al *Ardipithecus*)
- Primi ominini parte 2 (le Australopitecine)
- Il genere *Homo* in Africa
- L'out-of-Africa verso l'Asia
- Primo popolamento dell'Europa
- I Neanderthal
- Origine dell'*Homo sapiens*
- Le migrazione dell'*Homo sapiens*



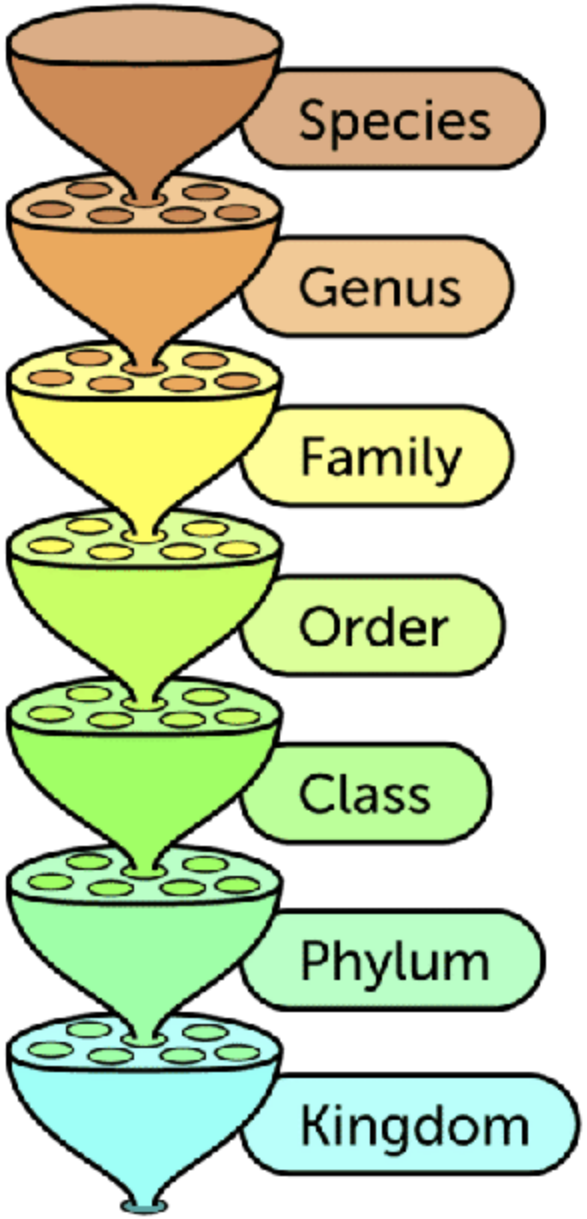
Laboratori (verranno organizzati alla fine delle lezione magistrale)**:**

- Cranio (~3ore): anatomia ed evoluzione
- Mandibola (~3ore): anatomia, dimensione ed evoluzione

Esame:

Orale (o scritto se richiesto dall* student*)

L'esame si può fare anche **fuori appelli**, basta scrivermi una mail per concordare una data!



Homo sapiens

Homo

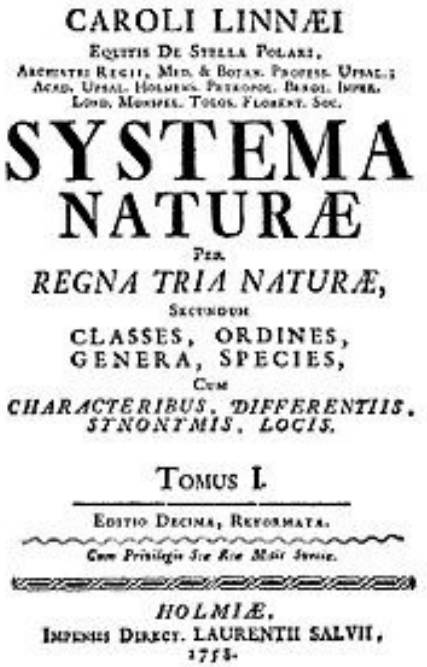
Hominidae

Primates

Mammalia

Chordata

Animalia


CAROLI LINNÆI

EQUITIS DE STELLA POLARI,

ARCHIATRI REGII, MED. & BOTAN. PROFESS. UPSAL.;

ACAD. UPSAL. HOLMENS. PETROPOL. BASIL. ISPER.

LOND. MONSPEL. TOLOS. FLORENT. SOC.

SYSTEMA NATURÆ

PER

REGNA TRIA NATURÆ,

SECUNDUM

CLASSES, ORDINES,
GENERA, SPECIES,

CUM

CHARACTERIBUS, DIFFERENTIIS,
SYNONYMIS, LOCIS.

TOMUS I.

EDITIO DECIMA, REFORMATA.

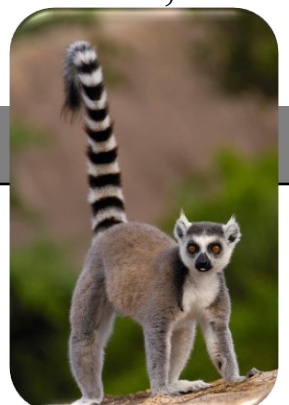
Cum Privilegio Sæ Reæ Mtis Suecæ.

HOLMIÆ,

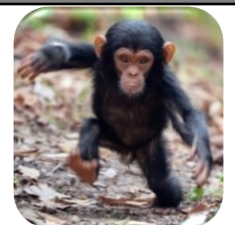
IMPENSIS DIRECT. LAURENTII SALVII,

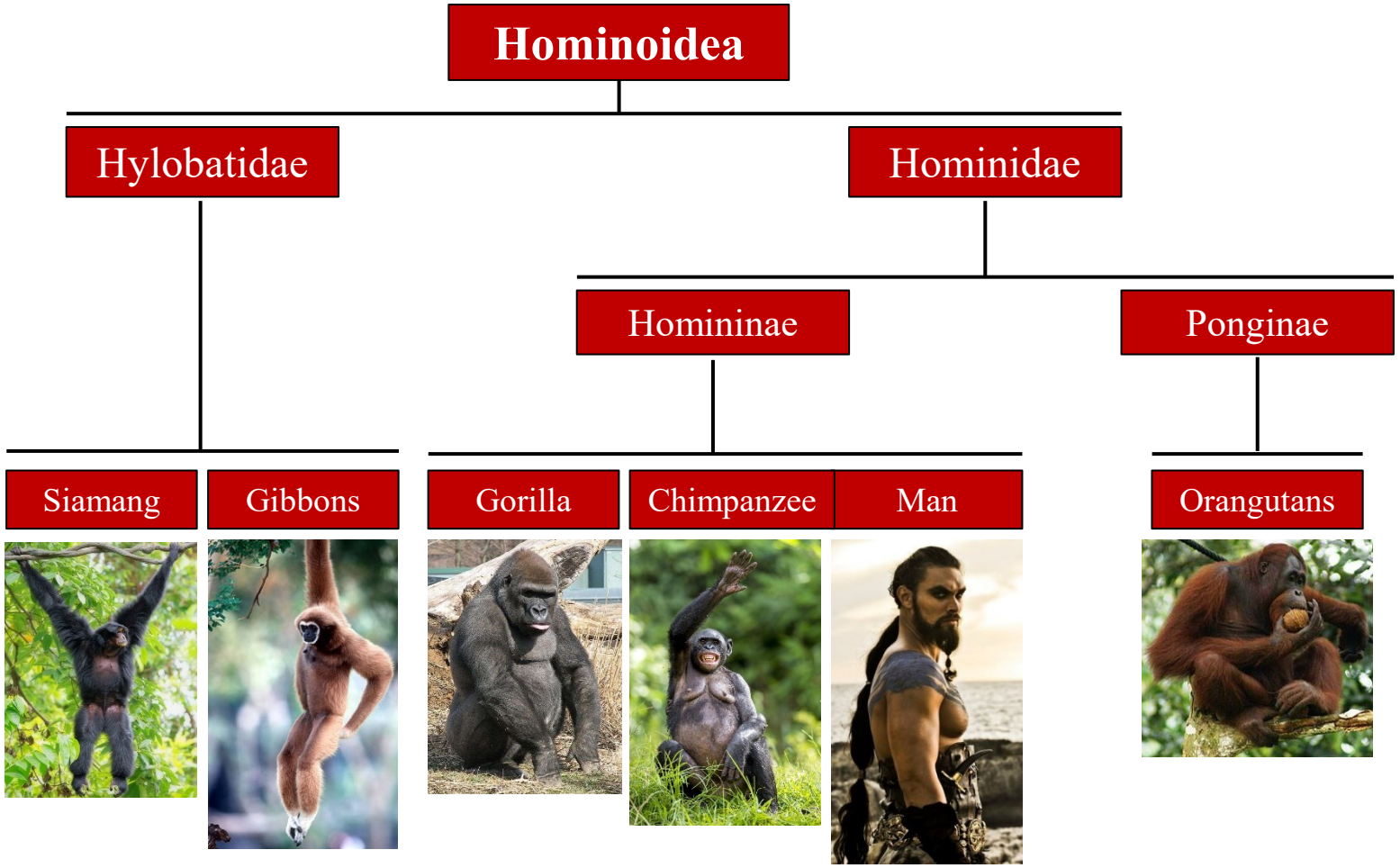
1758.

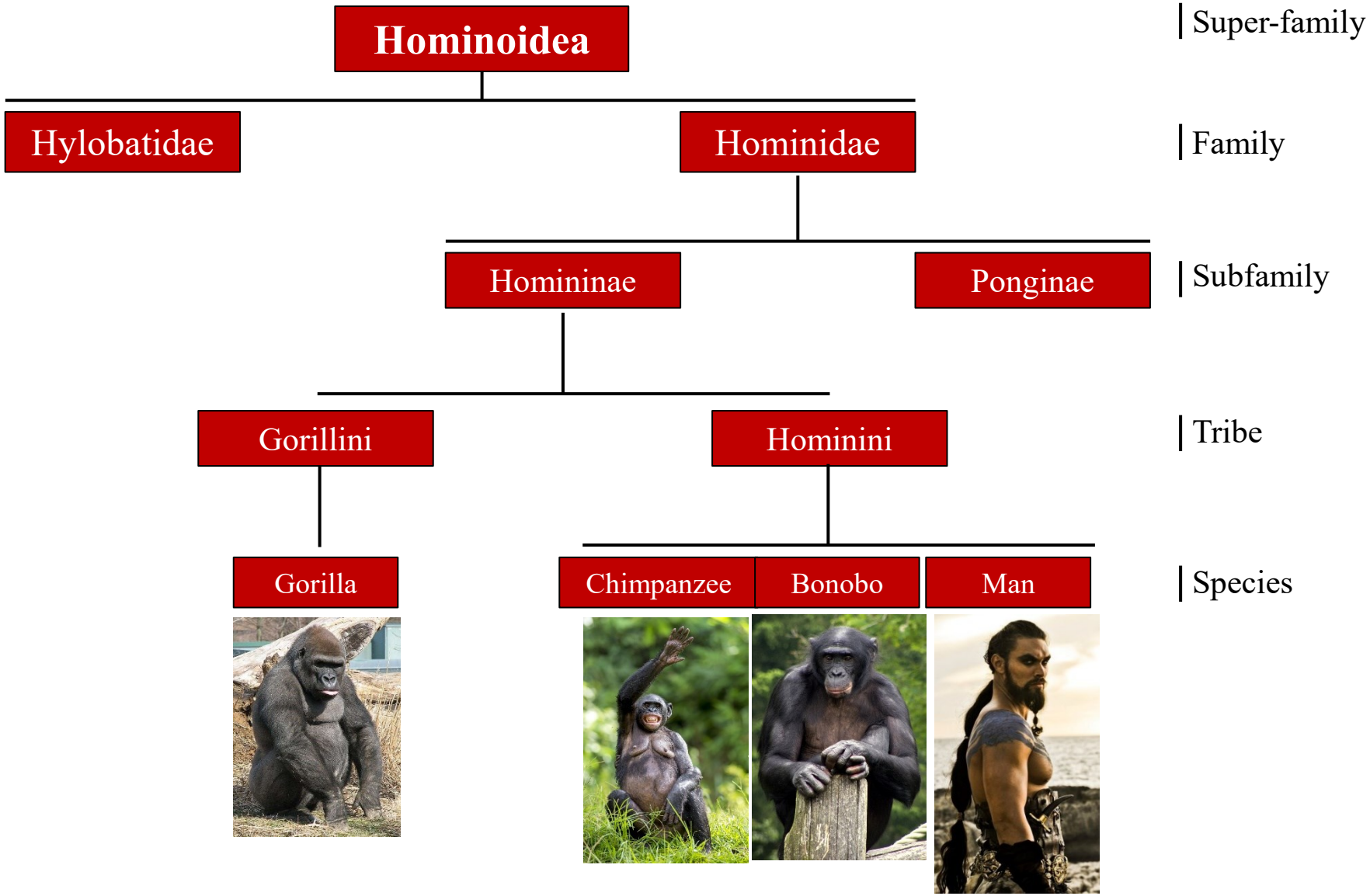
STREPSIRRHINI		HAPLORIHINI				suborder
LEMURIFORM		TARSIIFORMES	SIMIIFORMES (or ANTHROPOIDS)			Infra-order
			Platyrrhini	Catarrhini		
Lemuroidea	*Lorisoidea*	*Tarsioidea*	*Ceboidea*	*Cercopithecoidea*	*Hominoidea*	Super-family
Daubentidae *Indriidae* *Lepilemuridae* *Cheirogaleidae* *Lemuridae*	*Galagidae* *Lorisidae*	*Tarsiidae*	*Cebidae* *Atelidae*	*Cercopithecidae*	*Hylobatidae* *Pongidae* *Hominidae*	Family
36 o 40 teeth (3 or 4 premolars) With or without prehensile tail			**36 teeth** (3 premolars) Prehensile tail	**32 teeth** (2 premolars) Non prehensile tail	**32 teeth** (2 premolars) No tail	Anatomy
Africa, Madagascar and southeast asia			**America**	**Africa – Eurasia**	**World**	Geography
Indri, Lemure	Loris	Tarsi	Howler monkeys, Callithrix (marmose)	Macaca, Baboons	*Homo sapiens*, great apes	Species
PROSIMIAN			SIMIIFORME (O ANTHROPOIDE)			Infra-order

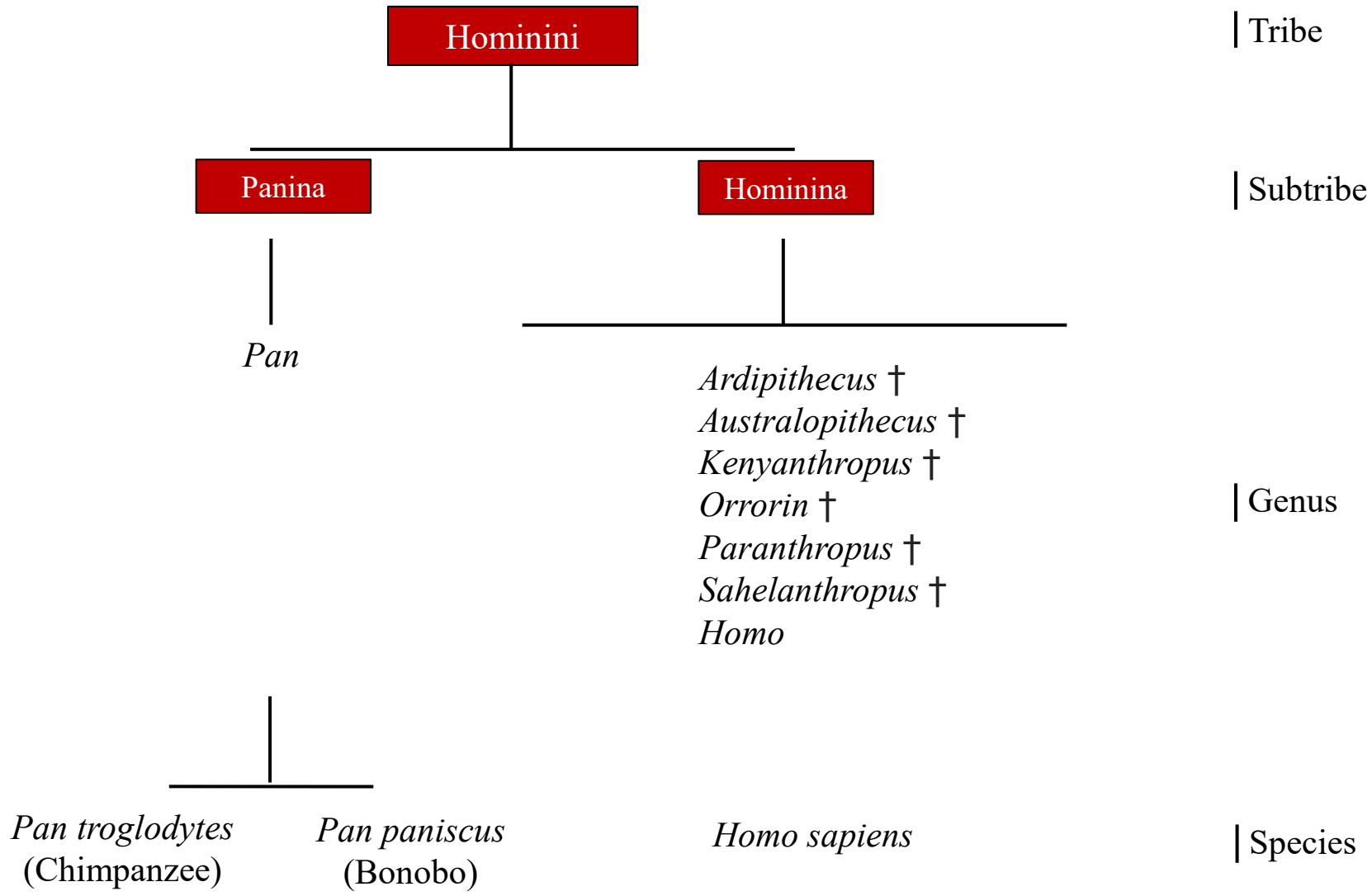


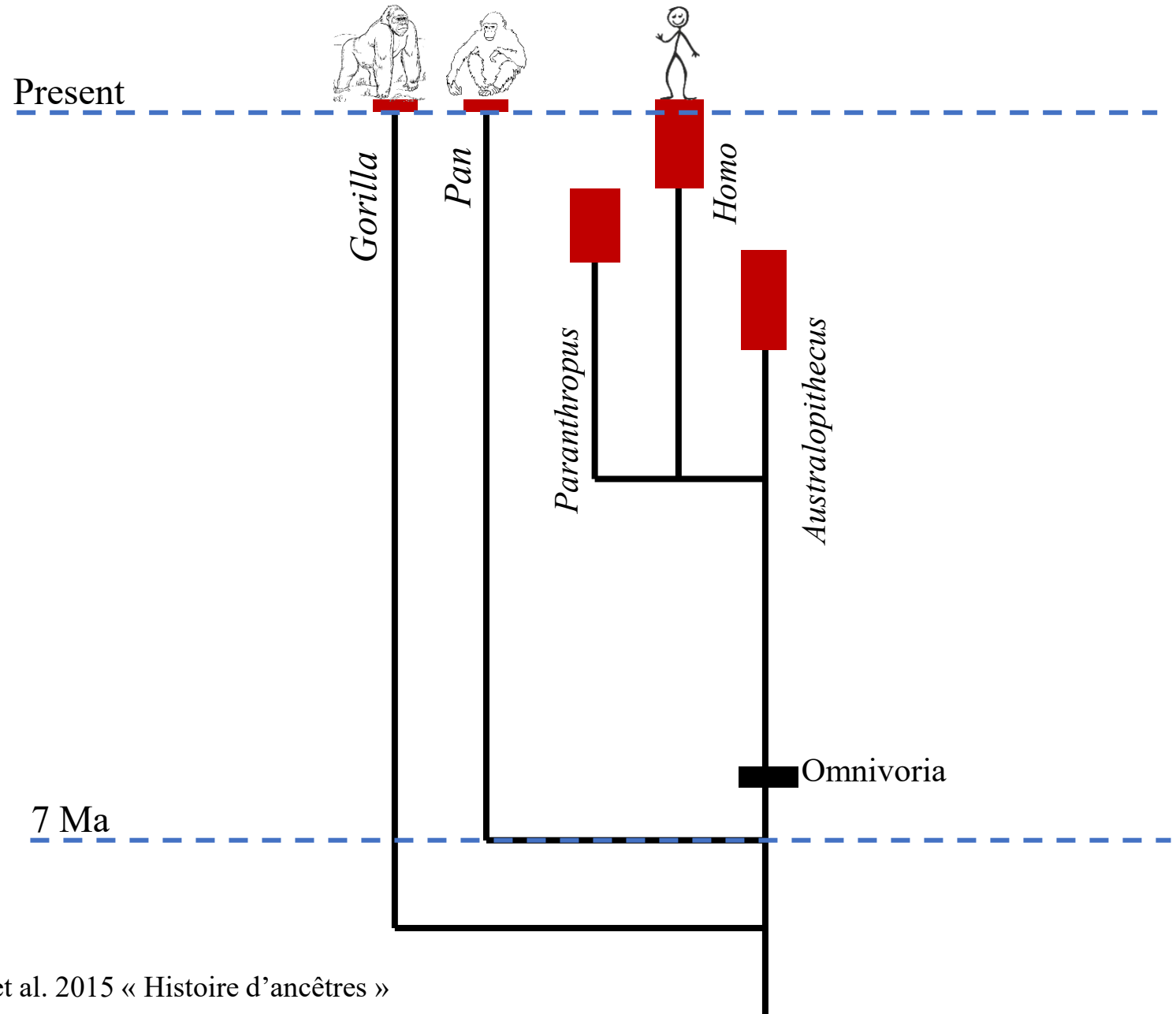


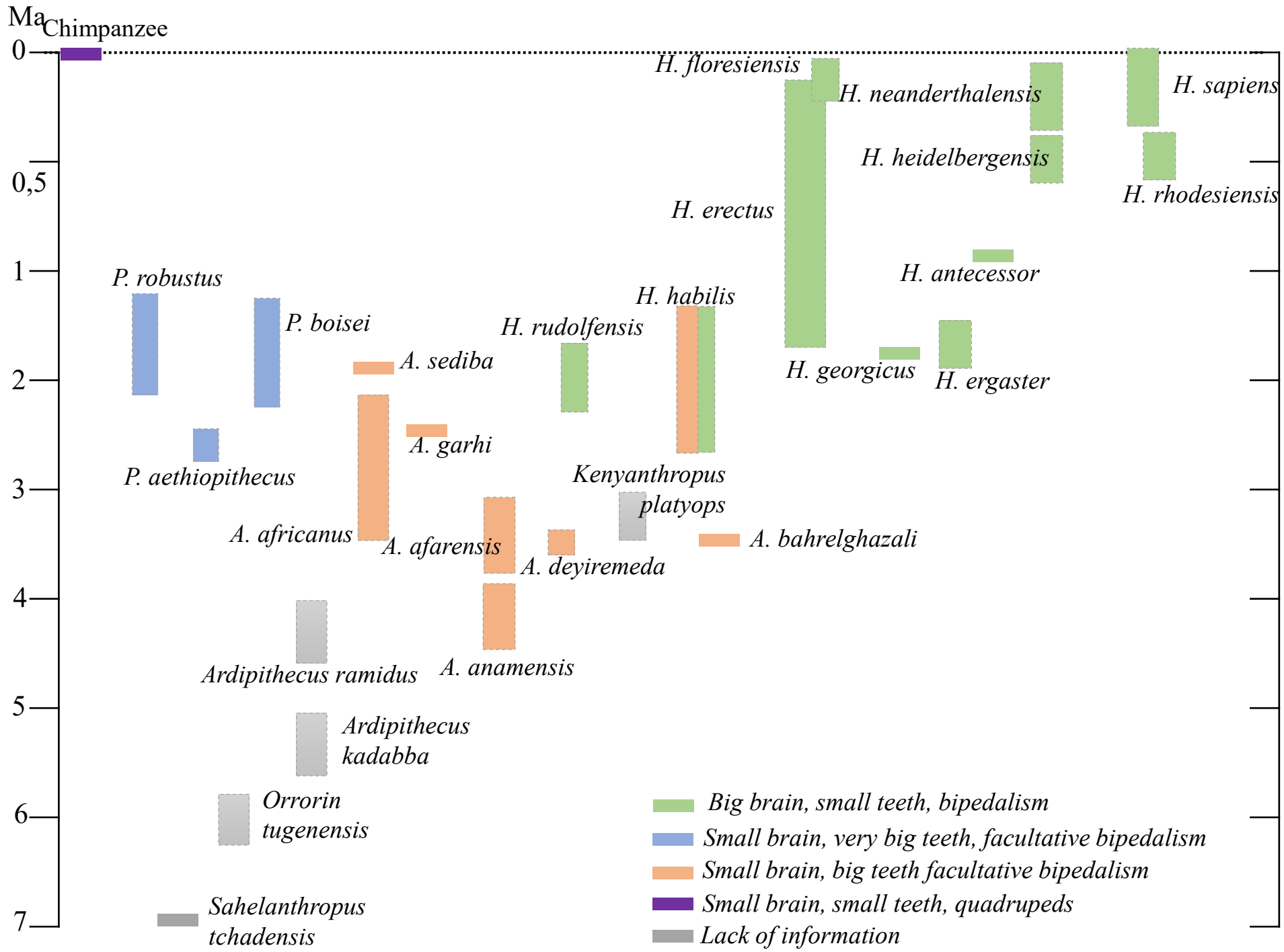

Hominoidea
Hylobatidae
Hominidae
Homininae
Ponginae
Siamang
Gibbons
Gorilla
Chimpanzee
Man
Orangutans
Super-family
Family
Subfamily
Species

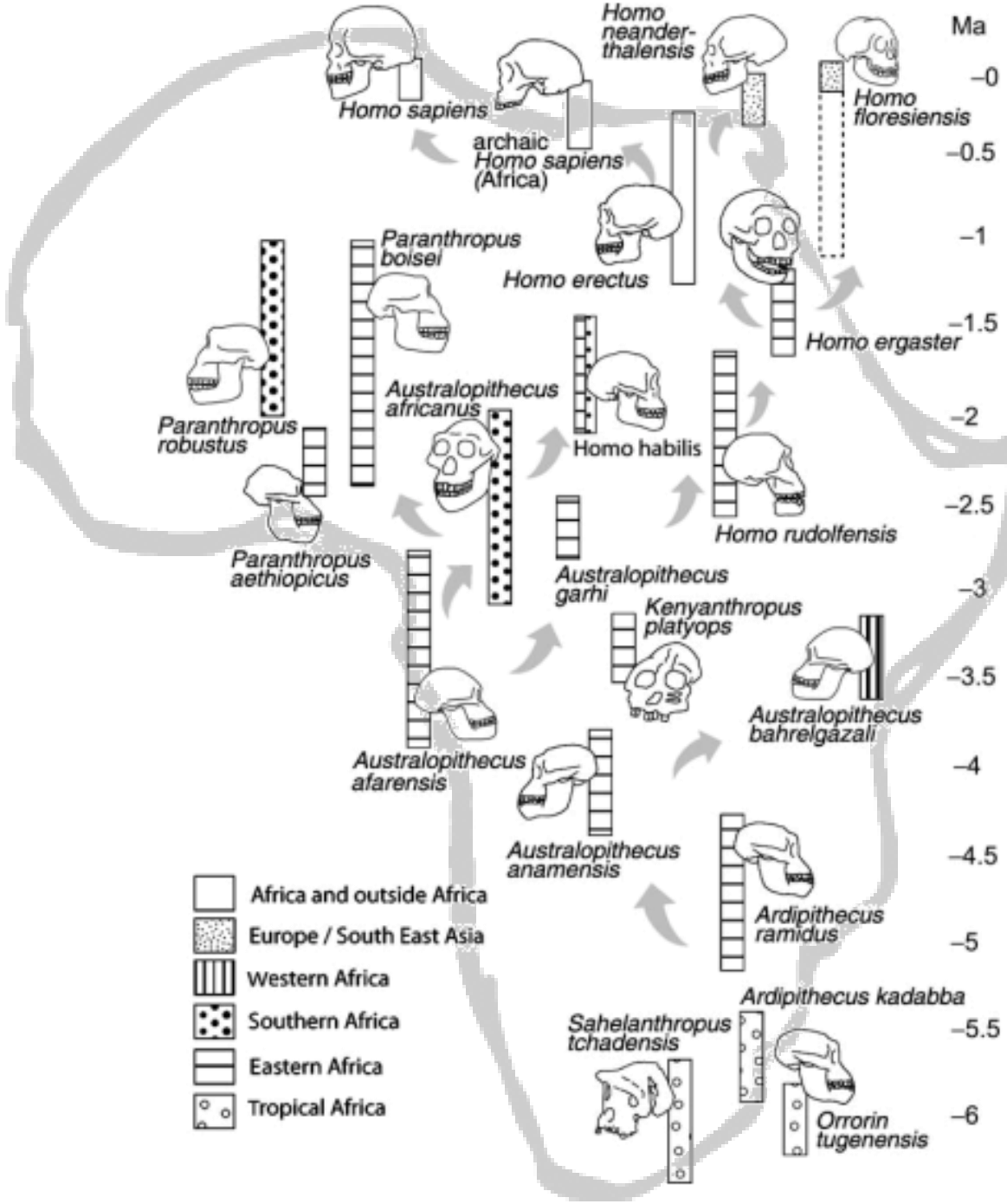

Hominoidea
Hylobatidae
Hominidae
Homininae
Ponginae
Gorillini
Hominini
Gorilla
Chimpanzee
Bonobo
Man
Super-family
Family
Subfamily
Tribe
Species


Hominini
Panina
Hominina
Pan
Ardipithecus †
Australopithecus †
Kenyanthropus †
Orrorin †
Paranthropus †
Sahelanthropus †
Homo
Pan troglodytes
(Chimpanzee)
Pan paniscus
(Bonobo)
Homo sapiens
Tribe
Subtribe
Genus
Species

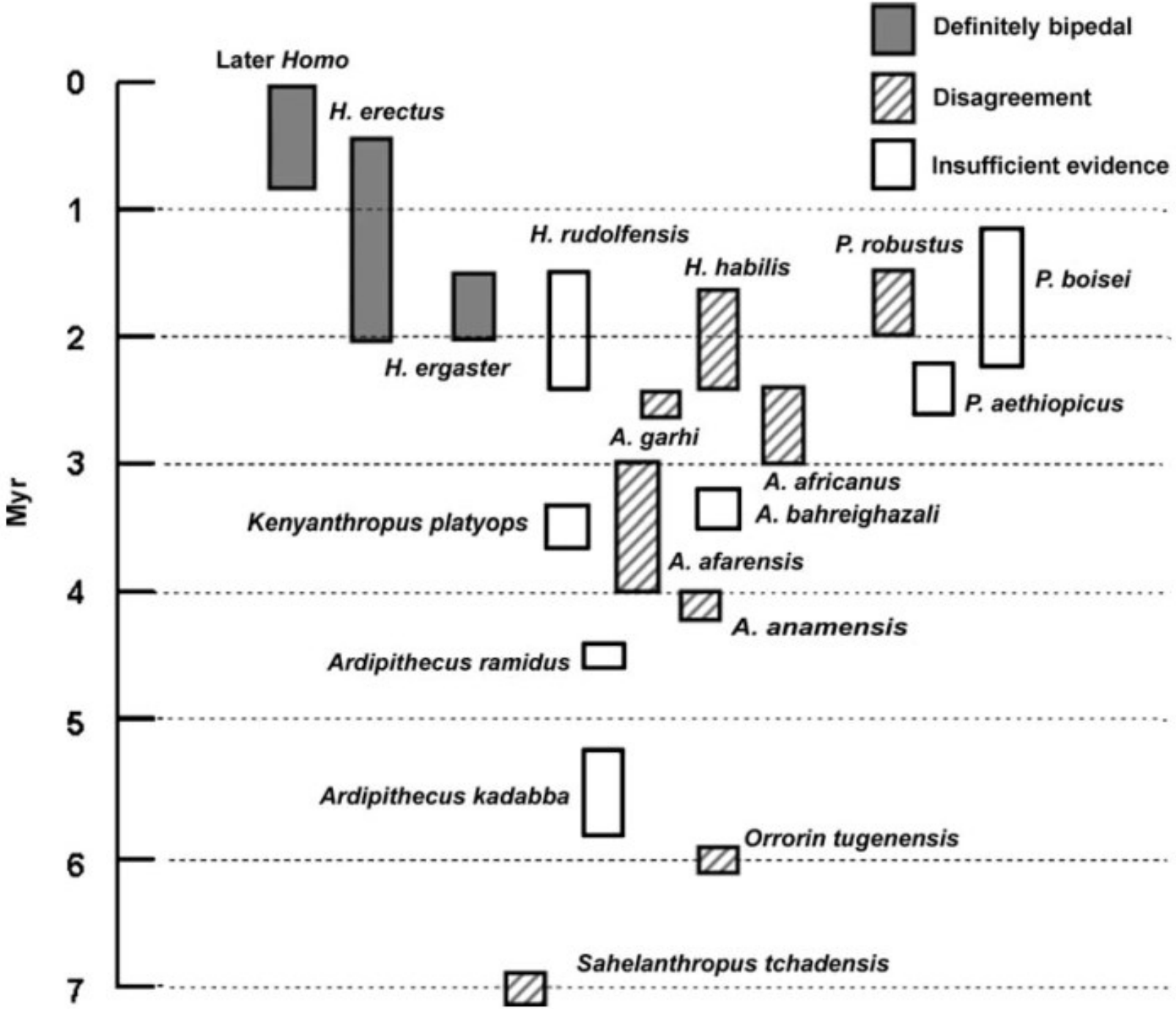


Grimaud-Hervé et al. 2015 « Histoire d'ancêtres »


Ma
Chimpanzee
0
0,5
1
2
3
4
5
6
7
H. floresiensis
H. neanderthalensis
H. sapiens
H. heidelbergensis
H. rhodesiensis
H. erectus
H. antecessor
P. robustus
P. boisei
H. habilis
H. rudolfensis
A. sediba
H. georgicus
H. ergaster
A. garhi
P. aethiopithecus
Kenyanthropus platyops
A. africanus
A. afarensis
A. bahrelghazali
A. deyiremeda
A. anamensis
Ardipithecus ramidus
Ardipithecus kadabba
Orrorin tugenensis
Sahelanthropus tchadensis
Big brain, small teeth, bipedalism
Small brain, very big teeth, facultative bipedalism
Small brain, big teeth facultative bipedalism
Small brain, small teeth, quadrupeds
Lack of information

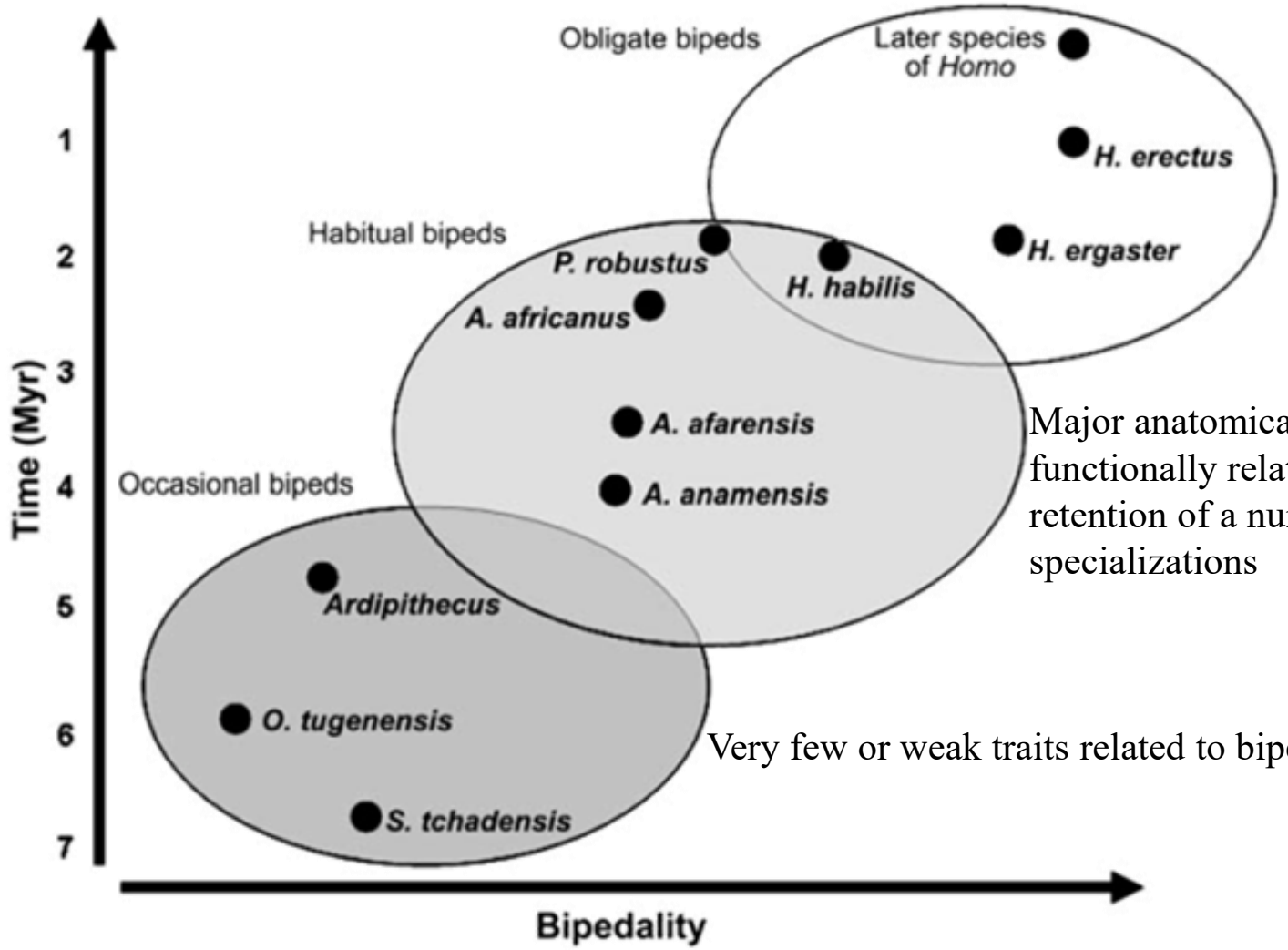


Henke & Tattersall, 2007



Henke & Tattersall, 2007; Wood, 2002

Degree of bipedalism in fossil Hominins through time.
Only well documented correlation between taxa and bipedalism are included.



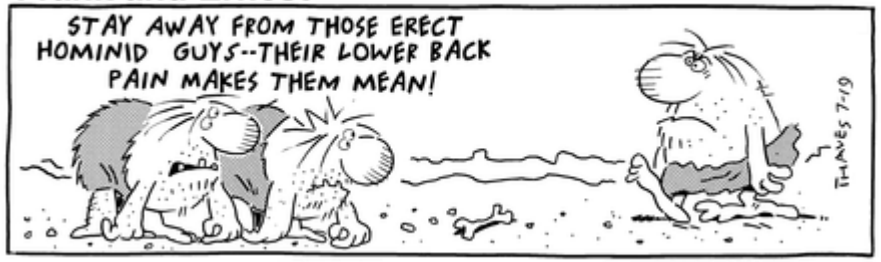
Obligate bipedalism.
H. habilis bipedality being discussed

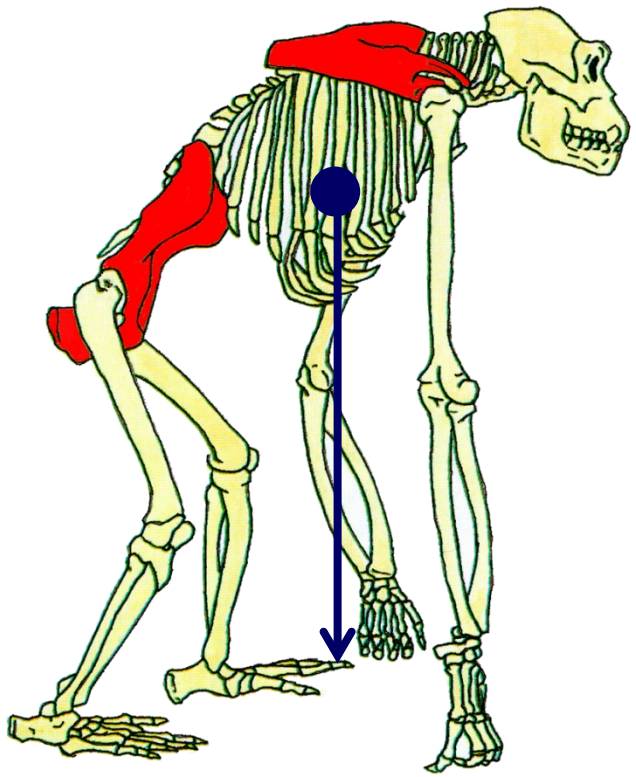
Major anatomical remodeling of structures functionally related to bipedality but retention of a number of apelike climbing specializations

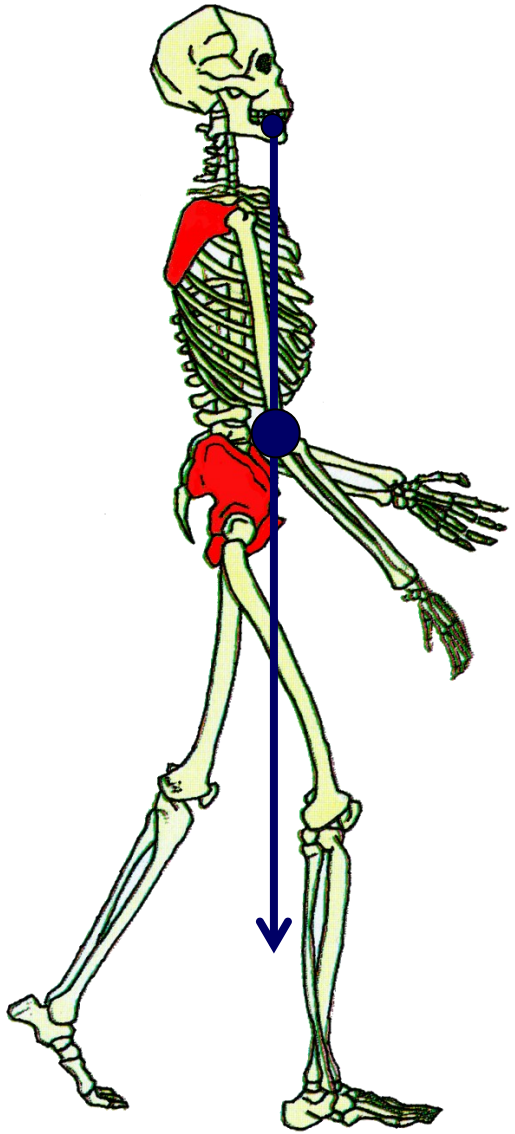
Very few or weak traits related to bipedality

Henke & Tattersall, 2007

Frank and Ernest



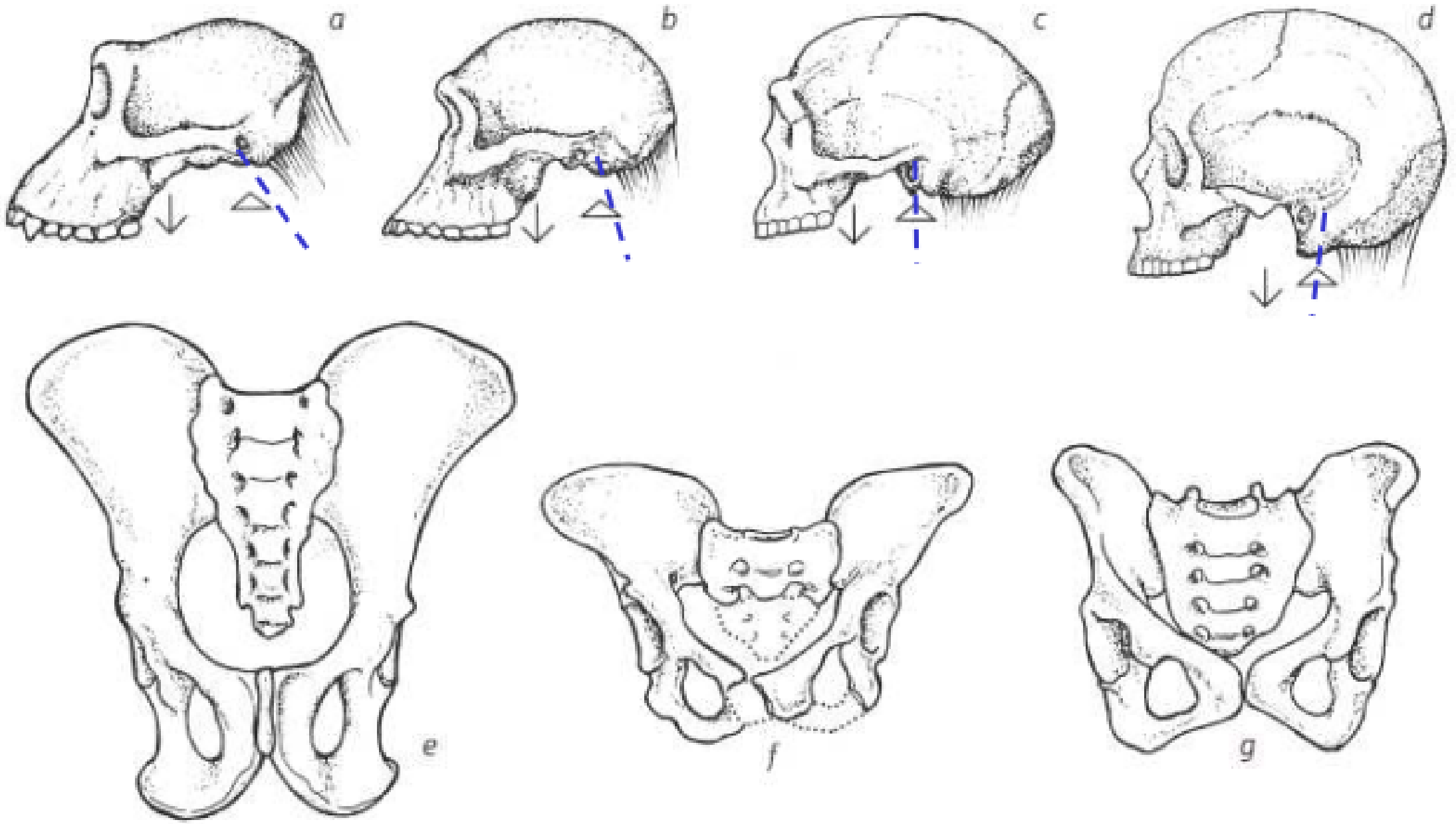


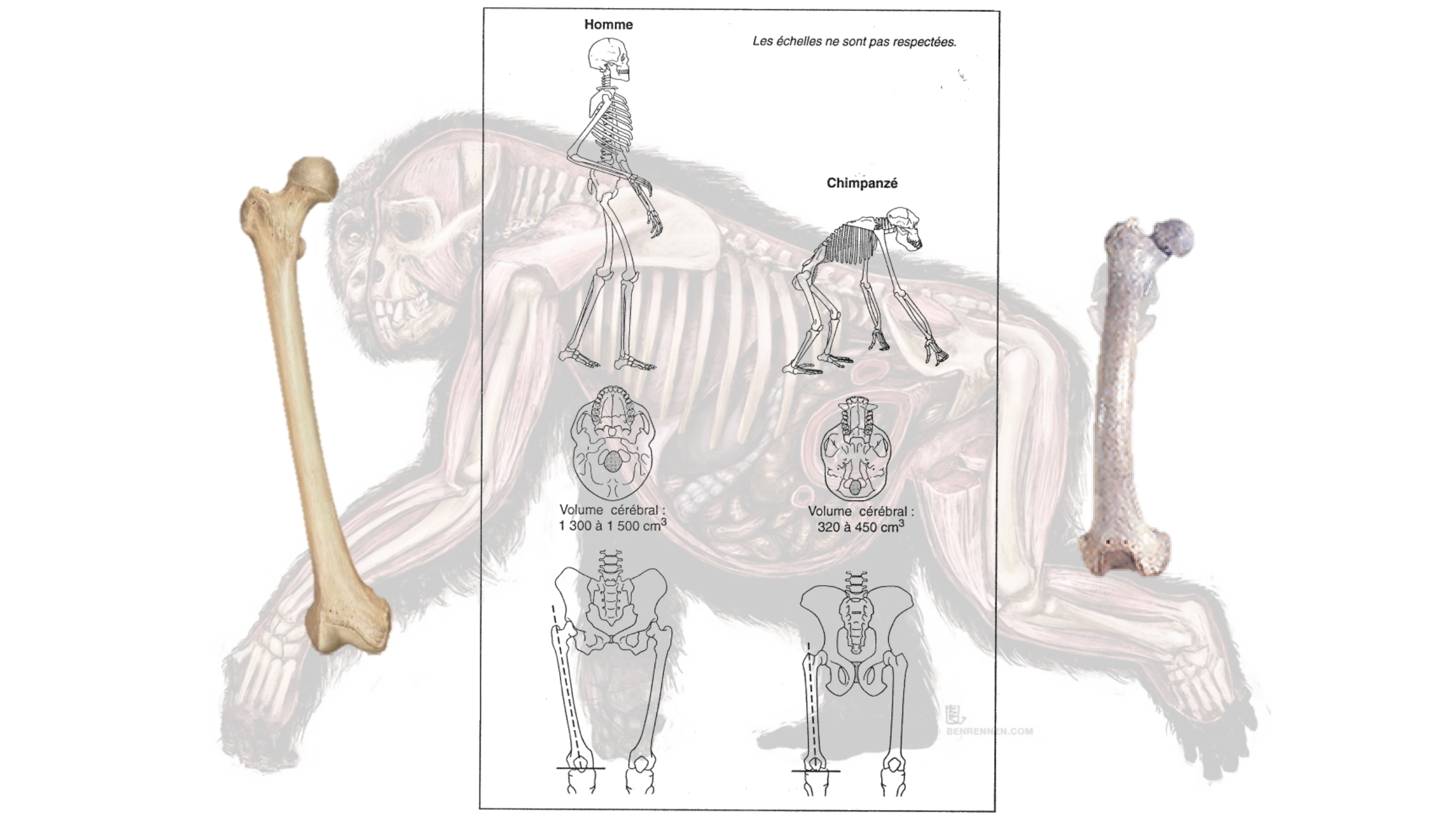


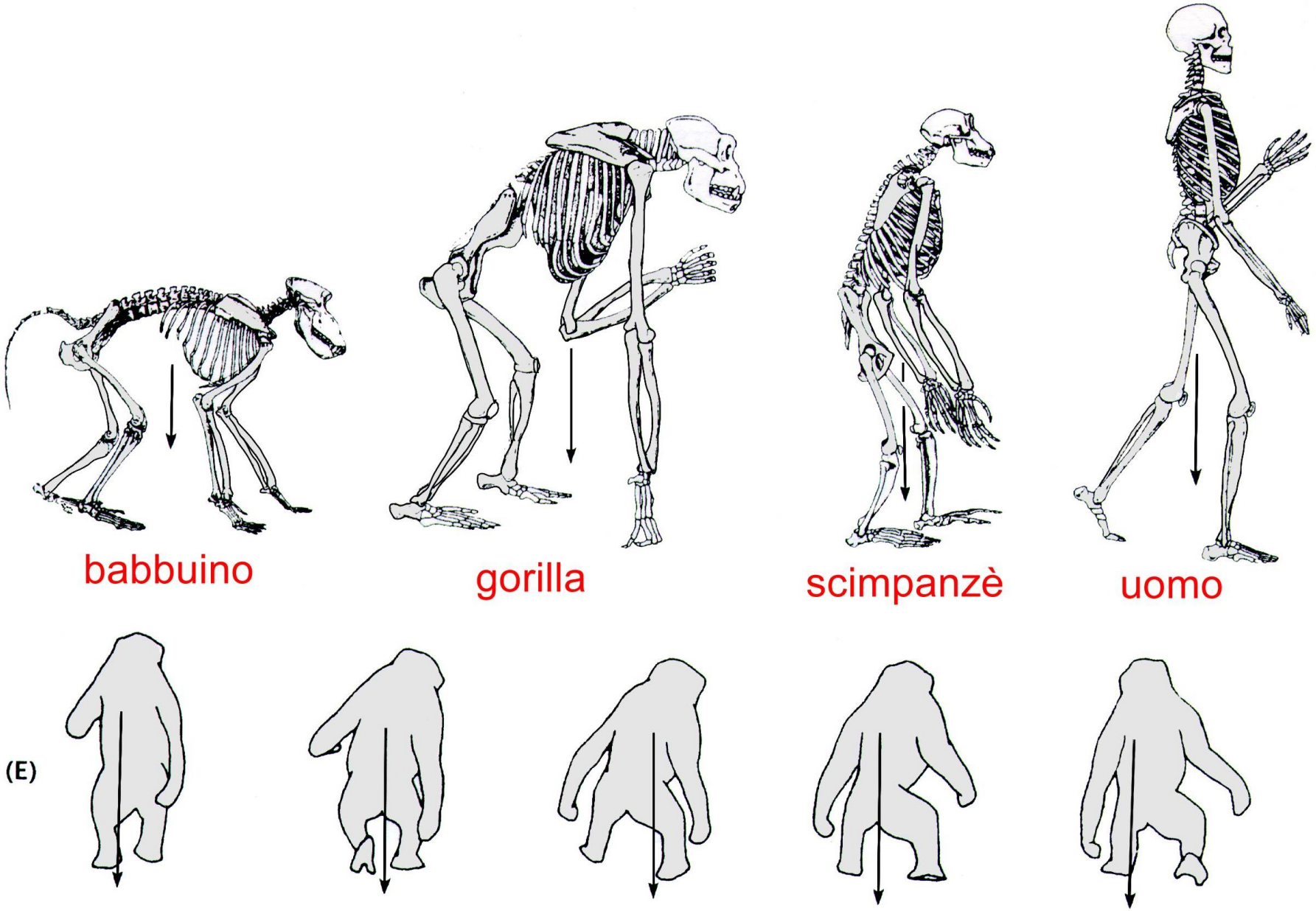
Axe de la colonne vertébrale

Point d'appui de la colonne vertébrale

« déséquilibre » face / boîte crânienne

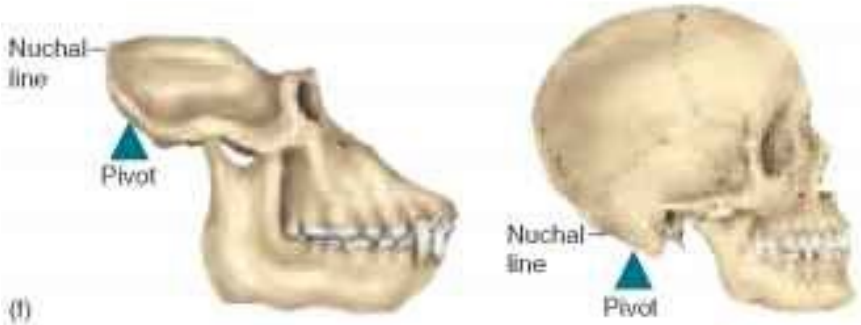



Homme
Les échelles ne sont pas respectées.
Chimpanzé
Volume cérébral :
1 300 à 1 500 cm3
Volume cérébral :
320 à 450 cm3
BENRENNEN.COM

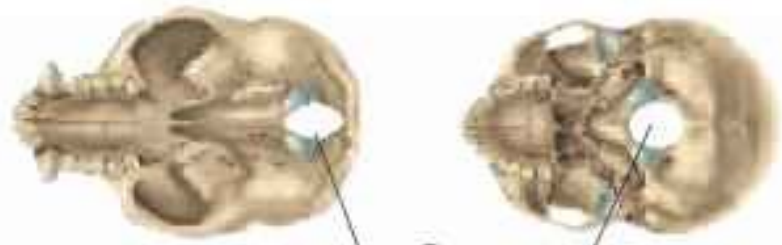

babbuino
gorilla
scimpanzè
uomo
(E)
Bipedismo occasionale

(d) Chimp Human

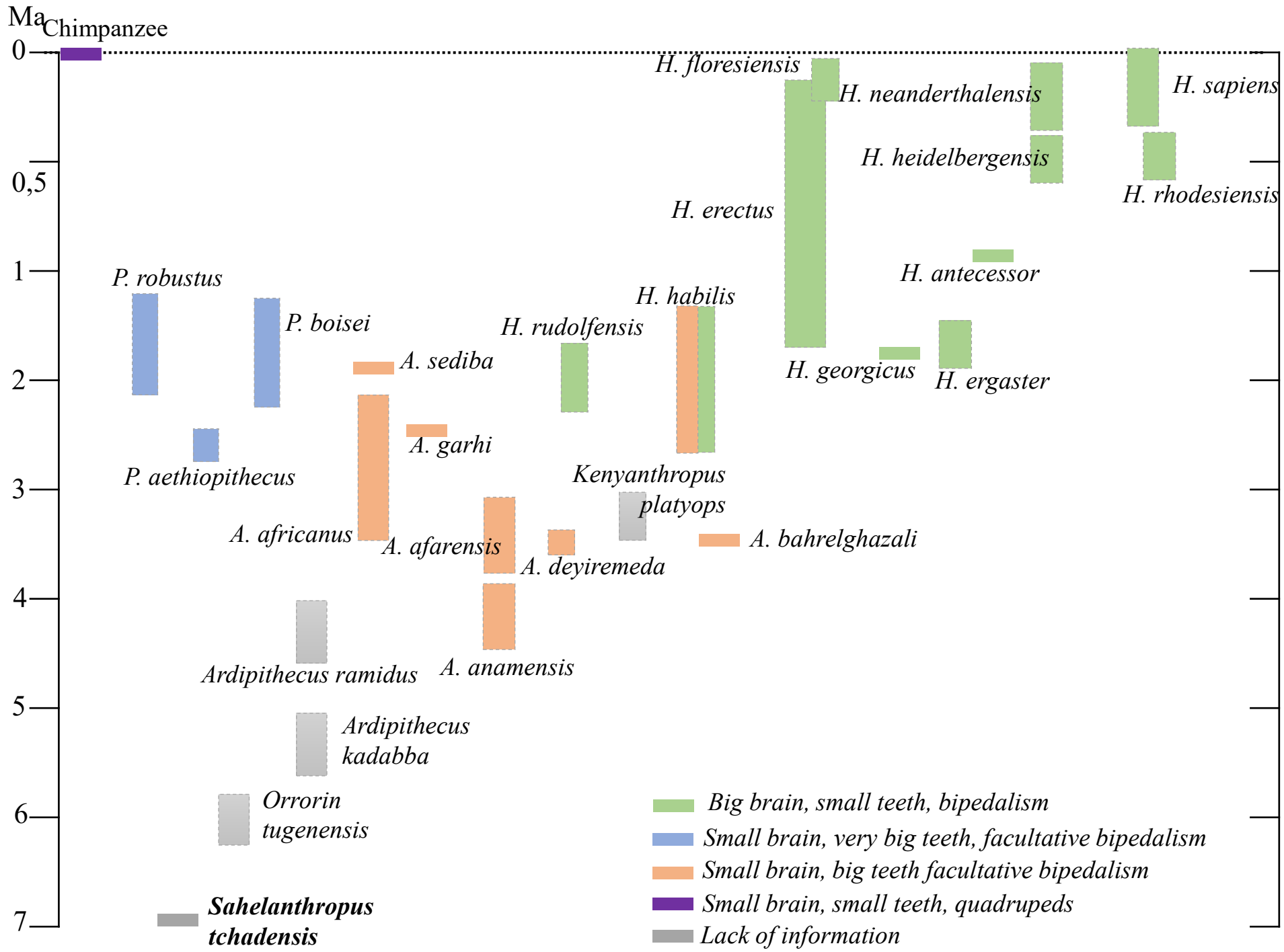
(e) Chimp Human



(f)



Chimp Human


Ma
Chimpanzee
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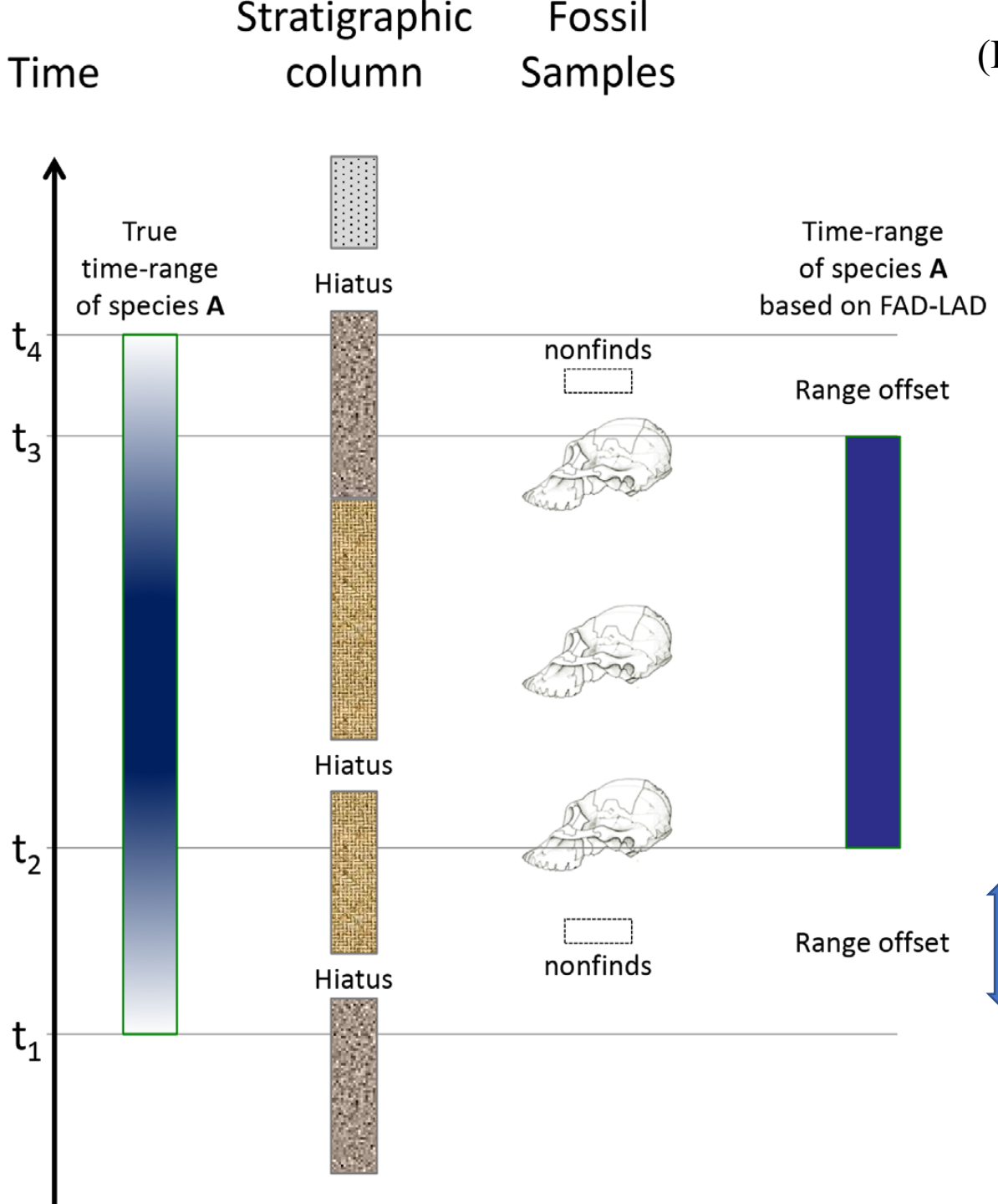
H. floresiensis
H. neanderthalensis
H. sapiens
H. heidelbergensis
H. rhodesiensis
H. erectus
H. antecessor
P. robustus
P. boisei
H. habilis
H. rudolfensis
A. sediba
H. georgicus
H. ergaster
A. garhi
P. aethiopithecus
Kenyanthropus platyops
A. africanus
A. afarensis
A. bahrelghazali
A. deyiremeda
A. anamensis
Ardipithecus ramidus
Ardipithecus kadabba
Orrorin tugenensis
Sahelanthropus tchadensis
Big brain, small teeth, bipedalism
Small brain, very big teeth, facultative bipedalism
Small brain, big teeth facultative bipedalism
Small brain, small teeth, quadrupeds
Lack of information

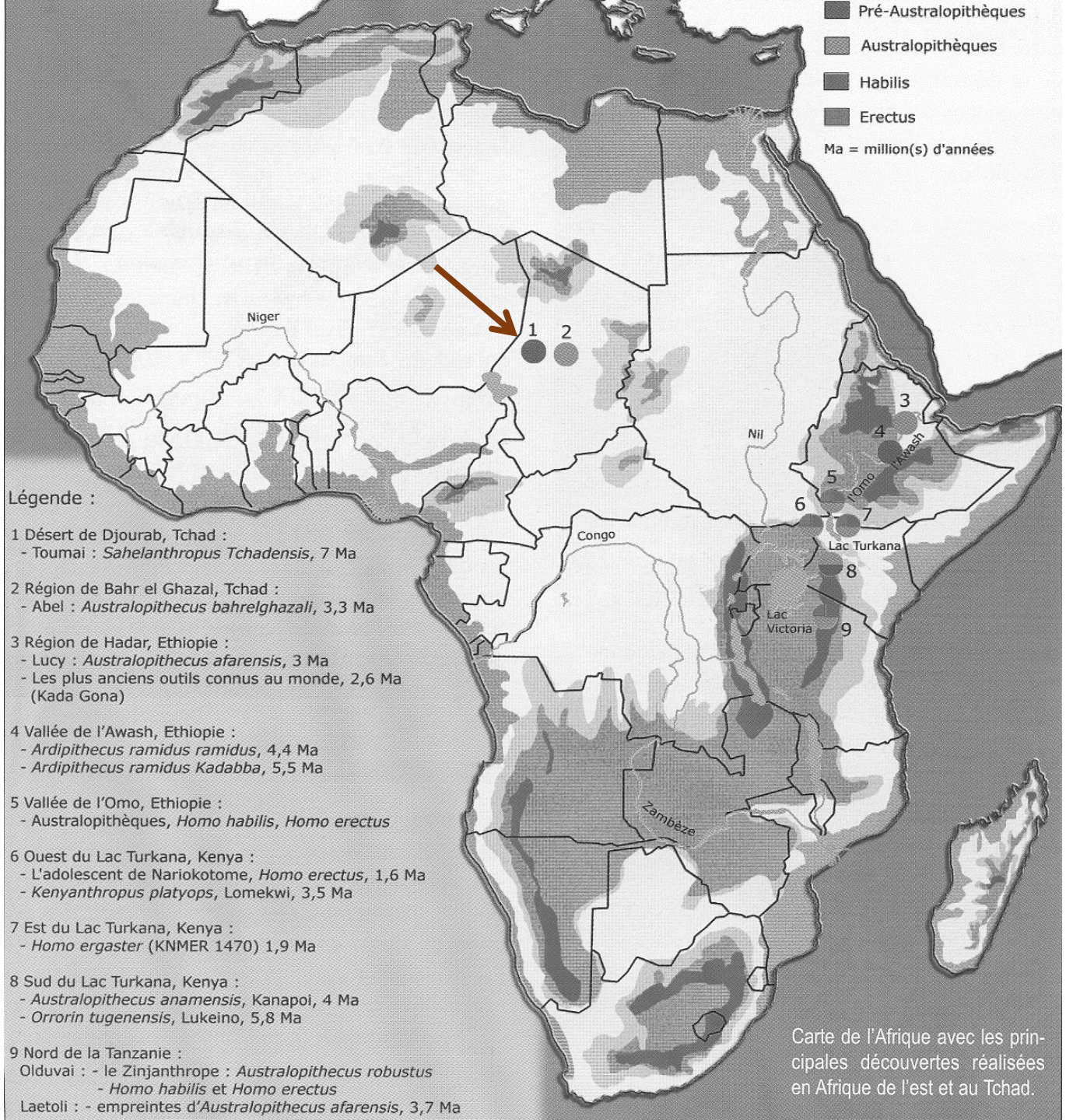
Hypothetical distribution of a species (species A) in a stratigraphic column in relation to its origin and extinction.

(Bobe and Wood, 2021)



The gap between the true origin of a species and its first appearance datum can be significant, especially if the species is rare, with few specimens per sample

Sahelanthropus tchadensis



Légende :

1 Désert de Djourab, Tchad :
- Toumaï : *Sahelanthropus Tchadensis*, 7 Ma

2 Région de Bahr el Ghazal, Tchad :
- Abel : *Australopithecus bahrelghazali*, 3,3 Ma

3 Région de Hadar, Ethiopie :
- Lucy : *Australopithecus afarensis*, 3 Ma
- Les plus anciens outils connus au monde, 2,6 Ma (Kada Gona)

4 Vallée de l'Awash, Ethiopie :
- *Ardipithecus ramidus ramidus*, 4,4 Ma
- *Ardipithecus ramidus Kadabba*, 5,5 Ma

5 Vallée de l'Omo, Ethiopie :
- Australopithèques, *Homo habilis*, *Homo erectus*

6 Ouest du Lac Turkana, Kenya :
- L'adolescent de Nariokotome, *Homo erectus*, 1,6 Ma
- *Kenyanthropus platyops*, Lomekwi, 3,5 Ma

7 Est du Lac Turkana, Kenya :
- *Homo ergaster* (KNMER 1470) 1,9 Ma

8 Sud du Lac Turkana, Kenya :
- *Australopithecus anamensis*, Kanapoi, 4 Ma
- *Orrorin tugenensis*, Lukeino, 5,8 Ma

9 Nord de la Tanzanie :
Olduvai : - le Zinjanthrope : *Australopithecus robustus*
- *Homo habilis* et *Homo erectus*
Laetoli : - empreintes d'*Australopithecus afarensis*, 3,7 Ma

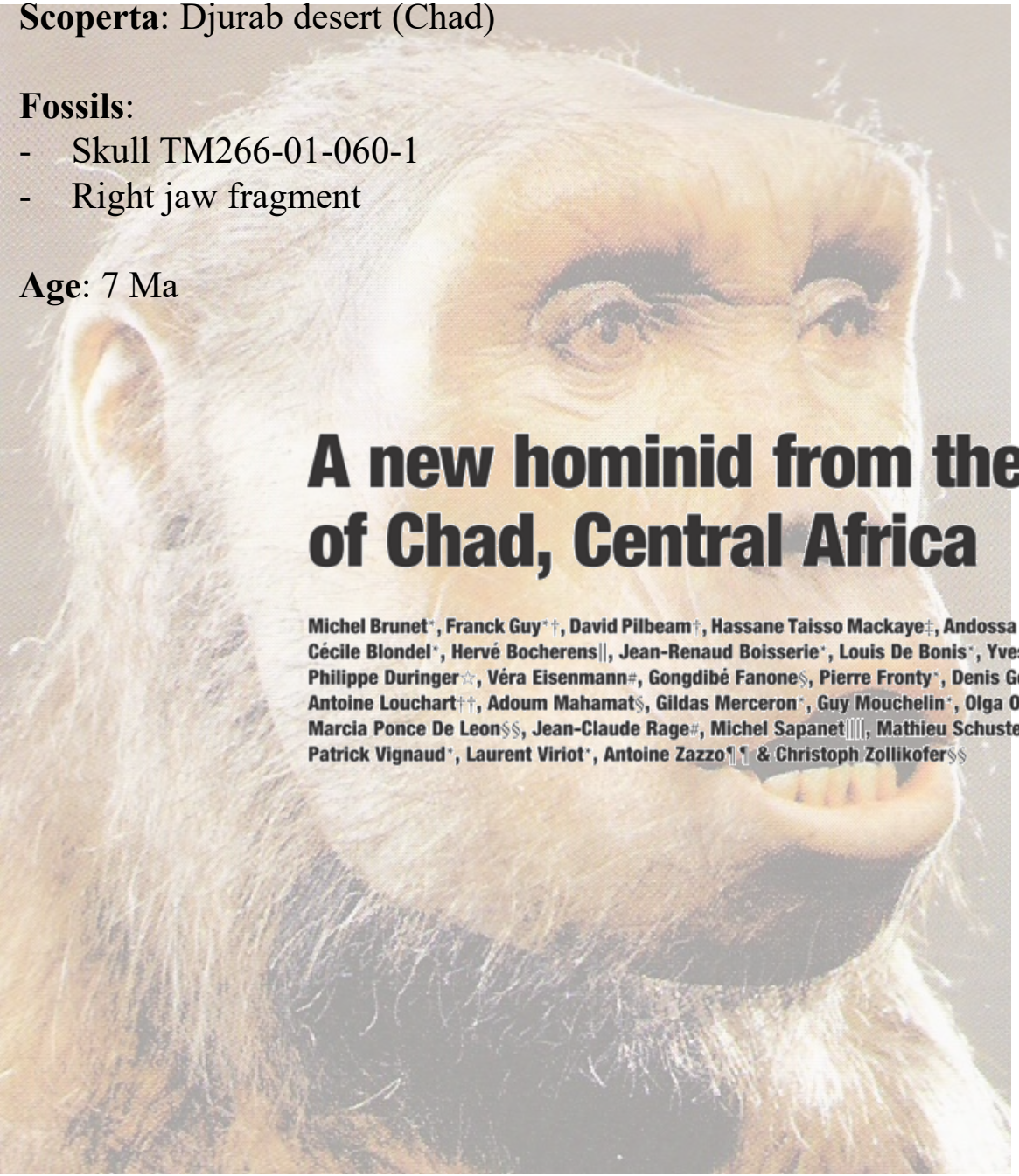
Carte de l'Afrique avec les principales découvertes réalisées en Afrique de l'est et au Tchad.

Sahelanthropus tchadensis (Toumai)

Scoperta: Djurab desert (Chad)

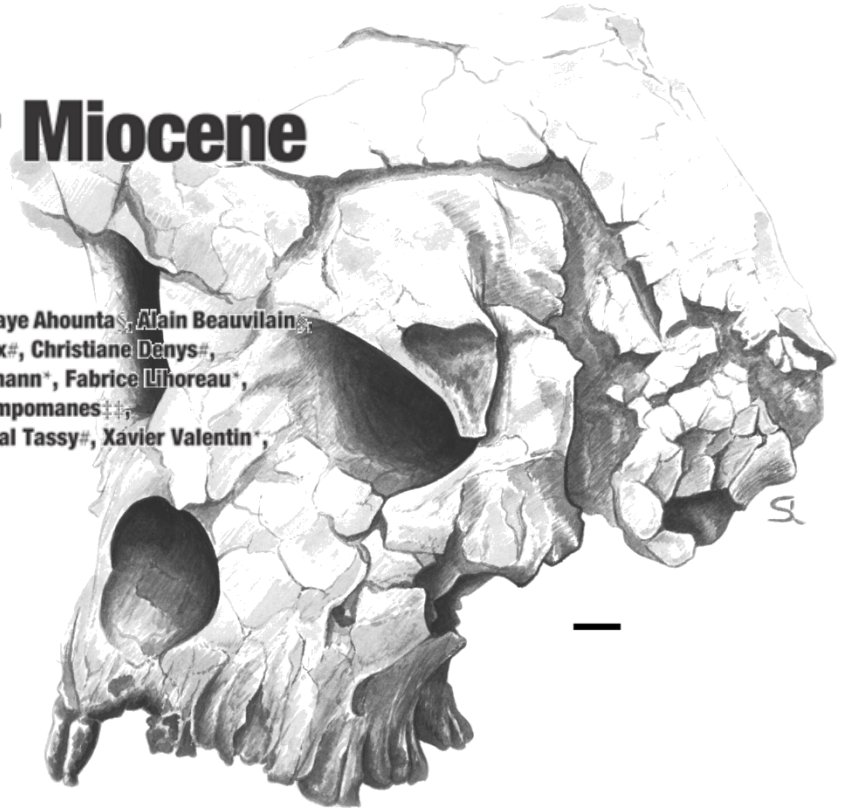
Fossils:
- Skull TM266-01-060-1
- Right jaw fragment

Age: 7 Ma



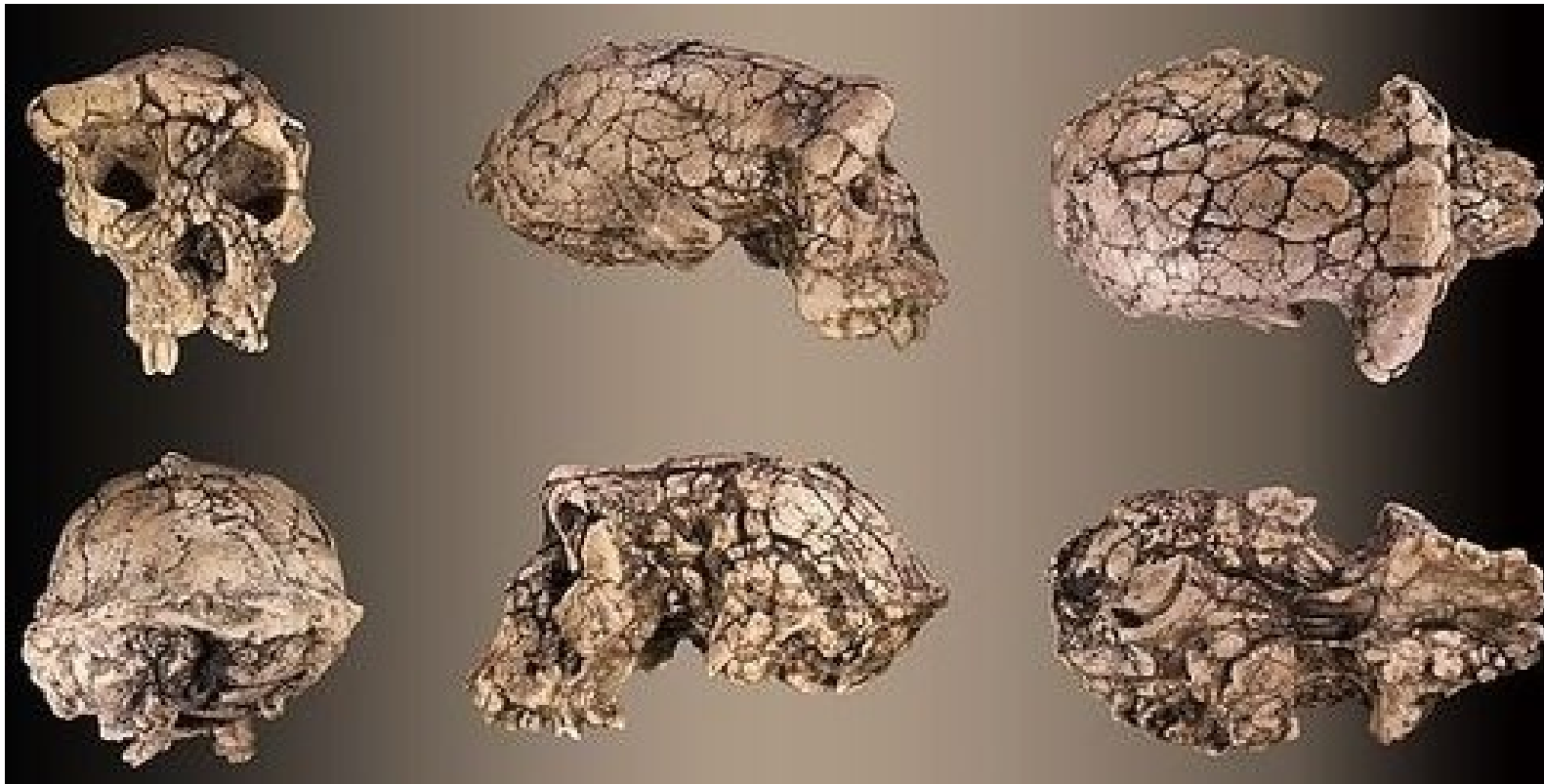
A new hominid from the Upper Miocene of Chad, Central Africa

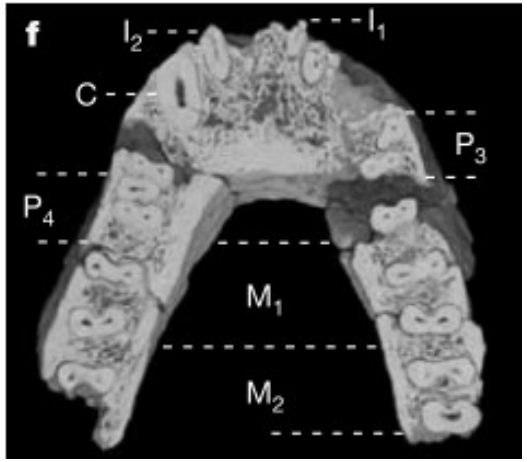
Michel Brunet*, Franck Guy*†, David Pilbeam†, Hassane Taisso Mackaye‡, Andossa Likius*‡, Djimdoumalbaye Ahounta§, Alain Beauvilain§, Cécile Blondel*, Hervé Bocherens‖, Jean-Renaud Boisserie*, Louis De Bonis*, Yves Coppens¶, Jean Dejax#, Christiane Denys#, Philippe Duringer☆, Véra Eisenmann#, Gongdibé Fanone§, Pierre Fronty*, Denis Geraads**, Thomas Lehmann*, Fabrice Lihoreau*, Antoine Louchart††, Adoum Mahamat§, Gildas Merceron*, Guy Mouchelin*, Olga Otero*, Pablo Pelaez Campomanes‡‡, Marcia Ponce De Leon§§, Jean-Claude Rage#, Michel Sapanet‖‖, Mathieu Schuster☆, Jean Sudre‖, Pascal Tassy#, Xavier Valentin*, Patrick Vignaud*, Laurent Viriot*, Antoine Zazzo¶¶ & Christoph Zollikofer§§



Robust supra-orbital morphology
(Male?)
Morfologia sovra-orbitaria
Robusta (Maschio?)

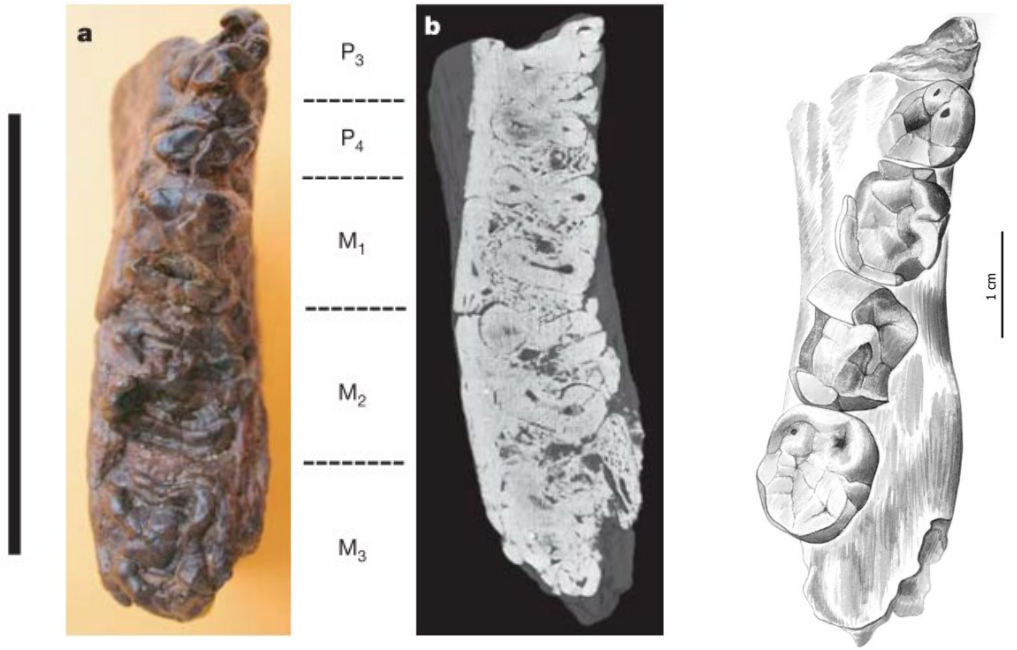
Low molar and premolar crown
Enamel thickness between chimp and Ardipithecus Corona dei molari e dei premolari bassa
Spessore dello smalto tra scimpanzé e *Ardipithecus*



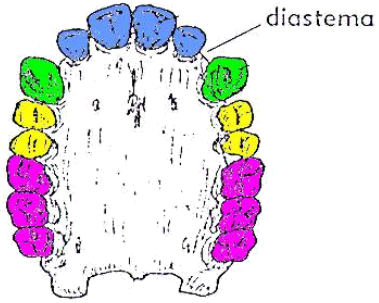


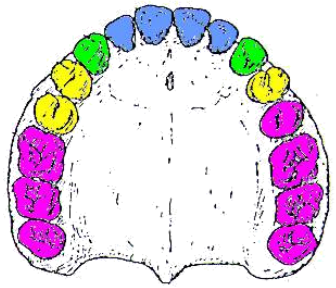
- C/P3 non affilati / *not sharp*
- Assenza di diastema tra C/P3

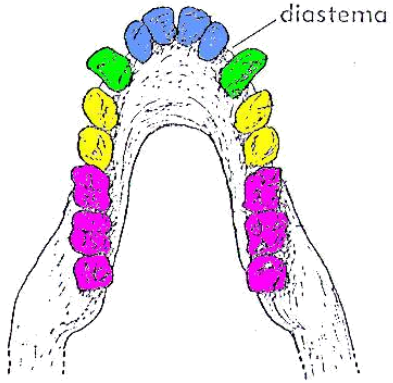
No diastema between C/P3

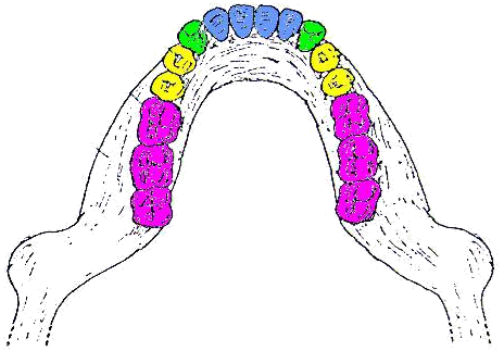


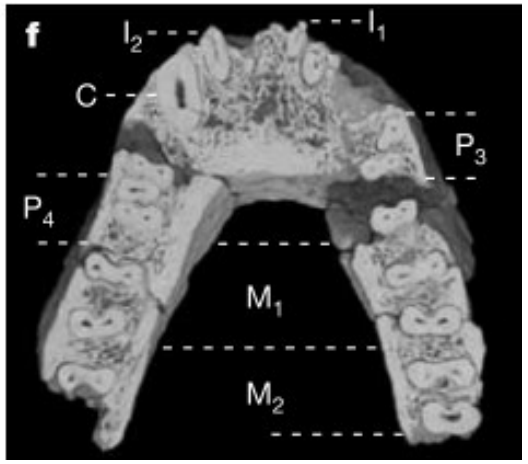
Brunet, 2005 (Nature vol 434)


diastema



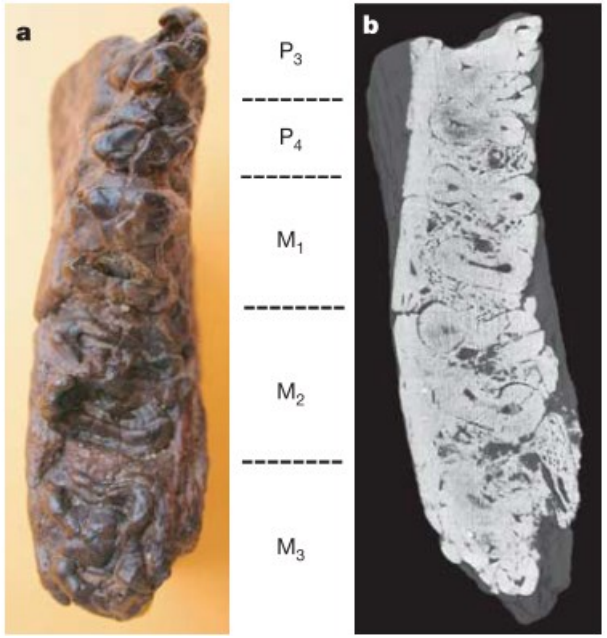

diastema

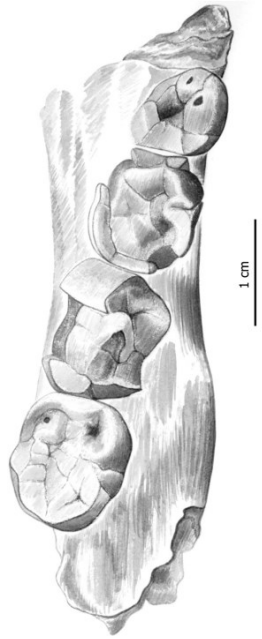




- C/P3 non affilati
- Assenza di diastema tra C/P3
- Sinfisi piuttosto verticale
- i denti post-C presentano un spessore dello smalto tra i scimpanzé e i australopitecine

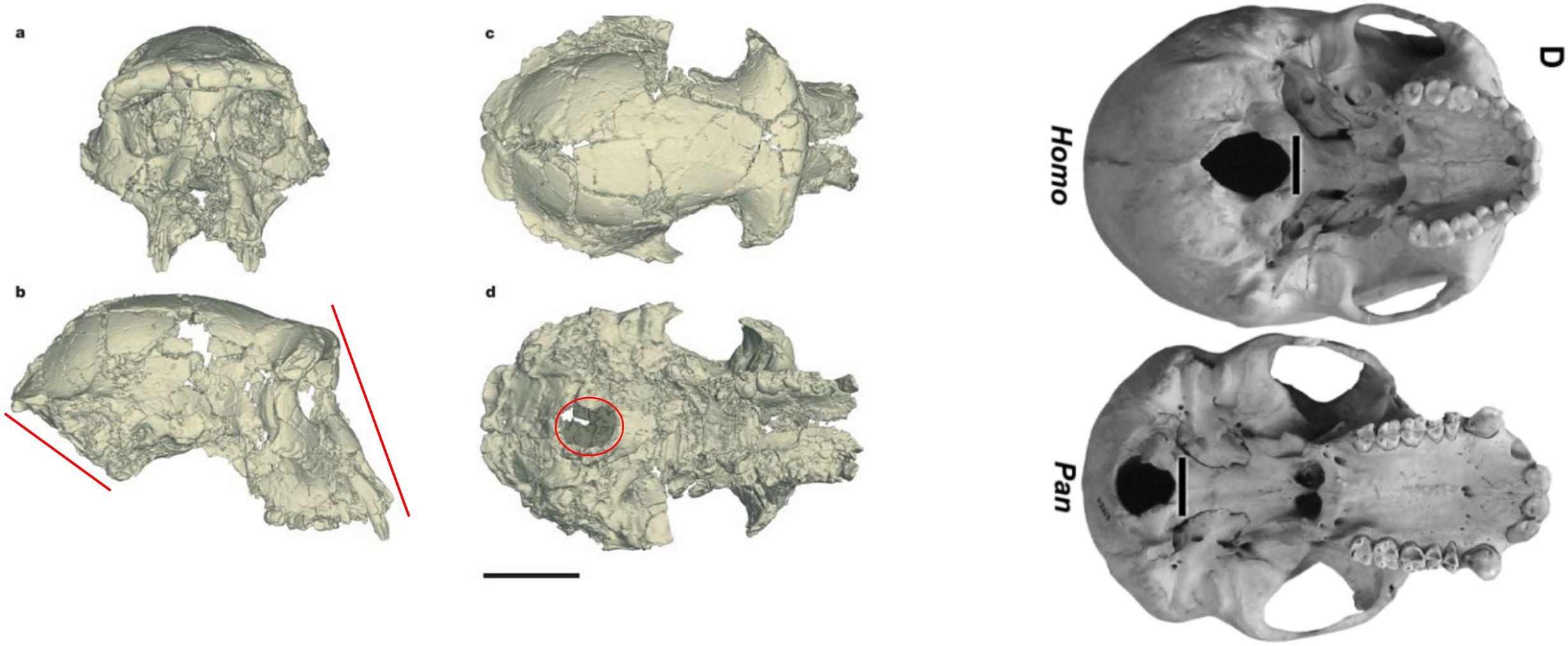
Post-C teeth present an enamel thickness between chimp and Australo





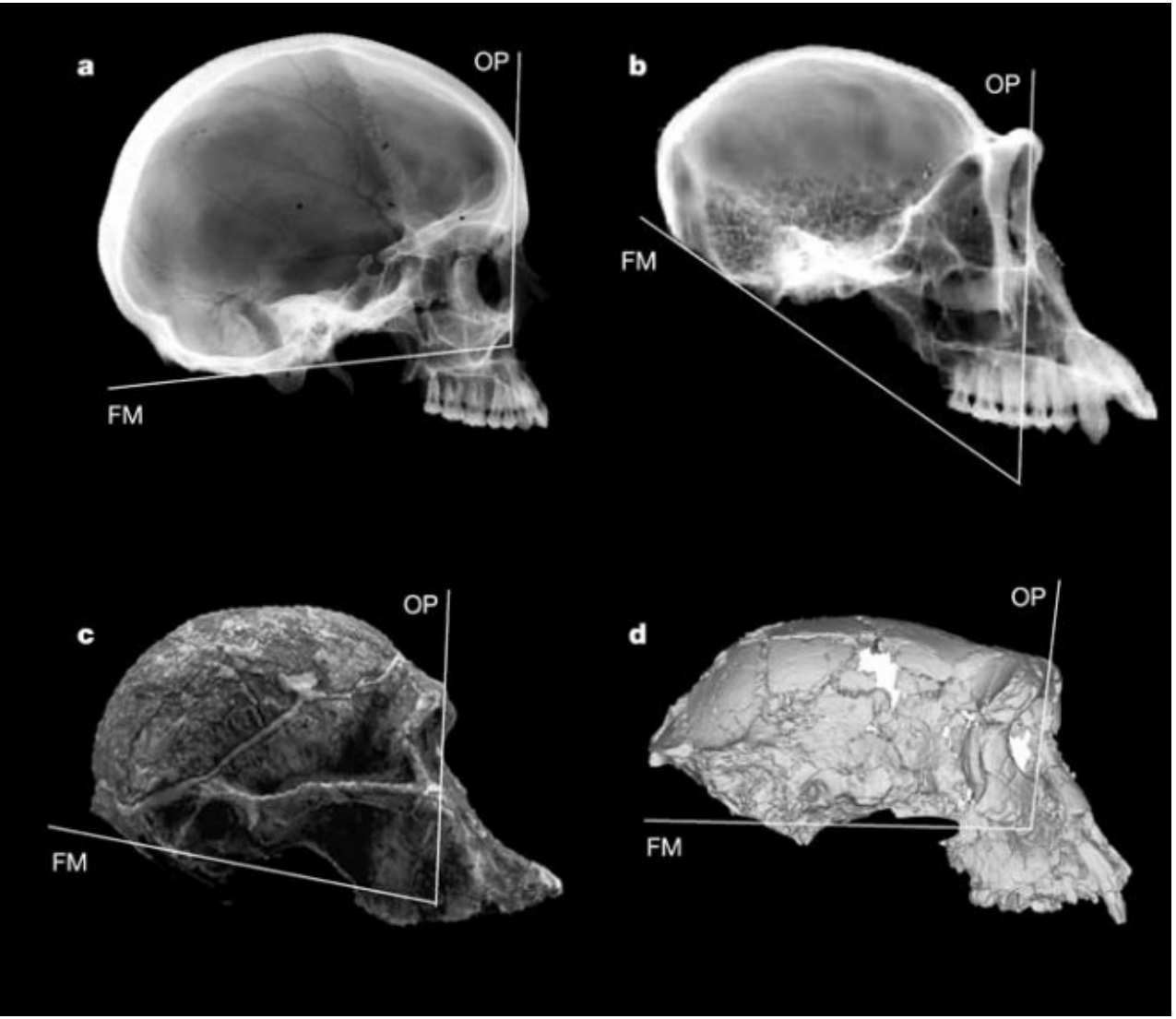
Brunet, 2005 (Nature vol 434)

(Zollikofer, 2005)



- Faccia relativamente verticale con un premascellare corto anteroposteriormente / *Face relatively vertical with a anteroposteriorly short premaxilla*
- Piano nucale piatto e largo / *Nuchal plan flat and wide*
- Foramen magnum posizionato anteriormente /*Anterior position of the foramen magnum*

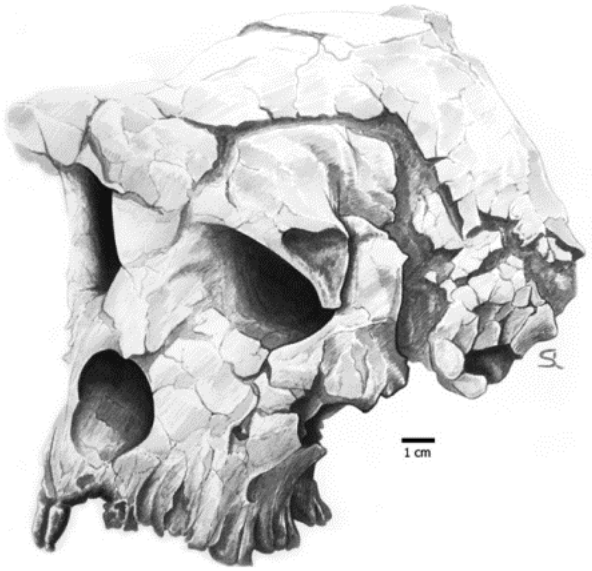
Bipedia?

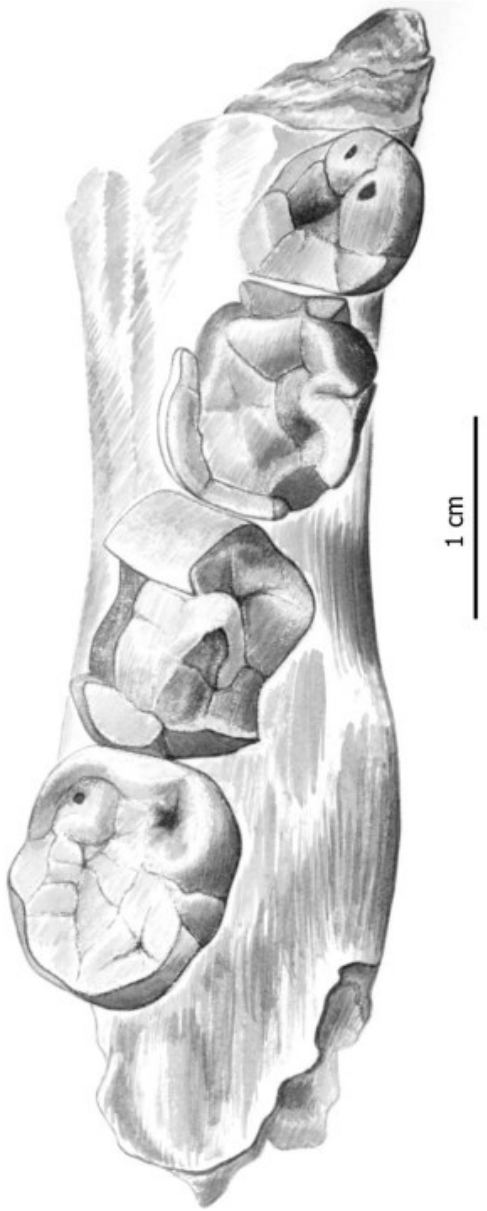


(Zollikofer, 2005)
FM: Foramen magnum
OP: orbital planes

- Angolo tra il piano orbitale (OP) e il piano del foramen magnum (FM)
Angle between the orbital plan and the foramen magnum

- Orientazione del piano nucale relativamente al piano di Francoforte nella variabilità dei Australopitecine e *Homo*
Orientation of the nuchal plane relative to the Frankfurt plan inside Australopitecine and Homo *variability*

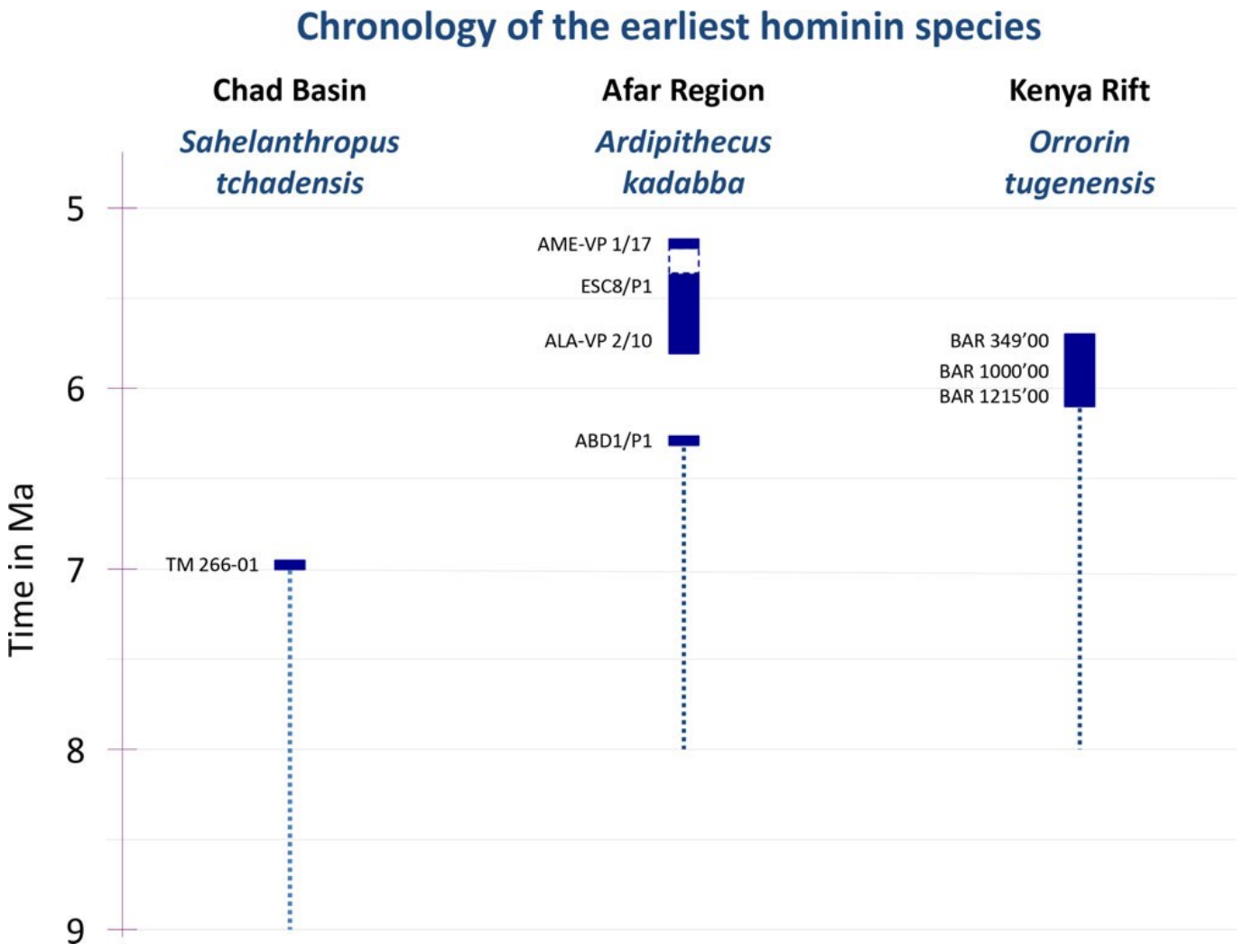


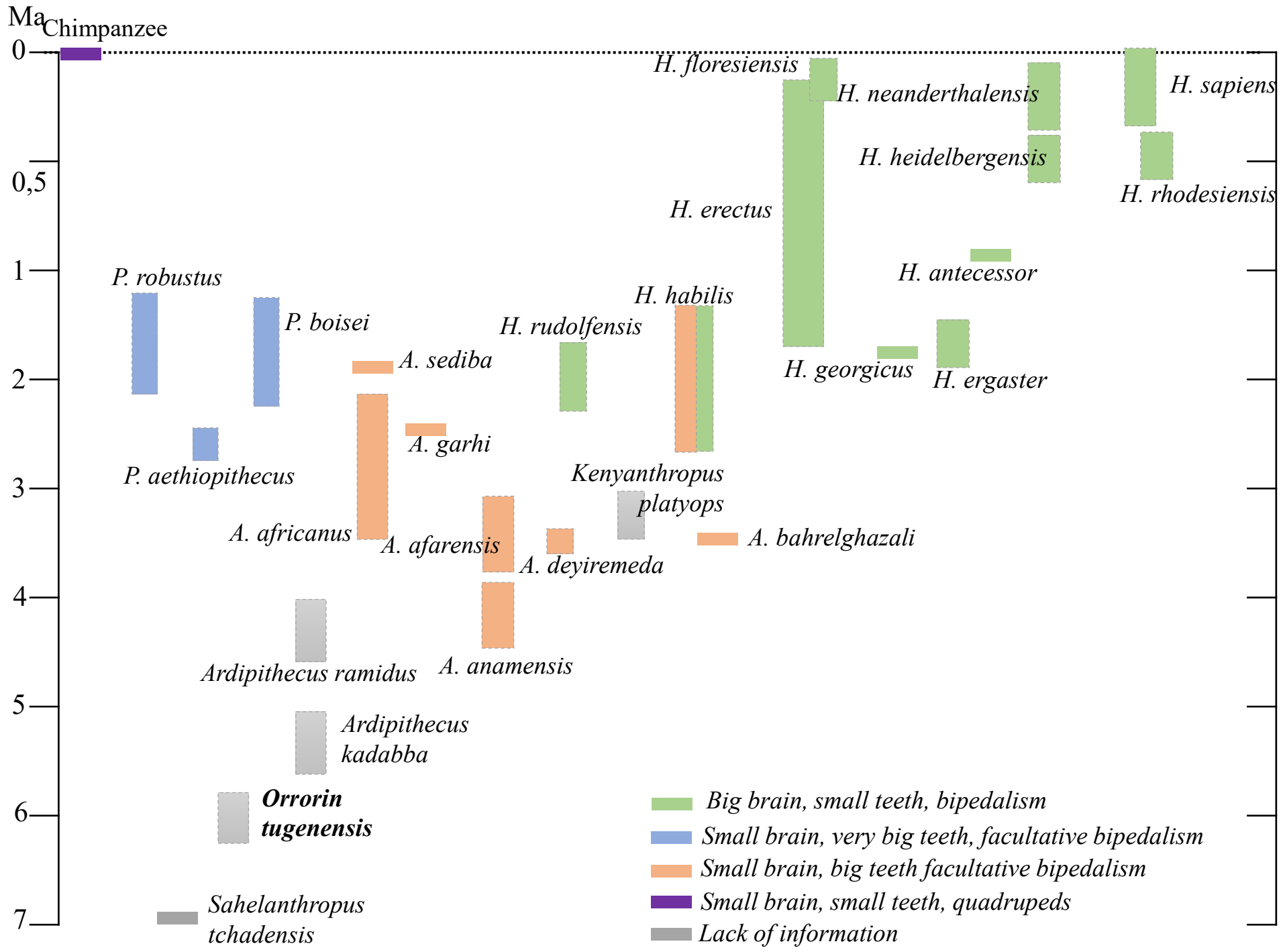


Probabilmente bipede
Probably bipedal

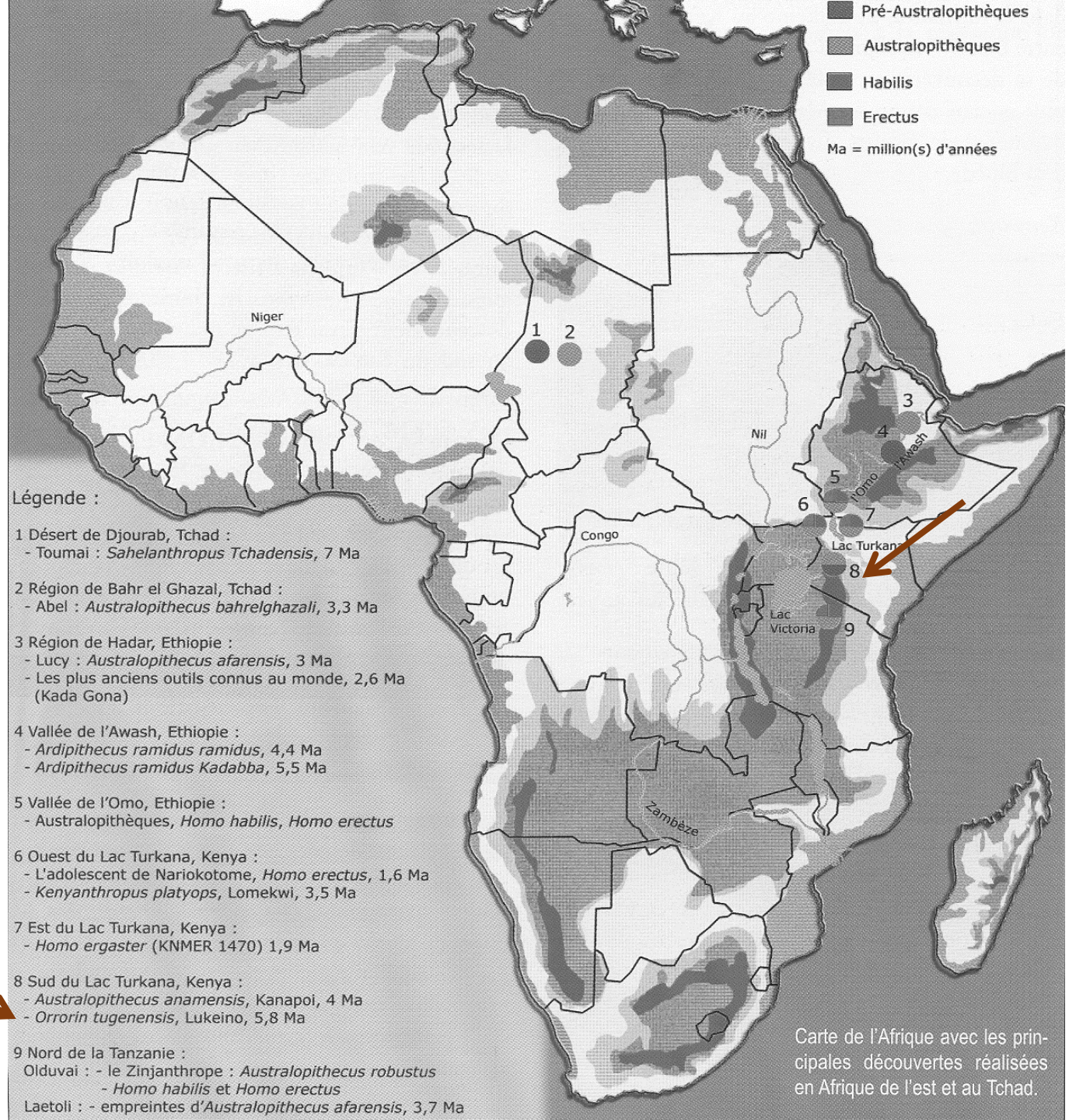
Frequentava spazi forestali
Associated with forest

Chronology of the earliest hominin species: *Sahelanthropus tchadensis*, *Ardipithecus kadabba*, and *Orrorin tugenensis*. The temporal distribution of each taxon is represented by a solid rectangle. The first appearance datum (FAD) is the earliest (stratigraphically lowest) record of each taxon. The dashed vertical lines represent confidence intervals on the origin of the taxon. Some of the key specimens for each taxon are noted on the left of the Columns (Bobe and Wood, 2021)




Ma
Chimpanzee
0
0,5
1
2
3
4
5
6
7
H. floresiensis
H. neanderthalensis
H. sapiens
H. heidelbergensis
H. rhodesiensis
H. erectus
H. antecessor
P. robustus
P. boisei
H. habilis
H. rudolfensis
A. sediba
H. georgicus
H. ergaster
A. garhi
P. aethiopithecus
Kenyanthropus platyops
A. africanus
A. afarensis
A. bahrelghazali
A. deyiremeda
A. anamensis
Ardipithecus ramidus
Ardipithecus kadabba
Orrorin tugenensis
Sahelanthropus tchadensis
Big brain, small teeth, bipedalism
Small brain, very big teeth, facultative bipedalism
Small brain, big teeth facultative bipedalism
Small brain, small teeth, quadrupeds
Lack of information

Orrorin tugenensis



Légende :

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- *Homo ergaster* (KNMER 1470) 1,9 Ma

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Laetoli : - empreintes d'*Australopithecus afarensis*, 3,7 Ma

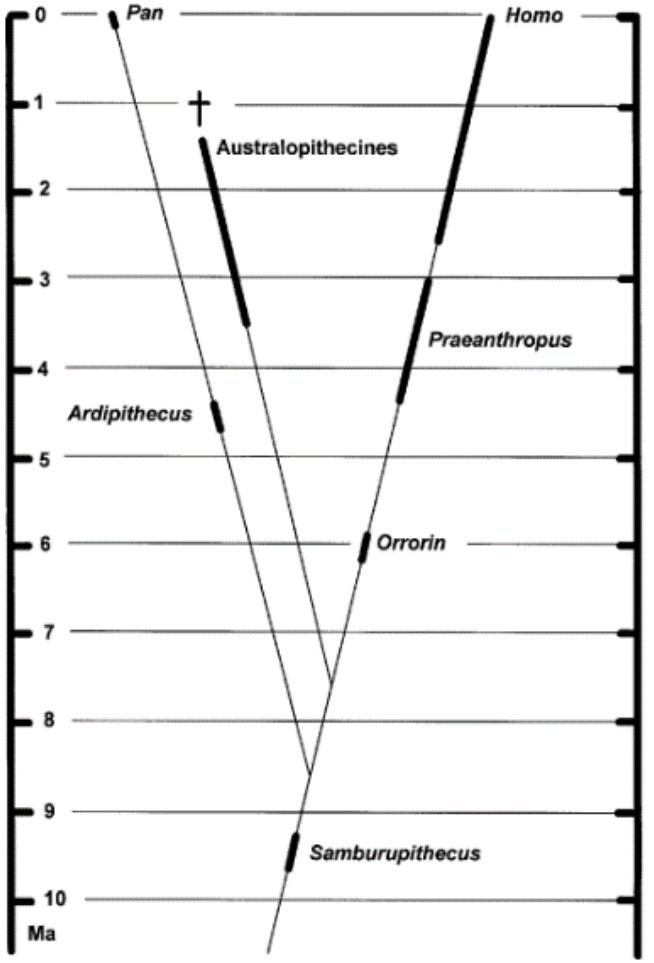
Carte de l'Afrique avec les principales découvertes réalisées en Afrique de l'est et au Tchad.

(Senut *et al.*, 2001)

Discovery: Tugen hills, Baringo Lake, Kenys

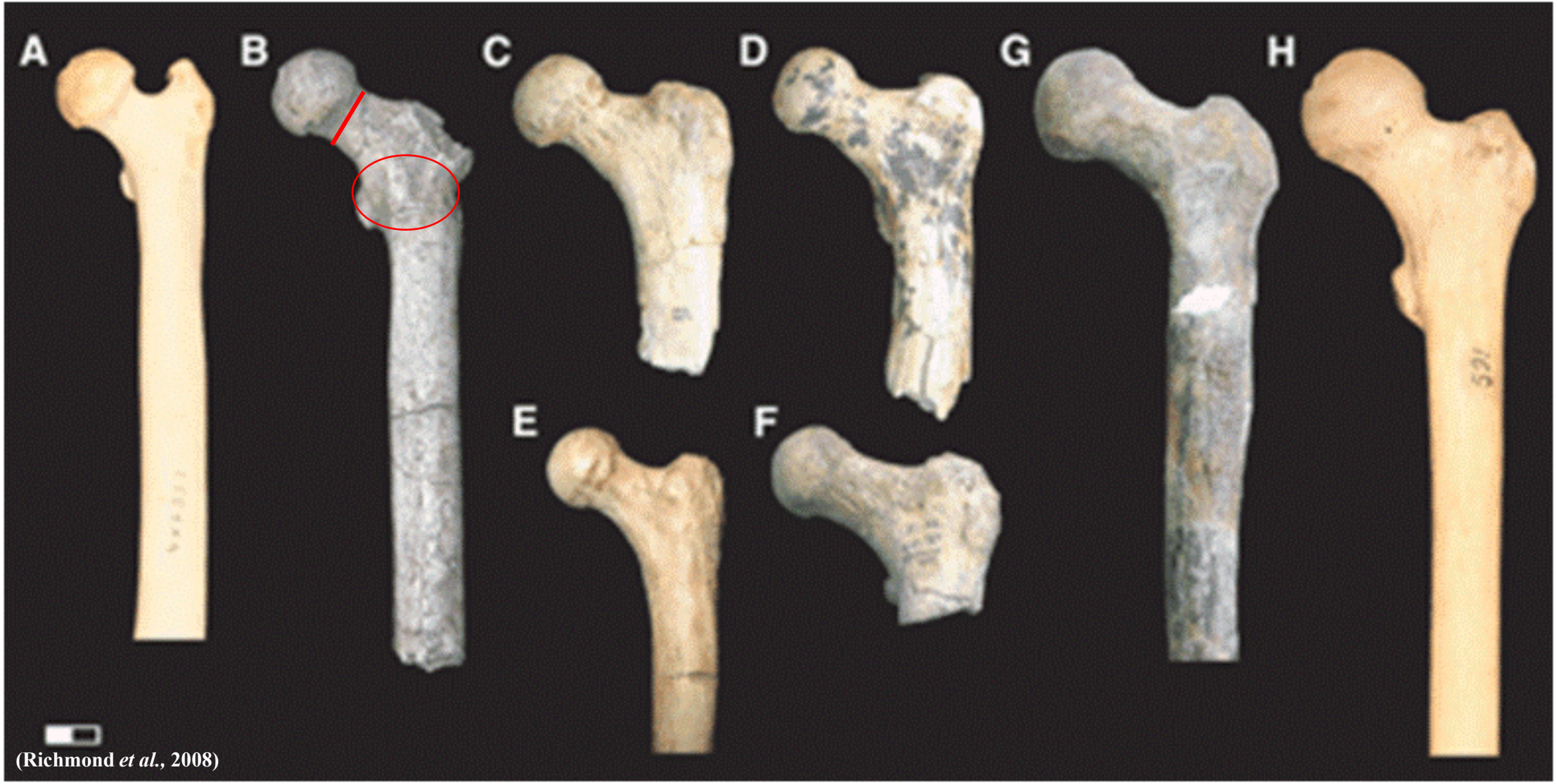
Reperti:
- Left femur (A, B)
- Right jaw fragment with M_3(C)
- Left jaw fragment with M_{2-3}(D,E)
- Right M^3 (F)
- Right P_4 (G)
- I^1 (H)
- Right C (I)
- Right humerus (J)
- Left proximal part of a femur (K)
- Proximal hand phalanx (L)
- Left M^3 (M)
- Proximal fragment of a right femur (N)

Età: 6 Ma



La taglia dei denti iugali mostra che la faccia era corta
Lo spessore dello smalto dei denti iugali attesta un regime alimentare probabilmente onnivoro

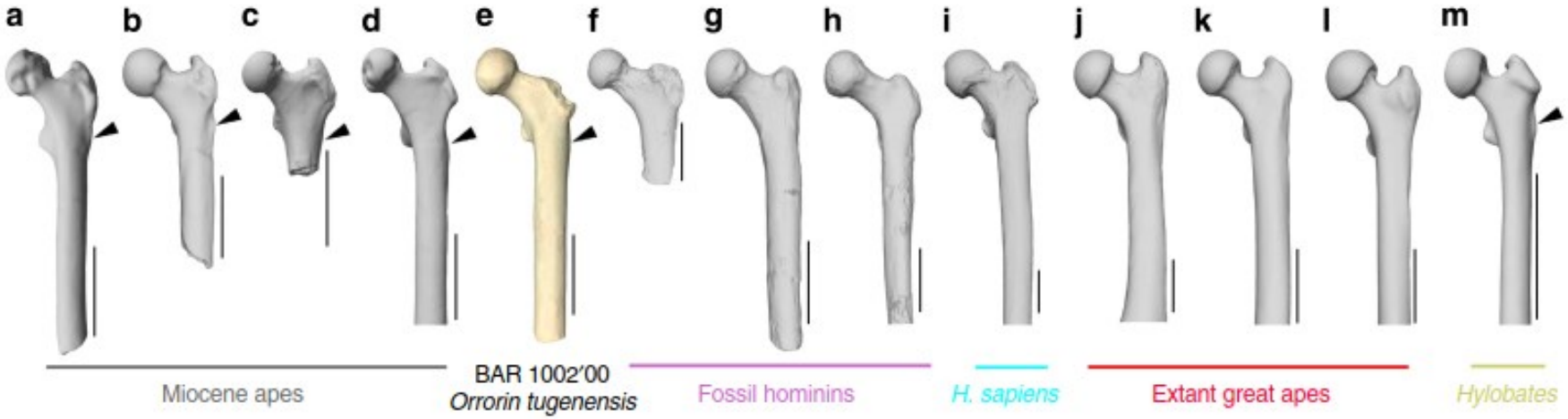
Molar and premolar highlight a short face
Enamel thickness attest an omnivore alimentation



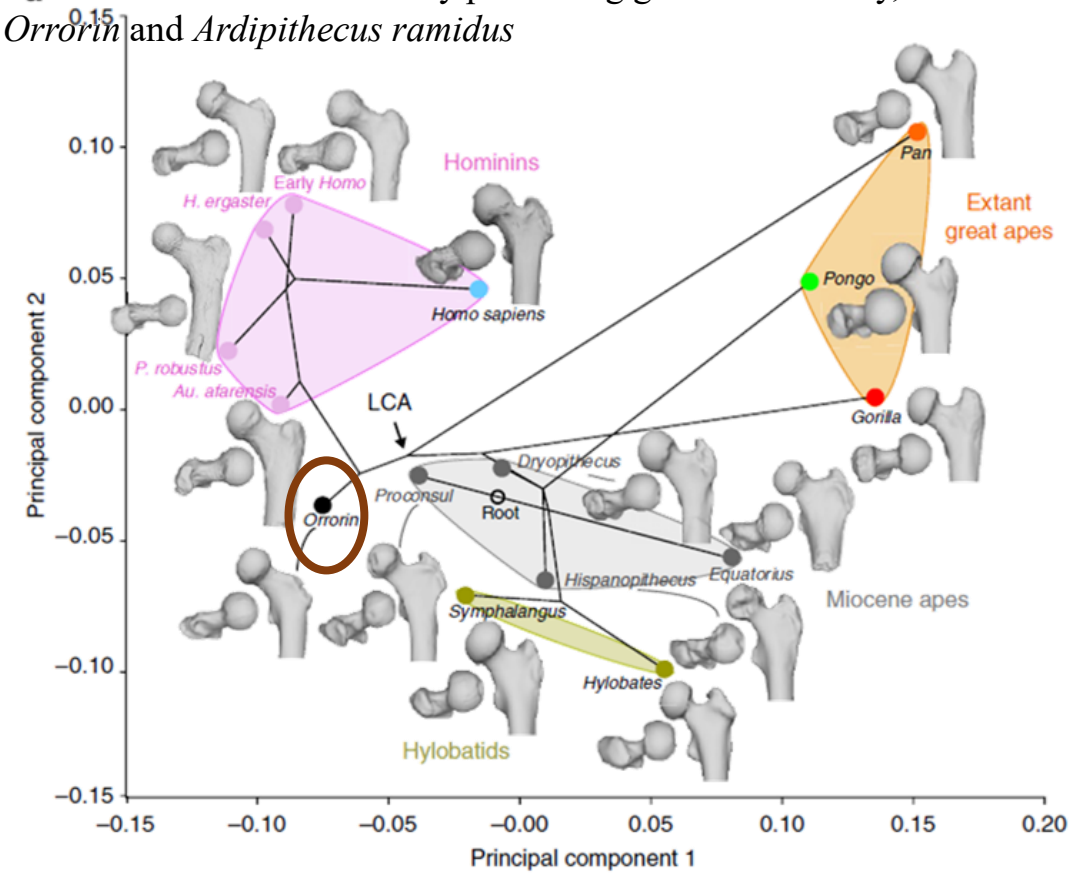
(A) P. troglodytes, (**B**) *O. tugenensis* (BAR 1002'00), (**C** and **D**) *Paranthropus robustus* (SK 97 and SK 82, reversed), (**E**) *A. afarensis* (A.L. 288-1ap), (**F**) *Paranthropus boisei* (KNM-ER 1503, reversed), (**G**) early *Homo* (KNM-ER 1481), and (**H**) modern *H. sapiens*. Scale bar, 2 cm.

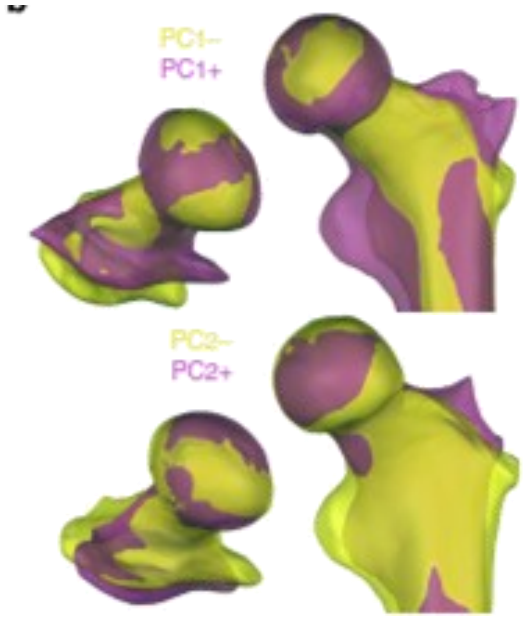
Like the other early hominins' femurs (C to F), Orrorin is different from modern human and great apes with a long and narrow femoral neck and a wide proximal diaphysis.

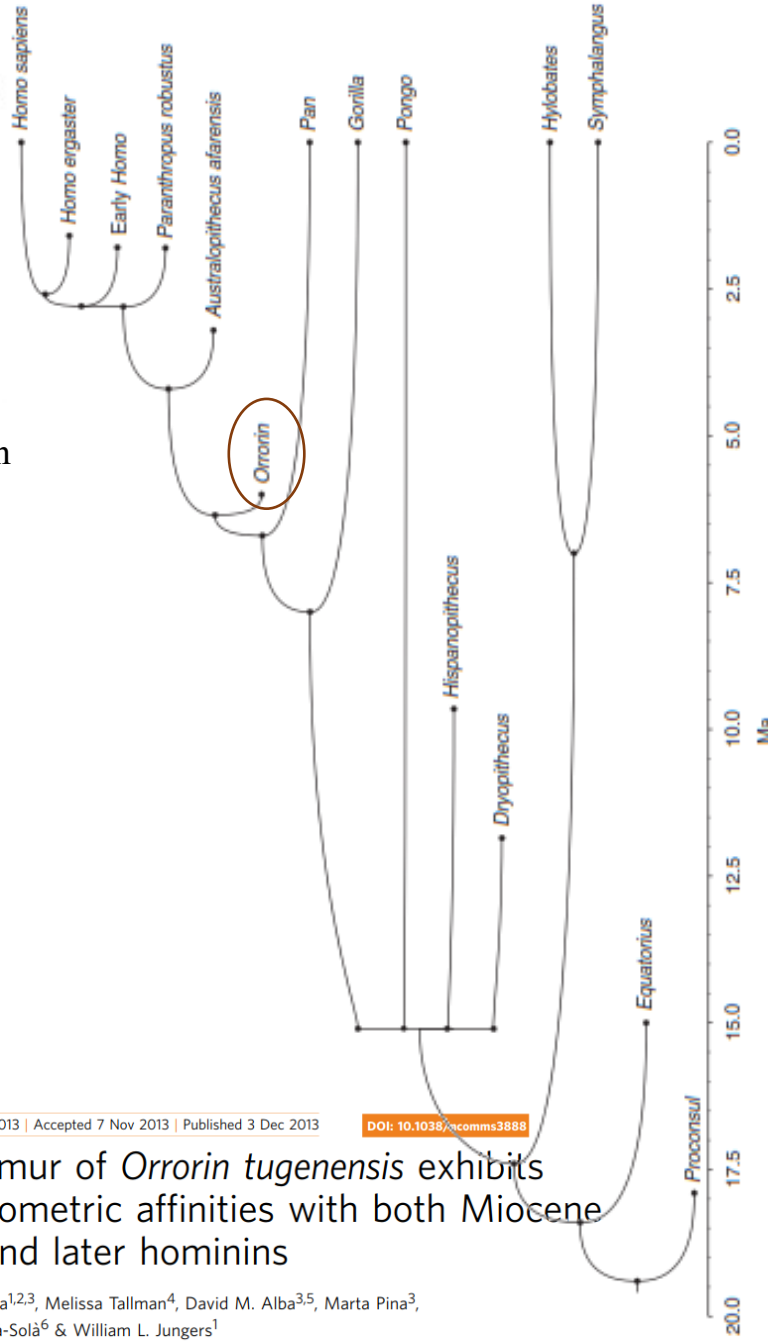
Come gli altri femore dei primi ominini (C a F), *Orrorin* si distingue dei umani moderni e delle grande scimmie con un collo femorale lungo e stretto e una diafisi prossimale larga.



The arrows indicate a laterally protruding gluteal tuberosity, observed in Hylobates, Miocene hominoids, as well as in *Orrorin* and *Ardipithecus ramidus*







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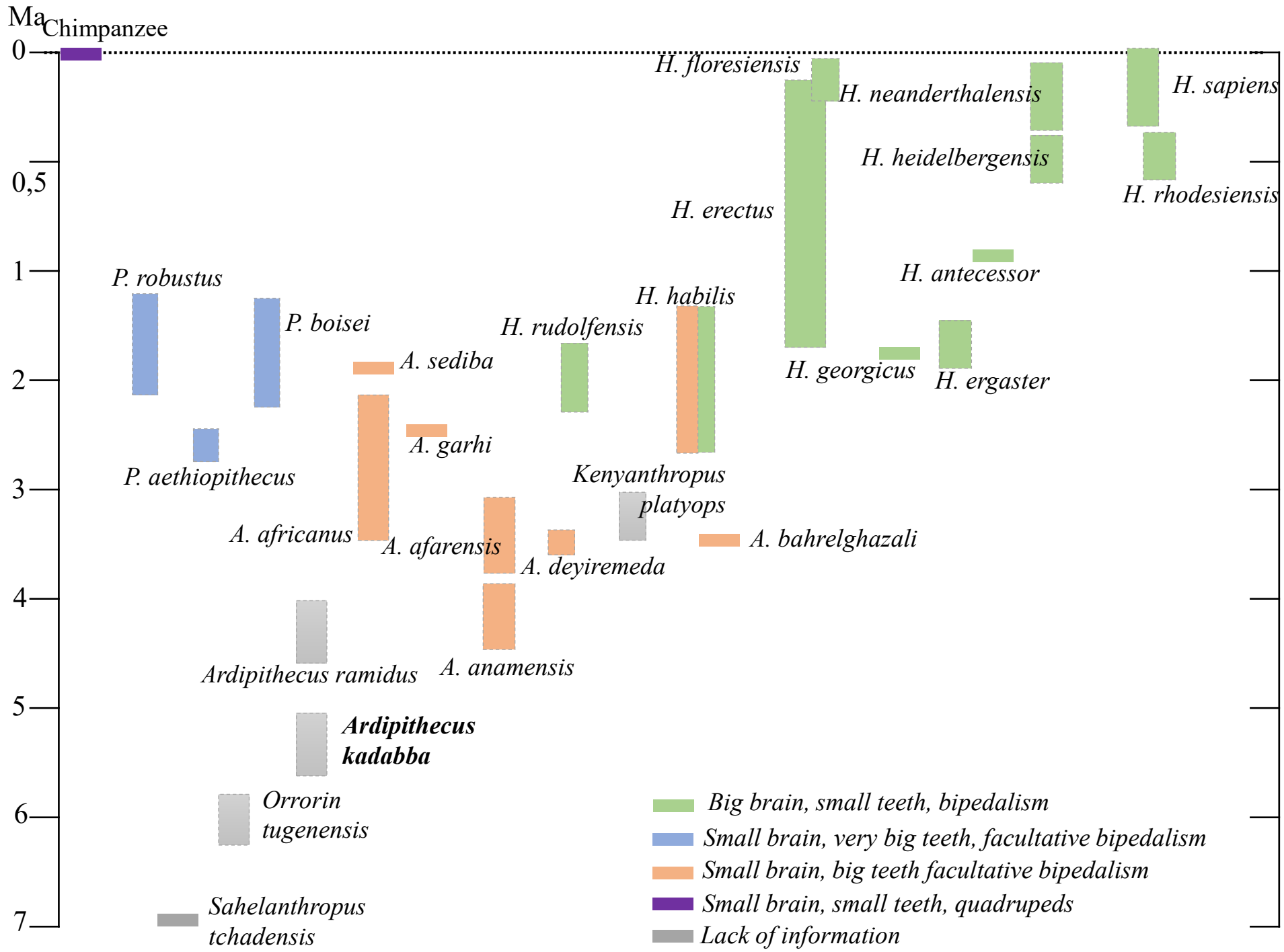
The femur of *Orrorin tugenensis* exhibits morphometric affinities with both Miocene apes and later hominins

Sergio Almécija[1,2,3], Melissa Tallman[4], David M. Alba[3,5], Marta Pina[3], Salvador Moyà-Solà[6] & William L. Jungers[1]


Ma
Chimpanzee
0
0,5
1
2
3
4
5
6
7
H. floresiensis
H. neanderthalensis
H. sapiens
H. heidelbergensis
H. rhodesiensis
H. erectus
H. antecessor
P. robustus
H. habilis
P. boisei
H. rudolfensis
A. sediba
H. georgicus
H. ergaster
A. garhi
P. aethiopithecus
Kenyanthropus platyops
A. africanus
A. afarensis
A. bahrelghazali
A. deyiremeda
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Ardipithecus ramidus
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Orrorin tugenensis
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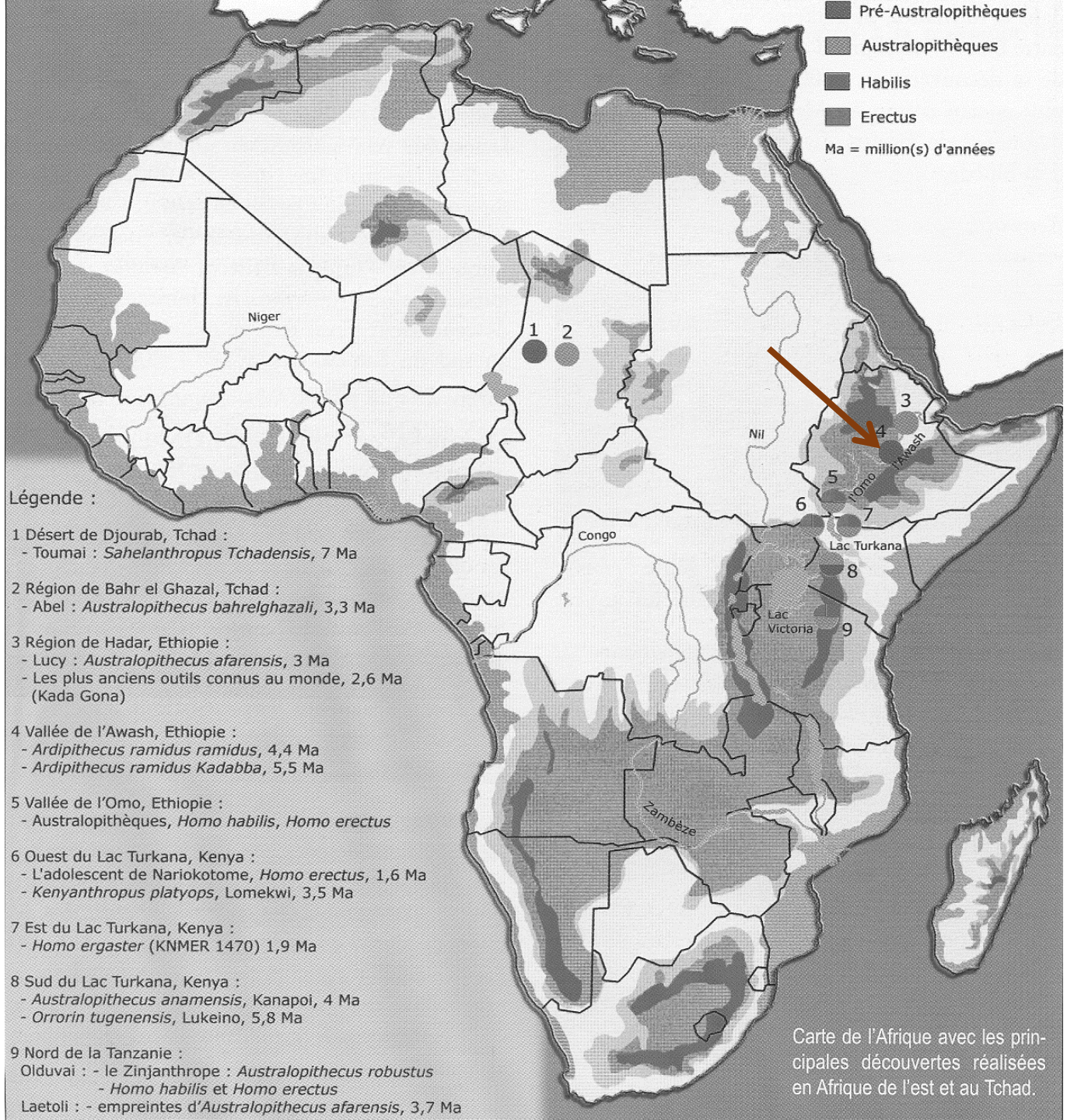
Big brain, small teeth, bipedalism
Small brain, very big teeth, facultative bipedalism
Small brain, big teeth facultative bipedalism
Small brain, small teeth, quadrupeds
Lack of information

Ardipithecus kadabba



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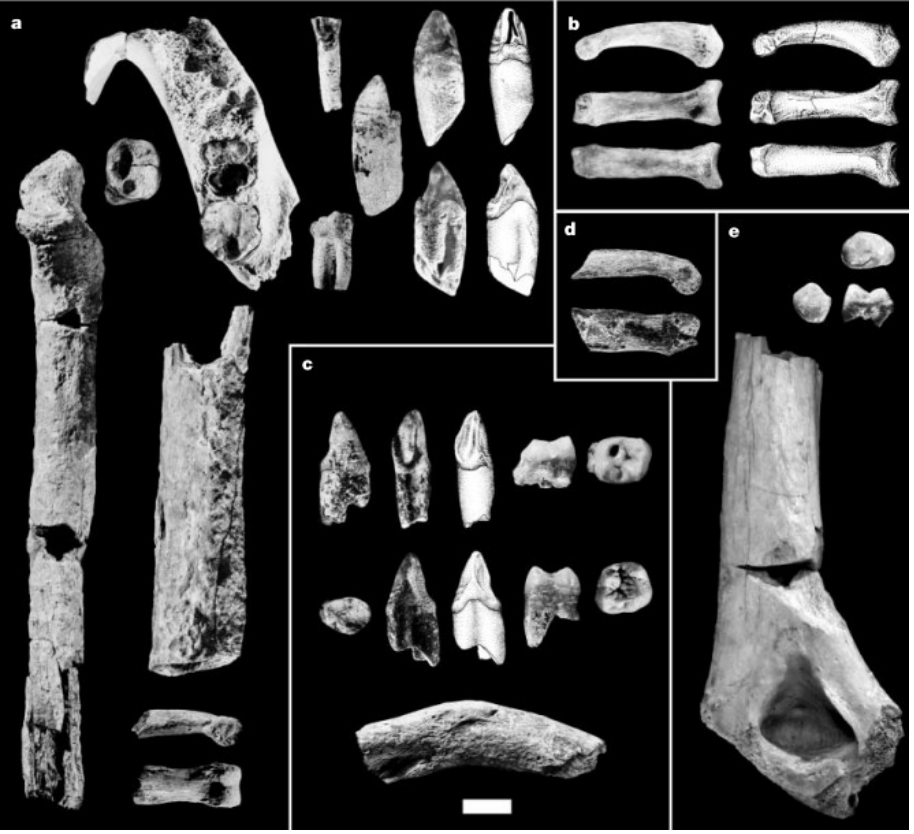


Discovery: Aramis area, Awash valley, Ethiopia
Fossils:

- Jaw fragment (a)
- Fragment of ulna and humerus (a)
- Clavicle fragment (c)
- Foot and hand phalanx (b,d)
- 11 isolated teeth (a,c,e)
- 4 post-cranial fragments

Age: 5,8 – 5,2 Ma

Late Miocene hominids from the Middle Awash, Ethiopia

Yohannes Haile-Selassie

Department of Integrative Biology and Laboratory for Human Evolutionary Studies, Museum of Vertebrate Zoology, 3060 VLSB, University of California, Berkeley, California 94720, USA

Molecular studies suggest that the lineages leading to humans and chimpanzees diverged approximately 6.5–5.5 million years (Myr) ago, in the Late Miocene[1–3]. Hominid fossils from this interval, however, are fragmentary and of uncertain phylogenetic status, age, or both[4–6]. Here I report new hominid specimens from the Middle Awash area of Ethiopia that date to 5.2–5.8 Myr and are associated with a wooded palaeoenvironment[7]. These Late Miocene fossils are assigned to the hominid genus *Ardipithecus* and represent the earliest definitive evidence of the hominid clade. Derived dental characters are shared exclusively with all younger hominids. This indicates that the fossils probably represent a hominid taxon that postdated the divergence of lineages leading to modern chimpanzees and humans. However, the persistence of primitive dental and postcranial characters in these new fossils indicates that *Ardipithecus* was phylogenetically close to the common ancestor of chimpanzees and humans. These new findings raise additional questions about the claimed hominid status of *Orrorin tugenensis*[8], recently described from Kenya and dated to ~6 Myr[9].

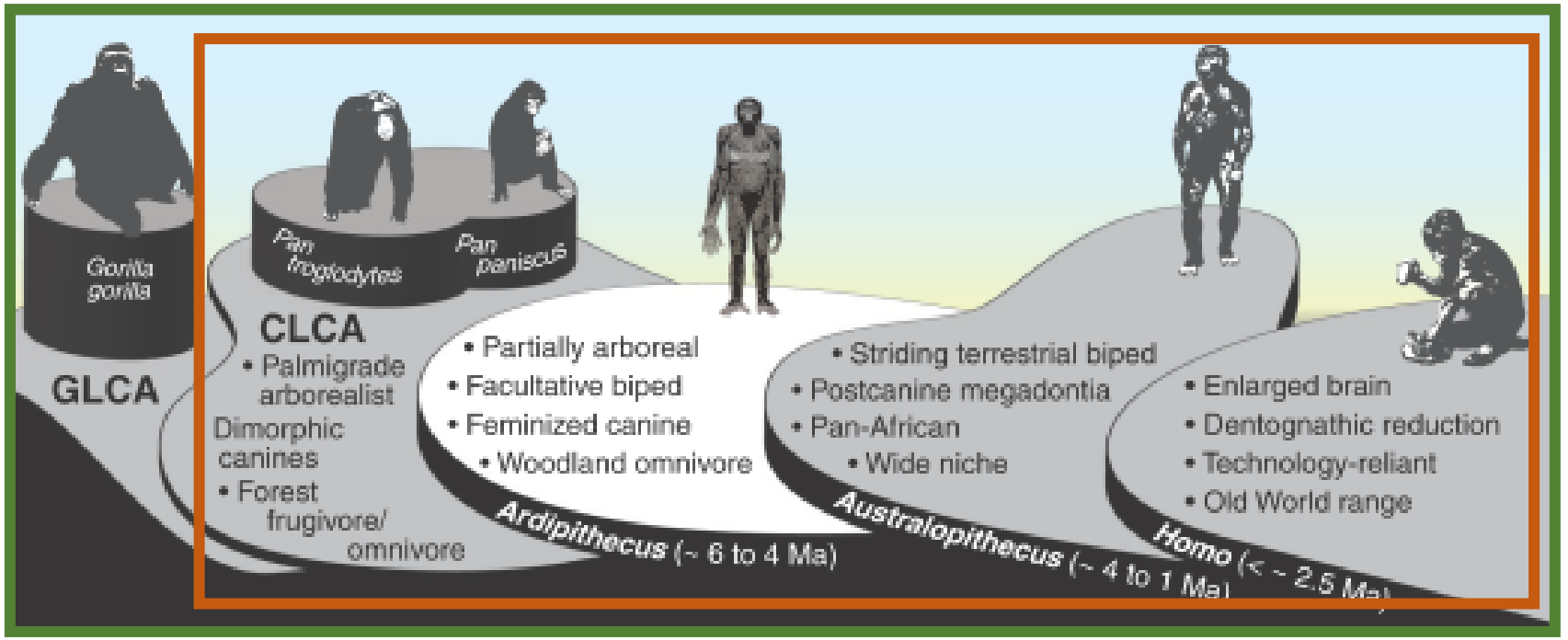
(Nature 412, 2001)

Ardipithecus ramidus kadabba

Ardipithecus kadabba

Canines are tendenzialy incisoforme
Post-cranial elements similar to great apes: adaptation to arboreal locomotion
Differences between *Ar. kadabba* e *Ar. ramidus* in teeth roots

Homininae Hominini



Evolution of hominids and African apes since the gorilla/chimp+human (GLCA) and chimp/human (CLCA) last common ancestors. Pedestals on the left show separate lineages leading to the extant apes (gorilla, and chimp and bonobo); text indicates key differences among adaptive plateaus occupied by the three hominid genera.

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Ardipithecus ramidus and the Paleobiology of Early Hominids

Tim D. White,[1]* Berhane Asfaw,[2] Yonas Beyene,[3] Yohannes Haile-Selassie,[4] C. Owen Lovejoy,[5] Gen Suwa,[6] Giday WoldeGabriel[7]

Fig. 1. Geography and stratigraphy of the Aramis region. Two dated volcanic horizons constrain the main *Ardipithecus*-bearing stratigraphic interval in the Aramis region. The top frame shows these tephra in situ near the eastern end of the 9-km outcrop. The dark stripe in the background is the riverine forest of the modern Awash River running from right to left, south to north, through the Middle Awash study area of the Afar Rift. The lower frames are contemporaneous helicopter views over ARA-VP-1 (Yonas Molar Site) to show the geographic position of the top photo and to depict the extensive outcrop of the upper tuff horizon (dotted lines show the DABT) across the local landscape. Vehicles are in the same position to provide orientation. Sediments outcropping immediately below this 4.4-million-year-old horizon yielded the floral, faunal, and isotopic contexts for *Ar. ramidus*. The frame to the left shows the slight eastward dip of the Sagantole Formation toward the modern Awash River. The contiguous frame to the right is a view up the modern upper Aramis catchment. The ARA-VP-6 locality where the partial *Ardipithecus* skeleton was excavated is near its top right corner (Fig. 2).

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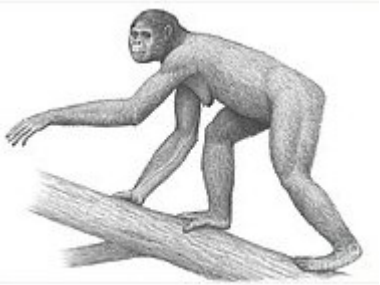
Età: 4.4 Ma



-110 resti ritrovati
- 50 kg , 120 cm di altezza
- Piccole differenze nella taglia corporea tra maschio e femmina
Little body size difference between males and females
- Capacità cranica / *Brain size* = chimpanzees
- Faccia piccola e canini/premolari ridotti (riduzione delle competizione sociali)
Small face and reduced canine/premolar complex (minimal social agression)
- Nessuna sospensione, o knuckle-walking ma una bipedia più primitiva che i Australopitecini
No suspension, vertical climbing of knuckle-walking but more primitive bipedy than Australopithecus
- Riduzione dello spessore delle smalto in confronto a *Australopithecus*
Reduced thickness of the enamel compared to Australopithecus

Ar. Ramidus indica che gli ultimi antenati comuni tra i umani e le scimmie africane non erano «chimpanzee-like» e che gli ominidi e le scimmie africani estinti sono fortemente specializzati, ma attraverso un cammino evolutive molto diverso.

Ar. ramidus *thus indicates that the last common ancestors of human and African apes were not chimpanzee-like and that both hominids and extant African apes are each highly specialized, but through very different evolutionary pathways.*

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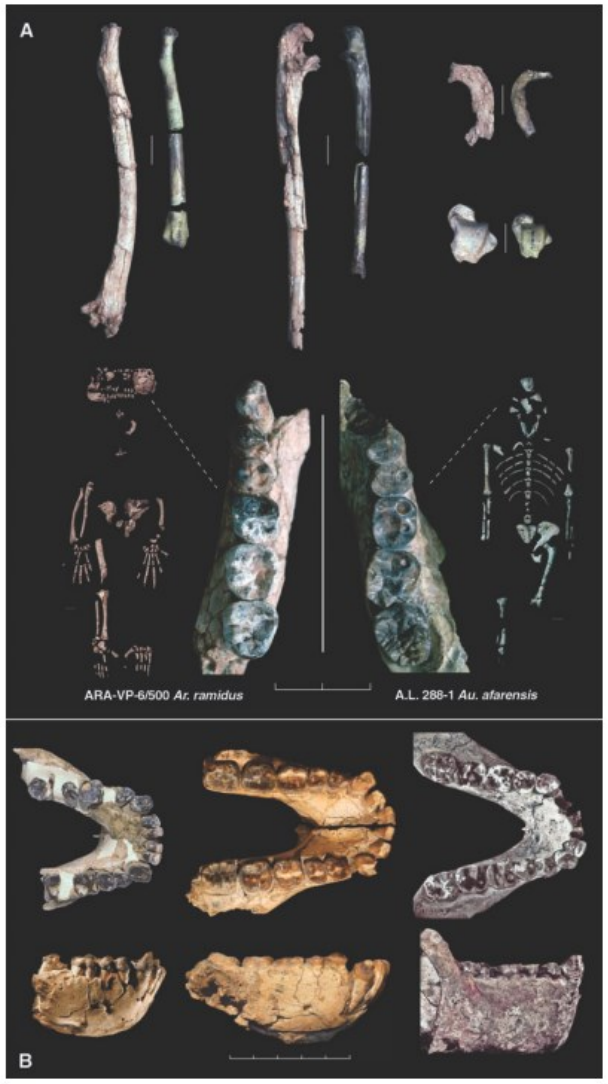


AR A-VP-6/500

KNM-KP 29281 *Au. Anamensis* 4,12 Ma

MAK-VP-1/12 *Au. Afarensis* 3,4 Ma

I scheletri dimostrano delle dimensioni postcraniali importanti relativamente alle dimensione dentarie

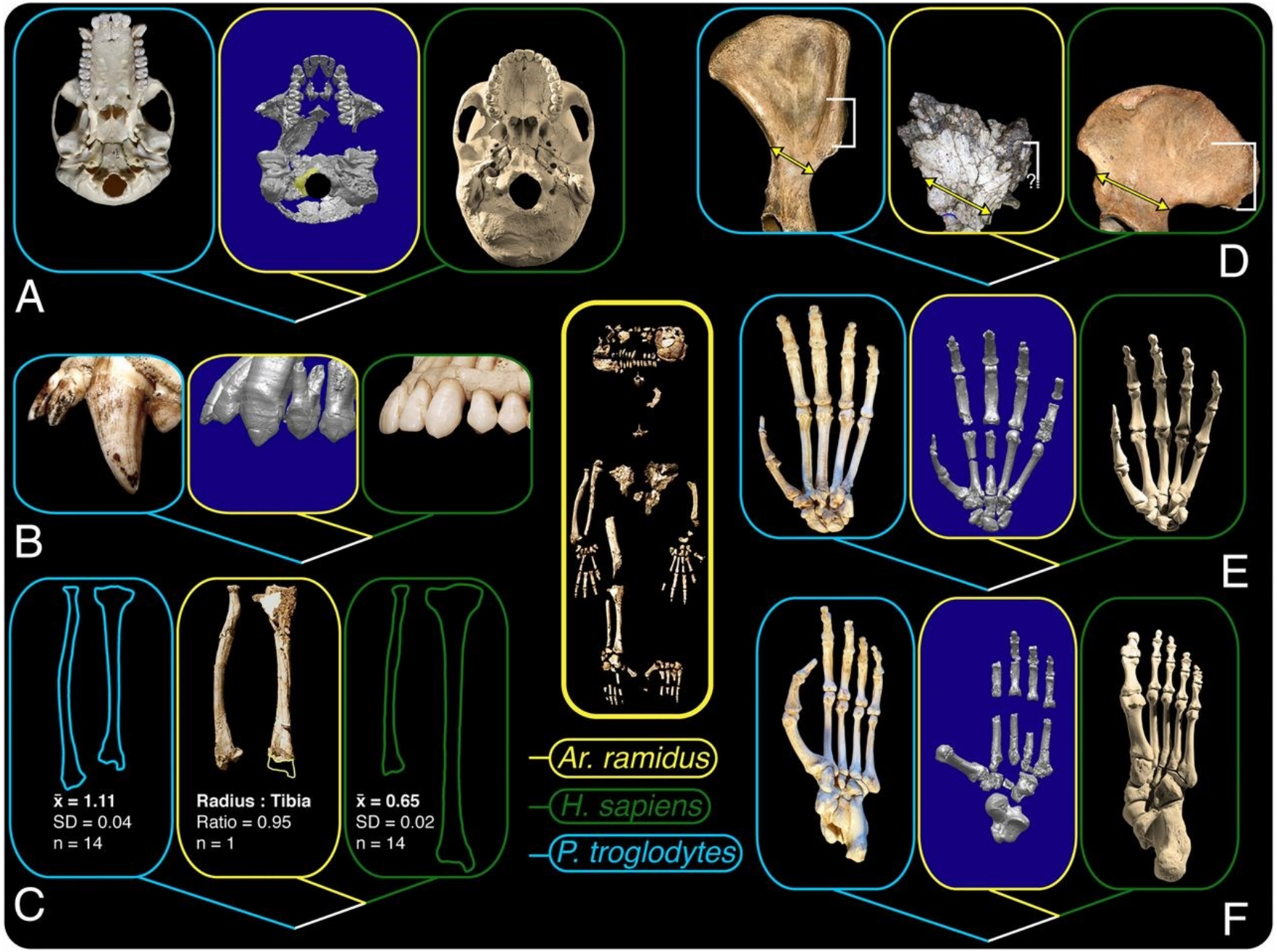
Skeletal individuals illustrate larger postcranial dimensions for the Ardipithecus *individual relative to dental size.*

Confronti tra dimensioni dentarie post canini rivelano la megadontia dei *Autralopitecini.*

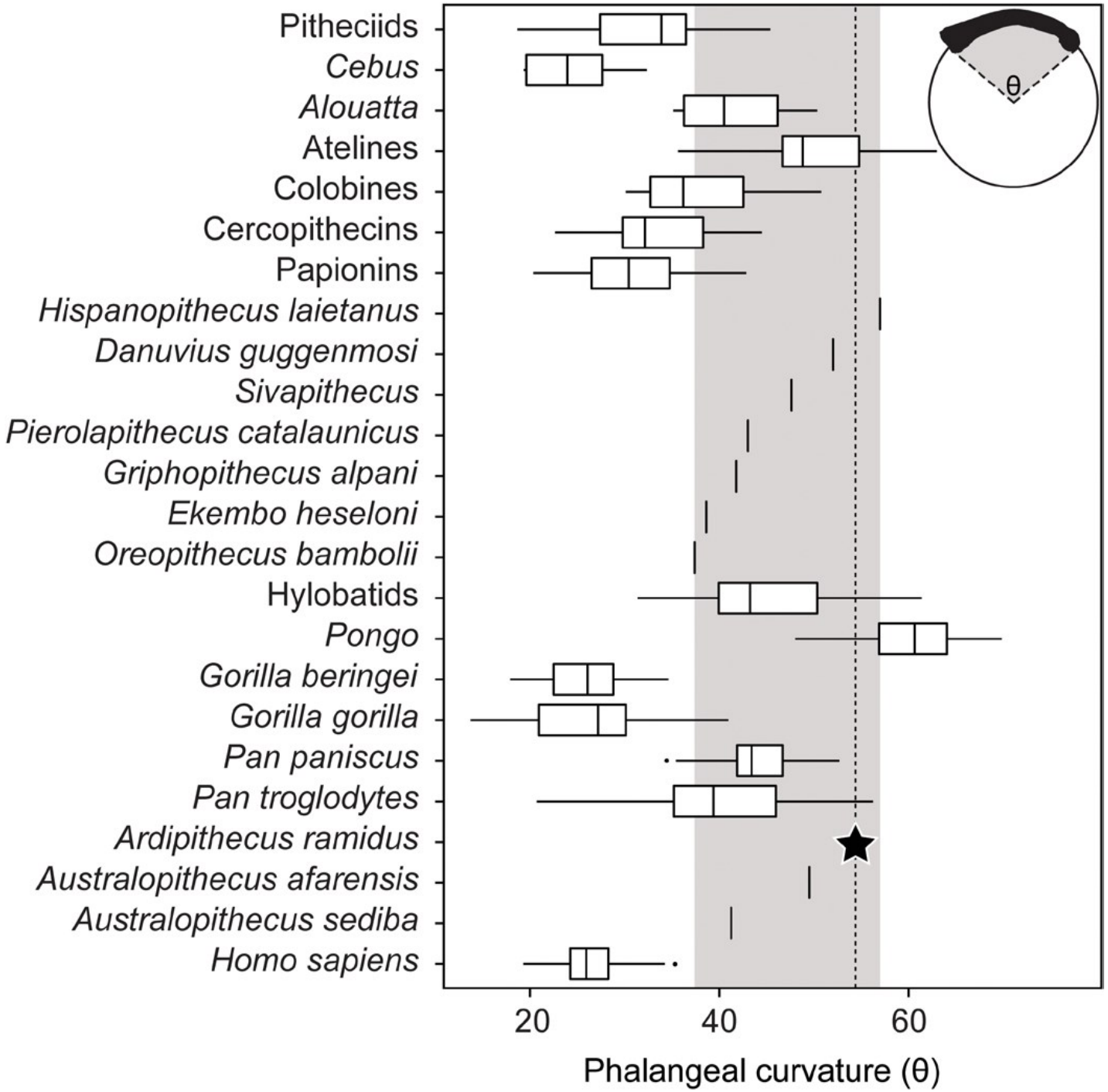
Comparison of the postcanine dentitions reveals the megadontia of the Australopithecus *individual*

Fig. 3. The *ARA-VP-6/500* skeleton. This is a composite photograph to show the approximate placement of elements recovered. Some pieces found separately in the excavation are rejoined here. Intermediate and terminal phalanges are only provisionally allocated to position and side.

Evolution in different directions.

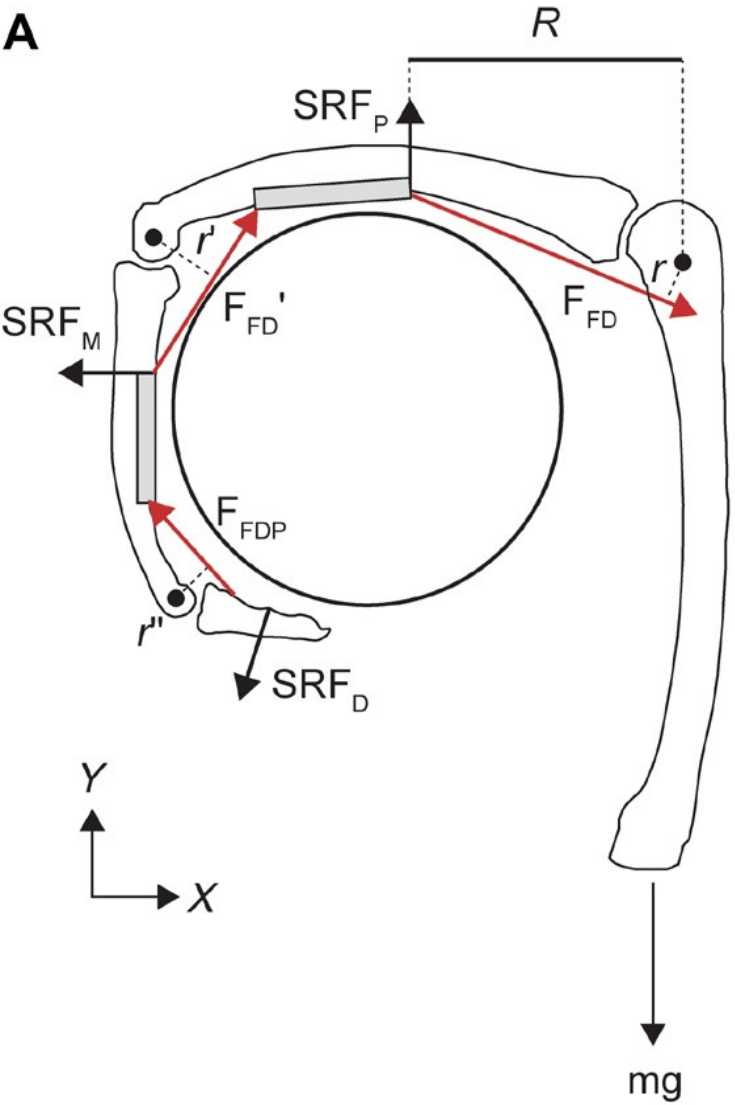


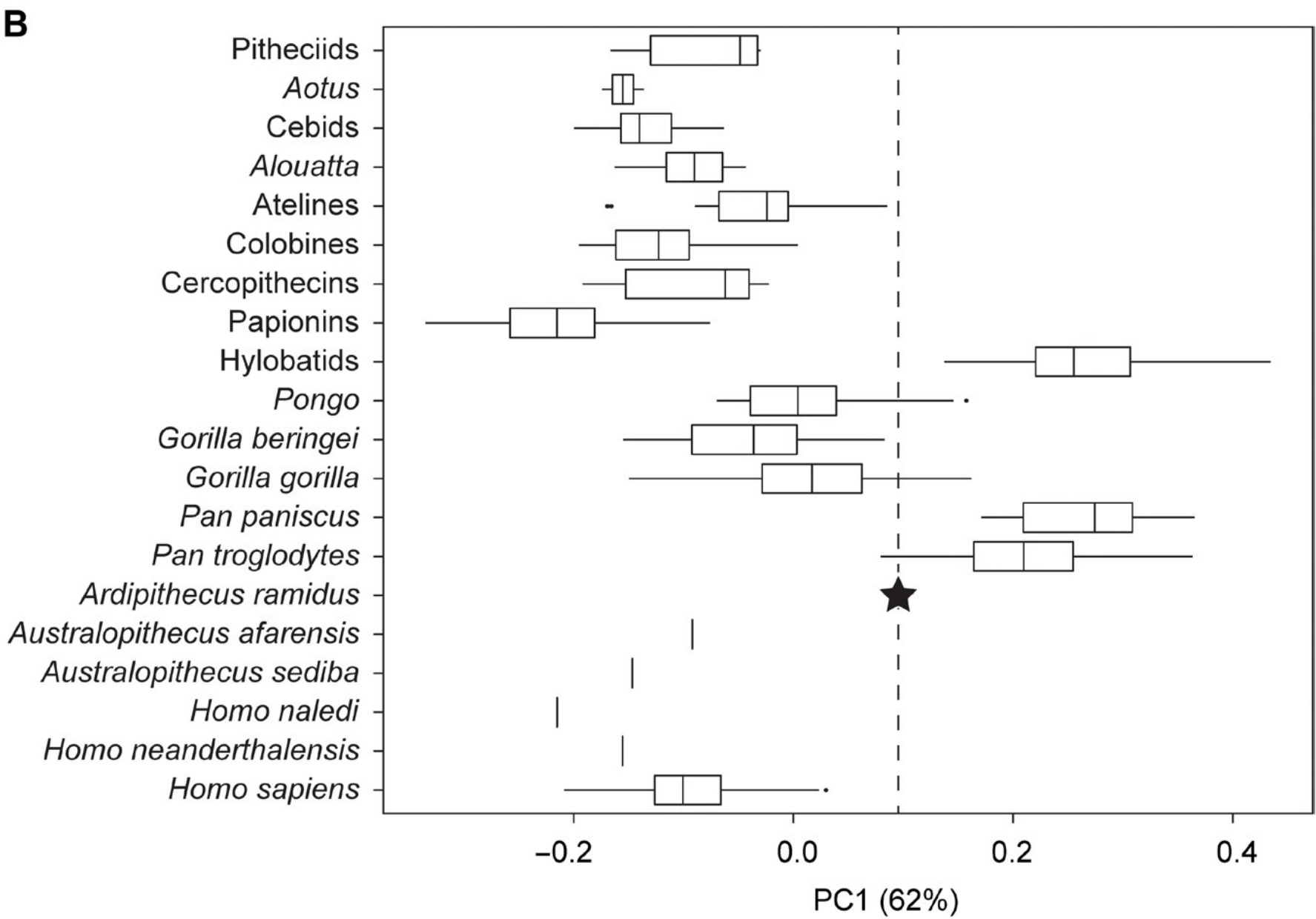
Tim D. White et al. PNAS 2015;112:4877-4884



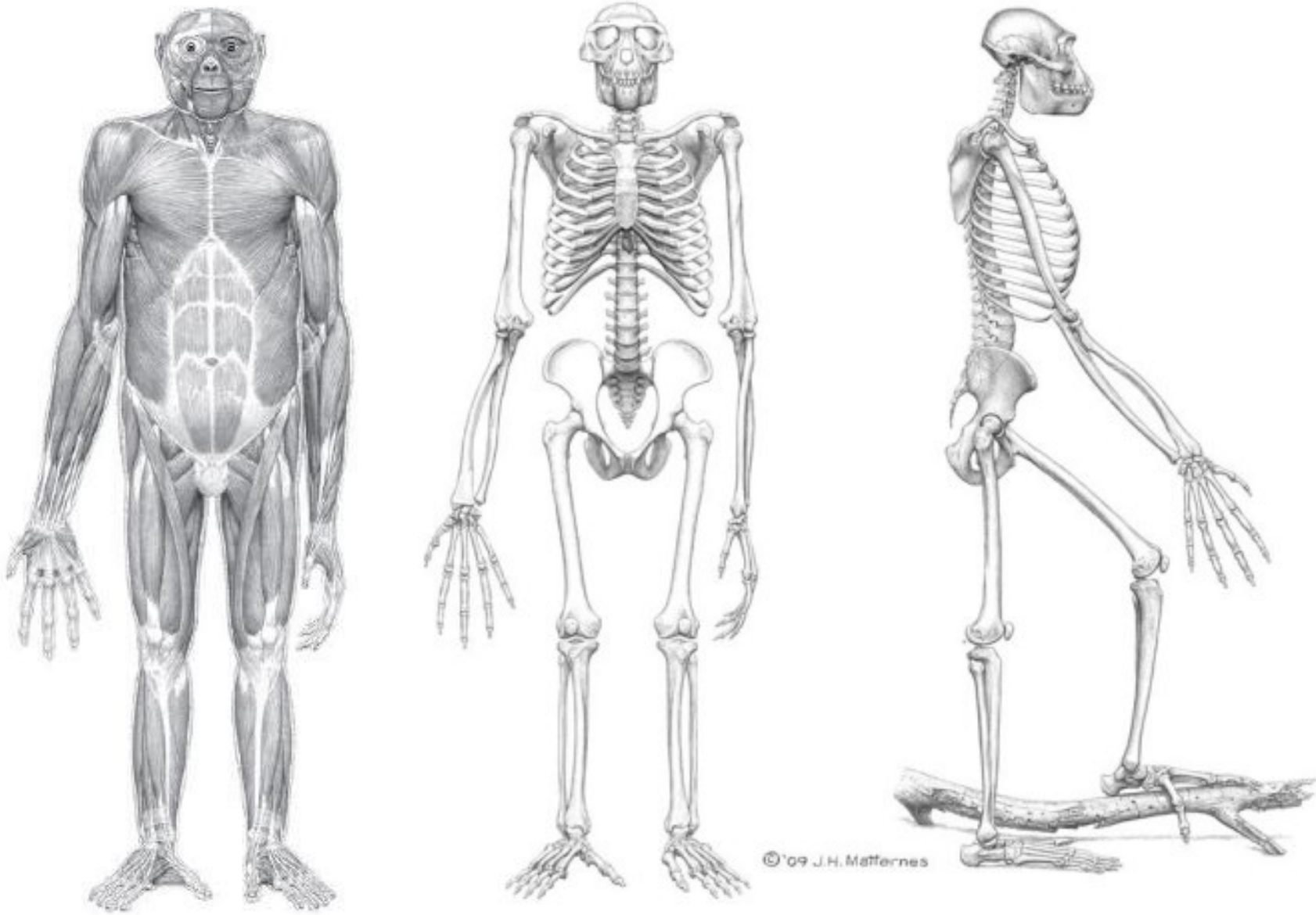
Proximal phalangeal curvature in anthropoid primates. The gray bar indicates the range of variation among the Miocene fossil hominoids included here. The curvature of the *Ar. ramidus* PP3 falls within the ranges of variation of *P. troglodytes*, *Pongo*, hylobatids, and atelines; between the highly suspensory Miocene hominoids *Danuvius* and *Hispanopithecus*; and above the ranges of variation of all other taxa.

(Prang et al. 2021)





Metacarpophalangeal and interphalangeal joint shape contributes to suspensory performance.


©'09 J.H. Matternes

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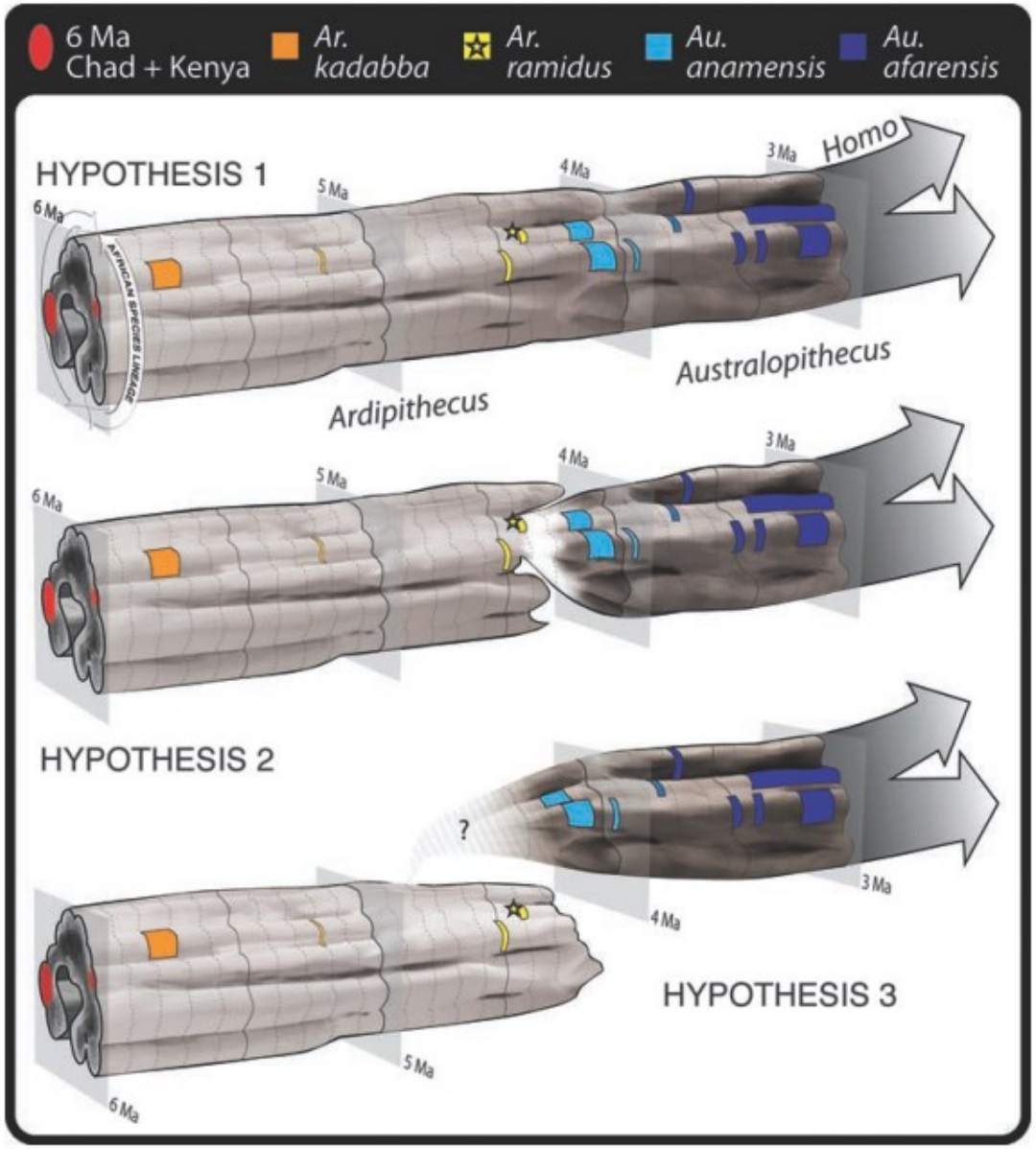

1 ipotesi: tutte le evidenze conosciute rappresentano un unica linea evolutiva

2 ipotesi; raffigura la stessa evidenza di una transizione diretta tra *Ardipithecus* e *Australopithecus* (speciazione) accaduta tra 4,5 e 4,2 Ma in un gruppo di popolazione regionale (o locale) che potrebbe avere incluso I rift dell'Afar e Turkana.

3 ipotesi: consente una speciazione allopatrica (cladogenesi attraverso una microevoluzione accumulata in una popolazione periferica isolata che è diventata separata al livello riproduttivo.

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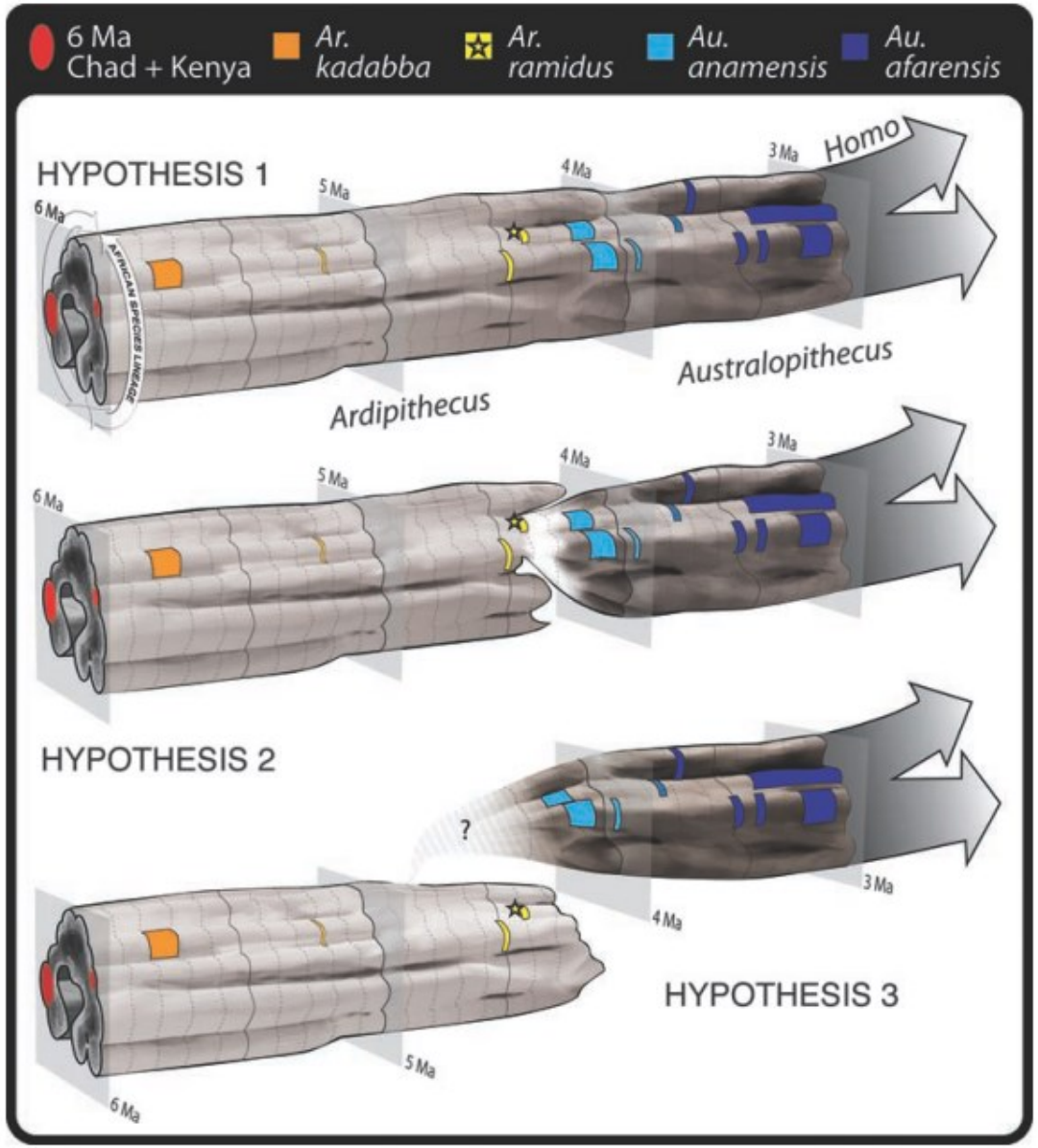
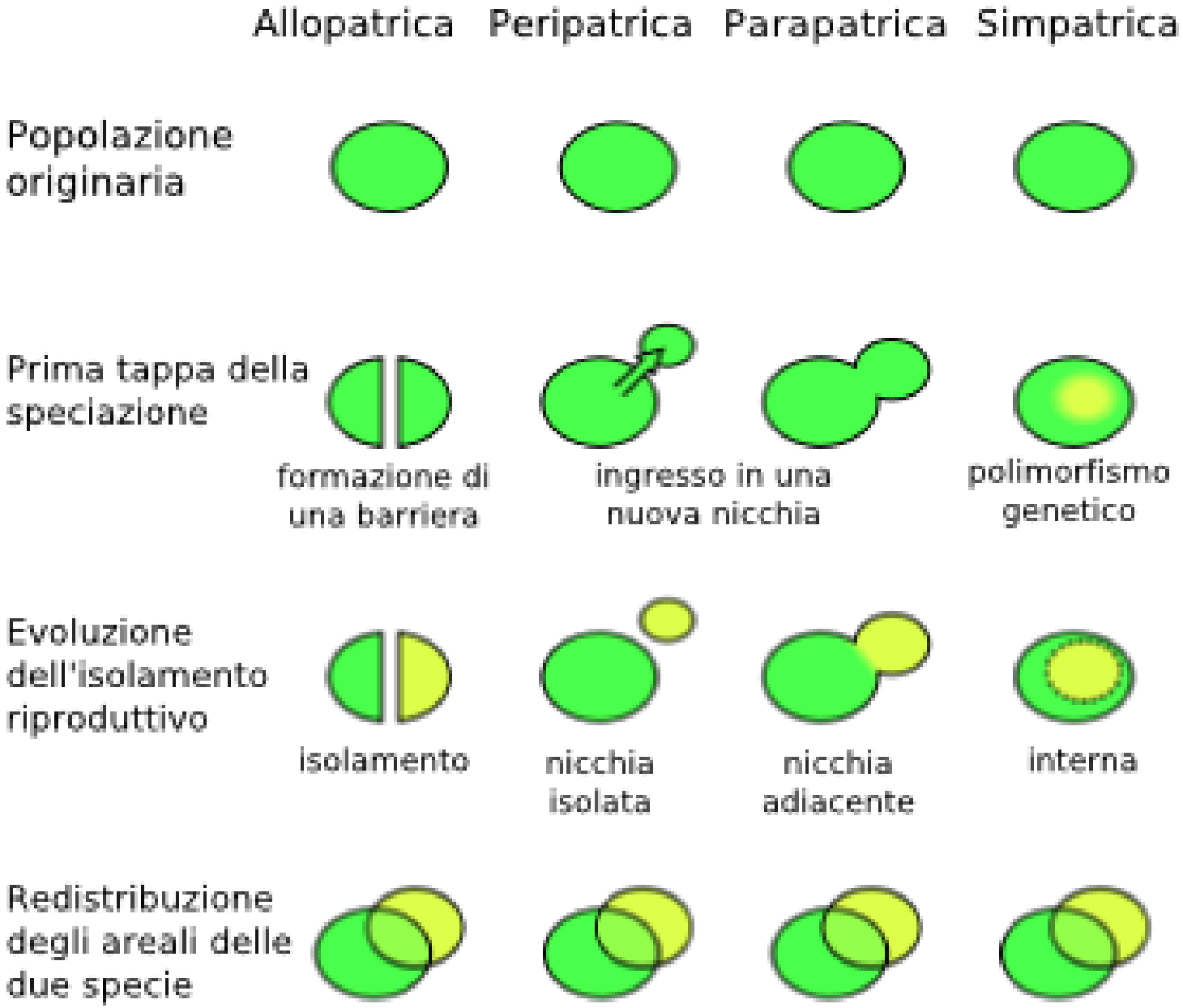


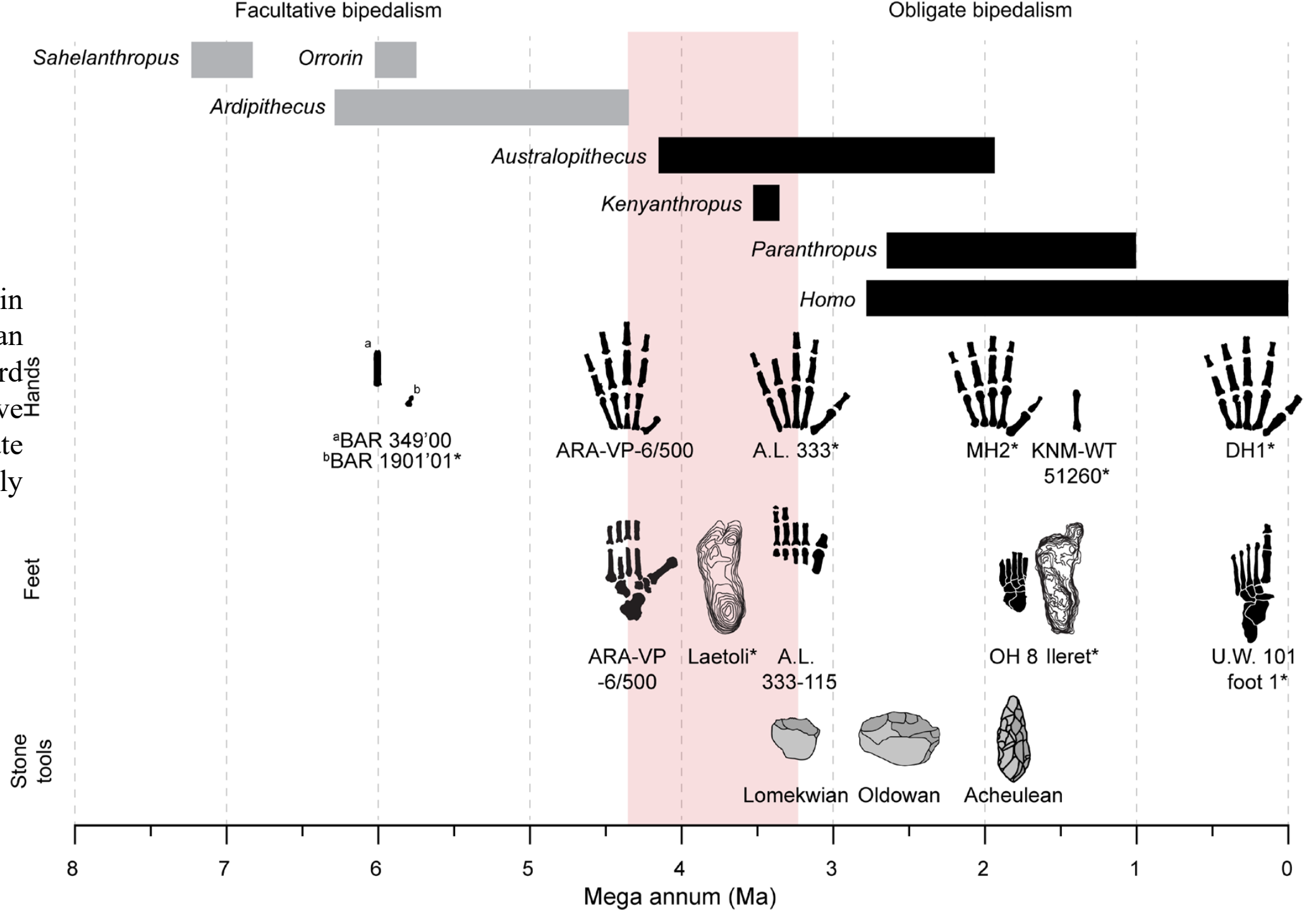
Hypothesis 1: interprets all known evidence to represent a species lineage evolving phyletically across its entire range.

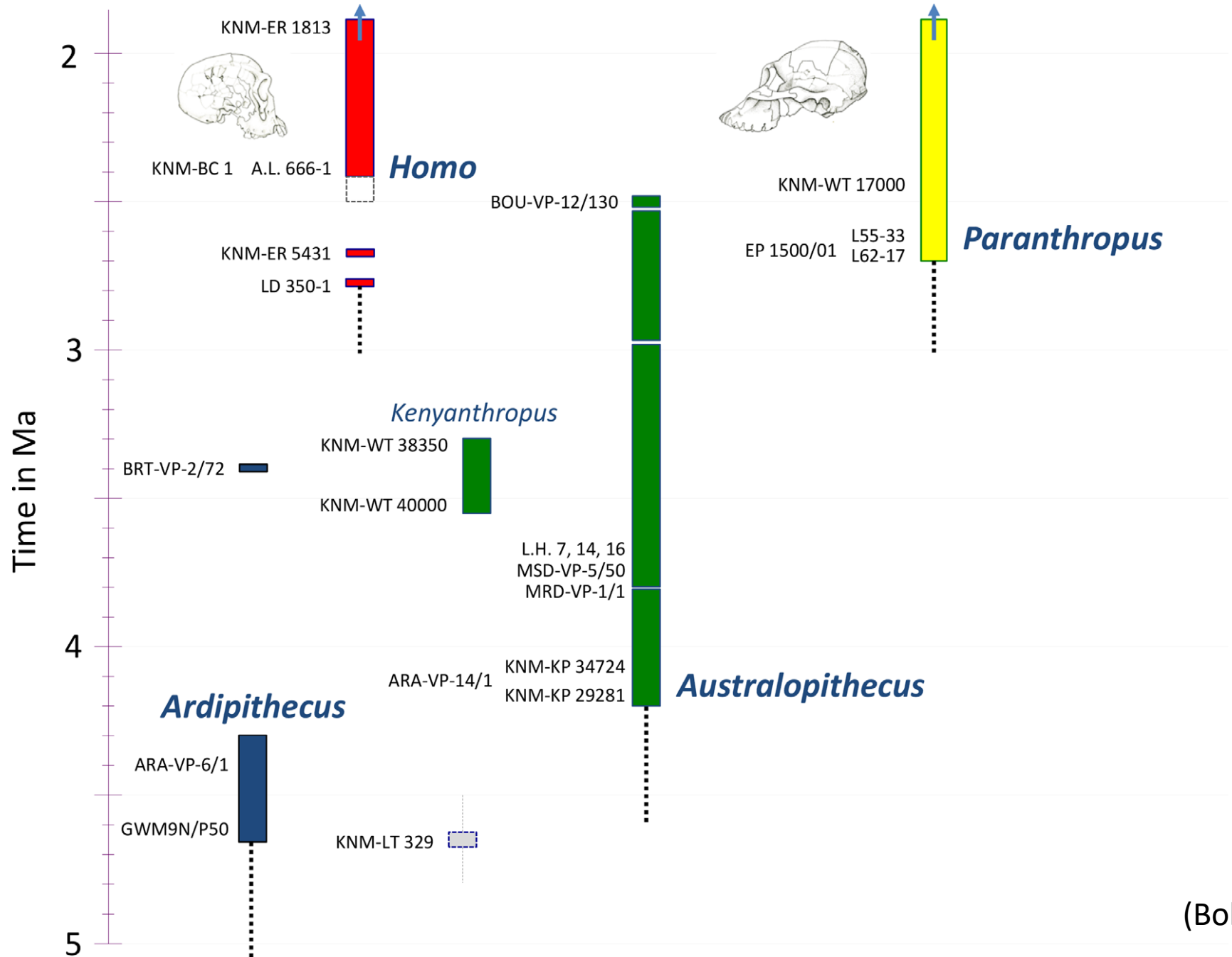
Hypothesis 2: depicts the same evidence in an Ardipithecus-to- Australopithecus transition (speciation) occurring between ~4.5 and ~4.2 Ma in a regional (or local) group of populations that might have included either or both the Afar and Turkana rifts.

Hypothesis 3: accommodates the same evidence to an alternative, much earlier peripheral allopatric "rectangular" speciation model (cladogenesis through microevolution accumulated in a peripheral isolate population, becoming reproductively separated).


Allopatrica
Peripatrica
Parapatrica
Simpatrica
Popolazione originaria
Prima tappa della speciazione
formazione di una barriera
ingresso in una nuova nicchia
polimorfismo genetico
Evoluzione dell'isolamento riproduttivo
isolamento
nicchia isolata
nicchia adiacente
interna
Redistribuzione degli areali delle due specie

The evolution of hominin hands and feet reflects an evolutionary shift toward enhanced manipulative capabilities and obligate bipedalism, respectively (Prang et al. 2021)





(Bobe and Wood, 2021)