The Australopithicines

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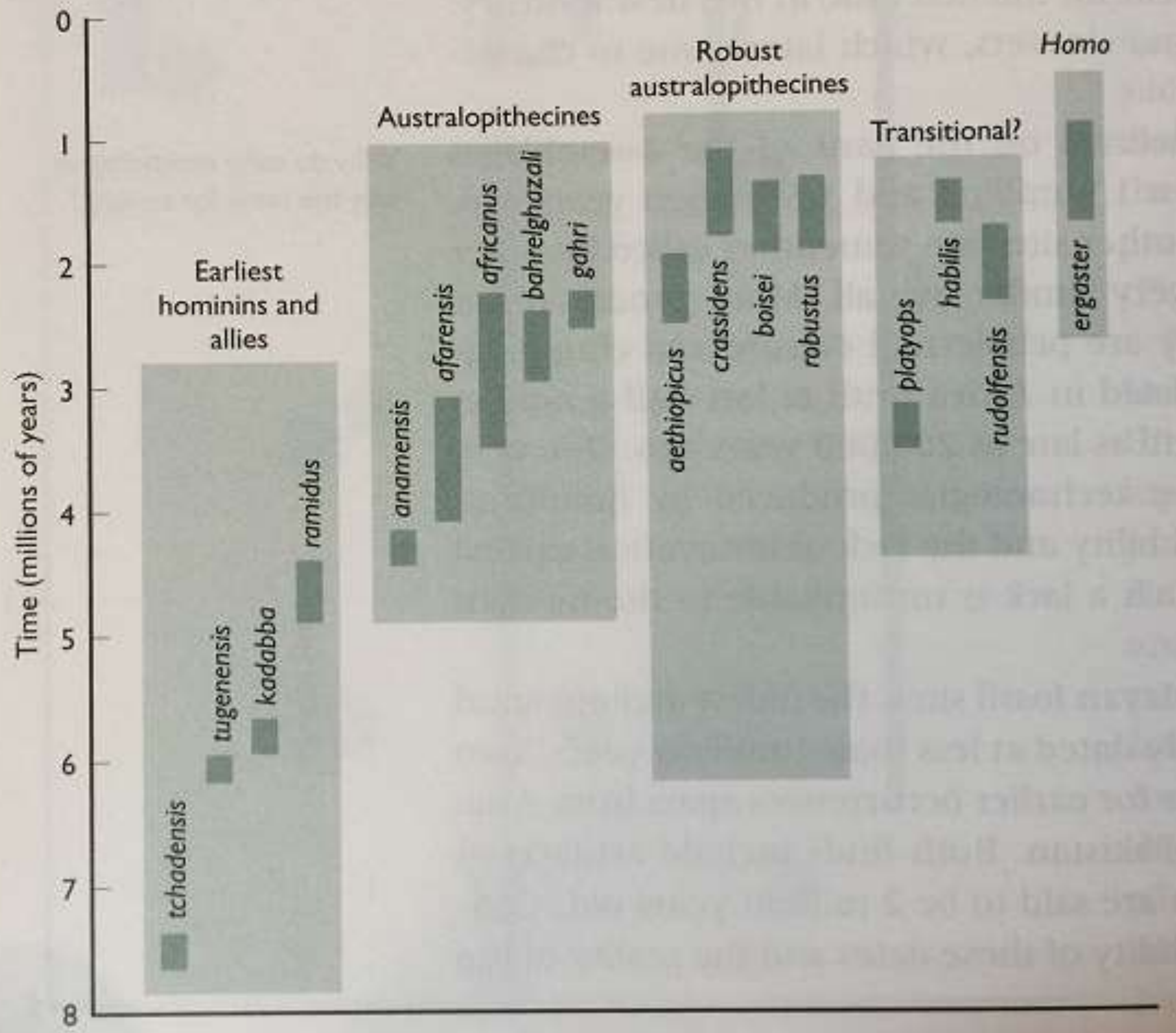
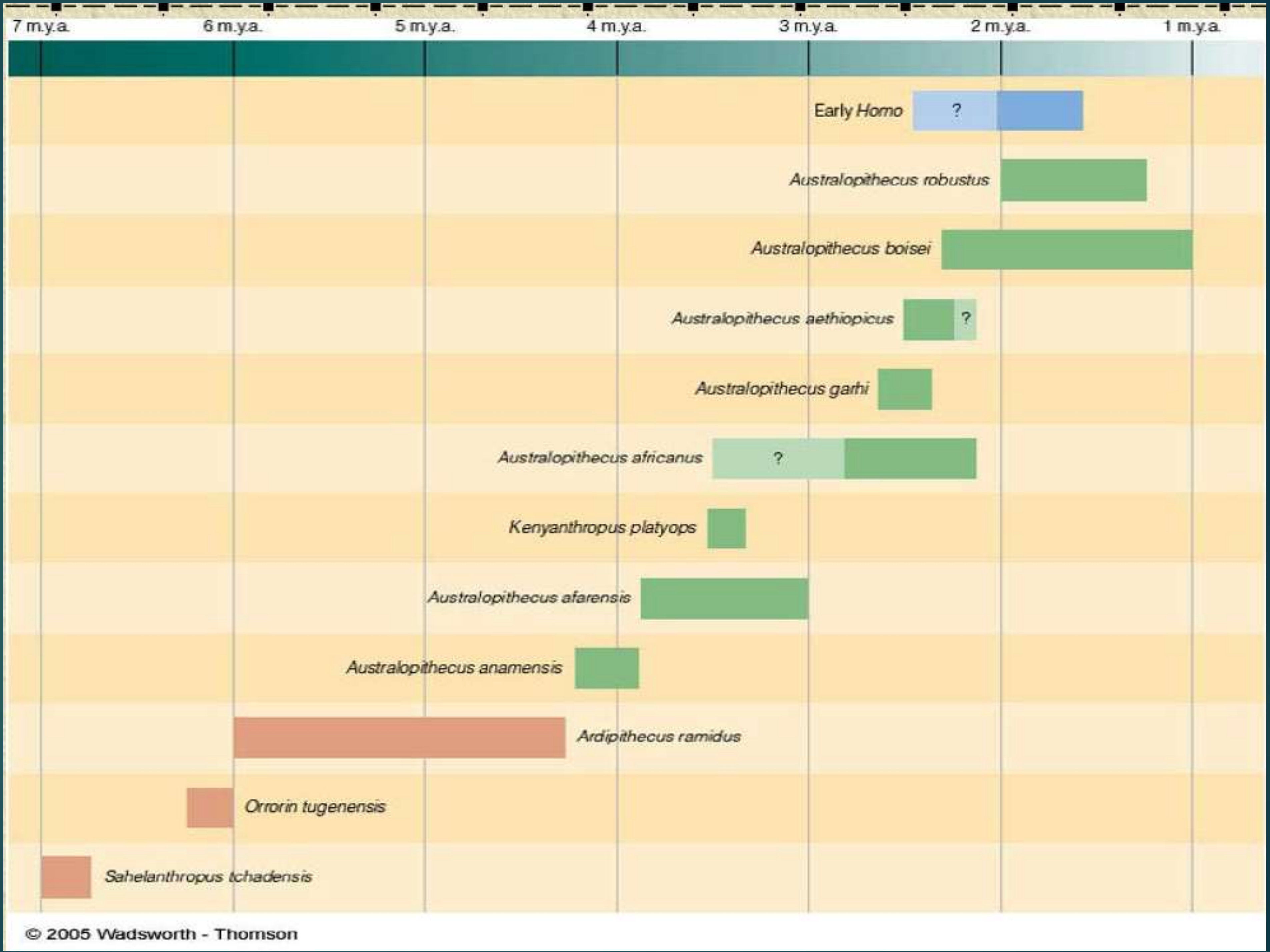
JULY 1, 2018



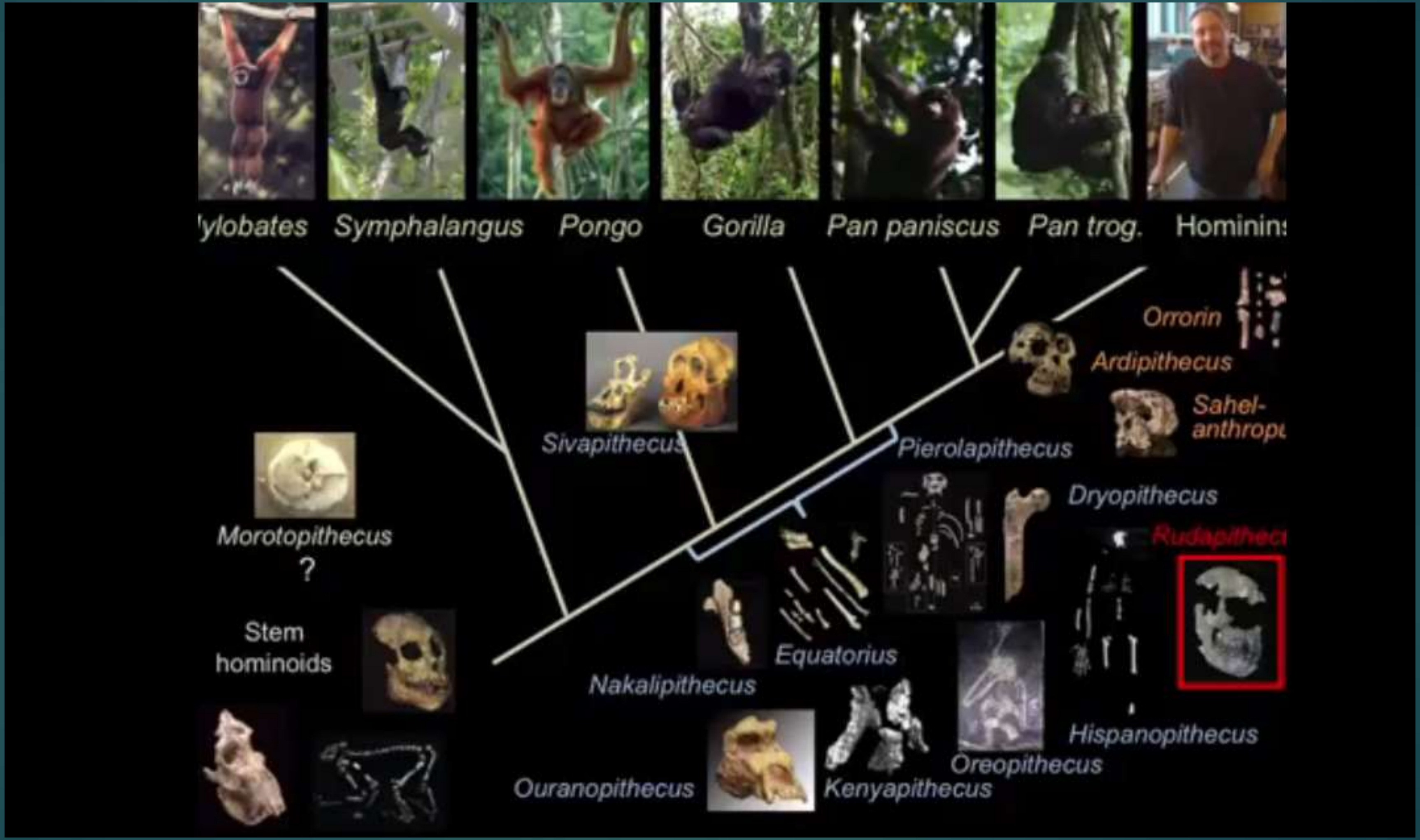
Time (millions of years)
0
1
2
3
4
5
6
7
8
Earliest hominins and allies
tchadensis
tugenensis
kadabba
ramidus
Australopithecines
anamensis
afarensis
africanus
bahrelghazali
gahri
Robust australopithecines
aethiopicus
crassidens
boisei
robustus
Transitional?
platyops
habilis
rudolfensis
Homo
ergaster

Pre-*Homo* Hominins

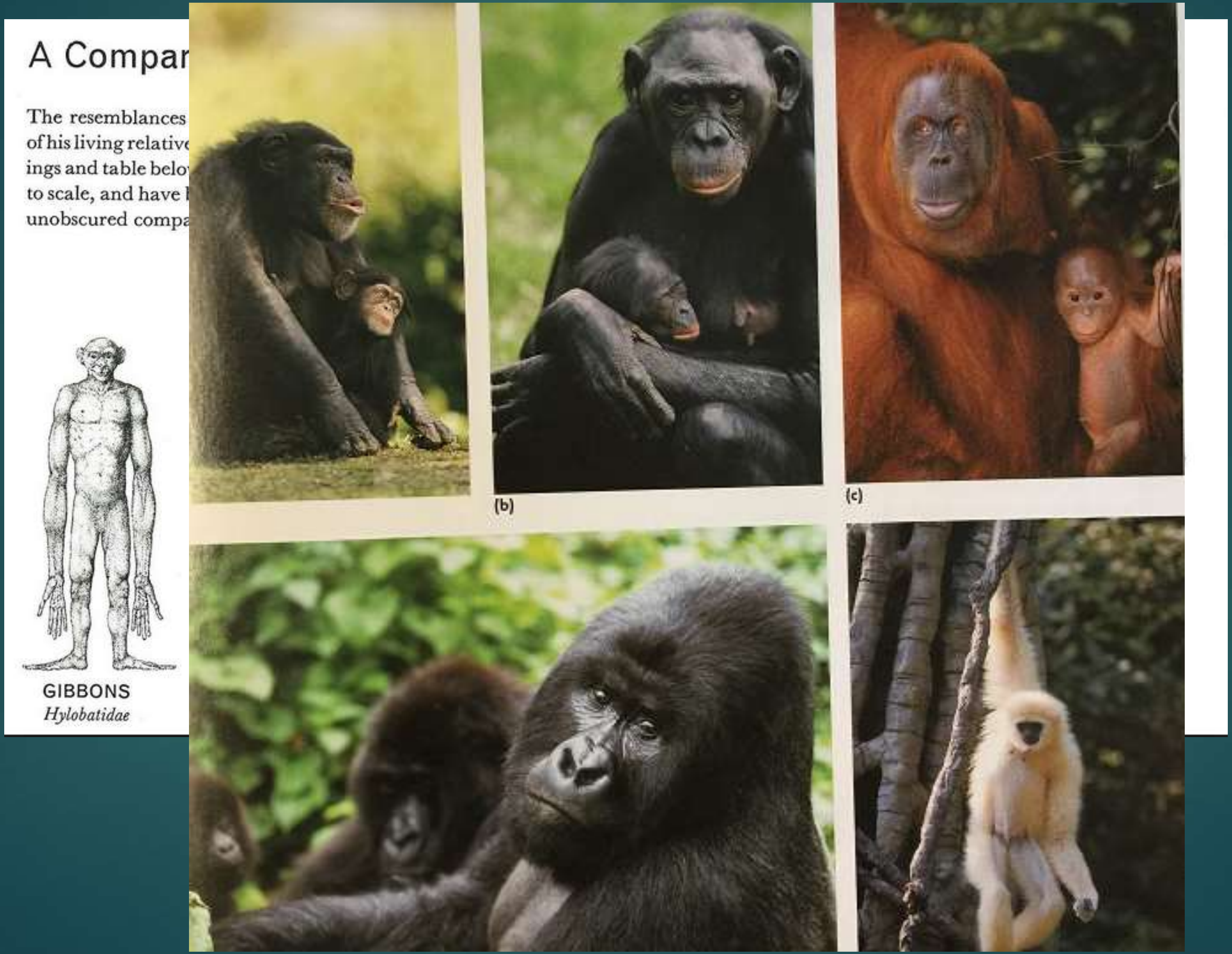


20 to 10 million years ago: 100s of great apes

Stem hominoids: many apes; eventually bipedal by 7 Ma; few moved exactly like modern apes

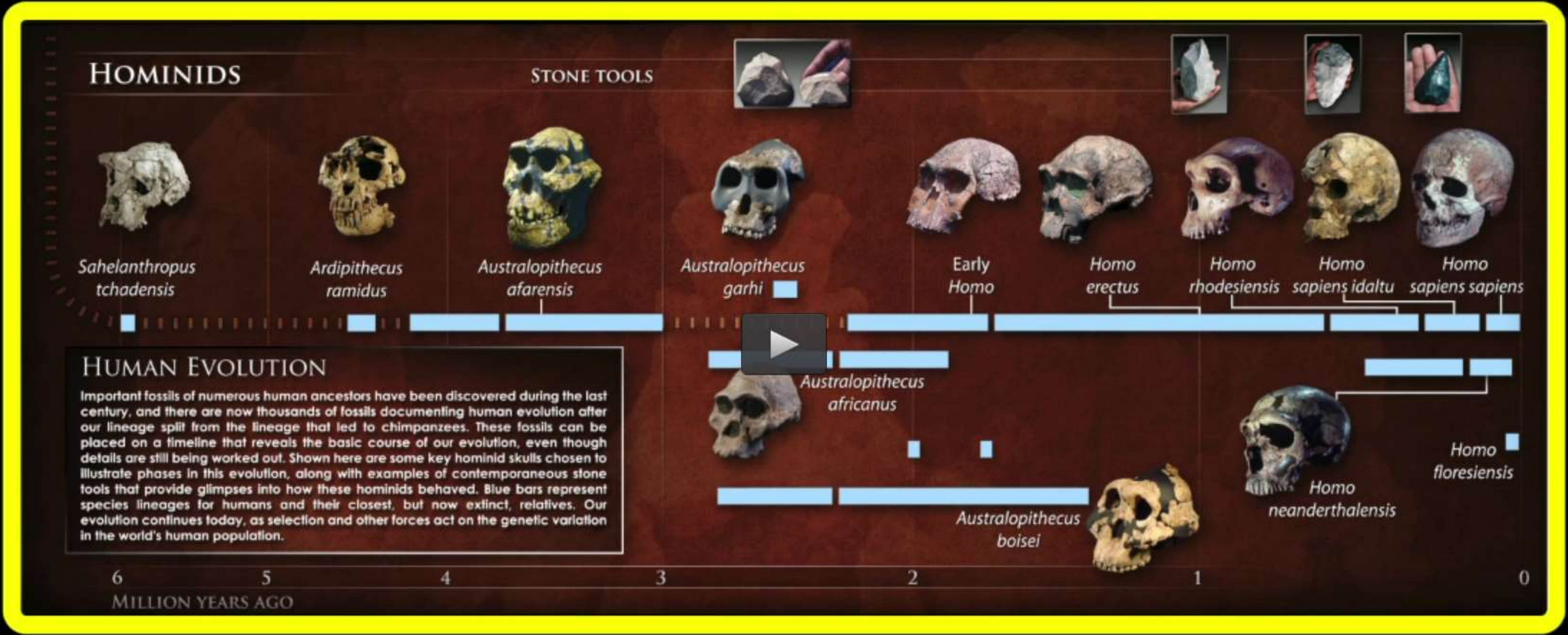


Current Great Apes



***H. sapiens*,**
A most bizarre <u>species</u>:

- Naked
- Bipedal
- Brainy
- Tiny faces & Canines
- Cultural
- No estrus
- Wide range, diet



The LAST Six Million Years of Human Evolution

Splitters & lumpers models of early hominin evolution

- Lumpers: only 3 possibilities for 8-5 my-old higher primate fossil:
  - Chimp/bonobo & modern human common ancestor
  - Primitive panin ancestral to living chimps
  - Primitive hominin ancestral to modern humans
- Splitters: first hominins and panins were just 2 of number of closely related lineages
  - Options above
  - An extinct clade that is the sister taxon of the *Pan/Homo* clade
  - 1 or more extinct panin and hominin subclades
- Splitters would expect homoplasies in this 8-5 my period. A **homoplasy** is a character shared by a set of species but not present in their common ancestor, i.e. wing, eye
- B. Wood: need much better evidence than we have to be able to sort earliest hominins from nonhominins with any degree of reliability

Putative hominid species

1. *H. sapiens*
2. *H. floresiensis*
3. *H. neanderthalensis*
4. *H. heidelbergensis*
5. *H. rhodesiensis*
6. *H. erectus*
7. *H. pekinensis*
8. *H. antecessor*
9. *H. ergaster*
10. *H. georgicus*
11. *H. habilis*
12. *Au. boisei*
13. *Au. robustus*
14. *Au. crassidens*
15. *Au. africanus*
16. *Au. sediba*
17. *Au. garhi*
18. *Au. aethiopicus*
19. *Au. barelghazeli*
20. *Au. afarensis*
21. *Au. platyops*
22. *Au. anamensis*
23. *Ar. ramidus*
24. *Ar. kadabba*
25. *O. tugenensis*
26. *S. tchadensis*

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Red: not really new--belong to already named fossils (synonyms = biologically redundant labels)

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Denote CHRONOSPECIES (segments of an evolving lineage) with the same color...

1. *H. sapiens*
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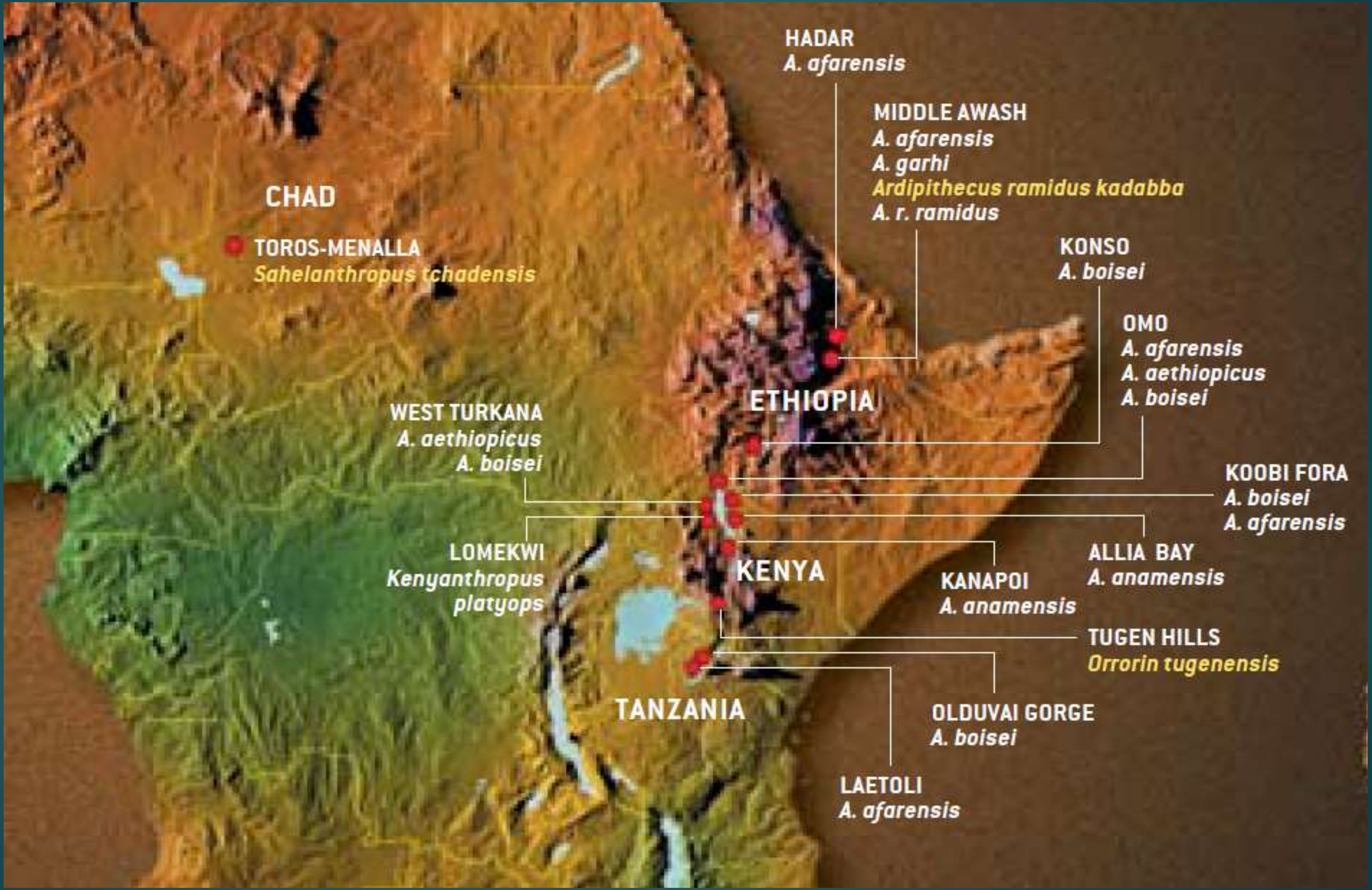
Same colors denote CHRONOSPECIES of a lineage.

Diversity of NAMES ≠ Biological SPECIES diversity

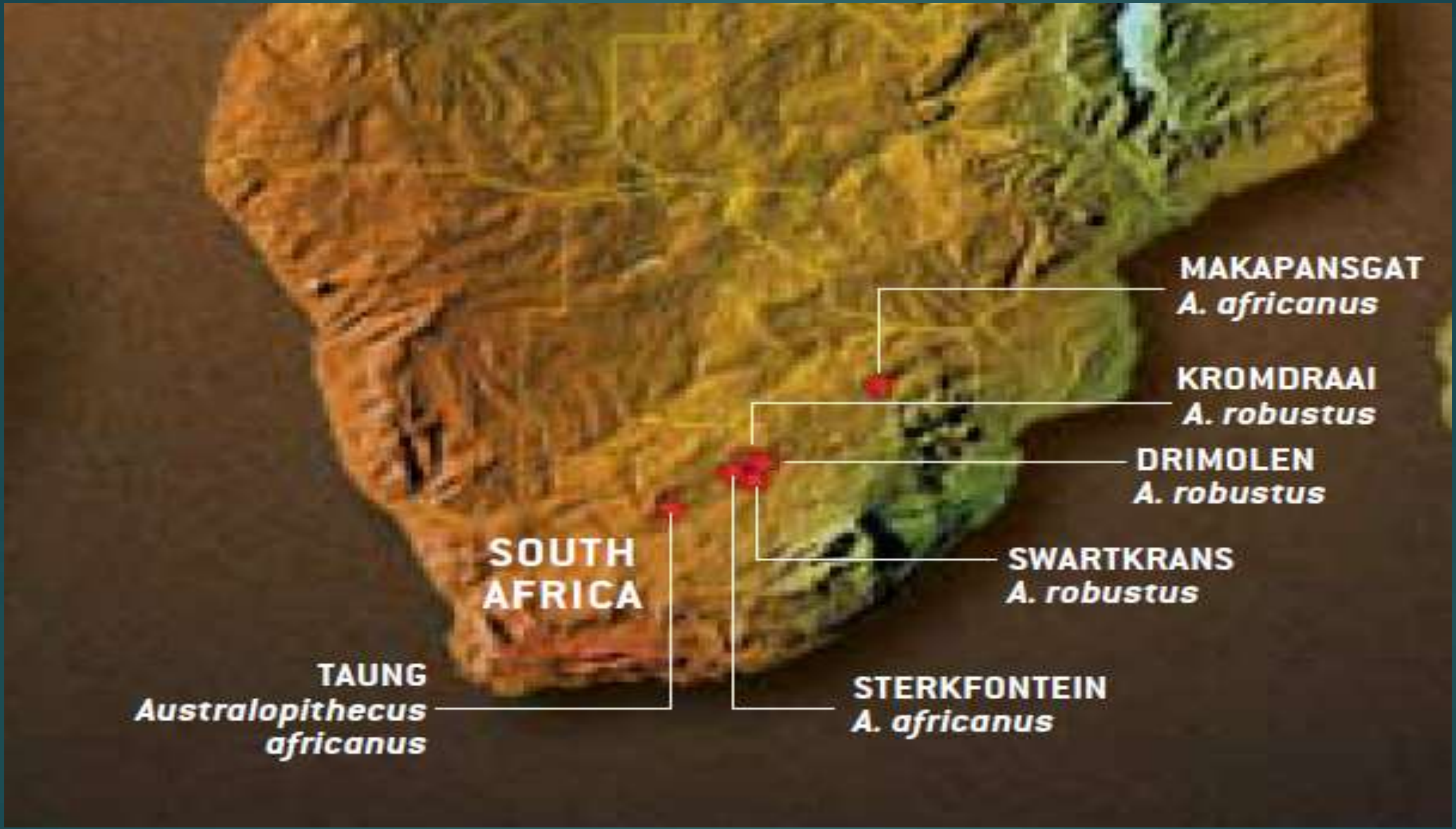
...And Then There Was One

- **23 + Species of Extinct Humans**
- Sahelanthropus
- Orrorin Tugensis
- Ardipithecus ramidus & kadabba
Australopithecus anamensis
Australopithecus afarensis
Australopithecus bahrelghazali
Australopithecus aethiopicus
Paranthropus boisei
Paranthropus robustus
Australopithecus africanus
Australopithecus garhi
- Kenyanthropus platyops
Homo rudolfensis
Homo habilis
Homo ergaster
Homo erectus
Homo antecessor
Homo heidelbegensis
Homo neanderthalensis
- Homo sapiens

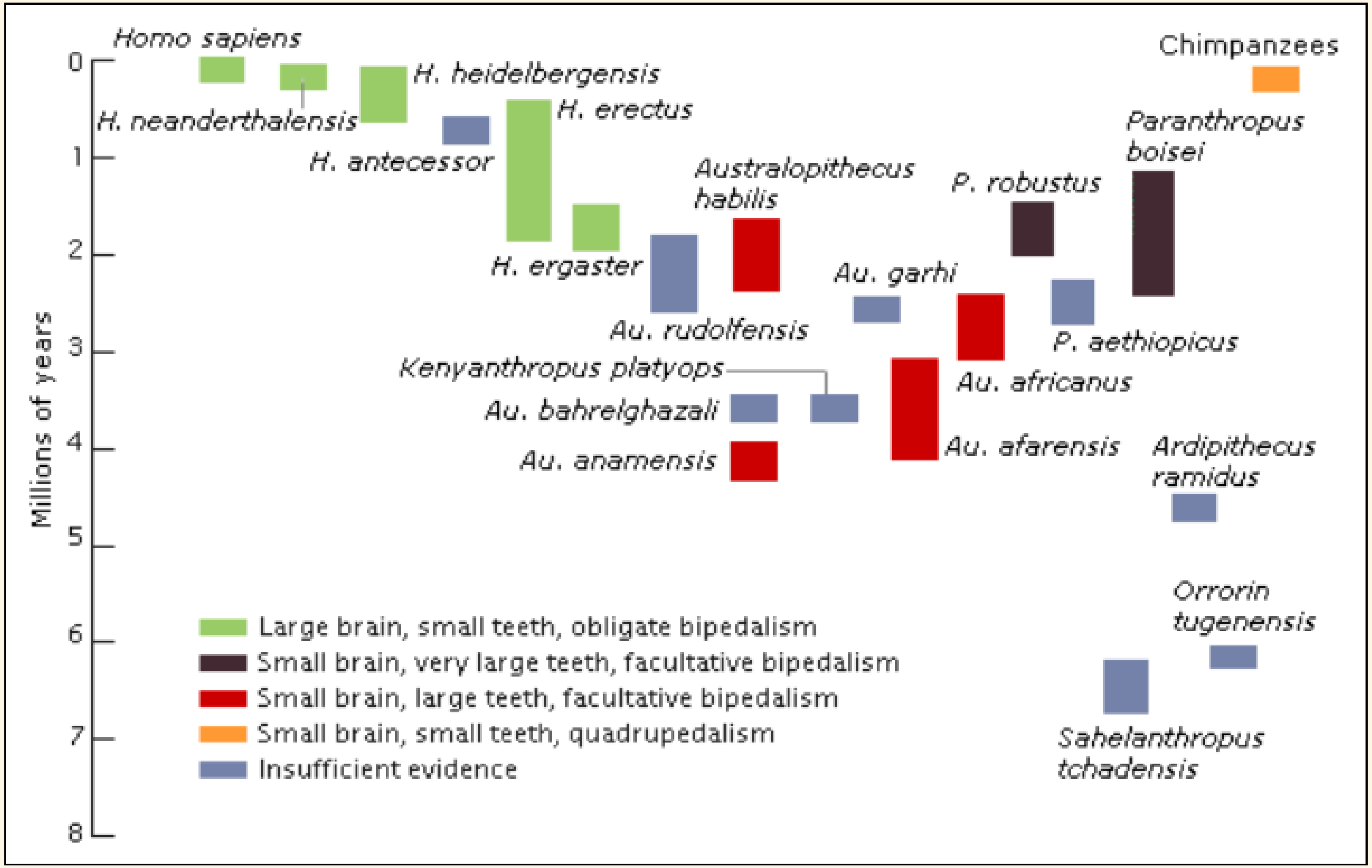
East African Locations



South African Sites



MIDDLE AWASH
A. afarensis
A. garhi
Ardipithecus ramidus kadabba
Ar. ramidus
HADAR
A. afarensis
TOROS-MENALLA
Sahelanthropus tchadensis
KONSO
A. boisei
OMO
A. afarensis
A. aethiopicus
A. boisei
WEST TURKANA
A. aethiopicus
A. boisei
KOOBI FORA
A. boisei
A. afarensis
LOMEKWI
Kenyanthropus platyops
ALLIA BAY
A. anamensis
KANAPOI
A. anamensis
TUGEN HILLS
Orrorin tugenensis
LAETOLI
A. afarensis
OLDUVAI GORGE
A. boisei
MAKAPANSGAT
A. africanus
KROMDRAAI
A. robustus
DRIMOLEN
A. robustus
TAUNG
Australopithecus africanus
STERKFONTEIN
A. africanus
SWARTKRANS
A. robustus



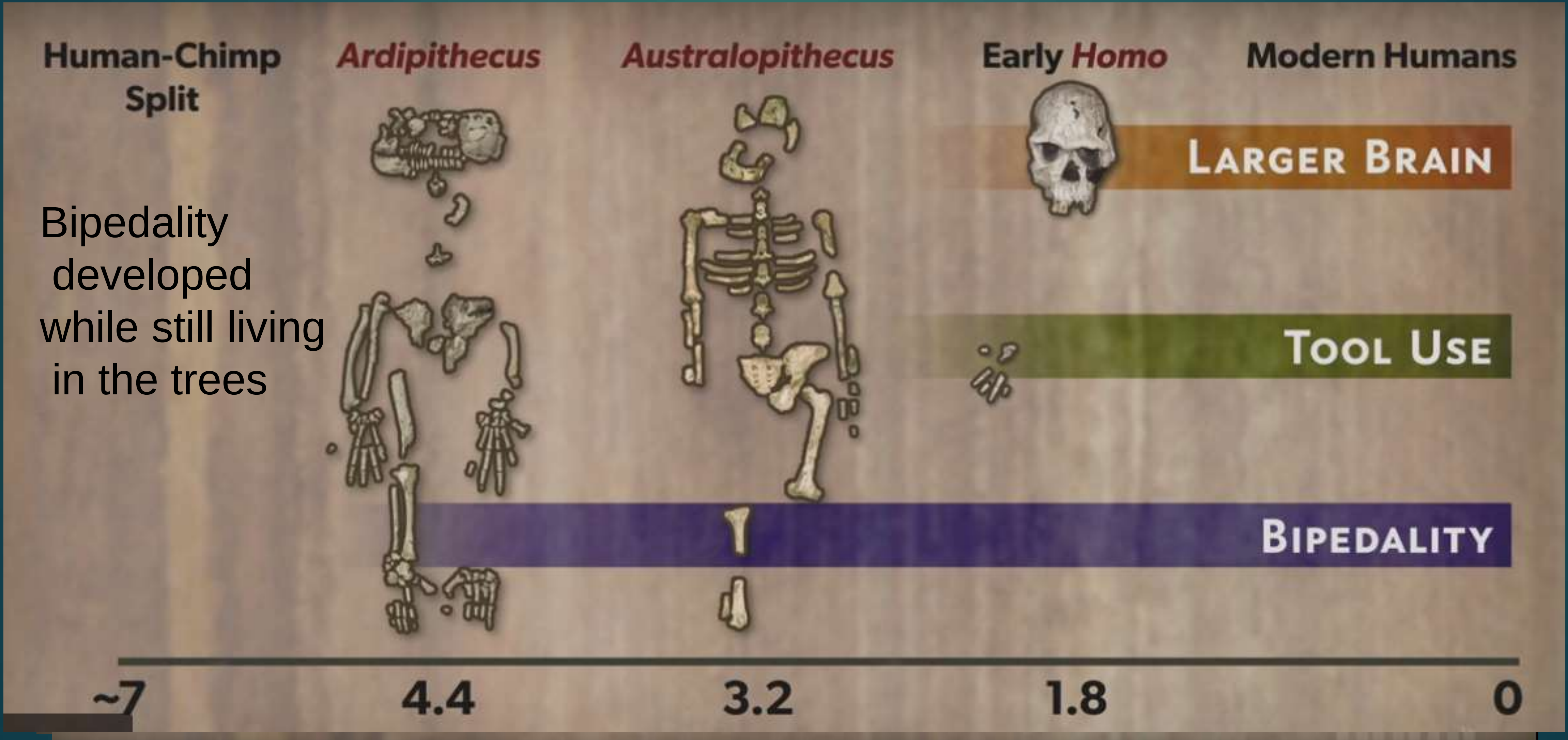
Note that as many as 4 or 5 species of early hominids were living at the same time. Observe also that, in at least a half-dozen instances, a parental species continued to exist for a lengthy period of time after a daughter species evolved. The arrangement shown here is not accepted by all paleoanthropologists. For instance, there are some who would merge H. erectus and H. heidelbergensis, considering them as one species. Also, there are those who maintain the H. neanderthalensis is a subspecies of H. sapiens while many others disagree.

A Tour Through 7 Million Years of Human Evolution

No clear fossil evidence of last common ancestor between the line that would lead to chimps and the line that would lead to modern humans has been found yet

However, many other intermediates have been found.....

Discovery of *H. habilis*: Larger brain, tool use & bipedality present at 1.8 Ma, must have evolved before 1.8 Ma



Bipedality developed while still living in the trees

Paleoenvironments and early hominins

- Andrew Hill: Baringo Paleontological Project, Tugen Hills, Kenya

- 1 - Origin of hominins: walking on 2 legs related to changing environment; origin of savanna grasslands
- What was environment like when hominins originated?
- Woodlands and forest or grasslands?

- 2 – Climate change forced by astronomical variations (earth wiggles around the sun) affect local environment in Africa.
- Did this actually affect human evolution

Soil Carbonate nodules

- Different form of carbon in different plants: the ratio of carbon-13 and carbon-12 isotopes in plant tissues is different depending on the type of plant photosynthesis and this can be used to determine which types of plants were consumed by animals, whether in woodland or grassland
  - plants using the C_4 photosynthetic pathway (grasses),
  - plants using the C_3 photosynthetic pathway (trees).
- Shift circa 7 Ma from wooded to grasslands in Pakistan
- But not in Africa where for 15 M years, wide variation between the two; no abrupt shift to grasslands
- Between 6-7 Ma, vegetative conditions in rift valley have been variable through time; with no sign of grasslands; much of the time there were woodlands with 50 m trees

Diatomites

- Blue green algae with silica skeletons
- Chemeron Formation in Tugen Hills, in Kenya: fine bedding planes of diatomite indicating enormous lakes; archive of climatic information
- Measure of precession: wobble of earth, Milankovich Orbital cycling of 23 K years; insolation = control amount of sunlight hitting earth
- Diatomites match insolation; at peaks of sunlight, in 23 K cycles, largest lakes
- Lakes last 5-10 K years; several hundred kms across; via Monsoon system; dry out each cycle

African Ancestors

- 8 MA: Africa was mostly thick forests interspersed with rivers and lakes; most primates were tree dwellers

- 8 to 5 MA: Climate change: the earth experienced beginnings of long-term drying and cooling trend because earth's moisture was locked up in ice sheets, extended further from north and south poles. Temperatures fell

- Hominin evolution began in Africa at time of these climatic changes. Dense forests were gradually replaced with open woodland. Grasslands began to appear between large patches of trees. Today's savannahs are recent event.

- Recent data suggests earliest hominins in a mosaic of habitats: woodland, grassland, lakes, and gallery forests along rivers. No early hominin fossils have been found in an exclusively densely forested habitat.

Big Picture

- 8-15+ Ma: Planet of the Apes; no hominins
- 7+ Ma: Last common ancestor with chimpanzee; hominin clade established
- 4.3 Ma: *Australopithecus* established; adaptation to heavily masticated diets; megadontia in *Australopithecus*
- 2.7 Ma: *Homo* clade established: Oldowan technology; large mammal butchery
- 2.1 Ma: First hominin expansion from Africa
- ~1.2 Ma – Last robust *Australopithecus* goes extinct
- 600 Ka: Neanderthal & Denisovan clade established
- 200 Ka: Anatomical modern *Homo sapiens;*
- ~100 Ka – *H. floresiensis* goes extinct
- 30 K: Neandertals go extinct; mini *Floresiensis* persist

Conclusions

- In Rift Valley, environments were varied, but primarily woodlands or forest at time of human origins and afterwards.
- Astronomical variations caused changes in climate and environment in Rift Valley on a predictable basis
- This has happened regularly from time of early hominins until today throughout Africa
- Not always lakes, but significant environmental change
- Causes breakup and recombination of communities of animals and hominins
- A perfect scenario for Darwinian speciation

African Ancestors

- Earliest hominins were adapted to both tree living and ground living.
- Trees provided fruit, nesting sites, protection from predators.
- Grassland had new food sources (tubers), while water sources offered fish and mollusks.
- Unlikely that they lived in caves (primates do not live in them), despite some fossils being found there.

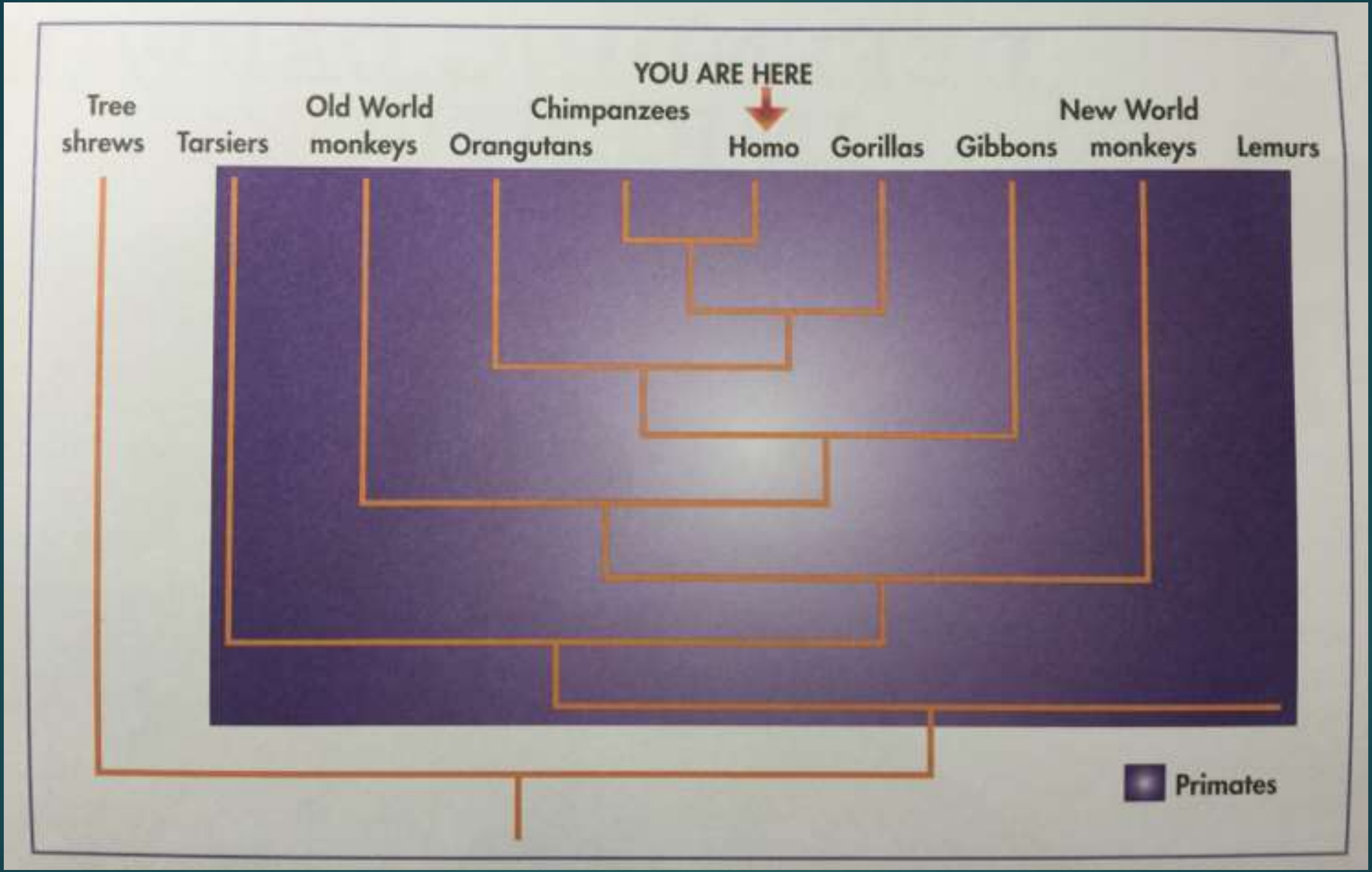
From Ape to hominin

- **Proto-hominins (Opportunistic bipeds)**
  - *Sahelanthropus tchadensis / Orrorin tugenensis*
- **Transitional Opportunistic-into-Habitual Bipeds**
  - *Ardipithecus ramidus / Australopithecus anamensis*
- **First True Habitual Bipeds**
  - *Australopithecus afarensis / A. africanus / A. garhi*
  - *Australopithecus robustus / P. boisei*

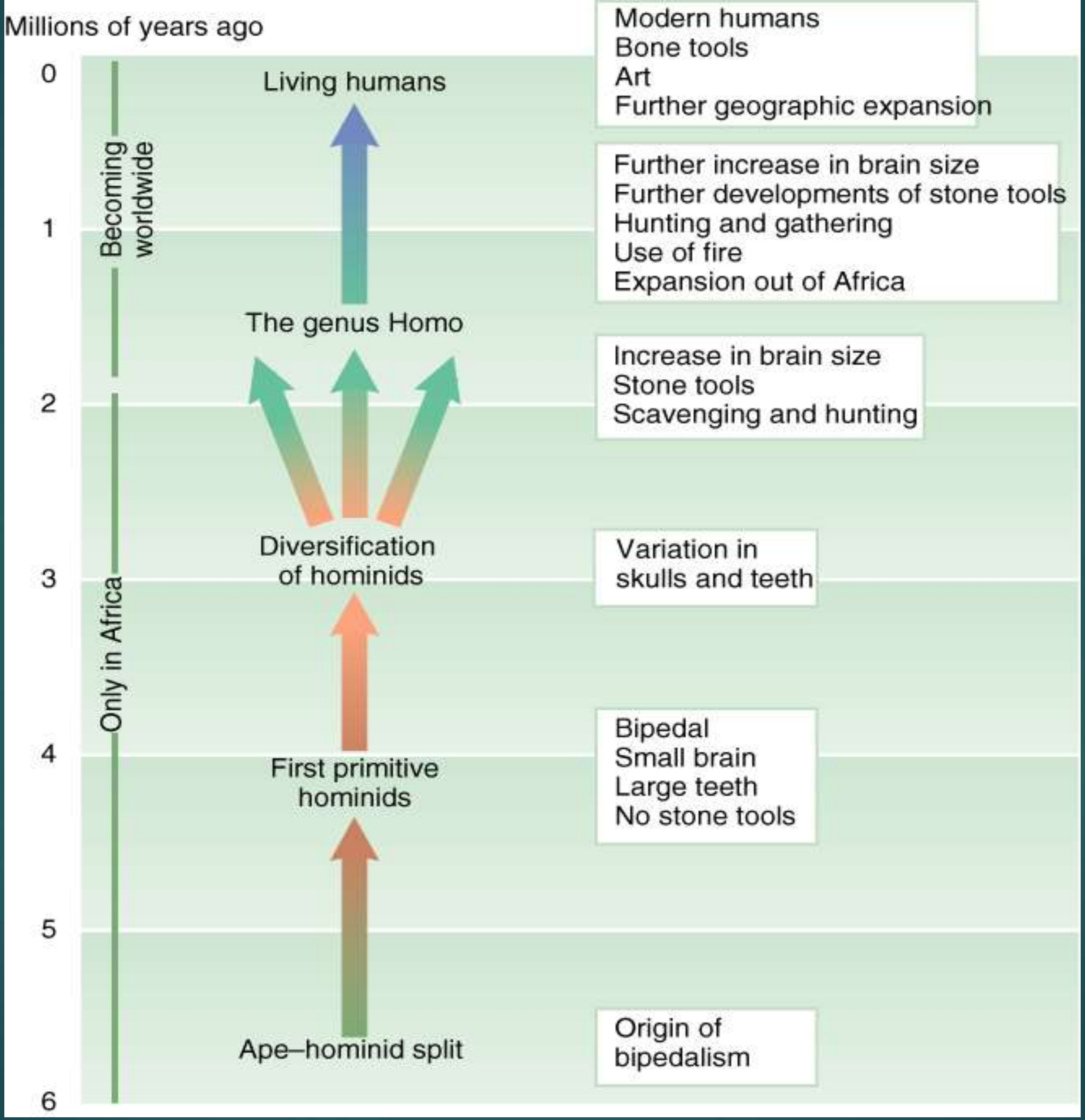
Last Common Ancestor of humans and chimps

- *Pan/Homo* common ancestor was neither a living chimp or human
- Ancestor was adapted to tree living; finger bones would be curved
- Limbs adapted to walk both on all fours and on hind limbs alone
- More snoutlike face, not flat; elongated jaws
- Modest-sized teeth, prominent canines, large upper incisor teeth
- Smaller canine teeth; larger chewing teeth; thicker lower jaws

Skeletal Differences	Modern	Chimpanzee
Forehead	Steep	Low
Face	Flat	Projecting
Cranial vault	Widest higher up	Widest at base
Brain size	Large	Small
Canine teeth	Small	Large
Base of skull	Angles	Straighter
Thorax	Straight sides	Conical
Lumbar vertebrae	5	3-4
Limb bones	Straight	Curved
Limb proportions	Lower limb long	Lower limb short
Wrist	Less mobile	More mobile
Hand	Cup-shaped & long thumb	Flat, long fingers, & short thumb
Foot	Arched & big toe straight	Flat, big toe angled
Pelvis	Neonatal head is tight fit	Neonatal head has ++ room
Development – bones & teeth	Slow	Fast


YOU ARE HERE
Tree shrews
Tarsiers
Old World monkeys
Orangutans
Chimpanzees
Homo
Gorillas
Gibbons
New World monkeys
Lemurs
Primates

Overview of hominin evolution



Overview of human evolution

- Circa 4-7 Ma, *Sahelanthropus, Orrorin, Ardipithecus*
- Early hominins had apelike teeth (except *Sahelanthropus*) but were bipedal and lived in and around forested woodlands of eastern Africa
- One or more hominins lived in Africa over next few million years, most classified as *Australopithecus*
- Retained apelike features in some teeth and had ape-sized brains.
- Early hominins were bipedal and arboreal

Overview of human evolution 2

- New fossils, *Ardipithecus ramidus* (4.4 MA) and *Ar kadabba* (5.2-5.8 MA) are fossils with new mix of features that is unlike *Australopithecus* and more like *Sahelanthropus*

- By 3 MA, stone tool technology & rapid diversification led to at least two distinct lines of hominin evolution.

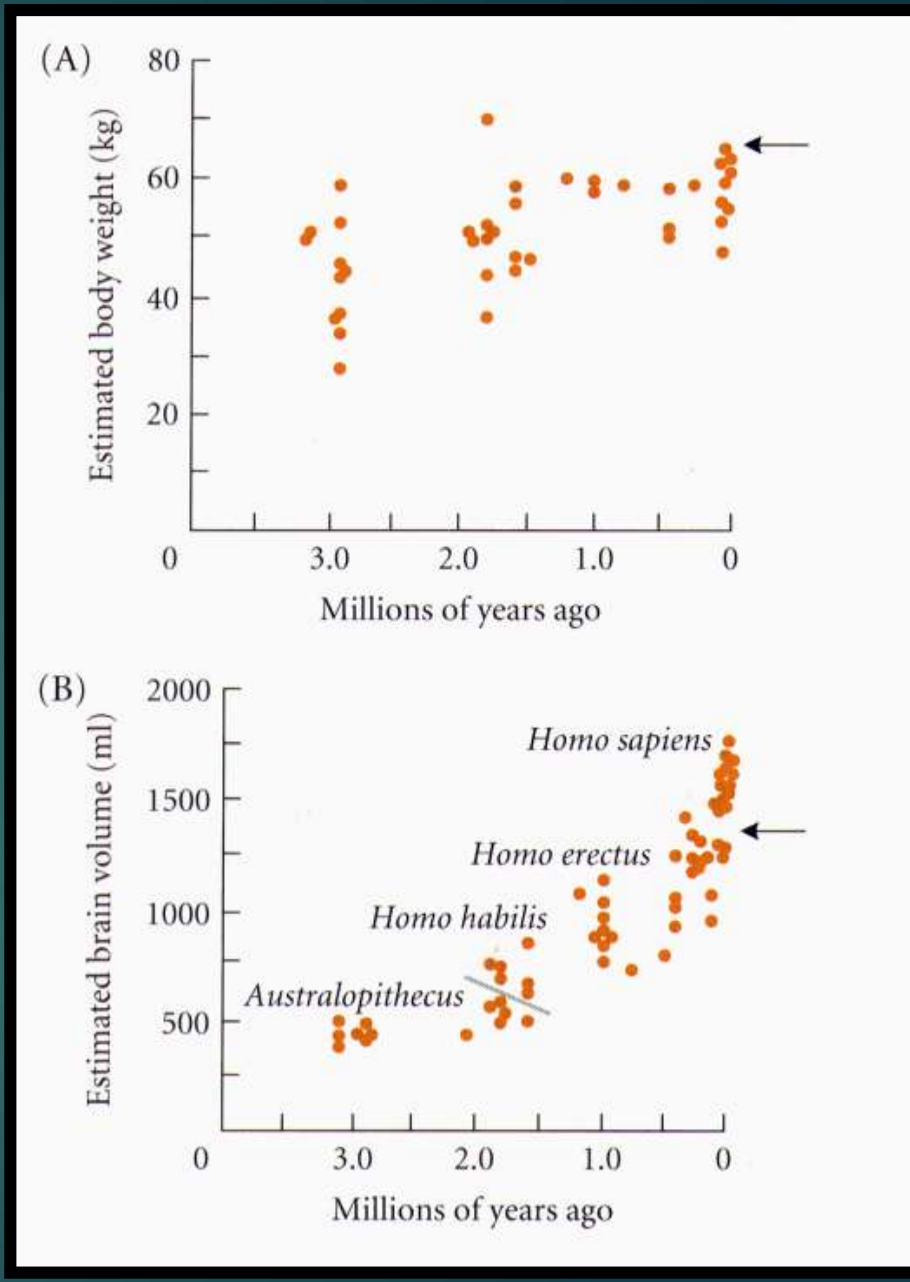
  -Robust or *Paranthropus*

  -Gracile or *Australopithecines*

- One species of *Australopithecus* evolved into first members of *Homo* sometime between 2.5 million and 2 MA. Unlikely that A. sediba was the immediate ancestor

Overview of human evolution 3

- Hominins at this time had robust faces and less well-rounded skulls compared with moderns.
- Still debate about whether these "archaic" hominins are earlier stage of our own species or indicate more than one species.
- *H. erectus* in Africa by 2 MA – essentially modern skeleton, full bipedal adaptations, much larger brain than earlier hominins. First hominin to expand out of Africa. Hunted, used fire, invented new form of general purpose stone tool known as Acheulean hand axe.



Slight body & large brain increase

Hominin Brain Volume Expansion

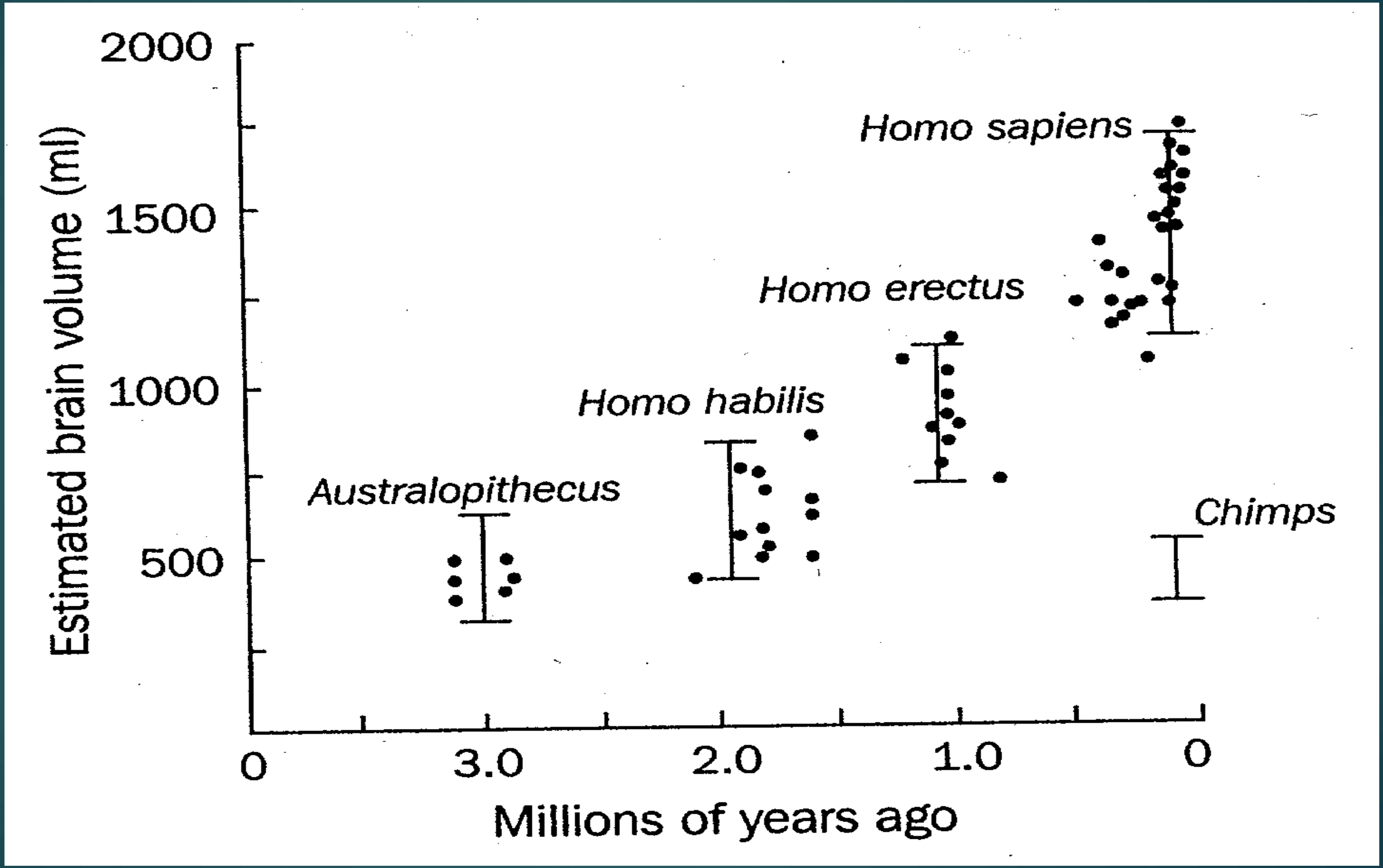
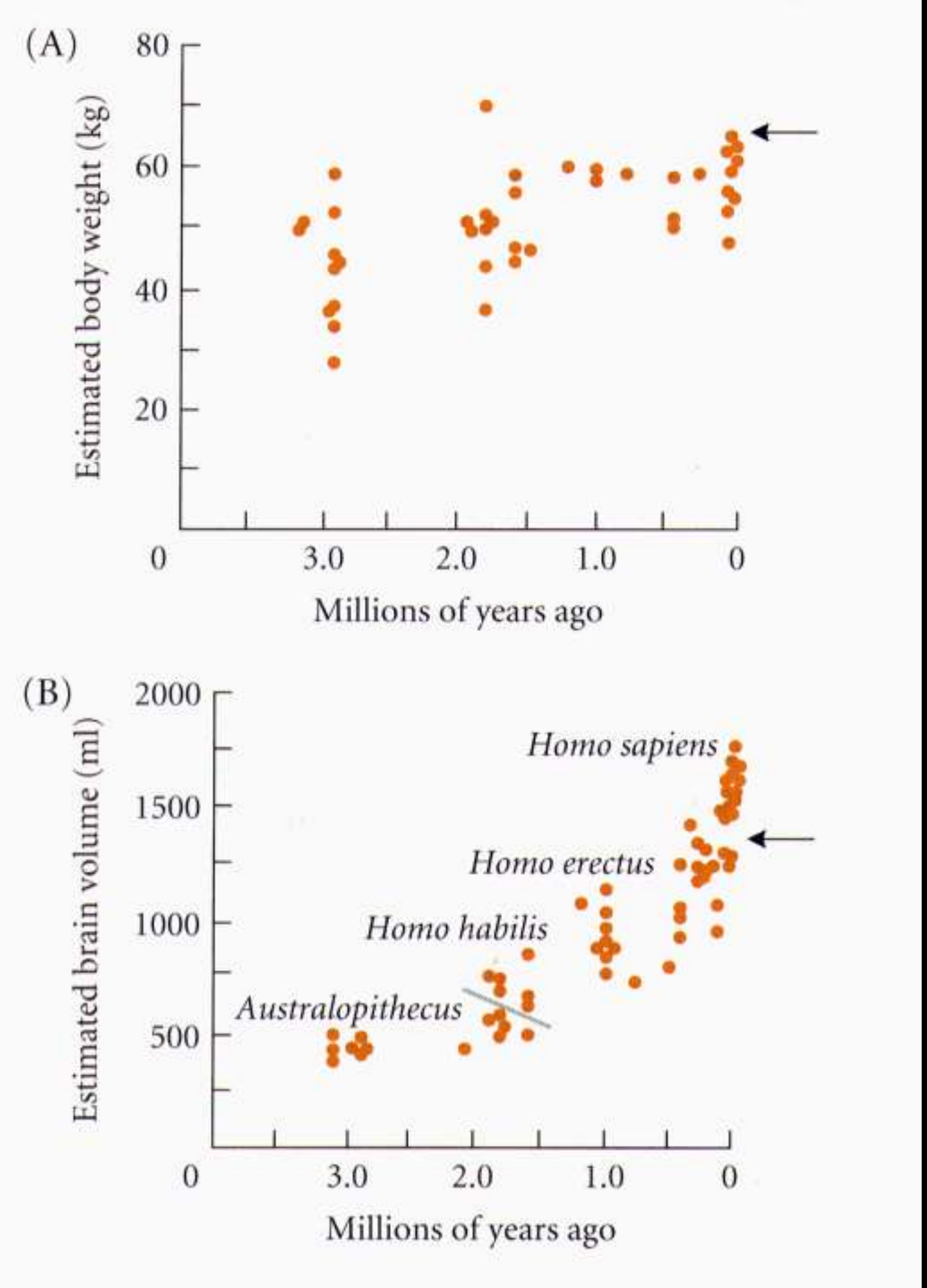


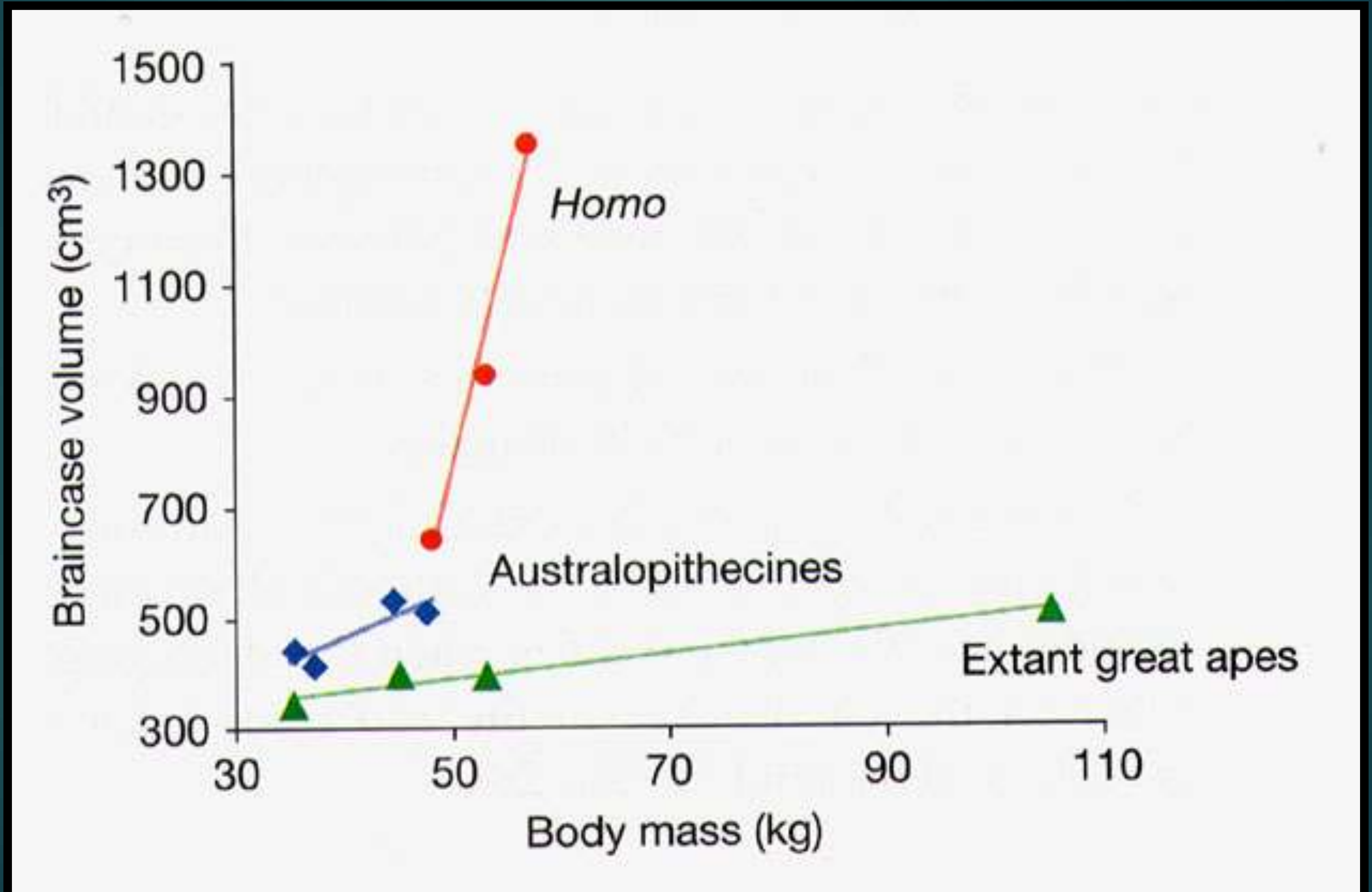
Diagram from Cartwright, 2000, p175.



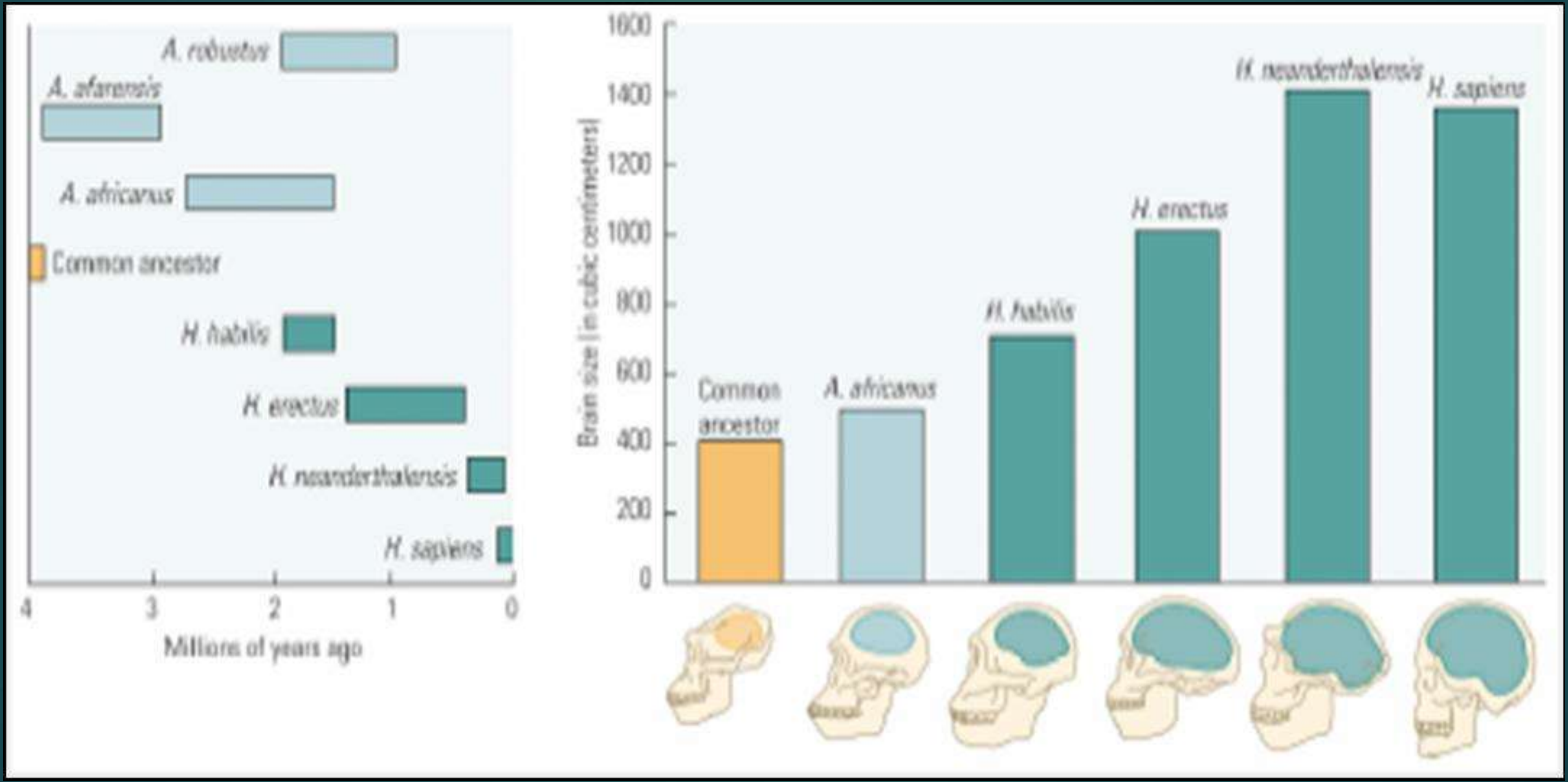
Slight Increase In Body Size

Much Greater Increase In Brain Volume

Braincase Volume and Body Mass



Brain size has always been the major criteria for being hominin; brain size increased in hominin line

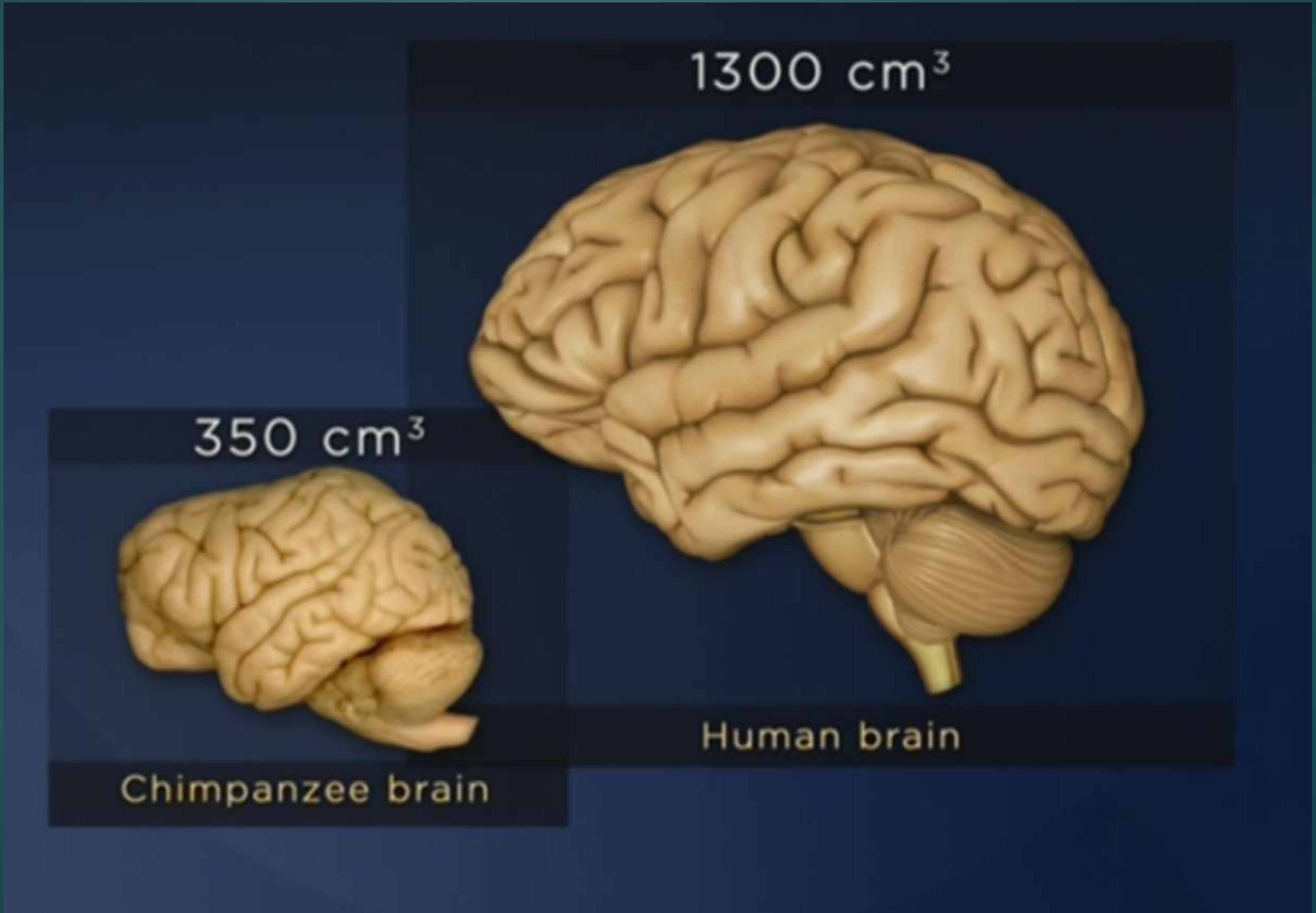


Brain volume for hominins

Hominin Species	Millions of Years Ago	Average Brain Volume (mL)
Australopithecus afarensis	3.5	440
Australopithecus africanus	2.5	450
Paranthropus robustus	2.0	520
Paranthropus bosei	1.5	515
Homo rudolfensis	2.0	700
Homo habilis	1.8	575
Homo ergaster	1.8	800
Homo erectus	0.5	1,100
Homo heidelbergensis	0.2	1,250
Homo neanderthalensis	0.05	1,450
Homo sapiens	0.08	1,350

Bigger brains and skulls - *Homo habilis to Homo sapiens:*
craniums from 300 cc to 1350 cc

Hominin brain size: Human is 3x larger than chimp; but brain size is not all cognition; brains also tracks with size of body



EQ, Allometric scaling, and neuron number

- Mammalian brain mass increases by an exponent of two-thirds compared to body mass.
- Encephalization quotient (EQ) is the ratio of a species' actual brain mass to its predicted brain mass. Shorthand for intelligence. Humans lead the pack with an EQ of 7.4 to 7.8, followed by other high achievers such as dolphins (about 5), chimpanzees (2.2 to 2.5)
- Suzana Herculano-Houzel: turned brains into soup & counted nuclei – in rodents, as brains get larger, the number of neurons grows more slowly than the mass of the brain itself; As the primate brain expands from one species to another, the number of neurons rises quickly enough to keep pace with the growing brain size. The neurons aren't ballooning in size and taking up more space, as they do in rodents. Instead, they stay compact. Different mammalian species' brains do not scale up the same way.
- At 1,350 cc, the human brain weighs 190 times as much as a marmoset brain and holds 134 times as many neurons—about 86 billion in total.

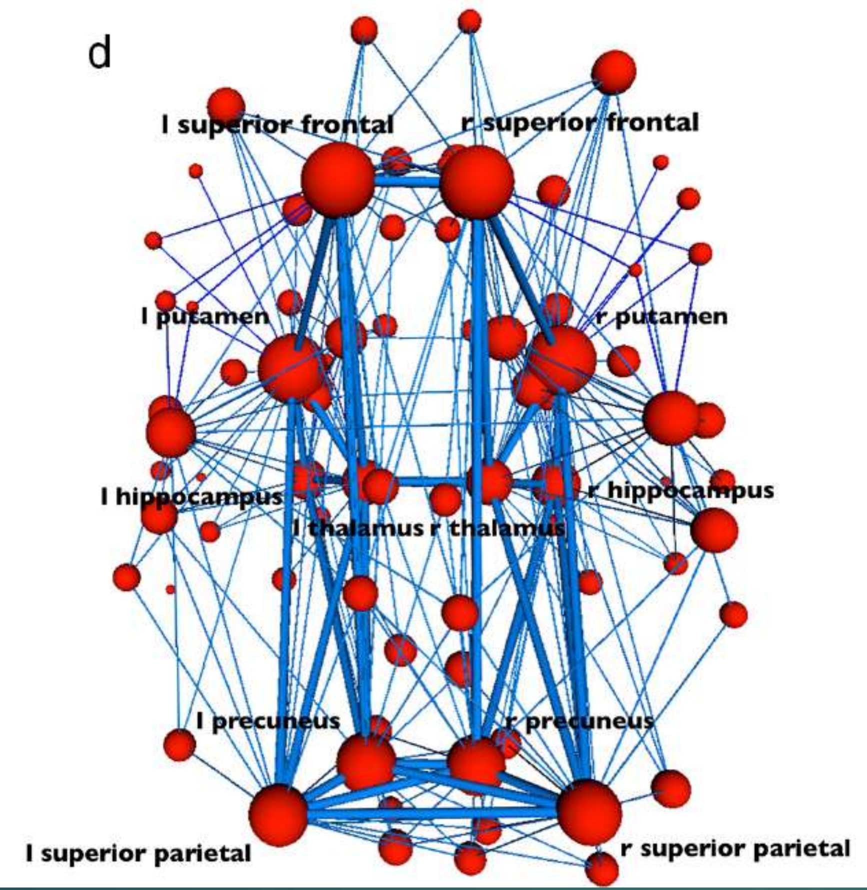
EQ, Allometric scaling, and neuron number

- Evan MacLean: impulse control in animals cannot be predicted by EQ; the best predictor for self-control was absolute brain volume, uncorrected for body size
- Herculano-Houzel found that the number of cortical neurons predicted self-control about as well as absolute brain size; most important factor that predicts cognitive capacity is the number of cortical neurons
- Jan Kaas: need to minimize connection distance or wiring cost between neurons; pattern of keeping most connections local, and having only a few cell types that transmit information long-distance; used lesser white matter amount; circumvented the problem/cost of long-distance communication.
- 1 percent of neurons = neurons that gather information from huge numbers of nearby cells and send it to other neurons that are far away;

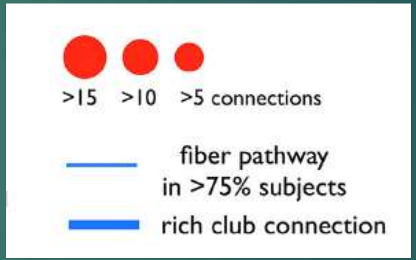
Organization into cortical areas due to local connectivity

- This pattern of keeping most connections local, and having only a few cells transmit information long-distance, had huge consequences for primate evolution. It actually changed how the brain does its work.
- Since most cells communicated only with nearby partners, these groups of neurons became cloistered into local neighborhoods. Neurons in each neighborhood worked on a specific task—and only the end result of that work was transmitted to other areas far away. In other words, the primate brain became more compartmentalized.
- And as these local areas increased in number, this organizational change allowed primates to evolve more and more cognitive abilities, via the specialized development of cortical areas in the brain. Rodents have 40; primates have 100s of cortical areas; humans, 360.

12 Rich World Hubs: Modern brain's central areas and freeways



Bilateral frontoparietal regions, including precuneus, superior frontal and parietal cortex, hippocampus, thalamus, and putamen are individually central & also densely interconnected, together forming a rich club.



Connections between rich-club regions (dark blue) and connections from rich-club nodes to the other regions of the brain network (light blue). The figure shows that almost all regions of the brain have at least one link directly to the rich club. Brain lesions that damage one of the rich club hubs will have more serious behavioral effects (3x more) than damage to non-hub area.

Ralph Holloway (1935-): hominin brain evolution

- Physical anthropology, evolution of brain and behavior, paleoanthropology
- Columbia University
- Hominin Endocasts
- Work on the Taung Child: one of the first to suggest brain reorganization occurring before the increase of brain size in hominins.
- His claim that the lunate sulcus, a sulcus which marks the boundary of the occipital lobe, was in a posterior position to that of apes suggests that the reduction of the occipital lobe was accompanied by enlargements of parts of the brain associated with higher cognitive function.
- 20 year battle with Dean Falk over lunate

Bushbaby

First phase of hominin brain evolution: *Australopithecines*

- About 7 Ma, first hominins became bipedal with brains about 1/3rd of modern size (400cc). For the first two thirds of our history, the size of our ancestors' brains was within the range of those of apes living today.
- Stone tools appear at 3.3 MA.
- From 3-2.5 Ma, small allometric (related to body size increase) growth (450-500 cc, *A. afarensis to A. africanus*). Question of brain reorganization.
- *Australopithecus afarensis (Lucy)* had skulls with internal volumes of between 400 and 550 cc, whereas chimpanzee skulls hold around 400 cc and gorillas between 500 and 700 cc.
- During this time, *Australopithecine* brains started to show subtle changes in structure and shape as compared with apes. The neocortex had begun to expand, reorganizing its functions away from visual processing toward more forward regions of the brain.

R. Holloway, 2009

Next phase: last 2 million years

- The final third of our evolution saw nearly all the action in brain size.
- From 2.5-1.8 Ma, rapid major growth (750 cc, *A. africanus to H. habilis*); meat & fish consumption?; an expansion of Broca's area?
- 1.8-.5 Ma, small allometric increase to 800-1000 cc (*H. habilis to H. erectus*); language development?
- .5-.1 Ka, gradual and modest size increase to *H. heidelbergensis*, mostly nonallometric, 1200-1700 cc (*H. erectus to H. neanderthalensis*)
- .015 to present, small allometric reduction in brain size in modern *H. sapiens*, averaging 1,350 cc.
- *Material culture* only in last 100-200 Ka

Robin Ian MacDonald Dunbar (1947-): Social Brain Hypothesis

- British anthropologist and evolutionary psychologist

- 1998: study proposing the Social Brain Hypothesis, which states brain size increases with social group size and complexity

Newer data: Whales, Humans, Elephants = largest brains, most social animals; Von Economo neurons; FTD

Neocortex size correlates with social group size not ecological variables

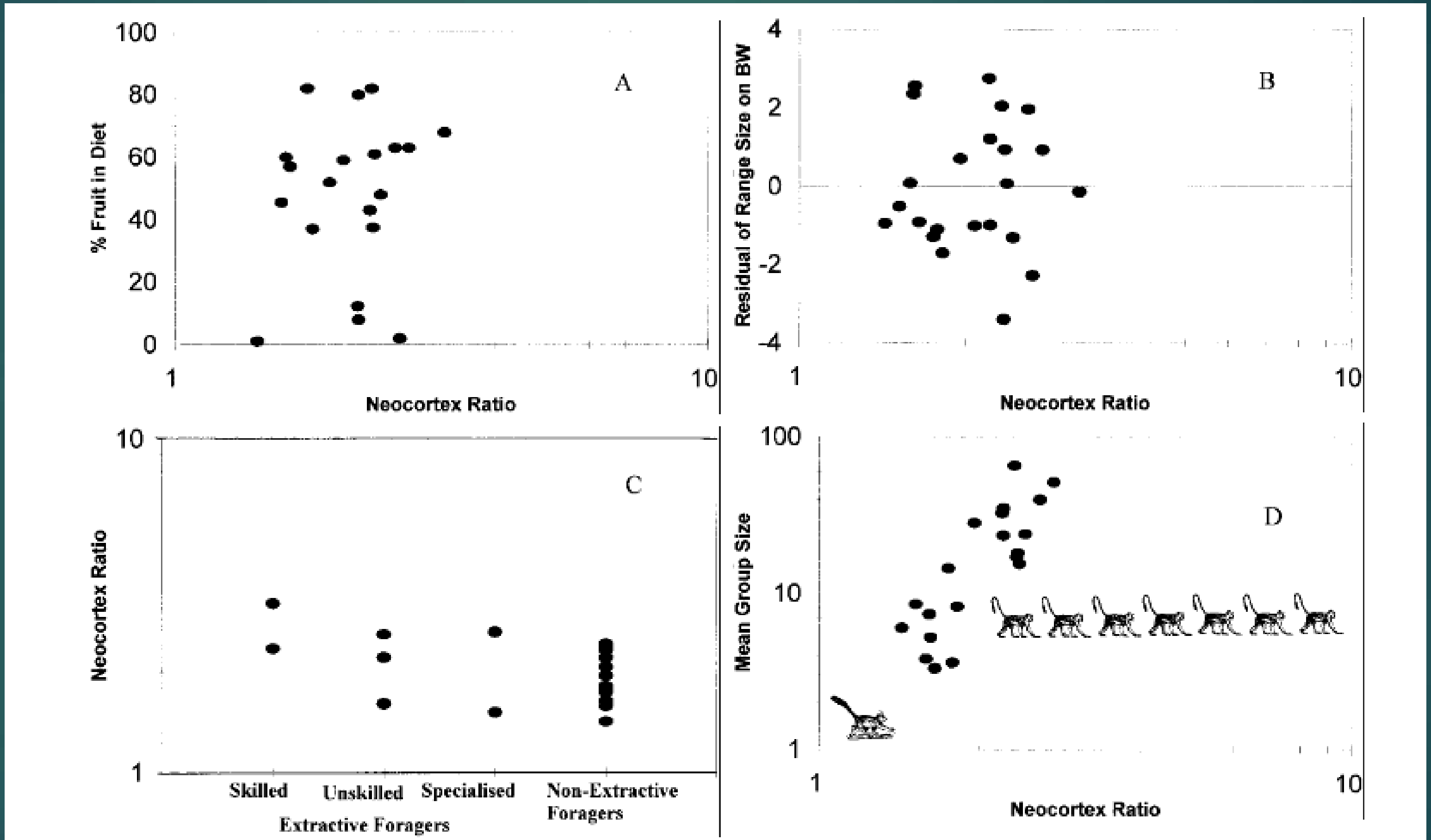


Figure 2. Relative neocortex size in anthropoid primates plotted against (a) percentage of fruit in the diet, (b) mean home-range size scaled as the residual of range size regressed on body weight (after Dunbar[24]), (c) types of extractive foraging (after Gibson[4]), and (d) mean group size. ((a), (b), and (d) are redrawn from Dunbar[24], Figures 6, 2 and 1, respectively; (c) is from Dunbar,[35] Figure 2.)

Fruit in diet, foraging type, foraging range vs. <u>group size</u>

Dunbar, 1998

Diet is more important, esp. fruit eating

- 2017 study's large sample size and robust statistical methods suggest diet and ecology deserve more attention than social brain hypothesis
- DeCasien: wanted to tease out whether monogamous primates had bigger or smaller brains than more promiscuous species. Collected data about the diets and social lives of more than 140 species across all four primate groups—monkeys, apes, lorises, and lemurs—and calculated which features were more likely to be associated with bigger brains. Neither monogamy nor promiscuity predicted anything about a primate's brain size. Neither did any other measure of social complexity, such as group size. The only factor that seemed to predict which species had larger brains was whether their diets were primarily leaves or fruit. Primates that eat fruit have about 25% more brain tissue than leaf-eaters of the same body weight.
- The cognitive demands of those relationships made bigger brains the best use of the extra fruit-derived energy. Better diets merely provided the fuel for that evolutionary brain change. "[Diet and sociality] are not alternative explanations" for larger brains, Dunbar says. "They are complementary explanations."
- She looked at overall relative brain size of different species, rather than the size of the neocortex

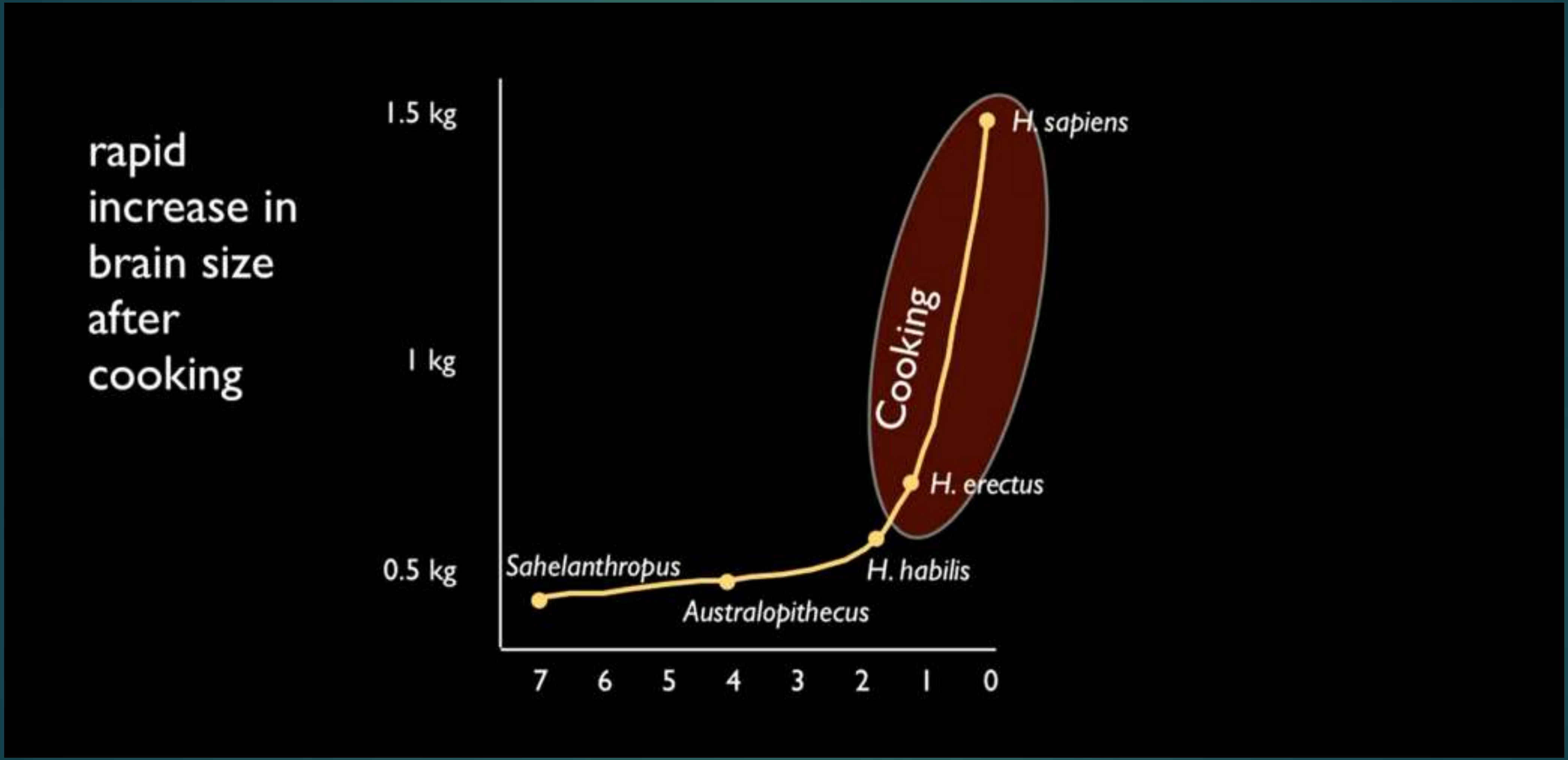
Diet

- DeCasien sees another possibility, one that keeps fruit-eating in the driver's seat. Eating fruit is more cognitively challenging than eating leaves, she says. A primate can find leaves basically anywhere, but it must remember where and when the best fruit is likely to grow. Fruit eaters also range over larger areas than leaf eaters, so they need top-notch navigation skills. And because some fruits may be hard to reach or protected by defenses like spines, primates also need problem solving skills or even tools. Evolution could have pushed fruit-eating primates to develop bigger brains to deal with these complex foraging conditions, DeCasien says. In that case, social life might be largely irrelevant.
- Dunbar: "You cannot evolve a large brain to handle anything, social or otherwise, unless you change your diet to allow greater nutrient acquisition so as to grow a larger brain," he said. "But that is not an explanation for why large brains evolved."
- Wrangham says, but it's notoriously hard to distinguish selective pressures from beneficial physiological changes in correlation studies like this one. He suspects that diet allowed, rather than drove, the evolution of big brains. But he's convinced that diet is intimately tied to evolution, especially in a particular species of primate: humans. "Cooking is what has taken the human lineage into a totally new realm," he says, especially after we learned to cook meat. The new study supports this history of diet-linked cognitive leaps, he says, and he hopes it will bring renewed attention to diet's role in evolution.

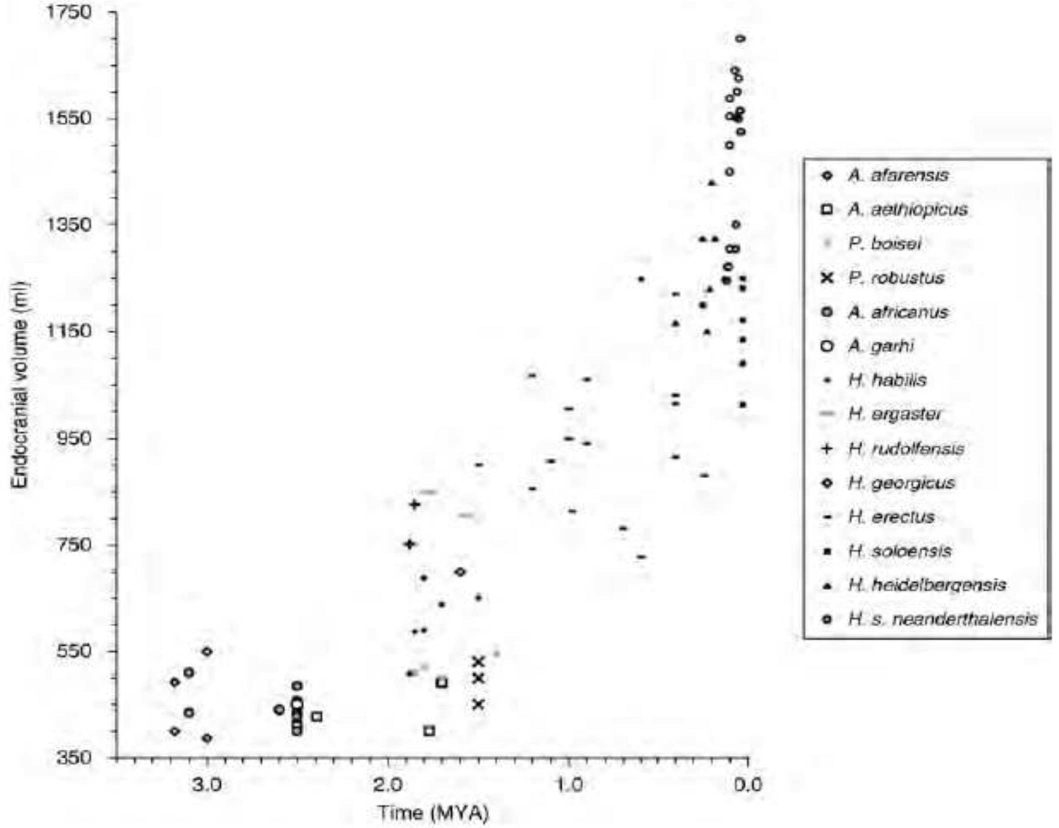
Brain size costs

- 1 – Development time: need longer childhood to develop larger brain
- 2 – Construction: need more protein for larger size
- 3 - Energetic cost: Brain is 2% of body mass, but uses 20% of oxygen and metabolism; needs more calories
- Metabolic cost met by increasing diet quality, cooking

Rapid increase in brain size after cooking discovered (*H. erectus*)

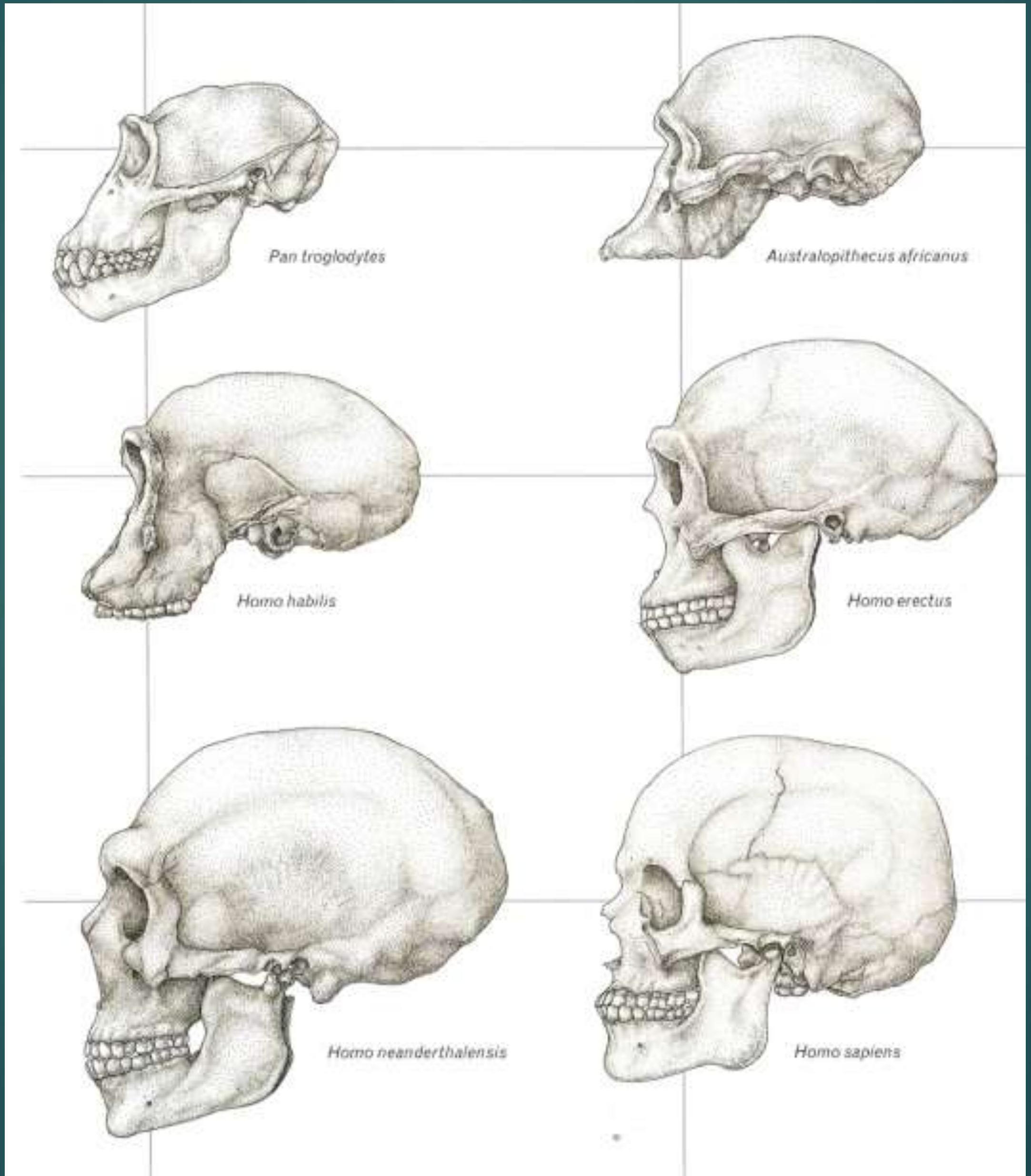


Increase in brain size during the past 3 million years based on fossil hominin endocasts



Evolution of the Brain in Humans – Paleoneurology. Figure 4 Graph showing increase in brain size during the past 3 million years from the fossil hominid endocasts available. While the graph appears smooth and continuous, it should be remembered that each symbol represents several thousand years, and such a graph cannot accurately portray all of the details of brain size changes with time, particularly given the incompleteness of the fossil record. After Holloway et al. [14].

Skulls got bigger to hold larger brains



What makes a hominin?

- Human uniqueness long defined in terms of brain evolution
- Now clear that bipedalism predates big brains by several million years
- Bipedalism associated with morphological changes
- Dietary changes associated with new habitats, also reflected in different chewing apparatus

Shared, derived traits of modern humans

- Habitual bipedalism
- Chewing apparatus
  - Wide parabolic dental arcade
  - Thick enamel
  - Reduced canines
  - Larger molars in relation to other teeth
- Much larger brains relative to body size
- Slow development with long juvenile period
- Elaborate, highly variable material and symbolic culture, transmitted in part through spoken language

Types of bipedality

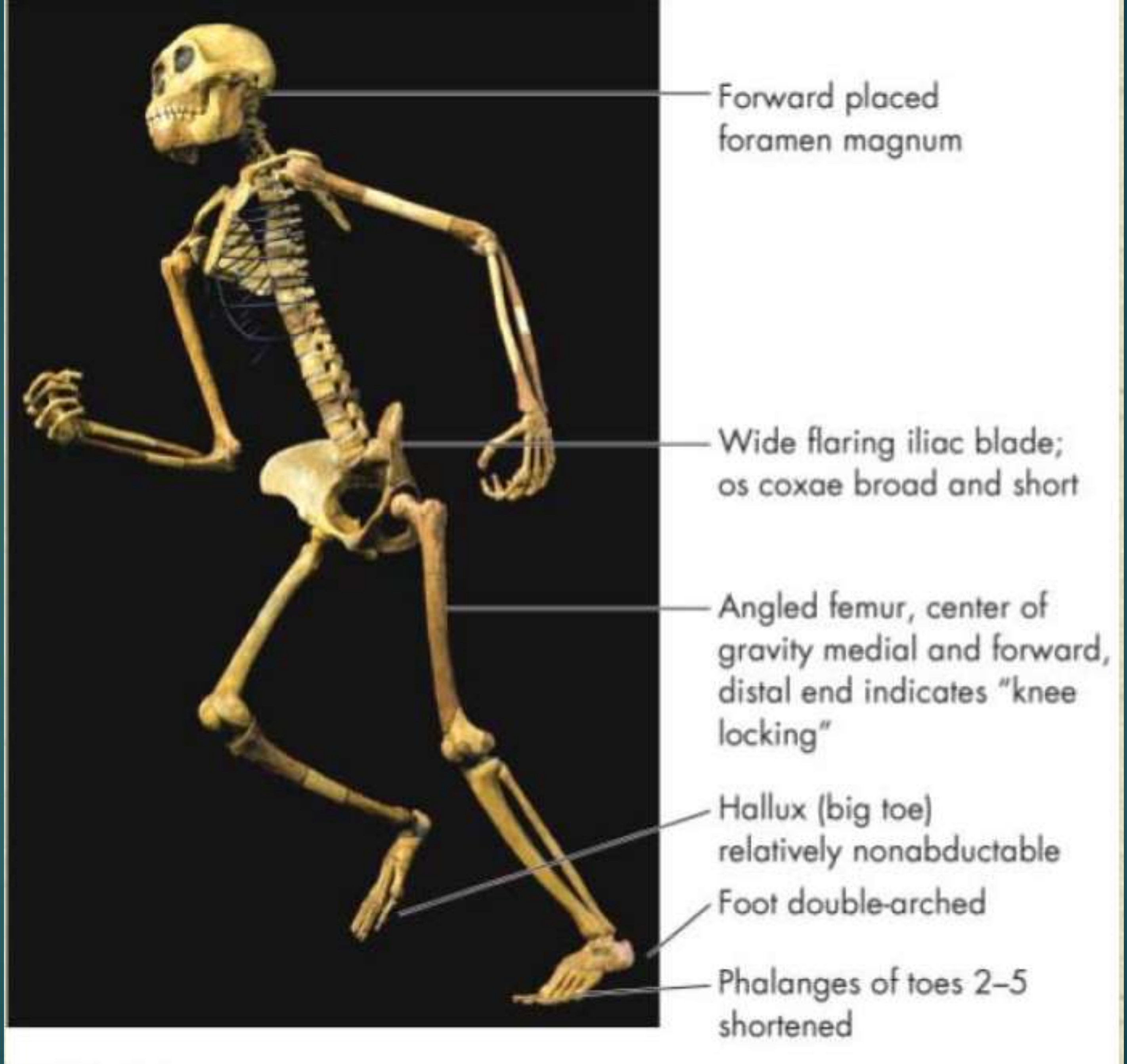
- Facultative biped: animal that is capable of walking or running on two legs, often for only a limited period, in spite of normally walking on four limbs, i.e. some lizards, chimps

- Habitual biped: normal method of locomotion is two-legged.

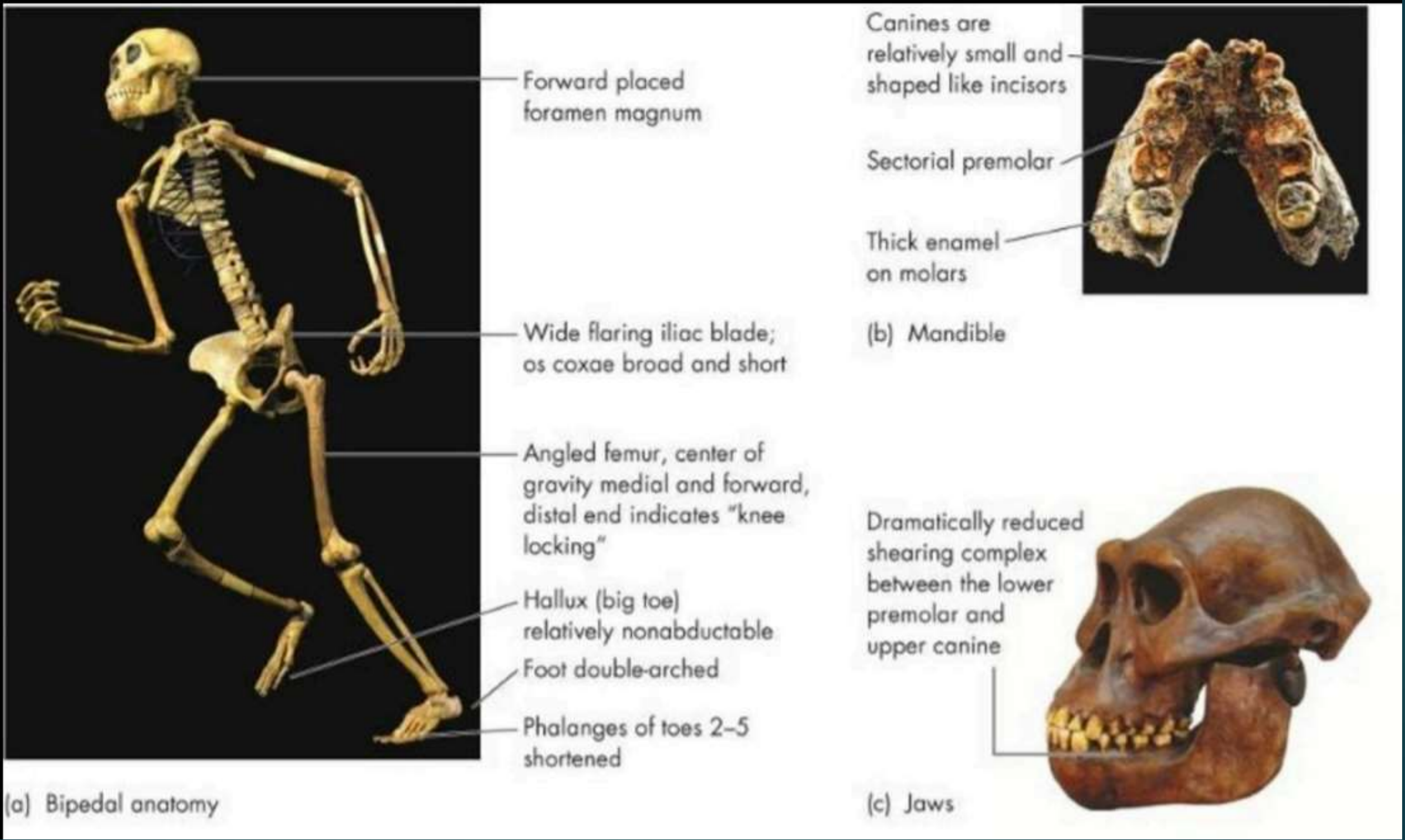
- Obligate biped: Adapted for walking only on two legs, with no ability to walk on four; for example, birds, us

- Strident bipedality: walk only on 2 legs

Bipedal characteristics



(a) Bipedal anatomy


Forward placed foramen magnum
Wide flaring iliac blade; os coxae broad and short
Angled femur, center of gravity medial and forward, distal end indicates "knee locking"
Hallux (big toe) relatively nonabductable
Foot double-arched
Phalanges of toes 2–5 shortened
(a) Bipedal anatomy
Canines are relatively small and shaped like incisors
Sectorial premolar
Thick enamel on molars
(b) Mandible
Dramatically reduced shearing complex between the lower premolar and upper canine
(c) Jaws

- Bipedal
- Small canines and incisors
- Non-sectorial premolar
- large face
- Short snout
- Relatively small brain ~420 cc
- large degree of sexual dimorphism
- chimp-like diet

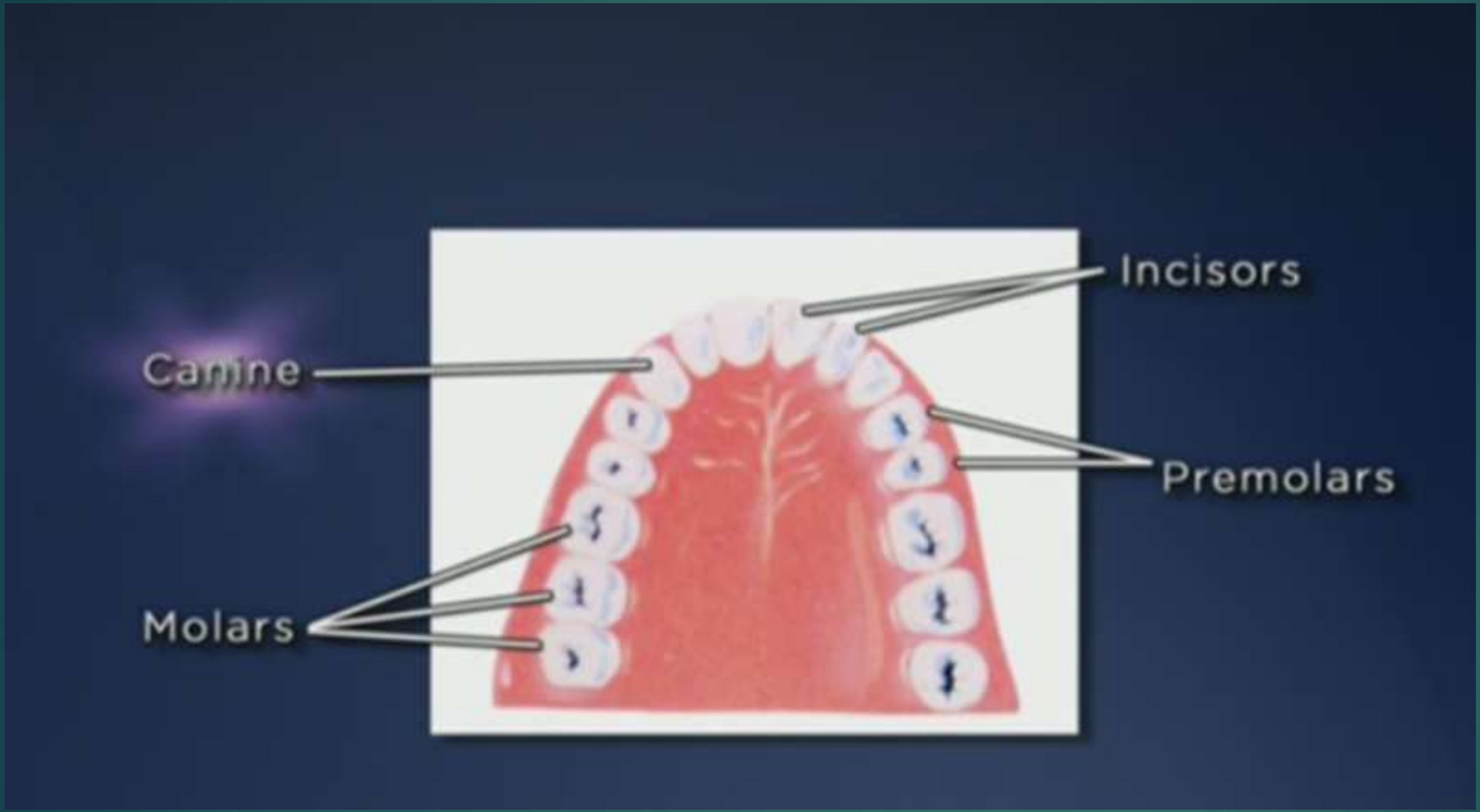
Earliest hominins: basic characteristics

- Inclusion in the hominin lineage is largely based on:
  - a reduction in canine size
  - absence of the C/P3 honing (shearing) complex (large canines cut food. Upper canines are sharpened against the lower third premolar)
  - presence of morphological adaptations for habitual or obligate (regular) bipedality generally found in the postcranial skeleton, particularly in the pelvis and hindlimb
  - Bipedality is often considered to be the hallmark of hominins, and its presence in fossil species is often the key to their inclusion in the hominin clade

Hominin characteristics

- Cranial characteristics
  - Canines small and incisiform
  - Forwardly placed foramen magnum: bipedality
  - Mastoid process (of temporal bone to which neck muscles attach): bipedality
  - Parabolic dental arcade

Mandible and teeth



4 incisors
2 canine
4 premolars
6 molars

Dentition

Reduction of anterior teeth

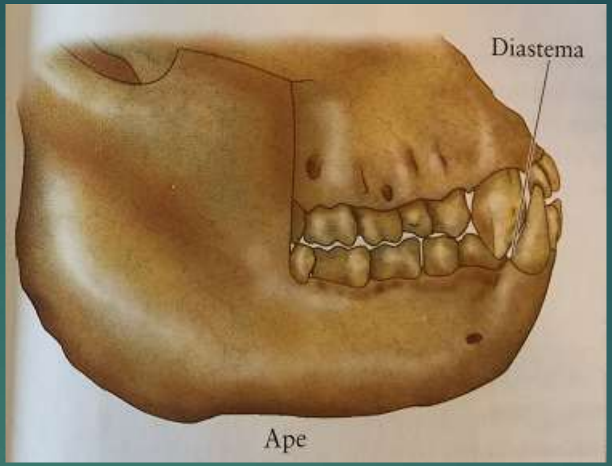
Dentition: Hominin loss of large canines and more oval shape

Boxcar shape
Large canine,
Gap (diastema)

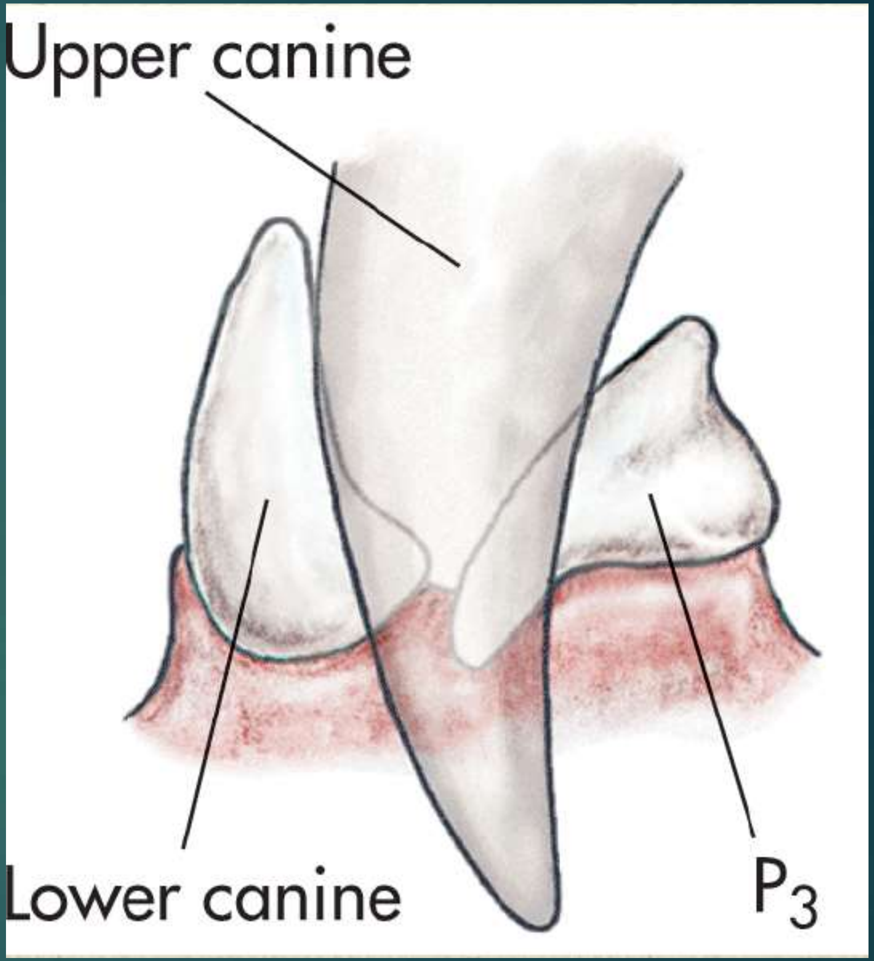
Comparison of Chimp (left), *A. afarensis* (middle), and human (right)

Parabolic
No gap

Dentition



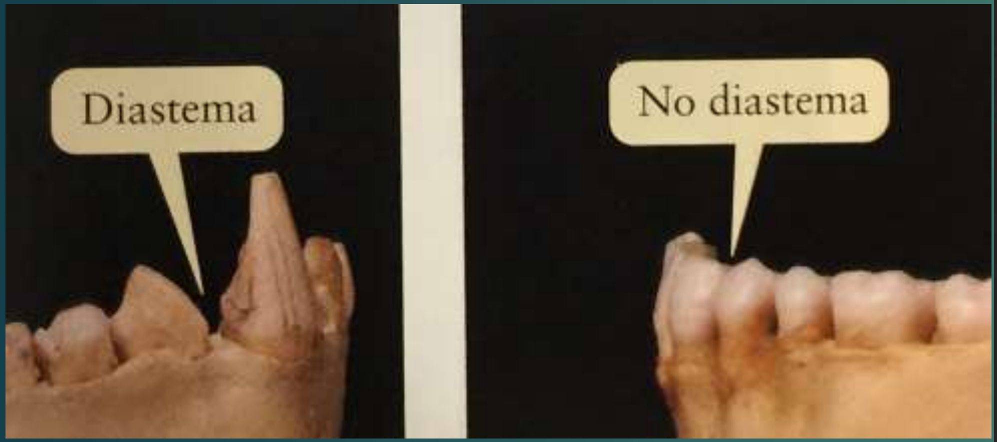
Chimp: diastema and the honing facet on LP3

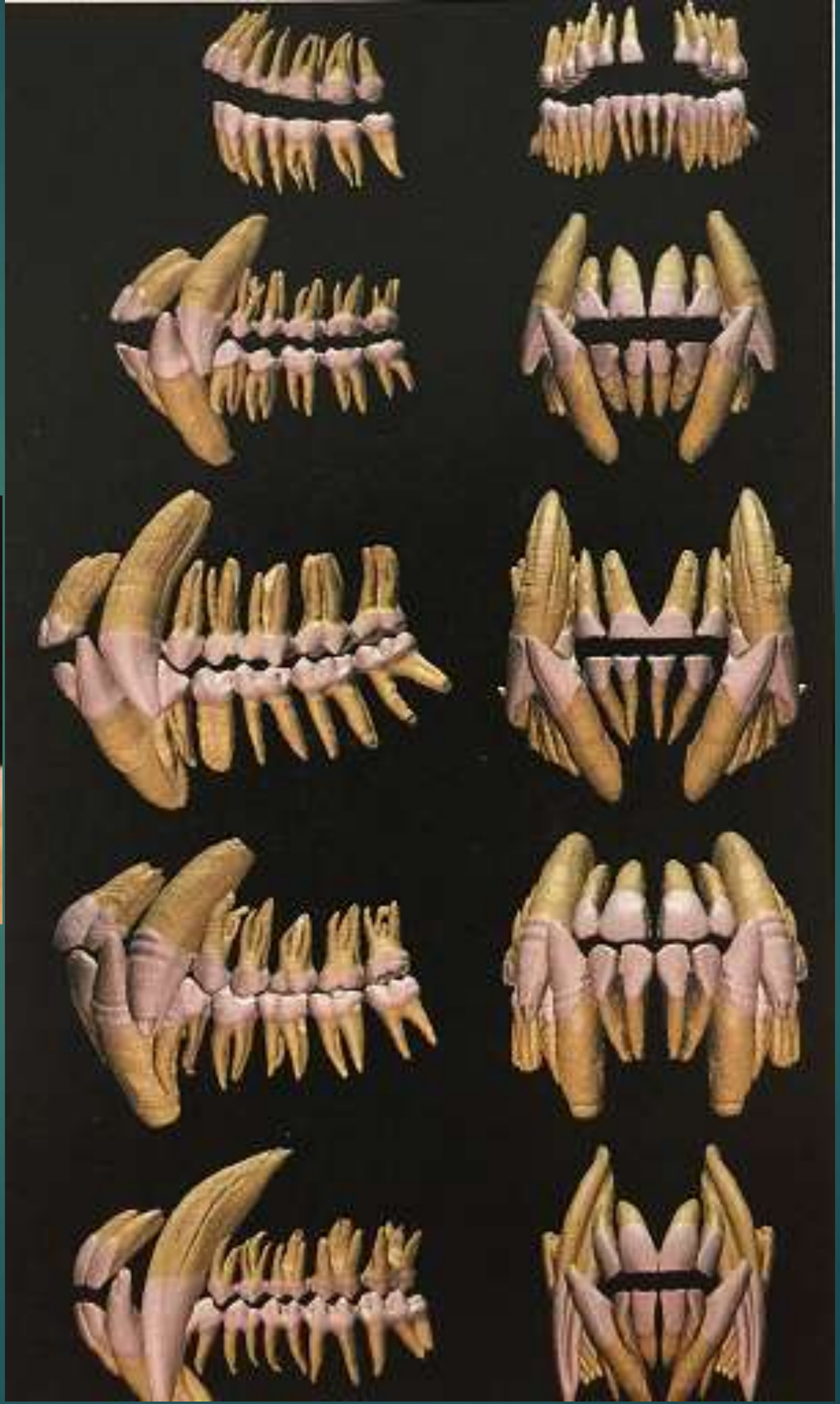


- Human: deciduous (infant) teeth: 212/212; adult = 2123/2123. Both childhood molars are replaced by adult premolars.
- Adult total is double the formula = 32.
- Dental **formula** 2.1.2.3 for upper **teeth** indicates 2 incisors, 1 canine, 2 premolars, and 3 molars on one side of the upper mouth.

C/P3 honing complex disappears as anterior teeth reduce in size

Dentition



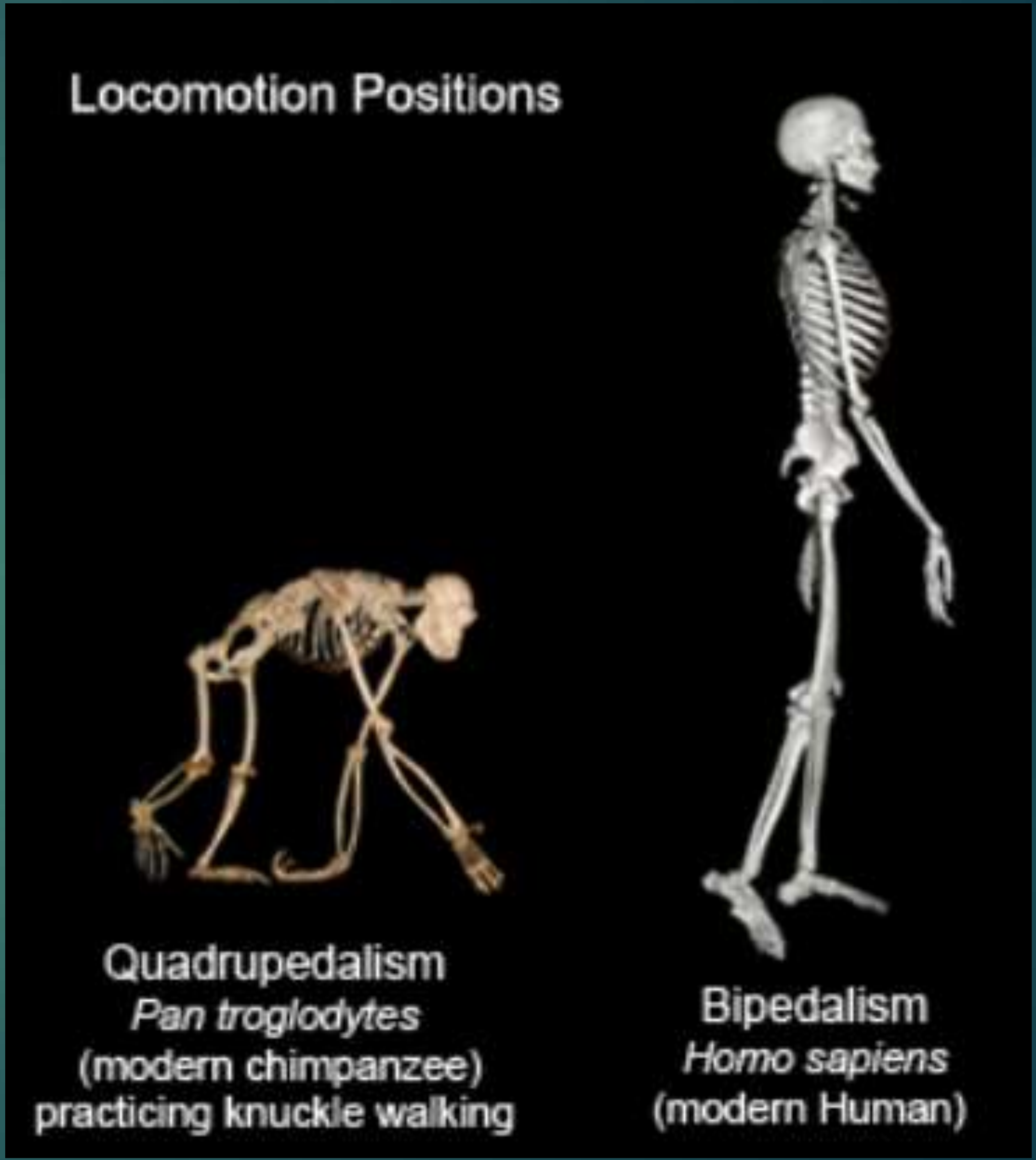


- Human
- Chimp
- Gorilla
- Orangutan
- Baboon

Changes for bipedality

- Changes in skull & skeleton linked to upright walking; greater dependence on hind limbs for bipedality
- Forward shift in foramen magnum (spinal column hole)
- Head is better balanced on body with vertical trunk, wider hips, straighter knees, more stable foot

Knuckle walking vs bipedality



CHIMPANZEE

SKULL
Chimpanzees have smaller molars than gorillas, but their incisors are larger and broad to cope with their omnivorous diet. The upper part of the face is flatter, and their brow ridges are smaller than in gorillas.

PELVIS
The very long, narrow pelvis keeps the legs at the correct angle to the torso when knuckle-walking and climbing. It broadens only at the top, where the gluteus medius—a muscle aiding side-to-side stability—is attached.

WHOLE SKELETON
Chimpanzees occasionally walk upright, but their skeletons are not adapted for walking (or running) long distances on two legs as humans can. Like the other great apes, their thigh bones are roughly parallel rather than angled, which gives them a rocking gait when they do walk upright. The size of the calcaneus (heel bone) is related to the amount of time spent on the ground, so a chimpanzee's is smaller than a human's. The pelvis does not reach up to the rib cage, and this gives the body greater flexibility. A chimpanzee's arms are only a little longer than its legs; in bonobos, they are the same length.

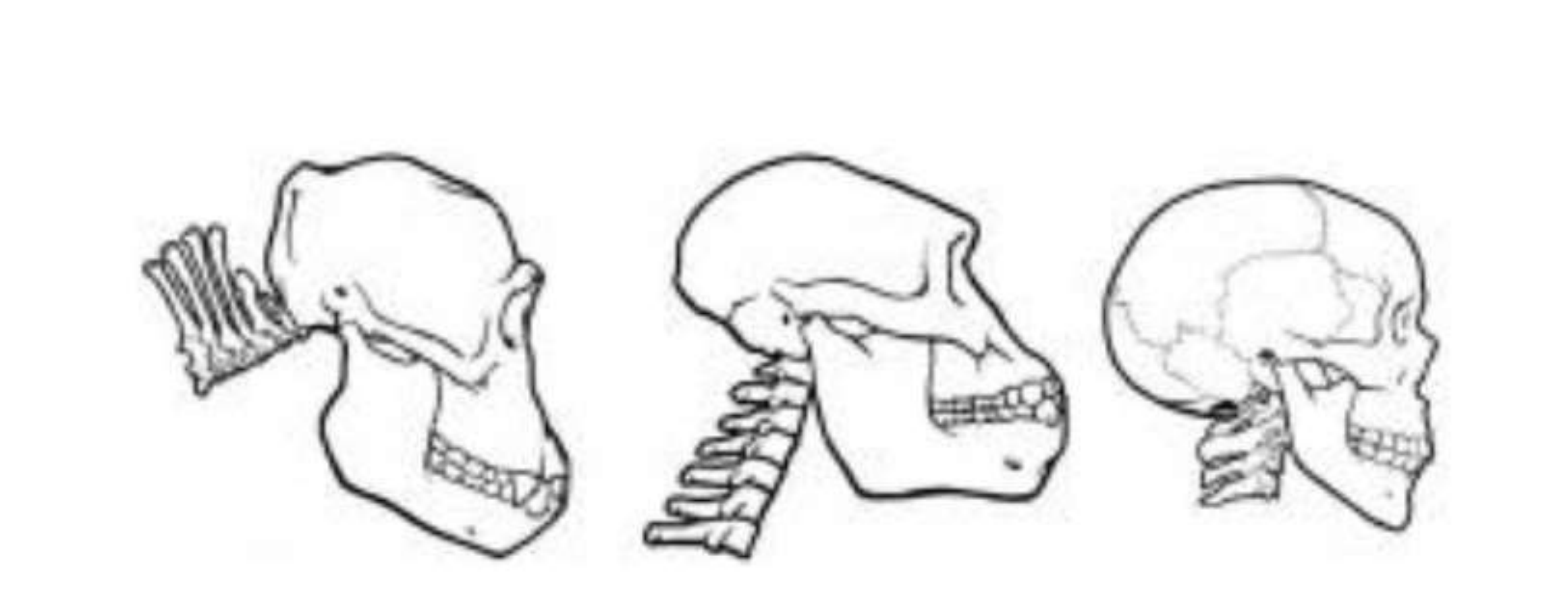
MODERN HUMAN

SKULL
A human skull is higher and more rounded than those of the great apes. The face is flat, and the jaws and teeth are much smaller, perhaps because cooked food requires less chewing.

PELVIS
The human pelvis is shorter and wider than those of the great apes. This centers the torso above the hips, and the deep hip sockets stabilize the hip joints so they can support the full body weight when walking upright.

WHOLE SKELETON
A human spine is S-shaped: it curves forward in the neck, backward in the chest, forward in the lumbar region, and backward in the sacrum. These curves keep the body balanced upright and allow the spine to absorb the shock of impact when walking or running. The thigh bones slant inward from the hips to the knees, placing the knees under the center of gravity.

Walking Upright



Chimp　　Lucy　　Human

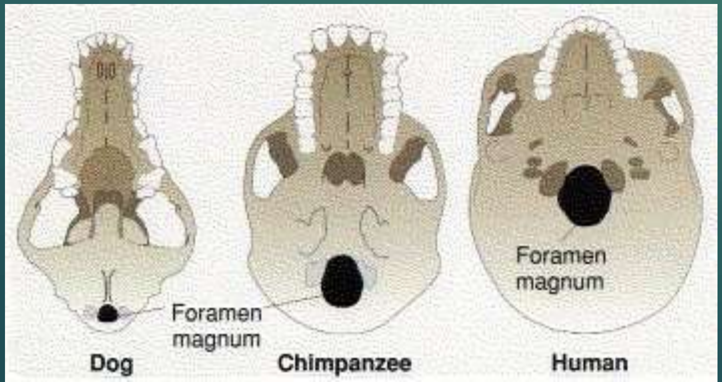
1. Chimpanzee 2. *Australopithecus africanus* 3. *Pithecanthropus erectus* 4. *Homo sapiens*

Foramen Magnum, Spinal Cord

Foramen magnum: Ape vs. hominin

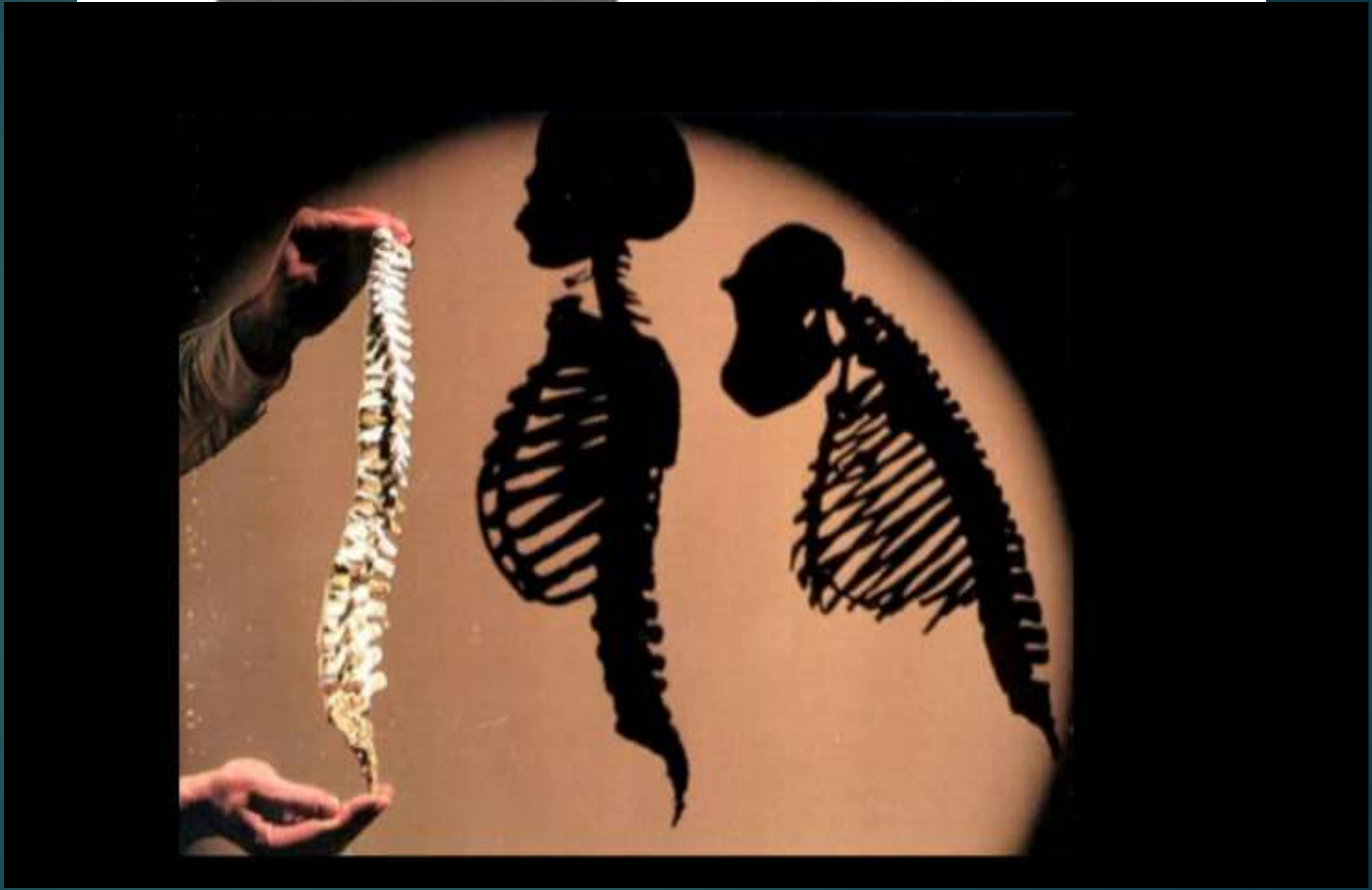
Modern human

In the back

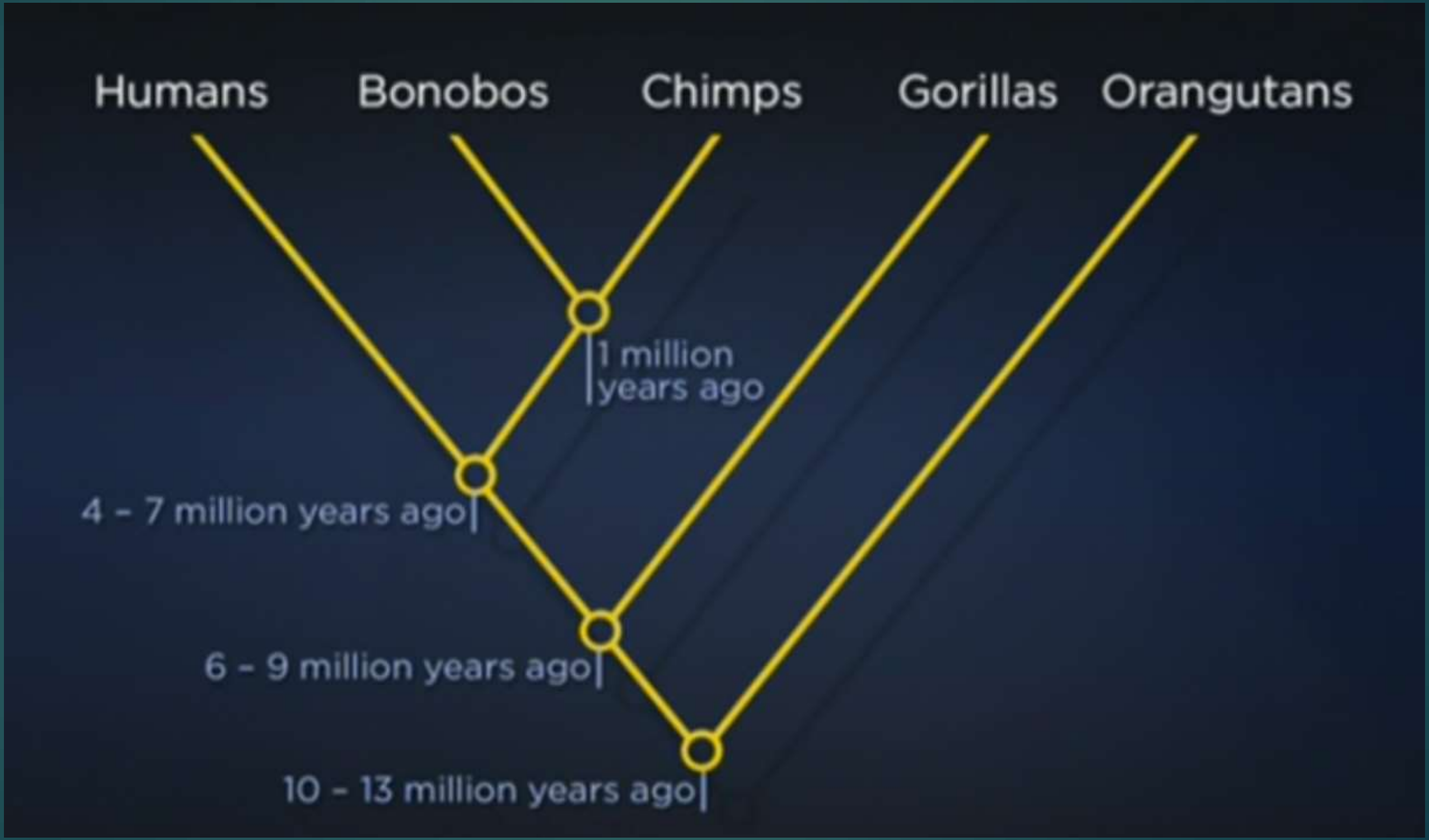


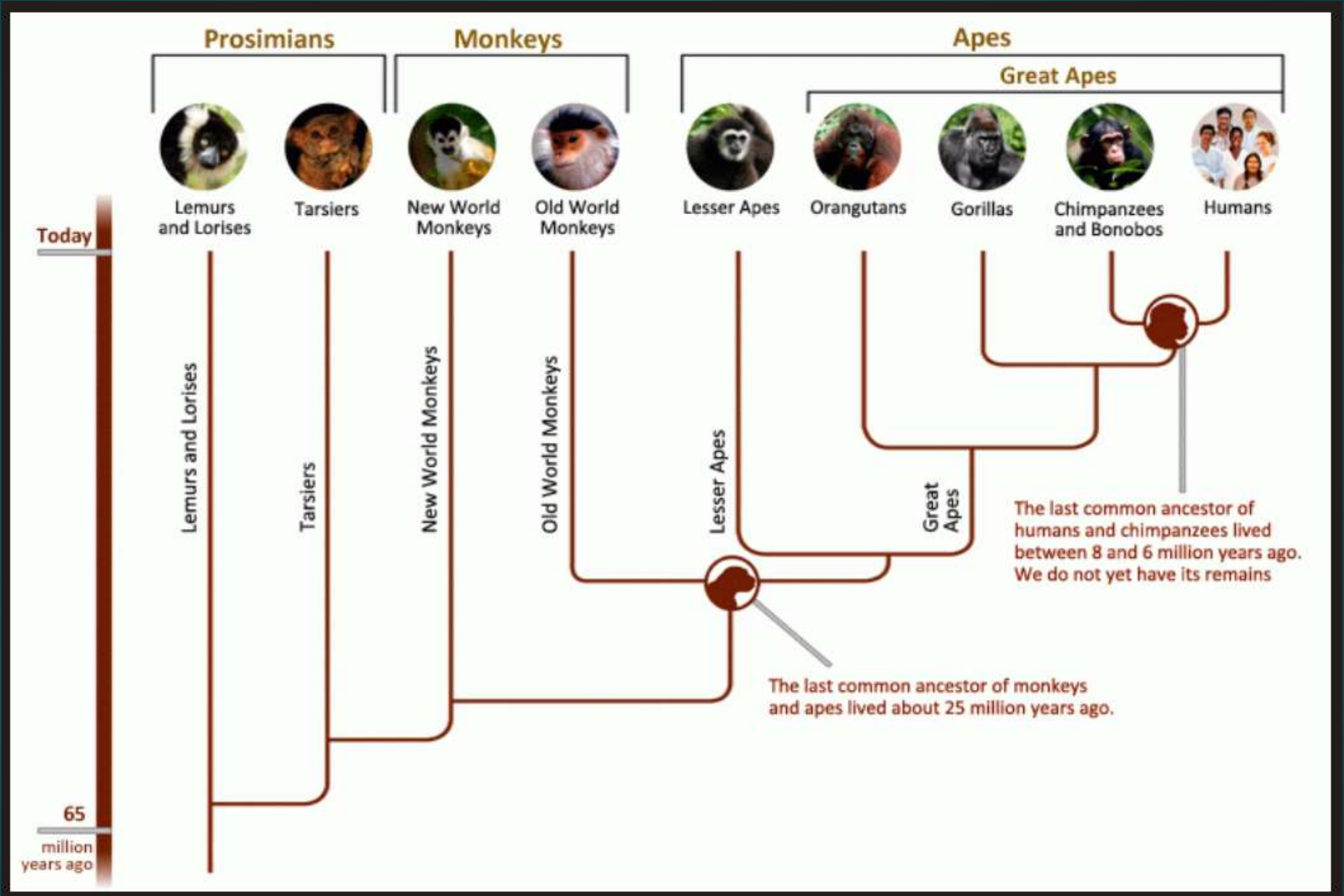
More forward

Curved Spine



Correct genetic relationships and times of divergence




Prosimians
Monkeys
Apes
Great Apes
Lemurs and Lorises
Tarsiers
New World Monkeys
Old World Monkeys
Lesser Apes
Orangutans
Gorillas
Chimpanzees and Bonobos
Humans
Today
65
million years ago
Lemurs and Lorises
Tarsiers
New World Monkeys
Old World Monkeys
Lesser Apes
Great Apes
The last common ancestor of humans and chimpanzees lived between 8 and 6 million years ago. We do not yet have its remains
The last common ancestor of monkeys and apes lived about 25 million years ago.

Human Migrations: Profoundly interrelated Species

- Out of Africa: Latest 2016 *Nature*: all non-Africans today trace their ancestry to a single population emerging from Africa between 50,000 and 80,000 years ago. All MH DNA is African by origin; all descend from Mitochondrial Eve circa 180 Ka

- MH originated in Africa circa 500-300 Ka

- MHs are 99.9% identical

- 2 humans on separate continents are closer genetically, than 2 chimps on opposite side of an African river in same jungle (100 chimps there are more diverse than all 7 B MHs)

- Genetic diversity in non-African MHs is incredibly low; of 14 "ancestral clusters" for all of humanity, 9 of those clusters are in Africa (due to longest time to accrue mutations)

Humans and Chimpanzees

- Morphologically humans and apes are distinct from one another.
  - Based on molecular data, enzymes and sequences of mitochondrial and genomic DNA, humans and apes, in particular, chimpanzees, are quite similar.
  - Humans and chimpanzees share 98.8 % of their DNA (35 million letter differences)
  - Humans and Chimpanzees share the same ABO Blood Types; 33% of coding ; chimps do not get malaria or Alzheimer's
  - Bonobos and chimpanzees share 99.6% of their DNA, having split into two groups 1 million years ago; Bonobos share about 98.7% of their DNA with humans

Humans and Chimps

- Bonobos share about 98.7% of their DNA with humans. 1.6%, is shared with only the bonobo, but not chimpanzees. And we share about the same amount of our DNA with only chimps, but not bonobos; implies LCA had 27,000 breeding individuals.
- Comparison of the entire genome, however, indicates that segments of DNA have also been deleted, duplicated over and over, or inserted from one part of the genome into another. When these differences are counted, there is an additional 4 to 5% distinction between the human and chimpanzee genomes. Humans have acquired 689 new gene duplicates & lost 86 since split; chimps have lost 789
- Gene expression may be quite different; genome level variation in the number, function and expression of genes rather than DNA sequence changes in shared genes

Humans and Chimps

- Was the common ancestor to humans and chimpanzees separated by the Great Rift Valley in Africa, leading to allopatric (geographic separation) speciation?

- The theory that humans probably evolved in response to changing environmental conditions as forests gave way to savannas is still controversial.

- According to the Chimpanzee Genome Project, both human (*Ardipithecus*, *Australopithecus* and *Homo*) and chimpanzee (*Pan troglodytes* and *Pan paniscus*) lineages diverged from a common ancestor about 7-8 million years ago, if we assume a constant rate of mutation.

Adrienne Zihlman, 1978: Pygmy chimpanzee hypothesis

- A. Zihlman's 'pygmy chimpanzee hypothesis' (Zihlman *et al*. 1978): proposed that the Bonobo *Pan paniscus* is "the best prototype for the common ancestor of humans and [other] African apes"
- Zihlman proposes that LCA was a knucklewalker and that hominins then lost knucklewalking trait via upright bipedality.
- 2019: LCA of modern apes expanded from Congo basin: gorillas went west to forests, circa 6 Ma; Australopiths went East to mosaic savannah, circa 4.5 Ma, bipedality allowing greater foraging distances; Chimpanzees went West; competition with gorillas altered their physiology; then went East and South; Bonobos & Pan troglodytes separate at 1 Ma

Zihlman et al. 1978; Zihlman 1984, p. 39.

Evidence for Bipedalism

- Foramen magnum that points down & is in forward position (the foramen magnum is the opening in the skull through which the spinal cord passes)

- Curved lumbar (lower) spine

- Lengthened lower limbs

- Femur that slants inward toward the knee; Bicondylar angle of femur (knock-kneed); Tibia go straight down to feet

- Neck grove below femur head, held ligament attachment in bipedals, which pushed leg toward middle of body; grove depth increases longer one is bipedal

- Strong, robust talus (ankle bone)

Evidence of Bipedalism 2

- Strong big toe that is in line with the other toes, making it supportive and nonopposable
- Extensible knee joint
- Complex two-way arch system in the foot: Side to side / front to back
- Shape of pelvic girdle; Chimps walk with a lot of lateral movement from hips; humans have almost no hip movement or lateral movement as they walk because of type of pelvis
- Upper body weight on hips
- Type of footprint (heel strike to toe)

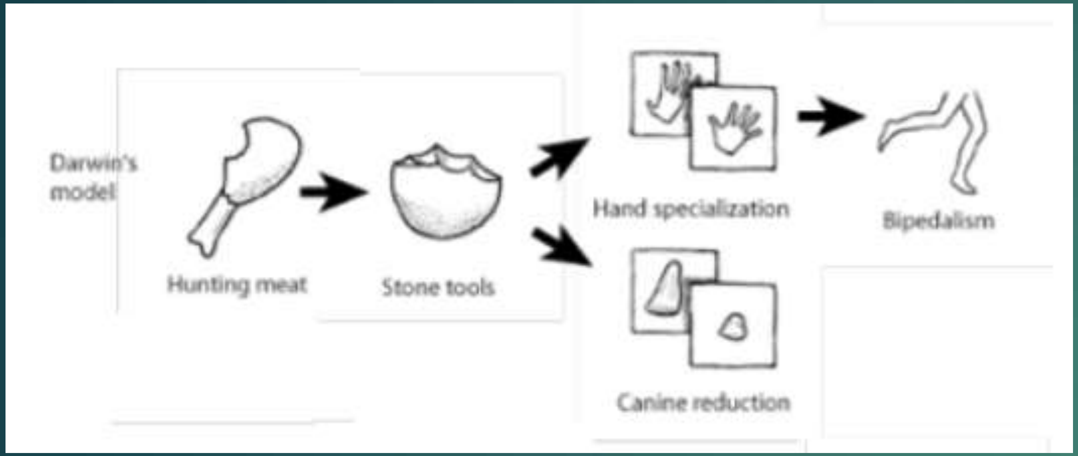
Why bipedal?

- If you asked a roomful of anthropologists why we walk on two legs, you probably would not get the same answer from any two of them.

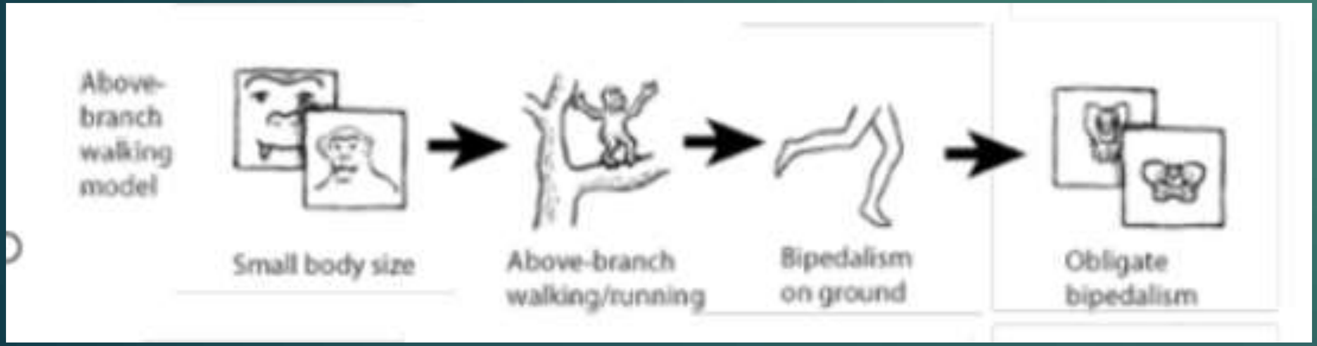
  Specialists cite everything from changing landscapes to needing to keep cool to heightening sexual attraction - generally agreeing only on one point: that everyone else's hypothesis is wrong.

  Let's take a look at some of these hypotheses.

Theories of origins of bipedality

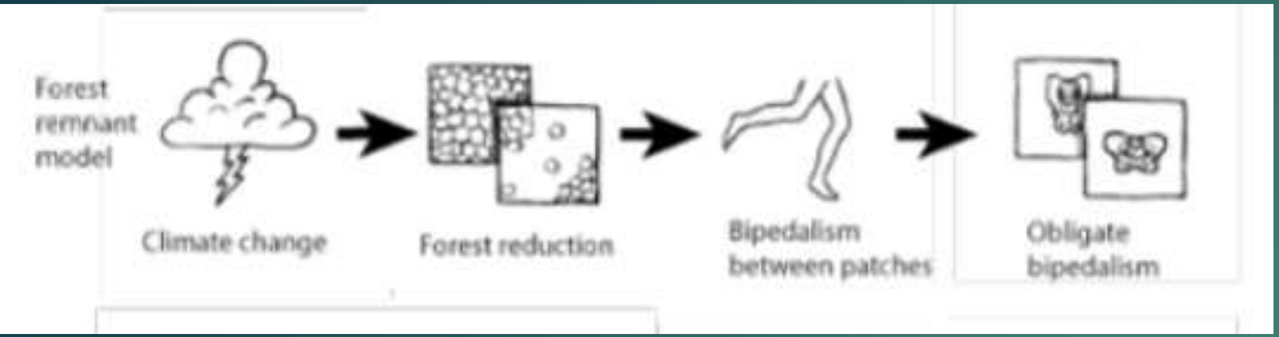


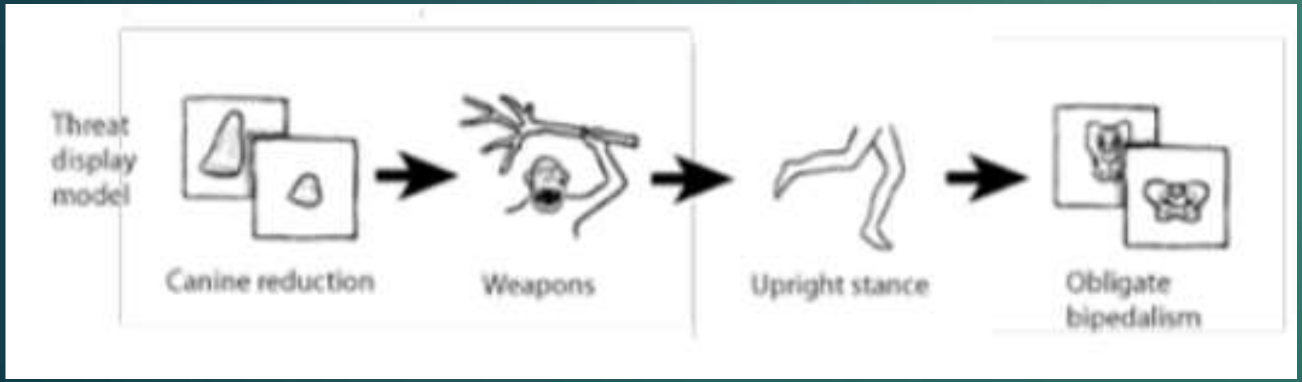
Darwin's theory: hunting meat → stone tools; required hand specialization; lead to canine reduction →→ bipedality
Wrong: bipedal long before stone tools



Above branch walking model: small body size → above branch walking/running → obligate bipedalism

Theories of origins of bipedality 2





Forest remnant model: climate change → forest reductions → bipedal between patches → obligate bipedalism
Wrong: savanna model wrong

Threat display model: canine reduction → weapons → upright stance → obligate bipedalism

Other Theories

Upright reaching

Long distance walking

Attracting Mates;

Male provisioning

Carrying

Keeping Cool: thermoregulation

Holding Weapons and Tools

Visual surveillance

ALL these models may have played a role in the emergence of habitual upright bipedalism

Advantages of Bipedalism

- Upright walking offers these advantages:
  - It frees the hands, enabling humans to carry and manipulate objects such as tools.
  - It increases the energy efficiency and endurance of humans.
  - It is easier to see potential predators and food sources from farther away.
  - It increases one’s size to better dominate over others.
  - The impact of the sun’s heat is lessened.

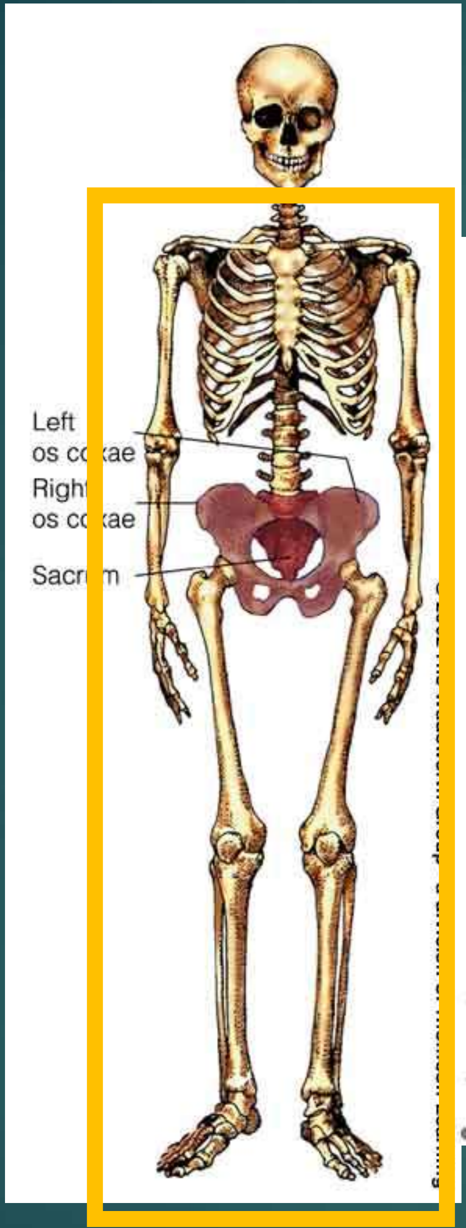
Disadvantages of Bipedalism

- Bipedalism is the direct cause of the following problems:
- Major spinal and lower limb problems, frequently disabling and incapacitating. The spine is the first organ in our body to deteriorate due to wear and tear, and 80% of people will have back problems sometime in their life. Ninety percent of people will have significant hip, knee, or foot problems during their lives.
- Vascular disorders, such as varicose veins, phlebitis, and hemorrhoids—usually disabling, not usually fatal
- Inguinal hernias—usually disabling, occasionally fatal
- High blood pressure—sometimes disabling, occasionally fatal
- Major obstetrical problems—sometimes fatal. The evolution of bipedalism produced a pelvis for upright walking which resulted in an obstructive birth canal for the infant

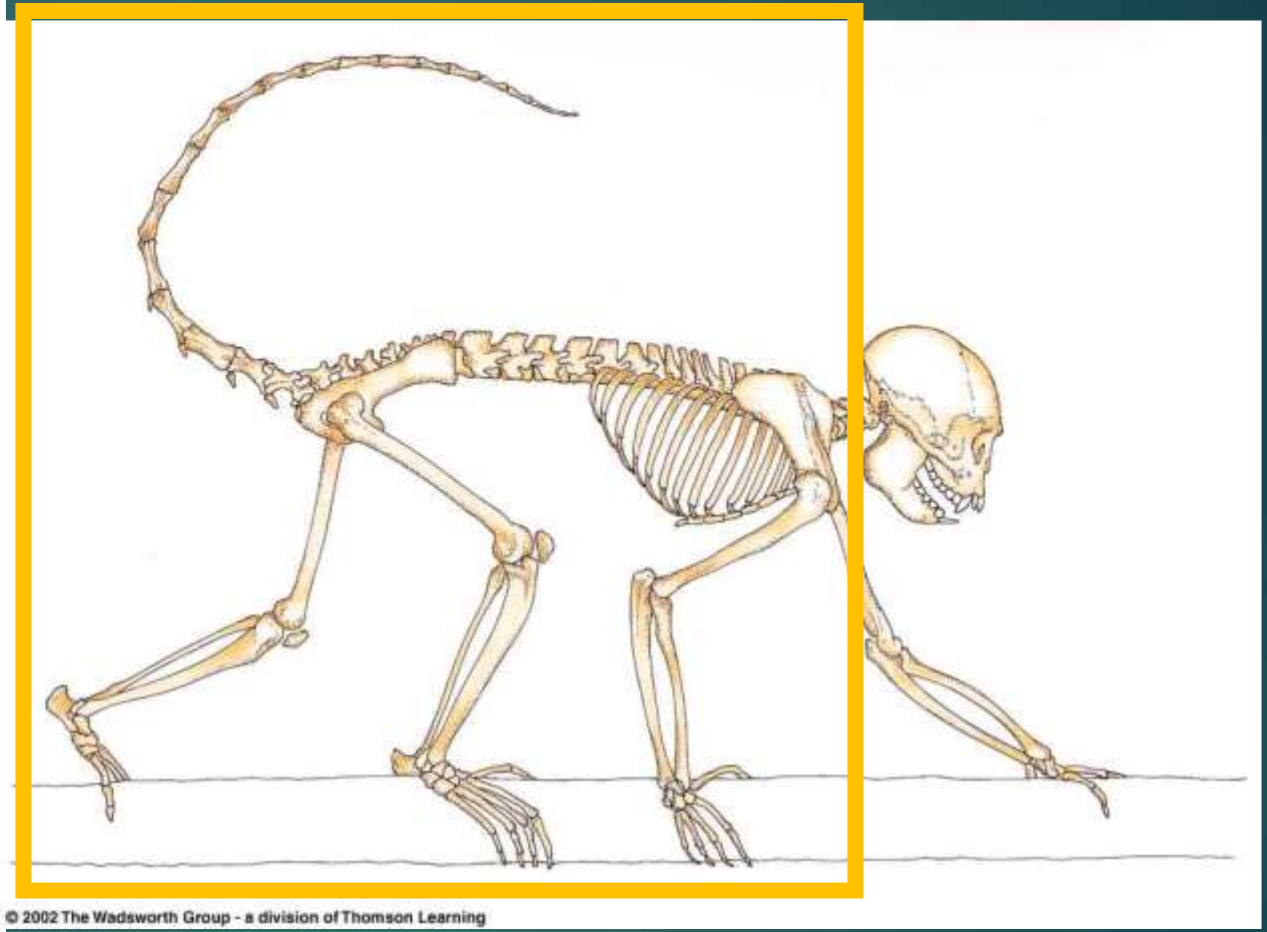
Postcranial changes due to bipedalism

- Arm swinging and erect (bipedal) or semi-erect walking resulted in a number of postcranial changes
- Postcranial =
  - below the head (with bipeds)
  - behind the head (with quadrupeds)
- The ability to assume a fairly erect posture produced important changes

Postcrania

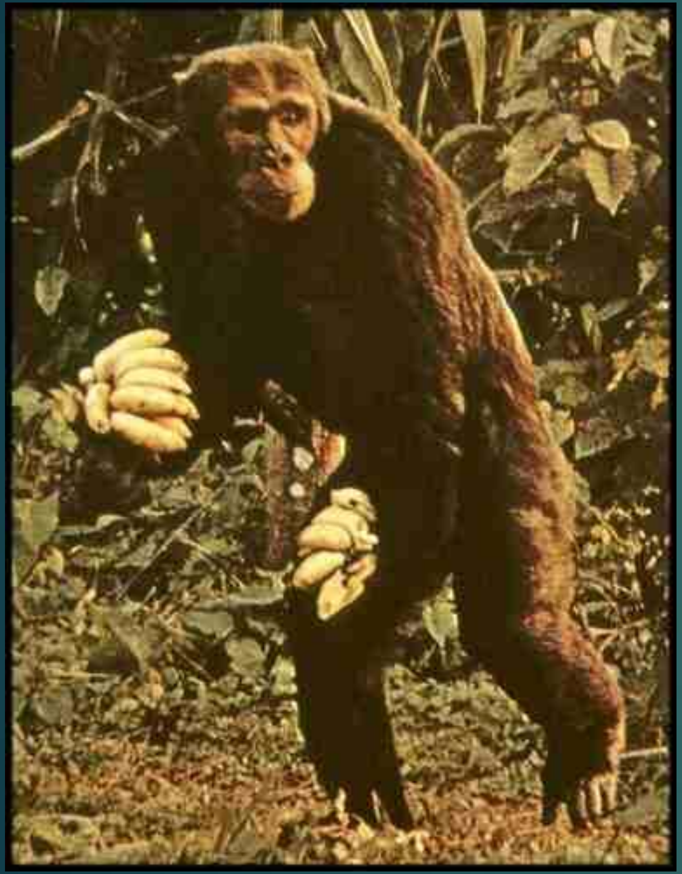


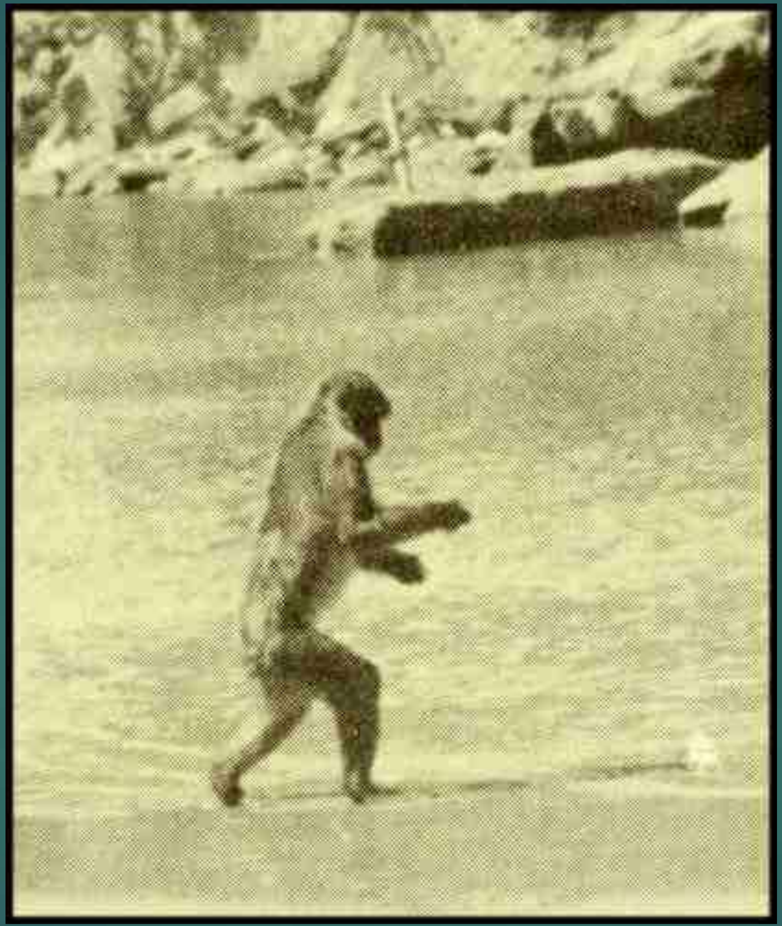
Modern human

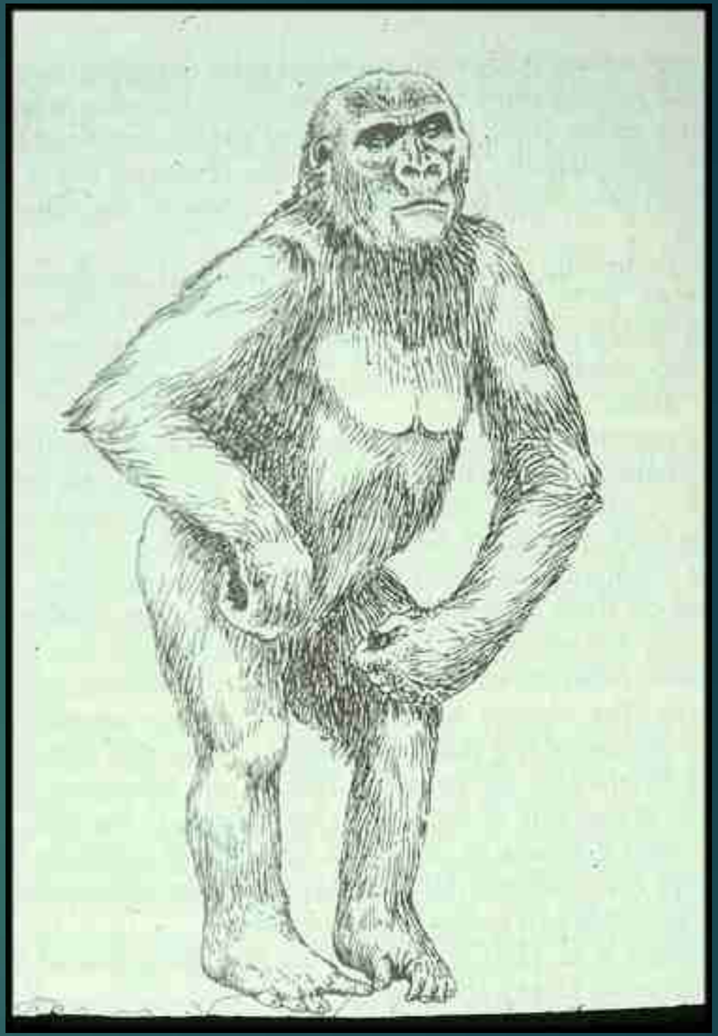


New World monkey

Understanding Physical Anthropology and Archaeology, 9th ed., pp. 200, 429, 121





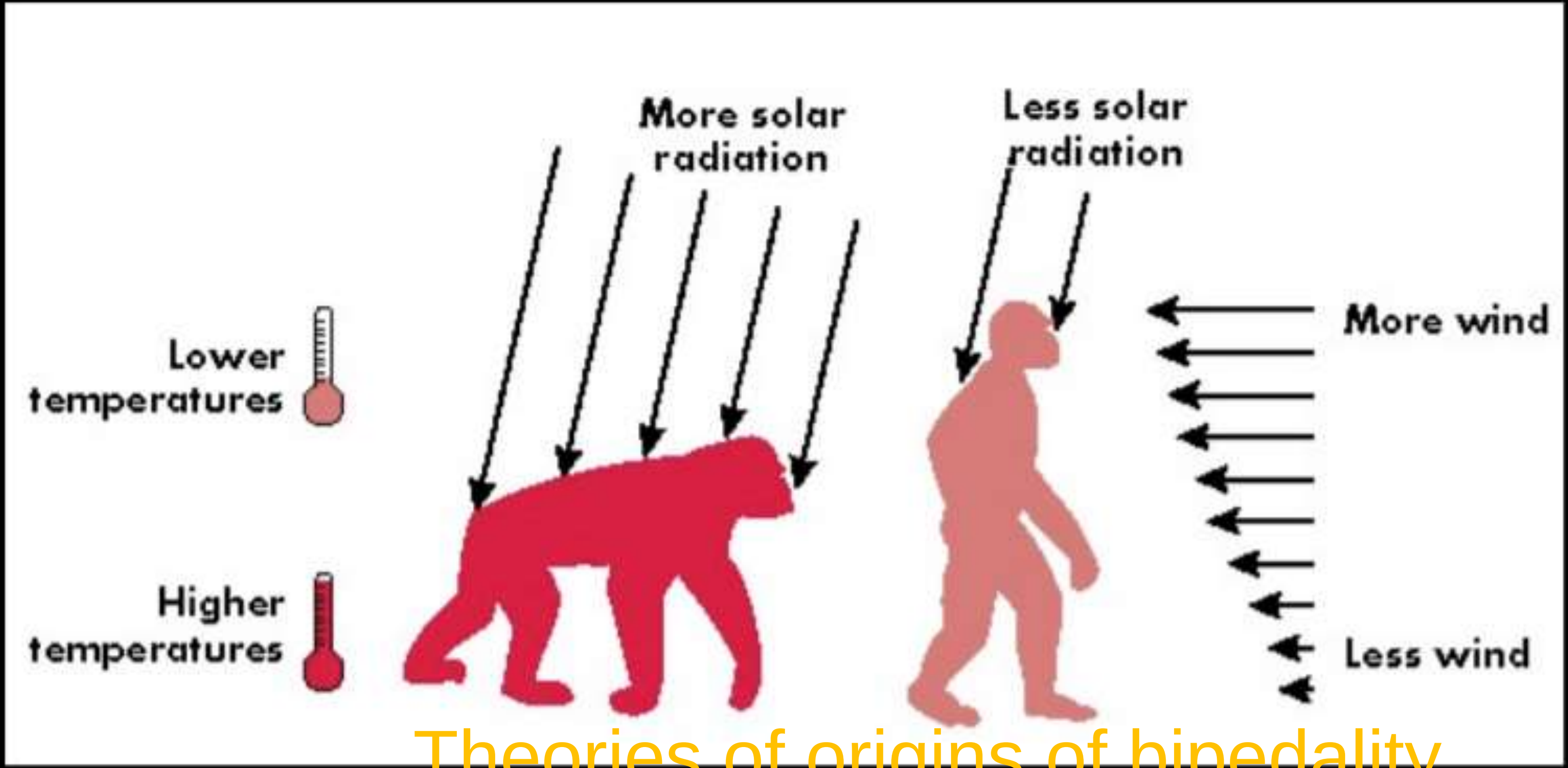


Chimpanzee and Gorilla:

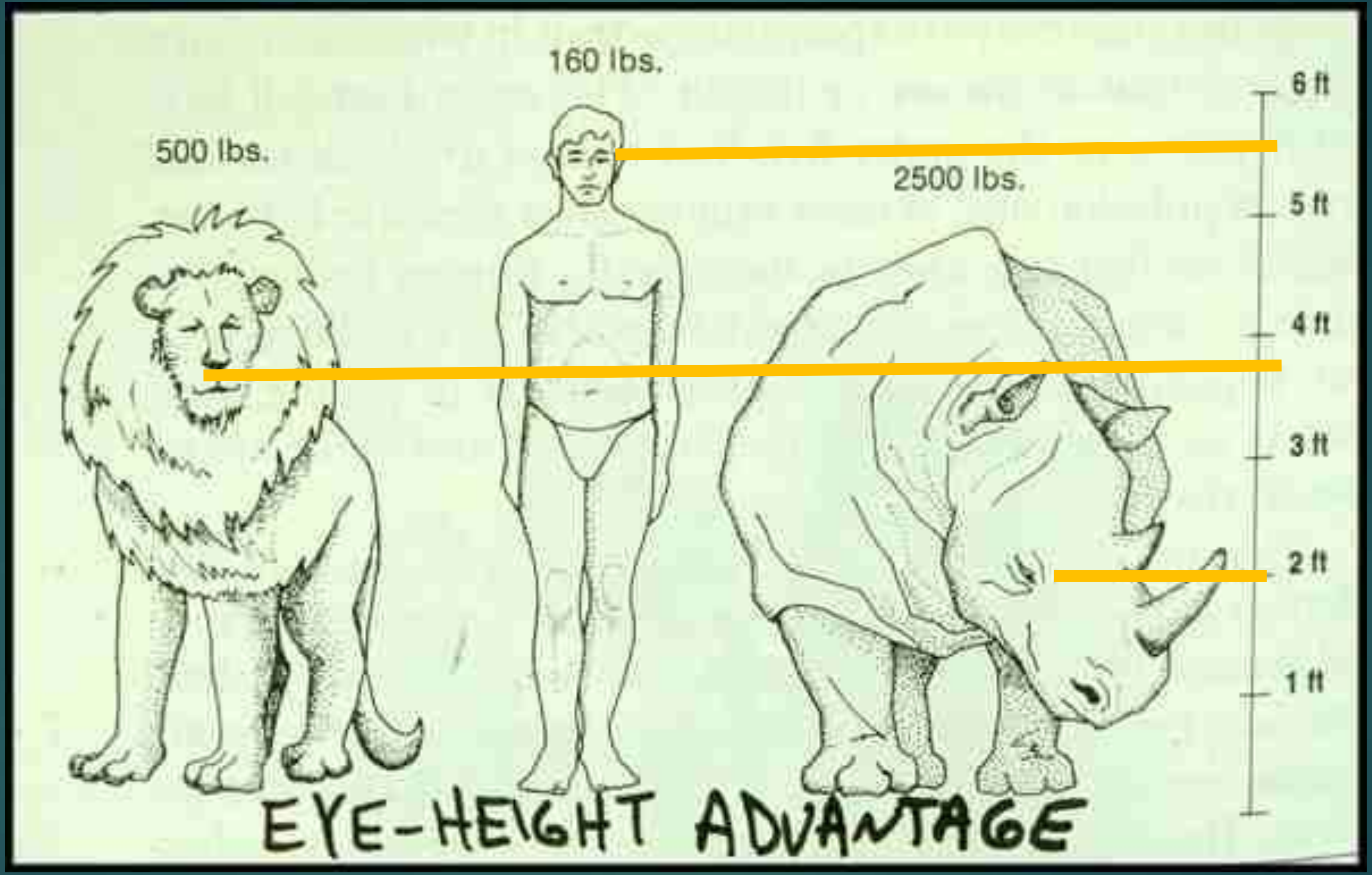
"Facultative" (i.e. optional) or "obligate" (the animal has no reasonable alternative) bipedalism.

The Primates, Time-Life (1974) p. 71

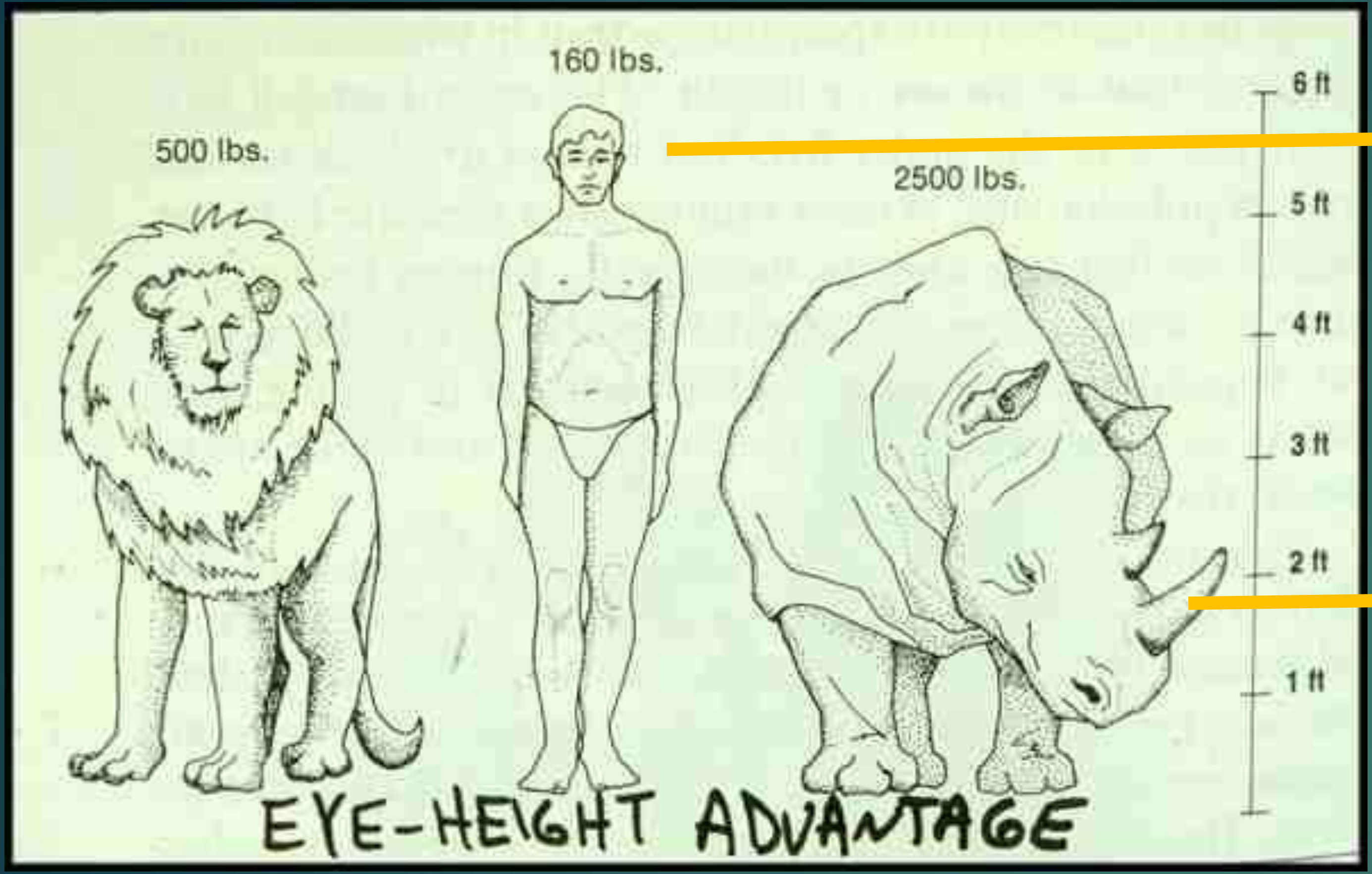
Thermoregulation

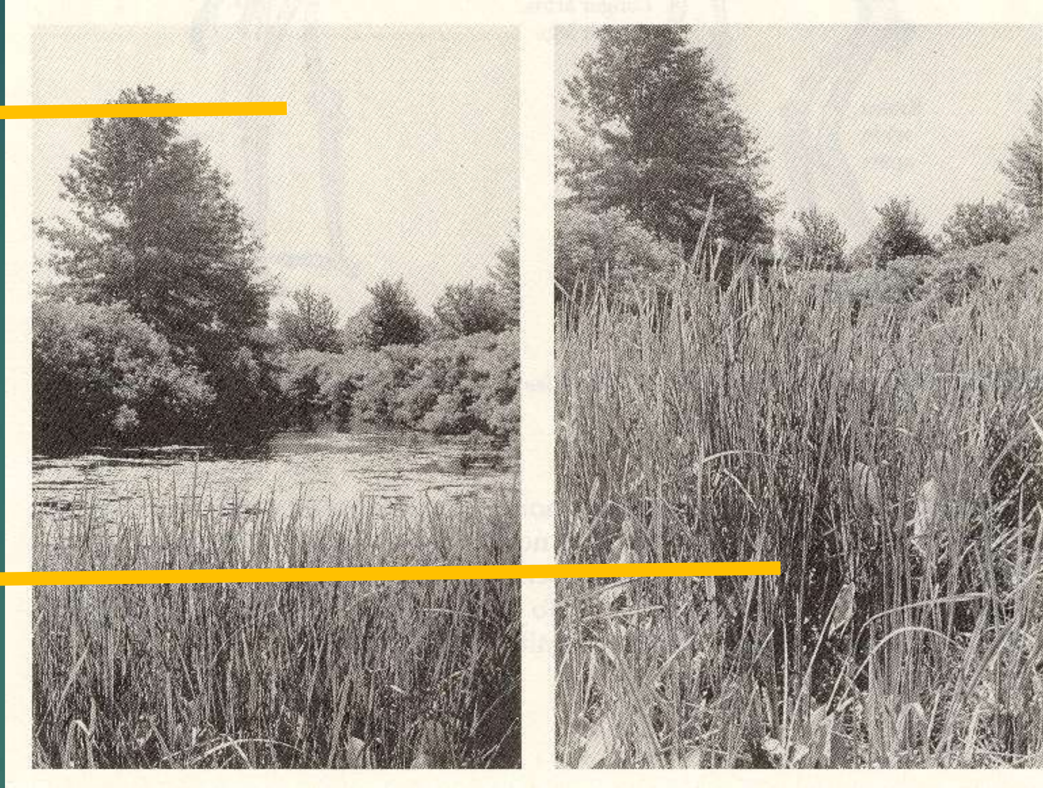


Theories of origins of bipedality



Visual Surveillance





Height of Eye Level gives advantage

Factor	Speculated Influence	Comments
Carrying (objects, tools, weapons, infants)	Upright posture freed the arms to carry various objects (including offspring)	Charles Darwin emphasized this view, particularly relating to tools and weapons; however, evidence of stone tools is found much later in record than first evidence of bipedalism
Hunting	As correlated with above theory, carrying weapons made hunting more efficient; in addition, long-distance walking may have been more energetically efficient (see below)	Systematic hunting is now thought not to have been practiced until after the origin of bipedal hominids
Seed and nut gathering	Feeding on seeds and nuts occurred while standing upright	Model initially drawn from analogy with gelada baboons (see text)
Feeding from bushes	Upright posture provided access to seeds, berries, etc., in lower branches; analogous to adaptation seen in some specialized antelopes	Climbing adaptation already existed as prior ancestral trait in earliest hominids (i.e., bush and tree feeding already was established prior to bipedal adaptation)
Visual surveillance	Standing up provided better view of surrounding countryside (view of potential predators as well as other group members)	Behavior seen occasionally in terrestrial primates (e.g., baboons); probably a contributing factor, but unlikely as "prime mover"
Long-distance walking	Covering long distances was more efficient for a biped than for a quadruped (during hunting or foraging); mechanical reconstructions show that bipedal walking is less energetically costly than quadrupedalism (this is not the case for bipedal *running*)	Same difficulties as with hunting explanation; long-distance foraging on ground also appears unlikely adaptation in *earliest* hominids
Male provisioning	Males carried back resources to dependent females and young	Monogamous bond suggested; however, most skeletal data appear to falsify this part of the hypothesis (see text)

Possible Factors Influencing the
Initial Evolution of Bipedal Locomotion in hominins.

Understanding Physical Anthropology and Archaeology, 8th ed., p. 217

Bipedalism

- Carrying: objects, tools, weapons, infants - upright posture freed the arms to carry various objects
  - Darwin emphasized this, esp. related to tools & weapons; Initially evidence of stone tool use was found much later than first evidence of bipedalism; until stone tools found at 3.3 Ma
- Hunting: carrying weapons made hunting more efficient; long distancing walking may have been more energetically efficient
  - Systematic hunting probably did not occur until after origin of bipedal hominins
- Seed & nut gathering – occurred while standing upright
  - Modeled after gelada baboons

Bipedalism theories

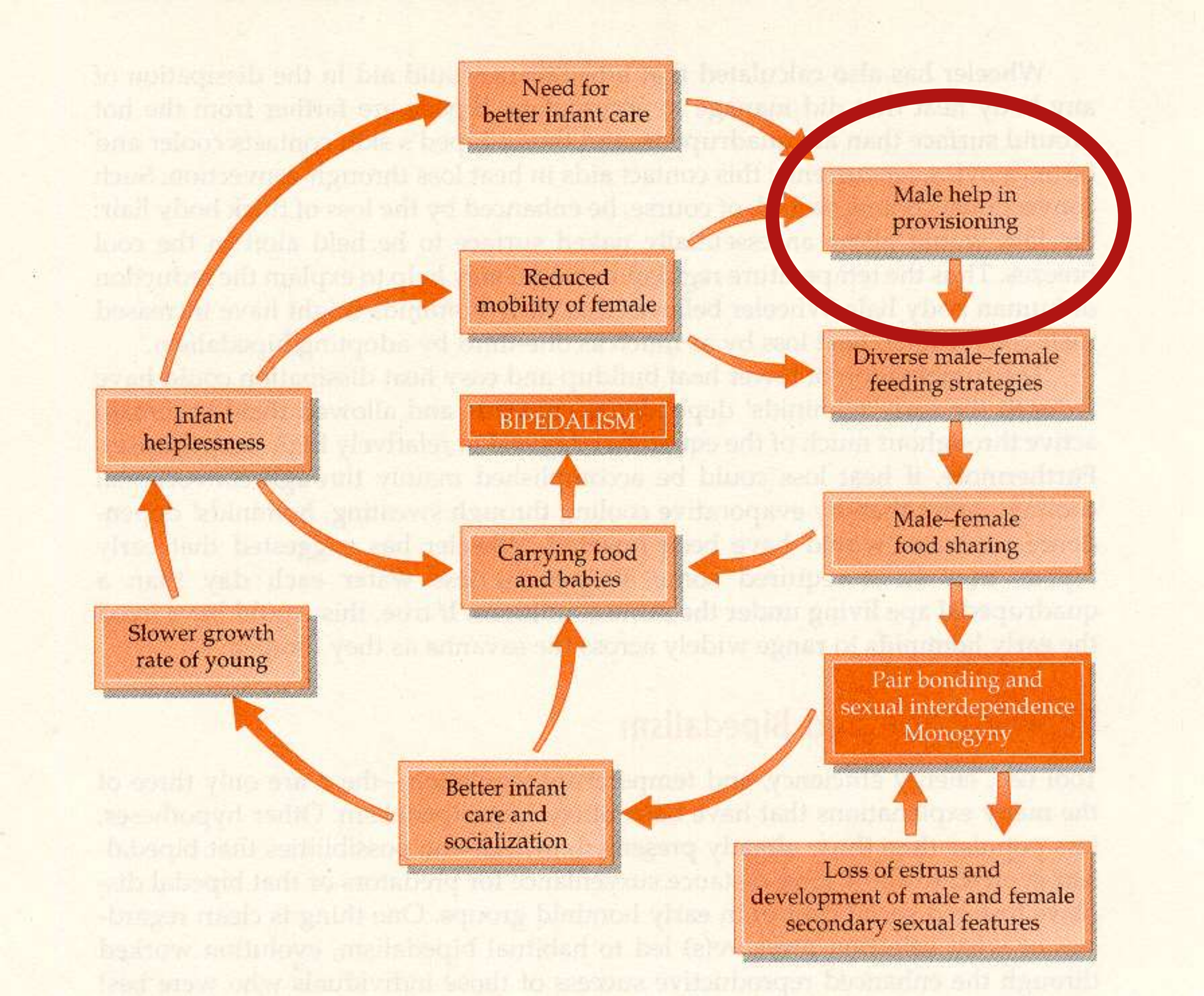
- Feeding from bushes: upright posture provided access to seeds, berries, etc. in lower branches
  - Climbing adaptation existed as prior ancestral trait in earliest hominins
- Visual surveillance: standing up provided better view of surrounding area (including predators & other group members)
  - Behavior seen occasionally in terrestrial primates (baboons); probably a contributing factor, but unlikely a primary cause
- Long distance walking: Covering long distances was more efficient for a biped than for quadruped; Bipedal walking is less energetically costly than quadrupedalism (but not bipedal running)
  - Like hunting, long distance foraging on the ground is also an unlikely adaptation in earliest hominins
  - Originally thought that bipedalism evolved because hominins had to walk great distances on the savanna to get food; now savanna theory is controversial.

Bipedalism theories

- Male provisioning: males carried back resources to dependent females and young; Owen Lovejoy “provisioning hypothesis”
  - Monogamous bond suggested; most skeletal data falsifies this option (sexual dimorphism, unequal numbers of males/females, etc.)

- Thermoregulation: Keeping cool - Upright walking involves far less heat exposure than being quadruped

- Or may have been an arboreal forest adaptation before they left trees
- Huge analysis of theories: http://www.waterside-hypotheses.com/UploadedFiles/Wading%20Paper/Supporting%20Files/model/



Provisioning Hypothesis - Lovejoy

Humankind Emerging, 7th ed., p. 270

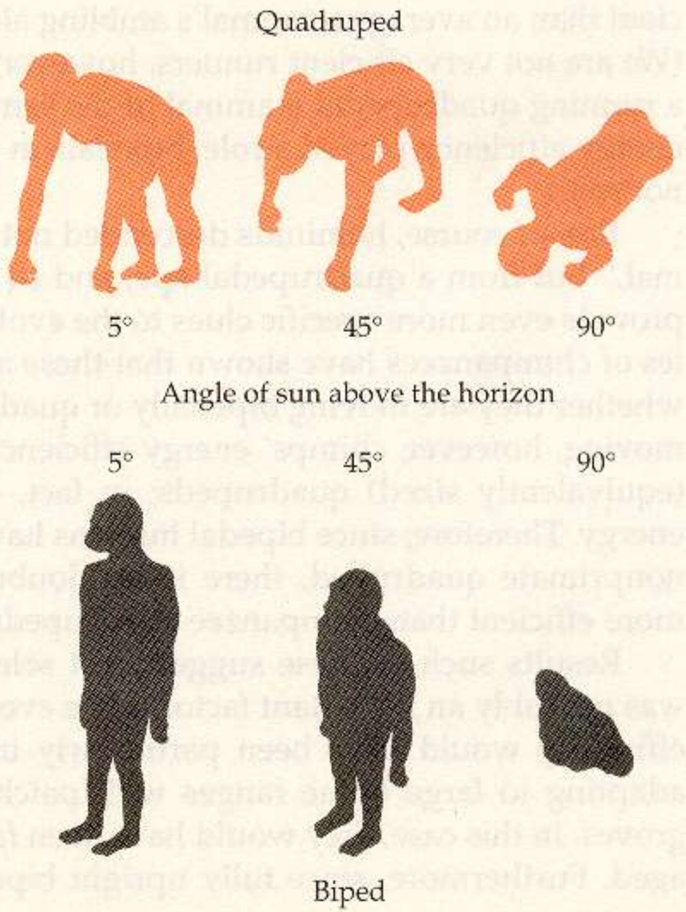
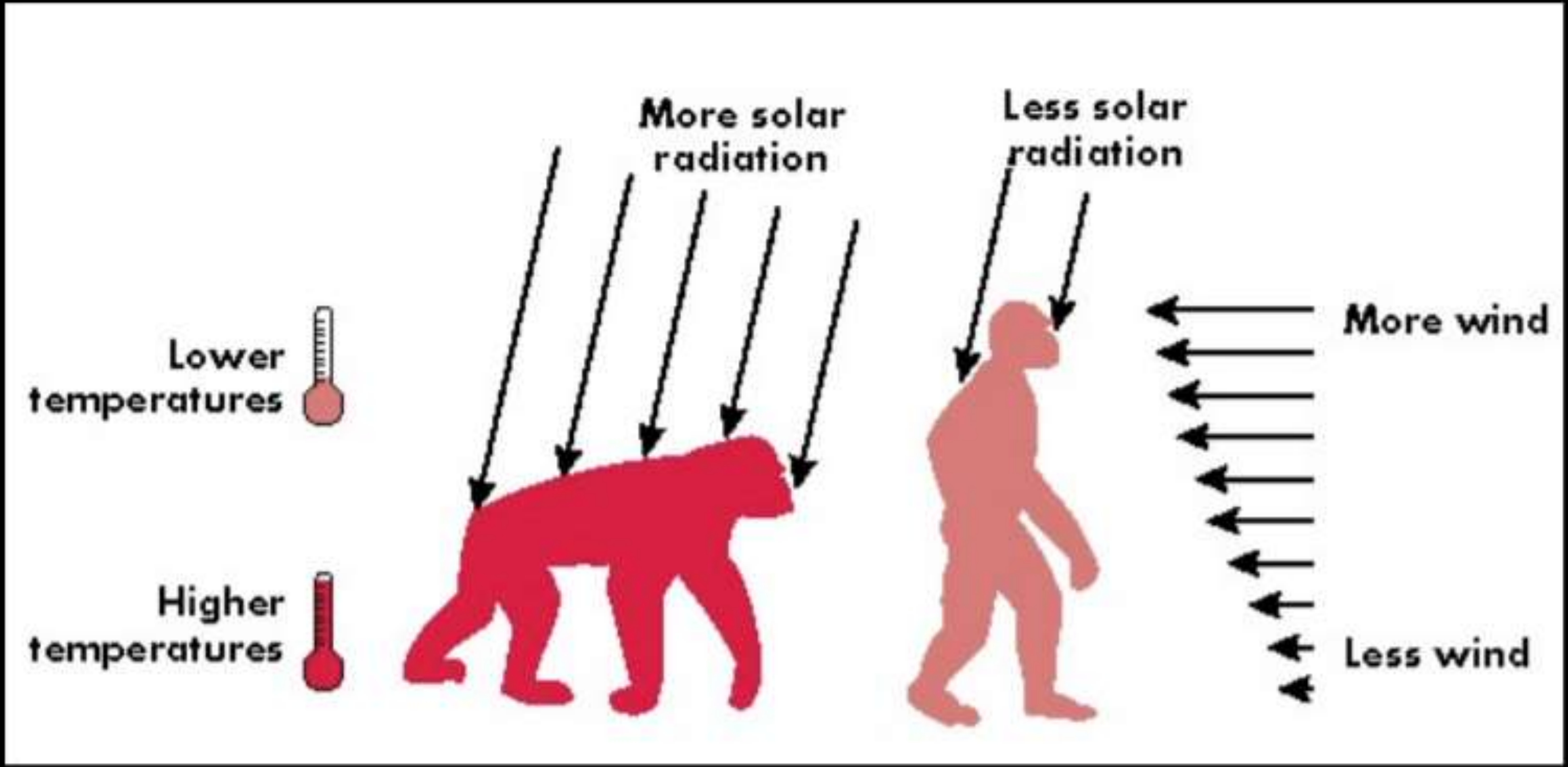


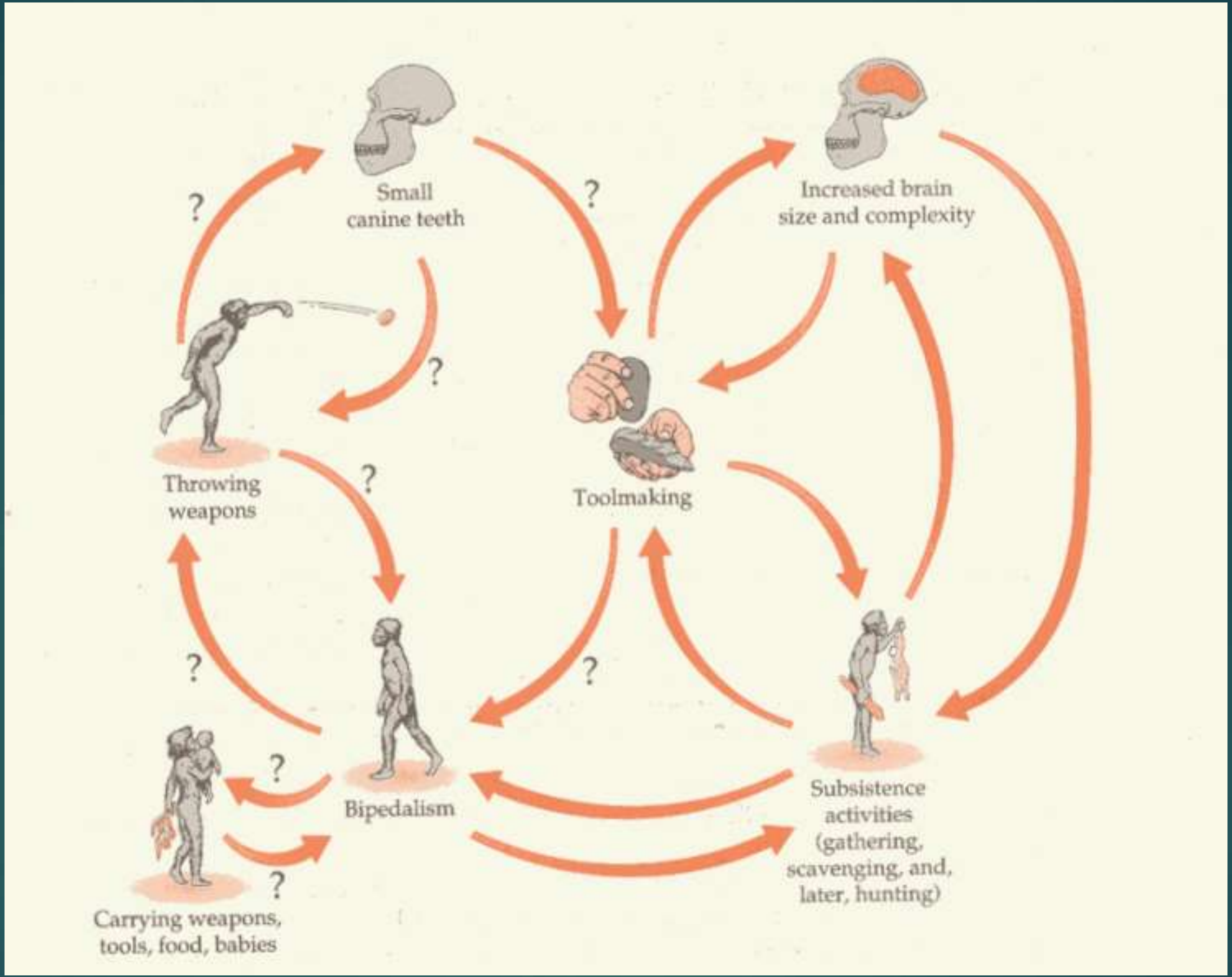
FIGURE 9–1 Models of hypothetical early hominids show how much body surface is exposed to direct solar radiation by quadrupeds (top) versus bipeds (bottom). From left to right, the sun is low on the horizon, 45 degrees above the horizon, and directly overhead. Note the small amount of body surface exposed by a biped at midday.

Body Surface and Solar Radiation.

Thermoregulation



Falk (1989) suggested that bipedalism also resulted in the development of a cooling mechanism for the brain.

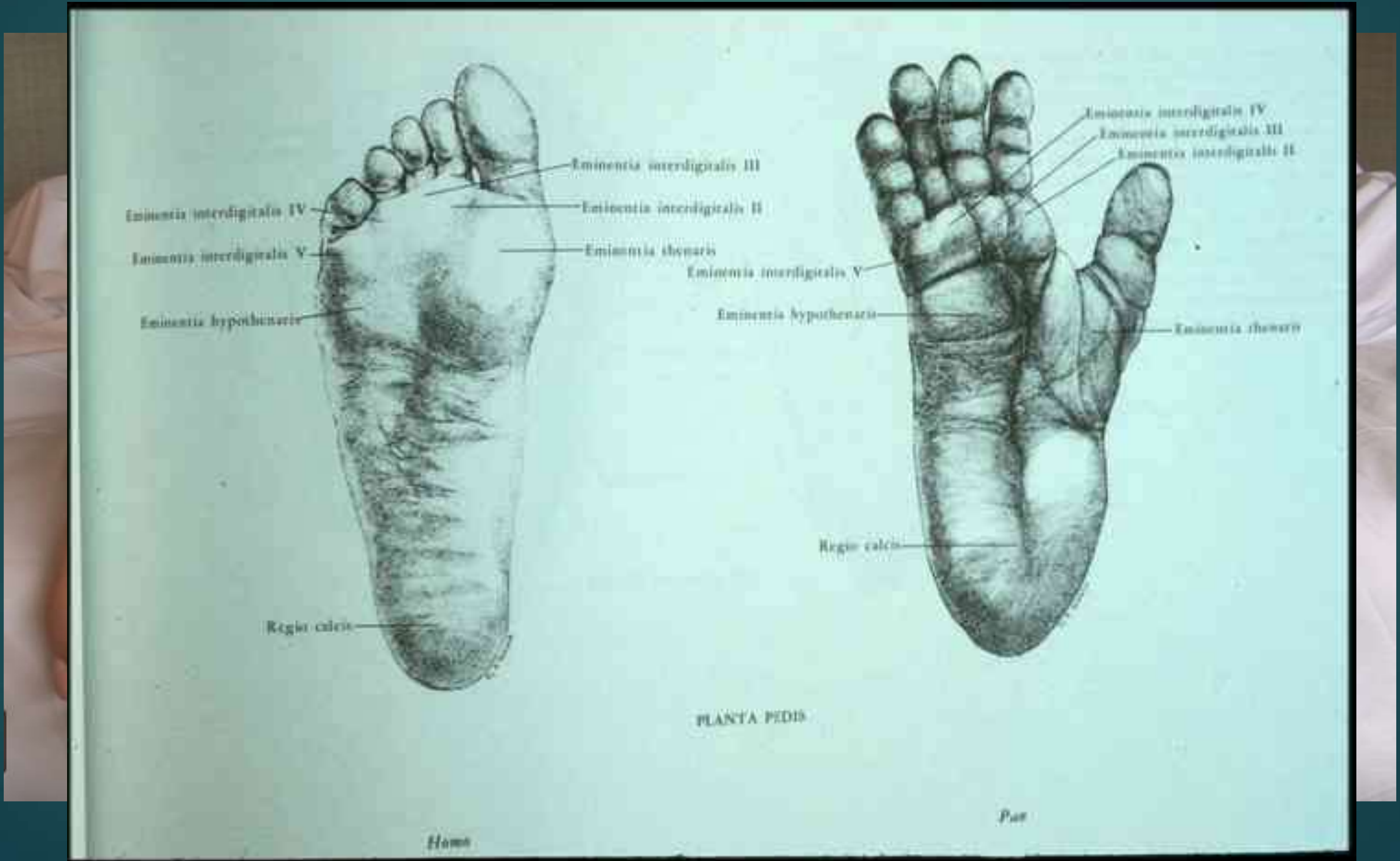


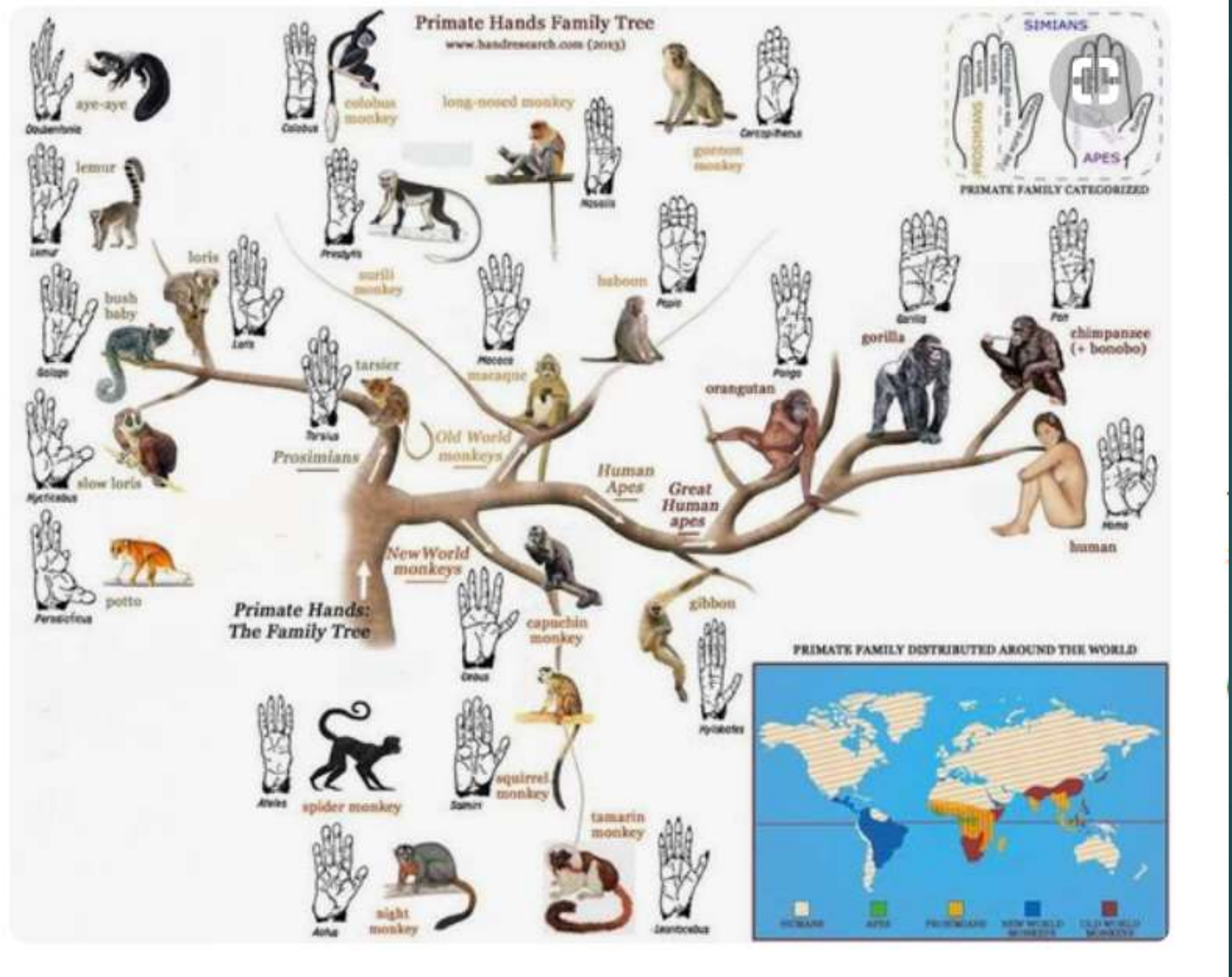
Positive Feedback Systems.

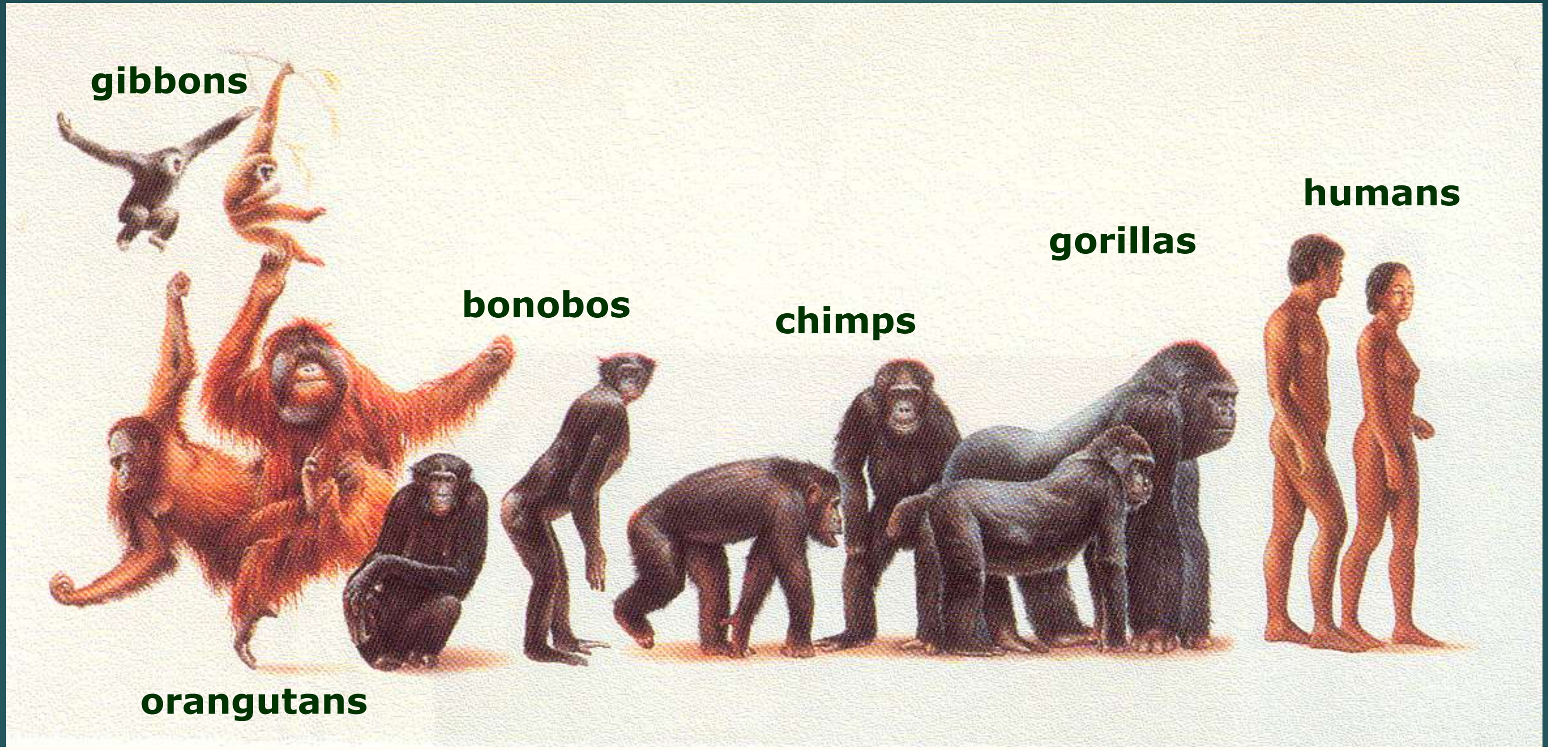
Humankind Emerging, 7th ed., p. 275

Bipedal walking

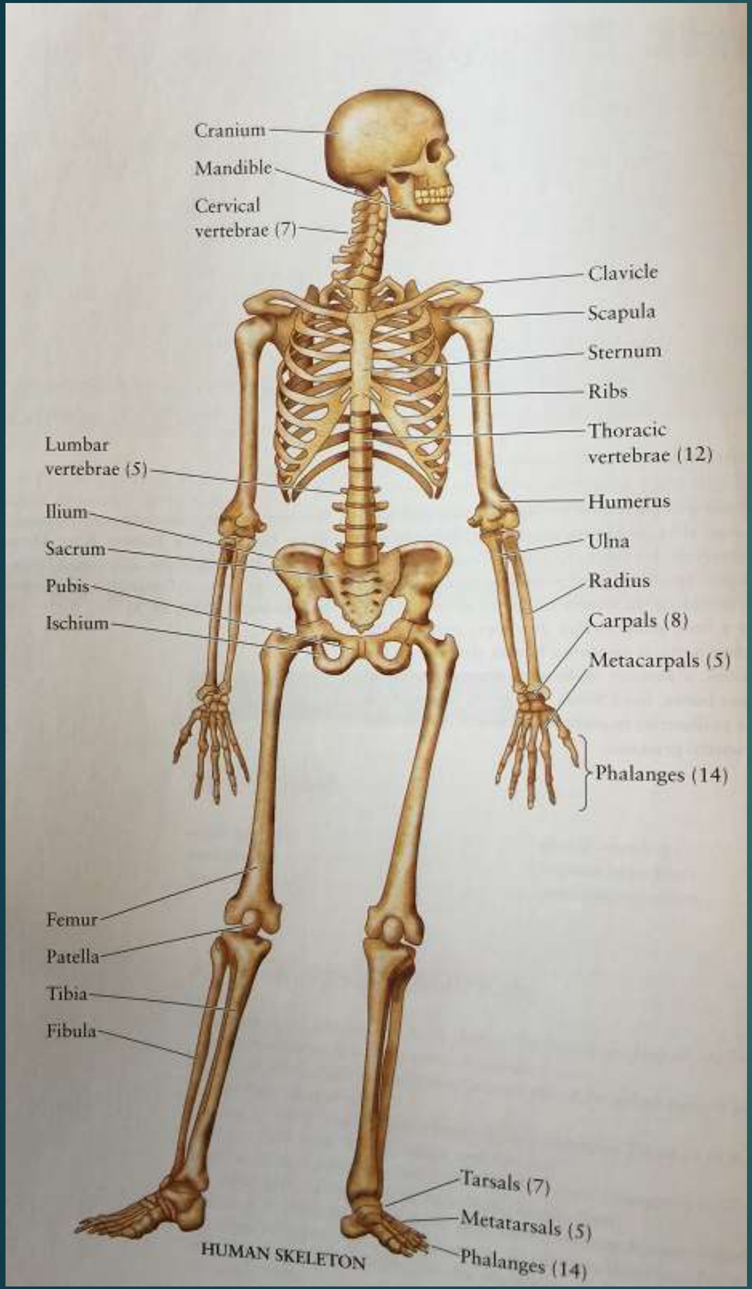
resulted in a number of postcranial changes in the legs and feet . . .

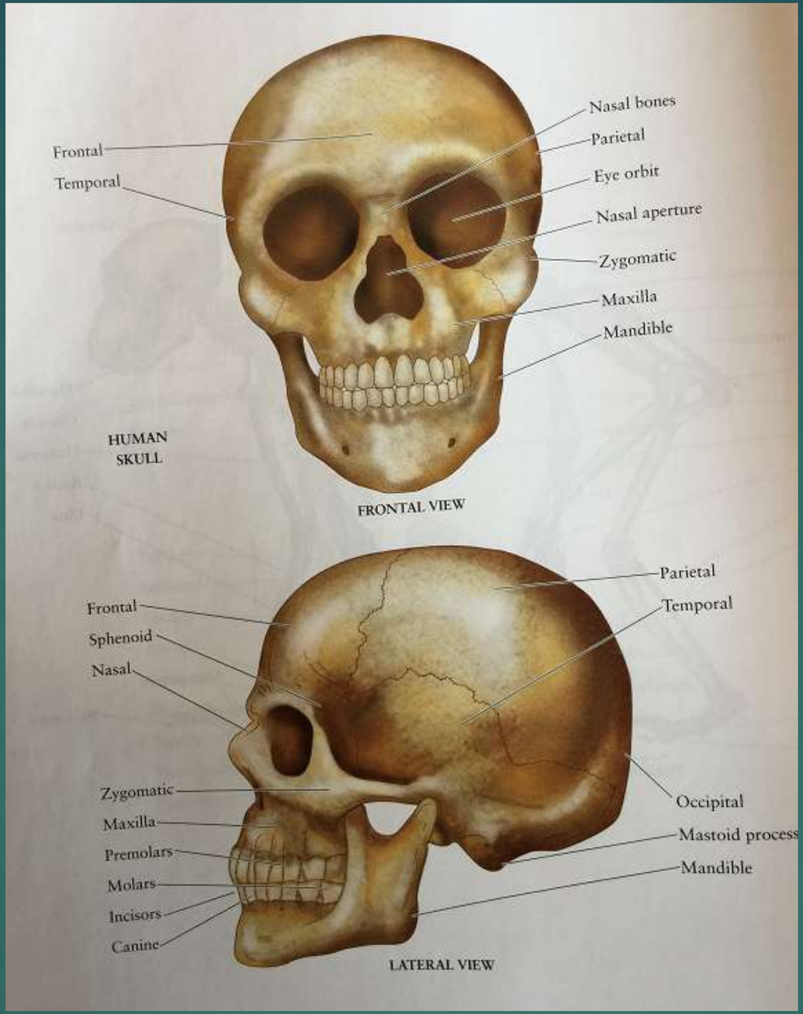


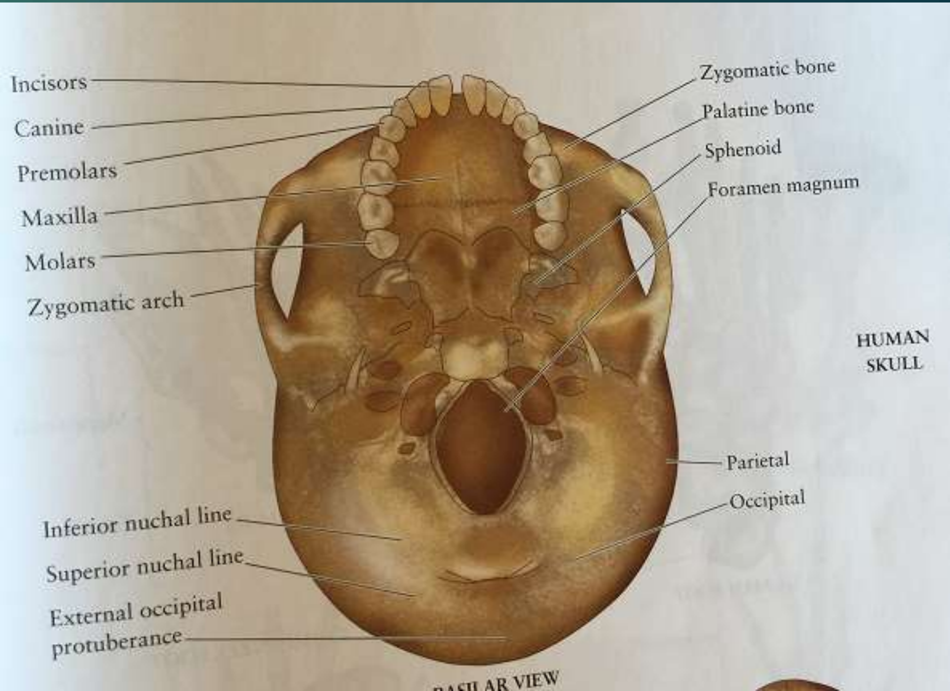

Primate Hands Family Tree
www.handresearch.com (2013)
aye-aye
lemur
loris
bush baby
slow loris
potto
tarsier
Prosimians
colobus monkey
long-nosed monkey
surili monkey
macaque
baboon
guenon monkey
Old World monkeys
Human Apes
Great Human apes
orangutan
gorilla
chimpanzee (+ bonobo)
human
gibbon
New World monkeys
capuchin monkey
spider monkey
squirrel monkey
tamarin monkey
night monkey
Primate Hands: The Family Tree
SIMIANS
PROSIMIANS
APES
PRIMATE FAMILY CATEGORIZED
PRIMATE FAMILY DISTRIBUTED AROUND THE WORLD


gibbons
humans
gorillas
bonobos
chimps
orangutans


gibbons
orangutans
bonobos
chimps
gorillas
humans

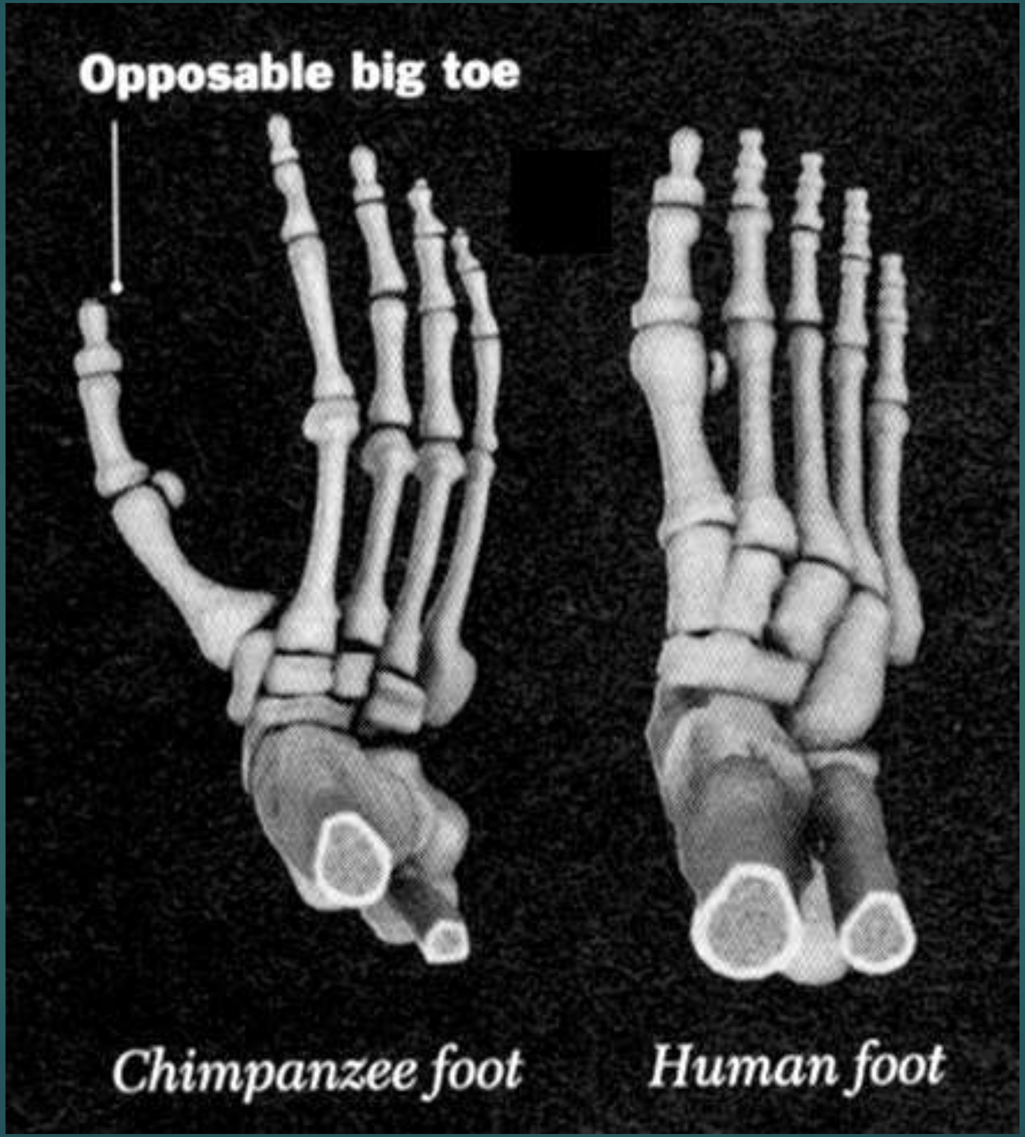

Cranium
Mandible
Cervical vertebrae (7)
Clavicle
Scapula
Sternum
Ribs
Thoracic vertebrae (12)
Lumbar vertebrae (5)
Humerus
Ilium
Ulna
Sacrum
Radius
Pubis
Carpals (8)
Ischium
Metacarpals (5)
Phalanges (14)
Femur
Patella
Tibia
Fibula
Tarsals (7)
Metatarsals (5)
Phalanges (14)
HUMAN SKELETON


Frontal
Temporal
Nasal bones
Parietal
Eye orbit
Nasal aperture
Zygomatic
Maxilla
Mandible
HUMAN SKULL
FRONTAL VIEW
Parietal
Temporal
Frontal
Sphenoid
Nasal
Zygomatic
Maxilla
Premolars
Molars
Incisors
Canine
Occipital
Mastoid process
Mandible
LATERAL VIEW


Incisors
Canine
Premolars
Maxilla
Molars
Zygomatic arch
Zygomatic bone
Palatine bone
Sphenoid
Foramen magnum
HUMAN SKULL
Parietal
Occipital
Inferior nuchal line
Superior nuchal line
External occipital protuberance

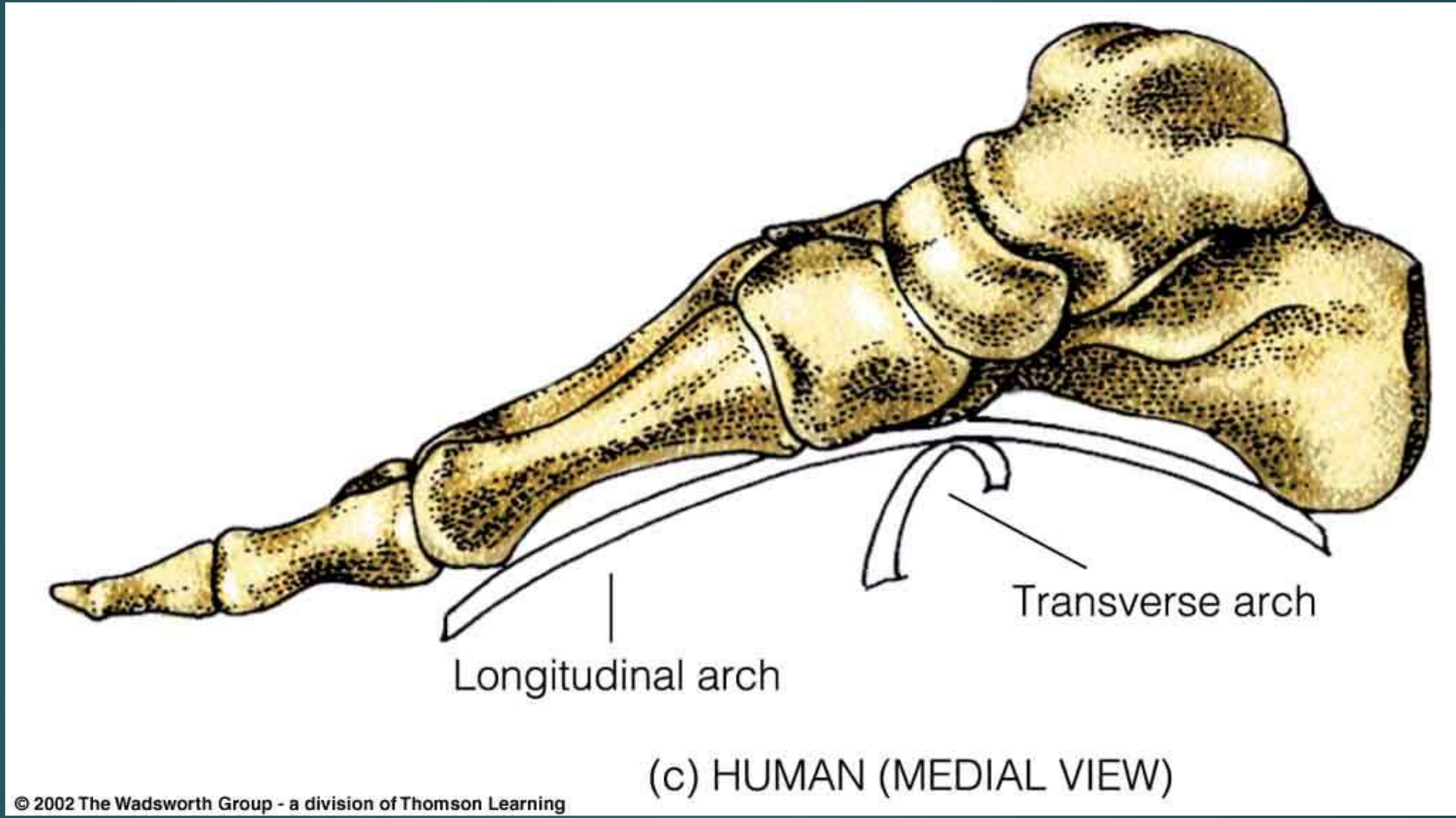
Chimp vs human foot

Grasping foot
Divergent toe



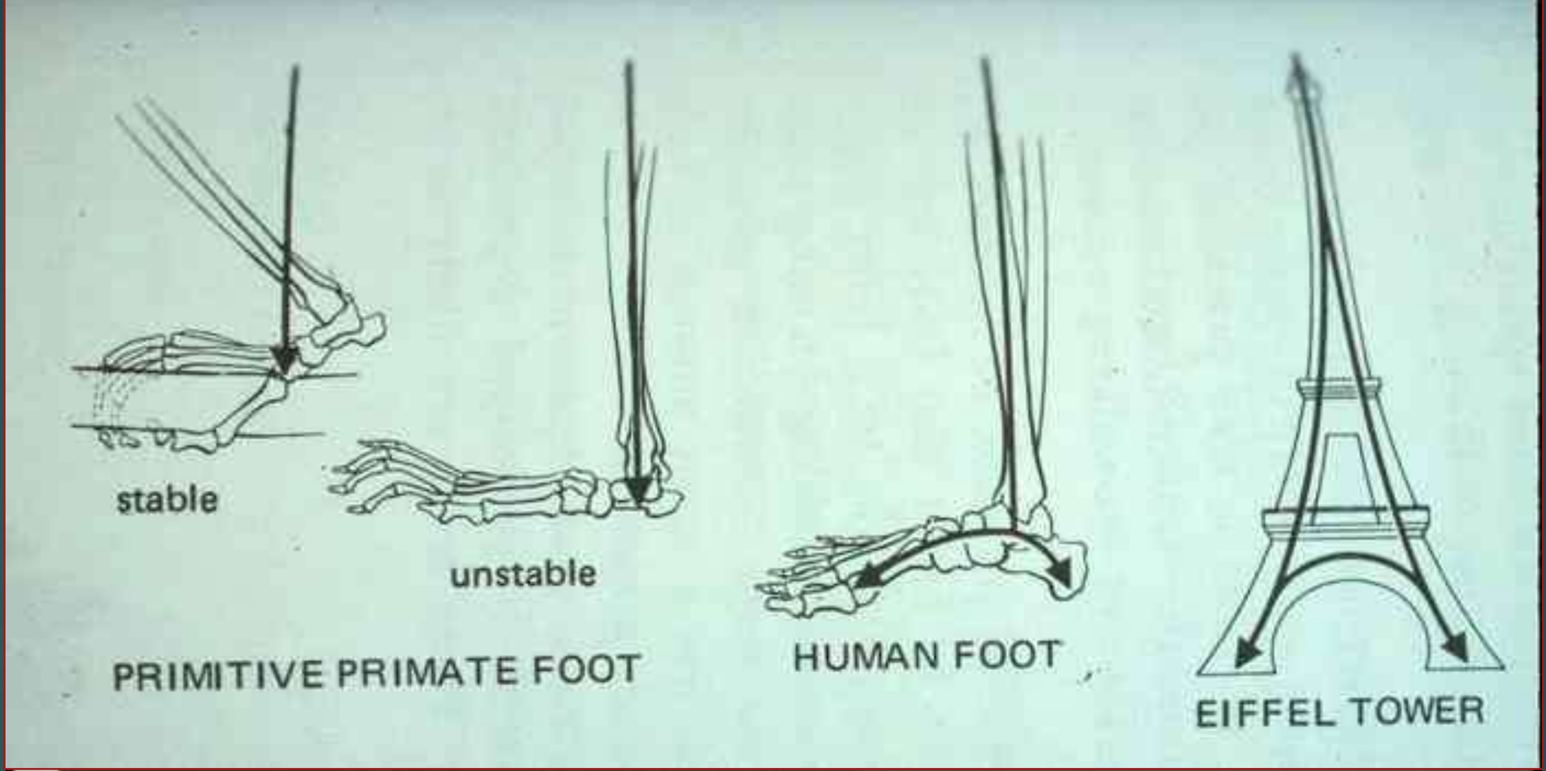
- Parallel toes
- Big toe
- Shorter, straighter toes
- Arches
- Big heel

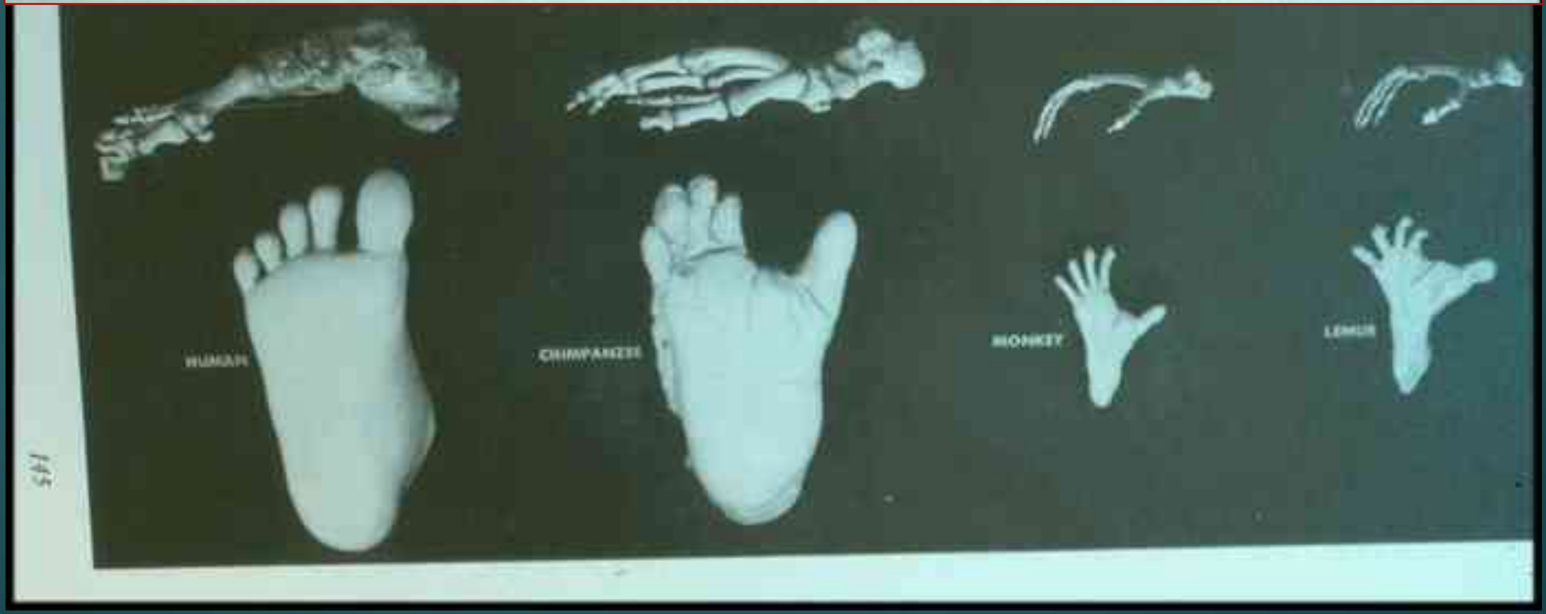
Present 3.7 Ma in australopithecines

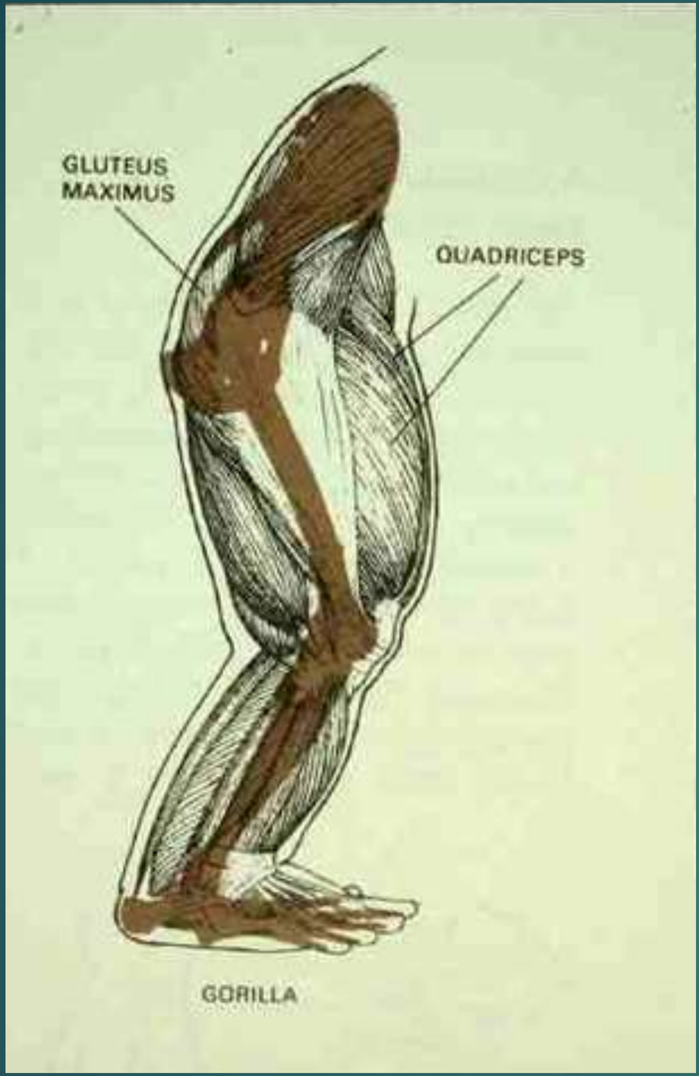


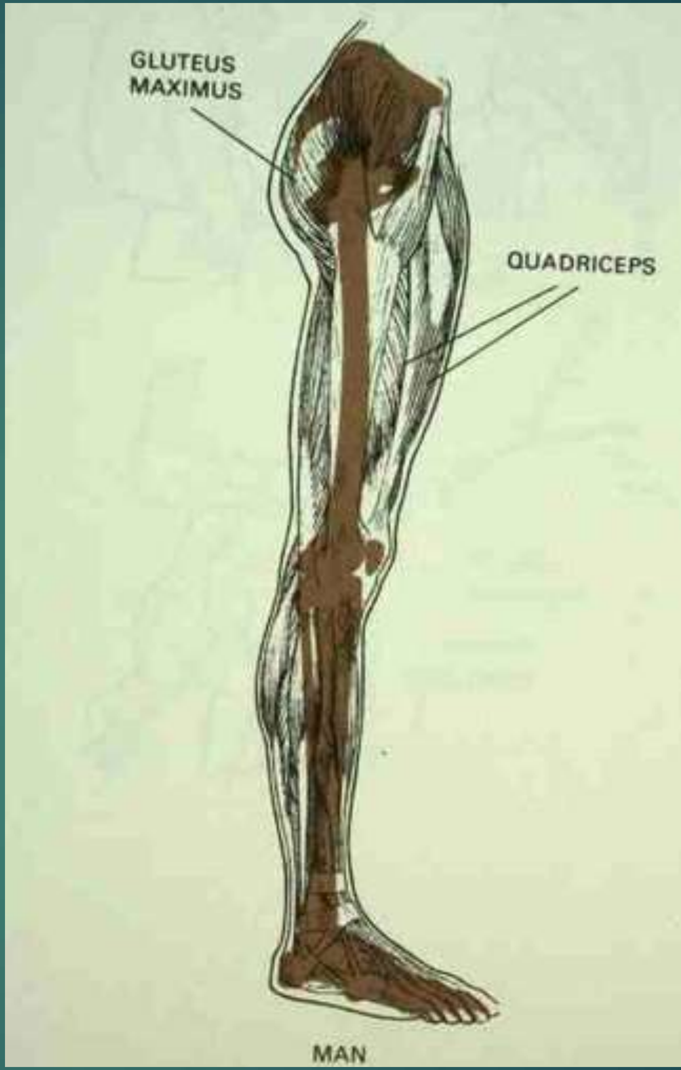
Arches of the Foot

Understanding Physical Anthropology and Archaeology, 9th ed., p. 436


stable
unstable
PRIMITIVE PRIMATE FOOT
HUMAN FOOT
EIFFEL TOWER


HUMAN
CHIMPANZEE
MONKEY
LEMUR



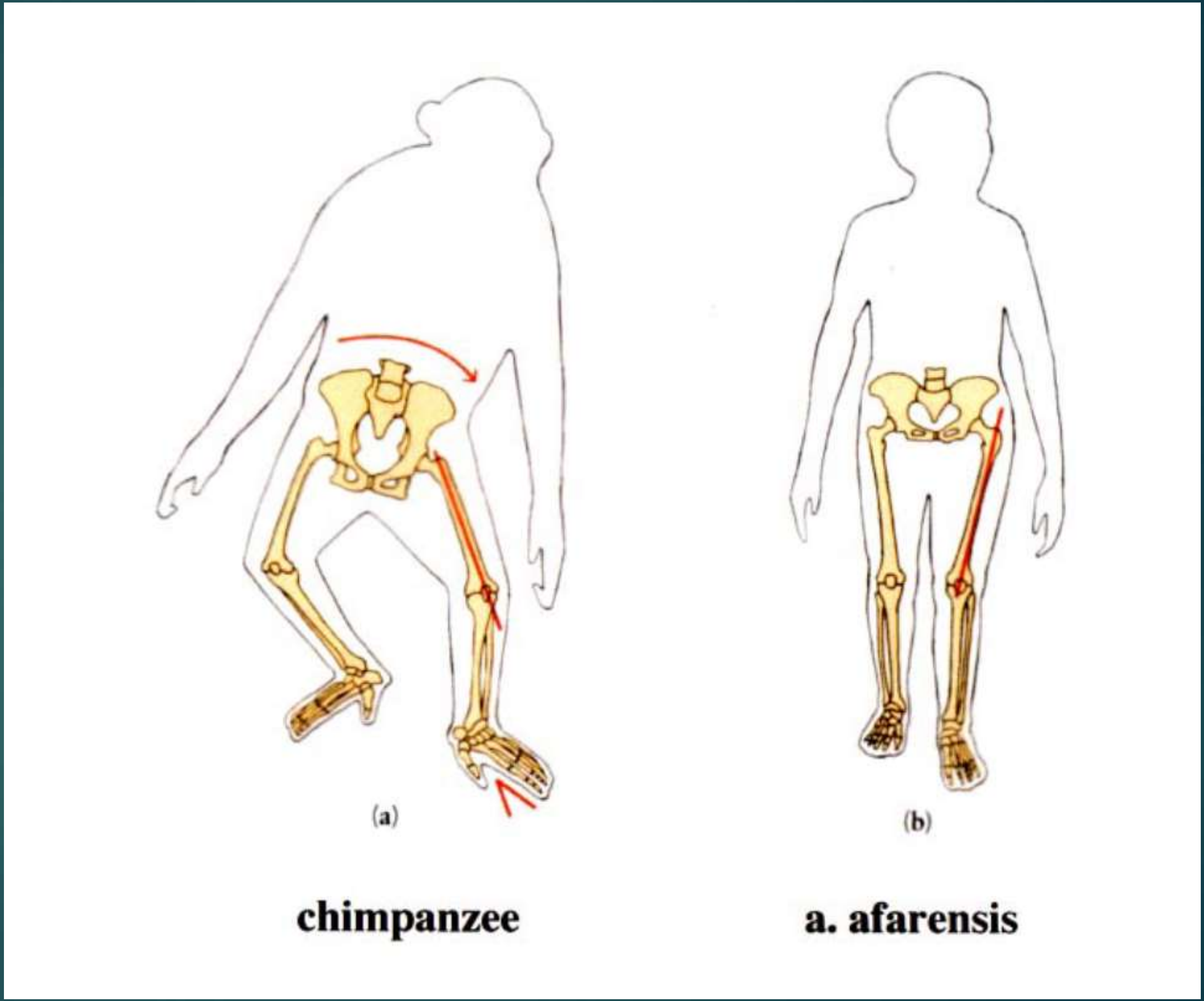


Leg muscle structures change

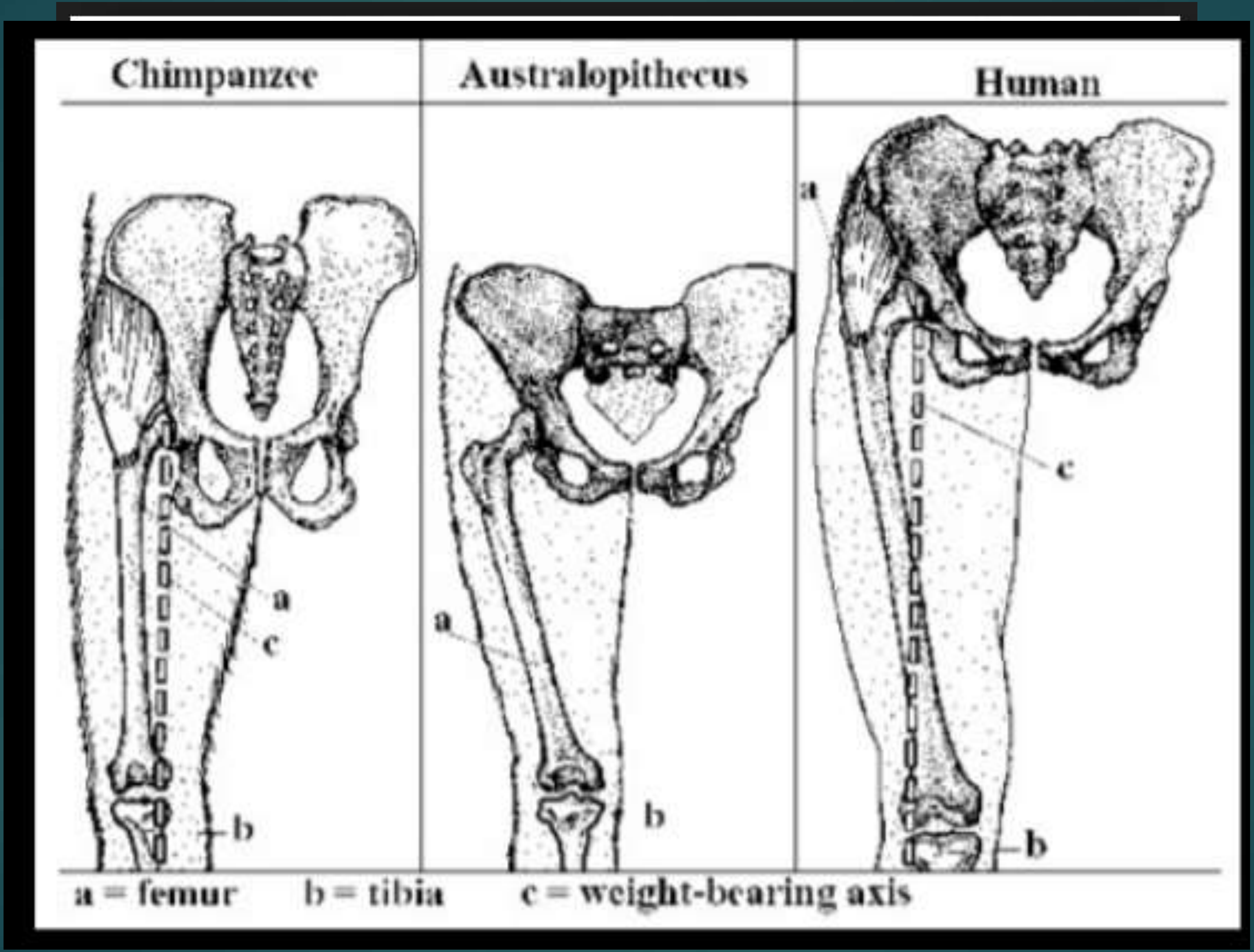
Walking Upright

Chimp = lots of lateral movement

Australopiths = no lateral movement



Pelvis and knees



Humans have developed a "closed-knee stance"

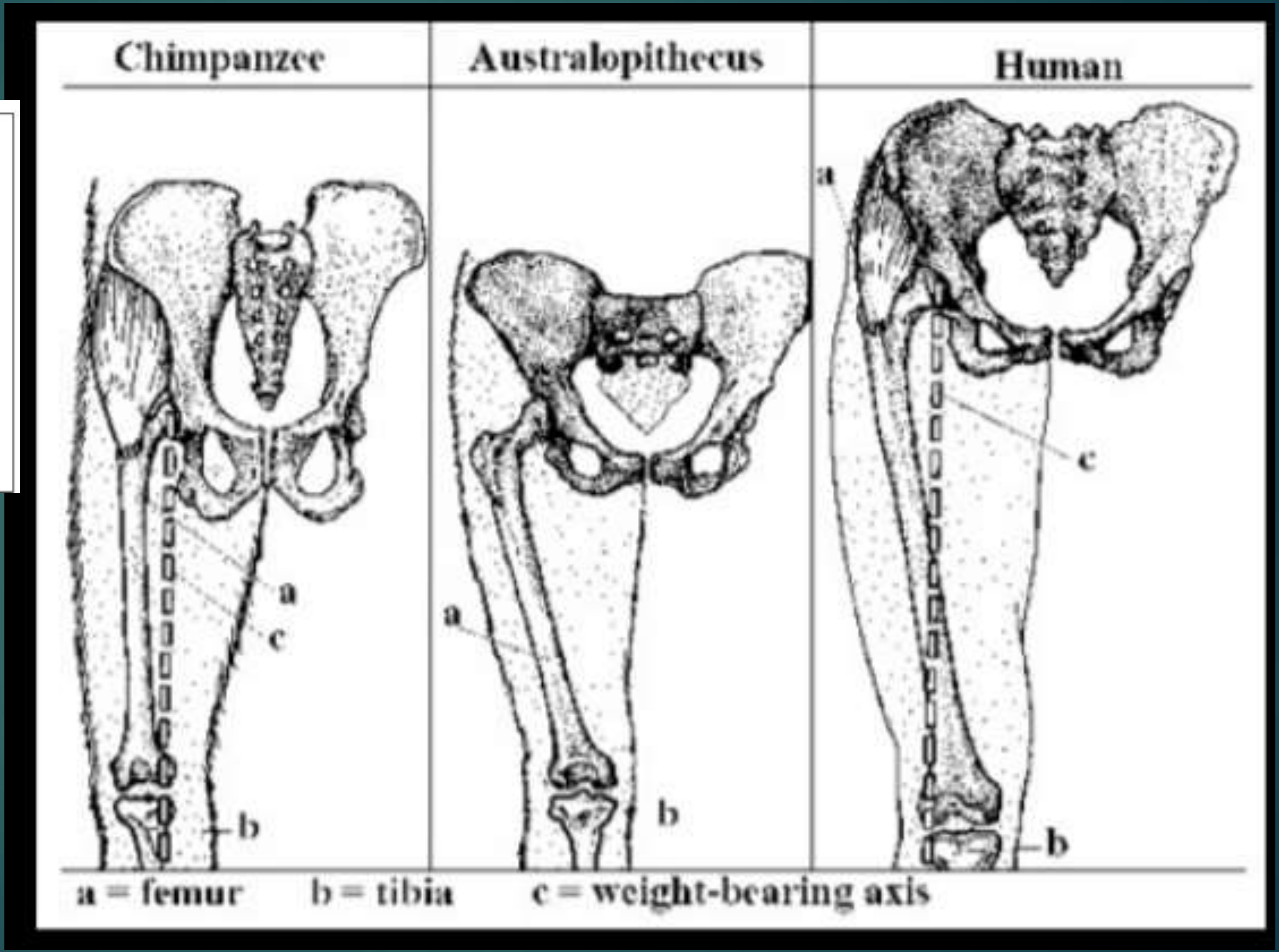
Knock-kneed

Lower limb adaptations

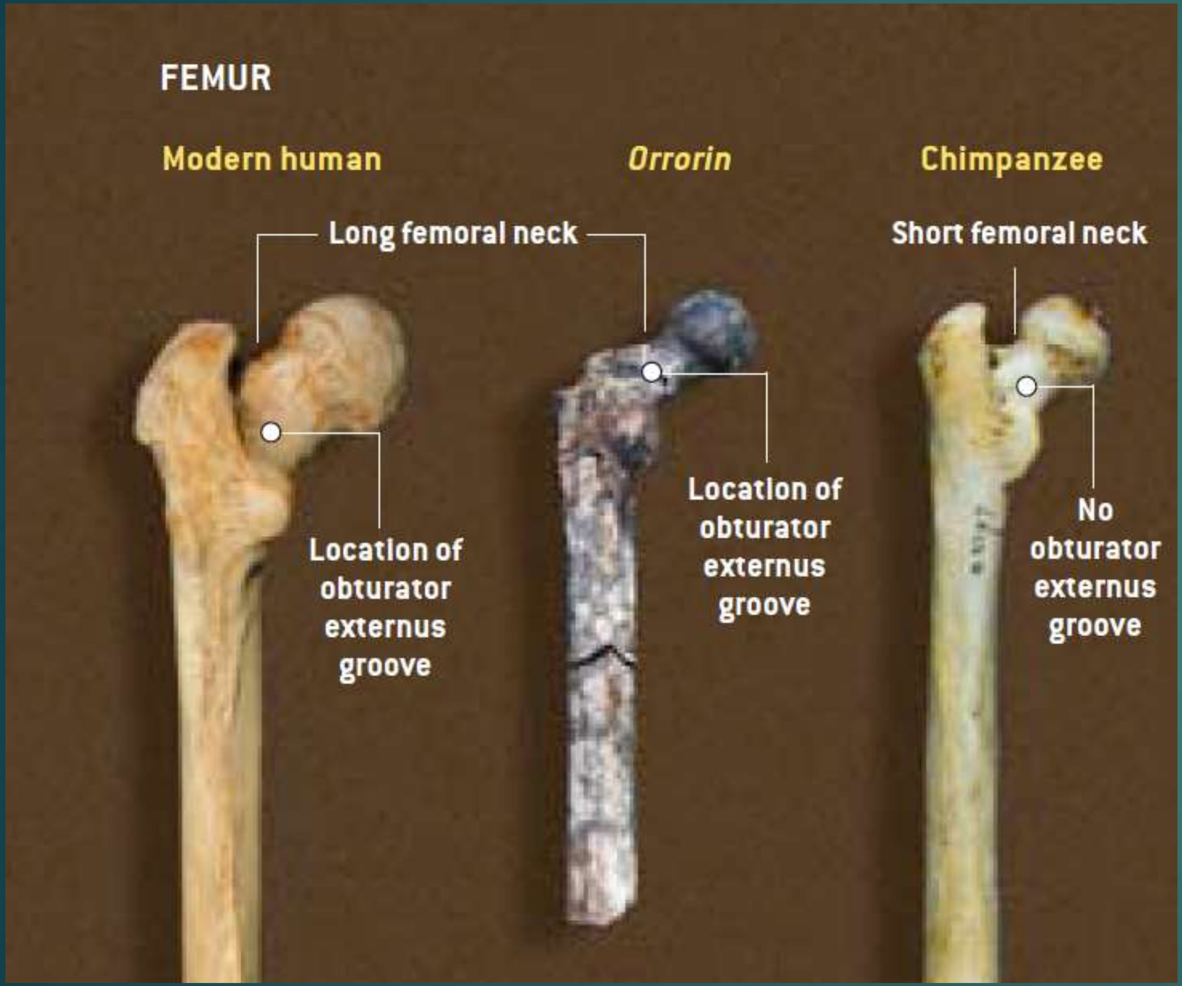
Chimpanzees

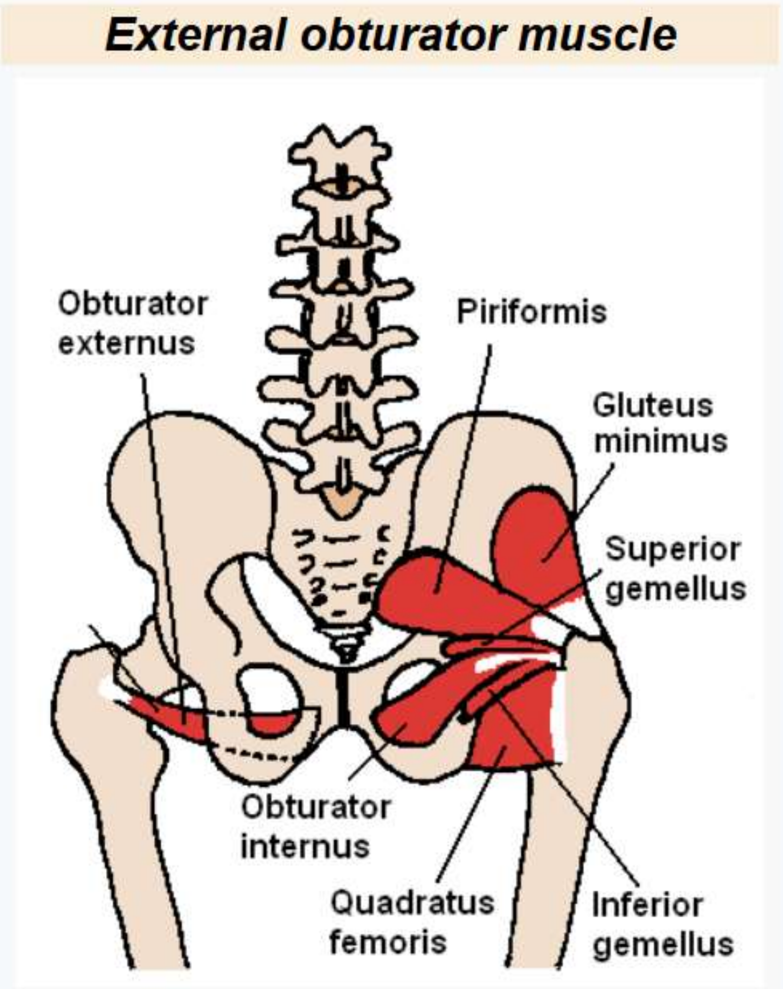
Because the connection between the upper thigh and hip bones is short in chimpanzees, the hip muscles cannot contract effectively to provide support for upright walking.

The chimpanzee knee joint is lightly built, so chimpanzees cannot rest their weight on one leg at a time to walk for long periods.



Femurs





The obturator externus and nearby hip muscles (posterior view)

Femur grove that attaches a ligament that allows bipedality

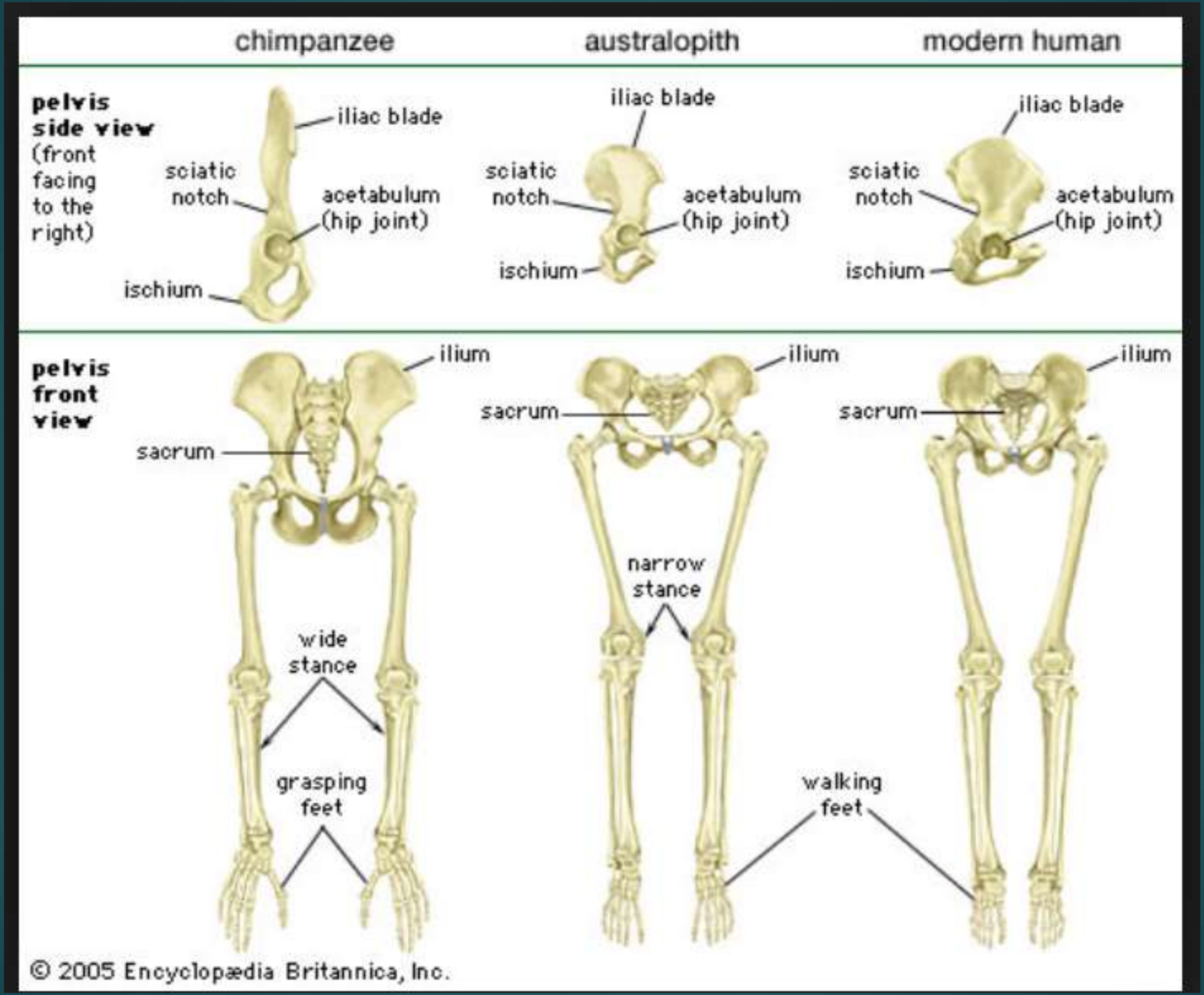
Orrorin grove

Obturator externus

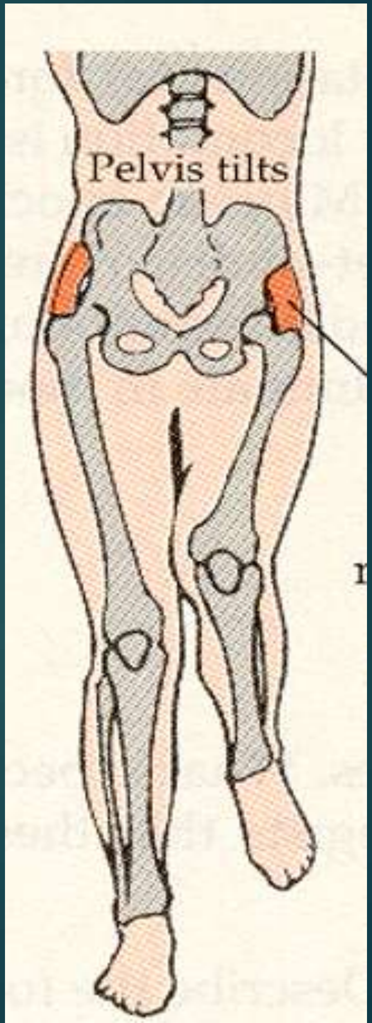
Pelvis

&

Knees



Humans have developed a "closed-knee stance"



Bipedal characteristics

Center of Gravity:

Human

Angled femurs

Shock absorber knees

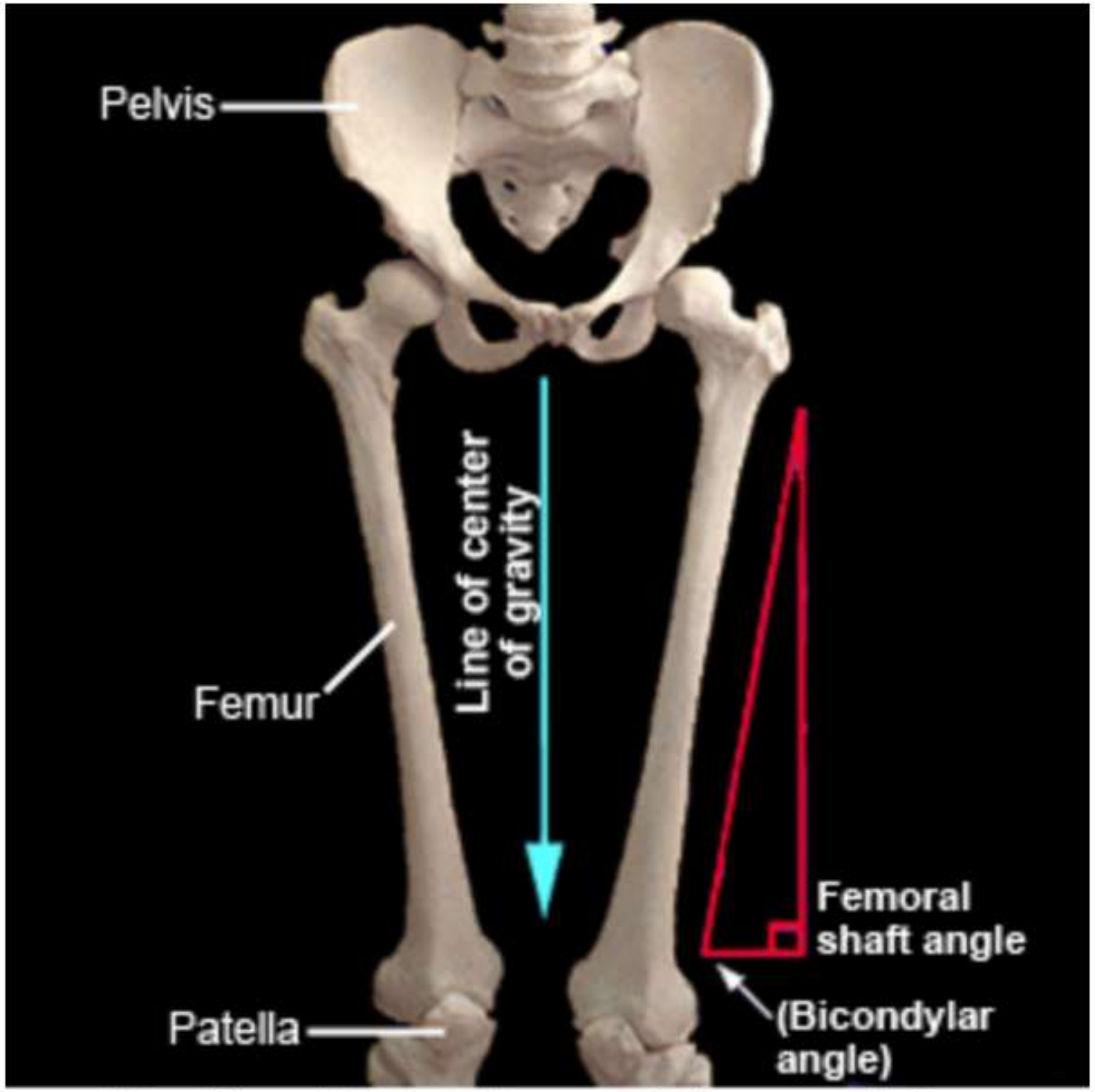
Ape:

flexed knee vs. extended knee

straight femur vs angled femur

Tall, flat ilium vs Short, curved ilium

Short stiff lumbar

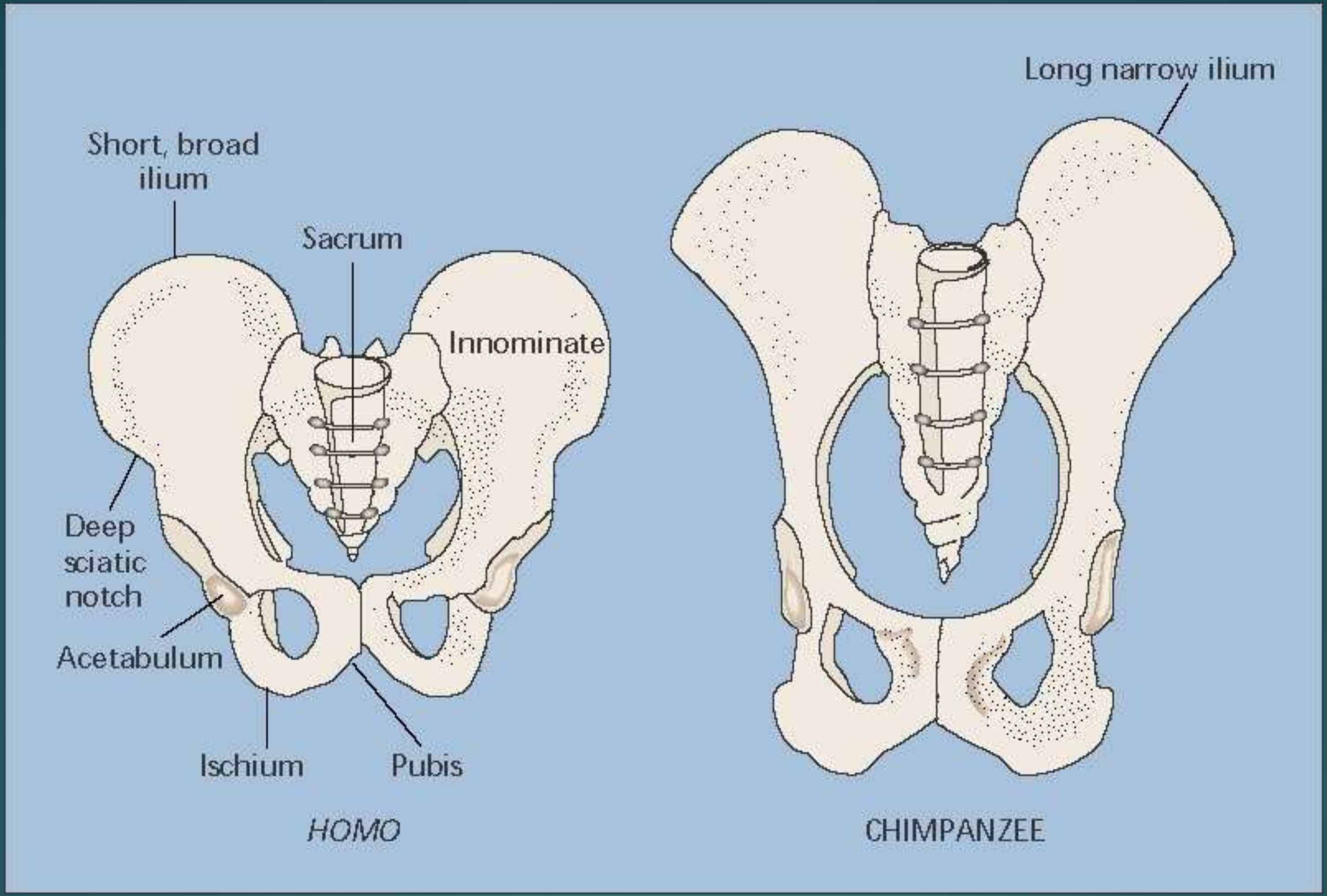


The bicondylar angle seen in humans brings the feet in line with the body's center of gravity, resulting in greater sstability.

A number of changes take place in the pelvis . . .

- becomes shorter and wider . . .
- has a “distinct pelvic bowl” . . .
- and the muscle attachment ridges become heavier
- Chimp’s pelvic hip bones are in the back, long, and tall, and stand high up the back
- Lucy’s are broader front to back, shorter, and wrap around the sides (for muscles that control pelvic tilting while walking), just like a human

Pelves

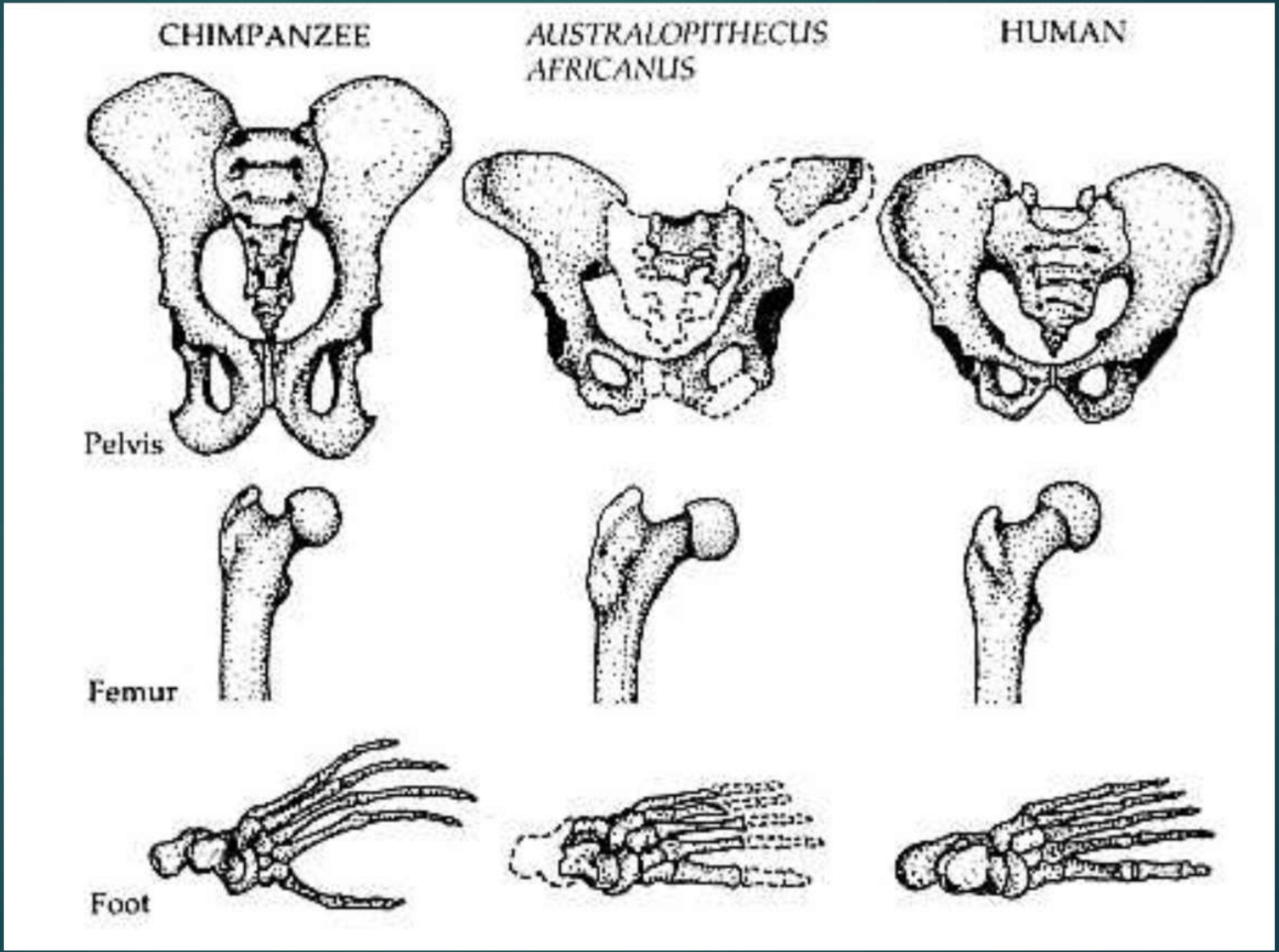


A comparison of human and chimpanzee pelves.

Bipedal bowl vs. Knuckle walking back brace

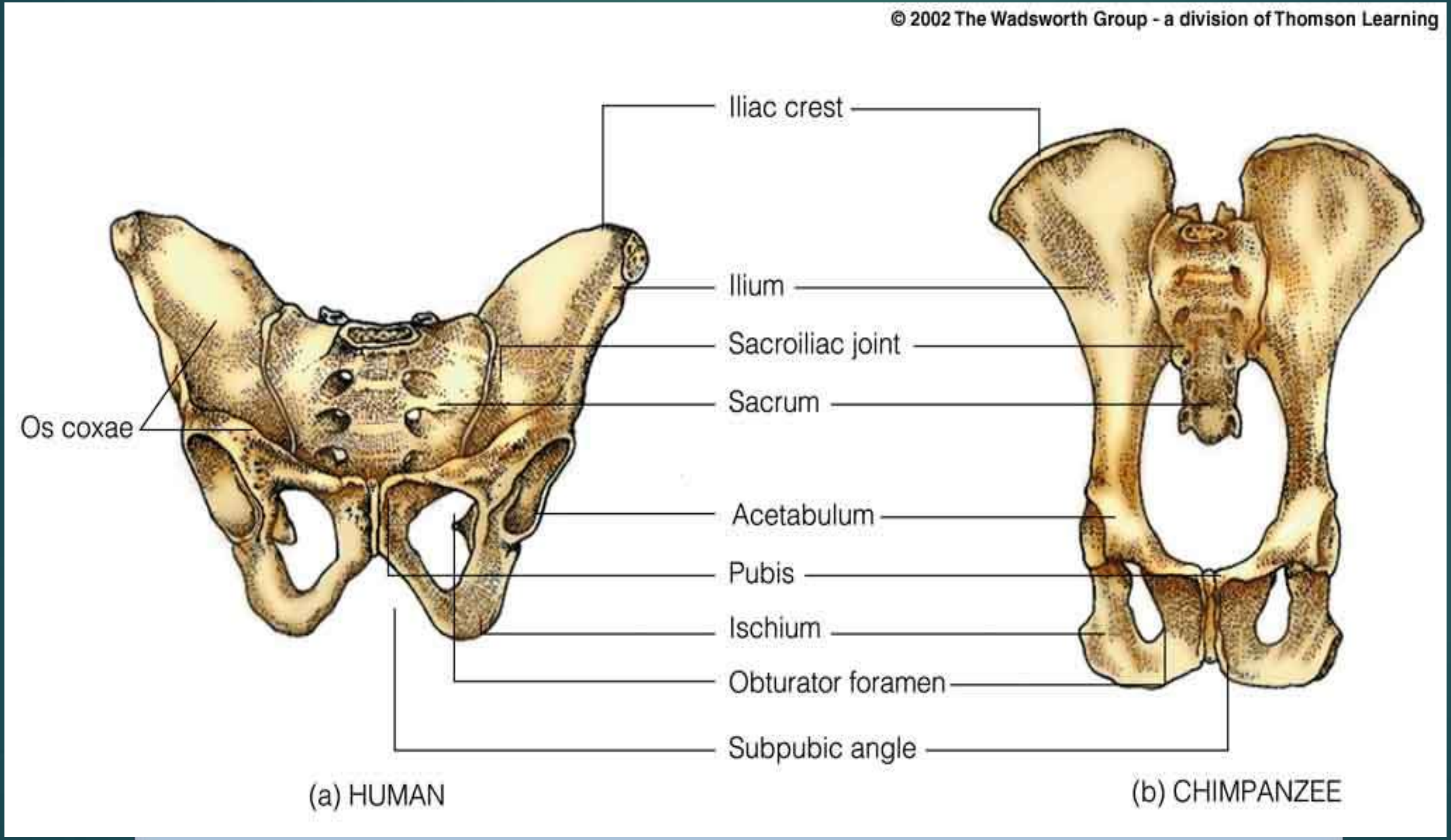
In humans, the blades are rotated inward **to support the internal organs and to center the weight of the body over the legs** while humans are standing upright. The curved, bowl-like pelvis of *Homo sapiens* allows us to balance the weight of our trunk effectively over our hips.

Walking Upright



Pelves

A comparison of human and chimpanzee pelves.



Bipedal bowl vs. Knuckle walking back brace

<u>Chimp pelvis</u>:

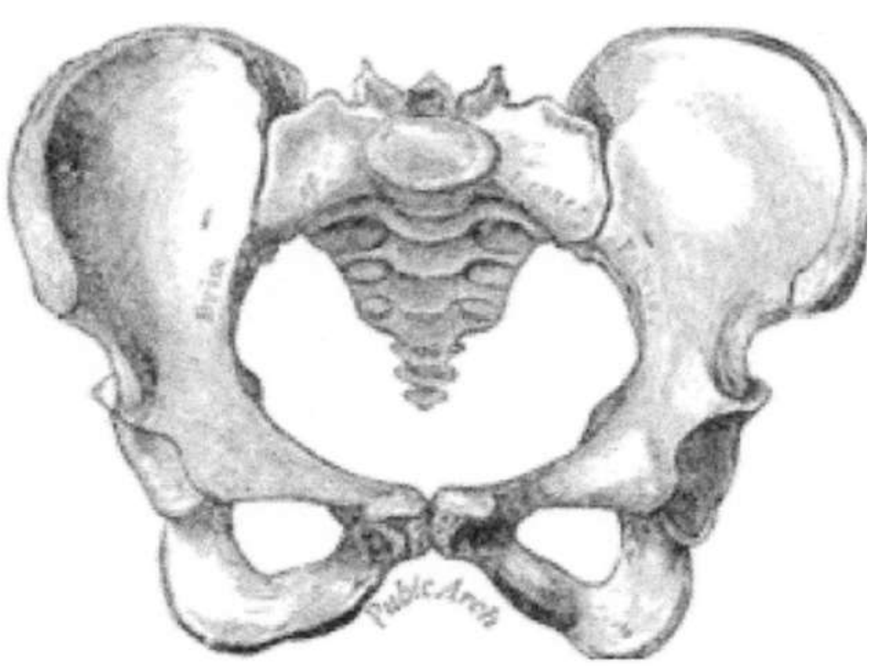
2 hip blades,

vertically up,

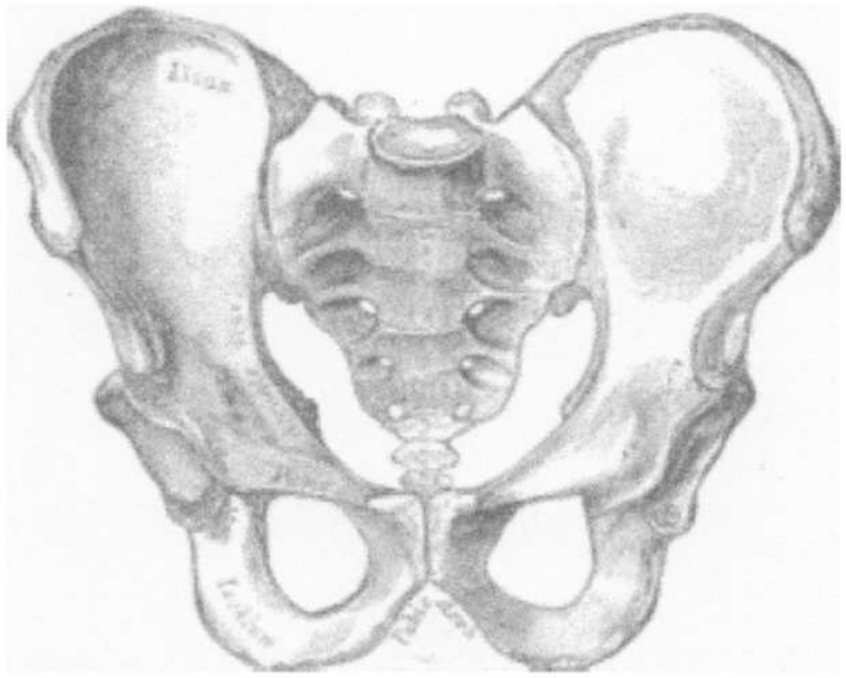
fused with spine by ligaments

back not flexible

Human Pelvis: Obstetric problem



Female Pelvis



Male Pelvis

omes shorter and
er . .

a “distinct pelvic
l” . . .

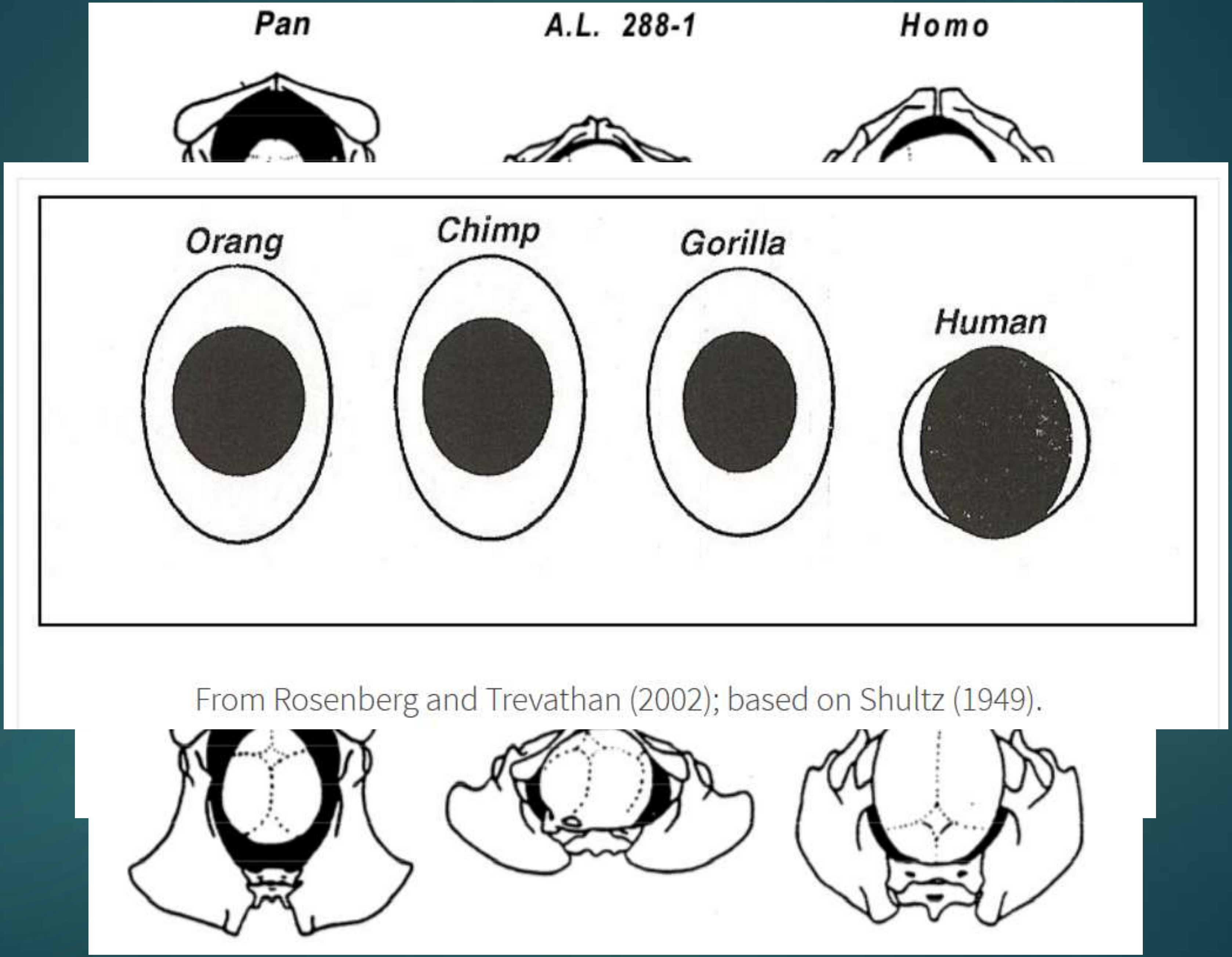
the muscle
chment ridges
ome heavier . .

Size of boy’s pelvis is controlled by maternal genes; female must be able to deliver large brained infant

A. afarensis:

- Wide opening;
- non rotational births

No extant *P. boisei* pelvis



From Rosenberg and Trevathan (2002); based on Shultz (1949).

Larger the brain, more birth difficulty.

Modern Human:

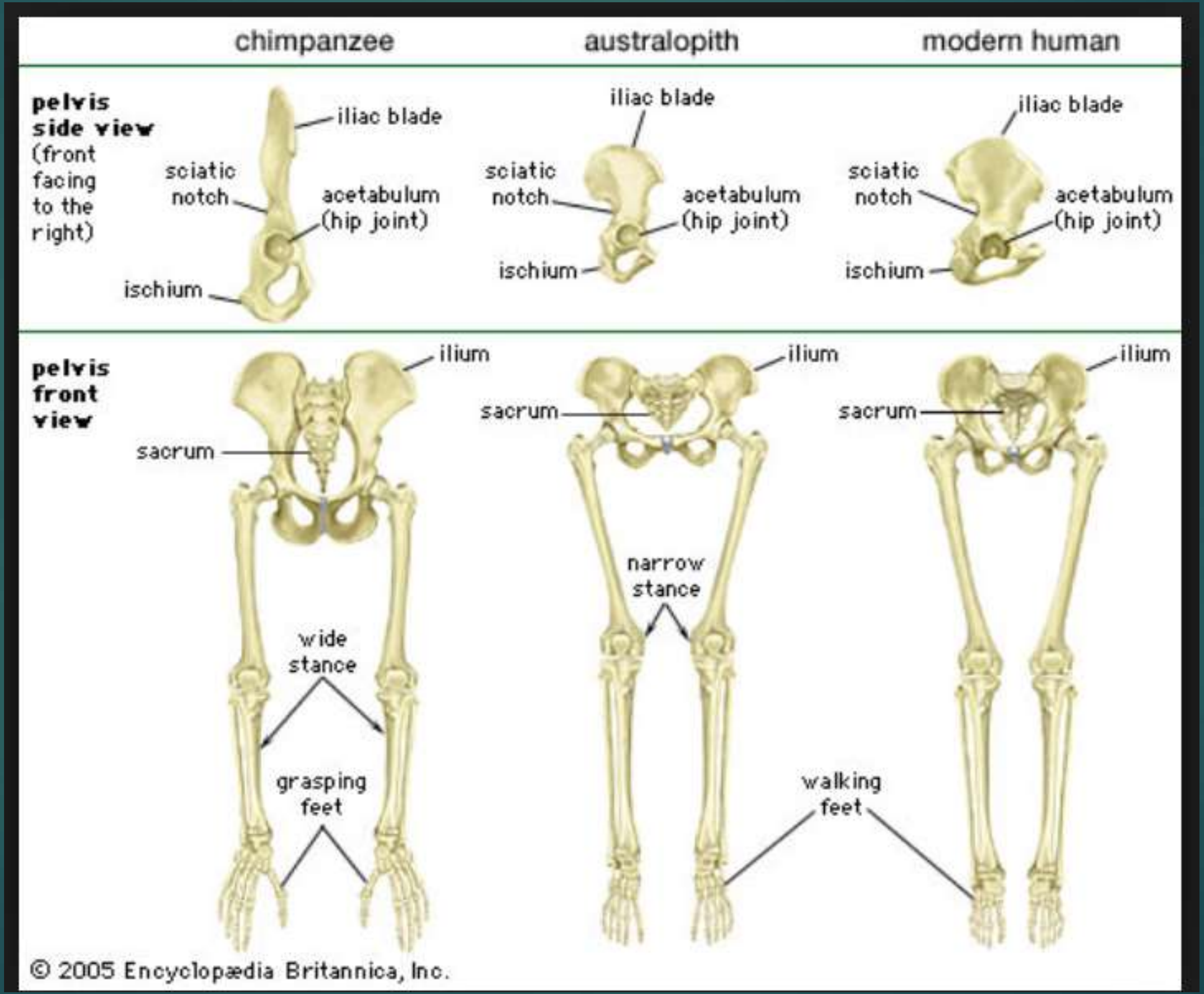
- rotational births,
- child comes out facing away from mother

Pelvis

Species	Iliac blade orientation (Curved forward or Flat)	Iliac blade width/height (Broad/Short or Narrow/Tall)	Sacrum Width (Broad or Narrow)
Humans	*Curved forward*	*Broad/Short*	*Broad*
Chimpanzees			
Australopithecus			

In humans, the blades are rotated inward **to support the internal organs and to center the weight of the body over the legs** while humans are standing upright. The curved, bowl-like pelvis of *Homo sapiens* allows us to balance the weight of our trunk effectively over our hips.

Pelvis and knees

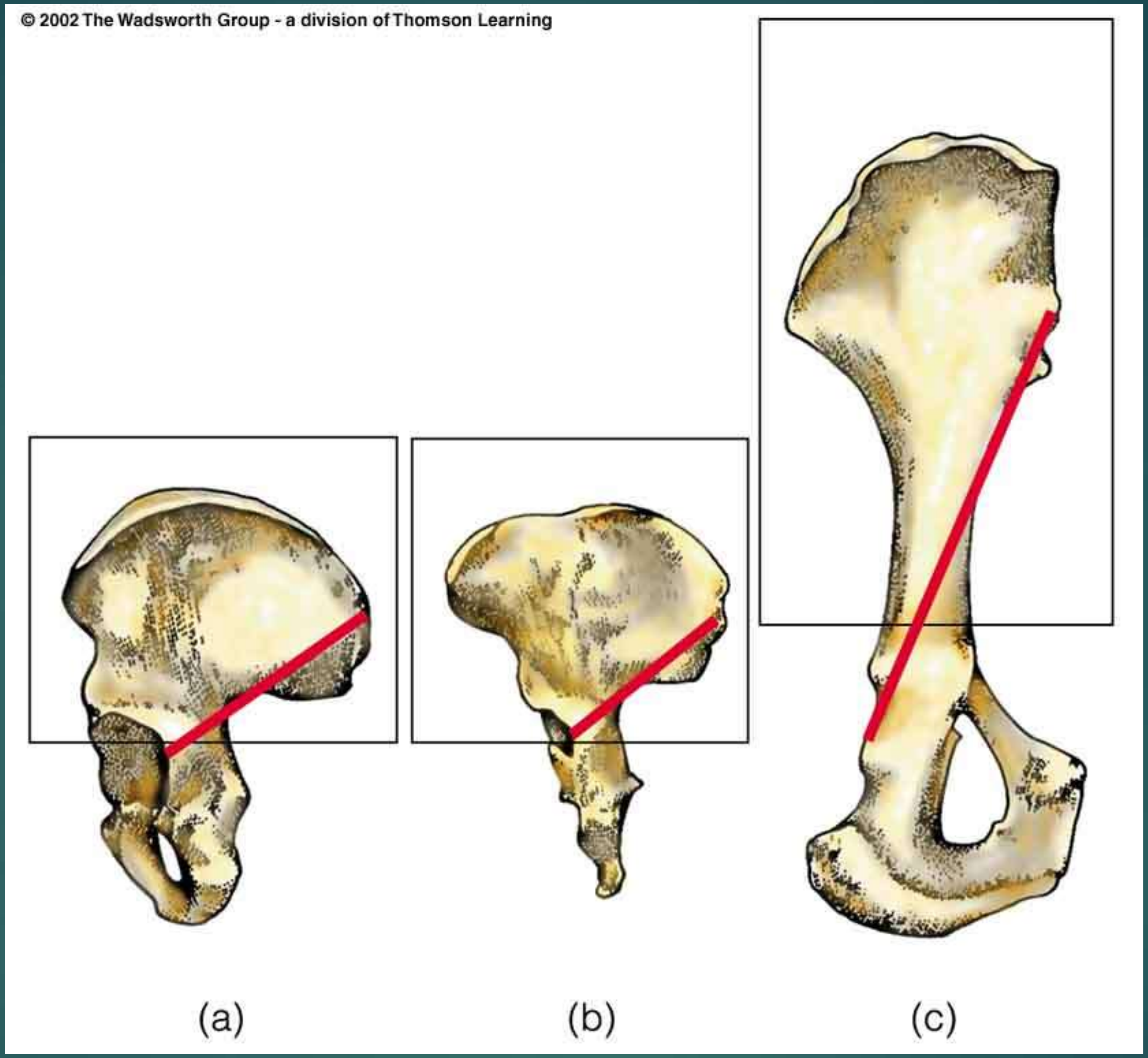


Growth of large brain: extended fetal growth of brain

Same sock monkey for scale

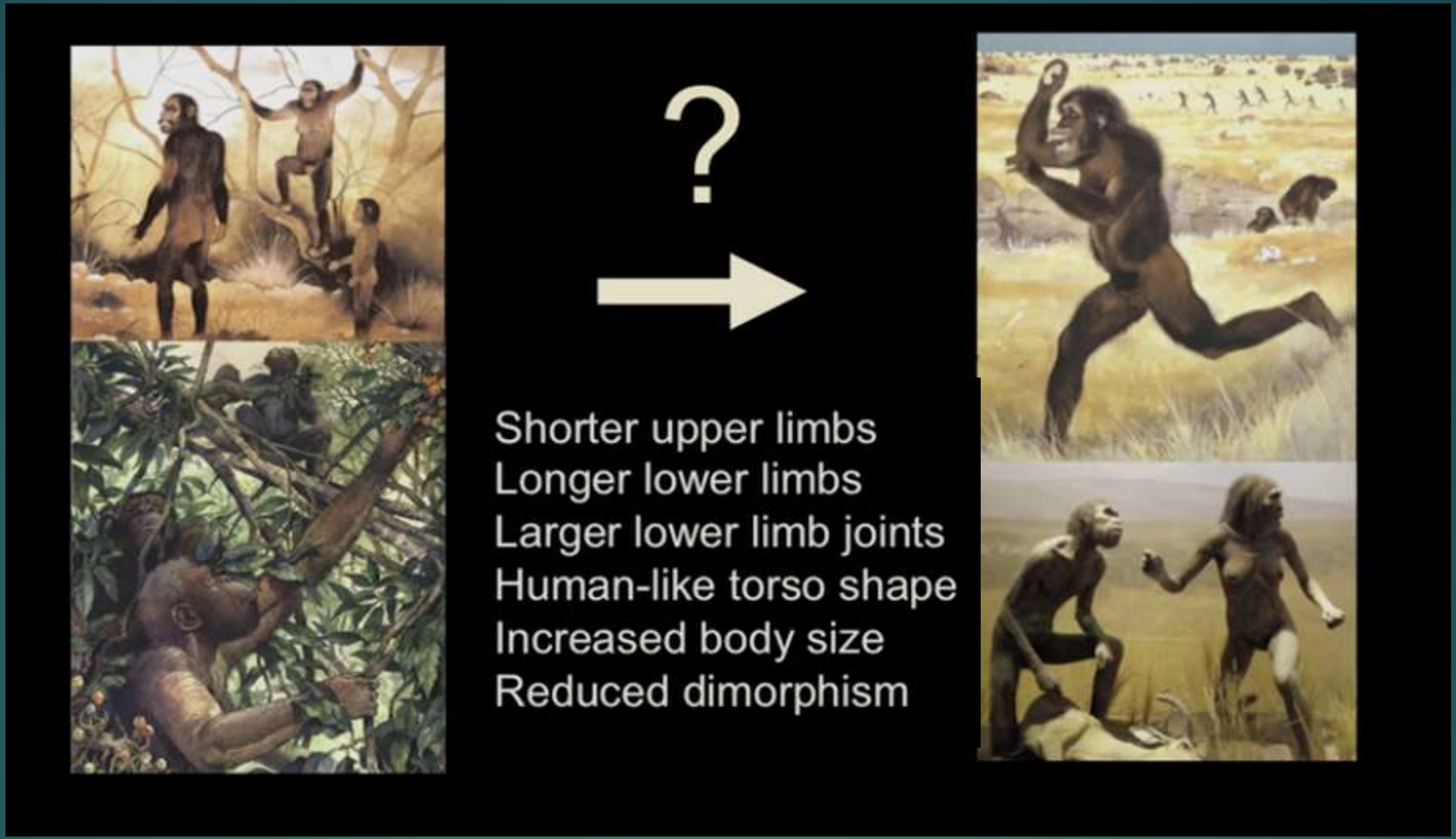
Human Pelvis and large head and shoulder girth

- Higher mortality
- Primate birth easier
- Australopithicines have more constricted pelvis
- Increased spinal curvature implies Lucy had given birth
- Did they have midwifery? Social cooperation – Karen Rosenburg argument
- Or later energetic demands of infant: pregnancy is energetically demanding, bringing fetus to term vs obstetric constraints associated with pelvis



***Ossa coxae*. (a) *Homo sapiens*.**
(b) *Australopithecus*. (c) Chimpanzee

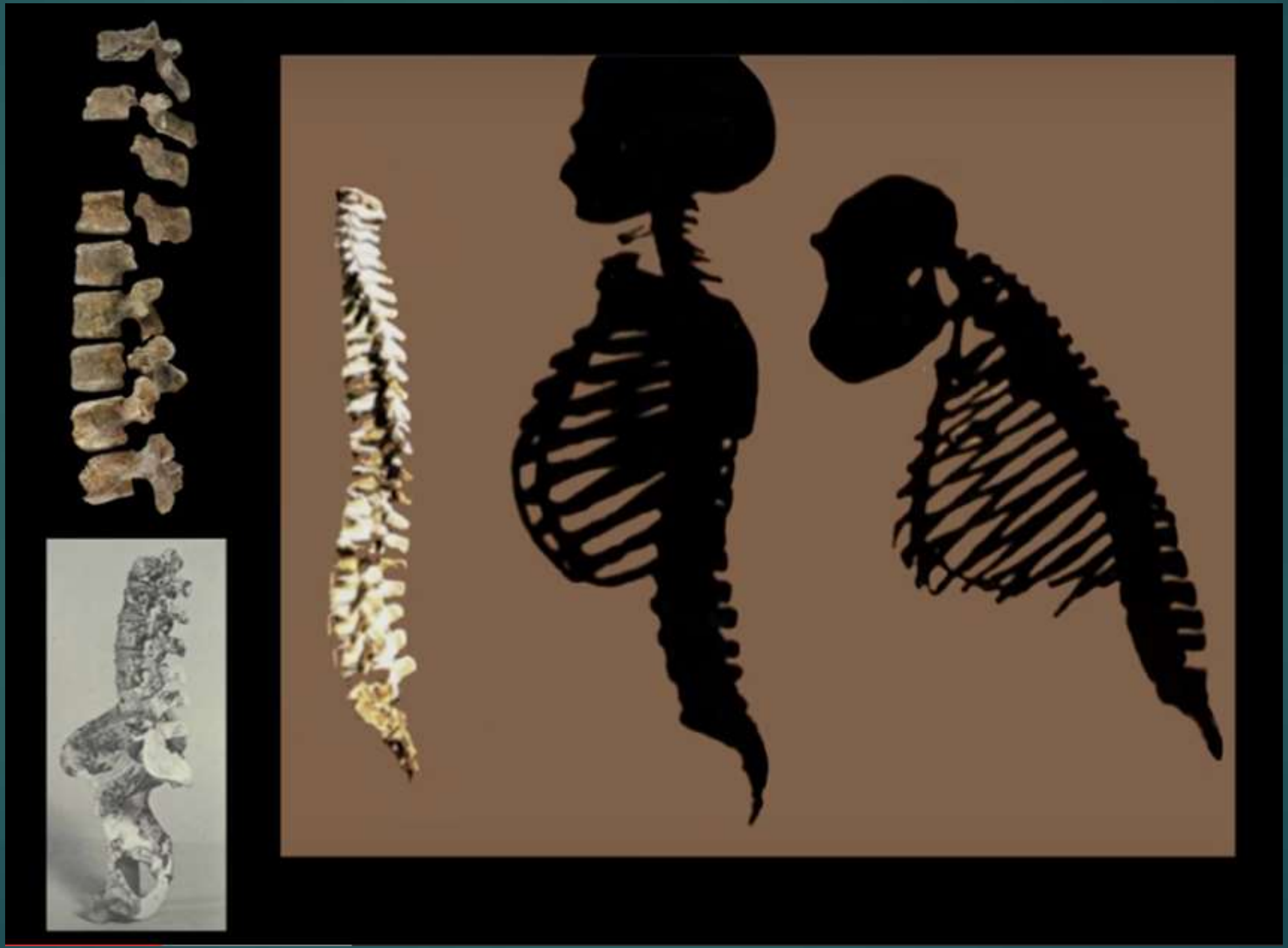
Understanding Physical Anthropology and Archaeology, 9th ed., p. 199



Australopiths: heavier,
Partial tree dwellers

Homo erectus: obligate
biped

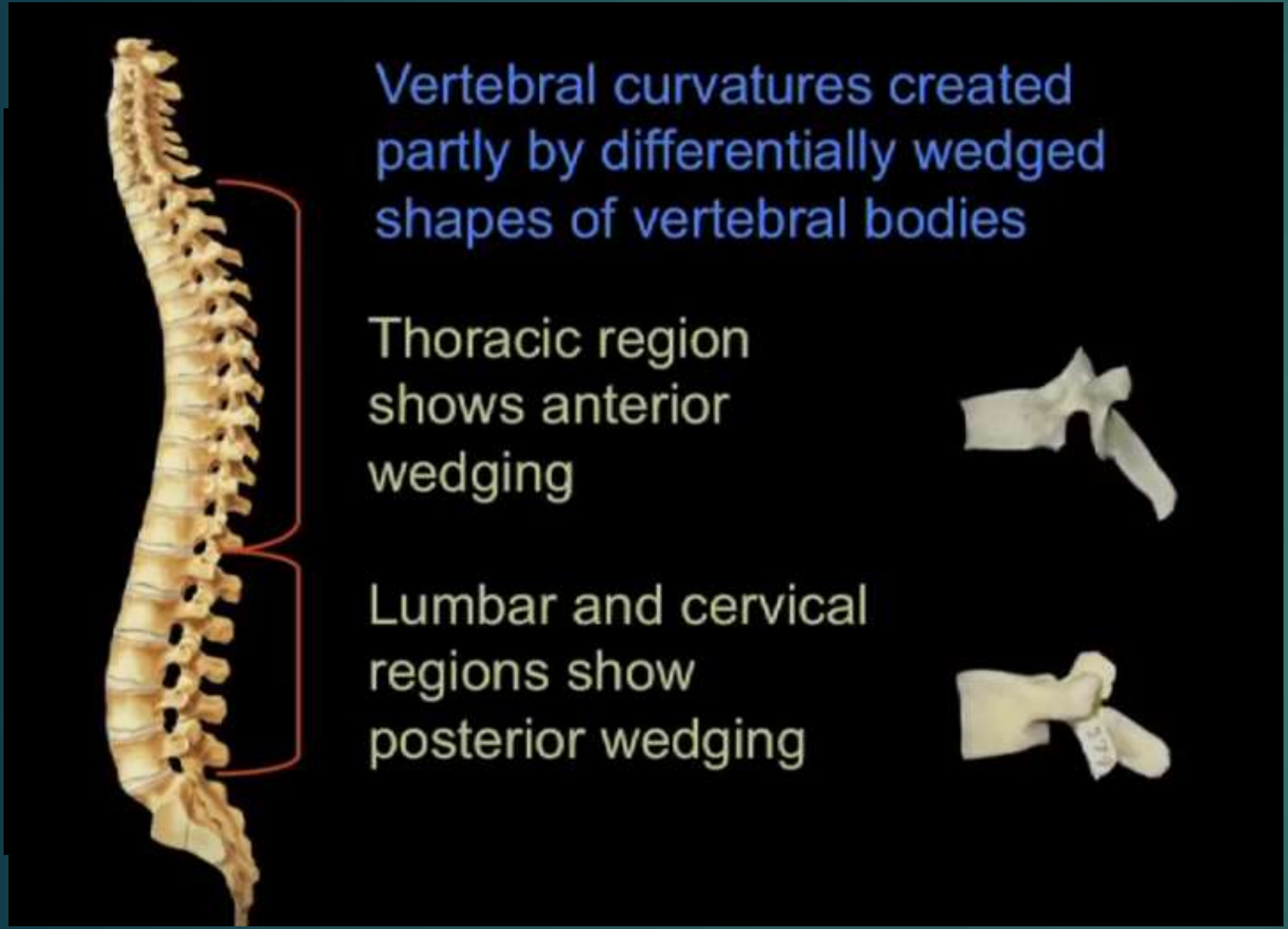
More modern evidence: curved vertebral column present in Australopiths (could stand upright)

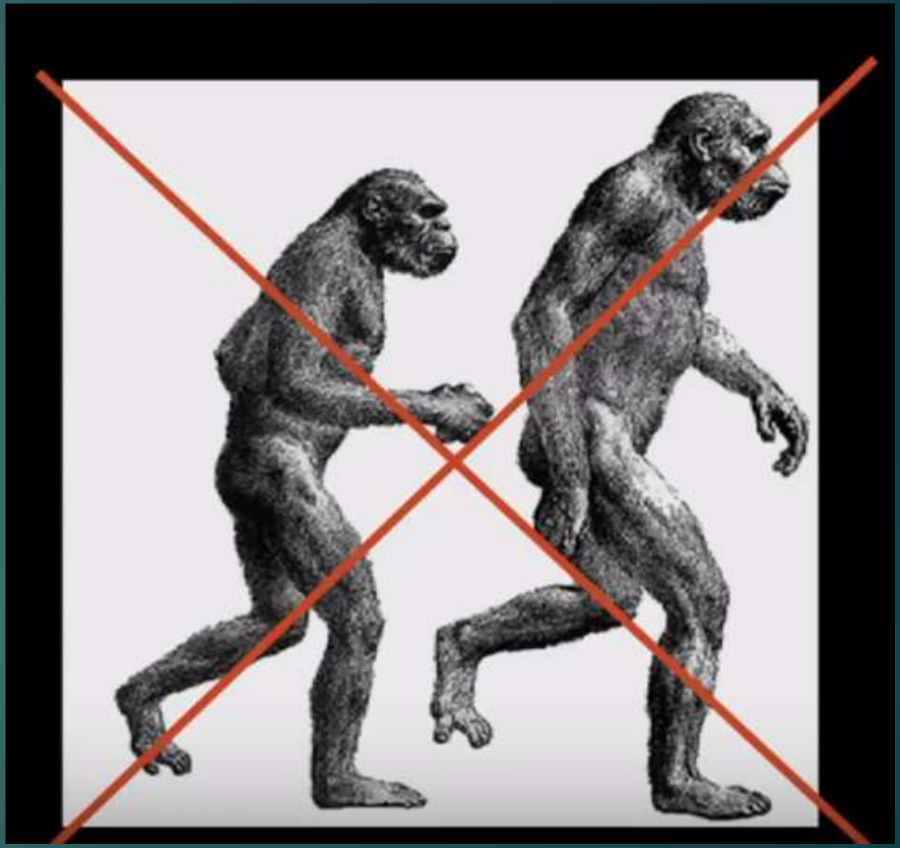


Apes: uniform concave structure for knuckle walking

sinusoidal curvature of modern spine: balance wgt over lower limbs

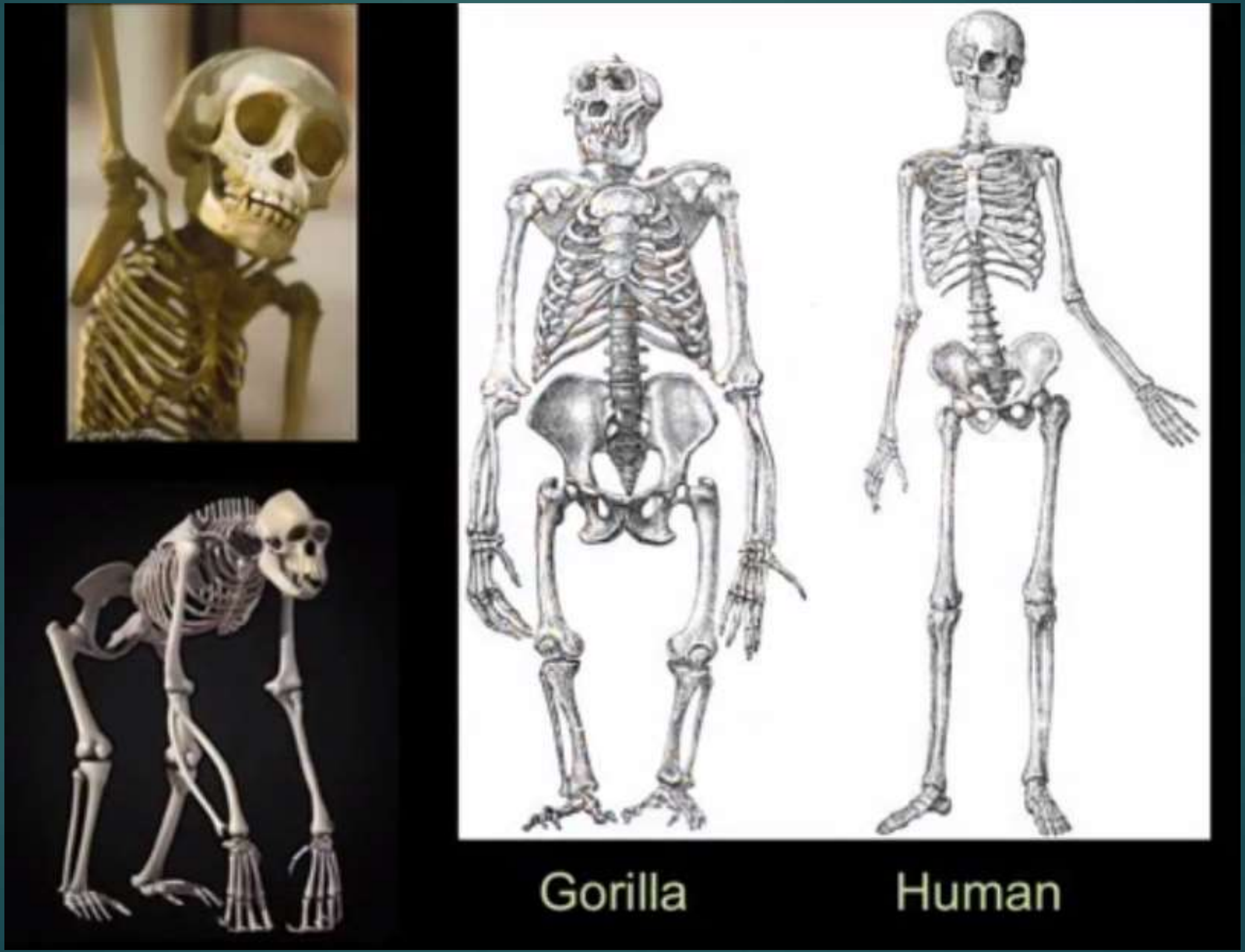
Chimp vertebrae wedged forward; hominins (incl. australopiths) have posterior wedging at bottom of column



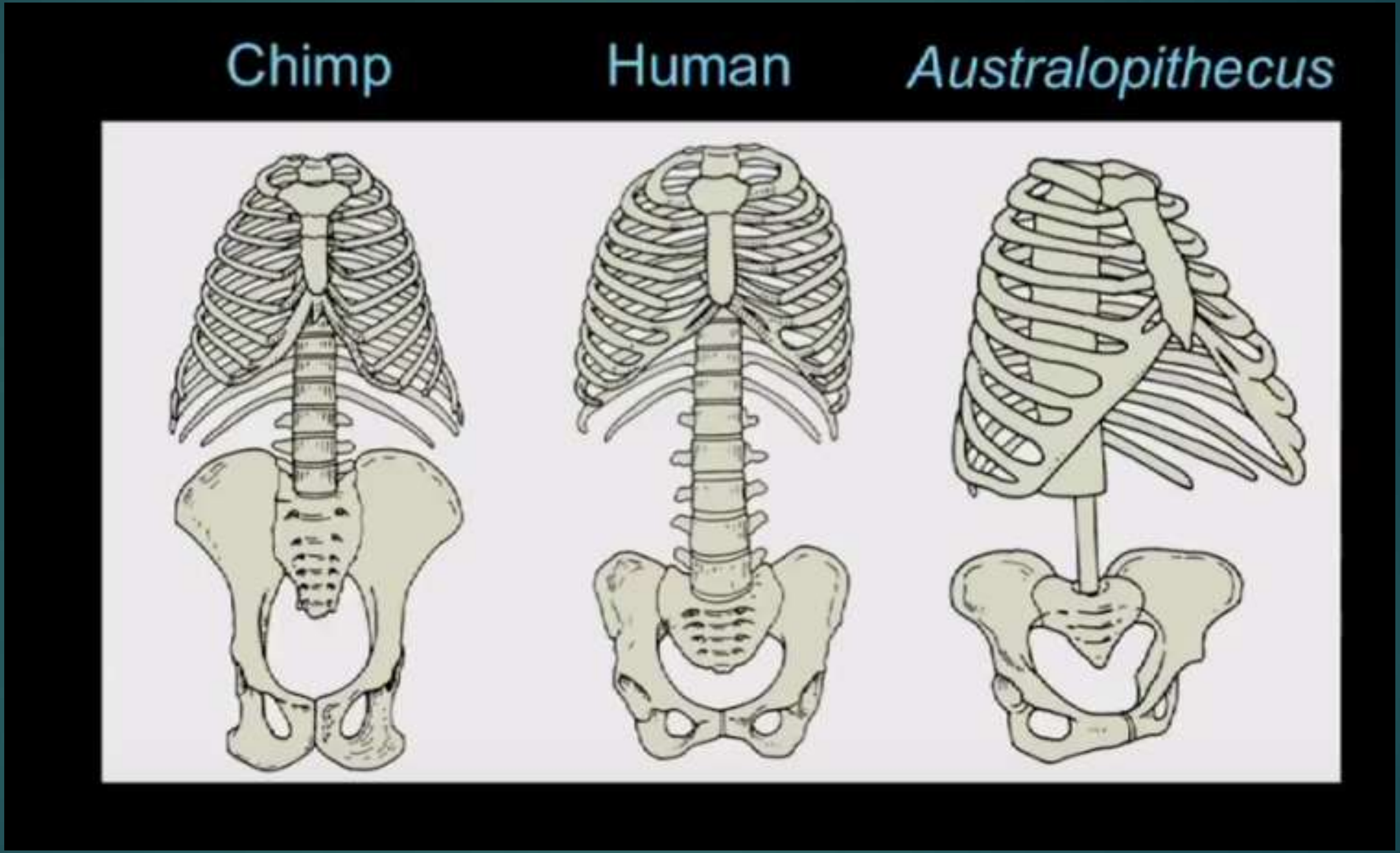


Not hunched forward; had upright posture due to spine

Rib & pelvis differences



Classic textbook differences



Cone shape

Barrel shape

1980’s model

Australopithecus afarensis

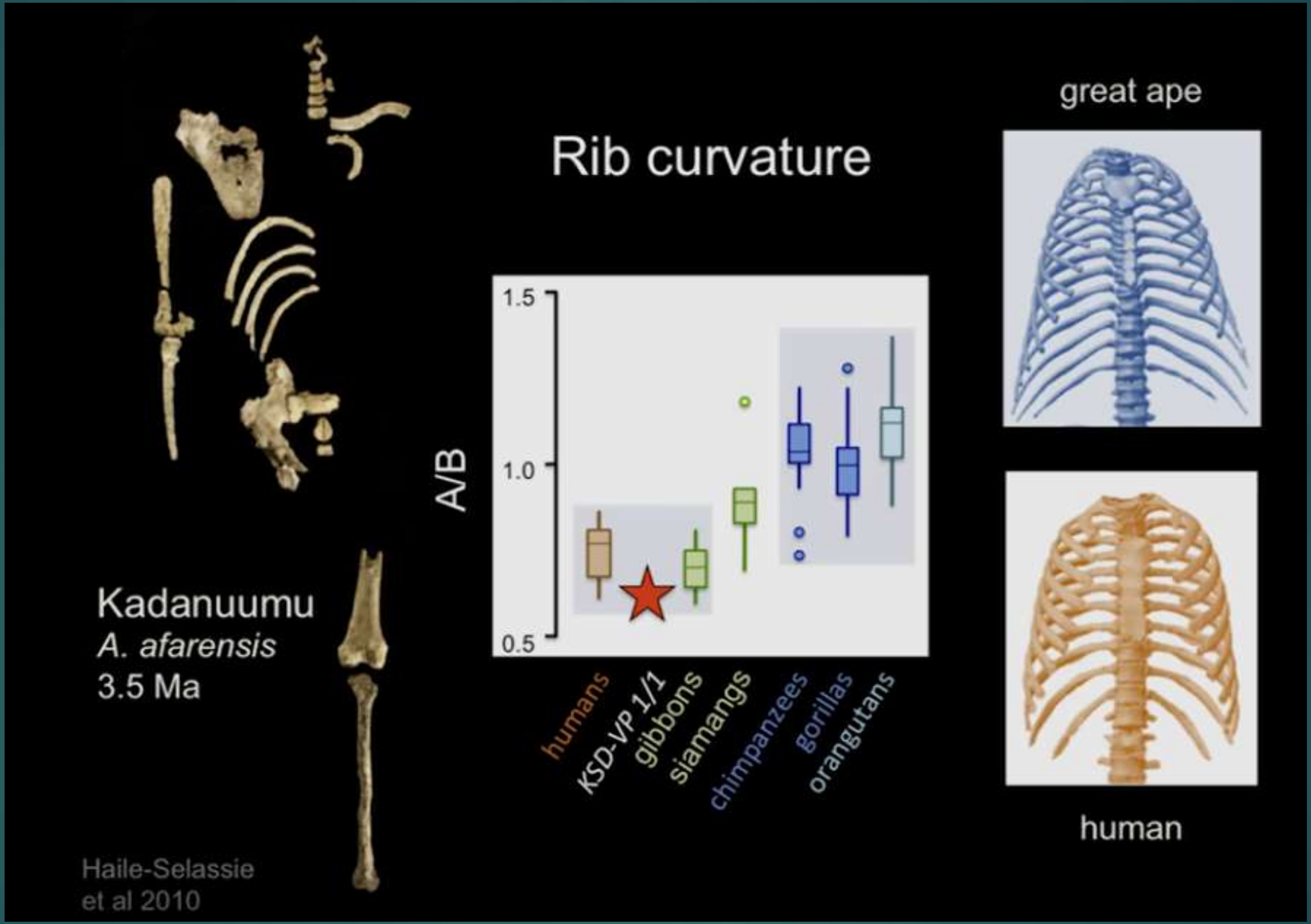
Cone-shaped rib cage?

Based on Lucy: few actual ribs

- No waist, limited pelvic rotation, compromised bipedal gait
- Large gut, tough food diet
- Retained tree-climbing?

Latest rib data indicates Australopiths were more human like, indicating more upright posture;

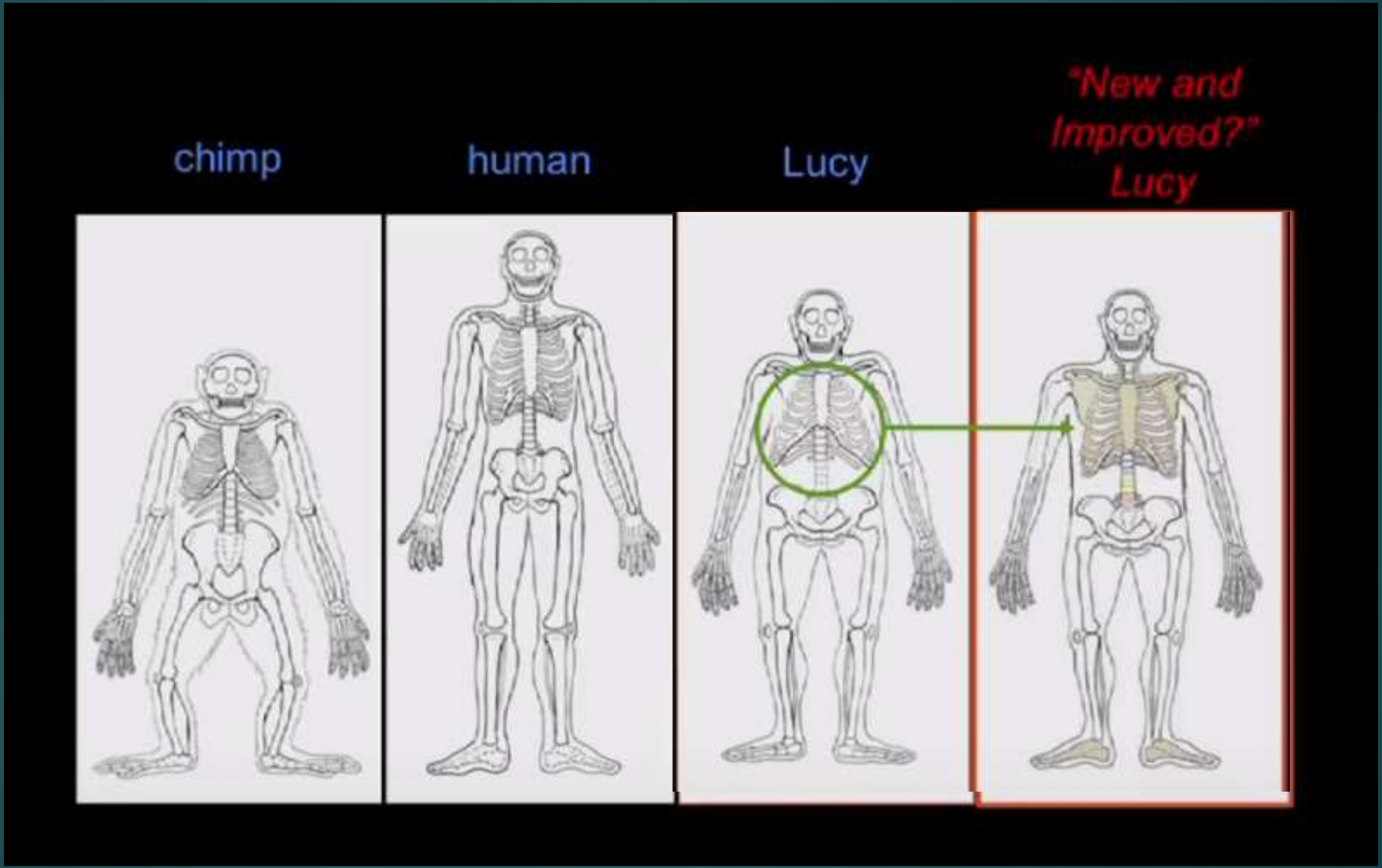
Ribs



Human ribs
Curve around;
More barrel like

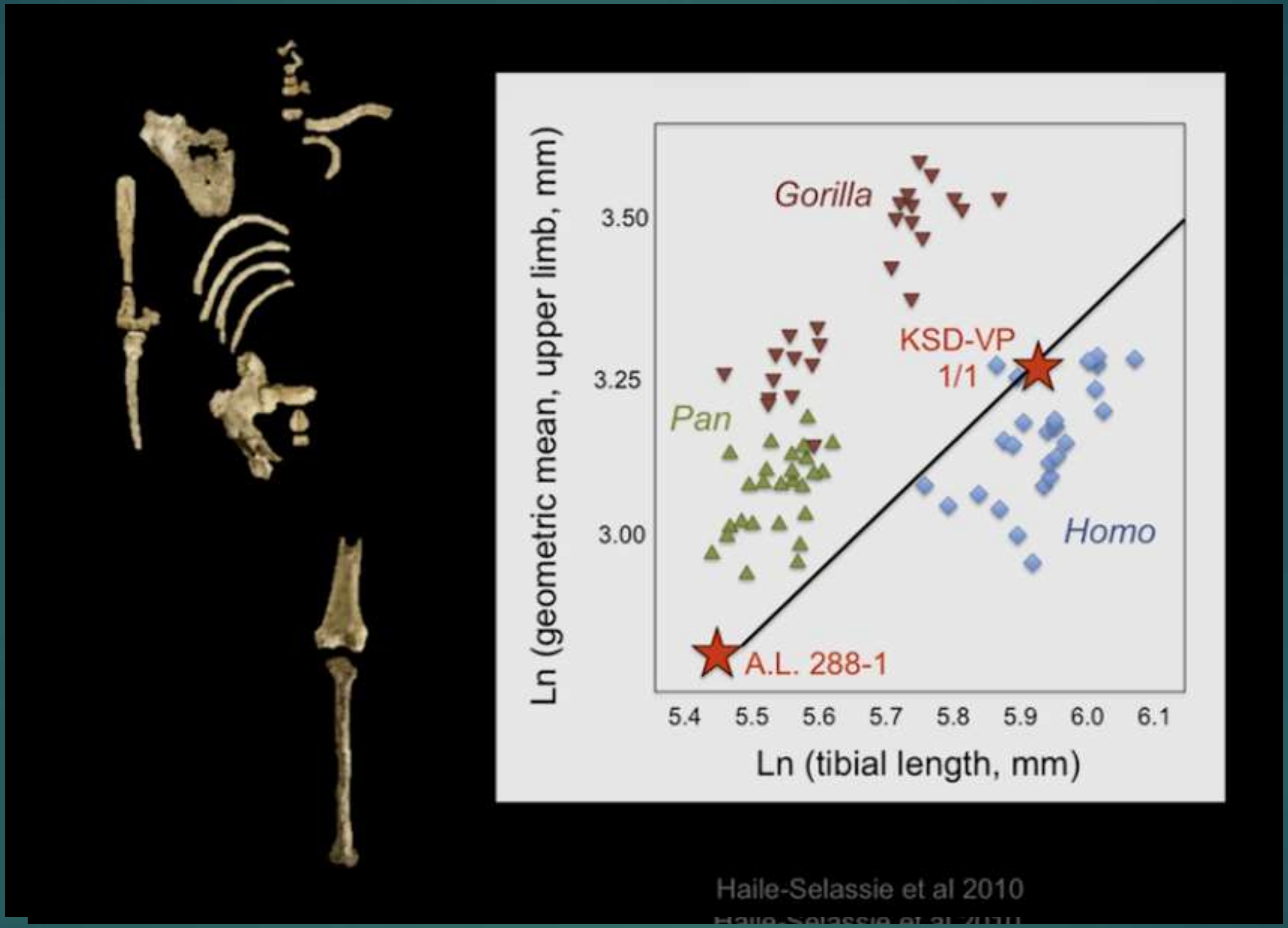
Kadanuumu (male): rib curvature is like human, not ape (blue)

Newer model of Lucy



More barrel shaped & more of a waist

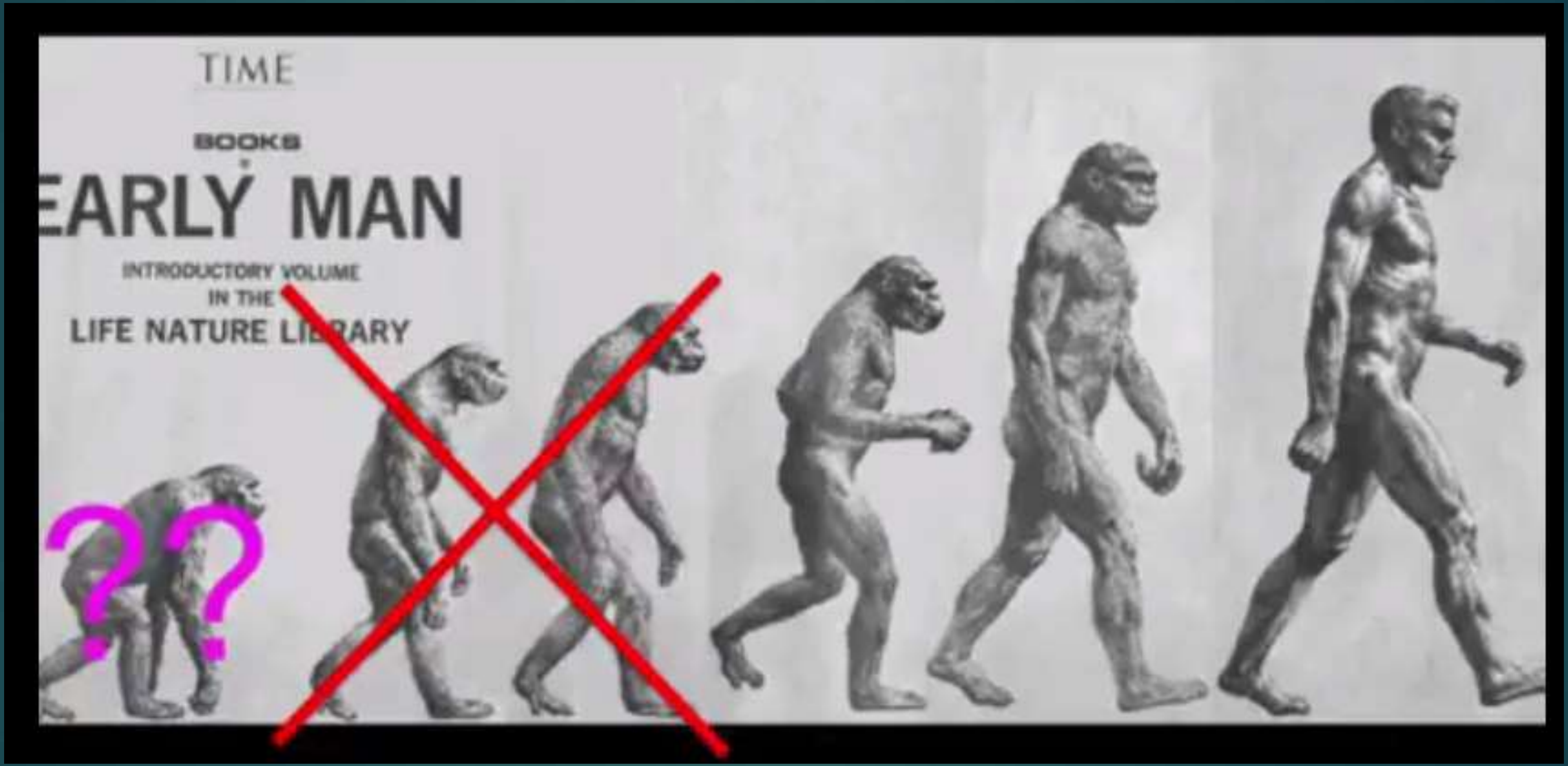
Limb length



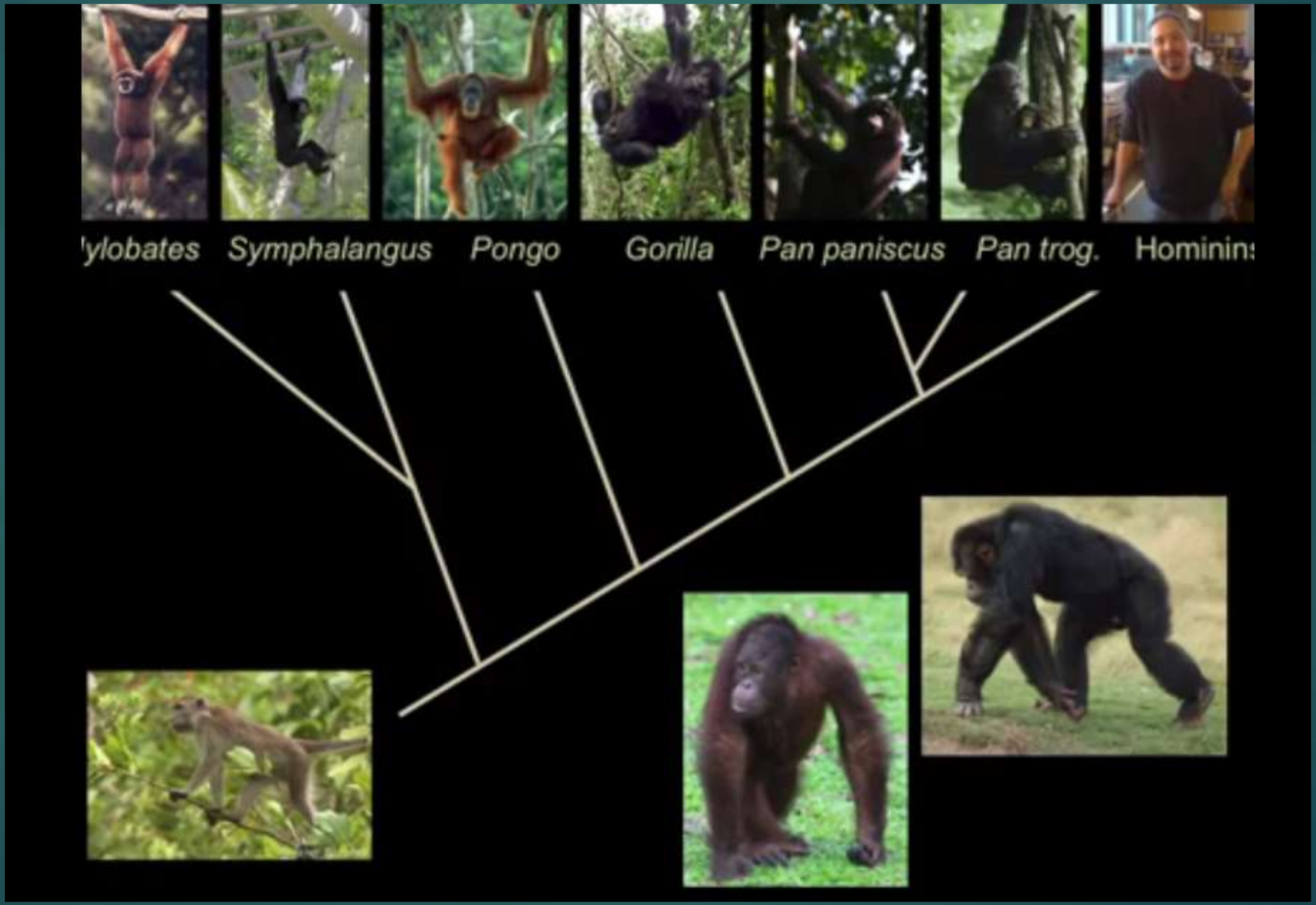
Lucy was more ape like in limb length; she was small

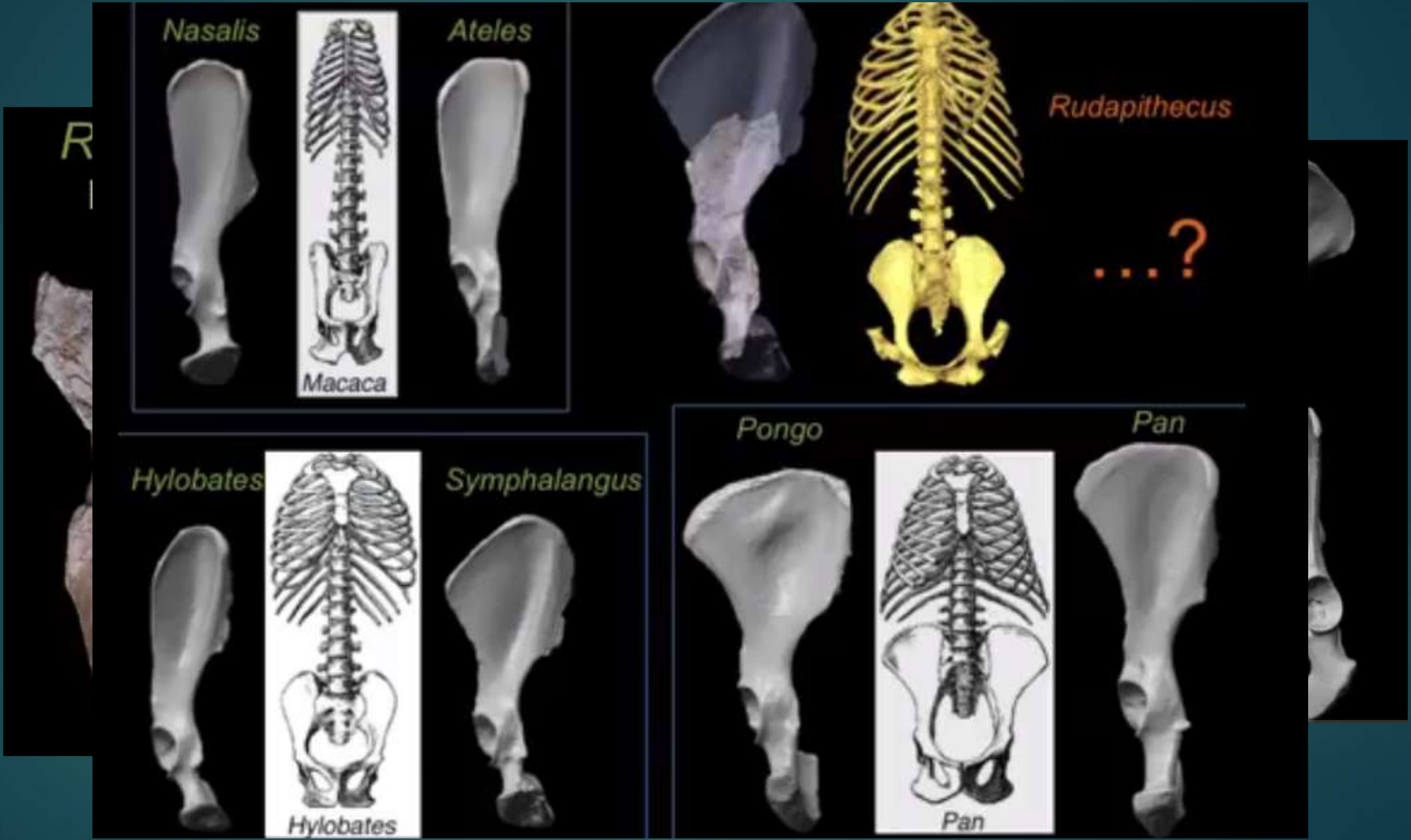
Kadanuumu: longer arms but legs not so short

Feet: apes have grasping feet; humans have stiff foot with arch; A. afarensis metacarpal was similar to us, with strong arch


TIME
BOOKS
EARLY MAN
INTRODUCTORY VOLUME
IN THE
LIFE NATURE LIBRARY

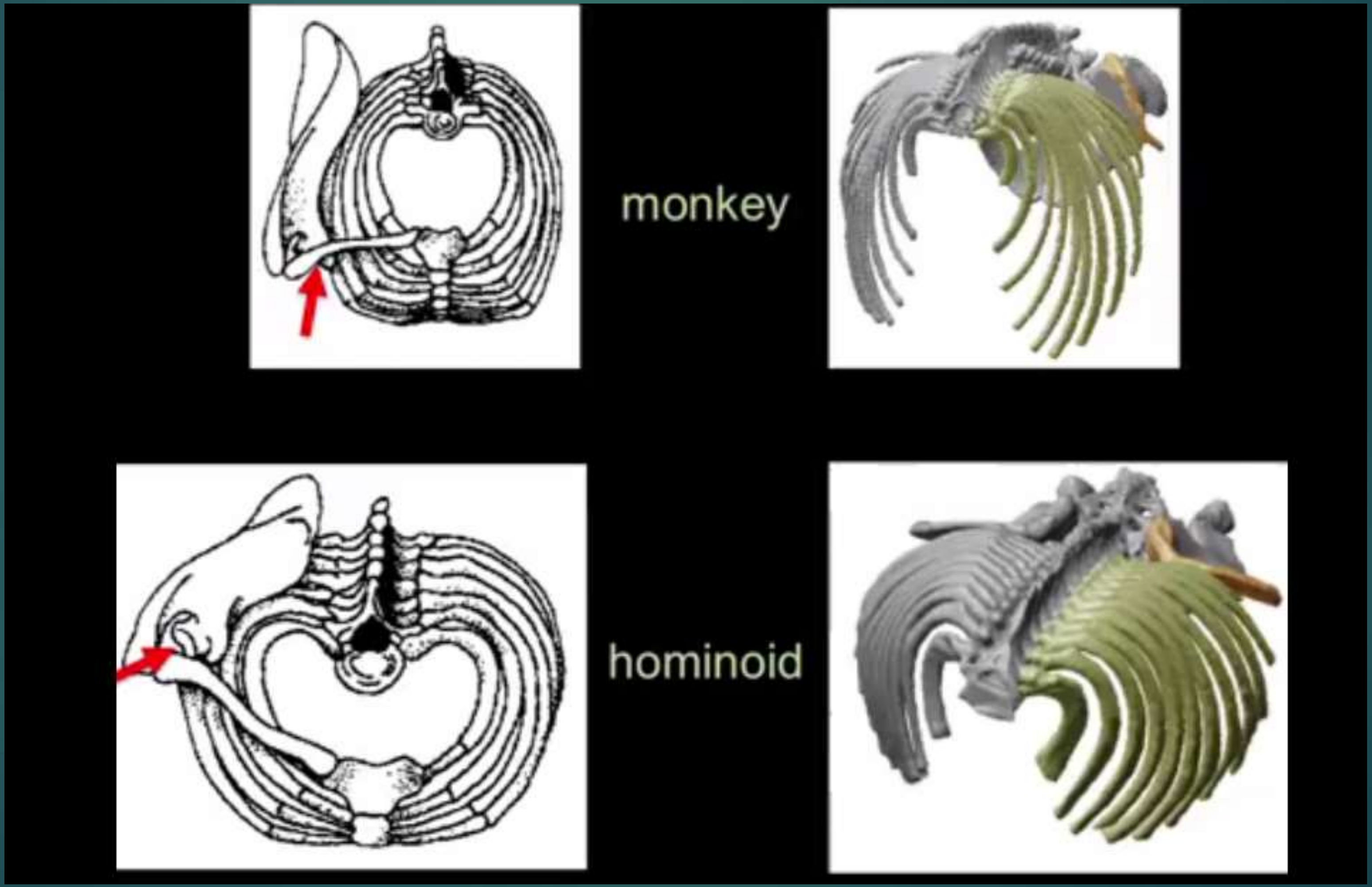
Apes mostly suspensory in the trees and walk on all 4s on ground





Less specialized than modern apes; more flexible backs

Cone vs barrel rib cage; implies narrow vs broader pelvis



If blow up Australopithecus to human size, very similar locomotion and erectness

Carol Ward: Not why did we stand up, but why did we not go down on all 4s like rest of modern apes?

Hominin Evolution: The 5 Major Steps examples

- Bipedalism: *Australopithecus afarensis*

- Tool Use:
  - *Homo habilis* (2 Ma)
  - *A. afarensis* (3.3 Ma) *(*Lomekwi 3 site, cut marks at Dikika site)
  - tool use (chimps do) vs tool making (modifying stones) vs making tools to make tools (MHs)

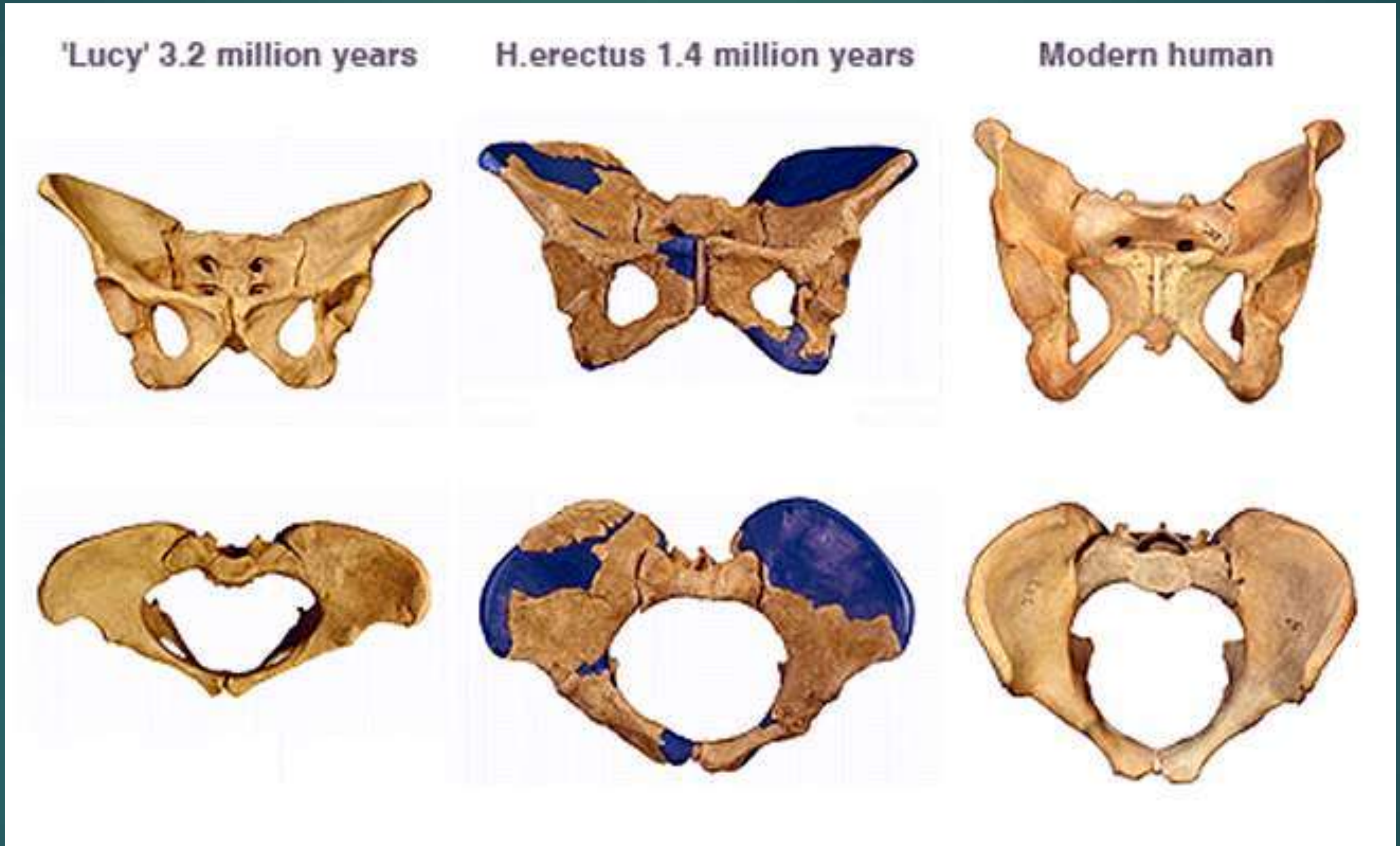
- Body Plan: *Homo erectus* (long legs, long distances)

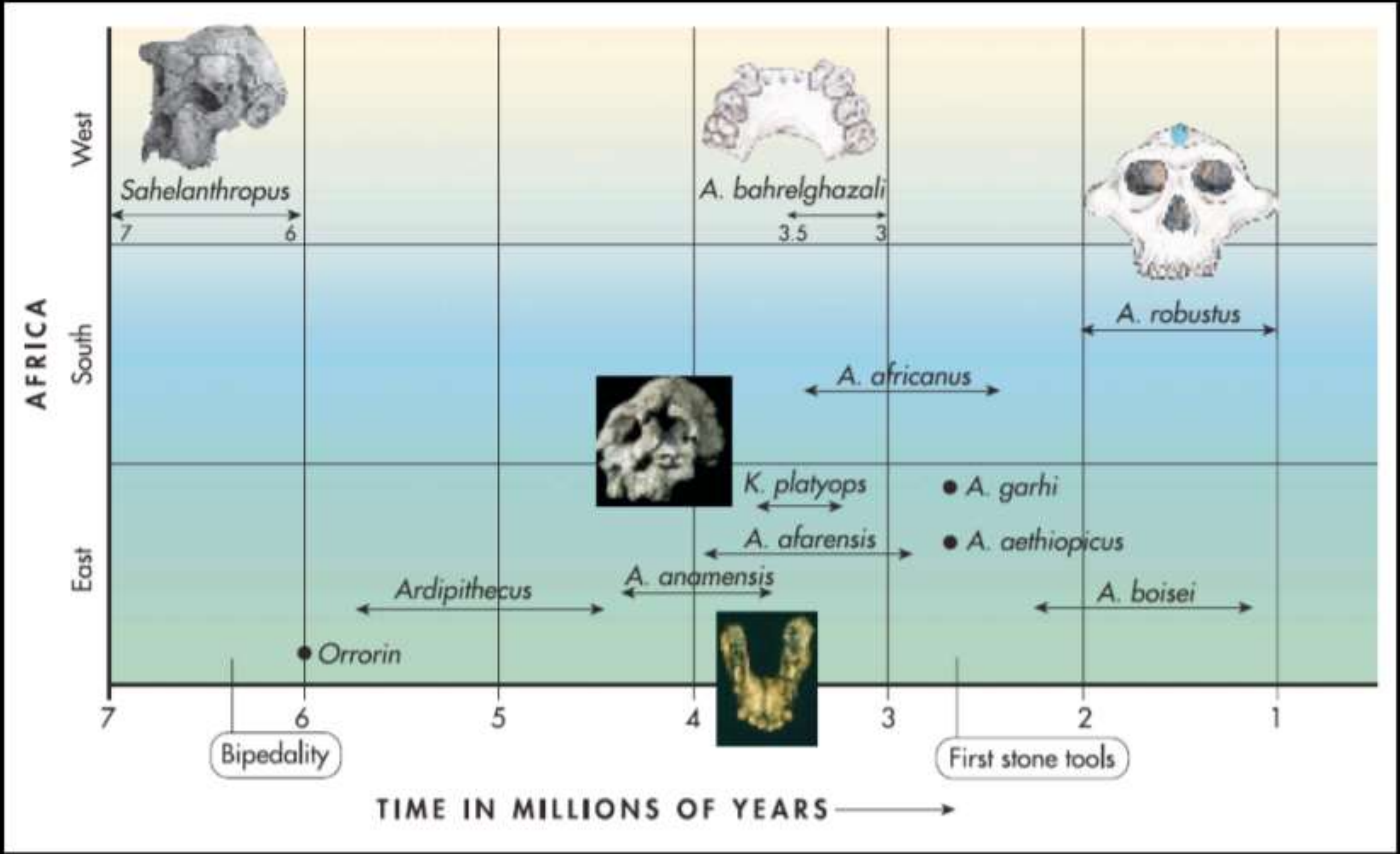
- Bigger Brain: *Homo heidelbergensis & neanderthalensis & sapiens*

- Symbolic thinking: *Homo sapiens* (c 100K, pigments)

Methodology: How we study material

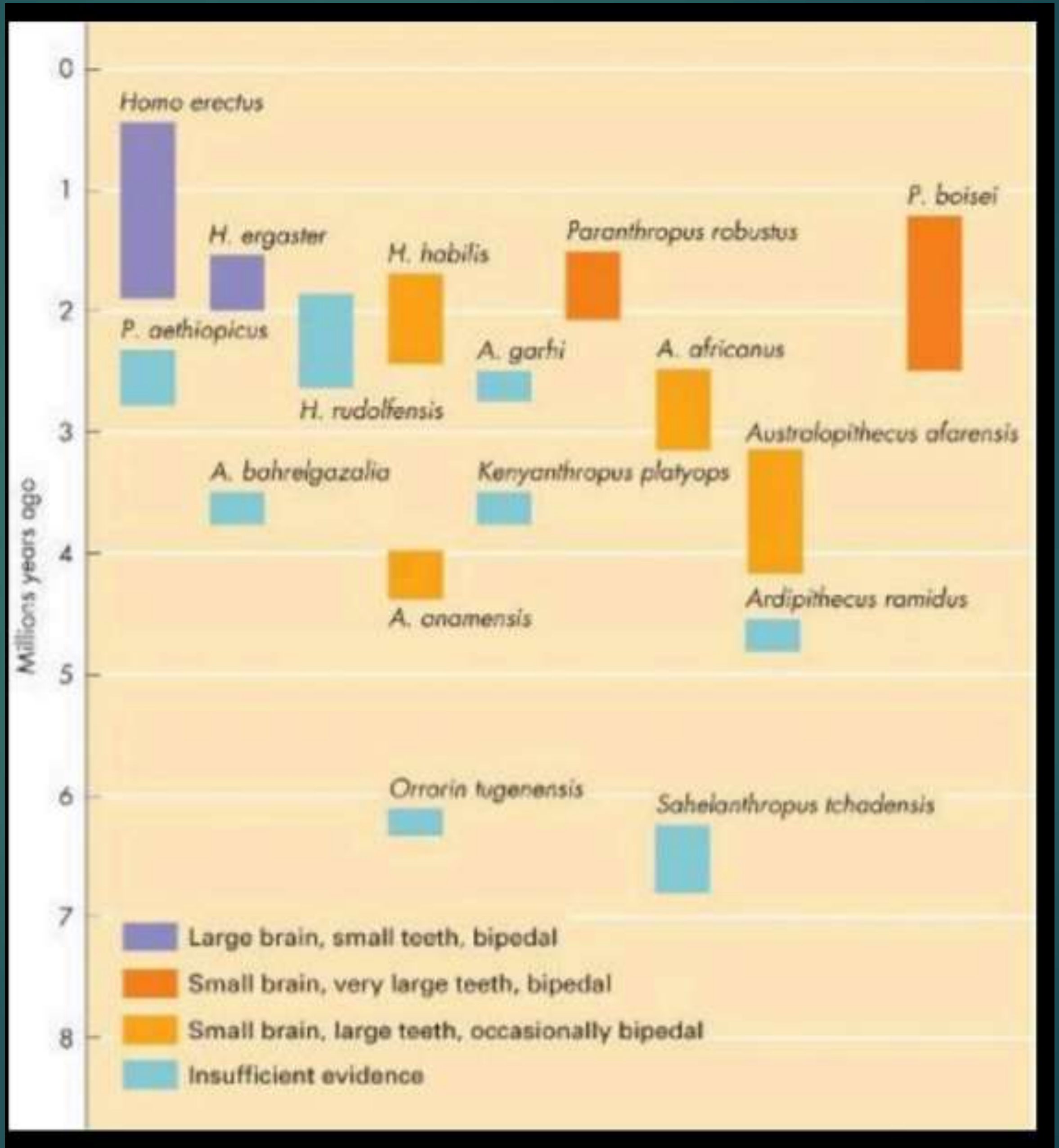
- Graphic of 3 skulls, 3 teeth, 3 pelvis: chimp, Lucy, MH
- Chimp: small brain, large canines, projecting face, receding skull/no forehead
- Pelvis: chimp high, rigid
- Dentition; human more parabolic, no large canine; chimp boxcar shape, large canine; Lucy intermediate
- Bipedality: 7 Ma

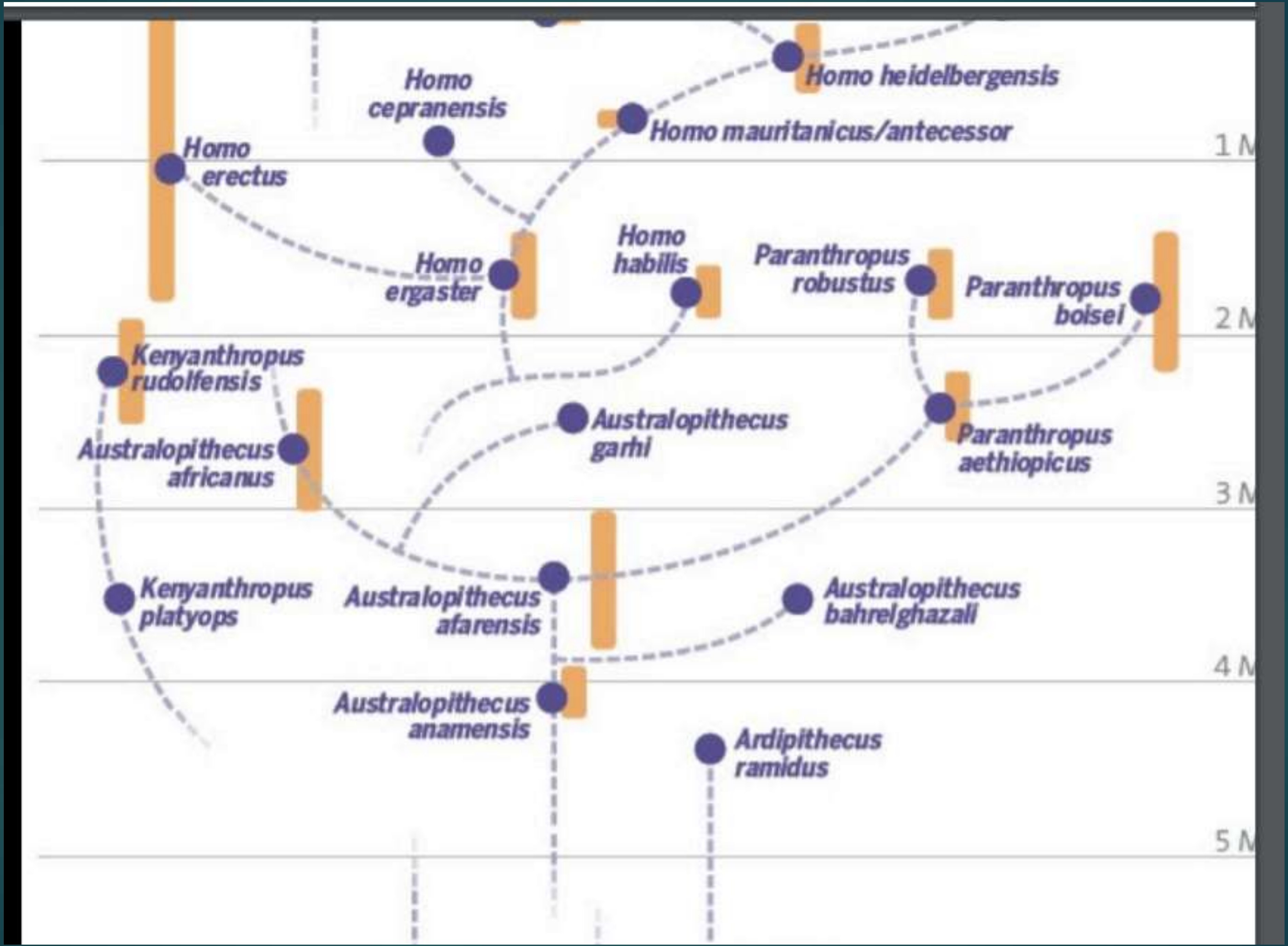

'Lucy' 3.2 million years
H.erectus 1.4 million years
Modern human



AFRICA
West
South
East
Sahelanthropus
7
6
A. bahrelghazali
3.5
3
A. robustus
A. africanus
K. platyops
A. garhi
A. afarensis
A. aethiopicus
A. anamensis
Ardipithecus
A. boisei
Orrorin
7
6
5
4
3
2
1
Bipedality
First stone tools
TIME IN MILLIONS OF YEARS

Hominin characteristics and time frame




Homo heidelbergensis
Homo cepranensis
Homo mauritanicus/antecessor
1 M
Homo erectus
Homo ergaster
Homo habilis
Paranthropus robustus
Paranthropus boisei
2 M
Kenyanthropus rudolfensis
Australopithecus garhi
Australopithecus africanus
Paranthropus aethiopicus
3 M
Kenyanthropus platyops
Australopithecus afarensis
Australopithecus bahrelghazali
4 M
Australopithecus anamensis
Ardipithecus ramidus
5 M

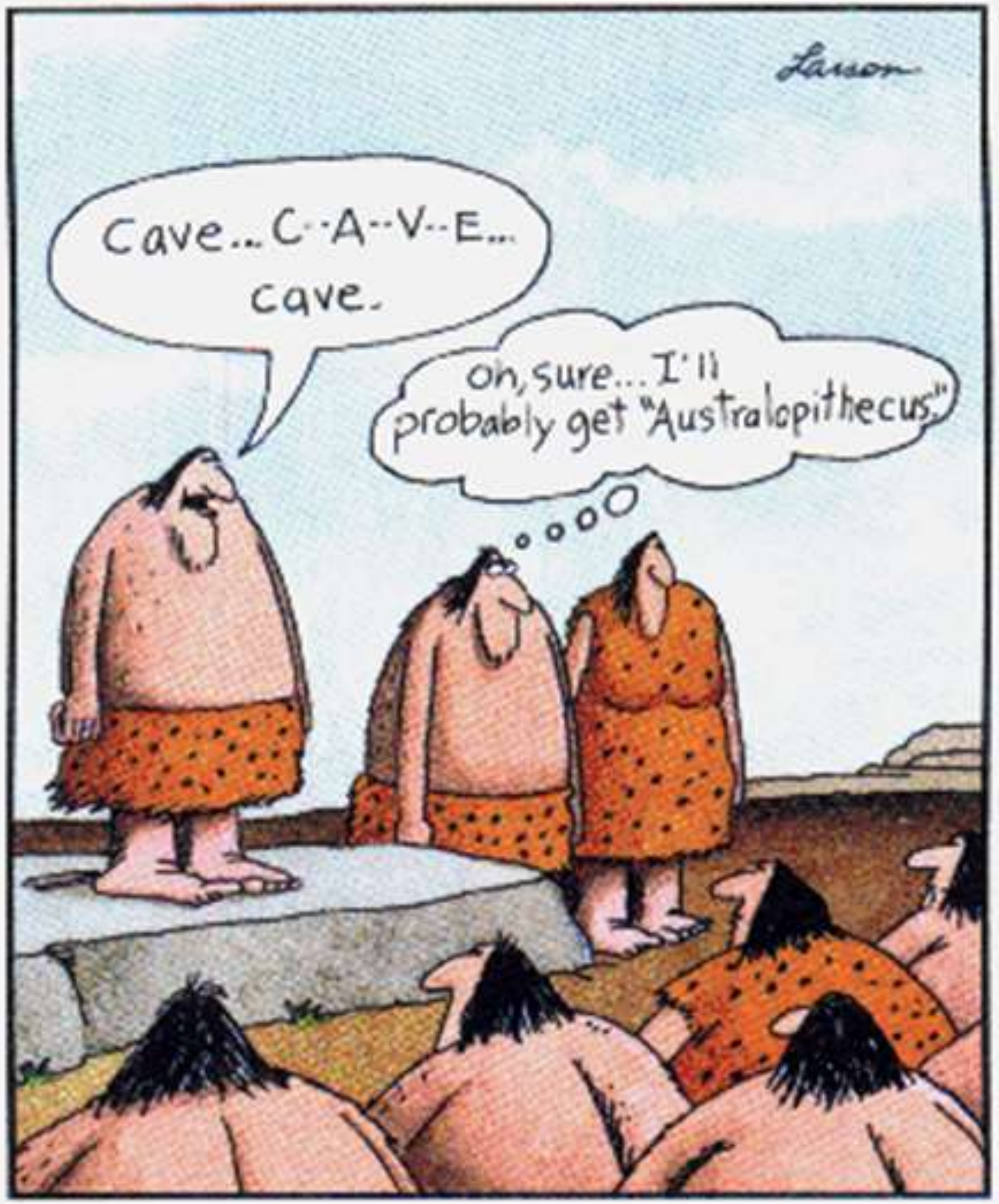
Archaic vs. Transitional Hominins

- The following creatures are almost certainly hominins.
- Share more of their morphology with modern humans than with chimps.
- Yet they do not show changes in jaw, tooth size, and body size and shape that mark hominin species in genus *Homo*.
- They are archaic hominins.
- There are also a group of hominins that seem to be part archaic hominin and part Homo. Could be called "transitional" hominins.

Australopiths

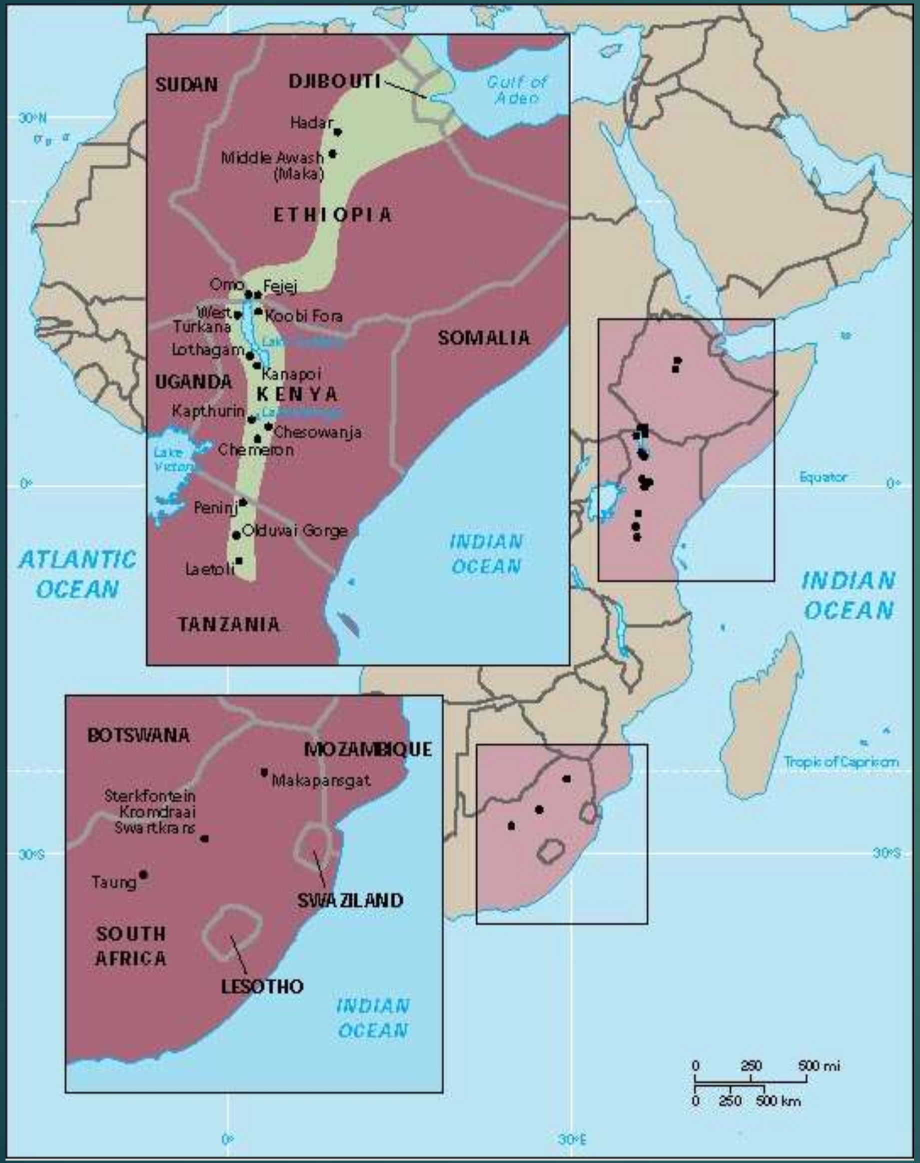
Australopithecus anamensis	4.2-3.9 mya	Lake Turkana, Kanapoi, Allila Bay (Kenya)	Smaller canine than *Ardipithecus*, CP3 complex.
Australopithecus afarensis	3.9-2.9 mya	Awash Valley (Ethipopia)	Cranial capacity – 350-500 cc, biped, smaller teeth than chimpanzee, "Lucy"
Australopithecus bahrelghazali	3.5-3.0 mya	West Africa	Single fossil: front mandible with seven teeth.
Kenyanthropus platyops	3.5 mya	Lake Turkana (Kenya)	Flat face
Australopithecus garhi	2.5 mya	Bouri (Ethiopia)	Small brain (450 cc), prognathic face, large canines, sagittal crest, near early tools.
Australopithecus africanus	3.5-<2.0 mya	South Africa	"Taung Child," ape-like jaw, moderate brain 450-550 cc, gracile *Australopithecus*.
Australopithecus sediba	1.97-1.78 mya	South Africa	Brain – 420-435 cc
Australopithecus (P.) aethiopicus	2.7-2.5 mya	Kenya	Sagittal crest, dished face, flared zygomatics, and huge molars.
Australopithecus (P.) boisei	2.3-1.2 mya	Kenya, Tanzania, Ethiopia	Estimated body at 75 – 110 pounds.
Australopithecus (P.) robustus	2.0-1.5 mya	South Africa	Cranial capacity – 500 – 550 cc

Australopithecine Spelling Bees



Primitive spelling bees

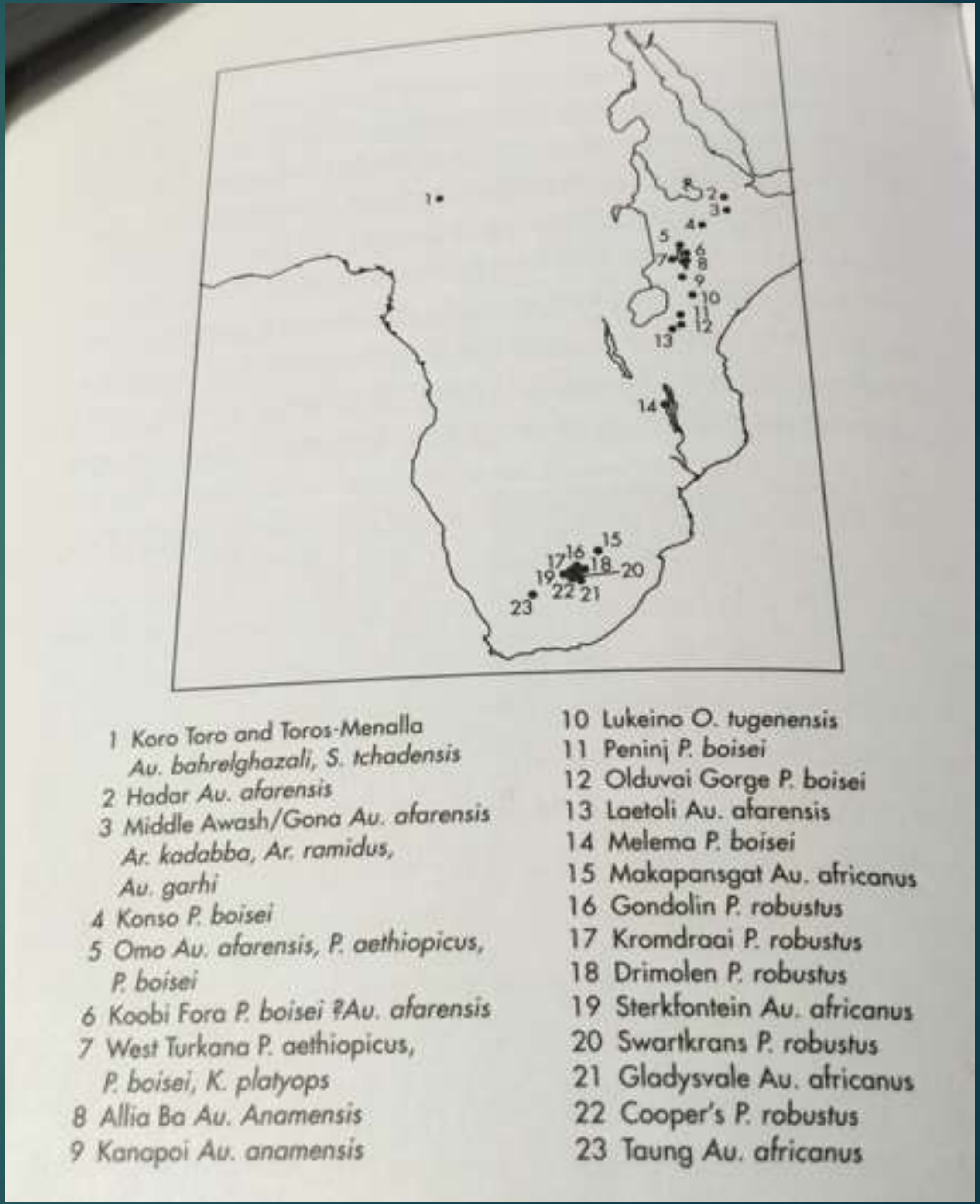
Map of Australopithecine Finds



- Map of major Australopithecus sites in Africa:
- East African rift valley
- limestone caves of South Africa.

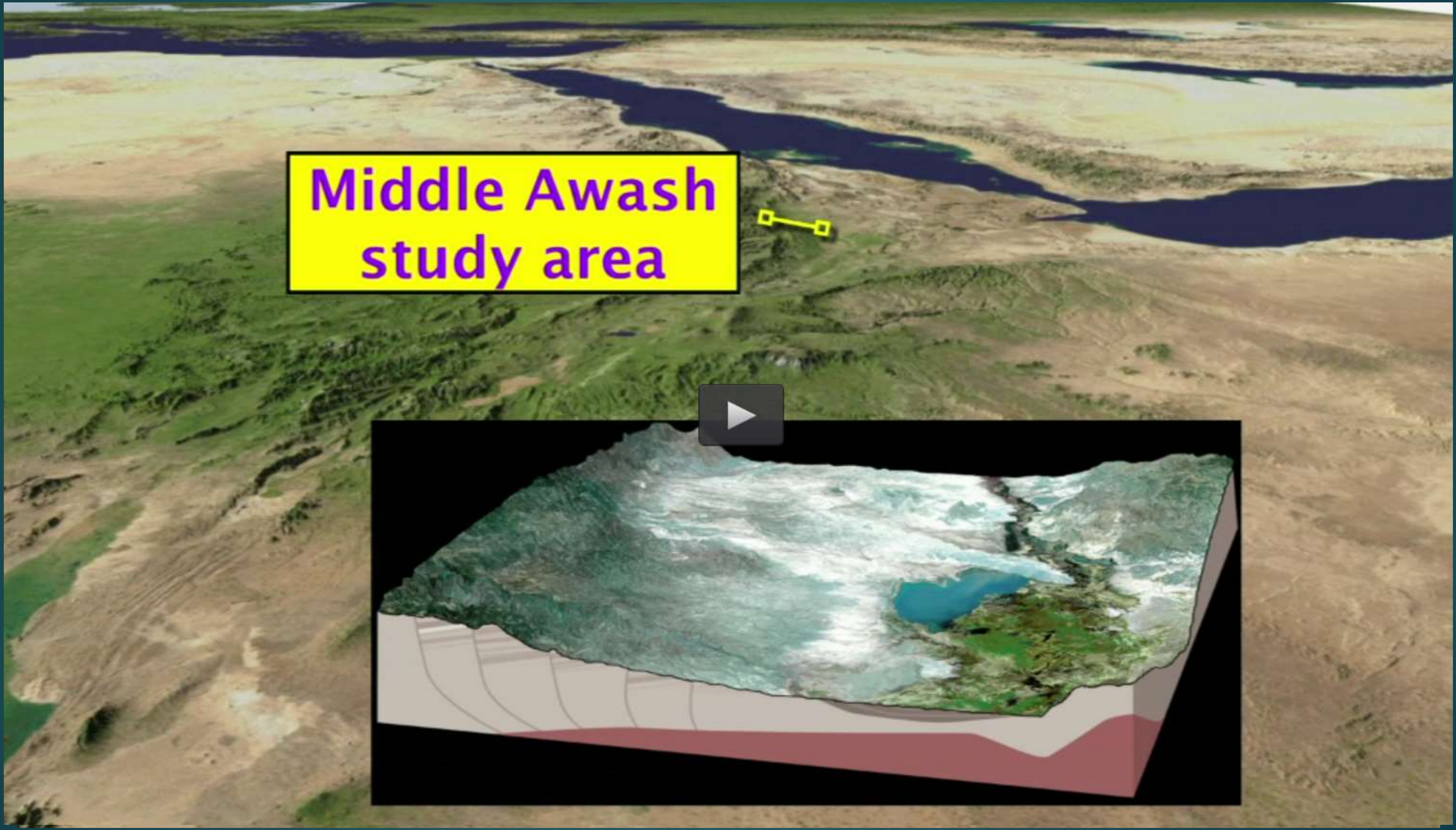
Major discoveries of hominins

Mainly South Africa and East Africa



Rift Valley: 3 tectonic rifts have expanded, revealing 6 M years of evolution

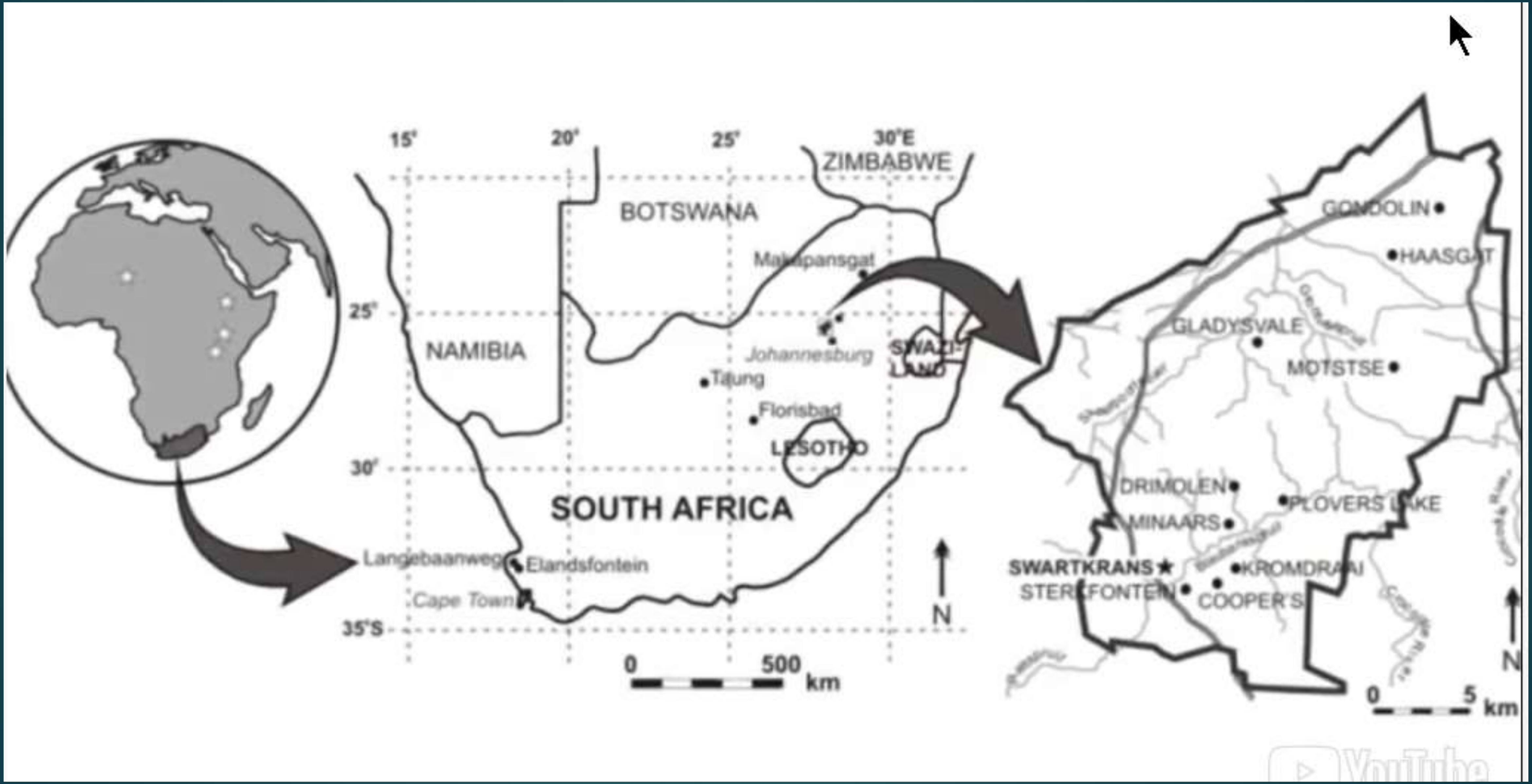
Rift valley/Afar: 3 plates pulling apart; rocks drop and form valleys; Afar is large lowland depression; lakes lie along rift; 1 mile deep sedimentation



Fossil trail. Many kinds of hominids lived in Africa 6 million to 2.5 million years ago, before *Homo* appeared.

North of Johannesburg, S. Africa

Cradle of Humankind: North of Johannesburg, S. Africa



Cradle of Humankind

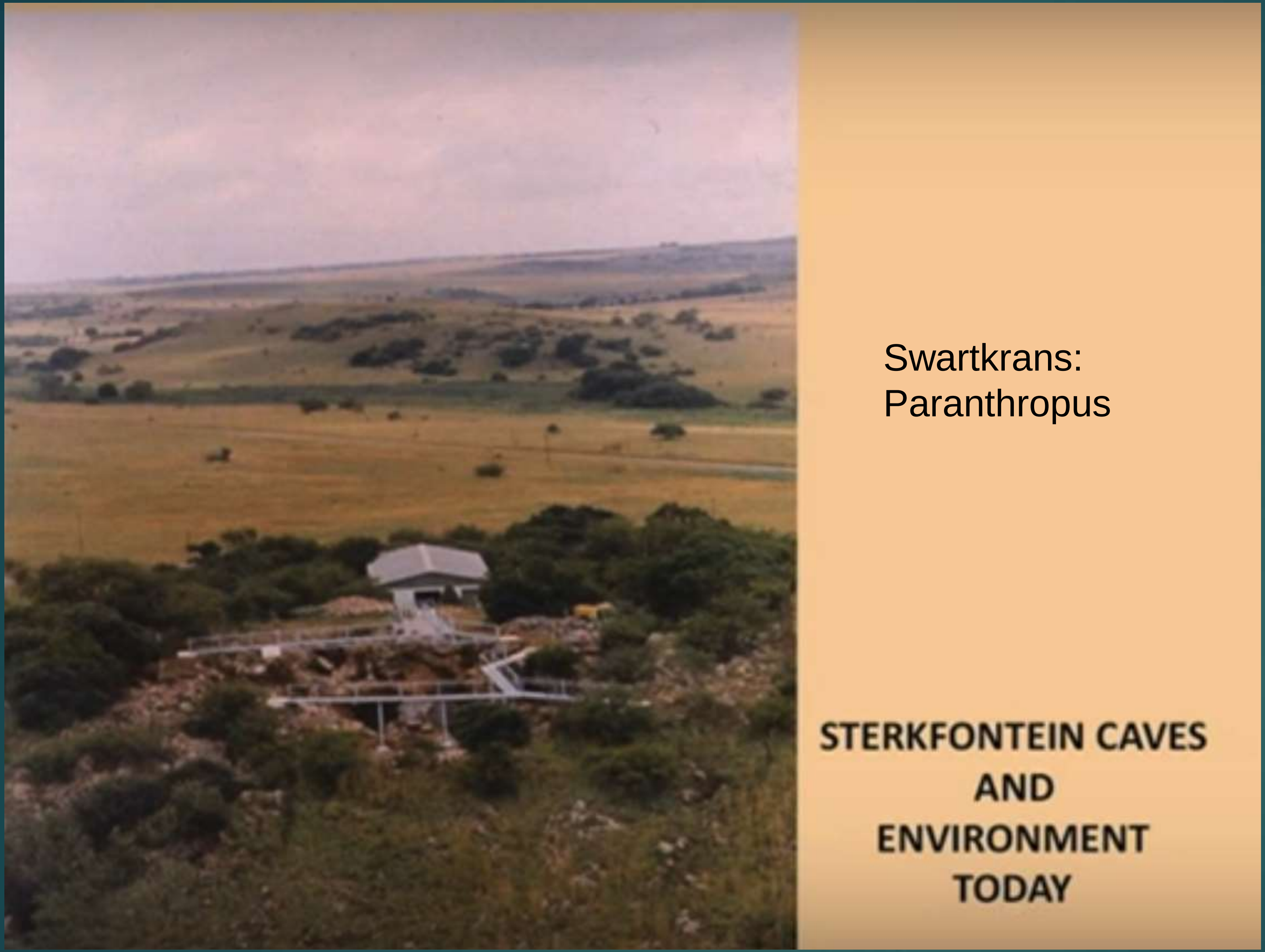
- The Fossil Hominin Sites of South Africa lies 45 km west of Johannesburg.
- It includes a number of caves and dig sites at 13 separate locations within an undulating landscape of low hills along a dolomitic limestone ridge.
- The importance of the area was discovered accidentally, as a result of fossil finds during limestone quarrying. Today the quarrying has ceased and the sites is being excavated and explored more systematically for its scientific values.
- The whole area (470 km2) is under private ownership, and most of the excavation sites are not accessible to the general public.
- The Cradle of Humankind, include 16 sites: Bolt's Farm, Cooper's Cave, Drimolen, Gladysvale, Gondolin, Haasgat, Kromdraai, Makapan valley, Malapa, Minaars Cave, Motsetsi, Plovers Lake, Rising Star Cave, Sterkfontein, Swartkrans, Wonder Cave
- The World Heritage Site was extended in 2006 to include two more distant localities - the Taung Skull Fossil Site (which lies in Northwest Province about 350 km WSW of Sterkfontein), and the Makapan Valley (about 300 km to the north-east in Limpopo Province).

Sterkfontein

Sterkfontein

- The ages of the *A. africanus*-bearing breccias are estimated to be between 2.4 and 4 Ma.
- At least seven hominin species are believed to have walked the cradle over a span of 4-million years.
- At about 2-million years ago, there were as many as five hominin species sharing the landscape, including possibly an early relative, Homo habilis.
- But recently far older hominin species have been pulled out of Sterkfontein, which the team are still trying to put names to.
- There are some deposits in the cave that Stratford believes could date to 5-million years.

Swartkrans:
Paranthropus



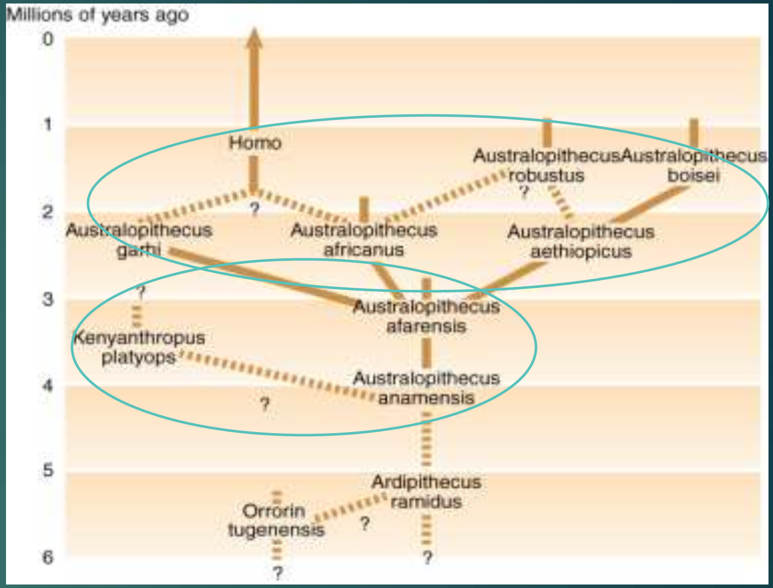
Dolomite caverns

25 meter depth

Swartkrans Cave

Primitive and later hominins

- Primitive hominins
  - *Australopithecus anamensis*
  - *Australopithecus afarensis*
  - *Kenyanthropus platyops*
- Later hominins
  - *Paranthropus* or robust *Australopithecus*
  - *Australopithecus africanus*
  - *Australopithecus garhi*
  - *Australopithecus habilis, A. rudolfensis*



Early australopithecines

- Ancestral traits:
- – Ape-sized brains
- – Projecting face & broad incisors
- – Climbing abilities
- – Sexual dimorphism

Derived traits:

– Smaller canines

– Crushing molars

– Effective Bipeds

Nomenclature

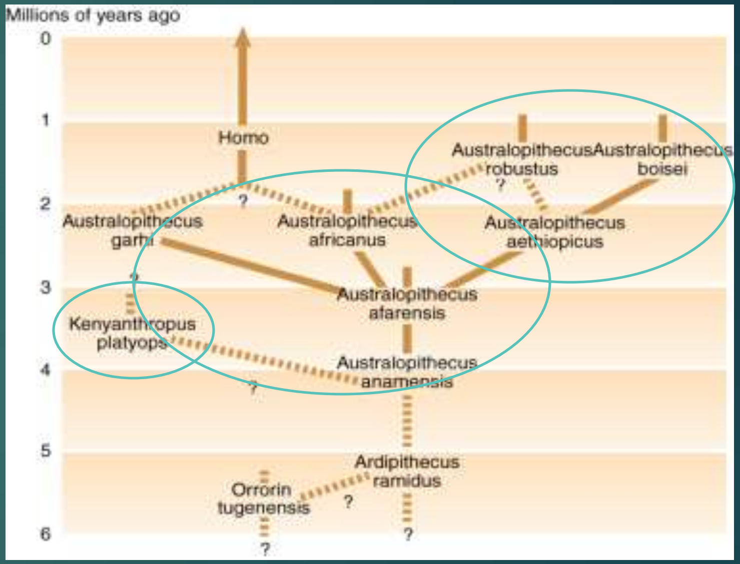
- Each name consists of a genus name, e.g., *Australopithecus, Homo*, which is always capitalized, and a species name, e.g., *africanus, erectus*, which is always in lower case, and both are italicized.

Hominin Tree Implications

- It is a bush not a straight line
- Earlier period gets murky in who ancestors were
- Typically, more than 1 species living at same time and place
- Except for *Homo erectus,* most hominin species lasted for 1 million years or less
- Last ape standing: *Homo sapiens* (us) is the only species to have survived.
- This process was random, with no innate progression; the most adaptable survived

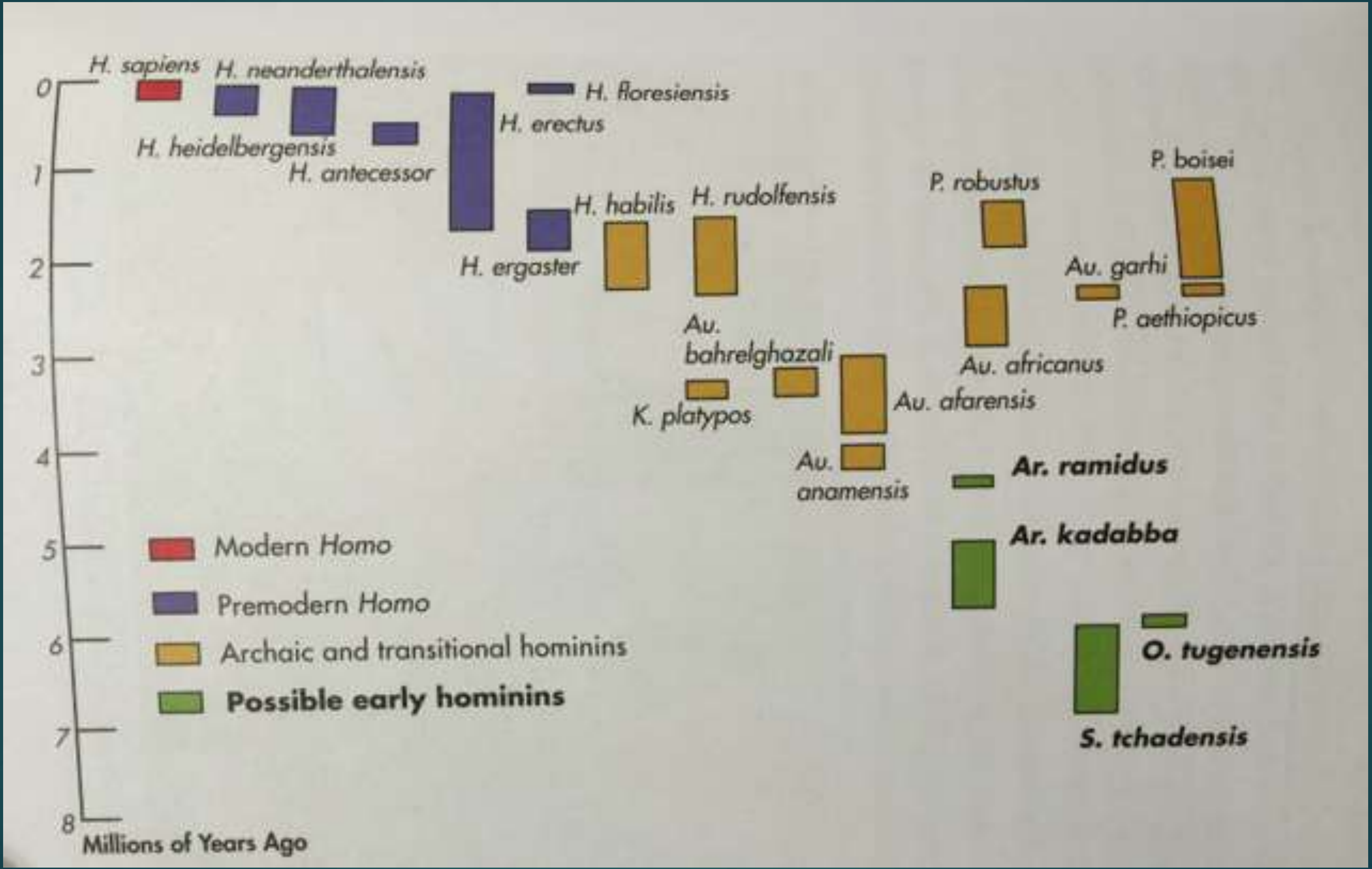
Diversification of hominins

- Hominin lineage proliferated 4–2 MA, likely with multiple species living in Africa at same time
- Taxonomic classification of these hominins hotly contested
  - Lumpers and splitters
  - Linear and bushy family trees
- Bernard Wood and Mark Collard advocate three genera
  - *Australopithecus, Paranthropus, Kenyanthropus*



Australopithecus

- Debate about how many species belong to genus
- Two major points of disagreement
  - Robust australopithecines
  - Early *Homo*
- Wood and Collard's scheme narrows definition of *Australopithecus* and of *Homo*
- Taxonomic debates reflect limitations of data, philosophical differences, and politics



H. sapiens
H. neanderthalensis
H. floresiensis
H. erectus
H. heidelbergensis
H. antecessor
H. habilis
H. rudolfensis
H. ergaster
P. robustus
P. boisei
Au. garhi
P. aethiopicus
Au. bahrelghazali
Au. africanus
Au. afarensis
K. platypos
Au. anamensis
Ar. ramidus
Ar. kadabba
O. tugenensis
S. tchadensis
Modern Homo
Premodern Homo
Archaic and transitional hominins
Possible early hominins
0
1
2
3
4
5
6
7
8
Millions of Years Ago

B. Wood

Fossil Preservation: hominin vs chimp

- Hominins may have lived all over Africa, but their remains are found only at sites where conditions allowed for the formation and preservation of fossils.
- Not all environments are conducive to fossil perseveration; some so acidic (forests), fossils rarely survive
- Fossil record for the chimp/bonobo clade is virtually nonexistent.
- The only panin fossil evidence in the last 8 myr consisted of a few 700 kya-old isolated teeth from a site called Baringo, in Kenya.
  - A. Little chance of erosion in forests and therefore no exposures, and thus no places where fossils could be uncovered by erosion.
  - High levels of humic acid in soils of forests dissolve bones before they fossilize.
- B. Wood is unconvinced by above arguments. Thinks fossils are out there but undiscovered.

Australopithecines: A 2 Million year span of existence

- Genus Australopithecus had maybe six, eight or eleven, species in it, depending on who you believe.
- Now that is an astonishingly successful genus as far as evolution goes.
- The oldest is *A. anamensis*, at 4 MA; youngest is *A. sediba, at* 1.9 MA.
- That's a life span of nearly two million years between these species.

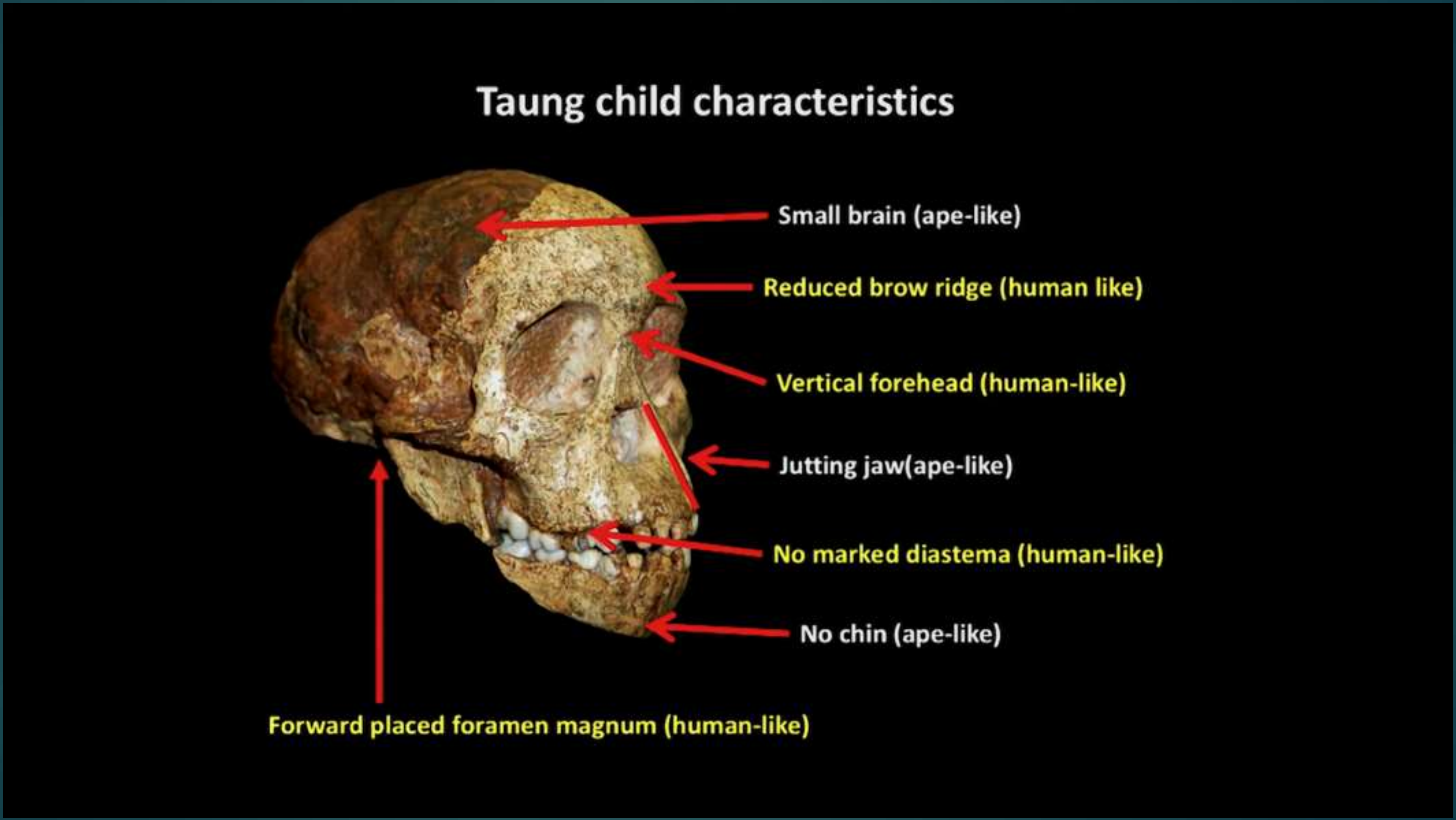
A historical review of the Australopithecines (11 species)

- 1924: Taung - *Australopithecus africanus*
- 1947: Mrs. Ples – *Australopithecus africanus*
- 1948: *Paranthropus robustus* at Swartkrans
- 1959: Zinj - *Paranthropus boisei* at Olduvai Gorge, Tanzania
- 1974: Lucy - *Australopithecus afarensis* in Ethiopia
- 1985*: Paranthropus aethiopicus*

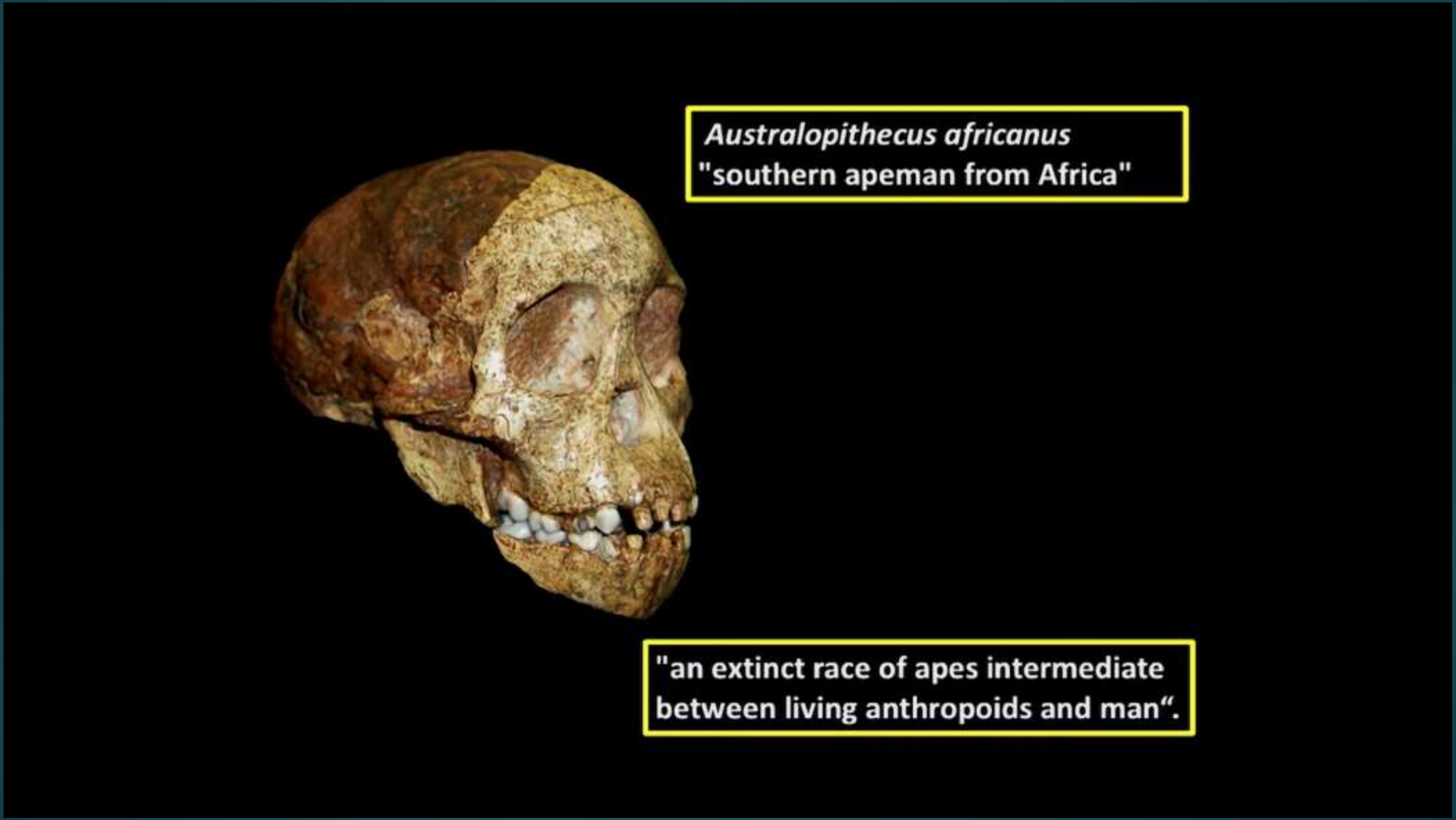
A historical review of the Australopithecines 2

- 1994: *Australopithecus anamensis*
- 1995: Abel - *Australopithecus bahrelghazali*
- 1997: *Australopithecus garhi*
- 1999: *Kenyanthropus platyops*
- 2008*: Australopithecus sediba*
- 2015*: Australopithecus deyiremeda*

Australopithecus – Job Kibii



Australopithecus



Rejection & Acceptance of Australopithecus

- Greek for "ape" (pithekos) and Latin "of the south" (australis),

Homo neanderthalensis

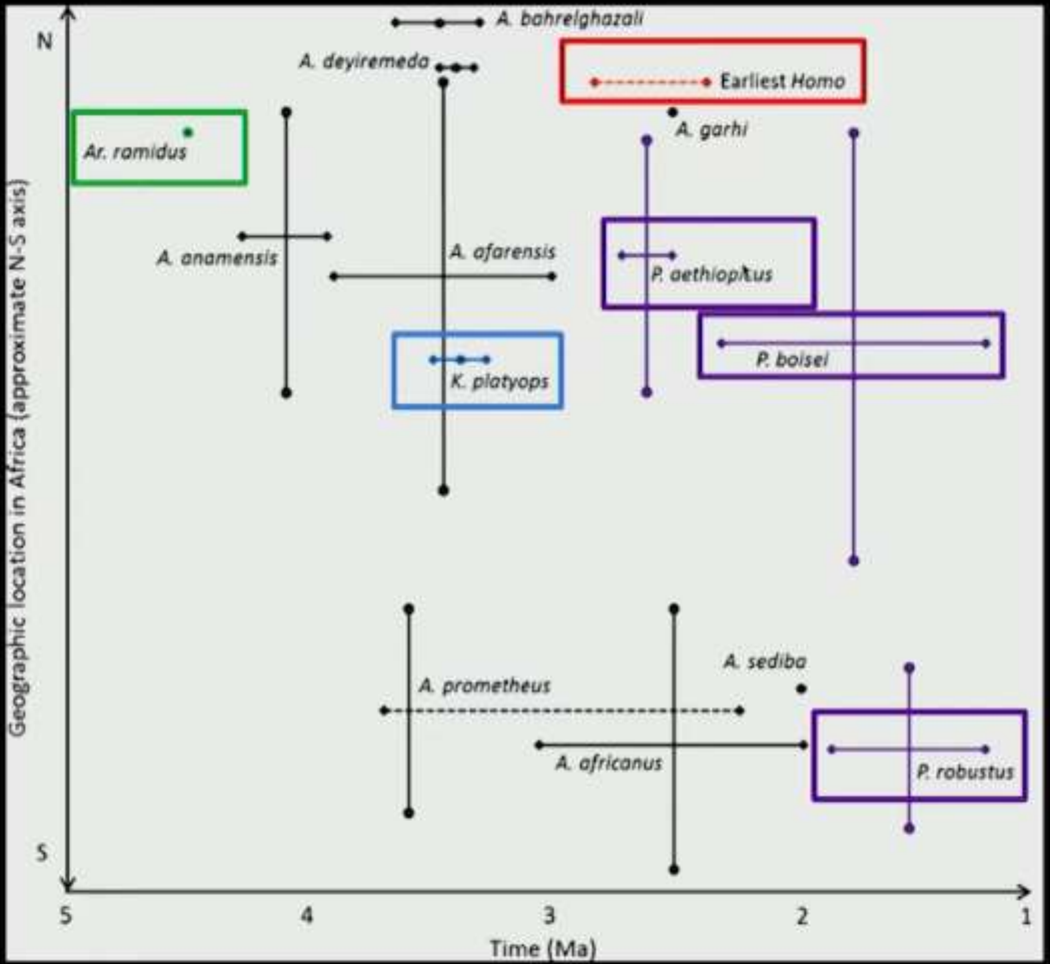
Homo heidelbergensis

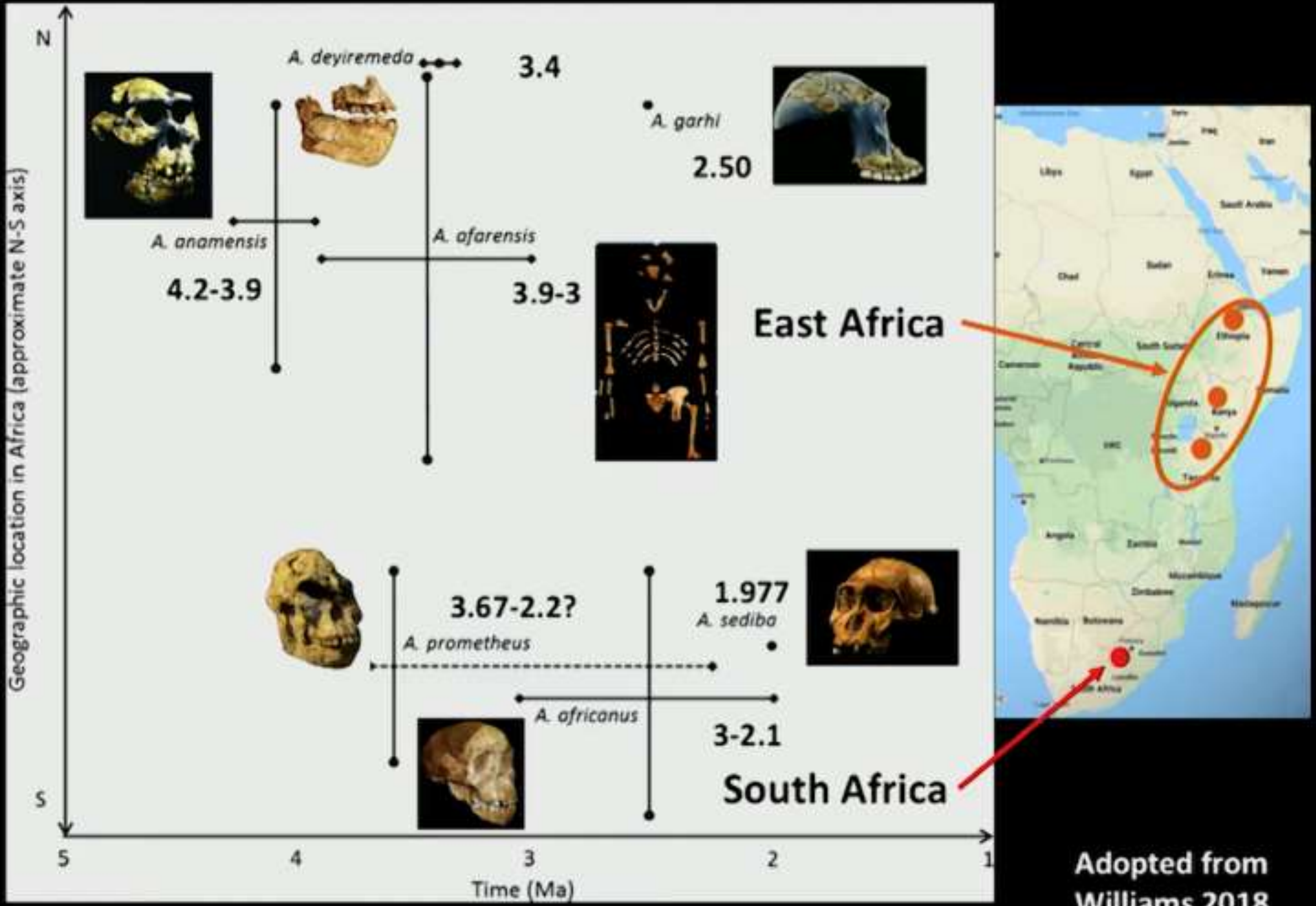
Homo erectus

Robert Broom

Mrs Ples

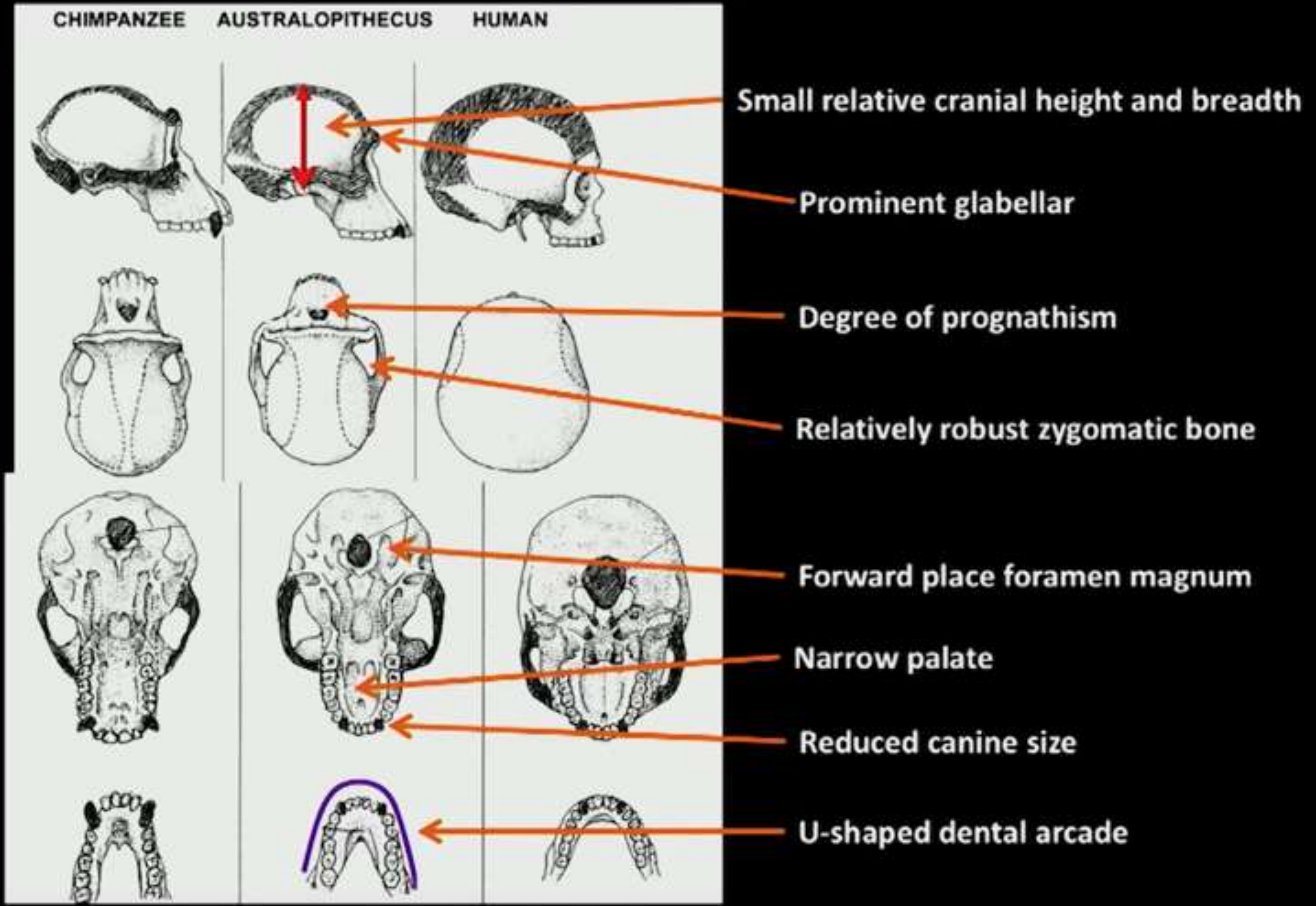
> ➢ *Australopithecus* occupy morphological space intermediate between early member of genus and the extant African apes.


A. bahrelghazali
A. deyiremeda
Earliest Homo
Ar. ramidus
A. garhi
A. anamensis
A. afarensis
P. aethiopicus
K. platyops
P. boisei
A. sediba
A. prometheus
A. africanus
P. robustus
N
S
Geographic location in Africa (approximate N-S axis)
5
4
3
2
1
Time (Ma)



Adopted from
Williams 2018

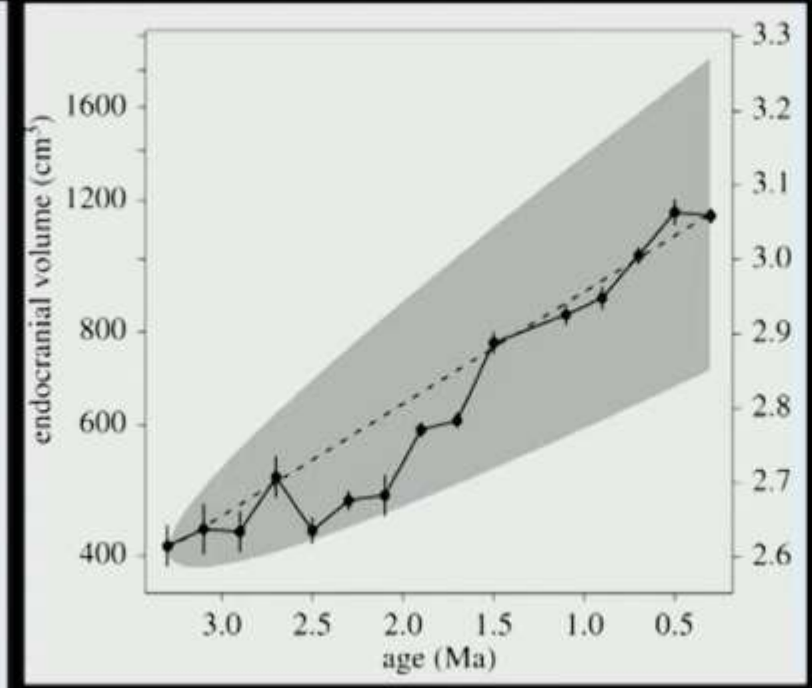
Cranium:


CHIMPANZEE
AUSTRALOPITHECUS
HUMAN
Small relative cranial height and breadth
Prominent glabellar
Degree of prognathism
Relatively robust zygomatic bone
Forward place foramen magnum
Narrow palate
Reduced canine size
U-shaped dental arcade

Brain:

Cranial Capacity

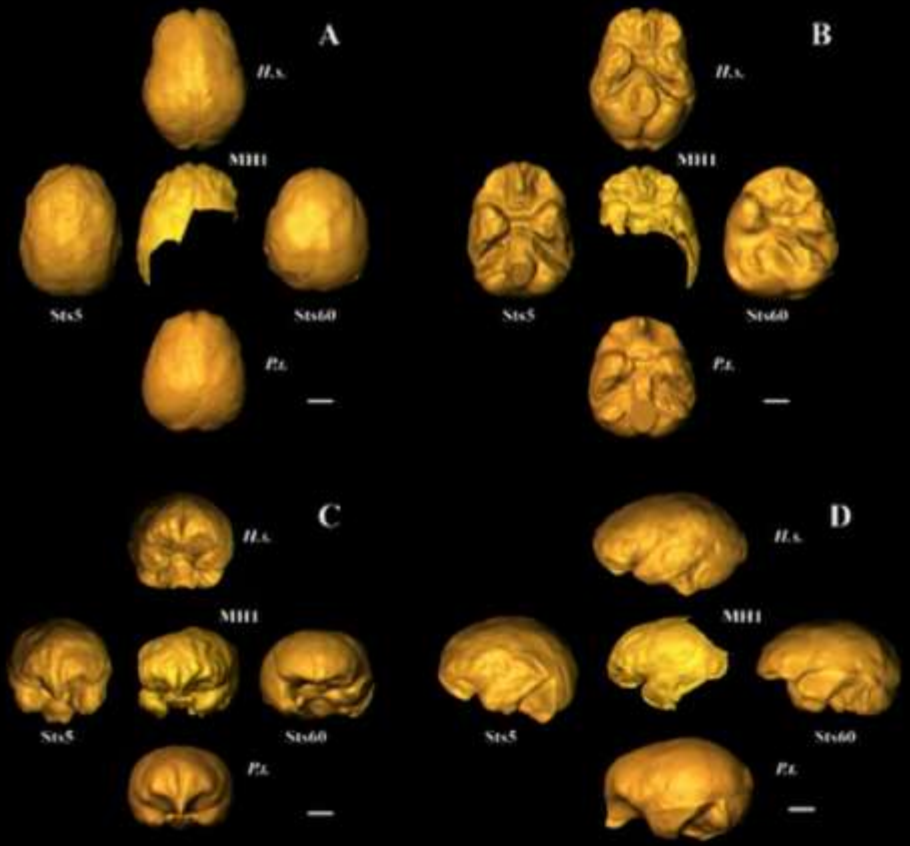
Species	cc	Reference
P. troglodytes	395	Pilbeam & Goud 1974
Au. anamensis	300-400	assumed
Au. prometheus	408?	Beaudet et al., 2019
Au. afarensis	481	Falk 1987
Au. africanus	459	Conroy et al., 1998
Au garhi	450	Holloway 2014
Au. sediba	420	Carlson et al., 2010
Homo habilis	752	Falk 1987
Homo erectus	909	Walker & Shipman 1996
Homo sapiens	1320	Aiello & Dunbar 1993

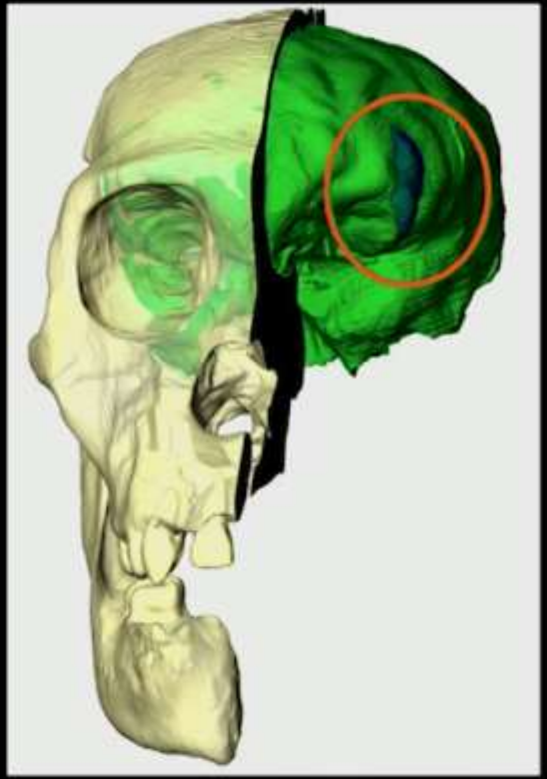


Du *et al.*, 2018

From *Australopithecus to Homo sapiens, the brain increased threefold*

Brain:

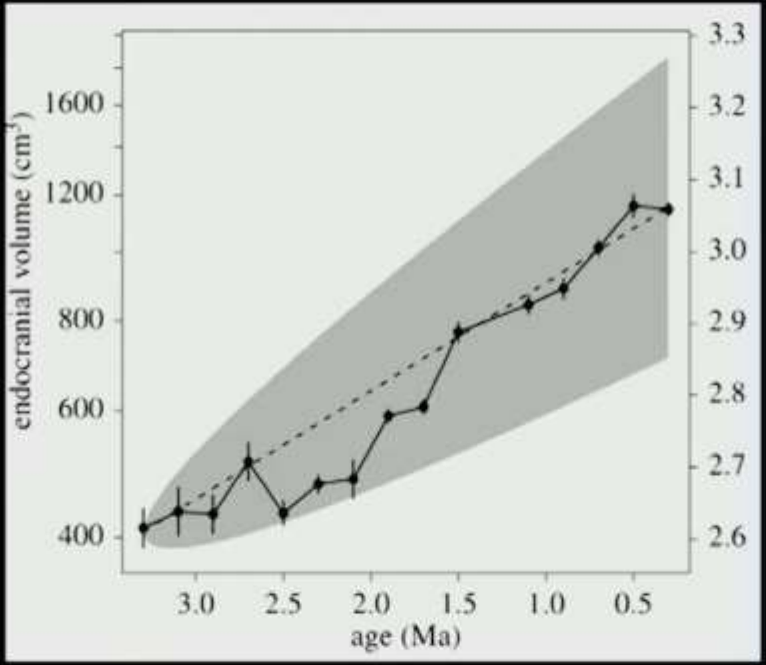




Carlson et al., 2011

- Overall cortical folding pattern from 3.67 my to 2 my is essentially chimpanzee-like.
- At 2my evidence of "early stages of bolstering local neural interconnectivity in area 45"
- The hominid brain reorganization preceded pronounced brain size increment.

Demands of an increasing brain size



Du *et al.*, 2018

Increase in energy intake

And/or

Reduction in energy allocation to other energy demanding functions:

- Locomotion
(efficient bipedal locomotion)

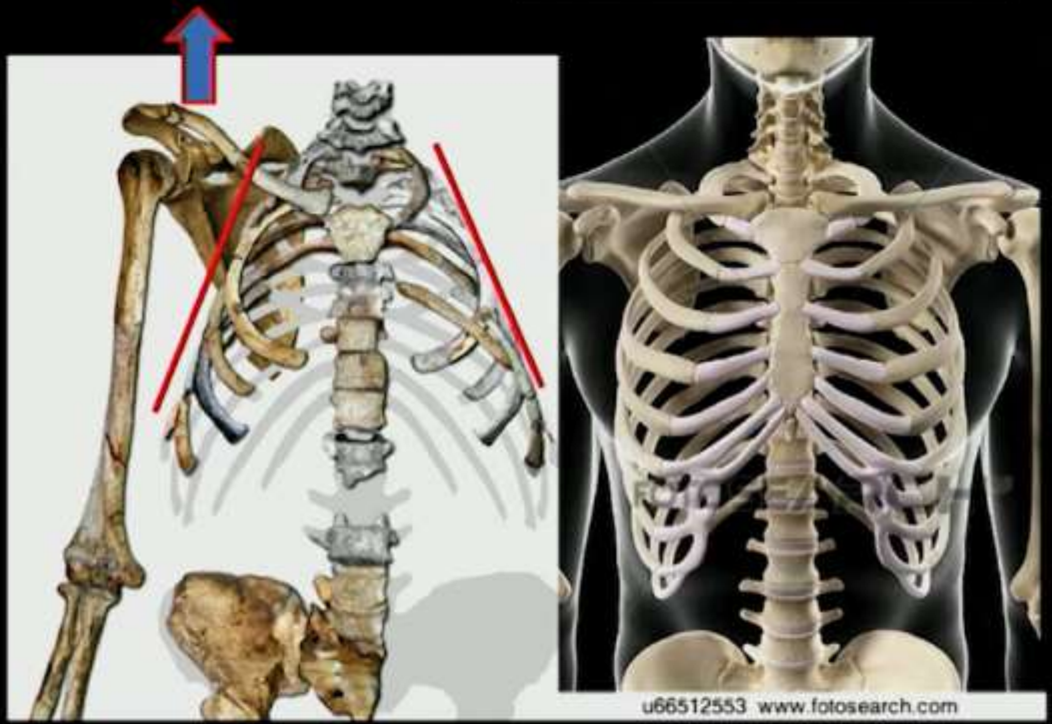
- Reproduction
Slower growth and reproduction

- Maintenance
Smaller guts

All these factors have been observed or inferred in the evolution from *Australopithecus* to *Homo*.

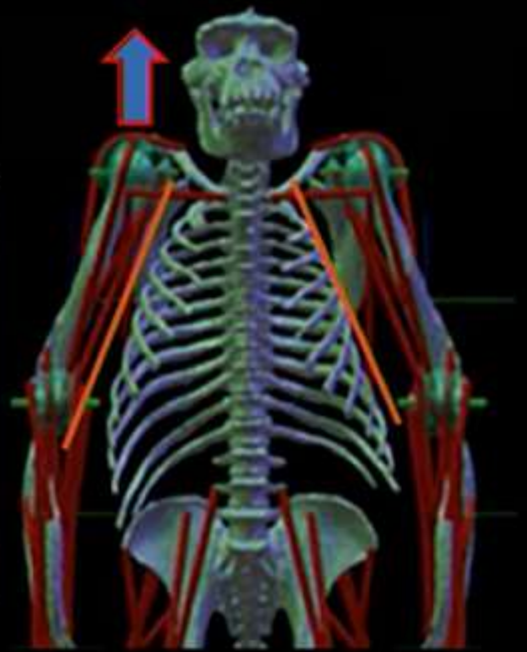
Anton et al 2014

Shoulder & Thorax:



Au. sediba
Schmid *et al. Science* 2013

H. sapiens



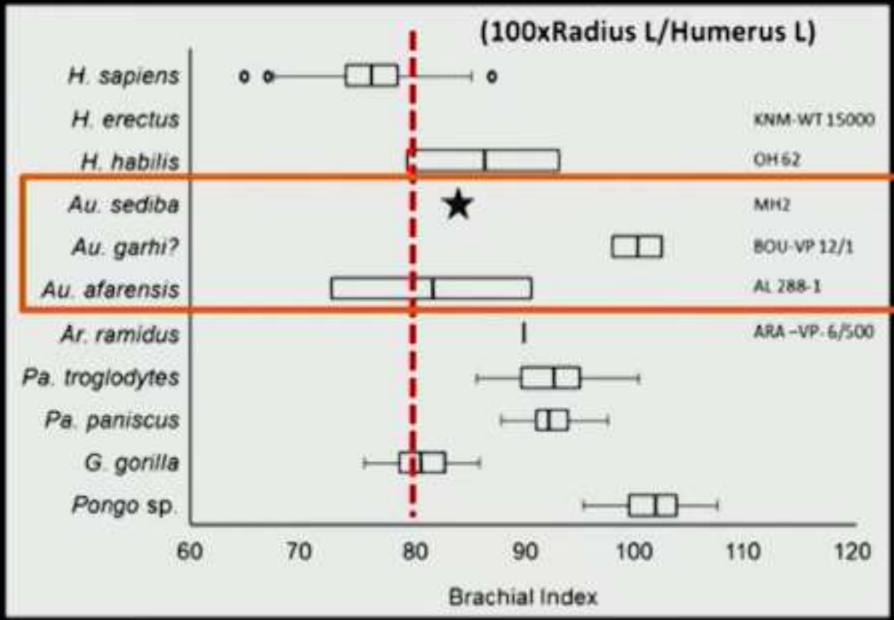
Pan troglodytes
Sellers 2013

- Elevated shoulders = habitual use of the arms in elevated positions
- Cone-shaped torso = minimal stress on the ribcage during arm-hanging
- Conical thorax = difficult in swinging arms when walking upright or running.

Forelimb:

H. sapiens Au. sediba Pan troglodytes

Berger et al. *Science* 2013

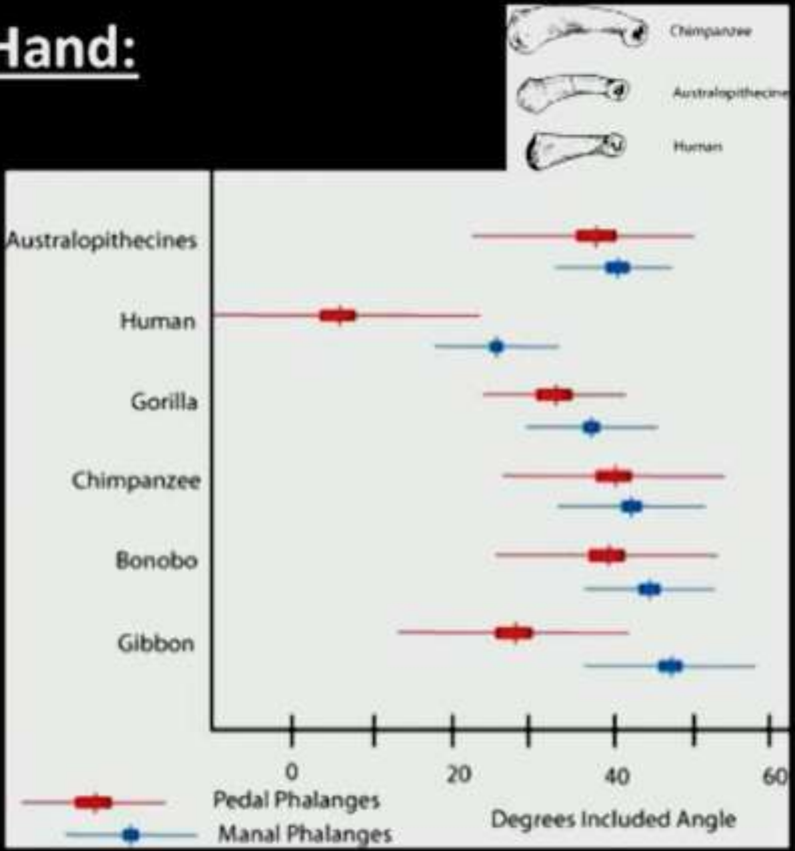


- **High brachial index**

Imply an upper limb that was habitually used in over-head arm postures in the context of arboreal locomotion and positional behaviors.

Hand:

Au. sediba (Kivell et al 2011)

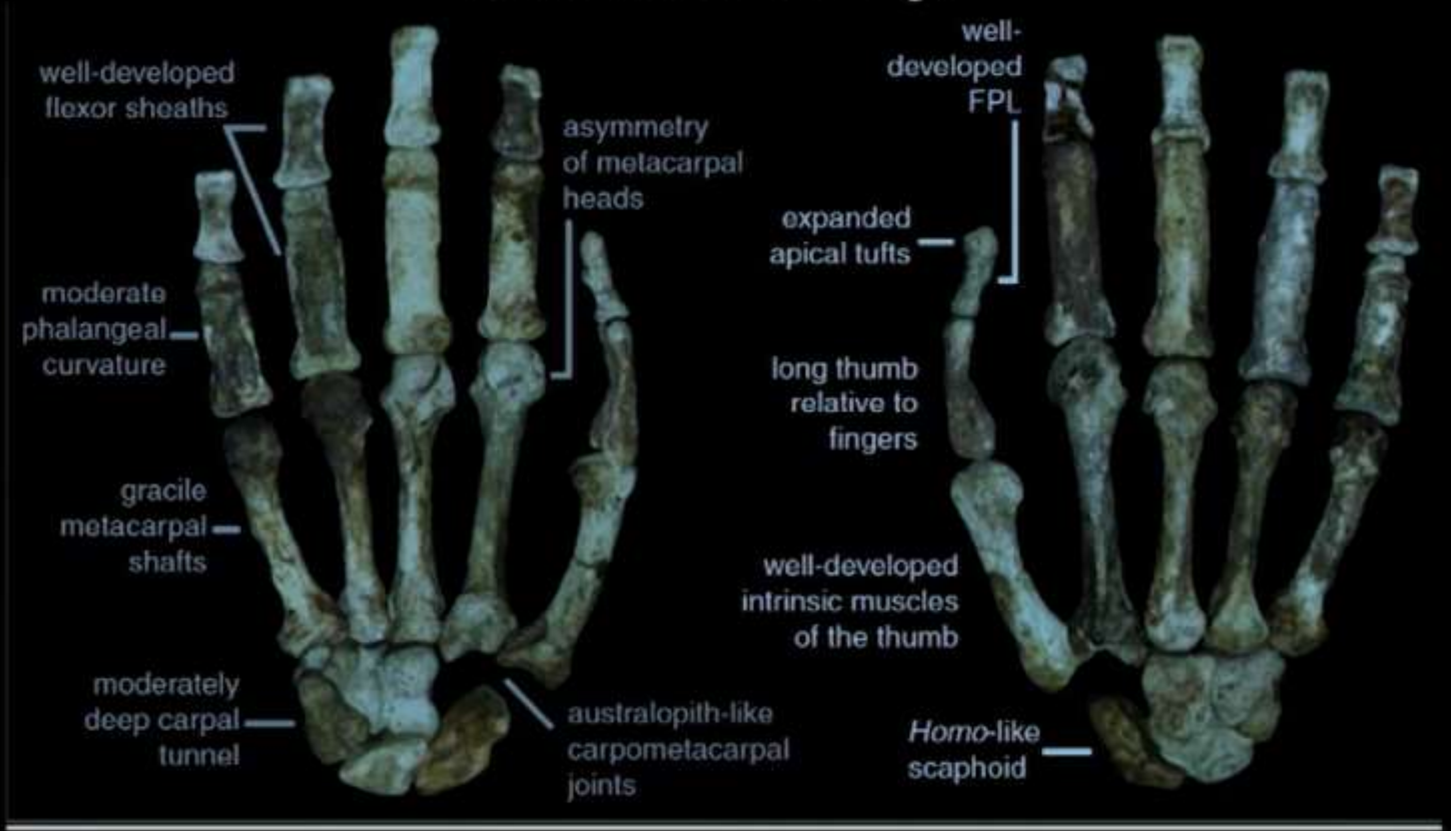


origins. swau.edu

- ➢ **Strong flexor apparatus**
- ➢ **moderate curvature of proximal phalanges**

❖ **Australopiths practiced regular substantial climbing & suspension**

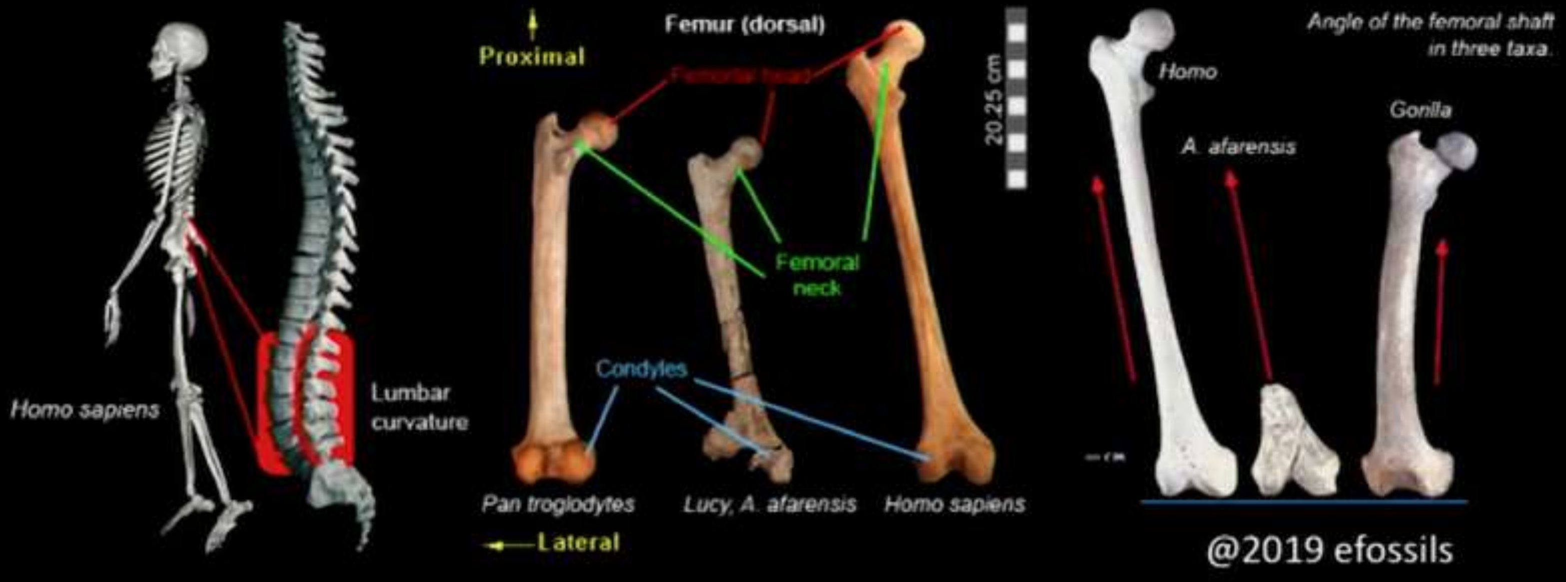
Stone tool making?



Earliest stone tools= 3.3 ma (Lomekwian)

Predates early members of genus *Homo by ~800,000 yrs*

Spine, leg and foot:



- Human-like lumbar curvature
- Long femoral neck
- Small knee joints surface
- Highly angled femur

- Shorter legs are less energy efficient in bipedal walking.

Spine, leg and foot:

De Silva et al., 2018

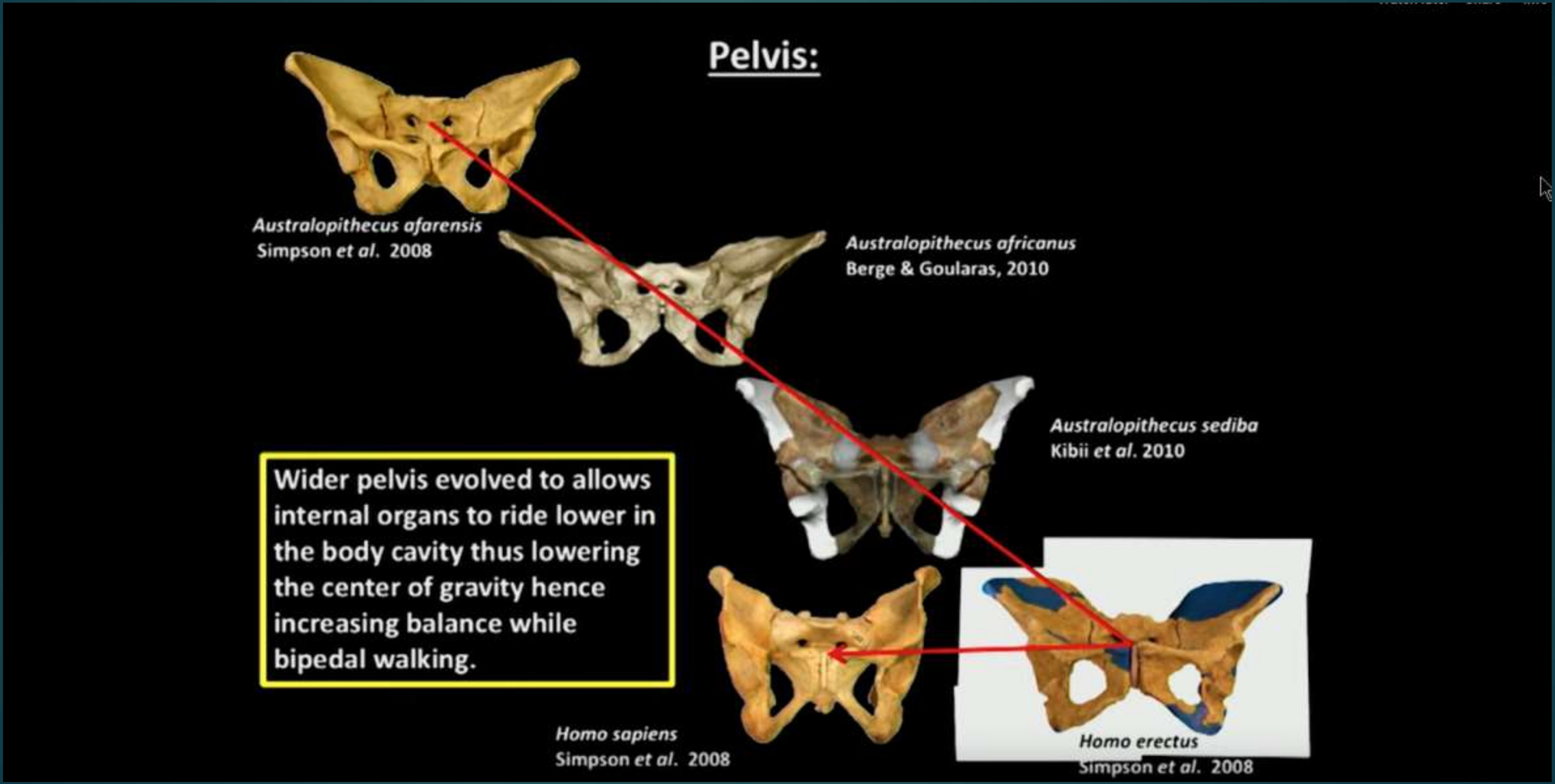
Ward et al 2011

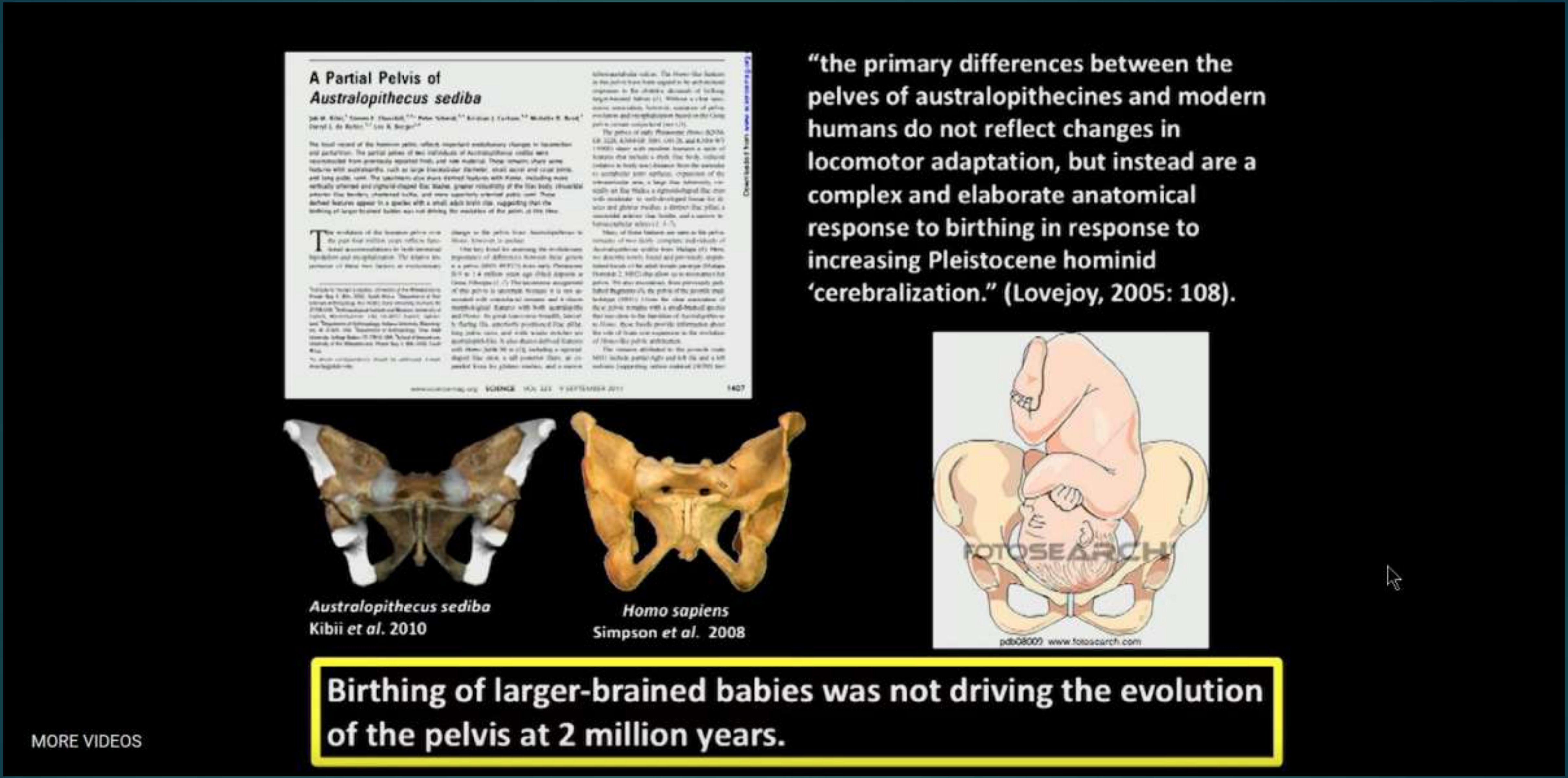
- ❖ **Anteroposteriorly expanded metaphysis**

Early bipedal adaptation that expanded volume of ankle for stress dissipation during walking.

- ❖ **Arched foot with non-opposable big toe**

Alignment provides a strong push during “toe-off”.


Pelvis:
Australopithecus afarensis
Simpson et al. 2008
Australopithecus africanus
Berge & Goularas, 2010
Australopithecus sediba
Kibii et al. 2010
Wider pelvis evolved to allows internal organs to ride lower in the body cavity thus lowering the center of gravity hence increasing balance while bipedal walking.
Homo sapiens
Simpson et al. 2008
Homo erectus
Simpson et al. 2008


A Partial Pelvis of
Australopithecus sediba
SCIENCE
1407
“the primary differences between the pelves of australopithecines and modern humans do not reflect changes in locomotor adaptation, but instead are a complex and elaborate anatomical response to birthing in response to increasing Pleistocene hominid ‘cerebralization.” (Lovejoy, 2005: 108).
Australopithecus sediba
Kibii *et al*. 2010
Homo sapiens
Simpson *et al*. 2008
FOTOSEARCH
www.fotosearch.com
Birthing of larger-brained babies was not driving the evolution of the pelvis at 2 million years.
MORE VIDEOS

Sexual dimorphism

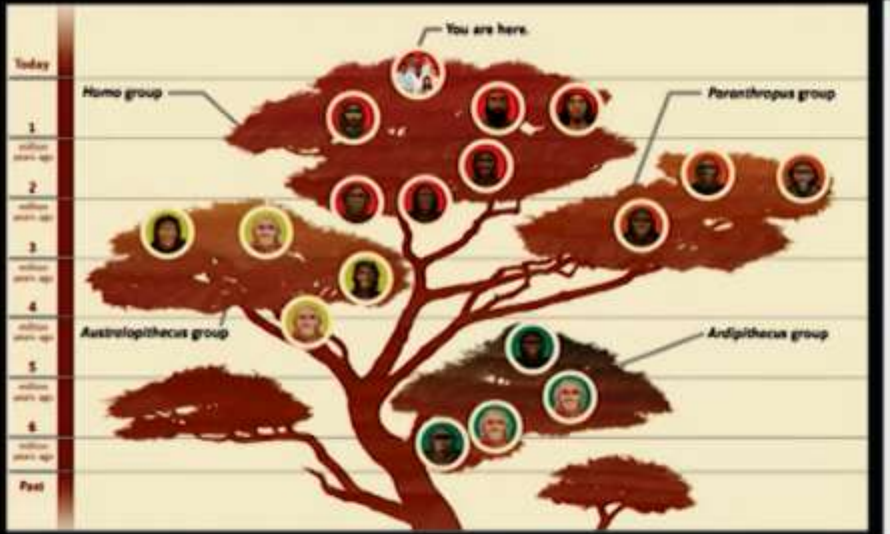
TABLE 1. Relative Body Mass and Height of Select Australopithecines and Extant Taxa

Species	Male Mass (kg)	Female mass (kg)	Male height (m)	Female height (m)
Australopithecus africanus	41.0	30.0	1.40	1.10
Australopithecus afarensis	45.0	29.0	1.50	1.10
Paranthropus boisei	49.0	34.0	1.40	1.20
Paranthropus robustus	40.0	32.0	1.30	1.10
Homo sapiens	68.2	50.0	1.75	1.61
Pan troglodytes	56.6	40.1	0.85	0.75
Gorilla gorilla	164.3	75.5	1.70	1.50

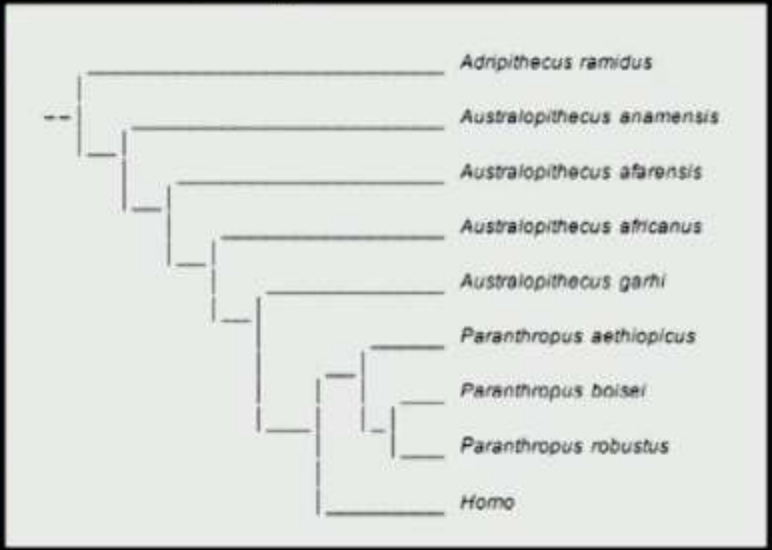
Szpak 2007

- Greater sexual dimorphism than in modern humans and chimpanzees
- Primate species with high sexual dimorphism are characterized by intense male-male competition.
- Australopiths social organization may have been characterized by multimale, cooperating kin groups (Larsen 2003).

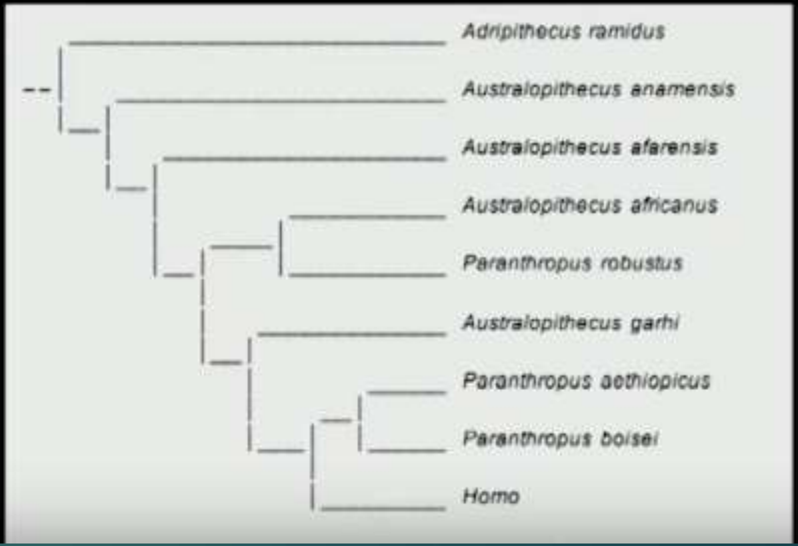
Evolutionary relationships



Courtesy of the Smithsonian Institution



No universally accepted phylogenetic tree.



Conclusions

- All australopith features considered together denote small-bodied, small brained, robust-jawed, bipedal apes that retained a substantial arboreal component to their locomotor repertoire.

- Available morphological evidence demonstrate that "the evolutionary transition from small-bodied and perhaps more arboreal-adapted hominin (such as *Au. africanus*) to a larger bodied, possibly full-striding terrestrial biped (such as *H. erectus*) occurred in a mosaic fashion."

- In terms of stone tool making, we need to investigate the relationship between posture, arm length, and their internal properties and not just the morphological traits of the hand to characterize a tool maker.

Australopithecus afarensis

If you put your parent 3 feet behind you, and his parent, etc., Lucy at 3.2 million years, is 90 miles back

First *Australopithecus afarensis* find

- Louis Leakey found what he thought was a baboon tooth in 1935 at Laetoli and sent it to the British Museum

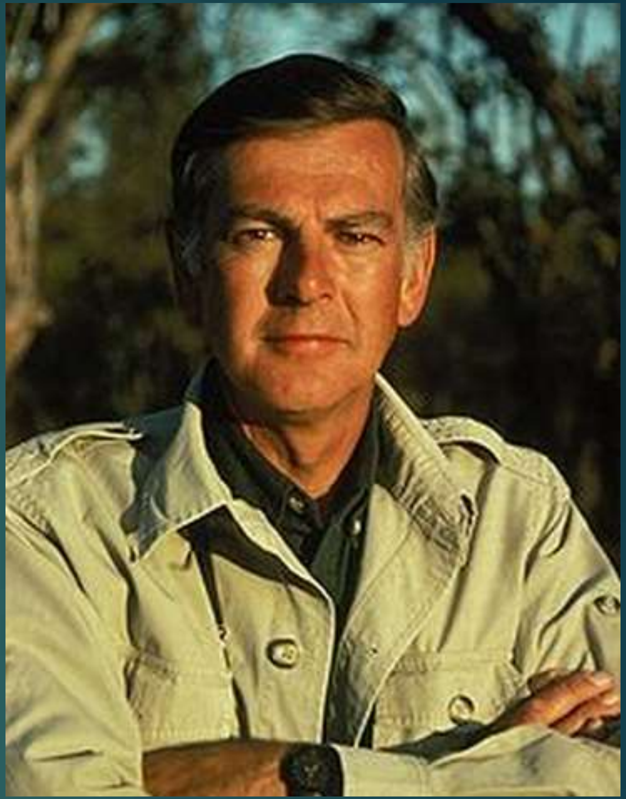
- Tim White identified it in 1979 as first adult *Australopithecus afarensis* tooth ever found.

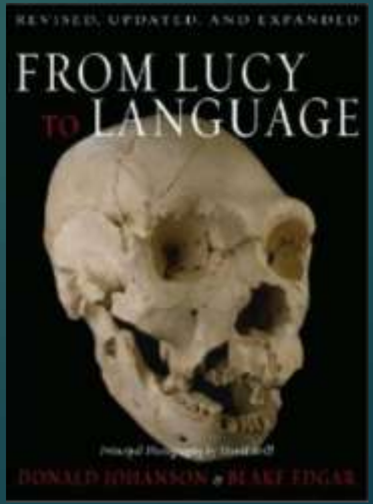
Donald C. Johanson (1943-): *Australopithecus afarensis,* "Lucy", 3.2 M

- American paleoanthropologist

- 1974: Maurice Taieb, Yves Coppens and Tim White, at Hadar, Ethiopia, discovered "Lucy", *Australopithecus afarensis*, 3.2 M; bipedal ape

- 1975: the "First Family," AL 333, is a collection of 200 Australopithecus afarensis teeth and bones (13 individuals) discovered in Hadar, Ethiopia, by Johanson's team



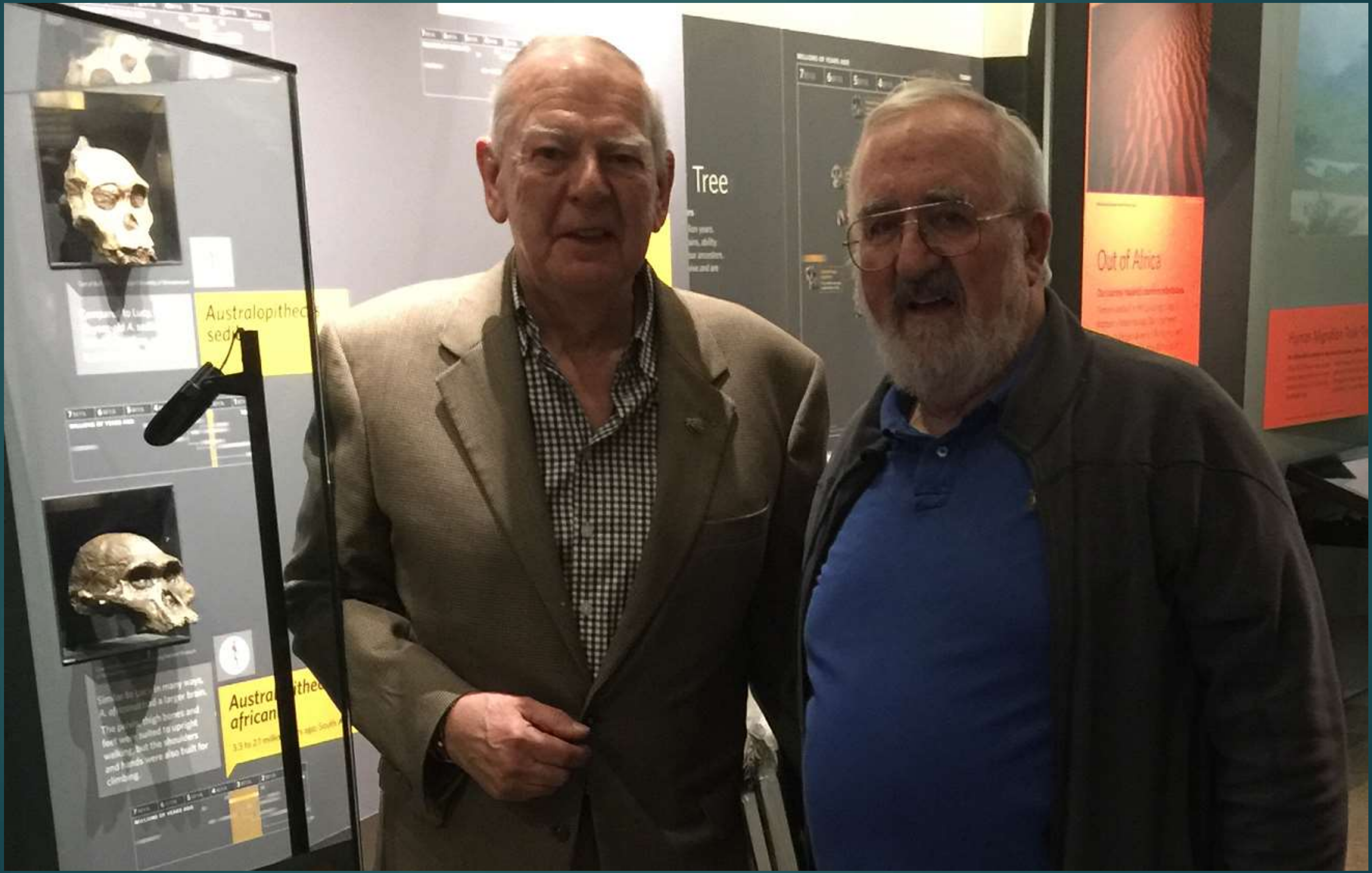


Lucy at California Academy of Science

- 1974: Lucy, *A. afarensis*, AL 333
- The dark-colored bones represent the bones of Lucy's fossil (42% of total)
- White colored bones were reconstructed from other *A. afarensis* fossils.

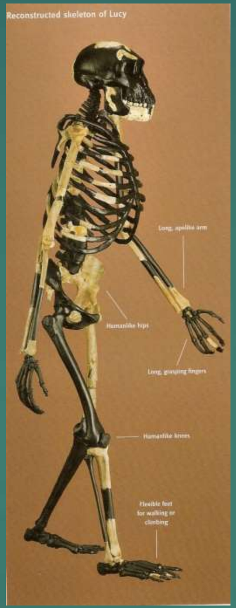
"Lucy in the sky with diamonds"

At CAS, May 2, 2018: Charlie discovers Don creeping around Lucy



Don Johanson:
Australopithecus afarensis

42% of complete skeleton

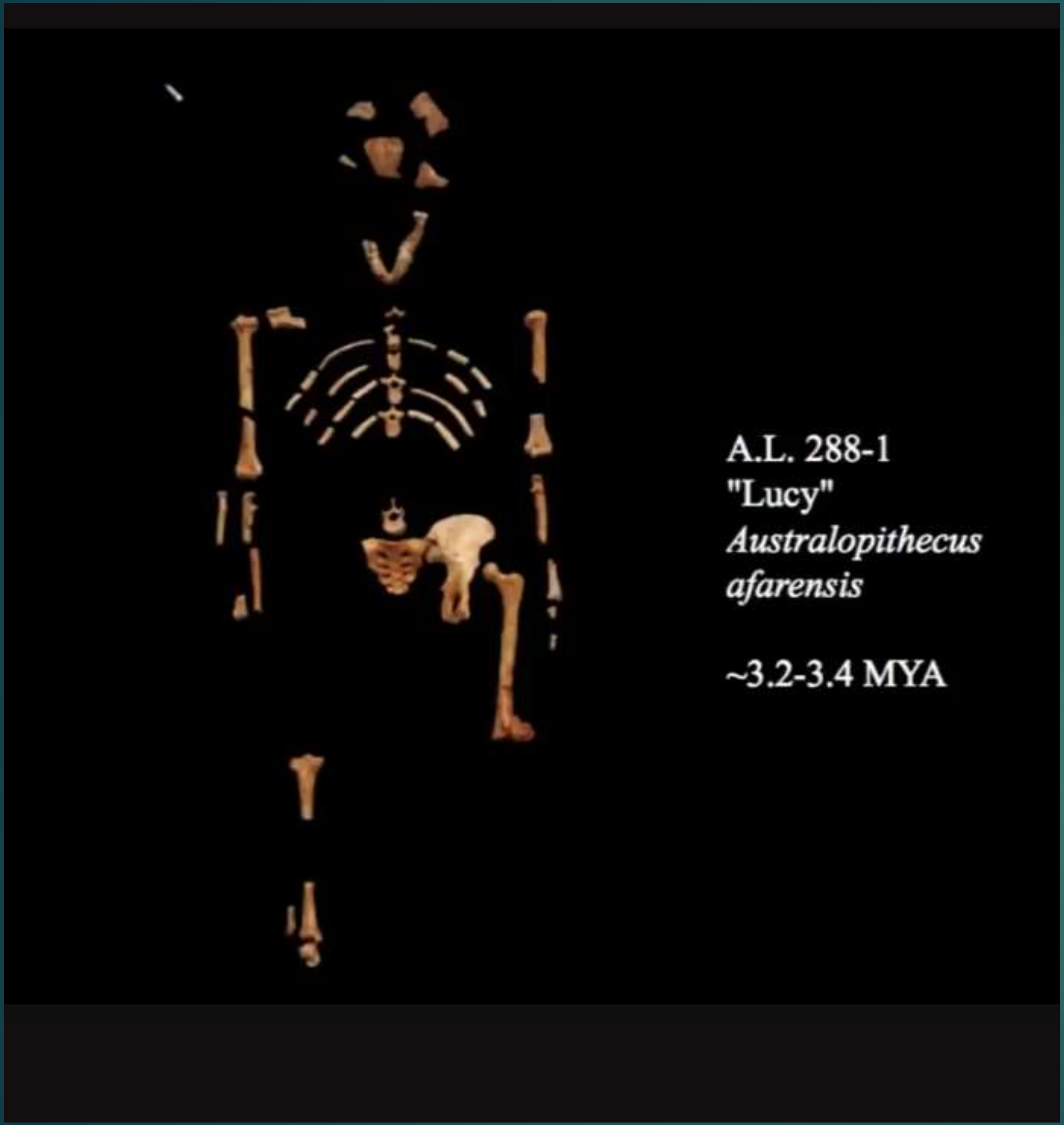


Australopithecus afarensis
(A. L. 288-1, "Lucy")
Discoverer: Don Johanson
Locality: Hadar, Ethiopia
Date: 1974
Age 3.2 M

Australopithecus afarensis
(L.H. 4, type specimen in 1978)
Discoverer: Maundu Muluila
Locality: Laetoli, Tanzania
Date: 1974
Age 3.6 M

In Ethiopia, she is called *Dinkinesh*, meaning “You are marvelous.”

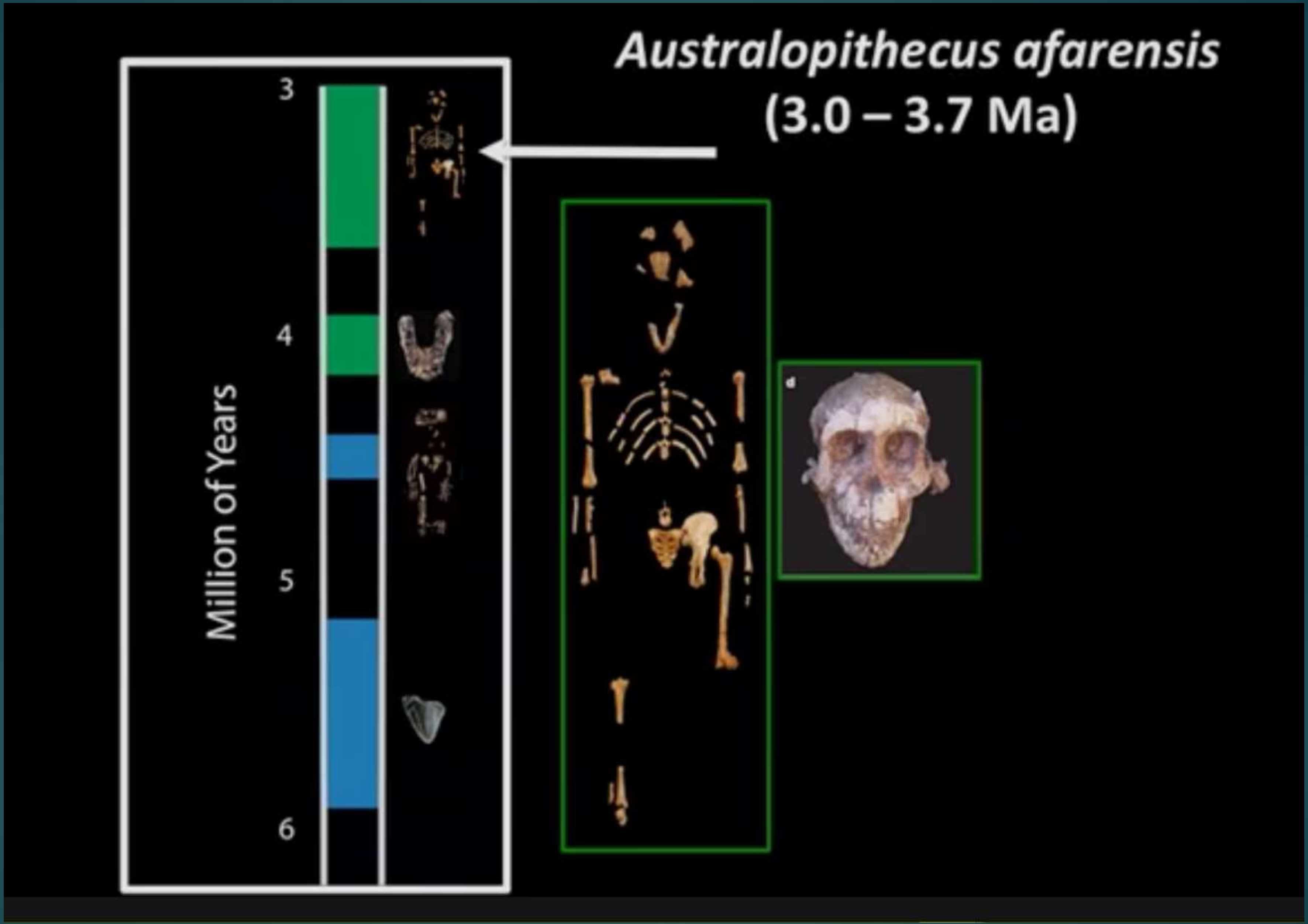
Her skeleton is in the collection of the National Museum of Ethiopia in Addis Ababa, Ethiopia.



The Hadar Australopithecine specimens constituted the first substantial collection of fossil hominin remains securely dated to older than 3 Ma.

Australopithecus afarensis

- The benchmark by which anatomy of all other early hominins is interpreted.
- Apelike features (long arms, prognathic face, toothrow, brain capacity)
- Pelvis, leg, feet, and foramen magnum all indicate bipedalism
- 3.2 MA, with oldest definite specimen placed at 3.8 MA
- Hundreds of specimens; mostly from Ethiopia, but also Kenya & Tanzania

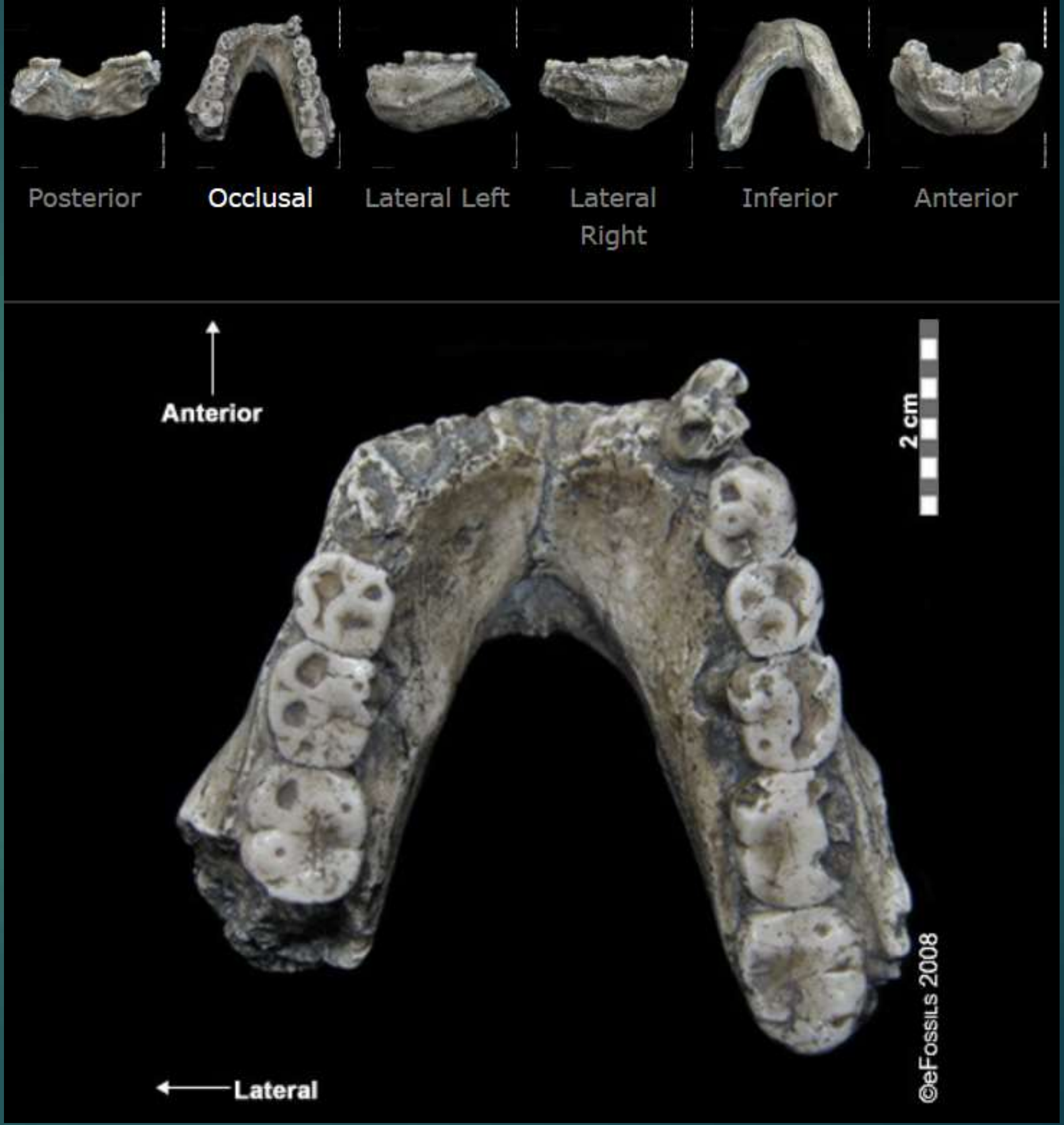


Hundreds of specimens; mostly from Ethiopia, but also Kenya & Tanzania

Laetoli hominin 4 (LH 4) discovered by Mary Leakey.

Made Type specimen for *Australopithecus afarensis* by Johanson

Molars are twice size of human molars; and has thicker enamel



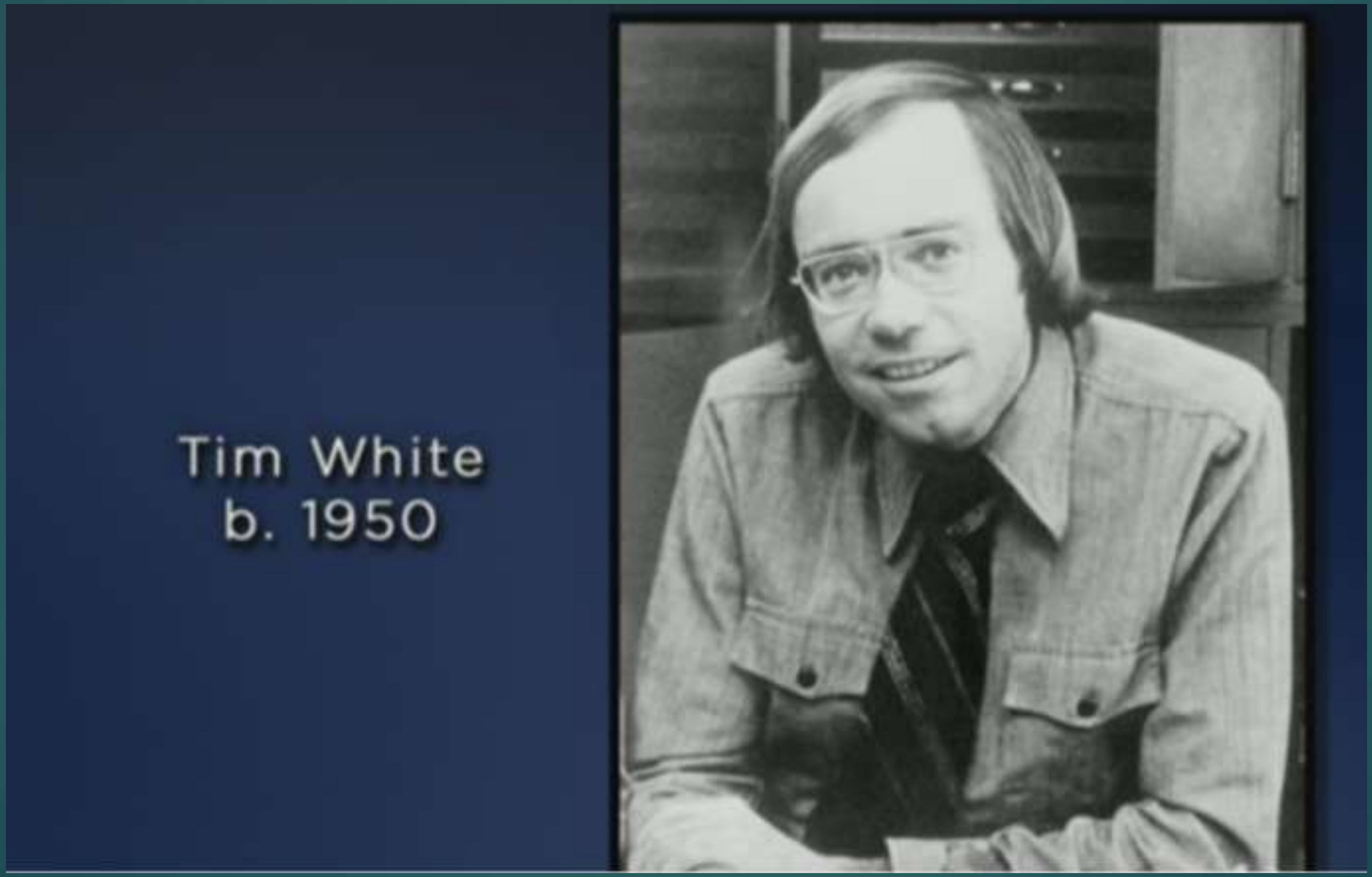
Mandibles

Chimp

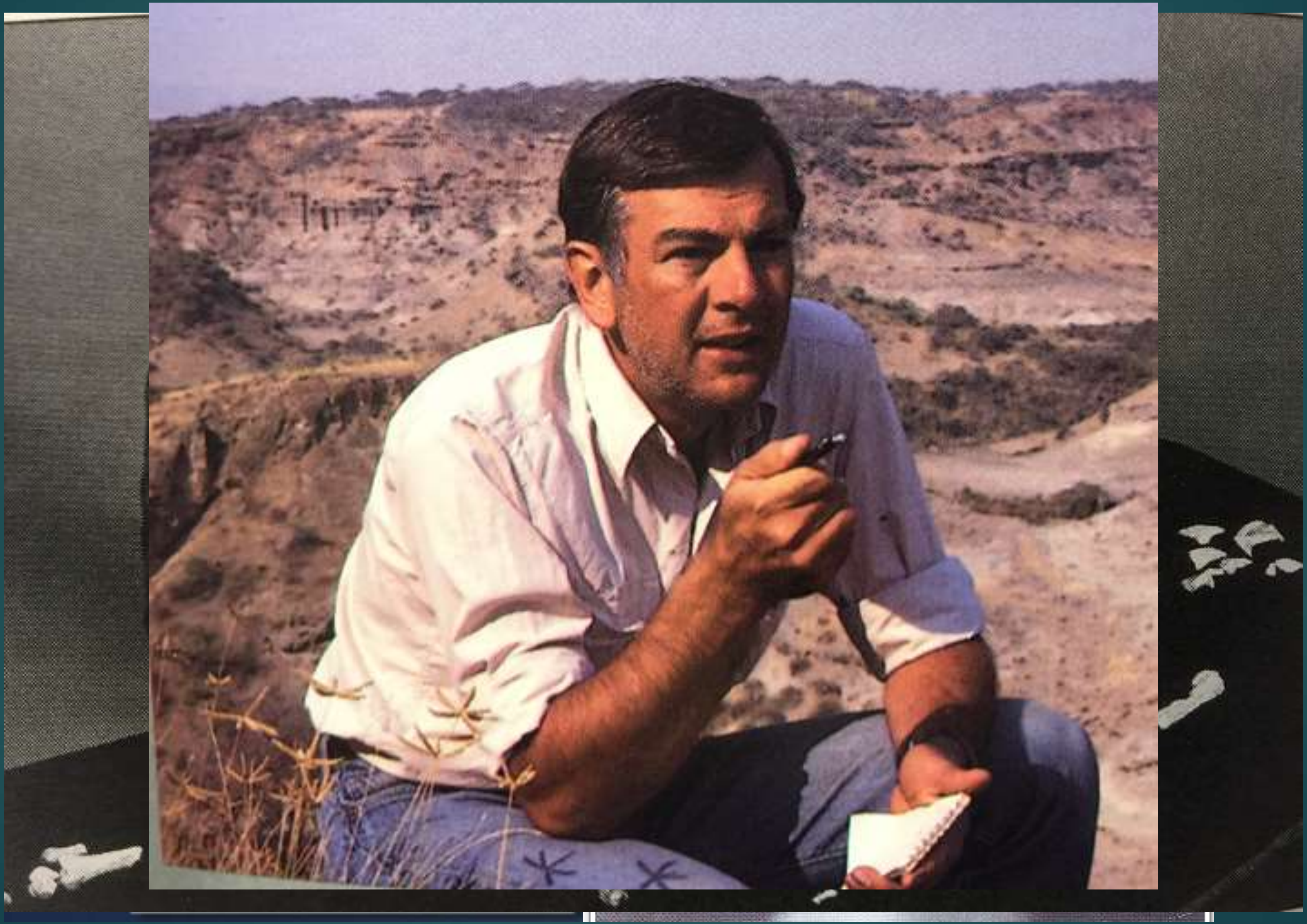
Human

A. afarensis: thick mandible, with parabolic, divergent teeth

Mary Leakey brings in Tim White to look at Laetoli fossils



1974: Donald Johanson discovers Lucy



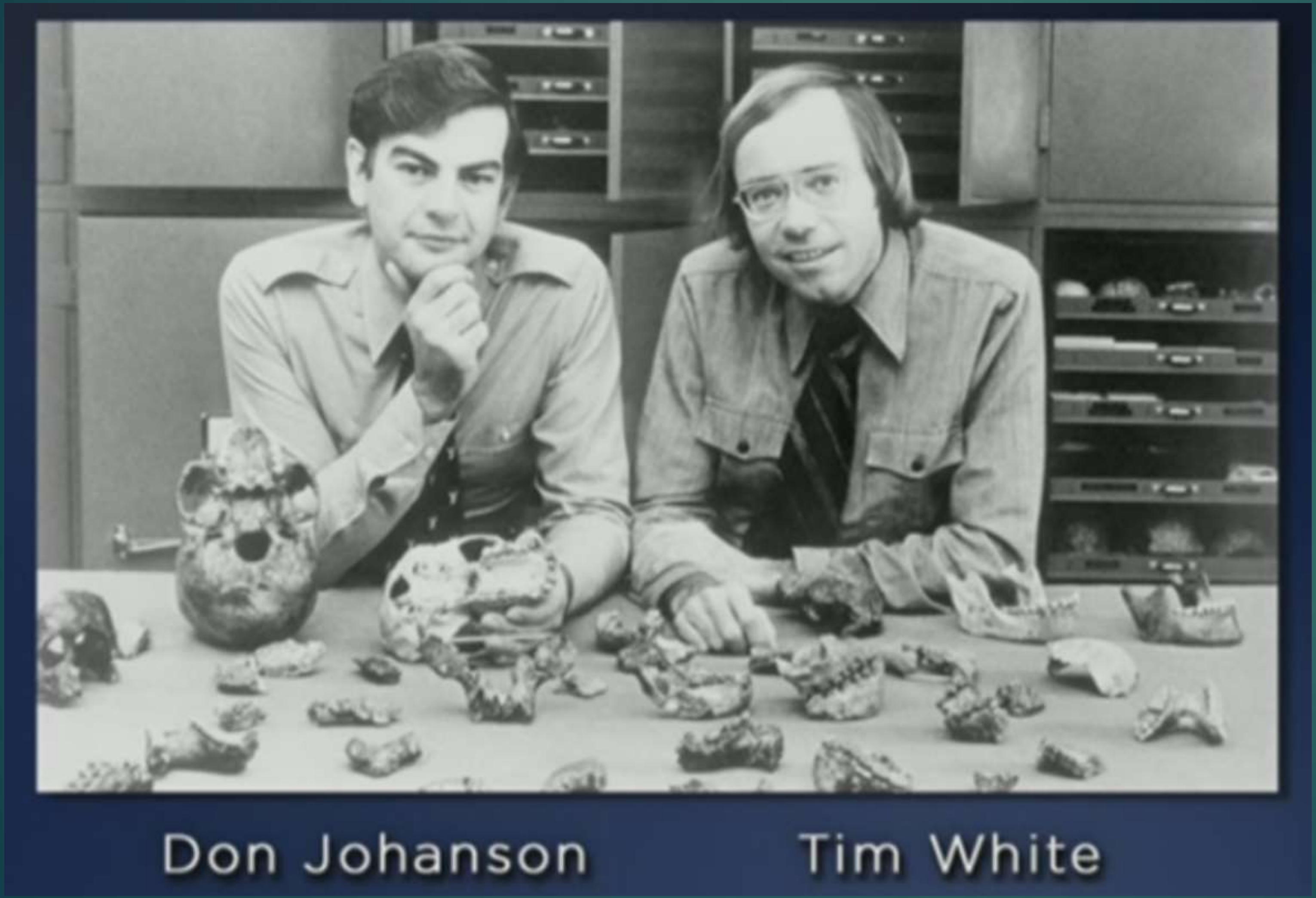
Lucy: has a more human-like pelvis; she is small

3 feet 4 inches

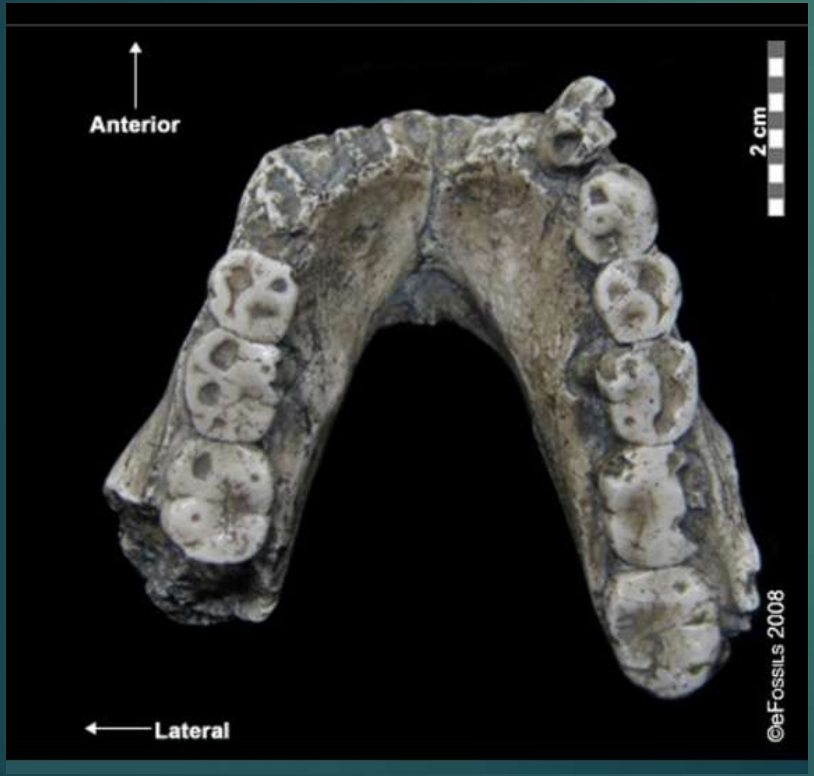
Lucy’s Pelvis

Lucy’s pelvic hip bones: broader front to back, shorter, and wrapping around the sides (for muscles that control pelvic tilting while walking), just like a human; are not behind, long, and tall, and up the back, like in chimps

First comparison of *A. afarensis* bones from Hadar & Laetoli



Johanson & White: conclude fossils of Hadar & Laetoli represent a single species: *Australopithecus afarensis*; and named LH4 (from Tanzania) the type specimen (without Mary Leakey's permission)



LH 4 – Laetoli, Tanzania

"Lucy" A.L. 288-1, jaw KO-036-J, Hadar, Ethiopia

Bones of Contention: Don Johanson vs Mary Leakey

- Mary Leakey discovered Laetoli footprints & part of child's skeleton & 2 adult mandibles, and some teeth.

- Best mandible = LH4. It would become bone of contention. She thought bones were *Homo*. Tim White wrote them up, as a species of *Homo.*

- Don Johanson, after Lucy find, discovered fossils in Ethiopia (First Family) that looked very similar. Looked different than Lucy. Thought they were *Homo*.

- Tim White split from Richard Leakey and joined Johanson.

- White changed his mind about the species & then changed Johanson's mind. They lumped all fossils from Ethiopia & Laetoli together & decided both were Australopithecines. Mary & Richard did not agree.

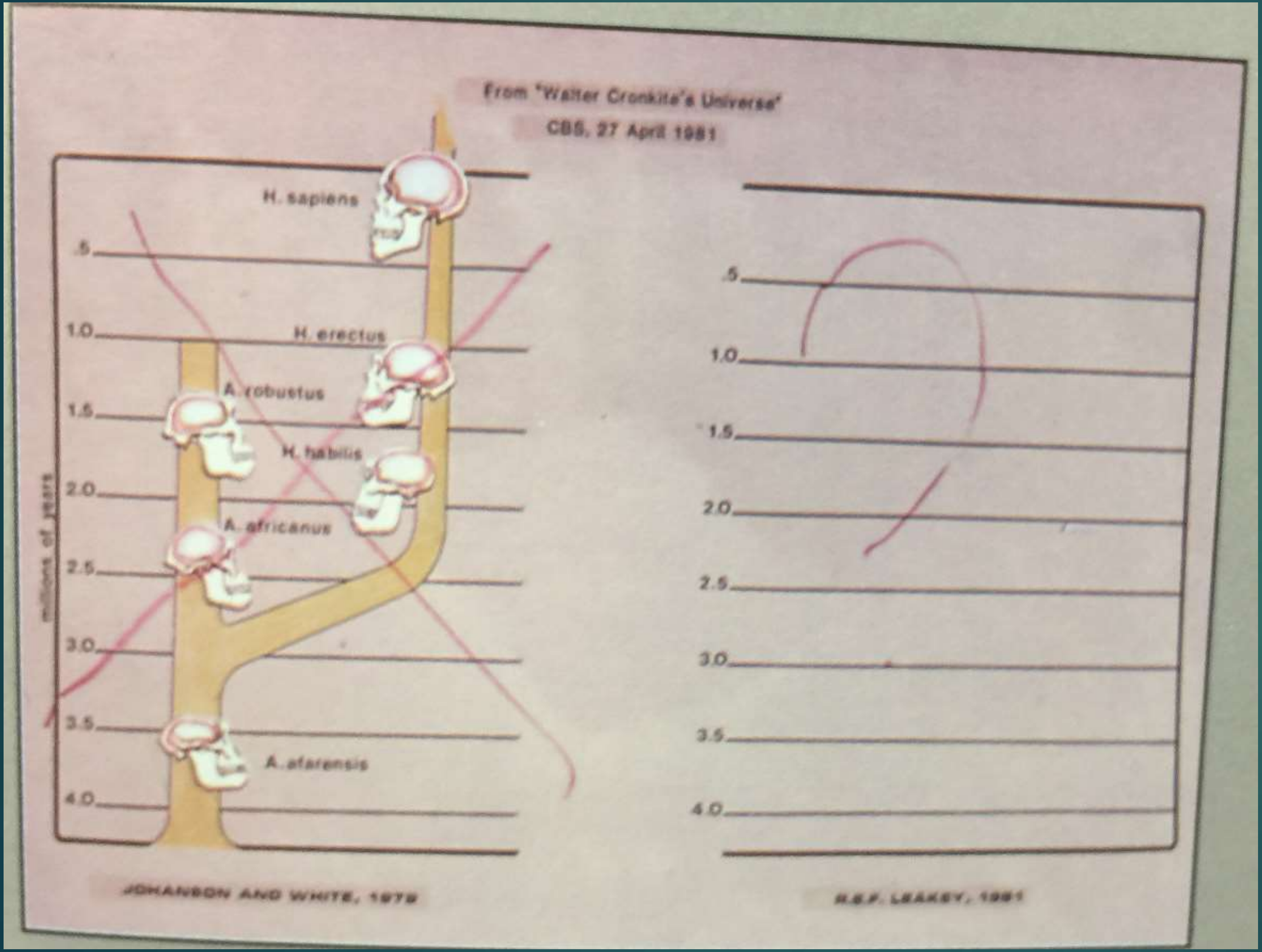
Bones of Contention 2

- In 1978, Don & Tim decided to announce a new name for them.
- Conference in Sweden in honor of Mary Leakey. First woman to receive both the Golden Linnaean Medal and a major embarrassment.
- Johanson spoke before her & and announced the new name for Ethiopian species & he included in this species Mary Leakey’s Laetoli discoveries & made LH4 the type specimen with new name, *A. afarensis*.
- Don spoke at length of Laetoli discoveries, scooping Mary’s own talk.
- She was angered and embarrassed. Johanson had named her discoveries, using a genus she did not agree with.
- Because he named them first, the name got taxonomic preference.

Austrolepithecus debate: Personalities in Paleontology

Were not getting along so well

Great Debate on Walter Cronkite's Universe, 1981



- Genealogical Debate

- On the left is Johanson-White proposed 1979 phylogeny.
- Johanson bought this chart with him to meet Richard Leakey on Walter Cronkite's *Universe* television series in 1981.
- On camera, Leakey crossed out the Johanson-White version of the family tree, & then scrawled a question mark in its place, indicating that the origins of *Homo* were still unknown

Johanson & White vs. Leakeys

- Johanson & White believed *A. afarensis* was ancestral to all later hominins, including *Homo.*
  - Johanson & White (1979):
    - *A. afarensis →→ H. habilis →→ H. sapiens*
    - *And A. afarensis →→A. africanus →→P. robustus/boisei*

- Richard Leakey contended that they mistakenly yoked two separate species under the name *A. afarensis* and that the true ancestor of man had yet to be found:
  - Leakey (1981):
    - ?? →→ *Homo* sp. indeterminate →→*H. habilis →→H. sapiens*
    - *?? →→A. afarensis →→ A. africanus →→P. robustus/boisei*

Johanson vs Leakeys

- By lumping his Hadar finds and several of Mary Leakeys Laetoli fossils together as representatives of the same ancient australopithecine family, Johanson challenged two of the Leakey's entrenched beliefs about human evolution:
  - first, that human beings are descended from an earlier variety of the genus *Homo* rather than from the australopithecines;
  - second, that the genus *Homo* has bona fide representatives much older than 2 million years, whose remains had not yet been discovered.
- The nomenclature *A. afarensis* -- the southern ape from Afar -- effectively undermines both these notions.
- Moreover, it receives formidable scientific support from the accuracy with which the Hadar fossils were dated and from the rigor with which Johanson and White scrutinized the dental structures of their finds.

Don Johanson

- Johanson wrote that he had been called "a prima donna, a slick operator, a publicity hound."
- In fight with Jon Kalb, who had prior Afar, Ethiopian excavation permission, for years had prevented Johanson's return to the Afar badlands of Ethiopia. Rumored that he started rumors that Kalb was CIA agent; Kalb lost rights in Ethiopia.
- Feud with the Leakeys; his haste in proclaiming a new species; lost Mary Leakey's friendship; suggestions that **White** and **Johanson** lumped the **Laetoli** finds in with the others to give the new species an older date.
- He then had the nerve to go to Olduvai Gorge and find *H. habilis* limbs.
- Owen Lovejoy: Tim White is the "original prickly, stubborn, I-won't-believe-it-until-you-can-prove-it-with fossils type. He'll argue with anybody about anything.' "Don's a nail-polish salesman, a real operator."

See *Adventures in the Bone Trade* by Jon Kalb

Lucy

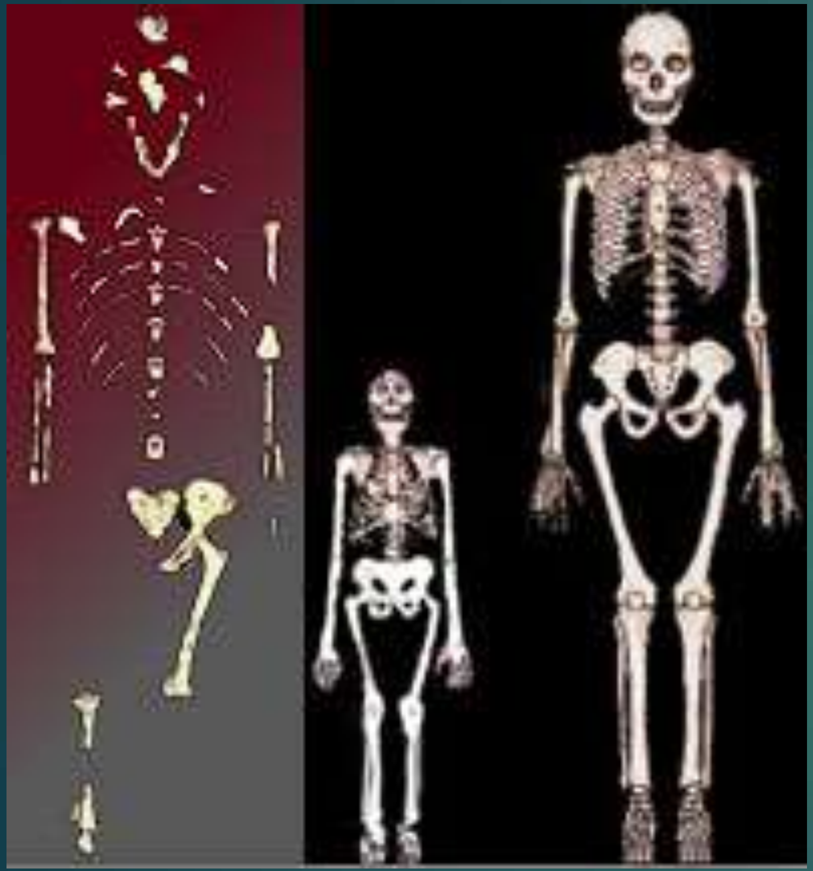
- Lucy is the most famous of the *Australopithecus afarensis* fossils.
- Using potassium-argon dating of the volcanic layers just above and below where Lucy was found, it was determined that Lucy was about 3.2 Ma.
- Her fossilized skeleton was found in 1974 at Hadar in Ethiopia.
- About 42% of her skeleton was found; this is much more complete than most finds.
- *A. afarensis* was a long-lived species that may have given rise to the several lineages of early hominins that appeared in both eastern and southern Africa between two and three million years ago.
- There is additional, indirect evidence that Lucy and her kind were bipedal. A set of hominin footprints was discovered in 1978 at Laetoli.
- These have hominin characteristics, including an arch in the sole of the foot, and do not have the divergent big toe characteristic of apes. The footprints' age was estimated at 3.7 Ma by the potassium-argon method. This is considerably older than Lucy's but is consistent with early *A. afarensis*.

Yves Coppens (1934-):
Lucy, East Side Story

- French paleontologist & paleoanthropologist
- 1974: one of the three co-directors of the team that discovered Lucy
- 1983: popularized *East Side Story* model (originally proposed by the Dutch ethologist Adrian Kortlandt):
  - Creation of the African Rift valley placed Eastern Africa in the drier savannah of the west: created an environmental barrier for split between chimpanzee (wet forests of west) and human gene pools (in dry grasslands of the east)

Lucy: *1st A. afarensis found*

Her discovery revolutionized ways of thinking about early hominins.



Left to right: Lucy's bones,

reconstructed Lucy vs modern human

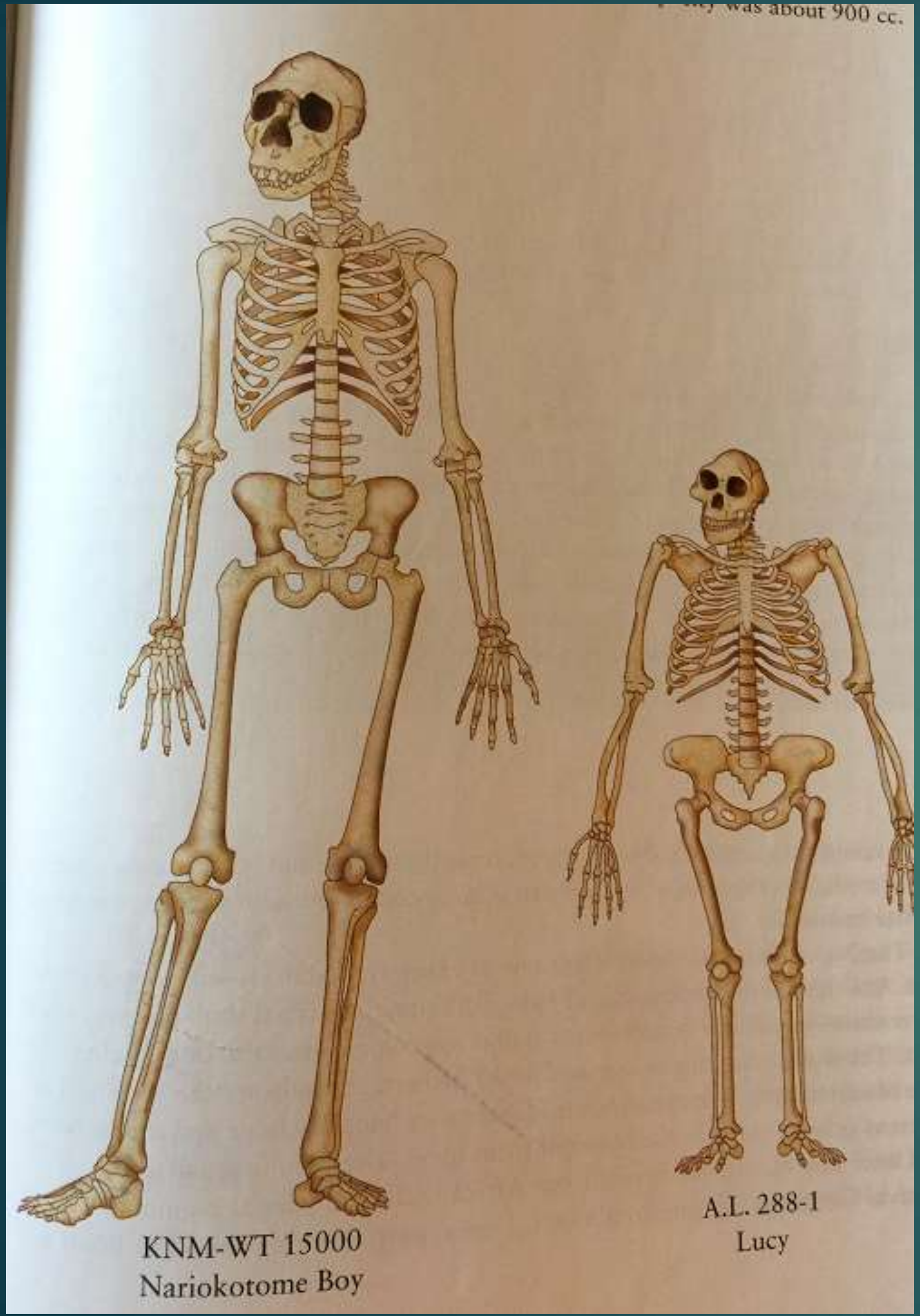
- **Nickname:** Lucy's species
- **Where Lived:** East Africa (Hadar, Ethiopia; Kenya, Tanzania)
- **When Lived:** Between about 3.85 and 2.95 Ma; survived for more than 900,000 years
- 300 specimens
- **Height:** Males: average 4 ft 11 in (151 cm); Females: average 3 ft 5 in (105 cm); some 5'5"
- **Weight:** Males: average 92 lbs. (42 kg) ; Females: average 64 lbs. (29 kg)
- Similar to chimpanzees, *A. afarensis* children grew rapidly after birth and reached adulthood earlier than modern humans
- Mid-20s when died
- Teeth: small & unspecialized, indicating a mixed, omnivorous diet of mostly soft foods (fruits)

Australopithecus afarensis

- 3.9 – 2.7 Ma
- Bipedal (Laetoli footprints 3.6 Ma old; pelvis and leg bones)
- Long arms / short legs; Long upper limbs with curved fingers suggests retention of climbing ability
- More primitive traits than later australopithecine
- Very sexually dimorphic
- Arboreal / terrestrial herbivore

Australopithecus afarensis

- **Brain size**: 375 cc to 50 cc range; Lucy's brain at around 380 cc; 30% larger than chimps
- Size: latest male = 5'5"
- **Diet**: Mostly mixed vegetables, fruit, and leaves
- No direct evidence of meat eating until 2010, when researchers with the Dikika Research Project found fossil animal bones bearing cut marks, dating to about 3.4 million years ago. These cut marks indicate butchering.


was about 900 cc.
KNM-WT 15000
Nariokotome Boy
A.L. 288-1
Lucy


Australopithecus afarensis
AL 288-1, Lucy
About 3.2 million years old
Homo erectus
KNM-WT 15000, Turkana Boy
About 1.5 million years old
Homo neanderthalensis
La Ferrassie 1 and Kebara 1
About 70,000 to 60,000 years old
Very short stature, long arms, and short legs characterized Australopithecus afarensis.
The skeleton of this young Homo erectus shows the long and lean proportions characteristic of humans who are adapted to hot environments.
Though descended from a taller ancestor, Neanderthals evolved a short, stocky body to cope with cold Eurasian winters. This body type helps retain heat.

Australopithecus afarensis

- Habitual bipedal, with ability to climb: Bipedalism in the pelvis and leg bones of this species. Pelvis more closely resembles that of a human, rather than an ape.
- The shape of the scapulae (shoulder blades) and this species' long arms indicate arboreal ability/tree climbing.
- Forward protruding face.
- U-shaped palate with cheek teeth parallel in rows, similar to an ape,
- Small braincase, low forehead, bony ridge over the eyes, a flat nose, and no chin.
- Much smaller canine teeth than those of modern apes, but larger and more pointed than those of humans. Thicker enamel & extended molars, imply new environment; not just fruit

Australopithecus afarensis

- A small adult: She was only 3-1/2 feet tall and weighed somewhere between 57–64 lbs (26 kg to 29 kg).

- Lucy's third molars had erupted so this was her adult weight.

- This indicates that she was female because the remains of *A. afarensis* show clear evidence of sexual dimorphism and her weight is on the low end for an *A. afarensis* adult.

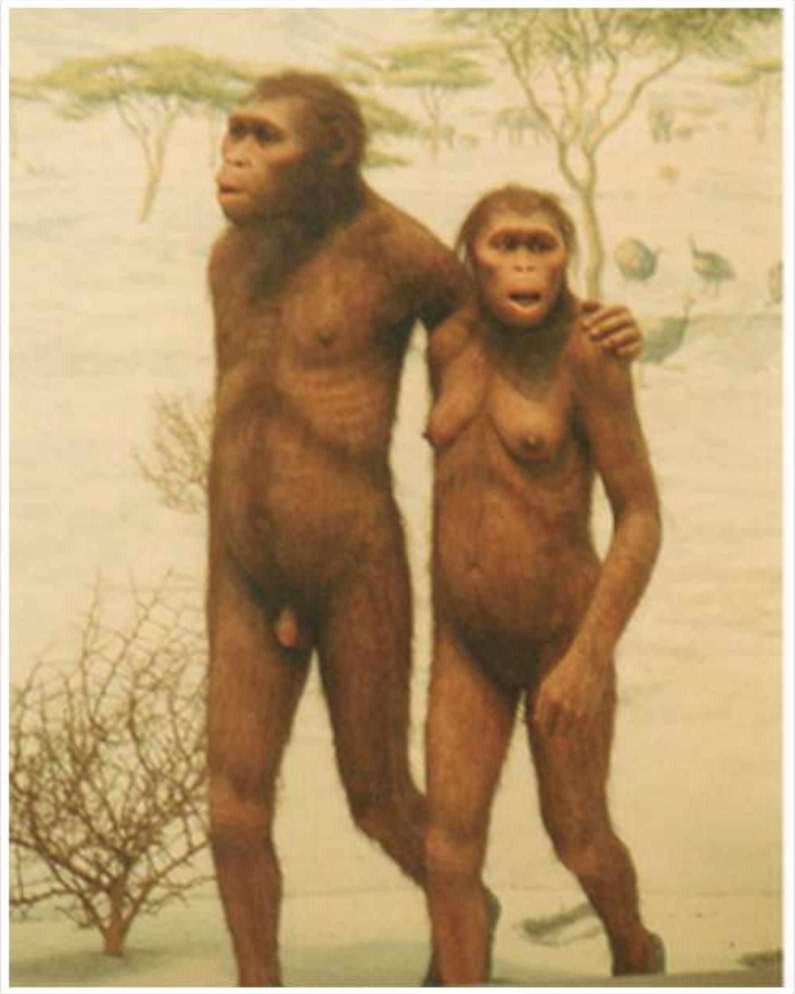
- Cut marks on animal bones indicate tool use, even though no actual tools were found at the Awash site.

- *Afarensis* was not a hunter; more likely, these small hominins were scavenging predator kills.
- Species' first and last known appearances at 3.7 and 3.0 Ma

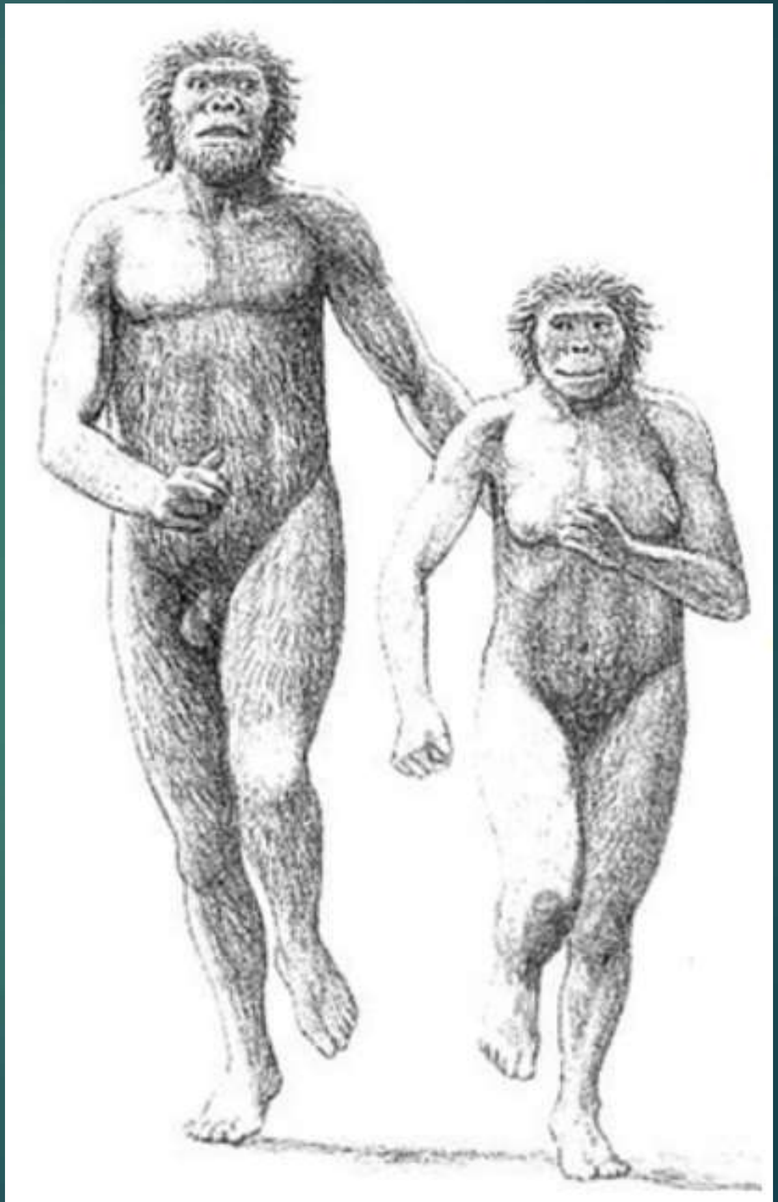
TABLE 11.2 Comparisons of *A. afarensis*, Great Ape, and Modern Humans

	Cranial Capacity (cc)	Sexual Dimorphism (Males X Percent Heavier)
A. afarensis	450	56%
Chimpanzee	400	15%
Gorilla	500	50%
Orangutan	400	Nearly 100%
Early genus *Homo*	600	63%
Modern human	1,400	15%

Sexual Dimorphism in *A. afarensis*

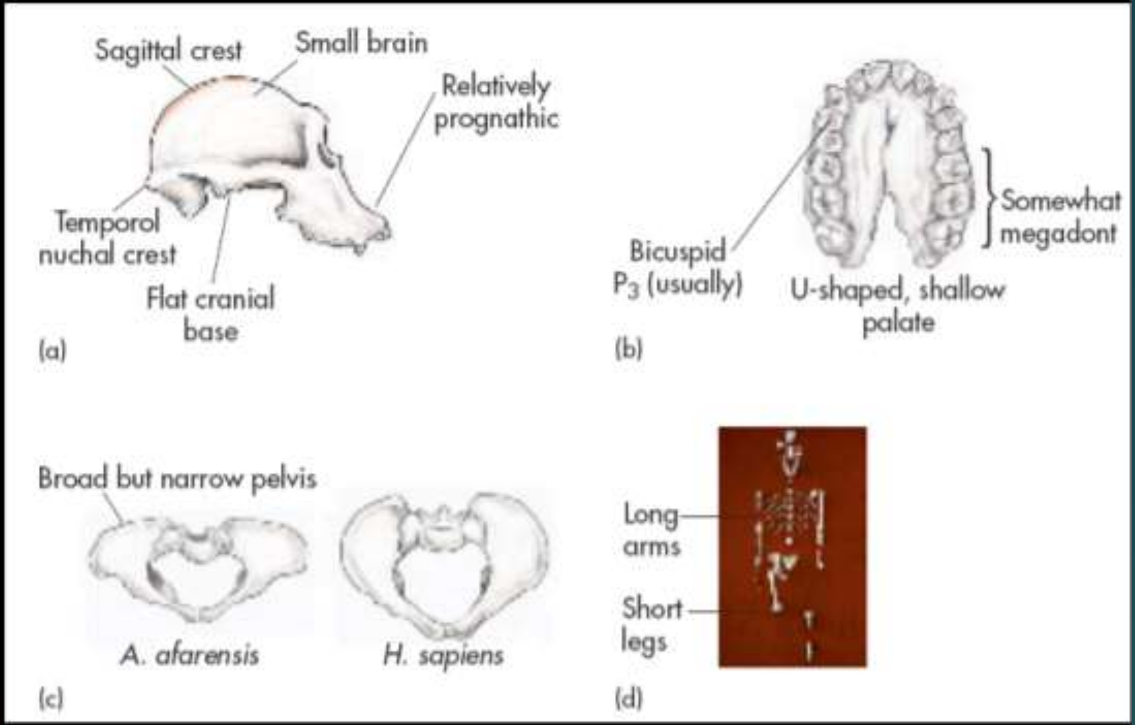


Depiction of male and female Australopithecines at the American Museum of Natural History.



Australopithecus afarensis

- 3.9-2.9 mya
- Short, broad pelvis
- tilted femurs
- In-line big toe
- Sagittal crest
- Sexually dimorphic
- Small bodied
- Small brain



Hundreds of specimens of A. afarensis

Australopithecus afarensis

Location: East Africa
Major site(s): Hadar, Laetoli
Date range: 3.9 - 3.0 MA. (K / Ar dates)

Associated paleoanthropologists: Tim White, Don Johanson, Mary Leakey

Average cranial capacity: 420 cc

Additional major points to know:

- More primitive traits than later australopithecine

- Thick enamel, large, pointed teeth w/ sectorial complex & diastema

While A. afarensis walked upright like a modern human, they had long arms. The ratio of upper arm bone (humerus) to upper leg bone (femur) in A. afarensis is virtually the same as that of a Chimpanzee--95%. The ratio of upper arm to upper leg in a modern human is around 70%.

Australopithecus afarensis

- Ancestral cranial features: forward protruding face, a "U-shaped" palate with cheek teeth parallel in rows
  - *A. afarensis' s* apelike face had a low forehead, a bony ridge over the eyes, a strongly projecting lower jaw and no chin.
  - canine teeth are much smaller than those of modern apes, but larger and more pointed than those of humans.
- The finger and toe bones are curved and proportionally longer than in humans, but the hands are similar to humans in most other details

- Shape & size of pelvis and lower limbs suggest that they stood on two legs and regularly walked upright (bipedal), but only for short distances.

A. afarensis body characteristics

- *A. afarensis* had both ape and human characteristics: members of this species had
  - small canine teeth like all other early humans (incisors smaller than chimps; molars larger than chimps; diet included hard-to-chew items than chimp diet); male/female canine teeth comparable in size
  - Knock-kneed (knee joint angled inward)
  - Heel bone heavily built (like ours)
  - Foot had high, fixed arches (Laetoli)
  - She was bipedal and yet had the cranial capacity of an ape, which shows that bipedalism preceded increase in brain size during the course of human evolution
- It is assumed that this species lived in small foraging social groups.
- Their adaptations for living both in the trees and on the ground helped them survive for almost a million years as climate and environments changed.
- *A. aferensis* is the benchmark by which the anatomy of all other early hominins is interpreted.

Australopithecus afarensis

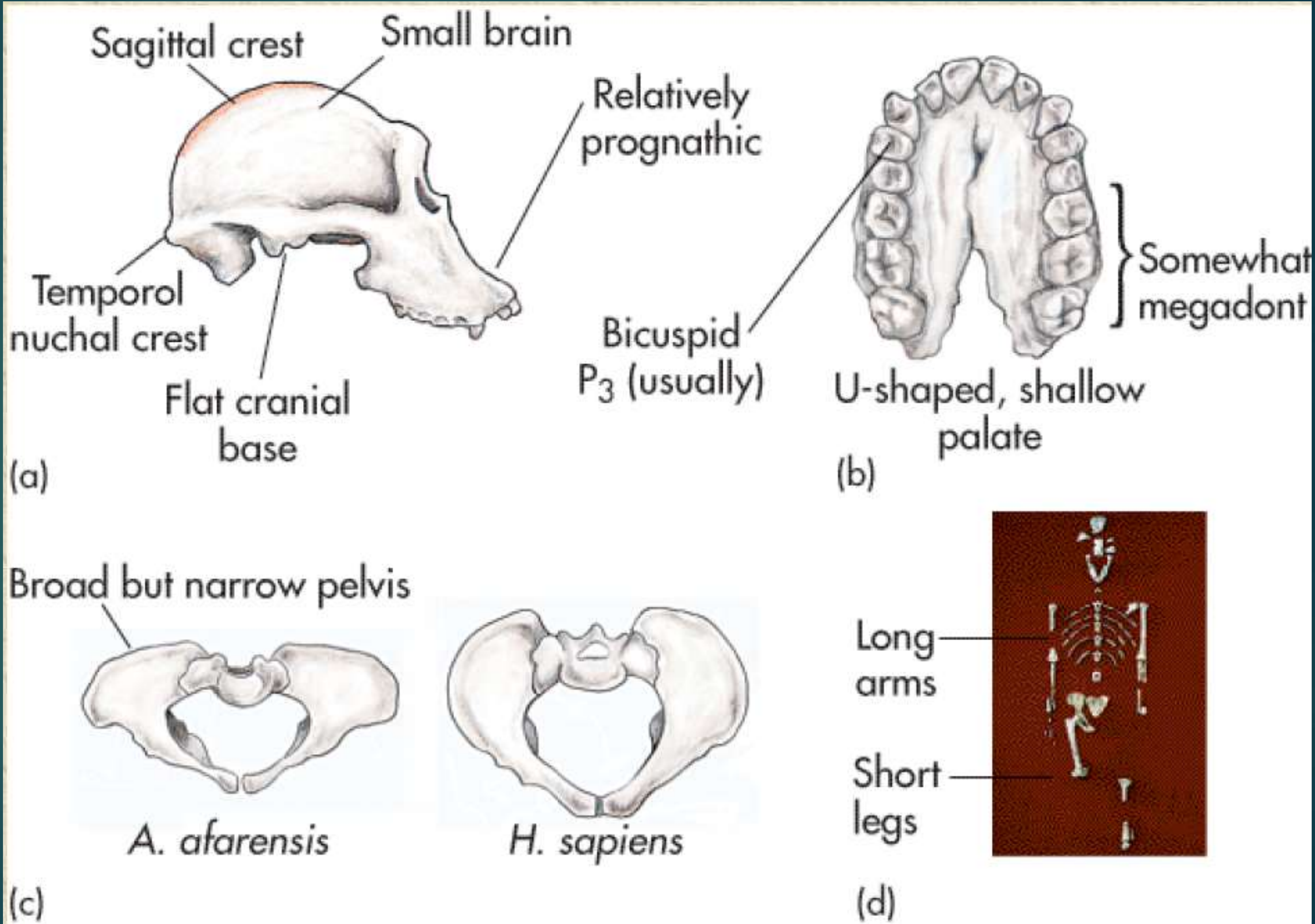
- Most well-known australopithecine = Lucy
  - Most complete skeleton (42%)
- Dates to 3.5-2.3 MA in East Africa (Don Johanson, 1970s)
- Bipedalism
  - Shape of pelvis, femur, foot, Laetoli footprints
  - May not have been fully modern gait
- Derived characters intermediate between humans and chimps
  - Dental arcade
  - Canines
  - Premolar cusps

A. afarensis: both ape and human like

- Lucy and chimpanzees share:
  - Elongated skull with small braincase
  - Face and jaw that jut out from the skull
  - Shoulder blades and joints that are suited for climbing trees
  - Long arms and hands with curved fingers

- Lucy and humans share:
  - Spine connection beneath the skull to keep the head steady and the eyes facing forward.
  - Basin-shaped pelvis to support the upper body and hold it upright
  - Angled thigh bones that place the weight directly over strong knee joints
  - Strong big toes in line with the other toes that function as a stiff lever for striding into the next step

A. afarensis


Sagittal crest
Small brain
Relatively prognathic
Temporol nuchal crest
Flat cranial base
(a)
Bicuspid P3 (usually)
Somewhat megadont
U-shaped, shallow palate
(b)
Broad but narrow pelvis
A. afarensis
H. sapiens
(c)
Long arms
Short legs
(d)

A. afarensis body morphology
Ground or tree-dweller?

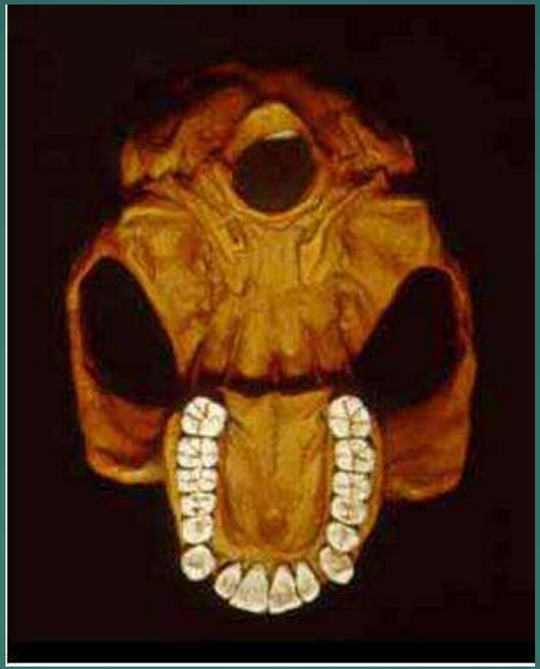
- Slightly curved hand & foot bones
- Relatively long and powerful arms
- Bowl-shaped pelvis
- Knock-kneed (knee joint angled inward)
- Heel bone heavily built (like ours)

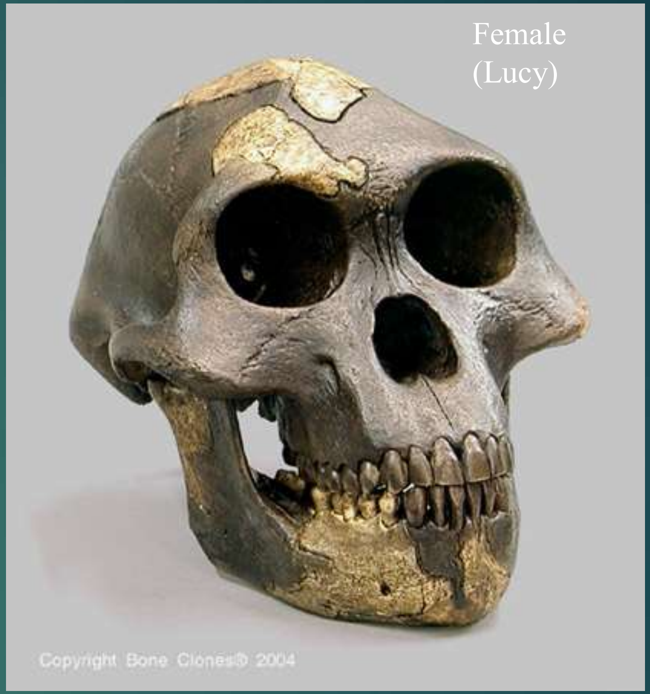
• Foot had high, fixed arches (Laetoli)

Latest Lucy reconstruction

A. afarensis, Lucy, 1974
Science reconstruction, 2013

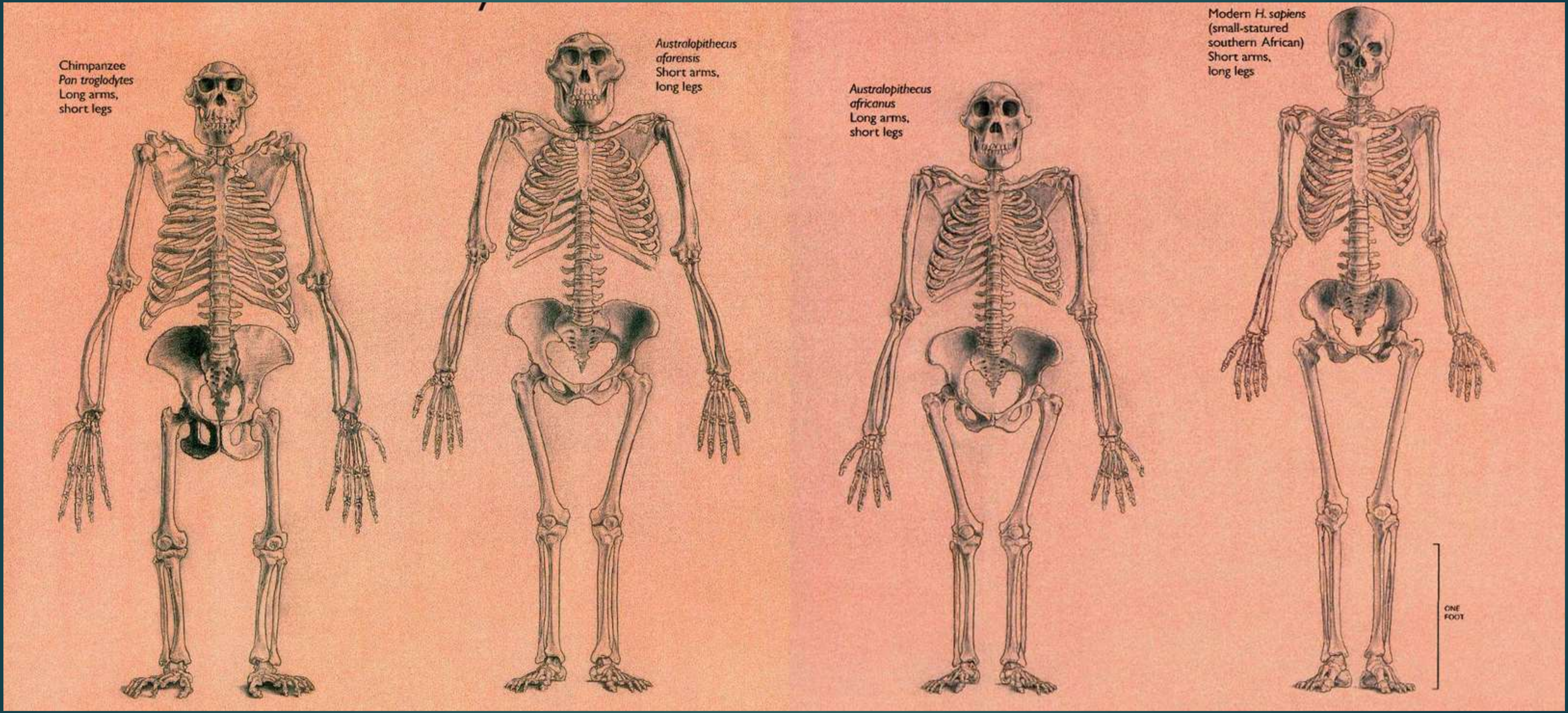
A. afarensis skull morphology



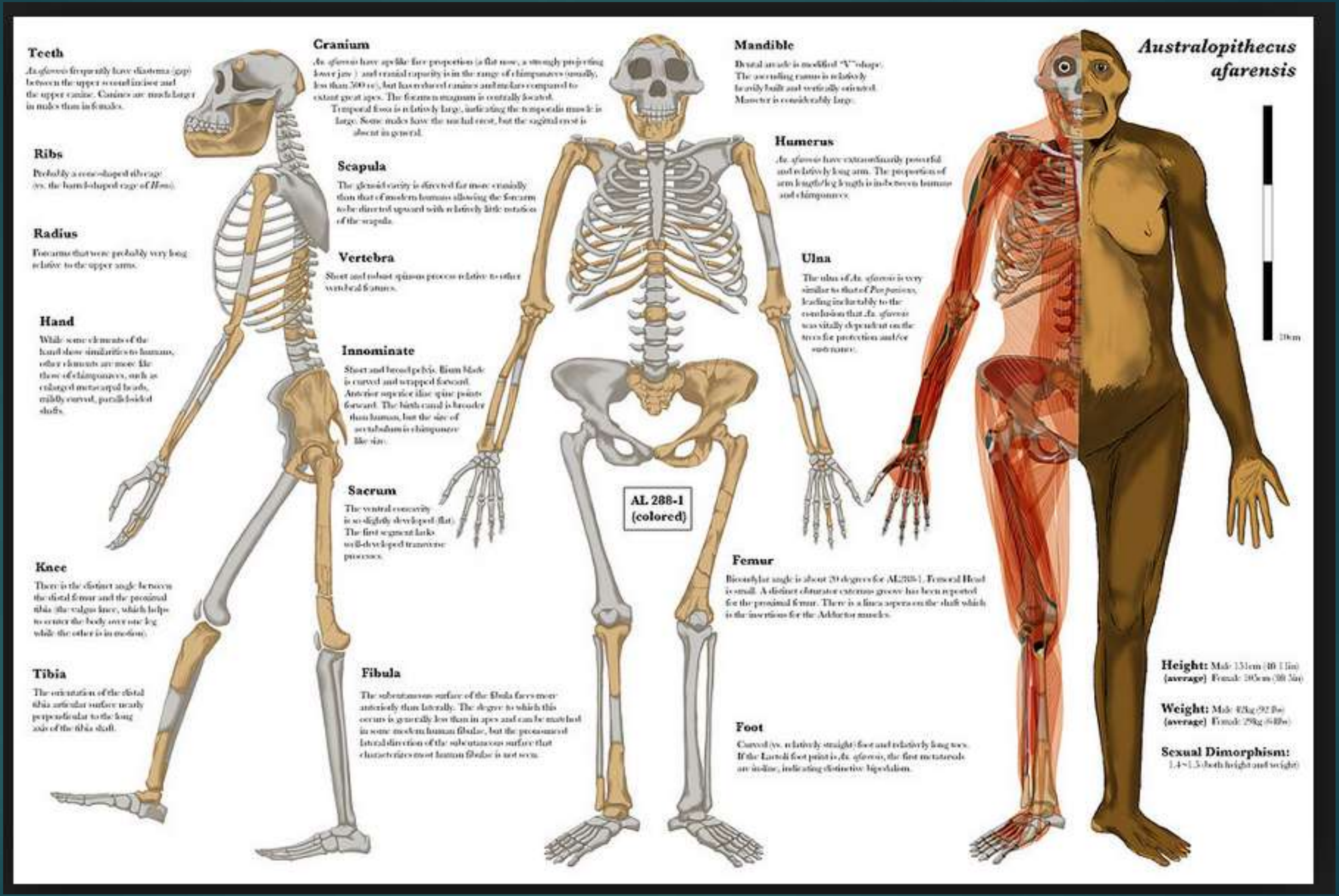


- Cranial capacity: 350 -500 cc
- Small sagittal crest in males
- Slightly projecting upper canine teeth in males
- Parallel rows of cheek teeth (like apes)

Comparison: Chimp, *A. afarensis & africanus*, MH



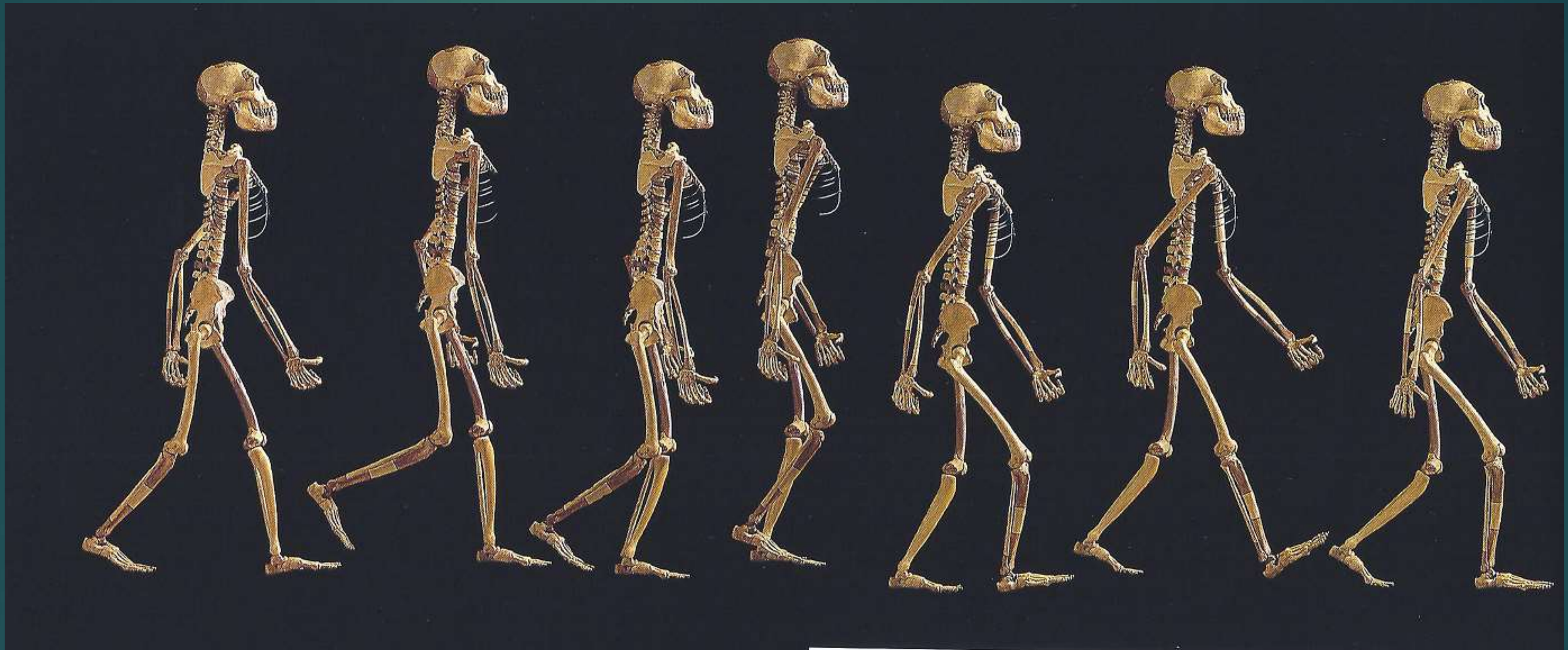
Latest: 5’5” male


Australopithecus afarensis
Teeth
Ribs
Radius
Hand
Knee
Tibia
Cranium
Scapula
Vertebra
Innominate
Sacrum
Fibula
Mandible
Humerus
Ulna
Femur
Foot
AL 288-1
(colored)
Height:
(average)
Weight:
(average)
Sexual Dimorphism:

C. Owen Lovejoy (1943-): Bipedal locomotion

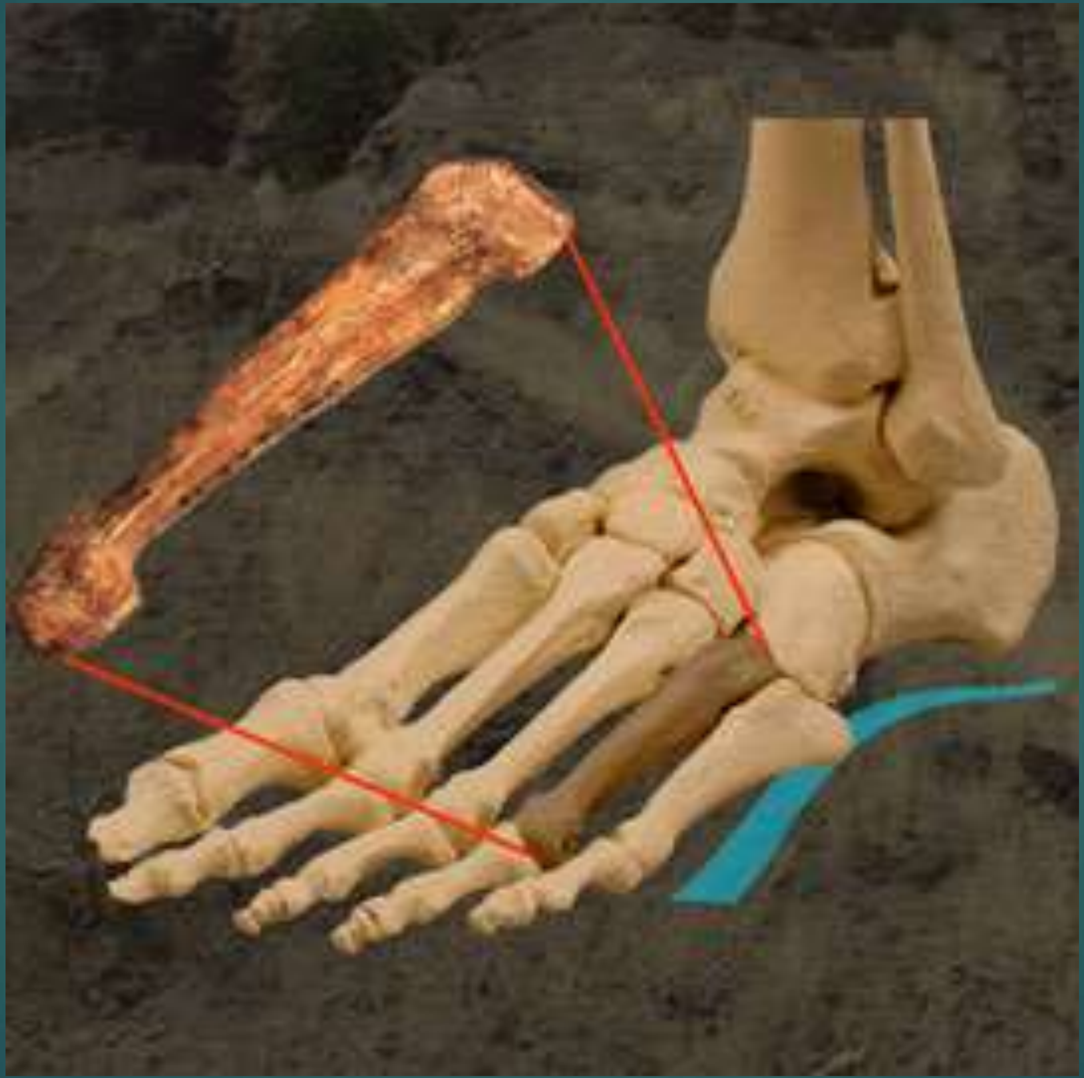
- Functional anatomist and biological anthropologist
- Kent State University, Ohio and Director of the Matthew Ferrini Institute for Human Evolutionary Research
- Work on reconstructing Lucy and *Australopithecine* locomotion and the origins of bipedalism;
- Biological analysis of **Ardi**
- Provisioning Model: Theorized that upright walking was closely tied to monogamous mating in early hominins

Lovejoy: Lucy’s ambulation



Articulated reconstruction of *Australopithecus afarensis*. The plaster skeleton created by anthropologist C. Owen Lovejoy and his students depicts this hominid as fully adapted to habitual bipedal locomotion. *Photograph by David L. Brill; courtesy C. Owen Lovejoy, Kent State University.*

Lucy’s foot: arched



New research: metacarpal bone indicates arched foot (bipedal sign)

Gait

- Upper half was more primitive, lower more derived
- Some referred to as a bent-knee, bent-hip gait, something that's a different kind of bipedal gait than we exhibit as obligate bipeds today, even though Lucy was also an obligate biped.
- In 2007, Lucy went on a unique, six-year tour through United States museums.

- Very flared pelvis of Lucy.

•This includes the sacrum, and a largely complete os coxae as well as the proximal femur

- pelvis is a critical link in obligate bipedality.

- It ties together the upper body with the lower limb.

- the femoral neck angle as well, which shows clear evidence of this kneeing-in, the movement of the weight into the midline of the body associated with the morphology of the femur.

- relatively complete femur preserved in Lucy.

- And in addition to the femoral neck angle, you can see that that it forms a specific angle into the knee, the bicondylar angle, which again

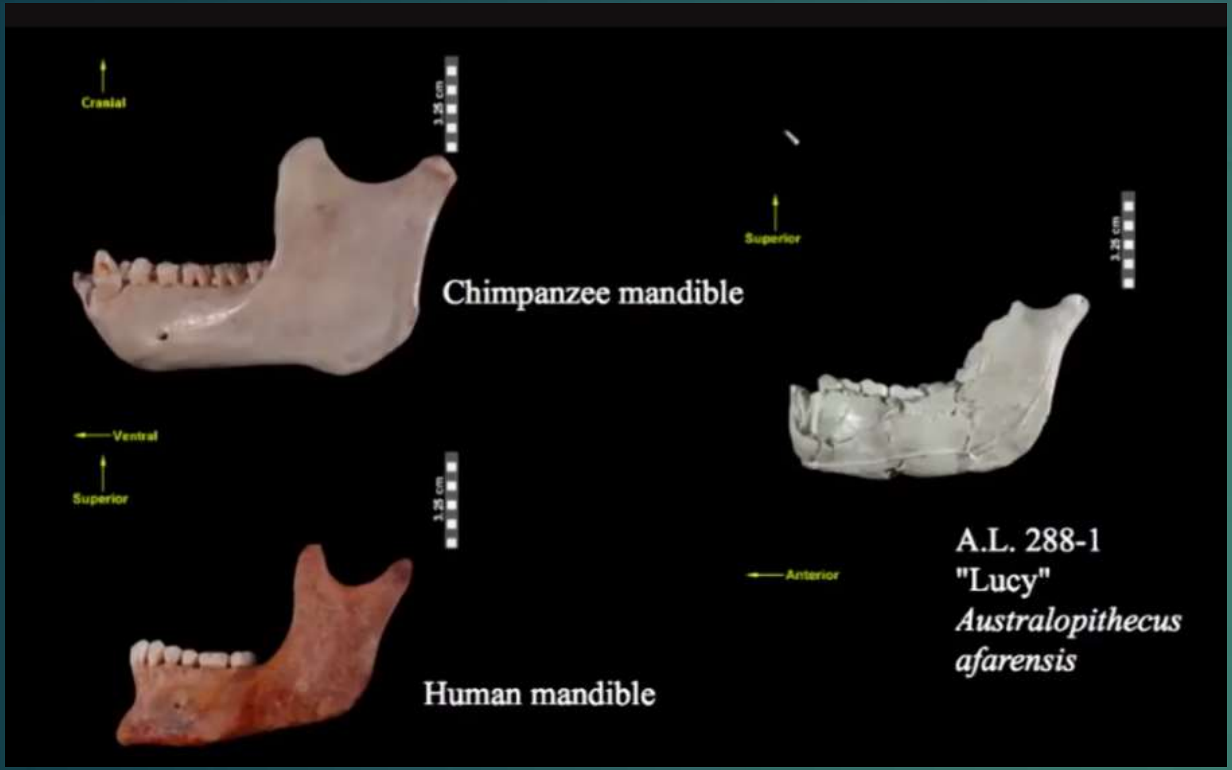
- shows evidence of this kneeing-in morphology.

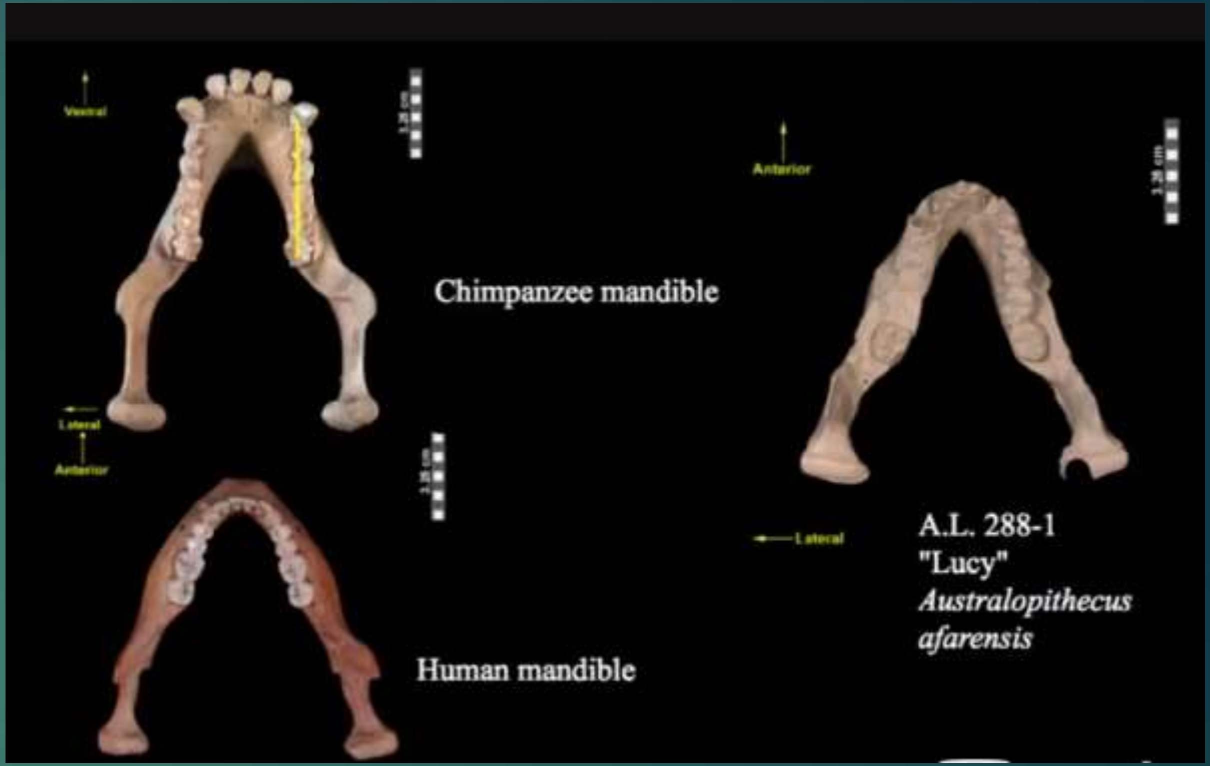
Upper body is more primitive and apelike

Triangular thorax is more primitive: an expanded lower thorax associated with a large gut area & reduced quality diet.

- The upper limbs of Lucy are very well preserved and provide evidence of having some retention of climbing ability in Lucy.
- the relative breadth of the distal humerus and the muscular attachments associated with it; gives evidence of some retained ability to climb.
- Returning to trees at night may have been defense vs. predators

Mandible

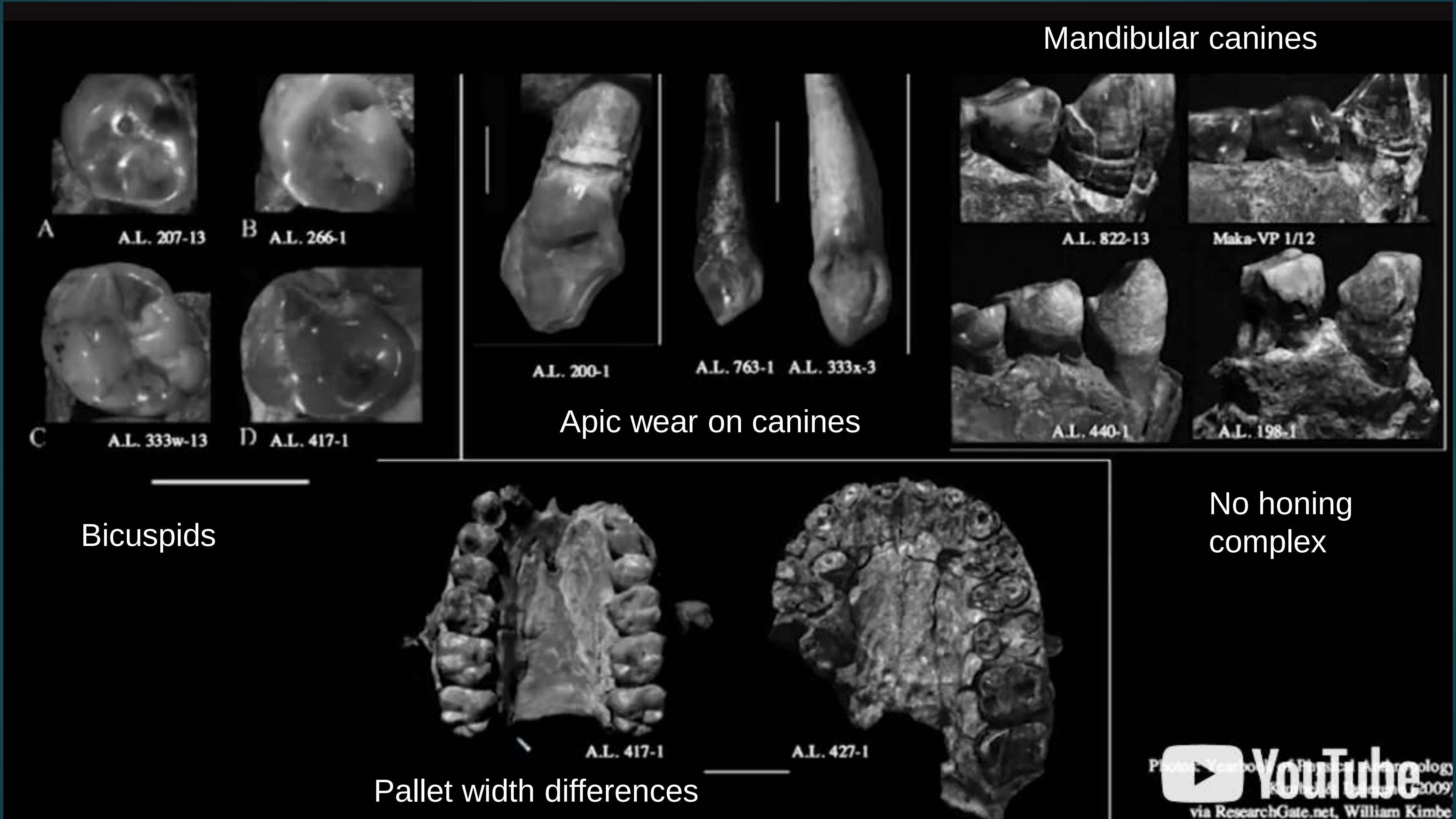


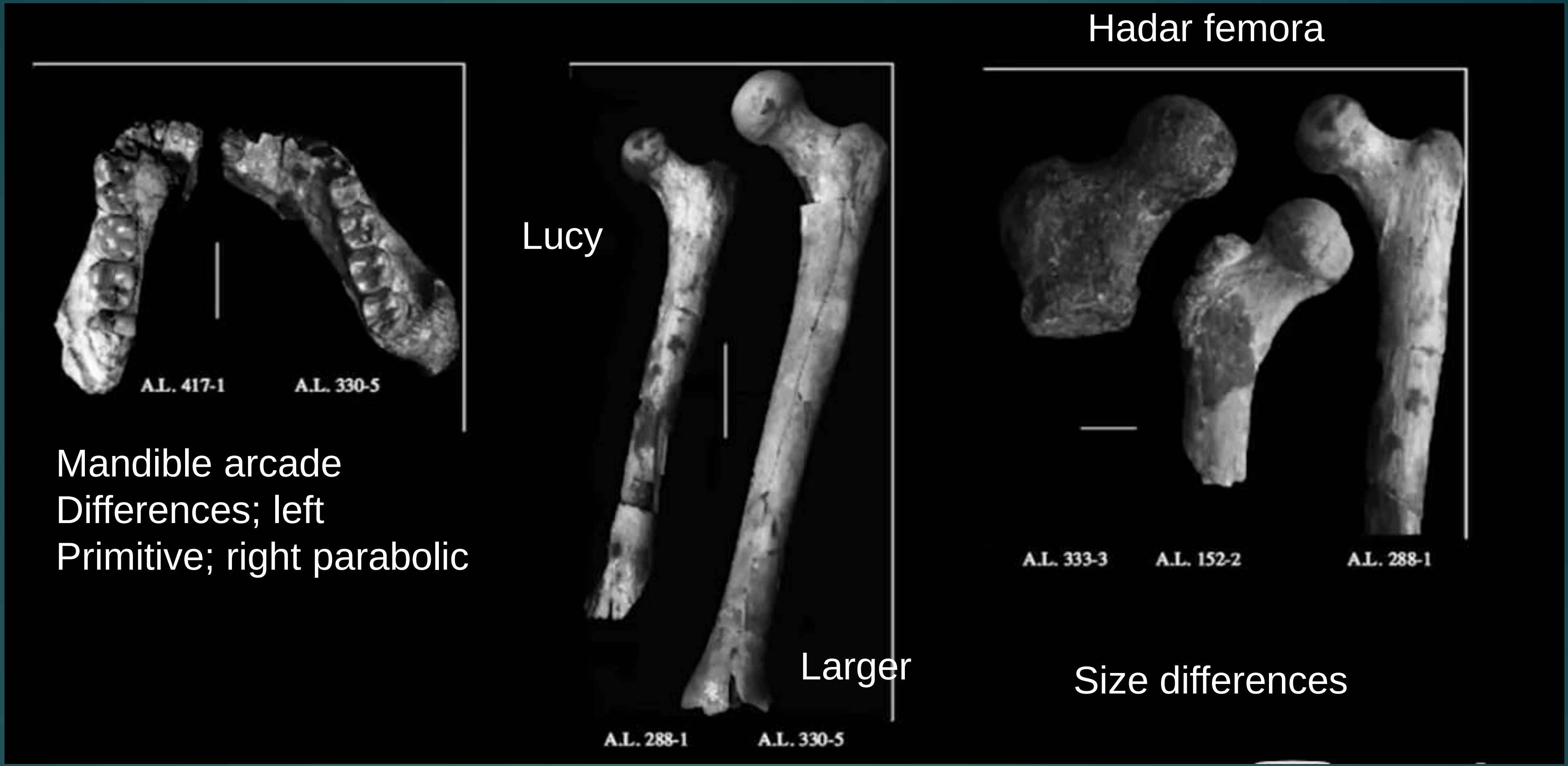


Chimp U shape; Lucy moving toward more derived parabolic shape; very large molars with increased enamel, more derived than us; less prognostic

- Does not have receding chin of chimps; humans have chin

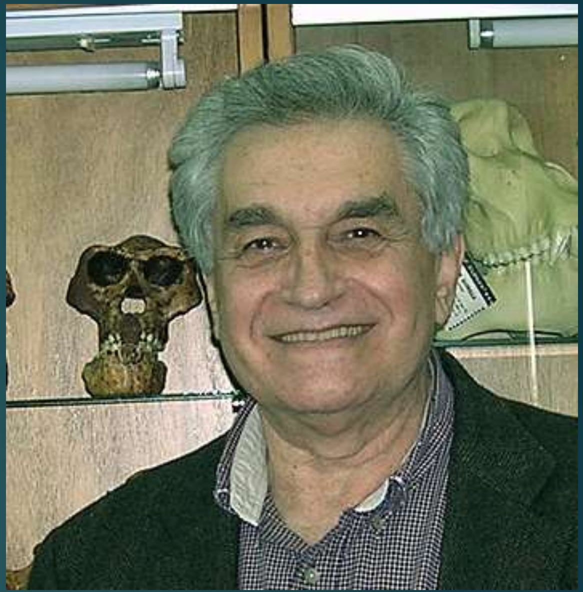
Lots of normal variation





- Femur is good estimator of body size
- Variation is the normal condition in biological species, i.e. only moderate skeletal dimorphism – humans 6-8% dimorphic; gorillas 20%

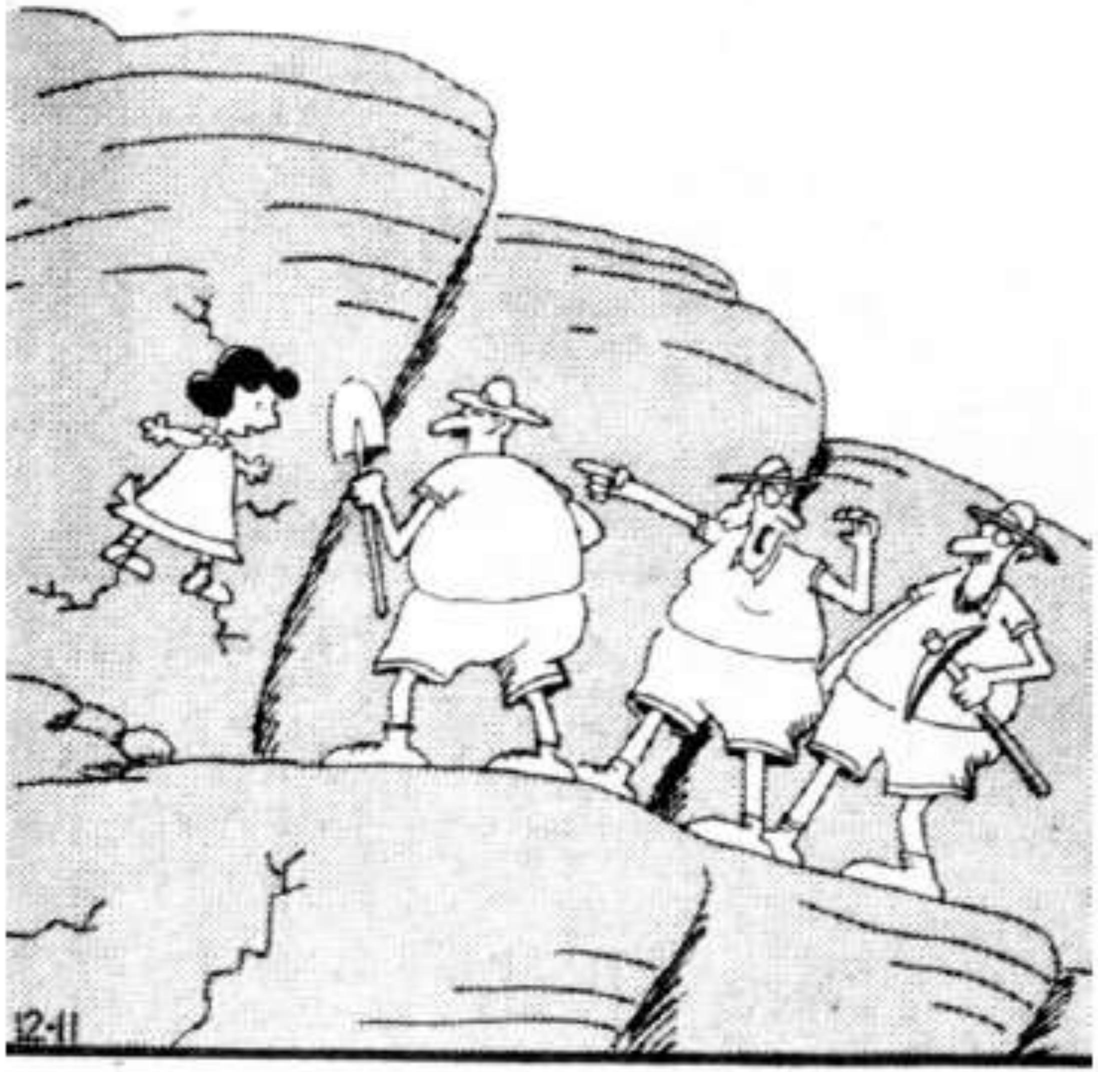
Yoel Rak (1946-):
A. afarensis



- Israeli physical anthropologist; Tel Aviv University
- 1992: *Australopithecus Afarensis* (A. L. 444 -2)

Australopithecus afarensis
(A.L. 444-2; 1st relatively complete skull)
Discoverer: Yoel Rak
Locality: Hadar, Ethiopia
Age: 3 M
Date 1992

Unfortunately…



Rocking the anthropological world,
a second "Lucy" is discovered
in southern Uganda.

A. afarensis, "First Family", fragments of 13 individuals

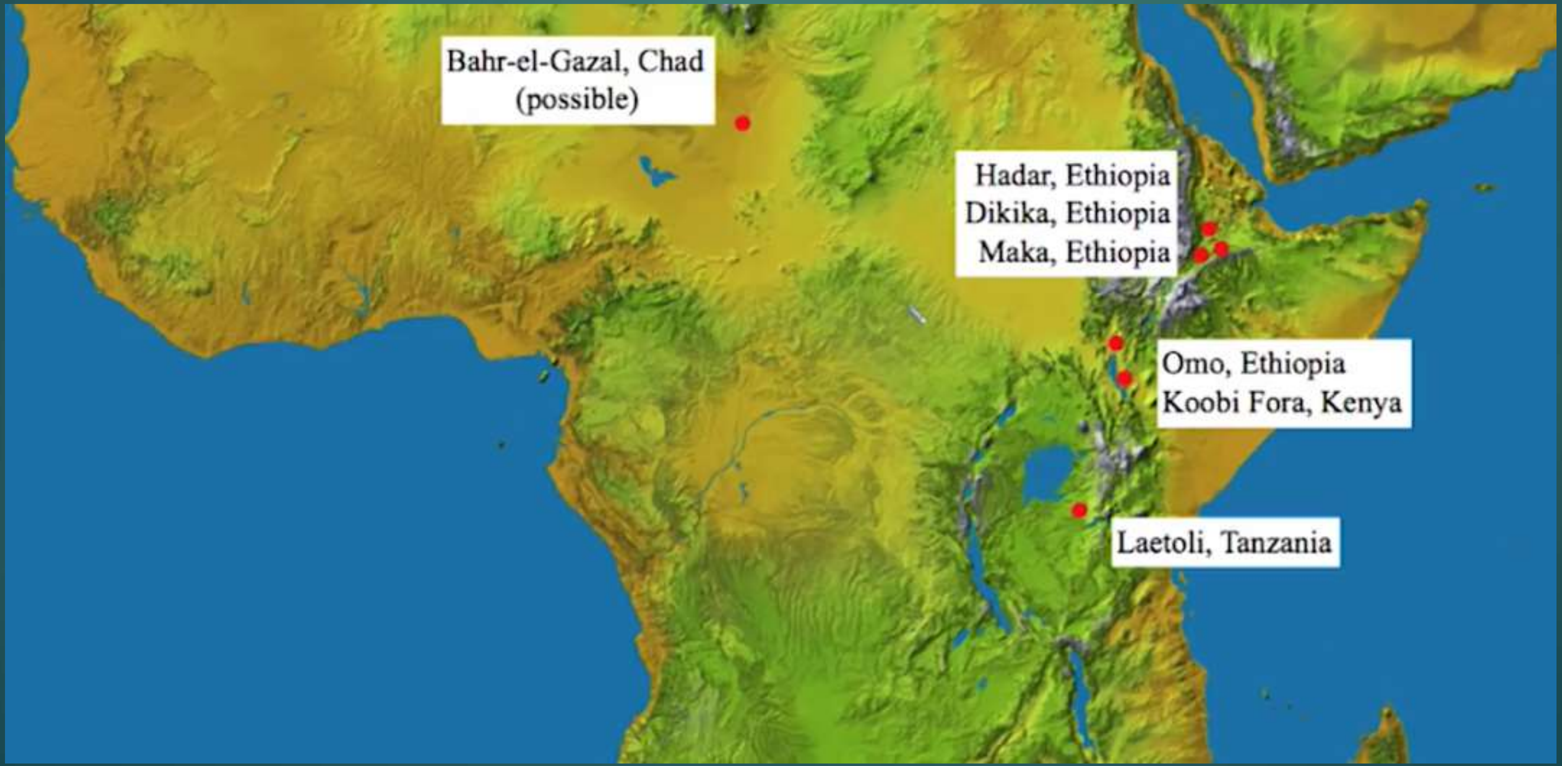
Australopithecus afarensis
(A.L. 333-105, juvenal)
Discoverer: Michael E. Bush
Date: 1975
Locality: Hadar, Ethiopia
Age: 3. 2 M

Locations of *A. afarensis*

- *Australopithecus afarensis* fossils have only been discovered within Eastern Africa.
- Despite Laetoli being the type locality for *A. afarensis*, the most extensive remains assigned to the species are found in Hadar, Afar Region of Ethiopia, including "Lucy" partial skeleton and the "First Family" found at the AL 333 locality.
- Other localities bearing *A. afarensis* remains include Omo, Maka, Fejej, and Belohdelie in Ethiopia, and Koobi Fora and Lothagam in Kenya.
- Species' first and last known appearances at 3.7 and 3.0 Ma

Many specimens of *A. afarensis*

- Can study variation in the species – in sexual dimorphism, life history development, normal variation, geographic and temporal variation



- 1979 display of *A. afarensis* specimens
- by 2009, 400 specimens (96 skulls)
- Lots of repetition of same skeletal elements
- First family, AL 333:

  200 specimens, 13 individuals

Afar,
Location 333

Lucy

Lucy redux: A review of research on *Australopithecus afarensis*" William H. Kimbel and Lucas K. Delezene, (2009)

TABLE 1. *The A. afarensis hypodigm*

Site	Age (Ma)	Skeleton	Skulls	Crania	Mandibles	Upper limb	Hand	Axial*	Lower limb	Foot	Isol. Teeth
Hadar, Ethiopia (A.L.)	3.4 3.0	288 1 438 1	333 45/96 417 1 444 2 487 1 822 1	58 22 125 11 162 28 166 9 199 1 200 1a 224 9 333 1 333 2 333 23 333 24 333 45 333 84 333 105 333 112 333 114 333 116 333 125 413 1 423 1 427 1 439 1 442 1 444 1 457 2 486 1 651 1 701 1 770 1 922 1	128 23 145 35 188 1 198 1 198 22 207 13 225 8 228 2 237 3 266 1 277 1 311 1 315 22 330 5 330 7 333w 1 333w 12 333w 27 333w 46 333w 52 333w 57 333w 58 333w 59 333w 60/32 333 59 333 74 333 97 333 100 333 108 333n 1 400 1a 411 1 418 1 432 1 433 1 436 1 437 1 437 2 440 1 443 1 582 1 604 1 620 1 729 1 766 1 996 1 1030 1 1045 1 1180 1	137 48a, b 137 50 223 1 322 1 333w 22 333w 31 333w 33 333w 36 333 11 333 12 333 29 333 38 333 87 333 94 333 98 333 107 333 109 333 119 333 124 333 127 333 128 333 129 333 130 333 141 333 144 333 149 333 150 333 153 333n 2 333x 5 333x 6/9 333x 14 333x 16 444 13 444 14 444 15	333w 4 333w 5 333w 7 333w 6 333w 11 333w 20 333w 23 333w 26 333w 29 333w 35 333w 38 333w 39 333w 53 333w 54 333 14 333 15 333 16 333 17 333 18 333 19 333 20 333 25 333 27 333 31 333 33 333 40 333 46 333 48 333 49 333 50 333 56 333 57 333 58 333 62 333 63 333 64 333 65 333 69 333 80 333 88 333 89 333 91 333 93 333 122 333 141 333 144 333 148 333 149 333 150 333x 13a, b 333x 18 438 4 444 3 444 4 444 5 1044 1	333w 8 333w 14 333 51 333 73 333 81 333 83 333 101 333 106 333 134 333 152 333 155 333 156 333 161 333 164 333x 12 444 7 444 8 444 9 444 10 444 11 444 12	128 1 129 1a c 129 52 152 2 211 1 228 1 330 6 333w 37 333w 40 333w 43 333w 56 333 3 333 4 333 5 333 6 333 7 333 9 333 39 333 41 333 42 333 61 333 85 333 95 333 96 333 110 333 111 333 120 333 123 333 126 333 131 333 132 333 135 333 140 333 142 333 145 333 147 333 154 333 157 333 158 333 160 333 162 333 163 333x 26 545 3 827 1	333w 25 333w 34 333w 51 333 8 333 13 333 21 333 22 333 26 333 28 333 36 333 37 333 47 333 54 333 55 333 60 333 71 333 72 333 75 333 78 333 79 333 102 333 115a m 333 145 333 147 333 167 333 168 333x 2 1a, b	161 40 176 35 198 17a, b 200 1b 207 17 241 14 249 26 249 27 293 3 309 8 333w 2 333w 9a, b 333w 10 333w 28 333w 42 333w 48 333 30 333 35 333 44 333 52 333 66 333 67 333 68 333 76 333 77 333 82 333 90 333 99 333 103 333 104 333 165 333 166 333x 1 333x 2 333x 3 333x 4 333x 17 333x 20 333x 25 366 1 388 1 400 1b 438 2 438 3 441 1 444 6 444 16 444 29 444 30 452 18 462 7 465 5 486 1 557 1 655 1 660 1 697 1 699 1 762 1 763 1 772 1 777 1 1017 1 1117 1 1256 1

(Continued)

2009

Site	Age (Ma)	Skeleton	Skulls	Crania	Mandibles	Upper limb	Hand	Axial*	Lower limb	Foot	Isol. Teeth
Dikika, Ethiopia (DIK)	>3.4–3.3	1-1			2-1						
Maka, Ethiopia (MAK-VP)	3.4				1/2 1/6 1/12 1/83	1/3 1/111			1/1		1/4 1/13
Koobi Fora, Kenya (KNM-ER)	3.4–3.3			2602							
Laetoli, Tanzania (LH)	3.7–3.5	21		Garusi 1 5	2 4 10 13					Footprints	M. 42323 Garusi 3 1 3a-t 6a-e 3/6a-c 8 11 12 14a-k 15 16 17 19 23 24 25 26 30 31
Tentative:											
Omo (Usno), Ethiopia	3.0										W7-23 W8-751 W8-978 W8-988 B7-39a, b B8-23a B8-4q L1-667
Bahr-el-Ghazal, Chad (KT)	(3.0–3.5)				KT12/H1 KT 40						
Belohdelie, Ethiopia (BEL-VP)	3.8			1/1							

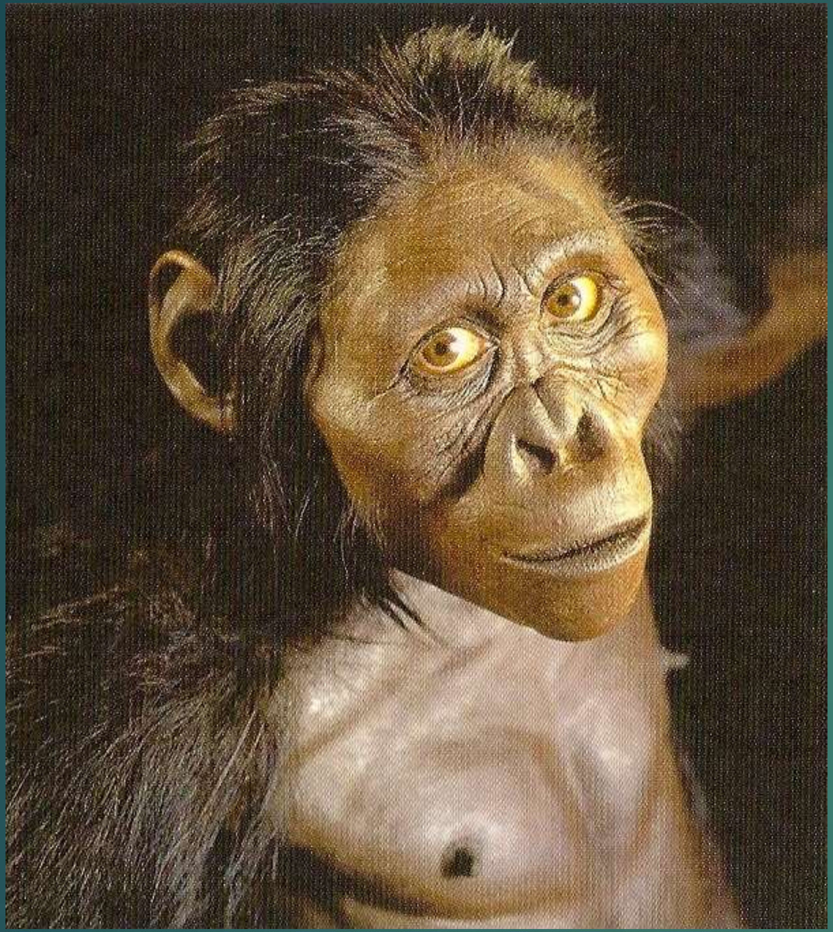
*Axial inventory for Hadar does not include isolated ribs and rib fragments from A.L. 333/333w.

In which environment did early hominins evolve?

Environment determination

- Examine soil fossil found in
- Examine collateral species found & their normal environments
- Isotopic exam of fossil can tell types of food they ate
- East Africa was drying out during the Pliocene, leading to break up of tropical forests
- East Africa was separating from Africa – Rift Valley
- Drier and more open landscapes
- A. afarensis were active during the day; this was heat intensive; required water access; most fossils found near water resources

Lucy



Australopithecus afarensis 3-2 MA

Australopithecine Foraging Behavior

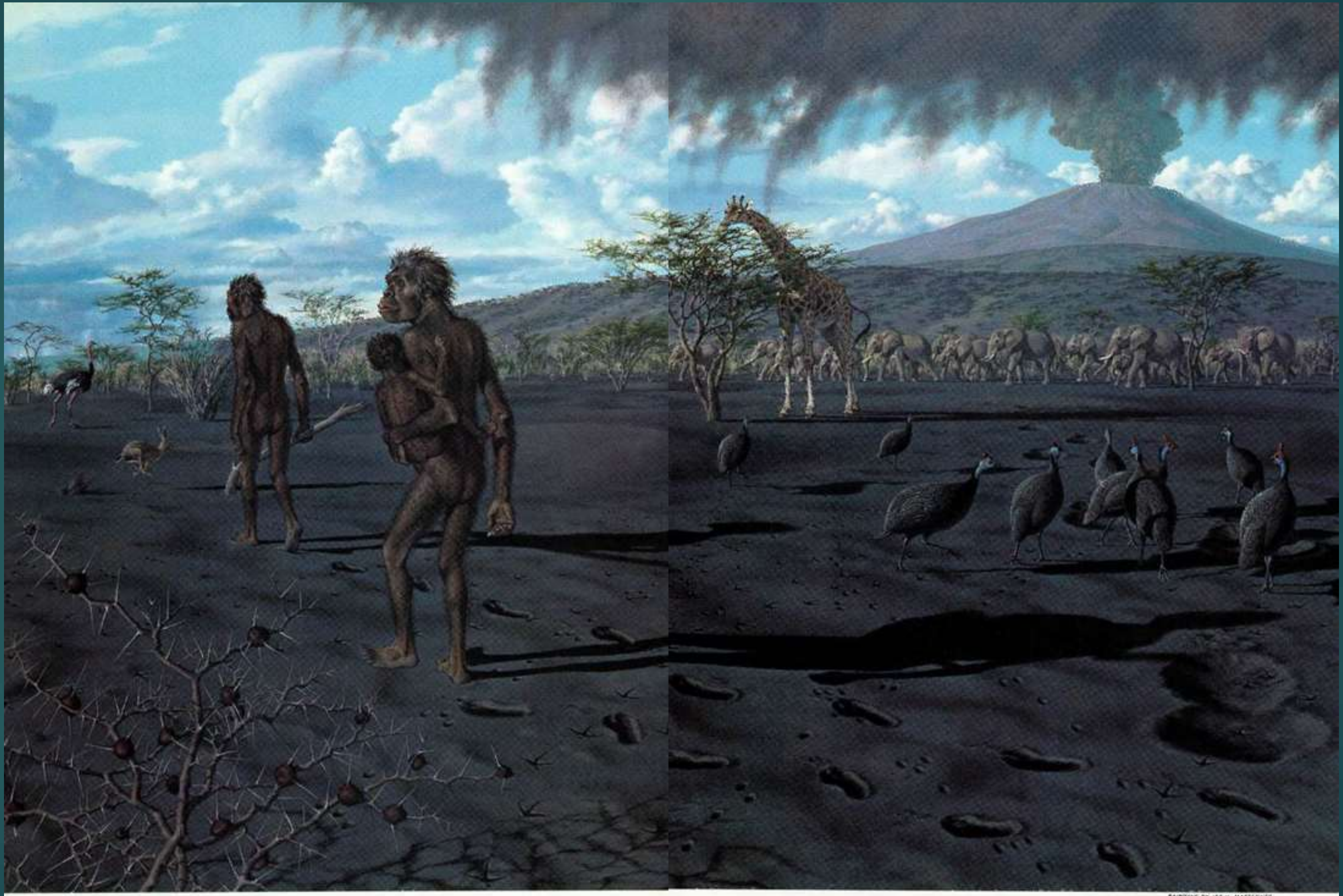
Foraging (the systematic search for food and other provisions) was THE lifeway of all hominins from the earliest australopithecines until about 10,000 years ago (the start of agricultural modes of subsistence.

Foraging by australopithecines and early species of Homo most likely consisted of collecting roots, berries, seeds, nuts, salad greens, insects, etc.

Around 2 MA, meat, obtained by scavenging, became part of the foraging way of life. Eventually fish and shellfish would be added.

Laetoli Footprints

Laetoli, Tanzania: 3.6 Ma, Oldest human footprints



PAINTING BY JAY H. MATTERNES

Sadiman booms and ash rains, as animals browse without fear and hominids travel northward beneath the volcano's cloud. Acacias, including whistling thorns with ant-infested galls, stud the plain. The ash, dampened by the rainy season's first showers, captures the double trail of hominid tracks as well as those of elephants, guinea fowl, giraffes, hares, and ostriches. In the tropical heat the tracks dry rapidly and are soon covered with another shower of ash. The hominid prints indicate heights of about four feet and four feet eight inches, possibly a female and a male. Although depicted here together, the individuals may have journeyed separately.

Mary Leakey (1913-1996):
Discoverer of Proconsul, Zinj, & Laetoli footprints

- Mary Douglas Nicol; British archaeologist and anthropologist
- As famous as her husband Louis.

- 1948: discovered the first ***Proconsul africanus*** on Rusinga Island, Lake Victoria; 18MY

- 1959: discovered the robust **Zinjanthropus** skull at Olduvai Gorge.

- Classification system of Oldowan tools.

- 1960: became director of excavations at Olduvai.

- 1978: discovered, with Tim White, **Laetoli footprints**, dated 3.6 million years ago; clearly bipedal.

Importance of Elephant Dung

- 1976, when paleoanthropologist Andrew Hill and a colleague were tossing elephant dung at each other in Laetoli, a hominin archeological site in Tanzania. As Hill dived out of the way, he stumbled on what turned out to be some fossilized animal footprints.

- In 1977, large elephant tracks were found by **Mary Leakey**'s son **Philip** and a co-worker, **Peter Jones**, and alongside them some tracks that looked suspiciously like human footprints

- This was the origin of one of the wonders of prehistoric finds: a trail of hominin footprints about 3.6 Ma.

1978: Laetoli *A. afare*

1978: Laetoli Footprints: *A. afarensis,* male and female, 3.6 M

88 feet long, 70 footprints; left foot of female

Left: Trail of footprints of A. afarensis made in volcanic ash, discovered by Mary Leakey at Laetoli.

Right: Close-up of footprint at Laetoli

Laetoli, Tanzania, footprints in volcanic ash: a bipedal species with big toe aligned with other toes; evidence of sexual dimorphism; human stride; foot arch

1979:
Mary Leakey &
Richard Hay
describe
the 3.6 myr-old
fossil footprints

Laetoli footprints, Tanzania

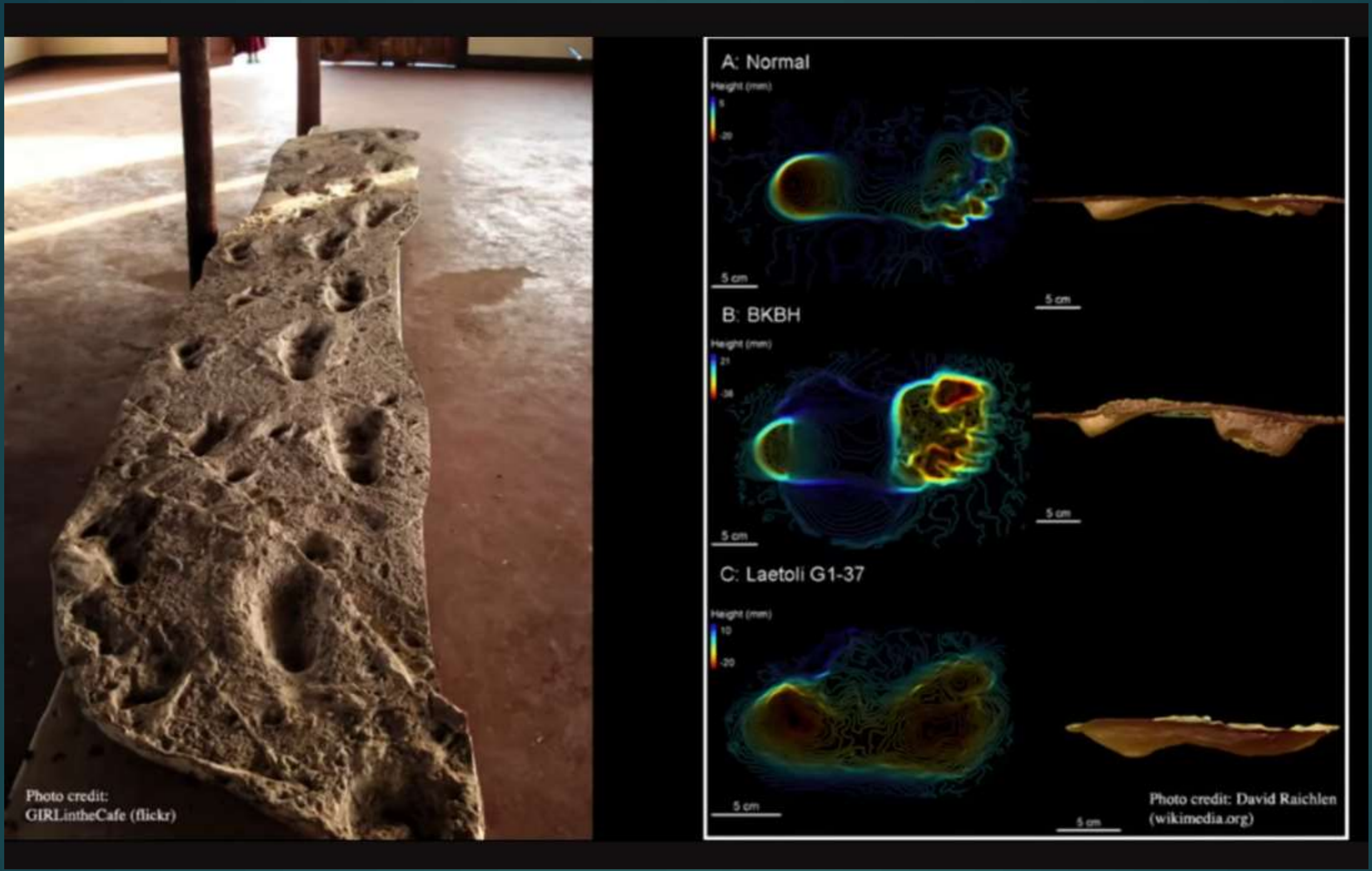
- Formed and preserved by a chance combination of events – an eruption of the Sadiman volcano, a rainstorm, and another ashfall, and erosion
- 2-3-4? individuals
  - Fainter of two clear trails is unbalanced, individual possibly burdened on one side w/ an infant? Or separate individuals.
- *A. afarensis*
  - No other hominin near this age, 3.6 MA

Australopithecus afarensis: AMNH reconstruction

AMNH exhibit: Tattersall was criticized by feminists

Laetoli footprints

- Laetoli Footprints were made by an early hominin, and the only known early hominin in the region at that time was *A. afarensis*.
- Nearby fossil mandibles in the same sediment layer indicate that *A. afarensis* was in the area at the same time the footprints were left.
- Big toes in line with digits. Apes have highly divergent big toes
- Gait of these early humans was "heel-strike" (the heel of the foot hits first) followed by "toe-off" (the toes push off at the end of the stride)—the way modern humans walk.
- Size of footprints and length of stride consistent with estimates of stature made using the limb bones of *A. afarensis* suggesting height of 3-4 feet.
- Close spacing of the footprints are evidence that the people who left them had a short stride, and therefore probably had short legs.



Modern human

BKBH: Bent knee & bent hip

Depth of foot prints

Laetoli: same basic features

Footprints at Laetoli are consistent with fully upright, human-like bipedal walking.

Dave Raichlen et al., 2018

Laetoli footprints

- These fossilized footprints reveal important information about the individuals who made them.
- First, it's clear that they walked upright.
- The initiation of our bipedal gait, the initiation of our step, begins when our heel touches the ground. This heel strike is the primary initiating factor of our bipedal gait.
- We place a lot of weight on our heel, and as a result, not surprisingly, we have a large calcaneus tuber, basically the bone in the back of our heel, to help support that heel strike.
- As our weight moves forward, our relatively stiff foot helps transfer that weight forward onto the balls of our feet.
- We finish our foot with a prominent toe off, where we extend our foot and actually through the big toe. All this is evident at Laetoli.
- Unclear is evidence for transverse and longitudinal arches.
- From stride length, scientists estimate that they were about 4 feet 8 inches and 4 feet tall, respectively.

2016: Lucy had taller, 5’5”, kin at 3.7 MA, Chewie at Laetoli

- 14 footprints, made by 2 individuals, walked across wet volcanic ash. 10 inches long; 32-meter-long track, L8 site
- All but 1 of 14 steps came from same individual (S1), “Chewie”; stood 5’5”, 100 lbs; tallest known *A. afarensis*; other footprint made by female, 4’9”, 87 lbs
- Lucy lived 500 Ka later; 3’6”

- Challenges idea that hominin body size increased only with *Homo*

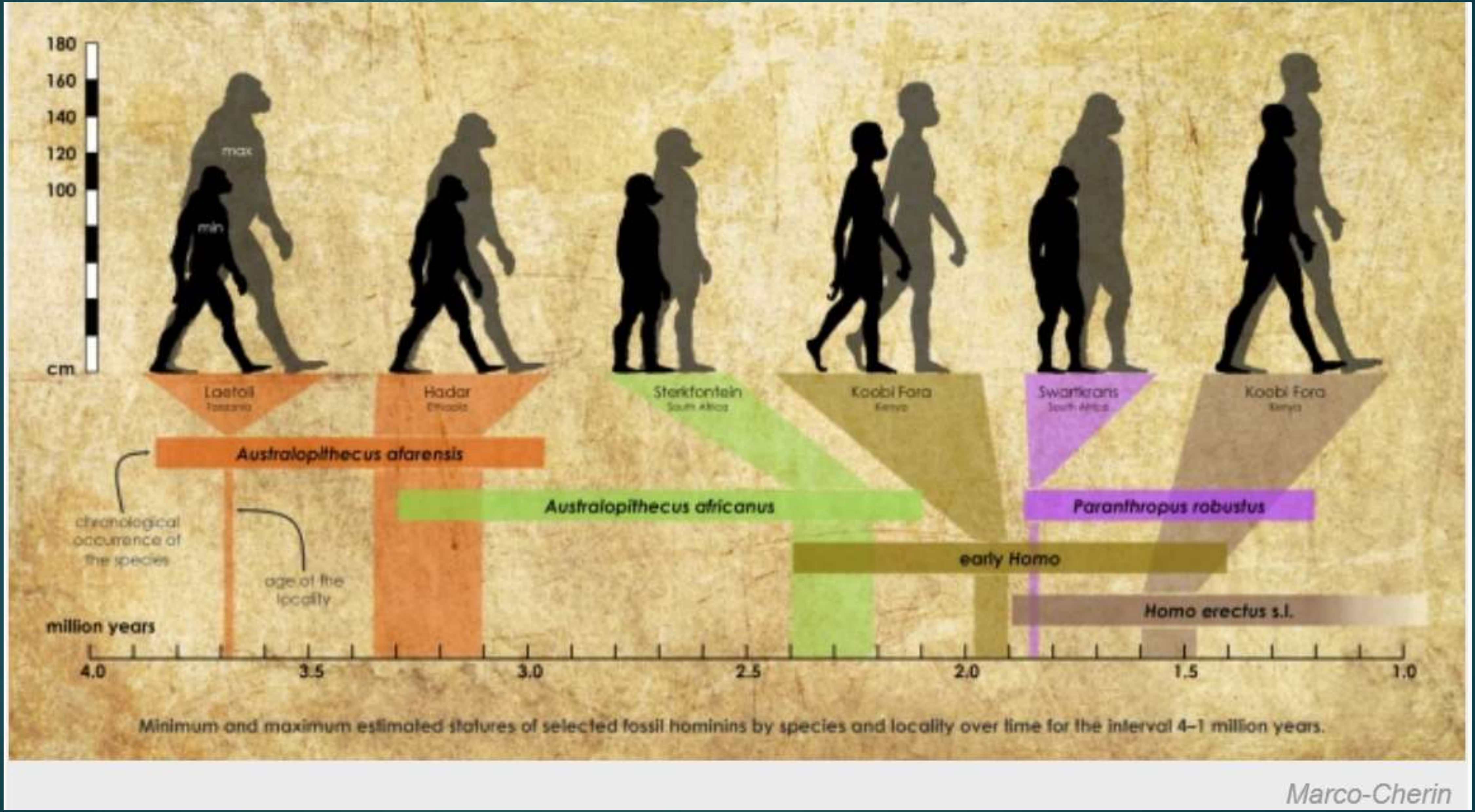
Fossilized footprints of a hominin, believed to be Australopithecus afarensis at the Laetoli site in northern Tanzania; 150 meters from original 1976 footprints. Laetoli, Tanzania; new footprints point to much greater variation in body size among early hominins than previously suspected

Giorgio Manzi, et al., 2016

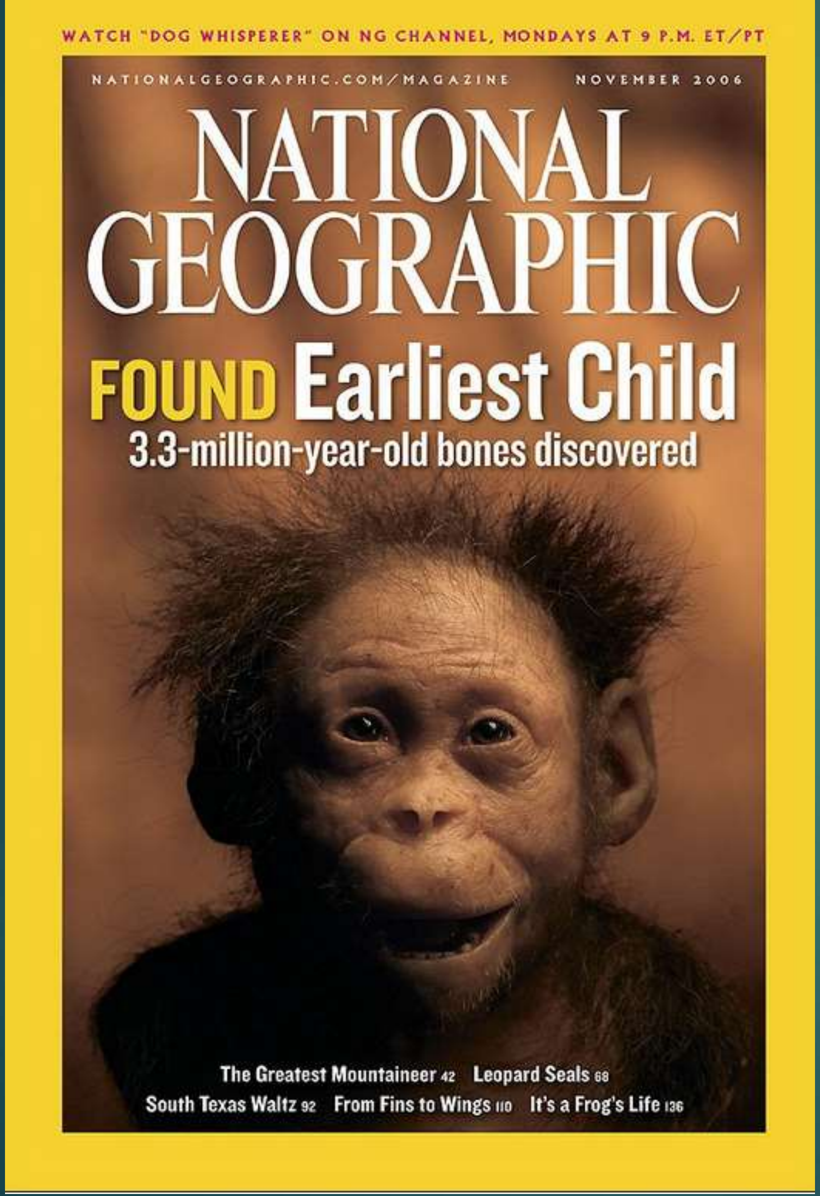
- Marco Cherin and his colleagues note that newfound footprints are in the same ash layer and orientation as the tracks found in 1978, suggesting both print sets are from the same group traveling across the landscape. According to Cherin, the newfound tracks were likely made within hours of the previously discovered prints.
- Since they see a marked size difference between the adult male and the females, the team says that *A. afarensis* may have socially mirrored modern-day gorillas—with multiple females sharing one male mate. In other words, Laetoli could be an ancient snapshot of a gorilla-like group on the move.
- William Harcourt-Smith & Lovejoy disagree; "The size variation they report has no bearing on sexual dimorphism, since we don't know the age of any of the footprint makers". New interpretation is "nuts."

Fidelis T Masao, et al., 2016

Tallest and smallest fossil hominins — by species — 1 to 4 MA.



Selam at Dikika

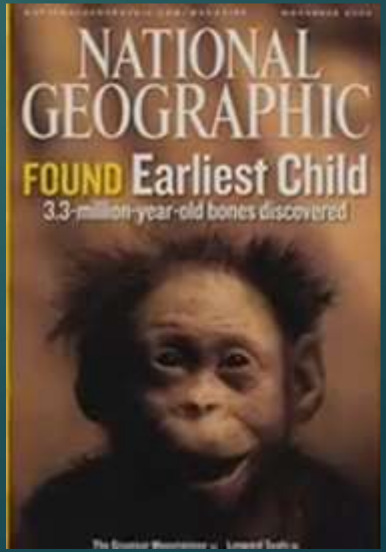


Selam and Zeresenay Alemseged

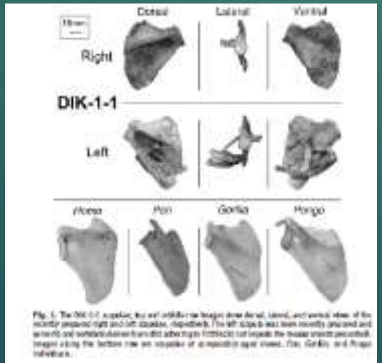
First sight

Zeresenay Alemseged (1969-): Dikika, A. afarensis child, Selam

- Ethiopian paleontologist; past curator and chair of anthropology at the California Academy of Sciences; now U of Chicago
- Director, Dikika Research Project (DRP), Afar, Ethiopia.
- 2006: at Dikika, Ethiopia, discovered an *Australopithecus afarensis* child (Selam), 3.3 M
- **Alemseged**, Z., Spoor, F., Kimbel, W.H., Bobe, R., Geraads, D., Reed, D., Wynn, J.G. A juvenile early hominin skeleton from Dikika, Ethiopia. Nature 443:296-301.



2006: *A. Afarensis*, Dikika, Selam



2011: Shoulders

Dikika Baby Girl, Selam

- Between 2000 and 2004 a paleoanthropological team led by Dr. Zeresenay Alemseged (once curator at CAS, now Univ. of Chicago) recovered the partial skeleton of a three-year-old *A. afarensis* girl in the Dikika area of Ethiopia. The fossil was named Selam ("peace" in Amharic).
- The skeleton consists of a virtually complete skull, the entire torso, and parts of the arms and legs. Even the kneecaps are preserved.
- Selam's age was estimated to be 3 yo; dated to 3.3 Ma. The skeleton represented the earliest and most complete juvenile hominin ever found— one that lived 150,000 years before Lucy. Earliest and most complete juvenile human ancestor ever found.
- Features of Selam's face identify her as *A. afarensis*.
- The apparent brain size hints that *A. afarensis* may have had delayed brain growth, a trait that is more characteristic of humans than chimps. The remains also include a hyoid bone—a bone that helps anchor the tongue and voice box. The size and shape of this bone suggests that Selam may have had a chimpanzee-like voice box.
- The tibia, femur, and foot demonstrate that she walked upright, even at the age of three. While the lower part of her body indicates bipedalism, with a very human-like heel, her upper body and the computerized imaging of her inner ear seem to indicate that she spent at least part of the time in trees.

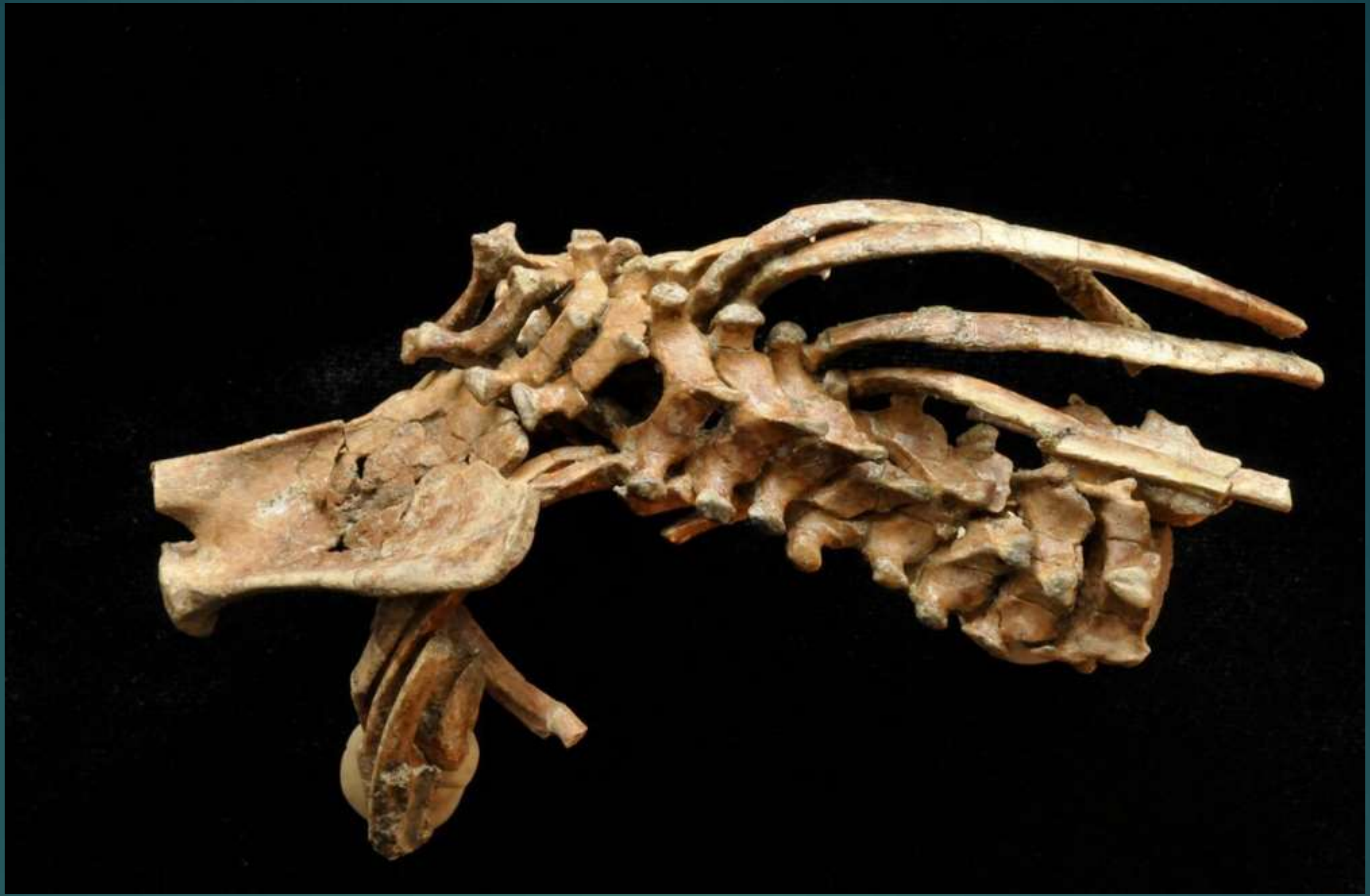
Selam: 3 yr old girl *A. afarensis,* 3.3 Ma, Hadar

- Earliest and most complete juvenile hominin ever found
- 60%: skull, the entire torso, and parts of the arms and legs; kneecaps are preserved.
- Ape-like scapula
- Human-like knees
- Finger bones partially curved; long arms
- Heel bone well-developed
- Endocast shows delayed brain growth (like us)
- Chimp-like hyoid bone
- Lower part of body indicates bipedalism; human-like heel; upper body & computerized imaging of inner ear indicate that she spent at least part of the time in trees.

Dikika

- 60 percent of a skeleton of a child dating back to 3.3 million years ago; Dikika child is an almost complete skeleton.
- One of the most startling findings comes from the toddler's spine, which had an adaptation for walking upright that had not been seen in such an old skeleton. Upper body was apelike, but whose pelvis, legs and feet had familiar, humanlike adaptations.
- The spinal column was humanlike in its numbering and segmentation. Selam's fossilized vertebrae is the only hard evidence of bipedal adaptations in an ancient hominin spine. Possessed the thoracic-to-lumbar joint transition found in other fossil human relatives, but they also showed that Selam had a smaller number of vertebrae and ribs than most apes have.

Selam's spine and ribs



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Selam, Dikika, Ethiopia: Can study development

Skull

Cervical spine

Hyoid bone is more bulbous like apes

Brain development in Australopithicines

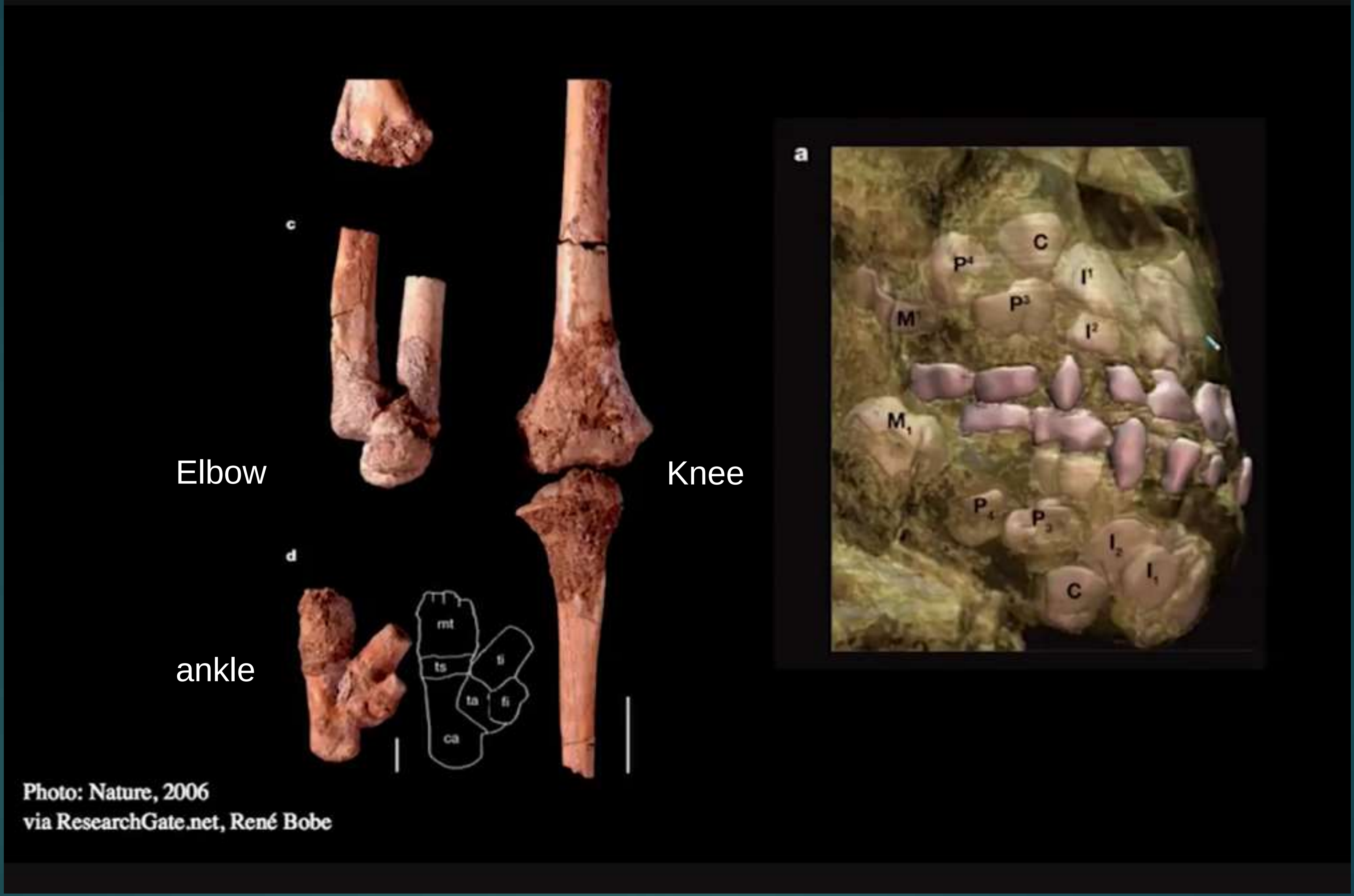
- Alemseged, *et al.* (2006) interpreted this as evidence of slower absolute brain growth that would have continued over a slightly longer period than in apes.
- The estimated age (~3 years) and endocranial volume (275-330 cc) of the Dikika 1-1 individual suggests that Australopithecus afarensis may have had slower brain growth than African apes.
- *A. afarensis* had a longer period of brain growth than in Apes in order to achieve a similar sized adult brain

Life history variables

- Life history variables are often inferred for fossil species from related variables such as body and brain mass, as well as **tooth eruption** ages.
- The age at which the first molar erupts closely predicts age at weaning across primate species, whereas third molar eruption age is highly correlated with age at first reproduction
- Humans are developmentally unique among living primates, weaning earlier and reproducing later than expected, creating a prolonged childhood
- A proportionately small brain at birth in a species with a very large adult brain typically requires more investment from the mother and/or other caregivers.
- Large adult brain sizes are achieved by high rates and/or long durations of brain development
- DeSilva & Lesnik (2008) recently showed that brain masses are good predictors of life history variables across taxa

Smith, T. M. & Alemseged, Z. (2013)
Reconstructing Hominin Life History. Nature Education Knowledge 4(4):2

Selam



Feet = Selam’s foot is more adapted to walking than climbing, but a grippy big toe that let it cling to its mom and climb tree trunks

Age from teeth: Selam was 3

Juvenile teeth already in; adult teeth above

Not same delayed maturation as humans; but Selam shows beginning of delay in development

Selam’s Left foot: DIK-1-1f

- Feet = Selam’s foot is more adapted to walking than climbing, but a grippy big toe that let it cling to its mom and climb tree trunks
- Selam's big-toe joint is even more curved than it is in adults of the species, which suggests that she had especially limber big toes well suited to grasping; the bone at the base of our big toe—called the medial cuneiform—has a connection for the big toe that is more curved and slightly more angled; curved surface would allow motion of that big toe—which modern apes use for grasping. She would have been able to climb, and to also grasp onto her mother during travel.
- the foot bones of adults don’t seem quite as ape-like; heel was much more delicate than the adult heel, which is similar to ours
- likely they spent the day foraging on foot and climbed into the trees to sleep
- evidence for habitual bipedality combined with some pedal grasping in the juvenile australopith

Adult toes & Selam’s foot

Jeremy M. DeSilva, et al., 2018

Did *Australopithecus afarensis* carve meat?

Evidence of Stone Tool Use and Meat-Eating in the Australopithecines:
Dikika cut bone at 3.3 MA

There were 12 marks on the two specimens

McPherron, S. P. et al. *Nature* no. 466, 2010, pp. 857-860

Dikika cut bone: tools at 3.3 MA

- *Nature* 2010 study by *Zeresenay Alemseged* reported bones exhibiting cut marks consistent with stone tools dating to 3.3 m years in the Lower Awash locality of Dikika, Ethiopia. This would have pushed back the age of stone tool use at that time by 800 Ky.
- Critics said that other factors, such as trampling by herbivores, could have been responsible for the observed damage to the bones.
- There were 12 marks on the two specimens -- a long bone from a creature the size of a medium antelope and a rib bone from an animal closer in size to a buffalo.
- Unambiguous association with *A. afarensis*, the only hominin of this period
- No hominin remains were found with the animal bone fragments that were uncovered 200 meters away from the site where Alemseged and a team discovered “Selam” (Lucy’s baby) in 2000.

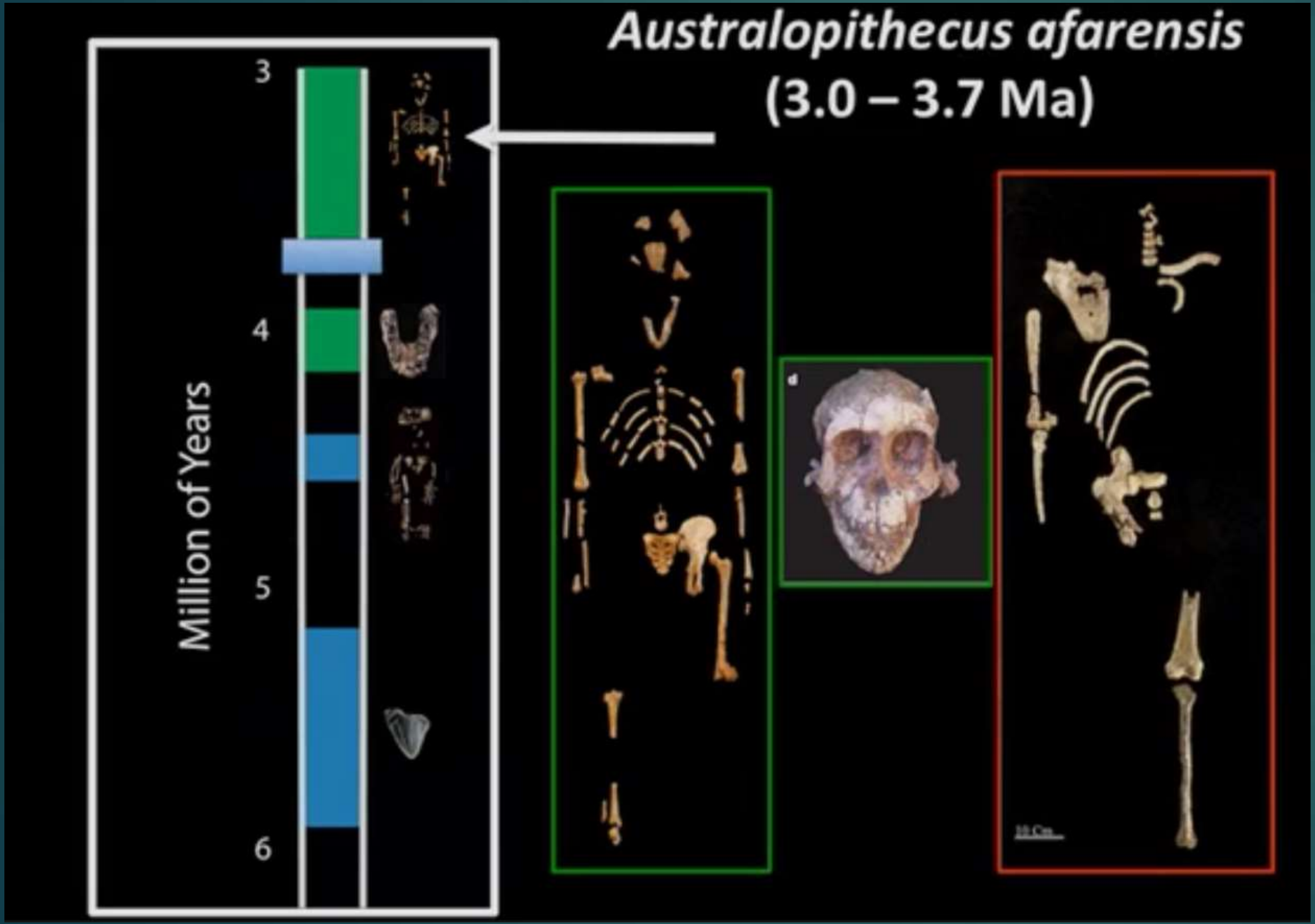
2015 studies confirms Zeray's butchery theory at 3.4 MA

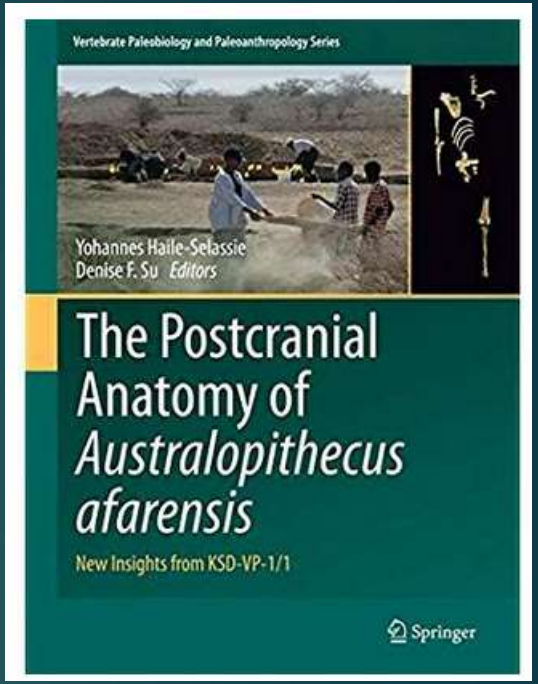
- Jessica Thompson: Zeresenay Alemseged was correct

- Analysis supports a previous finding, that the best match for the marks is butchery by stone tools (most closely resemble a combination of purposeful cutting and percussion marks, with tremendous force)
- Marks on two 3.4 million-year-old animal bones found at the site of Dikika, Ethiopia, were not caused by trampling, an extensive statistical analysis confirms.
- Extensive statistical analysis in The *Journal of Human Evolution;* which developed new methods of fieldwork and analysis: examined the surfaces of a sample of more than 4000 other bones from the same deposits. Investigated with microscopic scrutiny all non-hominin fossils collected from the Hadar Formation at Dikika
- "Our analysis shows with statistical certainty that the marks on the two bones in question were not caused by trampling," Thompson says. The surface modification data show that no marks on any other fossils resemble in size or shape those on the two specimens from DIK-55 that were interpreted to bear stone tool inflicted damage

Jessica C. Thompson, et al., 2015

3 partial skeletons





Lucy Selam Kadanuumuu 3.6 Ma

Australopithecus Kadanuumuu:

anatomically arranged elements of KSD-VP-1/1; Spatula below (B); similar to humans

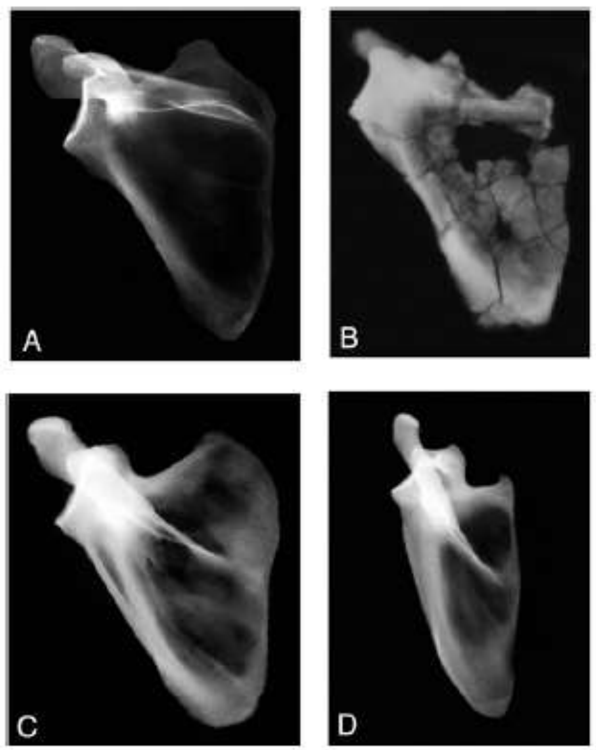


Fig. 3. X-rays of hominoid scapulas. (*A*) Modern human (CMNH-HTH-2450). (*B*) KSD-VP-1/1g. (*C*) *Gorilla* (CMNH-B-1730). (*D*) *Pan* (CMNH-B-3551). Each specimen has been scaled to the same approximate superoinferior glenoid height and aligned with its vertebral border approximately vertical. Note the uniqueness of *Pan* if a line is drawn connecting each specimen's superior and inferior angles (largely vertical in *D*). The human's glenoid angle is among the most superior in our sample (*n* = 21). All specimens, save *Pan*, have similar glenoid orientations. Both *Pan* and *Gorilla* are distinguished from the hominids by their substantially greater inferomedial spine orientation. KSD-VP-1/1g is most similar to humans. *Pan* is clearly the morphological outlier.

Yohannes Haile-Selassie et al. PNAS 2010;107:12121-12126

Australopithecus Kadanuumuu 3.6 Ma: Big Man

- Kadanuumuu ("Big Man" in the Afar language) is the nickname of KSD-VP-1/1. “Kadanuumuu” becomes the oldest *Australopithecus* afarensis skeleton yet found and is among the largest individuals of its species.
- It is a 3.58 Ma partial *Australopithecus afarensis* fossil discovered in the Afar Region of Ethiopia in 2005, by a team led by Yohannes Haile-Selassie.
- The fossil is believed to conclusively show that the species was fully bipedal.
- Height: 5’5”
- 400 Ka older than Lucy
- Renowned Ethiopian fossil hunter Alemayehu Asfaw found the first element of “Kadanuumuu” in February 2005 at Korsi Dora, about 210 air miles northeast of the Ethiopian capital Addis Ababa.. Excavations between 2005 and 2008 uncovered an upper arm, a collarbone, neck bones, ribs, pelvis, sacrum, a thighbone, a shinbone and the shoulder blade. Excavations took more than five years to complete.
- The scapula (part of the shoulder blade) provides no evidence of a history of suspension or vertical climbing.

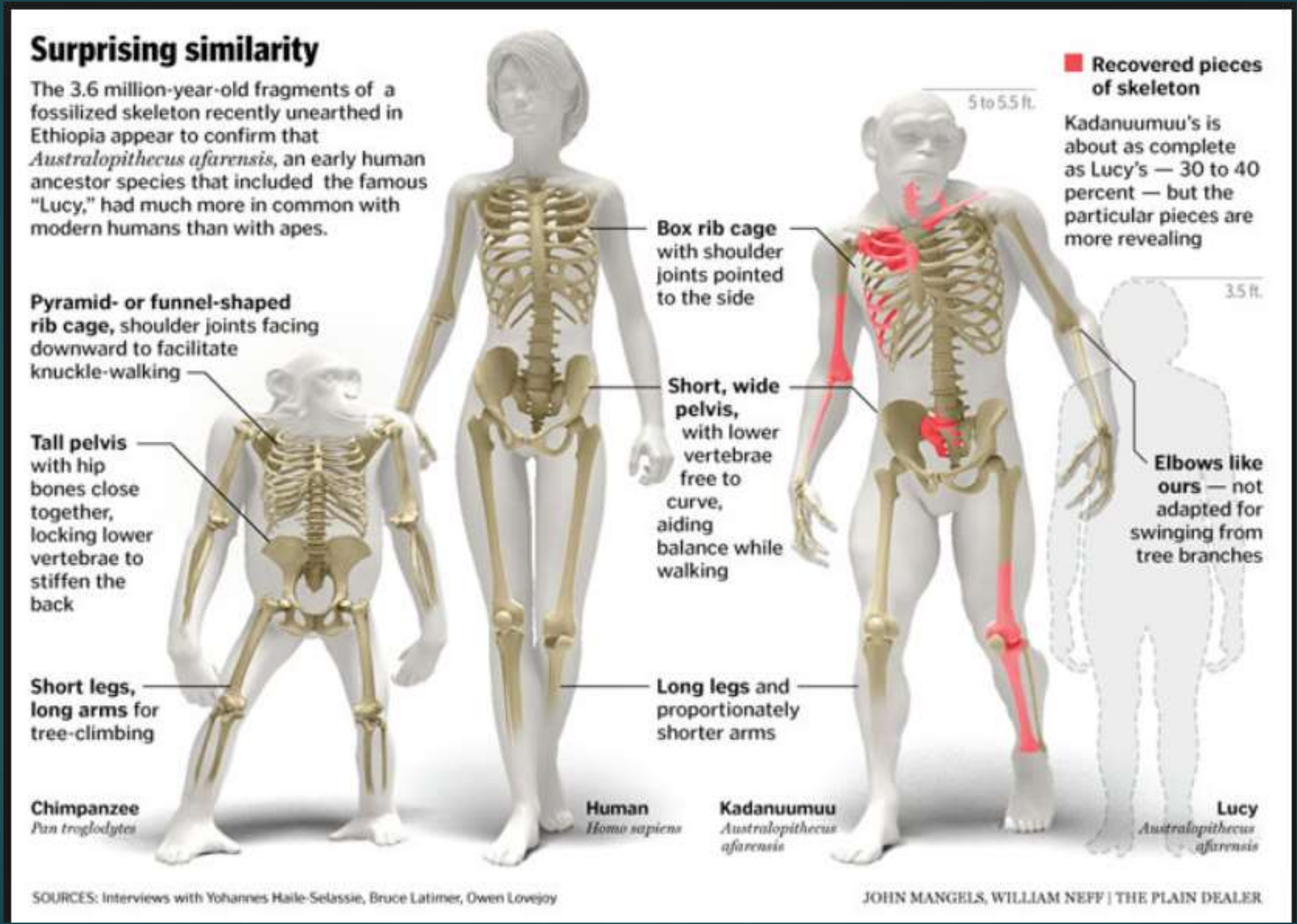
Yohannes Haile-Selassie, et al., 2010

Critique of Kadanuumuu

- Alemseged questions whether the new fossil indeed belongs to *A. afarensis.*

- The shoulder bone of Selam was more gorilla-like than human-like suggesting the <u>species still spent a major part of its time in trees</u>.

- A tree-dwelling lifestyle would have been useful to early species of Australopithecines, including *A. afarensis*, <u>for nesting and evading predators,</u>


Surprising similarity
The 3.6 million-year-old fragments of a fossilized skeleton recently unearthed in Ethiopia appear to confirm that *Australopithecus afarensis*, an early human ancestor species that included the famous "Lucy," had much more in common with modern humans than with apes.
Pyramid- or funnel-shaped rib cage, shoulder joints facing downward to facilitate knuckle-walking
Tall pelvis with hip bones close together, locking lower vertebrae to stiffen the back
Short legs, long arms for tree-climbing
Box rib cage with shoulder joints pointed to the side
Short, wide pelvis, with lower vertebrae free to curve, aiding balance while walking
Long legs and proportionately shorter arms
Recovered pieces of skeleton
5 to 5.5 ft.
Kadanuumuu's is about as complete as Lucy's — 30 to 40 percent — but the particular pieces are more revealing
3.5 ft.
Elbows like ours — not adapted for swinging from tree branches
Chimpanzee
Pan troglodytes
Human
Homo sapiens
Kadanuumuu
Australopithecus afarensis
Lucy
Australopithecus afarensis
SOURCES: Interviews with Yohannes Haile-Selassie, Bruce Latimer, Owen Lovejoy
JOHN MANGELS, WILLIAM NEFF | THE PLAIN DEALER

Lucy Had Neighbors

- A closer look at the currently available fossil evidence from Ethiopia, Kenya, and Chad indicate that *Australopithecus afarensis* was not the only hominin species during the middle Pliocene, and that there were other species clearly distinguishable from it by their locomotor adaptation and diet.
- Four identified hominin species that co-existed between 3.8 and 3.3 Ma during the middle Pliocene.
- "The question now is not whether *Australopithecus afarensis*, was the only potential human ancestor species that roamed in what is now the Afar region of Ethiopia during the middle Pliocene, but how these species are related to each other and exploited available resources."
- Scientists have long argued that there was only one pre-human species at any given time before 3 Ma that gave rise to another new species through time in a linear manner. This was what the fossil record appeared to indicate until the end of the 20th century.

Lucy Had Neighbors 2

- The discovery of *Australopithecus bahrelghazali* from Chad in 1995 and *Kenyanthropus platyops* from Kenya in 2001 challenged this idea.

- However, these two species were not widely accepted, rather considered as geographic variants of Lucy's species, *Australopithecus afarensis*.

- The discovery of the 3.4 Ma Burtele partial foot from the Woranso-Mille announced by Haile-Selassie in 2012 was the first conclusive evidence that another early human ancestor species lived alongside *Australopithecus afarensis*.

- In 2015, fossils recovered from Haile-Selassie's ongoing research site at the Woranso-Mille area of the Afar region of Ethiopia were assigned to the new species *Australopithecus deyiremeda*. However, the Burtele partial foot was not included in this species.

2016: Lucy fell from a tree and plunged 40 feet to her death?

- LUCY'S PLUNGE: Orthopedist concluded that damage to the 3.2-million-year-old partial skeleton suggests that Lucy plummeted to her death from high in a tree. That's a controversial conclusion.
- Bone breaks from head to ankle fit a scenario in which Lucy dropped the equivalent of least four to five stories, landing feet first before thrusting her arms out in an attempt to break her fall.
- Nonsense, responds Tim White of the University of California, Berkeley. He calls the new paper "a classic example of paleoanthropological storytelling being used as clickbait for a commercial journal eager for media coverage."
- Cracks and breaks throughout Lucy's skeleton occurred after her death, White asserts. Bone cracking was caused by fossilization and by pressure on fossils embedded in eroding sandstone.

John Kappelman, 2016

Early Savannah Bipedal Hominins

Superspecies: *Australopithecus africanus*
Species/Subspecies: *A. anamensis, A. afarensis, A. africanus, A. bahrelghazali*

General characteristics:

- are the early australopithecines.
- Although often described as gracile, these taxa are larger than chimpanzees, and mostly fall within the range of 45-60 kg.
- In absolute terms brain size is between 400 and 550 cc.

Early Savannah Bipedal Hominins 2

- General characteristics:
- Facultatively bipedal; in general terms these australopithecines have relatively long arms, short legs, and large guts and chests, suggesting a mixed locomotion/positional behaviors involving terrestrial and arboreal activities.
- Generally show a trend toward larger posterior teeth, with some anterior reduction. *Africanus* is often heavily megadontic. Tooth enamel is thick.
- On the basis of tooth morphology and wear, most of these are judged to have been frugivores, with elements of both coarser, lower-quality food and meat in the diet.
- Growth rates are apelike and rapid, with age of first reproduction probably similar to Pan.

Early Savannah Bipedal Hominins 3

General Characteristics:

- Probably sexually dimorphic
- These species are best considered geographical and time-transgressive (varying in age in different areas) variants on the theme of African apes, less specialized than the later australopithecines.

- Variation:
- *A. anamensis and A. afarensis* represent the earlier eastern forms, while *A. africanus and A. bahrelghazali* are slightly later southern and northwestern extensions of range and this allopatric species.
- They exhibit considerable body size variation within and between species (anamensis (47-55 kg), afarensis (27-45 kg), africanus (30-43 kg).
- Posterior tooth size and wear in *africanus* overlap with those of some later australopithecines.

South African Australopithecines

- *Australopithecus africanus*, *Paranthropus*, and *Australopithecus robustus*
- South African sites in very different geological context
- Not open landscapes but caves.
- Fossils cannot be dated reliably
- At all these southern African cave sites early hominin fossils are mixed in with other animal bones in hardened rock and bone-laden cave fillings, or breccias.
- Most dated by comparing remains of mammals (pig molars) found in caves with fossils found at better-dated sites in East Africa
- The ages of the *A. africanus*-bearing breccias are estimated to be between 2.4 and 3 MA.

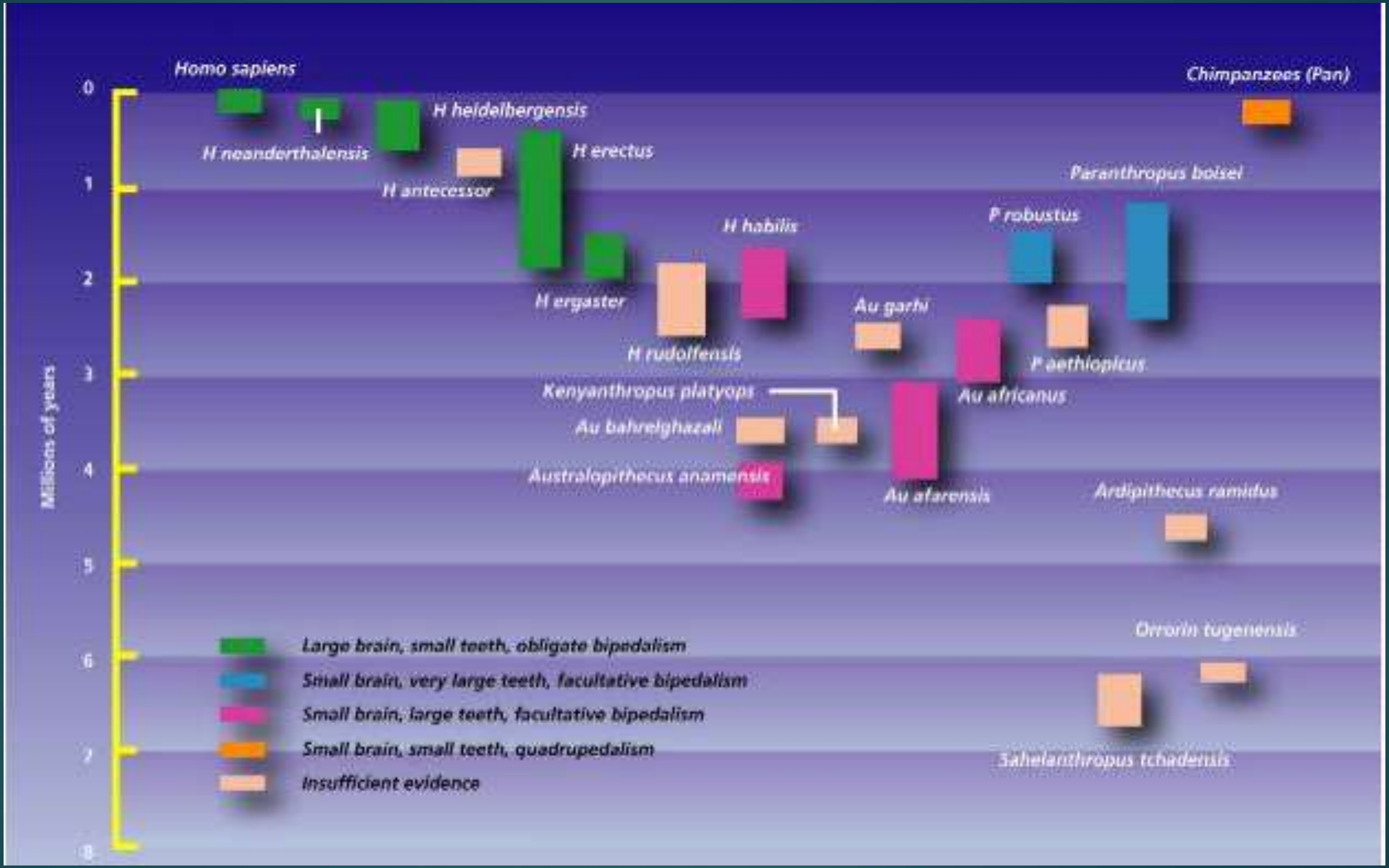
S. Africa breccia

East African Australopithecines

- East Africa: *A. afarensis, A. anamensis, A. bahrelghazali, A. garhi*

- Sites on the open landscape. Not necessarily places where hominins lived or camped; simply places where one or more hominin bones had accumulated. Maybe transported there by rainstorm runoff or was close to food cache or lair of a predator.

- Most sites dated by isotope-dating methods of volcanic ash either in same horizon as fossil evidence is likely to have come from or in layers above and below fossil-rich layer


Homo sapiens
Chimpanzees (Pan)
H heidelbergensis
H neanderthalensis
H erectus
H antecessor
Paranthropus boisei
P robustus
H habilis
H ergaster
Au garhi
H rudolfensis
P aethiopicus
Kenyanthropus platyops
Au africanus
Au bahrelghazali
Australopithecus anamensis
Au afarensis
Ardipithecus ramidus
Orrorin tugenensis
Sahelanthropus tchadensis
Millions of years
0
1
2
3
4
5
6
7
8
Large brain, small teeth, obligate bipedalism
Small brain, very large teeth, facultative bipedalism
Small brain, large teeth, facultative bipedalism
Small brain, small teeth, quadrupedalism
Insufficient evidence

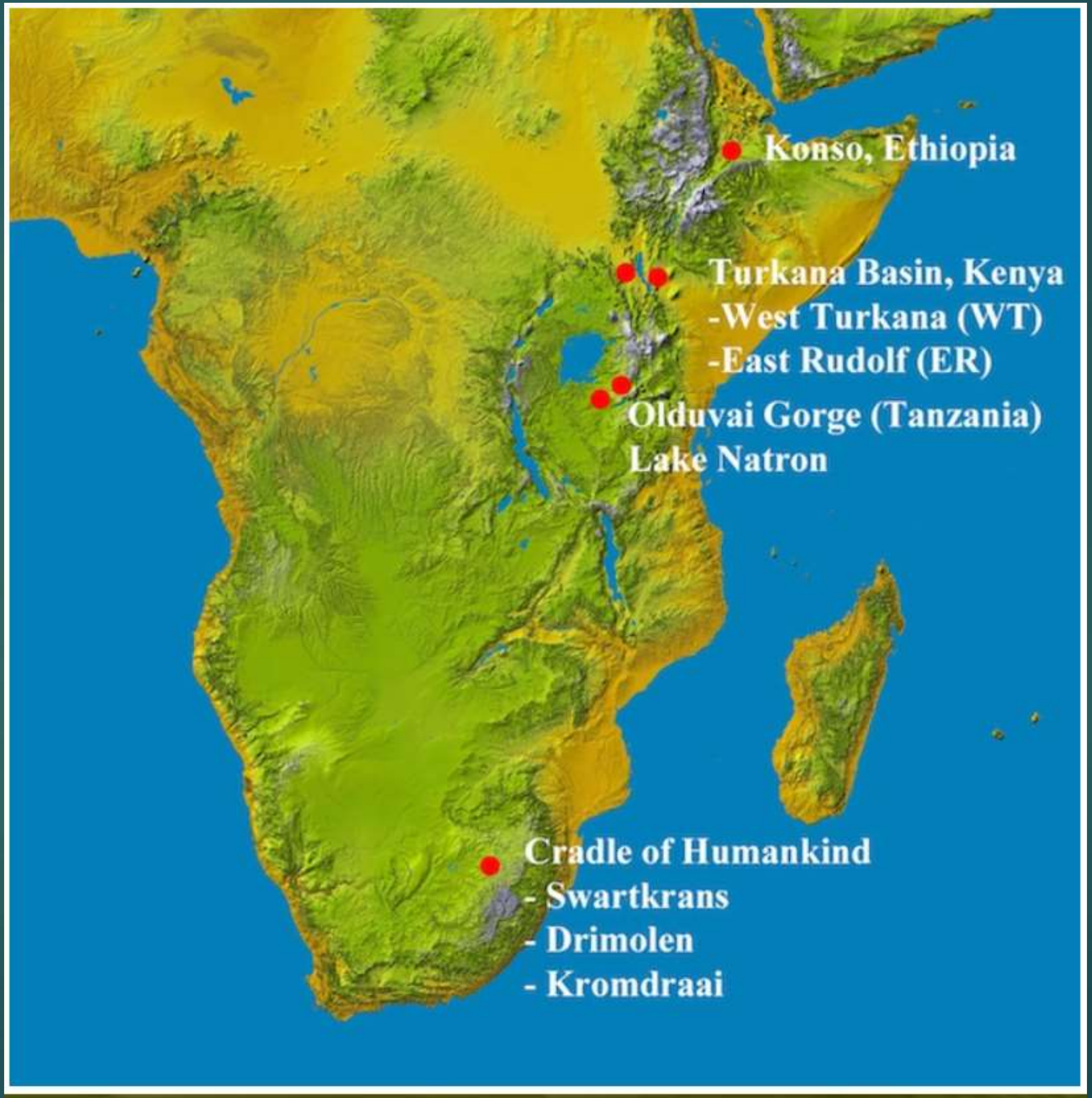
Robust Australopithecine Major Fossil Localities (~2.5-1.2 MA)

- Robust australopithecines persisted from at least 2 ½ Ma to 1.2 Ma
- Dietary changes
- Robust mastication
- Huge jaws
- Megadontic

- Side branch

- Evolutionary focus: robust dentition

- Lesson: hominin variation



Later Australopithecines

Gracile Australopithecines

Australopithecus gahri
Australopithecus africanus
Australopithecus sediba

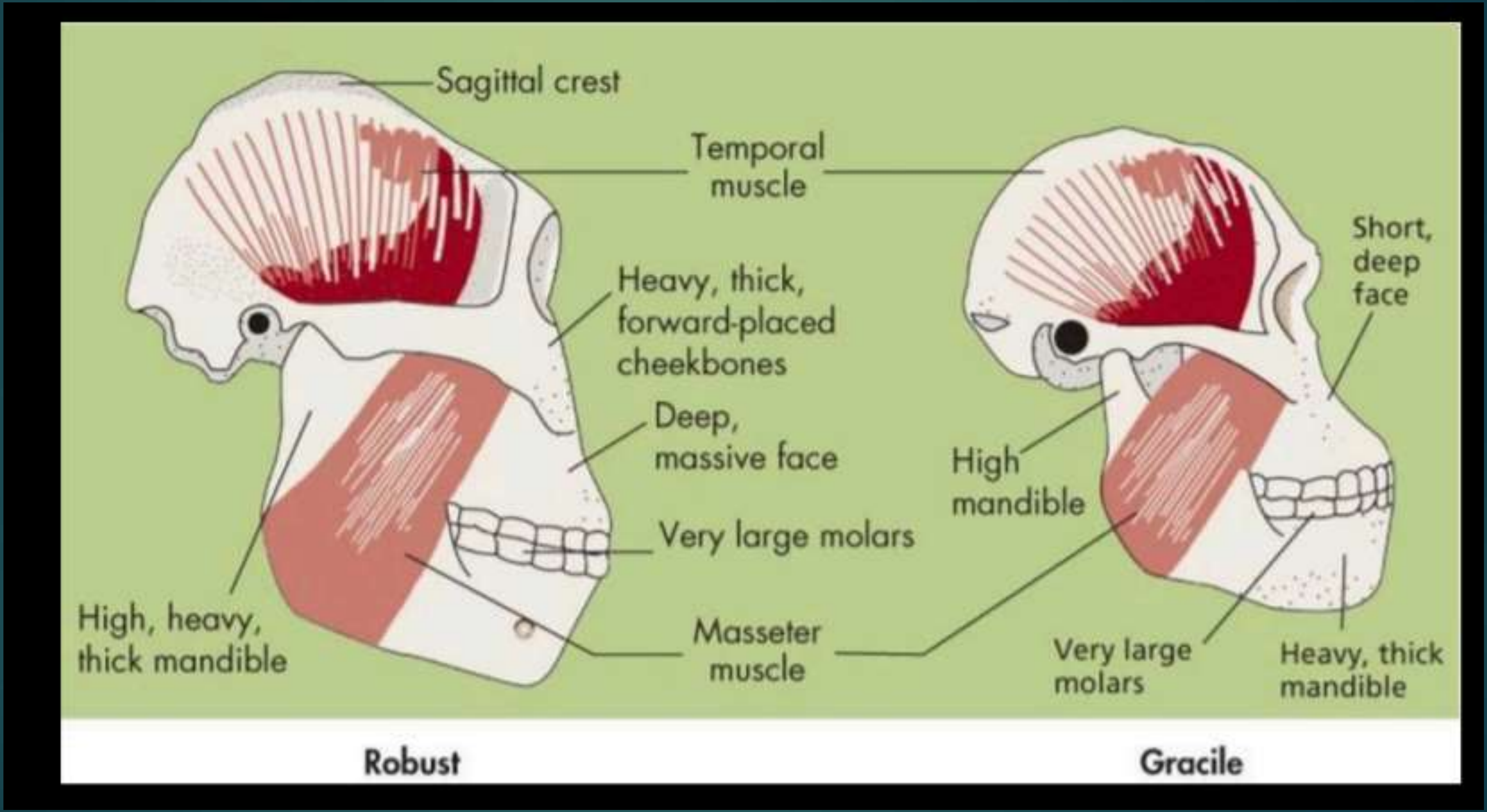
Robust Australopithecines

Australopithecus aethiopicus
Australopithecus boisei
Australopithecus robustus

Contemporaneous Hominins by Region

Age (Ma)	North Africa	West Africa	East Africa	South Africa	Asia	Europe
~6		*Sahelanthropus*	*Orrorin*			
~5						
~4.5			*Ardipithecus*			
3.9			*A. afarensis,* *A. anamensis*			
3.5		*A. bahrelghazali*	*A. afarensis,* *K. platyops*	*A. africanus*		
2.5			*A. garhi,* *A. aethiopicus*	*A. africanus*		
2.5-2			*P. boisei, A. garhi*	*A. africanus,* *P. robustus*	H. erectus	
1.5-1			*P. boisei,* *Homo sp.*	*Homo sp.,* *P. robustus*	H. erectus	
1 - .5					H. erectus	*H. heidelbergensis*
.5						*H. Neanderthalensis* Denisovans, Hobbits
.3-.03	*H. sapiens*		*H. sapiens*	*H. naledi*		same

Robust and Gracile



Gracile Australopithecines

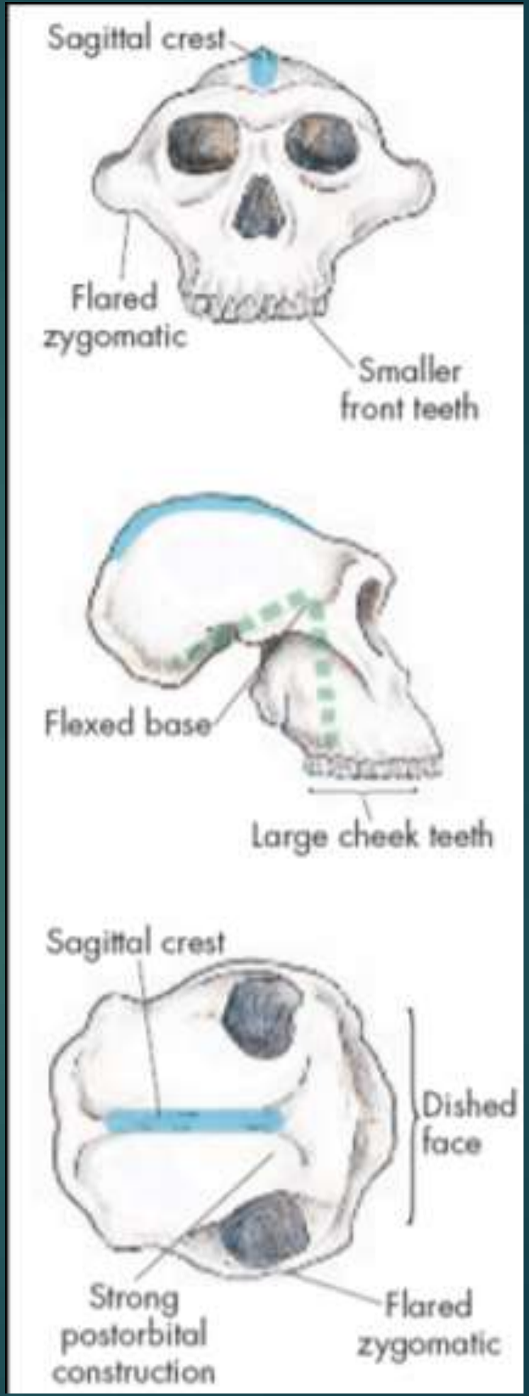
- Gracile: *A. africanus, A. afarensis, A. garhi, A. sediba, A. anamensis*
- 3.5 - <2.0 MA
- Slight brain size increase
- Rounded Vault
- No crests
- Less projecting face

Gracile Australopithecines

- *Australopithecus afarensis*
- *Australopithecus africanus (first found)*
- *Australopithecus anamensis*
- *Australopithecus garhi*

The Robust Australopithecines

- Robust, only cranially
- Aka Paranthropus
- Fibrous plants, hard object feeding
- Sagittal crest
- Large cheek teeth
- Flared zygomatic arch
- Dished face
- Extreme postorbital constriction
- Woodland and open woodland habitat



Robust Australopithicines (*Paranthropus*)

- ***Paranthropus*** (from Greek παρα, *para* "beside"; άνθρωπος, *ánthropos* "human")

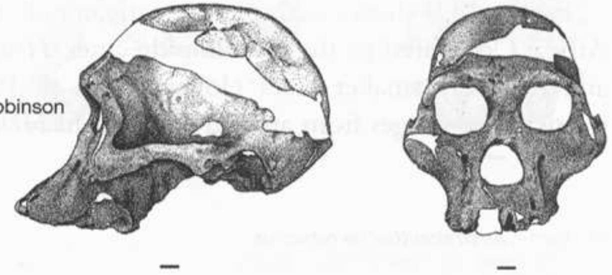
- *Australopithecus robustus = Paranthropus robustus*
- *Australopithecus boisei = Paranthropus boisei*
- *Australopithecus aethiopicus = Paranthropus aethiopicus*

- The emergence of the robusts could be either a display of divergent or convergent evolution.
- There is currently no consensus in the scientific community whether *P. aethiopicus, P. boisei* and *P. robustus* should be placed into a distinct genus.
- *Australopithecus robustus* and *Paranthropus robustus* are used interchangeably for the same specimens; Robert Broom & Bernard Wood believe they are different genera.

Gracile Australopithecines

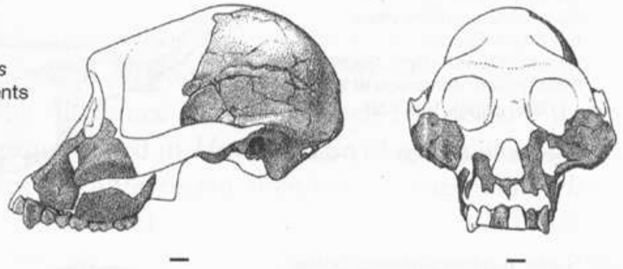
(a) Name: **Australopithecus africanus**
Specimen: Sts 5
Age: 2.5 million years
Found by: Robert Broom and John T. Robinson
Location: Sterkfontein, South Africa
Color photo: Johanson et al.
(1996) pages 3; 135

Species Time Range: ~2.4–2.8 Ma



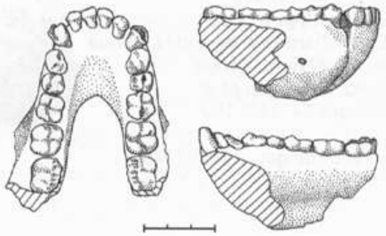
(b) Name: **Australopithecus afarensis**
Also known as: *Praeanthropus africanus*
Specimen: Reconstruction from fragments
Color photo of same species:
Johanson et al. (1996) page 129

Species Time Range: ~3.0–3.9 Ma



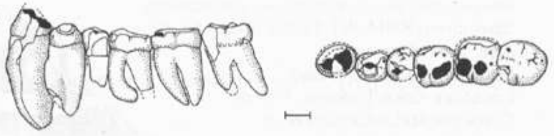
(c) Name: **Australopithecus anamensis**
Specimen: KNM-KP 29281
Age: 4.1 million years
Found by: Peter Nzube
Location: Kanapoi, Kenya
Color photo:
Johanson et al. (1996) page 123

Species Time Range: ~3.9–4.2 Ma



(d) Name: **Ardipithecus ramidus**
Originally named as: *Australopithecus ramidus*
Specimen: ARA-VP-1/128
Age: 4.4 million years
Found by: T. Assebework
Location: Aramis, Ethiopia
Color photo of same species:
Johanson et al. (1996) page 116

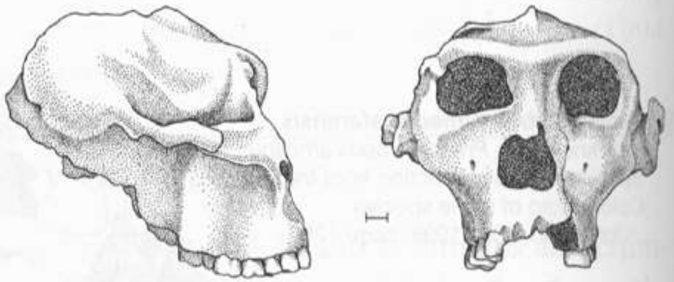
Species Time Range: ~4.4 Ma



Robust Australopithecines *Paranthropus*

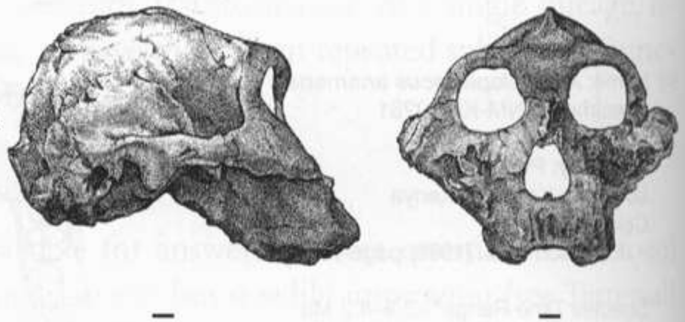
(a) Name: **Australopithecus robustus**
Also known as: *Paranthropus robustus*
Specimen: SK 48
Age: 1.5–2.0 million years
Found by: Fourie
Location: Swartkrans, South Africa
Color photo: Johanson et al.
(1996) pages 108; 150

Species Time Range: ~1.0–2.0 Ma



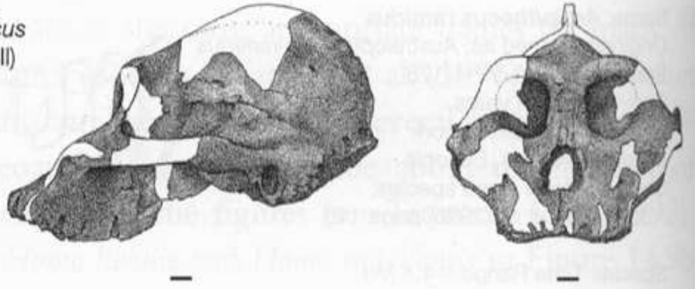
(b) Name: **Australopithecus boisei**
Also known as: *Paranthropus boisei*
Specimen: KNM-ER 406
Age: 1.7 million years
Found by: Richard Leakey and H. Mutua
Location: Koobi Fora, Kenya
Color photo: Johanson et al.
(1996) pages 54; 159; 160

Species Time Range: ~1.4–2.3 Ma



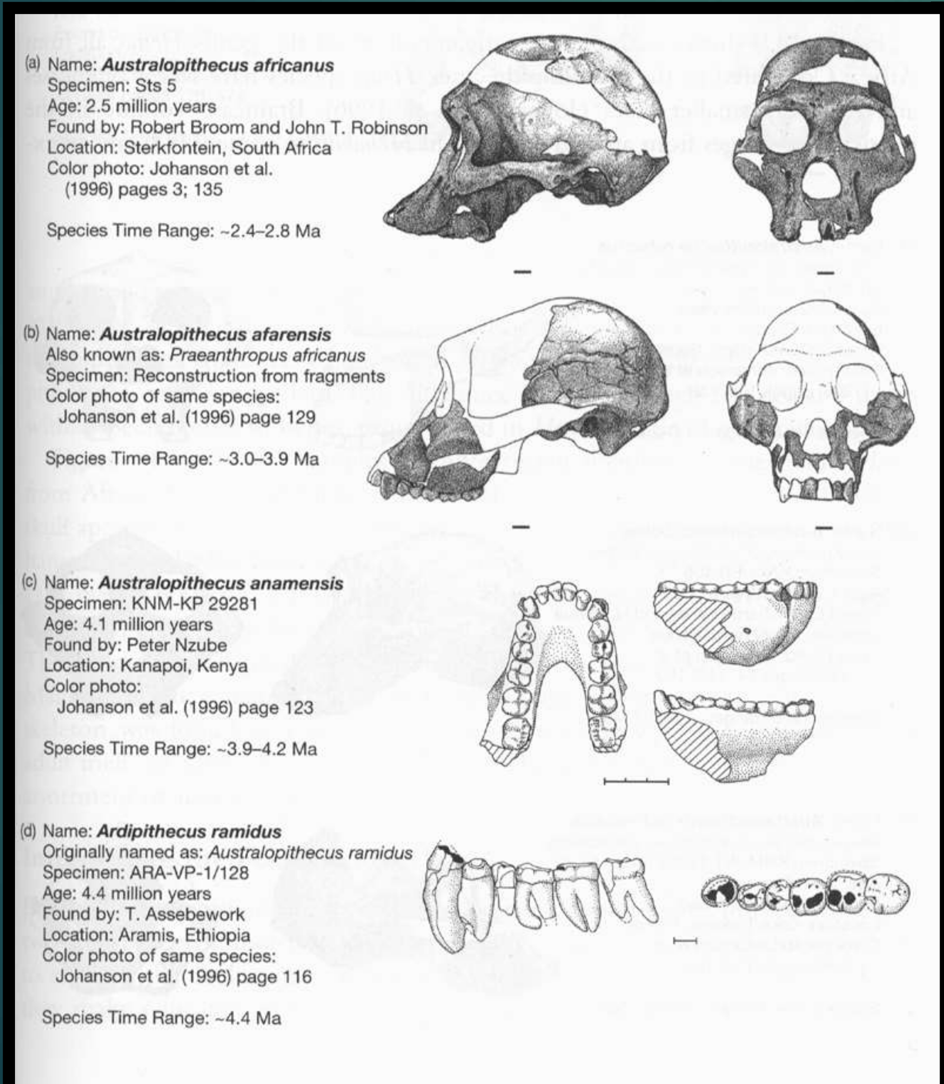
(c) Name: **Australopithecus aethiopicus**
Also known as: *Paranthropus aethiopicus*
Specimen: KNM-WT 17000 (Black Skull)
Age: 2.5 million years
Found by: Alan C. Walker
Location: Lake Turkana, Kenya
Color photo: Johanson et al.
(1996) pages 153; 154

Species Time Range: ~1.9–2.7 Ma



Gracile Australopithecines

Archaic *Homo*



(a) Name: ***Australopithecus africanus***
Specimen: Sts 5
Age: 2.5 million years
Found by: Robert Broom and John T. Robinson
Location: Sterkfontein, South Africa
Color photo: Johanson et al. (1996) pages 3; 135

Species Time Range: ~2.4–2.8 Ma

(b) Name: ***Australopithecus afarensis***
Also known as: *Praeanthropus africanus*
Specimen: Reconstruction from fragments
Color photo of same species: Johanson et al. (1996) page 129

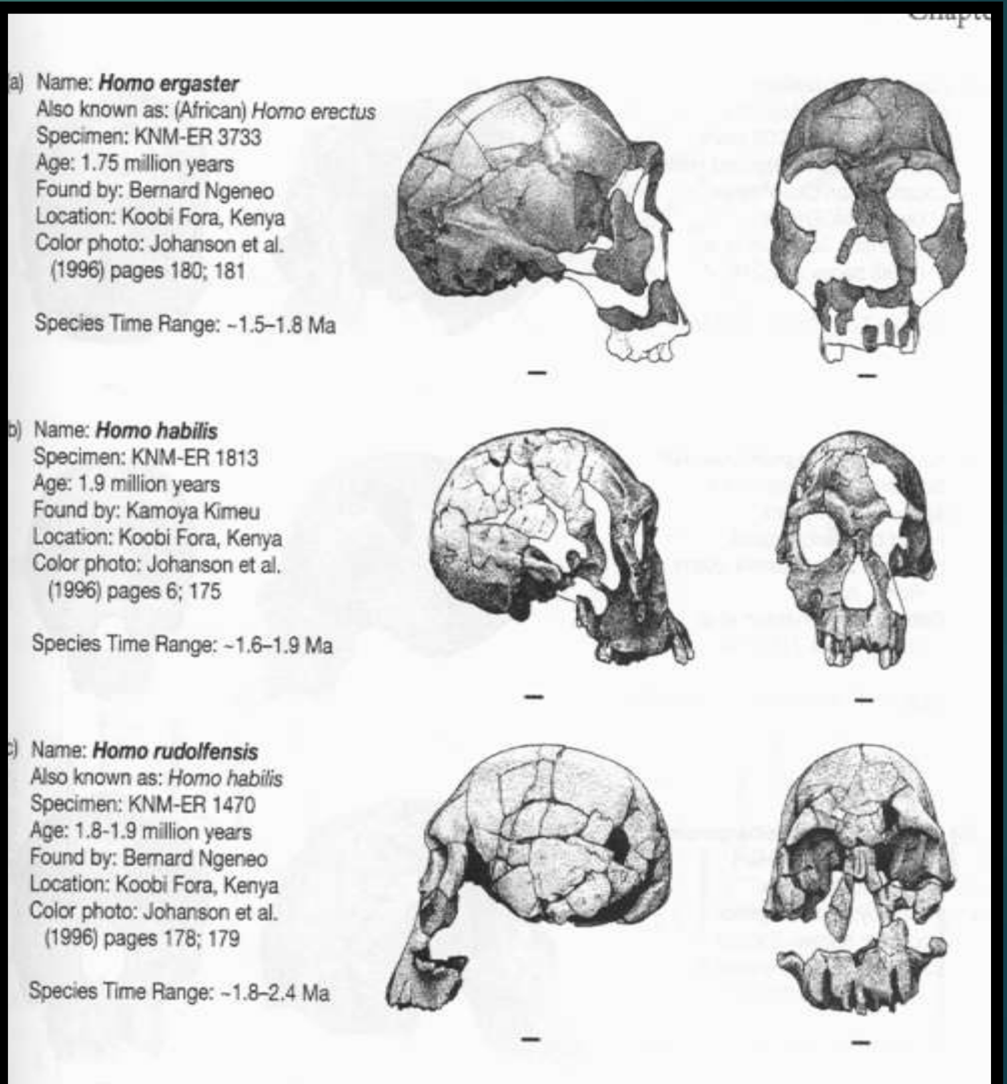
Species Time Range: ~3.0–3.9 Ma

(c) Name: ***Australopithecus anamensis***
Specimen: KNM-KP 29281
Age: 4.1 million years
Found by: Peter Nzube
Location: Kanapoi, Kenya
Color photo: Johanson et al. (1996) page 123

Species Time Range: ~3.9–4.2 Ma

(d) Name: ***Ardipithecus ramidus***
Originally named as: *Australopithecus ramidus*
Specimen: ARA-VP-1/128
Age: 4.4 million years
Found by: T. Assebework
Location: Aramis, Ethiopia
Color photo of same species: Johanson et al. (1996) page 116

Species Time Range: ~4.4 Ma



(a) Name: ***Homo ergaster***
Also known as: (African) *Homo erectus*
Specimen: KNM-ER 3733
Age: 1.75 million years
Found by: Bernard Ngeneo
Location: Koobi Fora, Kenya
Color photo: Johanson et al. (1996) pages 180; 181

Species Time Range: ~1.5–1.8 Ma

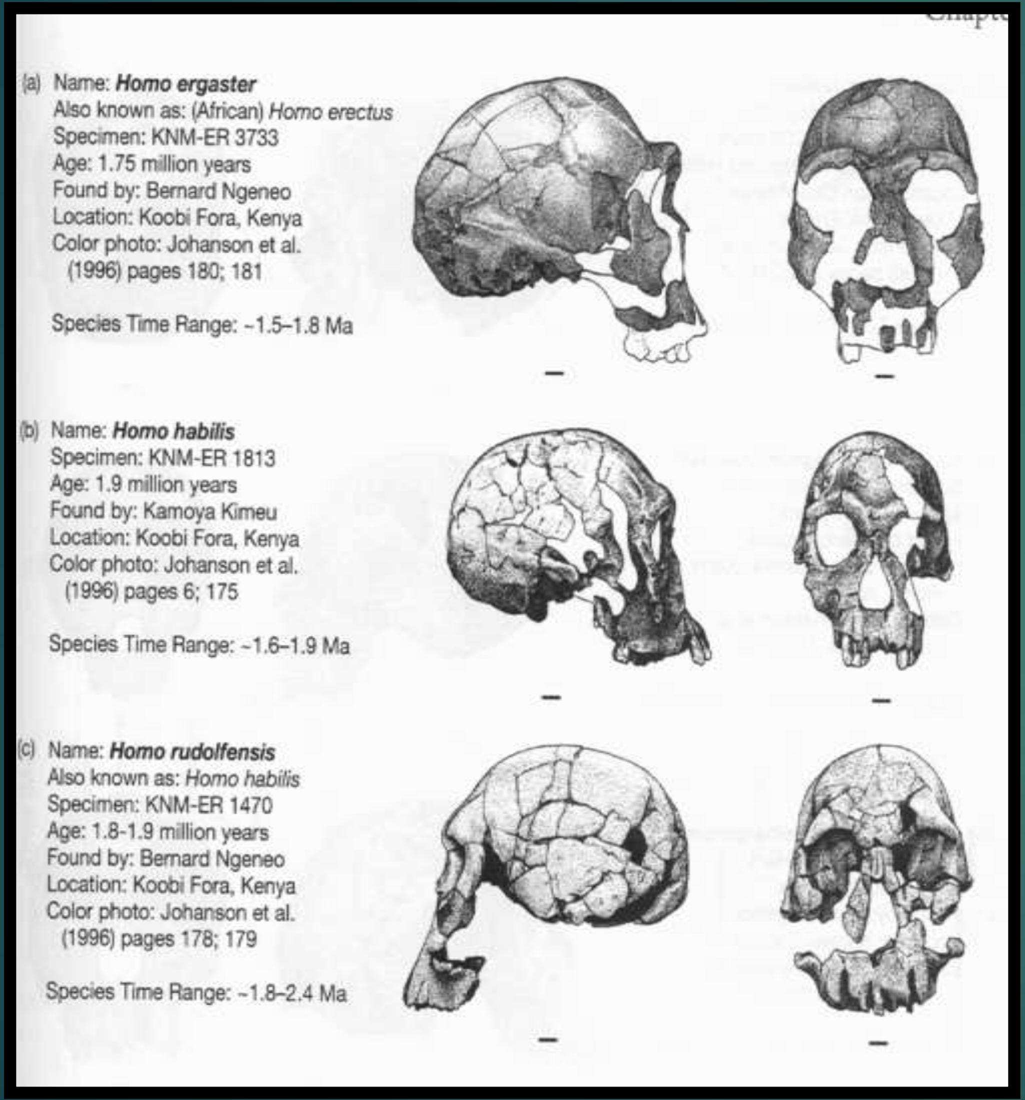
(b) Name: ***Homo habilis***
Specimen: KNM-ER 1813
Age: 1.9 million years
Found by: Kamoya Kimeu
Location: Koobi Fora, Kenya
Color photo: Johanson et al. (1996) pages 6; 175

Species Time Range: ~1.6–1.9 Ma

(c) Name: ***Homo rudolfensis***
Also known as: *Homo habilis*
Specimen: KNM-ER 1470
Age: 1.8-1.9 million years
Found by: Bernard Ngeneo
Location: Koobi Fora, Kenya
Color photo: Johanson et al. (1996) pages 178; 179

Species Time Range: ~1.8–2.4 Ma

Archaic *Homo*



(a) Name: ***Homo ergaster***
Also known as: (African) *Homo erectus*
Specimen: KNM-ER 3733
Age: 1.75 million years
Found by: Bernard Ngeneo
Location: Koobi Fora, Kenya
Color photo: Johanson et al. (1996) pages 180; 181

Species Time Range: ~1.5–1.8 Ma

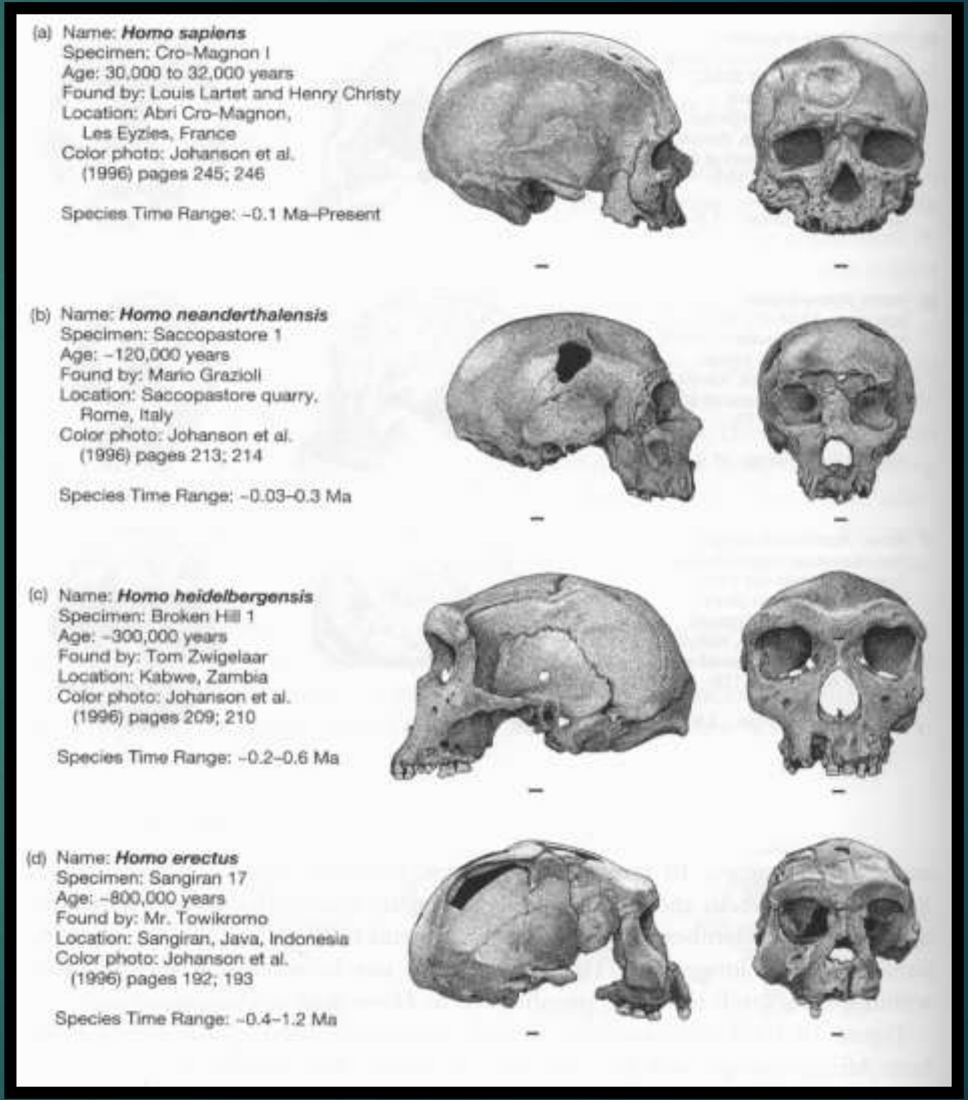
(b) Name: ***Homo habilis***
Specimen: KNM-ER 1813
Age: 1.9 million years
Found by: Kamoya Kimeu
Location: Koobi Fora, Kenya
Color photo: Johanson et al. (1996) pages 6; 175

Species Time Range: ~1.6–1.9 Ma

(c) Name: ***Homo rudolfensis***
Also known as: *Homo habilis*
Specimen: KNM-ER 1470
Age: 1.8-1.9 million years
Found by: Bernard Ngeneo
Location: Koobi Fora, Kenya
Color photo: Johanson et al. (1996) pages 178; 179

Species Time Range: ~1.8–2.4 Ma

Modern *Homo*



(a) Name: ***Homo sapiens***
Specimen: Cro-Magnon I
Age: 30,000 to 32,000 years
Found by: Louis Lartet and Henry Christy
Location: Abri Cro-Magnon, Les Eyzies, France
Color photo: Johanson et al. (1996) pages 245; 246

Species Time Range: ~0.1 Ma–Present

(b) Name: ***Homo neanderthalensis***
Specimen: Saccopastore 1
Age: ~120,000 years
Found by: Mario Grazioli
Location: Saccopastore quarry, Rome, Italy
Color photo: Johanson et al. (1996) pages 213; 214

Species Time Range: ~0.03–0.3 Ma

(c) Name: ***Homo heidelbergensis***
Specimen: Broken Hill 1
Age: ~300,000 years
Found by: Tom Zwigelaar
Location: Kabwe, Zambia
Color photo: Johanson et al. (1996) pages 209; 210

Species Time Range: ~0.2–0.6 Ma

(d) Name: ***Homo erectus***
Specimen: Sangiran 17
Age: ~800,000 years
Found by: Mr. Towikromo
Location: Sangiran, Java, Indonesia
Color photo: Johanson et al. (1996) pages 192; 193

Species Time Range: ~0.4–1.2 Ma

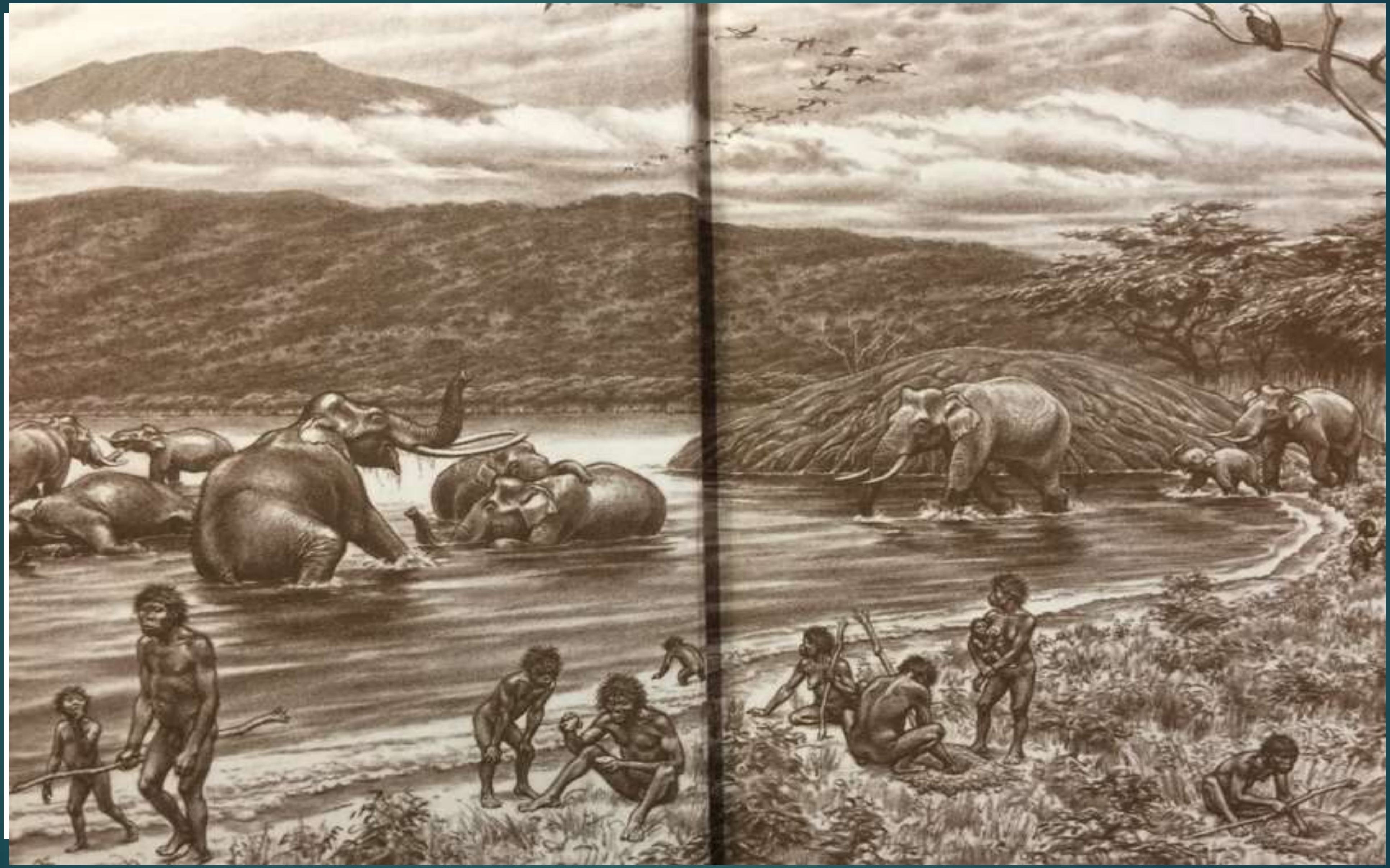
Gracile vs robust australopithecines

- Gracile: *A. afarensis*; "Lucy"
- Robust: *Paranthropus* - larger mastication apparatus

- ***"Robust" australopithecines*: *Paranthropus aethiopicus*, *robustus* & *boisei***
- Known as robust australopithecines because their skulls are more heavily built and because they had huge, broad cheek teeth with thick enamel.
- It is now known that 'robust' refers solely to tooth and face size, not to the body size of robust australopithecines.
- They have never been serious candidates for being direct human ancestors

Home of Robust & Gracile Australopithecines: South Africa's 5 Caves: Lots of species names

- Taung: *Australopithecus africanus* - Dart
- Sterkfontein: *Plesanthropus transvaalensis (A. africanus)* - Broom
- Makapansgat: *Australopithecus prometheus* – Dart (fire in cave)
- Three older caves above = gracile fossils, 2 younger below = robust fossils
- Kromdraai: *Paranthropus robustus* - Broom
- Swartkrans: *Paranthropus crassidens (robustus)*



Early Man by F. Clark Howell

Later Savannah Bipedal Hominins

Superspecies: *Australopithecus (Paranthropus) robustus*
Species/subspecies: *P. robustus (A. crassidens), A. aethiopicus, P. boisei*

General characteristics:

- These are the so-called robust australopithecines or paranthropines.
- Their robustness is largely cranial, although they do tend to be slightly larger than the earlier forms
- Overall body size ranges from around 40 kg to over 80 kg, with an average around 50.
- There is some increase in brain size compared to other australopithecines
- They have megadontic posterior dentition, with thick tooth enamel and highly reduced anterior dentition.
- All teeth show the effects of heavy wear and chewing, and have flat occlusal surface.

Later Savannah Bipedal Hominins 2

- Tooth wear and morphology indicate very coarse, fibrous plant foods, probably high in grit and fiber; occasional, fallback harder food

- Theses species are sexually dimorphic across all taxa where known.

- Variation:
- The robust australopithecines are all variants on a theme.
- *Boisei* is the most extreme in its megadonty while the older *aethiopicus* possesses the smallest brain (410 cc) and a projecting face.
- They may represent convergent evolutionary trends.

Australopithecus africanus

Raymond Dart (1893-1988):

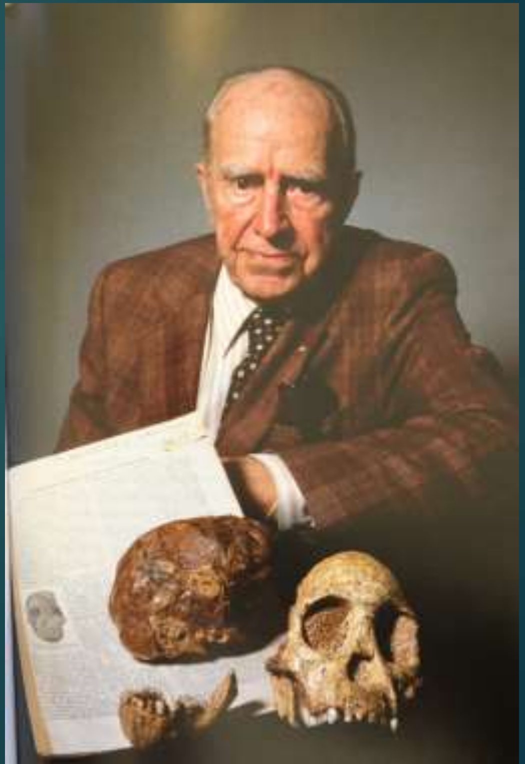
Taung Child: Bipedalism, not large brain, came first

- Australian South African anatomist
- Professor of anatomy at Univ. of Witwatersrand

- 1924: Taung child's cranium is the first African early hominin; changed course of human paleontology with this discovery of the first *Australopithecus africanus,* an erect walking ape

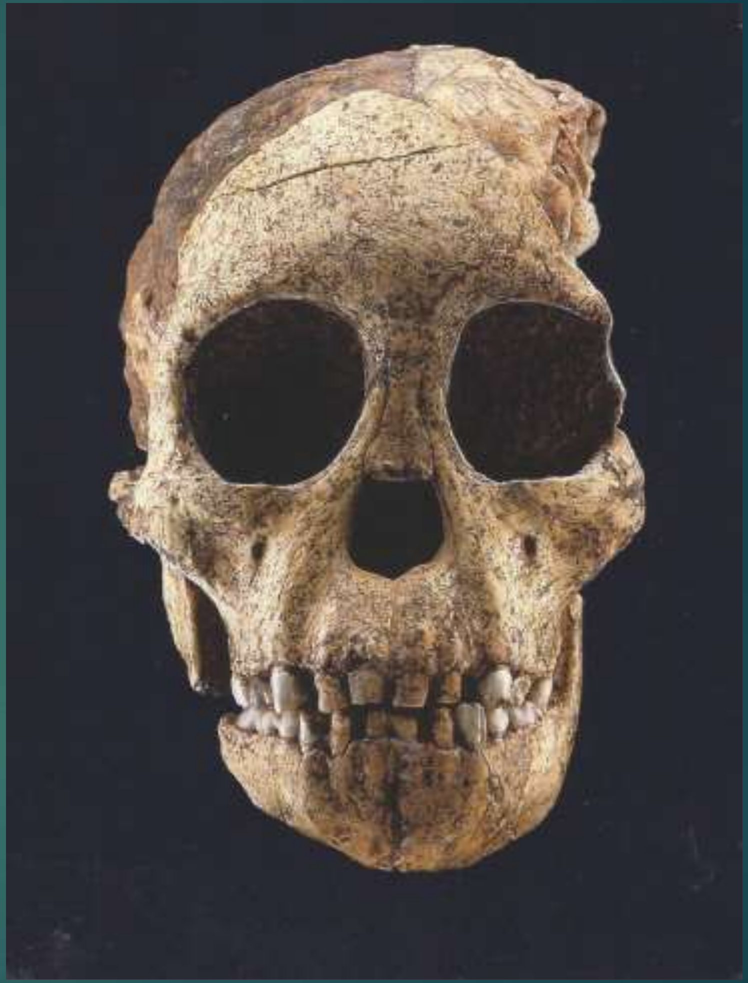
- 1925, Nature article: Dart made the Taung cranium the type specimen of *A. africanus*

- 1931: Wife Dora left Taung fossil in back of taxi cab (for 2 days; police thought they had a murder case). Returned to Dart.
- Interpretation of fossil as human ancestor largely rejected by the British scholars for 30 years



1924: First *Australopithecus africanus*, Taung Child, 2.8 Ma; 3.3 years old, bipedal, 440 cc, First brain endocast to be discovered

Australopithecus africanus (Taung Child; type)
Discoverer: M. de Bruyn, Robert Dart
Date: 1924
Locality: Taung, S. Africa
Age 2.8 M



Taung child

- Small cave exposed during mining at Buxton Limeworks at Taung, S. Africa
- Delivered in box on wedding day of friend
- Used his wife's sharpened darning needles, spent 6 months to expose face from rock
- Hominin conclusion based on lack of large canines and location of foramen magnum, called new fossil *Australopithecus africanus* (southern ape of Africa)
- Interpretation of fossil as human ancestor largely rejected by the British scholars for decades (Arthur Keith , Grafton Elliot Smith, & Arthur Smith Woodward) – partially because of Piltdown man; Only initial support was from Robert Broom
- Left in backseat of a London taxi by his wife Dora; police thought murder case

Taung Child

Small Brain: 440 cc

Australopithecus africanus

British Scholars: He's an ape.

- Historically, earliest australopithecine fossil find, but went against then current scientific paradigm of human ancestor as large brained;
- Taung child (small brain, small canines) was opposite of Piltdown man (large brain)

Importance of Taung Child

- Refocused origins of human question to Africa
- Clarified what came first in human evolution: little brain, bipedality; not large brain
- Modern paleoanthropology was born in South Africa; produced one of largest assemblage of fossil hominins that we know of anywhere in the world.

Australopithecus africanus

- First known australopithecine (Dart 1925)
- Dated to 3.3-2.1 MA in South Africa
- Cranial capacity: <500 cc
- This species slightly different from *A. afarensis*: slightly taller, less facial prognathism, smaller teeth, slightly larger brain.
- First hominin endocasts
- One candidate for immediate ancestor to *Homo*

Endocasts can be formed naturally by sedimentation through the cranial foramina which becomes rock-hard due to calcium deposition over time

Raymond Dart

- Also excavated in Makapansgat & interpreted Australopithecine tools & weapons (osteodontokeratic (bone-tooth-horn) theory); *Australopithecus* as bloodthirsty hunters, killer apes

- Actually result of taphonomy: breakages made items look like weapons

Robert Ardrey (1908-1980):

Screenwriter & anthropology writer

- American playwright and screenwriter who returned to his academic training in anthropology
- <u>Met Raymond Dart in his Australopithecines as killer apes phase</u>
- Wrote *African Genesis* (1961), *The Territorial Imperative* (1966), *The Social Contract* (1970), and *The Hunting Hypothesis* (1976) detailing the mid-20th century transition in paleoanthropologist studies and methodology.
- **<u>Proponent of the hunting hypothesis and the killer ape theory.</u>**

In a *Nature* letter to the editor in 1947, Arthur Keith wrote–for all the world to see–“I am now convinced … that Prof. Dart was right and that I was wrong.”

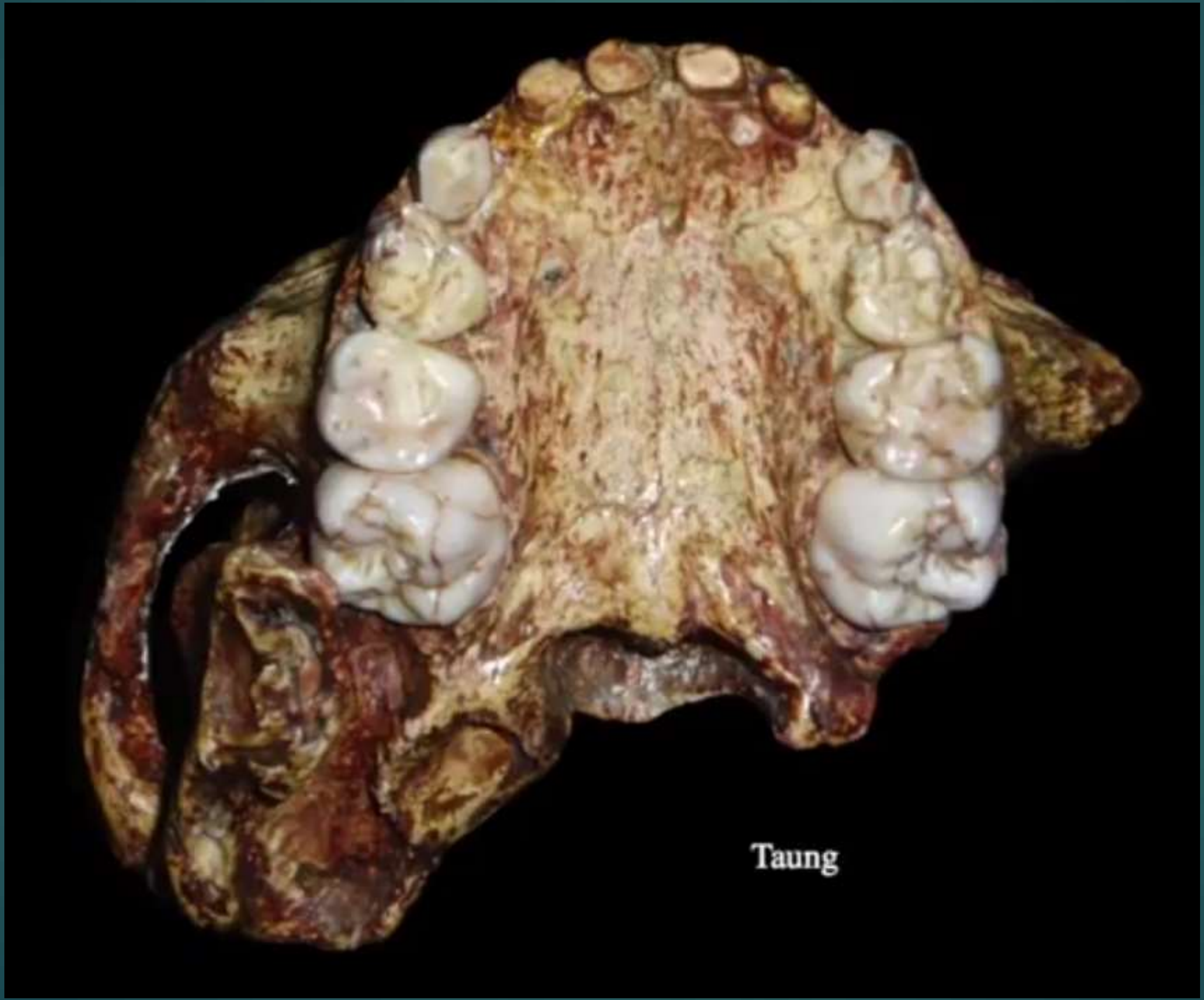
Taung Child, University of Witwatersrand archives

Taung, Wits University Archives

Taung Child

Small gracile, vertical face;

Taung Child dentition: human like



Small canines
Humanlike dentition

Taung dentation: canines coming in faster & are smaller; molars slower & are bigger

Taung endocast: Dart concludes brain is larger size for age (~3 y) and lower location of lunate gyrus

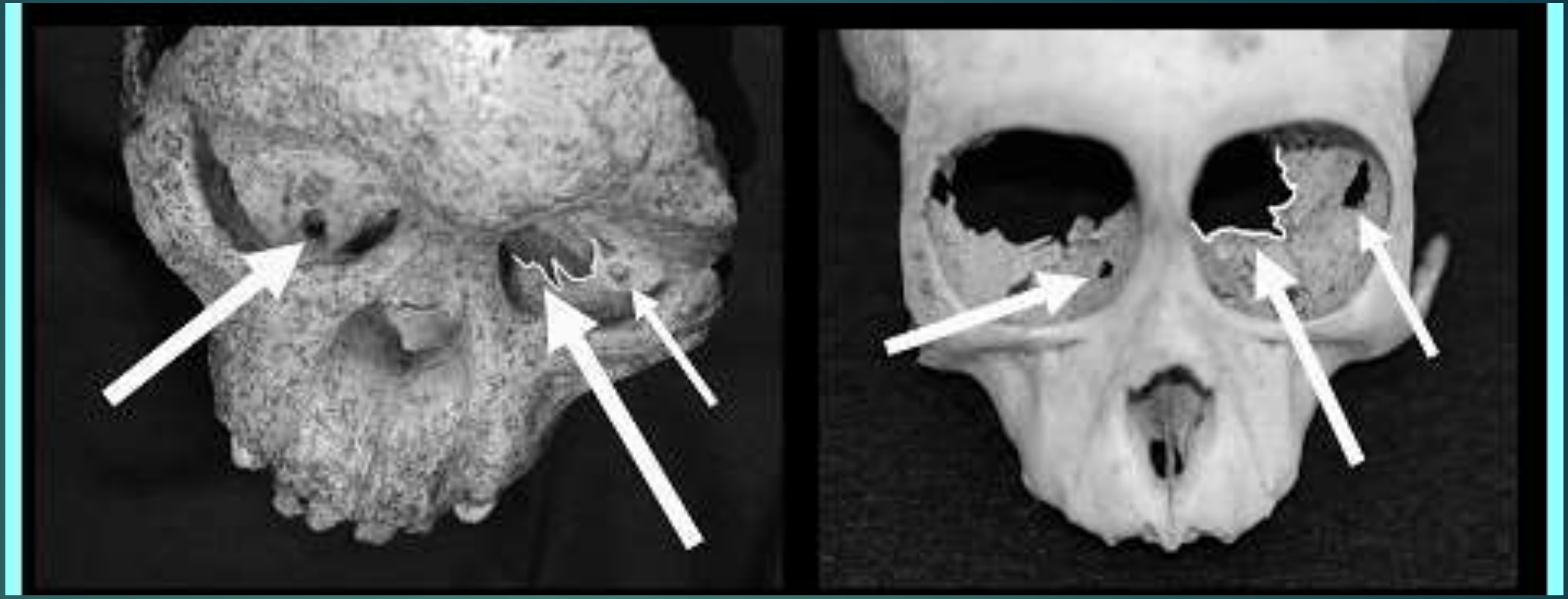
Taung Child, 1924, *A. africanus*

The face, teeth, and jaws as well as an endocranial cast of the brain were found.
The child was perhaps about three years old with a brain size of around 410 cc.

Taung child of S. Africa: a prey victim of an African eagle

Evidence of talon damage in eye sockets

Eagle Attack



- Eagles are primary predators of arboreal primates.
- Same damage as in modern 3 year olds attacked by *African hawk-eagle* (Aquila spilogaster)

Metopic suture of Taung

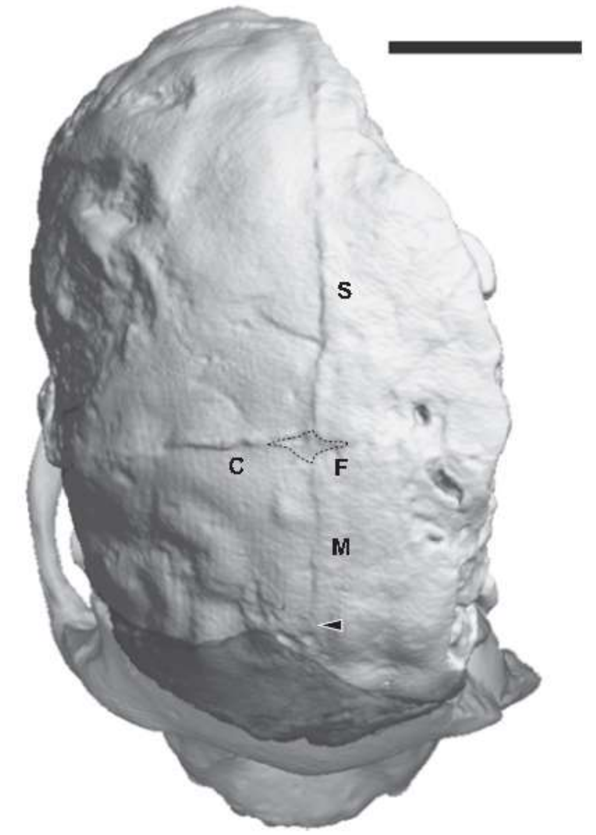


Fig. 1. CT-based superior view of the Taung natural endocast (solid) and face (transparent). Note imprints of sagittal (S, interparietal), coronal (C), and metopic (M) sutures (arrowhead denotes endpoint), and fontanelle (F, area delimited by dashed line). (Scale bar, 30 mm.)

- In great apes, the MS normally fuses shortly after birth, such that unfused MS similar to Taung's are rare.
- In humans, however, MS fuses well after birth, and partially or unfused MS are frequent. In gracile fossil adult hominins that lived between ~3.0 and 1.5 million y ago, MS are also relatively frequent, indicating that the modern human-like pattern of late MS fusion may have become adaptive during early hominin evolution.
- Selective pressures favoring delayed fusion might have resulted from three aspects of perinatal ontogeny: (i) the difficulty of giving birth to large-headed neonates through birth canals that were reconfigured for bipedalism (the "obstetric dilemma"), (ii) high early postnatal brain growth rates, and (iii) reorganization and expansion of the frontal neocortex.

Climate Change

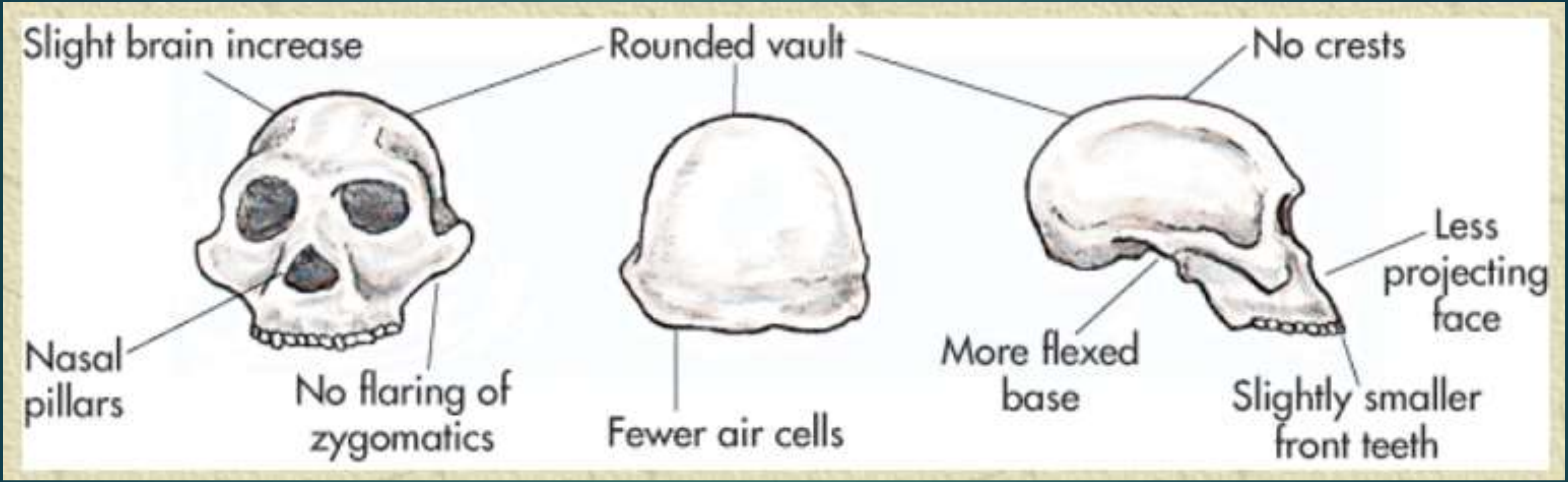
- 3.6 – 2.5 M
- Cooling of climate reduced rainfall
- Further advance of Antarctic ice
- Appearance of Arctic ice 2.4 Ma
- Development of scrubland and savannah
- Forest cover retreats

Australopithecus africanus

- Hundreds of fossils from several species at sites all across East and South Africa. *Australopithecus* was a highly successful genus that persisted for nearly three million years
- Transvaal region of South Africa: home to the species *Australopithecus africanus* (although remains have been found in Kenya and Ethiopia also), which lived 3.3 to 2.5 Ma.
- First of the australopithecines to be described.
  - Raymond Dart named the genus and species in 1925 after he discovered the famous Taung child, found in South Africa, 2.8 Ma.
- *A. africanus* was bipedal. It is similar to *A. afarensis* in both body shape and size although it is possible that *A. africanus* had longer arms and shorter legs.
- Brain size: little larger than *A. afarensis* (435 to 530 cc, ave. 450cc).

Australopithecus africanus

- Back teeth were larger than in *A. afarensis*. The teeth and jaws are much larger than those of humans, but the teeth are far more similar to humans than apes.
- Jaw is fully parabolic, like that of humans, and the canine teeth are smaller than those of *A. afarensis*. Teeth and face of *A. africanus* appear less primitive than *A. afarensis*.
- Earlier idea: *A. afarensis* to *A. africanus* to early *Homo*. Now believe that facial features link *A. africanus* to *Paranthropus robustus*.
- *A. afarensis* and *A. africanus* are known as gracile australopithecines because of their relatively lighter build in the skull and teeth. Despite this, they were still more robust than modern humans.



Slight brain increase
Rounded vault
No crests
Less projecting face
Nasal pillars
No flaring of zygomatics
Fewer air cells
More flexed base
Slightly smaller front teeth

Australoptihecus morphology

- Pelvis and lower limb: fully bipedal:
  - pelvis is short and bowl-shaped, bringing the gluteal muscles around to the side of the body, as in modern humans, for trunk stabilization during bipedalism, and the first toe is in line with the other toes.
- *Australopithecus* foot may even have had a human-like arch, based on analysis of the metatarsals and the fossilized Laetoli footprints
- Forearms were long (arms a bit longer than its legs) and the fingers and toes were long and somewhat curved, suggesting they were arboreal (for foraging and as a refuge from predators at night). This mixed terrestrial & arboreal strategy would have served these species well in the mixed woodland and savannah environments they inhabited.
- Sexually dimorphic. This level of dimorphism is not reflected in the canines, which were small, blunt, and monomorphic as in earlier hominins.

A. africanus

- This species slightly different from *A. afarensis*: slightly taller, less facial prognathism, smaller teeth, slightly larger brain.

- The pelvis, thigh bones and feet were suited to upright walking, but the shoulders and hands were also built for climbing

- Also lived in drier habitats (especially dry scrublands and perhaps open grasslands), and thus may have exploited different resources.

Australopithecus africanus

- 3.3 to 2.1 Ma
- Cranial capacity: 450 cc ; (Chimp = 400cc)
- Bipedal: wider pelvis, femur, and foot bones
- Climber: longer arm, ape-like tibia, grasping big toes; shoulder and hand bones indicate they were adapted for climbing
- Size: 3.8 - 4.5 feet tall, 66-90 lbs.
- More apelike physique than *A. afarensis*
  - Arms longer than legs – arboreality
  - Some adaptations for heavy chewing
- Wide pelvis
- Rounder skull

Australopithecus africanus

Location: South Africa
Major sites(s): Taung, Kromdraai, Sterkfontein, Makapansgat

Associated paleoanthropologist:
Raymond Dart, Robert Broom

Additional major points to know:

- Evidence of 6 lumbar vertebrae (STS 14)
- Relatively complete skeleton found at Sterkfontein
- *A. africanus* is currently the oldest known early hominin from south Africa.

Australopithecus africanus

- *A. africanus* is considered to be more derived than *A. afarensis* (larger brain, lacks cranial crests, has small anterior teeth)

- Physique much like that of *A. afarensis*; chewing teeth larger, skull not as apelike, limb proportions more apelike.

- Probably like other australopiths, matured rapidly like chimpanzees

- Many scientists consider either *A. africanus* of South Africa or *A. afarensis* of East Africa to represent a viable candidate for the ancestor of the genus *Homo*.

Diet

- No stone tools discovered with them; despite Dart's theory of killer apes
- Diet similar to modern chimpanzees, which consisted of fruit, plants, nuts, seeds, roots, insects, and eggs.
- Dental microwear studies found more scratches than pits on *A. africanus* teeth compared to a contemporaneous species, *P. robustus*. This pattern indicates that *A. africanus* ate tough foods but also had a very variable diet including softer fruits and plants.

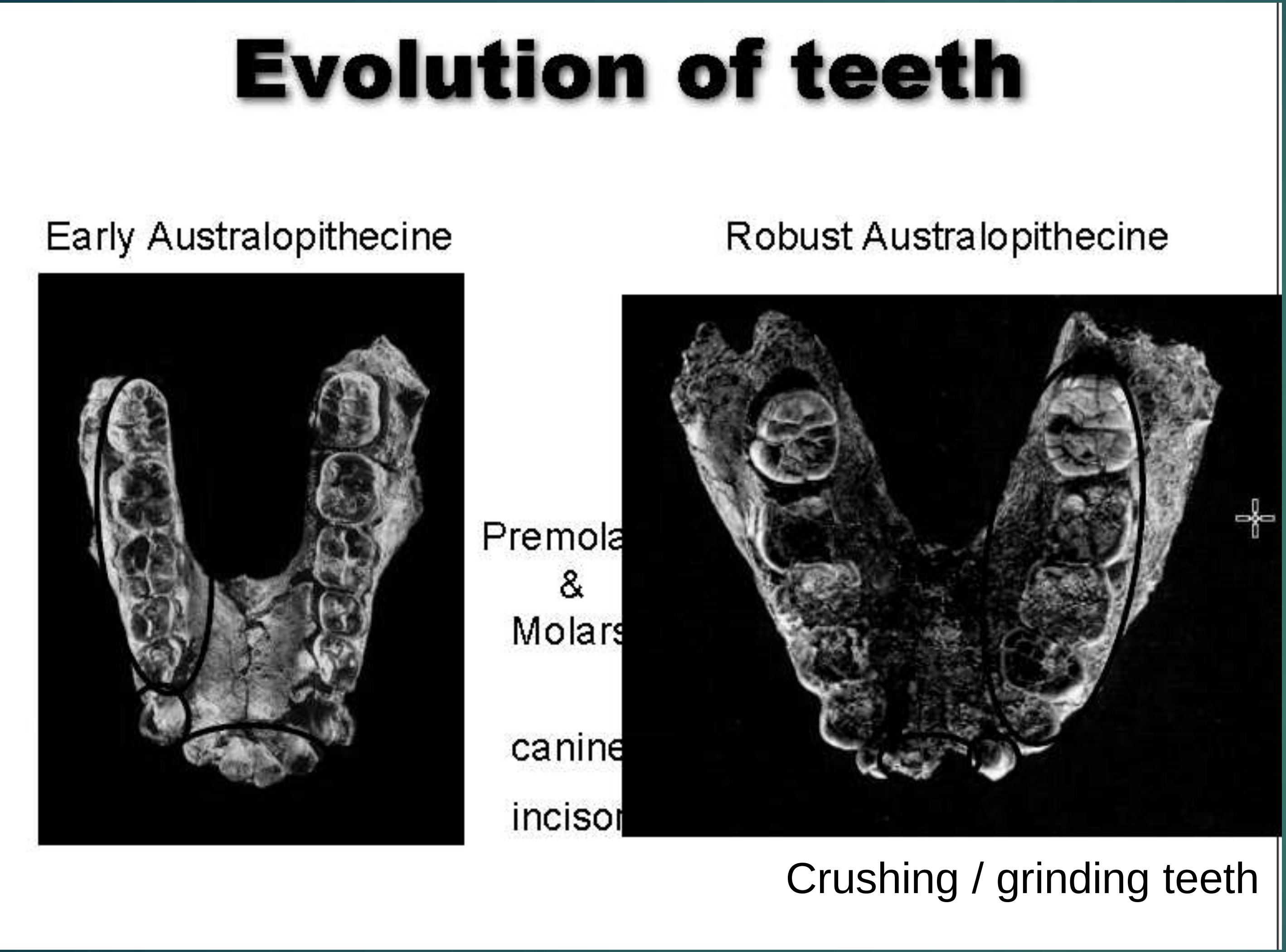
2019 A. africanus teeth study: mother’s milk as ongoing food source

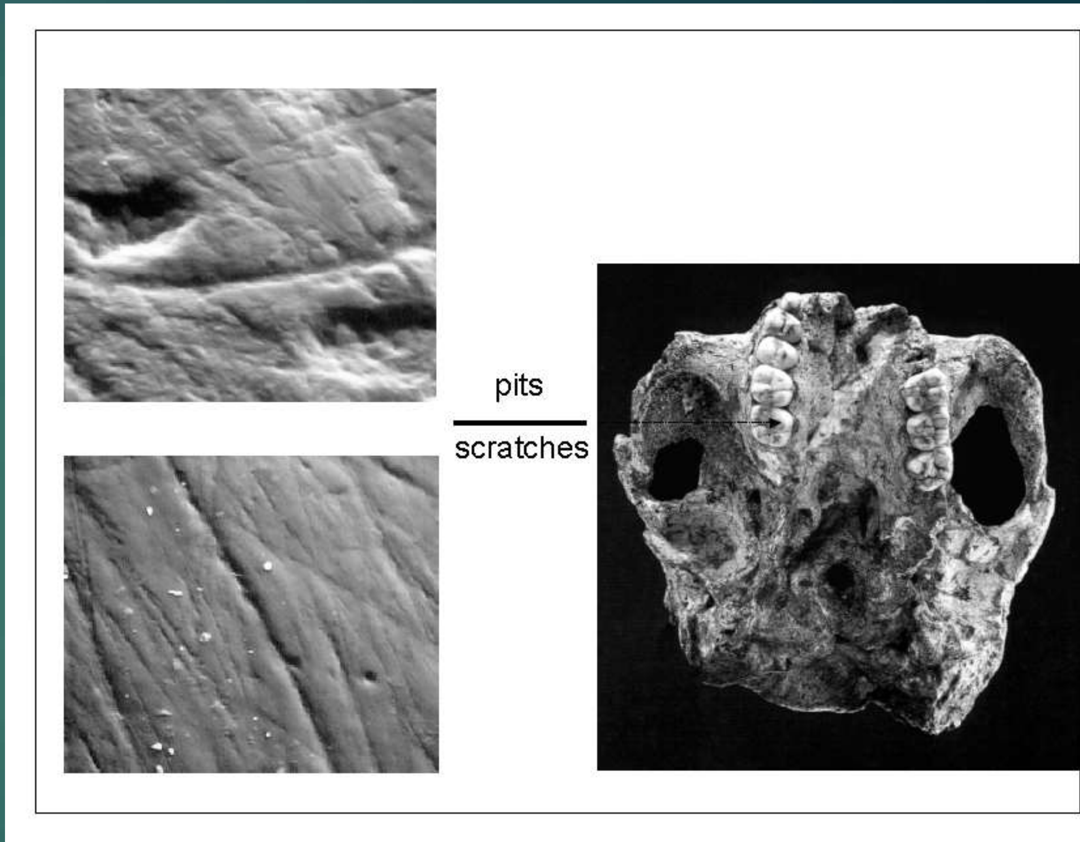
A. africanus is one of the earliest hominins known to inhabit the South African landscape, living from 3.03–2.61 million years ago (Ma) until sometime between 2.3 and 2.1 Ma. Decades of research on the diet and mobility[3] of this species has suggested an unusually high degree of dietary variability (which probably included the consumption of fruits, leaves, grasses, sedges and roots) relative to other hominins, which has led to the interpretation that *A. africanus* lived in a complex range of environments that included open grassland and forest. Mineralization of enamel and dentine occurs incrementally, and thus retains a sequential record of the early-life chemical exposure of an individual—Previous work has identified barium in teeth as a reliable marker of maternal milk intake.

Elemental signals (barium and strontium bands in the teeth) indicate that A. africanus infants predominantly consumed breast milk for the first year after birth. This indicates a diet predominated by breast milk for a minimum of 6–9 months, followed by increased supplementation with non-milk foods A cyclical elemental pattern observed following the nursing sequence—comparable to the seasonal dietary signal that is seen in contemporary wild primates and other mammals—indicates irregular food availability. Cyclical accumulation of lithium in A. africanus teeth also corroborates the idea that their range was characterized by fluctuating resources, and that they possessed physiological adaptations to this instability. This study provides insights into the dietary cycles and ecological behaviors of A. africanus in response to food availability, including the potential cyclical resurgence of milk intake during times of nutritional challenge (as observed in modern wild orangutans).

This pattern has been interpreted as seasonal dietary adaptation, in which Ba/Ca ratios in teeth increased when infants relied more heavily on their mother’s milk during periods of low food availability. It appears that *A. africanus* underwent seasonal food stress, and had to adapt to changing resources and food access. Varying milk intake can compensate for periods of extreme, and unpredictable, oscillations in food availability. This adaptation enables the survival of immature individuals, who are particularly vulnerable to fluctuations in food accessibility. During periods of abundance the infant can rely more heavily on solid food, which allows the mother to replenish her energetic and calcium reserves to support an increase in lactation during periods of food scarcity. During periods of severe food shortage, immature australopithecines might have developed physiological adaptations to compensate for low caloric intake from fallback resources, which perhaps included a long weaning sequence. Undoubtedly, the high Ba/Ca and Li/Ca ratio bands in *A. africanus* dental tissues attest to a strong seasonal oscillation in food access, which would have had a substantial effect on australopithecine development. This interpretation is reinforced by the high frequency of developmental defects in the enamel of this species, which was the result of nutritional deficiencies.

The geochemical findings for these teeth reinforce the unique place of A. africanus in the fossil record, and indicate dietary stress in specimens that date to shortly before the extinction of Australopithecus in South Africa about two million years ago. These adaptations in response to seasonal variability and resource scarcity would have extracted a toll on the resilience to other environmental pressures, and thus possibly had a role in the disappearance of the genus from the fossil record at about 2 Ma.


Evolution of teeth
Early Australopithecine
Robust Australopithecine
Premola
&
Molar
canin
inciso
Crushing / grinding teeth


pits
scratches

Australopithecus africanus. Reconstruction based on STS 5 by John Gurche

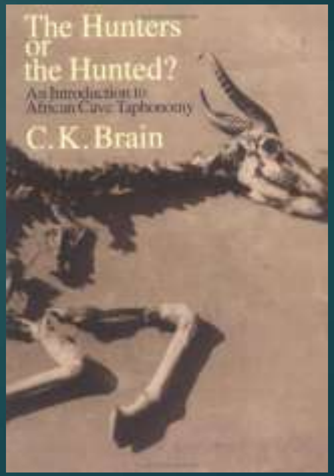
Australopithecus africanus

- No sign that either *A. africanus or P. robustus* lived in the caves their fossils are found in.

- Either bones:
  - were dropped into cave openings by leopards,
  - brought into the caves by hyenas or porcupines.
  - or fallen into cave or entered and could not leave.

Charles Kimberlin (Bob) Brain (1931 –):
Swartkrans taphonomy & Predation theory

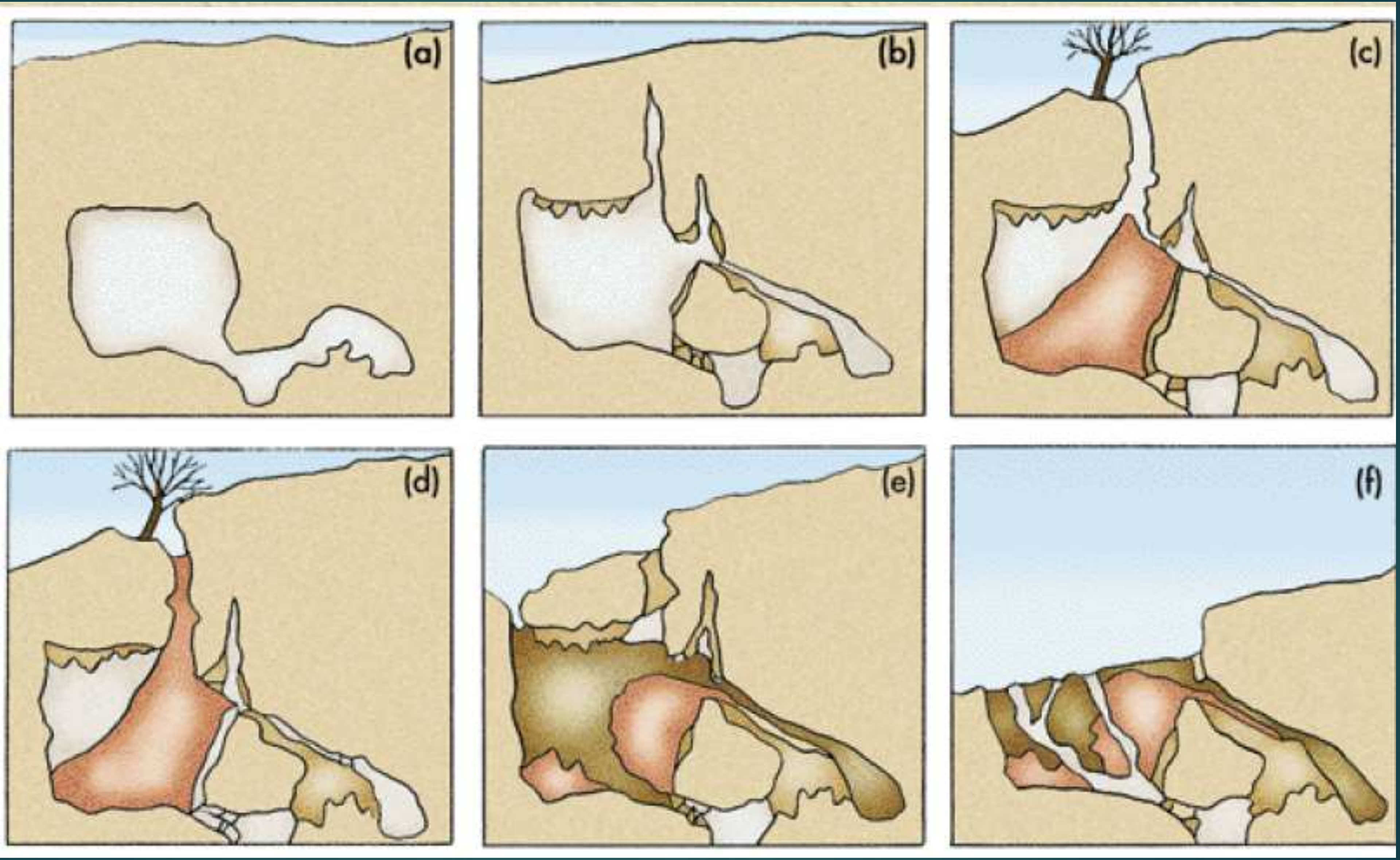
- South African paleontologist; Directed the Transvaal Museum
- Founder of the science of taphonomy (remains of creatures at the site of death)
- Supervised 30 year long excavation of the Swartkrans Cave in the Sterkfontein Valley;
- Did the only comprehensive geological survey of all five australopithecine sites of South Africa
- Discovered Acheulean handaxes at Sterkfontein
- 1983: Realized most fossil assemblages in the Cradle of Humankind resulted from the accumulation of bones by predators and scavengers. Emphasized importance of predation in hominin history: until recently, we were the hunted.



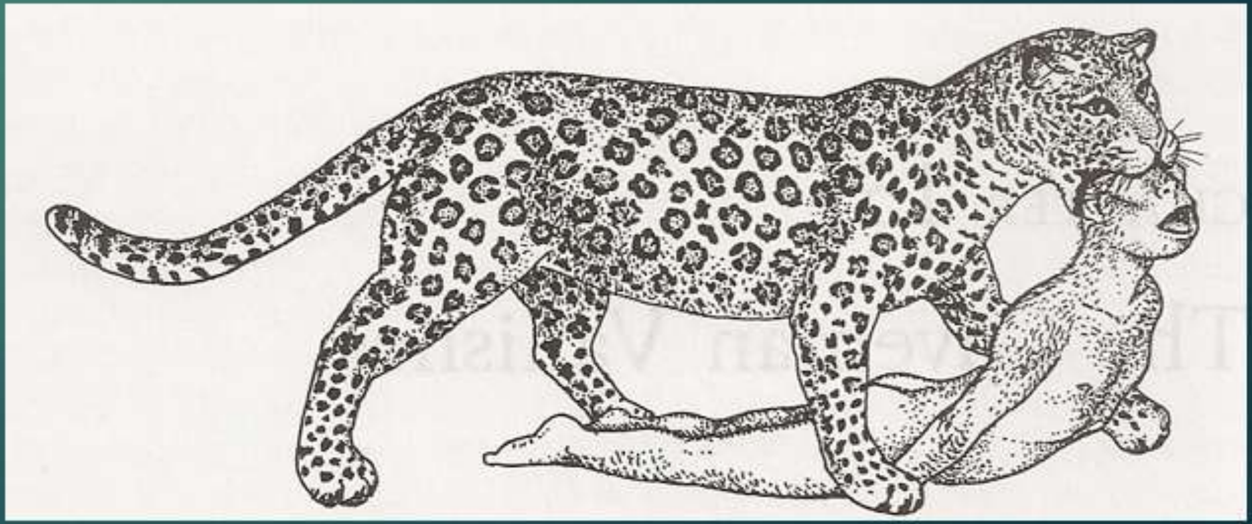
C. K. “Bob” Brain (1931-): South African taphonomy

- East Africa: volcanic ash layers that can be radioactively dated
- South Africa: collapsed ancient caves – hard to do stratigraphy
- Bob Brain specialized in taphonomy: what happens to an organism after its death and until its discovery as a fossil.

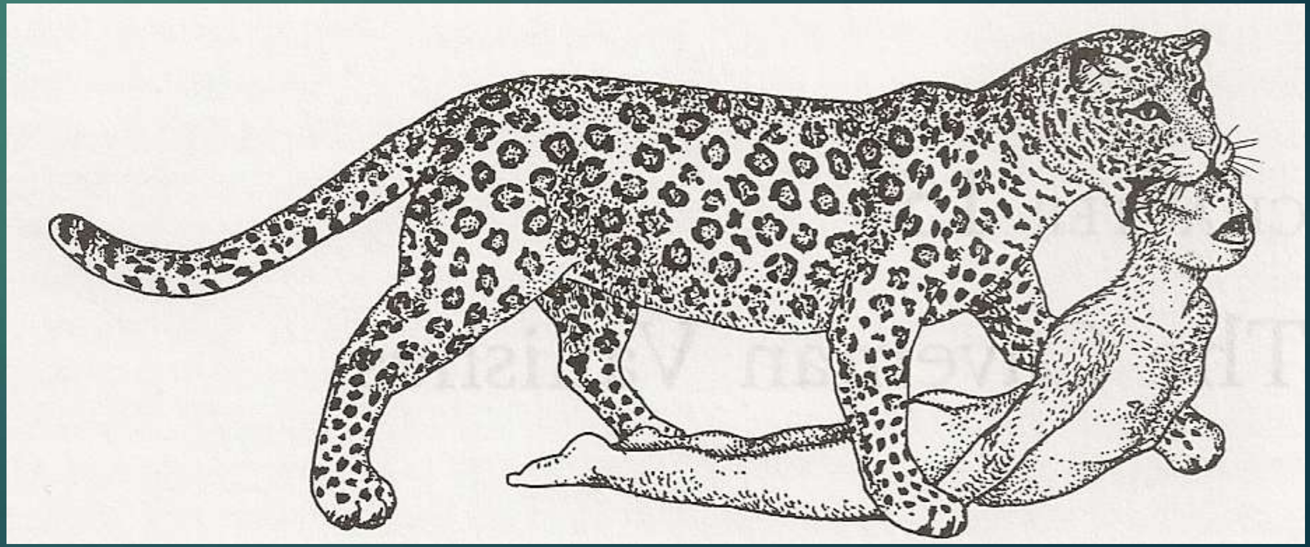
Cave formation



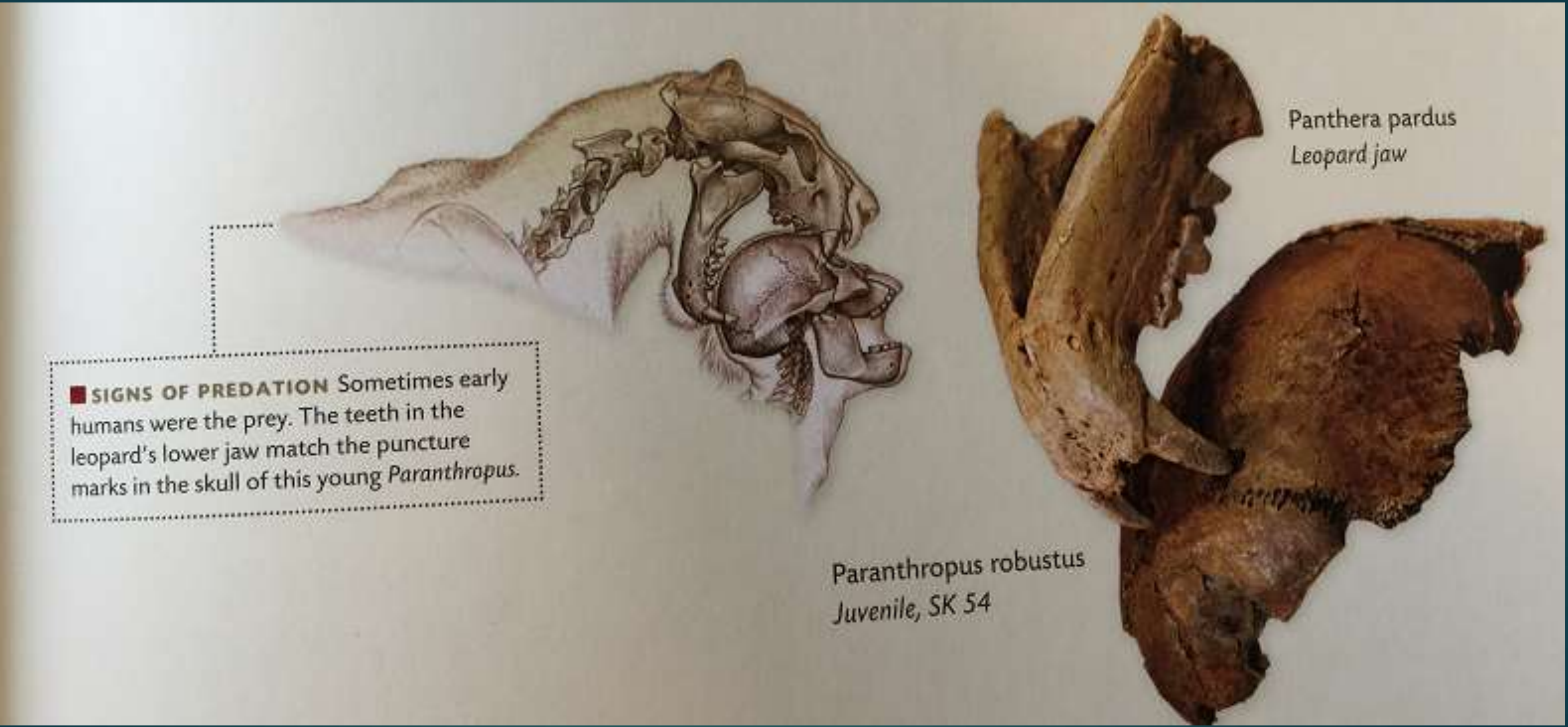
Hominin Predation
at Swartkans, S. Africa



Hominin Predation
at Swartkans, S. Africa



Hominins as prey: C. K. Brain: Hominin Predation at Swartkrans



Seeking answers to an old riddle

AFTER C. K. BRAIN, © MATTERNES

CAVE EXCAVATIONS at Swartkrans, South Africa (**left**)*, may show whether early man was the hunter or the hunted. During the Pleistocene epoch, beginning two million years ago, an underground cave complex acted as a catch basin for dead creatures whose remains washed or fell in—antelopes, baboons, saber-toothed cats, leopards, and some 130 Australopithecus robustus individuals. A partial juvenile cranium fossil found in 1949 had two holes about six millimeters in diameter, 33 millimeters apart. Some theorized they were caused by*

blows from a pointed weapon. But similar holes occur in skulls of baboons killed by leopards, chief excavator Bob Brain pointed out. He matched the lower canines of a leopard jaw found in the deposit to the holes in the juvenile's skull (**above**)*, demonstrating that this hominid was more prey than predator.*

Apparently in dragging its kill out of reach of hyenas, the leopard penetrated the skull with its canines. High in a tree, the leopard consumed the flesh, and the skull dropped into the cave shaft (**below**)*, where it was eventually covered by debris.*

Excavators use plumb bobs suspended from grids to plot the exact location of each find. Positive dating by radiometric methods has so far proved impossible, since the region is not volcanic. But faunal chronology has placed early man here at least 1.5 million years ago.

Dietary Hypotheses

- Robust Australopithecines
- What set them apart: ecological variability
- Larger masticatory (chewing) anatomy
  - Large jaws
  - large jaw muscles;
  - very large molars and premolars

Robert Broom (1866-1951):
Sterkfontein: *Australopithecus africanus*

- Scottish South African paleontologist
- Abrasive, MD with honors in midwifery, womanizer, with reputation for stealing & selling fossils; expert in mammalian fossils
- First Supporter of Dart's interpretation of Taung Child
- 1936: excavation at Sterkfontein, discovered an endocranial cast (found by G. W. Barlow, lime works foreman); named *Australopithecus transvaalensis (then Plesianthropus transvaalensis; then A. africanus)*
- First postcranial remains of *Australopithecus africanus*

Robert Broom: Swartkrans & *Paranthropus robustus*

- The first fossils attributed to the genus *Paranthropus* were announced in a 1938 *Nature* paper by Robert Broom; . The fossils were discovered by a schoolboy in Kromdraai Cave, just a couple miles upstream from the Sterkfontein. a single, presumably male, cranium, which became the type specimen of *Paranthropus robustus* Broom, 1938.

- 1947: With John T. Robinson, skull of *Australopithecus africanus* , STS 5 Ms. Ples

- 1947: *Australopithecus africanus* (STS 14), partial skeleton

- 1948: first *Paranthropus robustus* at Swartkrans

- Published 450 papers

- With Dart, changed human evolution theory by showing australopithecines were earliest hominins

Robert Broom

- 1936: excavation at Sterkfontein, discovered an endocranial cast (found by G. W. Barlow, lime works foreman); named *Australopithecus transvaalensis (then Plesianthropus transvaalensis; then A. africanus)*

- South African fossils: None associated with stone tools (we don't know about wood, which does not preserve.)

- After Sterkfontein, explored Kromdraai and Swartkrans

Sterkfontein fossil & article on its discovery

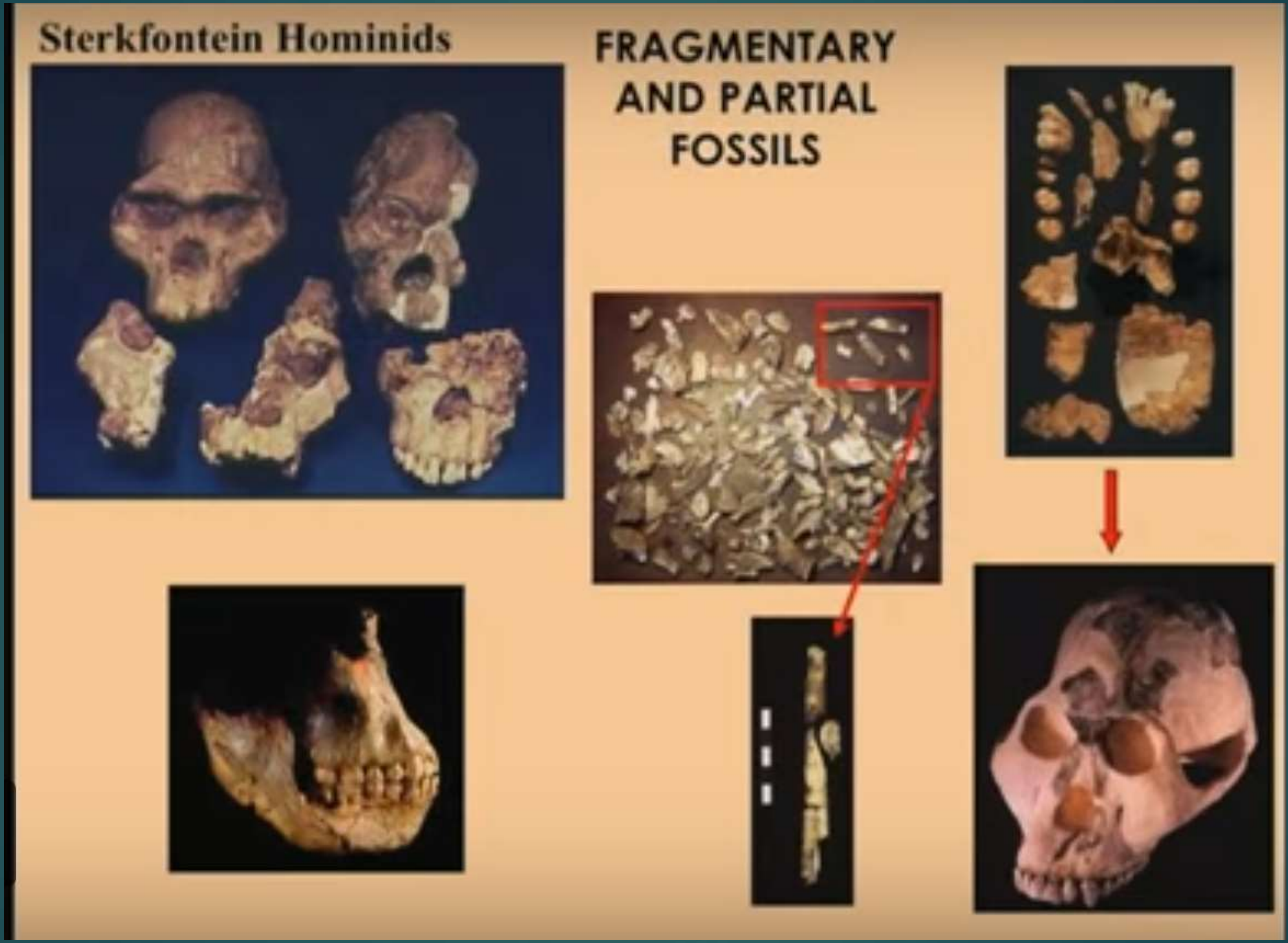
Fossil endocasts & facial remains of an adult Australopithicine (right) found at Sterkfontein in 1936 & other endocasts from Transvaal caves

- Broom was handed a brain endocast in 1936
- First adult Australopithecus
- Clarke found 2 of the teeth 66 years later

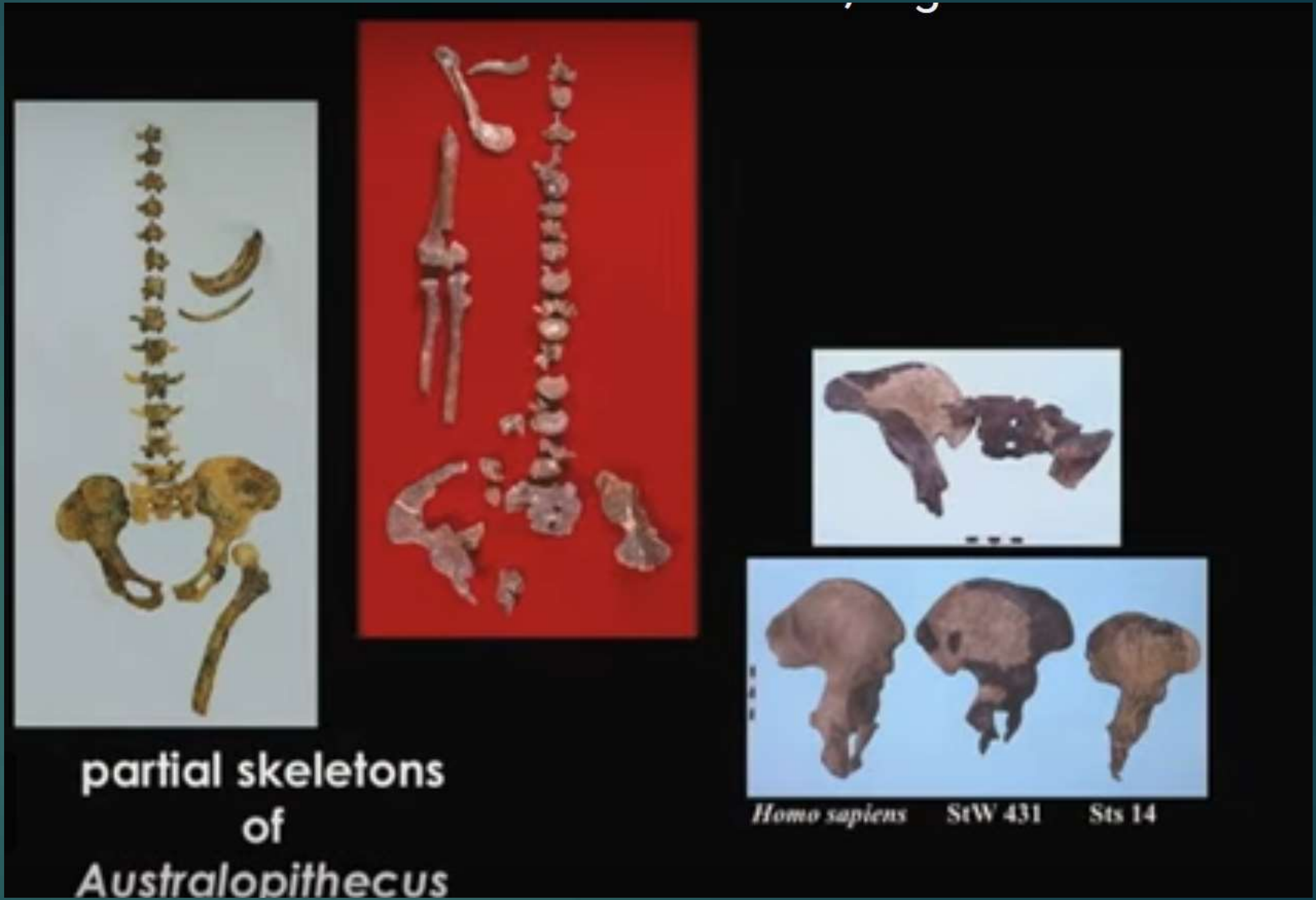
In 1938, at age 72, Broom said:

'If I live another 8 years, I may be able to do a little more. I think it is very likely that within the next couple of years we shall find other specimens of pleistocene apes and perhaps much of his skeleton. If we could find a pelvis, a foot and a hand of either the Sterkfontein or Kromdraai ape the importance of the discovery would be greater than all the previous discoveries put together.'

Only found a pelvis; 60 years until a skeleton was found


Sterkfontein Hominids
FRAGMENTARY
AND PARTIAL
FOSSILS

Partial Skeletons



1947 Broom

1947: *Australopithecus africanus, STS 14*, 2.5 Ma, first partial skeleton: More human than apelike skeleton

Australopithecus africanus
(STS 14)
Discoverer: Robert Broom & John T. Robinson
Date: 1947
Locality: Sterfontein
Age 2.5 M

Distinctly human-like shape of its pelvic blades, indicating a type of bipedalism.
This find was the first to demonstrate, without a doubt, pre-*Homo* bipedality.

Excavations at Sterkfontein

In 1947, Broom with zoologist John Robinson, discovered hominin skull, nicknamed Mrs. Ples.

By 1956, younger deposits were discovered by C.K. Brain, a geology student who also recognized primitive stone tools in these new sediments, associated with *Homo.*

After 10 years of inactivity at Sterkfontein, anatomist Phillip Tobias and his assistant Alun Hughes initiated systematic excavations at Sterkfontein in 1966. Over the next 25 years the two men would recover hundreds of fossils.

After Hughes died in 1991, paleontologist Ron Clarke took his place

Close-up of the statue: Broom & Mrs. Ples at Sterkfontein

- Broom had a preference for hunting for fossils in the nude (Broom was a strong believer in sunshine)

- In 1924, Broom originally walked into Dart’s lab and knelt before Taung cranium “in adoration of our ancestor”
- 1973: Raymond Dart, age 80, touching statue of Robert Broom & Mrs. Ples at entrance to Sterkfontein cave.

Brain endocasts & cranium of *A. africanus*, Sterkfontein, S. Africa; brains less than 500 cc

John Talbot Robinson (1923 – 2001): Mrs. Ples & *Homo ergaster*

- South African hominin paleontologist
- Professor at University of the Witswatersrand, and the University of Wisconsin–Madison
- Excavations, with Robert Broom, at the caves of Sterkfontein, Kromdraai and Swartkrans.
- 1947: His most famous discovery (with Robert Broom) was the nearly complete fossil skull of an *Australopithecus africanus*, known as Mrs. Ples.
- 1949: First discovered a mandible of a new hominin in southern Africa in 1949; he named the species *Telanthropus capensis*, now recognized as a member of *Homo ergaster/erectus*.
- 1956: *The Dentition of the Australopithecinae*

John T. Roinbson. Courtesy of the University of the Witwatersrand.

1947: Sts 5, *A. transvaalensis*, then *Plesianthropus transvaalensis*, then *A. africanus;* Mrs. Ples (a male), 485 cc

Australopithecus africanus
(STS 5)
Discoverer: Robert Broom & John T. Robinson
Date: 1947
Locality: Sterfontein
Age 2.4 M

Mr. or Mrs. Ples? Problems determining sex

- One of the most famous specimens in the hominin fossil record is Sts 5, an almost complete but toothless skull with no jaw associated, found at Sterkfontein by Robert Broom in 1947. It is dated at 2.5 Ma.
- Broom defined a new species *Plesianthropus transvaalensis* (which means "almost human of the Transvaal"), and from this name remained his charming nickname Mrs. Ples. It was later reclassified as *Australopithecus africanus*.
- But, is it Mrs. or Mr. Ples?

Sex of Mrs. Ples

- Since its discovery, different studies have alternatively changed the sex (and age) of Sts 5…
- To start, Broom considered that the skull belonged to an **adult female** according to:
- The size of the tooth sockets, mainly the small canines.
- The absence of sagittal crest.
- The small size and overall gracility of the skull.

Mr. or Mrs. Ples?

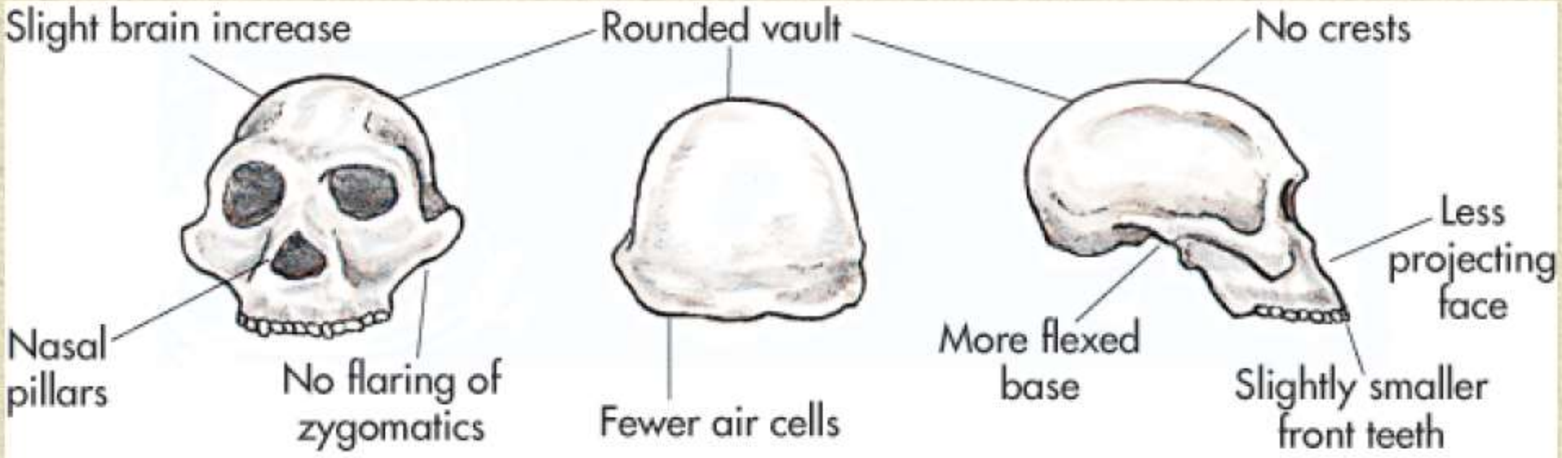
- **2.** In 1983 Joel Rak proposed that it was a **young male**, mainly for two reasons:
- The anterior pillars on the face, which resemble that of other male specimens of *A. africanus*.
- The canine sockets would have eroded after the death of the specimen, making it appear smaller than would normally correspond to the size of the anterior pillars.
- **3.** Already in the new century, and with the advantage of the latest technologies such as computed tomography (CT) scanning, other reasons supported the hypothesis of an **adolescent male**, such as the prominent glabella, the morphology of the supraorbital arch, and the temporal process of the zygomatic arch (Thackeray et al, 2002).

Mr. or Mrs. Ples?

- **4.** A few years later, more questions arose about its age. The suggested dental development would indicate that it was not an adolescent, but a **fully developed adult** (Bonmatí, 2008). Moreover, the extremely short, vertically oriented anterior roots could suggest a remarkable tooth wear and therefore Sts 5 would have been an **old adult!** (Villmoare, 2013)
  5. More recently, the virtual reconstruction of the tooth sockets of Sts 5 again suggests that it was an **adult female** (Grine et al, 2012) arguing that:
- The roots of the wisdom teeth (M3) of Mrs. Ples were fully developed and correspond to an adult aged 17-21 years (according to the dental development patterns of modern humans).
- Compared to other fossils, Mrs. Ples shows no relevant signs of erosion in its upper jaw, so the canine sockets reflect the exact size they were when it died. And that size suggests it was a female.
- **6.** Finally – for now – in 2018 it is proposed again that Sts 5 was in fact **"Mr. Ples"** (Tawane et al, 2018). The arguments of Grine and his colleagues are objected because, although the measurements of the tooth cavities on which Broom relied were published in 1950, and he had correctly used a hammer and chisel to separate the sediment, John T. Robinson later in the 1960s used acetic acid to separate more sediment debris, causing damage in Sts 5. Tawane and his colleagues take the original measurements and compare them to the 12 specimens of Australopithecus africanus published by Loockwood in 1999, to argue that Sts 5 is a male. However, they promise to continue working on the fossil's CT to help determine the sex of Mr/Mrs Ples.
- The determination of sex in the fossil record of *Australopithecus africanus* is important because this is a species with very wide morphological variability. This led many of Broom's contemporaries to suggest that the fossils known at the time actually corresponded to multiple species, although currently this variability is understood to correspond to the sexual dimorphism in australopithecines.

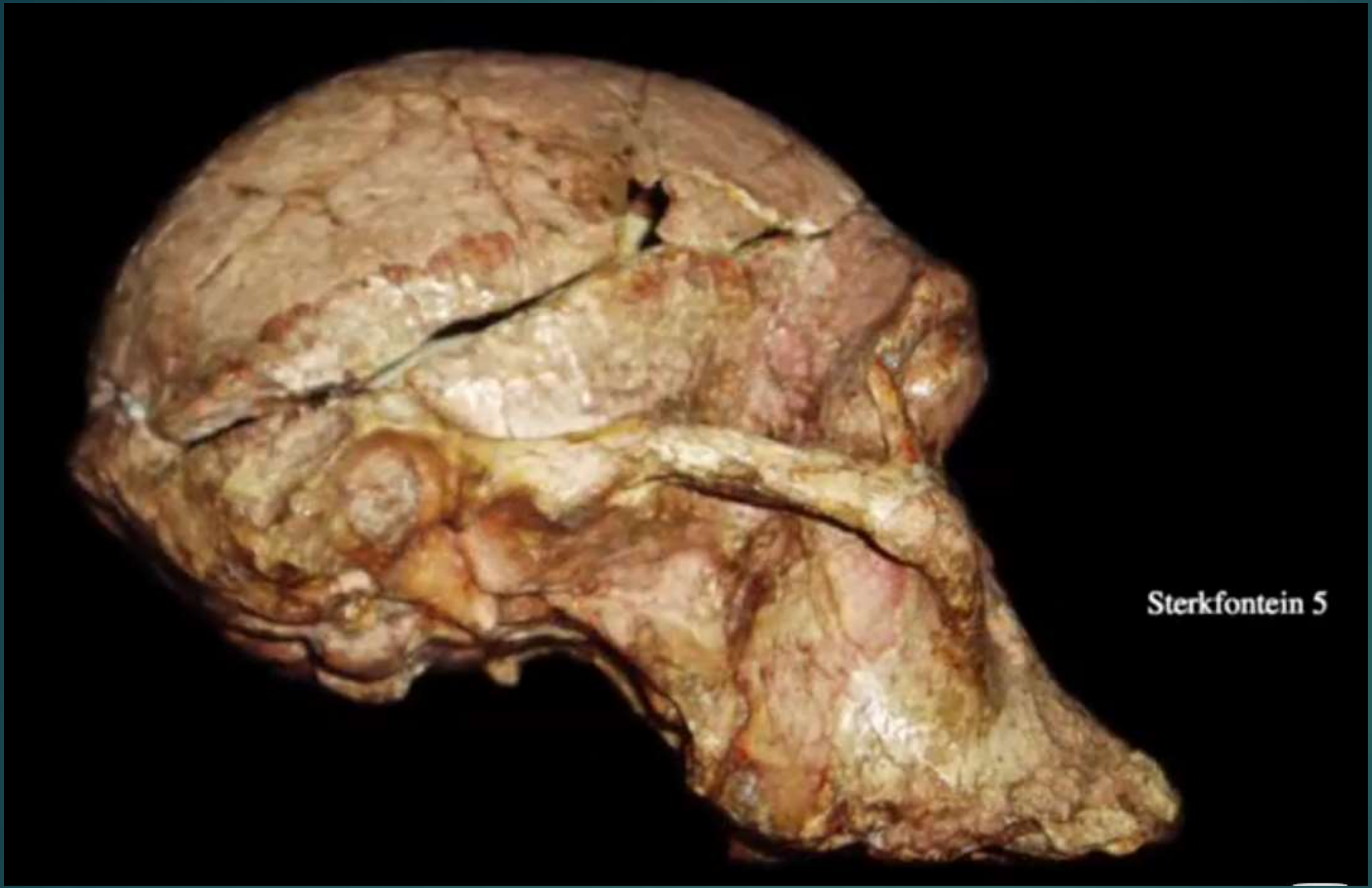
Australopithecus africanus

- Generalized teeth
- Smaller canines, but larger molars than earlier Australopithecines
- Some anterior pillars around nose
- Pelvis, leg, spine and foot bones show habitual bipedalism



A. africanus: Mrs. Ples (a female?): Taung child as adult

- Adult
- Flaring zygotic arches
- associated with still fairly large canine roots.
- small supraorbital torus that's double arched here in the front.
- fairly small nasal aperture and not much evidence of an external projecting nose.



- subnasal prognathism
- flexed, flaring zygomatic.
- this is the attachment point for the masseter muscle, one of the big chewing muscles
- relatively small brain size
- But no sagittal crest or nuchal torus development in back
- 2.5 MA
- Primitive: brain size; large mastication

Sts 5 (pictured above) is the most complete Australopithecus africanus specimen in the fossil record

Mrs. Ples

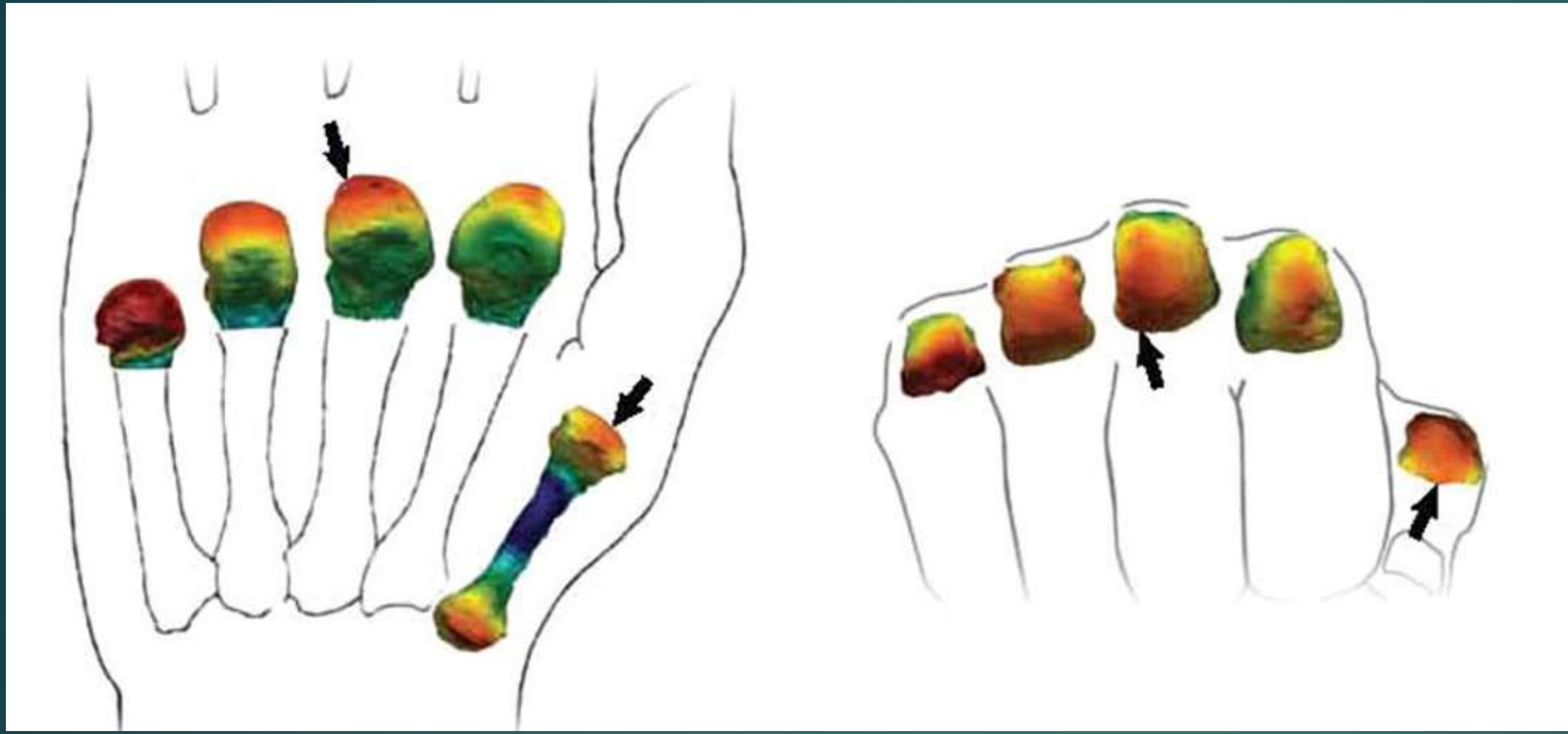
- Post orbital constriction, corresponding to small brain

2018: “Mrs” Ples was actually a “Mr”. Broom suggested that the specimen, which lacks teeth, represented a female individual on the basis of small canine sockets

Gaokgatlhe M. Tawane & J. Francis Thackeray, 2018

Oblique view

Even older: Fossil hand bones of *A. africanus* indicate stone tool capability at 2.8 MA



Advance Hand: High concentrations of spongy inner bone in an ancient hominin's knuckles and thumb base (indicated by arrows, red indicates more spongy bone) suggest humanlike hands evolved nearly 3 million years ago.

M.M. Skinner et al. *Science* Vol. 347 (2015)

Paranthropus robustus

Paranthropus robustus, 2.0 to 1.2 MA

- Fossil sites of *Paranthropus robustus* are found only in South Africa in Kromdraai, Swartkrans, Drimolen, Gondolin and Coopers.
- In the cave at Swartkrans, the remains of 130 individuals were discovered.
- The study made on the dentition of the hominins revealed that the average *P. robustus* rarely lived past 17 years of age.
- *Paranthropus robustus* was the first discovery of a "robust" species of hominin; it was found well before *P. boisei* and *P. aethiopicus*.
- Robert Broom's discovery in 1938 at Kromdraai, was the second australopithecine after *Australopithecus africanus*, which Dart discovered.

Robust Australopithecine Morphology

- The "robusticity" refers to the size of the masticatory apparatus.

- 3 species (*P. robustus*, *aethiopicus* or *boisei)* - united by suite of features related to eating tough foods:
  - Extremely large molars / premolars
  - Dished face
  - Extremely large chewing muscles
  - Wide-flaring cheekbones
  - Prominent sagittal crest

Robust hominins

- Really Megadontic Hominins in South & East Africa
- Debate over proper genus: *Australopithecus* or *Paranthropus*
  - *Paranthropus aethiopicus*
  - *Paranthropus robustus*
  - *Paranthropus boisei*
- In many small details, the species *A. robustus* resembles *A. africanus* more than it does either of the other "robust" species, *aethiopicus* or *boisei*

Paranthropus (Australopithecus) robustus

- South Africa, 2 to 1.5 Ma
- Body similar to that of *A. africanus,* but a larger and more robust skull and teeth.
- Massive face is flat or dished, with no forehead and large brow ridges.
- Relatively small front teeth, but massive grinding teeth in a large lower jaw.
- Sagittal crests.
- Diet: mostly coarse, tough food that needed a lot of chewing.
- Average brain size: 530 cc.
- Most *Australopithecus* species were extinct by 2 Ma, but some robust forms persisted until about 1.2 Ma in East and South Africa.

"Extreme" Australopithecines!

- Bipedal
- Bigger bodies: 40 –70 kg
- Cranial capacity: 530 cc (Chimp = 400cc)
- Very sexually dimorphic: males twice as bulky as females
- Sagittal crest
- Robust facial bones
- Small incisors and large molars
- Dish-shaped/flat face w/ flaring zygomatic
- Molarization of premolars and reduction of incisors and canines (post-canine megadontia)
- Big teeth, huge jaws and strong chewing muscles anchored to a skull crest helped *P. robustus* chew fibrous grasses and roots. Chew, chew, chew…
- Less exaggerated features than *P. boisei*

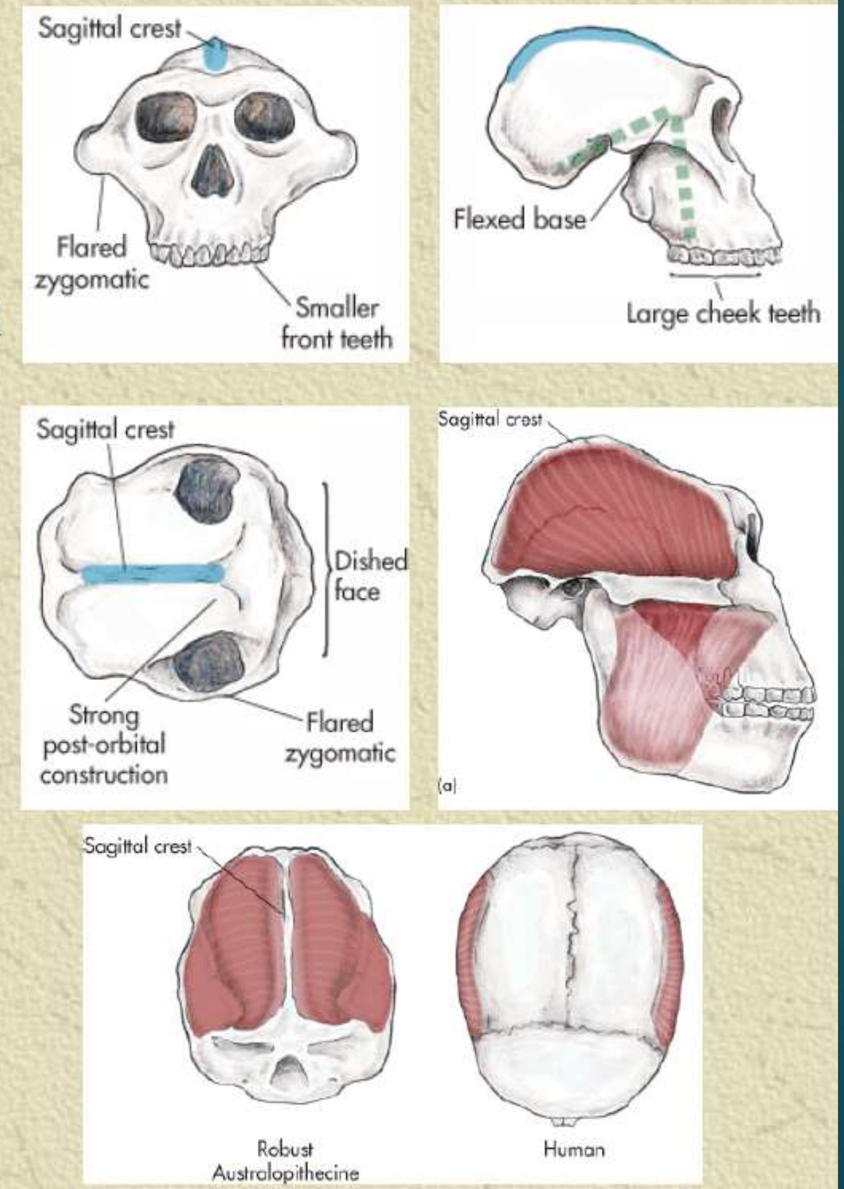
Robust Australopithecines

- We have a lineage in East Africa that evolves from at least 2 and ½ Ma, and survives until as late is 1.2 million years of age.

- Characterized by:
  - increasing molar dentition,
  - increasing size of the premolars,
  - increasing size of the jaw
  - increasing size of the temporalis muscle and the whole masticatory apparatus that is associated with it.
  - In other words, characterized by huge jaws.

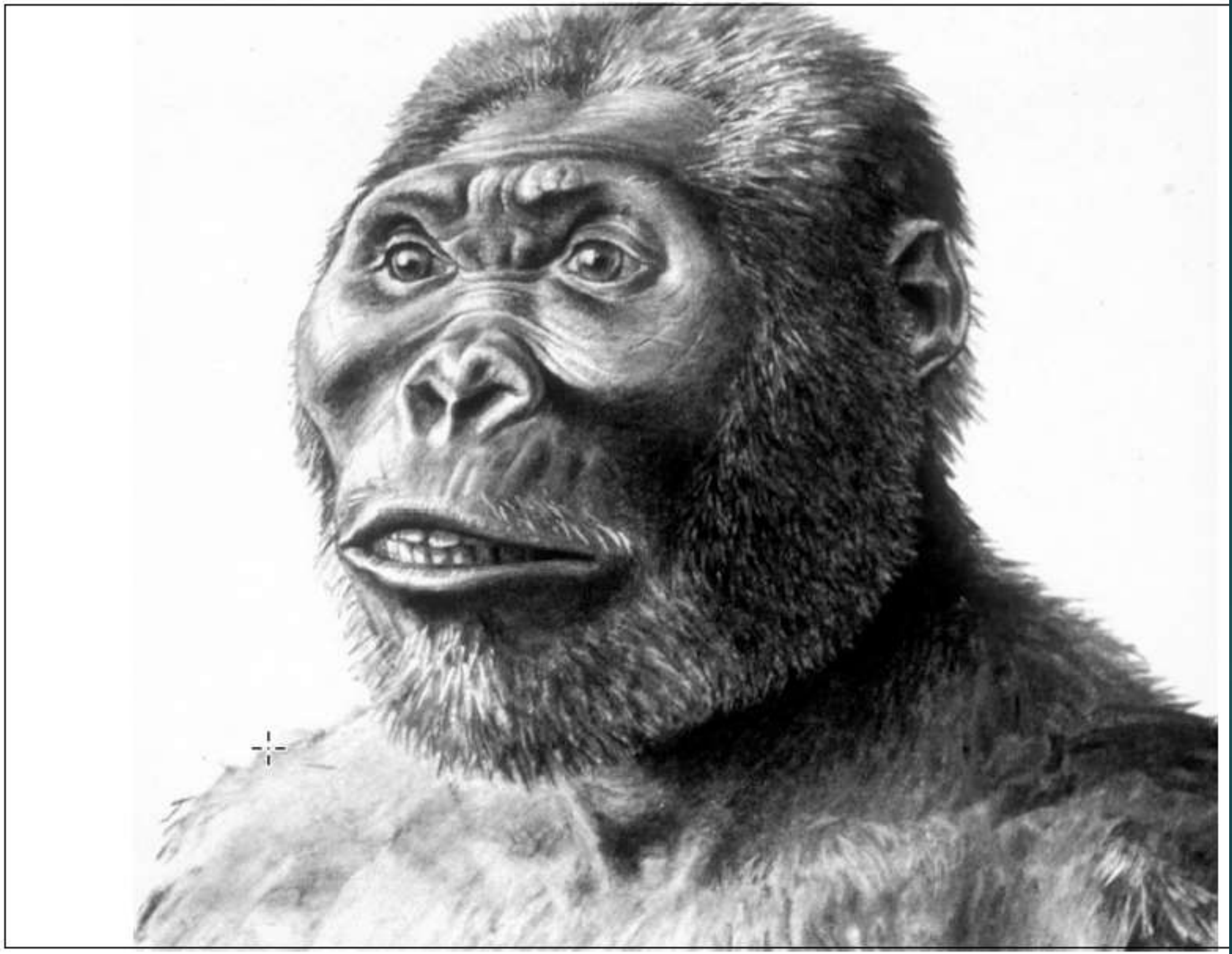
The Robust Australopithecines

- **Hard object feeding**
  - Sagittal crest
  - Flared zygomatic arch
  - Extreme postorbital construction
  - Large cheek teeth
- **Paranthropines?**
- **Woodland and open woodland habitat**



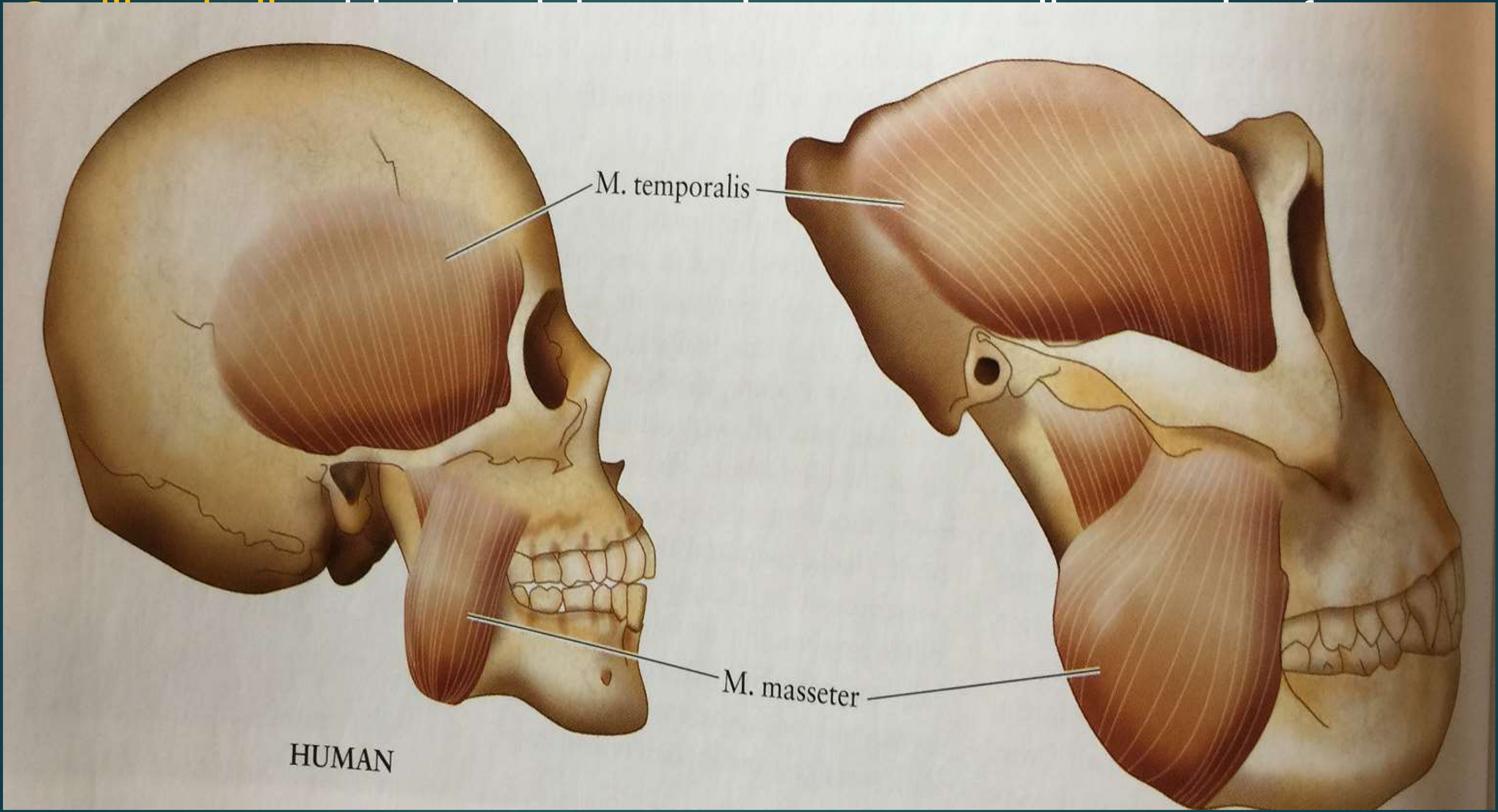
Cranium and dentition

- Cranial Robusticity:
  - large, thickly enameled, postcanine teeth
  - supported by deep and broad mandibular corpora with tall and broad rami.
  - zygomatic (cheek) bones that were extended both laterally and anteriorly,
  - face that was more orthognathic (i.e., pulled back towards the rest of the skull) than in other australopiths,
  - occasional presence of sagittal bony crests on the top and back of the skull, for the attachment of large jaw muscles.
- Taken together, these traits suggest a hominin that could both generate and dissipate huge bite forces, and they imply that at least some portion of the *Paranthropus* diet was particularly difficult to break down



Chimpanzees & Gorillas

- Chimpanzees: smaller body, brain size = 350 cc
- Modern Gorillas: larger body; brain size = 530 cc
- Chimp and gorilla behavior are very similar, despite different brain size; can’t just rely on brain size for hominin differentiation
- Humans: brain size variation: 900-2000 cc; but no IQ variation?


M. temporalis
M. masseter
HUMAN

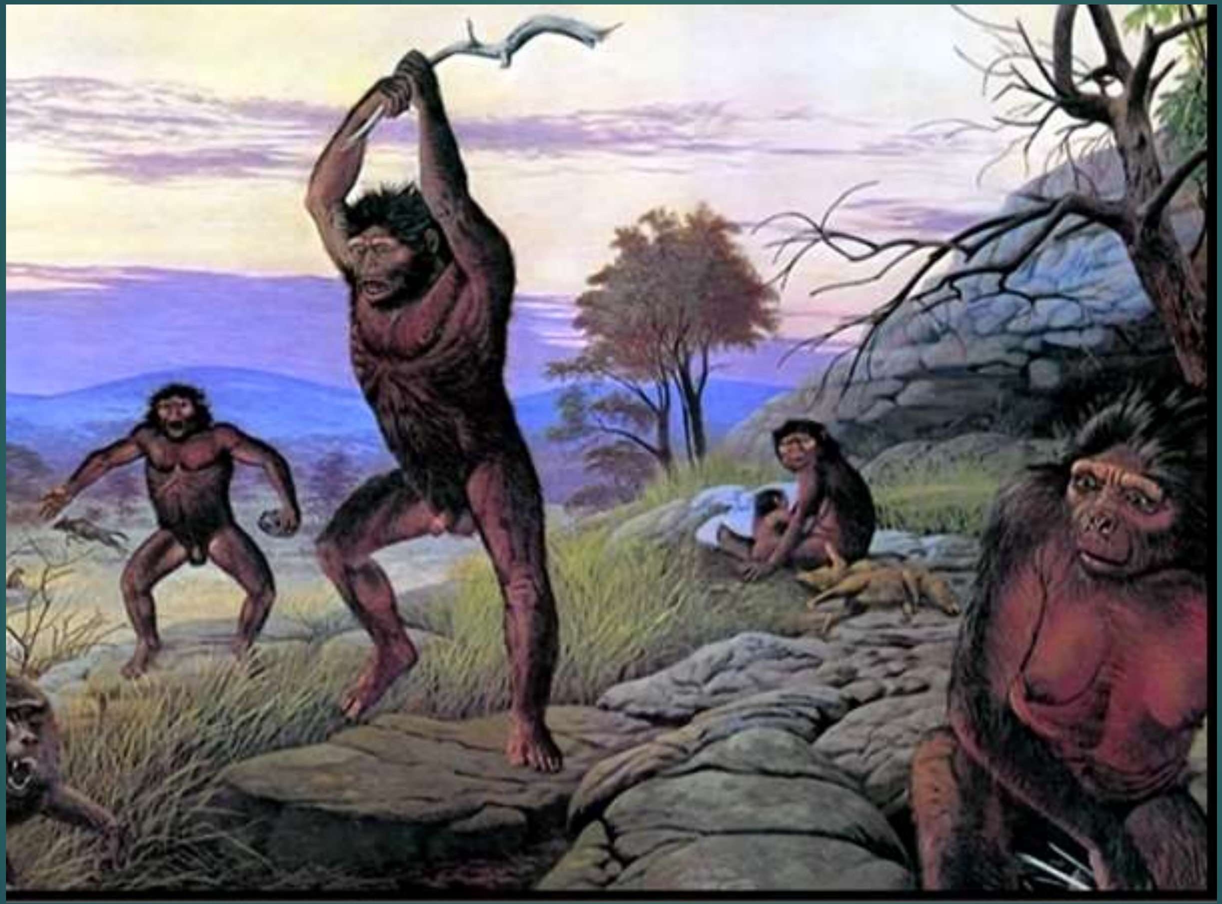
Sagittal Crown

- 2017 study of sagittal crowns in gorillas: sagittal crest appears right after their wisdom teeth emerge in early adulthood, so that fits in with the timing of social dominance; female gorillas prefer males with larger crests.
- *Paranthropus robustus*, *Paranthropus boisei, Paranthropus aethiopicus* and *Australopithecus afarensis* all have sagittal ridges
- Two functions of sagittal ridges:
  - Diet: Ability to eat tough food (used to infer the masticatory habits [chewing habits])
  - Sexual selection: social signaling, male dominance
- May imply male-male competition for access to females.
- It's a polygynous reproductive strategy rather than a monogamous one.
- A 2011 study using ratios of strontium isotopes in teeth suggested that *Australopithecus africanus and P. robustus* groups were patrilocal: females tended to settle farther from their region of birth than males did.

Katharine Balolia, et al., 2017

2001: Space Odyssey

Robust Australopithecines



Paranthropus aethiopicus
Paranthropus robustus
Paranthropus boisei
Australopithecus sediba
Australopithecus africanus
MEET a grass-eating specialist

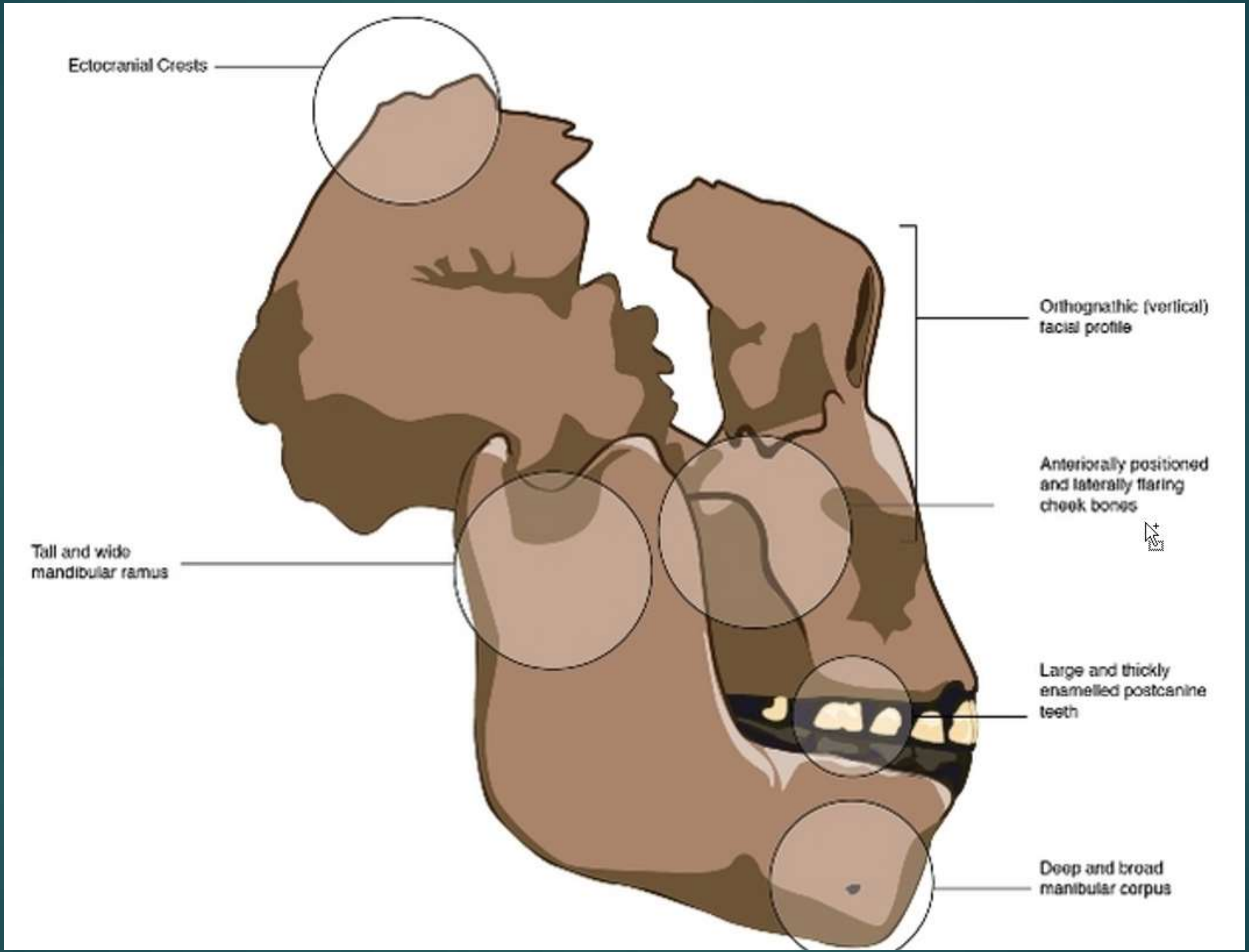
Paranthropus robustus
1.8 to 1.2 million years ago; South Africa
Paranthropus boisei
2.3 to 1.2 million years ago; eastern Africa
Teeth Comparison

Schoolboy Gert Terblanche found 1st robustus: Cash & 5 Chocolate bars for *P. robustus*

- 1938: A partial cranium and mandible of *Paranthropus robustus* was discovered by a schoolboy, Gert Terblanche, at Kromdraai (70 km south west of Pretoria) in South Africa.

- 1938: It was described as a new genus and species by Robert Broom of the Transvaal Museum. Broom made TM 1517 the type specimen of P. robustus

Australopithecus (Paranthropus) robustus


Ectocranial Crests
Orthognathic (vertical) facial profile
Anteriorally positioned and laterally flaring cheek bones
Tall and wide mandibular ramus
Large and thickly enamelled postcanine teeth
Deep and broad manibular corpus

1938: *Paranthropus robustus*, Swartkrans; 1st robust australopithecine discovered

Paranthropus robustus (TM 1517)

Discoverer: Gert Terblanche

Date: 1938

Locality: Kromdraai, S. Africa

Age: 2 M

Australopithecus (Paranthropus) robustus, 2-1 MA

Distribution: S. Africa
Diet: Roots and tough fibrous vegetable matter
Cranial capacity: 500 cc

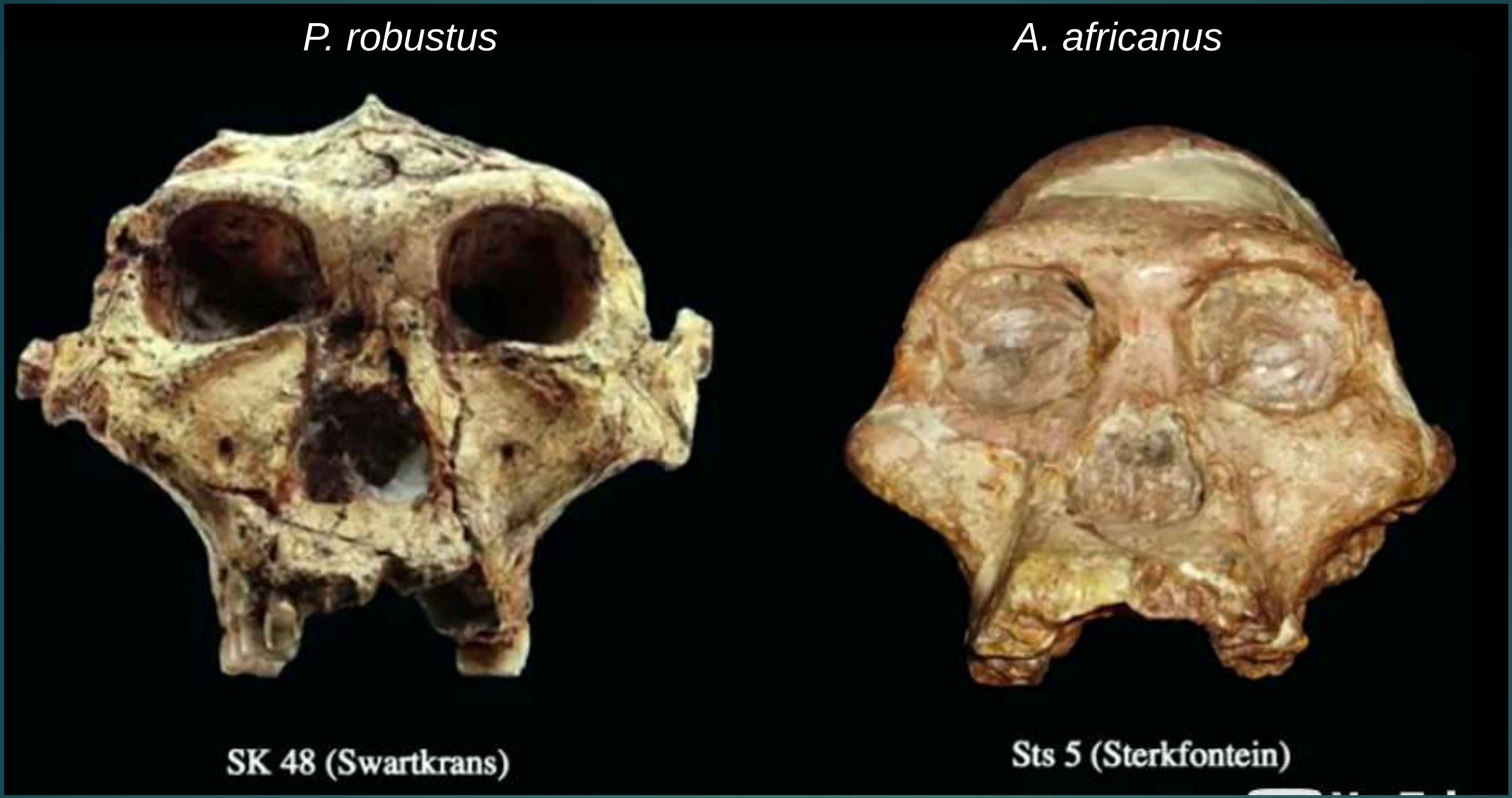
1948: *Paranthropus robustus*, SK 48

Big teeth, huge jaws and strong chewing muscles anchored to a skull crest

Only in South Africa; <u>130 individuals</u> at Swartkrans; life span = 17 years

Swartkrans 48: *P. robustus*

- The first evidence historically of this robust lineage, comes from South Africa.
- Indicates that across valley from Sterkfontein, there were other species
- Later than *A. africanus*
- Overall pattern of variation seen in these South Africa caves is tremendous. Variation in dental, facial, and postcranial morphology
- 2.5 MA
- Is this variation sexual or species?



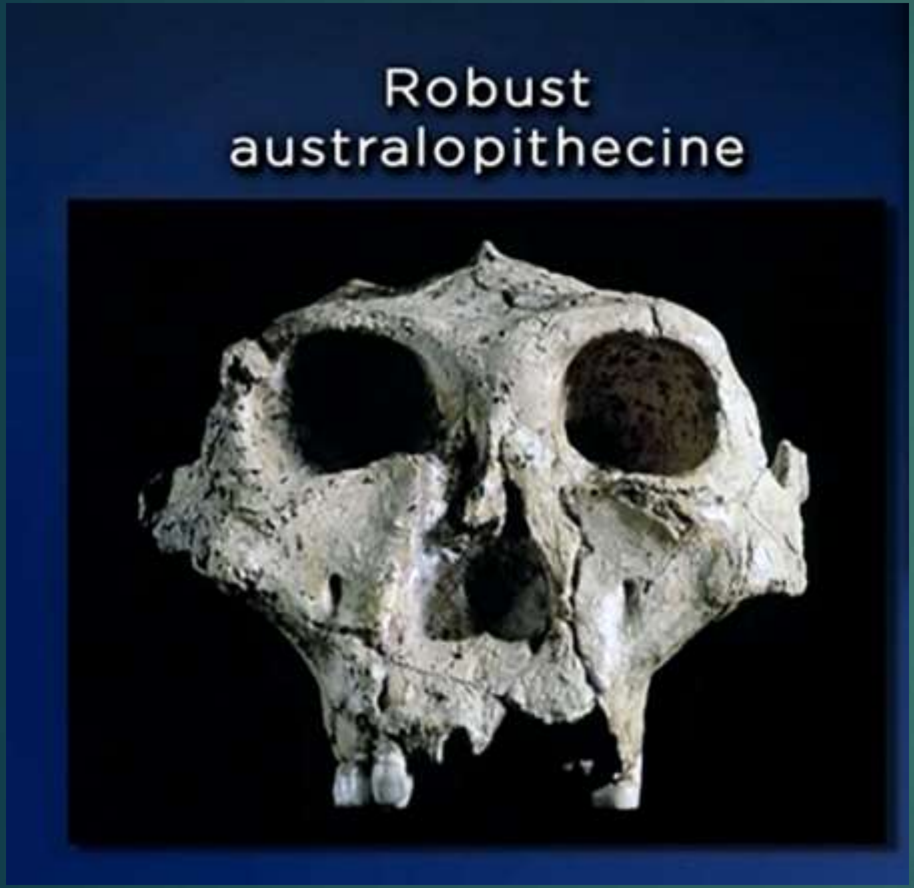
- Separated by few miles & several hundred thousand years
- Later SK 48 has wider face and zygomatics & hollowing out of face

P. robustus, SK 48 cranium from Swartkrans vs. *A. africanus*, Sts 5 from Sterkfontein

SK 48: very large molars

Figure 2: *Paranthropus robustus* and *Australopithecus africanus* from southern Africa. *P. robustus* is represented by the SK 48 cranium from Swartkrans and is shown in anterior (a), inferior (c), and superior (d) views. *A. africanus* is represented by Sts 5 from Sterkfontein and is shown in anterior view only (b). SK 48 is distinguished from Sts 5 by many of the traits depicted in Figure 1.

Robust Australopithecine: tall, vertical face; wide cheekbones (Masseter muscles connect here)



Small front teeth; huge flat premolars & molars made for grinding; can be as big as quarter; surface 4 x larger than humans; thick enamel

Australopithecus (Paranthropus) robustus

- Cooling of climate reduced rainfall
- Development of scrubland and savannah forest retreats
- Diet: Roots and tough fibrous vegetable matter
- Cranial capacity: 530 cc (Chimp = 400cc)
- Heavy muscular skull, sagittal crest

Makapansgat: oldest cave, 3.5 MA; Like *A. afarensis*

- Large molars with thick enamel
- Reduced canines with apical wear
- Apical wear throughout indicating abrasive diet

Makapansgat 40 & Kromdraai 1517: very robust

Unclear if species temporally overlapped or whether 1 was ancestral

Type specimen of *P. robustus*

Later robustus: SK 23

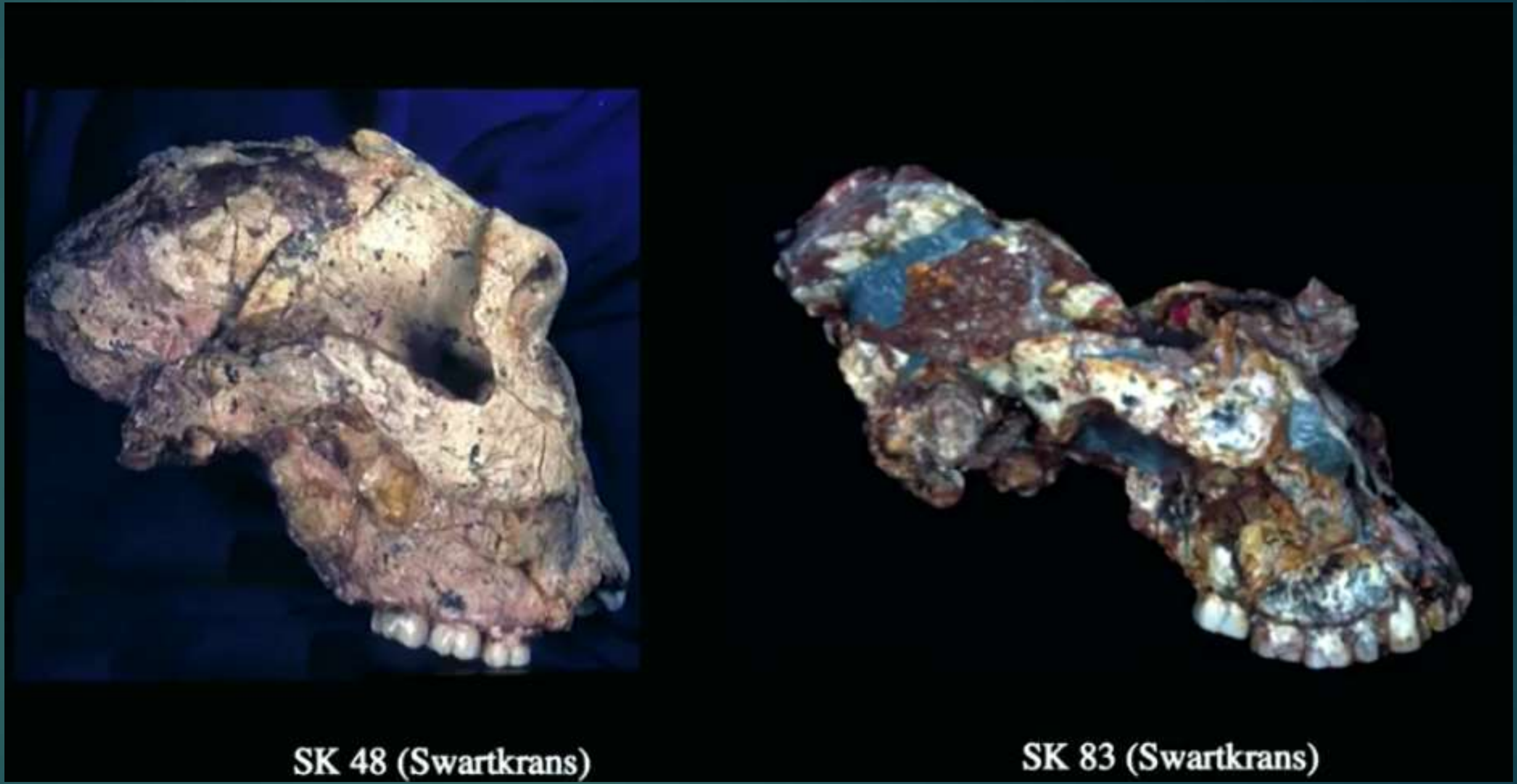
Characteristics:
Elongated molars;
molarized premolars
Very thick enamel
Dental crowding

SK 23 lateral

- very tall vertical ramus, associated with large chewing muscles.

Lateral

- Very large zygomatics
- Directly in line with molars



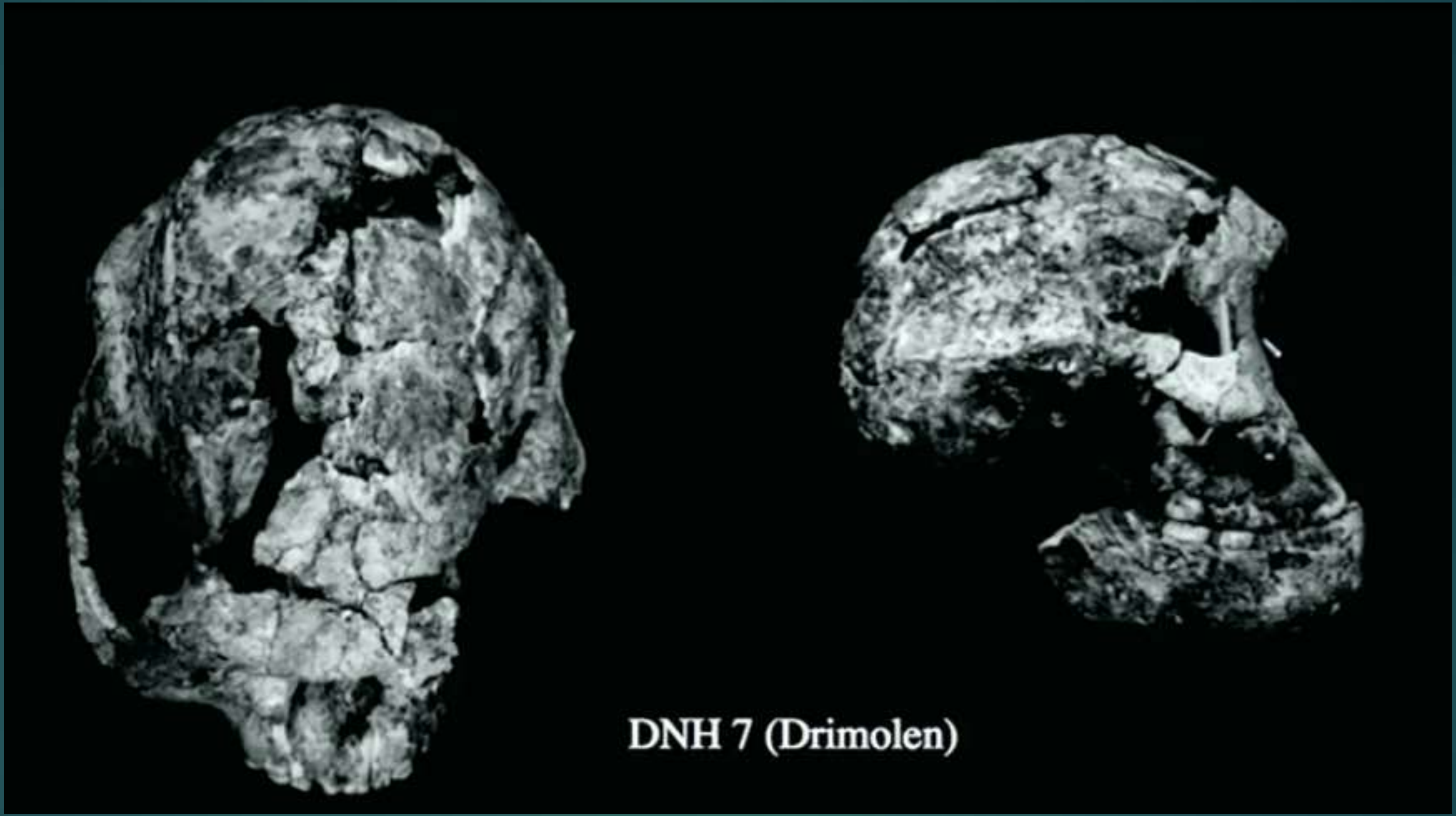
Frontal

Female

Issue of sexual dimorphism

Drimolen

Superior

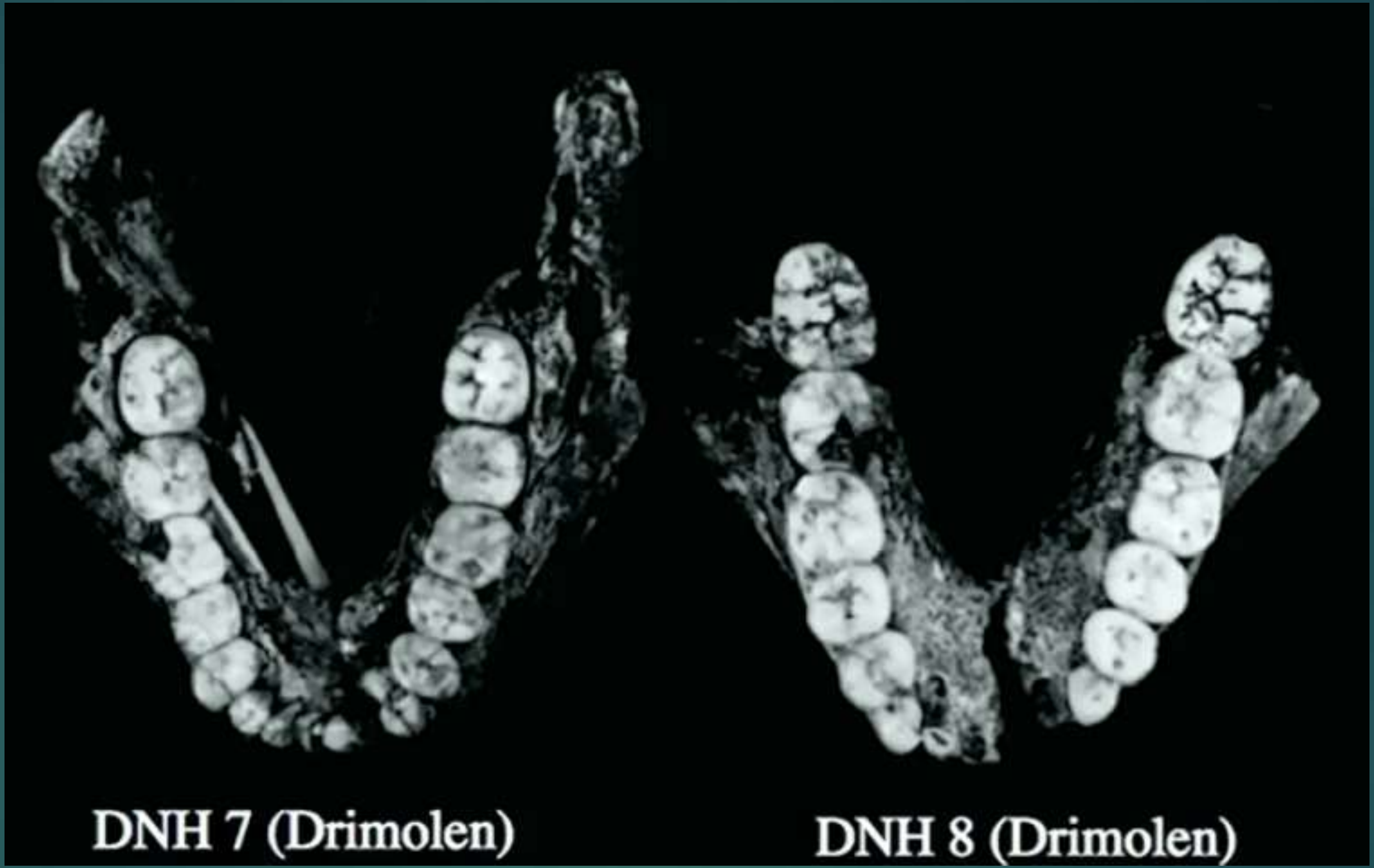


Lateral

Dished out face due to anterior movement of zygomatics

Mandibles

- Very large molars
- Very little space for incisors
- Emphasis on chewing in *robustus*
- Long duration chewing life



Male??

Robustus endocast

- Larger brain than *H. africanus*
- Slightly larger frontal lobe
- Increased posterior size

Sterkfontein 17

- Maxilla of Sterkfontein 17.
- Increasing size across the molar dentition with relatively small M1, a larger M2, and an M3 that's even a little bit bigger here if we reconstruct its full dimensions.
- So quite large teeth, even from the more gracile version of the South African specimens.

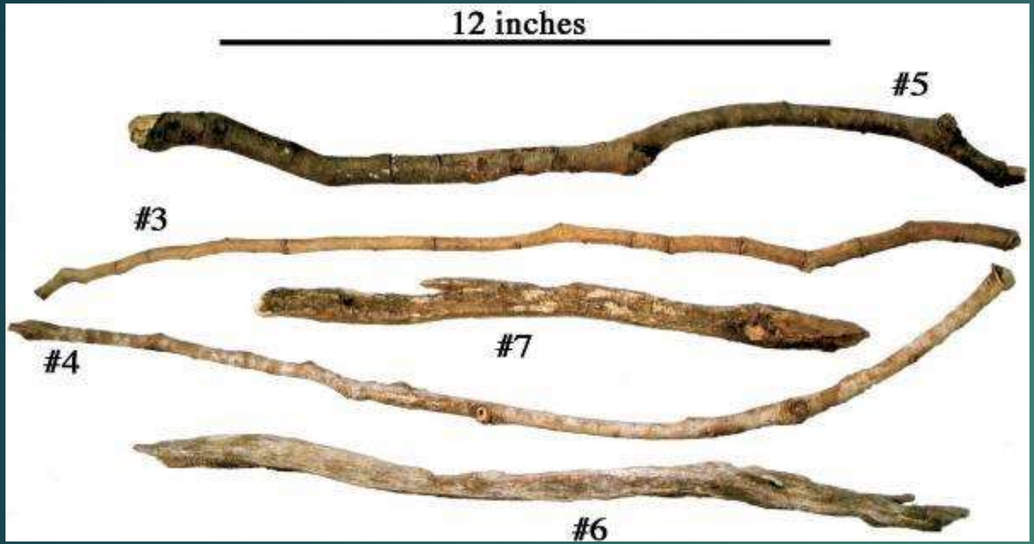
Sterkfontein 71: one of youngest S African fossils

- Less broad face
- Less robustness throughout

One of earliest sites of Sterkfontein: variation

- Like *A. afarensis*
- Diamond like large canine
- Large premolars
- Large, but not super robust molars
- Similarly sized molars

Robust australopithecine behavior



Digging sticks used by modern chimpanzees.

Pointed sticks have been found with robust australopithecine fossils

- Omnivores, but relied on hard to chew foods (nuts, roots, seeds)
- Probably used tools (bones/horns showing polishing, maybe used for digging up roots)
- Lived in (open) woodlands and savannas
- Evolutionary dead end

Australopithicine tool use

- Pointed sticks found with P. robustus show wear that matches that produced by modern hunter-gatherers when they use sticks to break into termite hills.
- Bone evidence at several australopithecine sites, including places like Swartkrans, that might have been tools.
- Small tools, small bones not unlike chimp termite stick that show evidence of polishing along the edges.
- This polishing around the edge might have been from repeated use.
- Australopithecines may have been using these small bone instruments much like chimpanzees use termiting sticks or for digging up tubers

Bone tools

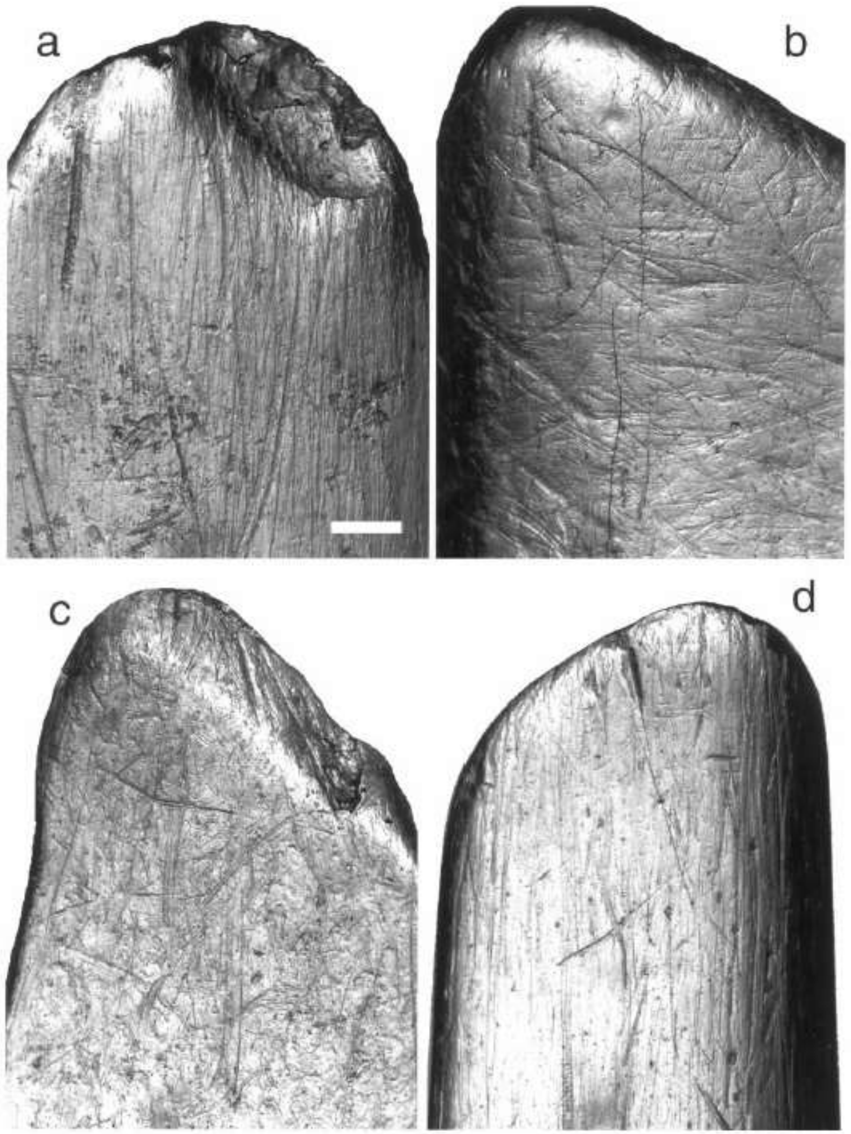


Fig. 1. Wear pattern on Swartkrans and experimental bone tool tips photographed in transmitted light from transparent resin replicas. (*a*) Bone tool from Swartkrans Member 3 (SKX 38830). (*b*) Tip of a tool used in Brain's experiment (7) to dig up *Scilla marginata* bulbs. (*c*) Experimental bone tool used to dig the ground in search of tubers and larvae. (*d*) Experimental bone tool used to dig in a termite mound. Note the similarity in the orientation and the width of the striations in a and *d*. (Scale bar, 2 mm.) Related figures are published as supplemental data on the PNAS web site, www.pnas.org: Fig. 4, Swartkrans bone tools; Fig. 5, use of a bone tool to dig a termite mound; and Fig. 6, wear patterns as in a and *d* above.

+ 23 others

Robustus in Swartkrans: bones with lots of scratches (replication indicates most similar to digging at termite mounds)

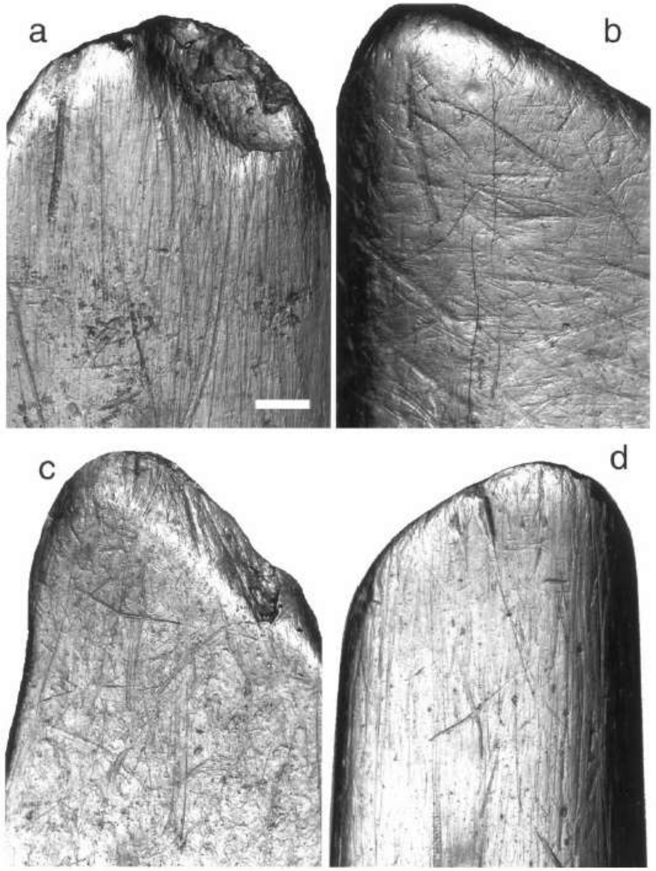


Fig. 1. Wear pattern on Swartkrans and experimental bone tool tips photographed in transmitted light from transparent resin replicas. (*a*) Bone tool from Swartkrans Member 3 (SKX 38830). (*b*) Tip of a tool used in Brain's experiment (7) to dig up *Scilla marginata* bulbs. (*c*) Experimental bone tool used to dig the ground in search of tubers and larvae. (*d*) Experimental bone tool used to dig in a termite mound. Note the similarity in the orientation and the width of the striations in *a* and *d*. (Scale bar, 2 mm.) Related figures are published as supplemental data on the PNAS web site, www.pnas.org: Fig. 4, Swartkrans bone tools; Fig. 5, use of a bone tool to dig a termite mound; and Fig. 6, wear patterns as in *a* and *d* above.

+ 23 other bone tools with scratches

Bone tools

- Presumed that modified bones from Swartkrans and Sterkfontein in South Africa represent the oldest known bone tools and were used by *Australopithecus robustus* to dig up tubers.
- Macroscopic and microscopic analysis of the wear patterns on the purported bone tools, pseudo bone tools produced naturally by known taphonomic processes, and experimentally used bone tools confirm the anthropic origin of the modifications.
- Analysis suggests that these tools were used to dig into termite mounds, rather than to dig for tubers. Indicates a bone tool material culture that may have persisted for a long period and strongly supports the role of insectivory in the early hominin diet.
- Protein & fat from termites: While a rump steak yields 322 Calories per 100 grams, and cod fish 74, termites provide 560 Calories per 100 grams

"Evidence of termite foraging by Swartkrans early hominins" (2001) by Linda Blackwell & Francesco d'Errico

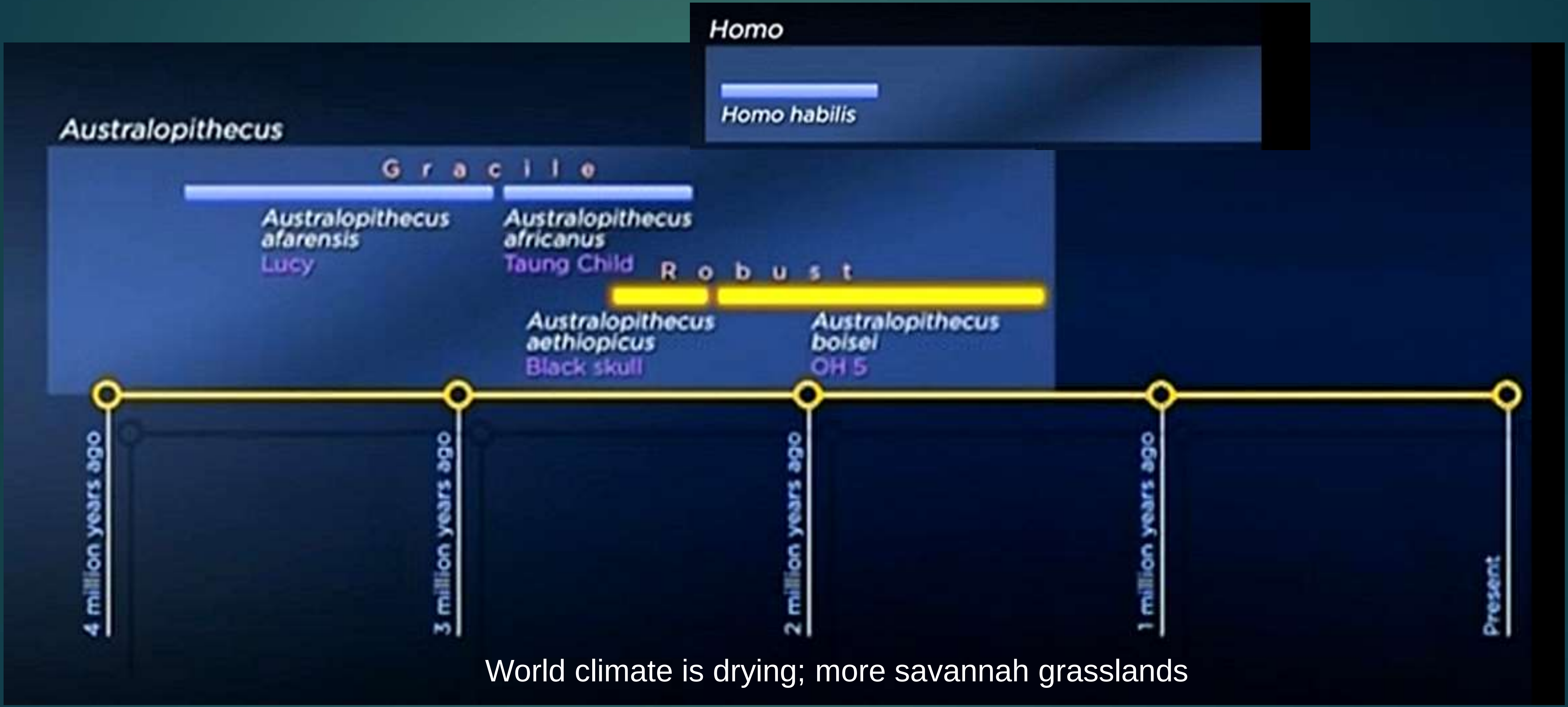
Matthew Sponheimer:
Isotope C3 & C4 & Diet

- Univ. of Colorado
- You are what you eat: type of carbon in your teeth
- C3: trees, shrubs; C4: grasses, sedges (Savannah)
- By about 2.5 Ma, Paranthropus in eastern Africa diverged toward C4/CAM specialization

C3 vs. C4

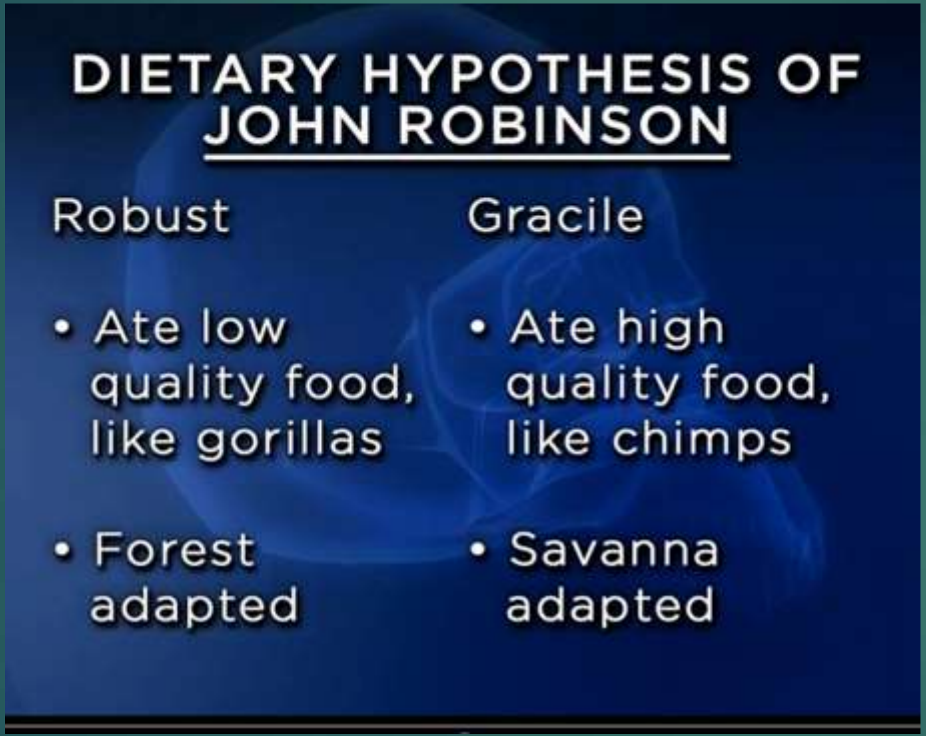
- Before 4 Ma, hominins had diets that were dominated by C3 resources and were similar to chimpanzees.
- By 3.5 Ma, multiple hominin taxa began incorporating 13C-enriched [C4 or crassulacean acid metabolism (CAM)] foods in their diets.
- Overall, there is a trend toward greater consumption of 13C-enriched foods in early hominins over time.
- Hominin carbon isotope ratios also increase with postcanine tooth area and mandibular cross-sectional area, which could indicate that these foods played a role in the evolution of enlarged australopith masticatory robusticity.
- *P. boisei* – C4 like a zebra
- Early homo – C4 from meat (animal that ate plant)

P. robustus: lived for 1 million years, overlapping Aust. and Homo



John Robinson (1923-2001) – South Africa robust australopithecines

- Robust vs gracile australopithecines: dietary specializations



- Later challenge to this hypothesis: other factors too

Robustus: Dietary flexibility

- *P. robustus*: lived for 1 million years, overlapping *Australopithecus* and *Homo*
- Remains of:
  - *A. africanus* from Sterkfontein had high Sr/Ca ratios, like grazers.
  - *P. robustus* from Swartkrans had substantially lower Sr/Ca ratios than *A. africanus*, within the range of all the other animals, including browsers, grazers, and carnivores.
  - Bone levels of barium and strontium decrease with an organism's increasing position in the food-chain; they are used by archaeologists to estimate past consumption of plants versus meat.
- Robustus tooth at Swartkrans: over 2 year period went from mostly C3 foods (trees) to mostly C4 foods (grasses)
- Survival no matter what food is available; survive in ecology of changing climate; flexibility gives survival advantage
- Potential to use lower quality food like grasses and seeds: Zinj was originally known as Nutcracker Man, but now known to mainly eat grasses & sedges
- Gracile & robust *Australopithecines* ate same range of foods; but as climate shifted, different fall back diets; in effect, more omnivore

Dietary conclusions

- Bones and teeth of early hominins reflect the typical diet that did not require a specialized dental adaptation.
- The dentition of chimps and *gorillas* reflects differences in fallback resources rather than preferred foods.
- Chimps and gorillas usually eat fruit in forested tropics; but gorillas can fall back on lower quality food when fruit unavailable; chimps look harder for fruit (or meat)
- Therefore, the dental specializations of early hominins, in particular the enlargement of the postcanine dentition, reduction of the incisors and canines, and the low crowns of the molar teeth probably were adaptations to fallback diet that nevertheless was extremely important at select times.
- This would be characteristic of fallback foods eaten at times of resource scarcity, and would evidently have consisted of hard, brittle food items that could be effectively pulverized and ground by low-crowned teeth with large surface areas and thick enamel.

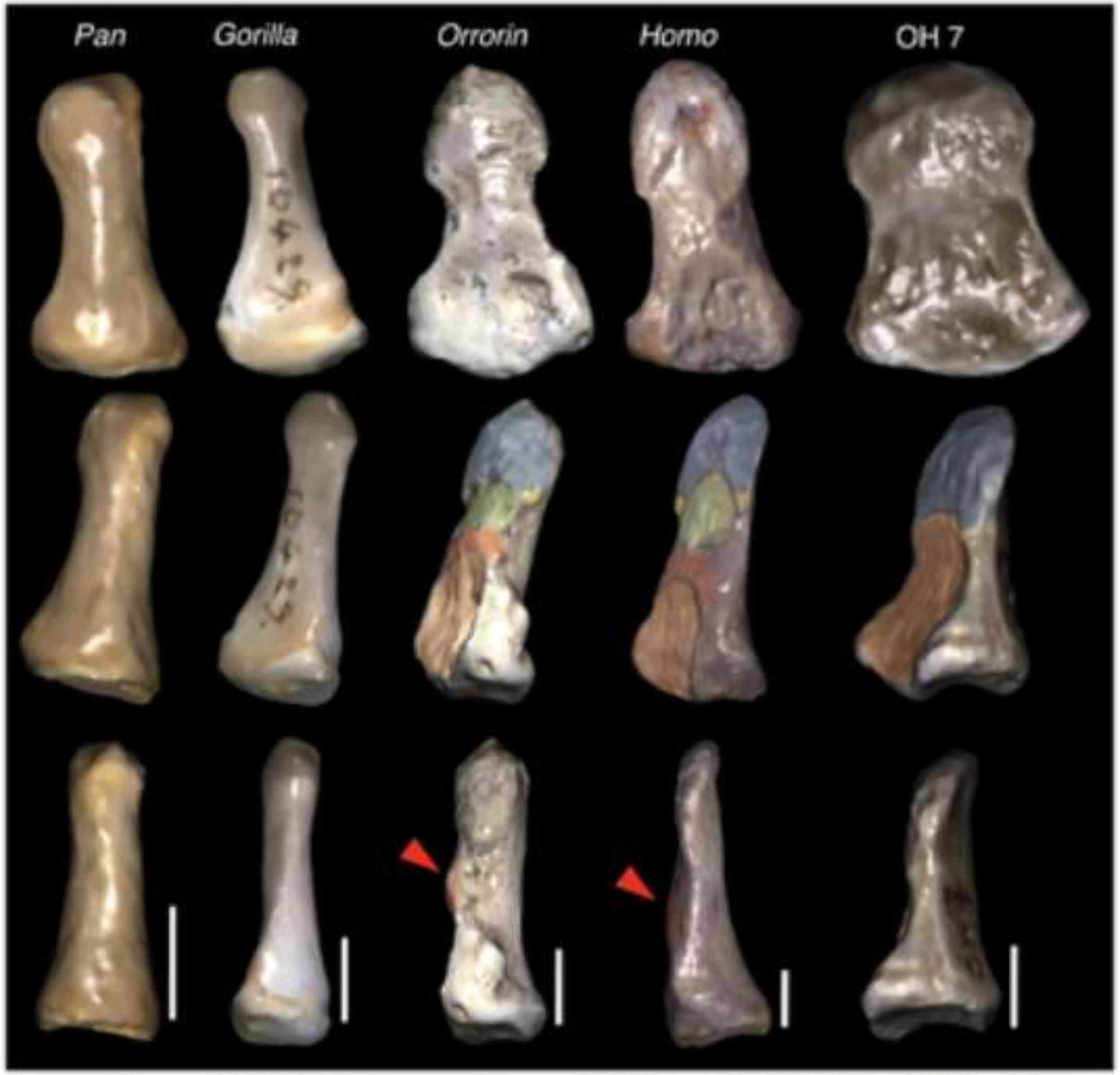
Rough food

Upper jaw of Paranthropus robustus, which lived 1.2-1.8m years ago. Credit: Ian Towle, Author provided

Peter Unger:
Teeth Microwear & Diet

- Paleontologist, U. of Arkansas
- Diet in human evolution
- Surface analysis technologies; Dental microwear texture analysis gives diet from tooth shape and patterns of use wear.
- Gorillas prefer fruit
- *A. afarensis*: grinding teeth: leaf, grasses
- *Paranthropus boisei*: parallel scratches - grasses, sedges
- *P. robustus*: pits - mixed;
- early *Homo*: cresty shear teeth - more meat, broader diet

Thumb comparison



Comparison of distal phalanges (bones at the end of the thumb) in chimps (Pan), gorillas, Orrorin, modern humans (Homo) and Homo habilis (OH 7) (source: Almécija et al. 2010).

Robustus

West Turkana, Kenya	**Nachukui**	**2.5-2.35**	**radiometric; marker beds**	**KNM-WT 17000 (cranium), KNM-WT 16005 (mandible)**	**P. aethiopicus**
		2.3-1.6		Various specimens	P. boisei
Koobi Fora, Kenya	Region	Site	Geologic Formation	Estimated Age of Hominins (Myr)	Dating Method
		1.88-1.65		KNM-ER 406, 407, 732 (all crania) and others	P. boisei
		1.65-1.39		KNM-ER 729, 3230 (both mandibles) and others	P. boisei
Omo, Ethiopia	Shungura	2.6-2.3	radiometric; marker beds	Omo 18-18 (edentulous mandible; holotype of P. aethiopicus), and others, mostly isolated teeth	P. aethiopicus

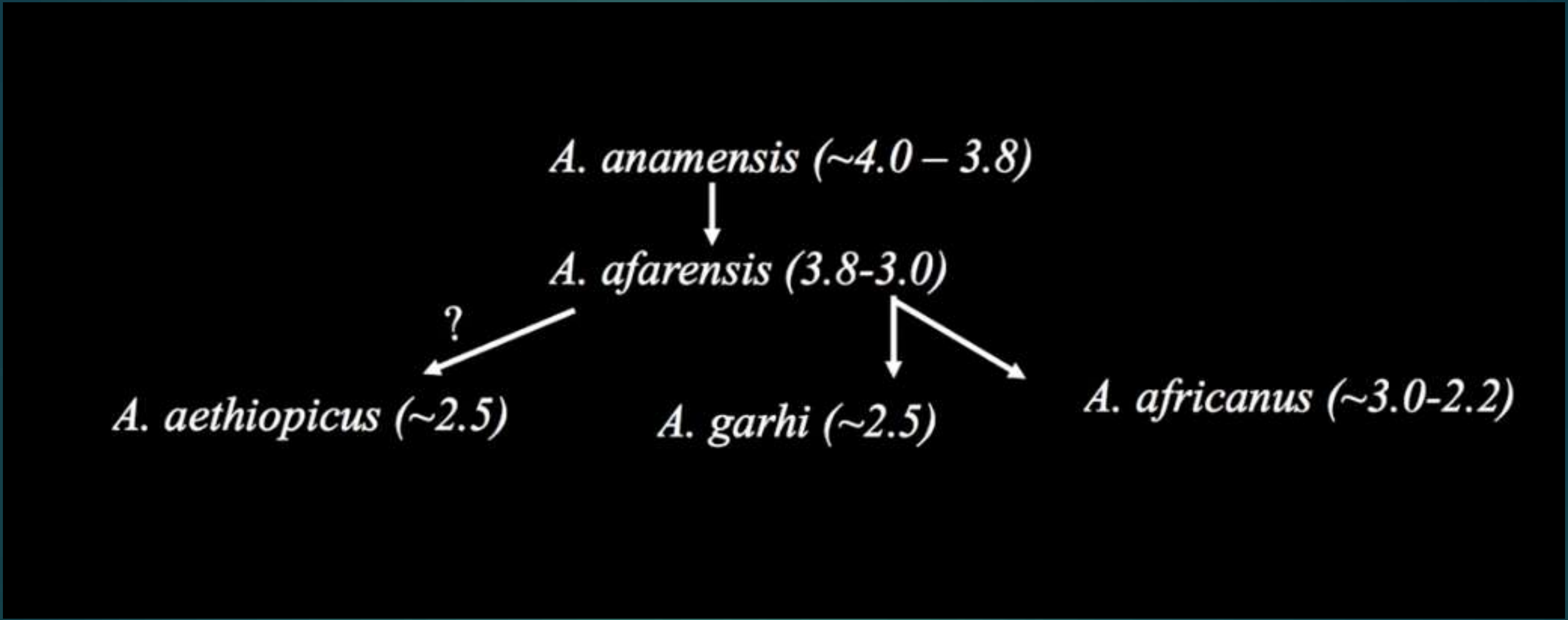
East Africa

Chesowanja, Kenya	**Chemoigut**	**2.0-1.5**	**biostratigraphy; radiometric of capping layer**	**CH1 (partial cranium), other fragments**	**P. boisei**
Konso, Ethiopia	Konso	1.4	radiometric; tephrostratigraphy; marker beds	KGA 10-525 (skull), and others	P. boisei
Malema, Malawi	Chiwondo	1.5	biostratigraphy	RC 911 (maxilla)	P. boisei
Peninj, Tanzania	Humbu	1.7-1.3	radiometric; magnetostratigraphy	Peninj mandible	P. boisei
Olduvai Gorge, Tanzania	Olduvai	1.9-1.7	radiometric; biostratigraphy	OH 5 (cranium; holotype of P. boisei)	P. boisei
		1.7-1.2		Various specimens	P. boisei
Swartkrans, South Africa	Monte Christo	1.8-1.5	biostratigraphy	>300 Paranthropus specimens total, mostly isolated dental remains, including SK6 (holotype of P. crassidens)	P. robustus (P. crassidens)
		1.5-1.0			P. robustus (P. crassidens)
		1.5-1.0			P. robustus (P. crassidens)

Southern Africa	**Swartkrans, South Africa**	**Monte Christo**	**1.8-1.5**	**biostratigraphy**	**>300 Paranthropus specimens total, mostly isolated dental remains, including SK6 (holotype of P. crassidens)**	**P. robustus (P. crassidens)**
			1.5-1.0			P. robustus (P. crassidens)
			1.5-1.0			P. robustus (P. crassidens)
	Kromdraai, South Africa	Monte Christo	2.0-1.5	biostratigraphy; reversed polarity	Close to 30 Paranthropus specimens, including TM1517 (skull; holotype of P. robustus)	P. robustus
	Sterkfontein, South Africa (M5B)	Monte Christo	1.4-1.1	magnetostratigraphy	Two specimens: Stw 566 & Stw 569	P. robustus
	Drimolen, South Africa	Monte Christo	2.0-1.5	Overall faunal assemblage composition; no absolute dates	>80 hominins, including DNH 7 (nearly complete female skull) and DNH 8 (male mandible)	P. robustus
	Gondolin, South Africa	Eccles	1.9-1.5	biostratigraphy (tentative)	GDA-2: a very large mandibular M2	P. sp.
	Cooper's Cave, South Africa	Monte Christo	1.5-1.4	radiometric; biostratigraphy	COB 101 (partial skull) and others, mostly teeth but also postcrania	P. robustus

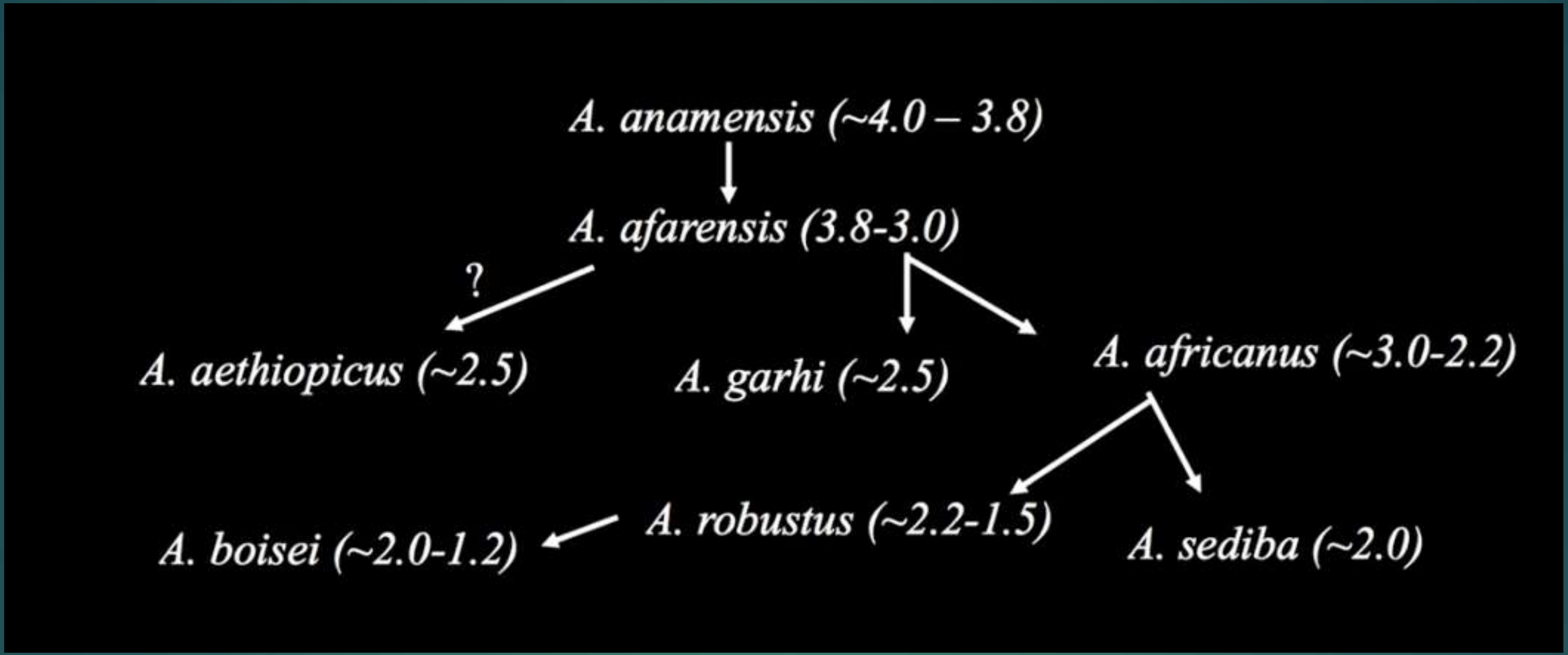
Table 1: The Paranthropus fossil evidence.

Ancestry



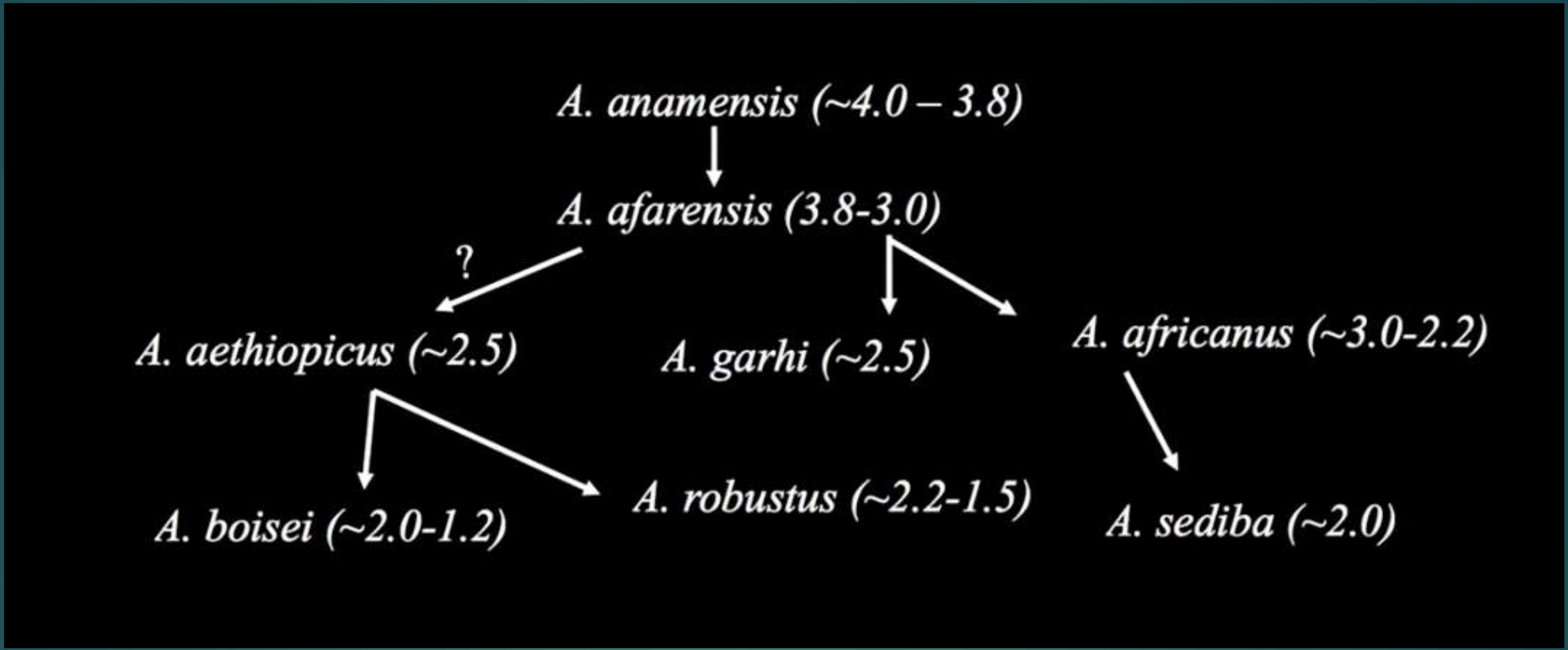
- ? Of whether Australopithecus africanus and Australopithecus garhi are actually the same thing or different species. Recall that garhi is actually very similar in terms of its preserved morphology with africanus, at least in terms of the dental remains; in East and Southern Africa

Ancestry



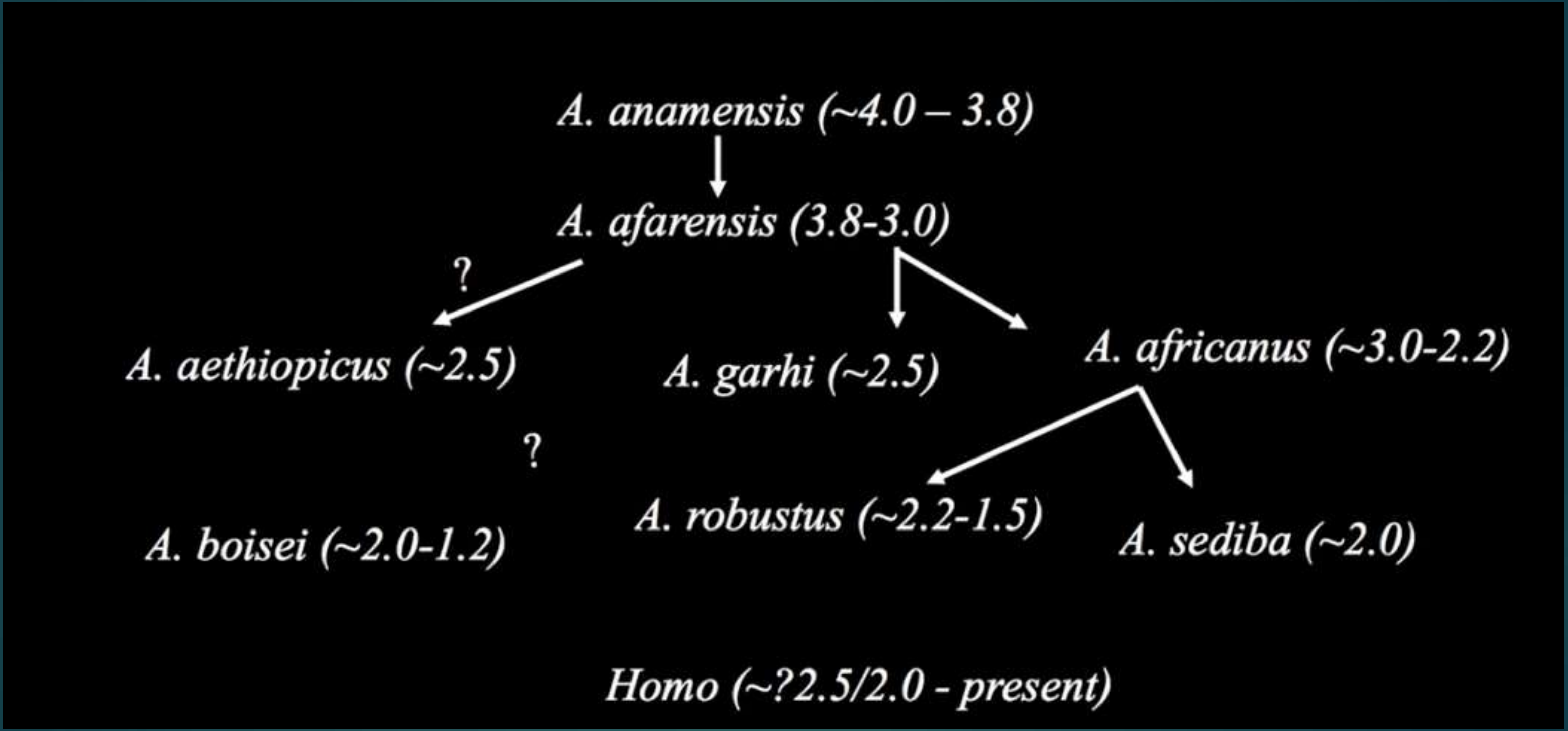
- A. africanus: ancestor ? of robustus and sediba (robust & gracile variants? An *Australopithicine* genus
- Boisei is descendant of robustus? Different species from common ancestor?

Ancestry



- Boisei and robustus as descendants of aethiopicus?
- A different genus: Paranthropus?
- The distinction of Paranthropus is a recognition or use of the term genus to mean, basically, an ecological shift. Things of the same genus are basically representative of similar kinds of ecological organisms.

Ancestry


A. anamensis (~4.0 – 3.8)
A. afarensis (3.8-3.0)
?
A. aethiopicus (~2.5)
A. garhi (~2.5)
A. africanus (~3.0-2.2)
?
A. robustus (~2.2-1.5)
A. boisei (~2.0-1.2)
A. sediba (~2.0)
Homo (~?2.5/2.0 - present)

Paranthropus Behavior

- Studies of dental growth and development, inner ear morphology and brain shape, all seem to indicate that *Paranthropus* was more ancestral than initially recognized. There was a fairly high level of sexual dimorphism, at least in *P. boisei* (KNM-ER 406 and KNM-ER 732 from Koobi Fora)
- On the other hand, several lines of circumstantial evidence point to a more "advanced" hominin, including studies suggesting that *Paranthropus* used, if not made, tools (Stone and bone tools at Swartkrans and bone tools at Drimolen, where most were *P. robustus*).
- Stone tools have also been found in the Oldowan Infill (aka M5B) of Sterkfontein's Member 5, where approximately half of the specimens are believed to be those of *P. robustus*.

Paranthropus Behavior

- Swartkrans hand fossils indicate a modern human-like precision grip to *P. robustus*.

- It appears that *Paranthropus* was one of the first hominin taxa to routinely venture into open grassland areas possibly to acquire novel open habitat resources such as termites or plant underground storage organs such as tubers, bulbs, and grass corms.

- Biochemical analyses of the diet of *P. robustus* indicate they were omnivorous and possibly even changed their diets seasonally.

Paranthropus Behavior

- Recent studies of *P. boisei*'s dental microwear and stable isotope composition indicate that their diet was limited to a C4-based plants (grasses & sedges).
- *Paranthropus* disappears from the fossil record sometime between 1.4 and 0.9 Ma, after a geologic lifespan of just over a million years
- The cause(s) of their extinction is a mystery.
- Early notions that they had become too specialized to cope with changing environmental conditions have been strongly challenged.
- Competition with *Homo* is plausible, but indisputable evidence for either direct or indirect interaction between the two genera has yet to be discovered.

Constantino, P. J. (2013) The "Robust" Australopiths. Nature Education Knowledge 4(1):1

Taxonomic Controversy: *Paranthropus* or *Australopithecus*?

- Ever since Broom's 1949 announcement of a new type of hominin from Swartkrans, paleoanthropologists have been debating the taxonomy and phylogeny of the "robust" australopiths
- Placing the three commonly recognized species (*P. robustus*, *P. boisei*, and *P. aethiopicus*) in their own genus requires that they are:
  - (1) adaptively different from *Australopithecus*, and
  - (2) monophyletic (i.e., more closely related to each other than to any other species).
- The current debate largely centers around the second criterion. The distinction of Paranthropus is a recognition or use of the term genus to mean, basically, an ecological shift
- Many researchers believe that the shared skull morphology of the "robust" australopiths is homoplasious (i.e., independently evolved in two or more of the taxa) and thus place them in the genus *Australopithecus* by default.

Taxonomic Controversy: *Paranthropus* or *Australopithecus*?

- Homoplasy does appear to have been prevalent in the evolution of African fauna throughout the course of human evolution, even in the hominins themselves, but several pieces of evidence are nevertheless consistent with *Paranthropus* monophyly.

- Most telling is the fact that in a thorough cladistic analysis of hominin relationships, *Paranthropus* monophyly was supported in every instance, even when masticatory characters were excluded.

- Therefore, retention of *Paranthropus* as a distinct genus is warranted until convincing evidence demonstrates otherwise.

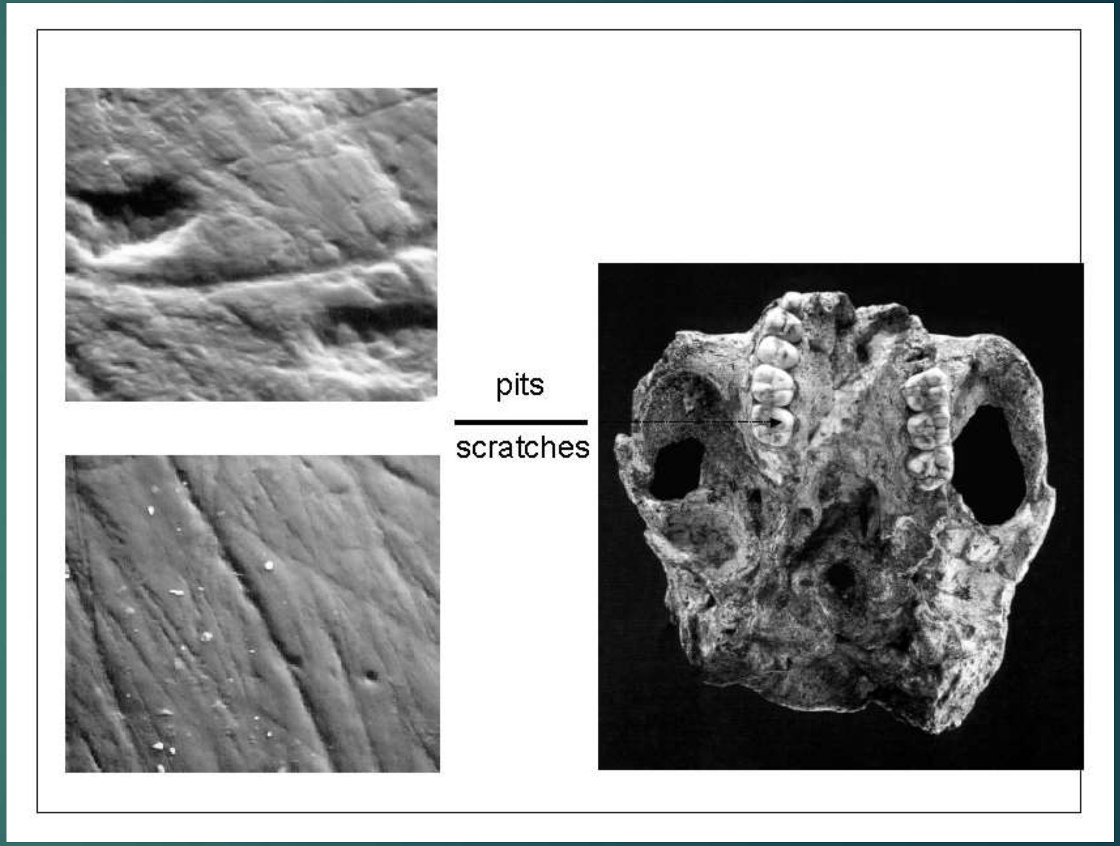
Eurydice, DNH-7, *P. Robustus*

- This is one of the most complete early hominin skulls ever found, and the first significant fossil of a female *P. robustus*. A lower jaw from a male of the same species, nicknamed Orpheus, was found a few inches away.

Paranthropus robustus skull, female, excavated 1994. "Eurydice", DNH-7 at the Sterkfontein caves.

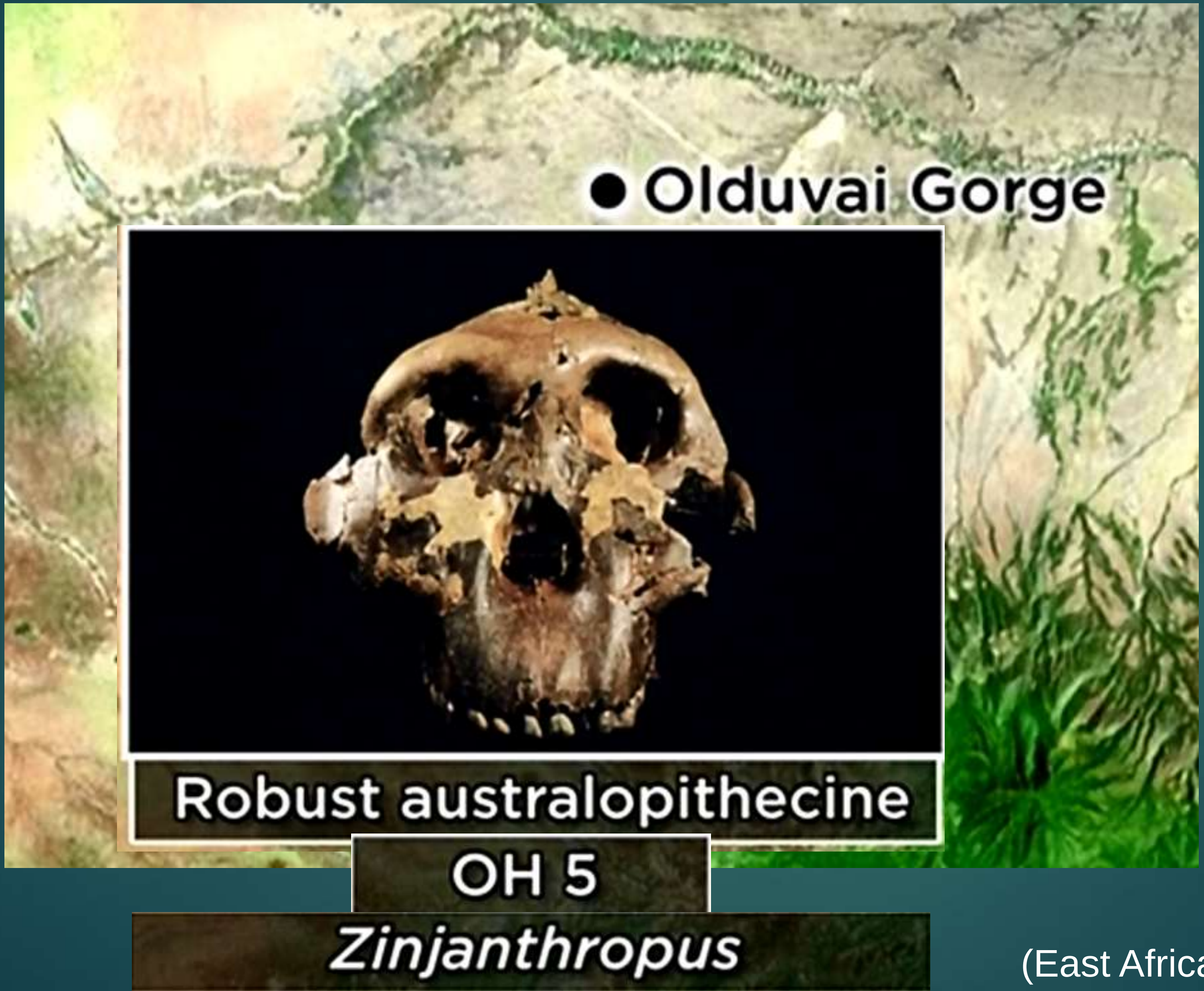
P. robustus reconstruction

Elephant teeth also made for grinding



Paranthropus boisei

The Leakeys discovers Robustus in East Africa



L. Leakey thought Zinj was the toolmaker of Oldowan tools found at Olduvai; but has the classic look of a *Robustus* vegetarian;
Now named *Paranthropus boisei*

(East African Man)

1959: *Paranthropus boisei:*
Most famous Olduvai Gorge fossil; “Zinj”: 1.8 M
Louis Leakey: “Why it’s nothing but a god-damned robust australopithecine!”

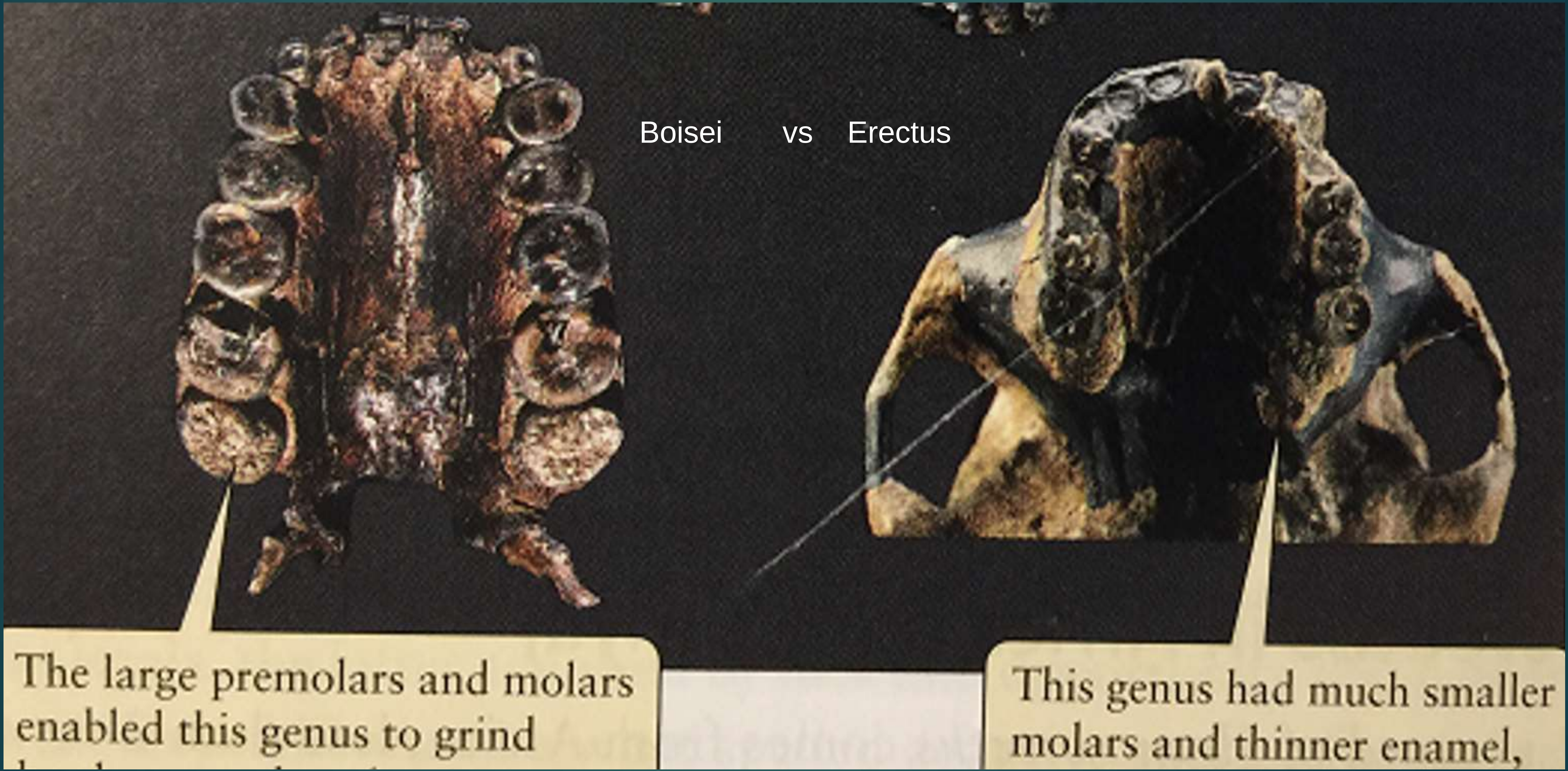
1959: Zinj, OH5, 1st dated fossil

Paranthropus boisei
(OH 5, type)
Discoverer: Mary Leakey

The greatest significance of *Paranthropus boisei* is that its 1959 discovery convinced the scientific world that the place to look for the earliest humans is Africa

Largest teeth of any hominin

Teeth: *Paranthropus* & *H. sapiens*

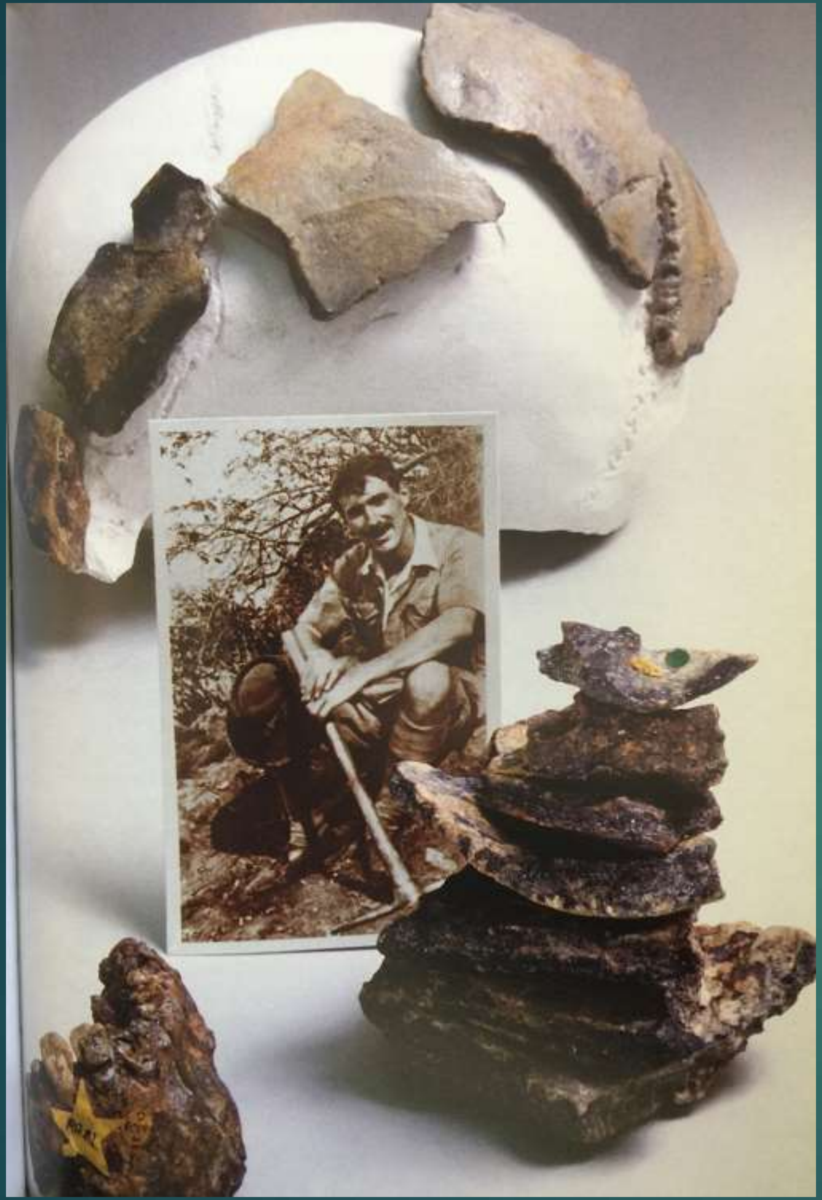


Boisei is no longer Nutcracker Man; only ate grasses and sedges

Early vegetarians returning from the kill.

Louis Leakey
First Superstar in Paleoanthropology

1920, Leakey as fully initiated Kikuyu Tribe member: “I still often think in Kikuyu, dream in Kikuyu,” 1936;



Louis Leaky was prone to exaggeration:
on early expedition: Kanjera fragments; Kanam jaw fragments in foreground

In 1932, he claimed the jaw was "the most ancient fragment of true *Homo* yet to be discovered anywhere in the world."

Ultimately, it was found that the Kanjera and Kanam specimens were relatively recent.

Leakey's reputation already had taken a beating when a British geologist visited Kanjera and reported that Leakey did not know exactly where he had found his famous fossil—an astonishing lapse for an anthropologist.

Louis Seymour Bazett Leakey (1903-1972): First Superstar in Paleoanthropology

- Pioneer East African paleontologist

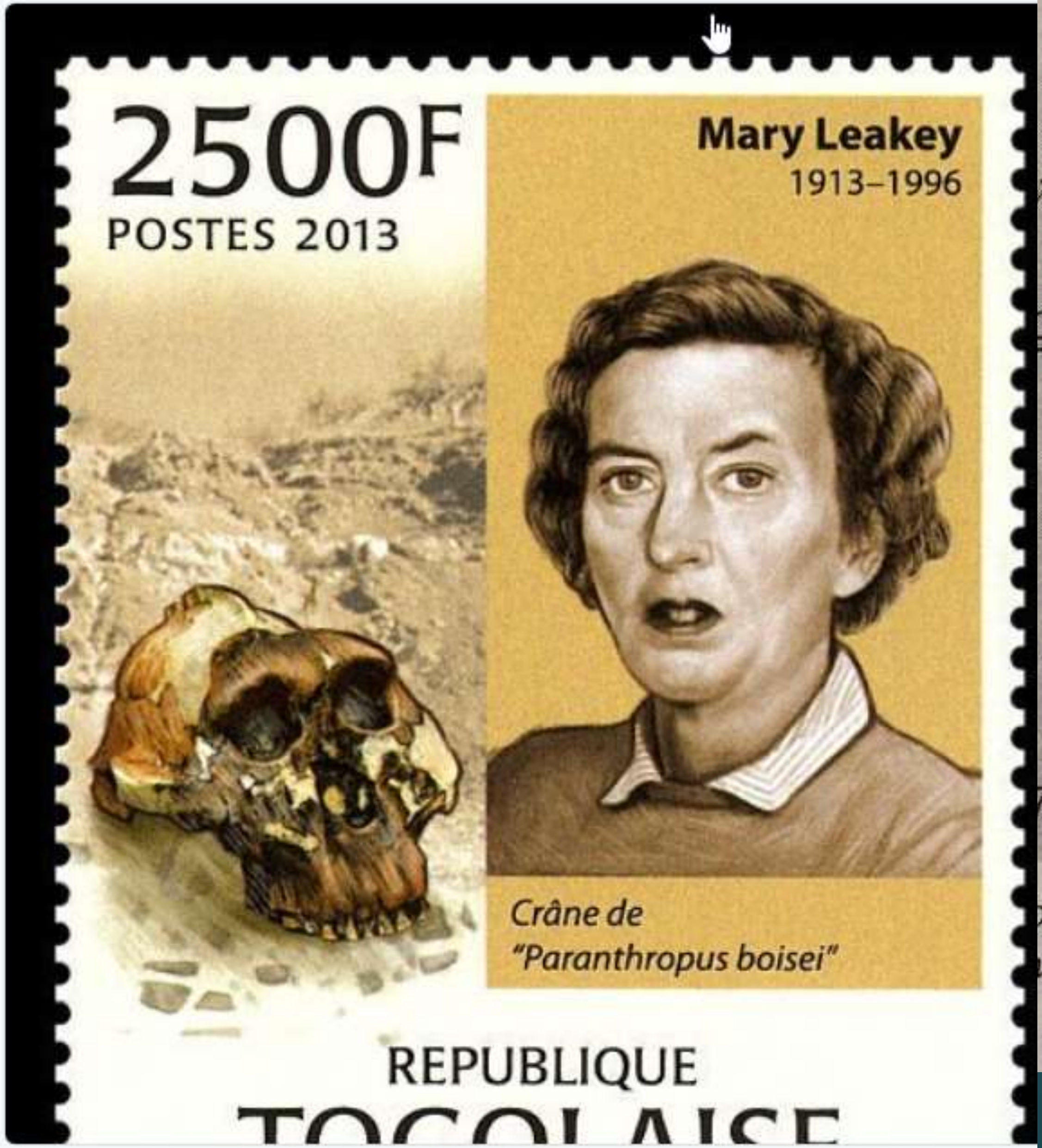
- One of the most renowned paleoanthropologists of all time; always controversial; a splitter

- In the 1930s discovered stone tools at Olduvai and elsewhere.

- 1943-1947: handaxes at Olorgesailie, Kenya, 400K

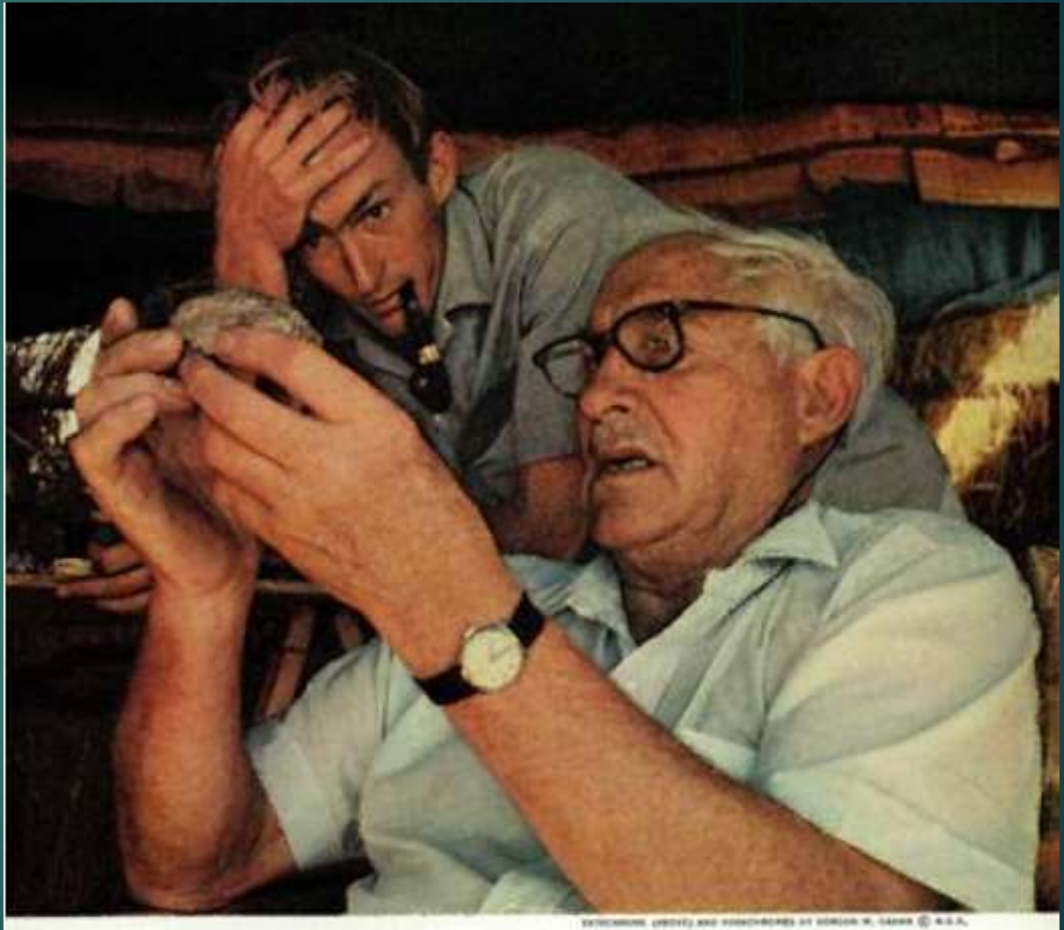
- 1959: son Jonathan Leakey found & Mary Leakey unearthed the first robust *Zinjanthropus boisei* (OH5) at Olduvai Gorge, Tanzania; first claimed as human ancestor; Later, reclassified as *Australopithecus*, then *Paranthropus*.

Postage Stamp issued by the Togolese Republic in 2013 depicting Mary Lea
and OH 5, the type specimen for Paranthropus boisei



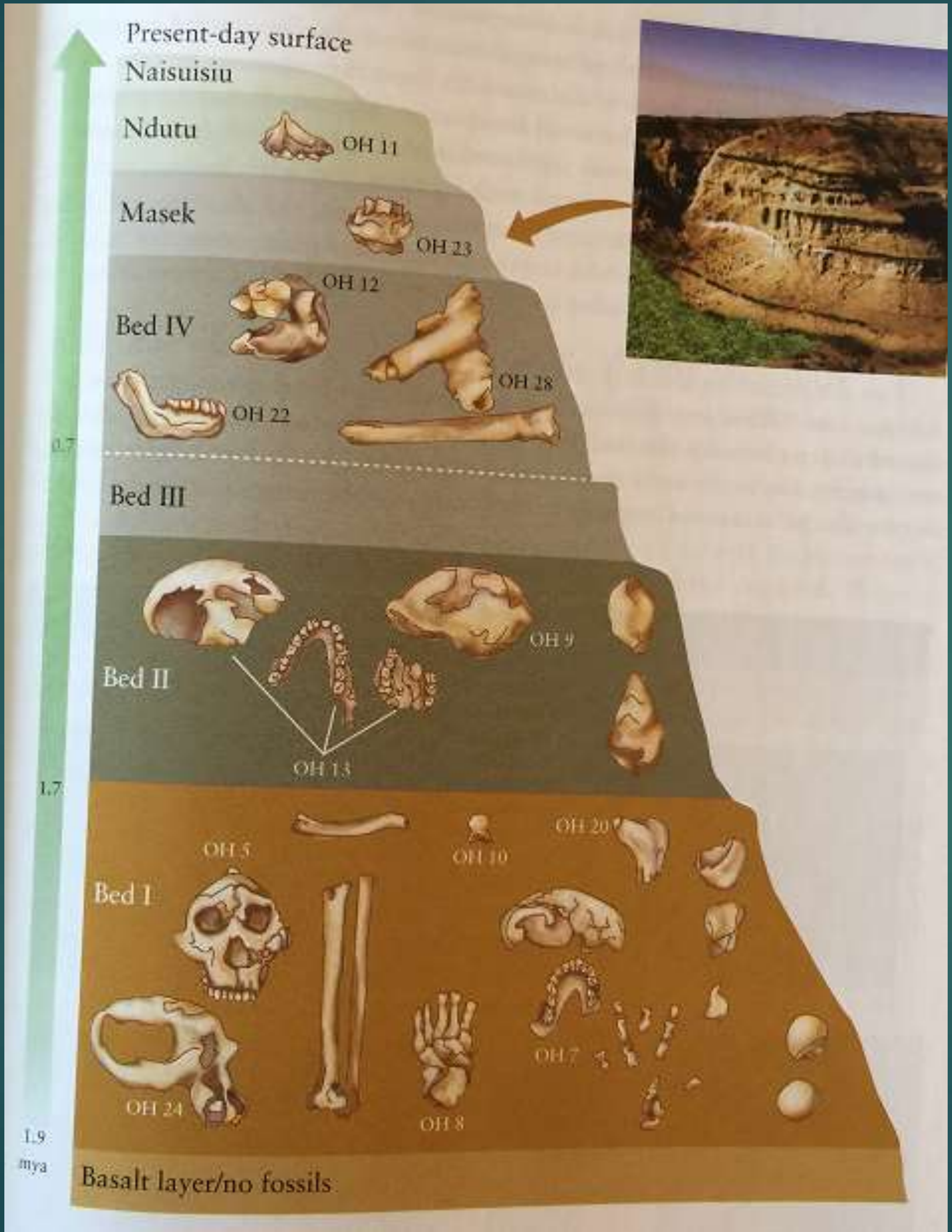
A pag … ous" in 1959.
"He i … uld be a good
name.

Richard Leakey: untrained son of famous paleoanthropological family (Louis & Mary)



Sharing their knowledge, Dr. Leakey and his son study the fossil skull of a monkey. The elder Leakey flew to the Koobi Fora camp to observe his son's progress and to see the new finds.

Olduvai Gorge



Paranthropus boisei

- ***Paranthropus boisei*** (formerly *Zinjanthropus boisei* and then *Australopithecus*) lived in east Africa between 2.1 and 1.1 Ma. It was similar to *P. robustus*, but the face and cheek teeth were even more massive. The brain size is similar to *P. robustus*.

- A few experts consider *P. boisei* and *P. robustus* to be variants of the same species.

- *P. boisei* is similar in body and brain size to *P. robustus*.

- Like members of many other Australopithecus species, males and females of P. boisei showed marked sexual dimorphism. The dentition was even larger than are those of *P. robustus*.

- Certain molars measure up to two centimeters in length /-----------/ from front to back.
- *P. boisei* probably inhabited mixed woodland and savanna habitats. Ate grasses and sedges.

Zinj = startlingly old; 1.7 MA

Dating of Zinj rocked the anthropological world when age established the 1.75 Ma

Zinjanthropus, pushing back the then-accepted age of the Pleistocene by 1 million years.

UNIVERSITY OF CALIFORNIA

DEPARTMENT OF GEOLOGY
BERKELEY 4, CALIFORNIA

May 20, 1961

Dr. Louis S.B. Leakey, Curator,
Coryndon Museum
Nairobi, Kenya,
East Africa

Dear Dr. Leakey:

The potassium-argon dating of the Olduvai fossils is progressing well, and though much remains to be done, the early results are so startling I thought you should know them at once.

Zinjanthropus and the "pre-Zinj" child are much, much older than anyone had suspected, except perhaps you and Mrs. Leakey. The average age of the samples my partner Dr. Jack Evernden and I have dated so far is 1,750,000 years.

Dr. Evernden and I believe that this date is close to the true age of Olduvai's early men, but that if anything it is slightly conservative.

One thing is certain -- Olduvai man is old, old, old!

Sincerely yours,

Garniss H. Curtis

Garniss H. Curtis

Geologist Garniss H. Curtis, a professor emeritus of earth and planetary science at the University of California, Berkeley, whose pioneering use of radioactive isotopes to date relatively young rocks provided the first solid timeline for human evolution; Used potassium/argon method in volcanic rock

“His major contribution was putting numbers on the timescale of human evolution.”

Olduvai Gorge

Olduvai Gorge

Olduvai Gorge: original Zinj pit in center

Stone tools, Olduvai Gorge, Bed IV, 700 Ka

Olduvai Fossils

Typical day with the Leakeys

Olduvai Gorge

- Mary Leakey & Gwen Isaacs interpretation: hominin bone & stone tool accumulation = interpretation of findings as "living floors" or "home bases"; by products of foraging activity & meat eating; animals brought back to central locale, where stone tools made, hominins gathered; camplike setting
- This was too human an interpretation; "human behavior" at 2 M; rather than taphonomic interpretation (processes that affect bones): cutmarks, carnivore gnawing
- <u>Modern hunter gathers make smelly mess of animals for weeks, then hyenas move in within hours</u>
- At FLK, site of Zinj, 250 stone tool cut defleshing marks on 3500 animal bones & hammerstone damage indicating breaking open bones for marrow
- But not at FLK North (water spring) (1000 stone tools & 50 animals; only 20 cutmarks in 10,000 bones; only 1 hammerstone breakage vs many hyena breaks; most bones whole)

Paranthropus boisei

- **Fossil Record:** *Zinjanthropus* found by Mary and Louis Leakey at Olduvai Gorge in 1959 was the specimen that defined the species
- 2.1 to1.1 Ma; average brain size of about 530 cc.
- **Diet:** Mixed, tough, vegetable diet that required lots of chewing.
- **Habitat and Distribution:** Ethiopia, Tanzania, and Kenya in East Africa.
- Basically they lived in a dry, grassland environment.

Paranthropus boisei

- The Olduvai Basin was occupied by a lake, fed by streams from the nearby highlands. Lake reed beds flourished, yielding to trees and finally to an arid grassland, as one became more removed from the lake.
- In the Omo basin of Ethiopia, *Paranthropus*-yielding deposits span a period in which the climate dried considerably. On the open plains, vegetation became sparser with time, though forests may have remained available along watercourses. *Paranthropus* living in the vicinity of Lake Turkana also had to deal with a fluctuating environment.

Paranthropus boisei

- The most striking feature of *P. boisei* is its huge teeth; it has the largest teeth found in any hominin group. These huge premolars and molars provide an enormous flat grinding surface. Its front teeth are relatively small.
- The jaws are large and heavy, and there is a large sagittal crest.
- Overbuilt for crushing very hard food & for dealing with very intense high-capacity forces, rather it was built to deal with lots and lots of repeated activity. Instead of dealing with the peak stress associated with high-force chewing, it was the fatigue, stress associated with chewing again and again and again and again. Ate hard C4 grasses that predominate in the East African Savannah environments.
- This hominin has a very long, flat face with no forehead and large brow ridges. It also has an elongated braincase. This species has been described as hyper-robust.

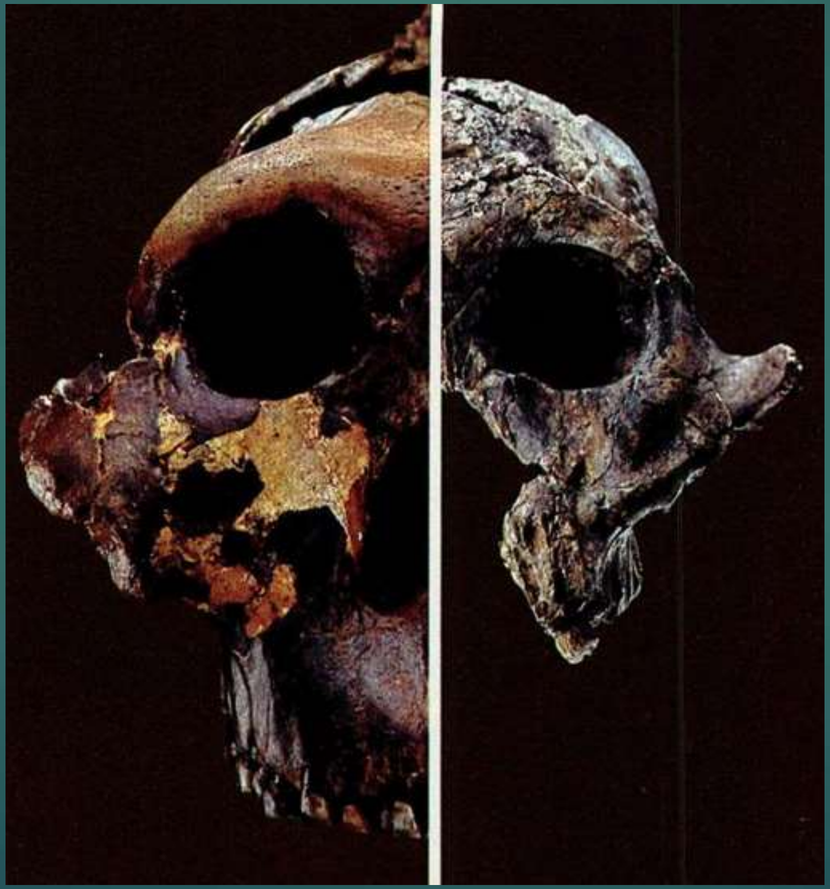
Paranthropus boisei:
Sexual dimorphism

OH 5, male

KNM-ER 732, female

Sexual dimorphism in P. boisei

OH 5, Zinj

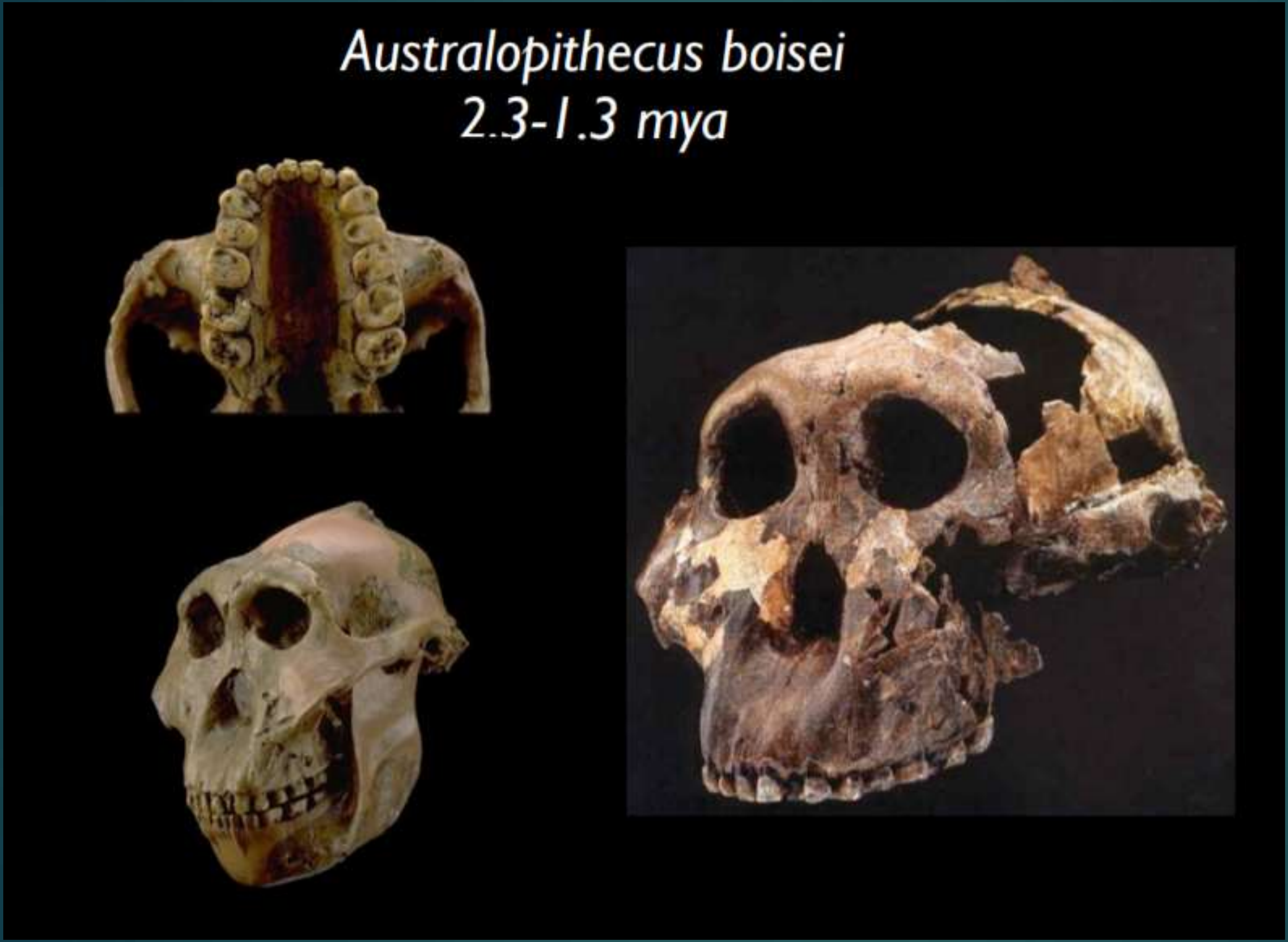


KMN- ER 732

Sexual dimorphism

Same place and time period; both flat, scooped out face, zygomatics; less sagittal crest in 732

- Again, if we look at KNM-ER 406 here on the left, this is a specimen from the Turkana Basin, we again see a very large zygomatic arch, a very projecting zygomatic process. Again, the anterior displacement puts this in line with the large buccal chewing teeth on the jaw, again, maximizing the efficiency the overall chewing structure.
- Posterior sagittal crest
- So many similarities to the robustus specimens in South Africa, although slight differences in terms of the exact pattern of morphology that we see in these specimens. Like the South African robust australopithecines, those from East Africa-- Australopithecus boisei-- also seem to show a large amount of dimorphism.



P. boisei locales:

• the Afar region in Ethiopia,

• the Lake Turkana and Omo Basin in southern Ethiopia and northern Kenya,

• and areas such as Olduvai Gorge and Lake Natron in northwestern Tanzania.

Paranthropus boisei

Location: East Africa
Major site(s): Olduvai Gorge, Koobi Fora
Date range: 2.0 - 1.0 MA.

Associated paleoanthropologists:
Mary, Louis and Richard Leakey

Additional major points to know:

- Sagittal crest, dish-shaped face w/ flaring zygomatic
- Molarization of premolars and reduction of incisors and canines (post-canine megadontia)
- Hyper-robust (more exaggerated features than *P. robustus*)

Paranthropus boisei, 2.3 to 1.2 MA

- Average cranial capacity: ~ 520 cc; increased over time
- No postcranial skeletal fossils of *P. boisei;* Only guesswork about posture and locomotion
- Size: Sexual dimorphic size difference estimates
  - Males: 4 feet 3 inches tall; weighed 154 pounds.
  - Females: 3 feet 5 inches; weighed 75-100 pounds
  - But no large canines typical of male dominance
- At least 26 specimens

Paranthropus boisei

- Most robust forms were similar in body and brain size to *A. Africanus;* the members of the genus *Paranthropus* were considerably more robust in all features involving chewing.

- Ancestral features: Large sagittal crest on top of the skull anchored huge chewing muscles

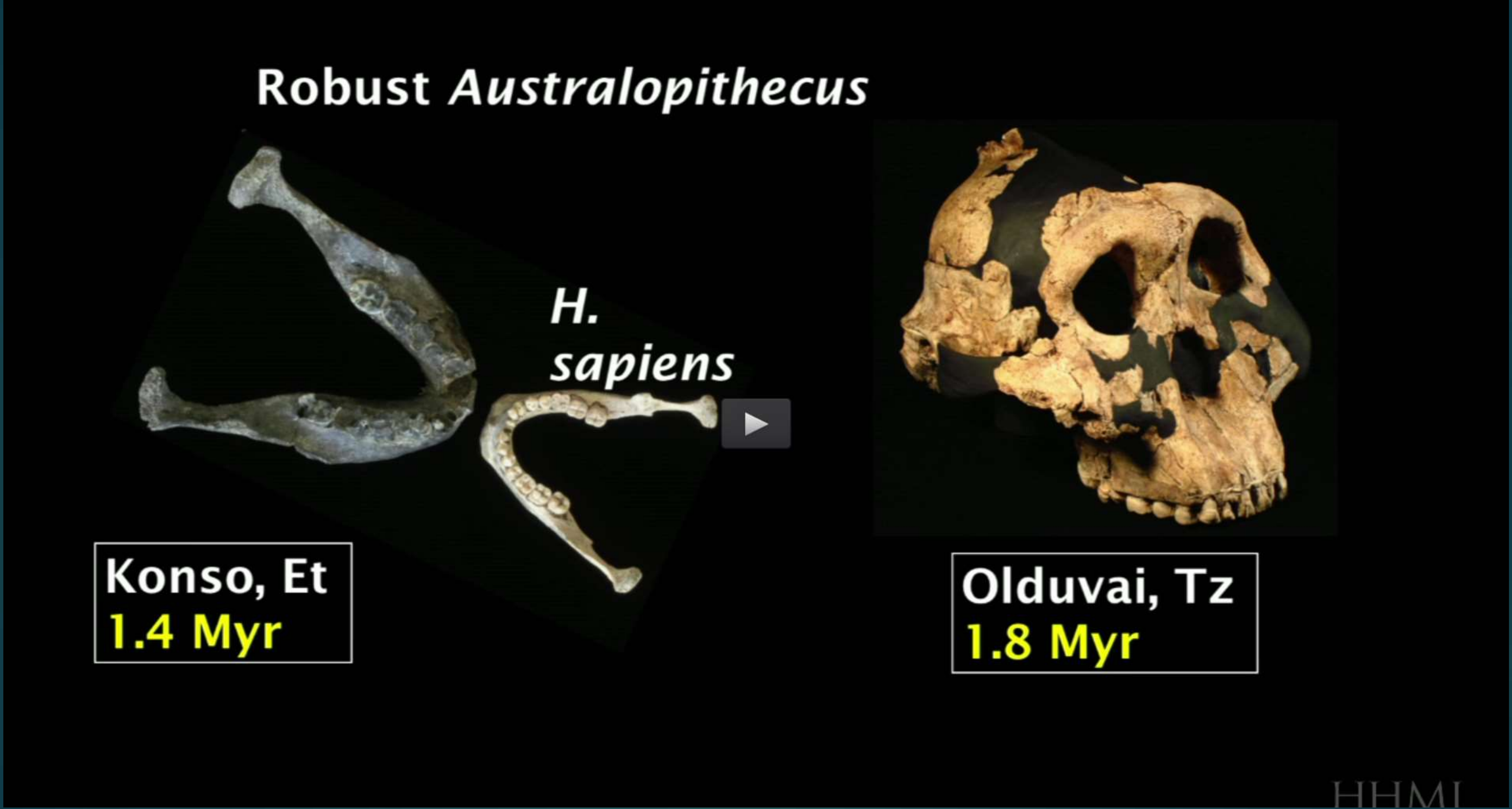
- Derived features:
  - Flatter face
  - Small canine teeth

P. boisei

- Unique features:
  - Wide, dish-shaped face; flaring cheekbones
  - Hyper robust, massive(size of nickel or quarter) molars clad in hard enamel
  - Very large mandible and ramus. increasing large masticatory apparatus. These huge jaws corresponding with huge temporalis muscles.

- Canines and incisors were small, but the molars were massive. This early hominin specialized in eating plentiful, abrasive plants.

- As these foods became scarce due to climate change, this genus was pushed into extinction.



Molar = size of quarter

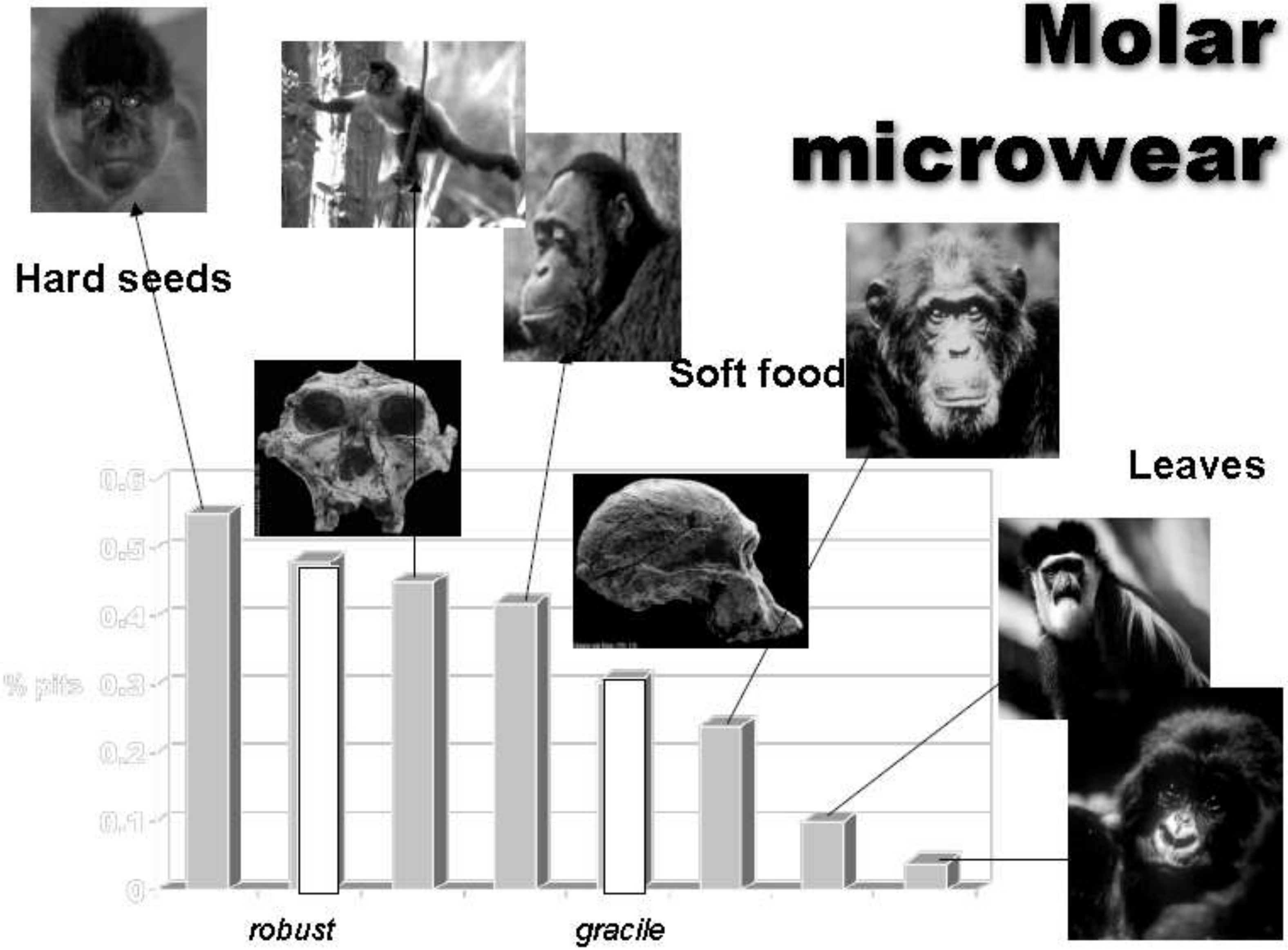
Diet Controversy

- *Paranthropus boisei* is nicknamed "Nutcracker Man" because it has the largest molars of any known hominin; grinding surface is twice as large as that of a modern human.
- Only hominin to combine massive, wide, flat face with very large chewing teeth and small incisors and canines
- No longer "Nutcracker Man": Initial interpretation that large-crowned, thick enameled chewing teeth, large mandibles, and sagittal crest as evidence that their diet was highly specialized, perhaps seed, hard covered fruit.
- But these jaws and teeth probably did not represent food eaten all the time, but were fallback foods. Foods were certainly abrasive given excessive thick enamel nearly worn away
- Diet was largely based on C4 resources, grasses or sedges

Time span of species

- 2 to 1.2 Ma: Have a robust lineage in East Africa
- In South Africa: *Australopithecus africanus*, the gracile australopithecine, precedes *Paranthropus robustus*
- In East Africa, *Australopithecus garhi* at 2½ Ma
- By 2 Ma, beginnings of the *Paranthropus boisei* lineage
- *P. boisei* might have persisted as long as 1.2 Ma;
- Also have the beginnings of the genus *Homo*, at 2 Ma
- Early *Homo* and *P. boisei* occupied similar or the same environments in East Africa for 800 K (evolutionary question as to how exactly they were able to coexist within same environments?)

Molar microwear



Robust Diet: low–quality vegetation or hard objects or both

- This notion emerged from interpretations of *P. boisei's* morphology, but gained indirect support from dental microwear studies of *Paranthropus robustus*; these concluded that wear on the molars of South African Paranthropus was consistent with its having ingested and chewed small, hard food items.
- Carbon isotope studies of *P. robustus* from South Africa:
  - some plants using C4 photosynthesis such as tropical grasses or sedges,
  - consistent with most of its dietary carbon (approximately 70%) having been derived from the C3 food items favored by extant chimpanzees (Pan troglodytes) such as tree fruits
- Study: *P. boisei* had a diet that was dominated by C4 biomass such as grasses or sedges. Its diet included more C4 biomass than any other hominin studied to date, including *Paranthropus robustus* from South Africa.
- Remarkable craniodental morphology of this taxon represents an adaptation for processing large quantities of low-quality vegetation rather than hard objects

Thure E. Cerlinga, et al., 2011

Diet: *P. boisei vs P. robustus*

- Given current evidence the simplest explanation is adaptive divergence between the eastern and southern African Paranthropus populations, with the former focusing on grasses or sedges and the southern population consuming a more traditional hominoid diet that included tree fleshy fruits, as well as variable C4 resources.
- In short, *P. robustus* had an expanded dietary repertoire relative to extant apes that included C4 resources, whereas *P. boisei* had completely abandoned the presumed ancestral diet (C3-based foods) to focus on a resource abundant in savanna and wetland environments.
- So *P. boisei* did not eat foods similar to those of African apes.
- They are also inconsistent with the notion that P. boisei ate nuts or hard fruits preponderantly, and also suggest that *Paranthropus* in eastern Africa (P. boisei) and southern Africa (P. robustus) had very different diets, a notion also supported by dental microwear.

Fallback foods

- Another story that has emerged in the past decade, is the importance of fallback foods.
- So the structures of the jaw itself may not be specifically evolved for the primary food it eats, as that might be something that doesn't evolutionary differentiate different populations of *boisei*, but rather for the fallback foods, the ability of basically to survive when what you normally isn't available.
- So one interpretation has been that the fallback foods are playing important role in the morphology as well.
- And it's possible that the fallback foods for *boise*i, even though it might have been eating grass, was something that was a little bit harder, that required a more stronger peak chewing force to crush and digest.
- Cow of the Pleistocene: So the story seems to be that boisei was primarily eating grasses. It survived by eating these very low-quality foods.
- And some of those fallback foods might been those very seeds and nuts that were originally thought to be the primary food for *boisei* and the other robust lineages.

Further Evidence

- Discovery of a mandible with a large, robust body, large chewing teeth, and small incisors and canines at the Peninj River, on the shores of Lake Natron, Tanzania by Kamoya Kimeu & Richard Leakey

- More *P. boisei* fossils found at Olduvai, and at other sites:
- In 1993, A. Amzaye found fossils of *P. boisei* at Konso, Ethiopia. The partial skull is designated as KGA10-525. Largest;
- Oldest specimen of *P. boisei* was found in Omo, Ethiopia, and dates to 2.3 Ma, classified as L. 74a-21
- Olduvai Gorge, Tanzania: youngest specimen dates to 1.2 Ma and is classified as OH 3 and OH 38.
- Koobi Fora, Kenya (KNM ER 406); and at Malawi

Catalog number Peninj 1

Catalog number KNM ER 406

Paranthropus boisei, ER 406: 1.7 MA in Koobi Fora, Kenya

“Dished out” face due to anteriorly positioned zygomatics

Found by Richard Leakey in 1968, also with a complete cranium of *Homo ergaster*, KNM ER 3733, discovered by Bernard Ngeneo in 1975.

Paranthropus boisei, ER 406: 1.7 MA in Koobi Fora, Turkana Basin in northern Kenya

- Posterior sagittal chest and nuchal crest
- Deep palate and massive tooth roots
- Very large and very projecting zygomatic process, with anterior position and the root far forward over the second upper premolar, maximizing the masticatory area
- Dish-shaped face, very wide face but short in height
- Remarkable postorbital constriction
- Projecting glabella
- 510 cc cranial capacity
- Like OH 5, this specimen ER 406 is suggested to be a male.

ER 406 (P. boisei) & ER 3733 (H. ergaster): Both 1.7 MA in Koobi Fora, Turkana Basin in northern Kenya

ER 406 P. boisei and ER 3733 H. ergaster. Photo credit: Roberto Sáez

- These finds were important because they were breaking the 'single species hypothesis' in human evolution.
- According to this principle, only one species can inhabit a specific ecological niche. Those two specimens *virtually* coexisted, but they were *really* different in terms of morphology, cranial capacity and type of resources consumed;
- Their coexistence has made the assignment of the postcranial fossils to either one or the other species very difficult

KNM-WT 17400 - Paranthropus boisei - 1.77 million years old from West Turkana, Kenya

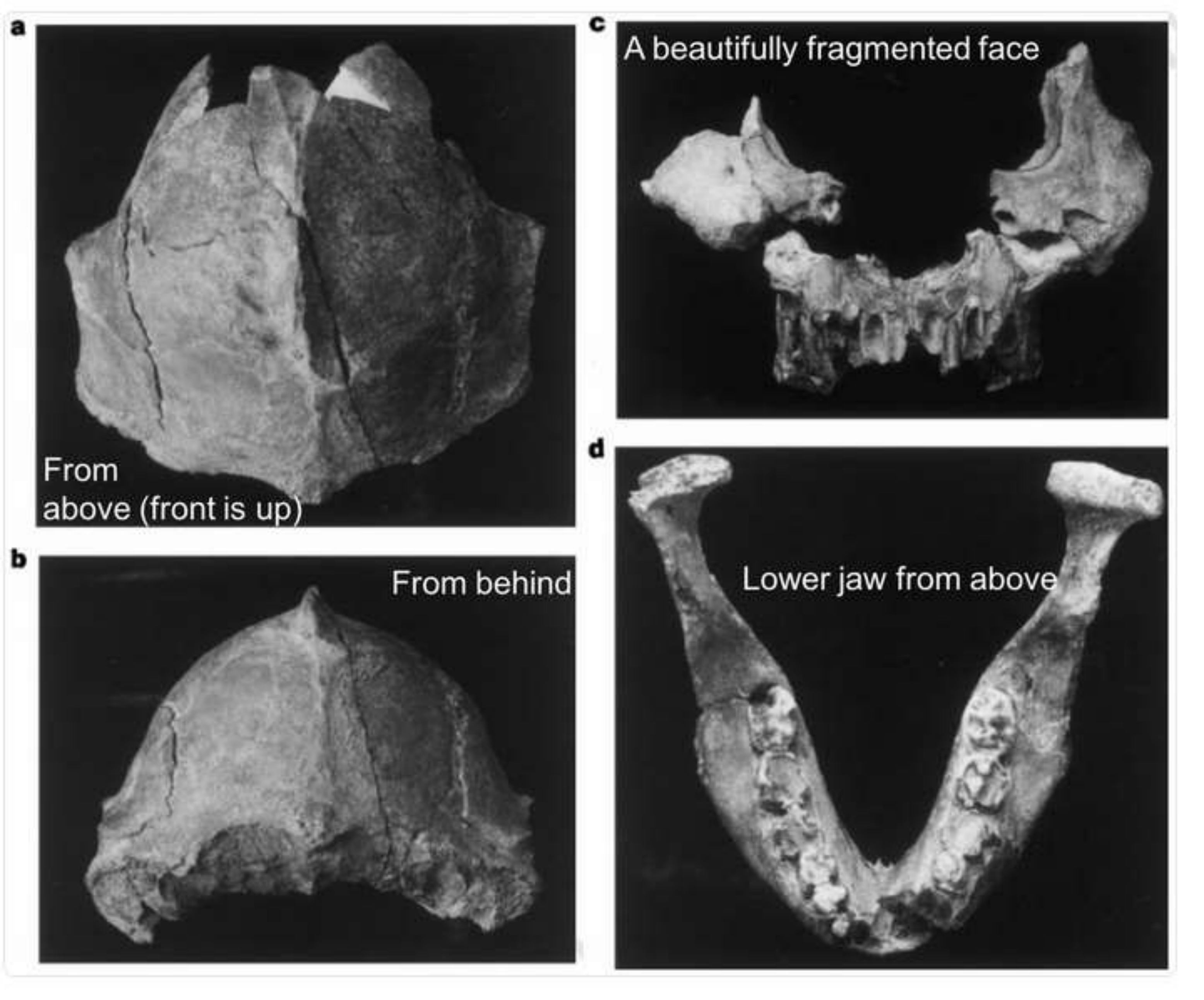
Konso KGA10-525: the largest *Paranthropus boisei*

- This skull is the largest specimen known of the species *Paranthropus boisei*.
- First to be found with both jaw and cranium.
- With a capacity of 545 cc

- What the Konso find has confirmed is that there was considerable morphological variation within the species in East Africa.

- A male.

- **Konso KGA10-525 Exhibit Item**
- **Site:** Konso, Ethiopia
- **Year of Discovery:** 1993
- **Discovered by:** A. Amzaye
- **Age:** About 1.4 million years ago
- **Species:** *Paranthropus boisei*

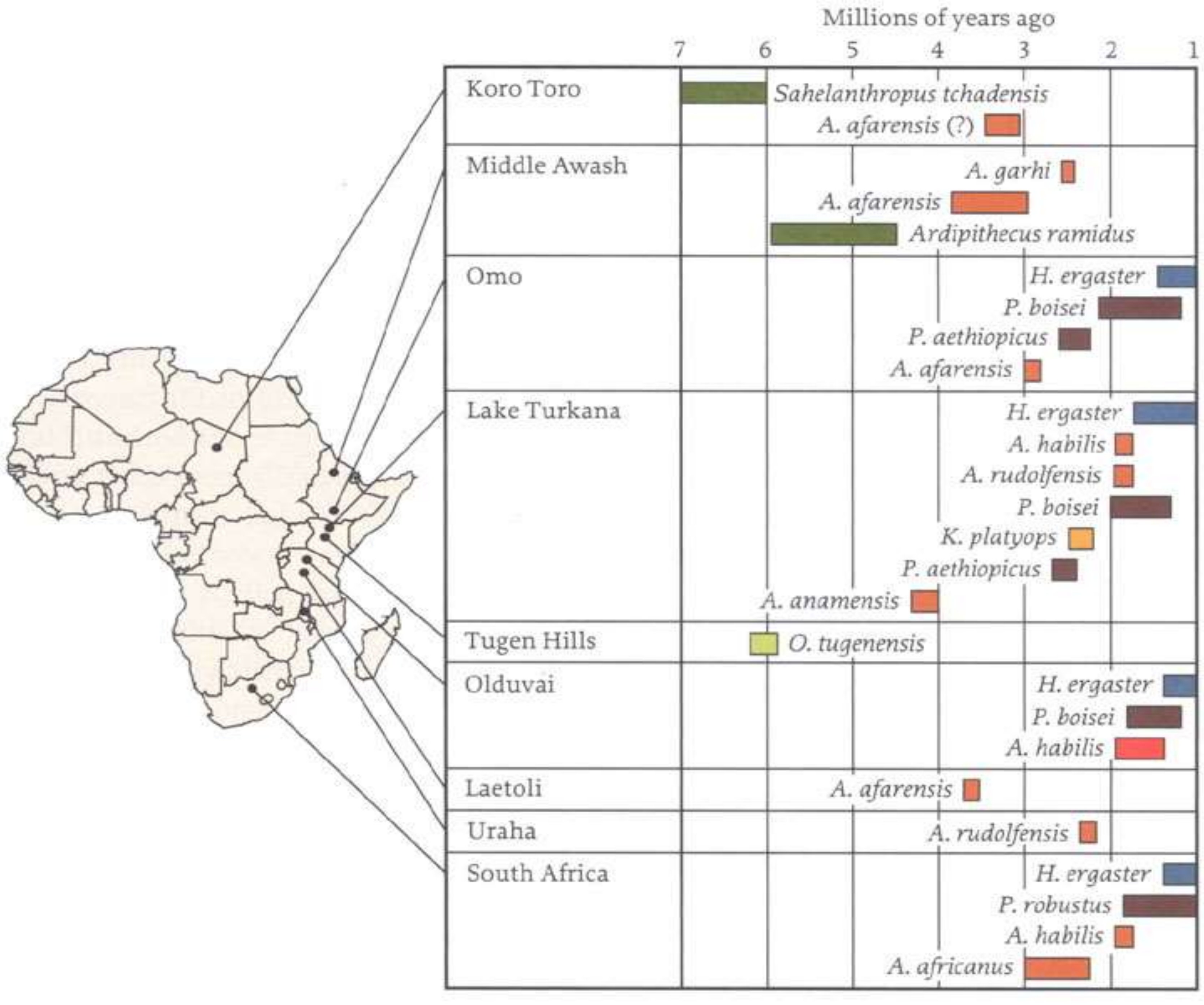

a
From
above (front is up)
b
From behind
c
A beautifully fragmented face
d
Lower jaw from above

Importance of Konso (KGA10-525)

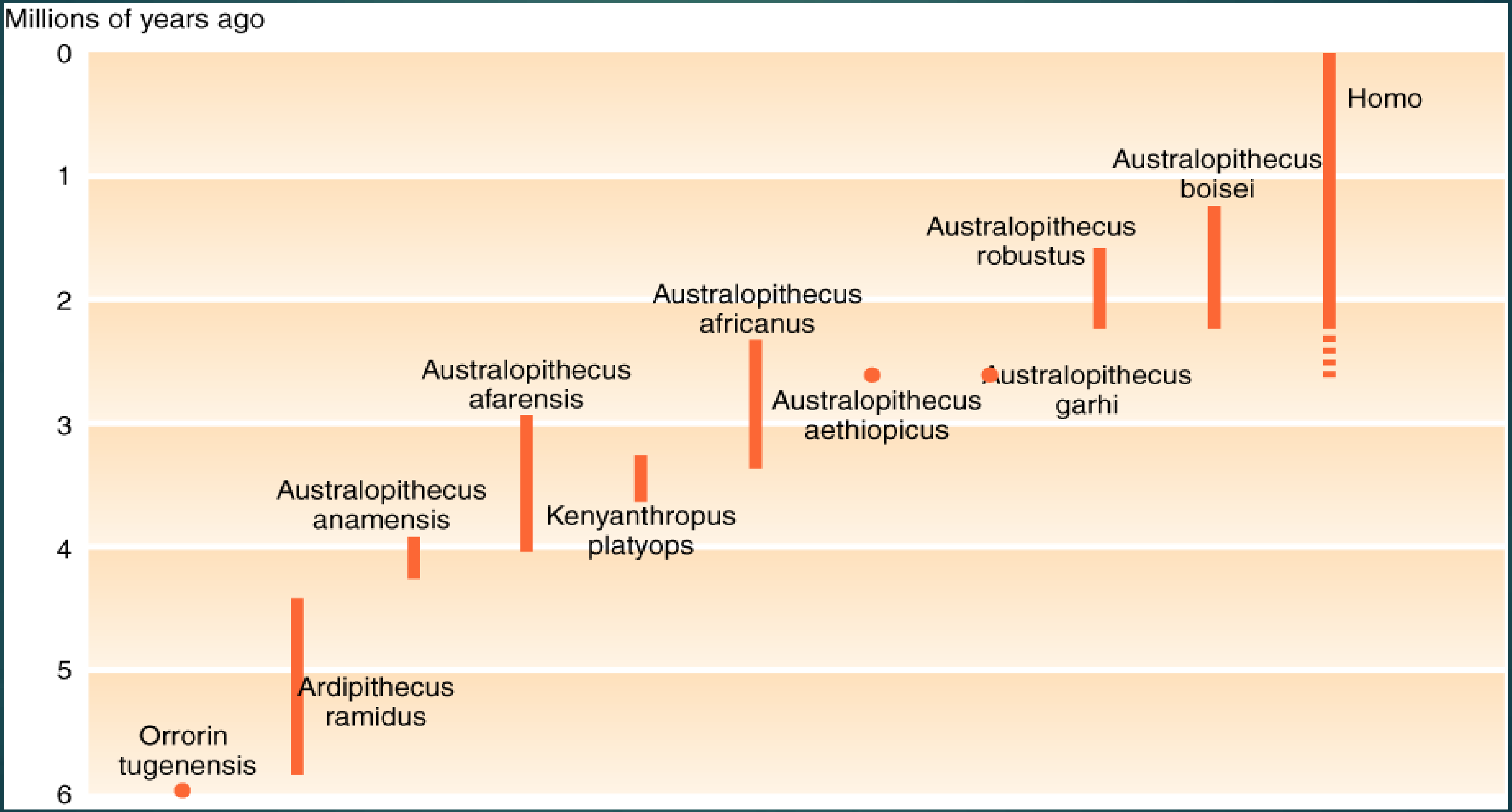
- Konso's skull is typical of a large *P. boisei* male. But with a few differences:
  - cheekbones look more like those of a southern African species called *P. robustus*.
  - back of the cranium resembles another species, *A. aethiopicus*.
  - short, broad palate is shaped like one from the genus *Homo.*
- The unexpected combination of cranial and facial features of this skull probably represented geographical variations.
- Team found the remains of at least eight other *P. boisei* in the same fossil bed (of 100 known), & yielded remains of *H. erectus* and one of the richest and oldest assemblages of hand axes ever found. The new finds point to the coexistence of *P. boisei* and *H. erectus*.

Geographic variation of robust australopithecines

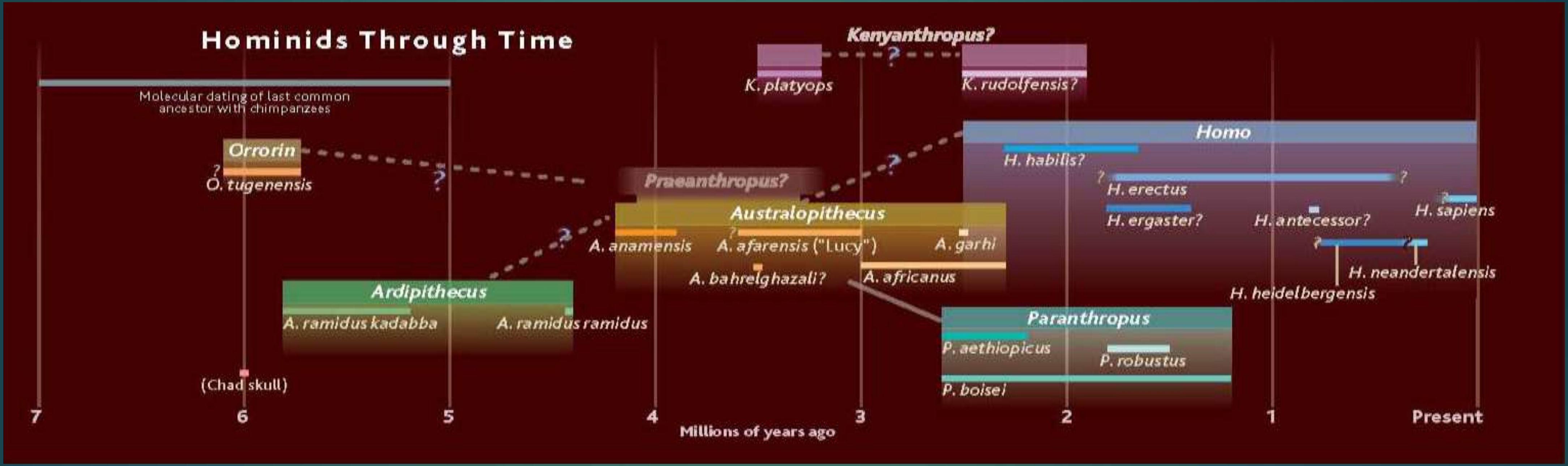
- *Robustus* in South Africa
- *Boisei* in East Africa
- *Aethiopicus* in East Africa
- Geographic variation or different species?
- Variation across time and space: evolutionary connections or different species, later species or different
- *Robustus* earlier than *Boisei*: ancestor or geographic variant; geographic continuity or isolation
- *Robustus* is not as robust as the later *Boisei* specimens.
- Current evidence supports the idea that *Boisei* is probably a separate species than *Robustus*, not simply a geographic variant.


Millions of years ago
7
6
5
4
3
2
1
Koro Toro
Sahelanthropus tchadensis
A. afarensis (?)
Middle Awash
A. garhi
A. afarensis
Ardipithecus ramidus
Omo
H. ergaster
P. boisei
P. aethiopicus
A. afarensis
Lake Turkana
H. ergaster
A. habilis
A. rudolfensis
P. boisei
K. platyops
P. aethiopicus
A. anamensis
Tugen Hills
O. tugenensis
Olduvai
H. ergaster
P. boisei
A. habilis
Laetoli
A. afarensis
Uraha
A. rudolfensis
South Africa
H. ergaster
P. robustus
A. habilis
A. africanus

Known dates for hominin species



hominin phylogenies



Gibbons, Ann. 2002. "In Search of the First hominins." *Science* 295:1214-1219.

Paranthropus reconstruction

Paranthropus bosei, 2.3 M
by V. Deak

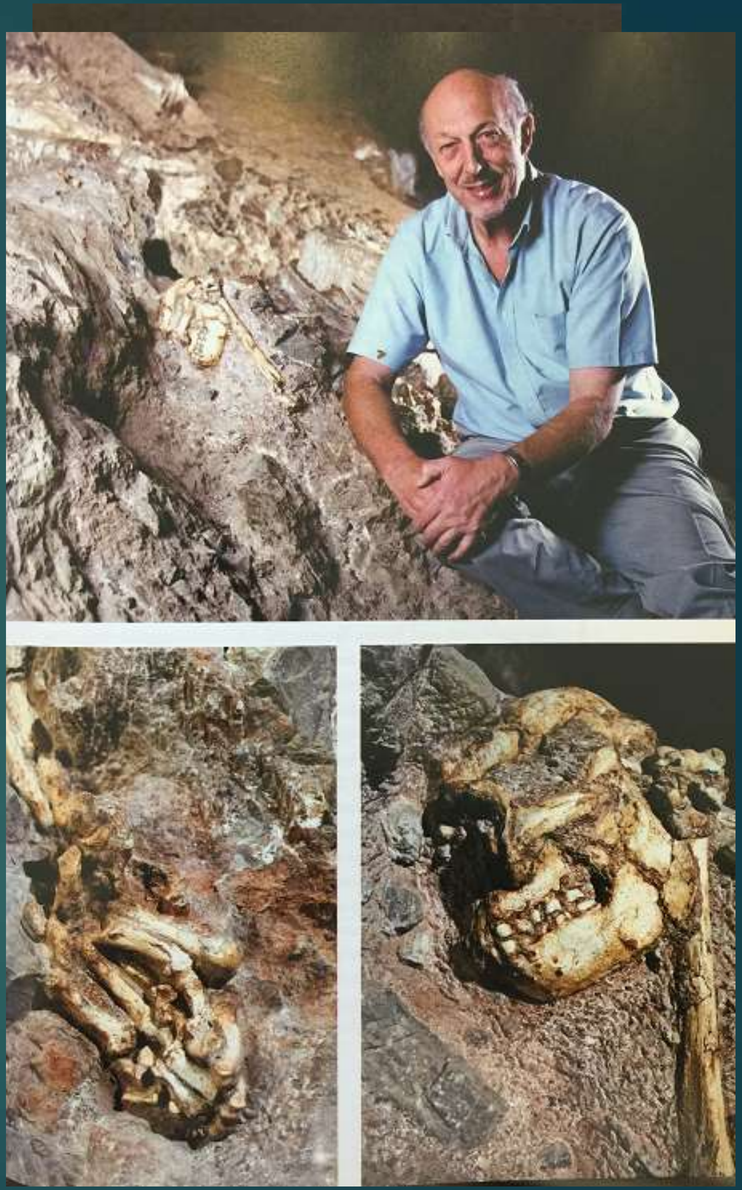
By Elisabeth Daynes:

No longer Nutcracker Man; only ate grasses and sedges

Australopithecus prometheus

Ronald J. Clarke (1944-)
“Little Foot”

- Paleoanthropologist
- University of the Witwatersrand's Institute for Human Evolution; field director of the ongoing Sterkfontein Caves excavation.
- 1997: Most notable for the discovery of "Little Foot", an extraordinary complete skeleton of *Australopithecus*, (StW 573), in the Sterkfontein Caves
- He also played a role in the discovery of a new skeleton of *Homo habilis* related to *Homo rudolfensis*



1997, Ron Clarke: Little Foot, StW 573

P. Tobias named the 4 bones Clarke had found in 1994 “Little Foot”

Australopithecus (StW 573)
Discoverer: Ron Clarke
Locality: Sterkfontein
Date 1994
Age: 3.0 M

In 1978, The Silverberg Grotto was cleared out and put in boxes; in 1994 Clarke found ankle and then toe of foot with divergent toe

Sterkfontein: Ron Clarke

- After Hughes died in 1991, paleontologist Ron Clarke took his place.
- In 1994 while searching through museum boxes labelled 'Cercopithecoids' containing fossil fragments, Ronald J. Clarke identified several that were unmistakably hominin. He spotted four left foot bones (the talus, navicular, medial cuneiform and first metatarsal) that were most likely from the same individual, as well as a right fragment of the distal tibia. He later discovered 12 bones of the foot and leg of a single ape-man.
- In June of 1997, two of Clarke's assistants, Nkwane Molefe and Stephen Motsumi, were tasked with the impossible: trying to find a tibia where the rest of Clarke's ape-man likely rested. He believed that since it was likely broken during the mining activities 65 years prior, that the remaining bone might still be visible.
- Molefe and Motsumi found the broken tibia after just two days of searching, armed only with handheld lamps.

Little Foot

- Over the next several years of extraction, Clarke's prediction of an entire ape-man skeleton was confirmed. What was nicknamed "Little Foot" by Tobias, has been lifted from the depths and is being prepared and described by Clarke.

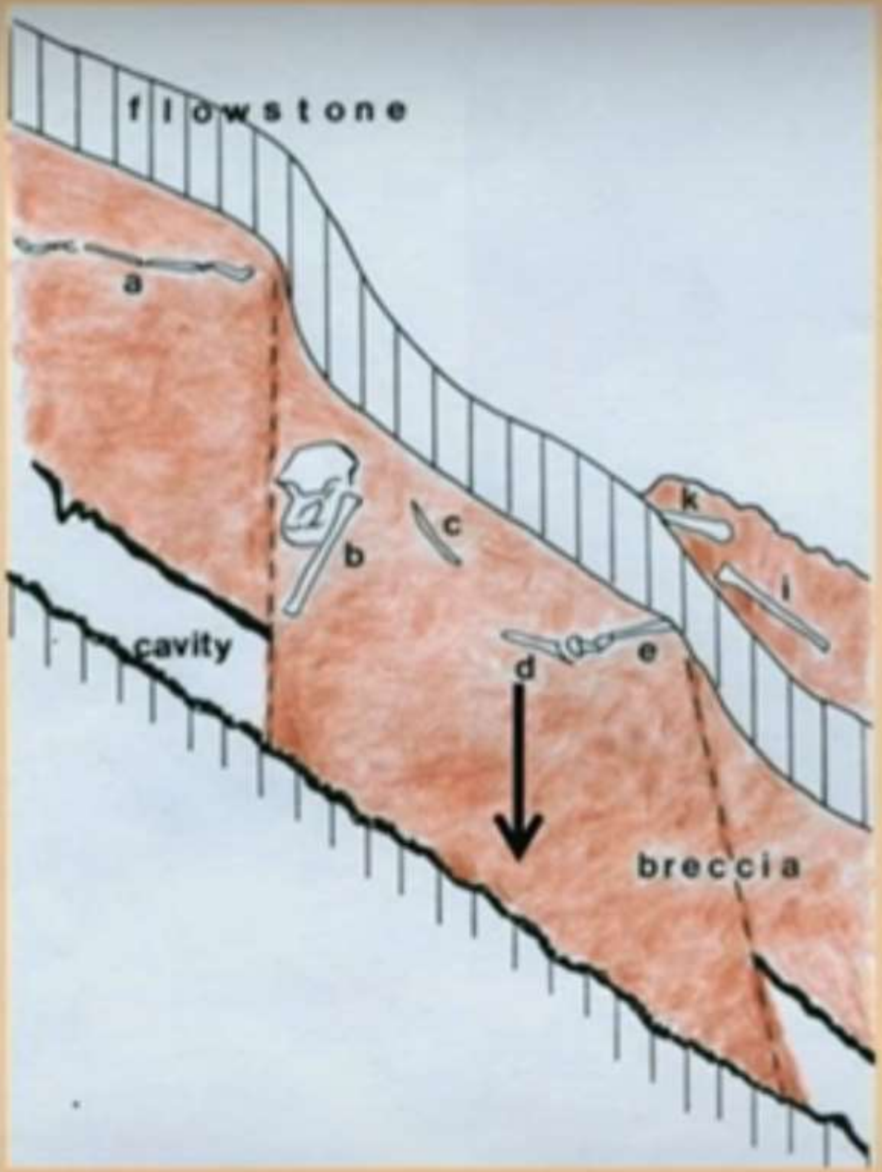
- Dating techniques estimate "Little Foot" to be 3.7 Ma. When finally fully described, "Little Foot" will be an anthropological "Rosetta Stone,"

Dr. Clarke found further foot bones from the same individual in separate bags in 1997, including a right fragment of the distal tibia that had been clearly sheared off from the rest of the bone; realized rest must still be in cave; sent 2 assistants (Stephen Motsumi and Nkwane Molefe) to find the fit; took them 1 and a half days.

Site of discovery of Little Foot

Nkwane Molefe and Stephen Motsumi

A million years later the breccia collapsed, and stalagmite filled the gaps.



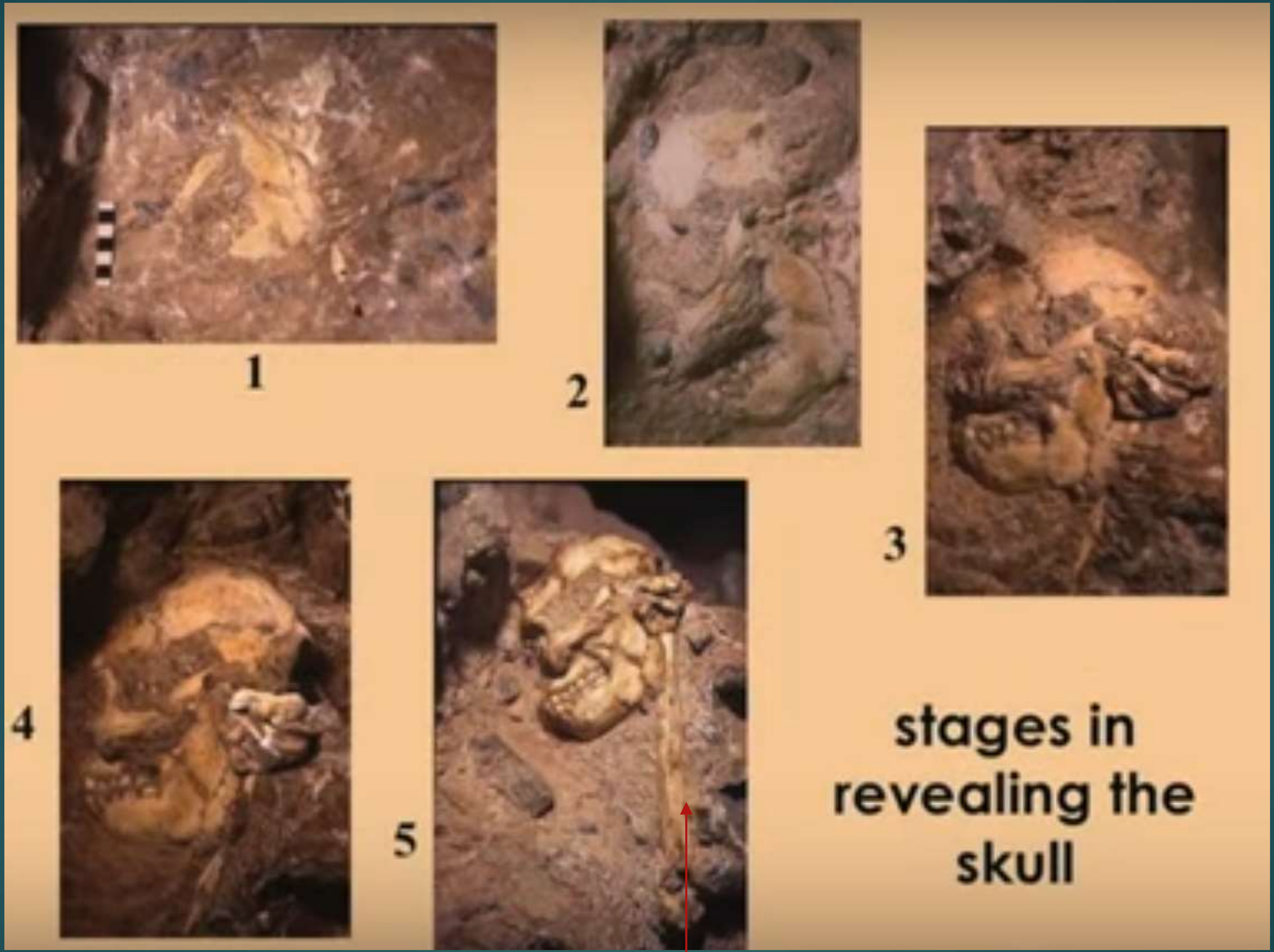
Skull and Foot


ute

Monkey bone

Two leg bones

Cavity



Humerus

Discovery of the arm and hand

Pneumatic needle and brushes

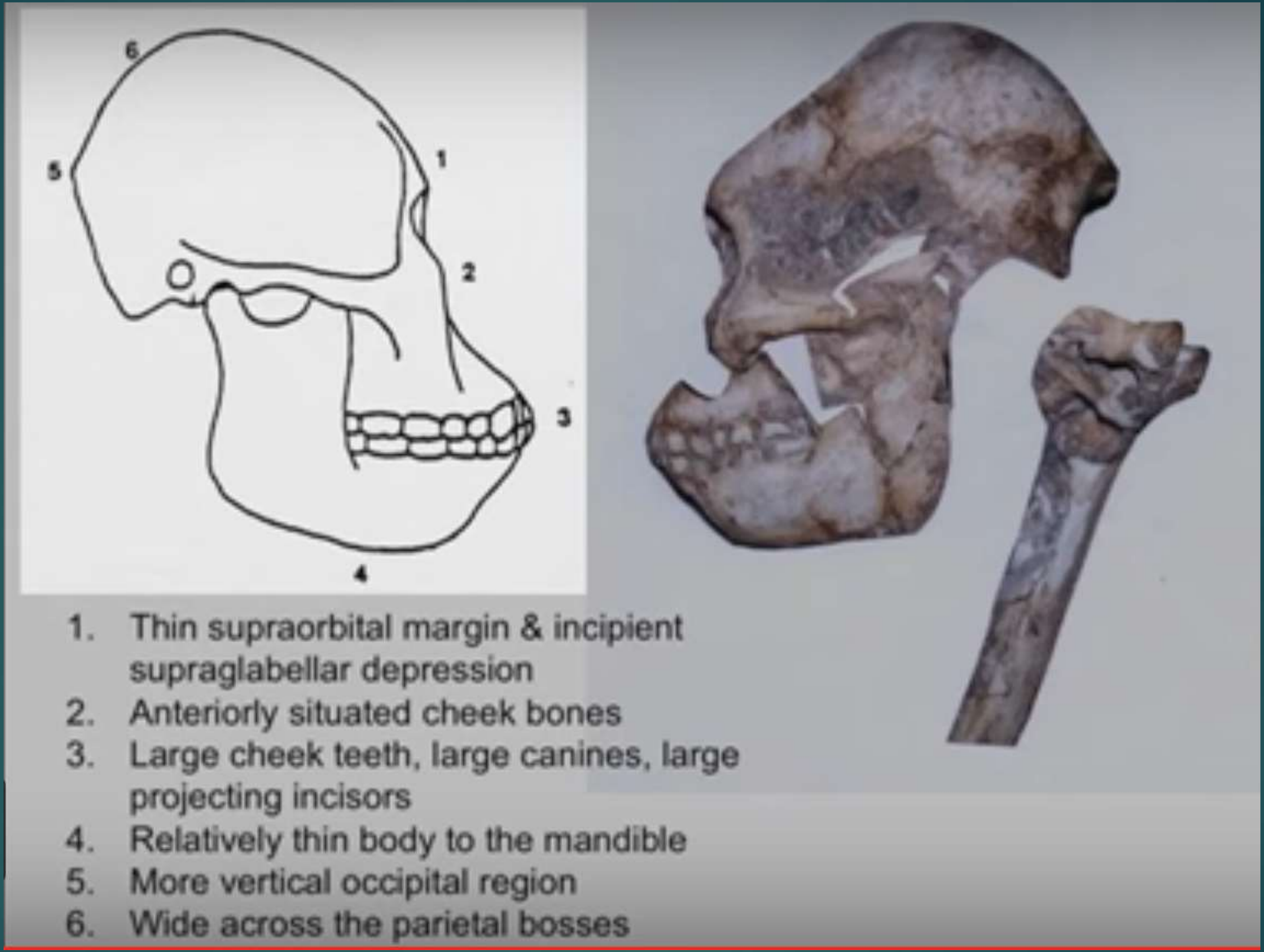
Scan

Hand

Very like human hand: long fingers, short palm, long thumb

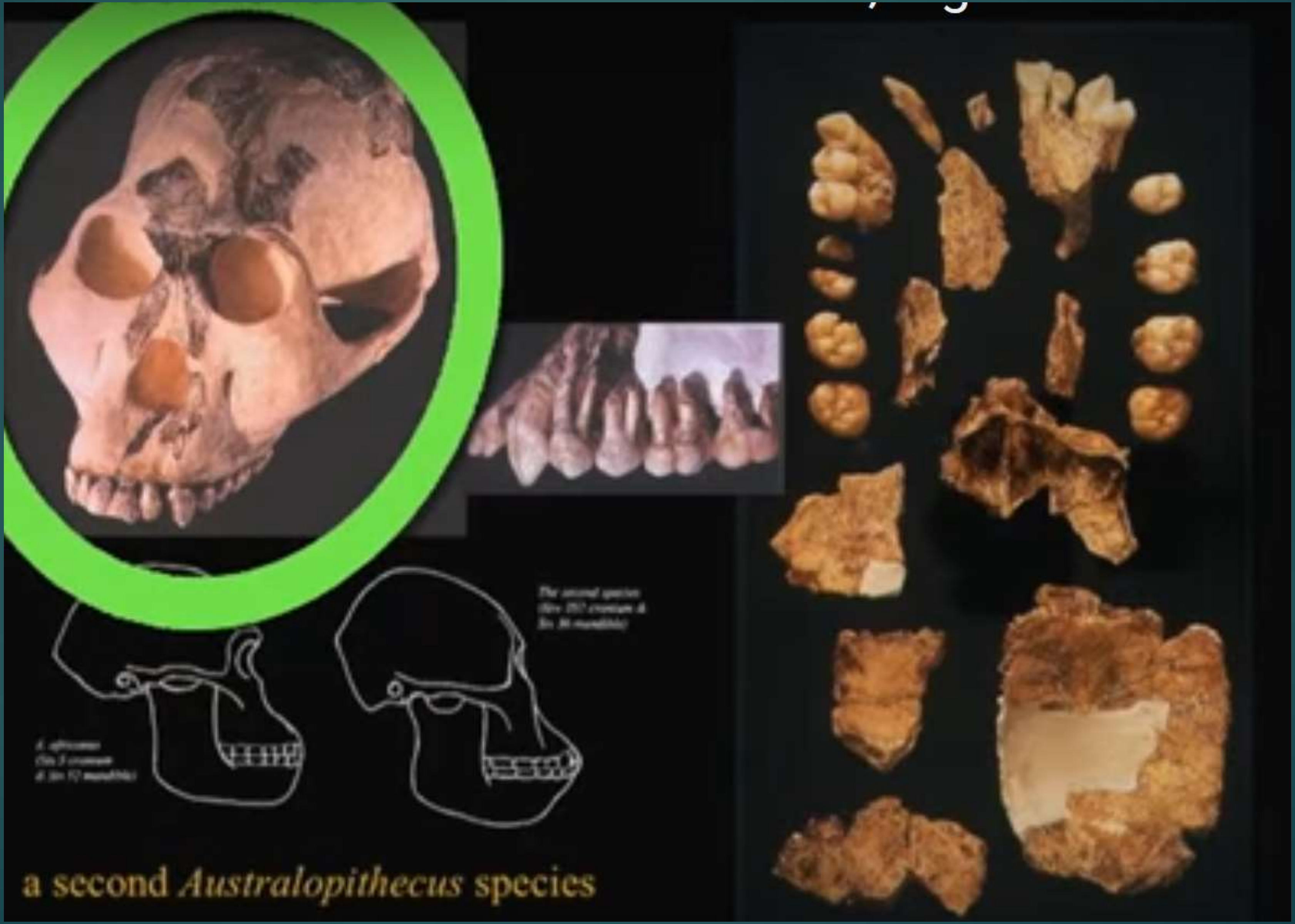
- In 1948, R. Dart named the Makapansgat ape-man as *Australopithecus prometheus*

- Clarke believes Little Foot is a unique *Australopithecus* species previously found at Makapansgat and Sterkfontein Member Four, *Australopithecus prometheus*.

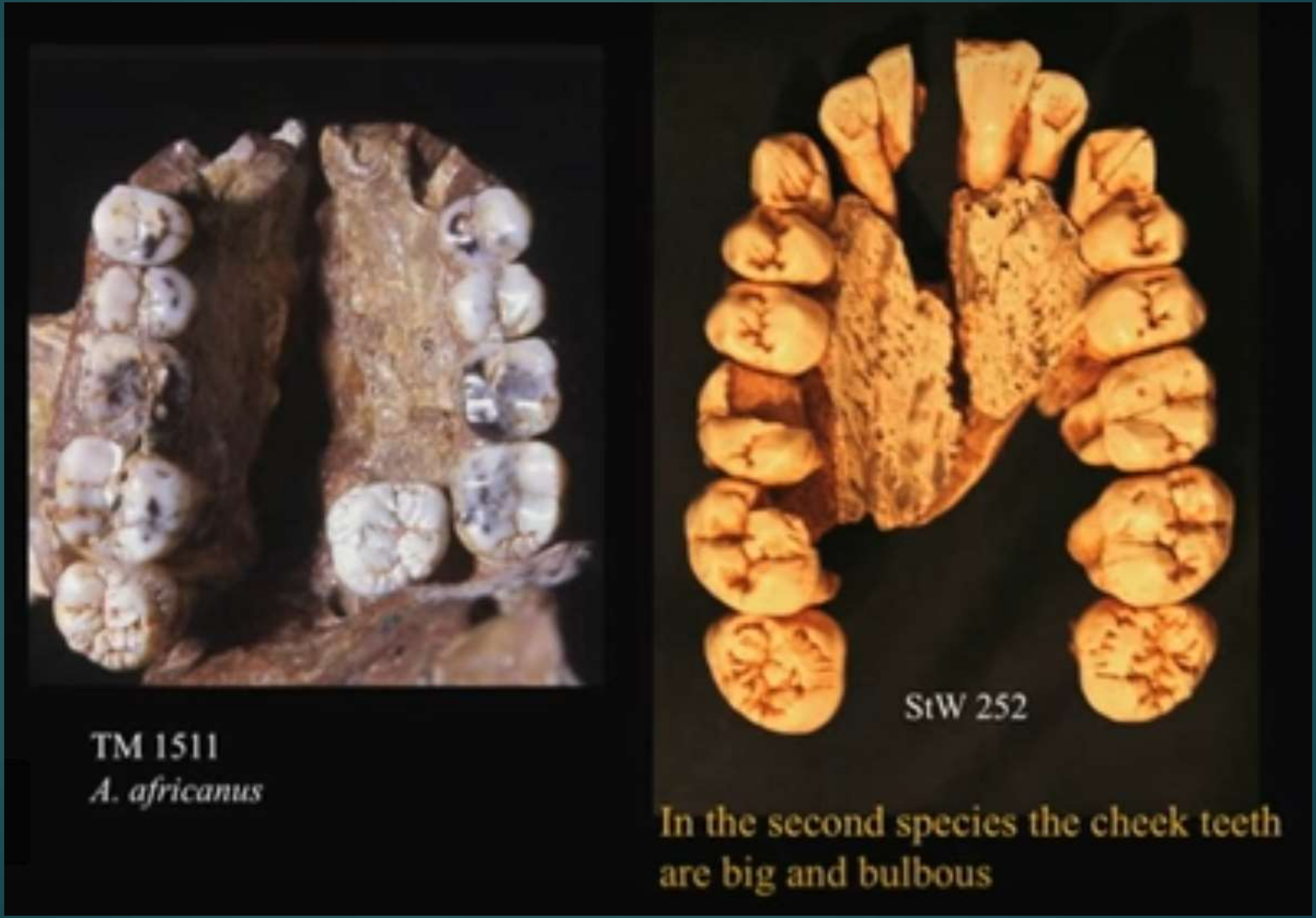


Clarke believes Little Foot is *A. prometheus.* StW 573 shows features similar to the second species which should be recognized as *A. prometheus*. *A. Prometheus*: longer, flatter face and larger cheek teeth than *A. africanus*.

Another species: *A. prometheus*



Dentition: *A. africanus vs A. prometheus*



Face

12/6/2017: 'Little Foot' makes public debut 20 years after discovery

"Little Foot": a near-complete fossil hominin skeleton dating back 3.67 Ma; oldest fossil hominin skeleton ever found in South Africa; *Australopithecus prometheus*, which was named back in 1948 from fragmentary fossils.

December 7, 2017: Exhibition of Little Foot

Now and then

90% of skeleton (compared to 40% for Lucy)

Paranthropus aethiopicus

Alan Walker (1938-): *Paranthropus aethiopicus*

- Prof. of anthropology and biology, Penn State Univ.
- 1985: discovered, at Turkana, Kenya, skull of *Paranthropus aethiopicus*, KNM WT 17000, 2.5 million years; the “Black Skull”
- 1994: Description of *A. anamensis*

New Four-Million-Year-Old hominin Species from Kanapoi and Allia Bay, Kenya. Meave G. Leakey, Craig S. Feibel, Ian McDougall and Alan Walker in *Nature,* Vol. 376, pages 565–571; August 17, 1995.
The Earliest Known *Australopithecus, A. anamensis.* C. V. Ward, M. G. Leakey and A. Walker in *Journal of Human Evolution,* Vol. 41, pages 255–368; 2001.

P. aethiopicus, "Black Skull", from west side of Lake Turkana; black because stained from manganese dioxide in sediments; 2.5 Ma; *P. aethiopicus* is the first evidence we have of the beginning of this robust lineage of australopithecines

Paranthropus aethiopicus
KNM WT 17000, Black Skull, 2.5 MA

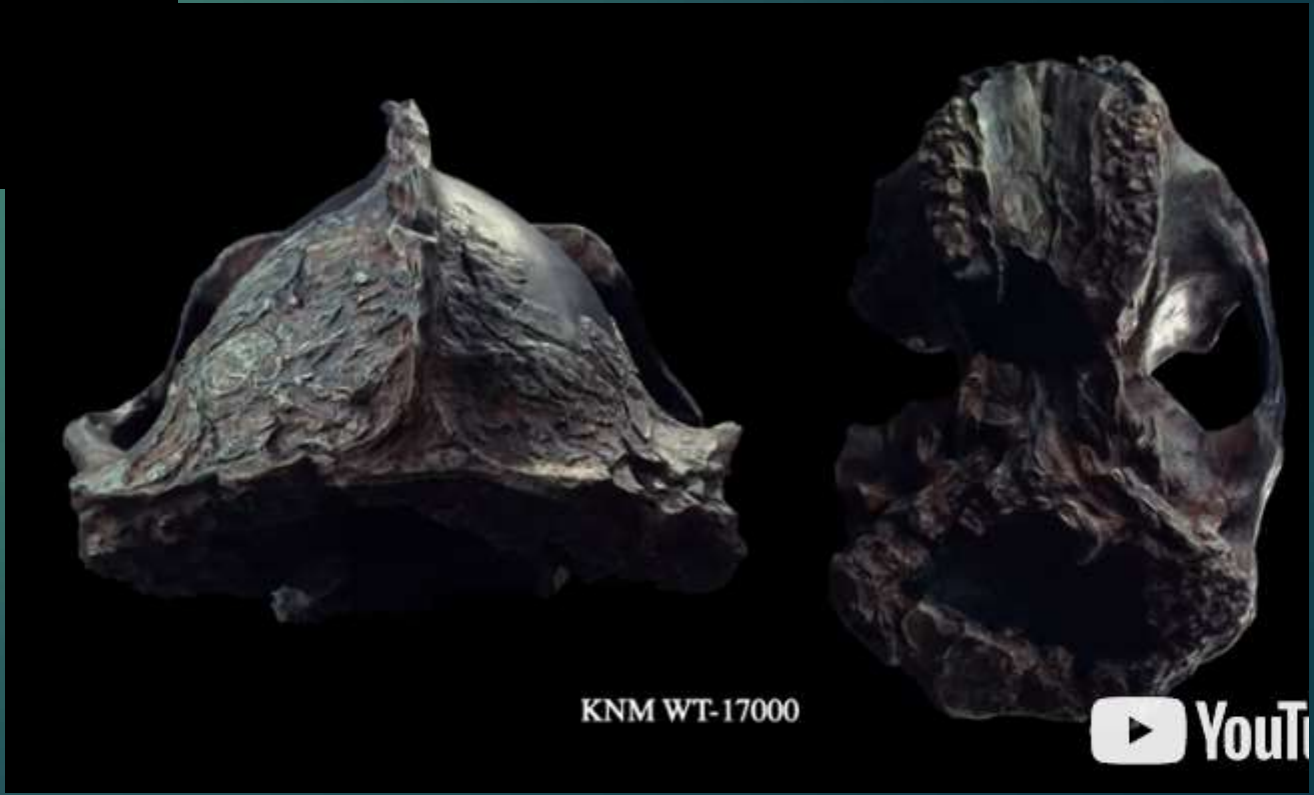
- P. aethiopicus:
- 2.7 to 2.3 MA
- Ethiopia, Kenya
- <u>prominent skull crest</u>, big jaws
- massive teeth

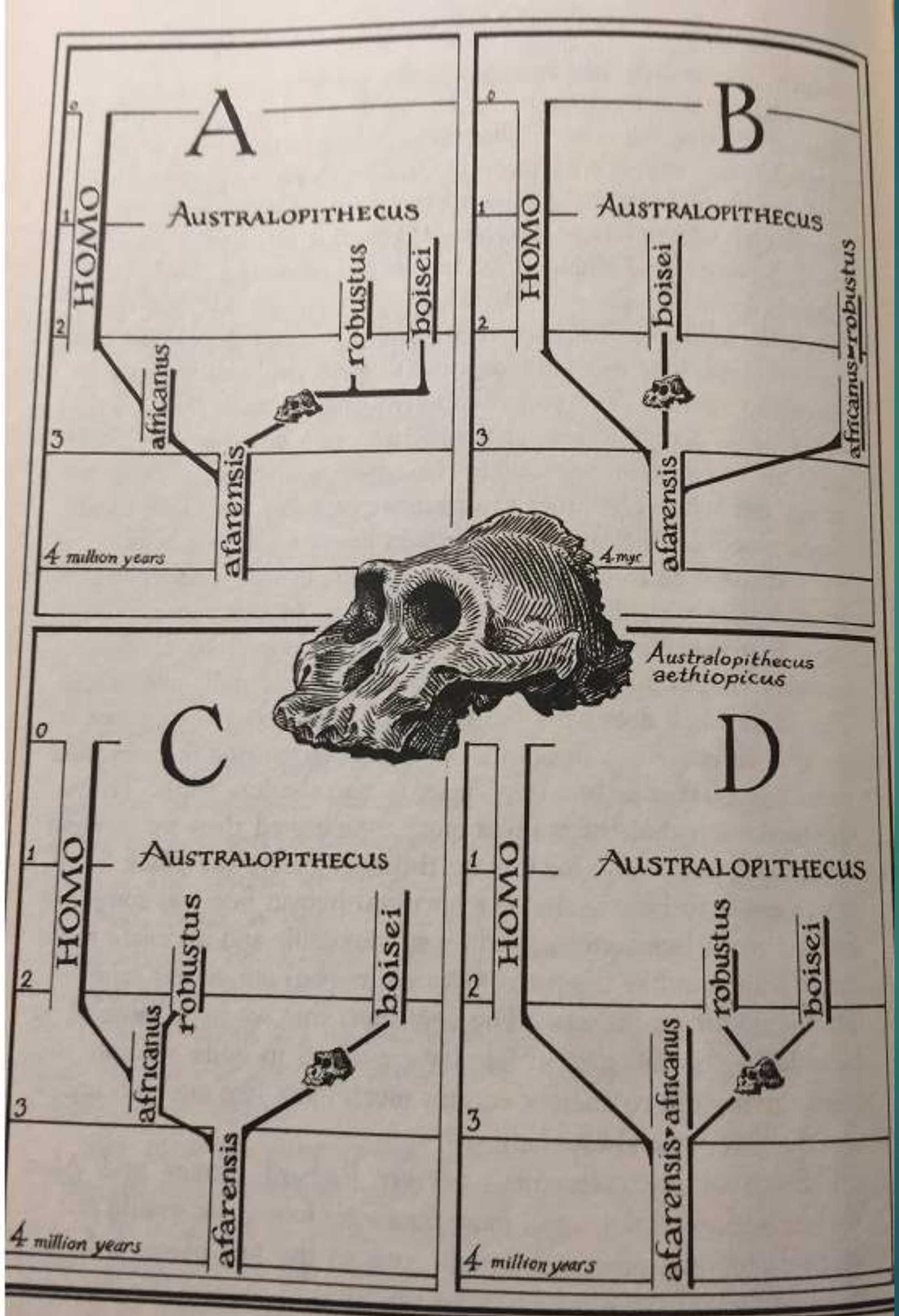
Australopithecus aethiopicus
(KNM-WT 17000, Black skull)
Discoverer: Alan C. Walker
Locality: Lake Turkana, Kenya
Age: 2.5 M
Date 1985

mix of primitive and advanced features; described by some as a nearly perfect intermediate between *A. afarensis* and *P. boisei.*

WT 1700

So WT 17000, *Paranthropus aethiopicus* otherwise known as the black skull, and sometimes referred to as *Australopithecus aethiopicus* is the first specimen indicative of this lineage of robust australopithecines.





- Black skull
- With its curious combo of ancestral and derived traits, the Black Skull forced a rethinking of all proposed human phylogenies.
- Four possible human phylogenies. Four possible family trees are compared.
- Version B is the most popular, but most scientists agree that the evidence now available does not clearly support any one phylogeny over the others.

Paranthropus aethiopicus

Location: East Africa

Major site(s): West Turkana, Kenya

Date range: 2.3 to 2.7 Ma

Associated paleoanthropologist:
Alan Walker

Average cranial capacity: 410 cc

Black Skull (WT 17000)

- Probably ancestral to *P. robustus* and *P. boisei;* Most primitive of paranthropocines

- Large sagittal crest situated posteriorly; big jaws and massive teeth were unique features of *P. aethiopicus*

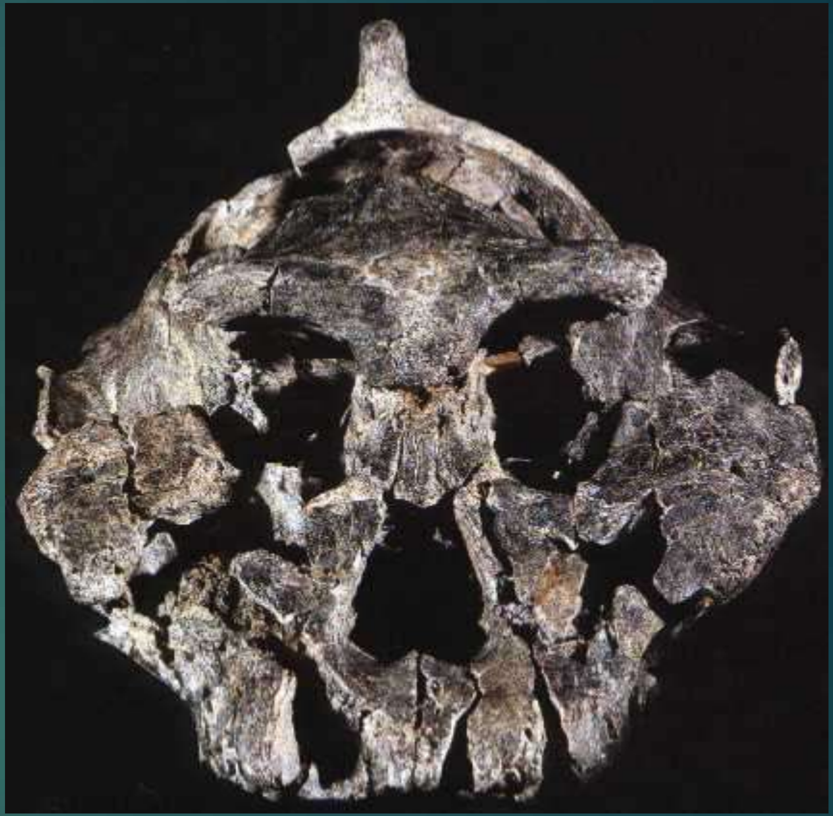
- Dish-shaped projecting face, larger incisors, face w/ flaring zygomatic bones

Paranthropus aethiopicus

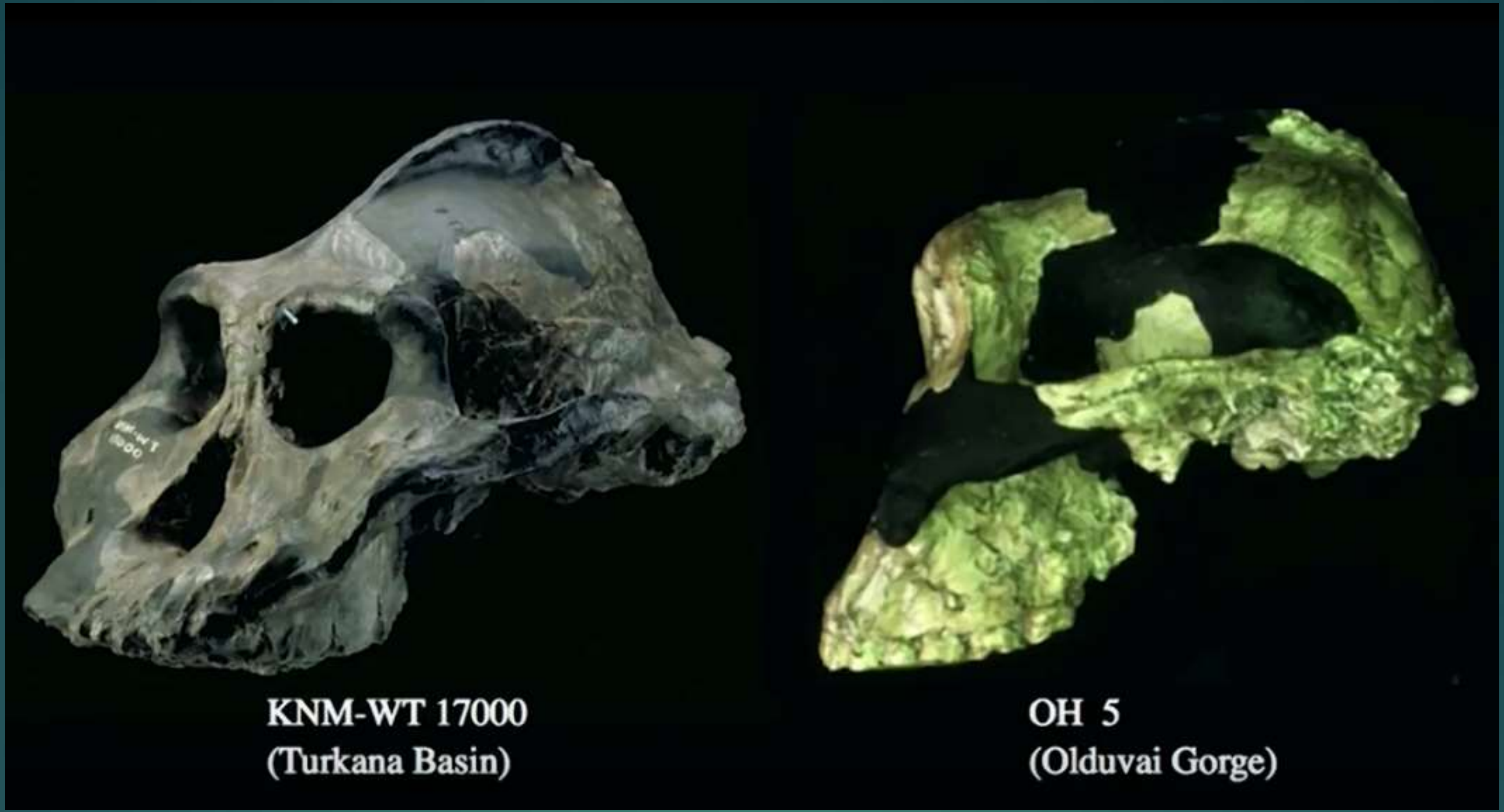
- 2.3 to 2.7 MA
- *Sagittal arch*
- Cranial capacity was rather small (410 cc) and, overall, the skull is apelike, much like that of a male gorilla.
- Cranial capacity ranges from 280 to 450 cc in adult chimpanzees, and from 350 to 750 cc in adult gorillas.

Paranthropus aethiopicus

- Most primitive of paranthropocines
- Best known fossil is KNM-ER 17000, Black Skull
- *Paraustralopithecus aethiopicus* was discovered in southern Ethiopia by French archeologists Camille Arambourg and Yves Coppens in 1967



KNM-ER 17000



P. Aethiopicus vs *P. boisei*

(hyperrobust features)

WT 1700, Black skull

- Largest sagittal crest in any known hominin, particularly posteriorly located on the skull. It's almost as if there's a big sail on the back of the skull.
- Flaring zygomatic arch that extends into a nuchal crest.
- So there's a really powerful masticatory apparatus in the specimen.
  had huge enormous chewing capabilities,
- Massive compound nuchal torus in back
- Really dished out face.
- There's also a huge amount of prognathism associated with this large
  upper jaw.
- Dentition is poorly preserved; root cavities indicate huge teeth.

Paranthropus aethiopicus

- It also has traits that link it with the earlier species *Australopithecus afarensis* such as increased prognathism and a more posteriorly positioned sagittal crest that merges with the nuchal crest.

- It thus appears that even if *P. boisei* and *P. aethiopicus* are retained as separate species, they likely represent chronospecies of the same lineage (i.e., a single ancestor/descendant anagenetic line).

- Tim White: A. afarensis → *P. aethiopicus* → *P. boisei*

Australopithecus aethiopicus

- ***Australopithecus aethiopicus*** existed between 2.6 and 2.3 million years ago.
- It is known from one major specimen and a few other minor specimens.
- The brain size (410 cc) is very small and parts of the skull are very primitive.
- Other characteristics, like the massiveness of the face, jaws, and the largest sagittal crest in any known hominin, are reminiscent of *P. boisei* (the sagittal crest is a bony ridge on top of the skull to which chewing muscles attach).

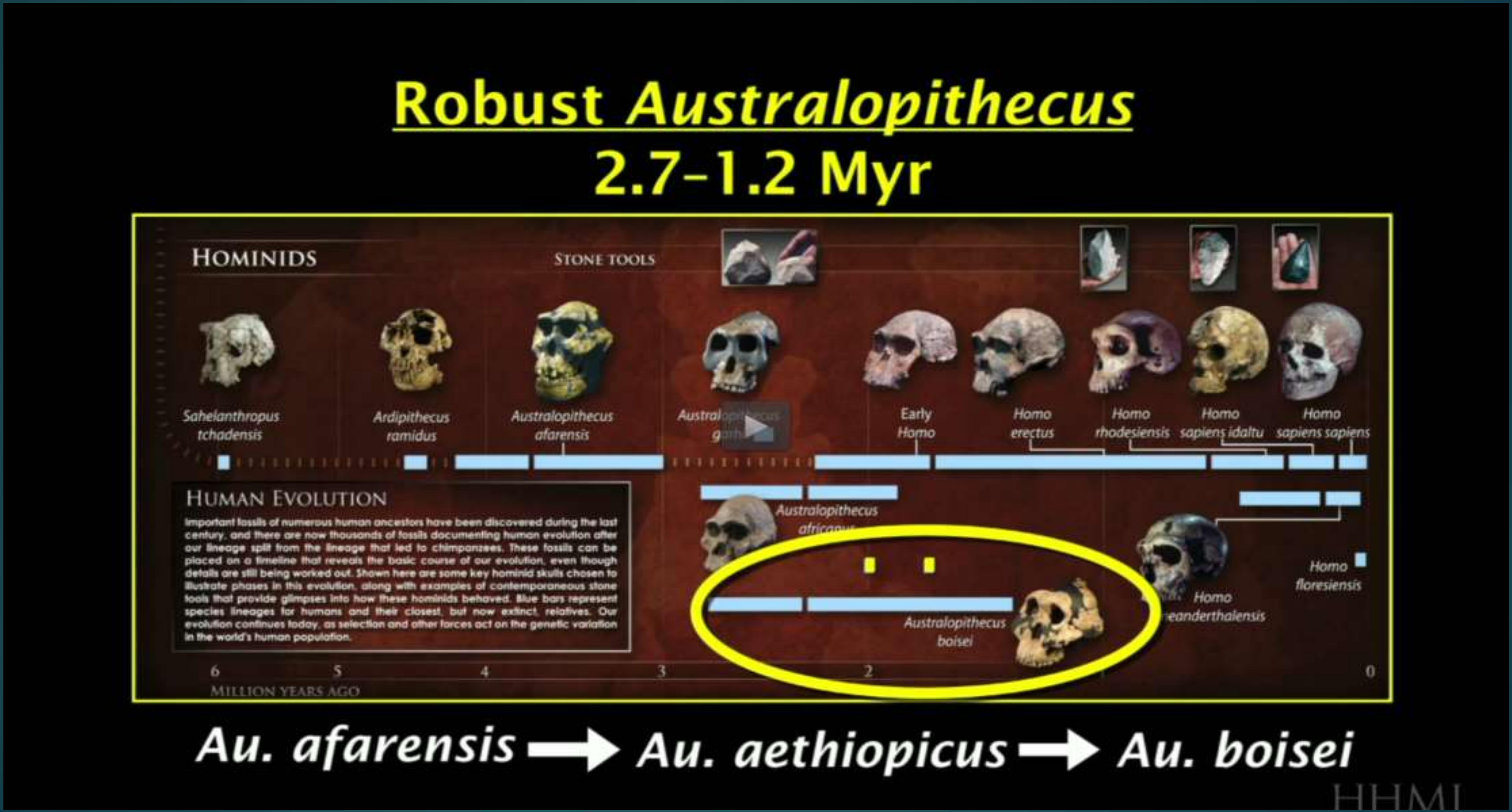
Australopithecus aethiopicus

- Australopithecus aethiopicus, is the first evidence we have of the beginning of this robust lineage of australopithecines.
- ***Australopithecus aethiopicus*** existed between 2.6 and 2.3 million years ago.
- It is known from one major specimen and a few other minor specimens.
- The brain size (410 cc) is very small and parts of the skull are very primitive.
- Other characteristics, like the massiveness of the face, jaws, and the largest sagittal crest in any known hominin, are reminiscent of *P. boisei* (the sagittal crest is a bony ridge on top of the skull to which chewing muscles attach).

WT 17000

- Most researchers include the cranium KNM-WT 17000 and the mandible KNM-WT 16005 from West Turkana in the *P. aethiopicus* hypodigm.
- KNM-WT 17000, more popularly known as the "Black Skull" due to the high concentrations of manganese in the soil that turned the bones a blue-black color upon fossilization, has several traits that link it with *Paranthropus* such as anteriorly positioned cheek bones and presumably large postcanine teeth (based mostly on tooth root size - the cranium is edentulous except for an associated left P^4).
- However, it also has traits that link it with the earlier species *Australopithecus afarensis* such as increased prognathism and a more posteriorly positioned sagittal crest that merges with the nuchal crest.
- It thus appears that even if *P. boisei* and *P. aethiopicus* are retained as separate species, they likely represent chronospecies of the same lineage (i.e., a single ancestor/descendant anagenetic line).

Tim White



Robust Australopithecus
2.7–1.2 Myr
Hominids
Stone Tools
Sahelanthropus tchadensis
Ardipithecus ramidus
Australopithecus afarensis
Early Homo
Homo erectus
Homo rhodesiensis
Homo sapiens idaltu
Homo sapiens sapiens
Human Evolution
Important fossils of numerous human ancestors have been discovered during the last century, and there are now thousands of fossils documenting human evolution after our lineage split from the lineage that led to chimpanzees. These fossils can be placed on a timeline that reveals the basic course of our evolution, even though details are still being worked out. Shown here are some key hominid skulls chosen to illustrate phases in this evolution, along with examples of contemporaneous stone tools that provide glimpses into how these hominids behaved. Blue bars represent species lineages for humans and their closest, but now extinct, relatives. Our evolution continues today, as selection and other forces act on the genetic variation in the world's human population.
Australopithecus boisei
Homo floresiensis
6
5
4
3
2
0
Million Years Ago
Au. afarensis → Au. aethiopicus → Au. boisei
HHMI

Aethiopicus vs. Boisei

- Although OH 5 and the other robust australopithecines from East Africa--boisei--share many functional similarities presumably with this earlier aethiopicus specimen, in actuality, in fine details, there's not a lot that necessarily connects them in terms of the overall pattern of morphology.

- Although they both have large chewing apparatuses, the rest of the morphology suggests that there's a lot of differences between aethiopicus and boisei.
- And it's possible that aethiopicus, again, doesn't connect later in time with boisei. That might simply be a convergence on similar kinds of characteristics.
- Tim White: A. afarensis → *P. aethiopicus* → *P. boisei*

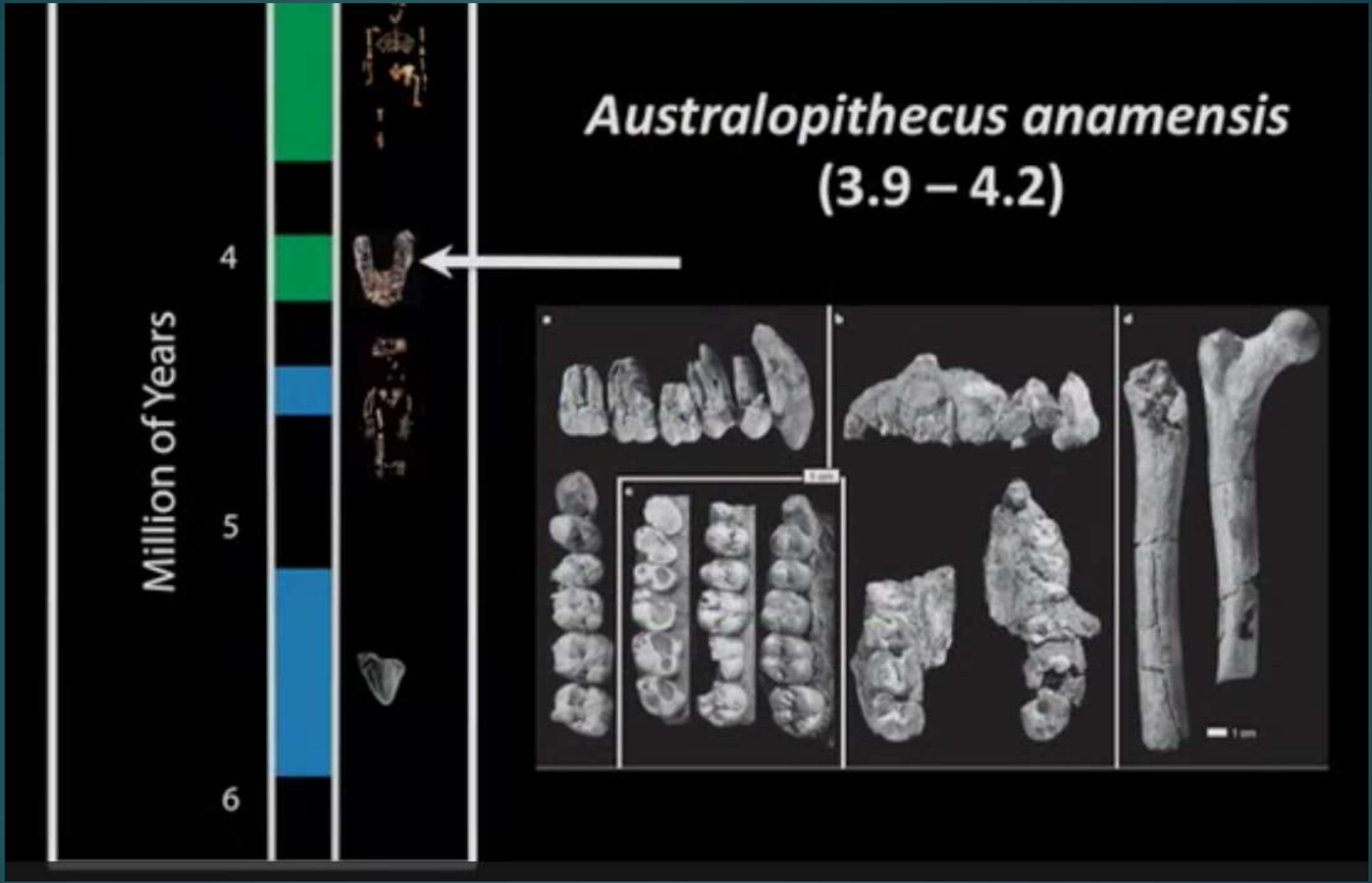
Australopithecus anamensis

A. anamensis

- Until 1994, *A. afarensis* was the earliest hominin species yet discovered.
- At that time, remains of another species, tentatively called *Australopithecus anamensis*, was discovered in the Lake Turkana region of east Africa and appears contemporary with *afarensis*, dating to approximately 4.2 million years ago.

A. A. anamensis is also an erect, bi-pedal species, and its discovery pushes direct evidence of our distinctive hominin form of locomotion back to over 4 million years ago.

B. There is evidence that, contrary to previous assumptions, these early hominins had developed bipedalism prior to the disappearance of woodlands and forests in eastern Africa--that is, our hominin ancestors were by chance "pre-adapted" to the conditions of drier, more open country that came to prevail in eastern Africa later on.



Kenya and Ethiopia

1994: *Australopithecus anamensis: Oldest Australopithecine*
4.2-3.9 Ma, biped

Oldest Australopithecine

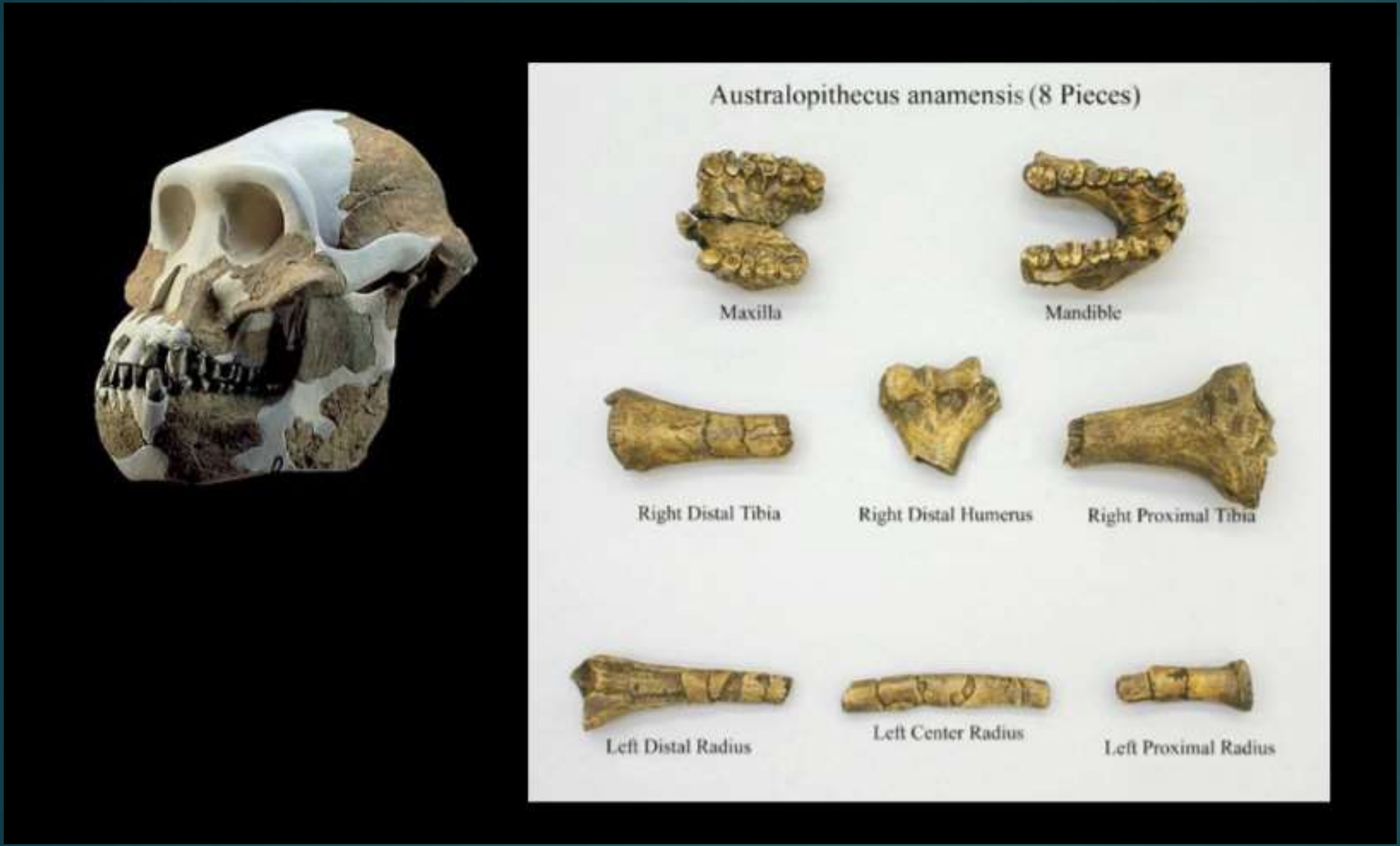
The teeth of *Australopithecus anamensis* are markedly apelike (large canines, parallel tooth rows)

May be earliest incontrovertible evidence of bipedalism

Possible obligate biped

Tim White: Early Australopithecus (4.2-3.0 Ma): *A. anamensis*→→*A. afarensis* = 1 species lineage, arbitrarily divided = “2 chronospecies”

Australopithecus anamensis



Arms & hands for climbing

Shock absorbing tibia

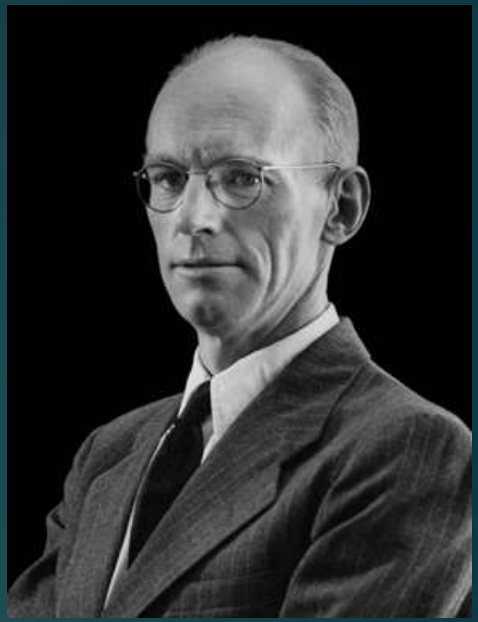
Knees for bipedal walking

Arms & hands for climbing

Shock absorbing tibia (lower leg bone)

Knees for bipedal walking

Bryan Patterson (1909-1979): *Australopithecus anamensis*



- American paleontologist at the Field Museum of Natural History in Chicago
- 1965: ***Australopithecus anamensis*** **discovered by his expedition at Turkana, Kenya;**
- Not **explicitly identified until 1994 by Maeve Leakey** when work on the site finally began

Bryan Patterson, Anna K. Behrensmeyer, & William D. Sill (6 June 1970). "Geology and Fauna of a New Pliocene Locality in North-western Kenya". *Nature* **226** (5249): 918–921

Maeve G. Leakey, Craig S. Feibel, Ian McDougall and Alan Walker. 1995. "New four-million-year-old hominin species from Kanapoi and Allia Bay, Kenya". *Nature* 376:565-571.

Maeve Epps Leakey (1942-):
Australopithecus anamensis, Kenyanthropus platyops

- Paleontologist; Head of the Division of Paleontology at the National Museums of Kenya, 1982-2001.
- Wife of Richard Leakey & mother of Louise Leakey

- 1994: at Kanapoi, Kenya, discovered, with hominin Gang, the mandible of *Australopithecus anamensis*, 4 Ma
- 1995: made KNM-KP 29281 the type specimen of *A. anamensis*
- 1999: discovered and named *Kenyanthropus platyops* (KNM-WT 40000)

Australopithecus anamensis

KP 29281

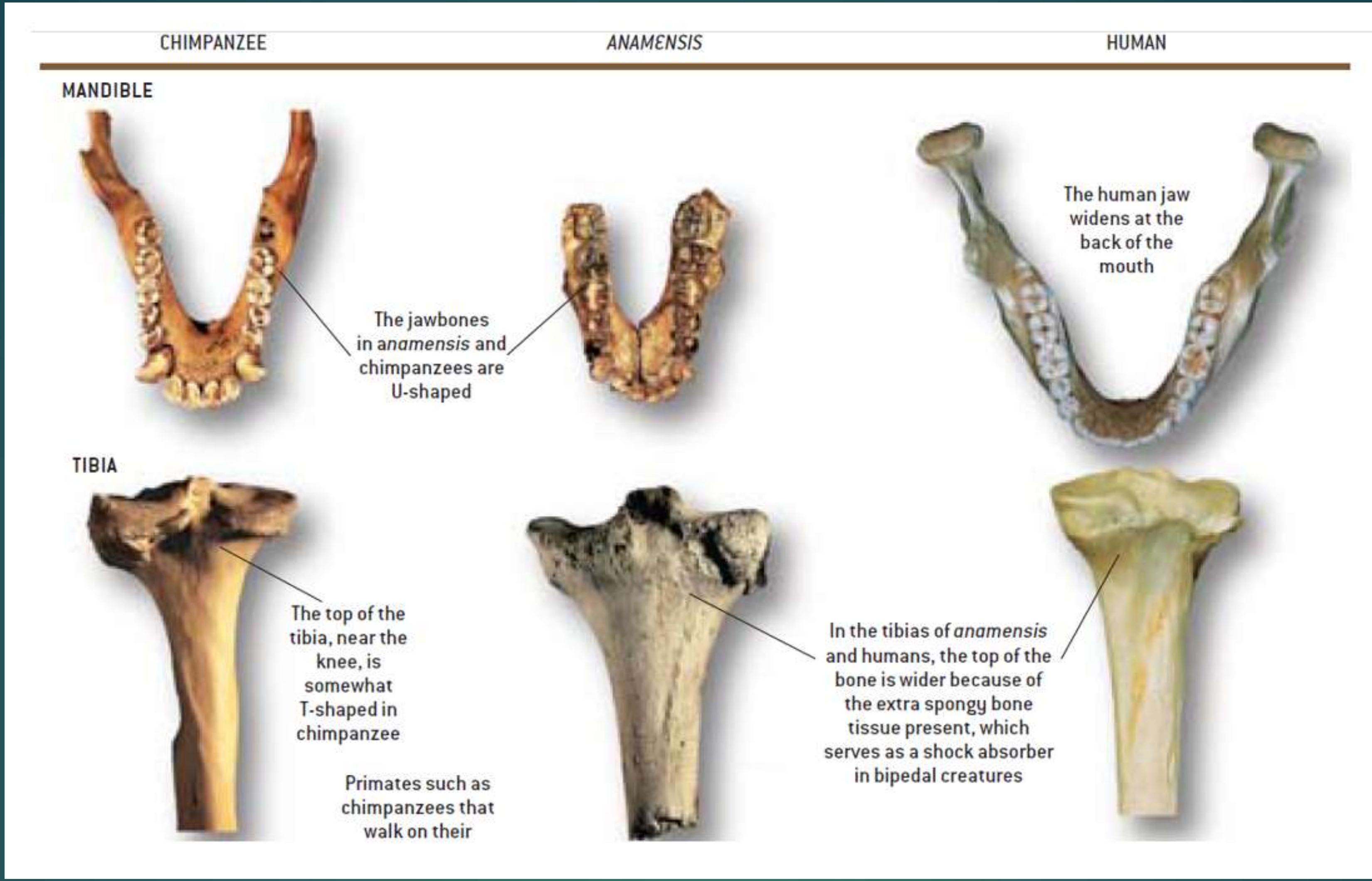
Maeve Leakey: *Australopithecus anamensis*

CAPTION
Partial upper jaw of *Australopithecus anamensis*, a primitive hominin, recovered from the bone bed excavated at the Allia Bay site.

Australopithecus anamensis
(KNM-KP 29281 – type specimen)
Discoverer: Peter Nzube
Locality: Kanapoi, Kenya
Date 1994
Age 4.1 M

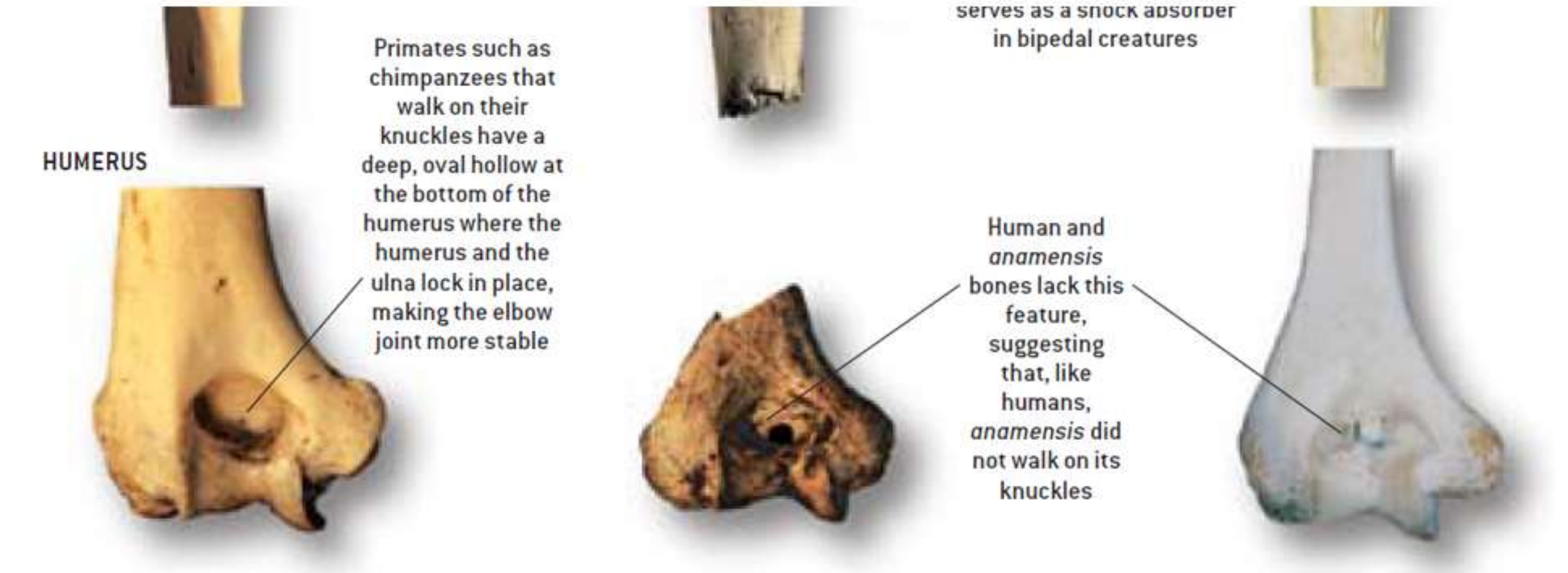
CAPTION

Partial upper jaw of *Australopithecus anamensis*, a primitive hominin, recovered from the bone bed excavated at the Allia Bay site.



Meave Leakey and colleagues reported in 1995 that *A. anamensis* was the first known species to evolve an expanded knee joint that allowed each of its legs to briefly bear all of its body weight during bipedal walking

Not a knuckle walker: hollow in humerus (upper arm bone)



FOSSILS from *anamensis* (*center*) share a number of features in common with both humans (*right*) and modern chimpanzees (*left*). Scientists use the similarities and differences among these species to determine their interrelationships and thereby piece together the course of hominid evolution since the lineages of chimpanzees and humans split some five or six million years ago.

Australopithecus anamensis

Location: East Africa

Major site(s): Kanapoi, & Allia Bay, near Lake Turkana, Kenya

The name *anamensis* is derived the from word "*anam*" meaning "lake" in the Turkana language.

Date range: 3.9 - 4.2 MA.

Associated paleoanthropologists: Meave Leakey, Alan Walker

Thickened tibia
Primitive dentition
Maybe same as A. afarensis?
Forested environment

Average cranial capacity: unpublished, small, ape-like (probably ~ 400 cc)

-

(Leakey et al. 1995, 1998)

Australopithecus anamensis

- Earliest species of genus australopithecine to be found: - evidence in proximal and distal ends of tibia shows it was a biped
- Thick enamel, large canines - sectorial complex & diastema
- Bipedalism inferred from knee and ankle joints
  - Thick enamel and smaller canines
  - Arm bone suggests primitive arboreal adaptations
  - Dental arcade and chin chimpanzee-like
- Strong leg bones and humanlike ankles suggest *A. anamensis* walked upright most of the time.
- But the long arms were suited for climbing trees.
- Larger canine teeth and broad molars suggest that *A. anamensis* ate abrasive foods.
- Contrasts with *A. afarensis* in mandibular shape, dental arcade more parallel (more splayed out in *A. afarensis*)
- Primitive characters suggest *A. anamensis* may be ancestral to later australopithecines

Australopithecus anamensis

- Australopithecus anamensis possesses a mix of advanced and primitive traits.

- A partial tibia (the larger of the two lower leg bones) suggests that A. anamensis probably walked upright.

- The teeth of A. anamensis were covered with a layer of enamel much thicker than that of Ar. ramidus, suggesting a diet of hard-to-chew foods. The thickened enamel is also a trait characteristic of all later hominins.
- In size and shape, however, the teeth of A. anamensis were primitive relative to later hominins.

- A. anamensis probably lived in open woodland habitats in what is now northern Kenya and southern Ethiopia.

Australopithecus anamensis

- The remains of *Australopithecus anamensis* consist of nine fossils from Kanapoi in Kenya and twelve teeth found in 1988 from Allia Bay in Kenya.
- Mixture of primitive features in the skull and advanced features in the body.
- The teeth and jaws are very similar to those of older fossil apes.
- A partial tibia is strong evidence of bipedalism, and a lower humerus is extremely humanlike
- Found in same area as Ardi; Ardi may have been ancestral
- Yohannes Haile-Selassie believes *Anamensis* is ancestral to *A. afarensis*, a chronospecies from 4.2 to 3.0 MA

Australopithecus anamensis

- The teeth of *Australopithecus anamensis* are markedly apelike (large canines, parallel tooth rows); chewing teeth very different from chimps
- This combination of apelike cranial traits with probable bipedality is reminiscent of *Ardipithecus ramidus*.
- Strong leg bones and humanlike ankles suggest *A. anamensis* walked upright most of the time. But the long arms were suited for climbing trees.
- Larger canine teeth and broad molars suggest that *A. anamensis* ate abrasive foods.
- Strongly resembles *A. afarensis;* may be ancestral to *A. afarensis*

(Coffing, et al. 1994; Leakey et al. 1995).

Australopithecus anamensis

- *Australopithecus anamensis* was discovered in nw Kenya Lake Turkana

  The lower Kanapoi specimens are between 4.17 and 4.12 Ma and include only cranial material.

- However, higher in the Kanapoi sequence, but below the locally occurring Kanapoi Tuff, which is about 3.5 Ma, postcranial remains have been found, including a near intact tibia and the distal portion of a humerus (Andrews 1995).
- Tim White: Early Australopithecus (4.2-3.0 Ma): *A. anamensis*→→*A. afarensis* = 1 species lineage, arbitrarily divided = “2 chronospecies”

Early *Australopithecus*
4.2–3.0 Myr

Au. anamensis* → *Au. afarensis

1 species lineage, arbitrarily divided
= 2 "*CHRONOSPECIES*"

Ardipithecus →→*A. Anamensis* →→*A. Afarensis*

Family relations.
A jawbone of Lucy's species (*left*) resembles that of its ancestor, *Australopithecus anamensis* (*center*), compared to a modern chimp (*right*).
CREDIT: 2005 DAVID L. BRILL/BRILL ATLANTA

- Many researchers had suspected: that Lucy's species, *Australopithecus afarensis*, evolved from a 4-million-year-old upright hominin called *Australopithecus anamensis*.
- Propose that an even older hominin called *Ardipithecus*, whose bones were found closer to the base of the rock layers, was the most likely ancestor of *A. anamensis* and all later australopithecines. Thus, they claim a three-part evolutionary series of human ancestors in a single river valley.
- Many researchers are now convinced that *A. anamensis* was the long-sought ancestor of *A. afarensis*, which ranged across east Africa from 3 to 3.6 Ma.
- Some aren't sure about *Ardipithecus* as direct ancestor of australopithecines. It has been postulated but not demonstrated

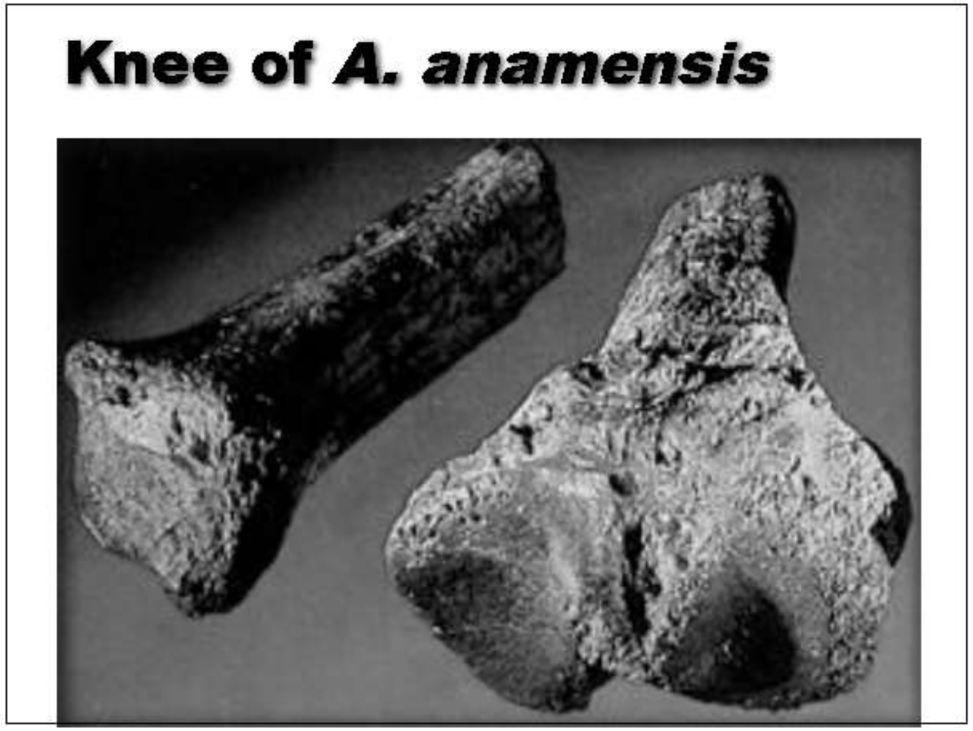
A. anamensis ancestor of *A. afarensis*

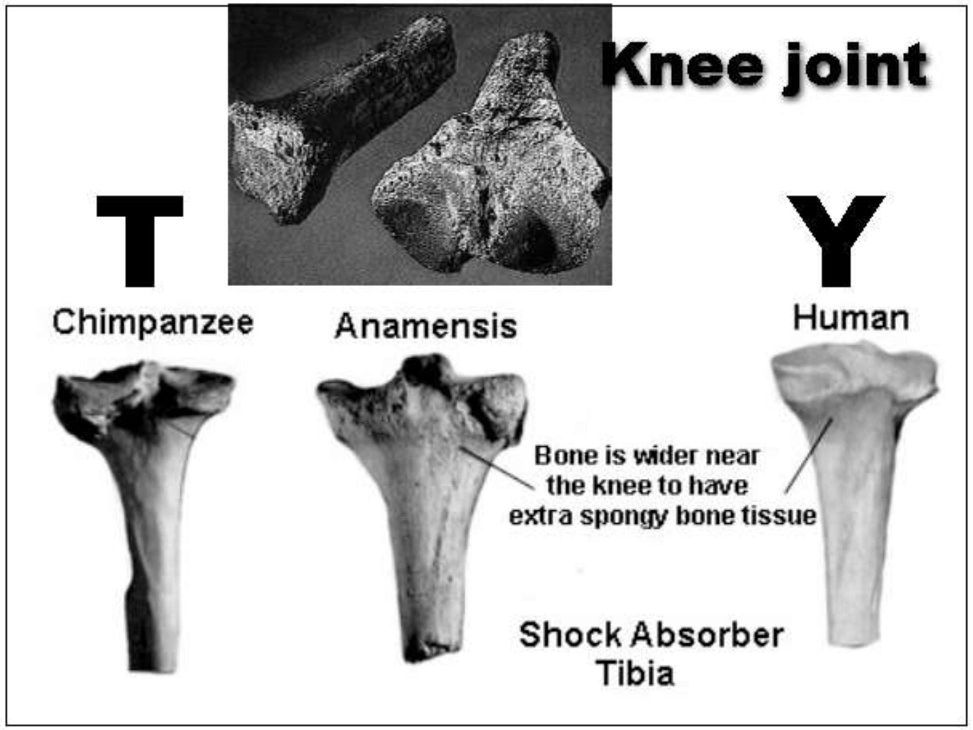
- Kimbel found that key skull and teeth traits support *A. anamensis* as *A. afarensis*'s ancestor.

- Researchers from the international Middle Awash research project, co-led by Tim White of the University of California, Berkeley, found fossils of the three species in the Middle Awash valley over the past 12 years.

- In one area, they found the newly described *A. anamensis* fossils, including jaws, teeth, a finger, a toe, and a thighbone, directly below a younger rock layer containing *A. afarensis* fossils. The fossils confirm that *A. anamensis*'s teeth and jaws were more primitive than those of *A. afarensis*, but the thighbone, the first from this species, was more like Lucy's species, suggesting upright walking, says White.

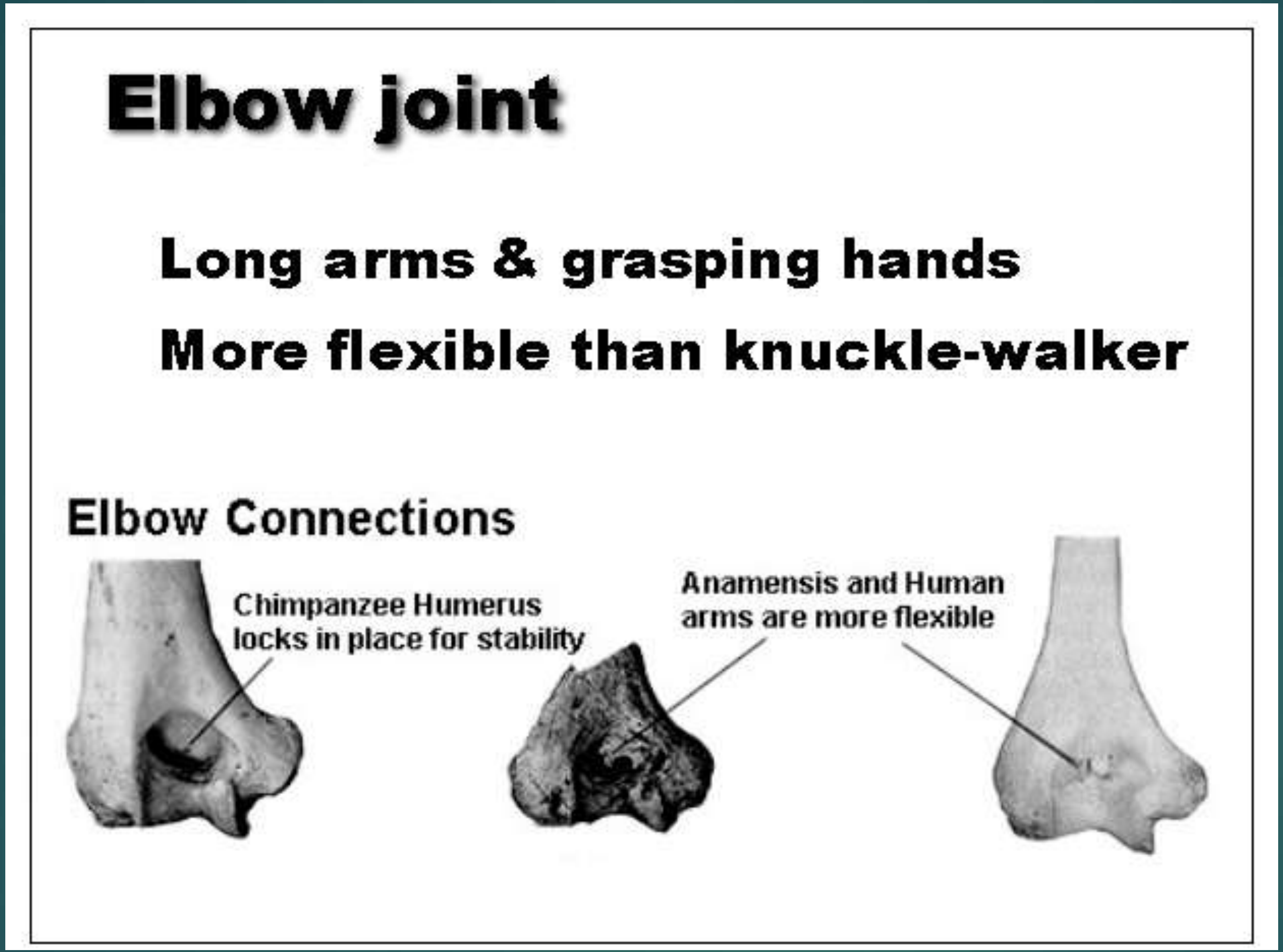
Knee





Tibia: KP 29285: his partial tibia (lower leg bone) indicates that A. anamensis probably walked upright.

Elbow


Elbow joint
Long arms & grasping hands
More flexible than knuckle-walker
Elbow Connections
Chimpanzee Humerus
locks in place for stability
Anamensis and Human
arms are more flexible

2016: Yohannes Haile-Selassie with MRD

A maxilla initially found by goat herder named Ali Bereino. Because locals often claimed they had found a fossil in order to get a ride, he sent a co-worker to see it. Had to sift through earth that was "1 percent dirt and 99 percent goat poop",

2019: A. anamensis, MRD-VP-1/1: a chance encounter with a goat herder

- The first complete skull of a male *Australopithecus anamensis* surfaced at Miro Dora, Woranso-Mille, in Ethiopia's Afar region, in 2016; 35 miles from where Lucy was found. It is oldest skull ever found of an australopithecine.

- MRD is the first specimen to shed light on the full cranial anatomy of the earliest known australopiths
- The cranial morphology of the earliest known hominins in the genus *Australopithecus* remains unclear. The oldest species in this genus (*Australopithecus anamensis*, dated to 4.2–3.9 Ma) is known primarily from jaws and teeth, whereas younger species (dated to 3.5–2.0 Ma) are typically represented by multiple skulls.

- Yohannes Haile-Selassie, et al., 2019
- Beverly Z. Saylor, et al., 2019

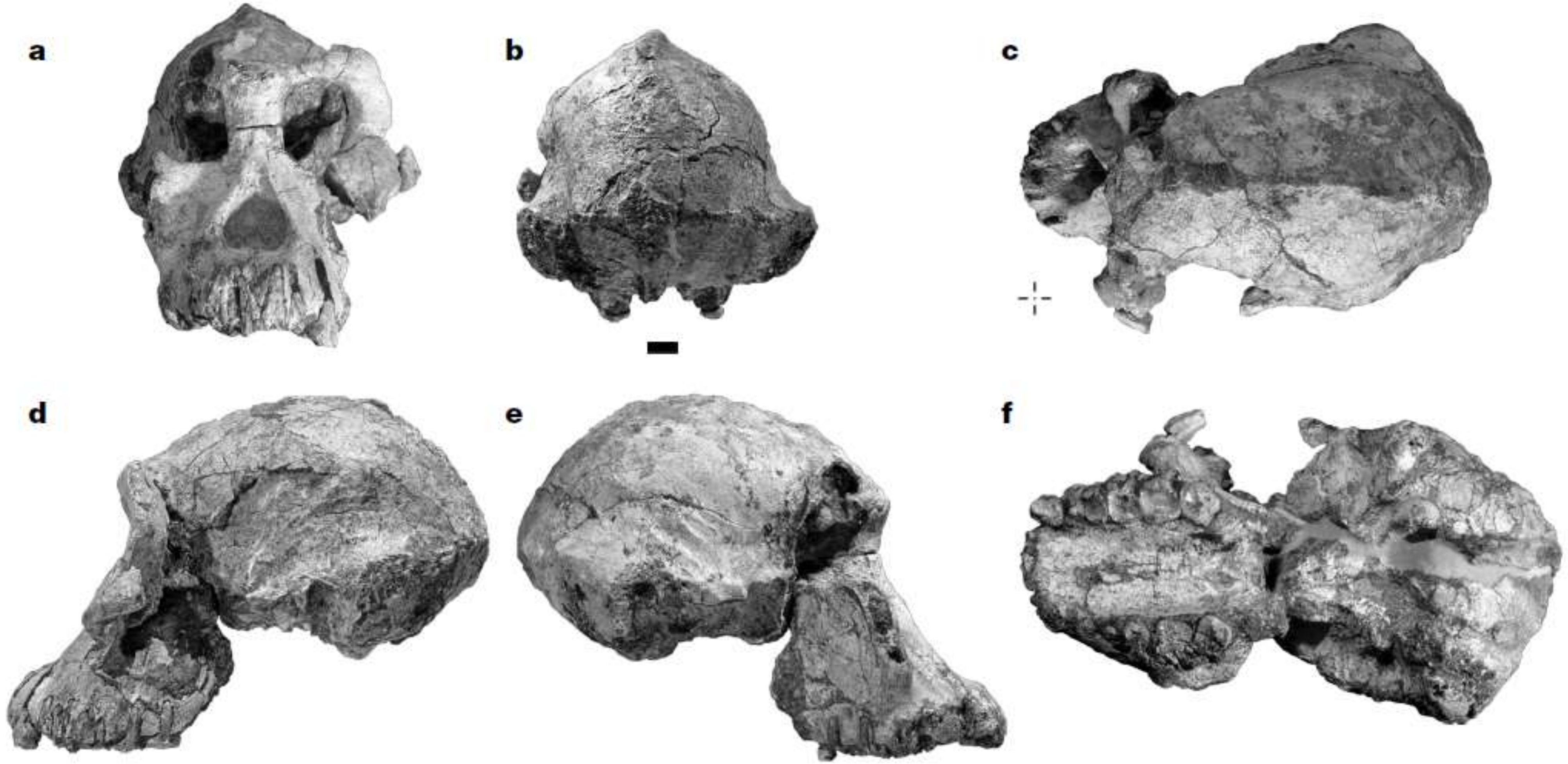
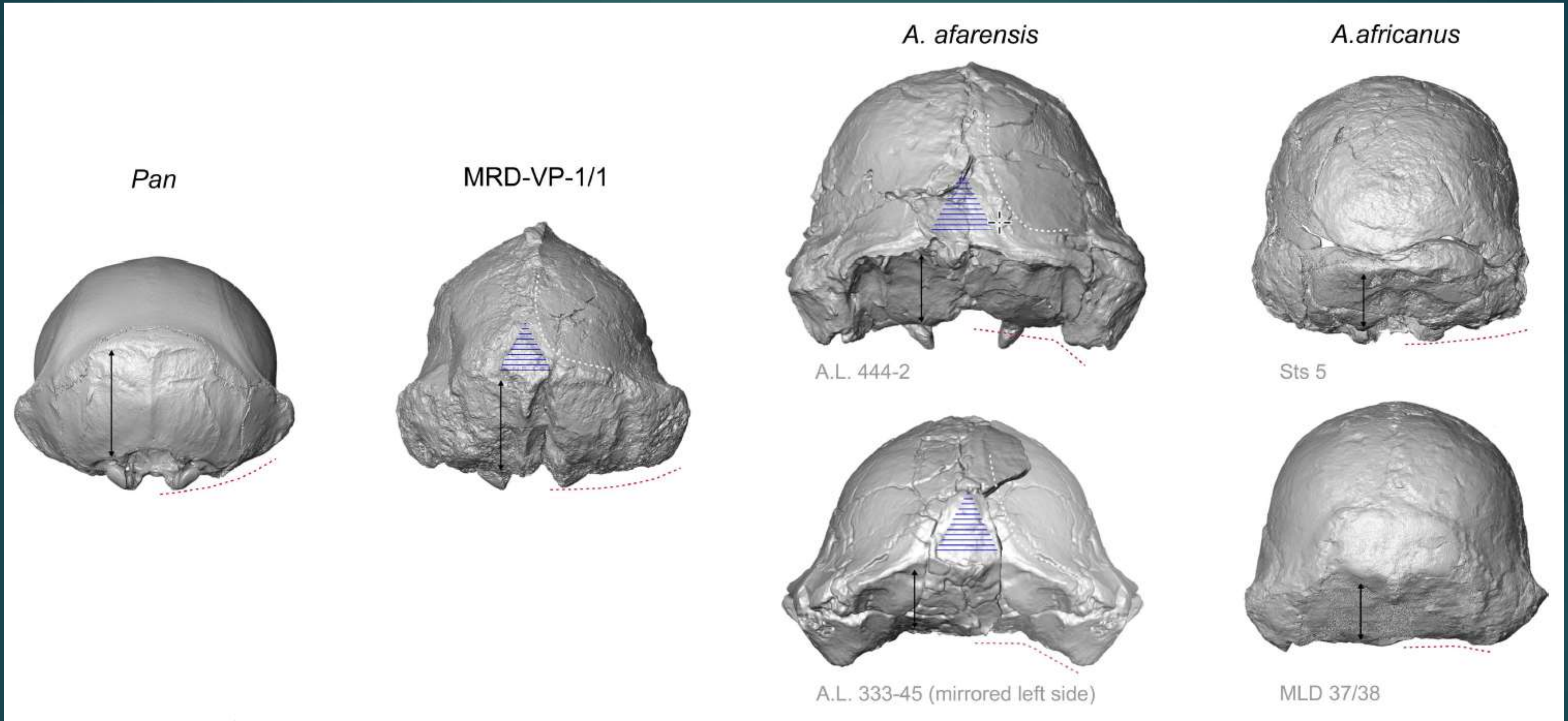


Fig. 1 | The MRD-VP-1/1 cranium. **a**, Anterior view. **b**, Posterior view. **c**, Superior view. **d**, Left lateral view. **e**, Right lateral view. **f**, Inferior view. The specimen is oriented in Frankfort horizontal plane. Scale bar, 1 cm.

Skull was found in just two large pieces; Some digital reconstruction was used.

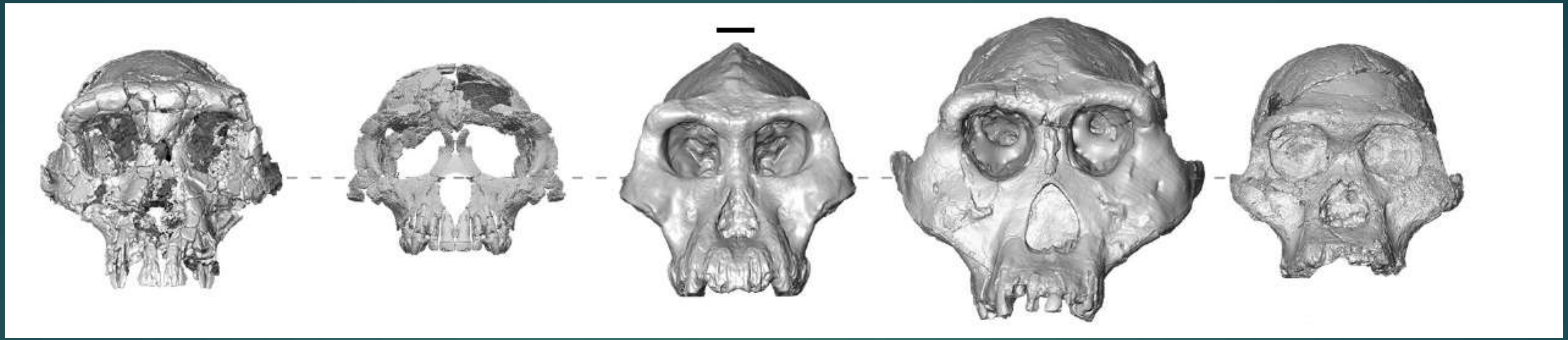
Posterior views



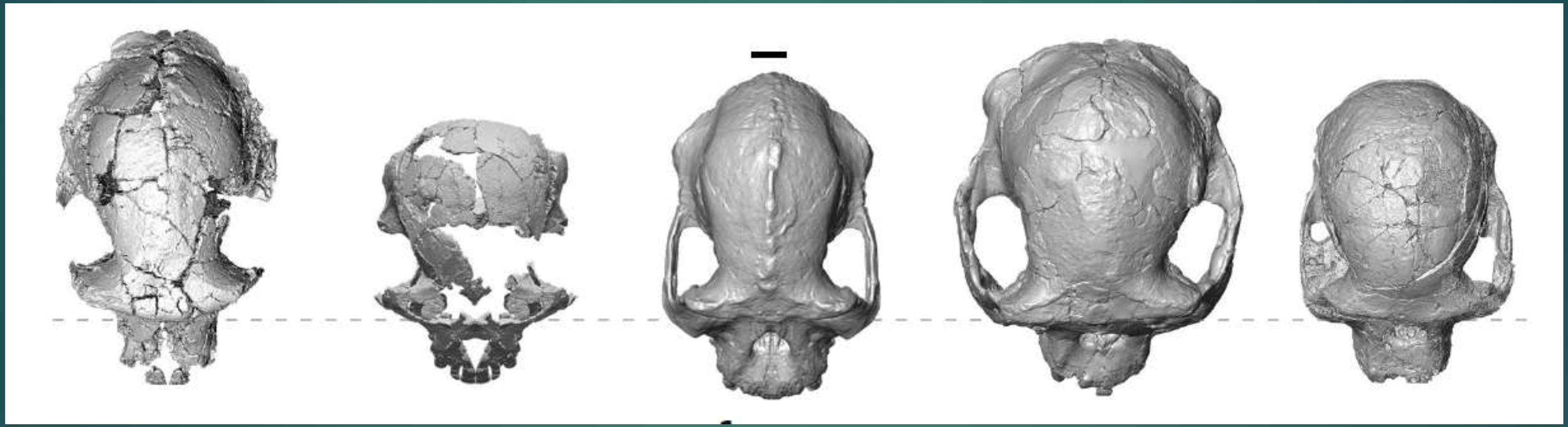
“Most of *A. anamensis’* own traits are quite primitive,” Haile-Selassie says, noting the individual’s small brain, protruding face and large canine teeth. “There are a few features exclusively shared with *A. afarensis*, like the orbital region in the frontal area. But everything else is really primitive. If you look at it from the back, it looks like an ape.

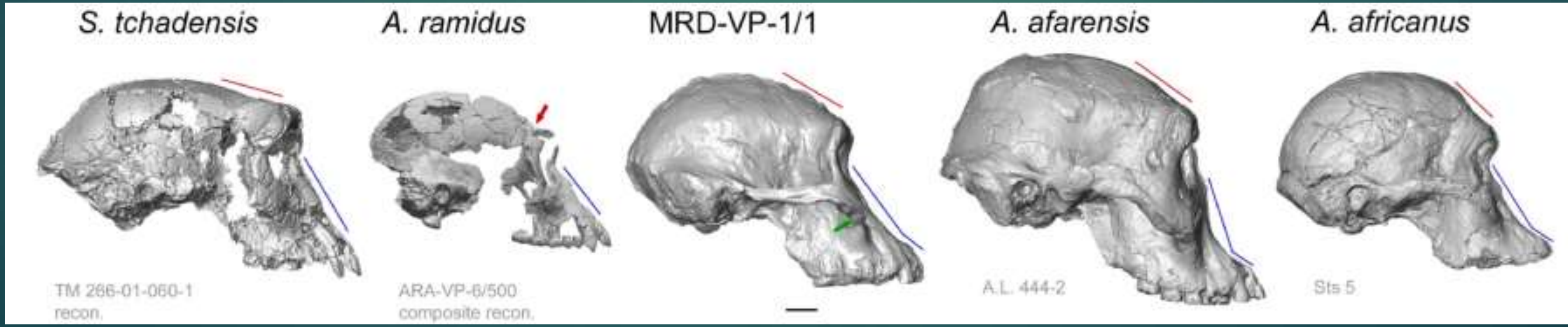
2019: A. anamensis, MRD-VP-1/1

- A nearly complete hominin cranium from Woranso-Mille (Ethiopia) that is dated to 3.8 Ma. Geologist Saylor's team: one tuff above the skull formed between 3.76 and 3.77 Ma, and a second below the skull formed slightly more than 3.8 Ma. Skull was buried in a river delta on a lakeshore, surrounded by shrubland and patches of trees. It probably was either along the river or along the shores of this lake. It died there, and then it was transported down and buried in the delta.
- The cranium was assigned to *A. anamensis* on the basis of the taxonomically and phylogenetically informative morphology of the canine, maxilla and temporal bone.
- This specimen provides the first glimpse of the entire craniofacial morphology of the earliest known members of the genus *Australopithecus*.
- *A. anamensis* and *Australopithecus afarensis* differ more than previously recognized and that these two species overlapped for at least 100,000 years—contradicting the widely accepted hypothesis of anagenesis.



S. Tchadensis *A. ramidus* MRD *A. afarensis* *A. africanus* (Sts 5).









MRD

- Morphology that is more primitive than that of any previously known *Australopithecus* cranium, including features that link early *Australopithecus* to the Mio-Pliocene genera *Sahelanthropus* and *Ardipithecus*.
- *A. anamensis* is consistently recognized as being phylogenetically positioned between *A. ramidus* and *A. afarensis*. Data for this idea are based on only jaws and teeth. Our understanding is thus primarily based on where *A. anamensis* fits with regard to documented trends in canine reduction and the development of masticatory robusticity
- Together, the secure dating of BEL-VP-1/1 and MRD indicate that *A. afarensis* and *A. anamensis* overlapped in the Afar Triangle for at least 100,000 years

Conclusions

- The hypothesis that *A. anamensis* and *A. afarensis* constitute a single evolving chronospecies was based on limited apomorphic features in *A. anamensis*, but is mostly due to perceived temporal trends in morphology in four time-successive samples of the two species from Kanapoi, Allia Bay, Laetoli and Hadar.

- The addition of MRD to the *A. anamensis* hypodigm changes our understanding of the relationship between the two taxa.

- *A. anamensis* can be clearly distinguished from *A. afarensis* such that the latter species may not have been a result of phyletic transformation within an unbranched lineage.

Conclusions

- It appears that there were at least four time-successive but allopatric *A. anamensis* populations (Woranso-Mille, Allia Bay, Asa Issie and Kanapoi) that showed variable cranial and dentognathic morphology.
- The 3.8-Myr-old MRD from Woranso-Mille is morphologically similar to the species from Kanapoi and Asa Issie (4.2–4.1 Myr ago). However, it is unlikely that an *A. anamensis* population represented by MRD gave rise to *A. afarensis*, as MRD postdates BEL-VP-1/1, which now appears to be the earliest known representative of *A. afarensis* with an age of approximately 3.9 Myr.
- Although MRD and other discoveries from Woranso-Mille do not falsify the proposed ancestor–descendant relationship between *A. anamensis* and *A. afarensis*, they indicate that *A. afarensis* may not have evolved from a single ancestral population. Most importantly, MRD shows that despite the widely accepted hypothesis of anagenesis, *A. afarensis* did not appear as a result of phyletic transformation. It also shows that at least two related hominin species co-existed in eastern Africa around 3.8 Myr ago, further lending support to mid-Pliocene hominin diversity.

A. anamensis

- Previously thought that *A. anamensis* gradually morphed into *A. afarensis*, implying that the two species never coexisted. This skull casts doubt on prior idea that the older lineage directly gave rise to the younger, instead suggesting that the two lived together, coexisting for at least 100,000 years.
- The new skull of *A. anamensis* narrows considerably behind the eye sockets. That feature could clarify the identity the “Belohdeli frontal,” a 3.9-million-year-old fragment of australopith skull found in 1981. Haile-Selassie says that the Belohdeli frontal isn’t *A. anamensis* and instead belongs to *A. afarensis*. Because the Belohdeli frontal is older than the new skull, the find suggests that *A. anamensis* and *A. afarensis* overlapped in time from 3.8 to 3.9 million years ago. That’s an evolutionary shakeup: Scientists had thought that successive generations of *A. anamensis* evolved into *A. afarensis*, a straight-line process that would have precluded any overlap. Instead, the researchers argue that by 3.9 million years ago, one group of *A. anamensis* had branched off from the rest and evolved into *A. afarensis* while other groups of *A. anamensis* stuck around.
- But the study authors stress that it’s still quite possible that early populations of *A. anamensis* gave rise to *A. afarensis* perhaps 4 million years ago—they just didn’t die out immediately afterwards. “Probably a small population of *A. anamensis* isolated itself from the main population, underwent major changes, and over time distinguished itself from the parent species of *A. anamensis*. That’s probably how *A. afarensis* appeared,” Haile-Selassie says.

- Haile-Selassie and his colleagues say it’s still likely that Lucy’s species evolved from *A. anamensis*. But they think it did so through a ‘speciation event’: perhaps a small group of *A. anamensis* became genetically isolated from the general population and evolved into *A. afarensis*, which eventually outcompeted the wider *A. anamensis* population.
- The research team argues that the relationship between the two ancient hominin species, believed to be ancestors to our own genus *Homo*, may be a prime example of a nonlinear evolutionary scenario common in other non-human species. Anagenesis, when one species evolves so completely into another species that the progenitor disappears, is not the primary way the branches on our family tree diverged. “Just because one species gave rise to another, it doesn’t mean that the source species (ancestor) disappeared,” Rick Potts.
- Both Strait and Ward think the evidence isn’t conclusive yet, because it rests heavily on just two fossils — the MRD cranium and the forehead fragment discovered in the 1980s. William Kimbel: “You cannot make a strong claim on the mode of evolution based on only two specimens.”

John Gurche: MRD

Australopithecus bahrelghazali

Australopithecus bahrelghazali, 3.5 M

- Discovery 1995: with MPFT, in Koro Toro, Chad (not far from site of *S. tchadensis);*
- *Australopithecus bahrelghazali*
- KT-12, named "Abel", type specimen in 1996
- age 3.5 M
- Same as A. afarensis?

Australopithecus bahrelghazali

- A mandibular fragment found at Chad east of the Bahr el Ghazal, near Koro Toro, by Michel Brunet, 1995 on the site called KT12. Named after the name of the fossil valley near where it was discovered, cataloged KT12 / H1, the holotype consists of a mandibular fragment, a lower second incisor, both lower canines, and all four of its premolars, still affixed within the dental alveoli.
- An upper premolar of another individual find on the same place 1996. This paratype is cataloged KT12 / H2.
- A third fossil, a fragment of maxilla cleft, was collected 1996 on the site of KT13, KT12 close neighbor. Cataloged KT13-96-H1, it appears in a scientific article in 1997 as *Australopithecus* sp. Indet. before being named *Australopithecus bahrelghazali* in 2012.
- Finally, a fourth fossil mandibular fragment with two teeth was unearthed in 2000, a few kilometers south of the site KT13 on the new site of KT40.
- The three sites are located at the foot of an ancient shoreline.

Australopithecus bahrelghazali

- The KT-12/H1 mandible has similar features to the dentition of *Australopithecus afarensis*, which fact has caused researcher William Kimbel to argue that Abel is not a separate species, but "falls within the range of variation" of the species *Australopithecus afarensis*. But the mandibular symphysis is more modern in appearance than that of *A afarensis*
- This claim is difficult to substantiate, as the describers, contrary to the *International Code of Zoological Nomenclature*, have kept the specimen locked away from inspection by the general paleoanthropological community.
- *A. bahrelghazali* is unique as it is the only australopithecine fossil found in Central Africa. It is also of great importance as it is the first fossil to show that there is a geographical "third window", that is, beyond East Africa and South Africa, of early hominin evolution.

Australopithecus deyiremeda

2015, New Species: *Australopithecus deyiremeda* (Holotype BRT-VP-3/1): *3.4 MA*

- *Australopithecus deyiremeda* (“close relative”) lived about 3.4 million years ago in northern Ethiopia, around the same time and place (35 km from Hadar) as *Australopithecus afarensis*.
- Lower jaw was beefier, and the teeth smaller, than Lucy’s species

Yohannes Haile-Selassie, et al., 2015

Australopithecus deyiremeda

- 2015: Dr. Yohannes Haile-Selassie, has discovered a 3.3 to 3.5 Ma species.
- From the Woranso-Mille area of the Afar region of Ethiopia, have been assigned to the new species *Australopithecus deyiremeda*.
- This hominin lived alongside *Australopithecus afarensis*
- *A. deyiremeda* is the most conclusive evidence for the contemporaneous presence of more than one closely related early human ancestor species prior to three million years ago.
- The type specimen of the species is an upper jaw with teeth discovered on March 4, 2011.

Australopithecus deyiremeda

- Differs from *Australopithecus afarensis* in terms of the shape and size of its thick-enameled teeth and the robust architecture of its lower jaws. The anterior teeth are also relatively small.
- According to Dr. Haile-Selassie, "The new species is yet another confirmation that *Australopithecus afarensis* was not the only potential human ancestor species that roamed in what is now the Afar region of Ethiopia during the middle Pliocene. Current fossil evidence from the Woranso-Mille study area clearly shows that there were at least two, if not three, early human species living at the same time and in close geographic proximity."
- It also raises significant questions, such as how multiple early hominins living at the same time and geographic area might have used the shared landscape and available resources in Afar.

Australopithecus deyiremeda

Nefuraytu Mandible (NFR-VP-1/29)

- NFR-VP-1/29 is one of the most complete and largest mandibles assigned to *Australopithecus afarensis* and likely represents a male individual. It was found in sediments radiometrically dated to 3.33-3.2 Ma.

- Its discovery confirms the existence of *A. afarensis* in the Woranso-Mille study area in close spatial and temporal proximity to the other middle Pliocene hominin taxa found in the area, i.e. *A. deyiremeda* and the Burtele Foot.

Burtele Foot (BRT-VP-2/73), 2009

- The fossil of the partial foot was found in 3.4 Ma rocks at Woranso-Mille in the Afar region of Ethiopia,
- Foot bones are among the rarest elements in the hominin fossil record.
- The first element of the Burtele Foot was recovered by Dr. Stephanie Melillo in 2009.
- The Burtele Foot consists of eight mostly intact bones of the right foot that reveals an unexpected mosaic of primitive and derived features - most significantly, an opposable big toe that suggests that it was not a habitual biped like *Australopithecus afarensis* and may have had a significant arboreal component to its locomotor repertoire.
- Radiometrically dated at 3.4 Ma, it is contemporaneous with *A. afarensis* and a million years younger than Ardi (*Ardipithecus ramidus*), found at the nearby site of Middle Awash, who also possessed an opposable big toe.
- Although it is not yet possible to assign the foot to a species, the Burtele Foot is the first conclusive evidence indicating that there were at least two species of hominins living in close proximity during the Middle Pliocene

Burtele Foot (BRT-VP-2/73)

- Haile-Selassie and colleagues say the partial foot fossil, which was discovered in February 2009, indicates that more than one species of early human ancestor with different means of locomotion, one walking upright, and the other climbing trees, existed between 3 and 4 million years ago

- Lucy's big toe is aligned with the other four toes, for walking on two legs, like we do. But the Burtele foot apparently has an opposable big toe, like a thumb, allowing the foot to grasp branches. This is like the earlier Ardi, and similar to modern apes. Lived in the trees

  The researchers write in their paper that the opposing big toe "not only indicates the presence of more than one hominin species at the beginning of the Late Pliocene of eastern Africa, but also indicates the persistence of a species with *Ar. ramidus*- like locomotor adaptation into the Late Pliocene".
- This individual would have likely had a somewhat awkward gait when on the ground.

A. africanus metacarpals

Top row: a selection of metacarpal bones. Bottom row: CT scans of the same specimens, showing the structure inside (Image: T.L. Kivell)

- Metacarpal bones – the five bones in the palm of the hand that articulate the fingers. Because the bone ends are made of soft, spongy bone tissue, they are shaped over a lifetime of use and molded by what that hand has done. Modern human metacarpals looked different because we use our hands differently. Most of our activities involve some kind of pinching – think of how you hold a pencil or pick up a cup.
  Metacarpals of early human species and neanderthals – they found bone ends that were shaped like modern human bones, and unlike ape bones.

  Metacarpals from four *Australopithecus africanus* individuals, up to 3 Ma. This revealed that their owners had been tree swingers but had also spent a lot of energy tightly pinching small objects, suggesting they were indeed early tool users.

  Difference reflects some powerful thumb-to-finger gripping, suggest that 3 million years ago – 400,000 years before the oldest known Oldowan hand axes – *A. africanus* was already starting to use its hands differently to its ancestors.

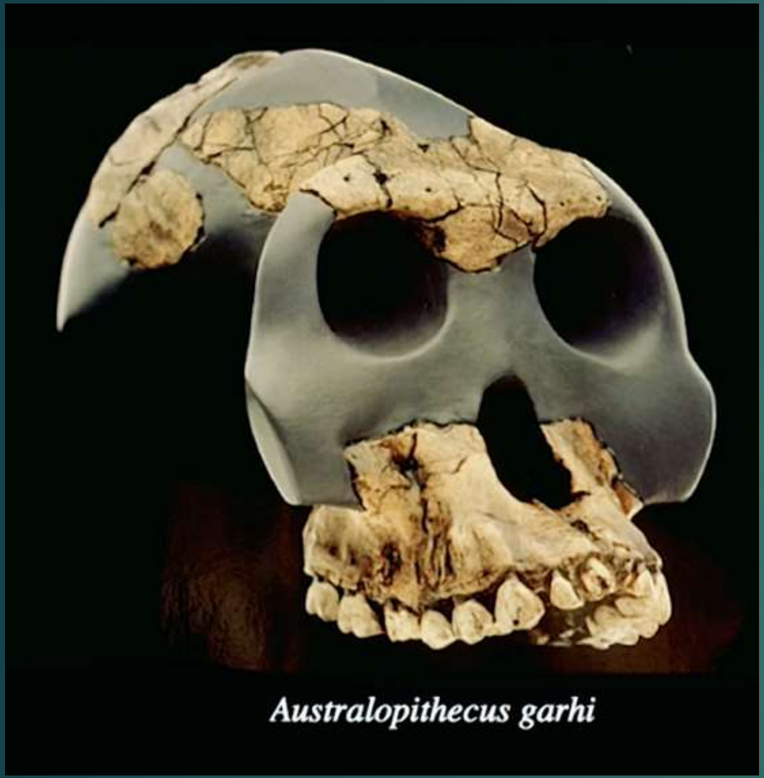
Australopithecus

- Currently, Australopithecus appears relatively abruptly in the fossil record at about 4.2 Ma.
- Relative to Ar. ramidus, available early Australopithecus is now revealed to have been highly derived: a committed biped with slightly enlarged brain, a nongrasping arched foot, further derived canines, substantially specialized postcanine teeth with thick molar enamel, and expanded ecological tolerances and geographic ranges.
-
- It is widely recognized that this is the adaptive plateau antecedent to *Homo*, which is now definable as the third such major adaptive shift in human evolution.

Australopithecus garhi

Australopithecus gahri
2.5 mya

1997: *Australopithecus garhi* :
Tim White & Berhane Asfaw, 2.5 MA



Australopithecus garhi
(BOU-VP-12/130)

Discoverer: Y. Halle-Selassie
Locality: Bouri, Ethiopia
Date 1997

- The very large teeth in this partial skull suggest that A. garhi may have descended from one of the other Australopithecus species, likely A. afarensis.

- Based on a set of cranial fragments (portions of the frontal bone, parietals, and a maxillary bone with teeth) from a single individual

- Very prognathic face
- Large teeth
- Glabellar projection
- Small cranial capacity

Australopithecus garhi

Location: East Africa

Major site(s): Middle Awash (Bouri), Ethiopia

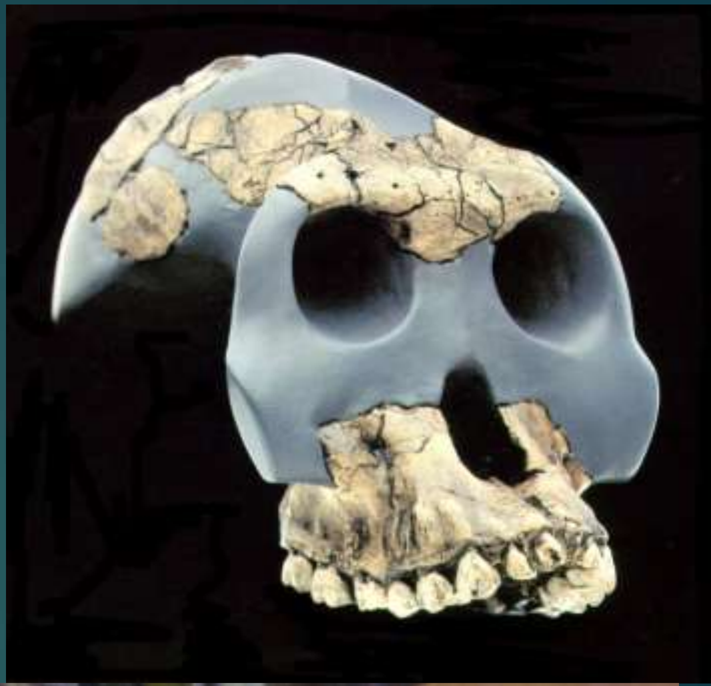
Date range: 2.5 MA. (Ar/Ar)

Associated paleoanthropologist: Tim White & Berhane Asfaw

Average cranial capacity: unpublished (450 cc)

Additional major points to know:

- Possible first tool users (Oldowan industry)
- Long forelimbs & hindlimbs - bipedal
- Large teeth & projecting face
- Likely ancestor of *Homo*



Australopithecus garhi

- Dated to around 2.5 MA in East Africa (Asfaw et al. 1999)
- Small brains like *A. afarensis* and *A. africanus*
- Similar to *A. africanus;* eastern version?
- Very prognathic face
- Significantly larger chewing teeth than 3 other East African australopiths & sagittal crest; suggests a diet including tough, fibrous foods.
- Another candidate for immediate ancestor to *Homo*
- It is currently believed that *A. garhi* is part of the eastern African lineage descended from *A. afarensis; White thinks they are a chronospecies*

BOU-VP-12/130

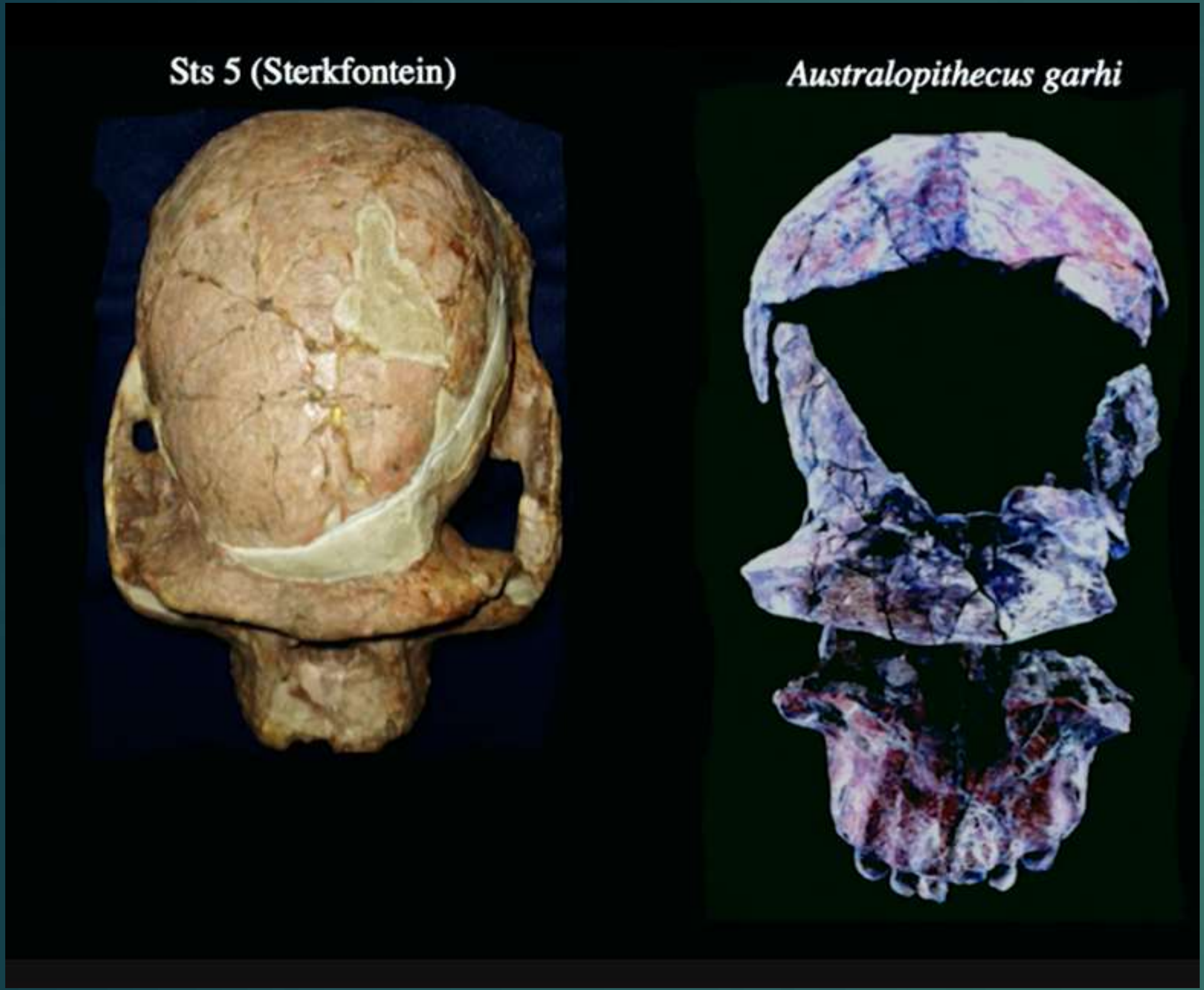
Australopithecus garhi

- A new species of hominin was recovered in the Awash region of Ethiopia in 1996 and 1997. The species has been named *A. garhi*.

- The sediments in which the fossils were found have been dated to roughly 2.5 Ma. The cheek teeth of *A. garhi* are quite a bit larger than *A. afarensis*. However, *A. garhi* lacks other characteristics of the robust forms of hominins, leading researchers to believe *A. garhi* is a sister taxon to the gracile forms.
- It is currently believed that *A. garhi* is part of the eastern African lineage descended from *A. afarensis; White thinks they are a chronospecies*

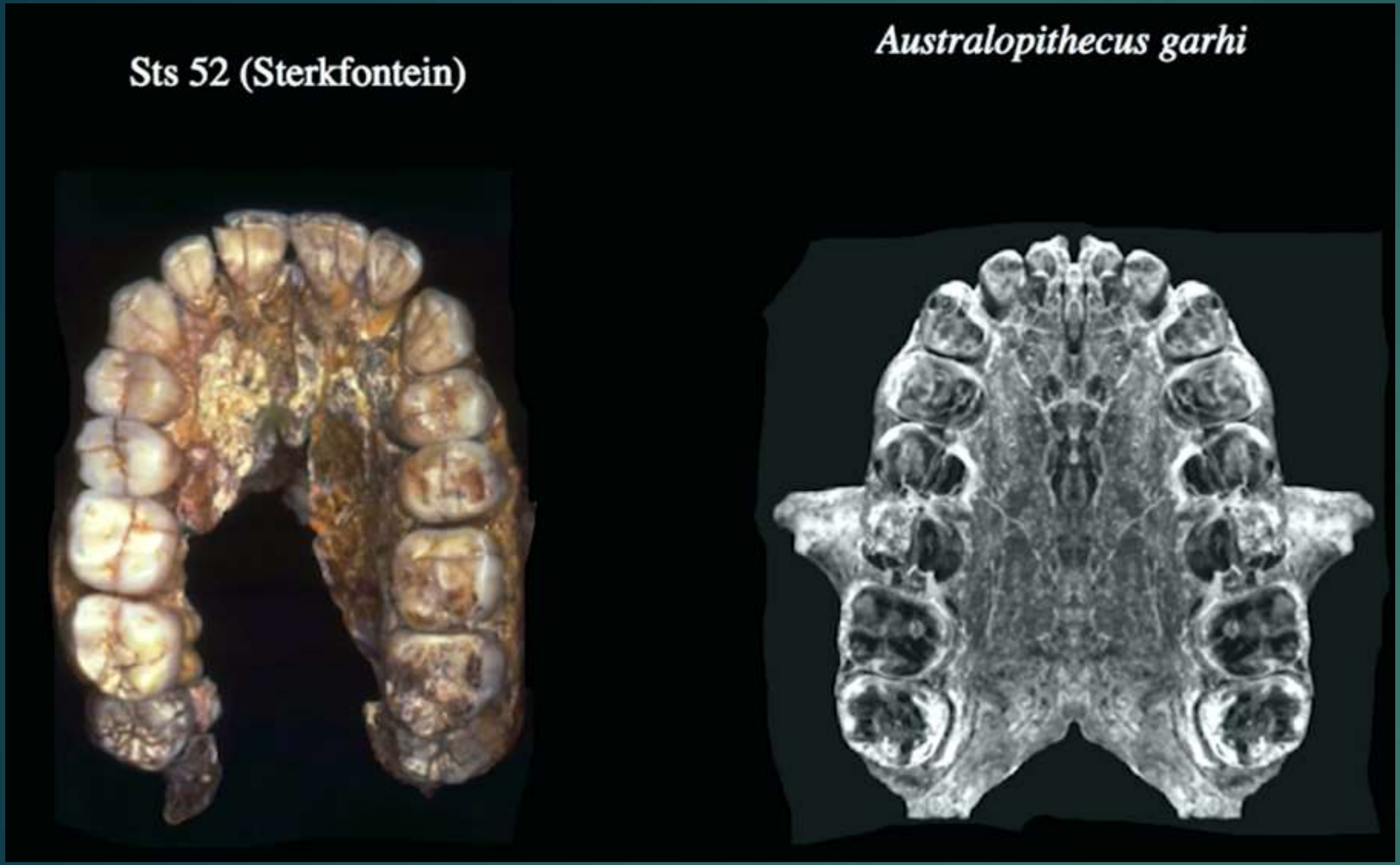
A. garhi

- Cranial capacity of around 450 cc (slightly larger than modern chimpanzees).
- Aspects of the dentition are similar to early specimens of the genus *Homo*.
- *A. garhi* shows human-like ratios for femur to humerus length while retaining ape-like proportions for the length of the forearm to upper arm. This strange admixture of traits leads some scientists to believe that *A. garhi* may be very close to the origin point of our own species. Since not all scientists agree with this interpretation, more evidence is needed to interpret these fossils more precisely.



- lots of similarities with South African *Australopithecus africanus*
- Similar post cranial constriction
- Both 2.5 MA

A. africanus



- Dentition:
- *A. garhi* has large canine, but similar elsewhere
- *A. garhi* may be eastern version of 1 My long southern *A. africanus*

Australopithecus garhi & stone tools

- The fossils, dating to approximately 2.5 MA, are from the Hatayae Member of the Bouri Formation, in Ethiopia's Awash Valley.

- They date to the period of the earliest known stone tools, and the remains of *Australopithecus garhi* are associated with antelope bones with marks that appear to be from stone tools.

- No stone tools found, but evidence that they made stone tools - animal bones that show signs that flesh was neatly removed by sharp-edged tool.

- Oldest evidence that hominins were deliberately defleshing animal carcasses. This evidence of butchery is perhaps the earliest evidence of that activity that we have of in the fossil record.

- In the case of Australopithecus garhi, an ancestral relation to Homo is proposed, not only by chronological and anatomical similarities but also by its association with cut-marked bones

A. garhi and some of earliest stone tools at 2.5 MA

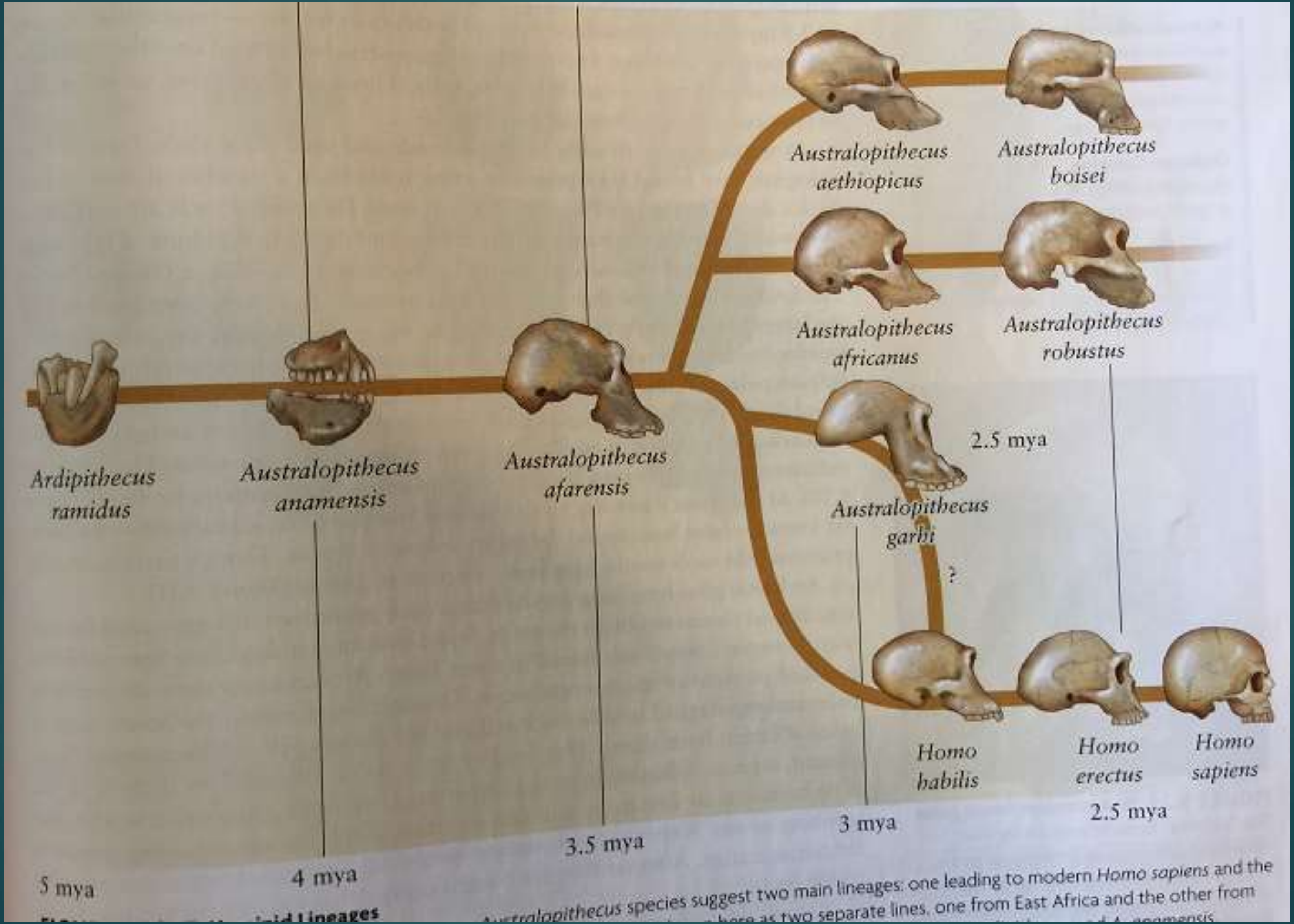
• Primitive stone tools were found at the nearby, contemporaneous site of Gona, but not at Bouri itself

•We have associated sites, not that have produced these fossils themselves, but are thought to be temporally and geographically associated with Australopithecus garhi, where we have evidence of very simple stone tools, just basic cores and flakes, and also perhaps the first evidence of butchering.

•Associated with these are cut marks on actually faunal remains, so fossils of animals that appear to show evidence of being cut marked or butchered using these stone tools.

• This evidence of butchery is perhaps the earliest evidence of that activity that we have of in the fossil record.

Hypothetical ancestry



Kenyanthropus platyops

Fred Spoor:

Kenyanthropus platyops, Dikika Child, KNM-ER 62000

- Paleoanthropologist
- Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology; Univ. College of London; affiliated with the Koobi Fora Research Project
- 2001: With Maeve Leakey, named KNM-WT40000, the type specimen *Kenyanthropus platyops*.
- 2006: With Z. Alemseged, description of A. Afarensis child from Dikika
- 2012: With Maeve Leakey, Lake Turkana 2M yo jaw and face (KNM-ER 62000) of new *Homo* species (possible match of KNM-ER 1470); species different from *H. habilis;* Tim White disagrees
- Multiple lineages of early *Homo* are present in the record at Koobi Fora.

Louise N. Leakey (1972-): *Kenyanthropus platyops*

- Kenyan paleontologist
- Daughter of Richard and Maeve Leakey

- Field expedition leader for Turkana paleontological expeditions; together with Meave Leakey, she leads the Koobi Fora research project
- 1977: at the age of six, when she became the youngest person to find hominin fossils
- 2001, with Maeve Leakey, discovered *Kenyanthropus platyops*

1999: Maeve Leakey (granddaughter of Louis):

Kenyanthropus platyops, 3.5M

Kenyanthropus platyops
(KNM-WT 40000)

Discoverer: Justus Erus
Locality: Lomekwi,
West Turkana, Keny
Date: 1999
Age: 3.5 M

Fossil skull is highly fragmented and the individual pieces are greatly distorted. Cranium is deformed by many matrix-filled cracks that permeate the face and rest of cranium.

Kenyanthropus platyops

Location: East Africa
Major sites(s): West Turkana, Kenya

Date Range: 3.5 - 3.3 MA.
Associated paleoanthropologist:
Meave Leakey

Average cranial capacity:
Within range of *A. aferensis* & *A. africanus* (about 420 – 440 cc)

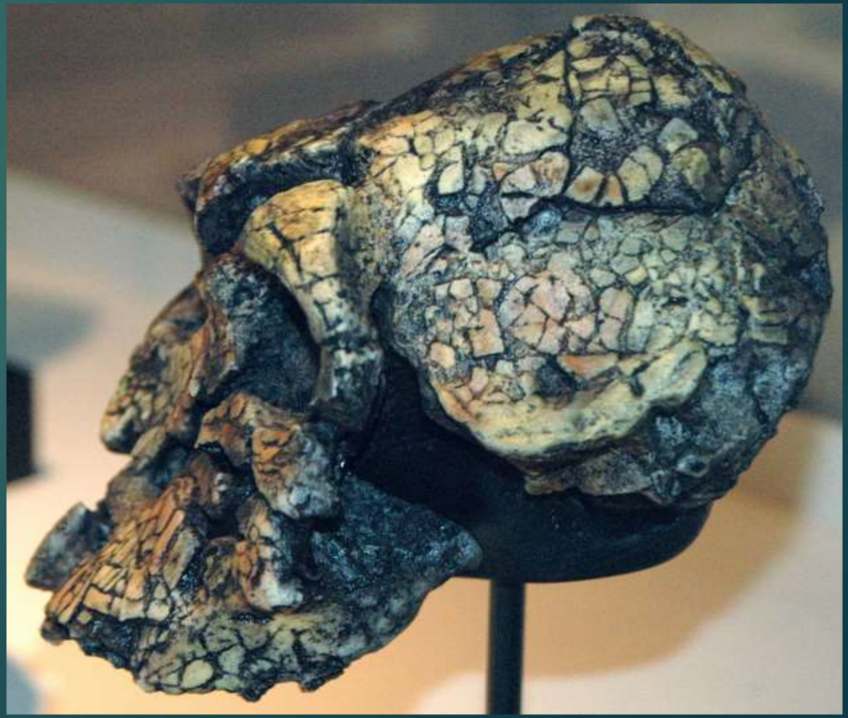
First new hominin genus described in 10 years

- Latin name translates to: "flat - faced Kenya man"

- Combination of a big, flat face and small cheek teeth make this hominin unique among all hominins

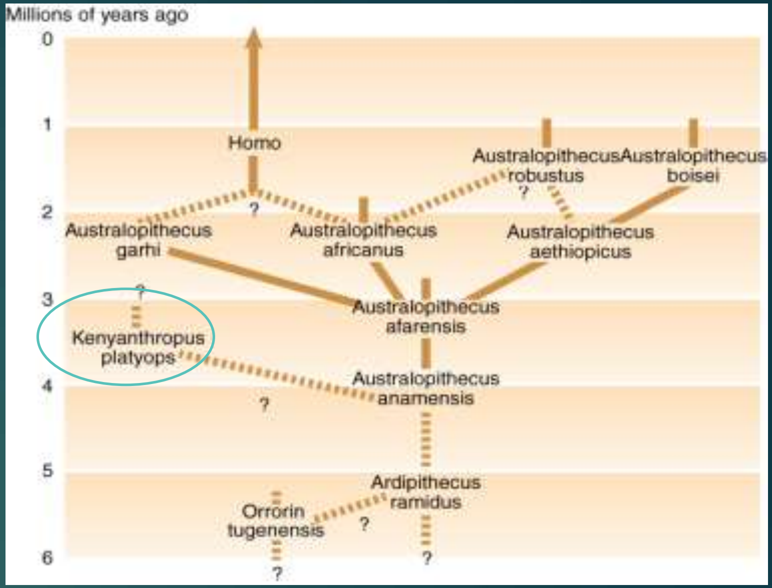
- The above justifies it's placement in a separate genus

(Leakey et al. 2001)



Kenyanthropus platyops

- Meave Leakey convinced that this is distinct from *A. Australopithecus*; thinks similar to *H. rudolfensis;* unsure if facial similarities are inherited from common ancestor (apomorphy) or whether shared facial morphology arose independently (homoplasy)
- *K. platyops* lived at the same time as Lucy's species, but had a tall, flat face and small molars. This shows that different species of human ancestors were living at the same time.
- Mosaic of features
  - Small ear hole (like early *Australopithecus*)
  - Thick enamel (like later *Australopithecus*)
  - Relatively flat face (like later hominins)
  - Apart from brain size, is similar to *Homo rudolfensis*



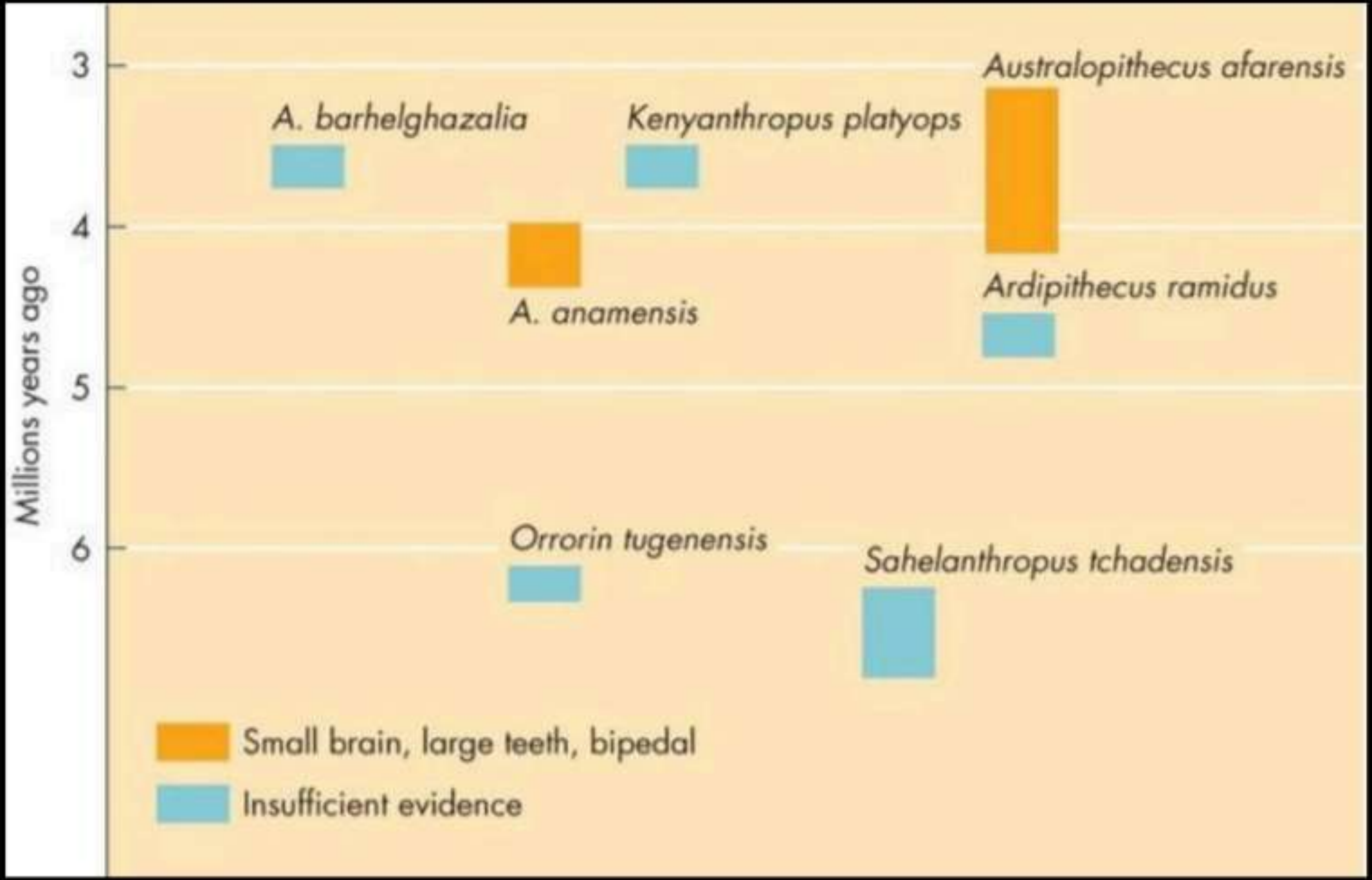
KNM-WT 40000

Kenyanthropus platyops

- It is about 3.5 Ma with an unusual mixture of features.
- The size of the skull is similar to *A. afarensis* and *A. africanus*, and it has a large, flat face and small teeth.
- These include small ear canals like those of Ardipithecus ramidus and Australopithecus anamensis and a flattened face and small teeth like Homo rudolfensis.
- While some authorities have suggested that this new form may be a better ancestor for *Homo* than any species of Australopithecus, more evidence is needed to establish this as a new taxon.
- •Same date as Australopithecus. A. afarensis? Ancestral to Homo?

Leakey M.G., Spoor F., Brown F., Gathogo P.N., Kiarie C., Leakey L.N. et al. (2001):
New hominin genus from eastern Africa shows diverse middle Pliocene lineages. Nature, 410:433-40.

Evolutionary Relationships



KNM-WT 400000: *Kenyanthropus platyops*

- Justus Erus, a Kenyan research assistant working on a team led by Meave Leakey, discovered the KNM-WT 40000 skull in 1999.

- The mostly complete cranium was found in two pieces, with the braincase separated from the face. The small brain and ear canal are similar to those of the very earliest humans like *Australopithecus anamensis* or even modern chimpanzees.

- Conversely, its flat face, high cheekbones, and small, thickly-enameled teeth are traits found in later human fossils like those of *Homo rudolfensis* or *Homo habilis* from around 2 million years ago.

- The flat-faced skull is considered the holotype for *Kenyanthropus platyops*; however, there is controversy around its identification. KNM-WT 40000 is considerably distorted, which leads some paleoanthropologists to believe that the skull actually belongs to an *A. afarensis* individual. Since KNM-WT 40000 is the only known *Kenyanthropus* individual, this makes features for the entire species hard to pinpoint. Until scientists find more fossils belonging to *Kenyanthropus platyops,* both the species identification and the sex of KNM-WT 40000 remain unresolved.

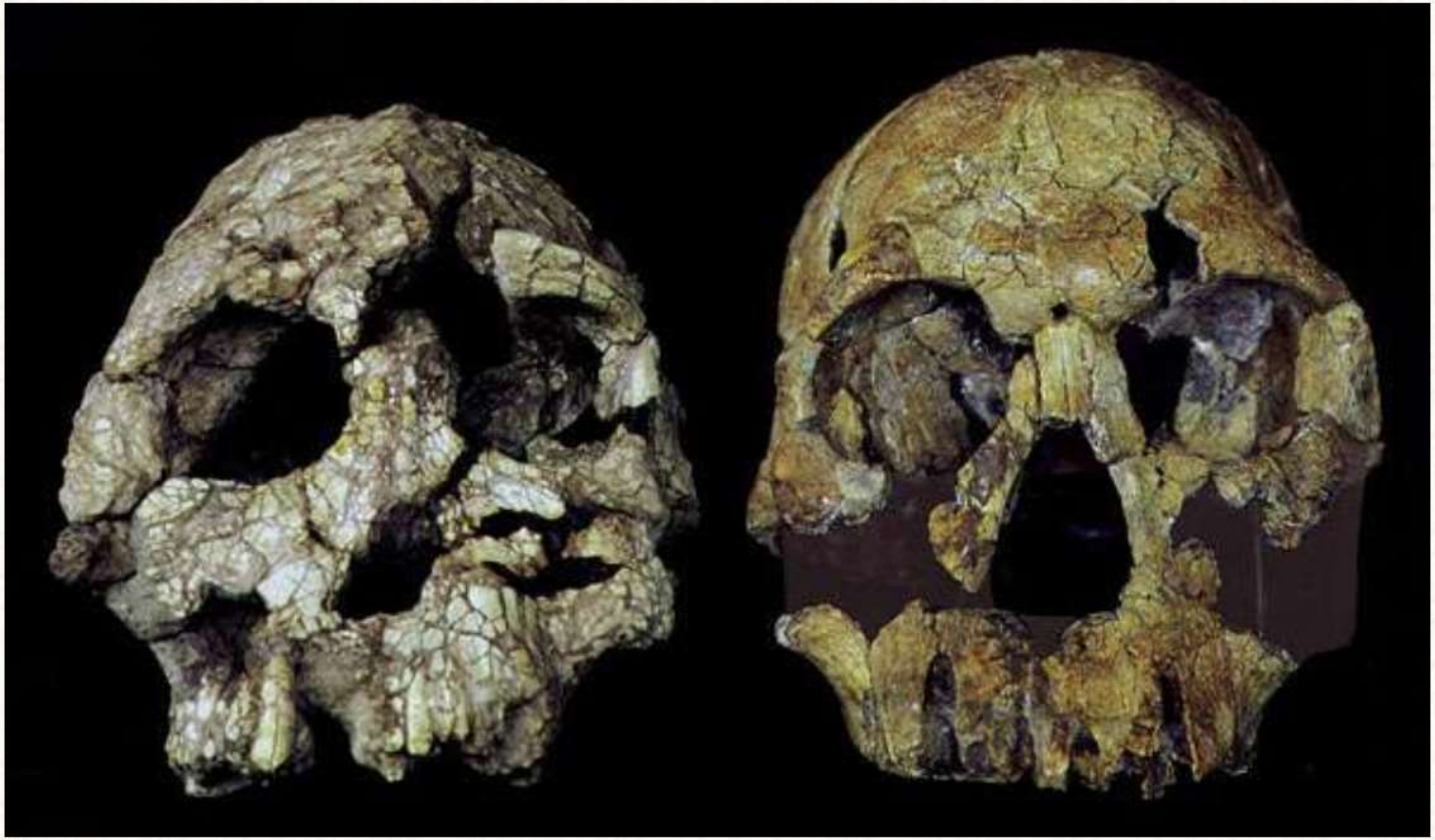
Kenyanthropus platyops

2001: *Kenyanthropus platyops:* in West Turkana, Maeve Leakey discovers *Kenyanthropus* = human ancestor?; Tim White disagrees = *A. afarensis*

Tim White (2003) has claimed that this fossil is so severely distorted that it cannot be reliably identified, and that it may merely be a Kenyan version of *Australopithecus afarensis*.

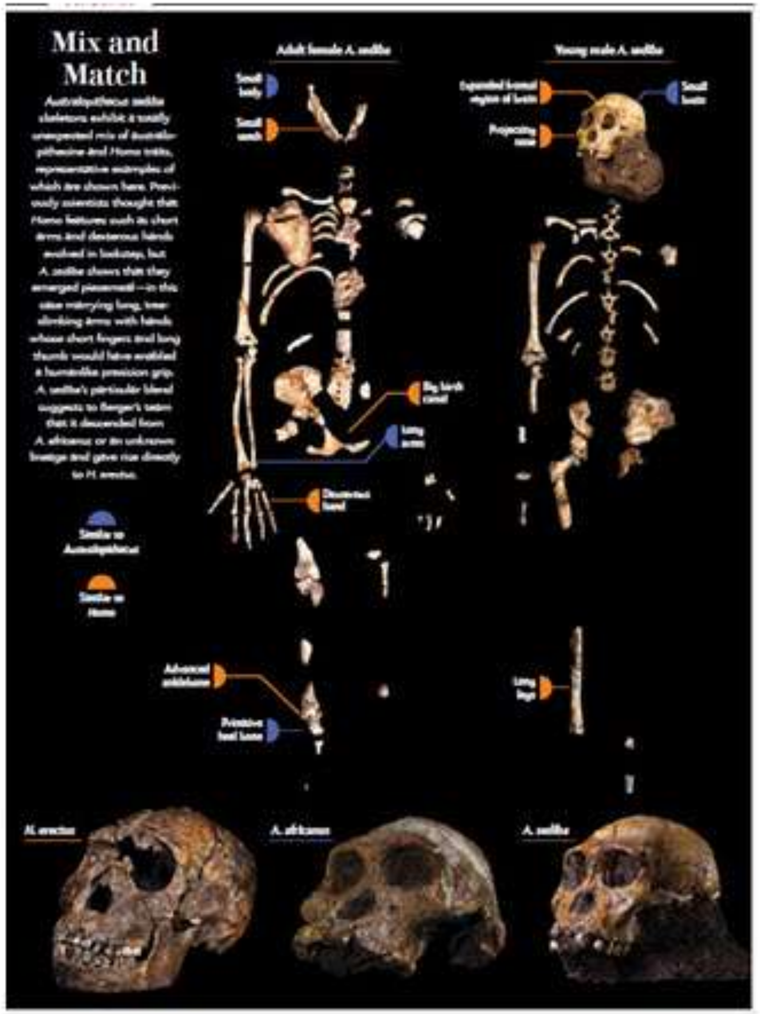
Maeve Leakey: *Kenyanthropus platyops* & Skull 1470, *Homo rudolfensis*

This photo of WT 40000 and ER 1470 is from Lieberman 2001:



Australopithecus sediba

Discovery by 9 year old boy



A. sediba, 1.9M, Matthew Berger, 9 Y old
Malapa, South Africa, 2008

Australopithecus sediba, 1.8-1.9M

- 2 specimens: a juvenile male & adult female.
- The remains, from Malapa cave, a fossil site about 50 kilometers northwest of Johannesburg, South Africa, are of Pleistocene age, dating to between 1.78 and 1.95 MA.
- Bipedal, with a height of about 1.27 meters, and that it shared certain physical traits of the early *Homo*.
- In particular, it had a somewhat prominent nose and strong hands that could have made and used stone tools
- Its brain size was still small (cranial capacity is estimated at 420–450 cc), but it had long legs
- Some paleoanthropologists believe Sediba might not be new species but a later form of Australopithecus africanus.

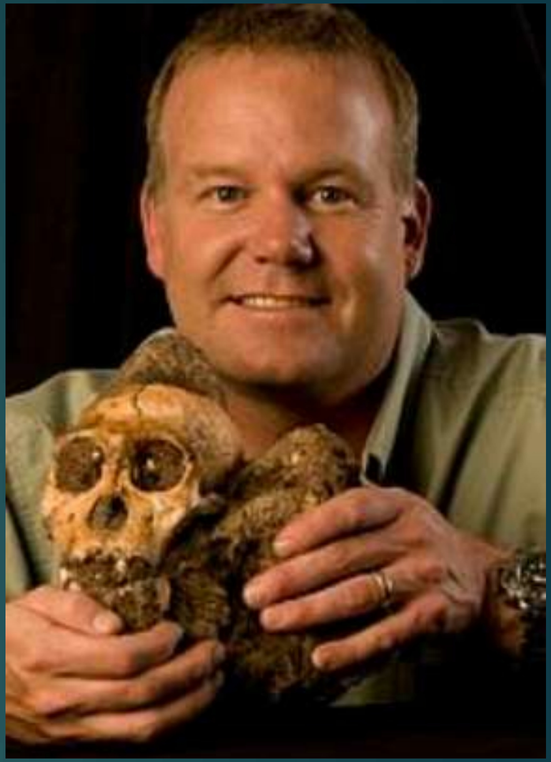
Derived features in *A. sediba* (synapomorphies with *Homo*)

- Reorganization of orbitofrontal regions of brain
- Maxillary zygomatic process coplanar with orbit
- Everted margins of nasal aperture
- Upper and mid facial widths equal
- Alveolar prognathism
- Inferior portions of superior temporal lines
- Reduced size of cheek teeth
- Expanded manual phalangeal apical tufts
- Reorientation of carpal/MC2 articulation
- Well-developed M2 flexor polices longus
- Well-developed intrinsic muscles of thumb
- Reduced transverse diameter of lower thorax
- Small sacrolumbar joint relative to body size
- Vertically oriented iliac blades
- Iliac buttressing
- Short acetabuloscral load arm
- Superiorly oriented pubis
- Narrow tuberoacetabular sulcus
- Tendinous insertion of M1 triceps surae (Achilles tendon)

Churchill: *A. sediba* as ancestor to *Homo* or sister species to this ancestor; but at 2 Ma, wrong place and time (too late) to be ancestor; shared features as homoplasies, via convergent evolution due to similar environment or adaptations

Lee Rogers Berger (1965-):

Homo naledi, Australopithecus sediba & Taung Bird of Prey Hypothesis.



- American paleoanthropologist, physical anthropologist and archeologist
- University of the Witwatersrand
- Surveying South Africa's Malapa Cave
- 2008: son Matthew discovers *Australopithecus sediba*, 1.98M
- Work on *Australopithecus africanus* body proportions and the Taung Bird of Prey Hypothesis.
- Rising Star Cave: *Homo naledi*

2008: *Australopithecus sediba, 1.98 M,* Malapa Cave, South Africa

Brett Eloff, via Lee Berger and the University of the Witwatersrand

Australopithecus sediba
(LH1, type, cranium)
Discoverer: Matthew Berger
Locality: Malapa Cave, South Africa
Cranial Capacity: 420–450 cc

Australopithecus sediba

- The *A. sediba* bones are important for their vintage—they date back to the moment about 2 Ma when the genus of human ancestors known as *Australopithecus* was just giving way to a new group called *Homo*, which would eventually produce *Homo sapiens*, or modern humans.
- The recently discovered species, *A. sediba*, is notable for its mixture of primitive and derived characteristics.
- For example, the arms are relatively long and apelike, suggesting *A. sediba* was a tree climber.
- However, the hands have human like short, straight fingers and a long thumb, a developed hands. Some scientists claim that *sediba* hands could have been used for making tools (although no tools have been found thus far). Despite this more modern conformation, *sediba's* hands still conserved several modifications for tree life

Australopithecus sediba

- The foot, in contrast to the pelvis, the hand, and the skull, is very ape-like.
- There are various properties that indicate erect, bipedal walking, while others are suitable for climbing.
- The *sediba* fossil combines a heel bone like an ancient ape's, but an ankle bone that is **mostly humanlike in form and inferred function**.
- Despite this mosaic of features, these hominins were competent bipeds on the ground, according to Lee Berger, the scientist who discovered this species. (Actually, his nine-year-old son made the discovery, but he did let his dad in on his finding.)

Australopithecus sediba

- Measurements of the strength of the humerus and femur show that *A. sediba* had a more human-like pattern of locomotion than some of the *habilis* fossils.
- These features suggest that *A. sediba* walked upright on a regular basis and that changes in the pelvis occurred before other changes in the body that are found in later specimens of *Homo*.
- The *A. sediba* skull has derived features, such as relatively small premolars and molars, and facial features that are more similar to those in *Homo*.
- The young male’s braincase shows that the brain, while small, possessed an expanded frontal region, indicating an advanced reorganization of gray matter

Australopithecus sediba: ancestral to Homo?

- Despite these changes in the pelvis and skull, other parts of the *A. sediba* skeleton shows a body similar to that of other australopithecines. This combination of primitive and derived traits shows part of the transition from a form adapted to partial arboreality to one primarily adapted to bipedal walking.
- The fossils also show that changes in the pelvis and the dentition occurred before changes in limb proportions or cranial capacity.
- Is *Australopithecus sediba* ancestral to *H. erectus*? As is common in the field of paleoanthropology, the discoverer of a new fossil (Lee Berger) is seeking to place it as close as possible to the direct line of human descent, while others are resisting that interpretation. Several notable anthropologists disagree with the idea that *sediba* could be ancestral to *Homo erectus*.
- Rene Bobe of George Washington University says that if the *A. sediba* remains were older (around 2.5 Ma), *sediba* might be a possible ancestor. However, at 1.977 Ma, the *sediba* fossils are simply too primitive to be ancestral to fossils from Kenya's Lake Turkana region that are just slightly younger with many more indisputable *Homo* traits.

Australopithecus sediba

- **Fossil Record:** Between 1.977 million years ago
- **Brain Size:** Small Brain (450 cc)
- **Diet:** Scientists were surprised to find that these hominins apparently lived almost exclusively on a diet of leaves, fruits, wood and bark. It contrasted sharply with available data for other hominins in the region and elsewhere in Africa that mainly consumed grasses and sedges from the savanna. The *A. sediba* diet also appeared to be a matter of choice, not necessity. Other evidence from animal fossils and sediments in the area indicated the presence at the time of vast grasslands in the vicinity. Yet these hominins, their skeletons adapted for tree climbing as well as upright walking, chose to feed themselves in adjacent woodlands. In this, scientists said, their behavior was more like that of modern chimpanzees, which tend to ignore savanna grasses.
- **Habitat and Distribution**: Malapa Cave, Southern Africa (South Africa)

Australopithecus sediba: **Behavior, Adaptations, and Things to Notice**

- • Details of the teeth, the length of the arms and legs, and the narrow upper chest resemble earlier *Australopithecus*, while other tooth traits and the broad lower chest resemble humans**.**
- • Modern humans walk by putting their broad and robust heel down and rolling to our toes, but *A. sediba*'s heel was so narrow, these hominins couldn't land on their heel, and likely walked on the sides of their feet and then pronated.
- • *A. sediba*'s torso had a conical and quite primitive shape, with short necks and a narrow clavicle, they appeared to be ape-like with a substantial adaptation for climbing

A. sediba

- • Due to the mixture of derived features in the pelvis and primitive features in other areas of the skeleton, it is unclear to some researchers the extent to which *A. sediba* used arboreal habitats or remained on the ground using terrestrial bipedal locomotion.
- • According to Dr. Alemseged & Tim White, the recent studies of *sediba* suggest that *A. sediba* was closely related to *Australopithecus africanus*, but not *Australopithecus afarensis*.
- Given the timing, *A. afarensis,* which lived between 3.8 and 2.9 million years ago, was likely the ancestor of *A. africanus*, which lived between 3.3 and 2.1 million years ago and in turn was the ancestor of *A. sediba*. Dr. Alemseged does not see evidence that indicates *sediba* gave rise to *Homo.*

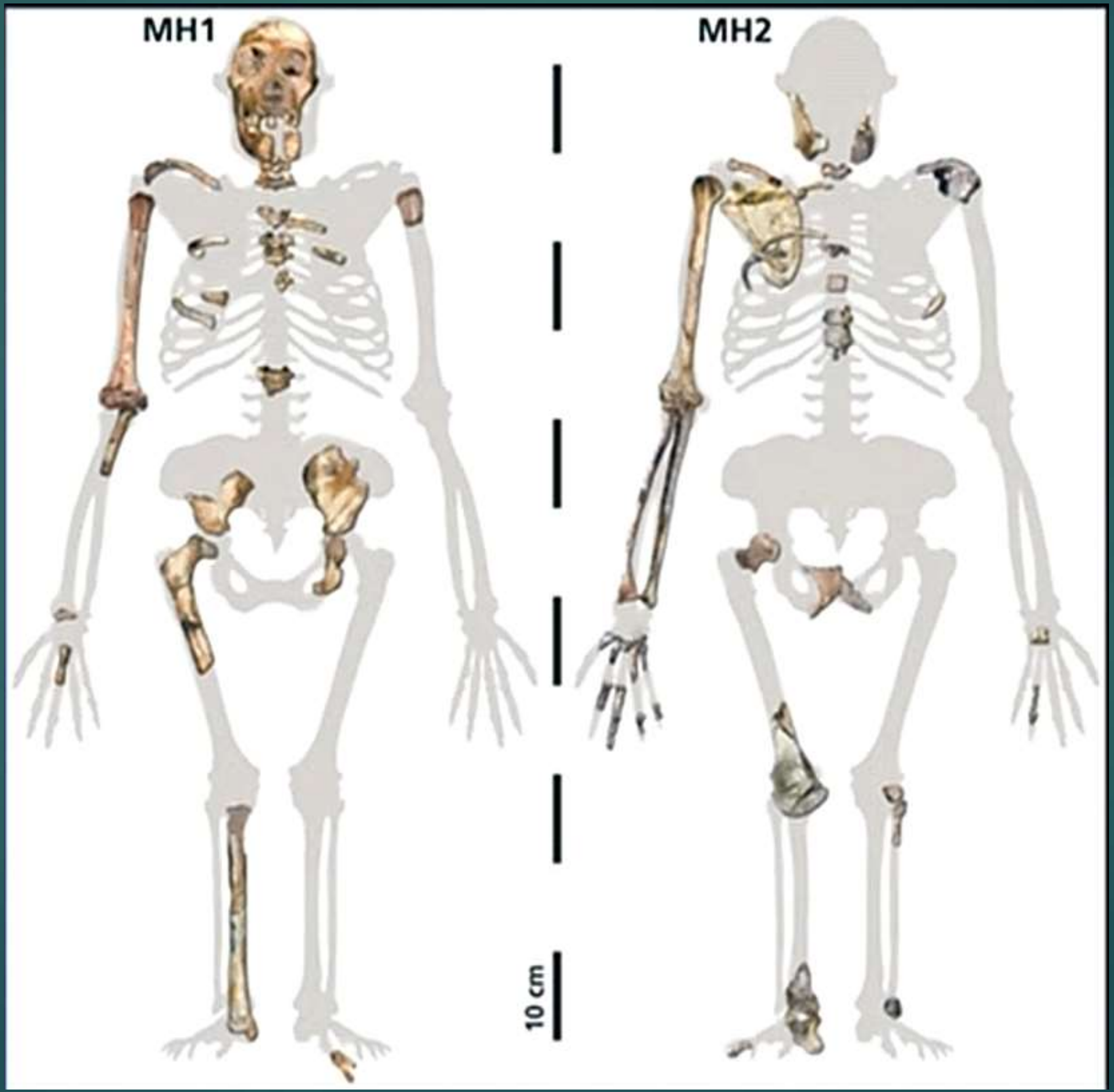
Australopithecus sediba, 1.8-1.9 M, 420–450 cc

- 2 specimens: a juvenile male & adult female.
- The remains, from Malapa cave, a fossil site about 50 kilometers northwest of Johannesburg, South Africa, are of Pleistocene age, dating to between 1.78 and 1.95 MA.

- Bipedal, with a height of about 1.27 meters, and that it shared certain physical traits of the early *Homo*.
- In particular, it had a somewhat prominent nose and strong hands that could have made and used stone tools

Lee Berger & Malapa, 2009: *Australopithecus sediba*

Recent study:
Kimbel thinks *A. sediba* is a closely related "sister species" of *A. africanus*



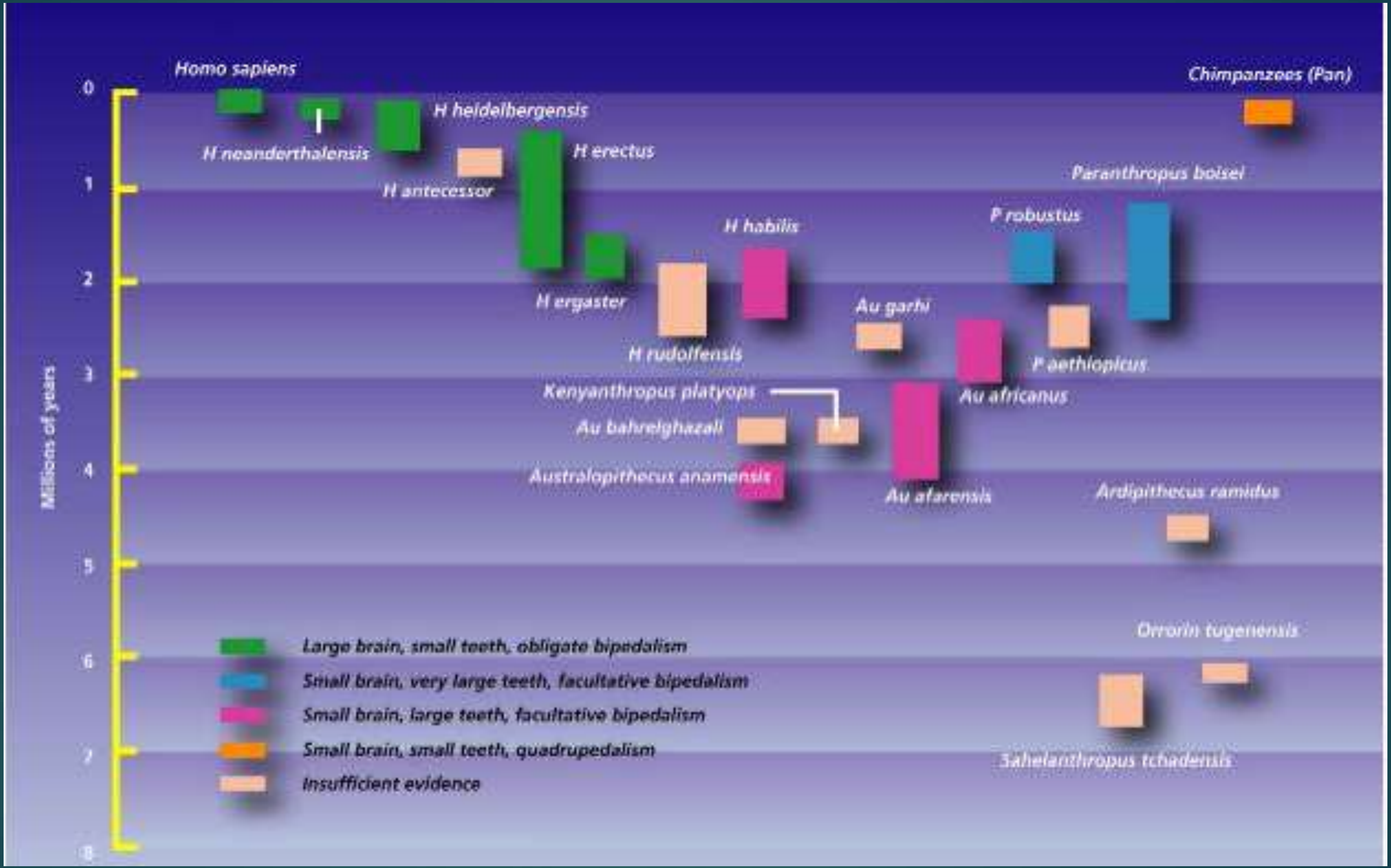
2 partial skeletons, 2 MA

Extremely small teeth, gracile face, small brain

Teeth more like us than *H. habilis*

Australopithecus sediba

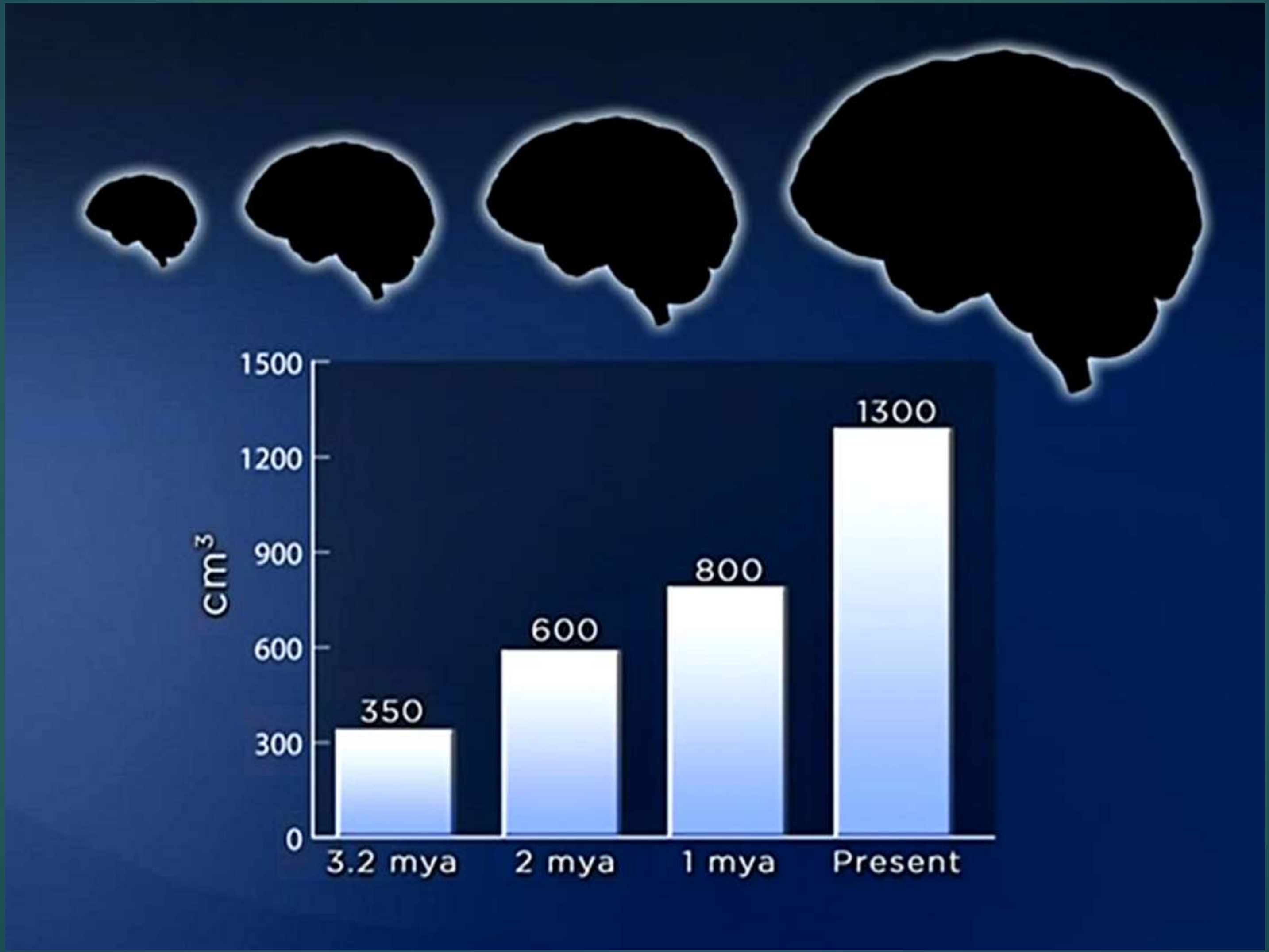
Compared to Lucy, this thirteen-year-old *A. sediba* boy had a flatter face, smaller teeth and a humanlike nose.



Homo sapiens
Chimpanzees (Pan)
H heidelbergensis
H neanderthalensis
H erectus
H antecessor
Paranthropus boisei
P robustus
H habilis
H ergaster
Au garhi
H rudolfensis
P aethiopicus
Kenyanthropus platyops
Au africanus
Au bahrelghazali
Australopithecus anamensis
Au afarensis
Ardipithecus ramidus
Orrorin tugenensis
Sahelanthropus tchadensis
Millions of years
0
1
2
3
4
5
6
7
8
Large brain, small teeth, obligate bipedalism
Small brain, very large teeth, facultative bipedalism
Small brain, large teeth, facultative bipedalism
Small brain, small teeth, quadrupedalism
Insufficient evidence

Brain Size and Structure

Brain size expansion



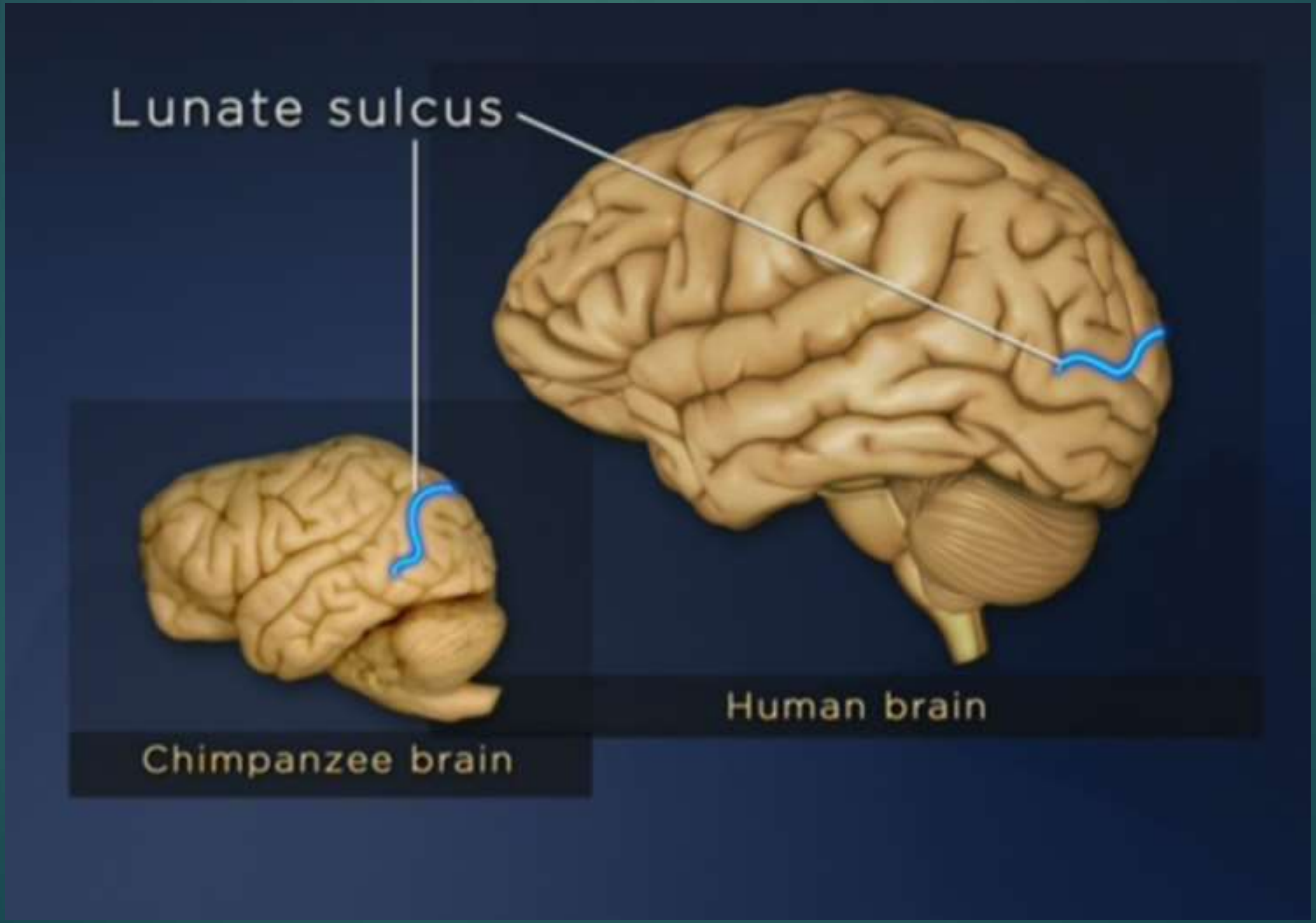
Aust. Homo →

Australopithicine brain size: 400-600 cc (ave = 450); same size, but slightly larger brain than chimps

Brain size costs

- 1 – Development time: need longer childhood to develop larger brain
- 2 – Construction: need more protein for larger size
- 3 - Energetic cost: Brain is 2% of body mass, but uses 20% of oxygen and metabolism; needs more calories
- Metabolic cost met by diet quality & reduced gut

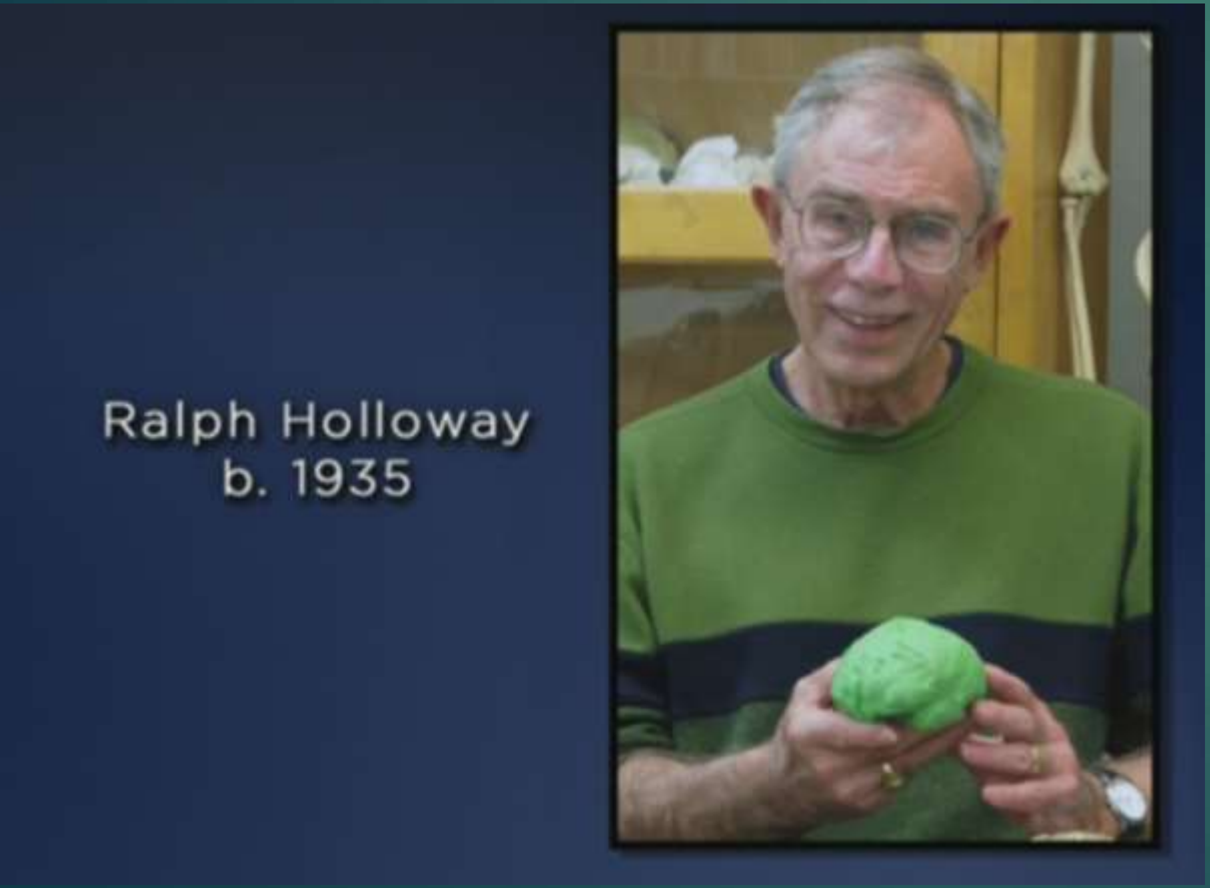
Lunate sulcus (separates visual occipital area from parietal): in humans lower than in apes; brain had enlarged; higher in chimps



Ralph Holloway (1935-): hominin brain evolution

- Physical anthropology, evolution of brain and behavior, paleoanthropology
- Columbia University
- Hominin Endocasts
- Work on the Taung Child: one of the first to suggest brain reorganization occurring before the increase of brain size in hominins.
- His claim that the lunate sulcus, a sulcus which marks the boundary of the occipital lobe, was in a posterior position to that of apes suggests that the reduction of the occipital lobe was accompanied by enlargements of parts of the brain associated with higher cognitive function.
- 20 year battle with Dean Falk over lunate

One of the great debates: *Australopithecus africanus*
Ralph Holloway: agreed with Dart; Dean Falk did not

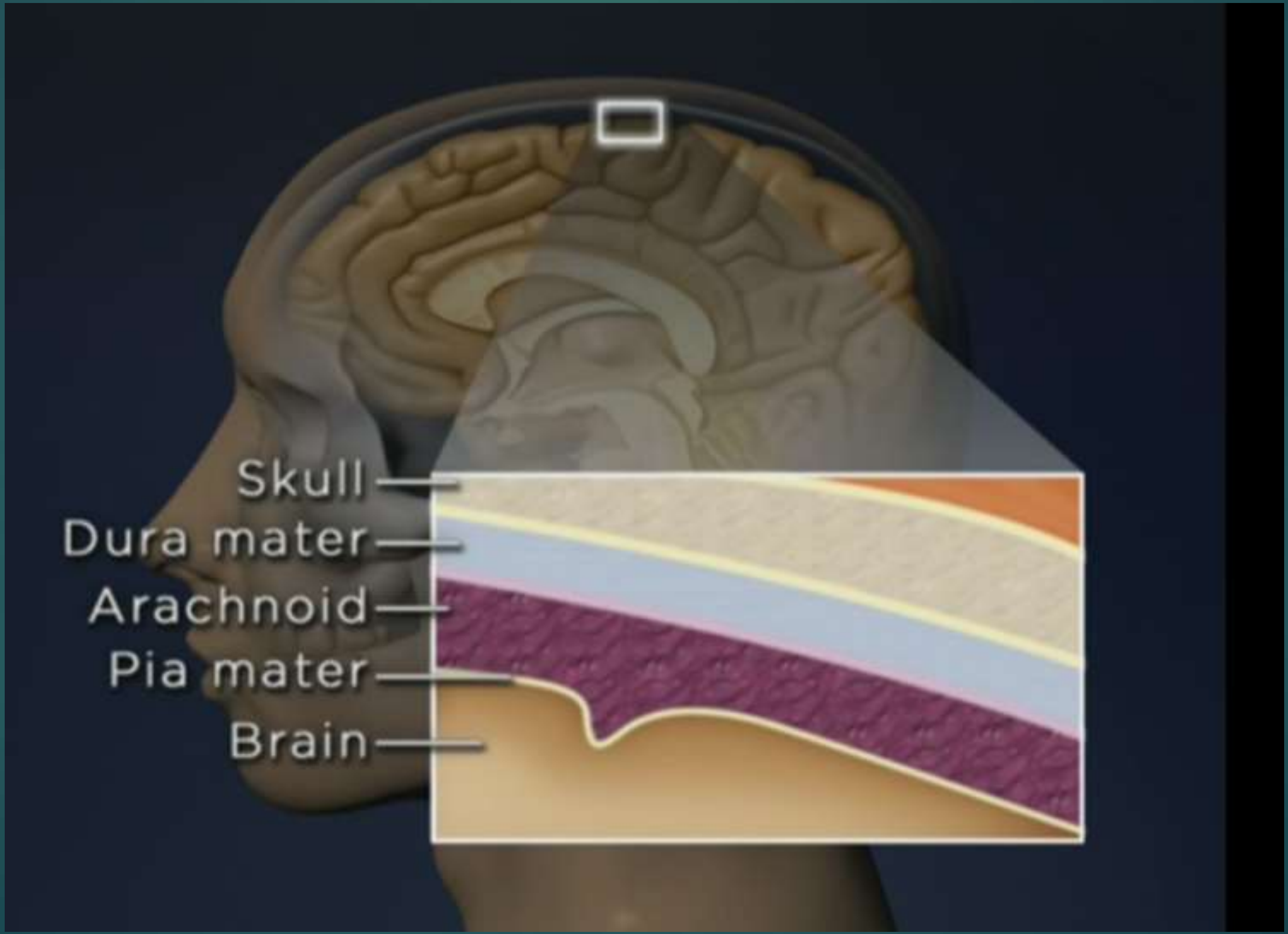


Brain evolution: size and/or organizational structure

- Brain structure: Did internal configuration of brain of *A. africanus* change? Changes in behavior or social structure via new configuration in brain; language; tool making

- Brain size: if size was the distinguisher, then changes came after 2 MA when hominin brain rapidly increased

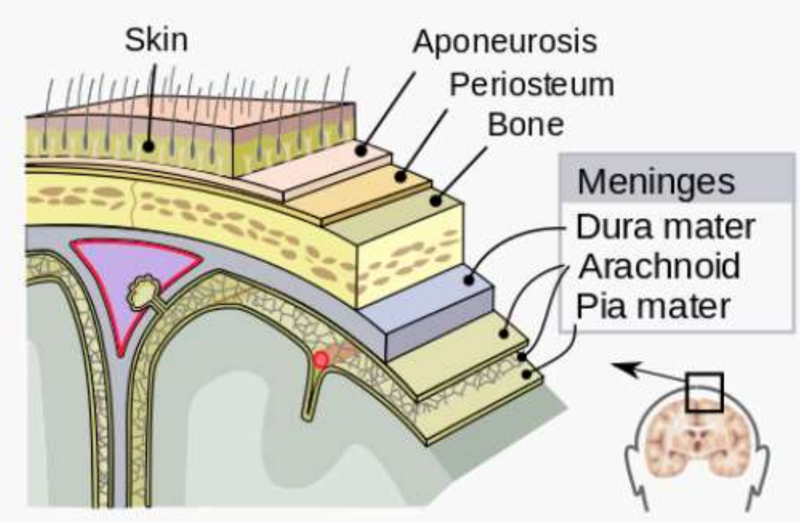
Endocasts: inside of skull is not equivalent to outside of brain



Brain coverings

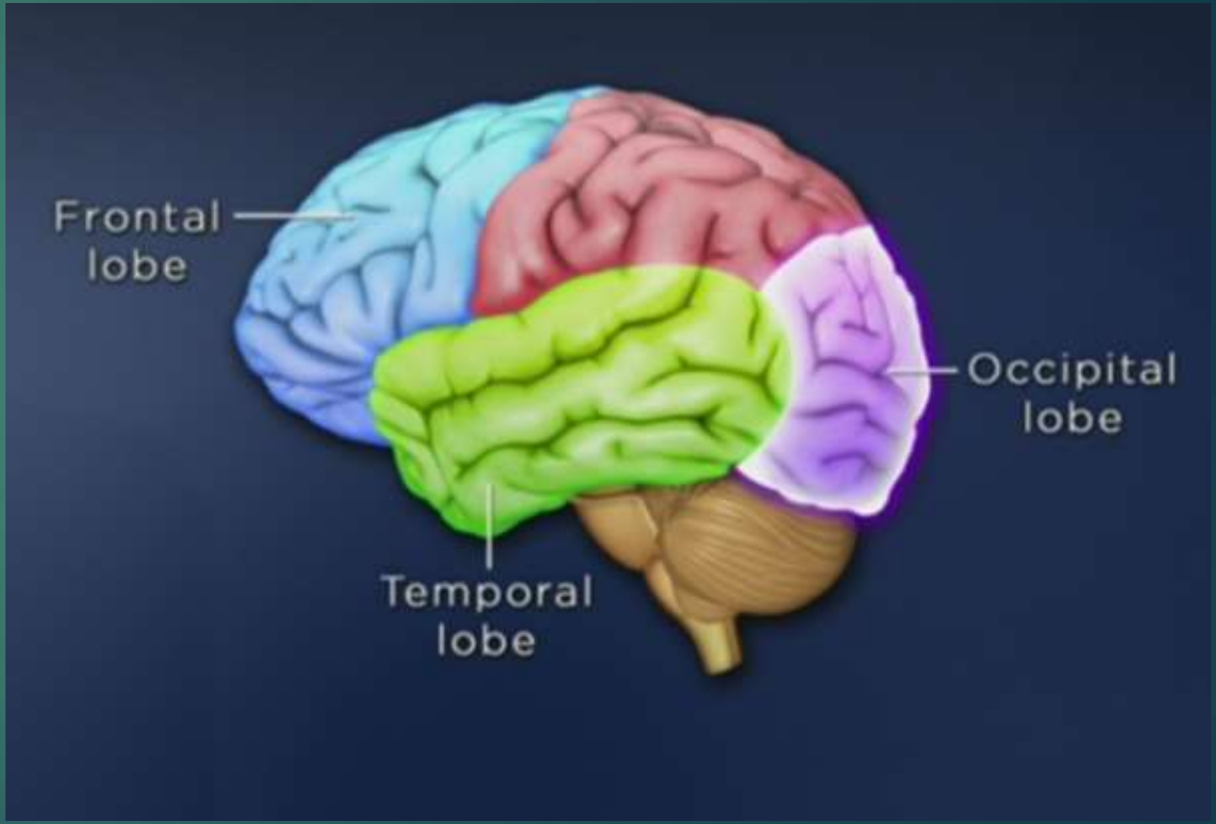
From right to left:

Scalp, Periosteum, Bone, Dura Mater, Arachnoid, Pia Mater, Brain



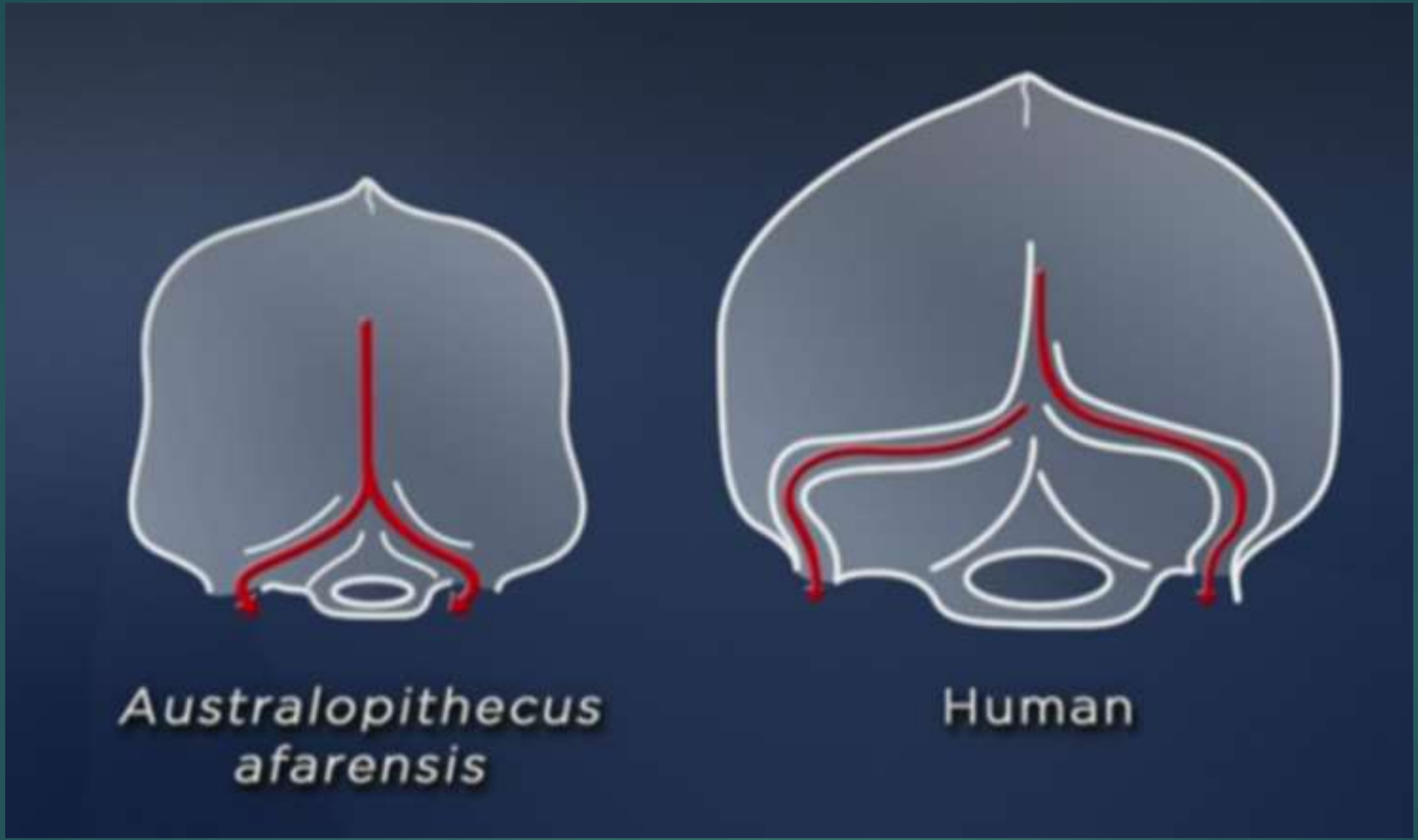
Meninges of the CNS

Outside of brain does not indicate internal configuration or function; individual's gyrifications are unique



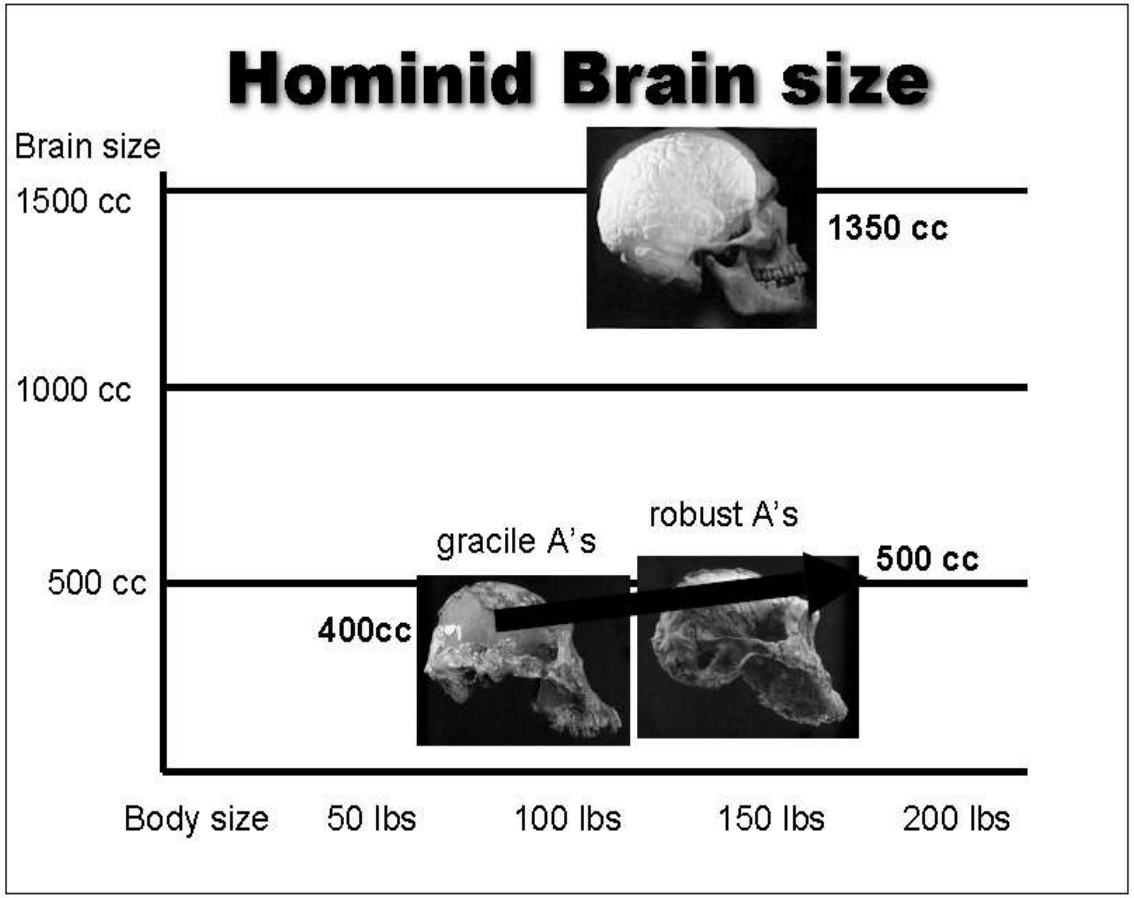
Constraints of the brain: Falk noted venous drainage differences in hominins (veins act as heat regulators for brain)

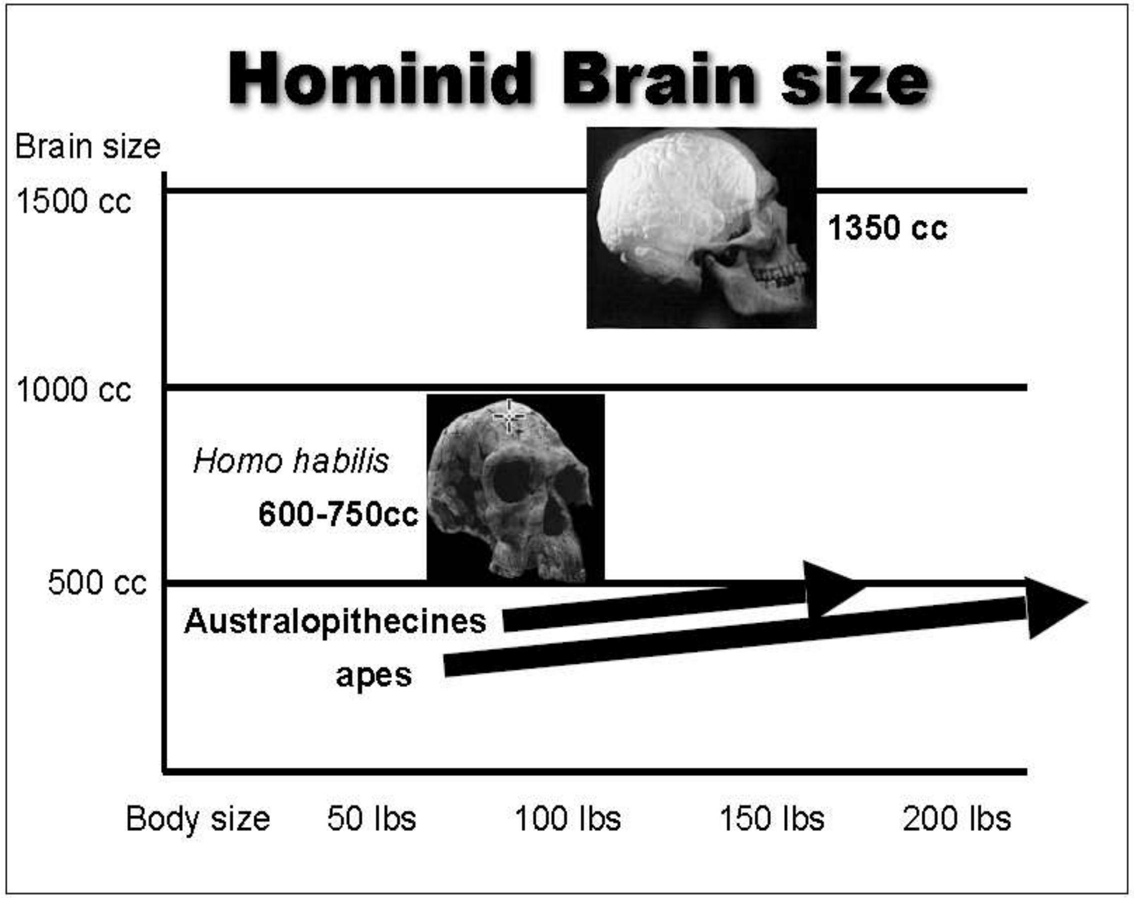
A. Afarensis and *Homo sapiens* venous drainage -



Thermoregulation adaptation: Occipital marginal drainage vs more efficient transverse drainage;
Bigger brains need better drainage

Brain Size


Hominid Brain size
Brain size
1500 cc
1000 cc
500 cc
1350 cc
gracile A's
robust A's
500 cc
400cc
Body size
50 lbs
100 lbs
150 lbs
200 lbs


Hominid Brain size
Brain size
1500 cc
1000 cc
500 cc
1350 cc
Homo habilis
600-750cc
Australopithecines
apes
Body size
50 lbs
100 lbs
150 lbs
200 lbs

Kenyan Stamps of Origins of Mankind