A Review of Pre-*Homo* Human Evolution

CHARLES J VELLA PHD

2019

Charlie Vella PhD,
Docent, California Academy of Science,
2nd 4th and 5th Mondays, 10AM to 1PM

My background

- My name is Charles J. Vella, PhD and I am a neuropsychologist and an amateur human evolution enthusiast.
- I received my PhD in Psychology at UC Berkeley and I worked at Kaiser Hospital, Dept. of Psychiatry for 35 years as Chief Psychologist and Director of the Neuropsychology Service. I am an expert in most brain related psychological topics and do public lectures in this area.
- Since my retirement in 2009, I have been an active docent at the California Academy of Science, specializing in the area of human evolution.
- I am not an anthropologist, but I have become an amateur expert in the field of human evolution.
- In the last 10 years, I have read extensively on most of the topics in human evolution, taken 8 online courses on this topic, and have taught a variety of docent classes in this area at the Academy and an 2018 OLLI course on pre-Homo hominin evolution.

2018: Human Evolution, The first 150 years of discovery

- www.charlesjvellaphd.com: Pds (Adobe reader) are available online
- Two versions: Full & actual lecture (briefer)
  - Week 1: A Historical Biographical Review of Paleoanthropology to 1960
  - Week 2: General Evolution (belief in evolution, creationism, processes)
  - Week 3: Basics of human evolution (dating techniques, fossilization, etc.)
  - Week 4: Basics of human evolution 2
  - Week 5: Early Hominins: *Sahelanthropus, Orrorin, Ardipithecus*
  - Week 6: The Australopithecines

The Evolution of *Homo:* Discoveries of the Last 60 years.

- This course was conceived as an attempt to cover the history of the study of Human Evolution.
- There is so much information to cover, that it was originally conceived as a two part course. Part 1 was the pre-*Homo* hominin class given in 2018.
- Given the amount of material to cover, OLLI suggested I do a once a month workshop for a year.
- This workshop will cover The Evolution of *Homo:* Discoveries of the Last 60 years.
- The first three sessions are free.
- I hope you will consider joining us for the full year series.

Downloads of workshop material and pdfs of lectures

- www.charlesjvellaphd.com
  - OLLI Human Evolution Pre-*Homo* Class 2018 – 6 classes: pdfs of all

- Papers also available on website:

  - Human Evolution Bibliography
  - Glossary of Evolutionary, Anatomical and Paleontological Terms
  - List of all Major Hominins Table
  - Continued Human Evolution - examples
  - Who’s Who in Hominid Evolution – short identifications
  - Original Hominid Species Type Journal Articles

Rules of the game

- I need to cover a lot of material, so this course is primarily a series of lectures with some time for discussion.

- 1 – During first session, I would like you to write out for me what you hope to get out of this course: topics, people, etc. Anything you would like me to cover.
- 2 – If you do not understand terminology I use, let me know. I will define. If you do not understand it, probably a number of people do not.
- 3 – If you ask a question about a topic that I will cover more fully later, I will let you know.
- 4 – Please let me know if you are concerned about anything about the course, in person, or by email: charlesvella@comcast.net

Issue of number of slides per lecture

- I love Powerpoint. I love slides. Usually do 200-300 in 2 hours.
- I normally use a slide to make 1 or 2 points then go to next slide, no matter how much material is on slide.
- The rest is for reading in pdf of lecture.

This project

- I have been a docent at California Academy of Science since 2009. I specialize in hominin evolution
- I wanted to offer all the information that I wanted to have when I began docenting, and did not learn until later.
- This is my personal compendium (but accuracy confirmed via textbooks & courses)
- There is much I know about human evolution, but also much I do not know. If I do not know something, I will tell you. It may be that you know it and can contribute.
- Please note any factual errors for me
- My pronunciation of French is nonexistent!

Acknowledgements

- Thanks to Bernard Wood, Erik Trinkaus, Pat Shipman, Ian Tattersall, Wikipedia, Don Johanson, UC Berkeley's online Evolution website

- Many Photos: David Brill, Great Courses, Online courses

- See Bibliography for sources

- Recommended Reading: All the works by Ian Tattersall of AMNH
  - *The Fossil Trail*
  - *Masters of the Planet*
  - *The Strange Case of the Rickety Cossack*
- John Reader
  - *Missing Links*

Human Evolution online courses I have taken

- Center for Cognitive Archaeology, Univ. of Colorado: Full semester courses
  - Neandertal Cognition – Frederick L. Coolidge and Thomas Wynn
  - Paleoneurology – Emilio Bruner
  - Cognitive Evolution - Coolidge & Wynn
- Great Courses Lecture series, 2011: *The Rise of Humans* by John Hawks, PhD, Univ. of Wisconsin
- Univ. of WI: Human Evolution: Past and Present by John Hawks
- Wellesley College: WellesleyX: ANTH207x Introduction to Human Evolution by Adam Van Arsdale, 2015
- Multiple online video documentaries on human evolution by well known researchers
- Carta online lecture series:
  - Ancient DNA and Human Evolution
  - Origins of Genus Homo
  - Behaviorally Modern Humans: The Origin of Us
  - Early Hominids
  - The Rise and Fall of Homo erectus
  - The Origin and Fate of the Neanderthals

Human Evolution Course

- We will learn about the major researchers who have shaped our understanding of human evolutionary history,

- We will visually explore the human fossil record.

- We'll talk about how we developed knowledge from the human fossil record, and we'll learn about key fossil localities

- And we will try to understand how and why we know the things we know about our evolutionary past.

- We will explore how we came to be human.

Human Evolution: The Evolution of *Homo:*
Discoveries of the Last 60 years:

- Month 1 (Feb. 27): Review of pre-*Homo* human evolution
- Month 2 (Mar. 27): A Historical Biographical Review of Recent Paleoanthropology: 1960 to 2019
- Month 3: (Apr. 24): *Homo habilis*
- Month *4:* (May 22): *Homo erectus*
- Month 5: (Jun 26): *Homo heidelbergensis*
- Month 6: (Jul 24): *Homo neanderthalensis, Part 1*

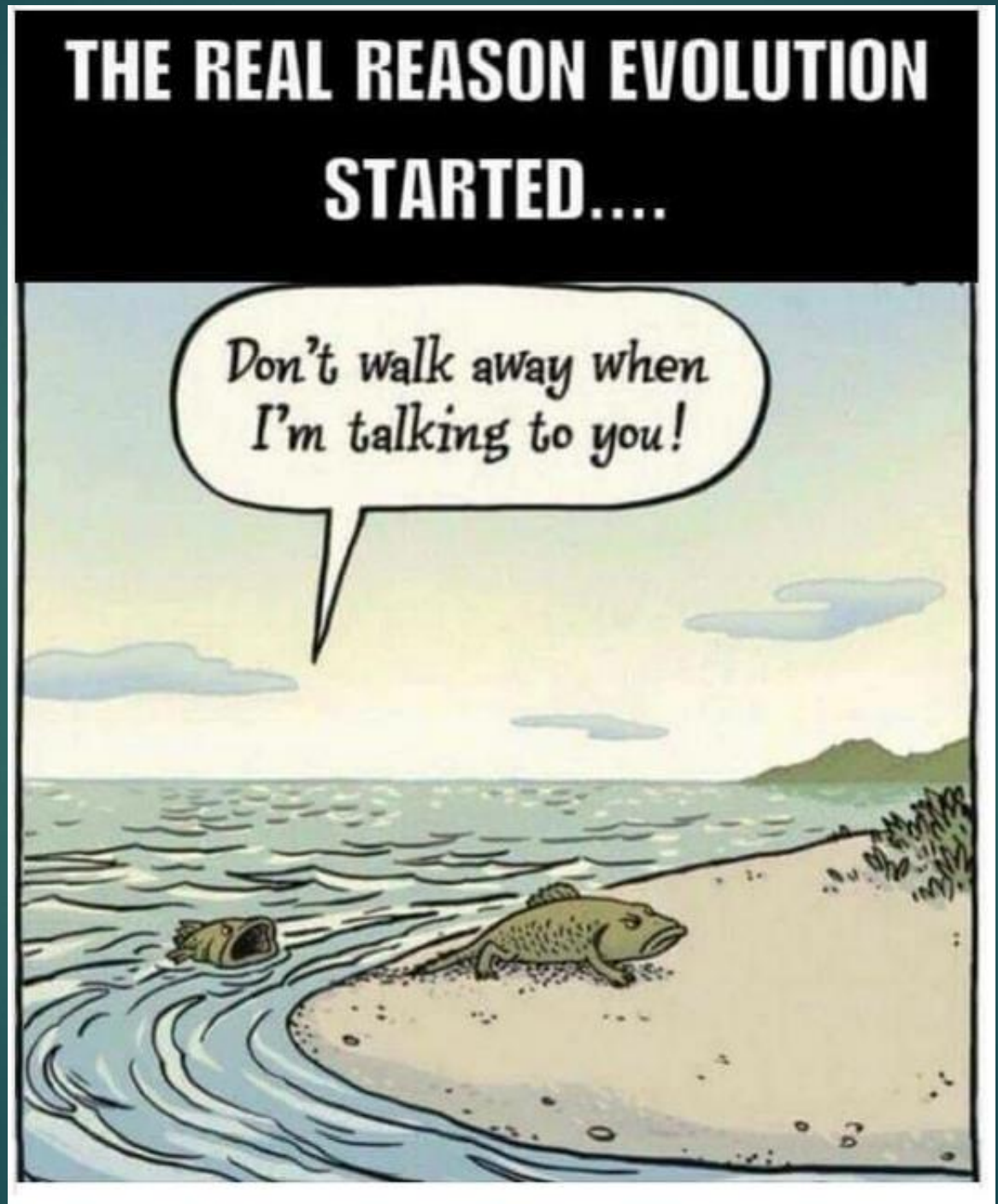
Human Evolution: The Evolution of *Homo 2*

- Month 7: (Aug 28): *Homo neanderthalensis, Homo denisova, Part 2*
- Month 8: (Sep 25): *Homo floresiensis*
- Month 9: (Oct 23): *Homo naledi*
- Month 10: (Nov 27): *Homo sapiens*
- Month 11: (Dec 25): No workshop
- Month 12: (Jan 22): Evolution of the human brain
- Month 13: (Feb 26): Paleogenetics Part 1
- Month 14: (Mar 25): Paleogenetics Part

Evolution: Descent with Modification

- Descent with Modification – each living species has descended, with changes, from other species over time.

- Common Descent – all living organisms are related to one another


THE REAL REASON EVOLUTION STARTED....
Don't walk away when I'm talking to you!

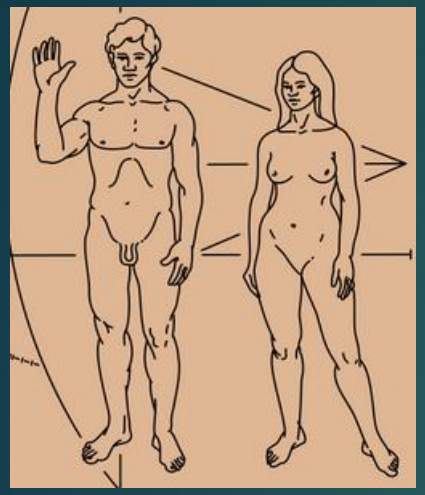
Natural Selection: 2 observations

Observation 1: Organisms generally have more offspring than can survive to adulthood.

Observation 2: Offspring are not identical. There is variation in their appearance, size, and other characteristics.

Inference: Those organisms that are better adapted to their environment have a greater likelihood of surviving to adulthood and passing these characteristics on to their offspring.

How Much of Your DNA You Share with:



99.9%

Neandertals 99.7%

98.4%

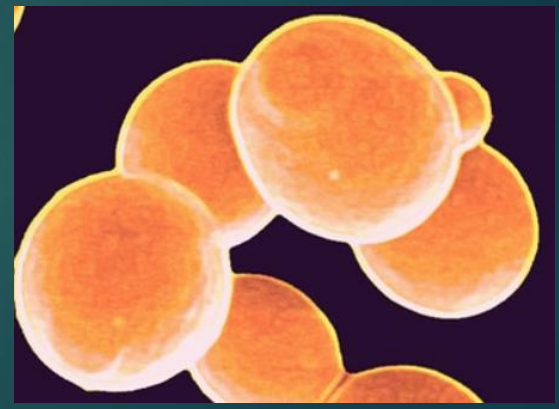
92%

70%

60%

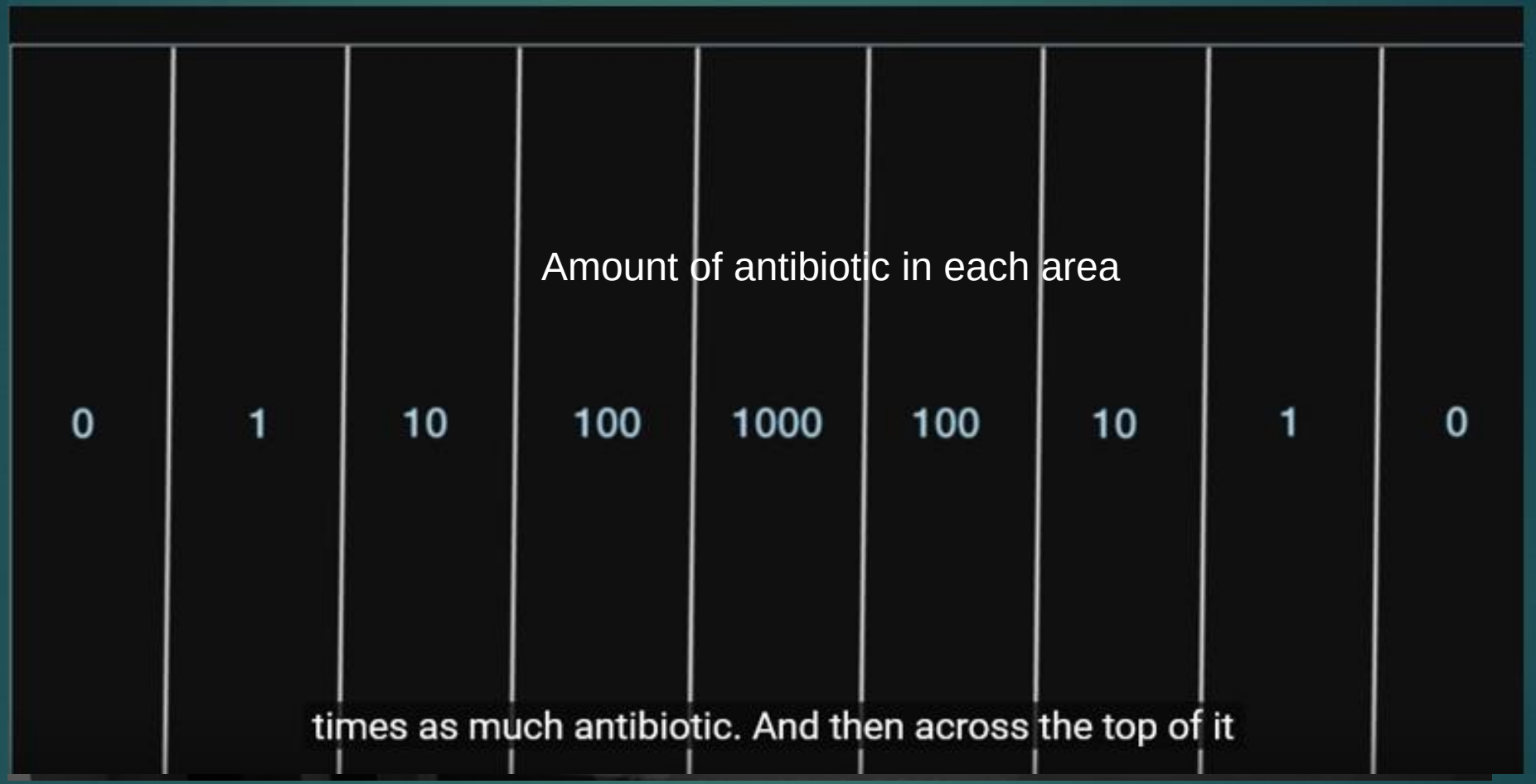
50%

You are related to every living organism on planet Earth



Yeast = 26%

Evolution of antibiotic resistance in real time in a 2’ x 4' petri dish



E. coli

Harvard Medical School and Technion-Israel Institute of Technology: Bacteria (white) grow up to the boundary where they can no longer survive. Mutants, capable of surviving the higher concentration of antibiotic, appear and invade the new band. Each section requires new mutations.

Michael Baym et al., Science, 2016

Evolution is a fact: Bacterial resistance development in 11 days

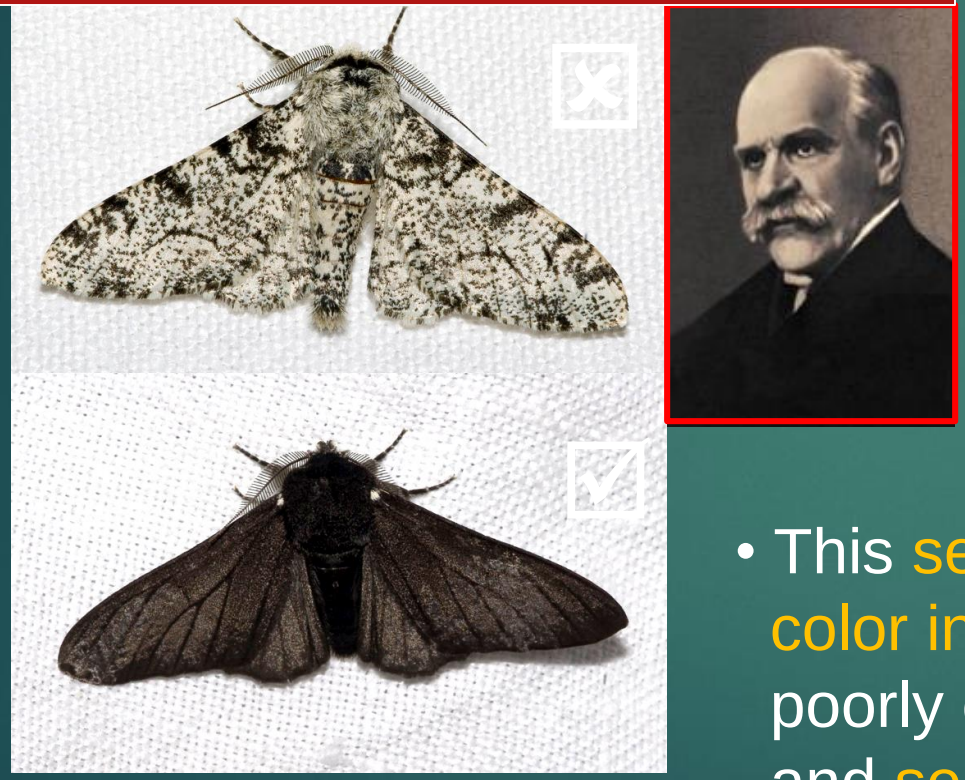
Reveals how bacteria develop resistance to increasingly higher doses of antibiotics in a matter of 11 days.;
Antibiotics*:* trimethoprim (TMP) or ciprofloxacin (CPR)

Joke

- Child bird: “Mom, why does brother’s beak look different than mine?”
- Mom: “I always worried you’d ask about this one day.”
- Mom: “It’s a secret, so you can’t tell anyone, but your brother’s adapted.”

Adaptation in Peppered Moth: Classic Example of observable evolution:

Haldane and the peppered moth



Original moth

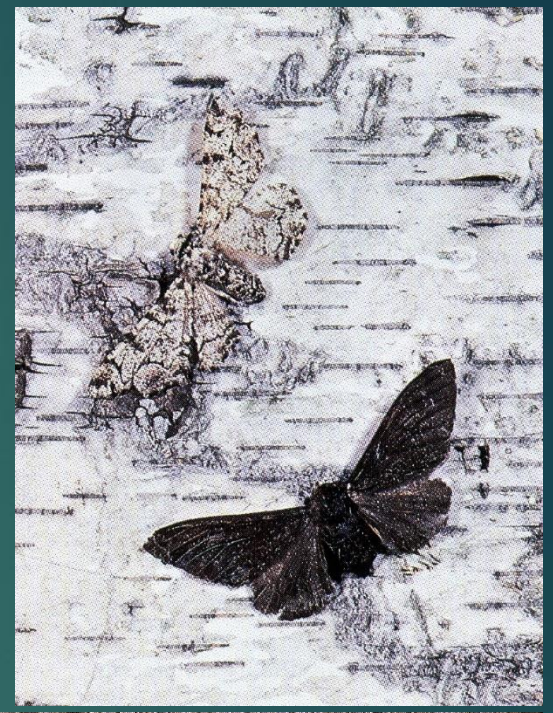
http://en.wikipedia.org/wiki/Image:Biston.betularia.7200.jpg
en.wikipedia.org/wiki/Image:Biston.betularia.f.carbonaria.7209.jpg
en.wikipedia.org/wiki/J._B._S._Haldane

- The Peppered Moth is an example of Natural Selection in action discovered by Haldane
- During the Industrial Revolution the light colored trees on which the moth rested became soot-covered.
- This selected against the allele for pale color in the population (which were poorly camouflaged from predators) and selected for the dark color allele.

Peppered Moth

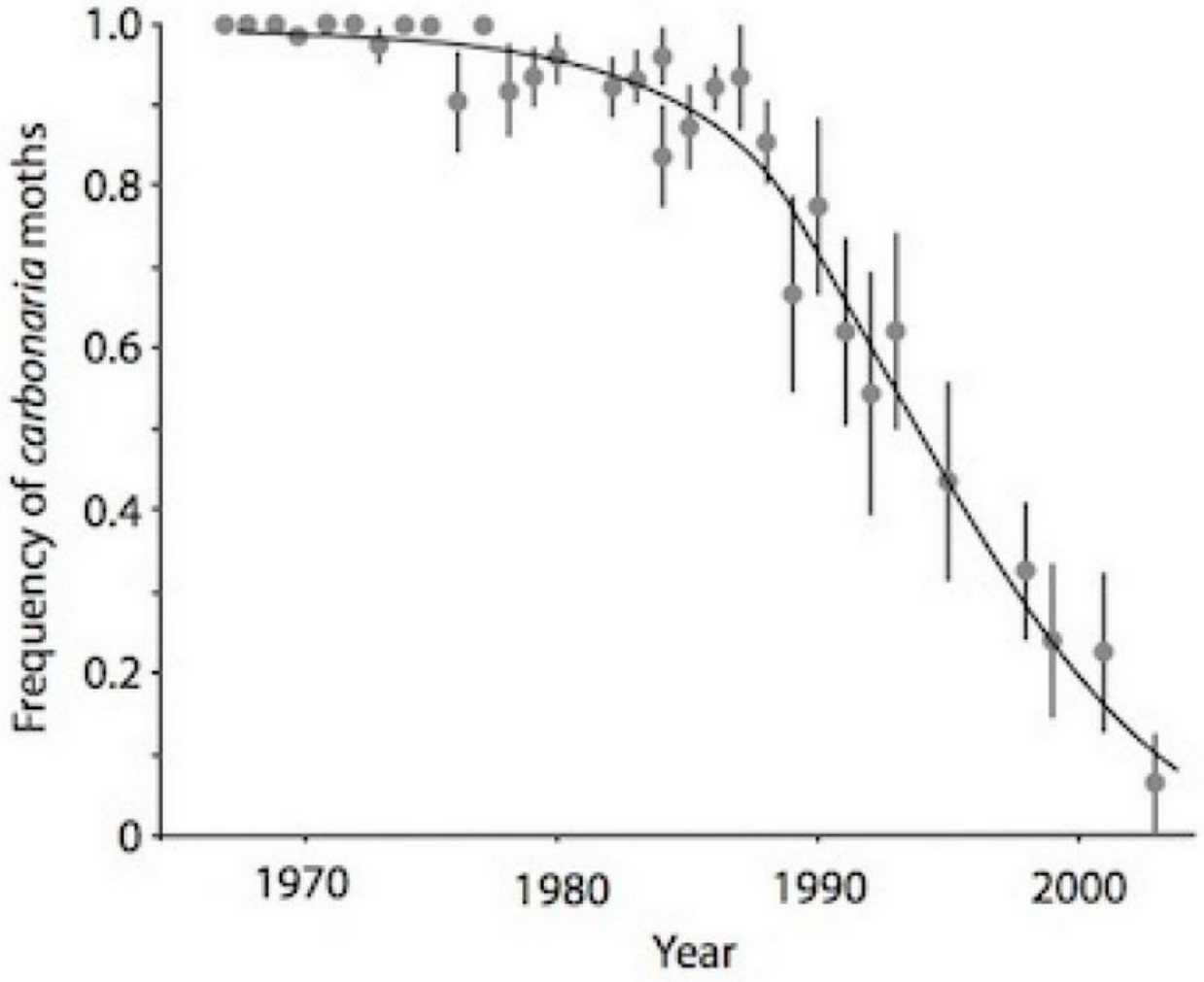
- Which moth will the bird catch?

A



B

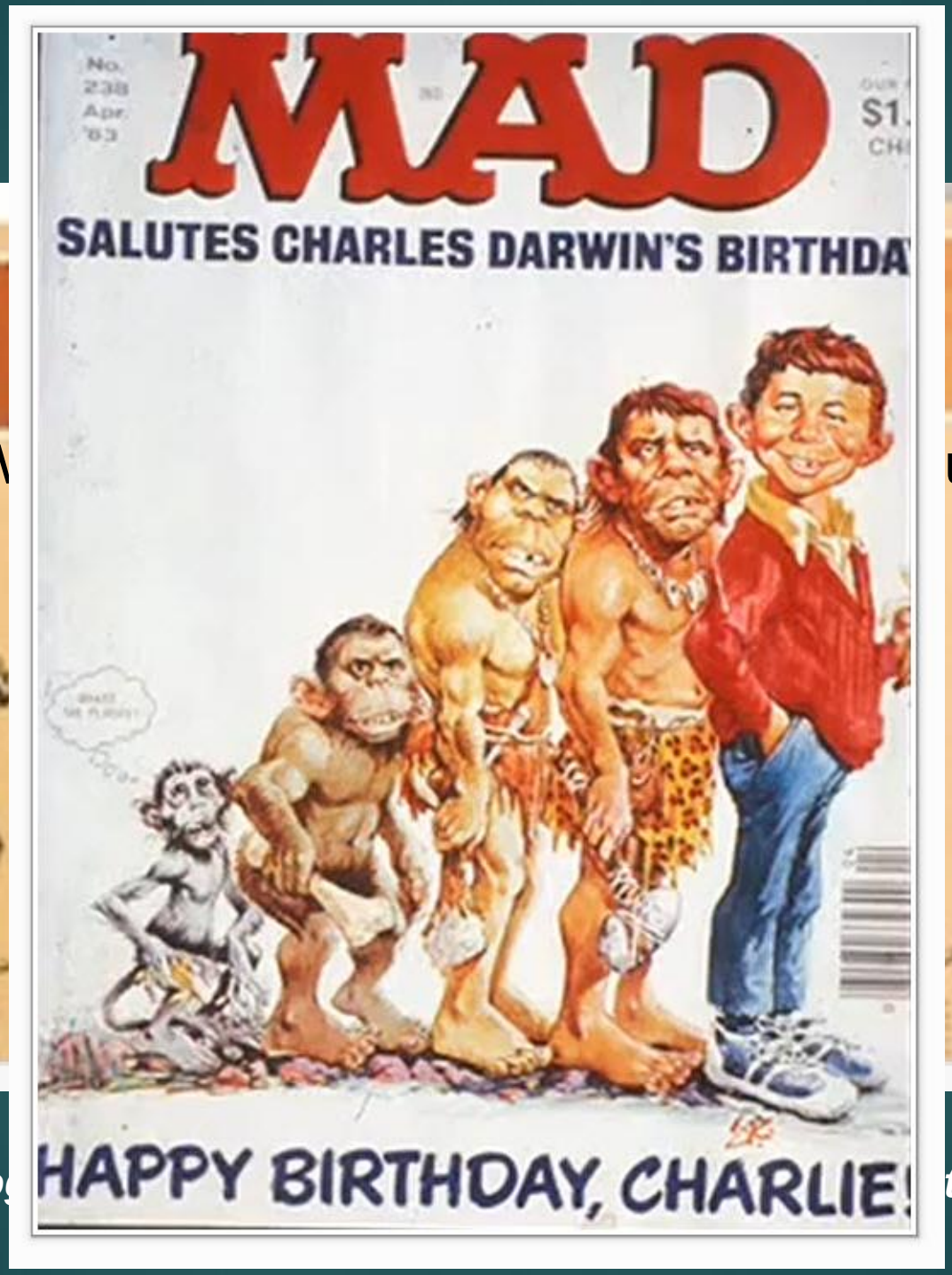
But evolution continues on…Reversal in Pepper Moths after the Industrial Era in England



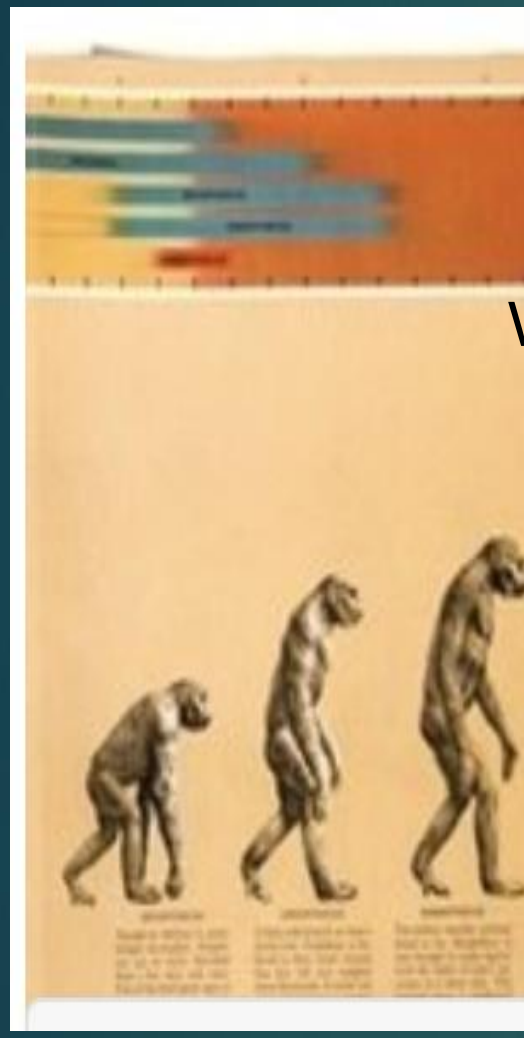
Decline of dark peppered moths around Leeds, England.

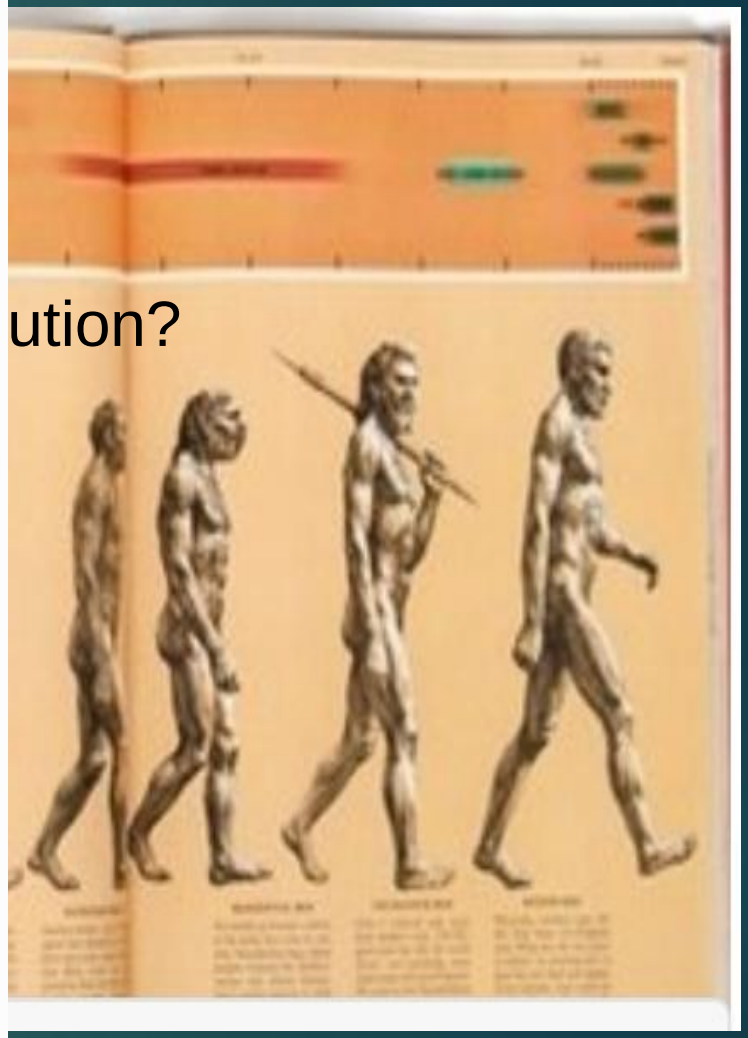
- Britain cleaned up their air in the late 1900s, and trees went from dark to light.
- Black became a liability. Dark moths declined.

Picture that got



Evolution





V ution?

The March of Prog ***ted by*** Rudolph Zallinger; *Early Man* volume

Misconception: Evolution as single line

- Wrong: Hominid evolution progressed along a single linear track directly from primitive ancestor to modern form.

- Wrong: Evolution is unidirectional; progression to higher form

- Correct: Most evolutionists assert that:
  - hominids evolved several branches (more like a bush than a stick)
  - some of these branches lived at the same time and in the place.

Hominin evolution

- Evolution is biological change over time.
- All species alive—including humans—evolved from ancestral species.
- The major process responsible for the evolution of adaptive change is natural selection.
- Natural selection is blind; it is not directional.
- None of our ancestors were trying to be us.

Hominin evolution 2

- Natural selection is about survival to reproduce.
- Evolution doesn’t follow a straight line.
- Our evolutionary history is littered with many branches, experiments and adaptations.
- Today, all species of *Homo* have disappeared except for one: us.

New paradigm

The Human Evolution story: a review of what's coming in this course

- Once upon a time, the story of our species' evolution was simple.
- A tale of a short, hairy, chimp-like creature living in Africa that gradually, over millions of years, transformed to become human.
- Now we know it's more interesting than that.

- Our ancestors were just one of many pre-human species living across a wide swath of the globe from South Africa to the Far East. They intermingling and sometimes interbreeding. Today we alone remain.

- Over the past 50 years, almost every part of our story, every assumption about who our ancestors were and where we came from, has been called into question.

Who are you? How the story of human origins is being rewritten
by Colin Barras, New Scientist, Aug 2017

Prior to 1959

- 1820 to 1958: Major historical hominin discoveries included:
  - Neanderthal and modern humans in Europe
  - Homo erectus in Java and China
  - Australopithecines in South Africa
  - Archaic humans in Africa

The New picture

- Since 1959, there have been a succession of spectacular fossil finds.
- The new species have upending what we thought we knew about the evolution of key traits such as bipedalism and brain expansion.
- Studies of ancient DNA : how different species are related and to track their migration across continents. Discovery of pre-human genes in our own genome – we are related to Neanderthals and the mysterious Eurasian pre-humans called Denisovans.
- Once upon a time, the human story seemed relatively straightforward. It began roughly 7 million years ago, somewhere in an east African forest, with an ape who was our LCA. Some of its descendants would change into modern chimps and bonobos. Others left the forest for the savannah. They learned to walk on two legs and, in doing so, launched our own hominin lineage.

New data

- By 4 Ma, the bipedal apes gave rise to a primitive group called the australopithecines, who may be our direct ancestors.
  - The most famous of them, named Lucy, was discovered in 1974 and has been given arch-grandmother status.
- By 2 million years ago, the *Homo* group developed larger brains and longer legs to become the earliest "true" human species.
  - *Homo erectus* used its long legs to march out of Africa.
- Other archaic humans continued to evolve larger brains, with new waves of these bigger-brained species migrating out of Africa over the next million years or so, eventually giving rise to the Neanderthals of Eurasia.

New look

- Those early migrant lines were all dead ends.
- The biggest brains of all evolved in those hominins who stayed in Africa; these gave rise to anatomically modern *Homo sapiens*.
- Until recently, the consensus was that our great march out of Africa began 60,000 years ago and that by 30,000 years ago, every other contender was extinguished.
- Only *H. sapiens* remained – a species with a linear history stretching some 6 million years back into the African jungle.
- Or so we thought.

Revolution in human evolution research: from a line to a bush

- When I first started learning about human fossils in East Africa nearly 60 years ago, the conventional wisdom was that almost all of our extinct close relatives were considered direct ancestors.

- But the discovery of multiple evolutionary branches who lived at the same time makes it much more difficult to identify our direct ancestors.

- In 1964, the path lead from *Australopithecus* to *Homo erectus* to *Homo Neanderthalensis* to *Homo sapiens*; all were assumed to be ancestral to modern humans.

Revolution in human evolution research 2

- When Louis and Mary Leakey discovered hominins at Olduvai Gorge in Tanzania, a shift occurred in the focus of research on early hominins that lived more than one million years ago from southern Africa to East Africa

- The focus changed because
  - trickle of fossil discoveries in East Africa in the early 1960s turned into a torrent
  - and the fossil evidence in East Africa was dateable, unlike those of S. Africa

- From 2.3 to 1.4 Ma, two very different kinds of hominins— *Paranthropus boisei* and *Homo habilis*— lived in the same region of East Africa.
  - Either 1 or both was not ancestral to modern humans.

Revolution in human evolution research 3

- The image of a single, simple branch no longer seems apt for representing humans a couple of million years ago. Our early ancestry looks more like a bundle of twigs— or a tangled bush.

- Yet we still have much to learn.
  - Some chapters of the human story are completely unknown from the fossil record;
  - others have been drafted on the basis of evidence so scanty that they are little more than speculation.

- 55 years ago, human fossils could fit in a box
- Today: From skeletons to teeth, early human fossils have been found of more than 6,000 individuals.

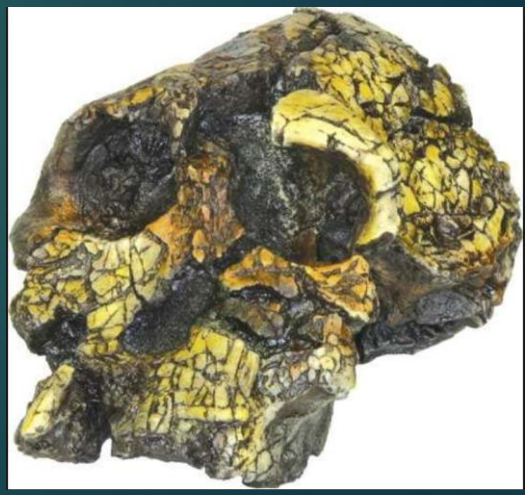
Revolution in human evolution research 4

- Whether before or after standing on two legs, at some stage our ancestors came down from the trees.
- Lucy shows up in 1974, dated at 3.2 Ma.
- By 2000, we knew of just one group that fitted the transition stage to humans: the australopithecines
- They lived in the right place at the right time to have evolved into humans just before 2 million years ago.

Australopithecus afarensis & Kenyanthropus platyops

- Since Lucy's discovery, she has served as the assumed foundation stone on which to build the rest of our hominin family tree, a direct ancestor who lived in east Africa's Rift Valley.

- Then, in 2001, researchers unveiled a 3.5-million-year-old skull was discovered in Kenya. The skull should have belonged to Lucy's species, *A. afarensis*, the only hominin species thought to be living in east Africa at the time.



- But its face didn't fit. It was so flat that it could barely be considered an australopith. Fred Spoor & Meave Leakey at Stony Brook University in New York, gave it a new name: *Kenyanthropus platyops*.

Who was ancestral to us

- The suggestion that Lucy's species shared east Africa with a completely different type of hominin seemed only of marginal interest. The potential significance of *Kenyanthropus* began to grow.

- Some researchers dared suggest that *K. platyops* was more closely related to us than any australopithecus species.

- The conclusion pushed Lucy on to a completely different branch of the family tree, robbing her of her arch-grandmother position.

Who was ancestral to us

- Other researchers were making a similar attack from a different direction
- The discoverers of *Orrorin tugenensis*, the 6-million-year-old hominin found in 2001, also concluded that its anatomy was more human-like than that of the australopiths.
- Most of the research community remains unconvinced by these ideas.
- A recent announcement that a human-like jawbone 2.8 million years old had been discovered at Ledi-Geraru, Ethiopia once more disputed Lucy's position.
- Intriguingly, in 2015, a team announced the discovery of the oldest known stone tools.

Who was Ancestral to us

- The 3.3-million-year-old artefacts were found in essentially the same deposits as *Kenyanthropus*. Was *Kenyanthropus* the tool-maker?

- But there is circumstantial evidence that some australopiths used stone tools too.

- In any event, determining which hominins evolved into humans is no longer as clear-cut as it once was.

Dmanisi

- The "Out of Africa" story is also being shaken up:
  - This idea assumes that the only hominins to leave Africa were big-brained humans with long legs ideally suited for long-distance travel, likely *H. erectus*

- But in 2002, a 1.75-million-year-old human skull, with small cranial capacity of 600 cc, was discovered. Such a fossil wouldn't be an unusual find in east Africa, but this one turned up at Dmanisi in Georgia, in the Caucasus region. Clearly, some small-brained hominins had left Africa.

- The Dmanisi hominins are now considered small-brained early versions of *H. erectus*.

The Out of Africa vs Multiregionalism debate

- Multiregionalism (regional continuity) states that all archaic human forms (*H. erectus,* Neanderthals, and modern forms), evolved worldwide into the diverse populations of anatomically modern humans (*Homo sapiens*) via genetic drift, gene flow and natural selection
  - Associated with Franz Weidenreich, Milford H. Wolpoff, Alan Thorne and Xinzhi Wu
  - Not polygenism i.e. separate or parallel, multiple origins for different populations
  - Most reject this model, but held by some nationalistic Chinese anthropologists
- Leading current theory is the "Out of Africa" theory of origin of AMHs; a single replacement model from Africa.

Flores

- A discovery in 2003 would ultimately prove far more problematic.
  - On the Indonesian island of Flores two bizarre skeletons were found
  - Had small body (3 feet tall) & brain.
  - It was named *Homo floresiensis*, better known by its nickname: the hobbit. Originated dated to 16 Ka, now 600-60 Ka.

- One hypothesis about the hobbit: possibility that a very early migration out of Africa involved an australopith-like hominins.

- The entire out-of-Africa narrative is now flux, with genetic and fossil evidence suggesting that even the once widely held opinion that our species left Africa only 60,000 years ago may be wrong.

Humankind’s Journey out of Africa: MHs

- Now the story is changing in light of new research
- Recent findings suggest that the 'Out of Africa' theory does not tell the full story of our ancestors.
- Instead, multiple, smaller movements of *H. sapiens* out of Africa beginning 270,000 years ago were then followed by a final major migration 60,000 years ago.
- Most of our DNA is made up of this latest group
- *H. sapiens* remains have been found at sites in Germany at 270 Ka, India at 170 Ka, and China circa 120 Ka

Out of Africa & 2 misfits

- Modern humans reached Southeast Asia and Australia prior to 65,000 years ago.

- Recently two more weird misfits had come to light, both in South Africa.

- *Australopithecus sediba* and *Homo naledi* are quite unlike any hominin discovered before, says Lee Berger at the University of Witwatersrand in South Africa, who led the analysis of both.

Out of Africa: Sediba & Naledi

- Their mosaic skeletons seem almost cobbled together from different parts of unrelated hominins.
  - Their mosaic mixtures have lead to the conclusion that you can no longer predict the whole fossil from one of its parts.

- Significantly, the mishmash of features in the *A. sediba* skeleton, unveiled in 2010, is very different from those in the *H. naledi* skeleton, unveiled in 2015.

- Historical assumption that ape-like species gradually morphed into human-like ones over millions of years is now questionable.

Complexity of human evolution: *Homo naledi*

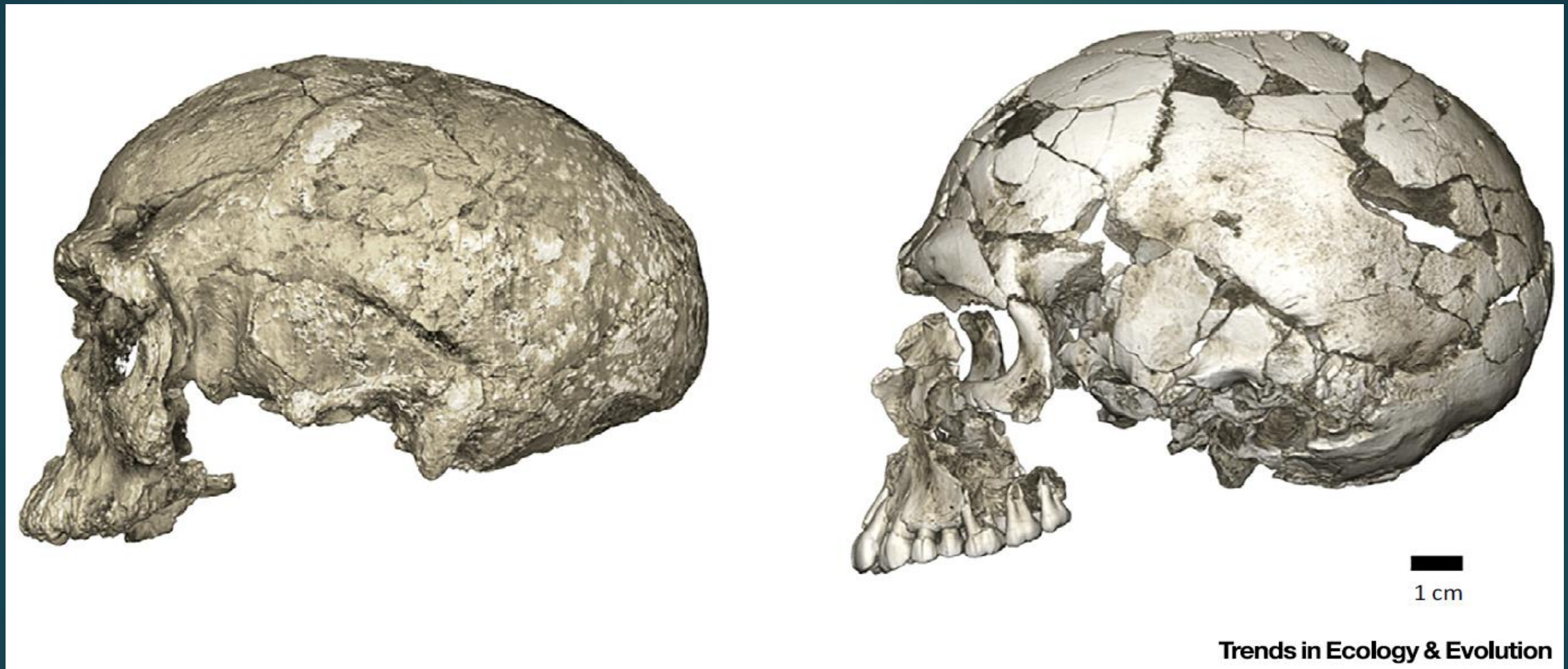
- In reality, Berger thinks, there may have been a variety of evolutionary branches, each developing unique suites of advanced human-like features and retaining a distinct array of primitive ape-like ones.
  - We were trying to tell the story too early, on too little evidence. It made great sense right up until the moment it didn't.

- In 2017, the age of the *H. naledi* was dated to 236,000 to 335,000 years old.

- Weeks later, news broke that 300,000-year-old fossils from Morocco might belong to early members of *H. sapiens*, extending our lineage by 100K.

- Was multiregionalism happening in Africa? Almost certainly.

Braincase changes in Jebel Irhoud 1 (300 Ka) to Qafzeh 9 (95 Ka)



Trends in Ecology & Evolution

Figure 1. Evolutionary Changes of Braincase Shape from an Elongated to a Globular Shape. The latter evolves within the *H. sapiens* lineage via an expansion of the cerebellum and bulging of the parietal. (Left) Micro-computerized tomography scan of Jebel Irhoud 1 (~300 ka, North Africa). (Right) Qafzeh 9 (~95 ka, the Levant).

Small and Large brains together: *Homo naledi*

- Human brains didn't grow and grow for millennia, with smaller-brained species falling to the wayside of the gradual evolutionary road.
- Africa was home to both large brained *H. sapiens* and humans with brains half the size of theirs.
- Can only speculate on how (or whether) the small-brained *H. naledi* interacted with the earliest *H. sapiens*.
- Controversial theory from Berger's team suggests that *H. naledi* intentionally disposed of its dead – perhaps a sign that even "primitive" hominins could behave in an apparently sophisticated way of dealing with their dead

Not as special after all

- Our species, *Homo sapiens*, is special. We have achieved things beyond the capacities of all others in our family tree.

- But the distinction between our species and those that went before may not be quite as stark as we once thought.

- In 2014, for instance, researchers found a zigzag that had been etched in a shell from 540 Ka at Trinil, Java. We had thought we were the only species to produce abstract symbols, yet here was *H. erectus* doing so more than 200,000 years before *H. sapiens* even evolved.

Not so special…Neandertals

- Neandertals are getting an intellectual upgrade.
- Researchers are also becoming increasingly convinced that Neanderthals had advanced behavior, like using watercraft to reach islands or exploiting simple chemistry to start fires.
- Evidence of Neandertal symbolic ability now include a carved a hashtag sign on a rock in Gibraltar, mysterious stone circles out of stalagmites in French cave, and an abstract painting in Spain, dated to 65 Ka. The latter makes Ns the first artists in Europe.

Not so special…*Homo naledi* & Neandertals

- And then there's *H. naledi*, with a brain size of 465–560 cc, half the size of our own.
- According to the team that excavated its remains, *H. naledi* might have deliberately disposed of its dead in deep, inaccessible cave chambers.
- In the late 1990s, geneticists began to show an interest in archaeological remains. Advances in technology allowed them to sequence a small chunk of mitochondrial DNA (mtDNA) from an ancient Neanderthal bone.
- That mtDNA sequence was genetically distinct from *H. sapiens*, initially suggesting that Neanderthals had gone extinct without interbreeding with our species.

Not so special…Ns & Ds

- But mtDNA is unusual. Unlike the nuclear DNA responsible for the bulk of human genetics, it passes intact from a mother to her children and doesn't mix with the father's genes.
- In 2010, Nuclear DNA proved that Neanderthals had interbred with our species after all.
- Then came the Denisovans.
- To this day, the Denisovans remain enigmatic:
  - one finger bone and three teeth from a single cave; no skeleton
  - *H. sapiens* considered them human enough to interbreed with them: a Denisovan nuclear genome sequence published in 2010 showed clear evidence of sex with our species.
  - The DNA indicates they once lived all across East Asia.
  - So where are their fossil skeletons?

Not so special… Ns

- Fast-forward to 2017, and the interbreeding story has become more complex than anyone could have imagined in 2000.
- Johannes Krause of U. of Tübingen reels off the list:
  - Neanderthals interbred with *H. sapiens*.
  - Neanderthals interbred with Denisovans.
  - Denisovans interbred with *H. sapiens*.
  - Something else that we don't even have a name for interbred with Denisovans – that could be some sort of *H. erectus*-like group…
  - And the suspicion is that variations of *H. sapiens* were interbreeding throughout Africa
- We all carry different Neandertal bits – to the extent that if you could add them all up, Krause says you could reconstitute something like 30 % of the Neanderthal genome and 90 % of the Denisovan genome. With this knowledge, can we even say that these species are truly extinct?
- Pushing the idea one step further, if most living humans are a mishmash of *H. sapiens* DNA with a smattering from other species, is there such a thing as a "true" *H. sapiens*?

And in July 2018…

- July 2018: *Did Our Species Evolve in Subdivided Populations across Africa, and Why Does It Matter?*
  - Major review article related to multiregionalism in Africa – the interbreeding of multiple early *H. sapiens* groups across Africa.

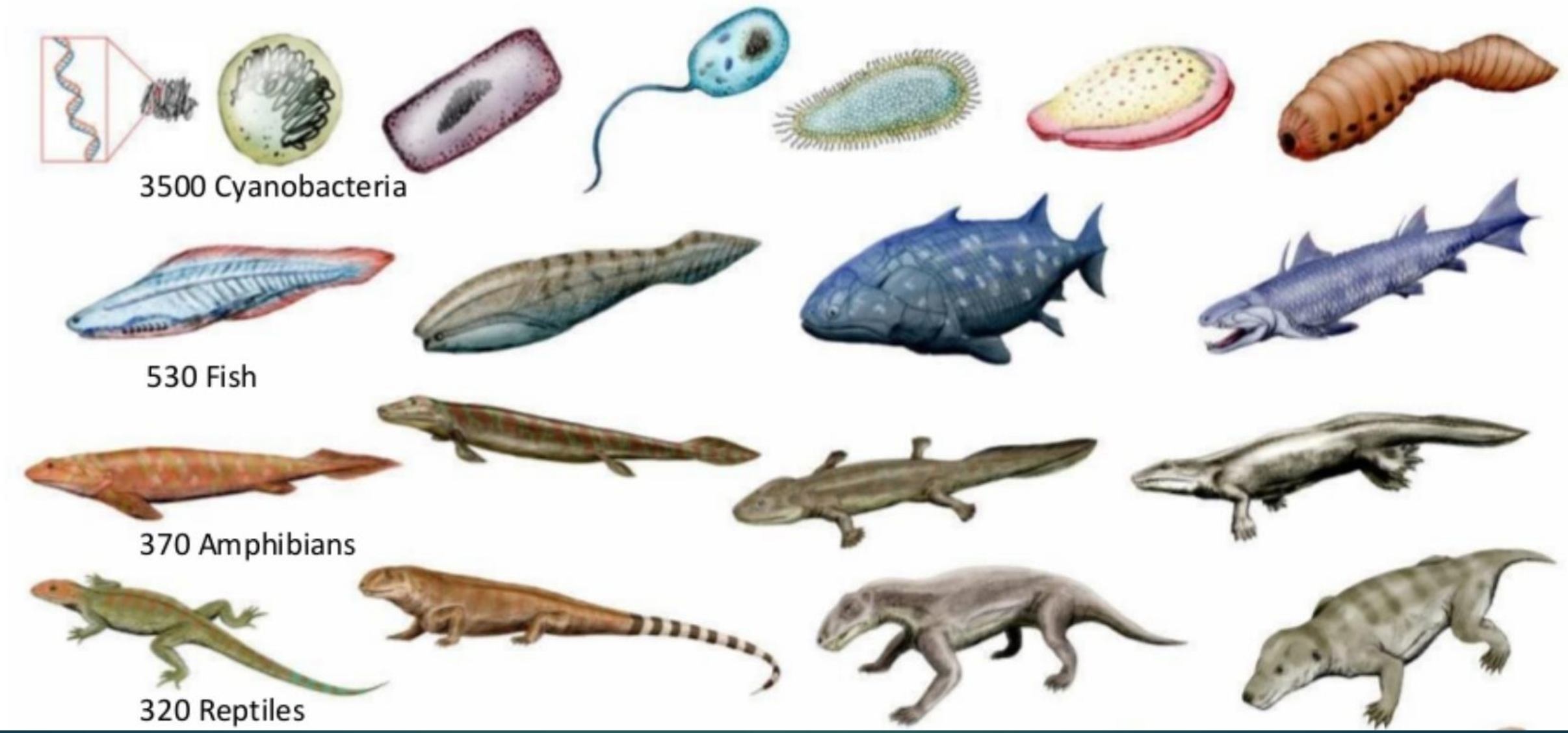
- July 2018: Oldest stone tools outside Africa at 2.1 Ma at Shangchen China, claimed to be made by pre-*H. erectus* hominin?

Not so special…

- Having dug ourselves into this paleoanthropologically troubling hole, there's probably only one way to find our way out again.

- Keep digging for fossils and probe them for more DNA.

More than 2 Billion year history of Multiple Early Ancestors



Oldest ancestor, Saccorhytus, 540 M: an early deuterostome

A tiny sea creature identified from fossils found in China may be the earliest known step on an evolutionary path that eventually led to the emergence of humans

Microscopic, bag-like sea creature, which lived about 540 million years ago.

Named Saccorhytus, after the sack-like features created by its elliptical body and large mouth; no anus

Jian Han, et al., Nature, 2017

Mother or uncle of us all?…*Megaconus mammaliaformis*

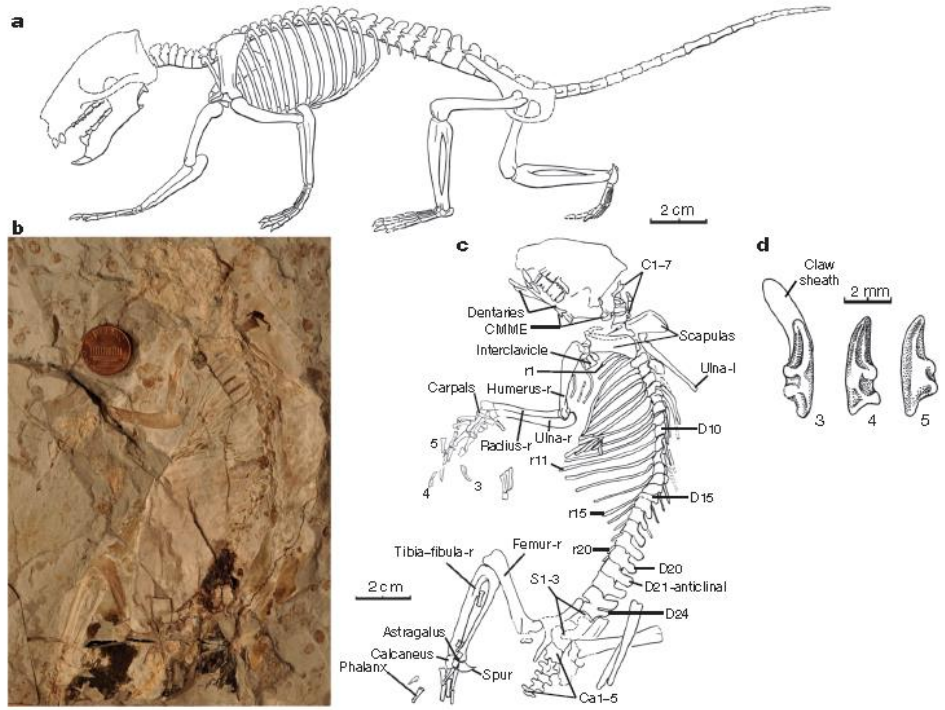


Figure 1 | New Jurassic mammaliaform *Megaconus mammaliaformis*. **a**, Skeletal reconstruction. **b**, Holotype counterpart (Paleontological Museum of Liaoning (PMOL)-AM00007B). **c**, Skeletal feature identification; the left (-l) versus right (-r) sides are designated according to the main-part PMOL-AM00007A (Supplementary Fig. 1). **d**, Manual terminal phalanges. Details on dental and skeletal structures can be found in Supplementary Figures. C, cervicals; Ca, caudal vertebrae; CMME, preserved elements of cynodont mandibular middle ear[24]; D, dorsal vertebrae (D1–15 designated as 'thoracic'; D16–24 as 'lumbar'); r, ribs; S, sacral vertebrae; 3–5, the preserved manual terminal phalanges 3–5.

- A Jurassic mammaliaform
- dated to be 165–164 Myr
- hair and fur residue; poisonous spur
- middle ear still attached to the jaw is more reminiscent of reptile,
- but derived molars
- herbivory evolved among mammaliaforms, before the rise of crown mammals

Chang-Fu Zhou, et al., 2013

Agilodocodon scansorius: Chinese Mother of us all?

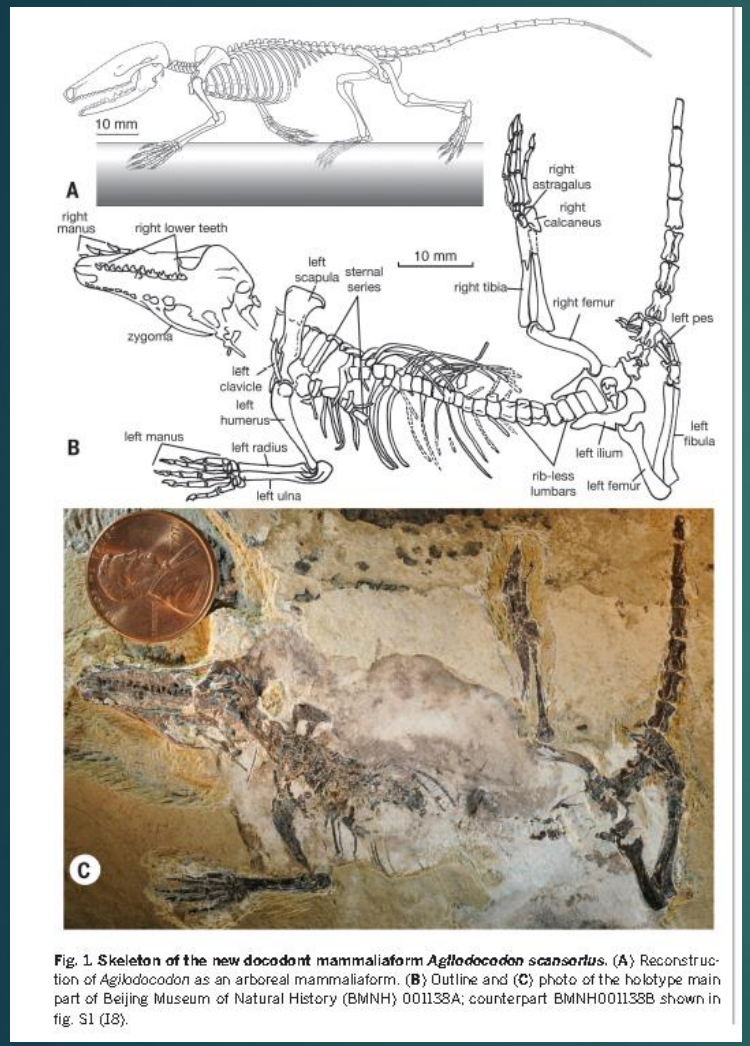
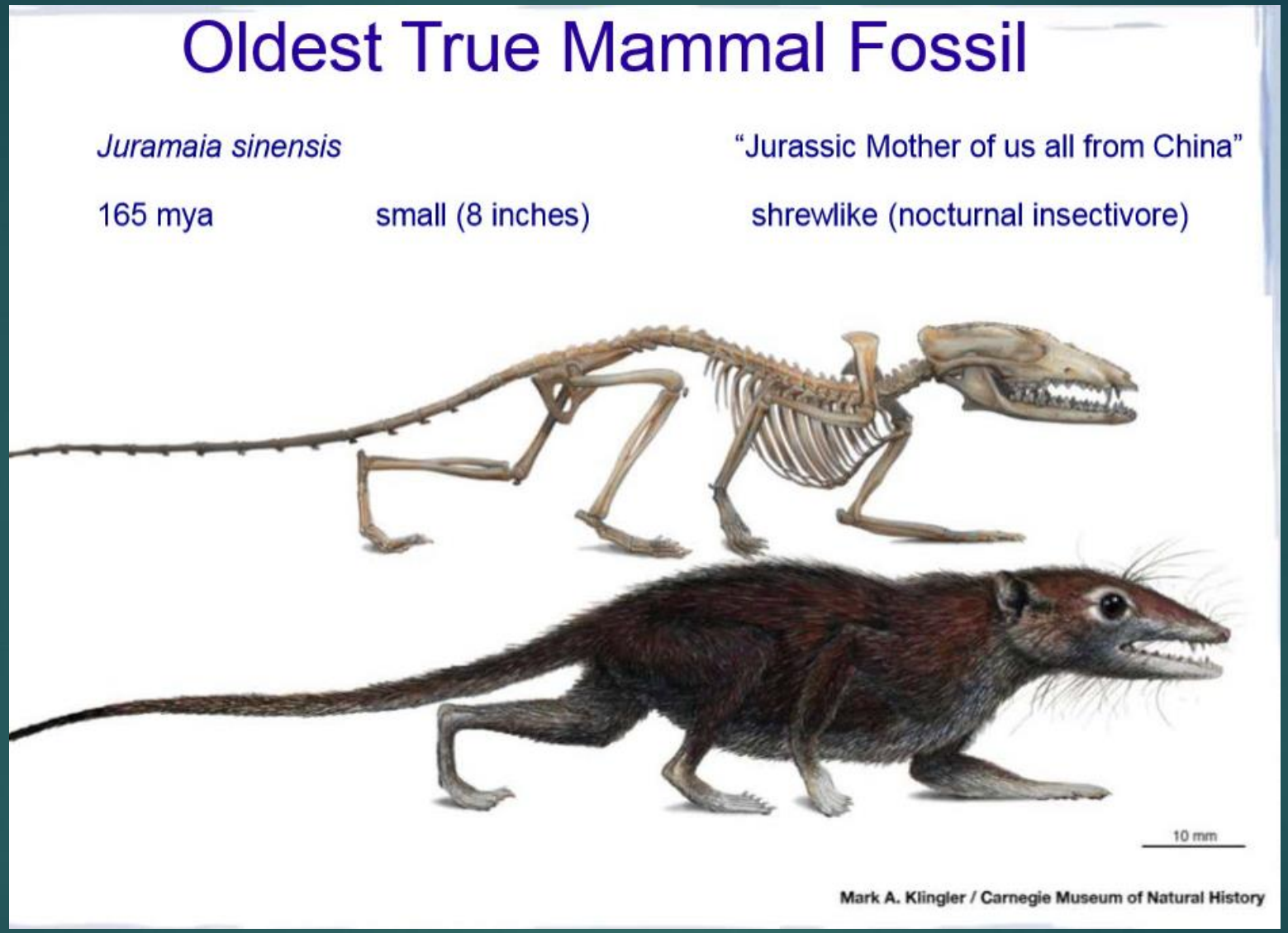


Fig. 1. Skeleton of the new docodont mammaliaform *Agilodocodon scansorius*. (**A**) Reconstruction of *Agilodocodon* as an arboreal mammaliaform. (**B**) Outline and (**C**) photo of the holotype main part of Beijing Museum of Natural History (BMNH) 001138A; counterpart BMNH001138B shown in fig. S1 (*18*).

OMNIVORE LIVED 165M YEARS AGO: SCIENTISTS EXPOSE TINY JURASSIC MAMMAL SPECIES IN CHINA

Qing-Jin Meng, et al., 2015

Docodontan mammaliaform from the Middle Jurassic of China: an omnivorous diet that included plant sap; 174-163 Ma



Liaoning, China: Juramaia sinensis - basal eutherian mammal from the Late Jurassic, 160 Ma; arboreal

Zhe-Xi Luo, et al., 2011

Our Ancestry

- From Eucynodontia (cynodonts) came the first mammals (small shrew-like animals that fed on insects; first neocortex; Triassic, 220 M>
- Eutherian mammal fossil, 160 M>Juramaia, Euarchontoglires (Last common ancestor of mice and humans, 100 M)
- Euarchonta (small, nocturnal and arboreal, insect-eating mammals), Plesiadapiformes, 85-65 M>
- Primates diverge into 2 suborders Strepsirrhini (wet-nosed primates) and Haplorrhini (dry-nosed primates; lost the ability to make its own Vitamin C; require fruit). 63 M>

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

Age of apes

- Miocene: 22 to 5 Ma; planet of apes
- Mediterranean was open ocean in East (Tethys Sea)
- Apes lived throughout 3 continents: Europe, Asia, Africa
- Dozens of species
- Fossil record of hundreds of apes; fossil record covers 12-14 M years; very large diversity of fossils; understanding of Miocene ape evolution remains limited because of that fact.
- Some of Ape species: Afropithecus, Kenyapithecus, Ouranopithecus, Oreopithecus, Proconsul, Dryopithecus, Sivapithecus
- 1 was our LCA (Last Common Ancestor)

Our Ancestry

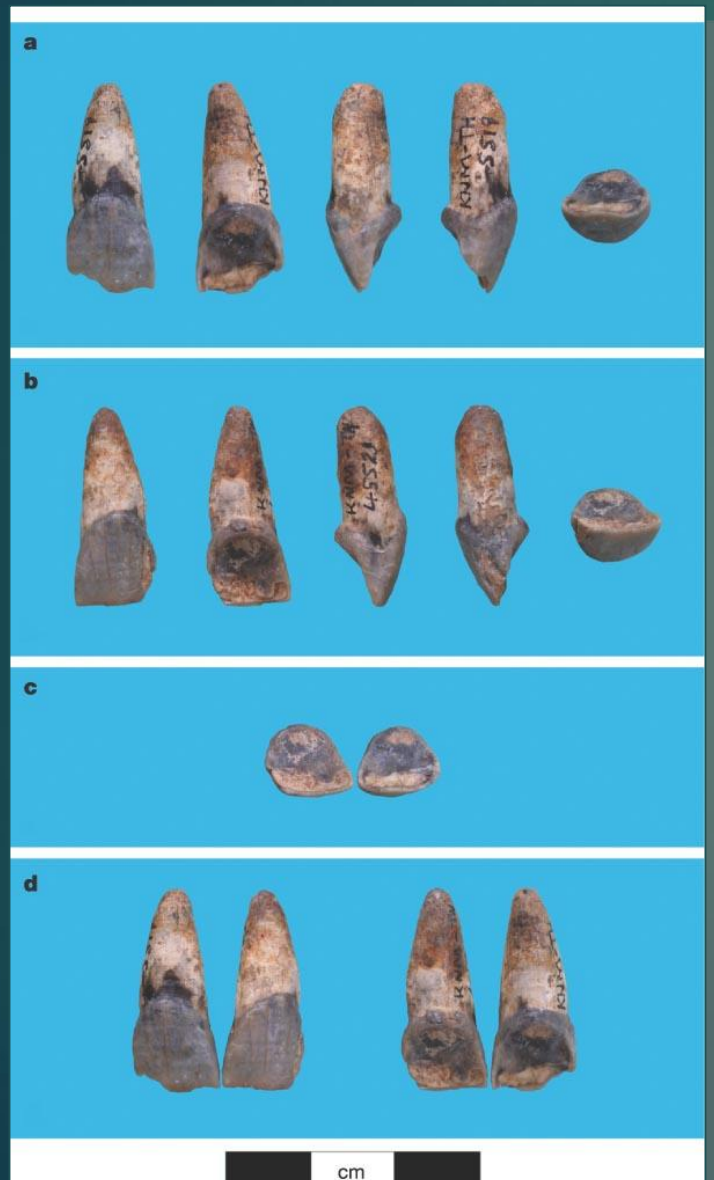
- Haplorrhini splits into infraorders Platyrrhini and Catarrhini. *Aegyptopithecus* or *Saadanius,* 30 M>
- Catarrhini (downward nosed primates) splits into 2 superfamilies, Old World monkeys (Cercopithecoidea) and apes (Hominoidea). Proconsul africanus, 25 M>
- Hominidae (great apes) split from gibbon (lesser apes), 15 M>
- Split from ancestor of orangutan, 13 M>
- Split from ancestor of gorilla, 10 M>

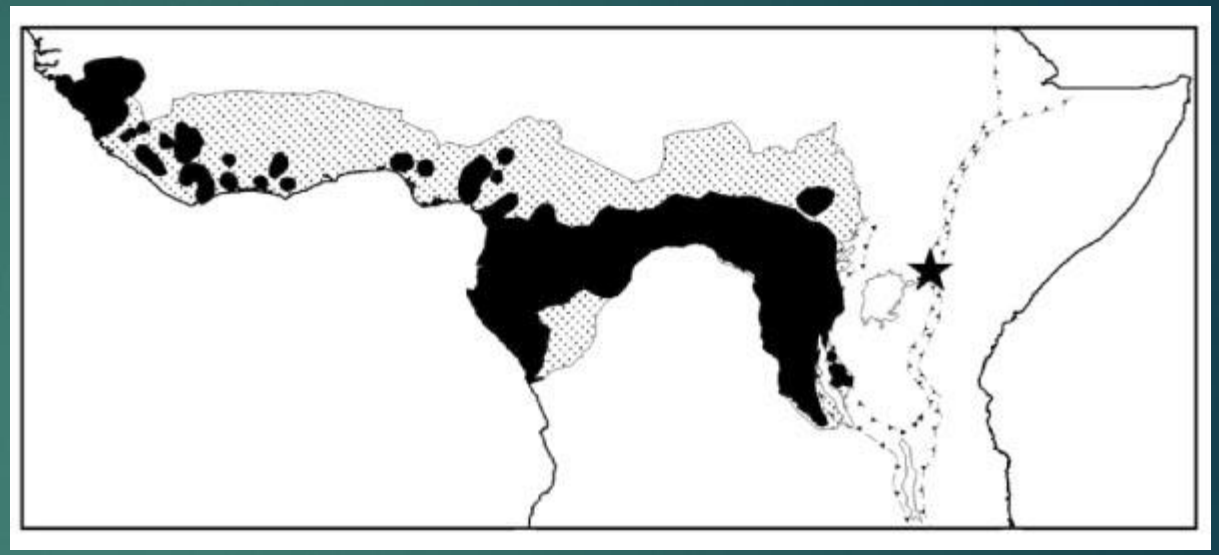
Current paradigm in study of human evolution

- Apes were widespread across Africa, Europe and Asia about 20 million years ago – at this time the world really was the Planet of the Apes
- Modern humans originated in Africa
- Molecular clock (mutation rate in species) indicates separation of both hominins and chimpanzees from LCA around 7 million years ago
- How many fossil chimpanzees have we discovered?

First and only chimpanzee fossils, 545 Ka

Sally McBrearty and Nina G. Jablonski, 2005

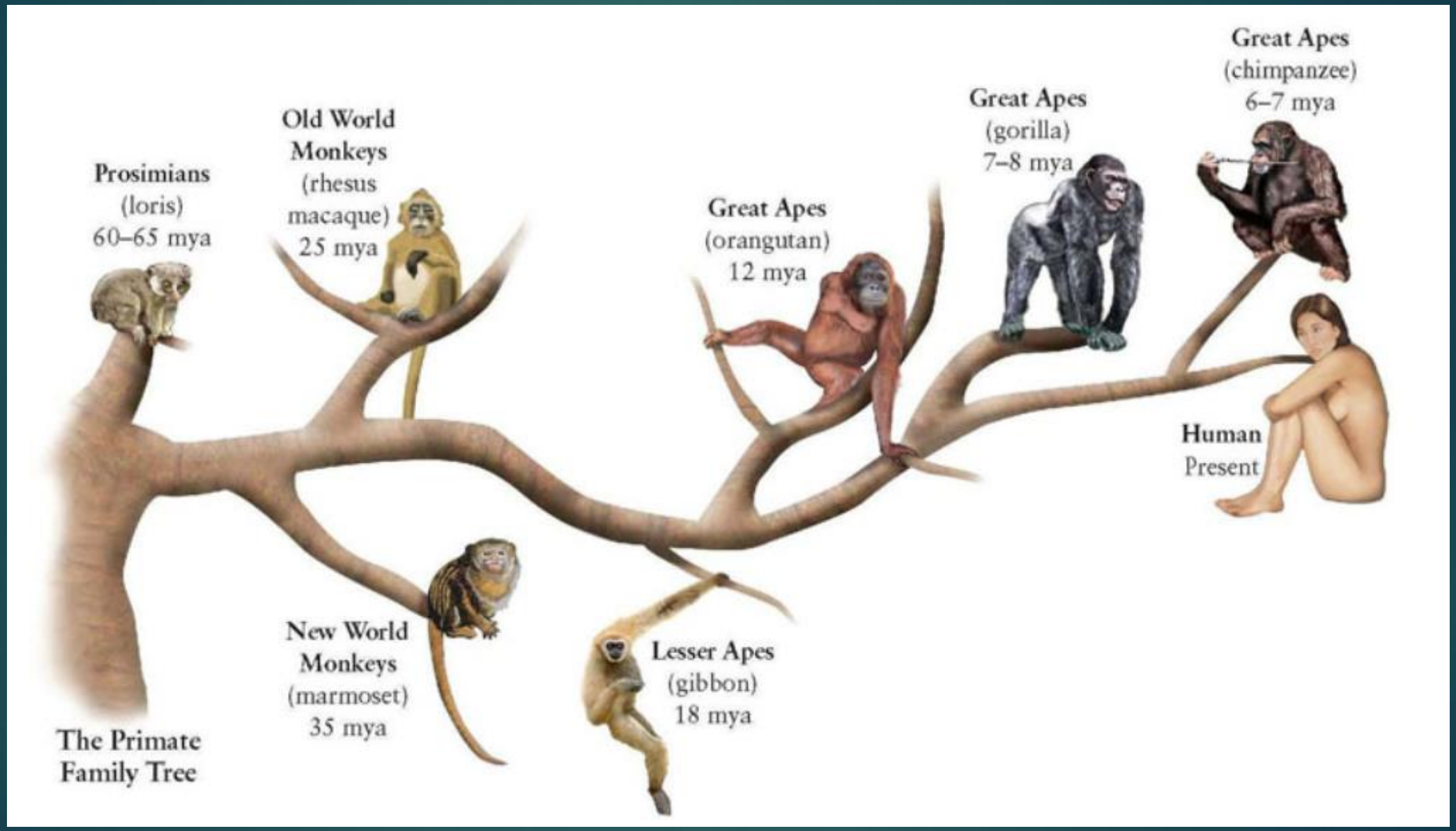




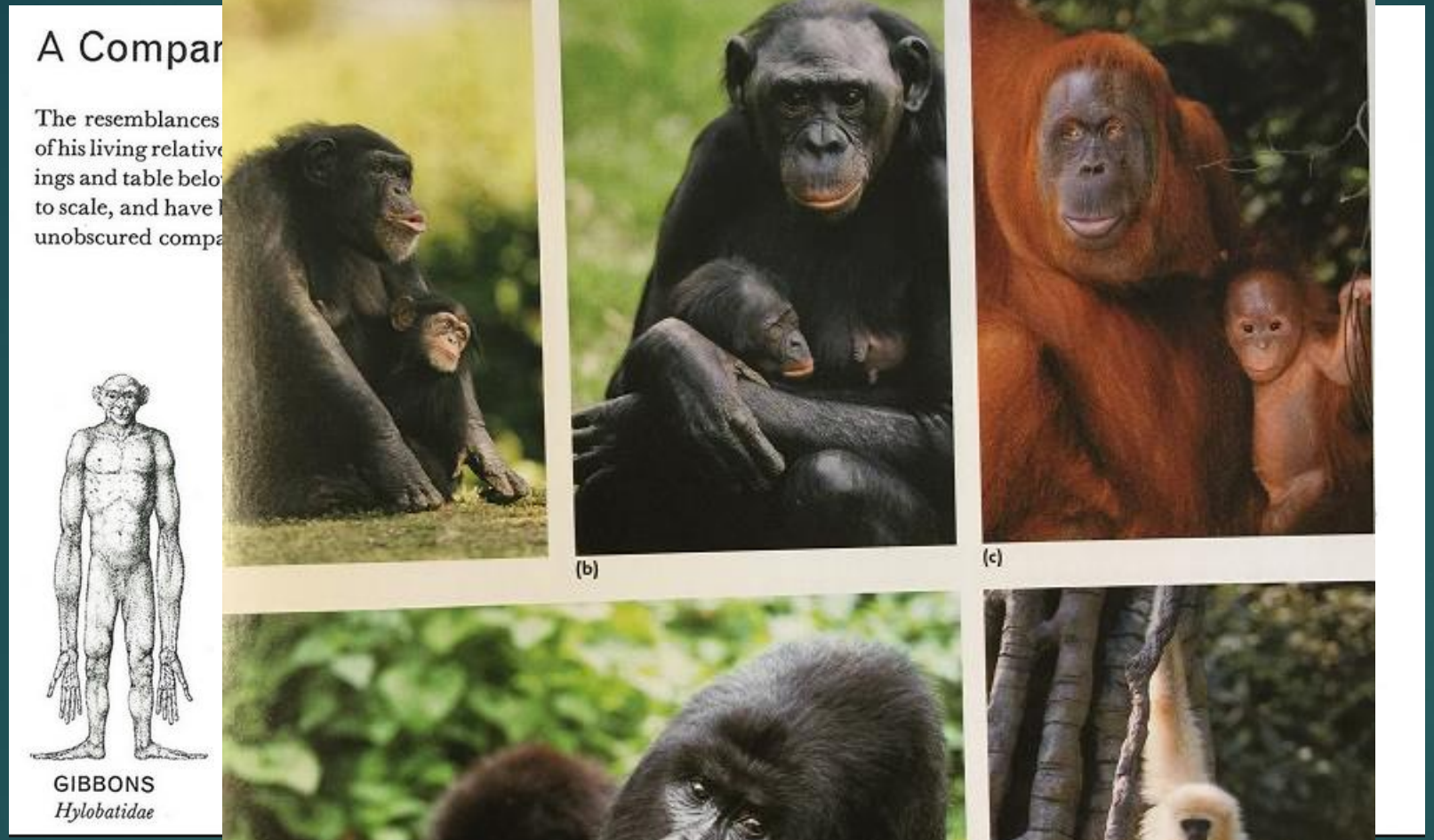
- First unequivocal chimp fossils dated to ~ 545 Ka. Contemporary with *Homo erectus* from the same site.

Nature **437**, 105-108 (1 September 2005)

Primate Family Tree



Current Great Apes



H. sapiens,
A most bizarre species:

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

Our potential ancestry

- Hominina, LCA: split from ancestor of chimpanzees, 7 M >
- *Ardipithecus ramidus,* 4.4 M>
- *Australopithecus afarensis*, 3.3 M>
- ?? – 2 to 3 Ma is fossil sparse: *Homo habilis, 1470, 1813*
- *Homo erectus*, 2 M> 75,000 generations ago
- *Homo antecessor*, 900 K
- *Homo heidelbergensis*, 800 K>
- *Homo sapiens & Homo neanderthalensis*, 500 K>

Historical Bomb Shells in Paleontology: Paradigm shifts

- Fossil discoveries that were fundamentally inconsistent with prevailing paradigm about the course of human evolution & responses to them:
- 1856: Neandertal (*H. neandertalensis*): a Mongolian Cassock with rickets
- 1891: Java man (*H. erectus*): an ape
- 1912: *Eoanthropus dawsoni*: Briton with a large brain
- 1924: Taung child (*A. africanus*): small brain, therefore an ape
- 1974: Lucy *(A. afarensis*): bipedality at 4 Ma?
- 1991-2005*: Dmanisi (H. erectus):* brain too small to be *erectus*
- 2004: *Homo floresiensis*: microcephalic *H. sapiens*?
- 2016: *Homo naledi:* burial practice in small brained hominin?

New Human Evolution Timeline 1

- 8-15+ Ma: Planet of the Apes; no hominins
- 7-8 Ma: LCA (Last Common Ancestor) of chimps and humans lives in forests of Africa
- 7 Ma: *Sahelanthropus tchadensis* (discovered in 2002); was the common ancestor of chimps and MHs earlier?
- 6 Ma: *Orrorin tugenensis* (2001)
- 5 Ma: Some early apes come down from trees, stand up on 2 legs

New Human Evolution Timeline 2

- 4.4 Ma: *Ardipithecus ramidus* (2009): walked on 2 legs in forest; hominins first walked in woods; death of savannah hypothesis?

- 4 Ma: Adaptation to heavily masticated diets; These hominins give rise to australopiths, including Lucy, *Australopithecus afarensis (1974);* is Lucy our arch-grandmother?

- 3.5 Ma: *Kenyanthropus platyops* (2001): contemporary of Lucy; closer to MHs than australopiths?

- 3.3 Ma: Lomekwi stone tools

New Human Evolution Timeline 3

- 3 Ma: Diversification of hominin species. Some evolve larger brains and longer legs; 3 to 2 Ma is mystery period – origins of *Homo* occurred then

- 2.8 Ma: Taung child, *Australopithecus africanus*, (1924) discovered

- 2.1 Ma: Shangchen, China stone tools (2018) - early *Homo*

- 2 Ma: African hominins continue to increase brain & body size (*Homo habilis*), Oldowan technology, and large mammal butchery; and some leave Africa for Eurasia (*Homo erectus)*

New Human Evolution Timeline 4

- 1.9 M & 2.4 Ma: artifacts and stone tool–cutmarked bones from Ain Boucherit, Algeria
- 2 Ma: *Australopithecus robustus* (1938) arises
- 1.8 Ma*:* *Australopithecus sediba* (2010): 2 skeletons show mosaic (ancestral & derived) features, that were previously attributed to different species
- 1.8 Ma, Eurasia: Dmanisi (2002): This *H. erectus* found in Georgia; indicates that small brained hominins left Africa
- 1.8 Ma, Africa: *Paranthropus boisei* (1959) arises

New Human Evolution Timeline 5

- 1 M to 800 Ka: *H. heidelbergensis* in Africa and Eurasia

- 600-100 Ka: *Homo floresiensis* (2003) - small brained hominin; 700 Ka stone tools and jaw – a dwarfed *H. erectus* or australopith/early Homo descendant?
- 800 Ka, divergence of Neanderthals and Denisovans from African archaic humans;
- 640 Ka, Eurasia: Neanderthals & Denisovans (2010) diverge: the later a widespread Eurasian species that lived at a time when we thought only Ns and MHs remained

- 300 Ka: DNA evidence (2013) in Denisovan genome suggesting they mated with an unknown earlier species (*H. erectus*?)

New Human Evolution Timeline 6

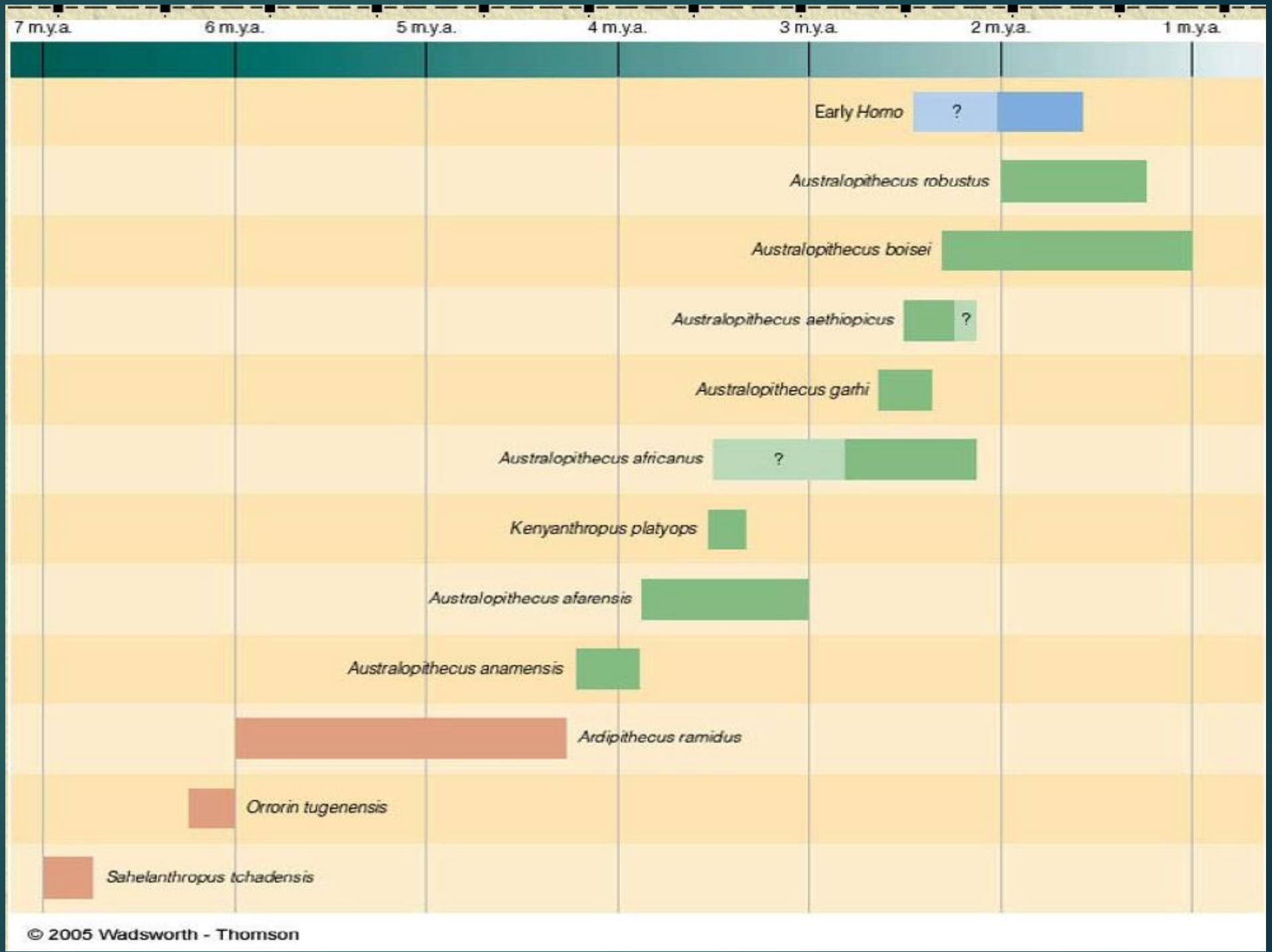
- 300-236 Ka: *Homo naledi* (2015) - its small brain undermines assumption of ever enlarging brain in hominin group
- 300 Ka: oldest *Homo sapiens* (2017) discovered in Morocco
- 200 Ka: anatomically modern *Homo sapiens* arises in Africa
- 143 Ka: *Homo erectus goes extinct* in Southeast Asia
- 60 Ka: *H. sapiens* successfully eaves Africa

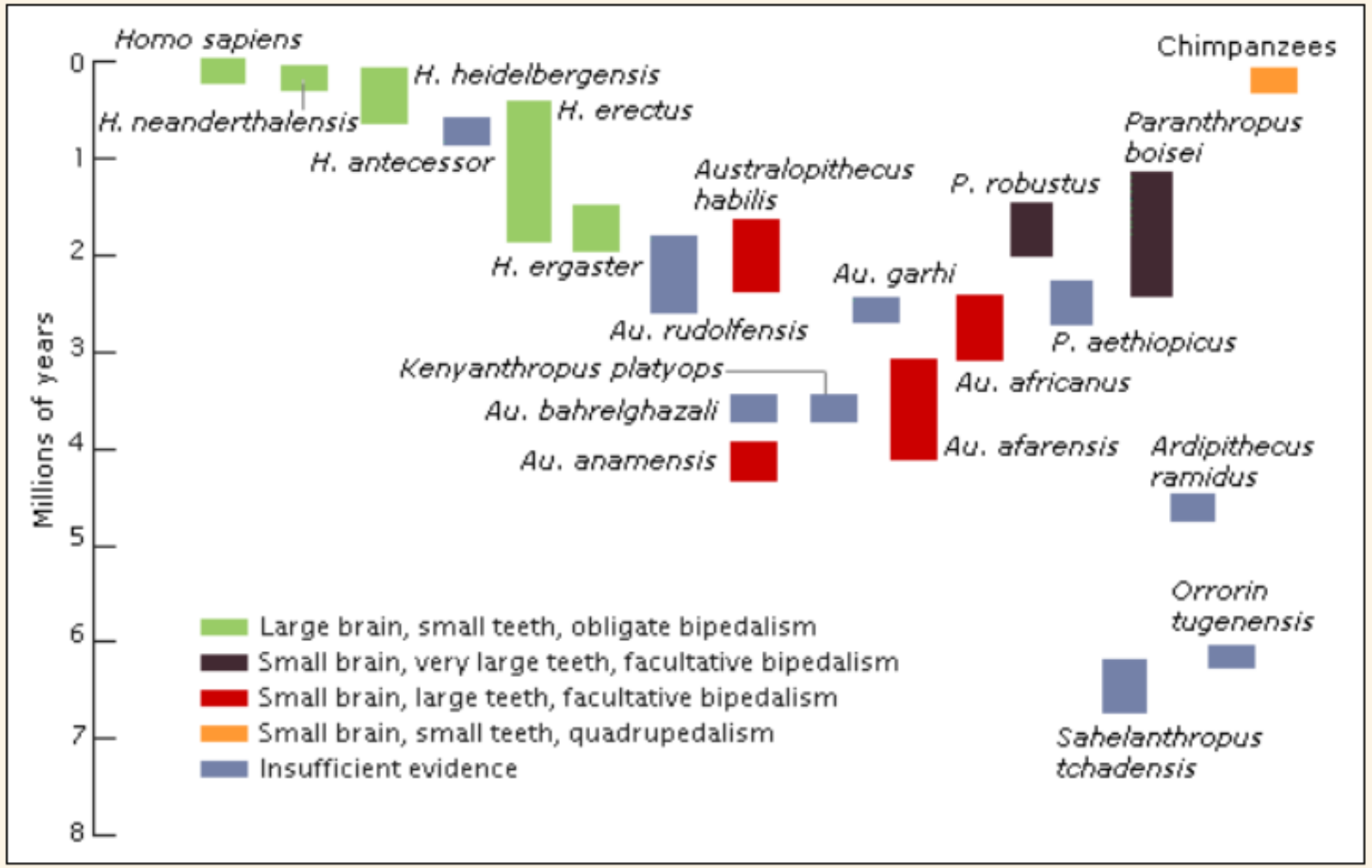
Simultaneous hominins

- At 300Ka, a bush of *Homo* species coexisted:
  - *Homo erectus* in Asia
  - *Homo sapiens* in Europe and Africa
  - *Homo neanderthalensis* in Europe
  - *Denisovans* in Asia
  - *Homo floresiensis* in Flores
  - *Homo naledi* in South Africa
  - Thus six hominin species roamed the planet simultaneously.

- Given that the fossil record always underestimates the number of species, we should expect that our current count is an underestimate

Pre-*Homo* Hominins





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.

Historical views of human evolution: science has changed

- Historical Views:
  - Large brain and complex language are unique to modern humans
    - No. Check out *H. heidelbergensis* and Neandertals brain sizes
  - Human features (brain size, bipedalism, etc.) emerged together
    - Bipedalism emerged 7 Ma, large brain size c. 700 Ka
    - Variety of MH skull shapes in Africa

Historical views of human evolution: science has changed

- Newer ideas:
  - Major differential for being hominin (closer to us than to chimp): bipedality & small canines & no tooth gap; not large brain
  - No linear progression of human evolution: now bush, tree model
  - Multiple hominin species existed at same time:
    - *P. boisei, H. habilis, H erectus* at 2 Ma
    - *H. erectus*, Neandertal, Denisovans, *H. naledi, H. floresiensis, H. sapiens* at 300 Ka
  - Out of Africa: Conclusive DNA evidence of MHs originally evolving in Africa

Milestones in Human Evolution

- **Five key traits** make us who we are today. These traits are listed in the order of development -- walking upright developed first, etc.
- **Bipedalism** - We get around by walking upright on two legs.
- **Tool Making** - We make and use tools ranging from stone hammers to smart phones.
- **Modern Body Plan** - We have longer legs and shorter arms than other primates.
- **Big Brain**- We have the largest and most complex brain of any primate
- **Symbolic Thinking** - We communicate using symbols such as images, numbers and letters

Hominin Evolution: 5 Major Steps – which hominins?

- Bipedalism: *Australopithecus afarensis, &* possibly in *Sahelanthropus tugensis. Orrorin*

- Tool Use:
  - *A. afarensis* (3.3 Ma) *(*Lomekwi 3 site, cut marks at Dikika site) ; *A. garhi (*2.6 Ma)
  - *Homo habilis* (2 Ma)
  - Difference between tool use (chimps do) vs tool making (modifying stones) vs making tools to make tools (MHs)

- Body Plan: *Homo erectus* (long legs, long distances), but some earlier australopiths

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

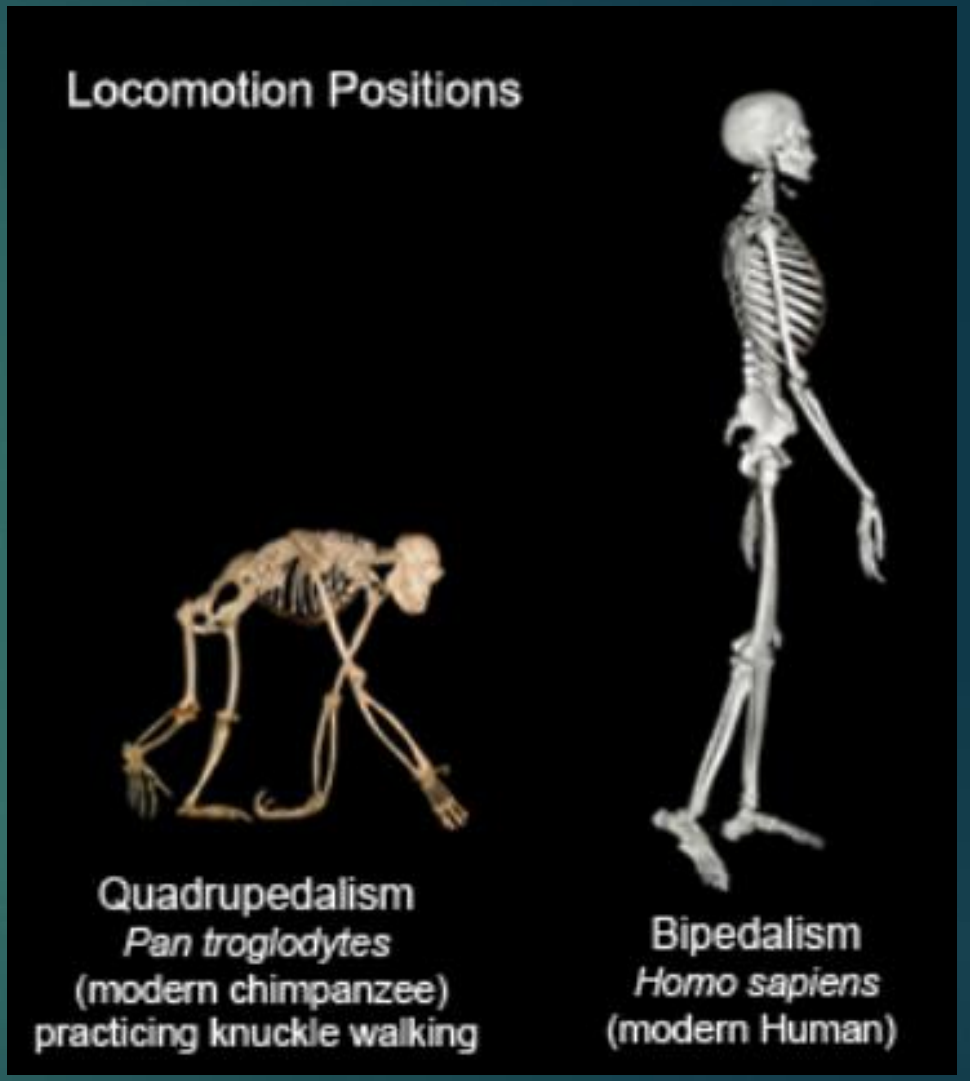
- Symbolic thinking: *Homo neanderthalensis & sapiens* (c 100K, art, pigments)

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

Anatomical Evidence of Bipedalism

- Forward placement of foramen magnum
- Shape of spine
- Shape of pelvic girdle
- Bicondylar angle of femur (knock-kneed)
- Parallel toes (no divergent big toe)
- Two fixed arches in foot
  - Side to side / front to back



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): for bipedality
  - Parabolic dental arcade

Occasional bipedality & curiosity: SF Zoo gorilla

Judy Reynolds

Terminology: Types of bipedality

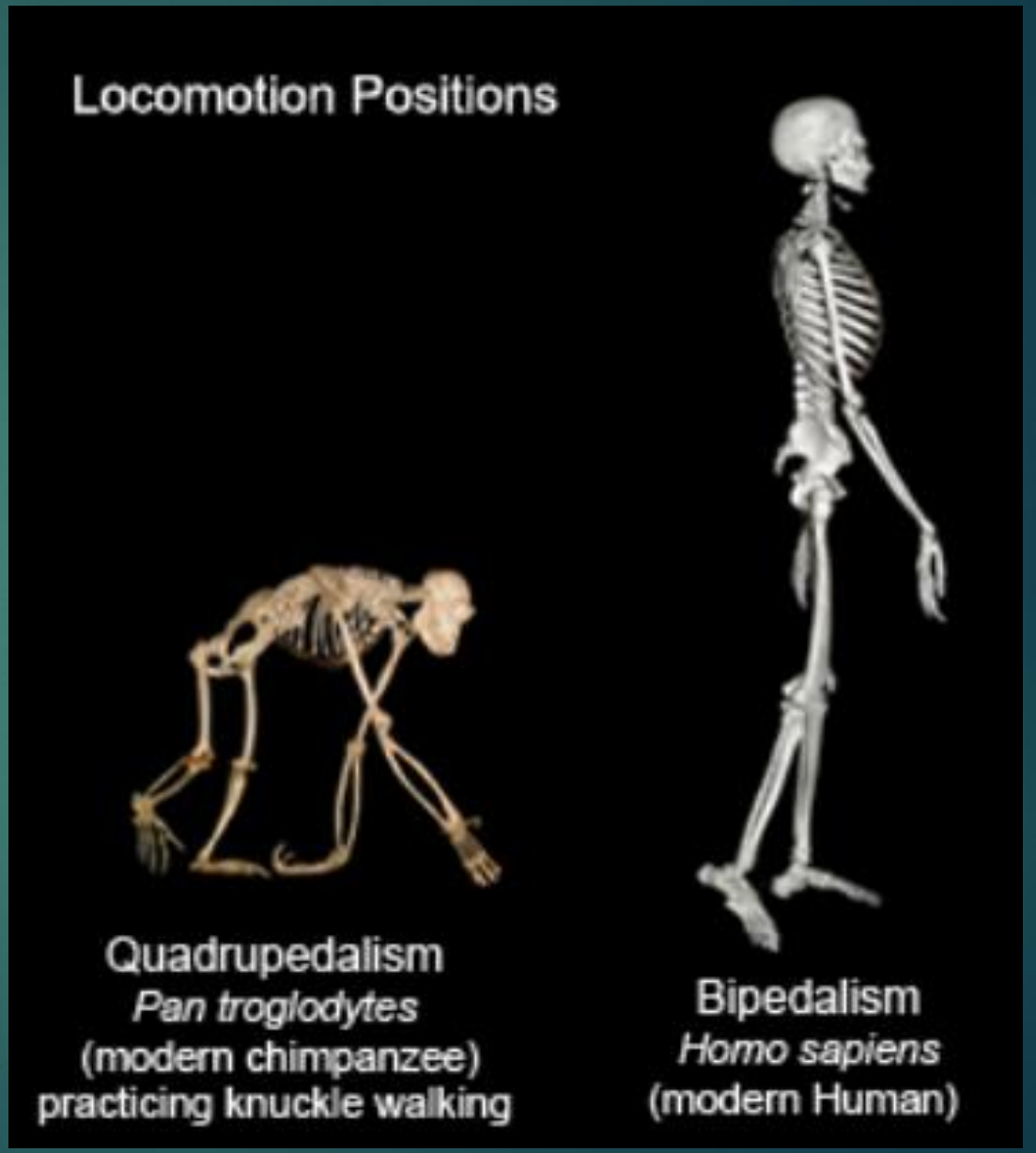
- Facultative biped: animal that is capable of walking or running on two legs, often for only a limited period, in spite of normally walking on four limbs, i.e. some lizards, chimps

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

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

- Strident bipedality: walk only on 2 legs

Knuckle walking vs bipedality



1st third


CHIMPANZEE
flat, nonprojecting nasal region
brow ridge
large front teeth
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.
large canine
rectangular dental arcade
foramen magnum
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.
hip bone
long sacrum
coccyx
small, low braincase
spine attaches to rear of skull holding head at an angle
shoulder joint
large projecting jaw, but no chin
cone-shaped rib cage
arms longer than legs
long, narrow pelvis
coccyx
thigh bones roughly parallel rather than angled
lightly built knee joint, so leg can only support weight for short periods of bipedal walking
opposable thumb
medium-sized calcaneus
long, curved fingers
opposable big toe
long toes
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
high, large braincase
small front teeth
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.
narrow cheekbones
projecting nasal region
short, flat face
pointed chin
skull positioned directly over spine
shoulder joint
small canine
curved dental arcade caused by short face
foramen magnum
rounded braincase
lumbar region curves forward under center of gravity
barrel-shaped rib cage allows arms to swing while walking
sacrum
short, wide pelvis positions body directly above hips
coccyx
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.
hip bone
sacrum with five (sometimes six as here) fused segments
large knee joint, so leg can support body's weight while walking long distances
coccyx
thigh bones angled inward toward knees
shorter, slender, straight fingers
knee can lock, enabling leg to extend fully in a long walking stride
legs longer than arms
arched foot
big toe fully aligned with other toes
very large calcaneus
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.

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

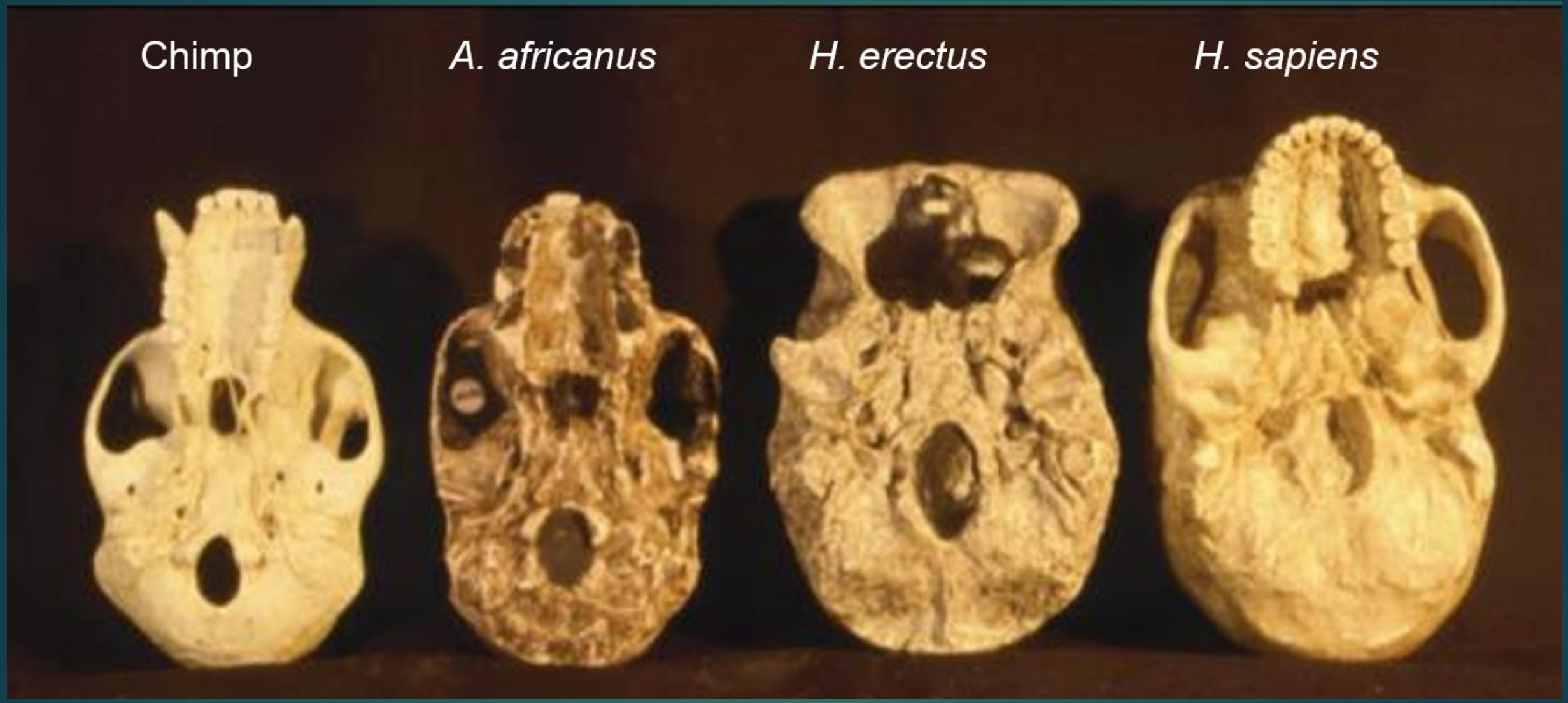
- Strong big toe that is in line with the other toes, making it supportive and nonopposable
- Extensible knee joint
- Complex two-way arch system in the foot: Side to side / front to back
- Bowl shape of pelvic girdle; Chimps walk with a lot of lateral movement from hips; humans have almost no hip movement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

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.

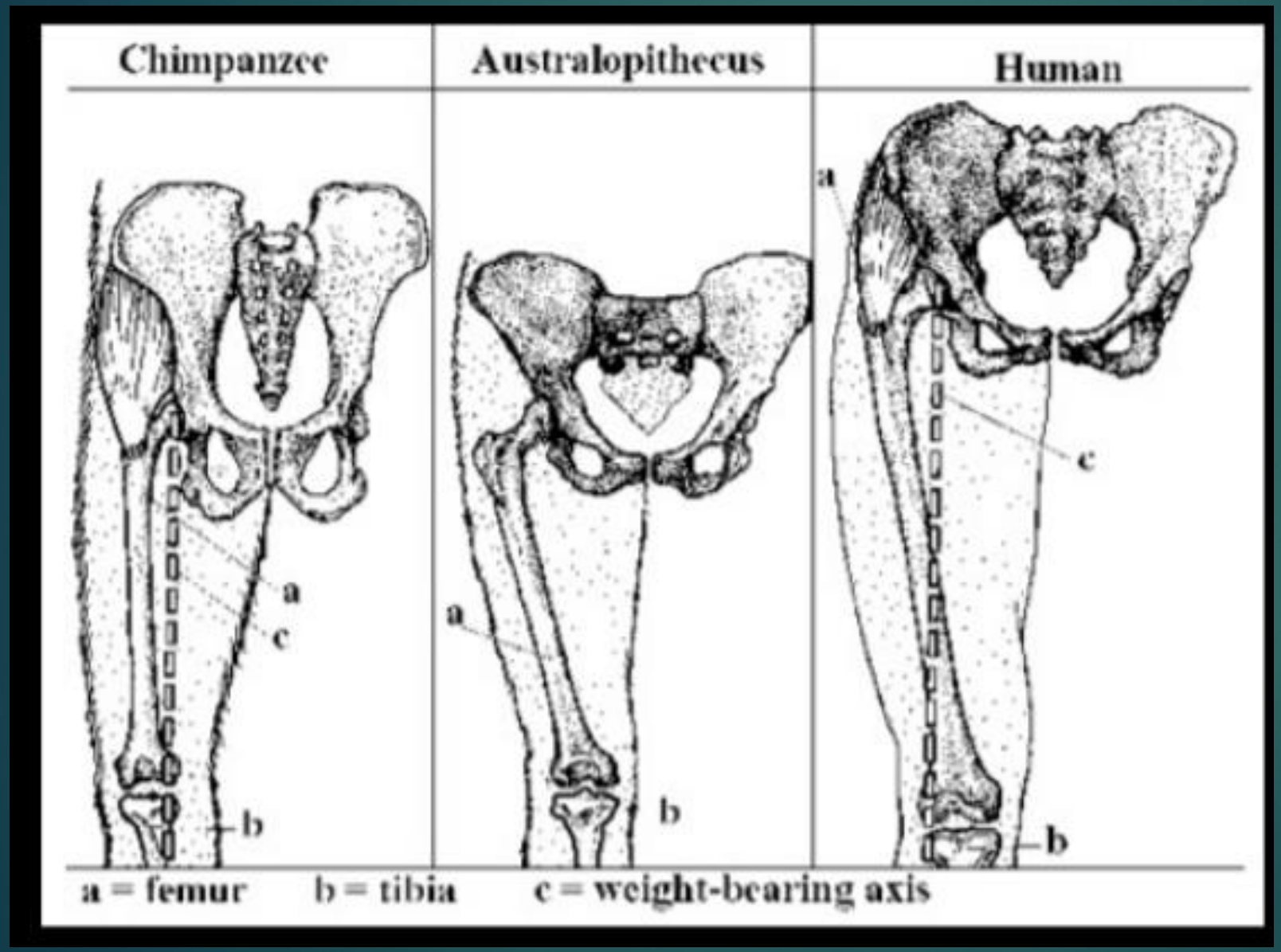
Dentition

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



Foramen Magnum, Spinal Cord

Lower limb adaptations



Chimpanzees

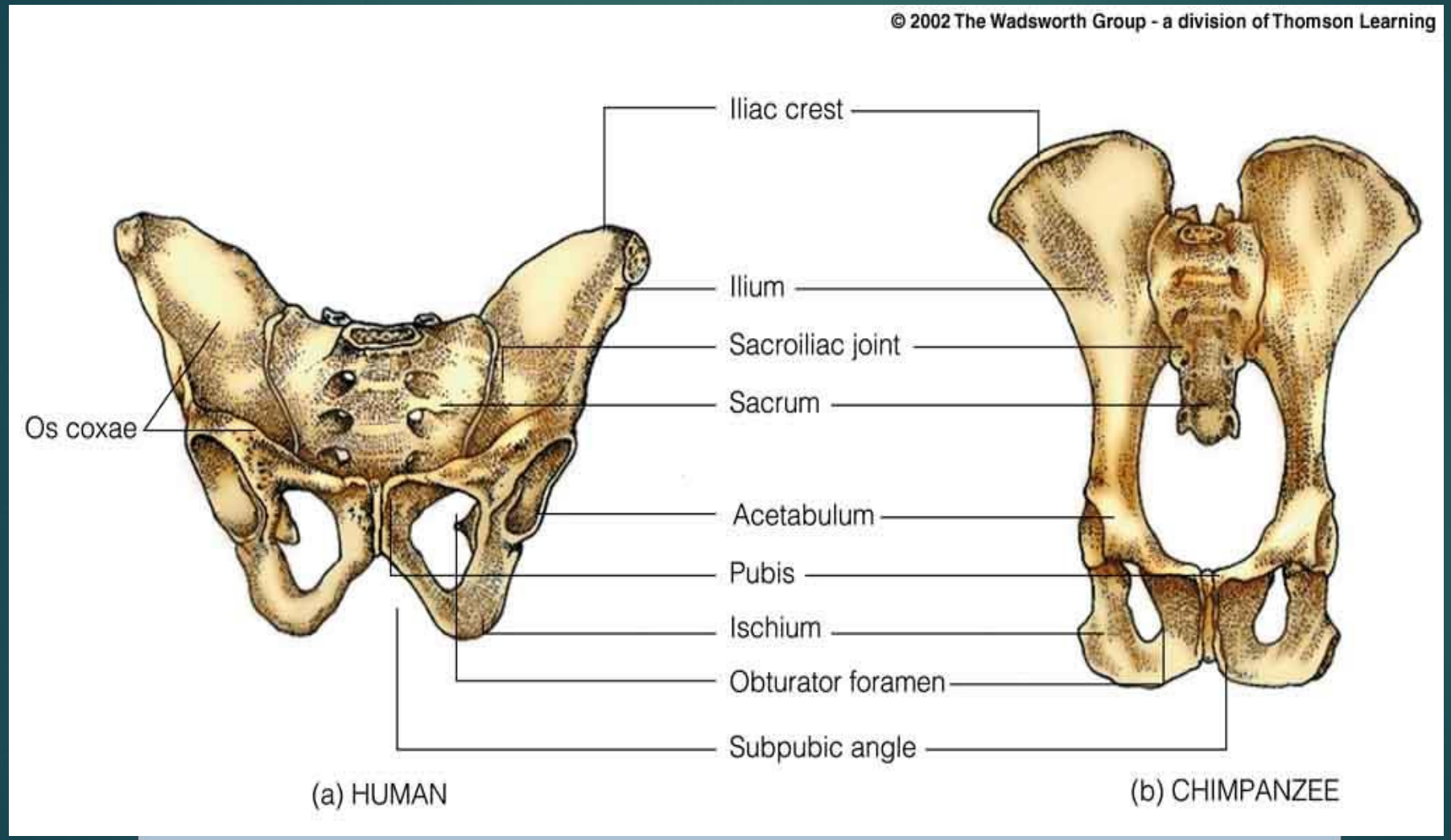
Because the connection between the upper thigh and hip bones is short in chimpanzees, the hip muscles cannot contract effectively to provide support for upright walking.

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

Humans have developed a "closed-knee stance"

"Knock kneed" direction, but strong knee

A comparison of human and chimpanzee pelves.



Bipedal bowl vs. Knuckle walking back brace

<u>Chimp pelvis</u>:

2 hip blades,

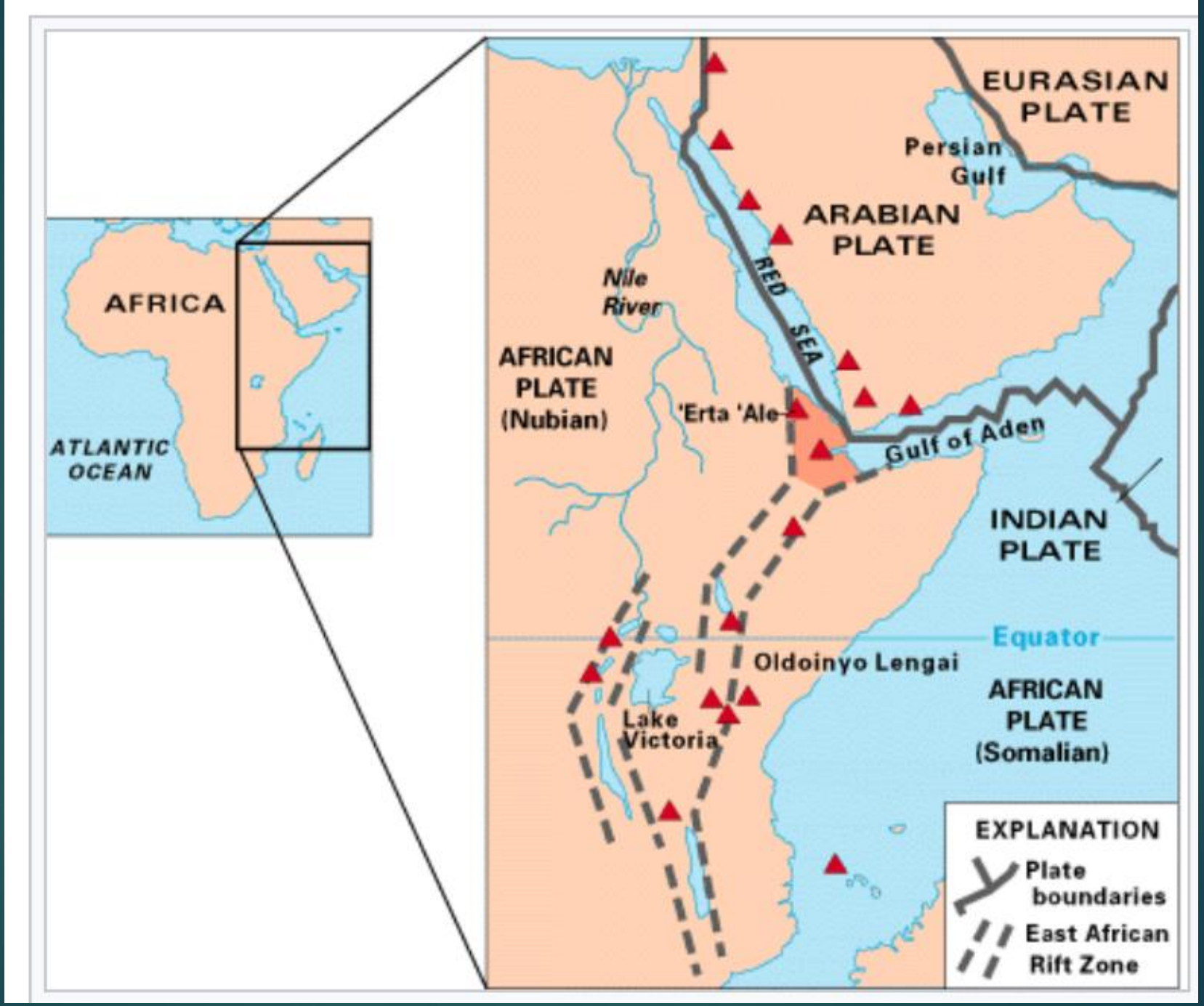
vertically up,

fused with spine by ligaments

back not flexible

East African Rift Valley:

3 plates splitting at 6–7 mm annually




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

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

Last Common Ancestor

- Tim White: *Ar. ramidus* reveals that the last common ancestor that we share with chimpanzees (LCA) was probably a:
  - palmigrade (whole foot down)
  - arboreal, climber/clamberer that lacked specializations for suspension, vertical climbing, or knuckle-walking
  - postcanine dentition associated with an omnivorous frugivorous diet
  - moderate canine dimorphism with minimal skull and body size dimorphism
  - relatively weak male-male antagonism in a male philopatric social system.

T. D. White et al., 2009

“Phases” of human evolution

- 3 Phases of human evolution:

- Early phase: 7-4 Ma – Africa – Still poorly known – Earliest bipeds? Canines reduced. Largely ape-like?

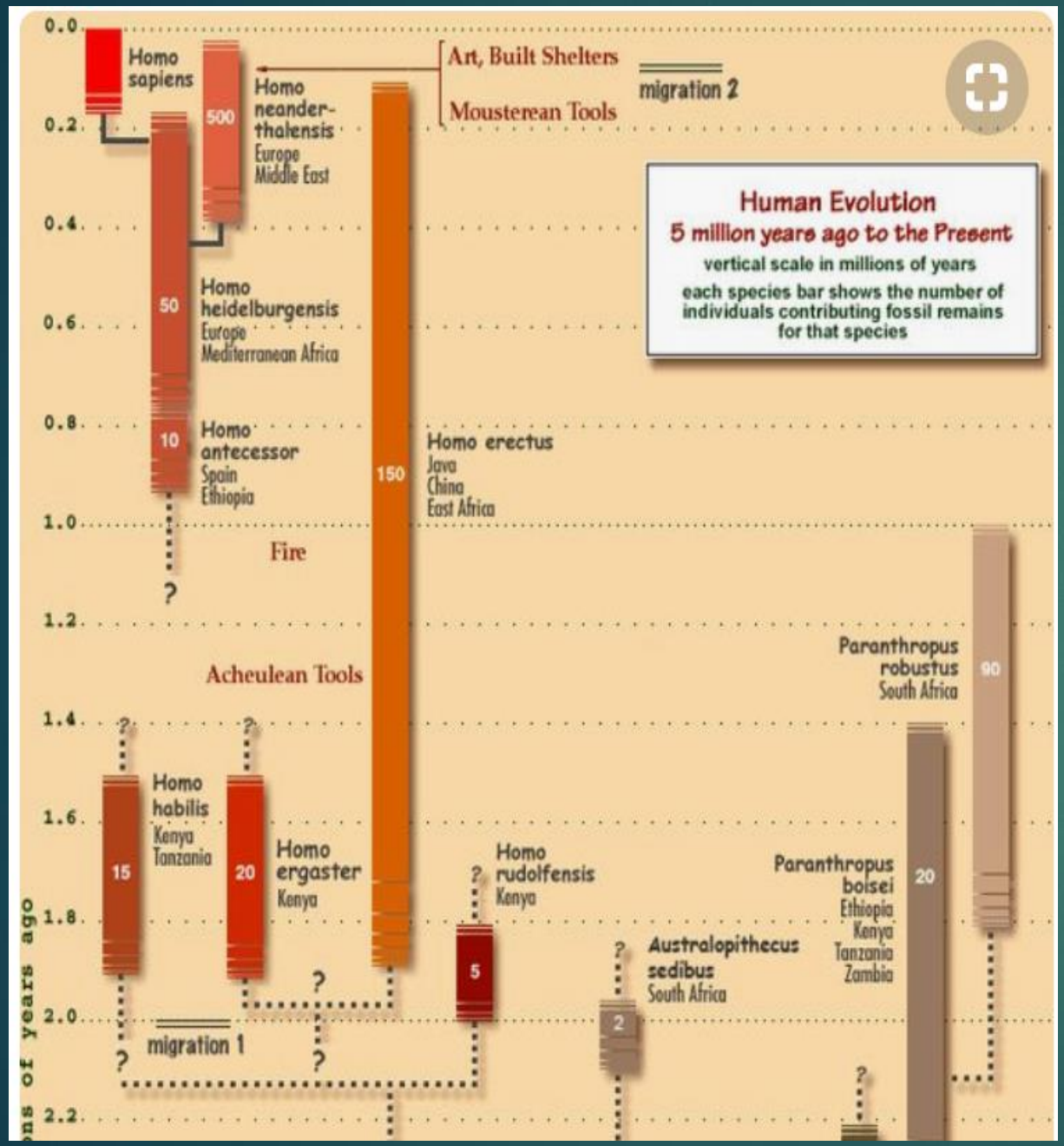
- Australopithecine phase: 4-2 Ma – Many species, widespread in Africa. Bipedal but still partly arboreal? Early tool use? Still some what ape-like?

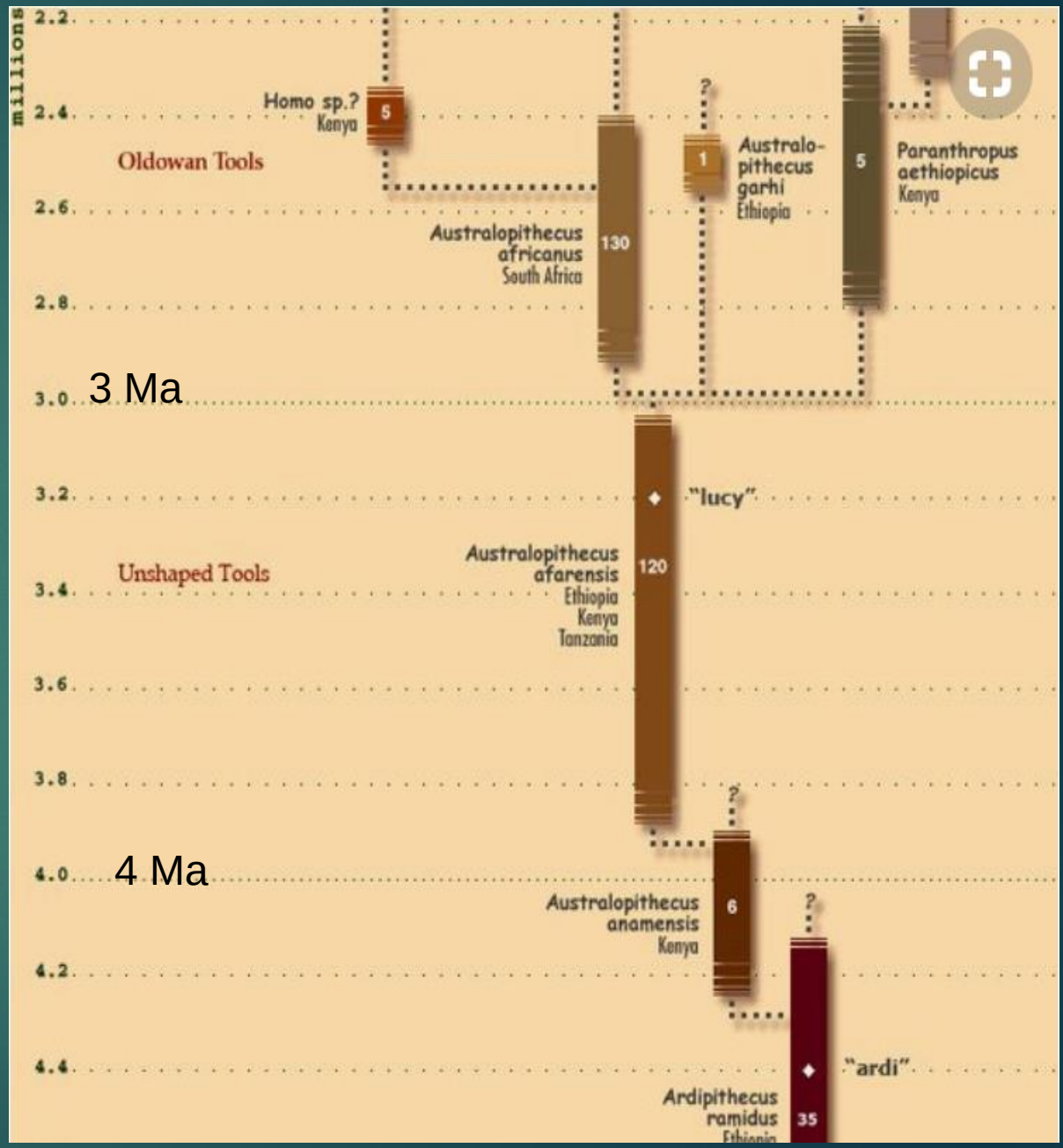
- *Homo* phase: 2-0 Ma – several species; global spread; “Human” anatomy; encephalized (brain larger than body size requirement); greater dietary range; behavioral complexity

200 Ka

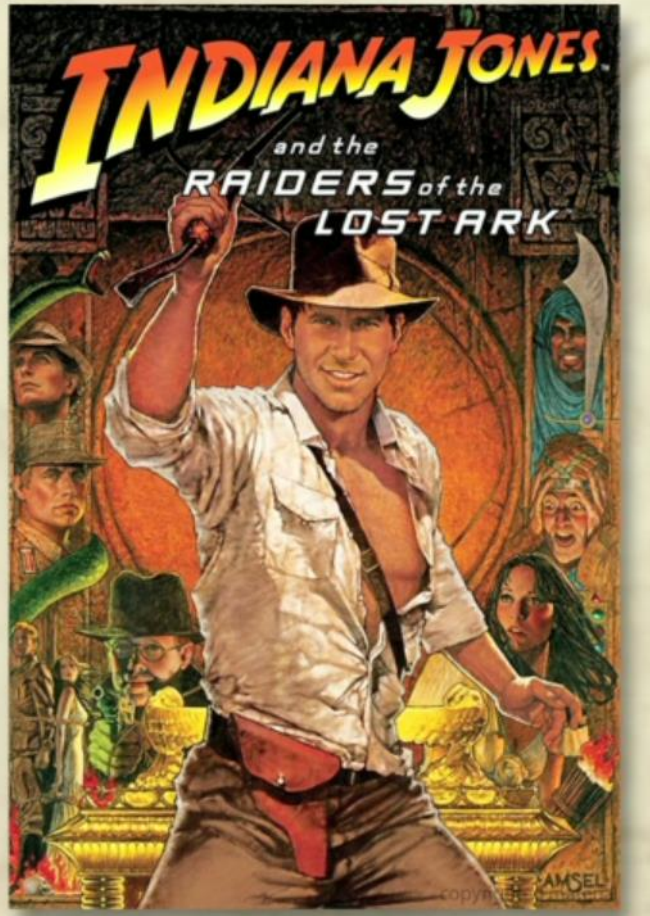
1 Ma

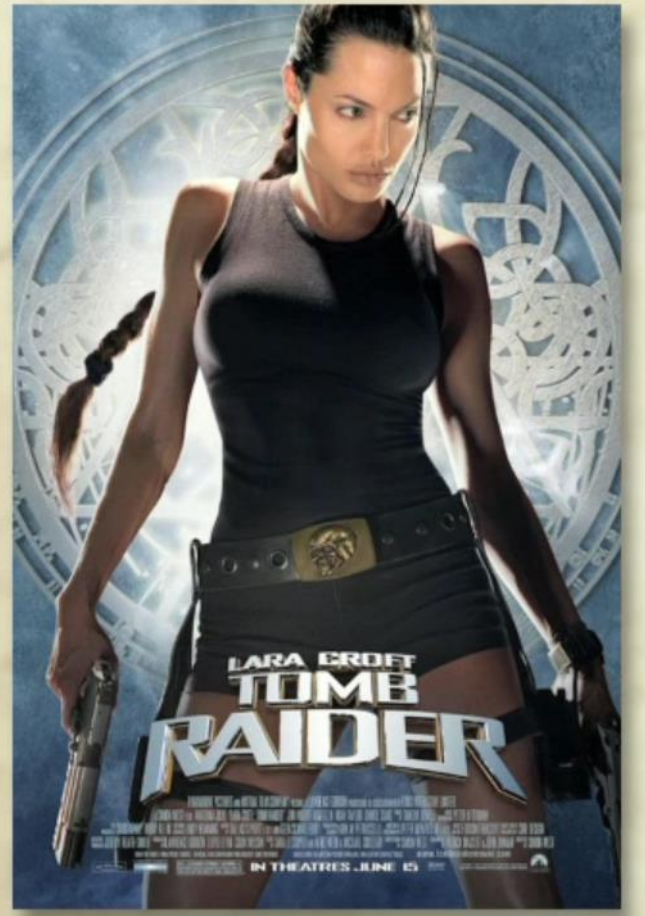
2 Ma





Archaeology Is In the Popular Media





Human Evolution Research

- The history of human paleontological research has been marked by misfortunes, false hopes, fraud, extraordinary bravery, and good luck.
- Until recently, it has been dominated by a handful of ambitious individuals, obsessed with their work and driven by hopes of fame and glory.
- The goal has been to find the oldest human ancestor. Each discovery was acclaimed as having iconic significance. Each wanted to name new species.
- This history has been marked by intense rivalries, personal feuds, and fierce controversies.

Human Evolution Research 2

- Ian Tattersall, a paleoanthropologist emeritus at the American Museum of Natural History, has said that the field often resembles “a swamp of ego, paranoia, possessiveness, and intellectual mercantilism.”
- Lee Berger: “It’s a competitive sport.” he said of paleontology.
- One scientist stated that his profession was marked by “treachery, cutthroat competition and backstabbing.”
- But also by increasing scientific professionalism.

Human Evolution

- Hominin fossils represent only 1% of fossil finds. Tracing a direct line of ancestry back along this branch is difficult because the fossil record is a patchy mosaic of incomplete skeletons.

- Entire species have probably become extinct without leaving a single toe bone for us to dig up in the smattering of places we are looking.

- And species that have been discovered are just as likely ancient "cousins" – offshoots of the branch leading to us – rather than our ancestral gggg…grandparents.

Human Evolution

- Most hominin fossils have been found in East & South Africa, thanks to Rift Valley & leopards in trees above caves. Incredibly few from West and North Africa.

- The fossil record between two and three million years ago – when our oldest *Homo* ancestors emerged – is particularly sparse, making it one of the least understood parts of human evolution.

- Some of the best evidence for evolution itself comes from non-human fossils of pigs, elephants, and antelopes, were there is massive fossil evidence; pig molars have been used to date human fossils

Terms: Hominid vs. Hominin

- Older term: Hominid; Newer term: Hominin

- **Hominoid** - all Great Apes (incl. gibbons, orangutans, gorillas, chimps, bonobos, humans)

- **Hominid** – the group consisting of all modern and extinct Great Apes (that is, modern humans, chimpanzees, gorillas and orangutans plus all their immediate ancestors).

- **Hominin** – the group consisting of modern humans, extinct human species and all our immediate ancestors (including members of the genera *Homo*, *Australopithecus*, *Paranthropus* and *Ardipithecus*).

- The subtribe Hominina is the "human" branch; contains the genus *Homo* exclusively.

Taxonomic terms

- Type specimen: fossil that originated the name of a species; defining the features of that particular taxon. This name takes precedence.

- Grade: a group of taxa that share a suite of functionally adaptive features; what you do, i.e. animals that locomote; SUVS; reptiles

- Taxon: A taxonomic unit, i.e. a population, or group of populations of organisms which are usually inferred to be phylogenetically related (genealogical family) and which have characters in common which differentiate the unit (e.g. a geographic population, a genus, a family, an order) from other such units. A taxon encompasses all included taxa of lower rank.

Wood and Collard, Science, 1999

Taxonomic terms

- Clade: all of the taxa that are descended from common ancestor (i.e. all Ford cars, from 1910 Model T; each car type is a taxa); a phylogenetic group

- A genus: a species or "monophyletic group" (clade, 1 ancestor) whose members occupy a single adaptive zone (grade) (not necessarily unique or distinctive, just consistent, more similar to than any other)); a genus needs to be both a grade and a clade; genus name is the first word of a binomial scientific name (the species name is the second word) and is always capitalized; i.e. *Equus, Rosa, Homo*

Rarity of human fossils

- Human fossils are exceptionally rare.
- Most have been fragments and isolated finds.
- Donald Johanson has said that before he found Lucy in 1974 all of the hominid fossils older than three million years could “fit in the palm of your hand.”
- The fossil remains of only about 6000 individuals have been found.

Number of Hominin fossils

- Total of hominin fossils in world:
  - Sima de los Huesos, Spain, 6500 from 28 individuals;
  - Rising Star, South Africa, 2000 from 18 individuals;
  - Krapina, Croatia, 30 individuals;
  - Sterkfontein caves, South Africa, 800;
  - Lake Turkana, Kenya, 100s
  - NMNH: hominin fossil record includes the remains of more than 6000 individuals, from pre-10 Ka.
  - Olduvai is up to Hominid #82 (teeth to partial skeleton).

Number of Hominin fossils 2

- Vast majority are isolated bone fragments; a science of fragments
- 90% are isolated teeth
- Natural History Museums: 100s of 1000s of modern human skulls
- Before *A. sediba*, only 10 skeletons with craniums associated with post-cranial bones; *sediba* adds 2 more
- Fossil sites with skeletons are exceptional: Malapa, Nariokotome, Aramis, Dmanisi, Sterkfontein, Hadar, Woranso-Mille, Olduvai Gorge, and Koobi Fora.

Number of Fossil Hominins 3

- More than 200 relatively complete skulls from hominins other than modern humans:
  - Series of *H. erectus* skulls: Sangiran and Ngandong in Indonesia, and Zhoukoudian, China, numbering close to a dozen for each of these areas
  - Skulls from sites like Jebel Irhoud, Morocco, Laetoli, Tanzania, and Herto, Ethiopia,

- Last index of fossils, 10 years ago: 1800 pages.

- Among the least fossils are from 2.5 to 1.8 Ma: rise of *Homo* period

Homo

- Until lately, evolutionary biologists believed that the genus *Homo* was distinguished from its apelike forebears by an "adaptive package" that included:
  - bigger brains and bodies,
  - smaller teeth,
  - bipedalism,
  - tool use.

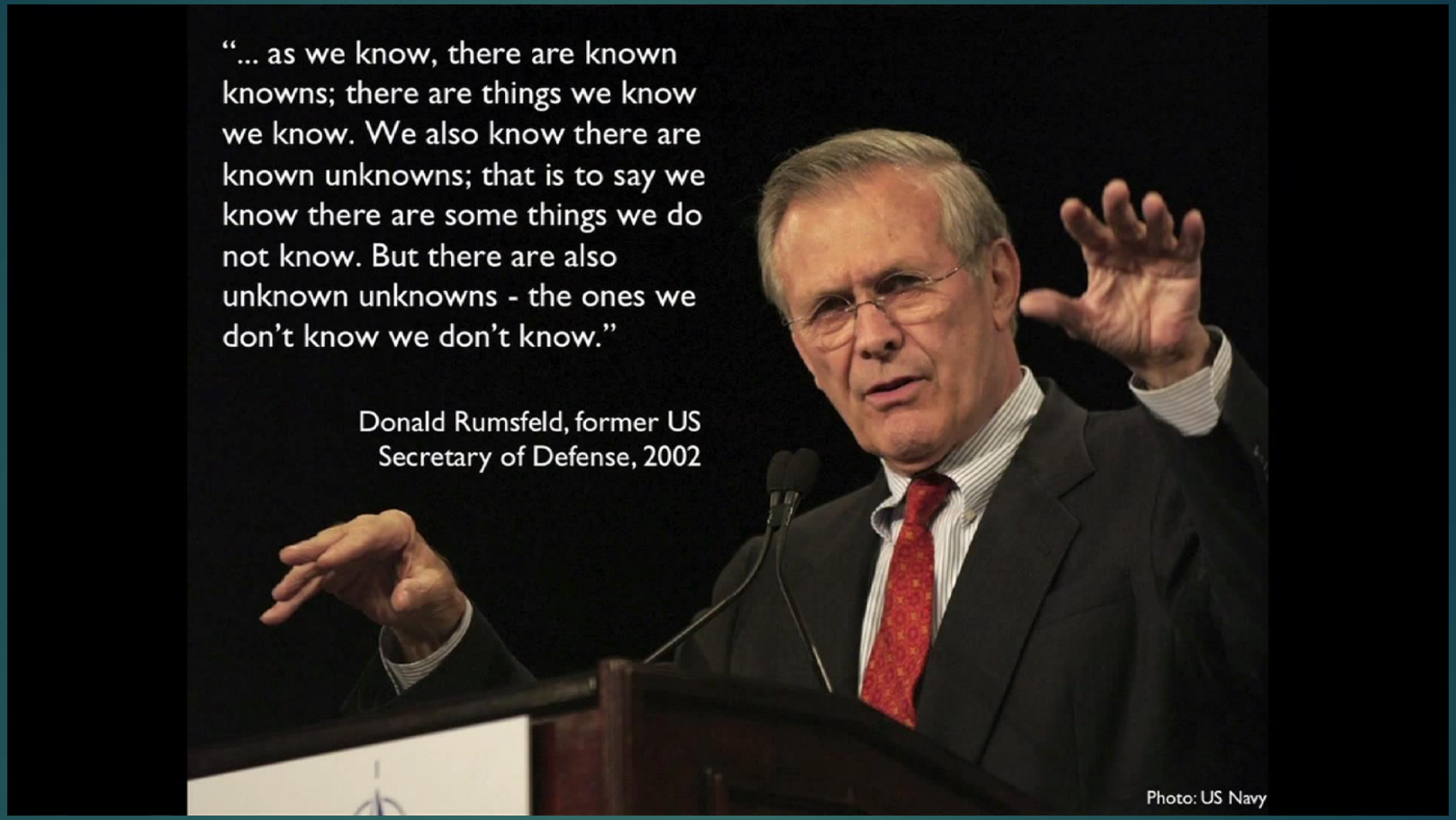
- Recent findings such as *H. naledi* suggest that these features may have arisen independently, in different combinations, in different species, at different times, in different places.

Current Research: use of multiple scientists

- Recent professionalization of paleontology
- What was once the field of fossil hunters, now includes:
  - molecular biologists,
  - biochemists,
  - geologists,
  - geneticists,
  - paleoclimatologists,
  - geochronologists

Bernard Wood on Evolutionary Success

- Someone asked Wood that because we survived and they did not, we hu volved" than Neandertals.
- "What do you mean by ed, and pointed toward a skull of a hominid calle *isei,* a hominid that looks more like an ape than a
- "These guys lasted a million years." he said of the *Paranthropus.* When Neandertals went extinct around 40 Ka, he said, they likely had been on Earth longer than we have been now. We can start feeling truly superior in about 750,000 years", he said.



Also true for fossilization

Taphonomy: Post death

• Taphonomy is the study of the process from how an individual goes from being a living, breathing organism to something that we might recover in the fossil record.

• This includes decomposition, post-mortem transport, burial, compaction, and other chemical, biologic, or physical activity which affects the remains of the organism.

Taphonomy

•Taphonomy: study of processes of fossilization (literally, "laws of burial"; study of diagenetic processes acting on a dead animal's remains); process of death, eventually decay, or perhaps fossilization, that individuals may go through.

- Diagenesis: sum of the physical, chemical, and biological changes affecting a fossil-bearing sediment; conversion of sediment to sedimentary rock: chemicals from surrounding sediments replace organic material in hard tissue; later chemicals replace inorganic material; so a bone turns into a fossil; most common replacement minerals are calcite, silica, pyrite and hematite

Fossils

- Teeth and jaws represent the majority of the fossil record. These are the densest bones in body. Teeth are highly mineralized (partially fossilized already)

- Some fossils preserve better than others. Some are not completely intact and are missing portions.

- If skull not completely intact, reconstruction requires hypotheses.

- Most specimens are small; often on surface; often difficult to identify what part of the skeleton it is or what species.

Gaps and biases in hominin record

- Temporal bias in interpretation of lineages: Fossil record back to 6-7 Ma, with majority of fossils in later part of record; many temporal gaps in the record

- Differential preservation:
  - Predators have preferences for which parts of carcass are eaten the most, i.e. leopards chew hands & feet of monkeys
  - Hands & feet are the parts mostly missing in human fossil record
  - We know more about fossil teeth than about hands & feet

- Body size: larger more likely to fossilize; will find larger individuals in a taxon more than smaller members

Gaps and biases in hominin record

- Differential body part preservation:
  - Teeth and mandible are the most well preserved,
  - Least preserved: post cranial skeleton (vertebrae, hands, feet)
  - Lighter vertebra swept along in floods into lakes, mixed in with animal fossil bones
  - Heaver skull and jaws fall to bottom of floodwaters, trapped in stones on bed of streams, preserved in sediments

- Postdepositional mixing: intermixed bones can be deposited at different times, i.e. bear & N bones found together, but 1 was laid down long after N bones were buried

- What are associated with the fossils. Are there signs of butchery/cutmarks? Is there evidence for cutmark vs toothmark vs grinding.

Fossilization: How to fossilize yourself

- Mechanisms required:
  - Protection from elements: sun, water, wind, rain will erode bone; better to be fossilized in a cave or in the ground (burial)
  - Area with high rate of sedimentation or movement of dirt (river banks, lake edges)
  - Need rapid sedimentation for burial
  - Fossils are most commonly found in sedimentary rock.

Fossilization 2

- Fossilization: the biological component of the bone gets leached away into the environment and replaced with mineral components within the soil itself.
  - This diagenesis is essentially turning a bone into a rock.
  - So the process of fossilization is the mineralizing of a bone. What the minerals are determines what the fossil looks like.

- Tropical forests have lots of decay processes and are mostly antithetical to fossilization

- Erosion for discovery: need fossil to erode from ground (often by movement of earth via tectonic action); i.e. Rift Valley

Dating S. African caves vs E. African volcanics

- East African volcanics:
  - use Potassium-Argon (40K-40Ar); Argon-Argon (40Ar-39Ar);
  - date layer above and below fossil

- South African caves:
  - Classical use of biostratigraphy – spatial and temporal use of well dated faunal fossils to date rock layers
  - pigs, carnivores, antelopes, rats, voles; but not always exactly same species

Relative dating methods: use of animal fossils

- **Biochronology**. Since animal species change over time, the fauna can be arranged from younger to older. At some sites, animal fossils can be dated precisely by one of these other methods. For sites that cannot be readily dated, the animal species found there can be compared to well-dated species from other sites. In this way, sites that do not have radioactive or other materials for dating can be given a reliable age estimate.

- Use of animal remains for dating (biochronology) has been important at S. African cave sites which have antelope and monkey fossils, which have been absolutely dated at key E. African sites. Has also been used in Chad and Dmanisi, Georgia.

Fossil hunting: S. African caves

- South African sites are found in caves that form when rain runs through cracks in limestone. These caves fill with soils from rain runoffs.

- Leopards use trees at entrances of these caves to hide carcasses & hyenas use caves as dens.

- Current theory is that most of S. African hominin fossils were taken there by leopards or hyenas or by bone-collecting animals such as porcupines (bones as chew toys for ever growing teeth).

Relative dating methods: use of animal fossils

- Paleohabitat: dating from types of animal fossils found along with human fossils; esp. micromammals (mice, gerbels) who have restricted ranges; can provide precise habitat reconstruction (i.e. parrots with Ardi means woodland)
- Rely on matching nonhominin fossils found at a site with equivalent evidence from another site that has been reliably dating using absolute methods.
  - Example: Animal fossils at Site A (i.e. E. Africa) are similar to those at Site B (S. Africa).
  - Site A can be assumed to be approximately same age as Site B. Only approximate ages for fossils.

Using pigs and elephants to date

- Evolution of pigs has been so well dated, via stratigraphy (geological strata), that pig molars have been used to date human fossils

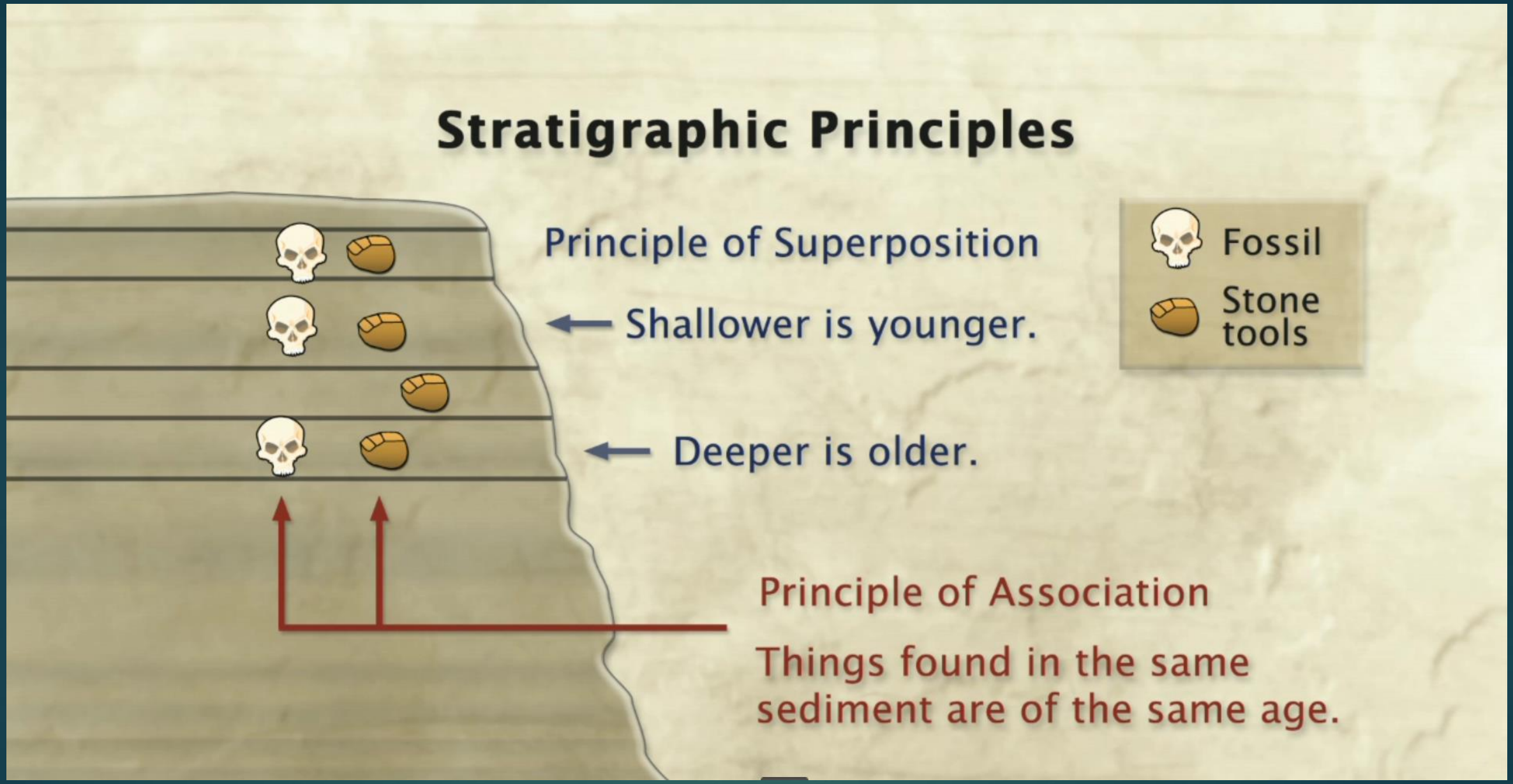
- Fossil suid (pig) data have been employed in a refinement of stratigraphic correlations at Omo Shungura, Olduvai, and east of Lake Turkana and in a correlation of East African and South African sites

- Famous fight:
  - R. Leakey found a fossil (1470), *H. rudolfensis*, that was dated as 2.9 Ma by Pot/Arg method of KBS tuff
  - brought in faunal specialist who looked at associated pig molars and he said it could not be older than 2 Ma;
  - turned out there had been an error in original radiometric dating of tuff;
  - turned out to be 1.8 Ma *H. rudolfensis* fossil

Fossil hunting: Museum drawers

- Museum samples: Some dramatic hominin fossil discoveries are made in old museum collections:
  - Spy N child
  - Complete Neandertal skeleton of baby recovered from site of Le Moustier was sent to Marcellin Boule for age determination. It vanished until new researcher found the bones of a neonate among stone tools from site of Les Eyzies! Luckily bones had original matrix which matched original site.

Dating Method	Basis	Material	Date Range
Relative Age			
Law of Superposition	Older is lower	Just about anything	Just about any time
Stratigraphic Correlation	Like strata in different regions are related to same event	Rocks and fossils	Just about any time
Biostratigraphic (Faunal) Dating	Evolution of animals	Bones and teeth	Just about any time
Chemical Dating	Fossils absorb chemicals, i.e. fluorine in soil	Bones	Less tan 100 Ka
Cultural Dating	Artifacts are time specific	Technology generally	Up to about 2.5 Ma
Numerical Age			
Dendrochronology	Tree growth	Specific tree types	12,000-8,000 yBP
Radiocarbon Dating	Carbon-14	Anything organic	75,000-50,000 yBP
Radiopotassium Dating	Potassium-40	Volcanic rocks	More than 200 Ka
Amino Acid Dating	Racemization	Bones, shells	1 Ma-40 Ka
Fission Track Dating	Fission tracks on rock crystal	Volcanic rock	Up to 3 Ma
Paleomagnetic Dating	Shifts in Earth's magnetic field	Sedimentary rocks	Up to 5 Ma
Electron Spin Resonance Dating	Concentration of radioisotopes	Bone, teeth	Several thousand to more than 1 Ma
Luminescence Dating	Trapped energy	Sediment, stone, ceramics	Up to 800 Ka



Deposited “at the same time” is sliding rule: days, weeks, years, etc.

How to determine age in a fossil

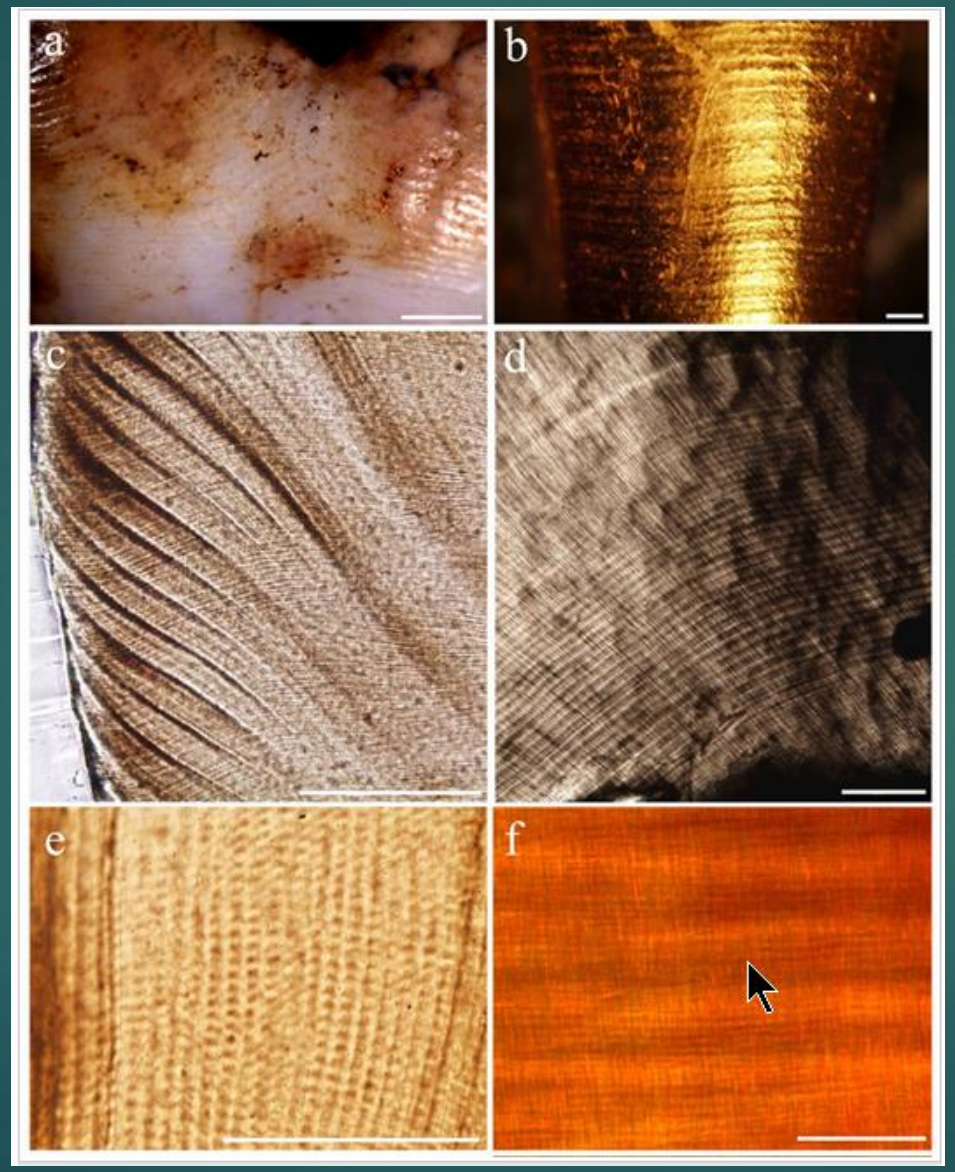
- Age at death of fossil individual that has finished growing is difficult to determine

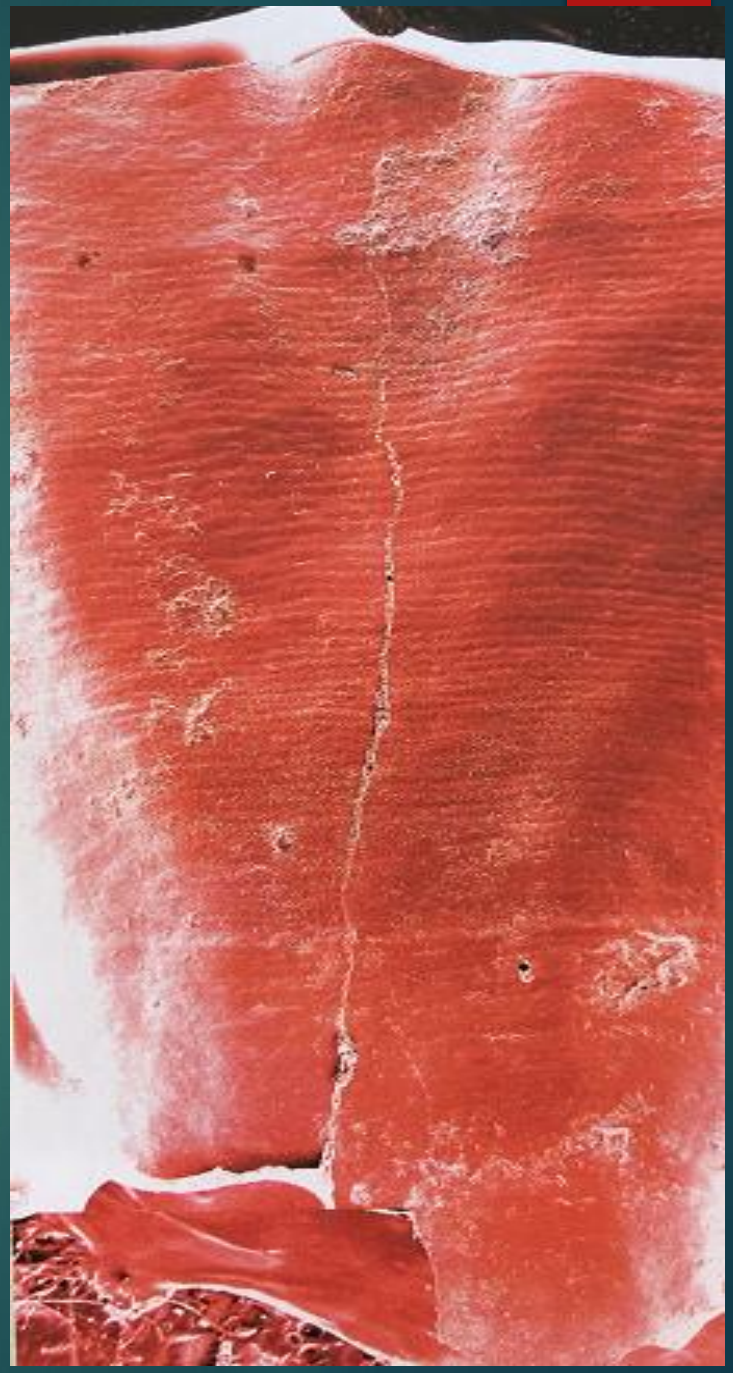
- Age can be confirmed by microscopic examination of tooth enamel. When tooth enamel grows, it produces tiny growth lines in the enamel. These lines can be counted to give the tooth's age.

- Dental development can help with age of immature individual; once all teeth erupted and roots of teeth formed, dental evidence is less useful.

Determining age from Teeth

- Tiny lines are laid down during **enamel** and **dentine** secretion, which faithfully record the speed of growth every day as these hard tissues take shape
- Histological age determination





Age from fossil

- Skeleton's teeth or lack of teeth:
  - If the skeleton has wisdom teeth/3rd molars, the person was past the age of 17.
  - If there is significant bone loss, it indicates a more advanced age.
  - Permanent teeth in a child's skull indicate that the person reached late childhood.

- Fusion of long bones indicate adulthood. Clavicle is last at 25. Tibia at 18.

C3 vs C4 plants: type of plant photosynthesis

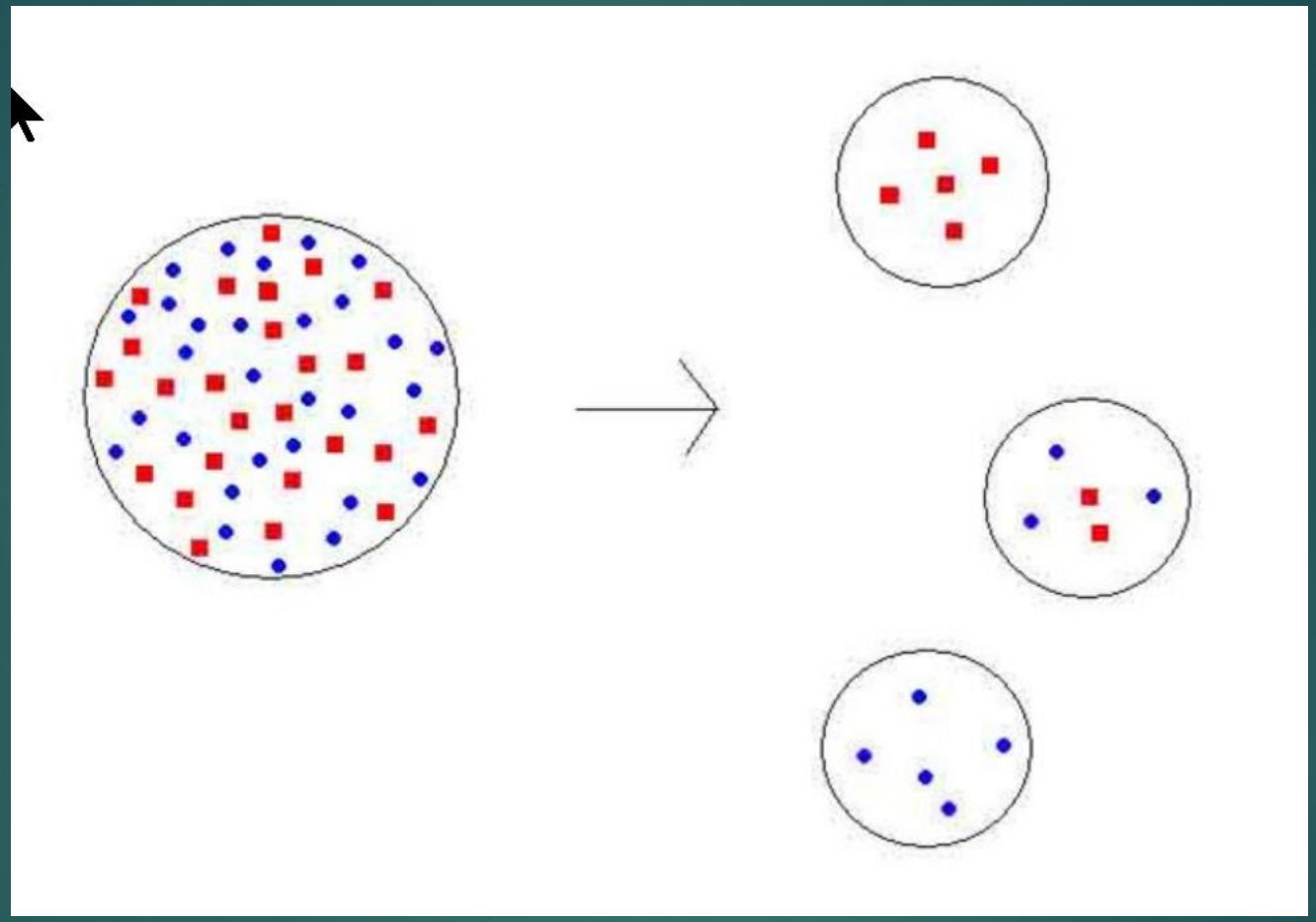
- Different form of carbon in different plants:
  - the ratio of carbon-13 and carbon-12 isotopes in plant tissues is different depending on the type of plant photosynthesis
  - this can be used to determine which types of plants were consumed by animals, whether in woodland or grassland
  - plants using the C_4 photosynthetic pathway (grasses); indicates tropical, semi-tropical areas
  - plants using the C_3 photosynthetic pathway (most plants; trees & shrubs; fruits); temperate

C3 before 4 Ma vs. C4 after 3.5 Ma

- Before 4 Ma, hominins had diets that were dominated by C3 resources (trees & shrubs) and were similar to chimpanzees.
- By 3.5 Ma, multiple hominin taxa began incorporating C4 foods (grasses) in their diets.
- Overall, there is a trend toward greater consumption of C4 plants in early hominins over time.
- These foods played a role in the evolution of enlarged australopith masticatory robusticity.
- *P. boisei* – not Nutcracker, but C4 grasses, like a zebra
- Early homo – C4 from meat (or from animal that originally ate plant)

Founder effect

Most genetically diverse populations are in Africa



Genetic variability is reduced In each new group produced by founder effect: each new group has only the founder’s genetic mix

Founder effect via migrations

- A founder effect occurs when a new colony is started by a few members of the original population. This small population size means that the colony may have:
  - reduced genetic variation from the original population.
  - a non-random sample of the genes in the original population.
- For example, the Afrikaner population of Dutch settlers in South Africa is descended mainly from a few colonists.
  - Current Afrikaner population has an unusually high frequency of the gene that causes Huntington's disease

Human migrations

- Bottleneck origin/near extinction:
  - circa 70 Ka,
    - 2000 -10,000? African MH pairs
    - not due to super volcano Mt. Toba explosion in Sumatra in 74K;
    - massive climate change?
  - full diversity of these African MHs, was diluted when small groups left Africa;
  - lead to low genetic diversity elsewhere

Founder effect

- Founder effect:
  - the further from Africa, less genetically diverse you are;
  - lose a portion of the original genetic diversity with each move you make;
  - so Native Americans have lower diversity than Asians who have lower genetic diversity than Africans

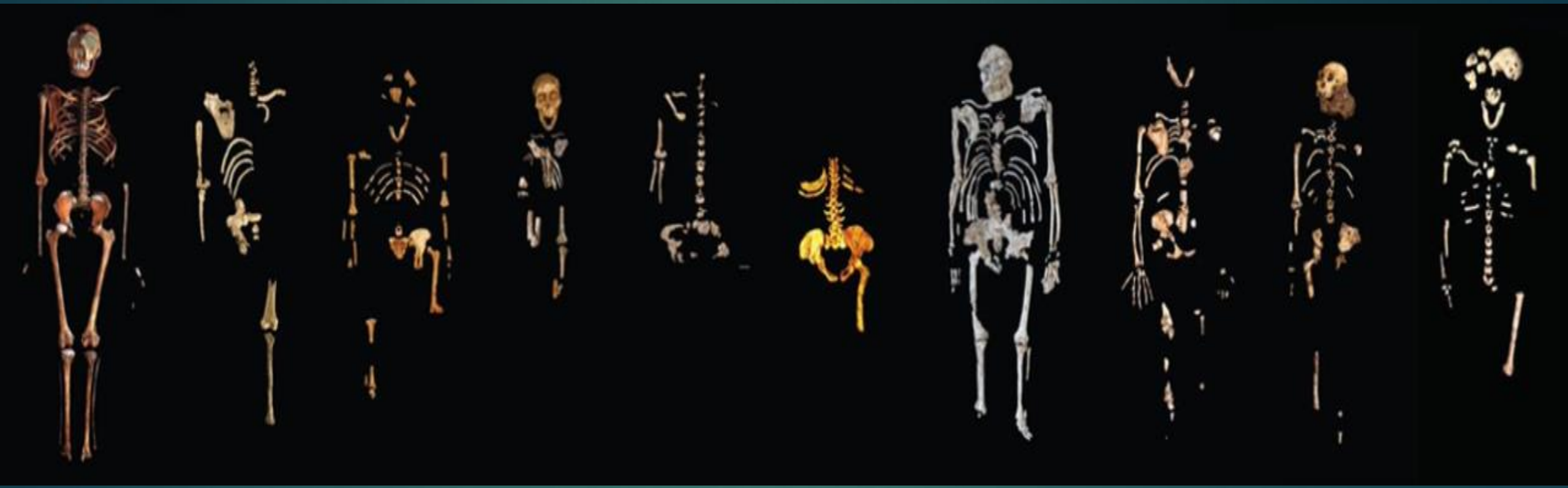
Multiple African Migrations that are currently known

- Migrations out of Africa:
  - 2.1 Ma, hominin to Shangchen, China
  - 1. 8 Ma, *H. erectus* to Dmanisi & China
  - *H. heidelbergensis* develop into Neandertals & Denisovans in Europe & Asia
  - *H. floresiensis* in Flores, 600 K
  - MHs in Germany, 270 K
  - MHs in India, 170 K

Multiple Migrations 2

- MHs, prior to 100K in South China (MH teeth, 80-120K)
- MHs, 70 K to Levant; probably failed attempt
- Australia, c 65 K
- Then AMH migration out of Africa at 50-60K
- MHs to Europe, c 40 K
- MHs to Americas, c 20 K

The 10 major fuller skeletons



KNM-WT 15000 “Turkana Boy”

KSD-VP-1/1 “Kadanuumuu”

A.L. 288-1 “Lucy”

DIK-1-1 “Selam”

StW 431 *Au. africanus*

Sts 14 *Au. africanus*

StW 573 “Little Foot”

MH2 *Au. sediba*

MH1 *Au. Sediba*

LES1 “Nero” *H. naledi*

KNM-WT 15000
“Turkana Boy”

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A.L. 288-1
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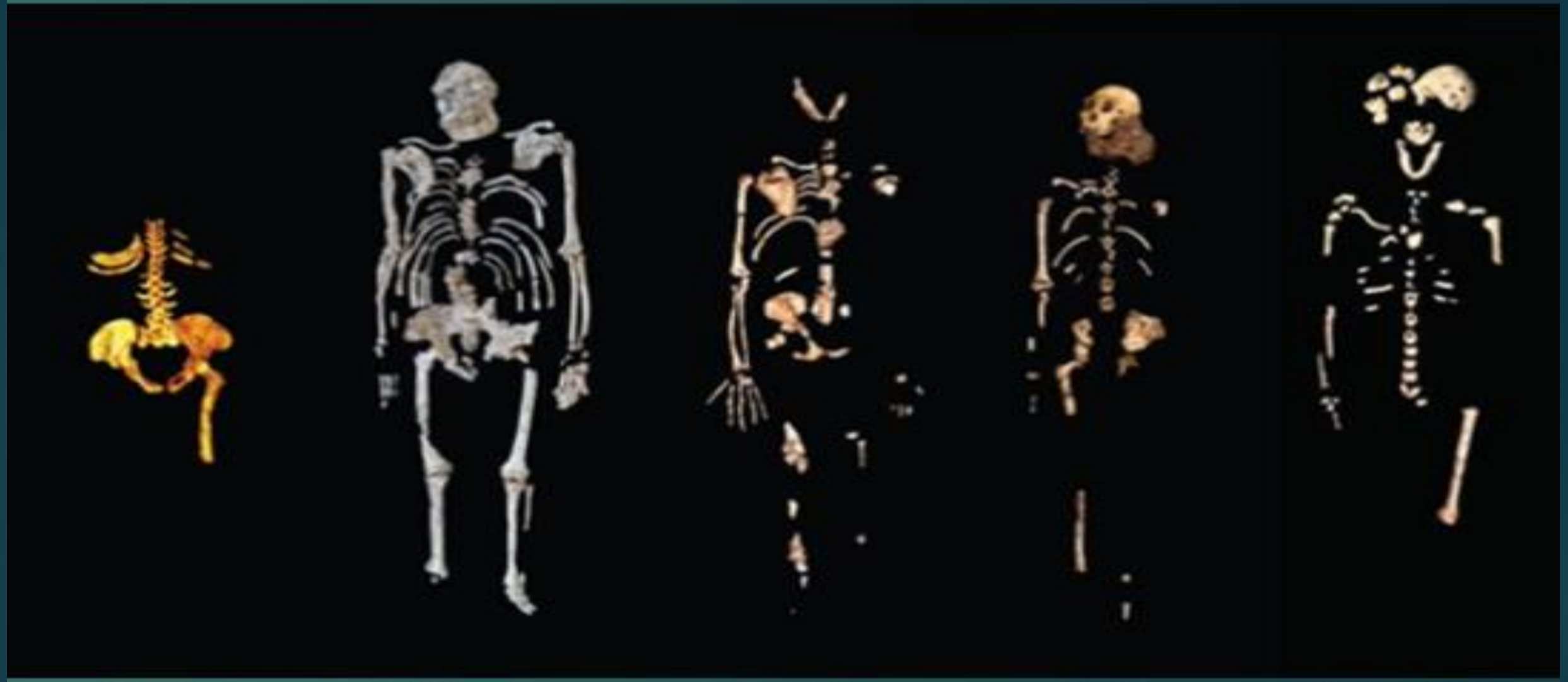
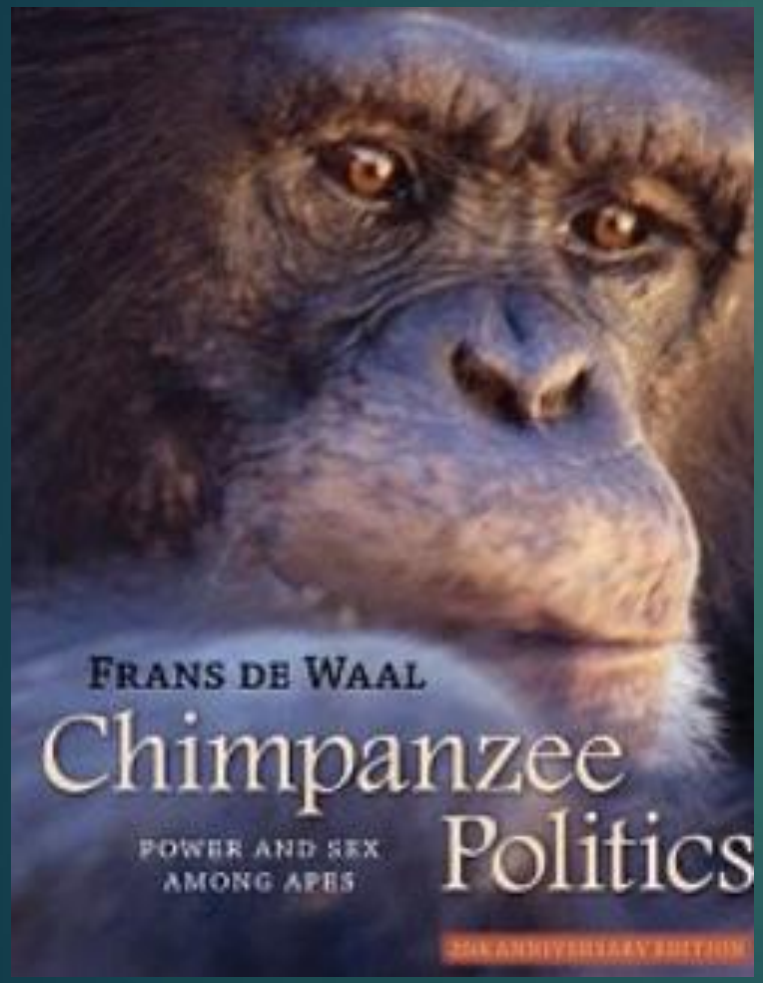
StW 431
Au. africanus



Sts 14	StW 573	MH2	MH1	LES1 "Nero"
Au. africanus	"Little Foot"	*Au. sediba*	*Au. Sediba*	*H. naledi*

Why did Newt Gingrich recommend this book to all new politicians?



Detailed and thoroughly engrossing account of ape rivalries and coalitions; social and political behavior of chimpanzees

Chimp Machiavellian Intelligence.

Chimpanzees use deception to mate with females belonging to alpha male

Frans de Waal 1982

Molecular clock: How do we find Last Common Ancestor (LCA)

- Molecular clock method: use the amount of genetic divergence between 2 organisms to extrapolate backwards to estimate date for LCA. An estimate of divergence times.

- This method compares the amount of genetic difference between living organisms and computes an age based on well-tested rates of genetic mutation over time.

- It's mainly useful for figuring out how long ago, living species shared a common ancestor, based on their DNA.

Closer to root species, more difficult to recognize

- The closer a species is to its speciation event, the more difficult it is to recognize. It will look almost identical to species it originated from. They will look a lot like each other, than to descendants

- Fossils of such a species will be difficult to differentiate.

Identifying the first hominins

- In Last Common Ancestor (L.C.A.), look for anatomical features shared by humans and living great apes
- Starting from there, 1st hominins must have evolved at least one feature that we see only in modern humans
- Most researchers focus on anatomy related to bipedalism
- Large brain size, hard evidence for culture, language, etc., come much later.

LCA characteristics

- LCA: current fossil and comparative evidence indicates that the following traits were likely present in Human Chimp LCA:
  - Ape-sized brain and body,
  - Finger bones would be curved; adapted for climbing
  - A grasping foot that allowed it to forage in the trees.
  - Limbs adapted to walk both on all fours and on hind limbs alone
  - More prognathic/snoutlike face, not flat; elongated jaws
  - Modest-sized teeth, large upper incisor teeth
  - Canine teeth were probably large and sharp, as seen in several Miocene hominoids.
  - Canines were probably **sexually dimorphic**, with males having much larger canines.
  - Relatively long arms and fingers

LCA characteristics 2

- The idea that, like living apes, LCA would have walked quadrupedally (on all fours) when on the ground, is now being seriously questioned.

- Its diet would have consisted almost entirely of plant foods, primarily fruit and leaves.

- The first human-like traits to appear in the hominin fossil record are:
  - **bipedal** walking
  - smaller, blunt **canines**.

Contenders for Title of Earliest Hominin: 7- 4 Ma

- *Ardipithecus ramidus*
  - 1992
  - Middle Awash in Ethiopia
  - Previously thought to be older than 5 Ma, now dated to 4.4 Ma
- *Orrorin tugenensis*
  - 2001
  - Tugen Hills in Kenya
- *Sahelanthropus tchadensis*
  - 2002
  - Toros-Menalla in Chad
- *Ardipithecus kadabba*
  - 2004
  - Middle Awash in Ethiopia

Evolution of hominins & African apes

- LCA of chimp/human per Tim White: palmigrade arborealist, dimorphic canines; forest frugivore/omnivore
- Ardi (~6 to 4 Ma): partially arboreal; facultative (capable, but not usual) biped; feminized (smaller) canines; woodland omnivore
- Australopithecus (~4 to 1 Ma): striding terrestrial biped; postcanine megadontia; Pan-African; Wide niche
- *Homo* (< 2.5 Ma): enlarged brain; facial/dental reduction; technology-reliant; Old World range

White, 2009

Early australopithecines

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

Derived (newer) traits:

– Smaller canines

– Crushing molars

– Effective Bipeds

Number of species: Splitters and Lumpers

- Number of current hominin species is controversial; not all researchers recognize the same number of species
- Splitters: those who think there are many species; new name for new find
- Lumpers: those who recognize fewer species

Splitters and Lumpers

- Both are looking at same evidence; just interpret it differently – primarily difference is in interpretation of variation
  - Those who stress importance of continuities within fossil record, opt for fewer species; often consider them a chronospecies
  - Those who stress discontinuities within fossil record, opt for more species
- Remember that all taxonomies are hypotheses

Climate change

- 8 Ma: Africa was mostly thick forests interspersed with rivers and lakes; most primates were tree dwellers
- Astronomical variations caused changes in climate and environment in Rift Valley of Africa
- 8 to 5 Ma: the earth experienced beginnings of long-term drying and cooling trend because earth's moisture was locked up in ice sheets, that extended further from north and south poles. Temperatures fell.

Climate change

- 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.

Environments of African Ancestors

- Originally thought that LCA probably lived in dense forest.
- But recent data suggests earliest hominins lived 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.

African Ancestors

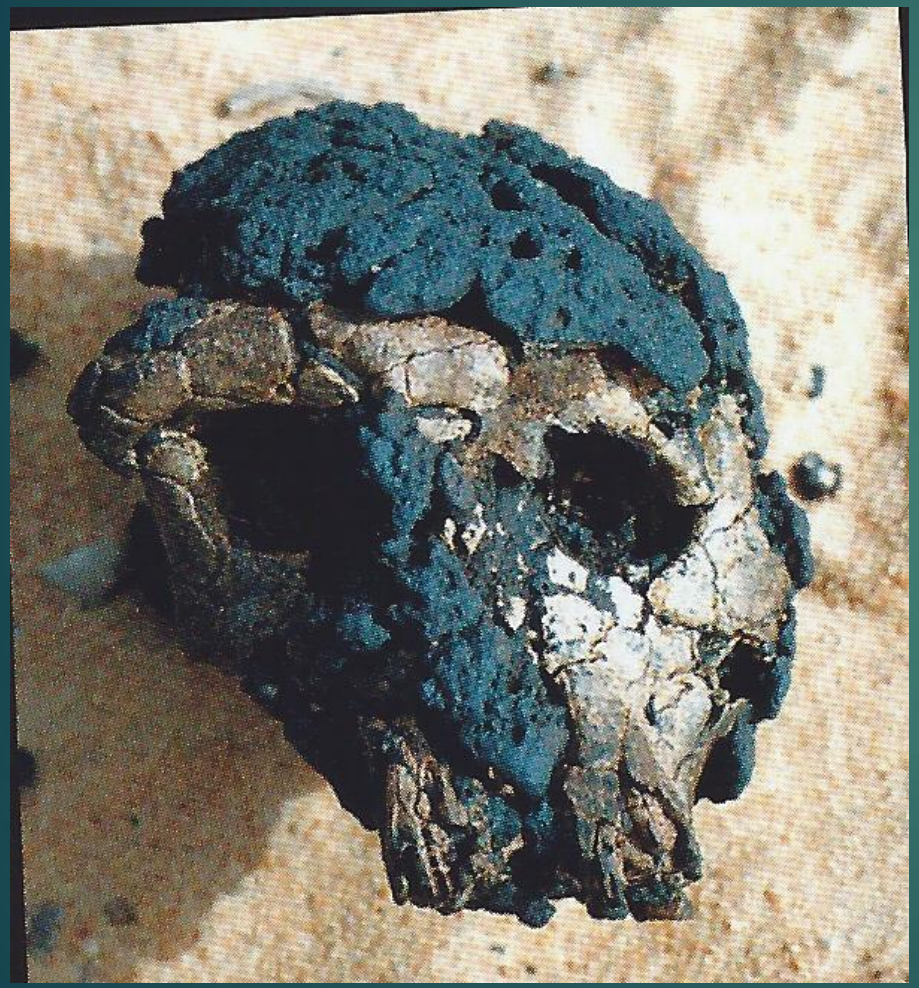
- Earliest hominins were adapted to both tree and ground living.
- Trees provided fruit, nesting sites, protection from predators.
- Grassland had new food sources (tubers), while water sources offered fish and mollusks.
- Unlikely that they lived in caves (primates do not live in them), despite some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

Significance of late Miocene hominins: Sahelanthropus, Orrin, Ardi

- Pushes back fossil record of hominins by 2-3 million years
  - Until early 1990s, earliest hominins were less than 4 Ma, i.e. Lucy
  - Now appears that multiple, diverse hominins may date to late Miocene (8 to 5 Ma)

- Forces rethinking of origins of bipedalism
  - Early hominins appear to have inhabited forested environments, not open savannas
  - This challenges some scenarios for adaptive value of bipedalism
    - Having hands free to use tools no longer seems to be reason for bipedalism since bipedalism predates tool use by 3 My

2001: *Sahelanthropus tchadensis*, Chad, 7M*:*
Extension of age and spatial range of early hominins



Sahelanthropus tchadensis

(*Type:* TM 266-01-060-1)

Discoverer: Ahounta Djimdoumalbaye

Locality: Toros-Manalla, Chad

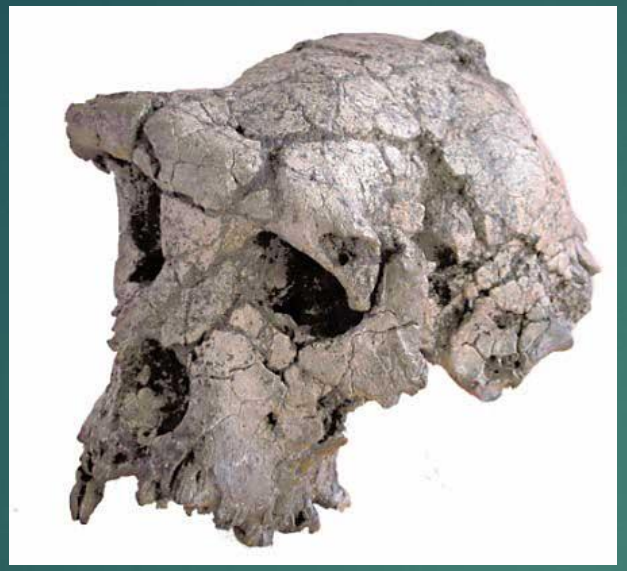
Date: 2001

Age: 6-7M

Sahelanthropus tchadensis

- ***Sahelanthropus tchadensis*** (“Toumai”) was discovered in Chad, in the southern Sahara desert.
- It is dated at 6 to 7 Ma. Oldest known species in the hominin family tree.
- Toumai is a nearly complete cranium with a very small brain between 320 and 380 cc, comparable in size to that of a chimpanzee.
- A cranium, jaw fragment, and several teeth were found. It has widely-spaced eye orbits and small canines.
- It has both apelike and hominin features.
- This species may be close to the hominin chimpanzee ancestor split.

2001: *Sahelanthropus tchadensis*, Chad, 7-6 M



Remarkably complete but distorted cranium & 2 mandibles; no postcranials?

Has been virtually remodeled

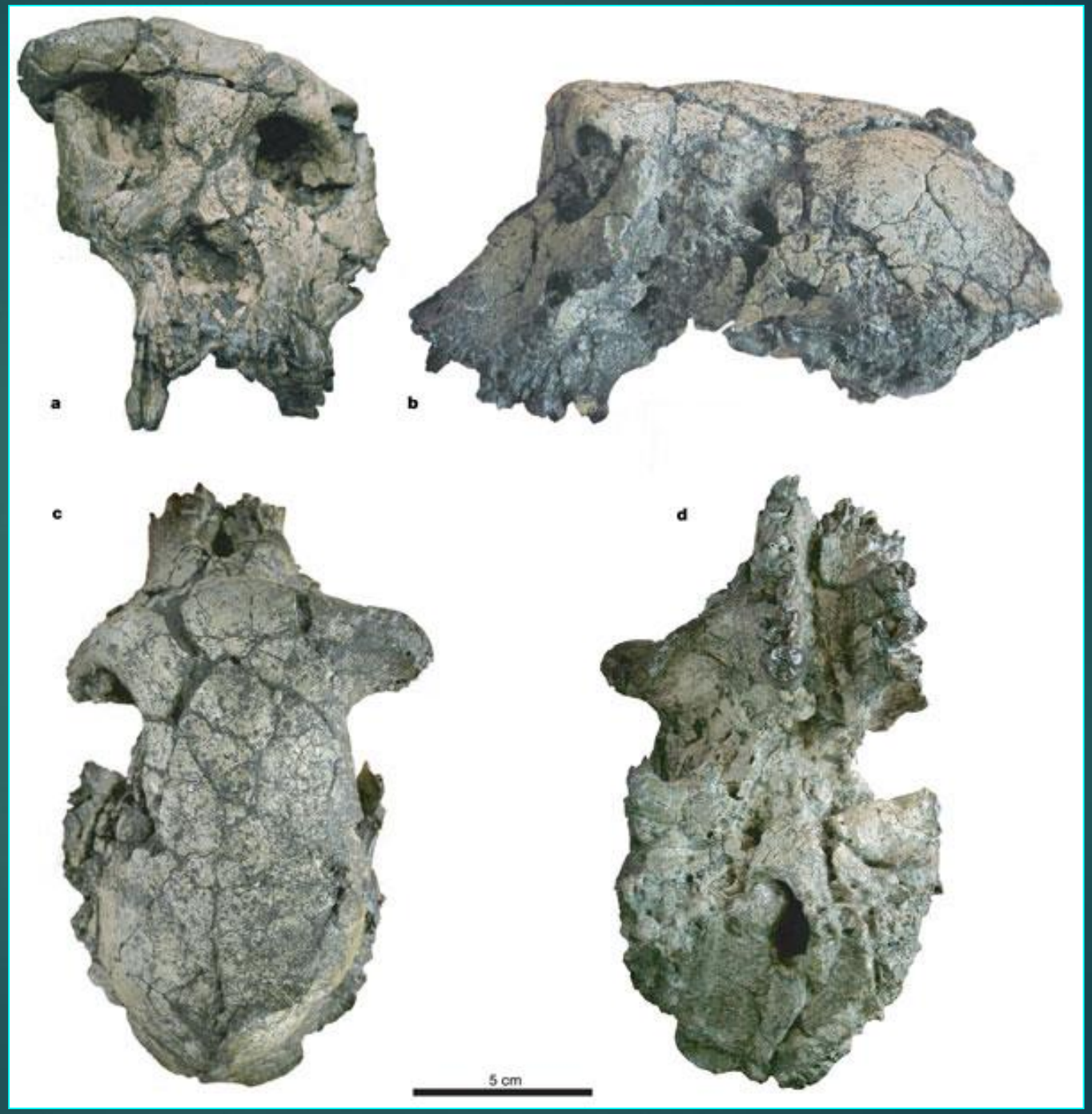
Largest hominoid browridge ever discovered

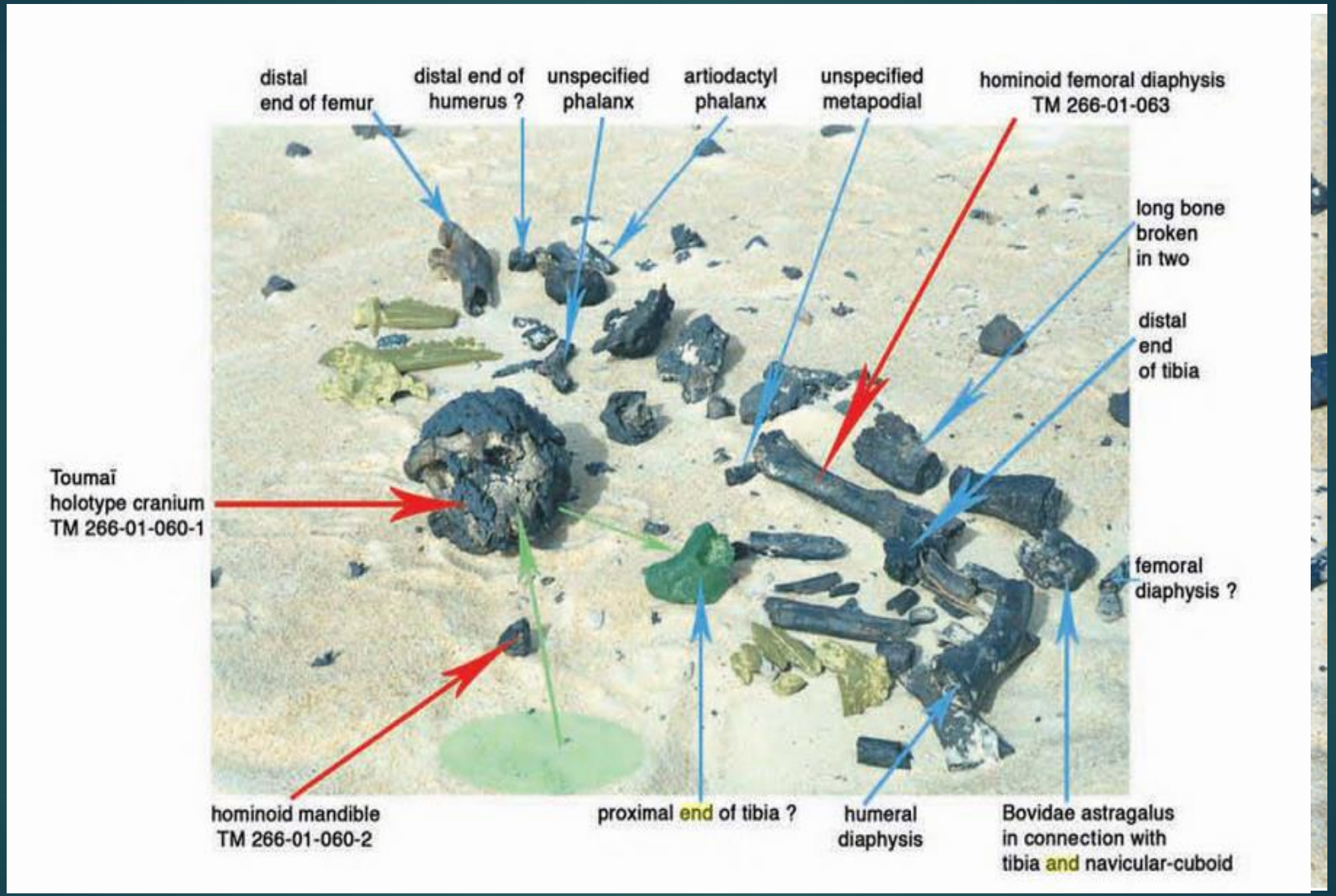
Smaller size than Ardi

Foramen magnum shape and forward positioning indicate bipedalism (like Ardi; both upright posture)

Canines smaller and shorter than those of the male chimp; thick enamel

Highly distorted cranium





Did camel herders rebury Toumai facing Mecca?

Sahelanthropus reconstruction

2000: *Orrorin tugenensis*

6 Ma - bipedality

Orrorin tugenensis
BAR 1000’00 - type

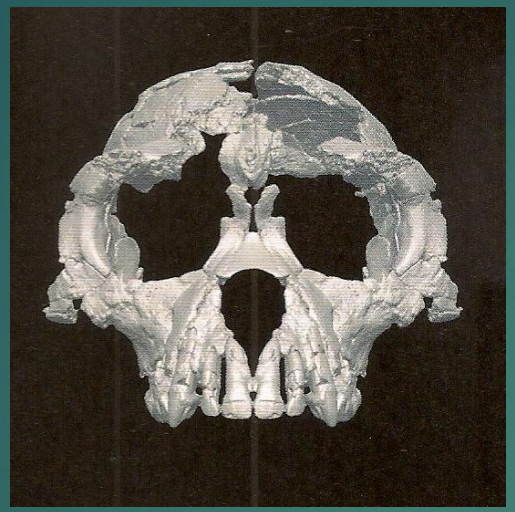
Discoverer:
Kiptalam Cheboi

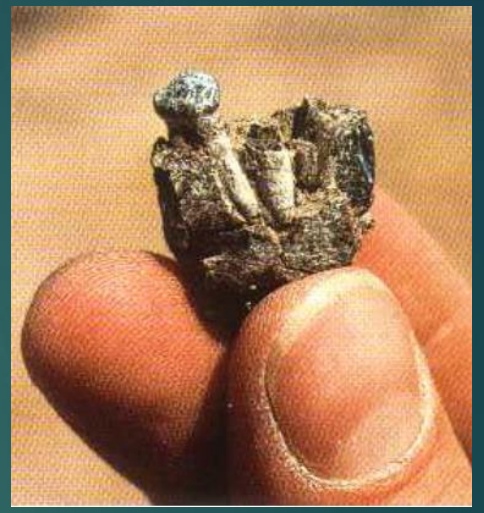
Locality: Tugen Hills, Kenya

Date: 2000

Age: 6.2-5.5 M (potassium/argon dating of sandwich layers); 6.1-5.8 M (magnetic dating)

1992: *Ardipithecus ramidus*, 4.4 M





Type specimen
ARA-VP-1/129

Discoverer:

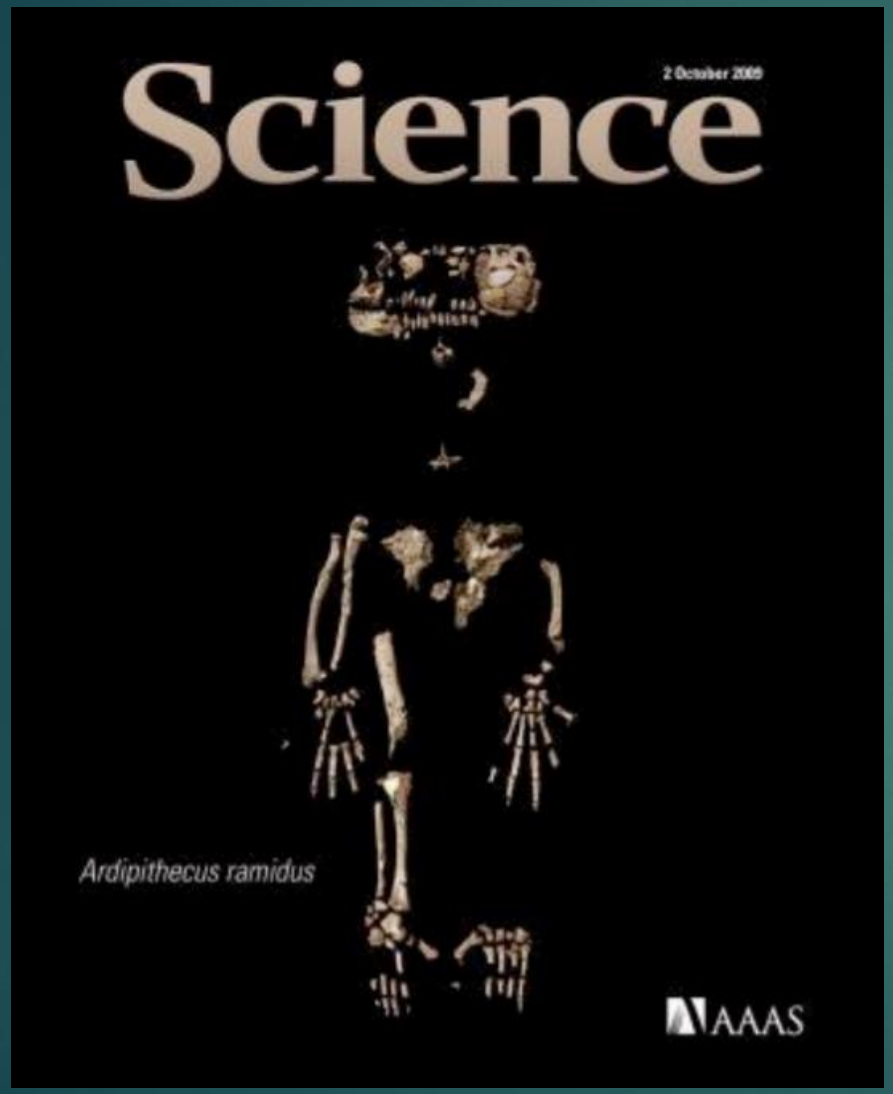
Alamayehu Asfaw

Locality: Aramis, Middle Awash, Ethiopia

Age: 4.4 M

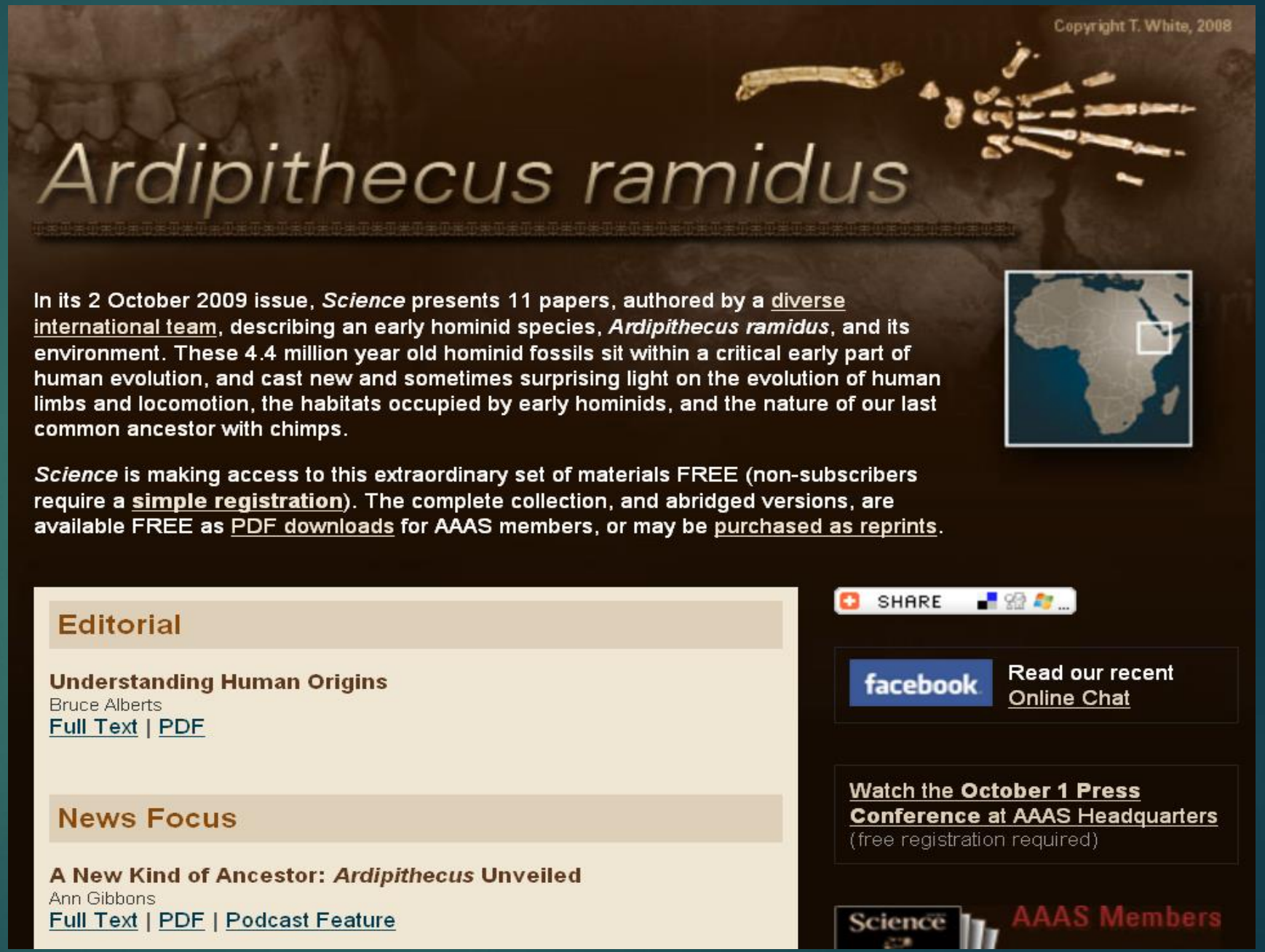
Project participant and famous hominid fossil finder Alemayehu Asfaw discovered a hominid lower jaw on February 9, 2006.
Photo by Yohannes Haile-Selassie.

Publication: White *et al*. 2009



Publication:

- 17 years later
- 11 papers; ~250 pages of a single issue of Science in 2009
- *Ardipithecus ramidus*



T. White: Ardi, Middle Awash, 4.4 Ma, 250 pages, 17 years later

Mission to the Pliocene: 47 authors from 10 countries; 11 papers, *Science*, 10/2/ 2009

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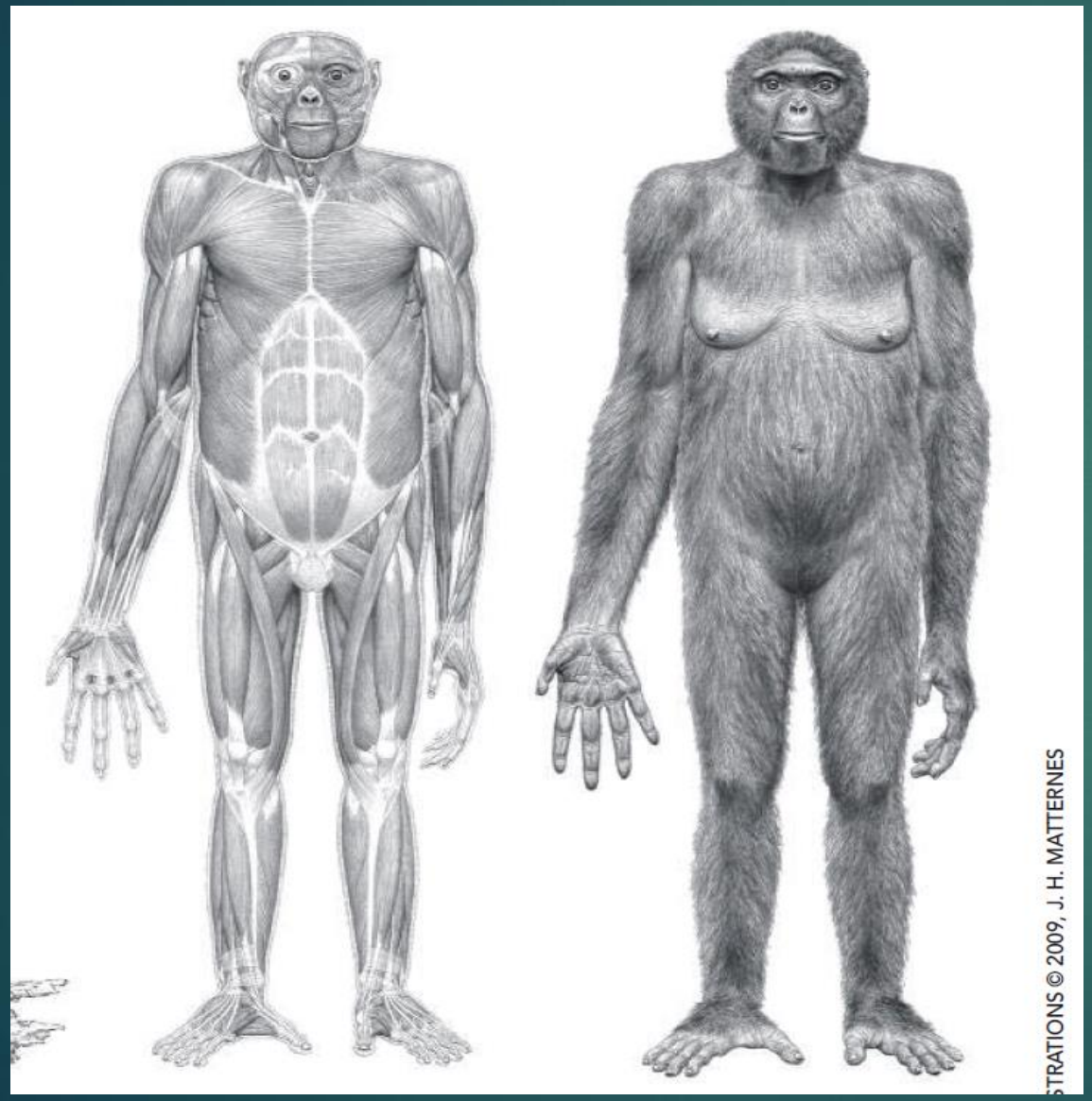
Ardipithecus: The ARA-VP-6/500 skeleton: a female

Widely scattered

Ardipithecus ramidus – “ARDI”

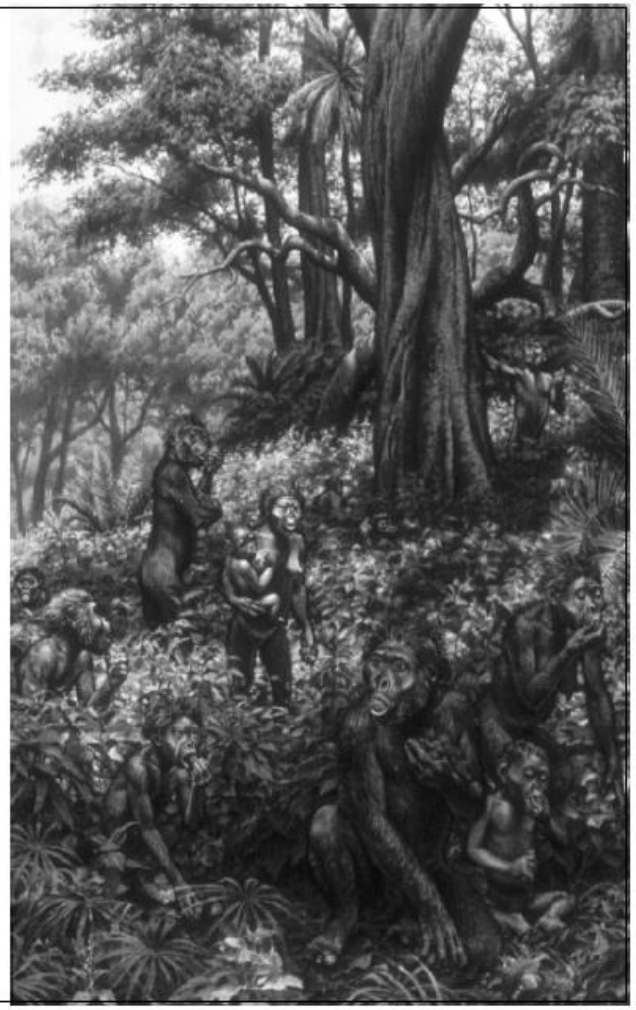


- Most complete skeleton older than Lucy
- 45% of the full skeleton: sets of teeth, part of underside of cranium, parts of several jaws, and some limb bones
- Canines less apelike than the older *Ar. kadabba*
- Not *Australopithecus*
- Similarities to *Sahelanthropus*
  - Very early stage of human evolution

Savanna Hypothesis

Problem with savanna hypothesis?

Earliest bipeds all found at sites with forests



First there were the Australopiths: Then came Ardi…

- Tim White: *Australopithecus* can no longer be legitimately viewed as a short-lived transition between apes and humans. Rather, it represents an adaptive plateau occupied for ~3 Ma by up to four species of small-brained African bipeds.
- Savanna hypothesis: Because *Australopithecus* is often found in open environments, hominid origins are frequently presented as the tale of a tropical forest ape forced to adapt to open savannas that expanded via global climate change. Ardipithecus disrupts such given wisdom.
- Note the importance of complete fossil finds. Ardi preserves so many anatomical parts—in such clear ecological context—that it transforms our understanding of early hominid evolution. It allows assessment of locomotion, diet, habitat preference, and even social behavior.

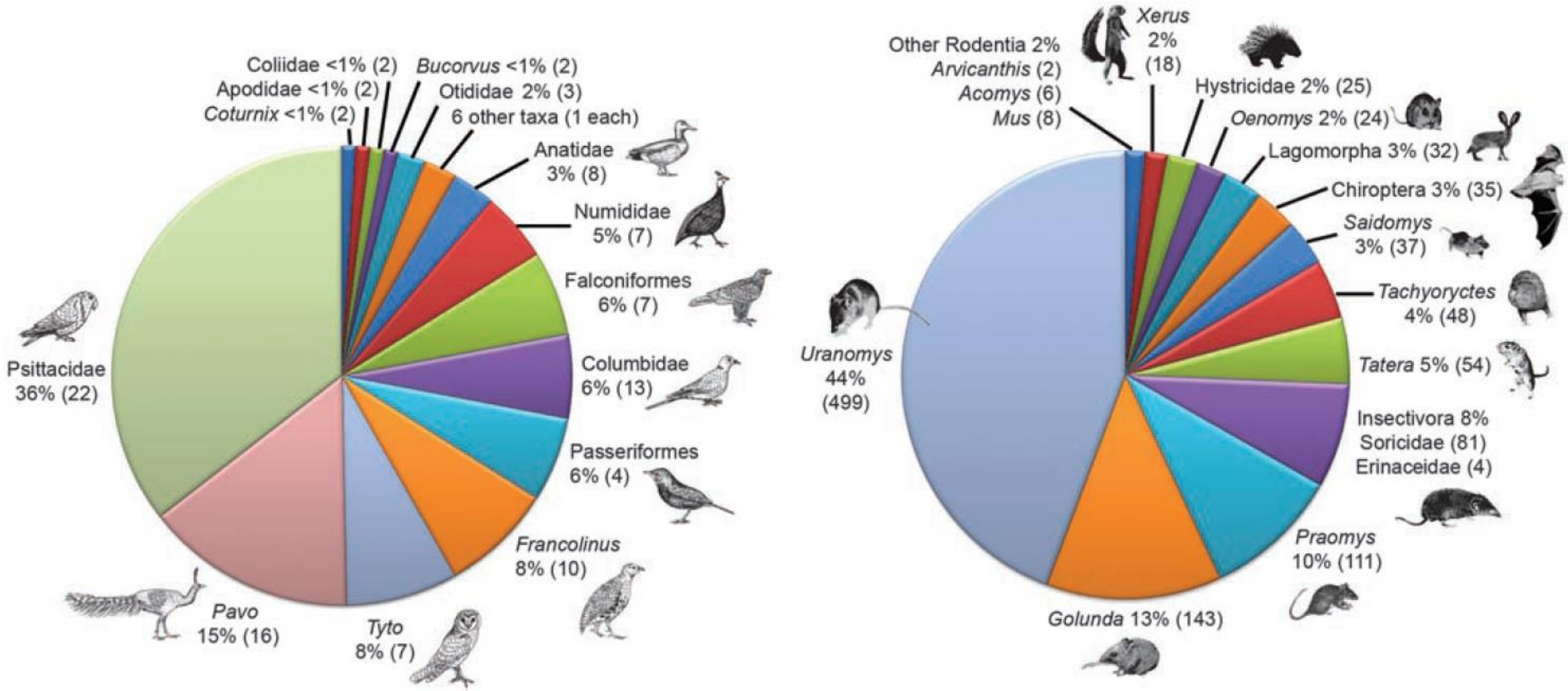
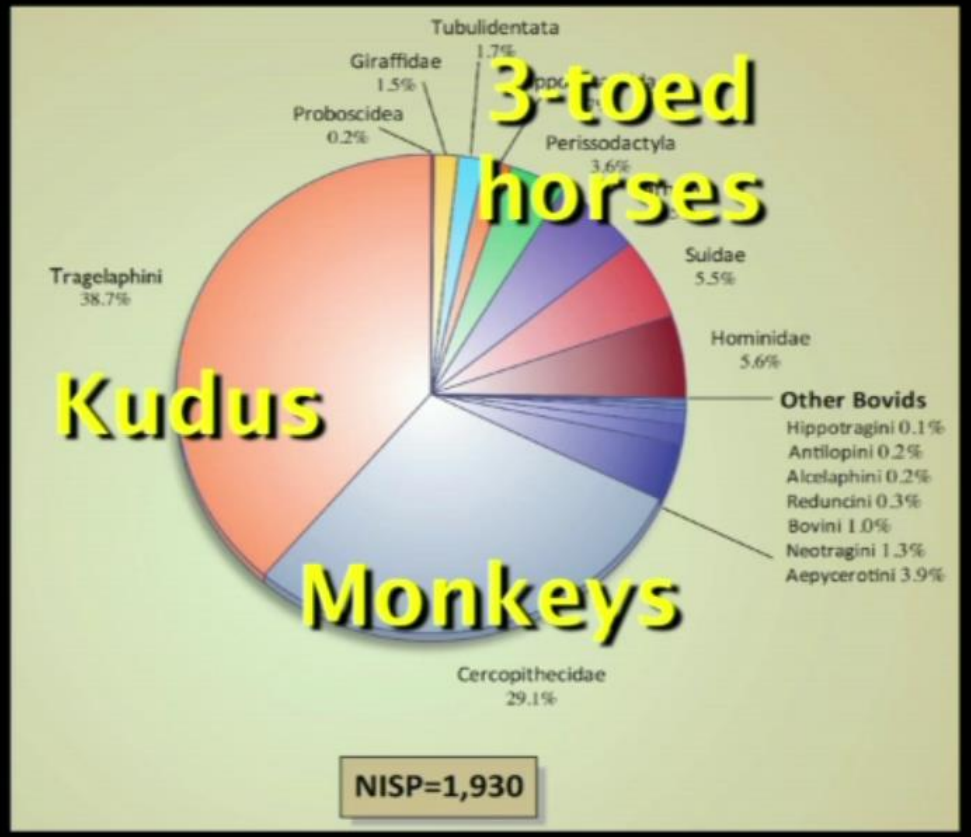


Fig. 2. Relative abundance of avian and small-mammal taxa. For each bird taxon, the pie slice and first number apply to the number of identified specimens (n = 263); the second (in parentheses) is the minimum number of individuals represented in the overall sample. For small mammals, the numbers apply to the number of identified specimens only (n = 1127), but closely reflect the minimum number of individuals because only craniodental specimens are included.

Ardi surrounded by parrots and peacocks (= woodlands), and mice; few ducks = not near water

Abundance



Lots of kudus (antelope) = eats leaves from thickets; and monkeys - eat leaves = trees; few horses - eat grass; Conclusion: Ardi was in woodland

Hypotheses tested by Ardi:

- Bipedality evolved in savanna environment

1 - Falsified. Lived in woodland

- We evolved from a knuckle-walker

2 - Falsified. No KW features

- Chimpanzees are good models for the last common ancestor we shared with them.

3 - Falsified. Chimps have their own evolution

Ardi represents a major paradigm shift in terms of how and where we should look for a model for the last common ancestor

Ardipithecus:

Shows that today's chimpanzees are highly specialized/derived in their:

- Behavior ("demonic males": chimp male violence)
- Diet (fruit specialists)
- Locomotion (knucklewalkers)
- Habitat preferences (tropical forest)

The last common ancestor we shared with chimpanzees…was NOT like a chimpanzee.

LCA: ? of knuckle walking

- Parsimony (simplest explanation)-based appeals to knuckle walking (KW) in contemporary African apes have been used to argue that this locomotor mode must have been the primitive condition for our LCA.

- However, despite intensive searching of African, European, and Asian deposits, no compelling Miocene evidence of KW has so far been found

LCA: ? of knuckle walking

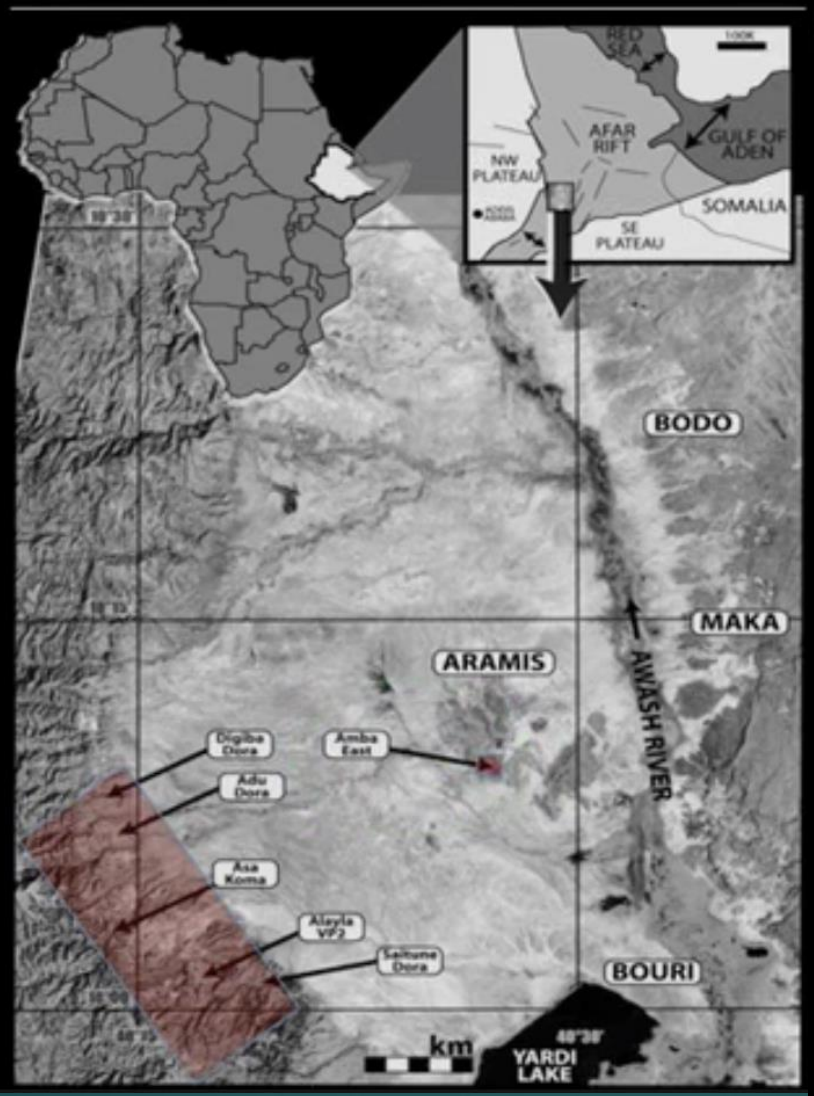
- Many chimp adaptations must have evolved after chimps split with the hominid clade:
  - their territoriality and intergroup aggression, complex male alliances, strong intragroup competition and aggression linked to “advertised” female estrus, etc. are derived

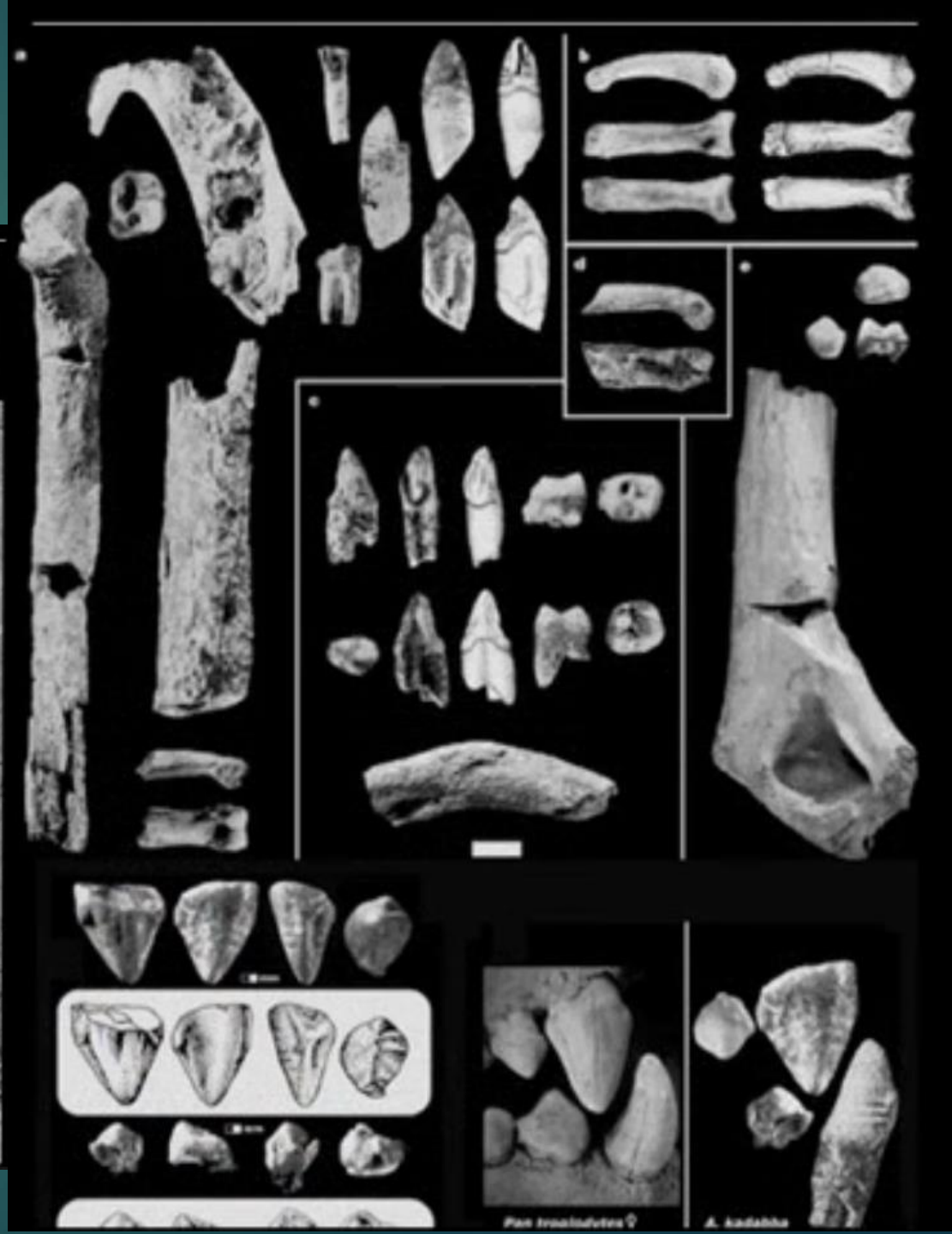
- Hominins appear to have emerged by developing a search-intensive terrestrial feeding niche, accompanied perhaps by food transport and sharing in less densely forested but still wooded areas.

Ardipithecus kadabba, 5.2-5.8 Ma

Ardipithecus kadabba

- Mostly known from the Western Margin of the Middle Awash study area
- One specimen from the Central Awash Complex





Ardipithecus ramidus is descendant of *Ardipithecus kadabba*

- *A. ramidus:* 4.4 Ma
- *A. kadabba:* 5.2-5.8 Ma

- *A. ramidus* has smaller canine than *A. kadabba*

- Anterior foramen magnum

- Grasping feet

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 both 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*

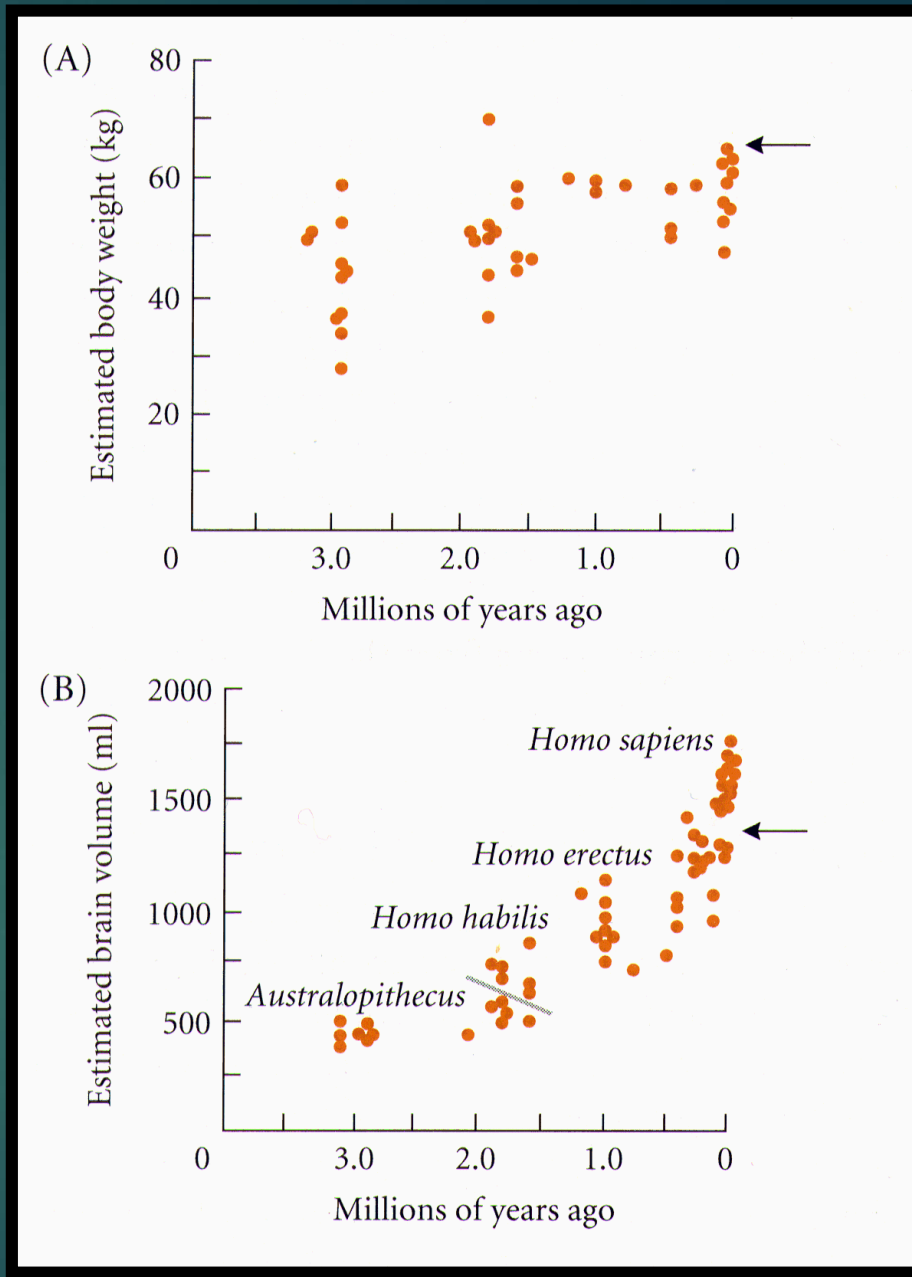
- One species of *Australopithecus* evolved into first members of *Homo* sometime between 2.5 million and 2 MA.

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

First phase of hominin brain evolution: *Australopithecines*

- About 7 Ma, first hominins became bipedal with brains about 1/3rd of modern size (400 cc). 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.

R. Holloway, 2009

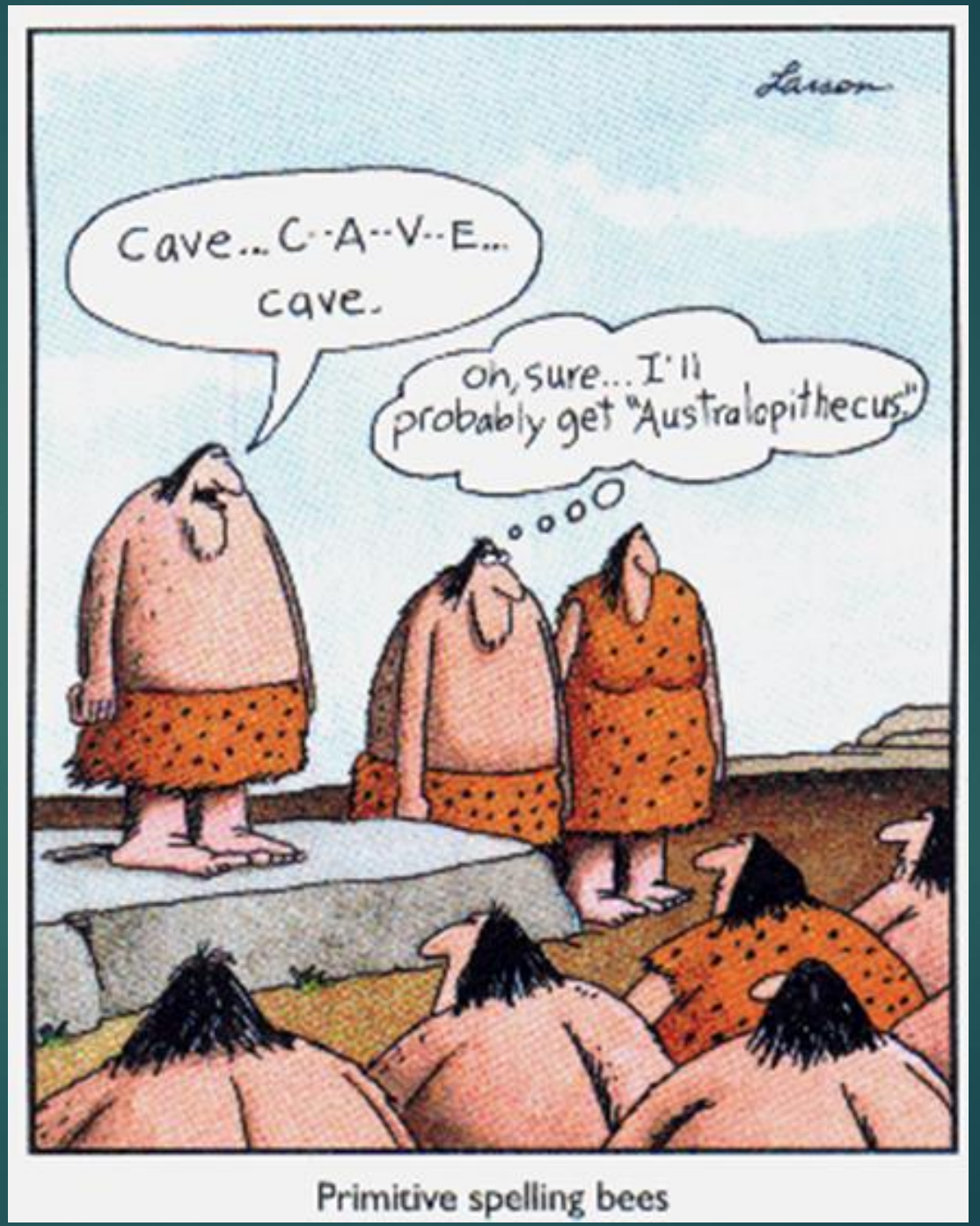
First phase of hominin brain evolution: *Australopithecines*

- *Australopithecus afarensis (Lucy)* had skulls with internal volumes of between 400 & 550 cc, whereas chimpanzee skulls hold around 400 cc & 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.

Australopithecine Spelling Bees



2nd third

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 (related to body) increase to 800-1000 cc (*H. habilis to H. erectus*); language development?

Next phase: last 2 million years

- 500-100 Ka, gradual and modest size increase, mostly nonallometric, 1200-1700 cc (*H. erectus to H. heidelbergensis 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

Australopithecines: A 2 Million year span of existence

- Genus *Australopithecus* has six, eight or eleven, species in it, depending on whether you are a splitter or lumper.
- This was 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*

First *Australopithecus afarensis* find

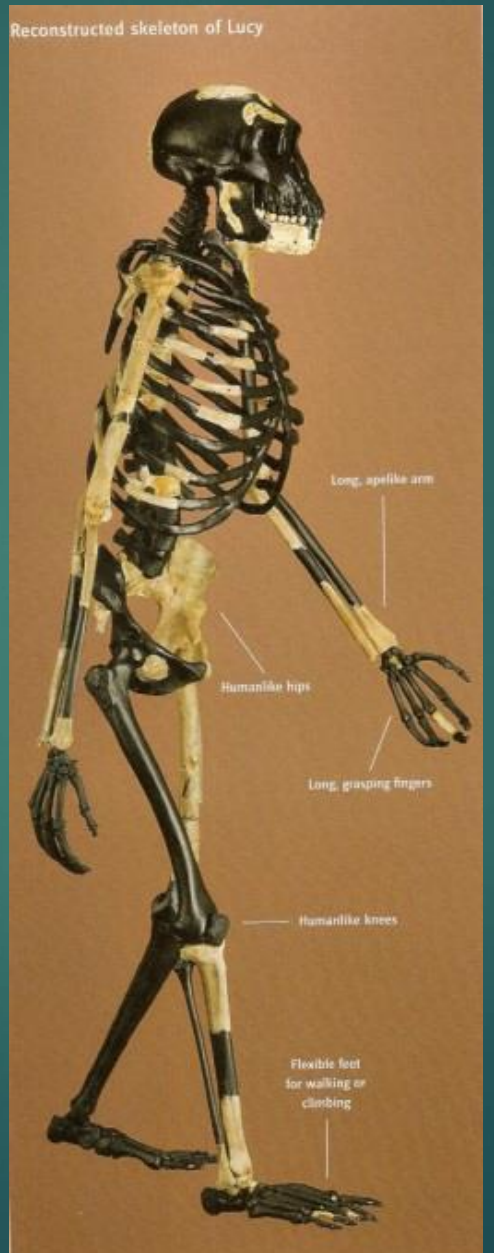
- Who found the first Australopithecus?
- Louis Leakey found what he thought was a baboon tooth in 1935 at Laetoli and sent it to the British Museum.
- Tim White identified it in 1979 as the first adult *Australopithecus afarensis* tooth ever found.

Don Johanson, 1974: Lucy – 3.2 Ma

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



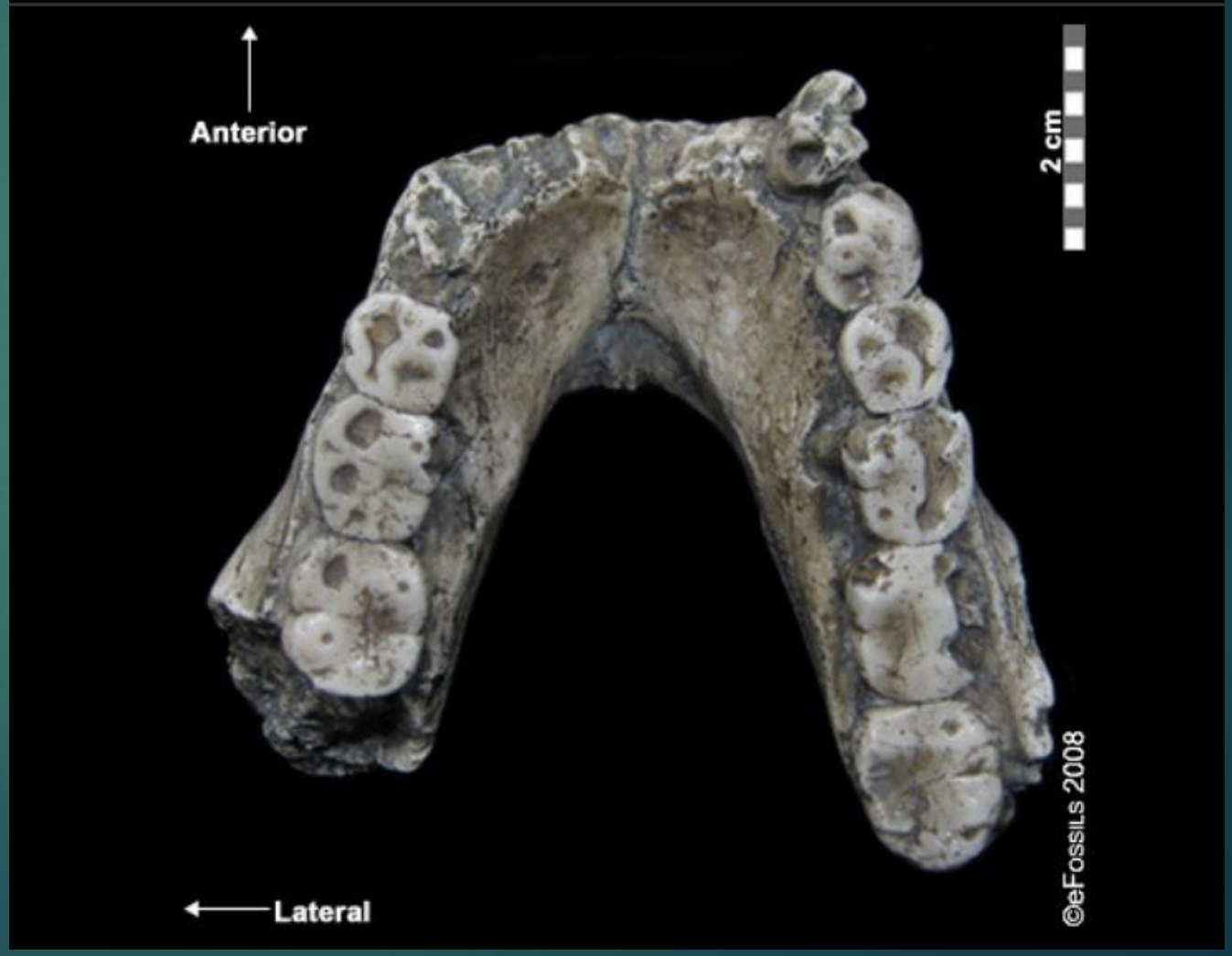
Australopithecus afarensis
(L.H. 4, type specimen in 1978)
Discoverer: Maundu Muluila
Locality: Laetoli, Tanzania
Date: 1974
Age 3.6 M

At CAS, 5/2/2018: Charlie discovers Don Johanson creeping around Lucy

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

Johanson & White made LH 4 the Type specimen for Australopithecus afarensis

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



Bones of Contention: Don Johanson vs Mary Leakey

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

- 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 Hadar, Ethiopia (First Family) which looked very similar to Laetoli specimens. Looked different than Lucy. Originally thought they were *Homo*.

Bones of Contention

- Tim White split from Richard Leakey and joined Johanson.
- White changed his mind about the genus affiliation & then changed Johanson's mind. They lumped all fossils from Ethiopia & Laetoli together & decided both were Australopithecines. Mary & Richard did not agree.
- 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.

Bones of Contention 2

- 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.

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.

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

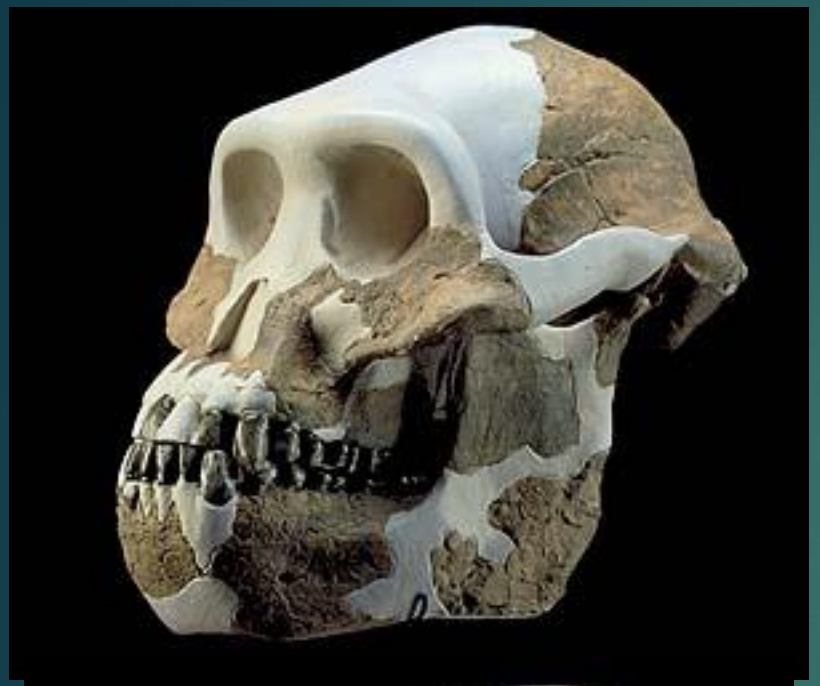
  200 specimens, 13 individuals

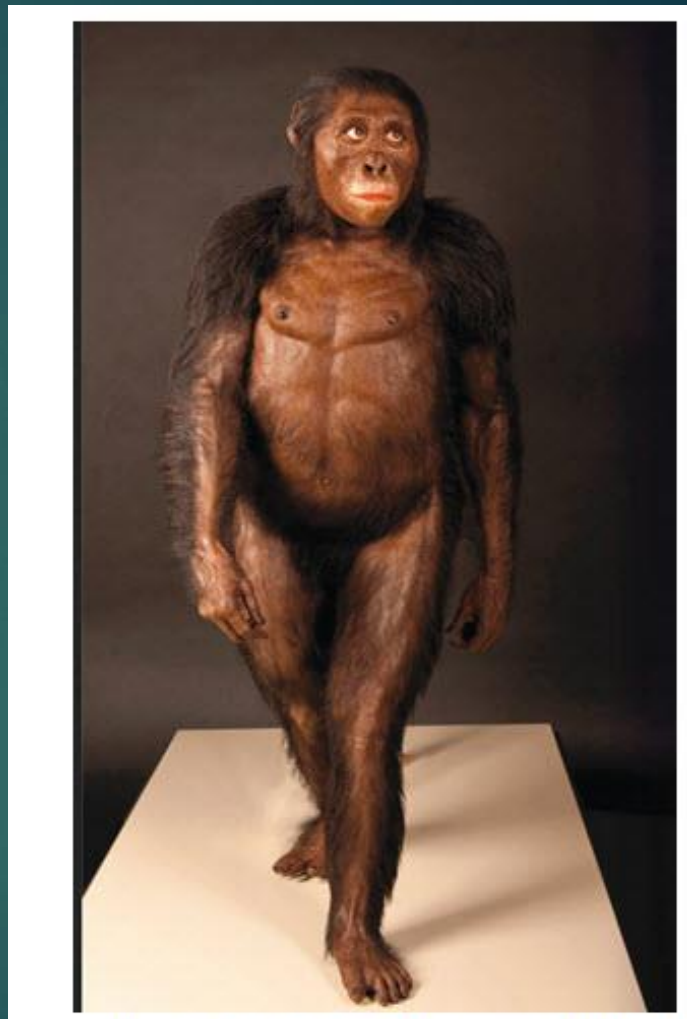
Afar,
Location 333

Lucy

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

Latest Lucy reconstruction





A. afarensis, Lucy, 1974
Science reconstruction, 2013

Laetoli, Tanzania: 3.6 Ma, Oldest human footprints

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.

PAINTING BY JAY H. MATTERNES

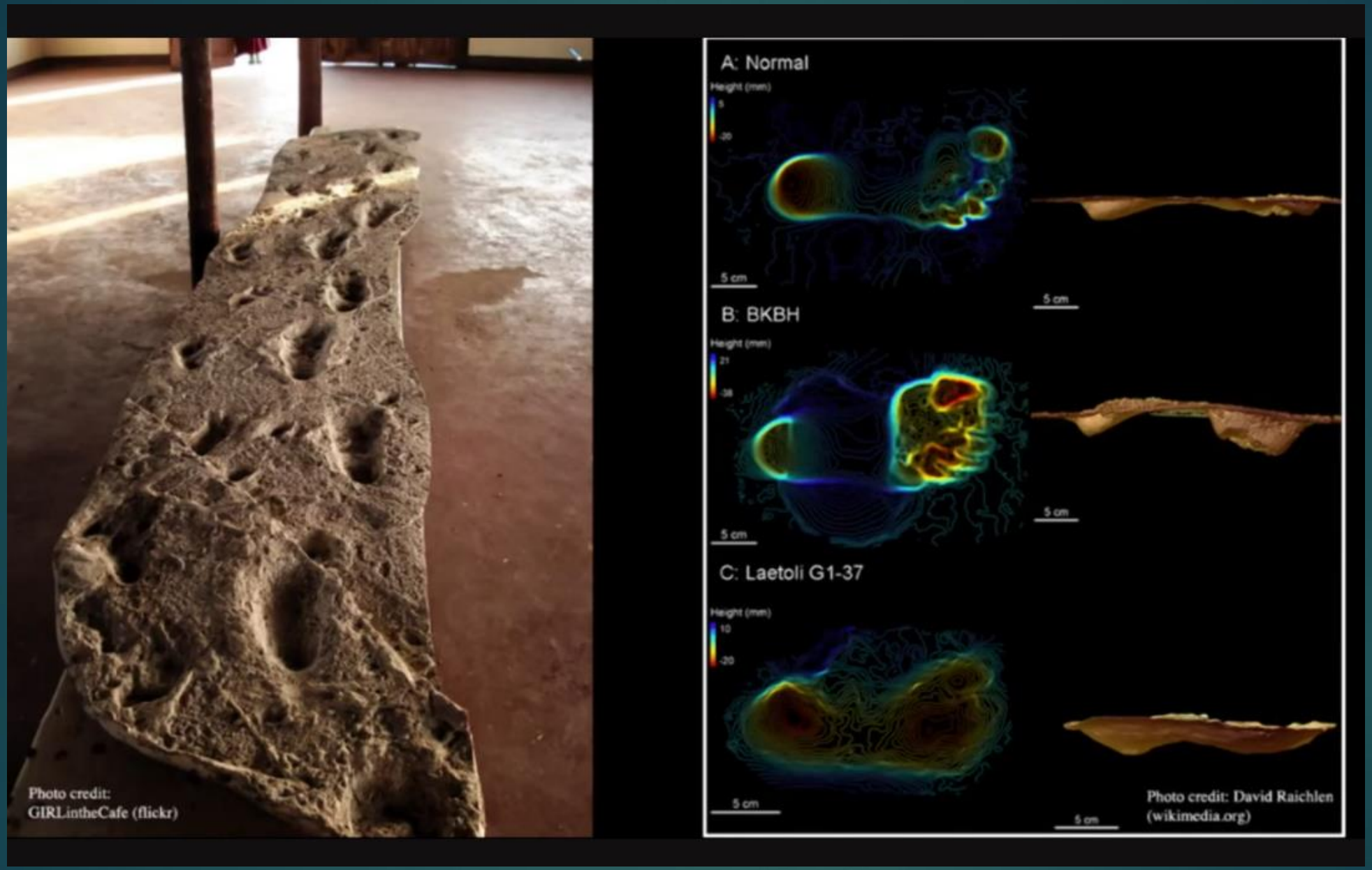
1978: Laetoli *A. afare*

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



Depth of foot prints

Modern human

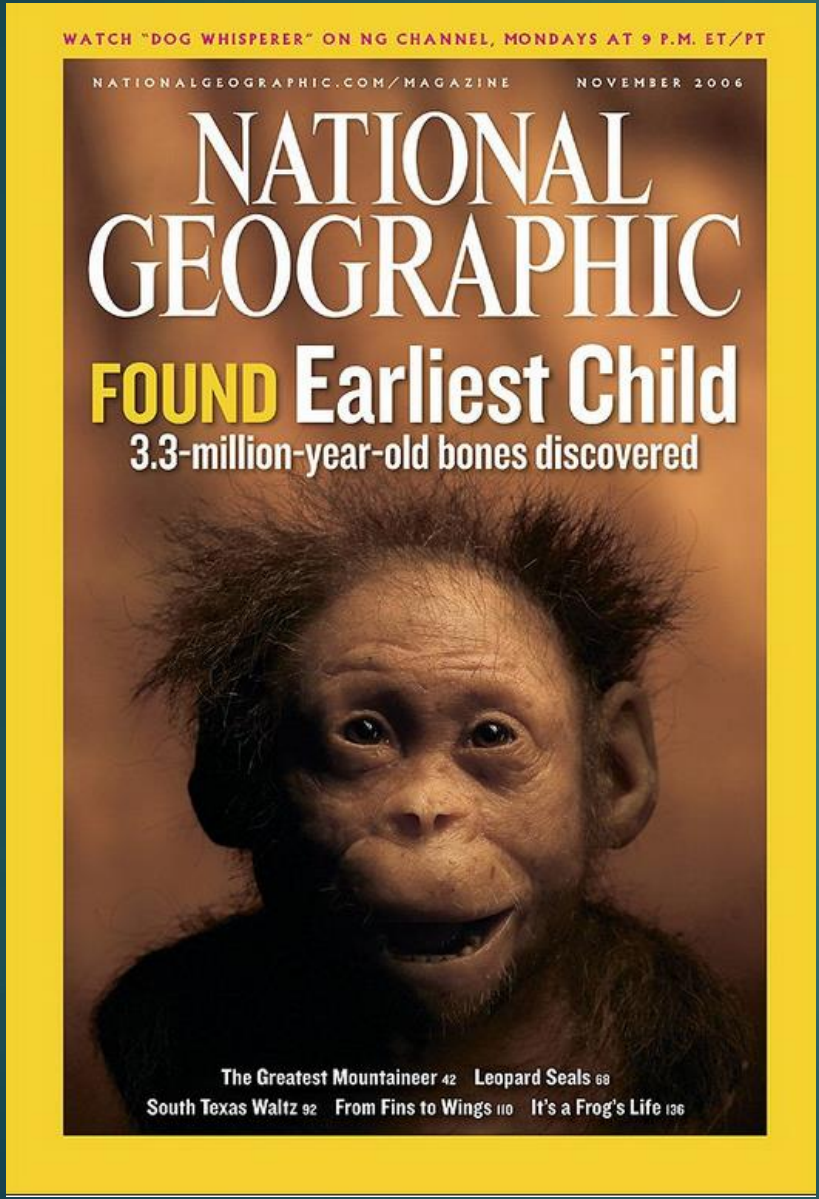
Chimp - BKBH:
Bent knee
& bent hip

Laetoli: same
basic features

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

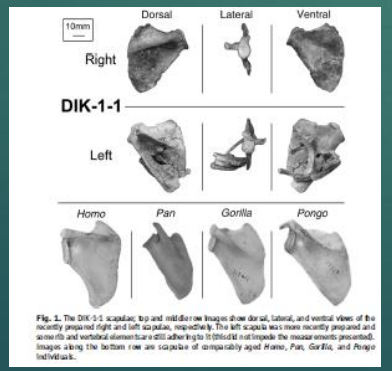
Dave Raichlen et al., 2018

Selam at Dikika, Ethiopia



Selam and Zeresenay Alemseged

2006: *A. Afarensis*, Dikika, “Selam”, 3.3 Ma, 3 y o



2011: Shoulders

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

Australopithecus, Kadanuumuu:

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

Kadanuumuu
"Big Man" in Afar

3.58 Ma

5"+

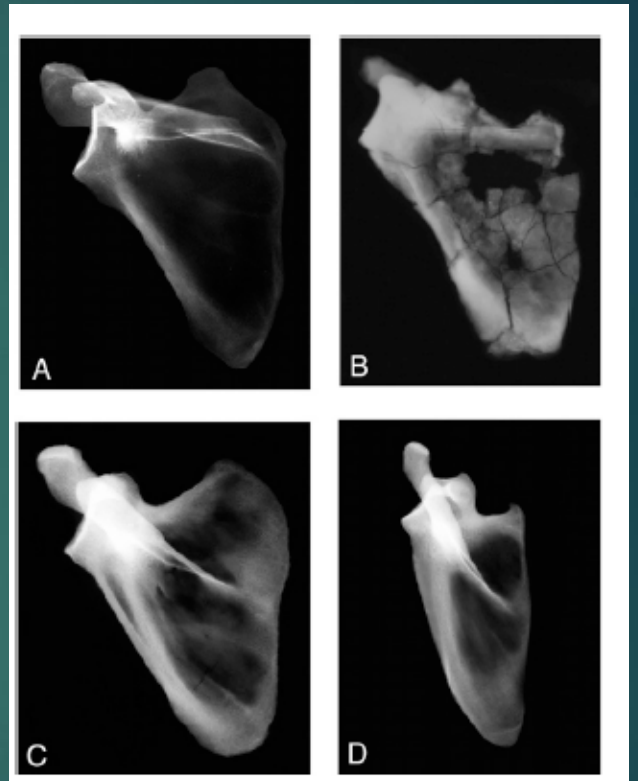


Fig. 3. X-rays of hominoid scapulas. (*A*) Modern human (CMNH-HTH-2450). (*B*) KSD-VP-1/1g. (*C*) *Gorilla* (CMNH-B-1730). (*D*) *Pan* (CMNH-B-3551). Each specimen has been scaled to the same approximate superoinferior glenoid height and aligned with its vertebral border approximately vertical. Note 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

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*, *Homo*	*A. africanus*, *P. robustus*	*H. erectus*	
1.5-1			*P. boisei*, *Homo*	*Homo*, *P. robustus*	*H. erectus*	
1 - .5					*H. erectus*	*H. heidelbergensis*
.5					*H. erectus*	*H. neanderthalensis* Denisovans, Hobbits
.3-.03	*H. sapiens*		*H. sapiens*	*H. naledi*	*H. erectus*	same

South African Australopithecines

- *Australopithecus africanus*, *Paranthropus*, and *Australopithecus robustus*
- South African sites in very different geological context
- Found in caves, not open landscapes.
- Fossils could not be dated reliably, until 2019

S. Africa breccia

South African Australopithecines 2

- Mixed in with other animal bones in hardened rock and bone-laden concrete-hard cave fillings, or breccias.

- Biostratigraphy: Most dated by comparing remains of mammals (pig molars) found in caves with faunal 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.

Flowstone dating of Cradle caves

- 2019: U–Pb-dated flowstones restrict South African early hominin record to dry climate phases, between 3.2 and 1.3 Ma

- Uranium–lead (U–Pb) analyses of horizontally bedded layers of calcium carbonate (flowstone)

- 29 flowstones, from eight caves, and found that the flowstones all date to the same six narrow time windows. For example, 2 million years ago, all the important cave sites across the Cradle were closed – nothing was being washed into them – with flowstone forming inside them. This represents wetter periods and correspond to predominantly closed caves.

Robyn Pickering, et al., 2019

Flowstone dating of Cradle caves

- 6 flowstone age groups: 3.1–2.8, 2.6–2.3, 2.2–2.1, 2.0–1.8, 1.6–1.4 and less than 1.3 Ma

- Flowstones can only form during times when it rains more

- The sediments with the fossils in them inside the caves, are all sandwiched between flowstones. This pattern, flowstone-sediment-flowstone, is interpreted as a signal of these changing climates, with the sediments representing drier times.

- All the fossils accumulated during drier times; they are dry-adapted fauna.

Flowstone dating of Cradle caves

- Implications for the interpretation of the South African hominin fossil record:
  - record is discontinuous; unresolvable gaps in the hominin record
  - discontinuities suggest that changes within hominin lineages across sedimentary periods will appear punctuated
  - makes it impossible to falsify hypotheses of punctuated equilibrium
  - ability to observe pivotal milestones that pertain to the origin of *Homo* and advances in tool technology are temporally restricted

Flowstone dating of Cradle caves 2

- Record is biased towards representing drier-adapted plant and animal communities.
- Fossils during wettest periods are still missing as the caves were closed during speleothem formation; inability to observe behaviors during wet periods constrains our ability to evaluate hypotheses of hominin adaptation
- Some hominin taxa (for example, *A. africanus*, *P. robustus* and early *Homo*) are found during dry periods that unequivocally straddle wet periods, indicating either that these species were ecological generalists or that they vacated the Cradle landscape during wet periods only to return at a later, drier time.

East African Australopithecines

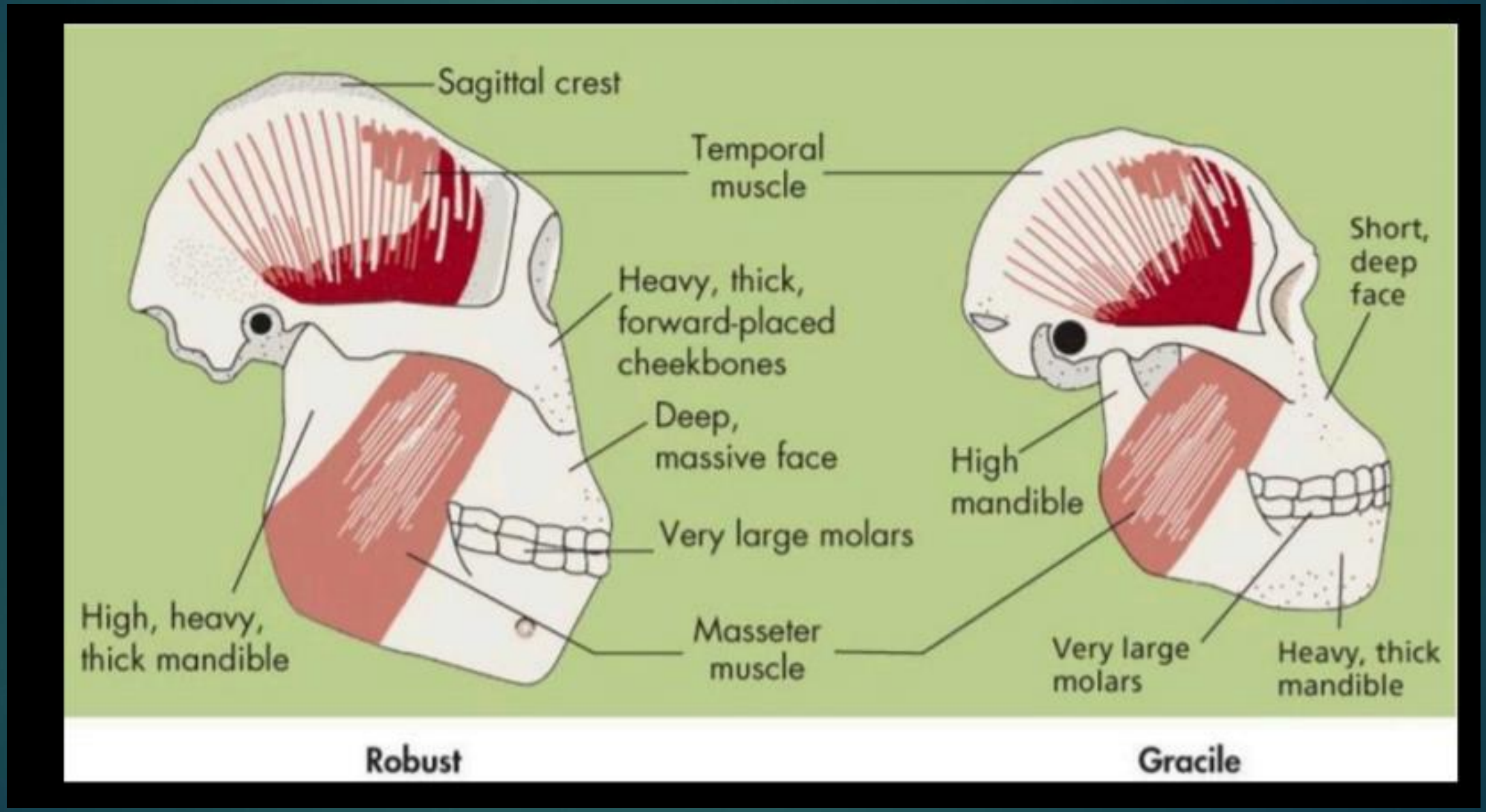
- East Africa: *A. afarensis, A. anamensis, A. bahrelghazali, A. garhi*

- Eastern discovery 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.


East Africa erosion

- 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

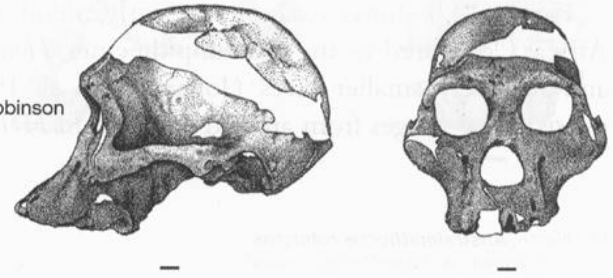
Robust and Gracile



Gracile Australopithecines

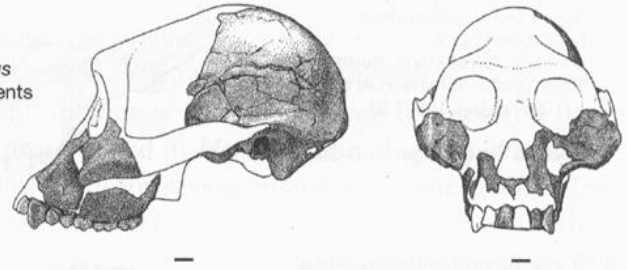
(a) Name: ***Australopithecus africanus***
Specimen: Sts 5
Age: 2.5 million years
Found by: Robert Broom and John T. Robinson
Location: Sterkfontein, South Africa
Color photo: Johanson et al. (1996) pages 3; 135

Species Time Range: ~2.4–2.8 Ma



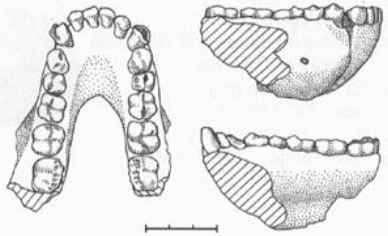
(b) Name: ***Australopithecus afarensis***
Also known as: *Praeanthropus africanus*
Specimen: Reconstruction from fragments
Color photo of same species: Johanson et al. (1996) page 129

Species Time Range: ~3.0–3.9 Ma



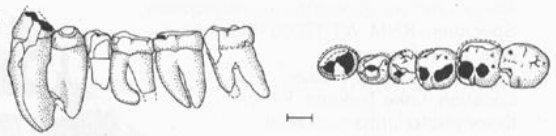
(c) Name: ***Australopithecus anamensis***
Specimen: KNM-KP 29281
Age: 4.1 million years
Found by: Peter Nzube
Location: Kanapoi, Kenya
Color photo: Johanson et al. (1996) page 123

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

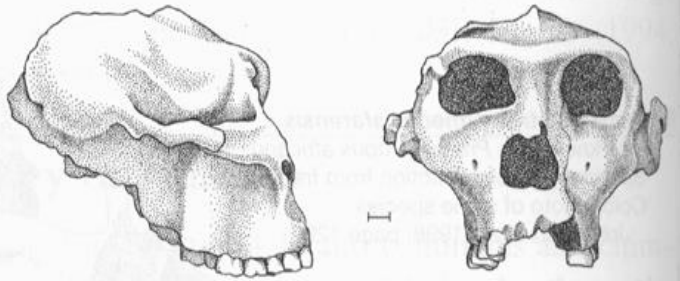
Species Time Range: ~4.4 Ma



Cranially 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

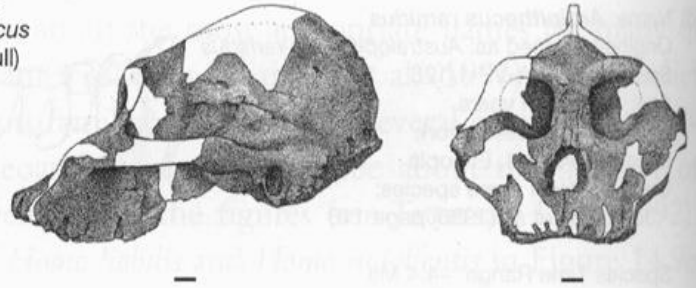


(b) Name: ***Australopithecus boisei***
Also known as: *Paranthropus boisei*
Specimen: KNM-ER 406
Age: 1.7 million years
Found by: Richard Leakey and H. Mutua
Location: Koobi Fora, Kenya
Color photo: Johanson et al. (1996) pages 54; 159; 160

Species Time Range: ~1.4–2.3 Ma

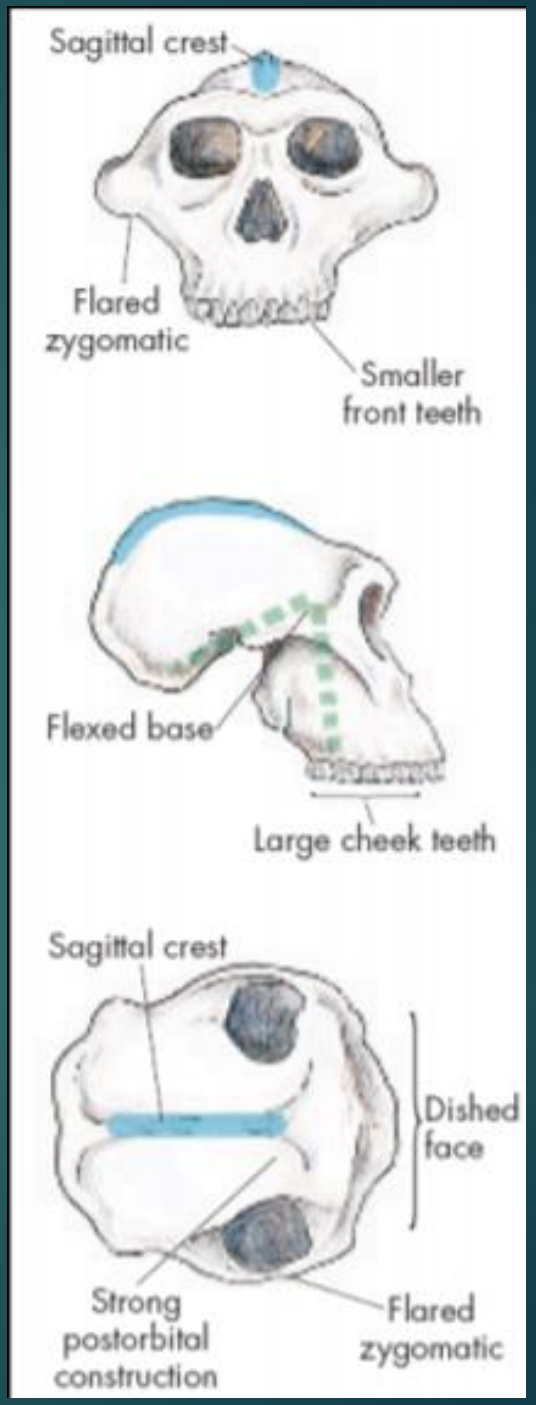
(c) Name: ***Australopithecus aethiopicus***
Also known as: *Paranthropus aethiopicus*
Specimen: KNM-WT 17000 (Black Skull)
Age: 2.5 million years
Found by: Alan C. Walker
Location: Lake Turkana, Kenya
Color photo: Johanson et al. (1996) pages 153; 154

Species Time Range: ~1.9–2.7 Ma



The Robust Australopithecines

- Only cranially robust (not body size)
- 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

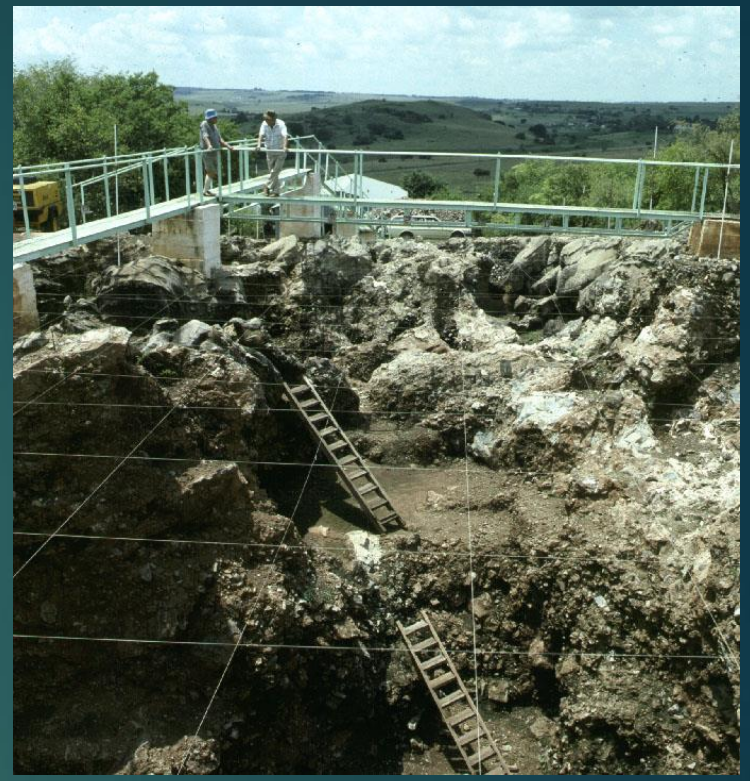


Gracile vs robust australopithecines

- Gracile: *A. afarensis*; “Lucy”
- Robust: *Paranthropus* - larger “robust” mastication apparatus

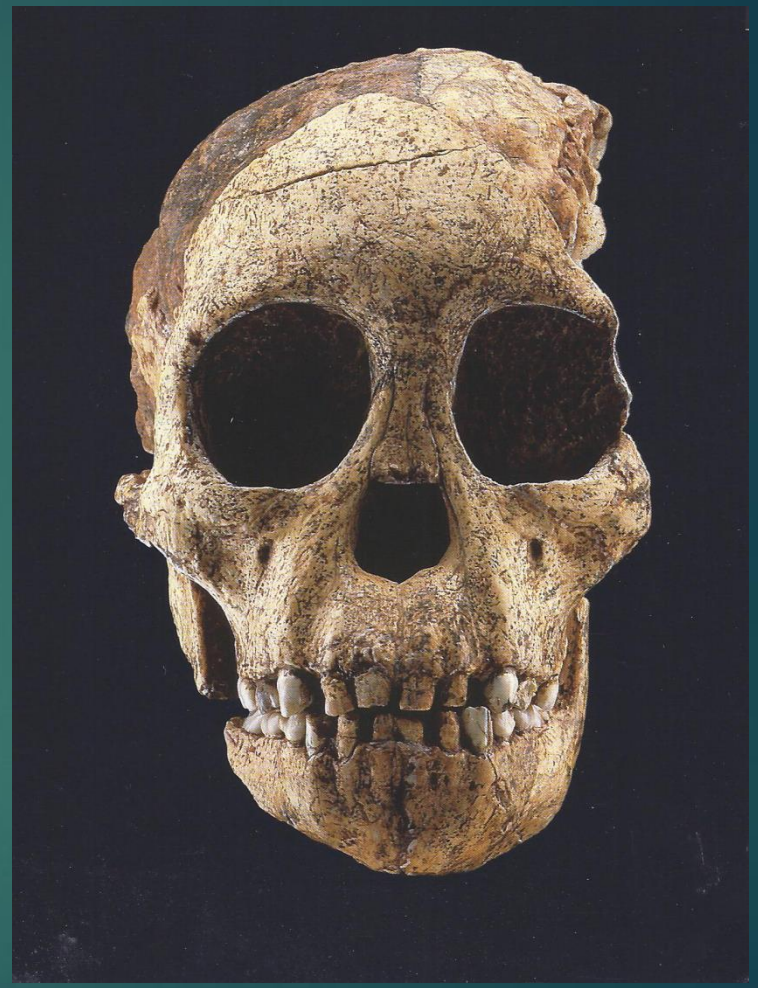
- ***“Robust” australopithecines:*** *Paranthropus aethiopicus, robustus & boisei*
- Known as robust australopithecines because their skulls are more heavily built and because they had huge, broad cheek teeth with thick enamel.
- ‘Robust’ refers solely to tooth and face size, not to the body size of 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



- Gracile fossils at older caves:
- Taung: *Australopithecus africanus* - Dart
- Sterkfontein: *Plesanthropus transvaalensis (A. africanus)* - Broom
- Makapansgat: *Australopithecus prometheus* – Dart (fire in cave)
- Robust fossils at younger caves:
- Kromdraai: *Paranthropus robustus* - Broom
- Swartkrans: *Paranthropus crassidens (robustus)*

1924: First *Australopithecus africanus*, Taung Child,
2.8 Ma; 3.3 years old, bipedal, 440 cc, 1st African hominin
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

Importance of Taung Child

- Originally controversial (because of Piltdown): an ape
- Refocused origins of human question to Africa
- Clarified what came first in human evolution: bipedality, little brain; 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

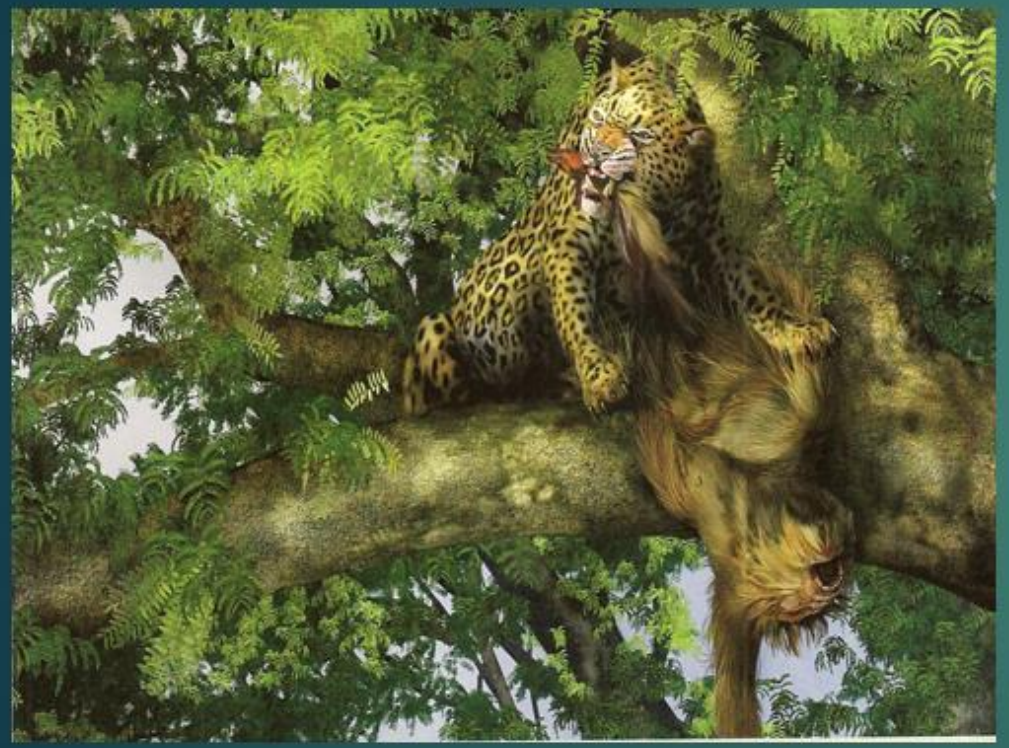
- First known australopithecine (Dart 1925)
- Dated to 3.3-2.1 MA in South Africa
- Cranial capacity: <500 cc
- This species slightly different from *A. afarensis*: slightly taller, less facial prognathism, smaller teeth, slightly larger brain.
- First hominin endocasts
- One candidate for immediate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

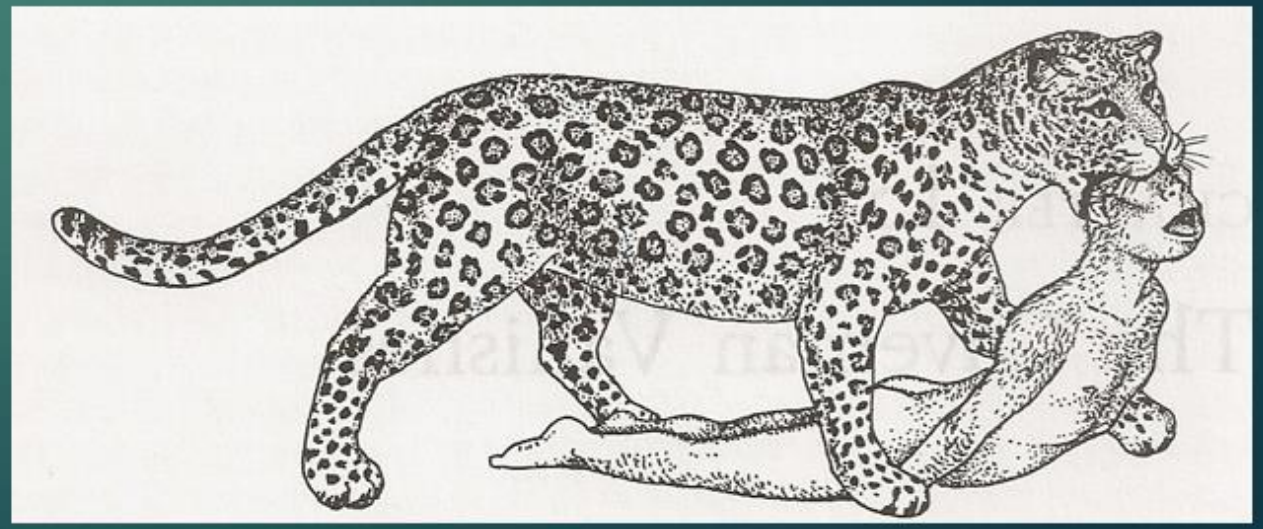
Endocasts can be formed naturally by sedimentation through the cranial foramina which becomes rock-hard due to calcium deposition over time

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

Evidence of talon damage in eye sockets

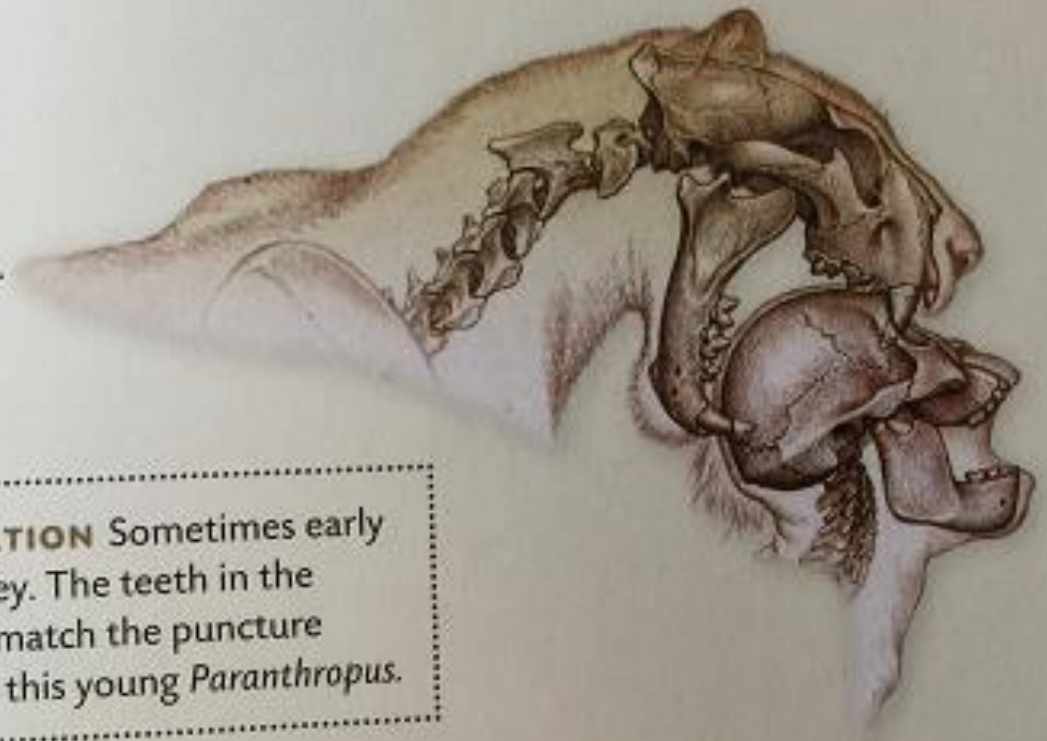
Hominin Predation
at Swartkans, S. Africa





1983: Brain realized that 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.

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



SIGNS OF PREDATION Sometimes early humans were the prey. The teeth in the leopard's lower jaw match the puncture marks in the skull of this young *Paranthropus*.

Panthera pardus
Leopard jaw

Paranthropus robustus
Juvenile, SK 54

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

Australopithecus africanus in Caves

- No evidence that either *A. africanus or P. robustus* lived in the caves in which their fossils were found.
- Bones were:
  - dropped into cave openings by leopards,
  - brought into the caves by hyenas or porcupines.
  - fallen into cave
  - or entered and could not leave.

2.6-Million-year-old stone tools and associated bones from Gona, Afar, Ethiopia

No hominin remains were found in association with these Oldowan tools and they predate the oldest known remains of the genus *Homo.*

These tools are unlikely to be evidence of the very first use of tools.

The use of tools in apes and monkeys can be used to argue in favor of tool-use as an ancestral feature of the hominin family.

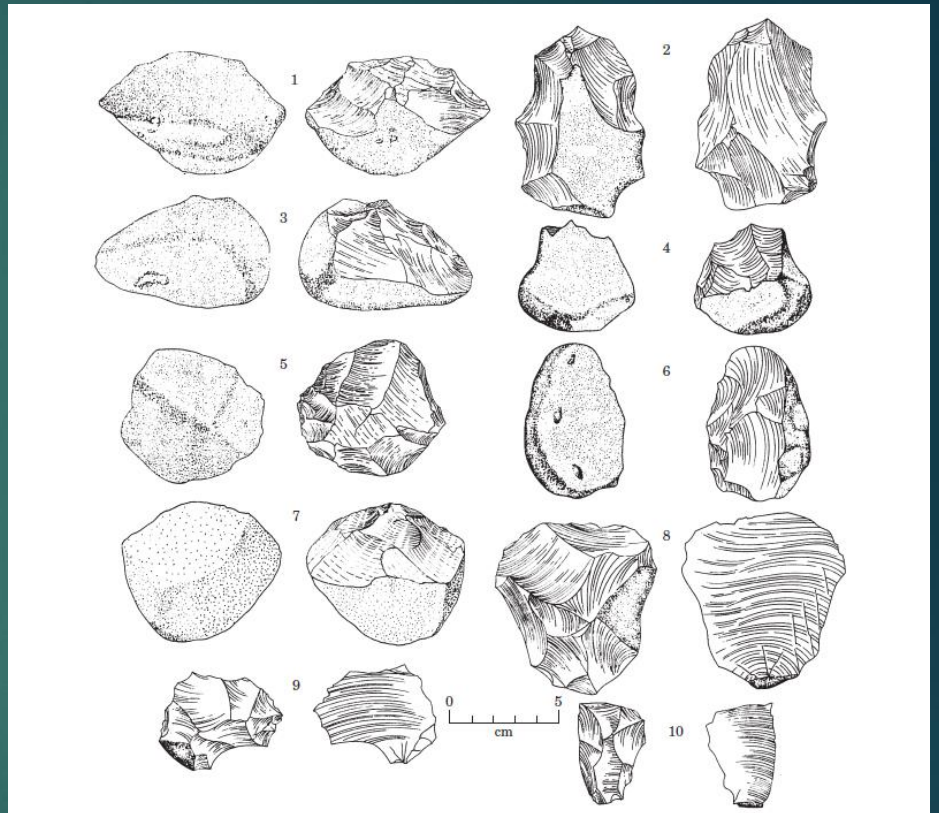


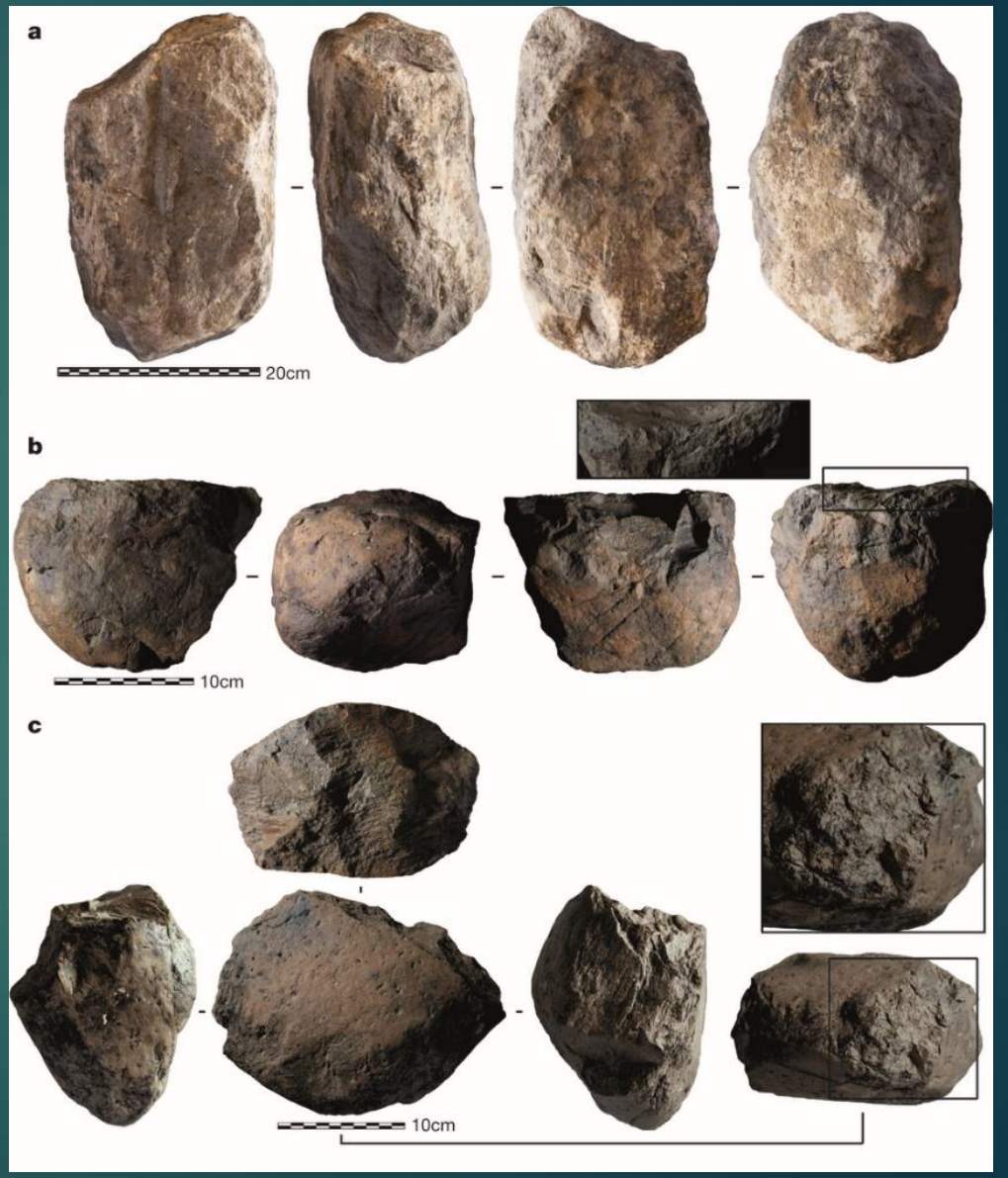
Figure 6. Drawings of artefacts (cores and whole flakes), excavated from EG10 and EG12. (1) unifacial chopper, EG10, (2) discoid, EG10, (3) unifacial side chopper, EG12, (4) unifacial end chopper, EG12, (5) partial (irregular discoid), EG12, (6) unifacial side chopper, EG10, (7) unifacial side chopper, EG12, (8–10) whole flakes, EG10.

Sileshi Semaw et al. 1997 & 2000

Pre-Oldowan Tools: Now 3.3 Ma old stone tools: Lomekwian

The recent discovery of stone tools, dated at 3.3 MA, was made near Olduvai Gorge at the site Lomekwi 3, situated to the west of Lake Turkana in Kenya.

The Lomekwian tools are larger; produced sharp flakes by pounding stones against a passive hammer or anvil, rather than through a freehand technique; similar to nut-cracking activities of chimpanzee stone tool-use behavior



Who made the first stone tools?
Was it *Homo habilis*? Or the Australopithecines?

- Now we have the Lomekwian stone tools at 3.3 Ma.
- Closer to less developed chimpanzee technique of hammer-on-anvil than to the direct freehand percussion evident in Oldowan assemblages.
- Also cut marks from stone tools on bones dated at 3.4 Ma at Dikika in Ethiopia (Zeray Alemseged's discovery).
- Guess which species are around at that time in East Africa? The Australopithecines: *A. afarensis*, *K. platyops* and *A. deyiremeda*.
- Clearly Australopithecines used tools before *Homo.*

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

A. africanus: Mrs. Ples: 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

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

Paranthropus robustus (TM 1517)

Discoverer: Gert Terblanche

Date: 1938

Locality: Kromdraai, S. Africa

Age: 2 M

Olduvai Gorge

1959: *Paranthropus boisei:*
Most famous Olduvai Gorge fossil; "Zinj": 1.8 M

Disappointed 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

Zinj = startlingly old; 1.7 MA

Dating of Zinj rocked the anthropological world when age established at 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.

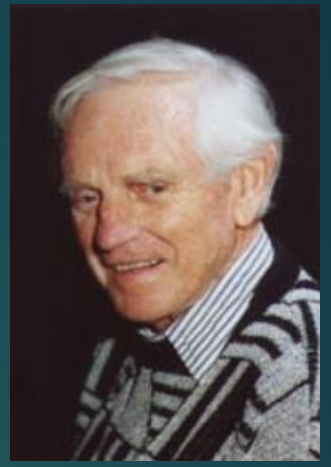
Dr. Evernden and I believe that this date is close to the true age of Olduvai's early men, but that if anything it is slightly conservative.

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

Sincerely yours,

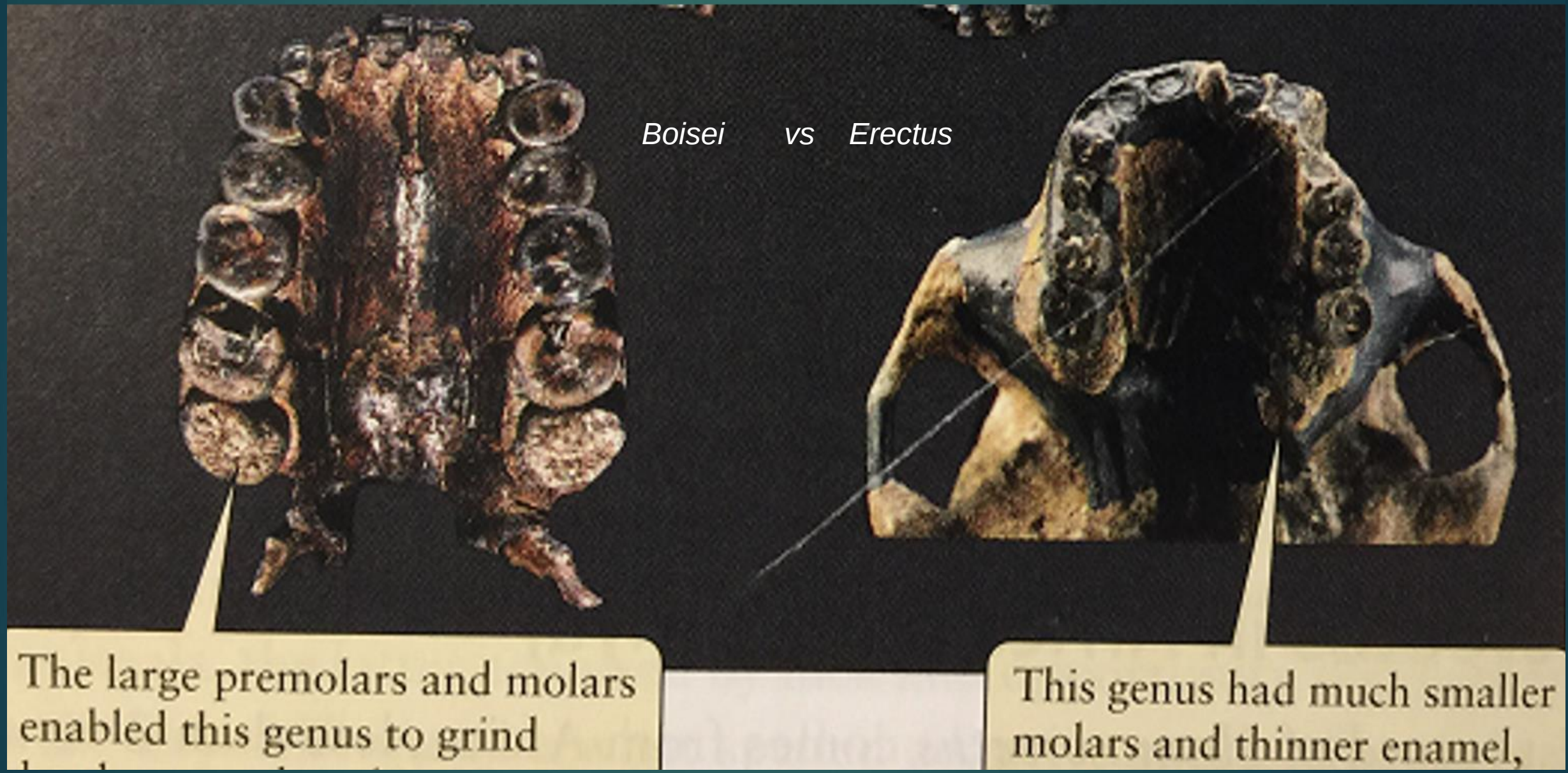
Garniss H. Curtis

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.”



Boisei is no longer “Nutcracker Man”; ate grasses and sedges

Paranthropus boisei:
Sexual dimorphism

OH 5, male

KNM-ER 732, female

1960, Leakey: *Homo habilis* and stone tools at Olduvai Gorge

- Finds made by Louis and Mary Leakey at Olduvai Gorge, Tanzania, claimed they had discovered the first stone tools, chronologically dated to around 1.85 Ma
- The Oldowan, Mode 1 type,
- 2.6 to 1.7 Ma
- Associated with H. habilis, early H. erectus in Dmanisi & Asia

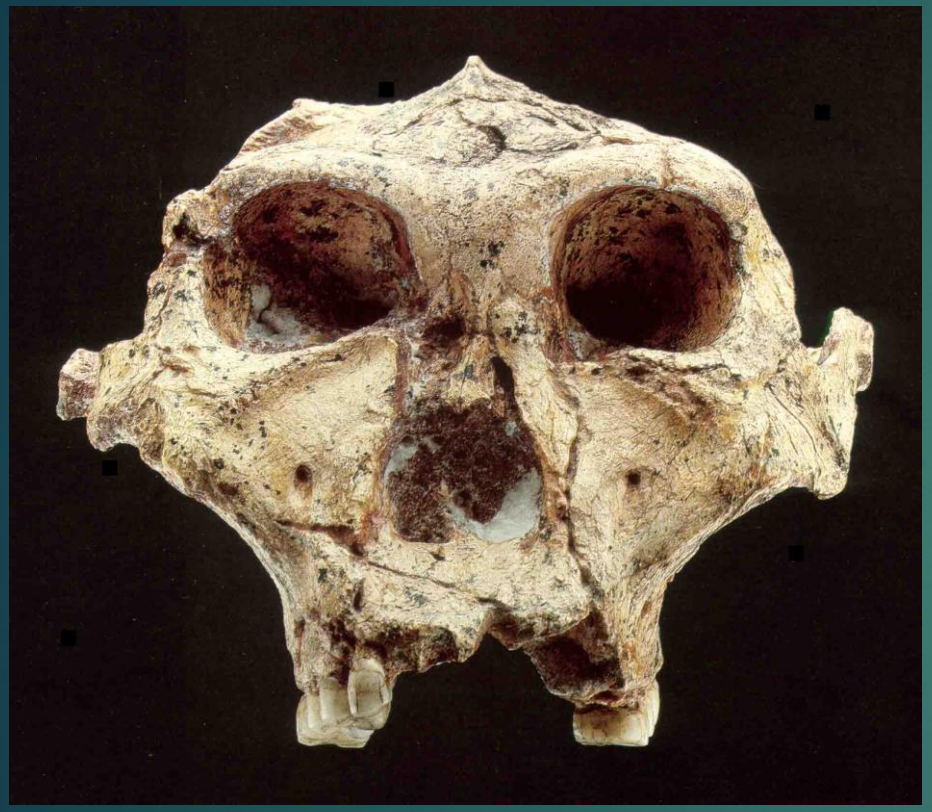
(Toth & Schick, 2013).

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 broke the ‘single species hypothesis’ in human evolution.
- According to this principle, only one species can inhabit a specific ecological niche. Those two specimens 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

Australopithecus (Paranthropus) robustus, 2-1 MA



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

“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 arches (cheek bones)
- 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*

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

Concept of Fallback foods

- Another story that has emerged in the past decade, is the concept of fallback foods.

- The large structures of the jaw itself may not be specifically evolved for the primary food it eats, but rather for occasional fallback foods; food that helps you survive when what you normally eat isn't available.

- So one interpretation has been that the fallback foods are playing important role in the morphology as well.

Dietary conclusions

- 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.
- 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.

Fallback foods

- And it's possible that the fallback foods for *boisei*, even though it might have been eating grass, was something that was a little bit harder, that required a stronger peak chewing force to crush and digest.

- *P. boisei* was the Cow of the Pleistocene: *boisei* was primarily eating grasses. It survived by eating these very low-quality foods.

- Could some of those fallback foods have been those very seeds and nuts that were originally thought to be the primary food for *boisei* and the other robust lineages?

- No.

2014 study: Challenges ideas of dentition and diet

- *P. boisei*, the apex of jaw robusticity, presents molar microwear suggesting that it processed hard foods *less* frequently than the closely related but less-specialized *P. robustus*, who has evidence of at least seasonal hard-object feeding.

- The dentition of *P. boisei* cannot be explained by a fallback food scenario.

- Instead, the remarkable jaws of *P. boisei* probably reflect regular consumption of items that required intensive postcanine processing, resulting in masticatory stresses that exceeded those experienced by *P. robustus*.

Dentition and diet

- The microwear signatures of *P. boisei*, *Australopithecus anamensis*, and *Australopithecus afarensis* are striking in their uniform lack of evidence for consumption of very hard or very tough items.

- Microwear data reject the idea of frequent hard-object feeding in *P. boisei*; this species must have masticated considerably tougher foods on a regular basis.

- Increases in jaw robusticity from *Ardipithecus* to *Australopithecus* to *P. boisei* reflect progressively greater reliance on tough, probably C4 foods and concomitantly elevated masticatory stresses resulting from extended bouts of milling and grinding. Food now known to be grasses and sedges.

Robust australopithecine behavior

Digging sticks used by modern chimpanzees.

Pointed sticks have been found with robust australopithecine fossils

- Omnivores, but also could chew harder 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

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

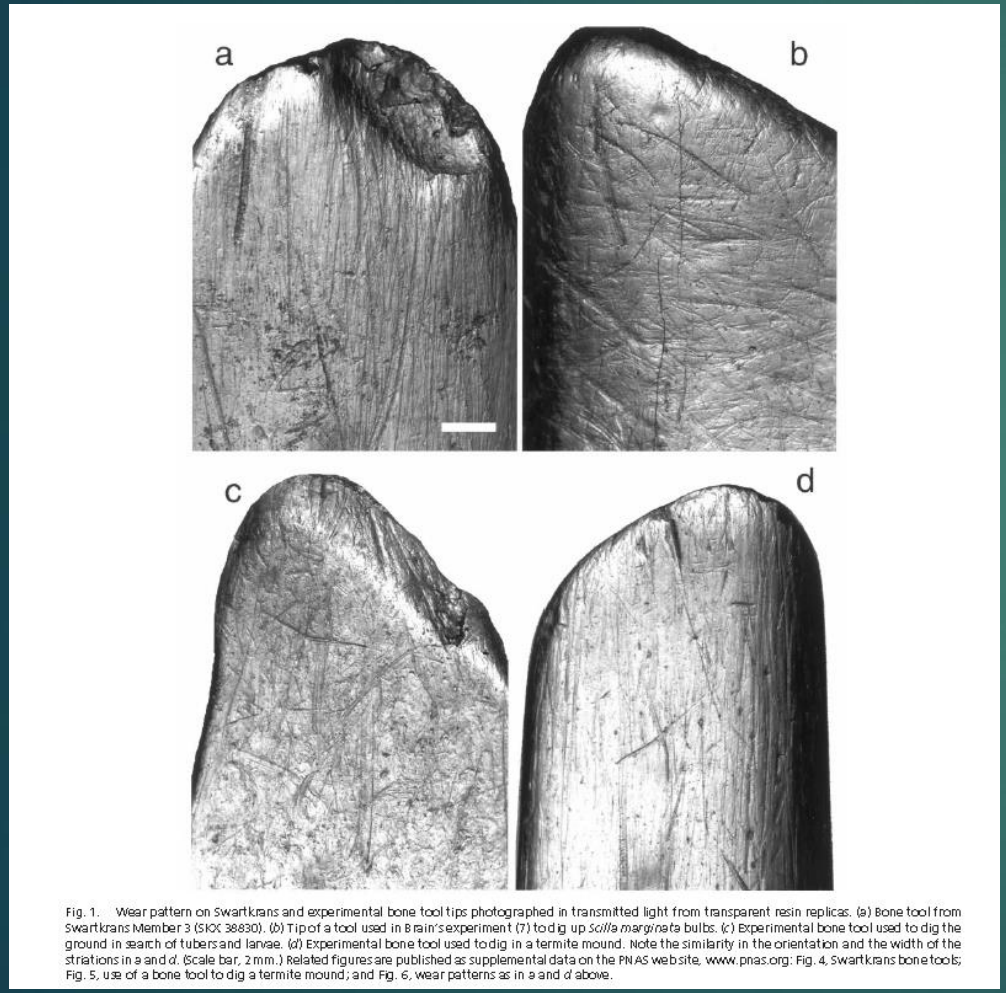


Fig. 1. Wear pattern on Swartkrans and experimental bone tool tips photographed in transmitted light from transparent resin replicas. (*a*) Bone tool from Swartkrans Member 3 (SKX 38830). (*b*) Tip of a tool used in Brain's experiment (7) to dig up *Scilla marginata* bulbs. (*c*) Experimental bone tool 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

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

Relatively small stature and **certain skull features** suggest it was probably a female of advanced age, with a brain size of about 408 ccs; **suffered a forearm injury** early in life, and her relatively long legs, in proportion to her arms, suggest **she probably walked upright**

A. prometheus ??

- Clarke says Little Foot's features most closely match *A. prometheus*, a species proposed in 1948 by anthropologist Raymond Dart

- Clarke argues that a number of features differentiate Little Foot—and at least a dozen other nearby fossils—from *A. africanus*. These include larger, flatter faces with a wider distance between eye sockets; larger canines and forward-tilting incisors; larger mandibles; and slightly concave foreheads. Differences in teeth wear indicate *A. africanus* was omnivorous, whereas Little Foot and her kin were mostly vegetarian, Clarke argues. Together, he says, that suggests *two* species of hominins were living near the caves some 3 million years ago.

Little foot virtual brain

Virtual rendering of the brain endocast of "Little Foot," possibly a new species of *Australopithecus*. M. Lotter and R.J. Clarke/Wits University

- More ape-like than human. Little Foot's visual cortex, in particular, took up a greater proportion of its brain than that area does in the human brain. It's visual cortex, in particular, was larger compared to later *Australopithecus* brains
- Was asymmetrical, with slightly differing protrusions on each side; indicates that *Australopithecus* had brain lateralization, meaning that the two sides of its brain performed different functions.
- The finding means that brain lateralization evolved very early in the primate lineage.

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
- prominent skull crest, 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.*

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

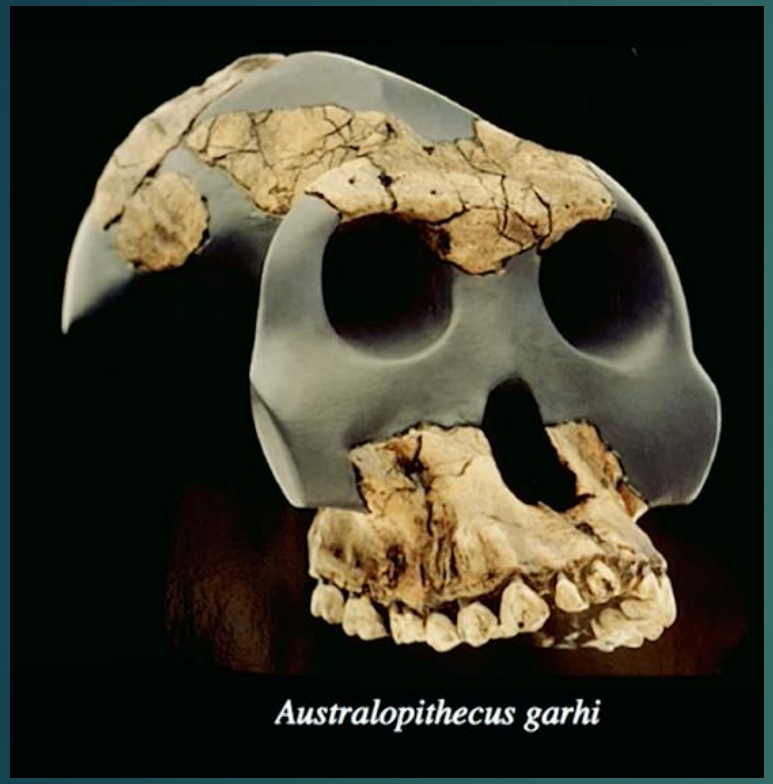
Tim White: Early Australopithecus (4.2-3.0 Ma): *A. anamensis*→*A. afarensis* = 1 species lineage, arbitrarily divided = "2 chronospecies"

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

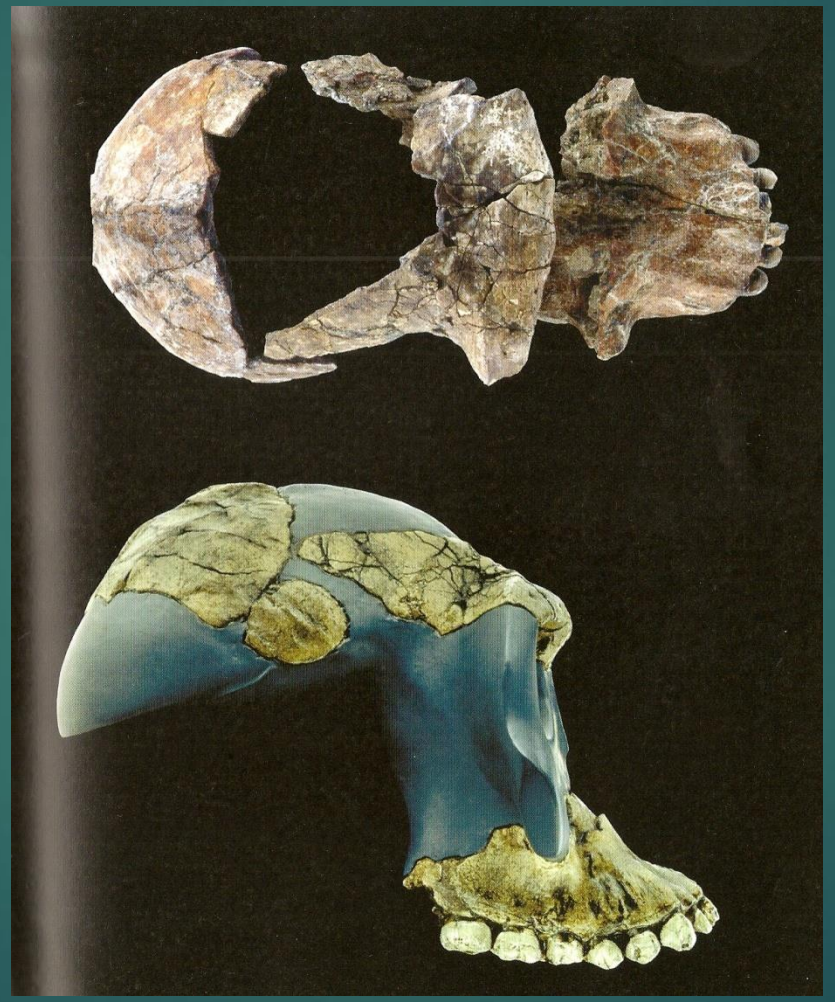
- Many researchers had suspected: that Lucy's species, *Australopithecus afarensis*, evolved from a 4 Ma *A. anamensis*.
- Propose that the older *Ardipithecus*, whose bones were found closer to the base of the rock layers, was the most likely ancestor of *A. anamensis* and all later australopithecines.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

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



Australopithecus garhi
(BOU-VP-12/130)

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

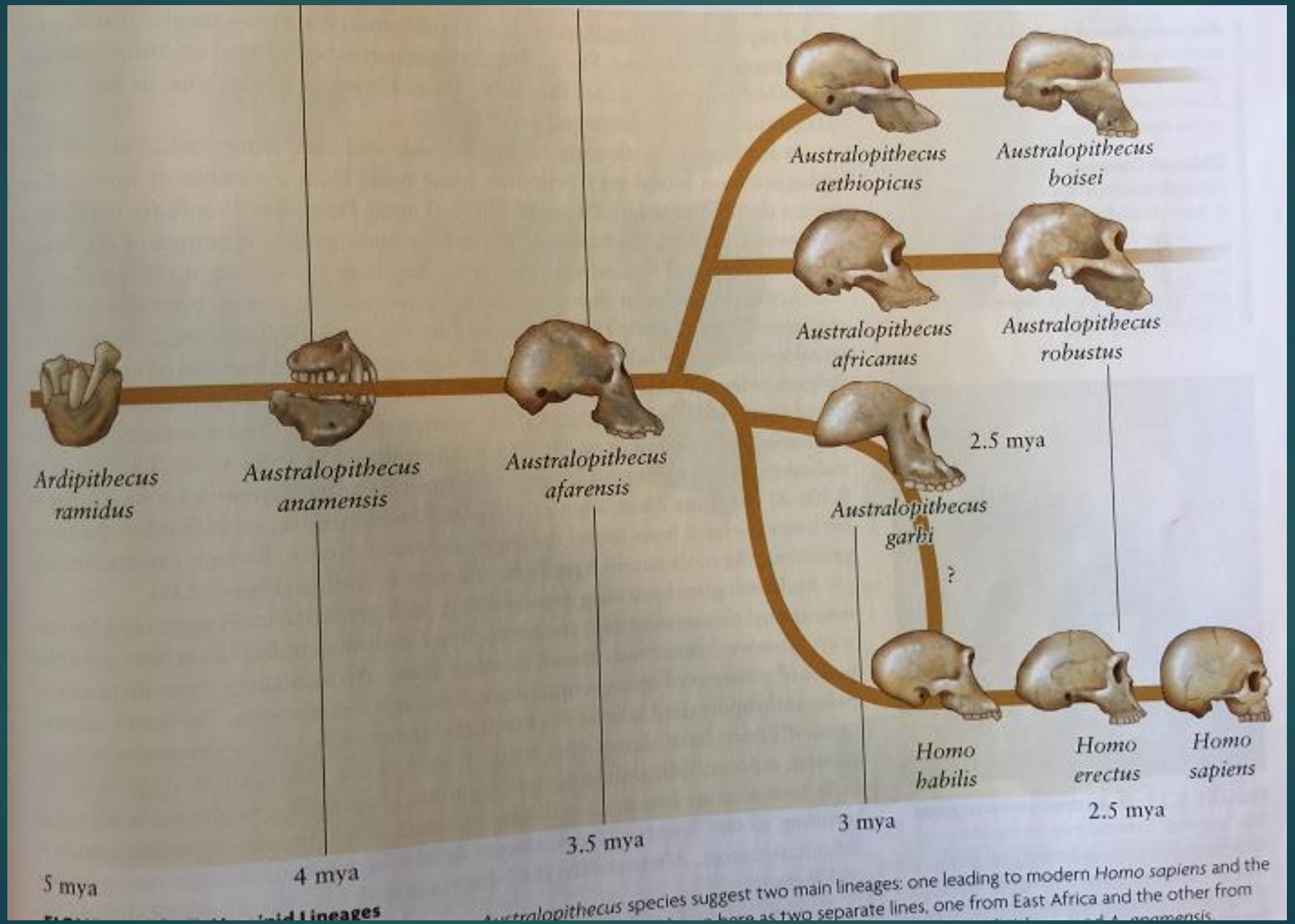


- The very large teeth in this partial skull suggest that A. garhi may have descended from one of the other Australopithecus species, likely *A. afarensis.*

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

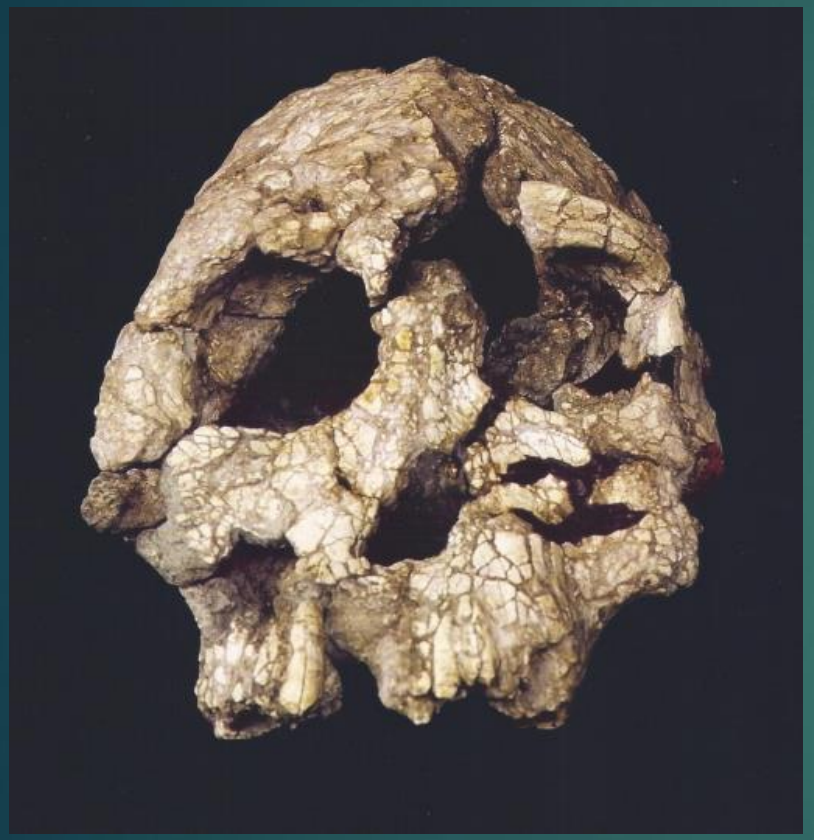
- *A. garhi* dates to the period of the earliest known stone tools, and the remains of *A. garhi* are associated with antelope bones with cut marks that are from stone tools.

Hypothetical ancestry



Australopithecus species suggest two main lineages: one leading to modern *Homo sapiens* and the

1999: *Kenyanthropus platyops*, 3.5 Ma
Maeve Leakey (granddaughter of Louis)

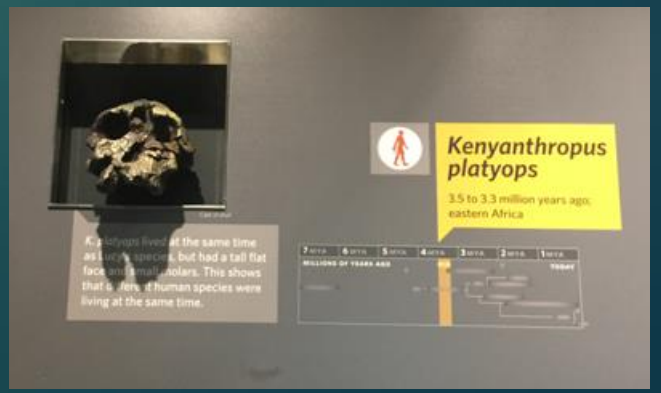


Kenyanthropus platyops
(KNM-WT 40000)

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

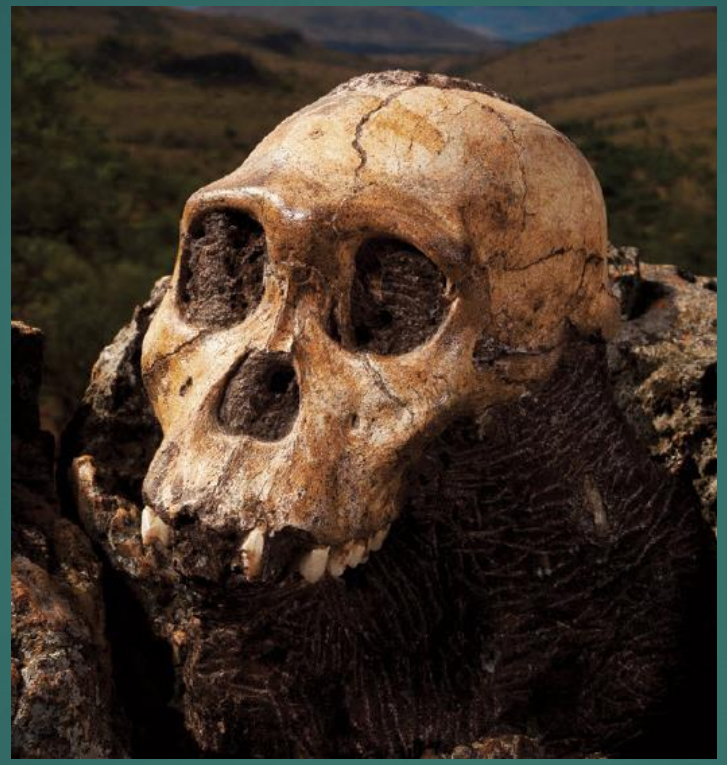
Fossil skull is highly fragmented and the individual pieces are greatly distorted. Cranium is deformed by many matrix-filled cracks that permeate the face and rest of cranium. Tim White: *A. afarensis*

2001: *Kenyanthropus platyops:* in West Turkana, Maeve Leakey discovers *Kenyanthropus* = human ancestor?; Tim White disagrees = *A. afarensis*



2008: *Australopithecus sediba*, *1.98 Ma*, Malapa Cave, South Africa


Brett Eloff, via Lee Berger and the University of the Witwatersrand

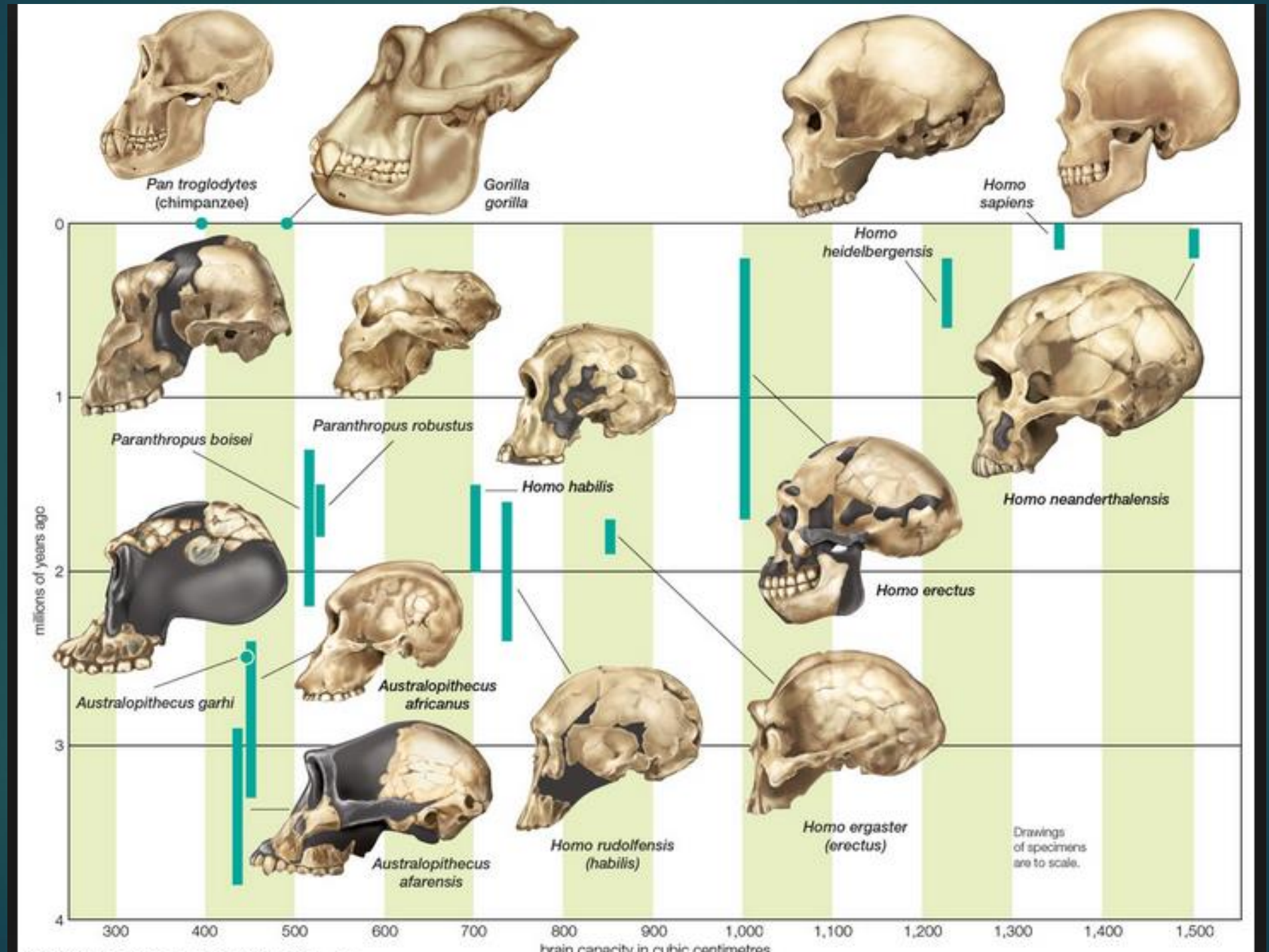


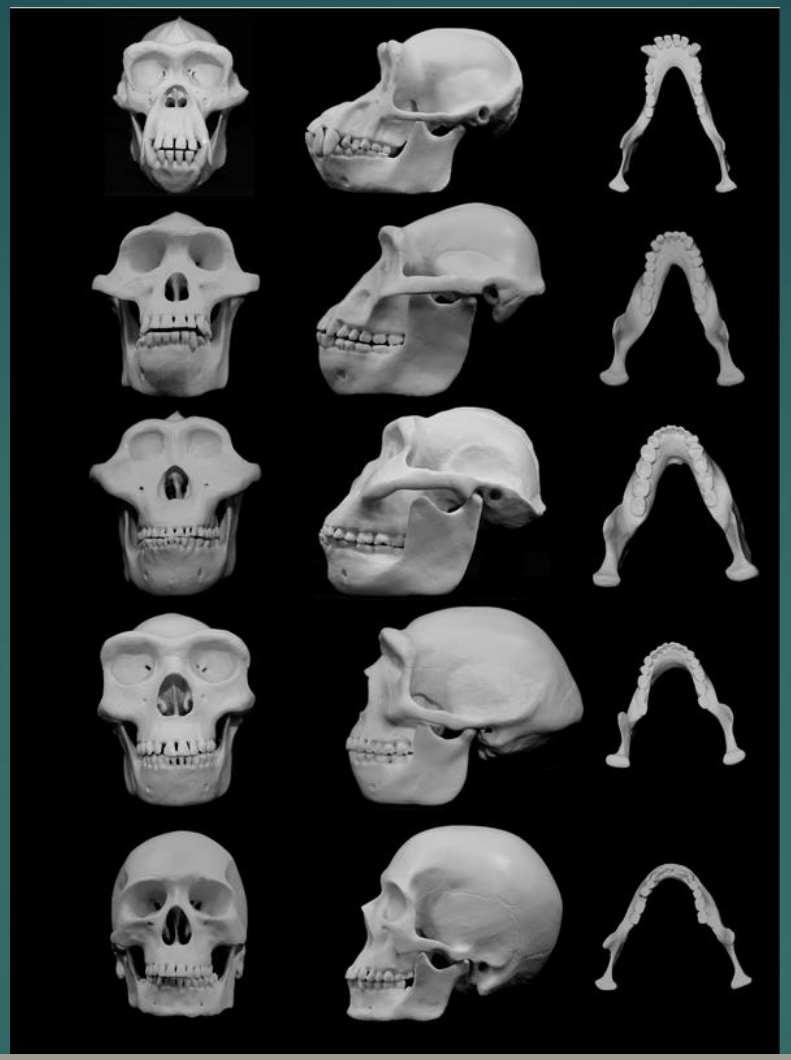
Australopithecus sediba
(LH1, type, cranium)
Discoverer: Matthew Berger
Locality: Malapa Cave, South Africa
Cranial Capacity: 420–450 cc

MH1 and MH2

Later

Earliest





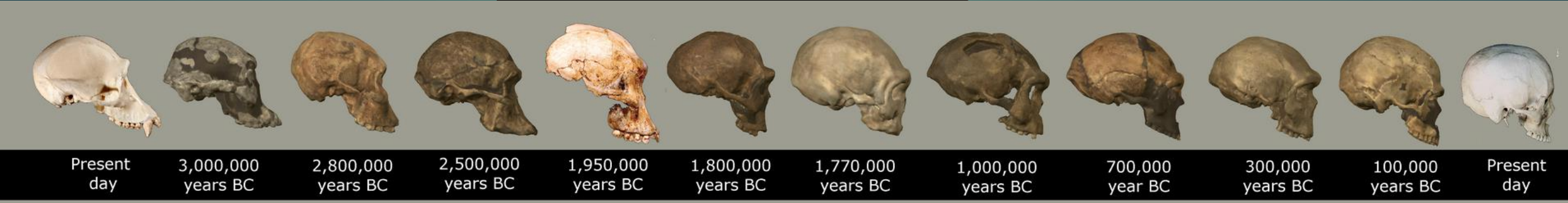
Pan

A. afarensis

P. boisei

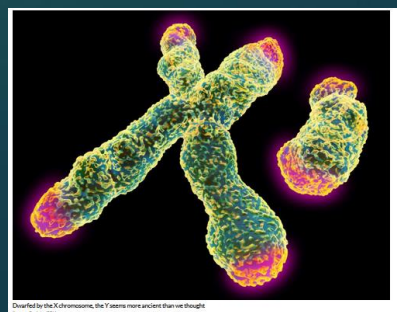
H. neanderthalensis

H. sapiens



Mitochondrial Eve and Y-chromosomal Adam

- Because mitochondrial DNA are transferred from the mother to her offspring unchanged, scientists can use the variation in mitochondrial DNA across modern humans to estimate a rate of mutations (one every 3,500 years) and estimate a time back to a common ancestor who lived around 200,000 years ago. Mitochondrial Eve (Haplogroup L) in Africa
- Because Y-chromosomes are transferred from father to son unchanged, we can trace our ancestry using this DNA sequence. Using a survey of Y-chromosomes from all over the world and a reconstruction of ancestral Y-chromosome DNA from reversing mutated DNA segments, we can estimate that all men had a common ancestor: Y-DNA Haplogroup A, also known as Y-chromosome Adam, is the father of all human males, and is estimated to be 254,000 ybp
- All men except Albert Perry

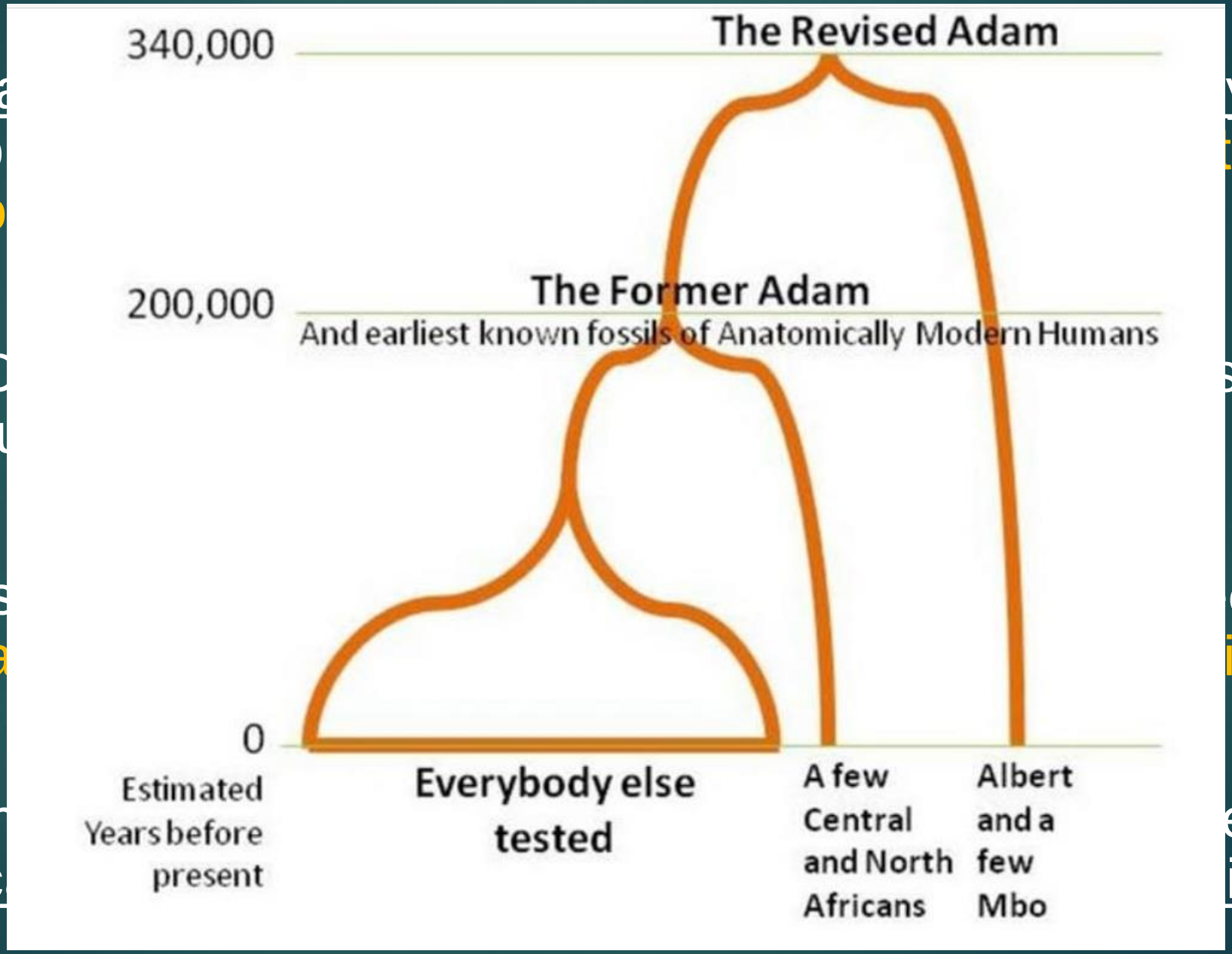


Value of doing family genealogy

- Albert Perry was an African-American, b. c 1827, who lived in South Carolina. A few years ago, one of his female relatives, Jacqueline Johnson, in 2008, submitted a sample of his descendant's DNA to a company called Family Tree DNA for genealogical analysis.
- When Family Tree DNA's technicians tried to place Perry on the Y-chromosome family tree, they just couldn't. His Y chromosome was like no other so far analyzed.
- Perry did not descend from the genetic Adam. In fact, his Y chromosome was so distinct that his male lineage probably separated from all others about 338,000 years ago. (Some debate: 208-307, concurrent with emergence of AMHs)
- Examination of an African database of nearly 6000 Y chromosomes found similarities between Perry's and those in samples taken from 11 men, all living in one village of Mbo people in Cameroon. This may indicate where in Africa Perry's ancestors hailed from.

Value of doing family genealogy

- The first a … y 195,000 years, so … t of humanity long befo…
- His is Y-D… some haplogrou…
- One poss… en inherited from an a… inct.
- If that's th… ears, anatomic… ican human.



Stone tool modes

- Mode 1: pebble core – round rock, split off flacks
- Mode 2: large cutting tools (LCT) – scaled up versions of 1, Hummer
- Mode 3: prepared cores – split off from core, broad & thin, sharp
- Mode 4: prismatic blades – long, thin narrow – stretch of version 3
- Mode 5: geometric microliths – miniaturization, tiny versions of 4; glued to shafts to make complex tools; tips of arrow
- Mode 6: ground stone tools – edges ground by abrasion, sharp cut

- But complexity of stone tools is not perfect match for complexity of toolmaker; 5 year olds can do Mode 3

Acheulean

Acheulean Tool Kit

Hand Axe

Acheulean Hand Axe

Cleaver

Acheulean: associated with *H. erectus & H. heidelbergensis*

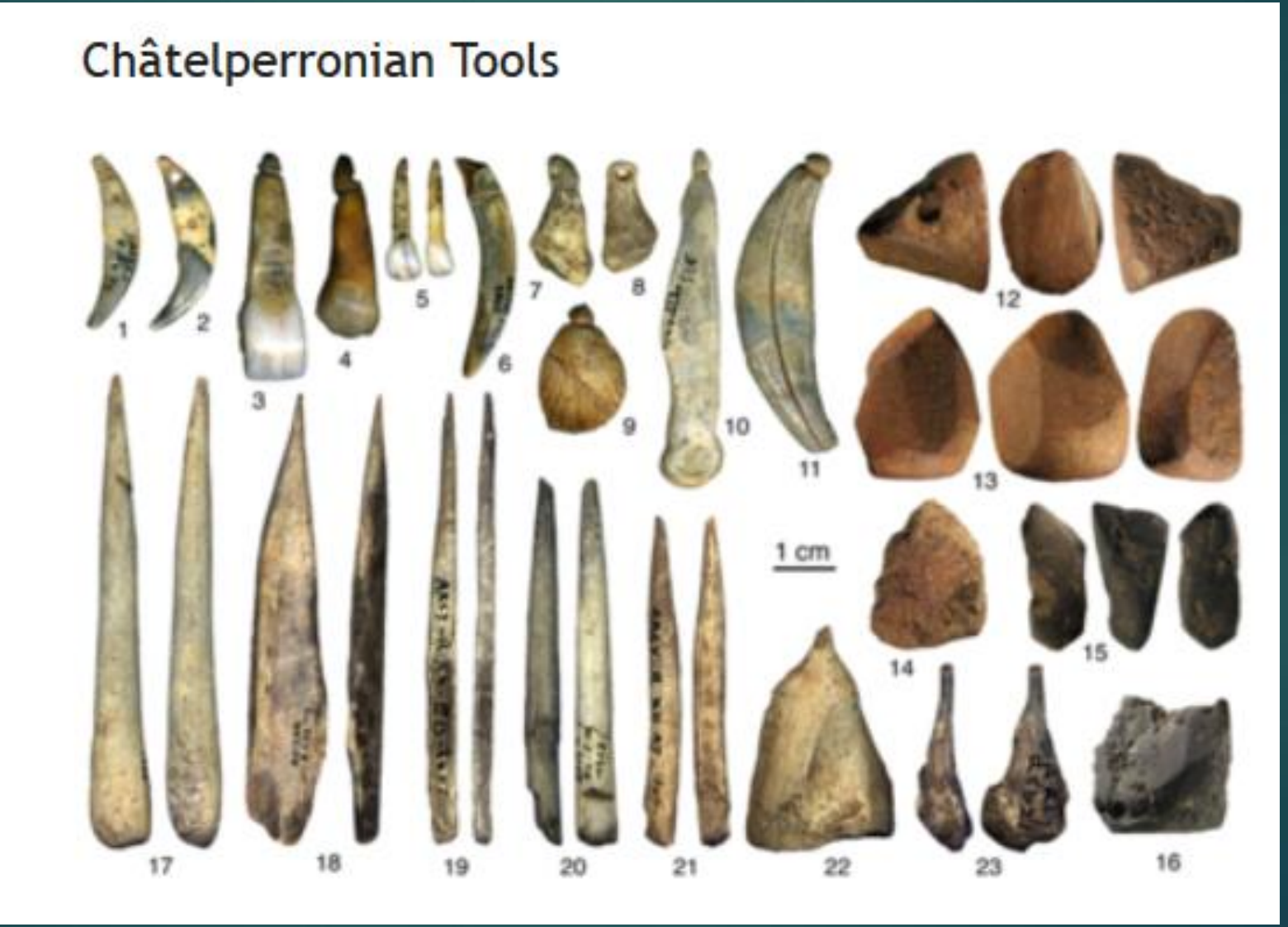
Middle Stone Age: Mode 3, prepared core, Mousterian

- The Mousterian is …of a method of stone-knapping or reduc…echnique, named after the type site in the Le…, France
- **Levallois, or prep…** the suburb in Paris where it was first recogni…paration of a rough stone core so that a num…ape could be removed.
- One of the main ir… technique," was a core that was carefully …flake of predetermined size and shape co…blow. This technique probably raised th…d predictability in stone technology.
- Middle Stone Age … which could be hafted on to shafts to make spears.

Upper Paleolithic Tools

Associated with *H. sapiens*

Châtelperronian Tools made by Neandertals



Stone Tools Origins

- Conventional wisdom in human evolutionary studies has assumed that the origins of hominin sharp-edged stone tool production were linked to the emergence of the genus *Homo* in response to climate change and the spread of savannah grasslands.
- In 1964, fossils looking more like later *Homo* than australopithecines were discovered at Olduvai Gorge (Tanzania) in association with the earliest known stone tool culture, the Oldowan, and so were assigned to the new species: *Homo habilis* or ‘handy man’.
- The premise was that our lineage alone took the cognitive leap of hitting stones together to strike off sharp flakes and that this was the foundation of our evolutionary success.

Stone Tools Origins

- Subsequent discoveries pushed back the date for the first Oldowan stone tools to 2.6 million years ago (Ma) and the earliest fossils attributable to early *Homo* to only 2.4–2.3 Ma, opening up the possibility of tool manufacture by hominins other than *Homo* before 2.6 Ma.
- The earliest known artefacts from the sites of Gona (~2.6 Ma), Hadar (2.36 Ma), and Omo (2.34 Ma) in Ethiopia, and especially Lokalalei 2C (2.34 Ma) in Kenya, demonstrate that these hominin knappers already had considerable abilities in terms of planning depth, manual dexterity and raw material selectivity.
- Cut-marked bones from Dikika, Ethiopia, dated at 3.39 Ma, has added to speculation on pre-2.6-Ma hominin stone tool use. It has been argued that percussive activities other than knapping, such as the pounding and/or battering of plant foods or bones, could have been critical components of an even earlier, as-yet-unrecognized, stage of hominin stone tool use

1.9 M & 2.4 Ma artifacts and stone tool–cutmarked bones from Ain Boucherit, Algeria

- The strongest evidence of early humans having butchered animals in North Africa

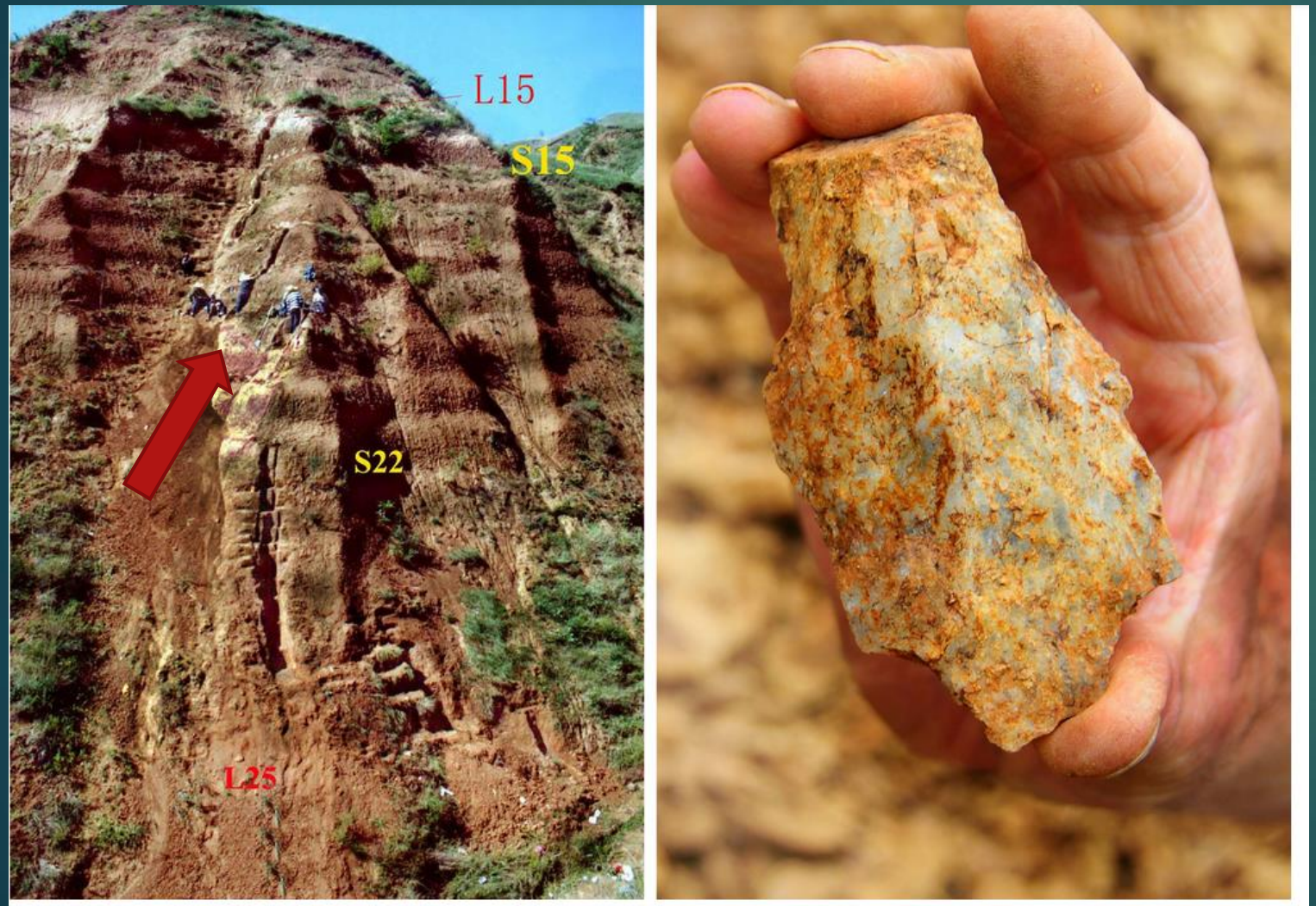
  East Africa has provided the earliest known evidence for Oldowan stone artifacts and hominin induced stone tool cutmarks dated to ~2.6 million years ago (Ma).

- New report older stone artifacts and cutmarked bones excavated from two nearby deposits at Ain Boucherit estimated to ~ 1.9 Ma, and the older to ~2.4 Ma.

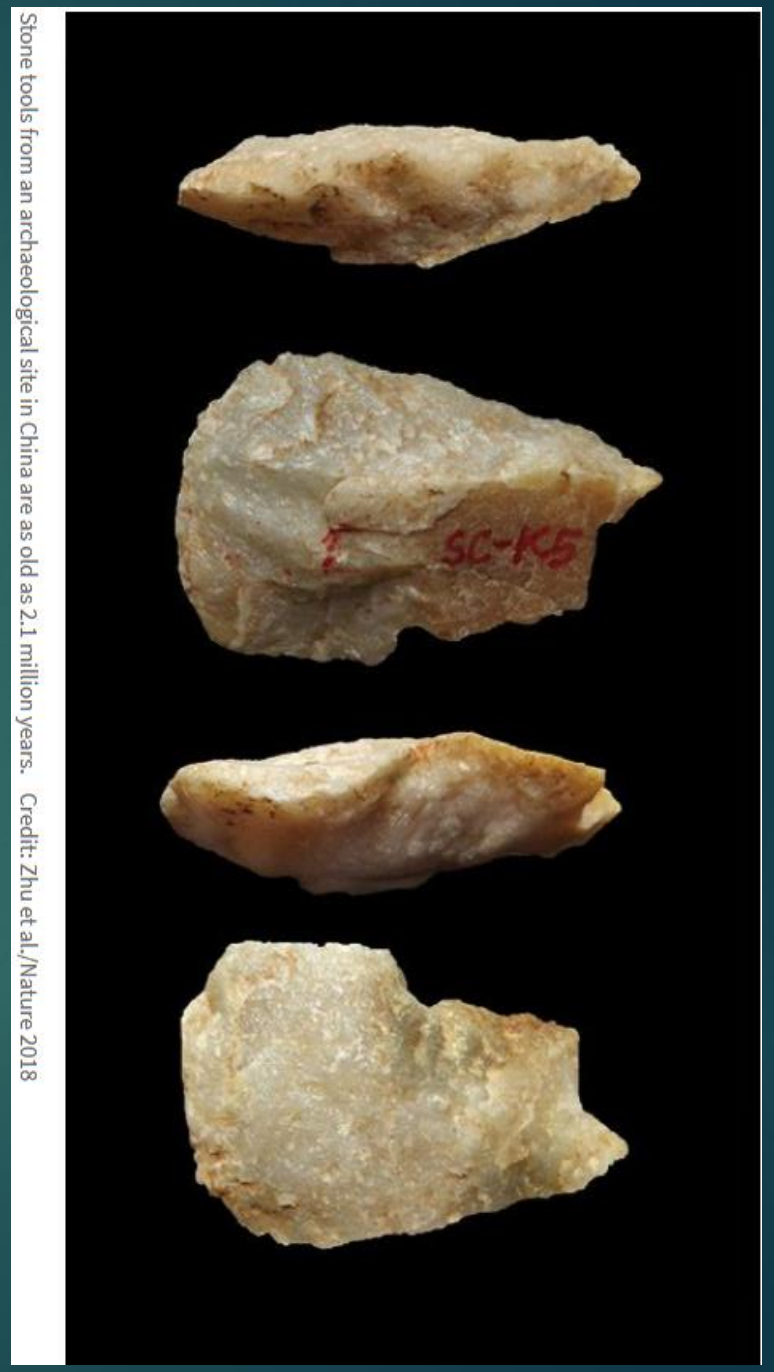
- Hence, the Ain Boucherit evidence shows that ancestral hominins inhabited the Mediterranean fringe in Northern Africa much earlier than previously thought. The evidence strongly argues for early dispersal of stone tool manufacture and use from East Africa, or a possible multiple origin scenario of stone technology in both East and North Africa.

Mohamed Sahnouni et al., 2018

July 2018: Chinese stone tools dated to 2.1 Ma; Shangchen, Lantian region, China

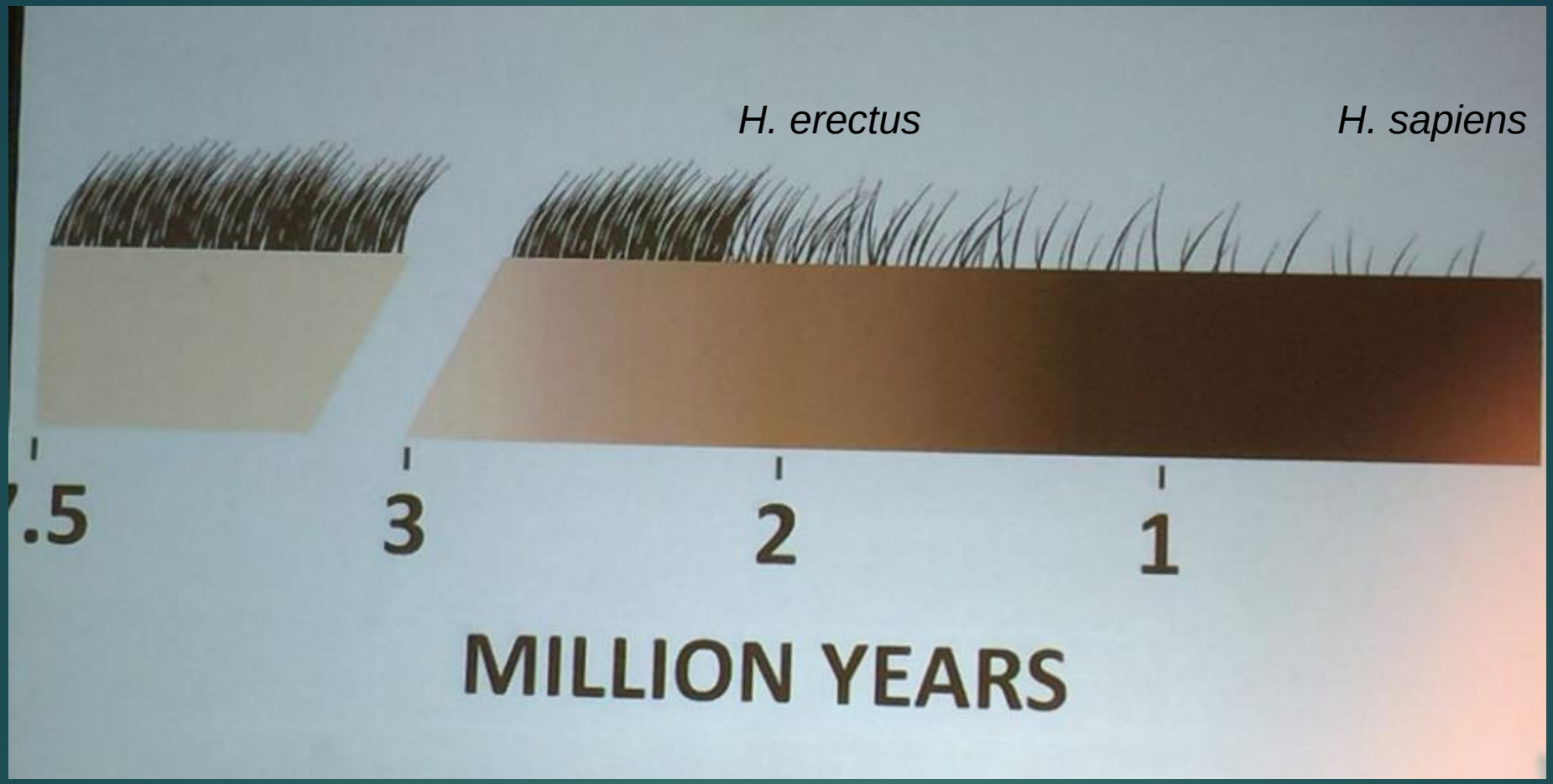


One of the 2.1 million-year-old artifacts, right, recovered from a gully in western China, left, suggest that hominins may have left Africa far earlier than previously believed. Zhaoyu Zhu



Stone tools from an archaeological site in China are as old as 2.1 million years. Credit: Zhu et al./Nature 2018

Nina Jablonski: Skin Color & Hair & Human Evolution



Light skin has only developed in Northern latitudes in last 10 Ka

Living Color: The Biological and Social Meaning of Human Skin Color by Nina Jablonski

OLLI workshop on Human Evolution: The Genus *Homo* – Discoveries since 1960

- This course will briefly review the Genus *Homo* in Human Evolution; it will focus on all the major *Homo* species, including *Homo habilis, Homo erectus, Homo neanderthalensis, Homo denisova and Homo sapiens,* as well as *Homo floresiensis and Homo naledi.* We will also review the new field of paleogenetics.

- Month 1: Review of Pre-*Homo* evolution
- Month 2: A Historical Biographical Review of Paleoanthropology from 1960 to present
- Month 3: *Homo habilis*
- Month 4: *Homo erectus*
- Month 5*: Homo heidelbergensis*
- Month 6: *Homo neanderthalensis 1*
- Month 7*: Homo neanderthalensis, Homo Denisova 2*
- Month 8: *Homo floresiensis*
- Month 9: *Homo naledi*
- Month 10: *Homo sapiens*
- Month 11: Dec 25 - No class
- Month 12: Evolution of the human brain
- Month 13: Paleogenetics 1
- Month 14: Paleogenetics 2

Downloads

- www.charlesjvellaphd.com
- Lecture Pdfs in:
  - 2018 OLLI: Human Evolution: The First 150 Years of Discovery