What's New in Hominid Evolution

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SEPTEMBER 28, 2015

Tinkering with Wikipedia's science pages

Wikipedia article	Maximum daily edits	Average words changed per day
Global warming	231	111
Evolution	89	142
Continental drift	19	24
General relativity	37	20

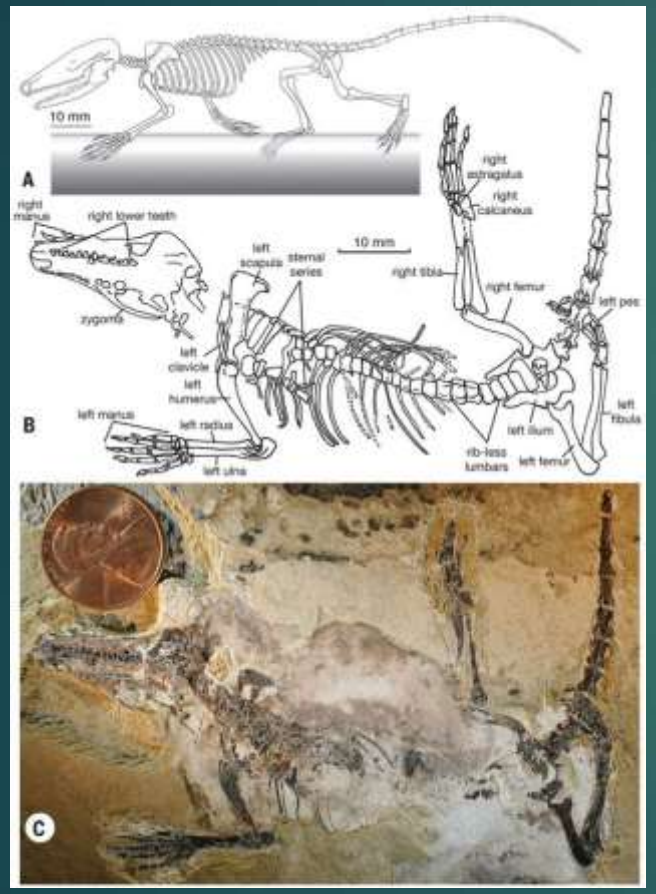
SOURCE: A.M. WILSON AND G.E. LIKENS/*PLOS ONE* 2015

EDIT WARS Wikipedia science articles on politically charged topics get edited more frequently and more extensively than articles on less partisan subjects.

Wikipedia Article	Mean Daily Page Views ± SD[a]	Maximum daily edits[b]	Edits per day geometric mean ± SD (n) [b,c]	Words changed per Day geometric mean±SD (n) [b,d]
Acid_rain	2 954 ± 1 310	26	0.5±2.0 (3307)	36.2±10.2 (1103)
Global_warming	15 549 ± 6 897	231	1.9±2.7 (3307)	110.9±10.3 (2211)
Evolution	6 260 ± 2 450	89	1.3±2.5 (3307)	142.3±22.9 (1867)
Continental_drift	1 335 ± 641	19	0.3±1.7 (3307)	23.6±7.8 (844)
Heliocentrism	1 026 ± 564	20	0.3±1.6 (3307)	25.2±8.6 (818)
General_relativity	2 060 ± 1 443	37	0.4±1.7 (3307)	19.7±7.8 (1107)
Standard_model	1 202 ± 2 792	25	0.2±1.4 (3307)	9.4±5.0 (575)

[a] "Mean Daily Page Views" from http://toolserver.org/~emw/wikistats/ were only available after 2008-01-01 and include programmatic page requests.

Oldest fossil mammal: 165 MYA – mother of us all



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

Australopithecines: A 2 Million year span of existence

- Genus Australopithecus had six, maybe seven species in it, depending on who you believe.
- Now that is an astonishingly successful genus as far as evolution goes.
- The oldest yet found is *A. anamensis*, which is more than 4m years old.
- The youngest is *A. sediba* which is about 1.9m years old.
- That’s a life span of nearly two million years between these species.

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

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

Yohannes Haile-Selassie, et al., 2015

Ethiopian Jaw Bone (LD 350-1): 2.8 M – oldest genus *Homo*

- Jaw bone fossil discovered in Ethiopia is oldest known human lineage remains
- Around 400,000 years older than previous discovery of homo lineage, 2.8m-year-old jaw and five teeth was found on rocky slope in Afar region, at a site called Ledi-Geraru, 40 miles from where Lucy was found.
- The picture that emerges from the fossil record is that 3m years ago, the ape-like *Australopithecus afarensis* died out and was superseded by two very different human forms. One, called *Paranthropus*, had a small brain, large teeth and strong jaw muscles for chewing its food. The other was the *Homo* lineage, which found itself with much larger brains, a solution that turned out to be more successful.

LD 350-1 mandible

Villmoare, et al., 2015

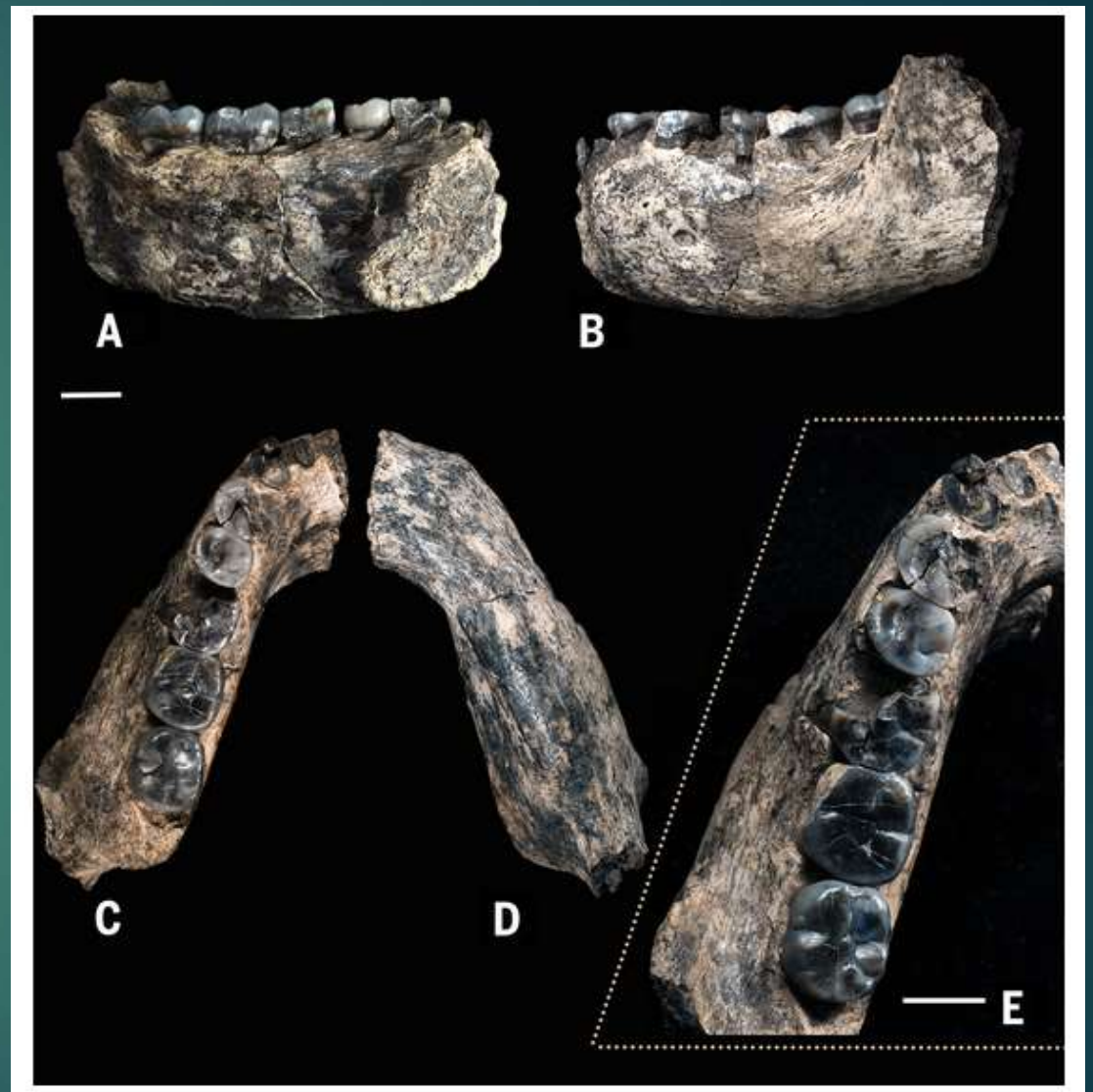
Ledi-Geraru LD 350-1 mandible: 2.8 MYA

Teeth becoming more slender than in A. afarensis.

It is the face; it's the way the jaws are built.

Leading edge of the origin of the genus *Homo* was our teeth, not brain.

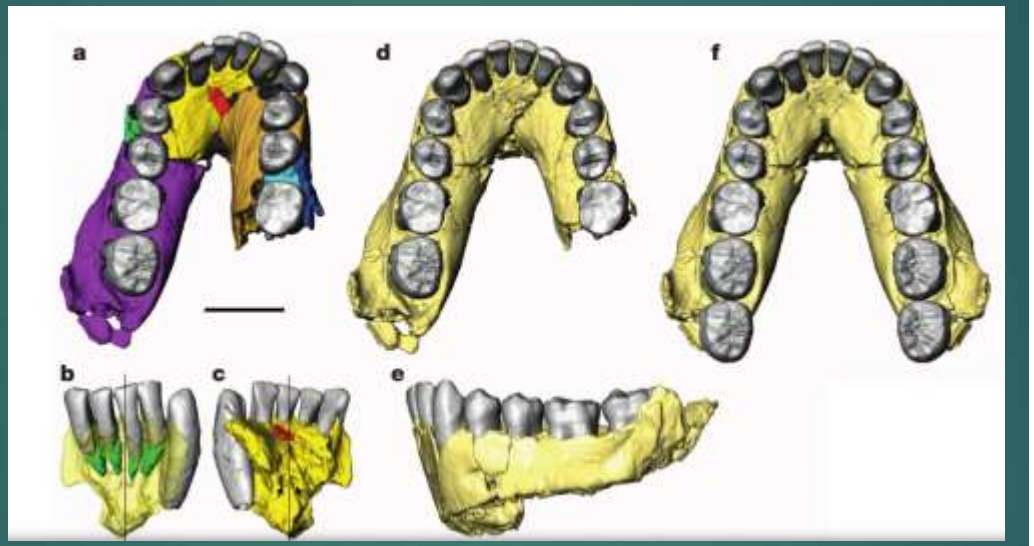
Theory: You don't need big jaws and teeth if you have stone tools to process food

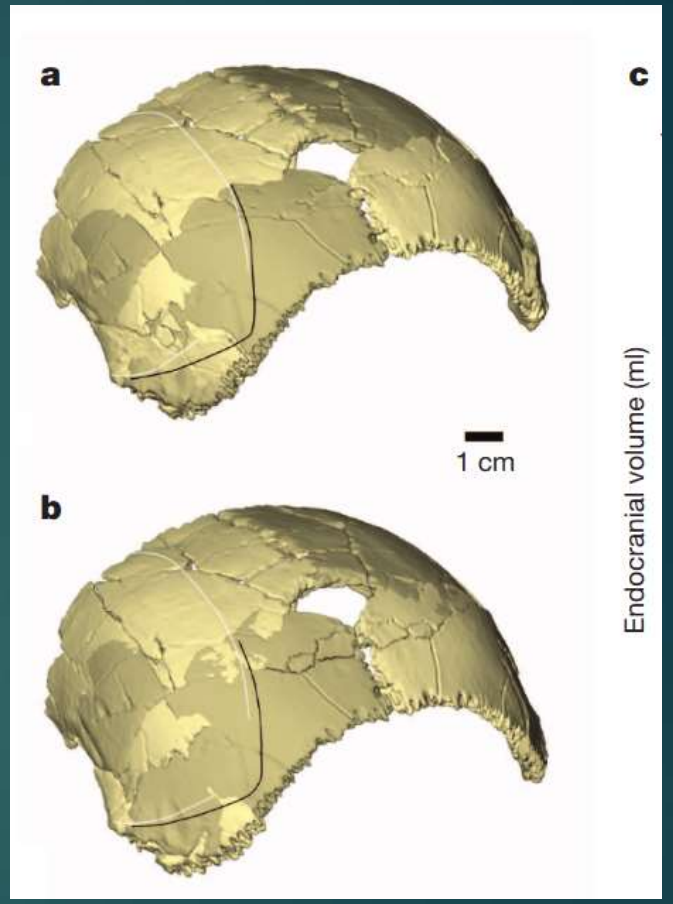


Five views of the fossilized jawbone highlight teeth that are becoming more slender, scientists say, relative to the blocky, more apelike teeth of *Australopithecus*.

New digital reconstruction of *Homo habilis,* OH 7, 1.8 MYA

Cranial size of 729-824 ml



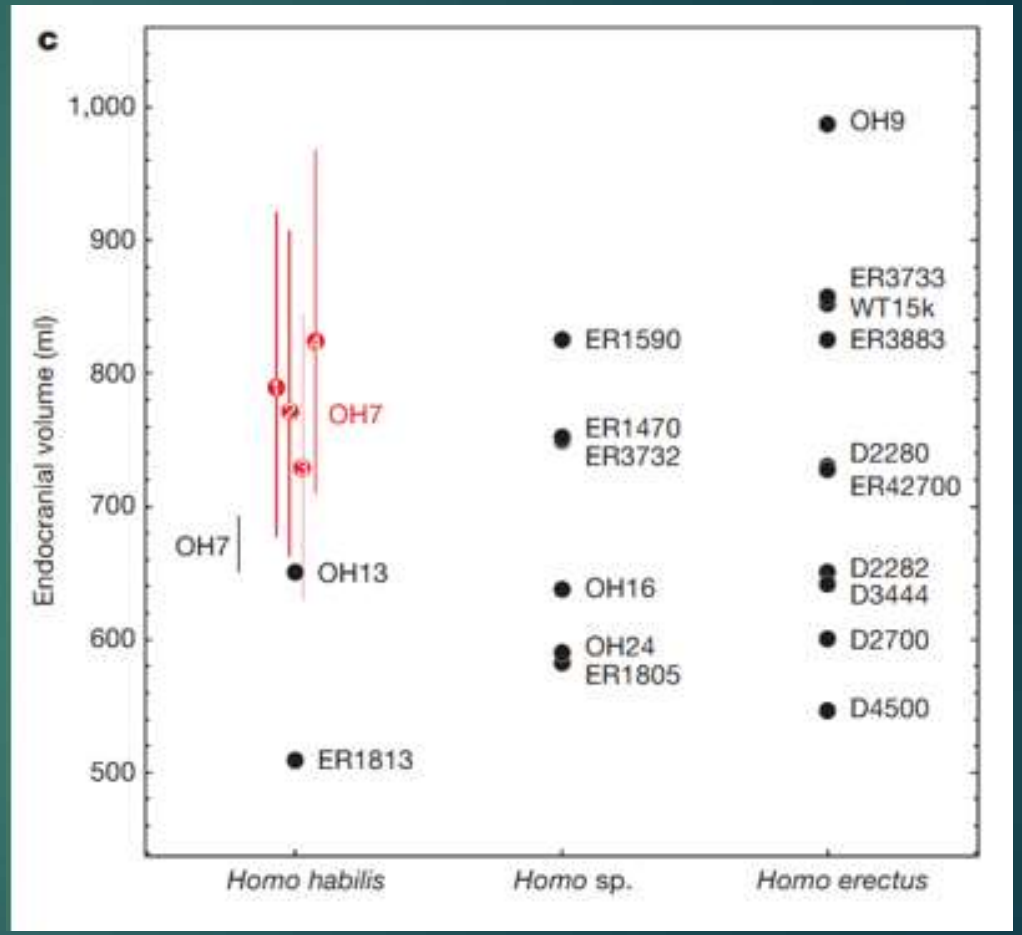


Mandible is remarkably primitive; more similar to *A. afarensis* than to parabolic jaw of *Homo erectus*
Not consistent with any single species of early *Homo, including Homo rudolfensis;* implies origin of Homo species before 2.3 MYA; parietal lobe reconstruction implies

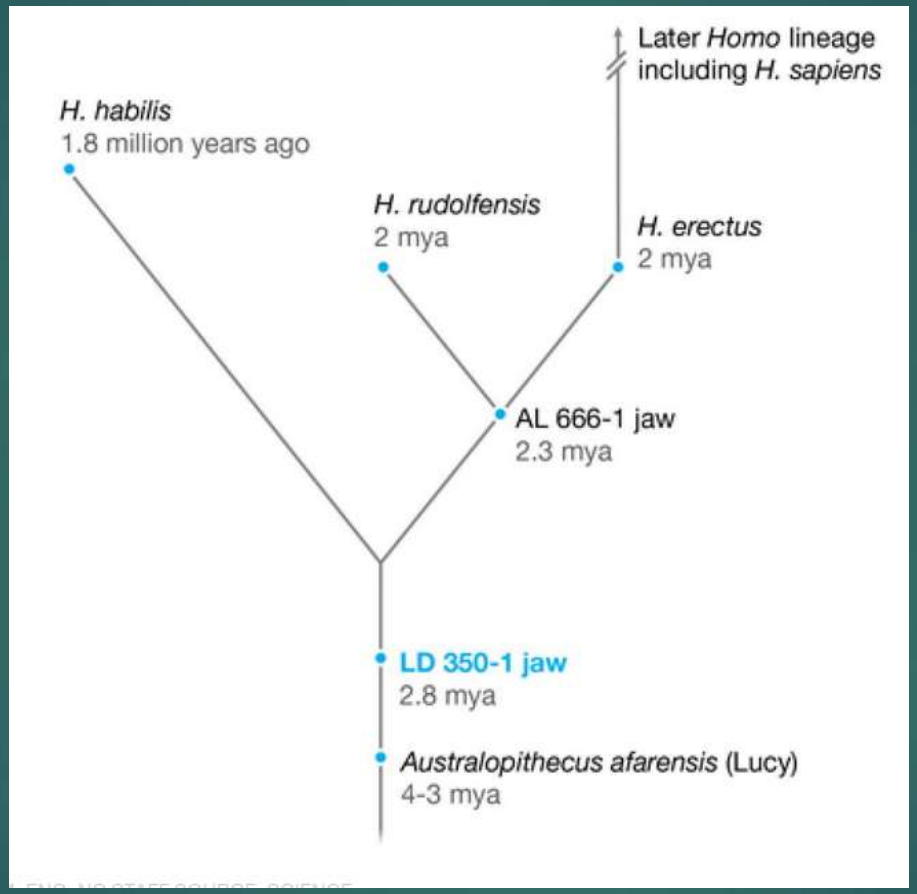
F. Spoor, et al., 2015

It was face protrusion, not brain capacity, that differentiated early *Homo*

- Implication that cranial capacity of *Homo habilis, Homo rudolfensis, and Homo erectus*, who were alive between 2.1 and 1.5 MYA, were all within the range of 500-900 ml.
- Early *Homo* characterized more by facial morphology (gnathic diversity) than by cranial size difference.



Possible lineage



"The Ledi-Geraru jaw has turned up as if 'on request,' suggesting a plausible evolutionary link between *Australopithecus afarensis* and *Homo habilis*," says Spoor.

Language-competent bonobo-chimpanzees Kanzi and Pan-Banisha: Apes produce and use tools

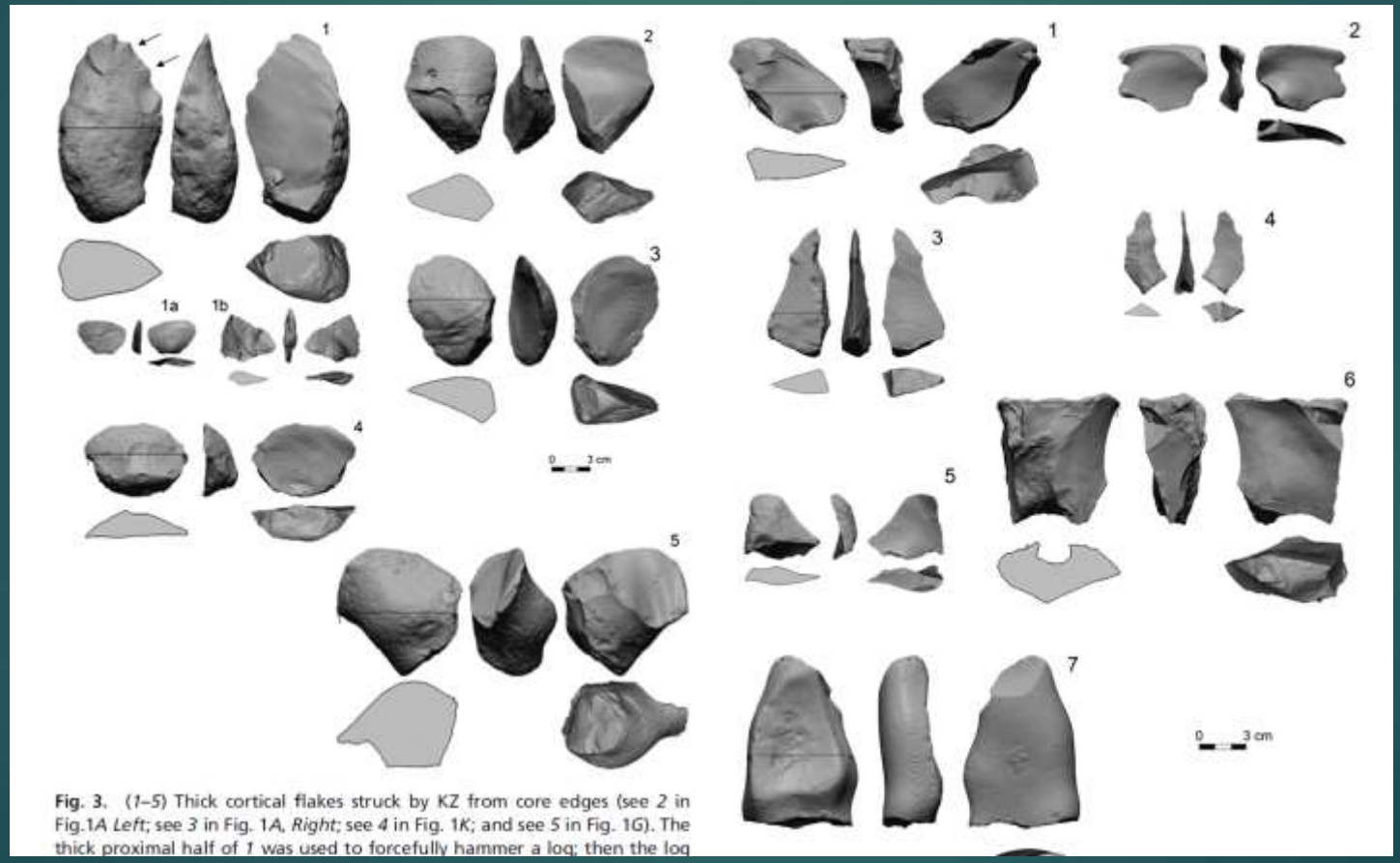


Fig. 3. (*1–5*) Thick cortical flakes struck by KZ from core edges (see *2* in Fig.1*A Left*; see *3* in Fig. 1*A, Right;* see *4* in Fig. 1*K;* and see *5* in Fig. 1*G*). The thick proximal half of *1* was used to forcefully hammer a log; then the log

Table 1. List of types of tool use in Taï chimpanzees observed during a 9-year period

Tool-use activity	Tool-use aim	Number of observations	Tool material	Tool size in cm: length (range) thickness (range)	Number of tools used (number of tools made)
(1) Insert	ant dipping	20	twigs; (n = 28)	23.9 cm (58–11) 5.7 mm (3–10)	35 (34)
	wood-boring bee killing	6	twigs; (n = 3)	29.0 cm (29) 7.3 mm (7–8)	11 (11)
	honey fishing	15	twigs; (n = 42)	28.1 cm (60–14) 7.8 mm (3–18)	45 (45)
	bone marrow extraction	33	leaf stem, twigs; (n = 24)	14.4 cm (5–35) 4.0 mm (2–7)	51 (50)
	brain eating	1	twigs		1 (1)
	eye eating	1	twigs		3 (3)
	nut emptying	93	twigs; (n = 91)	15.4 cm (4–80) 4.1 mm (2–9)	196 (172)
(2) Probe	wood boring bee nests	6	leaf stem, twigs; (n = 7)	14.8 cm (10–22) 4.8 mm (4–6)	11 (10)
	corpses	4	twigs		4 (0)
	wounds	1	twigs		1 (1)
	bark interstice	1	twigs		2 (2)
	other objects	3	twigs		3 (1)
(3) Clean	sponging	12	leaves		12 (12)
(4) Display	aimed throwing	6	branches		16 (2)
	throwing	3	branches		13 (1)
	dragging	7	branches		12 (0)
	hitting	4	branches		4 (0)
(5) Pound	nuts	932	clubs, stones; (n = 719)	clubs = 81% stones = 19%	1,037 (85)[1]

Chimps make & use tools, esp. for pounding nuts

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 1.85mya
- The Oldowan, Mode 1 type

(Toth & Schick, 2013).

Dmanisi, Georgia

- Oldowan tools at 1.8 My found in 1984 at Dmanisi, Georgia associated with *H. erectus*

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

No hominid 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.

Oldowan stone tools are simply the oldest evidence for material culture in the archaeological record.

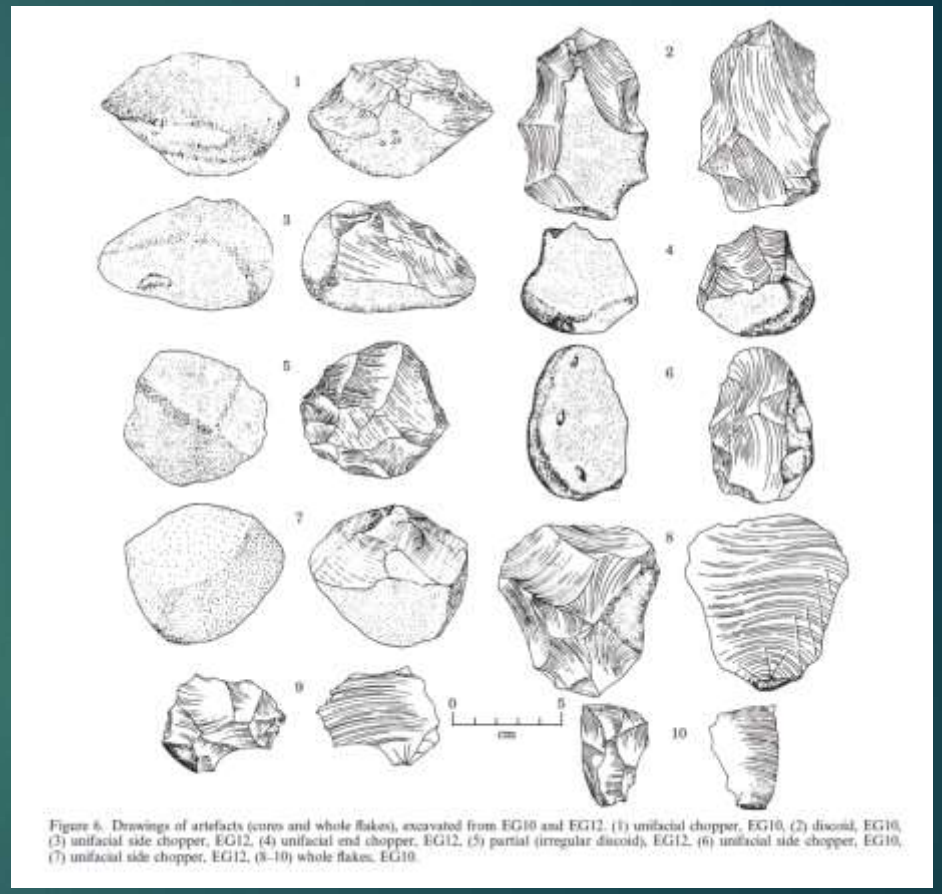


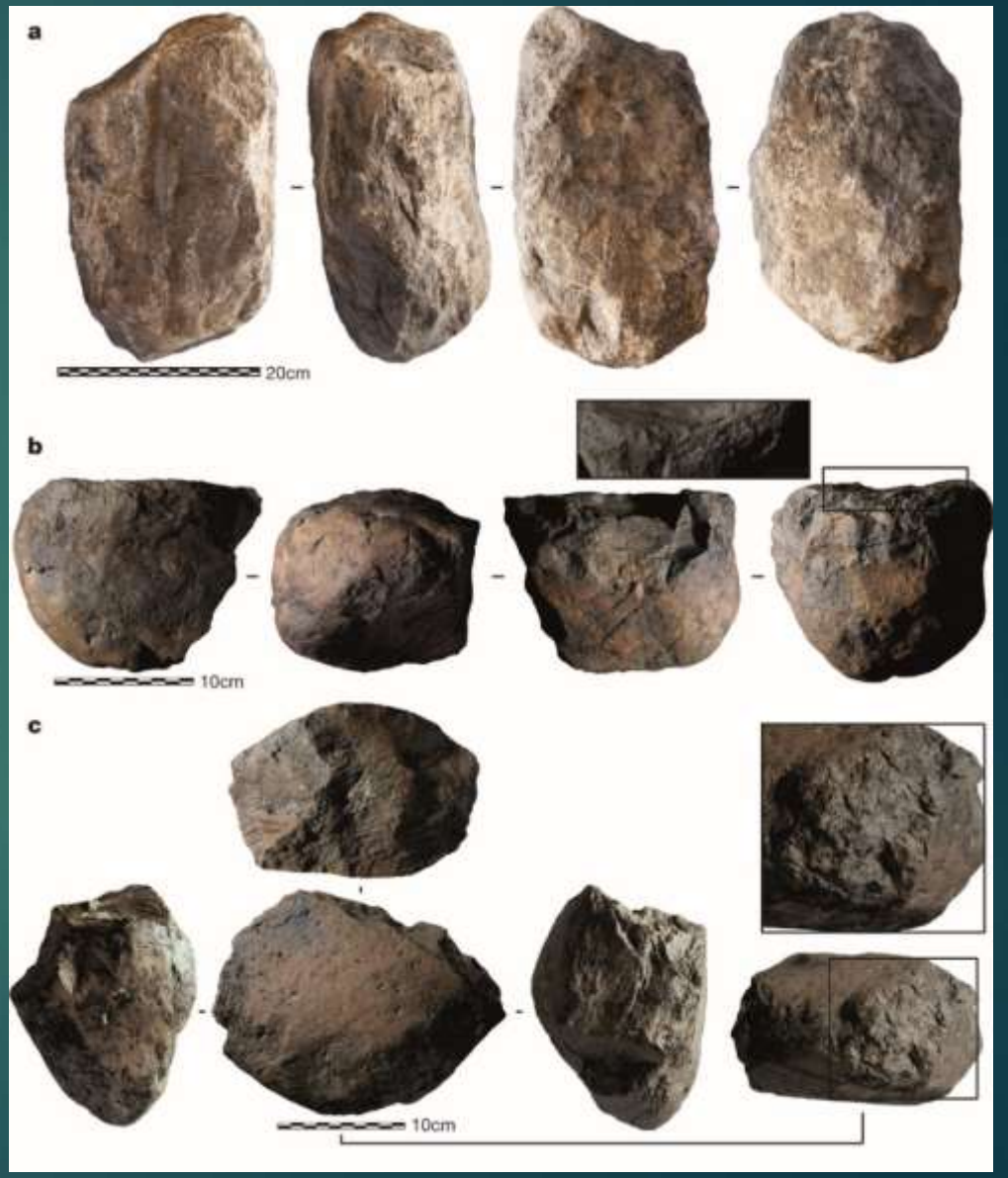
Figure 6. Drawings of artefacts (cores and whole flakes), excavated from EG10 and EG12. (1) unifacial chopper, EG10, (2) discoid, EG10, (3) unifacial side chopper, EG12, (4) unifacial end chopper, EG12, (5) partial (irregular discoid), EG12, (6) unifacial side chopper, EG10, (7) unifacial side chopper,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

Sileshi Semaw et al. 1997 & 2000

Now 3.3 MY old stone tools: Lomekwian

The recent discovery of stone tools, dated at 3.3 MYA, 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

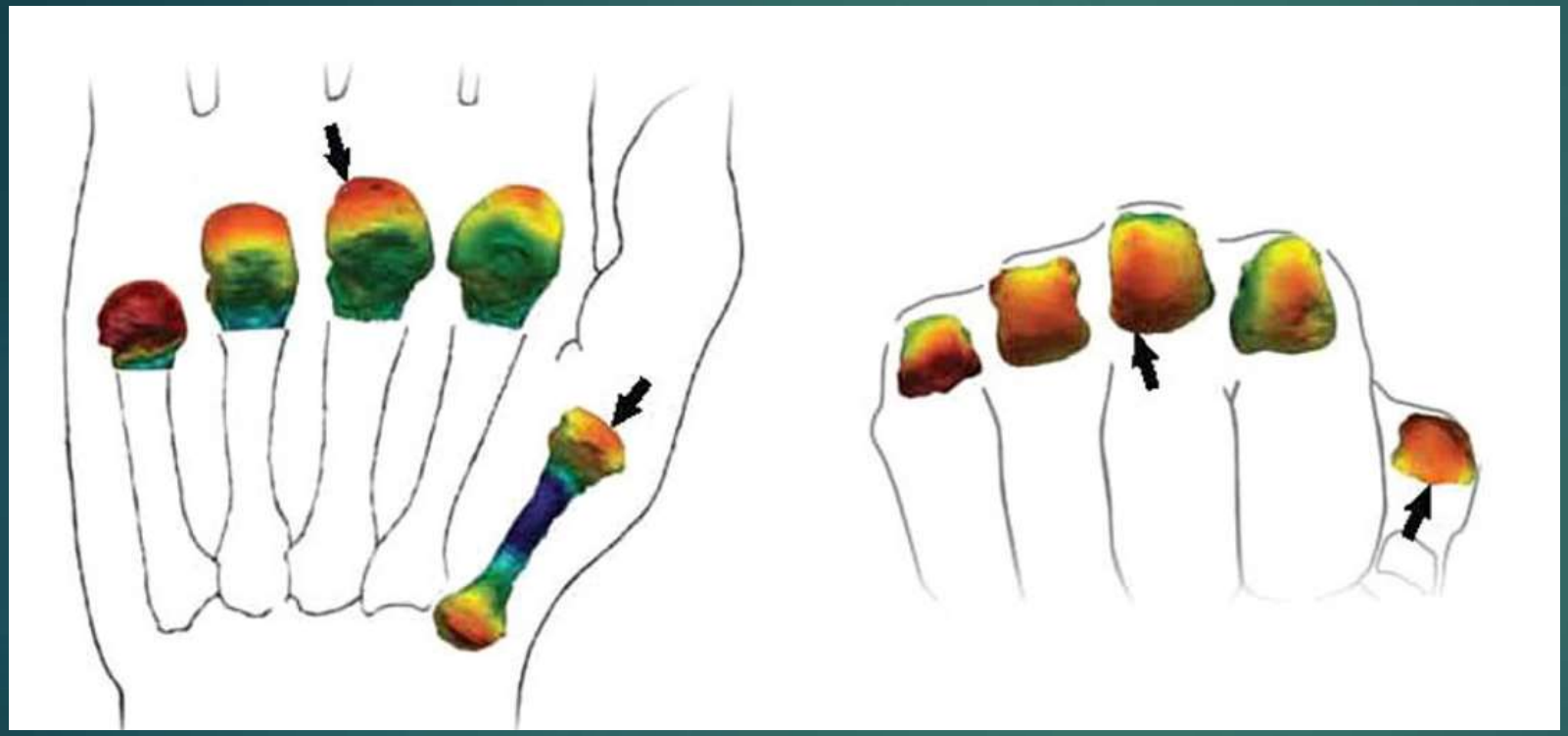


Who made the first stone tools?

Was it *Homo habilis*? Or the Australopithecines?

- Now we have the Lomekwian stone tools at 3.3 MYA.
- There are also contested cut marks from stone tools on bones dated at 3.4m years ago at Dikika in Ethiopia (Zeray'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.*

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



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

M.M. Skinner et al/*Science* Vol. 347, issue 6220 (2015)

Did *Australopithecus afarensis* carve meat?

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

Dikika cut bone: tools at 3.3 MYA

- *Nature* 2010 study by *Zeresenay Alemseged* reported bones exhibiting cut marks consistent with stone tools dating to 3.3 m years in the Lower Awash locality of Dikika, Ethiopia. This would have pushed back the age of stone tool use at that time by 800,000 years.
- Critics said that other factors, such as trampling by herbivores, could have been responsible for the observed damage to the bones.
- There were 12 marks on the two specimens -- a long bone from a creature the size of a medium antelope and a rib bone from an animal closer in size to a buffalo.
- Unambiguous association with *A. afarensis,* the only hominid of this period
- No hominin remains were found with the animal bone fragments that were uncovered 200 meters away from the site where Alemseged and a team discovered “Selam” (Lucy’s baby) in 2000.

2015 studies confirms Zeray's butchery theory at 3.4 MYA

- Analysis supports a previous finding, that the best match for the marks is butchery by stone tools (most closely resemble a combination of purposeful cutting and percussion marks, with tremendous force)
- Marks on two 3.4 million-year-old animal bones found at the site of Dikika, Ethiopia, were not caused by trampling, an extensive statistical analysis confirms.
- Jessica Thompson: Zeresenay Alemseged was correct
- Extensive statistical analysis in The *Journal of Human Evolution;* which developed new methods of fieldwork and analysis: examined the surfaces of a sample of more than 4000 other bones from the same deposits. Investigated with microscopic scrutiny all non-hominin fossils collected from the Hadar Formation at Dikika. They then used statistical methods to compare more than 450 marks found on those bones. Even investigated the angularity of sand grains at the site (round, not angular). Trample marks tend to be shallow, sinuous or curvy. Purposeful cuts from a tool tend to be straight and create a narrow V-shaped groove, while a tooth tends to make a U-shaped groove.

Jessica C. Thompson, et al., 2015

Dikika: When did we start eating meat?

- Dikika cut bones are from the same sediments and only slightly older than the 3.3-million-year-old fossils unearthed from Dikika belonging to the hominid species *Australopithecus afarensis*.
- "Our analysis shows with statistical certainty that the marks on the two bones in question were not caused by trampling," Thompson says. The surface modification data show that no marks on any other fossils resemble in size or shape those on the two specimens from DIK-55 that were interpreted to bear stone tool inflicted damage

Earliest modern human-like hand bone from a new >1.84-million-year-old site at Olduvai in Tanzania

OLD BUT MODERN A newly discovered hominid finger bone dating to at least 1.84 million years ago is shown from two sides (right) and overlaid on a modern human hand (left). A team of scientists regards the fossil as the oldest known humanlike hand bone.

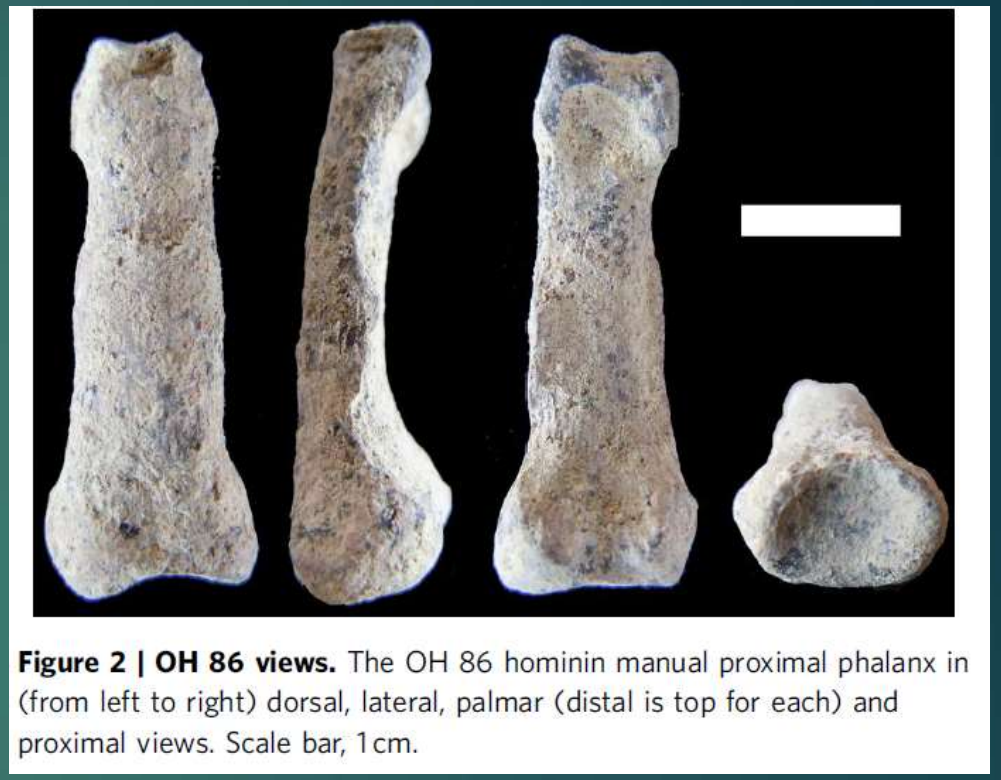


Figure 2 | OH 86 views. The OH 86 hominin manual proximal phalanx in (from left to right) dorsal, lateral, palmar (distal is top for each) and proximal views. Scale bar, 1 cm.

From little finger of left hand; found at Tanzania's Olduvai Gorge, pinkie bone is 1.84 million years old; looks more like corresponding bones of modern humans than like finger fossils of previously discovered Olduvai hominids; new finger fossil is more humanlike than comparably ancient Olduvai hand fossils from *Homo habilis* and *Paranthropus boisei*; entire hand probably looked humanlike; tool making capability; could come from a number of species that were around at the time, including *Homo erectus (*Acheulean tools show up soon after at 1.7M*)*.

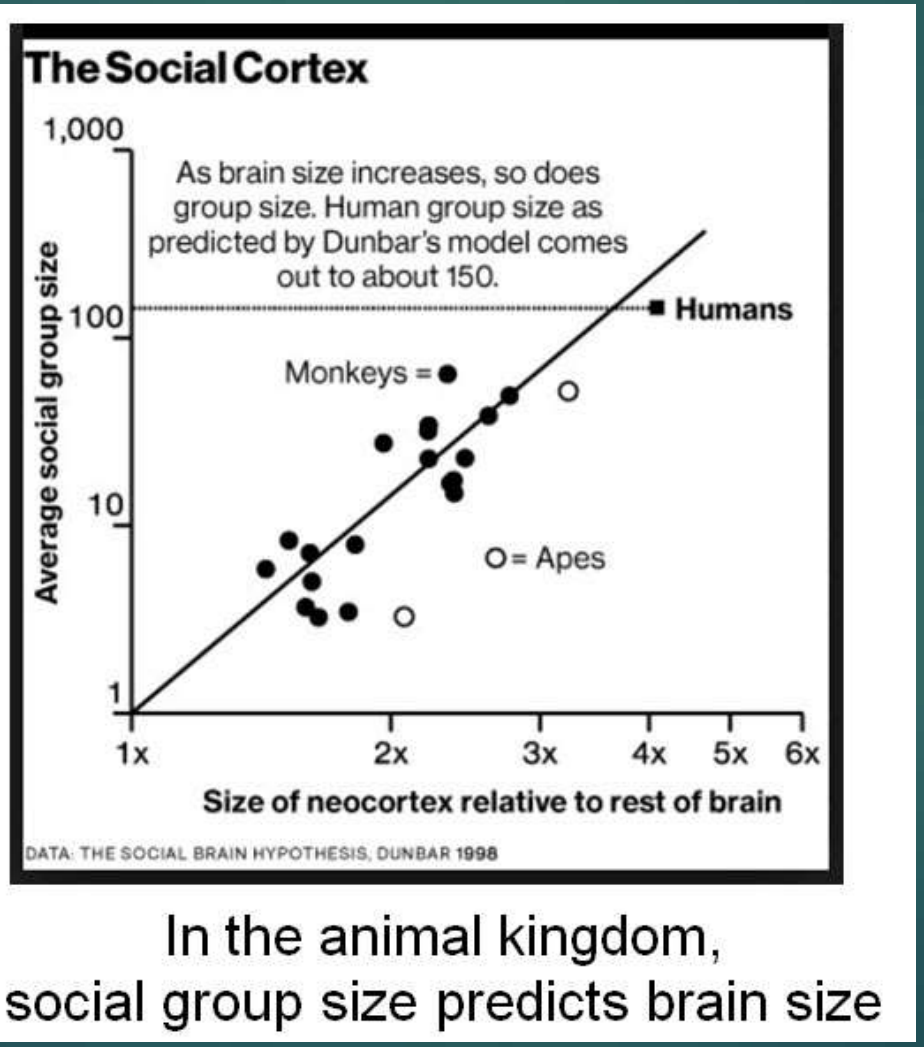
Manuel Domínguez-Rodrigo, et al., 2015

Earliest modern human-like finger bone ever found - - Phalangeal curvature comparison

Figure 4 | Phalangeal curvature in extant and fossil hominoids. (**a**) Included angle values (in degrees) in a modern and fossil sample of fifth proximal phalanges. OH 86 is (exclusively) within the modern human variation (distinct from australopiths). Boxes represent 25th and 75th percentiles, centreline is the median, whiskers represent non-outlier range and the dot is an outlier. Samples for each boxplot are *Homo sapiens* ($n = 36$), *Pan paniscus* ($n = 8$), *Pan troglodytes* ($n = 16$), *Gorilla* ($n = 22$), *Pongo* ($n = 16$) and Hylobatidae ($n = 22$). (**b**) The fossil hominin specimens analysed in this study are compared in lateral view. All pictures were taken from the originals with the exception of AL333-62 (cast) and ATE9-2 (modified from the literature[56]; Supplementary Table 4). Scale bar, 1cm.

Collectively, these results lead to the conclusion that OH 86 represents a hominin species different from the taxon represented by OH 7, and whose closest form affinities are to modern H. sapiens. However, the geological age of OH 86 obviously precludes its assignment to H. sapiens, and ambiguity surrounding the existing potential sample African H. erectus (sensu lato) hand bones also prohibits its confident assignment to that species at this time. Conclusion: Just <2Ma at least one East African hominin taxon/lineage showed marked reduction in manual phalangeal arboreal adaptations (as reflected by the proximal phalanx curvature and flexor sheath ridges development in the shaft), along with the concomitant expression of an overall MHL phalangeal morphology (as far as it is possible to infer from a single phalanx)

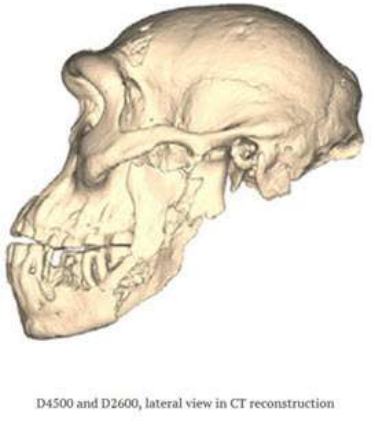
Social group size predicts neocortex size

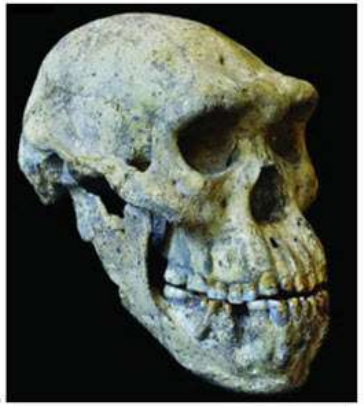


In the animal kingdom,
social group size predicts brain size

Dmanisi, Georgia

Dmanisi, Georgia
Earliest known hominid site outside of Africa, 1.8M





Skull D4500. Credit: Guram Bumbiashvili, Georgian National Museum

D4500, *Homo erectus*, Dmanisi:
Most perfectly preserved hominid skull

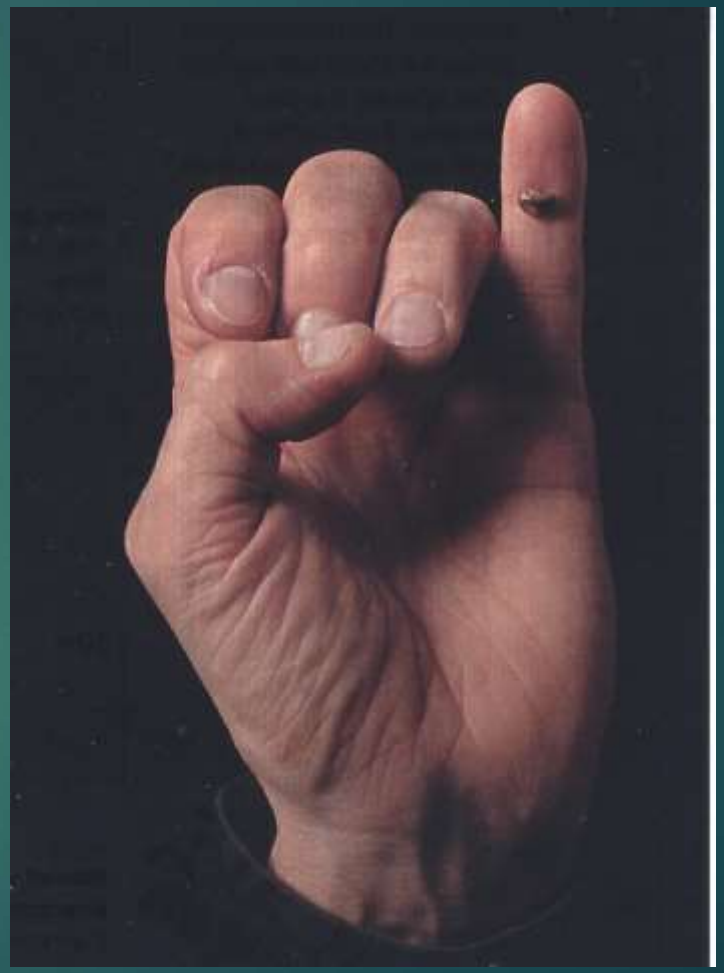
Old Man of Dmanisi survived losing all of his teeth
By at least 4 years (bone regrew): implies social empathy and caregiving 1.8 MYA

Old Man of Dmanisi,
Evidence of Empathy at 1.8 M

Denisova Cave, Siberia

2008: X Woman (girl), 63-83 T yo

Pinkie bone, 30-48K, Denisova cave



Paabo’s hand & bone
Laid around in lab for 1 year

2010: Homo Denisova

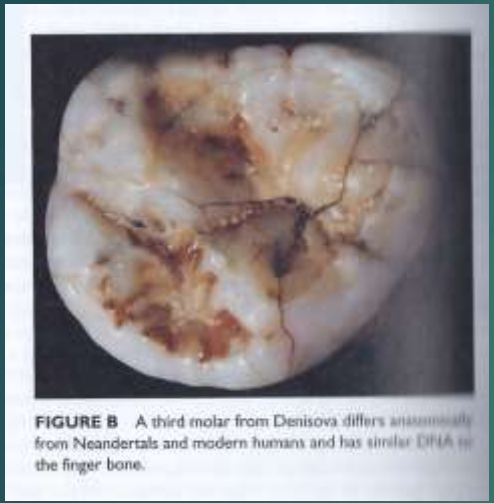
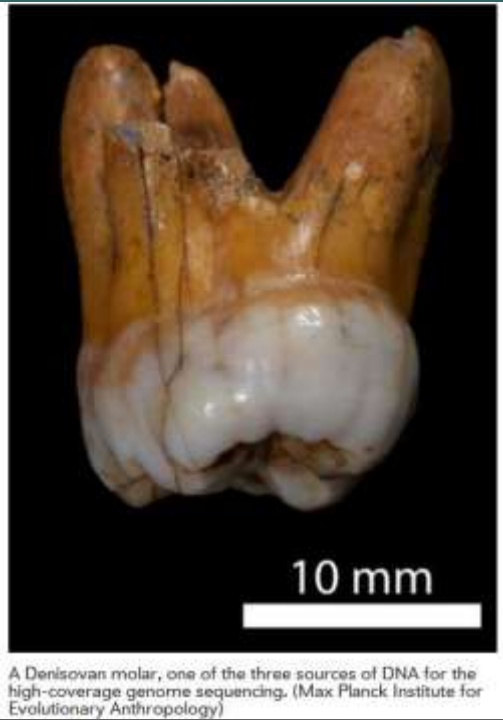


FIGURE B A third molar from Denisova differs anatomically from Neandertals and modern humans and has similar DNA to the finger bone.



A Denisovan molar, one of the three sources of DNA for the high-coverage genome sequencing. (Max Planck Institute for Evolutionary Anthropology)

FRAGMENT OF A FINGER: This replica of the Denisovan finger bone shows just how small of a sample the researchers had to extract DNA from. *Image: Image courtesy of Max Planck Institute for Evolutionary Anthropology*

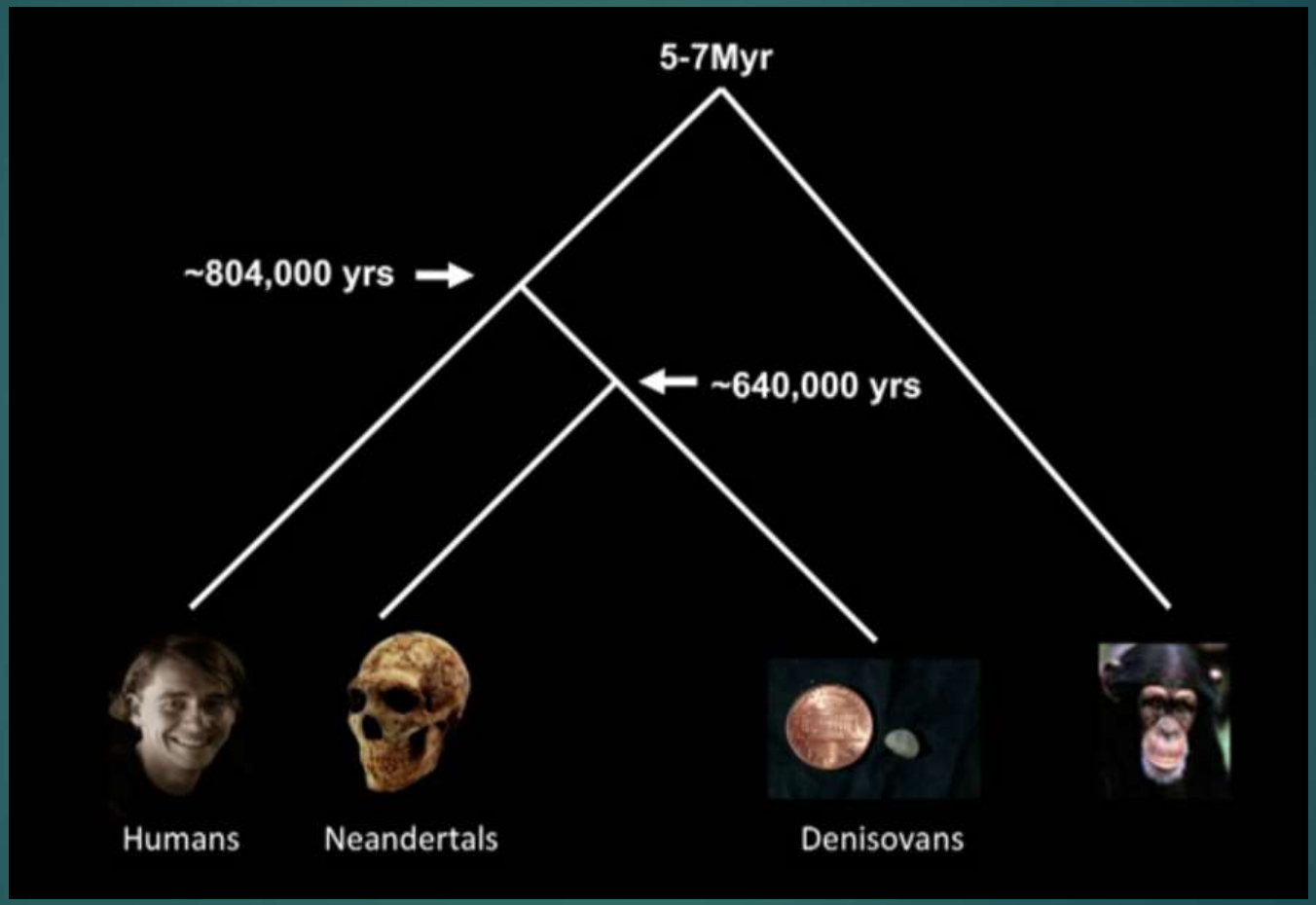
Pinkie Bone, 30-48K,
Denisova Cave

Krause et al. 2010: When the mitochondrial DNA of the bone was sequenced in 2010 however, it belonged neither to a Neandertal nor to a modern human. A new species, *Homo denisova*

Denisovans

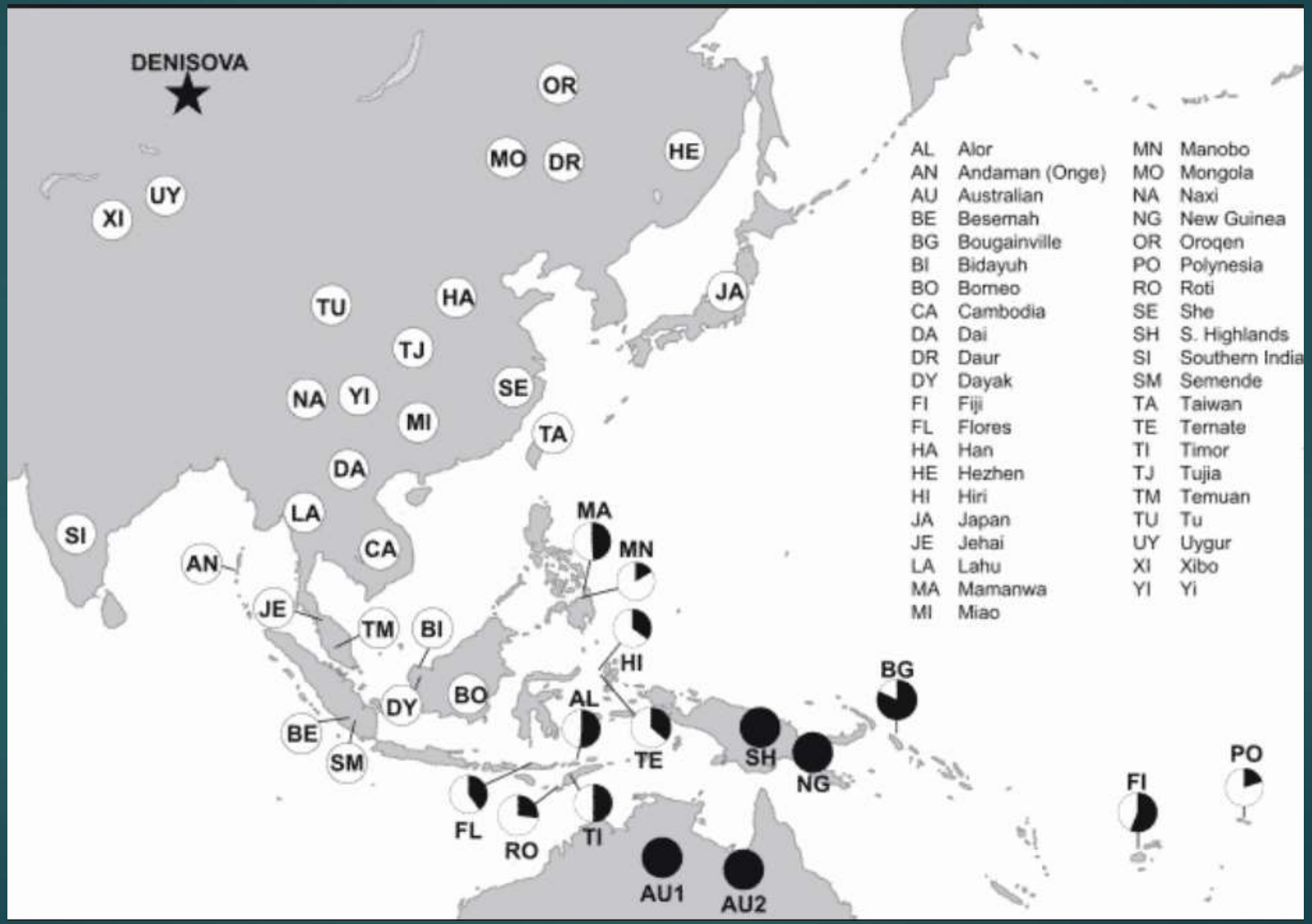
- Result of an earlier migration out of Africa, distinct from the earlier out-of-Africa of *H. erectus* and later migrations associated with modern humans,
- They ranged from Spain to Siberia to Southeast Asia.
- 3% to 6% of the DNA of Pacific Islanders and Aboriginal Australians deriving from Denisovans.
- DNA shows they had dark skin, brown hair and brown eyes

2014: Time to Common Ancestor of 3 hominids: ~804 KYA

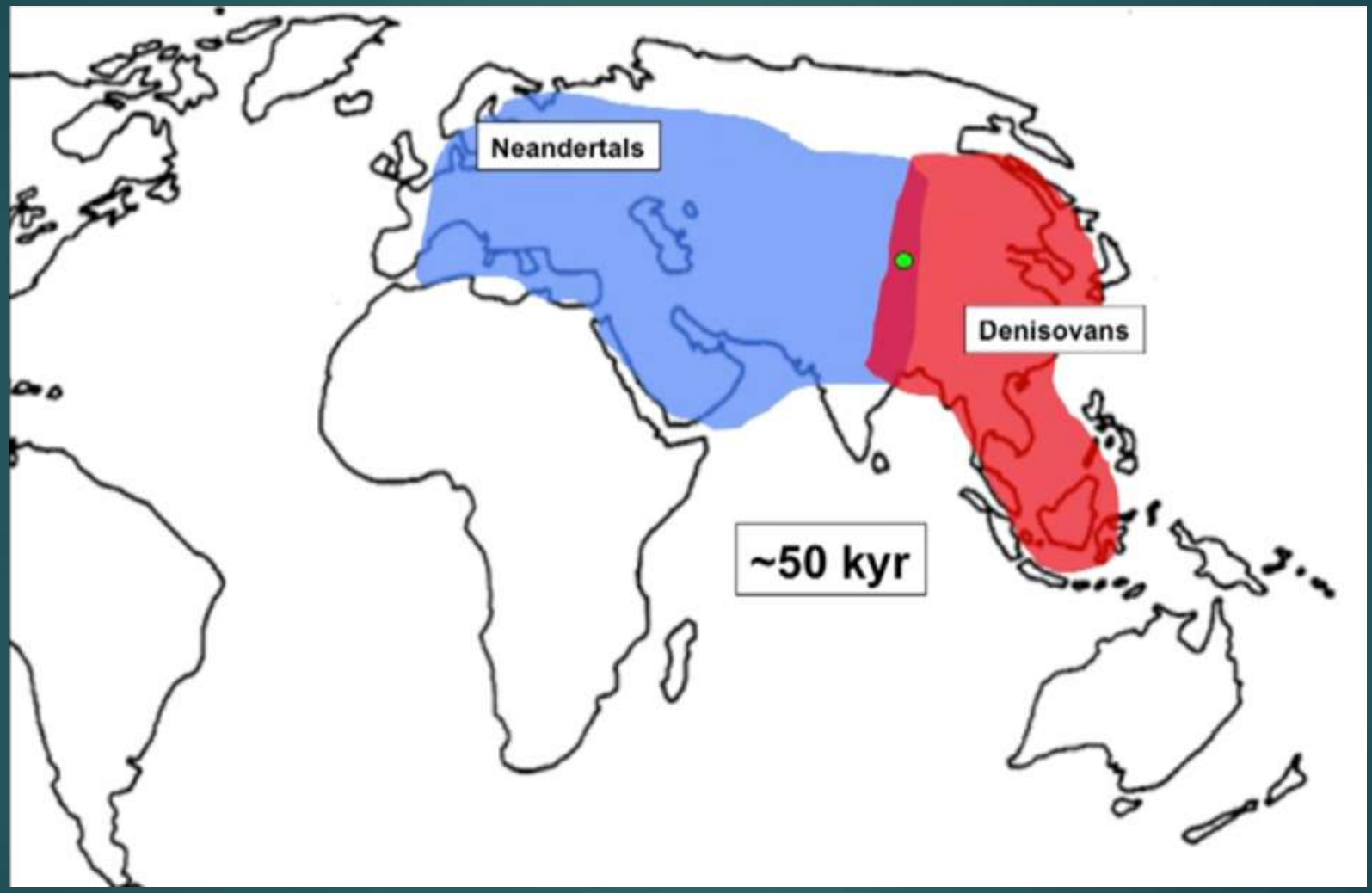


- Denisovans related to both N and MH; both N & D had long independent histories; genetic diversity in these archaic hominins was extremely low

Spread of Denisovans: China to Australia



Neandertal & Denisovan Territories



What world looked like when MH came out of Africa: N in West, D in East;
Both in southern Siberia

Denisovan DNA: EPAS1 gene – Oxygen capacity of Sherpas

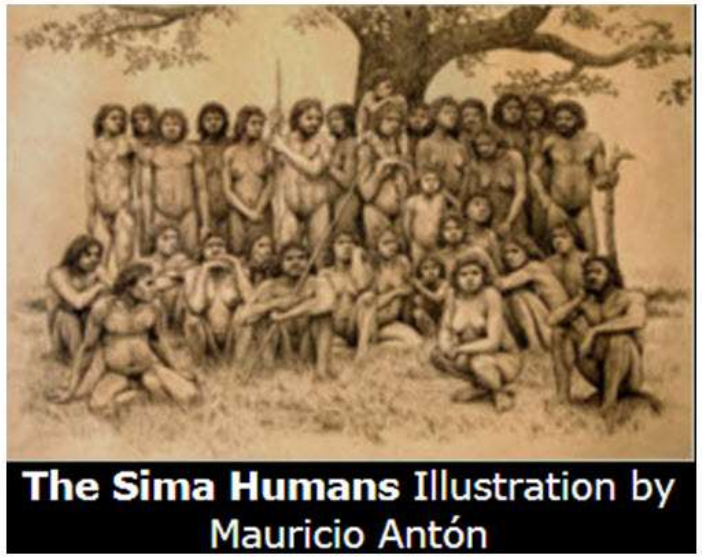
Mt. Everest, 1953: Edmund Hilary & Sherpa Tenzing Norgay (Denisovan DNA) & fastest Darwinian evolution

Hypoxia gene, *EPAS1*, positive selection in Tibetans; hemoglobin & oxygen at high altitude; 3000 year divergence

Less red blood cells & less hemoglobin

Sima de los Huesos (Pit of the Bones), Atapuerca, Spain

Sima de los Huesos, Atapuerca, Spain



Sima de los Huesos
Homo heidelbergensis hominins, 400K

Human fossils, Sima de los Huesos
E436/0172 Rights Managed

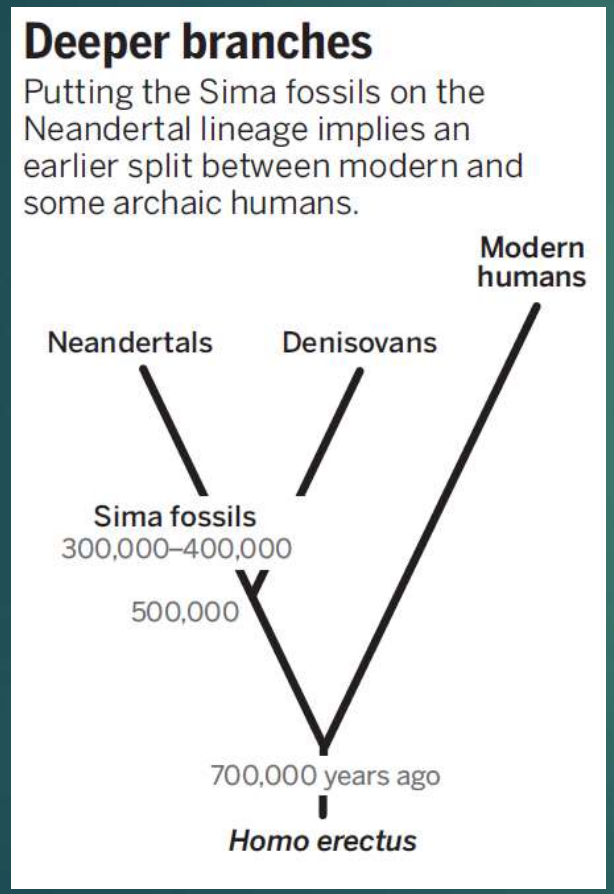
28 people's body parts from 400 KYA

2015: Pit of the Bones in Spain: 400 K – oldest mtDNA = Neandertal

2014: Oldest human mitochondrial genetic material: The thighbone of the 400K hominid from Sima de los Huesos, Credit: Javier Trueba

Originally thought to belong to an ancient human species known as *Homo heidelbergensis*:
Original mitochondrial study: Denisovan ancestry
2015 nuclear study: Neandertal ancestry

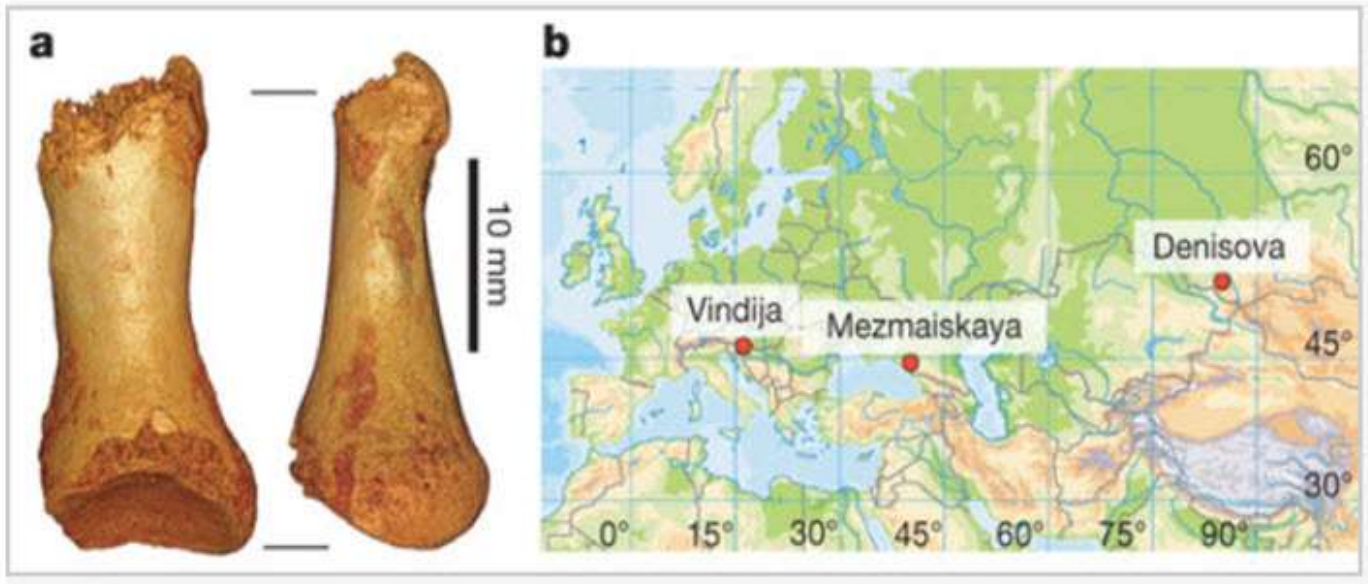
2015: Atapuerca Neandertals: earlier split



Neandertals & Denisovans are more closely related to each other than to modern humans; split from each other ~500,000 YA

Therefore ancestors of modern humans must have
Split away even earlier, ~550,000 to 765,000 years ago

2014: Reason for Neandertal Demise:
Low population number with interbreeding



Denisova: woman's toe bone = Neandertal 130K;
Clear inbreeding = her parents were closely related,
possibly half-siblings or another near relation.

Chromosome 21: M & F genetically related (19 Mb base pairs with no difference)

- Half siblings
- Grandfather-granddaughter
- Aunt-nephew
- Double first cousins

Some other archaic DNA (H. erectus?)

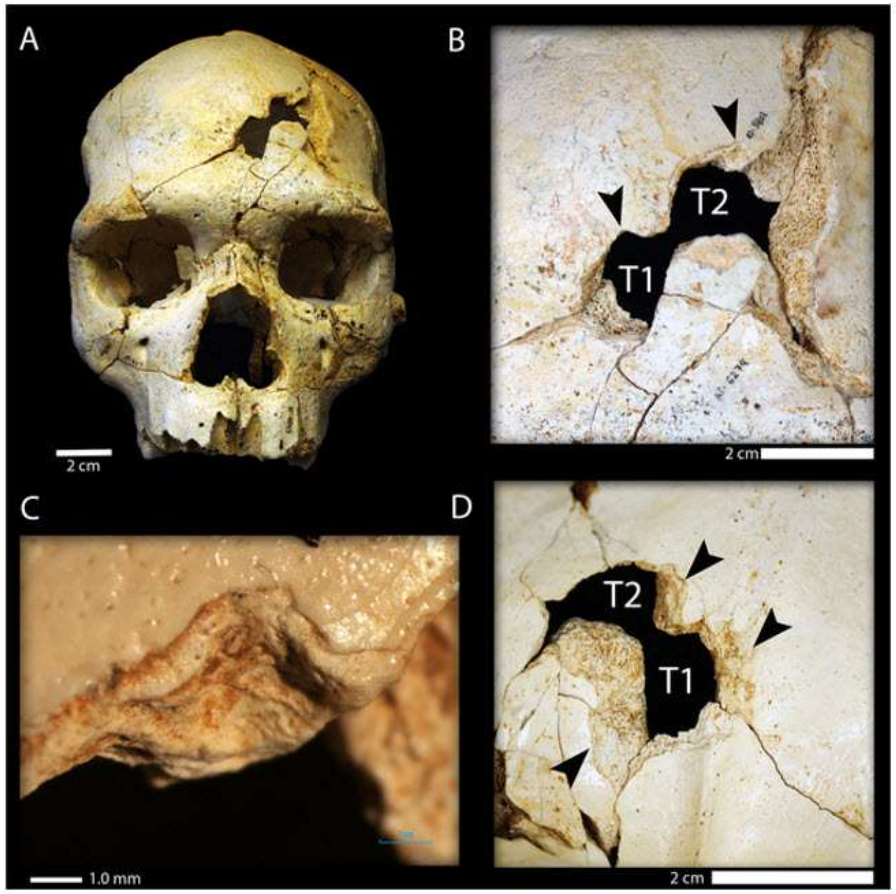
Pruefer et al., , Nature, 2014

Neandertal DNA is slightly detrimental to modern humans, making some people more prone to certain diseases, but also contributed to our immune function

- Conditions associated with Neandertal alleles:
  - Lupus
  - Primary biliary cirrhosis
  - Crohn’s disease (2 alleles)
  - Type 2 diabetes
  - Variation in keratin in skin and hair
  - Variation in interleukin-18 levels
  - Variation in optic disc size
  - Variation in smoking behavior

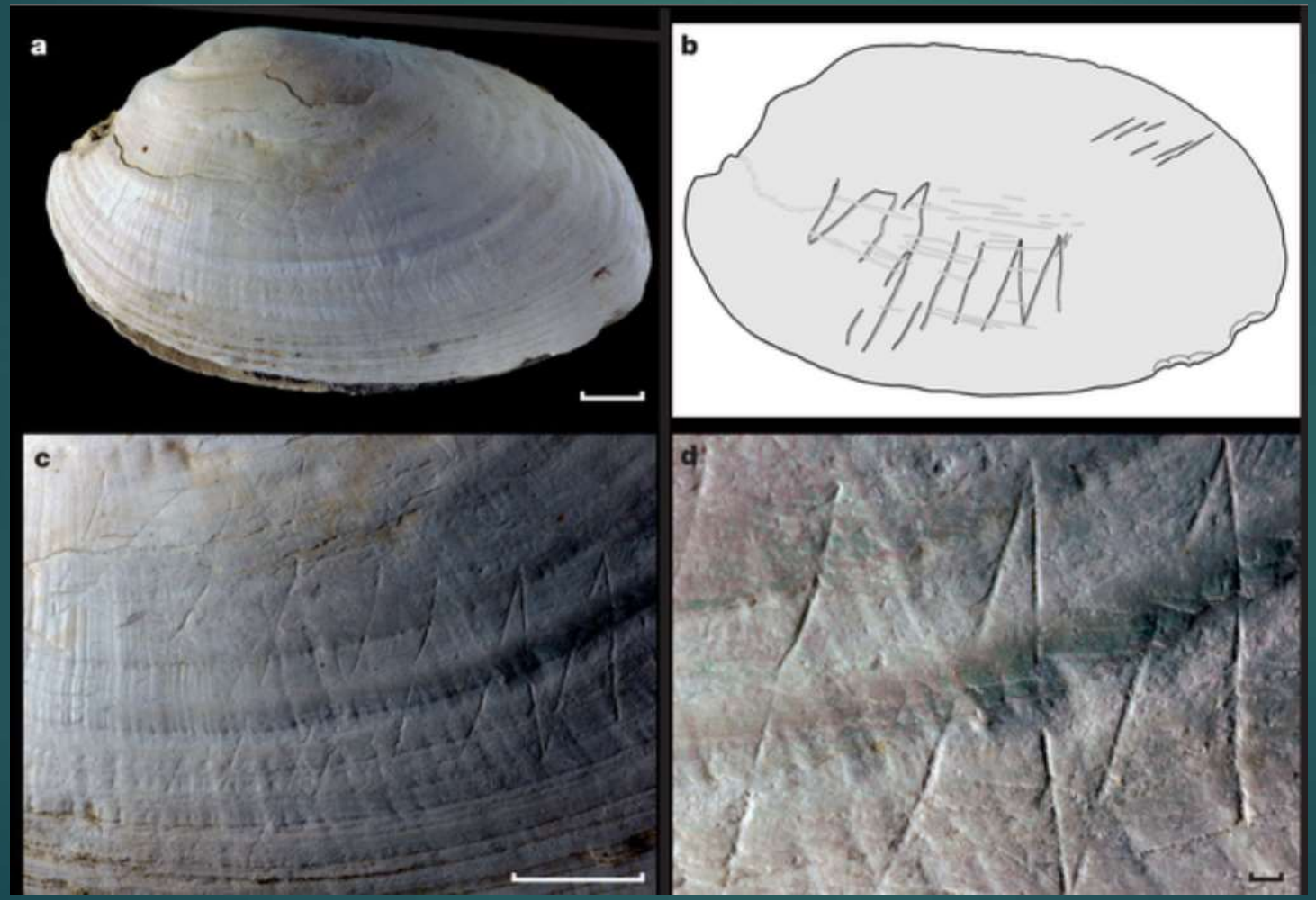
B. Vernot and J. M. Akey, Science; Sanka et al., Nature, 2014

CSI: Murder case 400K; Pit of the Bones



Sala N, Arsuaga JL, Pantoja-Pérez A, Pablos A, Martínez I, et al. (2015) Lethal Interpersonal Violence in the Middle Pleistocene. PLoS ONE 10(5): e0126589. doi:10.1371/journal.pone.0126589

2 MYA, Java, *Homo erectus*: Geometric design carved on clam shell



Neandertal Art: Gibraltar Cave hatch mark

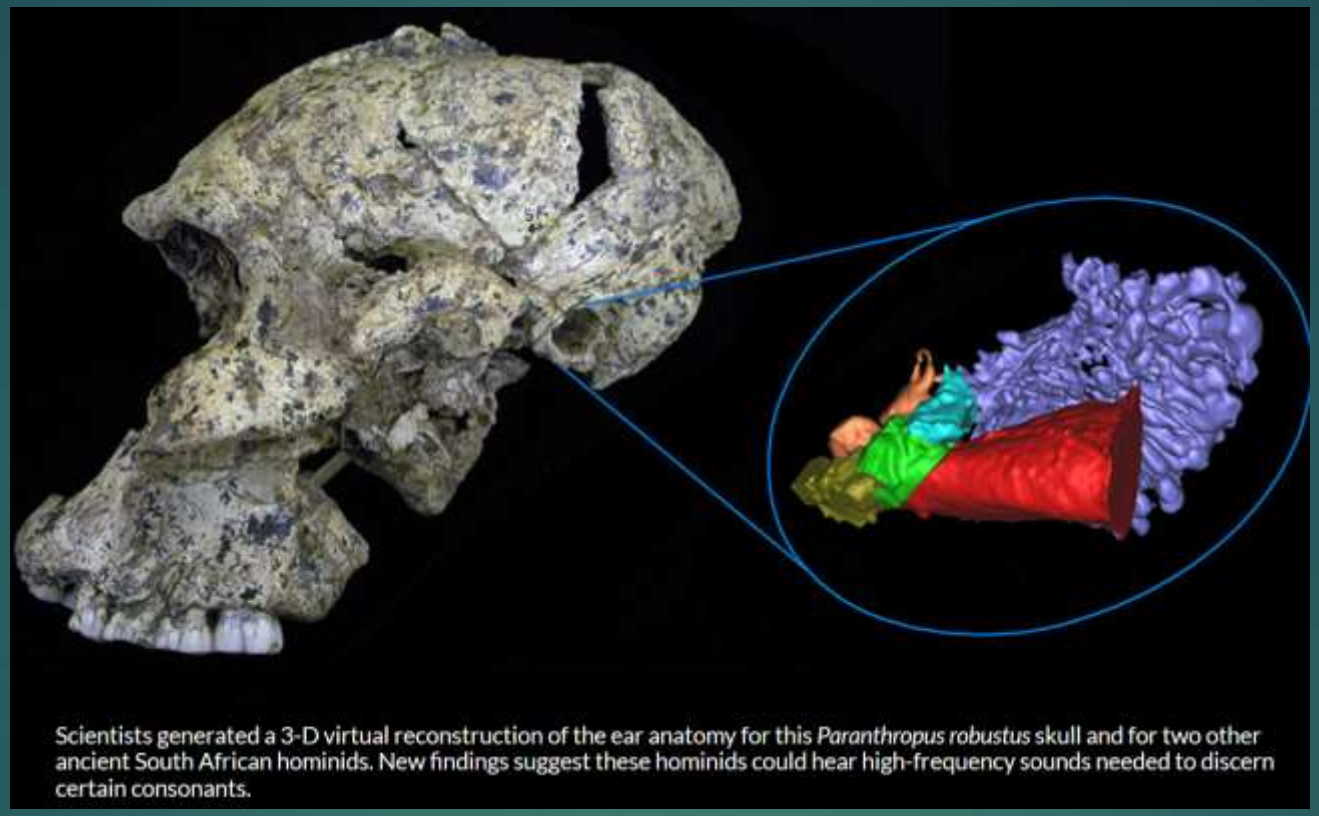
Neandertal Eagle Talon necklace, 130K

Neandertal Pendant, 130K

Chauvet Cave, France: Clay bison sculpture, 40K

Gabarnmung in Northern Australia: 35K

Ancient hominid ears were tuned to high frequencies



Scientists generated a 3-D virtual reconstruction of the ear anatomy for this *Paranthropus robustus* skull and for two other ancient South African hominids. New findings suggest these hominids could hear high-frequency sounds needed to discern certain consonants.

Using CT scans and digital technology, team reconstructed the ear anatomies of two *Australopithecus africanus* skulls and one *Paranthropus robustus* specimen. Modern human ear measurements guided virtual recreations of soft tissue around ear bones, enabling calculations of audible sound frequencies. *A. africanus* and *P. robustus* could have heard high-frequency consonants associated with the letters *t*, *k*, *f* and *s* better than either chimps or present-day people do. An ability to hear, and make, such sounds enhanced communication among hominids foraging in groups across open landscapes. Such communication need not have required a humanlike language, only vowel and consonant sounds with shared meanings.

5 Lessons from Hominid Evolution

- Do what Lucy did: physical exercise is best protection vs. dementia
- Climate change was major factor in extinction of many human species
- Sixth extinction event is underway: 99 % of all animals have gone extinct;
- Killing the planet: climate denial, rising carbon dioxide levels, anti-evolution thinking, habitat destruction
- Help sustainability: use less lights, recycle, drink tap water, drive less/use less gas, walk, unplug, buy local food

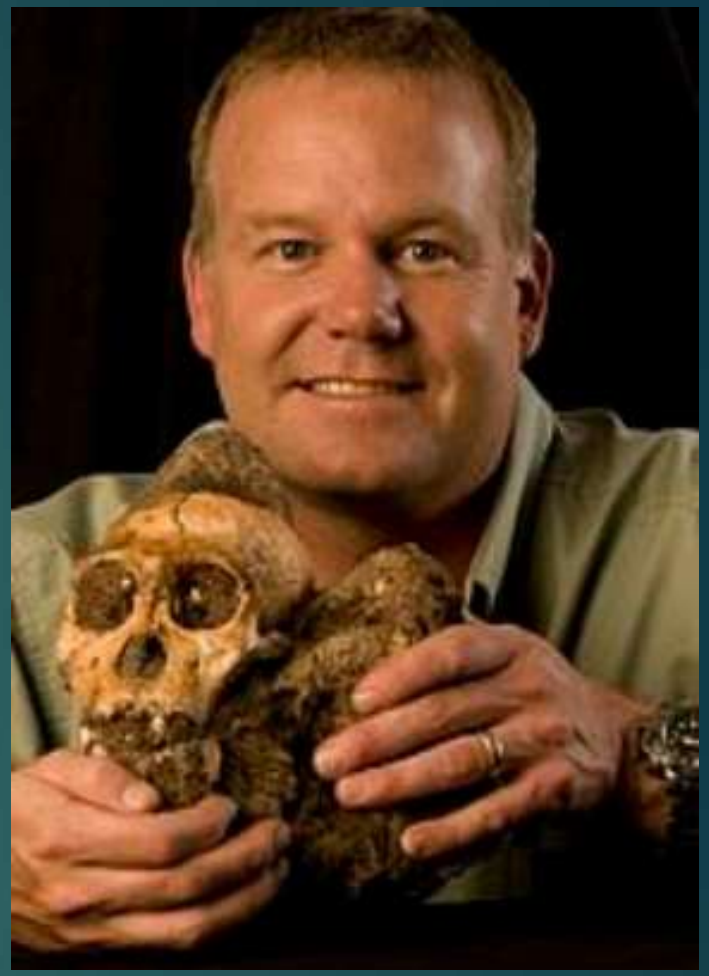
Homo naledi

The Star Man

Charles J. Vella
September 28, 2015

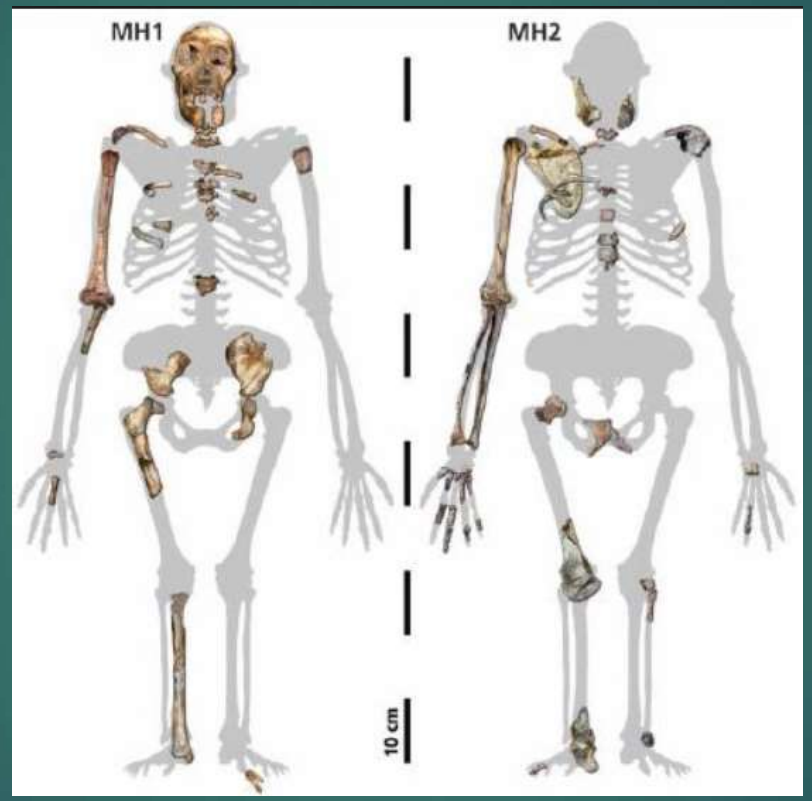
Lee Rogers Berger (1965-):

- American paleoanthropologist, physical anthropologist and archeologist
- University of the Witwatersrand
- Surveying South Africa's Malapa Cave
- 2008: son Matthew discovers *Australopithecus sediba*, 1.98M



2008: *Australopithecus sediba,* 1.98 MYA


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



Australopithecus sediba
(LH1, type, cranium)
Discoverer: Matthew Berger
Locality: Malapa Cave, South Africa
Date: 2008

2015 Discovery: More than one way to be human

Homo naledi

New species of the genus Homo
from the Dinaledi Chamber, South Africa

One of the most staggering finds in the history of paleoanthropology

Supervised by Lee Berger of University of the Witwatersrand

http://elifesciences.org/content/4/e09560#sthash.ZMyt0Qr5.dpuf

2015: 2 papers published

- 1 *Homo naledi*, a new species of the genus Homo from the Dinaledi Chamber, South Africa - Lee R Berger, John Hawks, et al. (45 other authors), 2015, *eLife4*:e09560. DOI: 10.7554/eLife.09560

- *2* Geological and taphonomic context for the new hominin species *Homo naledi* from the Dinaledi Chamber, South Africa - Paul HGM Dirks, Lee R Berger, et al. (22 other authors), 205, *eLife,* 4:e09561. DOI: 10.7554/eLife.09561

- Location: 26°1′13″ S; 27°42′43″ E;

  800 meters SW from well explored Swartkrans cave

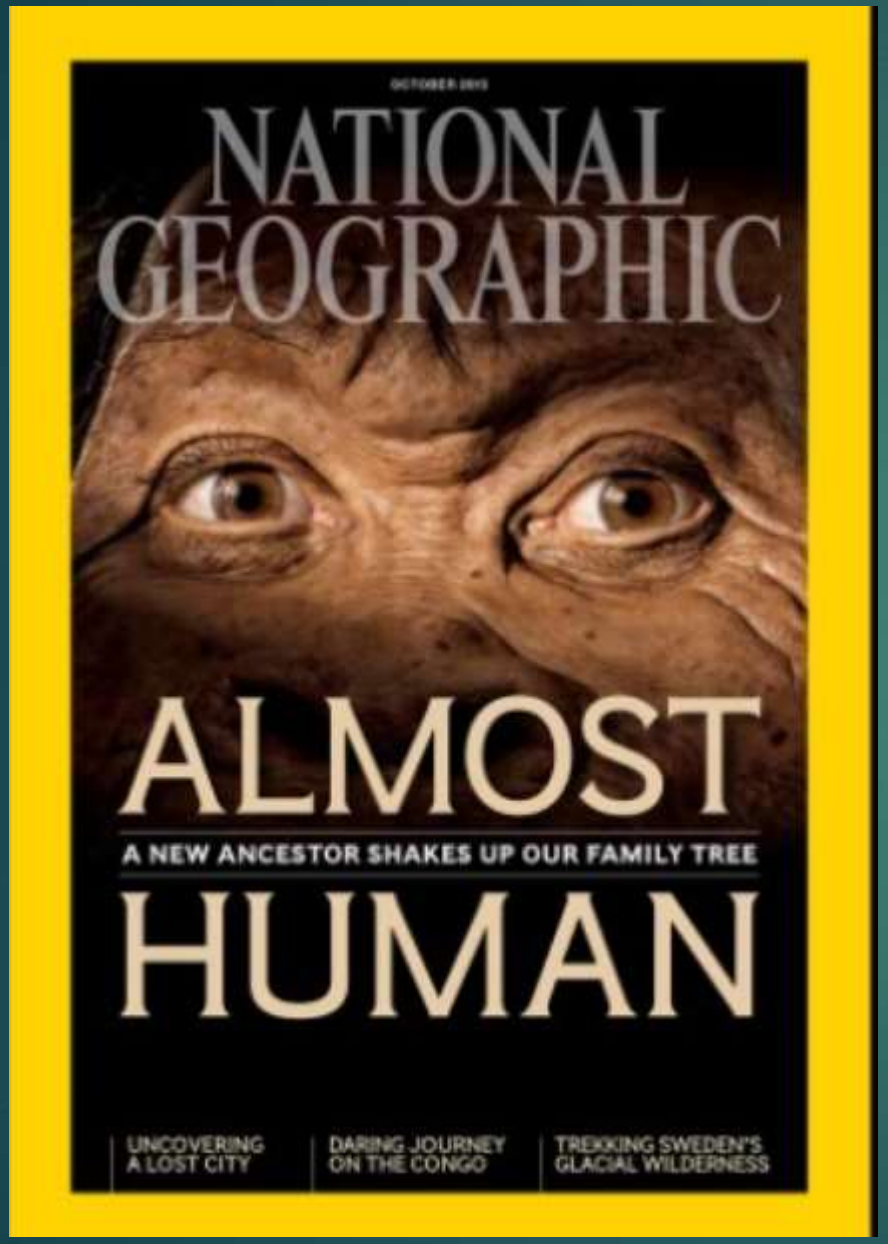
- November 2013 and March 2014 excavations

The “King Tut’s Tomb” of Hominid Fossil Discovery:

Rising Star Cave, Dinaledi Chamber

Homo naledi

Largest assemblage of a single species of hominins yet discovered in Africa: 15 individuals, including multiple examples of most of the bones in the skeleton.



October 2015

Lee Burger and friend

Entrance to Rising Star Cave

Spelunkers found a narrow, vertically oriented "chimney" measuring 12 m (39 ft) long with an average width of 20 cm (7.9 in)

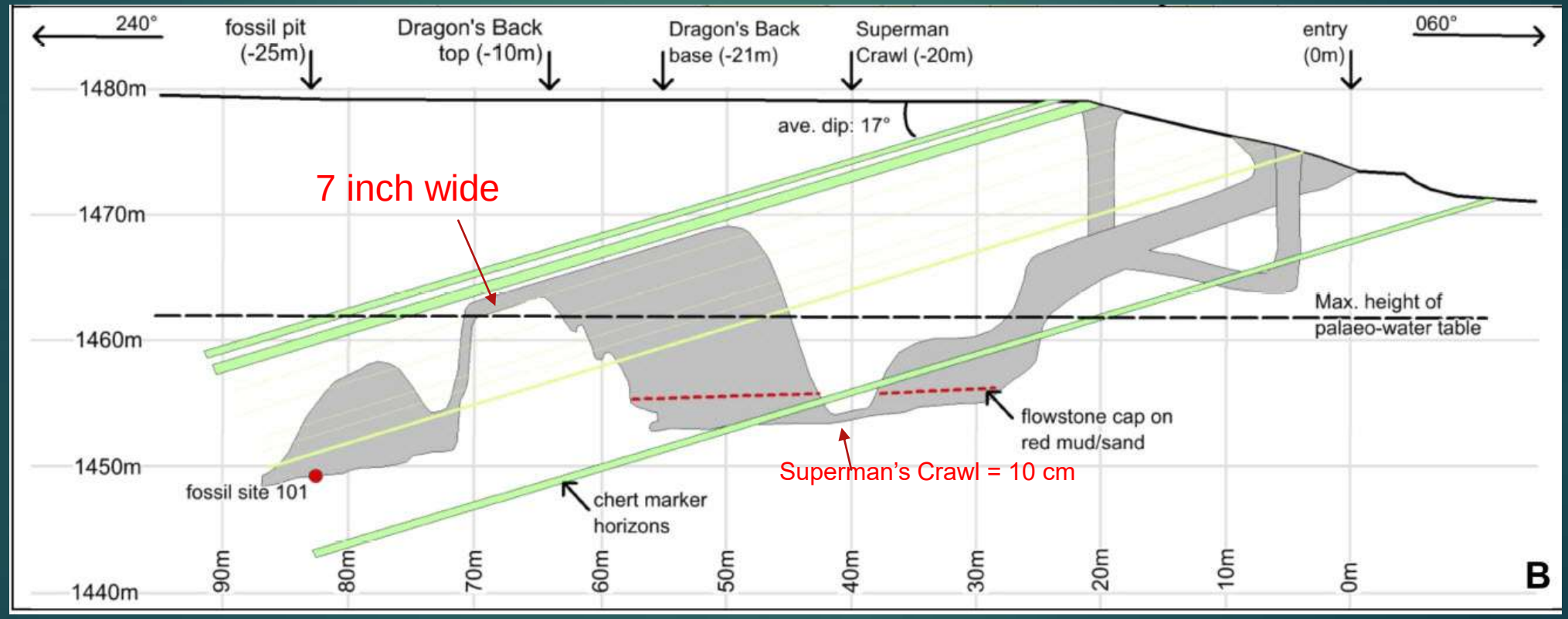
Steve Tucker:
1st spelunker into
The 30 m (98 ft) long
Dinaledi Chamber

Pedro Boshoff; bone hunter hired by Lee Berger to hunt for fossils

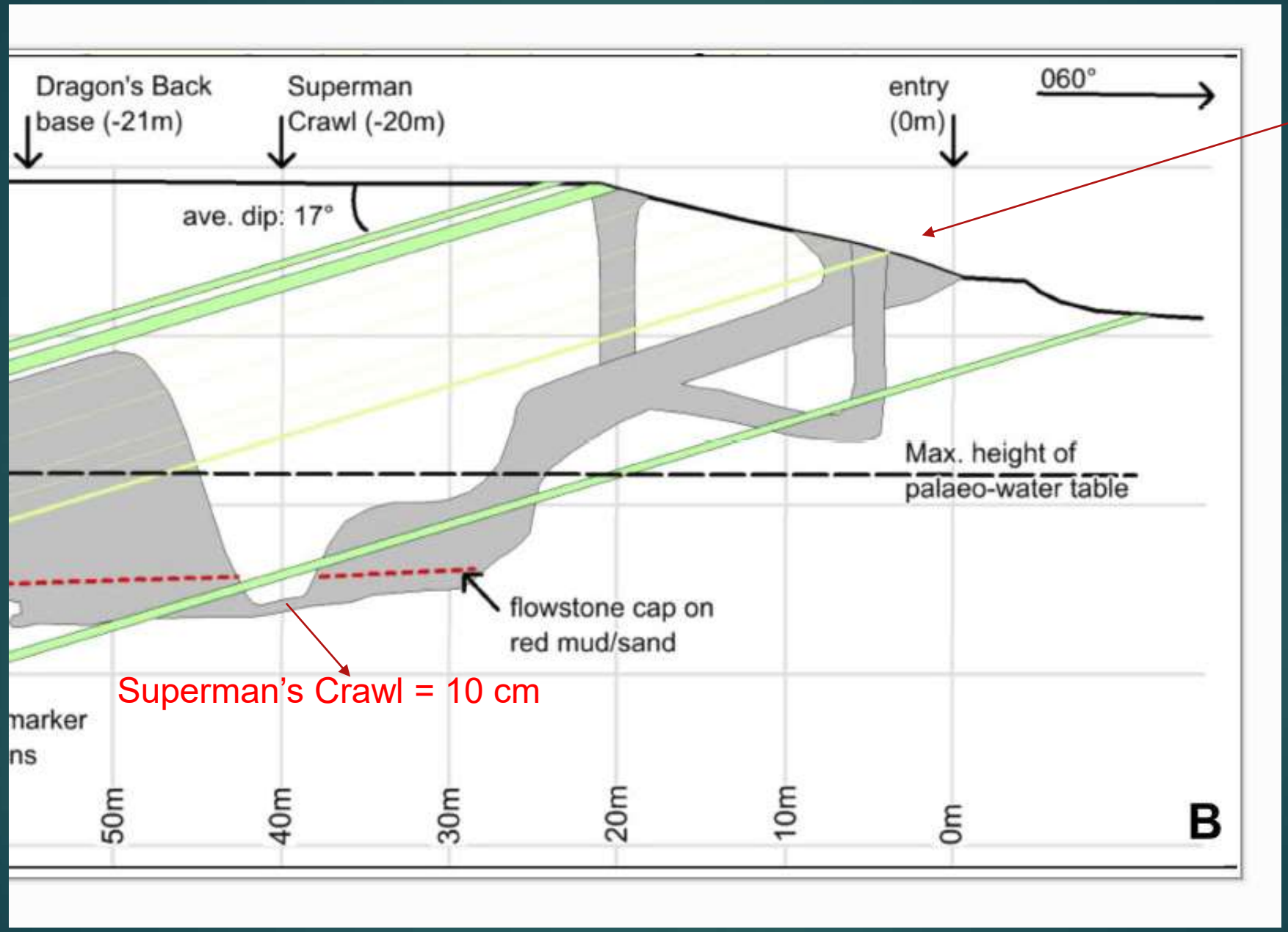
Rick Hunter

2015: *Homo naledi (*“star” in South African language Sotho; from chamber of stars “Dinaledi”)

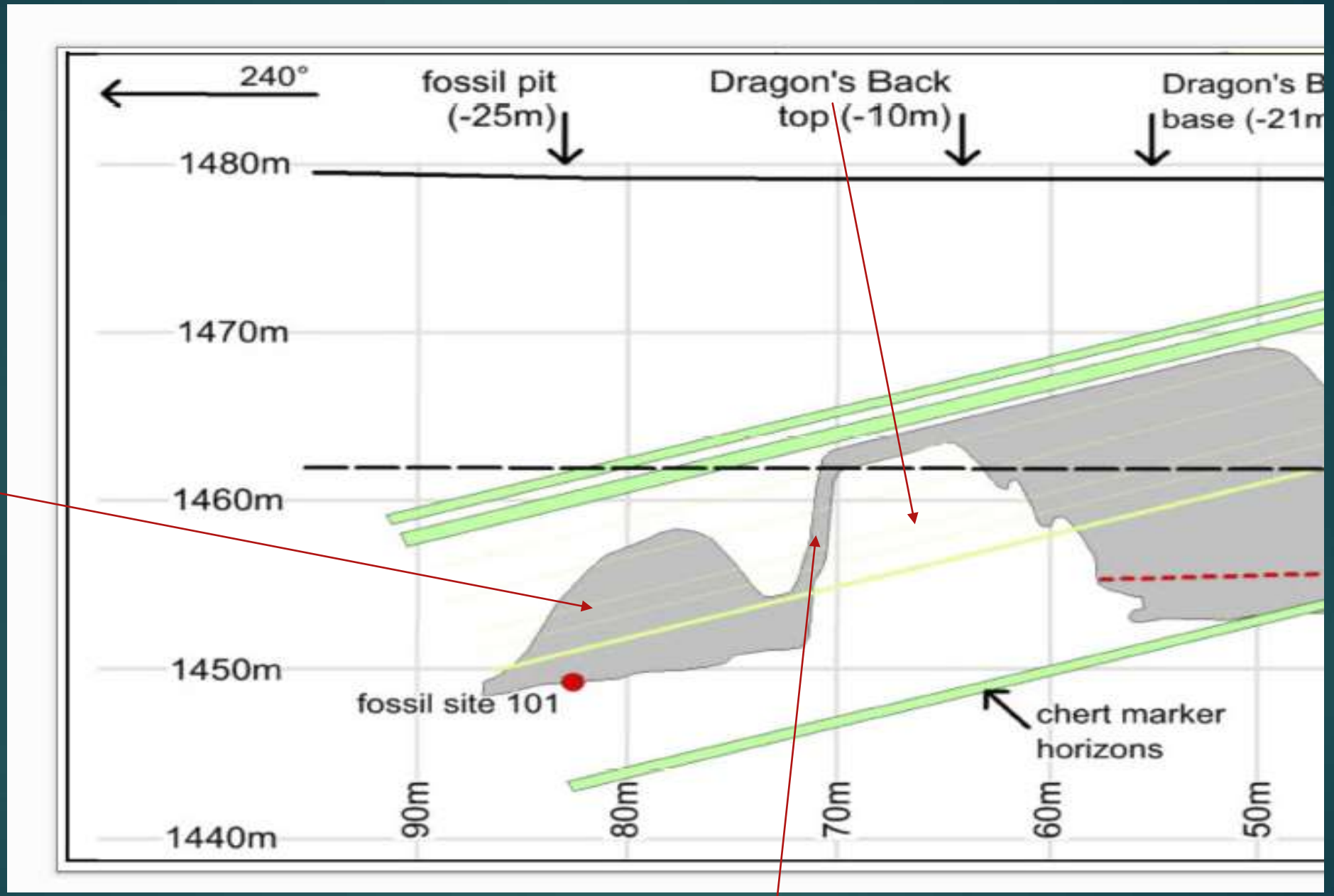
Lee Burger, 2013 Rising Star dolomite cave system in South Africa (caved for 50 years): new area reveals paleological bonanza



Through a 39-foot crack just seven inches wide at times, finally the Dinaledi Chamber, 30 feet long and only a few feet wide, with bones everywhere


Dragon's Back
base (-21m)
Superman
Crawl (-20m)
entry
(0m)
060°
ave. dip: 17°
Max. height of
palaeo-water table
flowstone cap on
red mud/sand
Superman's Crawl = 10 cm
marker
ns
50m
40m
30m
20m
10m
0m
B

Entry



Dinaledi Chamber

The Chute

First footage of discovery

Tight spots: 7 inch (18 cm) crawl space

Then drop down into a cavern of unknown depth
(actually 10 meter deep)

One of the wider spots

2013 Facebook, Twitter, LinkedIn Ads for “underground astronauts”

- “We need perhaps three or four Individuals with excellent archaeological/ palaeontological and excavation skills for a short term project...the catch is this, the person must be skinny and preferably small and they must not be claustrophobic; they must be fit; they must have some caving experience, and climbing experience could be a bonus…it will be unpaid work”

- 57 applied, all women; 6 women picked
- Rising Star is the most open paleoanthropological project that has ever been attempted. Published on internet; 50 researchers (20 early career)

Underground astronauts of the Dinaledi Chamber

All-female early career team – Hannah Morris, Marina Elliott (1st down the chute), Becca Peixotto, Alia Gurtov, Lindsay Eaves and Elen Feuerriegel – were drawn from Australia, Canada and the US. Worked for free. They brought out the largest assemblage of fossil human relatives ever discovered in the history of the continent of Africa.

A triumph for open access and education

- Cameras put in the cave, and research streamed live from day one.
- Lee Berger pulled together 40 senior researchers and invited 20 early career PhD researchers to put together the original papers. First paper involved 47 authors. Second paper included spelunker discoverer. Both papers are freely available & downloadable from eLife (already 170K downloads; when 50% of 1.8M scientific papers published annually are never cited).
- He has been an advocate of paleodemocracy: the idea the fossils should not be hidden away by researchers for 10-25 years; that they should be immediately available to other researchers.
- Twitter, Facebook and Hawkes Rising Star Expedition blog were immediately available.
- Many of our fossils are now represented by research-quality 3D scans on MorphoSource (1700 downloads in 1st weeks).

Lee Burger was too big to fit in cavern; so supervised it all on HD TV Monitor; he has never been in the cavern

Lee Berger received funding ($2 M) from the National Geographic Society to excavate the site

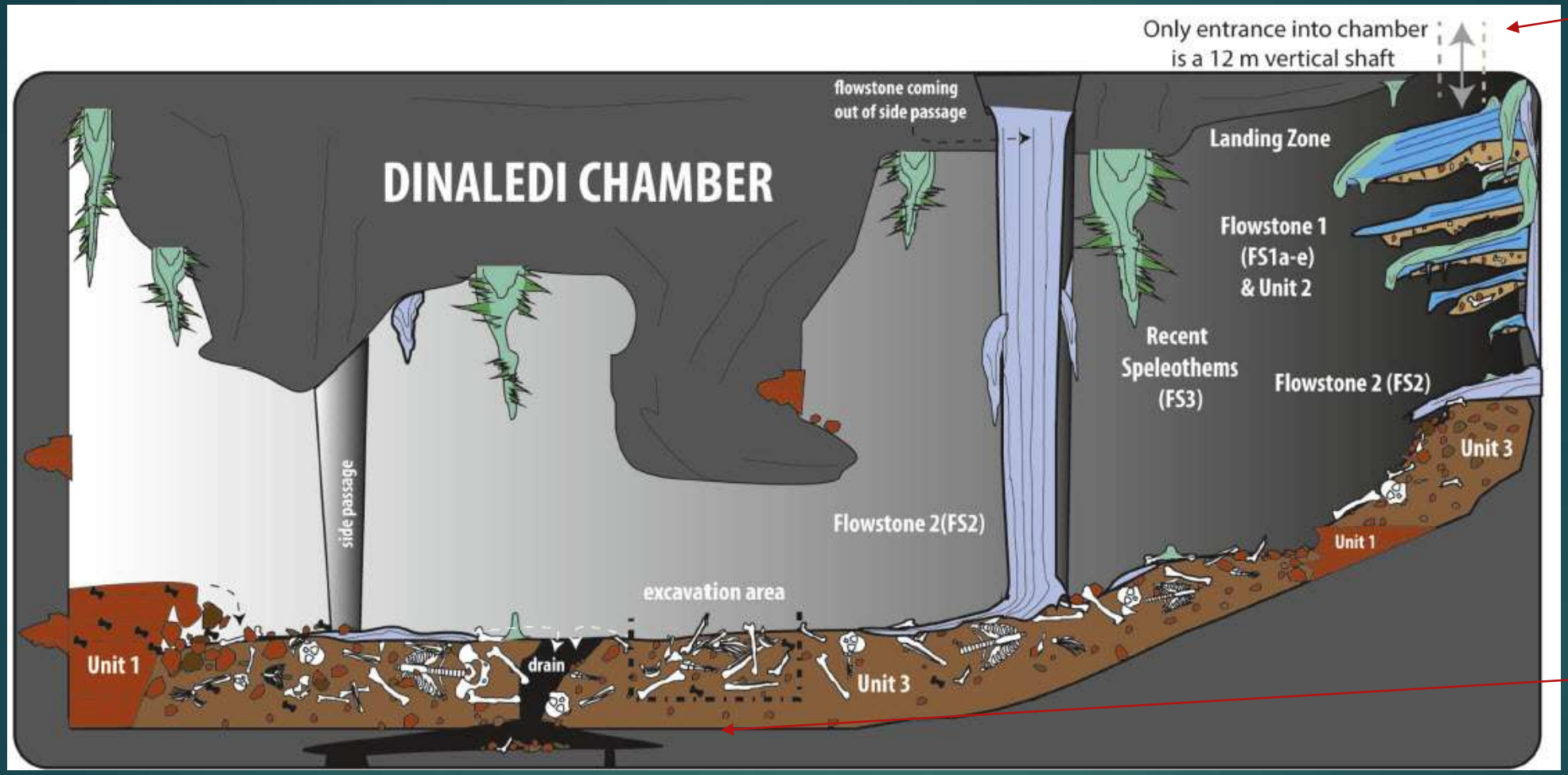
Beautiful limestone cave

Homo naledi: First view of 30 x 2 foot cavern space

First haul: the mandible

2015: Dinaledi Chamber (“chamber of many stars”)

Only Entrance



1 square meter excavation area

This cave chamber lies some 80 meters into the Rising Star system, and was always in constant darkness; a periodically wet or water-saturated, dark depositional environment (with no water movement of bone). No animal remains except for 6 bones of 1 owl & some rodent incisors; nothing else except partially mineralized hominid bones. No evidence for green fractures associated with trauma. H. naledi fossils entered the chamber over an extended period of time; that is, not all remains were deposited at once

Bones, Bones, Bones lying around

The concentration is so dense that there’s more fossils than sediment in some areas,”

“A sea of bone” just lying on the ground: 400 bones on surface;
“Rick kicked the dirt and hominids fell out”

Homo naledi: 15 separate individuals in1550 bones collected in first sweep of surface (400 bones) and an excavation of 1 square meter x half a foot (1150 bones)

Dinaledi skeletal specimens:
737 partial or complete anatomical elements

Homo naledi: Multiple samples of same bone

Individuals of practically every developmental age, from neonate to elderly: senile3 infants, 3 young juveniles, 1 old juvenile, 1 sub-adult, 4 young adults and 1 old adult. Infants were identified by their thimble-size vertebrae.

Skulls. Jaws. Ribs. 190 teeth. A nearly complete foot. A hand. Bones of the inner ear.

An animal right on the cusp of the transition from Australopithecus to *Homo*

- Mix hints at a species close to the origin of the genus *Homo*, between two million and three million years ago.
- The shoulders were apish & the widely flaring blades of the pelvis were as primitive as Lucy's—but the bottom of the same pelvis looked like a modern human's.
- The leg bones started out shaped like an australopithecine's but gathered modernity as they descended toward the ground. The feet were virtually indistinguishable from our own.
- Its shoulders, hips, and torso hark back to earlier ancestors, while its lower body shows more humanlike adaptations. You could almost draw a line through the hips—primitive above, modern below.
- The skull and teeth show a mix of traits.

A schizoid creature: a mix of primitive & modern features

- Australopithecine like: the small brain size (550cc), curved fingers and canted up shoulder, trunk and hip joint (widely flaring blades of the pelvis were as primitive as Lucy's), top of legs, resemble the prehuman australopithecines and the early human species *Homo habilis*.

- Homo like: thumb, wrist, and palm bones, bottom of the pelvis, lower legs and feet look most like those of Neanderthals and modern humans; cranium has frontal bossing & as is a marked degree of parietal bossing. No indication of a sagittal crest or temporal/nuchal cresting

- Vertebrae are most similar to genus *Homo,* whereas the ribcage is wide distally like *Au. afarensis*

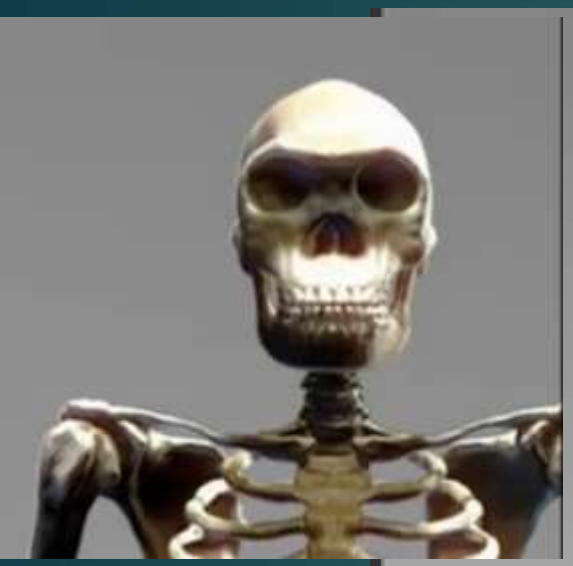
Teeth

- The teeth have some primitive features (such as increasing in size towards the back of the tooth row, larger molars & premolar roots) and humanlike features: small front teeth, molar crowns were small with five cusps, and set in lightly built, more curved jawbone.
- The teeth of this new species were relatively small, which is a modern trait. However, Homo naledi's back teeth were the largest, which is more primitive.
- The new species goes against the previously held belief that a small brain and large teeth go together since as brains got larger, teeth could get smaller because of improved use of technology like fire to cook food.
- However, Homo naledi has a small brain and small teeth.

Homo naledi cranium

- Cranium lacks primitive features like well developed sagittal and nuchal crests.
- Standard *Homo* skull traits include:
  - frontal and parietal bossing,
  - cranial bones relatively thin (like *H. habilis*),
  - flexed occipital and transverse torus (like *H. erectus*),
  - supraorbital torus well developed and weakly arched (as *H. erectus* and *H. habilis*)
  - gracile mandible;
  - larger body mass and stature,
- *Homo naledi has all above traits.*

H. naledi vs. *A. sediba* skeletons



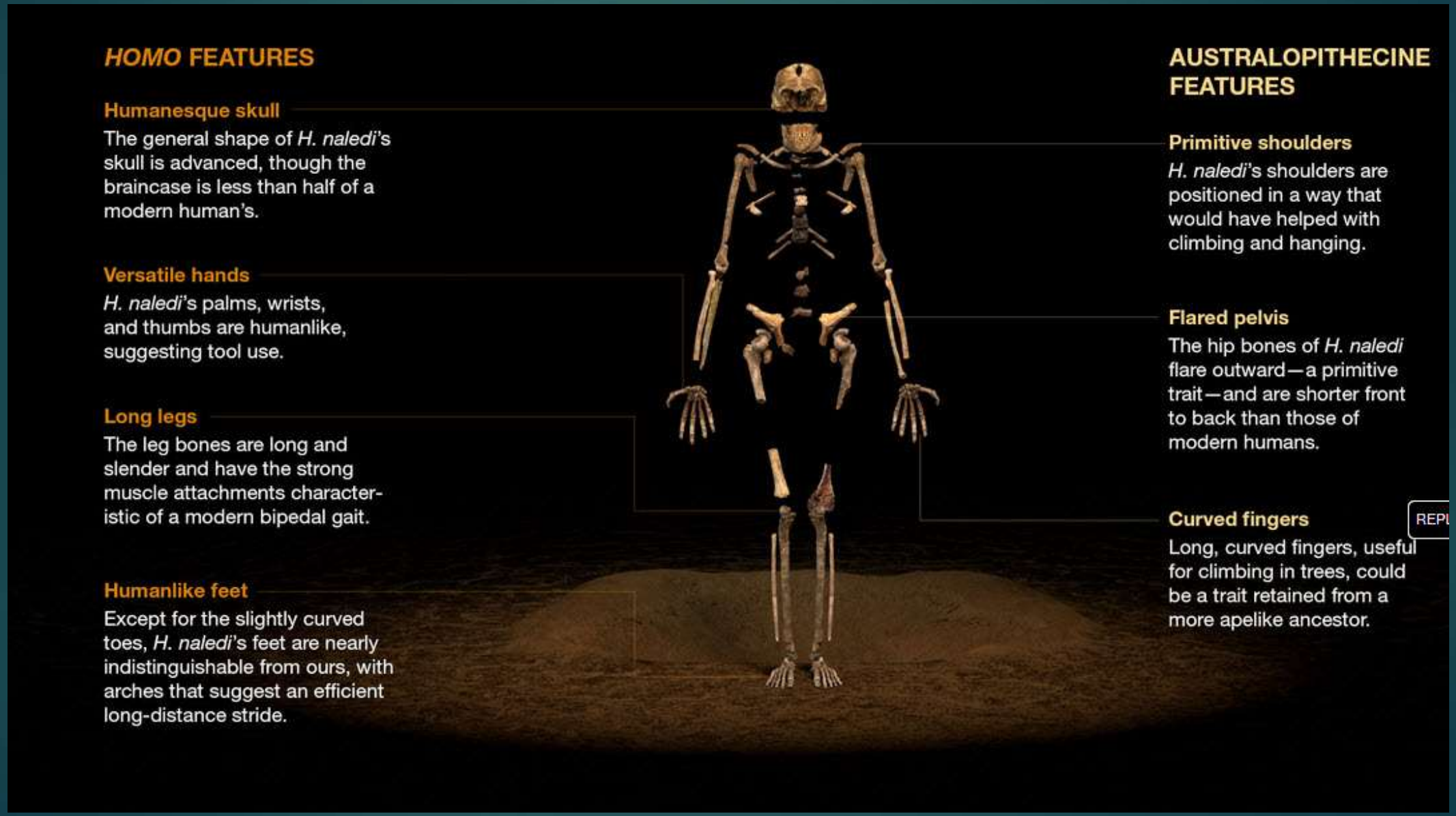
A. sediba found a few kilometers away: *Naledi* is almost mirror of *sediba*. Where you see primitive features in *sediba*, in *naledi* you see derived; Everywhere that *sediba* is derived, *naledi* is primitive.

Humanlike: Feet, hands, teeth: anything that interacts with environment is Homo

Humanlike: Skull, hands, feet

Australopithecine: Everything that is central (the trunk, architecture of vertebral column, & small brain) is primitive; as if evolution was crafting us from outside in

Homo naledi: an anatomical mosaic



Homo naledi: Hand

Found articulated as seen here

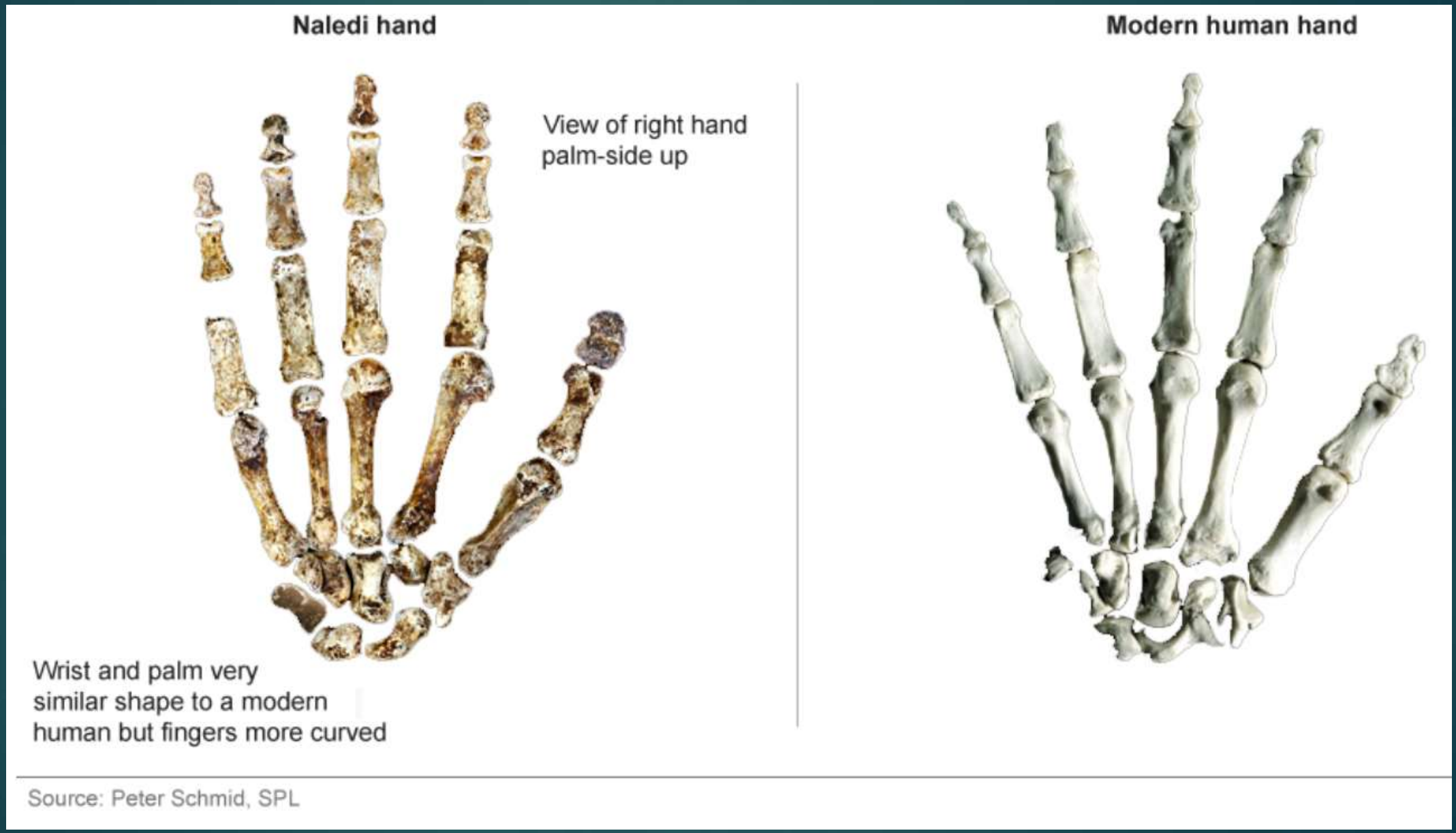
Australopithecine-like *a*rboreal capable curved fingers, but thumb and wrist are stiffer like Homo (tool use)


The diminutive hand of naledi. The bones were found in position

Hand is small because, even as adults, *naledi* is diminutive.

Naledi hand

Modern human hand



Homo naledi: Leg

U.W. 101-1391 paratype femur.(**A**) Medial view; (**B**) posterior view; (**C**) lateral view; (**D**) anterior view. Scale bar = 2 cm.

U.W. 101-484 paratype tibia.
(**A**) Anterior view; (**B**) medial view; (**C**) posterior view; (**D**) lateral view.
The tibiae are notably slender for their length. Scale bar = 10 cm.

Homo naledi: Foot – meant for walking - upright biped

A

B

C

Found articulated as seen here

10 cm

Arch, but lower than H. sapiens

Toes a bit curved

Foot 1 in (**A**) dorsal view; and (**B**) medial view.(**C**) Proximal articular surfaces of the metatarsals of Foot 1, shown in articulation to illustrate transverse arch structure. Scale bar = 10 cm.

A perfectly human, but small, foot

Naledi foot

Modern human foot

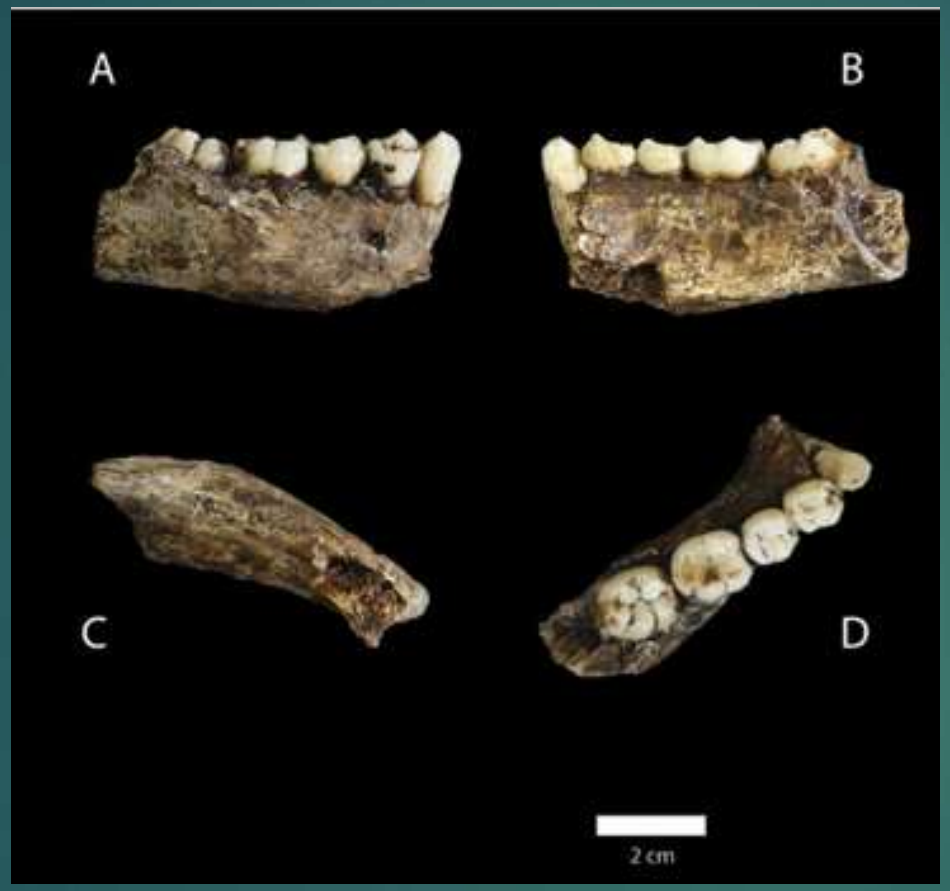
Naledi foot

Short foot similar in size to modern human

Arch suggests naledi walked on two feet

Modern human foot

Homo naledi: Mandible



Mandible:
Too small to be an austrolopith;
More curved than H. habilis

U.W. 101-377 mandible.(**A**) Lateral view; (**B**) medial view; (**C**) basal view; (**D**) occlusal view. (**D**) The distinctive mandibular premolar morphology with elongated talonids in unworn state. Scale bar = 2 cm.

Homo naledi: Mandible

190 Teeth: complete sets

Infants (top left) to very old (bottom right)

Benefit of multiple copies of same bone

- Species often have to be identified by just a few fossils, but this time, not only were there hundreds of fossils found, but there were also many different examples of each fossil, which gave a much more complete picture.
- For example, imagine the only bone found was a femur. There's no way of knowing if that represents the species as a whole or if the individual was short, tall, malformed or typical.
- With multiple examples of the same part, researchers could better determine if what they were seeing was normal and get a better picture of what the species as a whole looked like.

A fossil part does not predict the whole anymore

- A total mosaic creature: This species combines a humanlike body size and stature with an australopith-sized brain; features of the shoulder and hand apparently well-suited for climbing with humanlike hand and wrist adaptations for manipulation; feet are solidly bipedal; australopith-like hip mechanics with humanlike terrestrial adaptations of the foot and lower limb; small dentition with primitive dental proportions.

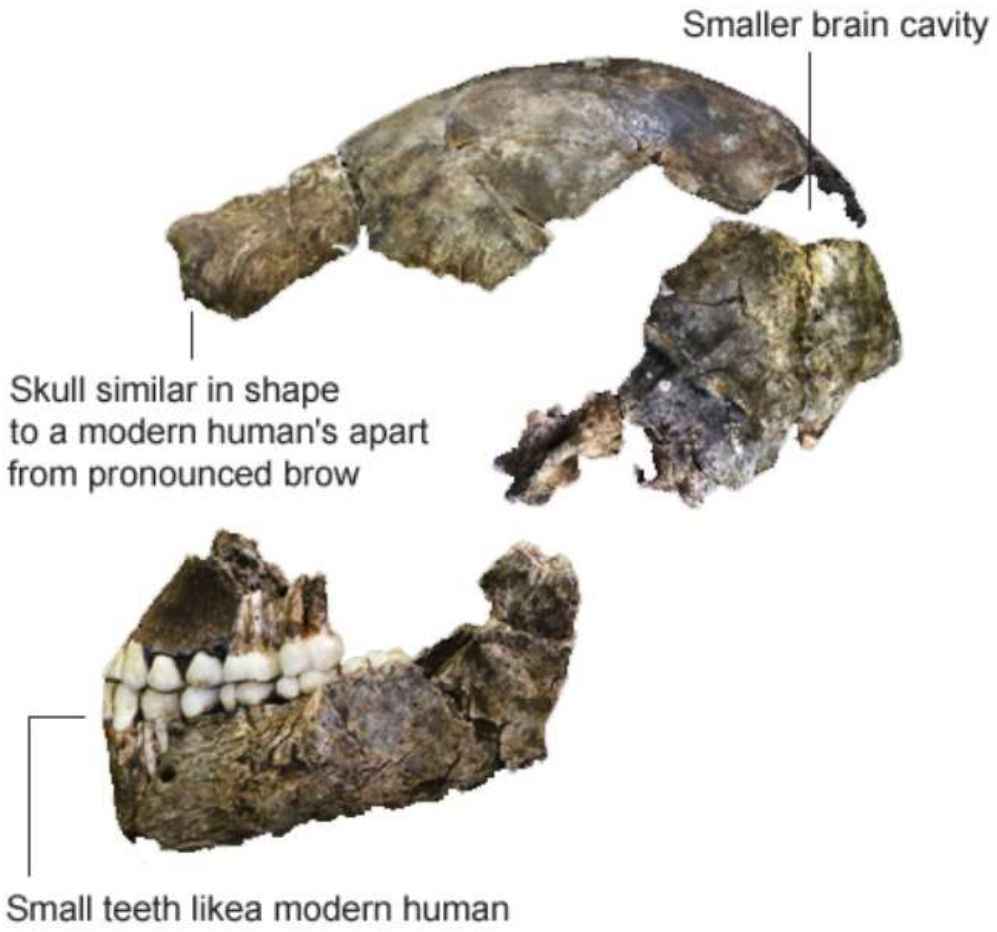
- In light of this evidence from complete skeletal samples, we must abandon the expectation that any small fossil fragment of the anatomy can provide singular insight about the evolutionary relationships of fossil hominins. Its Mosaic nature indicates that we can never again predict whole fossil creature from single bone feature (i.e. foot, or mandible); may need to reassess all prior partial fossil findings. Mosaicism may not have been exception, but the rule.

- The entire Dinaledi collection is remarkably homogeneous. Very little variation. Not only size, but also anatomical shape and form are homogeneous within the sample.

Homo naledi: Cranium 465-560 CC compared to *H. sapiens*

Five partial skulls had been found—two were likely male, two female. In their general morphology they clearly looked advanced enough to be called *Homo*. But the braincases were tiny—a mere 560 cubic centimeters for the males and 465 for the females. Only the smallest specimens of H. habilis, one single H. erectus specimen, and H. floresiensis overlap with these values.

Naledi skull



Modern human skull

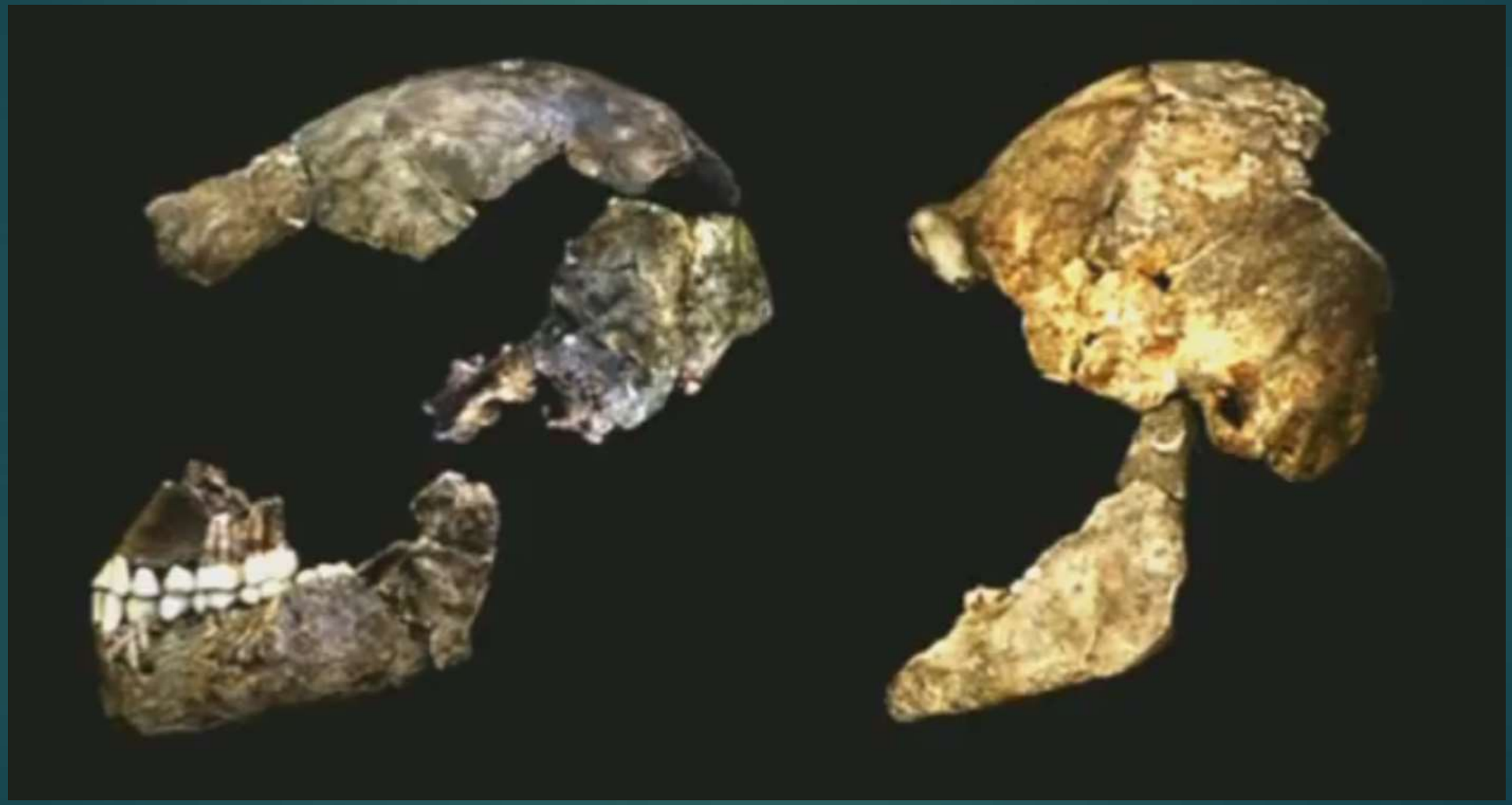
Source: John Hawks, Thinkstock

BBC

H. sapiens *H. naledi* *H. erectus*

Note curved hand

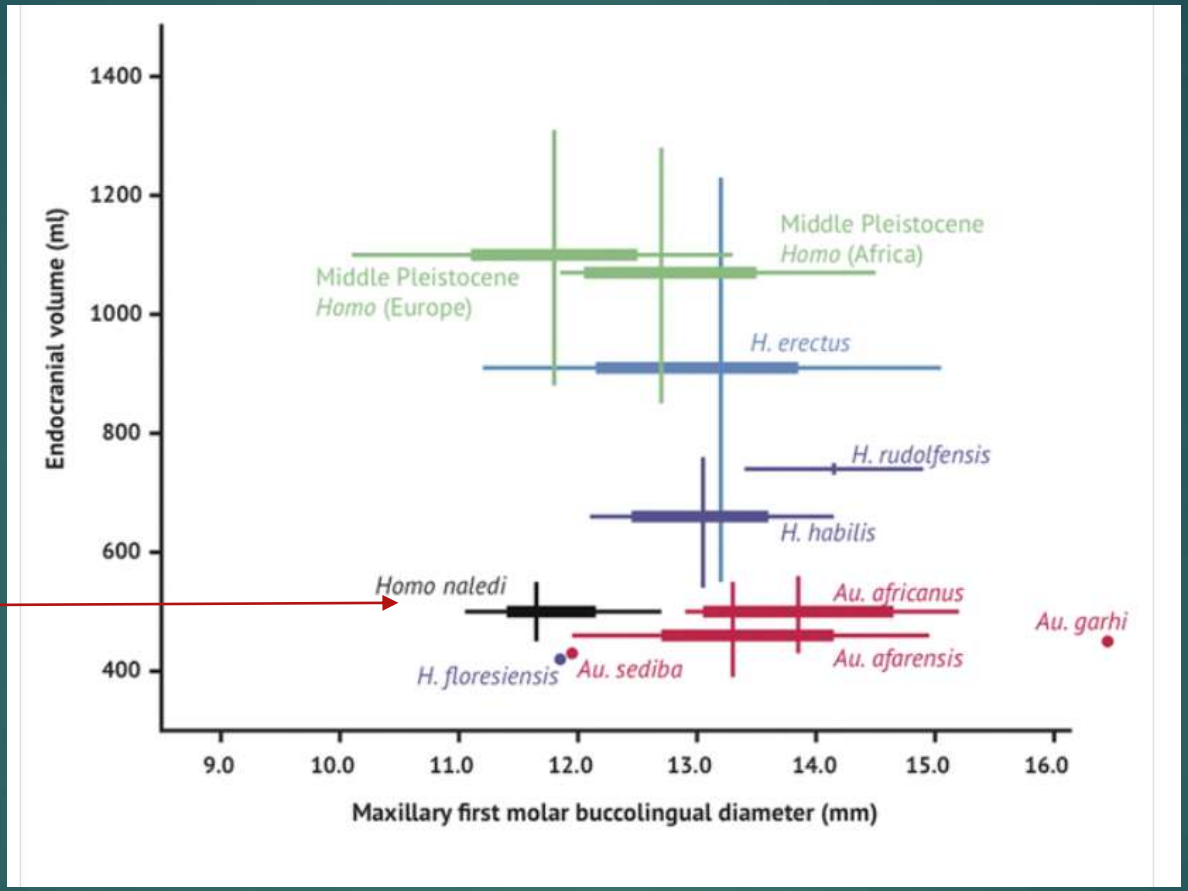
Cranium: DH1 (probably male) & DH 3 (female)



Homo naledi: Reconstructed Skull

Low variation: Small Brain size & 1st Molar Size Comparison

Homo naledi



H. naledi occupies a position with relatively small molar size (comparable to later *Homo*) & relatively small endocranial volume (comparable to australopiths). The range of variation within the Dinaledi sample is also fairly small, in particular in comparison to the extensive range of variation within the *H. erectus sensu lato*. Vertical lines represent the range of endocranial volume estimates known for each taxon.

Homo naledi vs *Homo sapiens* sizes

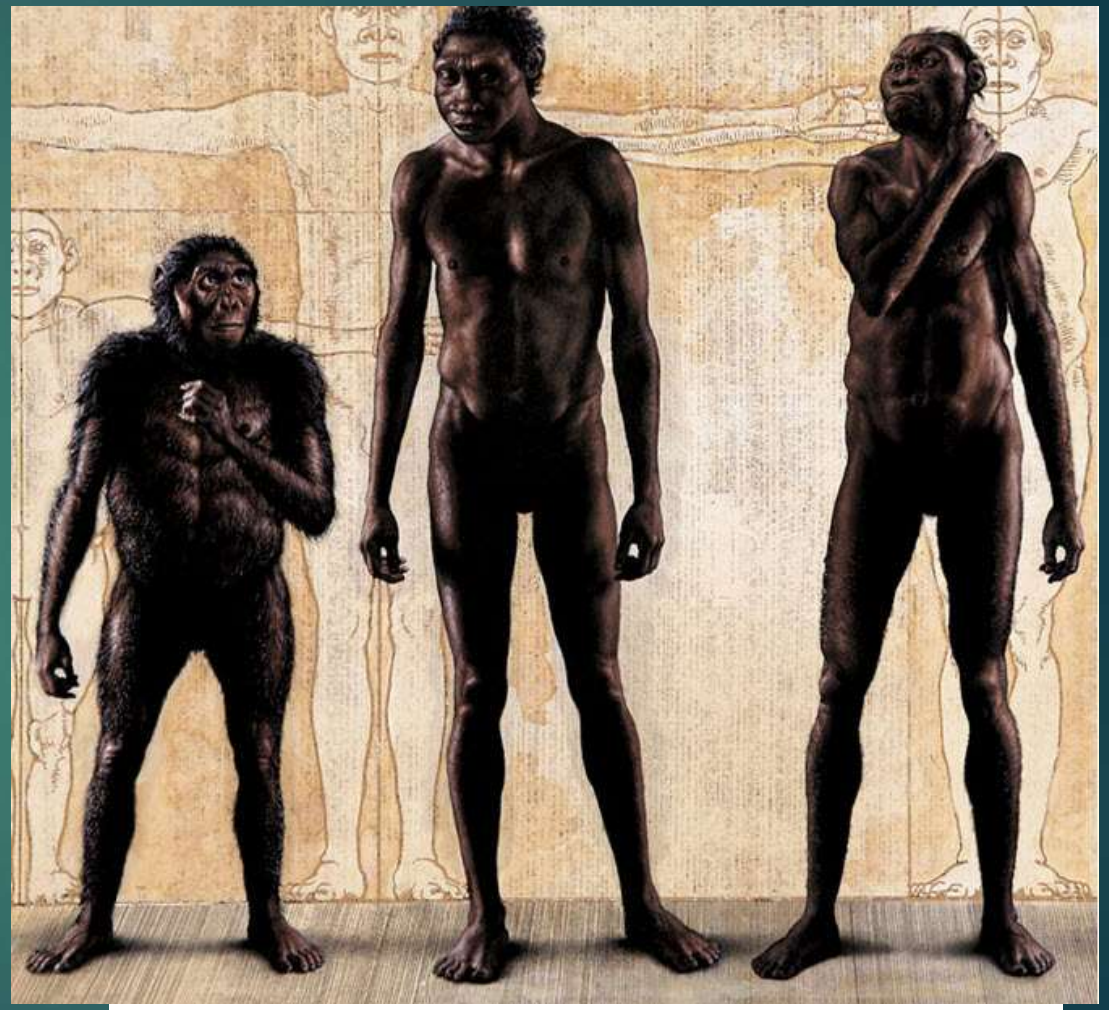
A bush of *Homo* species appear circa 2 MYA: no linear progression toward humanness

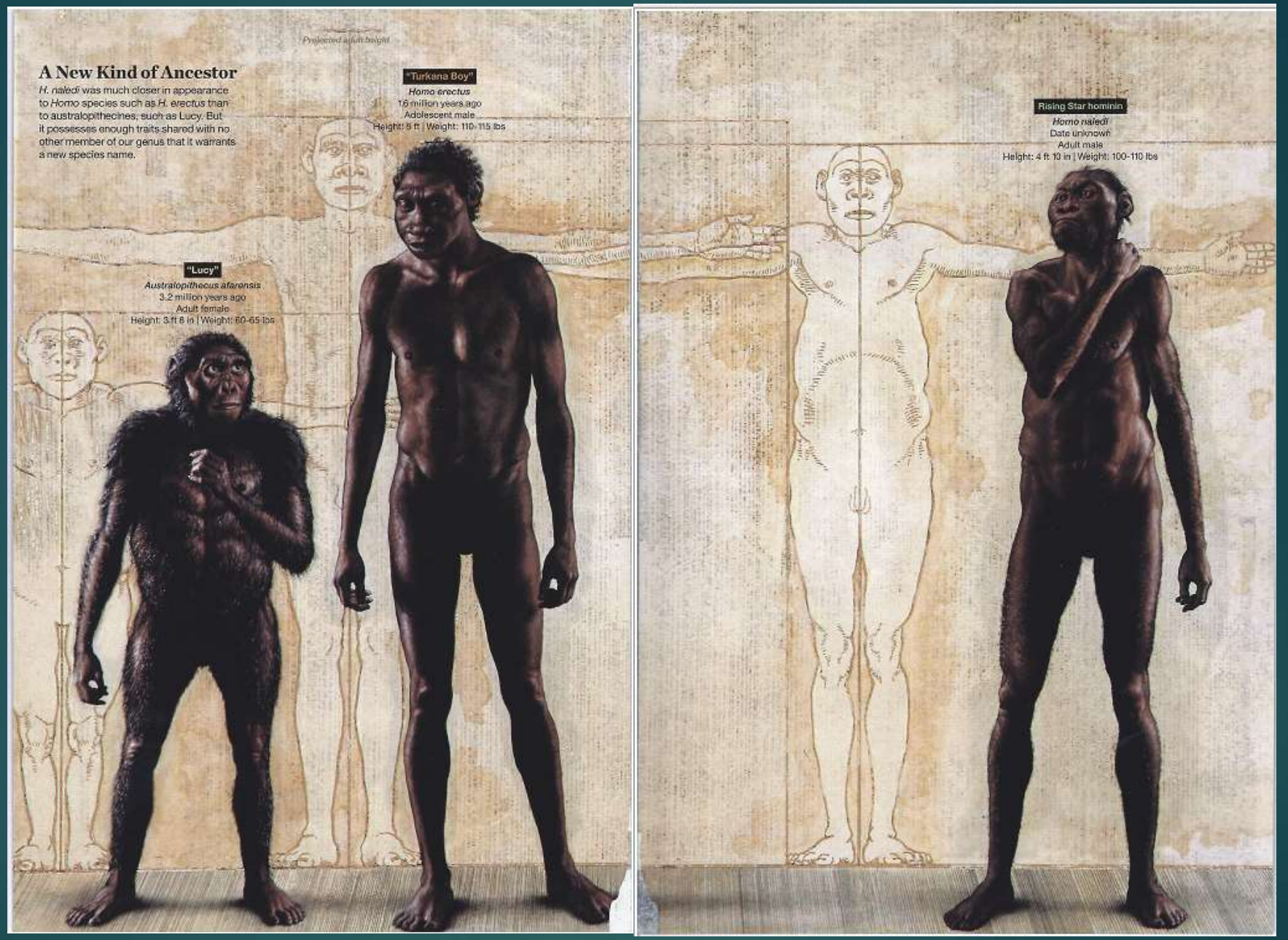
A trio of other *Homo* species, all first appearing in the fossil record around two million years ago, argues against a linear progression toward humanness—a message underscored by *H. naledi*'s unique blend of primitive and advanced traits.

IMAGES NOT TO SCALE

Homo naledi: 1.5 Meters (5 feet) tall, 100 lbs

Skinny, humanlike arms, apelike thorax, primitive pelvis, long legs, humanlike feet





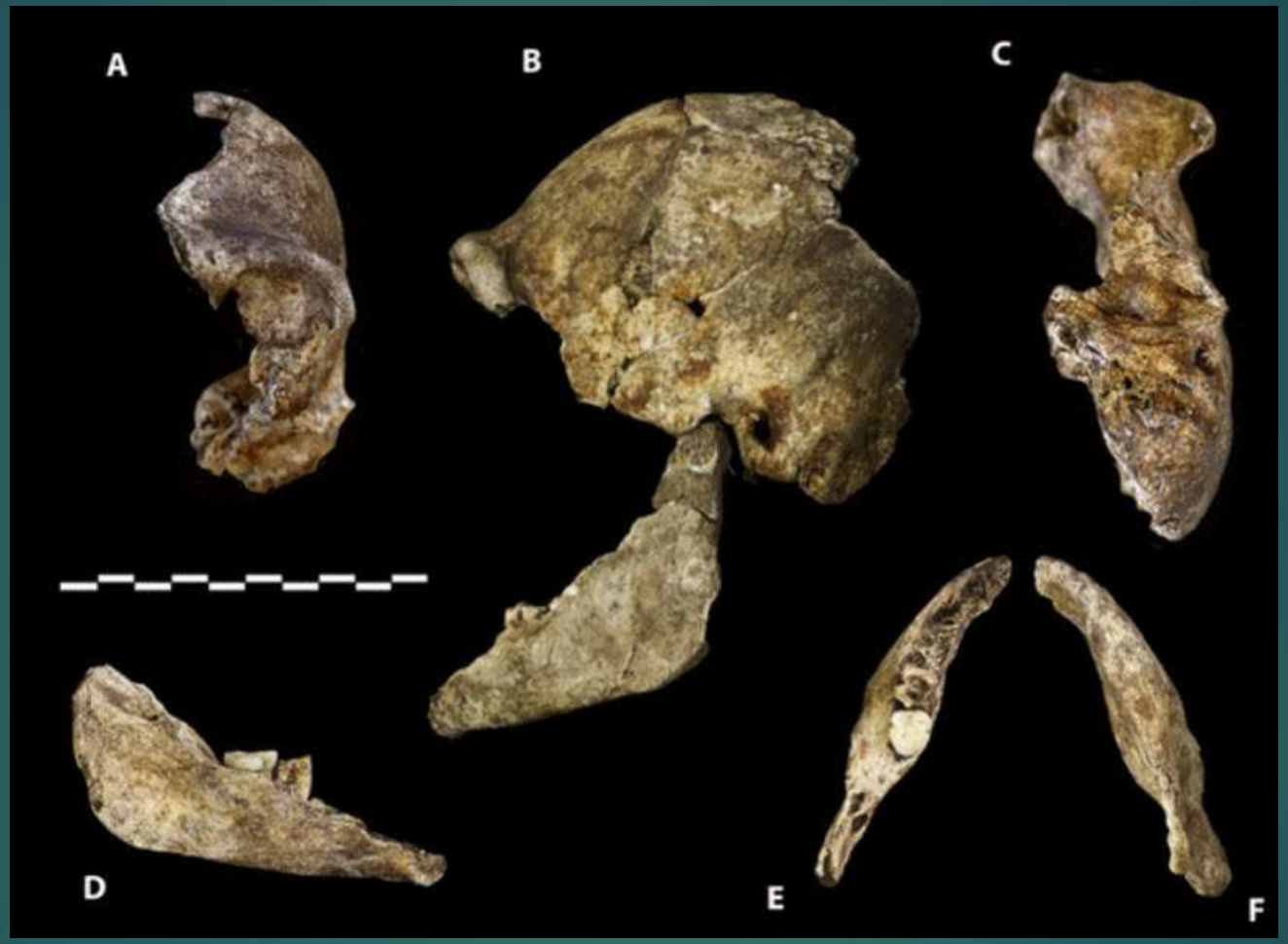
National Geographic comparison

Homo naledi: Globular Braincase & Mandible

Holotype specimen of Homo naledi, Dinaledi Hominin 1 (DH1)

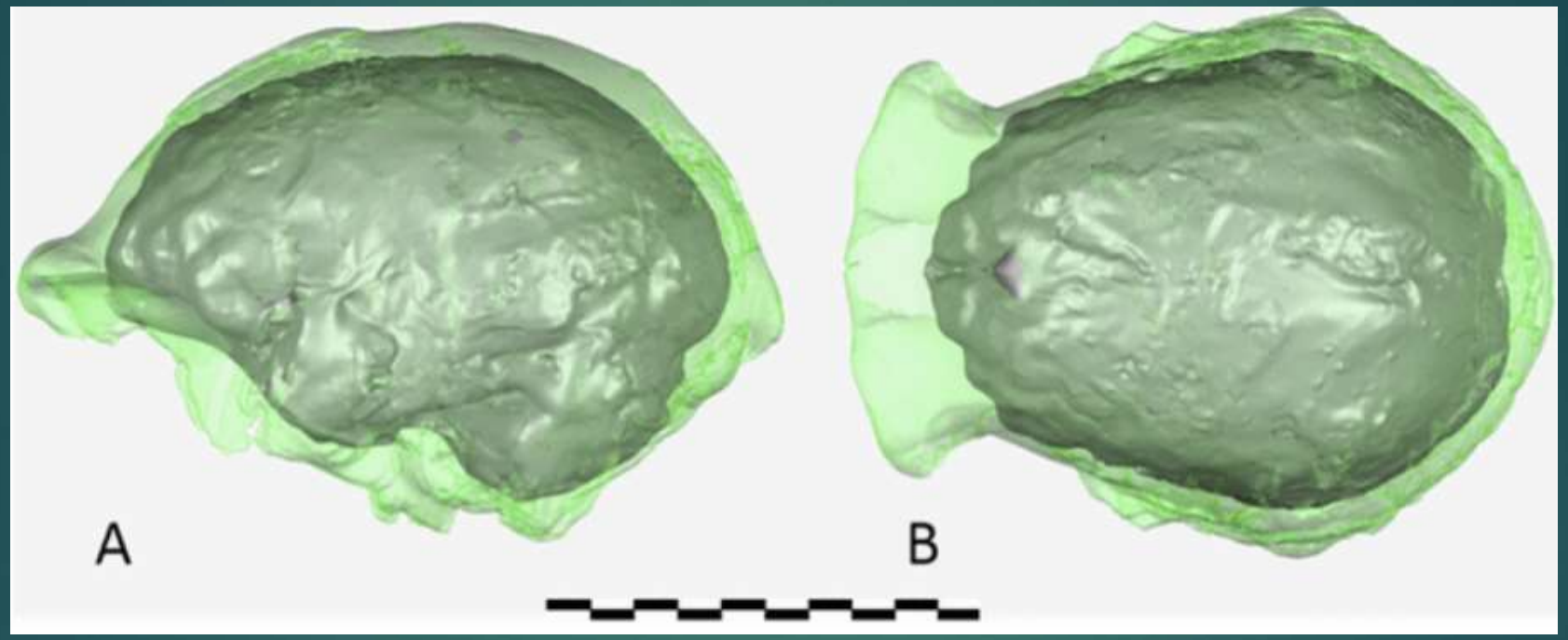
(A) DH2, right lateral view. (**B**) DH5, left lateral view. (**C**) DH4, right lateral view. (**D**) DH4, posterior view.
(B) Scale bar = 10 cm.

Homo naledi: DH3, an elder with worn teeth



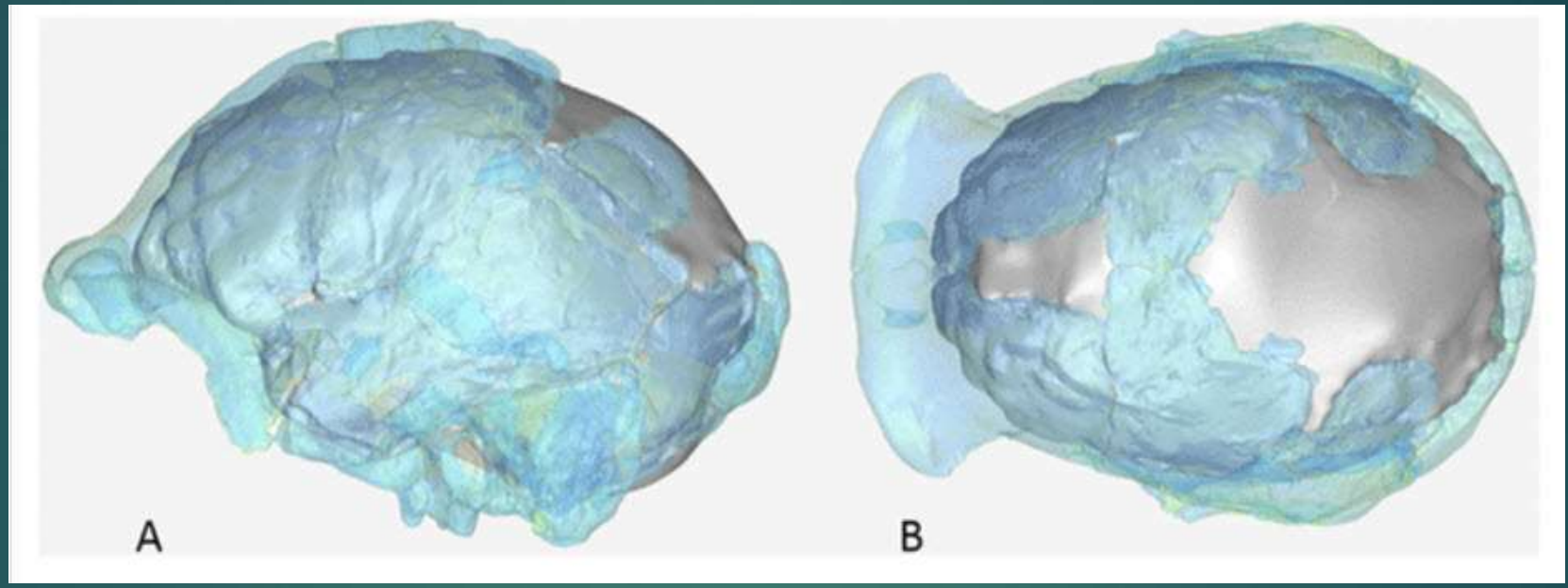
Paratype DH3.(**A**) Frontal view. (**B**) Left lateral view, with calvaria in articulation with the mandible (U.W. 101-361). (**C**) Basal view. Mandible in (**D**) medial view; (**E**) occlusal view; (**F**) basal view. DH3 was a relatively old individual at time of death, with extreme tooth wear. Scale bar = 10 cm.

Homo naledi: DH1 & DH2 endocranium: 550 cc



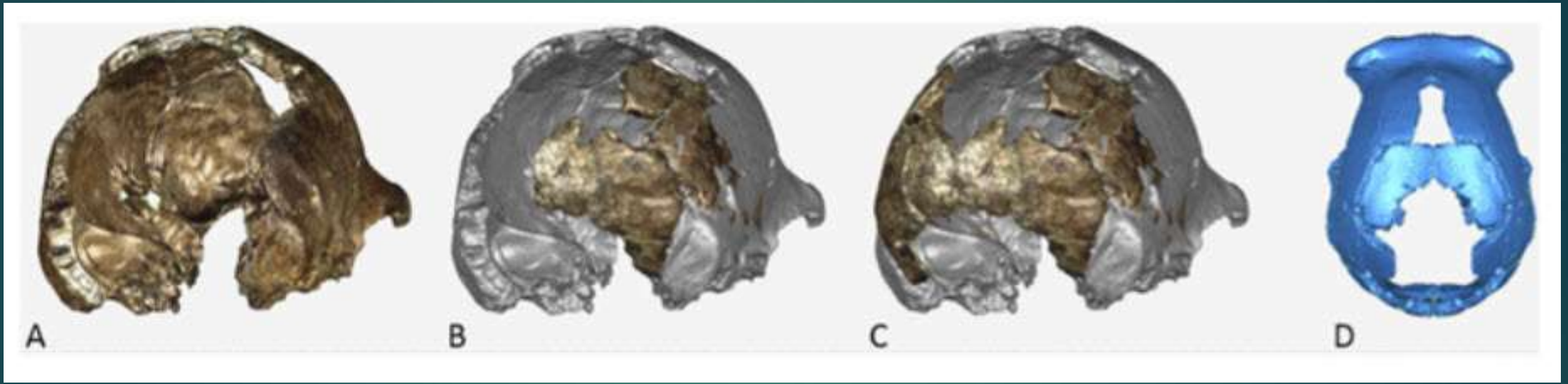
Virtual reconstruction of the endocranium of the larger composite cranium from DH1 and DH2 overlaid with the ectocranial surfaces. (**A**) Lateral view. (**B**) Superior view. The resulting estimate of endocranial volume is 560cc. Scale bar = 10 cm.

Homo naledi: DH3 (female) & DH4 craniums



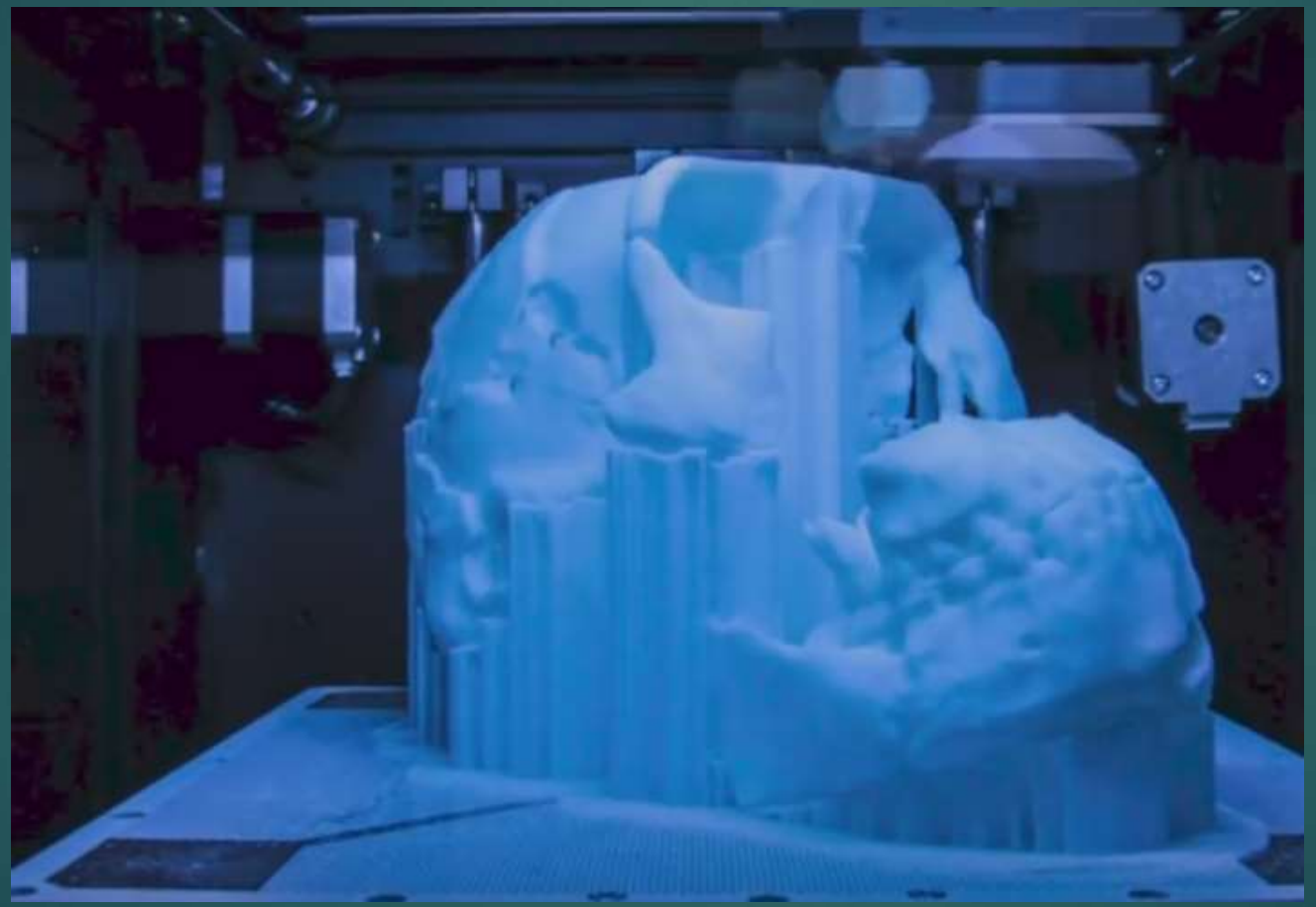
Reconstruction of DH3 & DH 4

Homo naledi: DH3 & DH4



Postero-lateral view of the virtual reconstruction of a composite cranium from DH3 and DH4.

3 D Printing of *Homo naledi* skull



You can 3D Print your own 96 bones from *H. naledi*

- http://morphosource.org/index.php
- Anyone can sign up for a free login and download the shape files, and print them out
- To 3D print other hominid fossils, files at:
- http://africanfossils.org/

Homo naledi

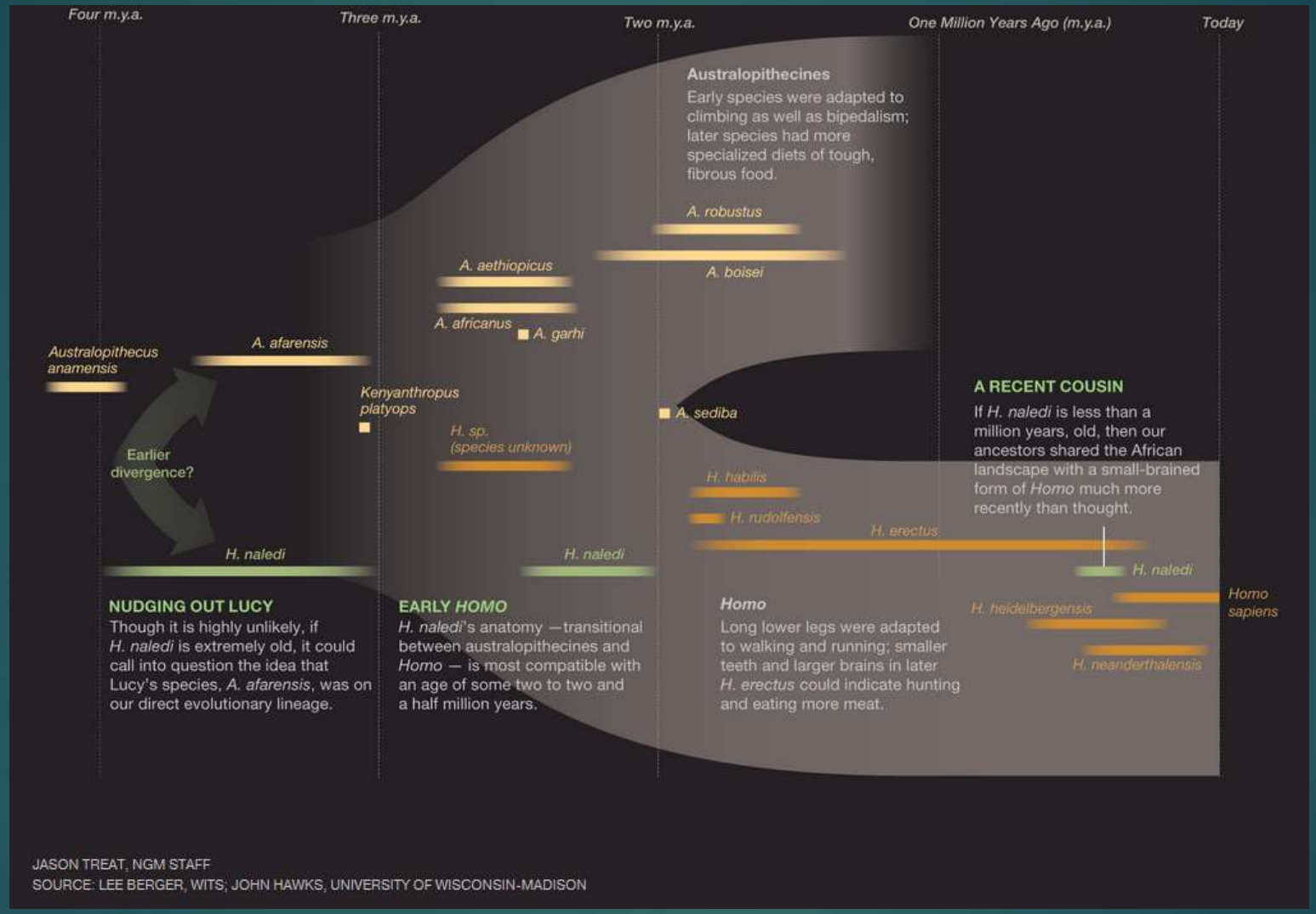
A reconstruction of Homo naledi's head by paleoartist John Gurche, who spent some 700 hours recreating the head from bone scans

Image is from the 10/2015 issue of National Geographic


1 day ago

Homo naledi: Undated; estimate is <2.5 MYA divergence

If older than Lucy, she would no longer be our ancestor

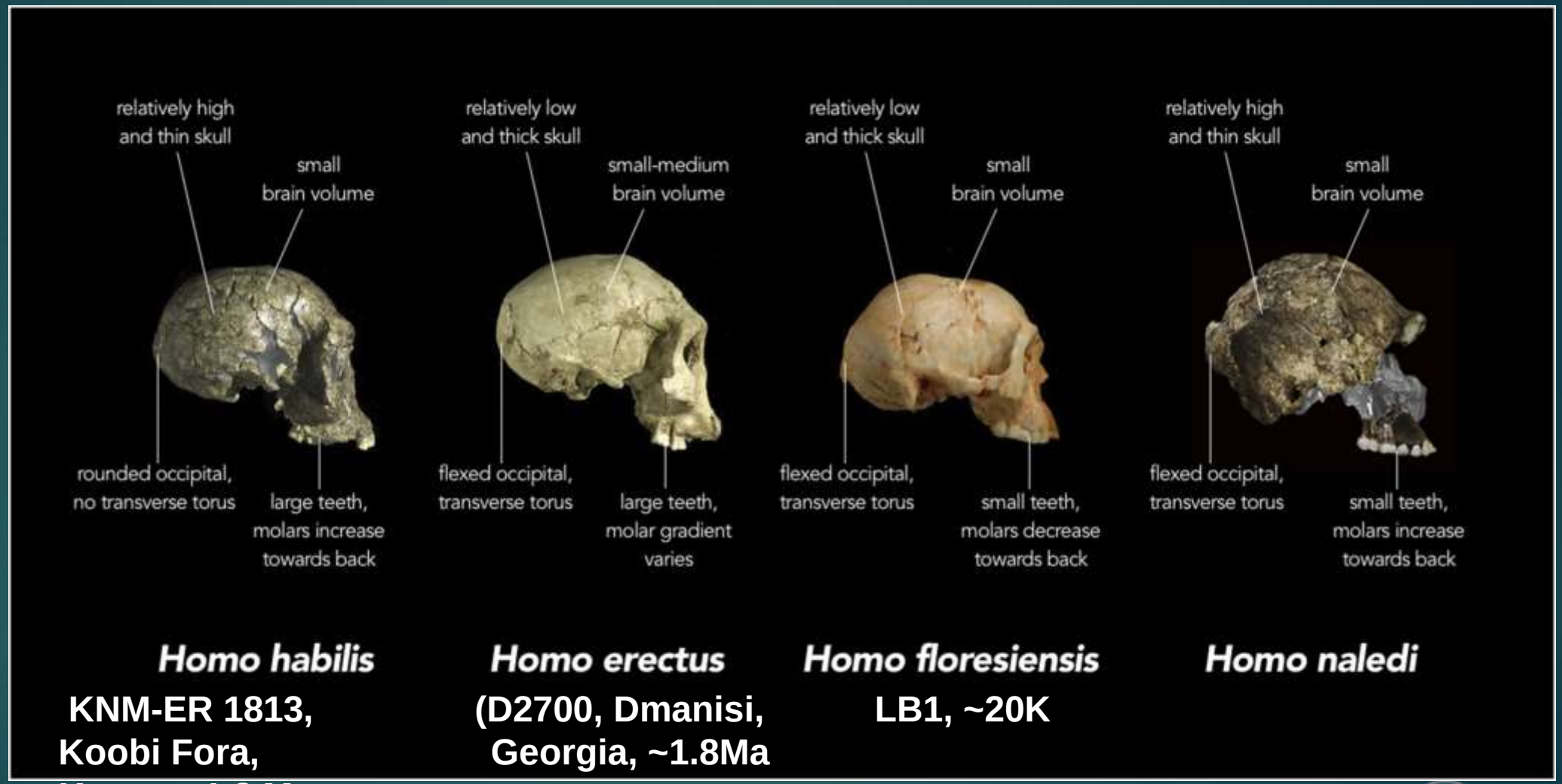


If less than 1 million ears, then our ancestor *Homo erectus* lived with a small brained form of Homo

No fauna, no upper/lower stone layers, no embedded flowstones to be able to date

If *H. naledi* is more than 2 million years old, which Berger et al. suggest could be possible, the species might lie close to the very origin of the genus *Homo*.

Comparison of skull features of Homo naledi and other early human species.



KNM-ER 1813, Koobi Fora, Kenya ~1.8 Ma,

(D2700, Dmanisi, Georgia, ~1.8Ma

LB1, ~20K

Chris Stringer eLife Sciences 2015;4:e10627

eLIFE

Geological and taphonomic context for *Homo naledi*

- Macro-vertebrate fossils are exclusively *H. naledi*, and occur within clay-rich sediments derived from in situ weathering, and exogenous clay and silt, which entered the chamber through fractures that prevented passage of coarser-grained material.
- The chamber was always in the dark zone, and not accessible to non-hominins. Bone taphonomy indicates that the bodies were intact when they arrived in the chamber, and then started to decompose.
- Hominins accumulated over time as older laminated mudstone units and sediment along the cave floor were eroded. Preliminary evidence is consistent with deliberate body disposal in a single location.
- No other large animal remains were found in the chamber, and the bodies were not damaged by scavengers or predators. Only damage made by modern snails and beetles and their larvae.

Burial Site??

Homo naledi: Controversy! Was this a burial site?

- The individuals show signs of having been deliberately disposed of within the cave.
- Possible explanations:
  - Death trap scenario?
  - Bones of age range in typical cemetery (very young & very old; not much in middle); came in as whole bodies (not bits and pieces)
  - no signs of predation (no teeth marks on bones); no predator eats only hominids;
  - no signs of occupation/habitation debris

Burial site?

- no green bone (pressure) breakage, only dry bone (age) breakage
- layered distribution of the bones suggests that they had been deposited over a long time, perhaps centuries;
- not deposited by a water flow of material into chamber (no other debris);
- completely isolated depositional environment (different than other chambers); only clay sediment
- No other entrances (intact chert ceiling)
- Leaves hypothesis that they were put there via “burial” (dropped into chamber)

Homo naledi

- The remains of *H. naledi* could have accumulated as a result of a catastrophic event during which a large group of animals was trapped in the cave:
  - during a single event when a large number of hominin individuals were in the chamber,
  - or in a death trap scenario over a period of time as individuals repeatedly entered the Dinaledi Chamber and died.
- Both hypotheses have evidence against them.
- Mourning behaviors are common in chimpanzees & elephants.
- Or removal of stinking corpses from the places where they lived.

- Recognize that the intentional disposal of the dead bodies is a surprisingly complex behavior for a creature with a brain no bigger than that of *H. habilis* or a gorilla.

Homo naledi: an amazing treasury

- The Dinaledi collection is the richest assemblage of associated fossil hominins ever discovered in Africa, and aside from the Sima de los Huesos collection and later Neanderthal and modern human samples, it has the most comprehensive representation of skeletal elements across the lifespan, and from multiple individuals, in the hominin fossil record.
- The abundance of evidence from this assemblage supports our emerging understanding that the genus *Homo* encompassed a variety of evolutionary experiments.

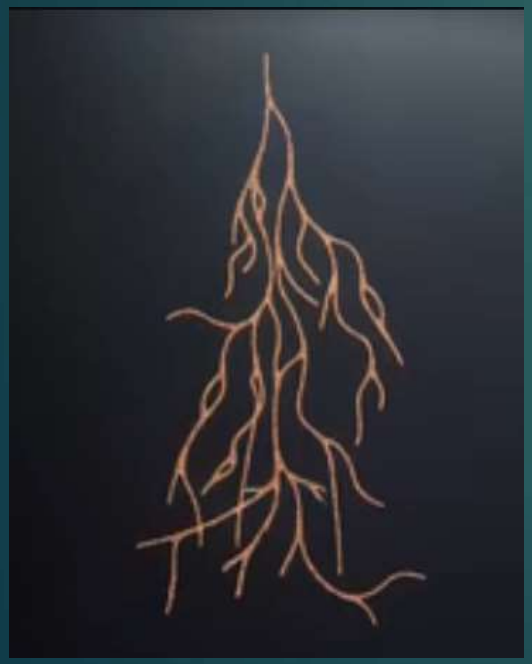
Was Homo polyphyletic?

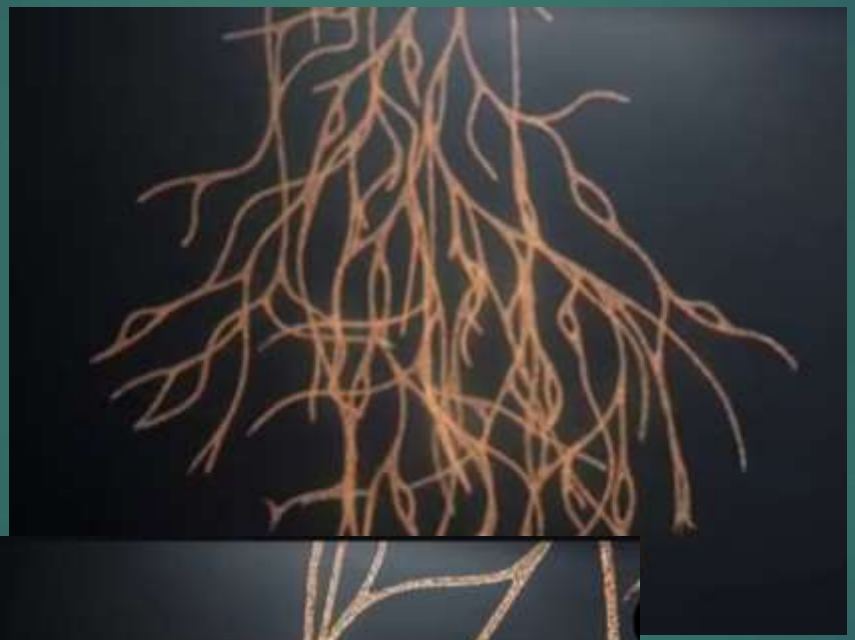
- Chris Stringer: “The mosaic nature of the *H. naledi* skeletons provides yet another indication that the genus *Homo* had complex origins. The individual mix of primitive and derived characteristics in different fossils perhaps even indicates that the genus *Homo* might be ‘polyphyletic’: in other words, some members of the genus might have originated independently in different regions of Africa.
- If this is the case, it would mean that the species currently placed within the genus *Homo* would need to be reassessed.”

Just scratched the surface: Unanswered questions

- Only 1 meter of 12 meters excavated so far.
- Provisionally assigned to the genus *Homo*
- How old are the fossils?
- Where does *H. naledi* fit phylogenetically in human evolution?
- How did the remains arrive deep within the cave system?

Lee Berger’s new metaphor for hominid evolution: Braided Stream – glacier produces a river that divides into rivulets which all merge again downstream in a lake; divergence from common ancestor, then coalesced again; difficult to tell which branch was responsible for us being here today





Only because a skinny caver fit through a crack: *Homo naledi*

- Rising Star cave is 1/2 mile from Swartkrans Cave, one of the most heavily explored caves in Africa; implication of many other possible sites; we don't have a clue what else might be out there
- There is more to come:
  - Age determination: now can use carbon dating & thermolumenescence (South Africa has law that you can not destroy a fossil until published); estimate that species is 2.5-2.8 MY old (not these fossil bones necessarily)
  - DNA attempt
  - Attempt to find soot
  - Thousands more bones
  - Hint of multiple other discoveries by Lee Berger

Potential Implications of *Homo naledi*

- The effect on the field is transformative.
- If older than 3.0 MYA, then *H. naledi* becomes our most likely ancestor; not *A. afarensis* or *Homo habilis*
- Evolution produced different types of humanlike creatures originating in parallel in different parts of Africa.
- Was there multiple early hybridizations? Or an incomplete lineage separation?
- Is this a relic population that may have evolved in near isolation in South Africa or an ancestor?
- Is there a point at which we became human or are there many ways to be human?

Potential Implications of *Homo naledi*

- Apart from our language capacity, no uniqueness claim has survived unmodified for more than a recent decade since it was made. Tool use, tool making, culture, food sharing, theory of mind, planning, empathy, inferential reasoning — it has all been observed in wild primates.
- Frans de Waal: “It is an odd coincidence that “naledi” is an anagram of “denial.” We are trying way too hard to deny that we are modified apes…We are one rich collection of mosaics, not only genetically and anatomically, but also mentally.

Criticisms

- Nature rejected several manuscripts submitted to them (but *eLife* is peer reviewed)
- Paleontologists Jeffrey Schwartz and Ian Tattersall suggested in the Aug. 28 issue of Science that the bones might represent at least two different species. And Tattersall told the New York Times it might turn out that *Homo naledi* was not *Homo* at all.
- Tim White, UCB: Might be a variant of *H. erectus; (*but Hawkes*:* body is unlike erectus*;* long, anteroposteriorally flattened and anteverted femur neck; tibia is exceptionally mediolaterally thin and long, with a rounded anterior border and tubercle for the pes anserinus tendon; scapula has a superiorly oriented glenoid; a short, flared ilium; form of skull looks like early erectus, but premolar teeth unlike *erectus*; only 1 *erectus* brain is as small as *naledi*)

Bibliography

- *Homo naledi*, a new species of the genus Homo from the Dinaledi Chamber, South Africa - LR Berger, J Hawks, et al., *eLife*, 2015
- Geological and taphonomic context for the new hominin species *Homo naledi* from the Dinaledi Chamber, South Africa - PH Dirks, et al., *eLife*, 2015
- Human evolution: The many mysteries of *Homo naledi* **-** Chris Stringer, *eLife*, 2015
- Two hour NOVA, this Wednesday, September 16 or online at:
  - http://www.pbs.org/wgbh/nova/evolution/dawn-of-humanity.html
  - http://video.pbs.org/video/2365559270/
- October 2015 Issue of National Geographic
- For a critical look at Lee Berger: http://www.pbs.org/wgbh/nova/next/evolution/lee-berger/

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  - Hominid Evolution 2015
  - Human Brain Evolution 2015
  - A Brief Biographical History of Paleoanthropology 2012

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