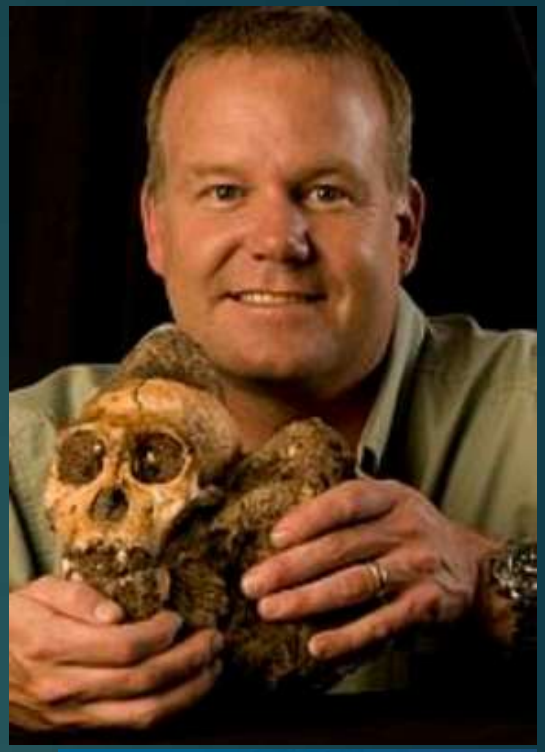
Homo naledi

The Star Man

“This must surely be a glorious moment to be a paleontologist.“

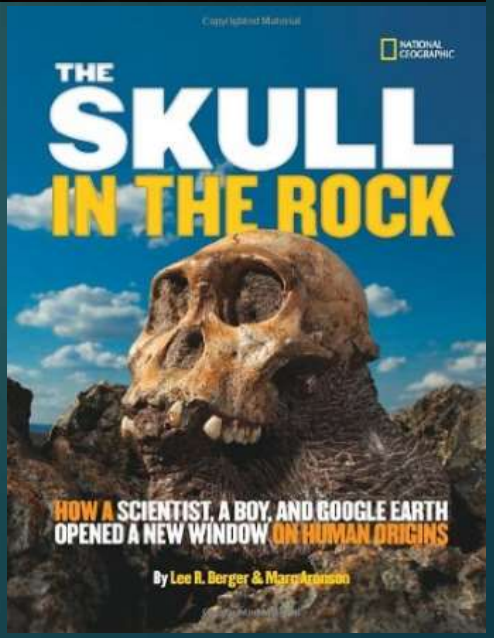
Charles J. Vella
June, 2016

Lee Rogers Berger (1965-):



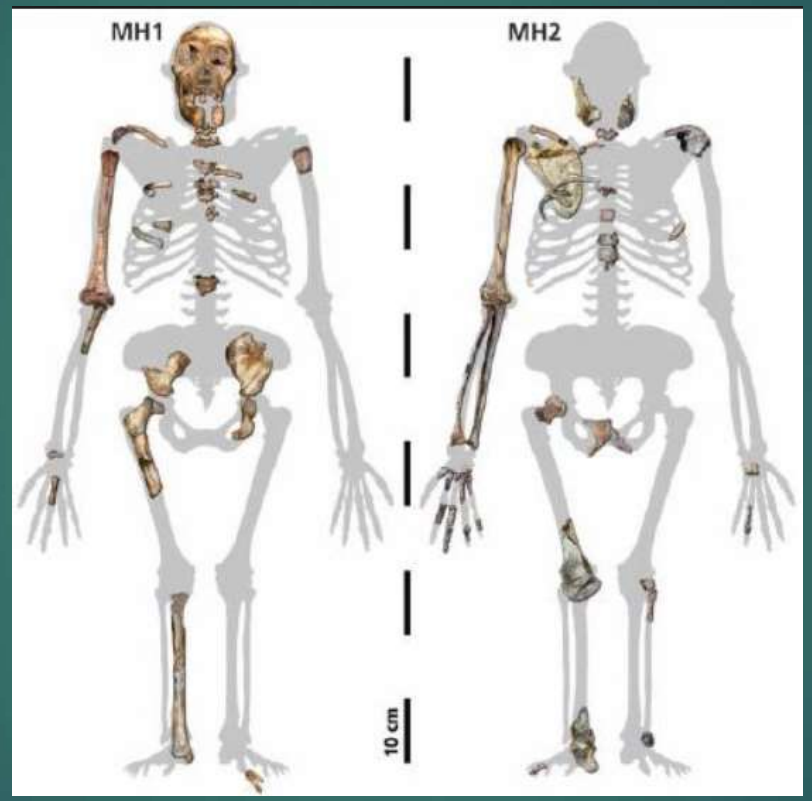
- Grew up in Georgia; grandfather was oil wildcatter
- Berger moved to Johannesburg to study for his doctorate under Phillip Tobias (Raymond Dart's student); He is a paleoanthropologist, physical anthropologist and archeologist

- University of the Witwatersrand
- He hunted for fossils in South Africa for 17 years before making his first major discovery.
- Surveying South Africa's Malapa Cave in 2008: son Matthew discovers *Australopithecus sediba*, 1.98M
- In 2012, Berger published a children's book, *The Skull in the Rock*, about evolution and how he and his 9-year-old son, Matthew, found the first *Australopithecus sediba* fossil together.



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:

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

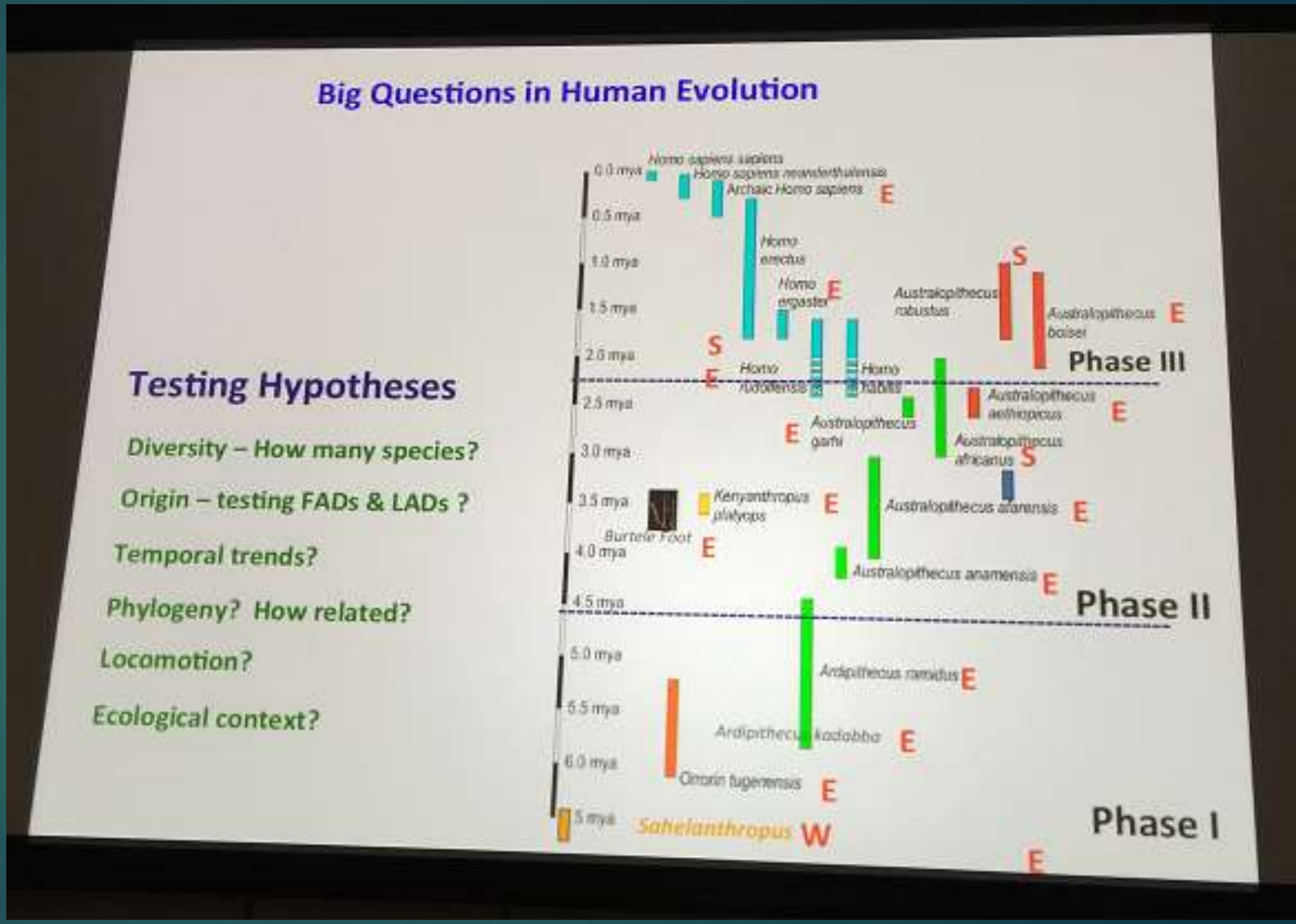
Homo naledi

- A major fossil discovery
- Huge media coverage
- Questions of methodology

Phase I = bipedal, incipient

Phase II = Australopiths, Megadont, diet shift

Phase III = emergence of Homo



Scenarios & Hypothesis

Phases?
Diversity?
Phylogeny?
Origin?
Temporal trends?
Ecological context

Answers Come from

Understanding paleobiological & paleoecological parameters
Variation
Functional anatomy
Behavior
Dietary adaptation
Ontogeny
Paleo-environmental setting

Cradle of Humankind

- The 50,000-hectare (123,550-acre) area of hilly grasslands is recognized as the Cradle of Humankind, featuring a network of caves that has yielded nearly 40 percent of known hominid fossils

In the middle of the most explored fossil sites of South Africa…

Rising Star Cave system – 30 miles north of Johannesburg; explored for 50 years

Location: 26°1′13″ S; 27°42′43″ E; 800 meters SW from well explored Swartkrans cave

2015: 4 papers on *Homo naledi* published

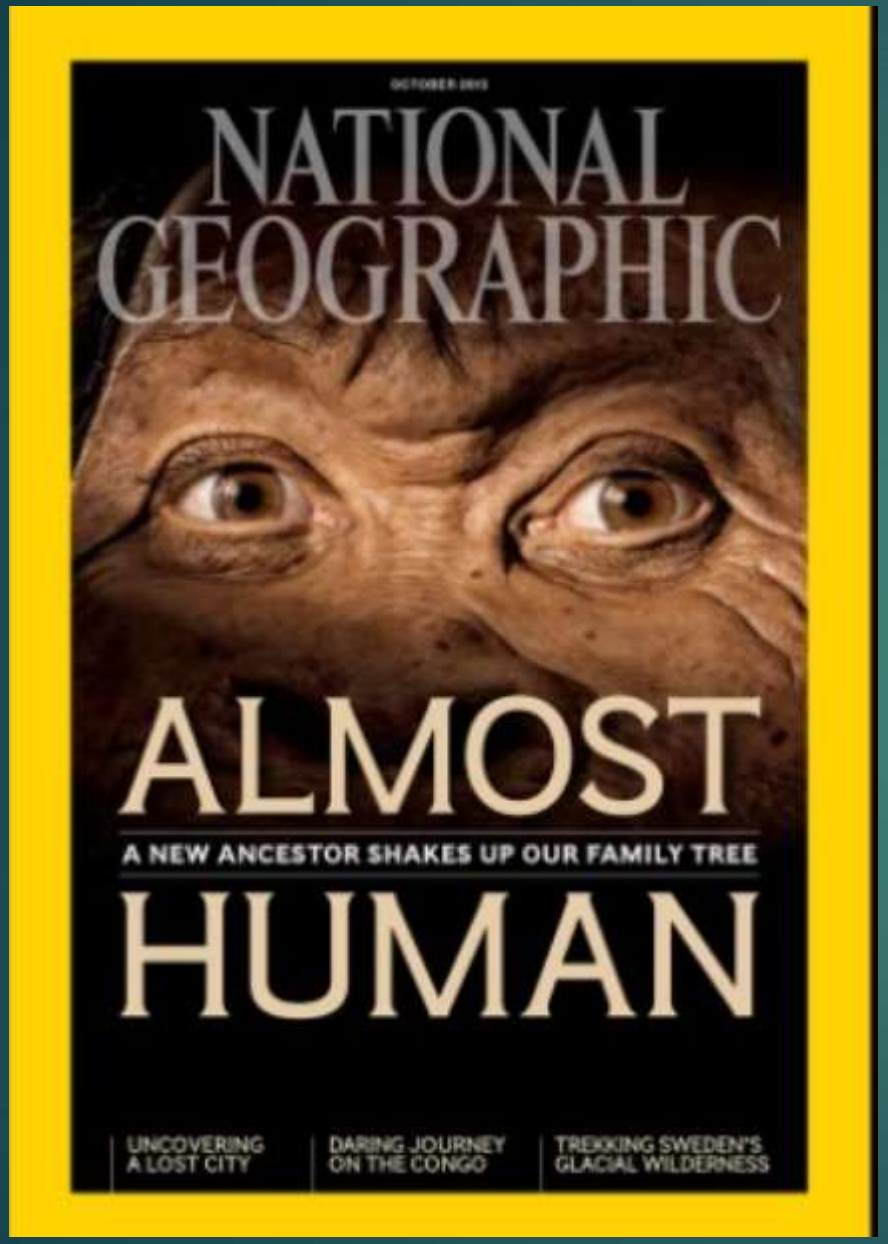
- 1 *Homo naledi*, a new species of the genus Homo from the Dinaledi Chamber, South Africa - Lee R Berger, John Hawks, et al. (45 other authors), 2015, *eLife*
- *2* Geological and taphonomic context for the new hominin species *Homo naledi* from the Dinaledi Chamber, South Africa - Paul HGM Dirks, Lee R Berger, et al. (22 other authors), 2015, *eLife*
- 3 The foot of *Homo naledi* **-** W. E. H. Harcourt-Smith et al., 2015, *Nature Communication*
- *4* The hand of *Homo naledi* **-** Tracy L. Kivell, et al., 2015, *Nature Communication*

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

The Discovery:

- On September 13, 2013 while exploring the Rising Star cave system, looking for an extension, recreational cavers Rick Hunter and Steven Tucker of the Speleological Exploration Club (SEC) of South Africa found a narrow, vertically oriented "chimney" or "chute" measuring 12 m (39 ft) long with an average width of 20 cm (7.9 in).

- This chute led to a room 30 m (98 ft) underground (Site U.W. 101, the Dinaledi Chamber), the surface of which was littered with fossil bones.

- Berger had asked Pedro Boshoff to help investigate about 800 sites he had identified using Google Earth. Hunter & Tucker reported the find to Boshoff.

The Discovery

- On 1 October 2013 photos were shown to geologist Pedro Boshoff, and then to Lee Berger.
- On 6 November the news was made official to the world through National Geographic.
- On 10 Nov. the first group of scientist/cavers enter the fossil chamber. 3D scans are done and towards the end of the day the first fossil sees the light of day - a mandible.
- There were two field expeditions, in November 2013 and March 2014.
- Sep 10, 2015: First official announcement: https://www.youtube.com/watch?v=QiiOJ4Y9ZLo

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)

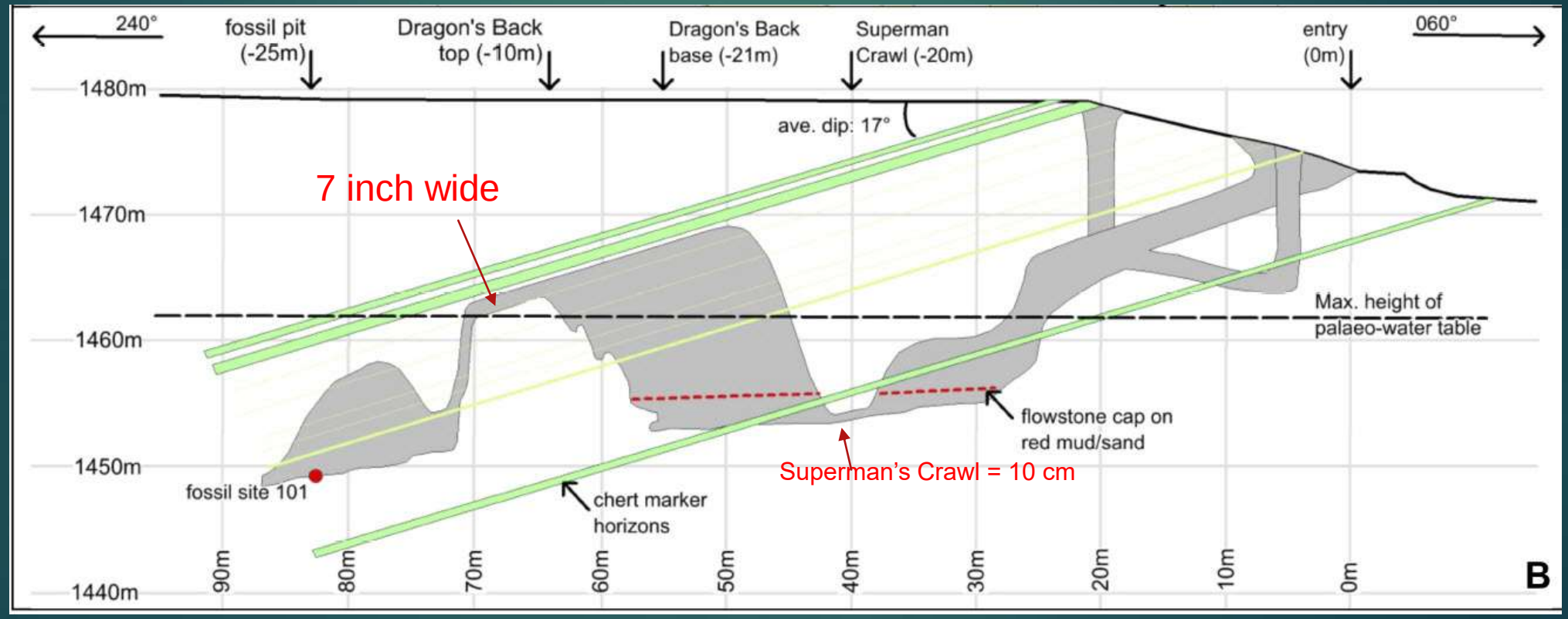
Steve Tucker: 1st spelunker into the 30 m (98 ft) long Dinaledi Chamber

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

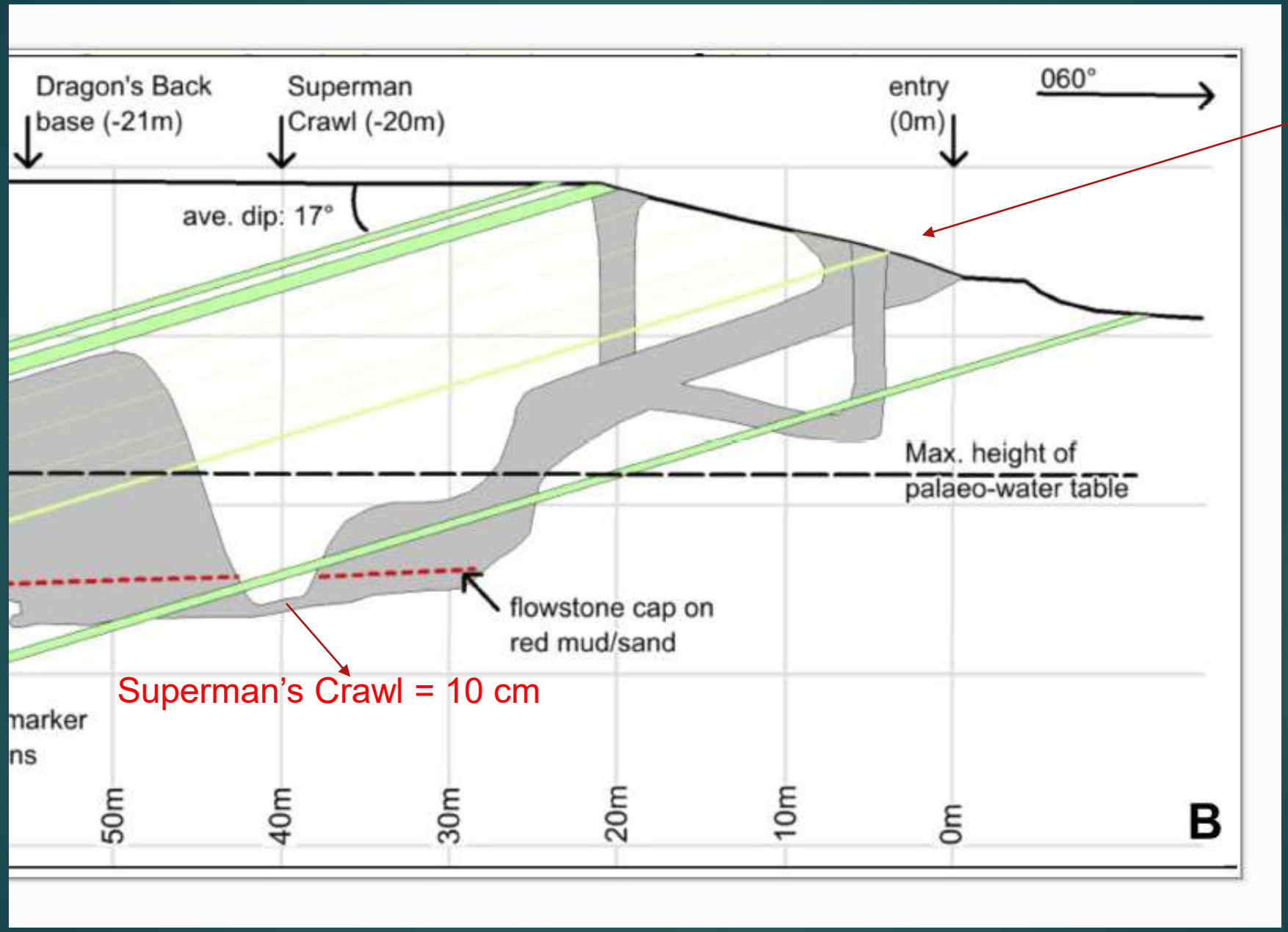
Rick Hunter: kicked out of high school for causing an explosion in a chemistry lab.

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

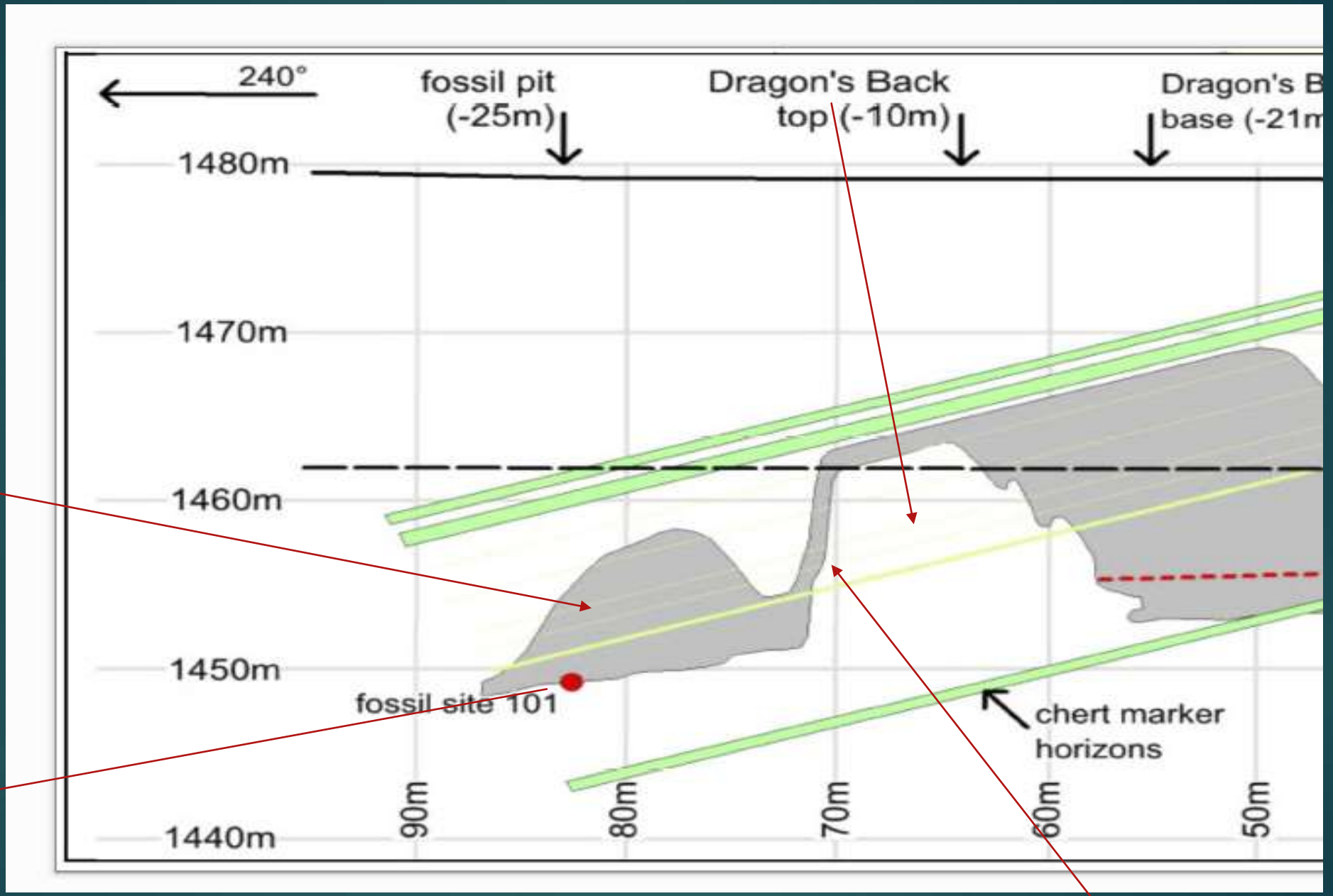
Rising Star dolomite cave system in South Africa: 90 meters long, pitch black; ~30 m below surface and ~80 m, in a straight line, away from the present, nearest entrance to the cave



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

Most Fossils

The Chute: 12 m, punctuated by shark-teeth protrusions

Not the first ones in the cave

- Among all of the fossils, they found old survey pegs left behind in this chamber, and evidence that some of the fossils on the surface had been moved. Apparently, the cavers that discovered the chamber were not the first ones to have stumbled upon it.

- Yet until quite recently, no one knew this cave existed; whoever left those survey pegs did not recognize the importance of this find and didn't bother to note it on a map.

- Instead of dispatching a lithe paleoanthropologist with caving experience, he sent Matthew, his son, who was 14, down with Tucker and Hunter.

Berger on “freshly” broken bones *

- “These ‘freshly’ broken bones are presumably being identified because of the chalky white appearance of edges and indeed that is what they are. They were there when Rick and Steve first entered the chamber in mid-September of 2013. They were presumably created by at least one earlier visitation to this chamber by an unknown caver(s) who had entered the cave and even left their visit documented by a marker on the wall – though they never placed the chamber on any map known to exist to us. They clearly did not recognize the bones on the floor, or if they did, their importance and they clearly stepped on some damaging them. These are those chalky white breaks you see in images and there were quite a number of them damaged like this (I’ve attached a couple more that have not been published). The (presumably) amateur caver(s) who had managed to get into the difficult chamber did most of this type of damage that seems to be being pointed to as poor or sloppy excavation methods. It’s not and that should be settled once and for all for history’s sake”

No preservatives

- Why did we choose not to put preservative on the bones during the process of excavation? There are a few reasons. The first is that the vast majority of the elements did not need it. In addition to the underground excavators we had a wealth of highly trained senior scientists on the surface receiving this material as it came up. Combined the senior scientists present making these decisions have tens of thousands (if not hundreds of thousands) of hours of experience in excavating everything from human remains, fossil hominins and fauna from I would hazard most situations where these have been found. We made that call at the time based on the material and its condition and we stand by it. Secondly, the situation inside the chamber suggested ‘preservatives’ might do more harm than good. The humidity approaches 100%, in a South African context we have seen scientists put preservatives on “wet” fossils such as these and it usually results in the eventual destruction of the fossil.

No preservatives 2

- Why? Well, most appropriate preservatives use some sort of solvent to dilute them such as acetone or even water in order to make them thin enough to penetrate the fossil or bone. When a bone is wet (from ambient humidity or water), usually this reduces the effect of a chosen preservative to penetrate the bone and thus coats it, pretty much like wrapping it in plastic. This is a bad thing. Why so? Imagine the difference between a sandwich that is moist. If you wrap it in plastic wrap and just leave it what happens is it stays moist. This is great for a day or so, but pretty soon you begin to grow things, you retain the moisture and while you may have a sandwich shaped plastic covered experiment, in a few days the inside is destroyed. This can happen to bones, particularly in the South African environment where there is calcium carbonate. Coating them in a preservative can cause the interiors to retain moisture and eventually destroy internal structures and cause the surface to flake off. Also, solvents like acetone, which can replace water, often in these circumstances dry the bone too quickly and cause cracking. We made the judgement call on site that we were not going to take that risk and were very happy with the condition the bones came up in while wet. We then went through a slow drying process which allowed the bones to harden and they did, to near bone like strength.
  As an aside, there are woefully few studies on the effects of such preservatives on modern studies.

Excavation

- We also chose to take only a tiny percentage of what we believe is in the chamber to preserve the context and other aspects of the assemblage for future work at the site, either by us or by teams of scientists years or decades from now. This we felt was prudent so that unlike many sites with hominins that have been literally excavated until they exist no longer, new technologies, new methods and new techniques may be applied to the Dinaledi assemblage in-situ as appropriate.

First footage of discovery

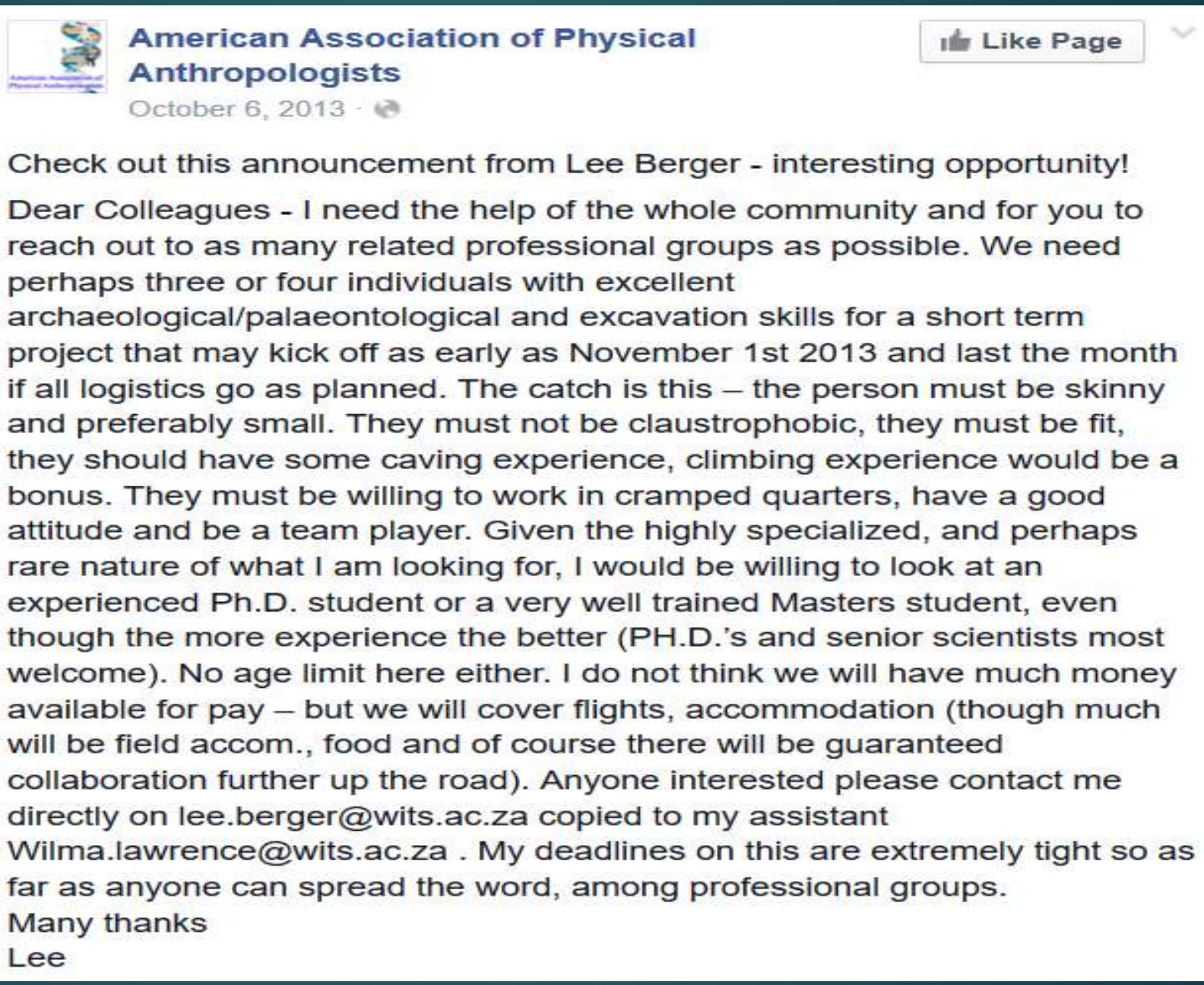
Tight spots: 7 inch (20 cm) crawl space

Then drop down into a cavern of unknown depth
(actually 12 meter deep)

One of the wider spots

Fly through of Rising Star Cave: https://www.youtube.com/watch?v=vI-JF28T44U

Original Internet Ad



American Association of Physical Anthropologists

October 6, 2013 ·

Like Page

Check out this announcement from Lee Berger - interesting opportunity!

Dear Colleagues - I need the help of the whole community and for you to reach out to as many related professional groups as possible. We need perhaps three or four individuals with excellent archaeological/palaeontological and excavation skills for a short term project that may kick off as early as November 1st 2013 and last the month if all logistics go as planned. The catch is this – the person must be skinny and preferably small. They must not be claustrophobic, they must be fit, they should have some caving experience, climbing experience would be a bonus. They must be willing to work in cramped quarters, have a good attitude and be a team player. Given the highly specialized, and perhaps rare nature of what I am looking for, I would be willing to look at an experienced Ph.D. student or a very well trained Masters student, even though the more experience the better (PH.D.'s and senior scientists most welcome). No age limit here either. I do not think we will have much money available for pay – but we will cover flights, accommodation (though much will be field accom., food and of course there will be guaranteed collaboration further up the road). Anyone interested please contact me directly on lee.berger@wits.ac.za copied to my assistant Wilma.lawrence@wits.ac.za . My deadlines on this are extremely tight so as far as anyone can spread the word, among professional groups.
Many thanks
Lee

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

- Successful candidates could not be claustrophobic; they had to be cavers; they had to hold a relevant master’s degree or doctorate; they had to come to Johannesburg immediately and accept a blind mission, for no pay. (Travel expenses would be covered.) Nearly sixty people applied. Berger chose six.
- 60 applied, not all women; final list of 10 contained 1 man; 6 women picked

- Rising Star is the most open paleoanthropological project that has ever been attempted. Published on internet; 47 researchers (20 early career)

Underground astronauts of the Dinaledi Chamber

All were larger than largest *H naledi* males.

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.

Historical paleontology

- Paleontology is a field of science noted for the amount of time senior experts take to study a single skeleton in isolation before publishing their results in an established peer-reviewed journal, while retaining tight control of the fossils they have discovered. Some take more than a decade to do so.

- Tim White at UCB is classical example of this approach (15 years before publication for *Ardipithecus*).

Excavation

- The majority of the material came from a meter by meter square pit excavated to a depth of ~25 cm.
- Three to four weeks work in such a space with loose clay is not a speedy endeavor. They used two shifts of 2-3 excavators, in six-hour shifts (= 8 weeks in person-time)
- The entire excavation took place under no less than three surveillance cameras, which were monitored at all times by senior scientists above ground.
- Meticulous protocols set in place before entering the cave and then modified as conditions warranted. The 3D surface scans and high-resolution forensic camera photos of the process used in lieu of traditional hand-mapping not only have yielded greater detail, but also allow us to “re-dig” the site virtually from any angle.
- In sum, any inference of impropriety or sloppiness in field methods is very easily refuted using solid evidence.

A triumph for open access and education

- Cameras put in the cave, and research streamed live from day one.
- The dig, in November, 2013, lasted three weeks; a smaller dig followed in March, 2014. National Geographic live-blogged and tweeted the latest developments.

- Discovery to publication: under 2 years

- 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 170,000 downloads; whereas 50% of 1.8M scientific papers published annually are never cited).

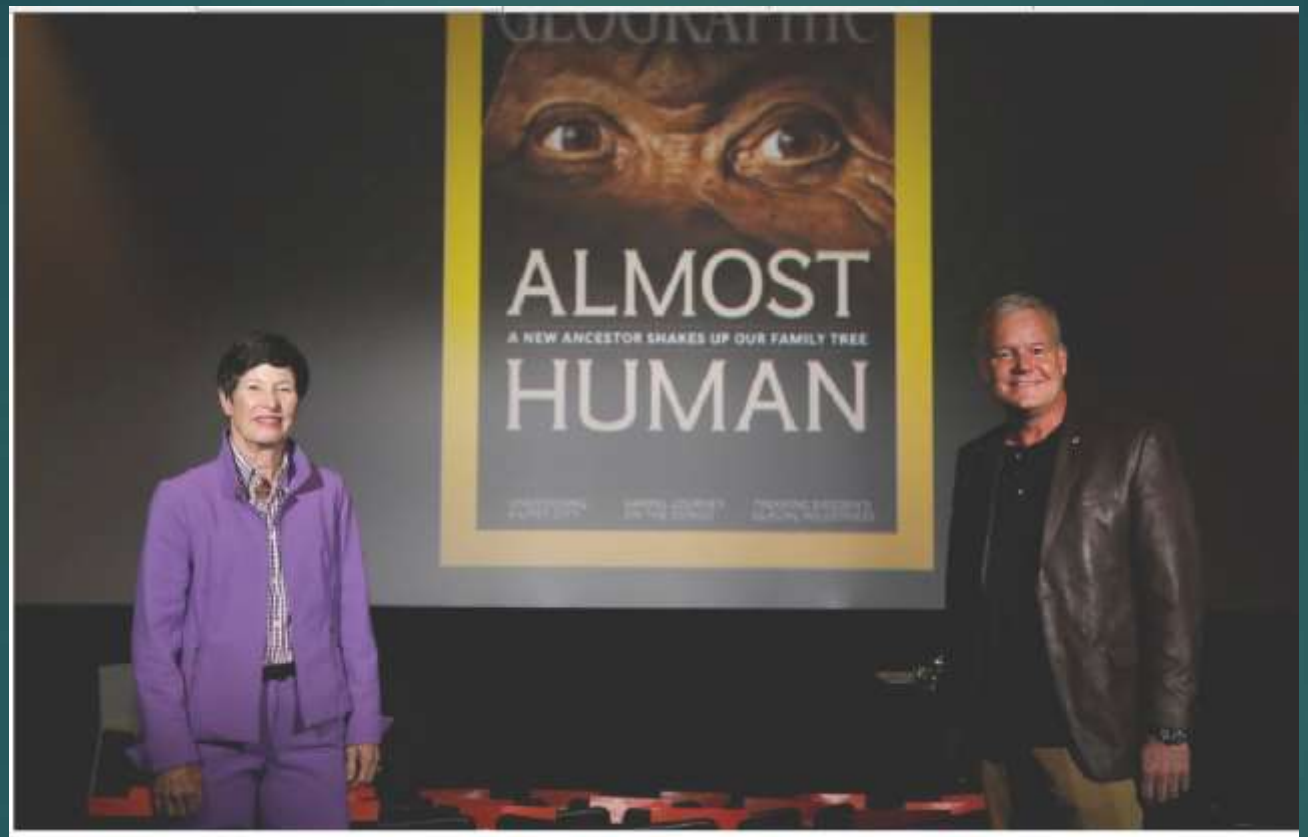
Open Access 2

- Berger has been an advocate of paleodemocracy and open access: the idea the fossils should not be held by researchers for 10-25 years (White: Ardi 1994-2009); that they should be immediately available to other researchers.
- Twitter, Facebook and Hawkes Rising Star Expedition blog were immediately available.
- Many of the fossils are now represented by research-quality 3D scans on MorphoSource (1700 downloads in just 1st few 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

Lyda Hill, Texas oil billionaire, has been in the cave



Lyda Hill and Lee Berger celebrate October issue of National Geographic.

His groundbreaking expedition and research was largely financed by nearly $3 million from Lyda Hill, the 73-year-old Dallas billionaire and philanthropist who's the granddaughter of legendary oil tycoon H.L. Hunt. Hill became Big Rich with the sale of her family's Hunt Petroleum Corp. for $4.2 billion in 2008 to Fort Worth-based XTO. Hill was among the first billionaires to sign Warren Buffett's Giving Pledge.

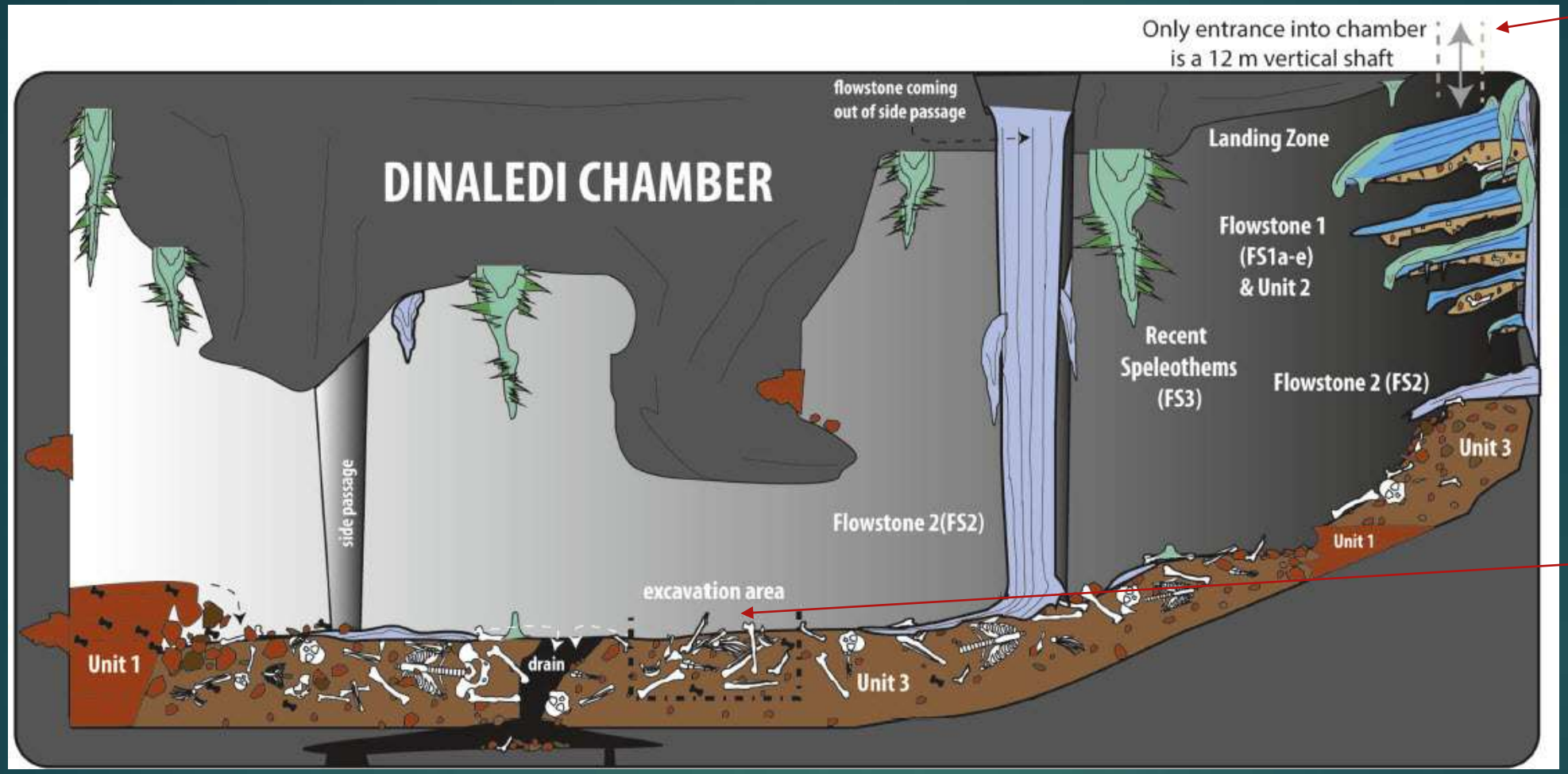
Beautiful limestone cave

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. H. naledi fossils entered the chamber over an extended period of time; that is, not all remains were deposited at once

Temperature

- Marina Elliott: "It's pitch dark except for your head lamp and it is very warm. It's an 18 degrees Centigrade (64 degrees F) constant temperature there, but it's actually 99 per cent humidity. So it's very, very damp and sort of smells like warm, moist earth."

No animal remains

- Except for 6 bones of 1 avian leg & some rodent incisors;
- Nothing else except partially mineralized hominid bones.
- “The lack of other contemporaneous fauna in the assemblage, and complete lack of surface modifications by vertebrates (carnivores, scavengers or rodents) further suggests that the Dinaledi Chamber remained undisturbed by other animals, which could not reach the chamber.”

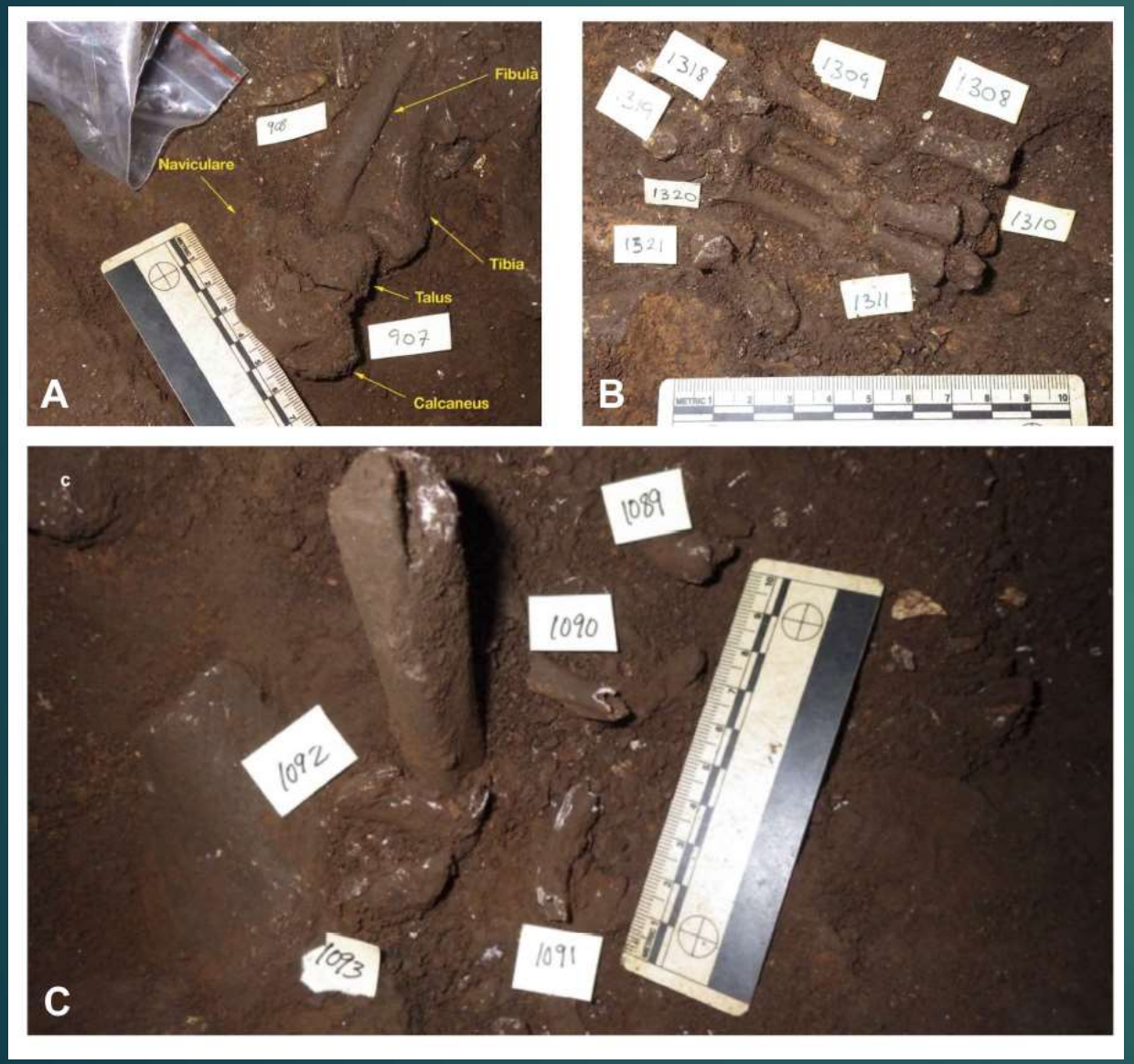
Bones, Bones, Bones lying around

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”

3D lasered the entire chamber; 30,000 photos of location of bones

Taphonomic spatial patterning



A.Ankle
B.Hand
C. Disarticulated elements in a non-horizontal resting state.

Continual reworking of Units 2 and 3 due to the gradual erosion of the cave floor as it slumps toward floor drains in the chamber

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

Skulls. Jaws. 48 Ribs. 190 teeth. A nearly complete foot. A hand. Bones of the inner ear.

Age distribution:

- 13 Individuals of practically every developmental age, from neonate to elderly:
  - 3 infants (Infants were identified by their thimble-size vertebrae),
  - 3 young juveniles,
  - 1 old juvenile,
  - 1 sub-adult,
  - 4 young adults and
  - 1 old adult.
- 8 of 13 were not adult (not repeated cave exploration by socially isolated adult males)

A side note on terminology: “Primitive” vs advanced features

- Describing an organism or trait in “primitive” vs “advanced” terms, promotes the misconception that evolution proceeds along a direct path, with organisms getting increasingly "advanced" or "complex" over time.

- This sort of ladder-of-life thinking does not accurately reflect how evolution works. Every species that has lived had traits shaped by its environment over time in a way that enhanced its chances of passing on its genes to the next generation.

- No one species or trait is inherently superior to another.

“Ancestral to” or “more derived”: plesiomorphic vs apomorphic

- Primitive or advanced features?

- A better way to describe a species or a trait is as either “ancestral to”, or “more derived” than another species or trait.

- Derived trait (apomorphic): a trait that has changed since the time of a common ancestor.
- The term *syn*apomorphy refers to an apomorphy shared by a group; i.e. for hominins, for example, is greatly reduced canine teeth.
- Male chimpanzees and other close non-hominin relatives have huge canine teeth, probably used in threat displays. Hominins do not have this character, suggesting that the trait changed sometime after the hominin lineage and chimpanzee lineage split.

Plesiomorphic vs apomorphic

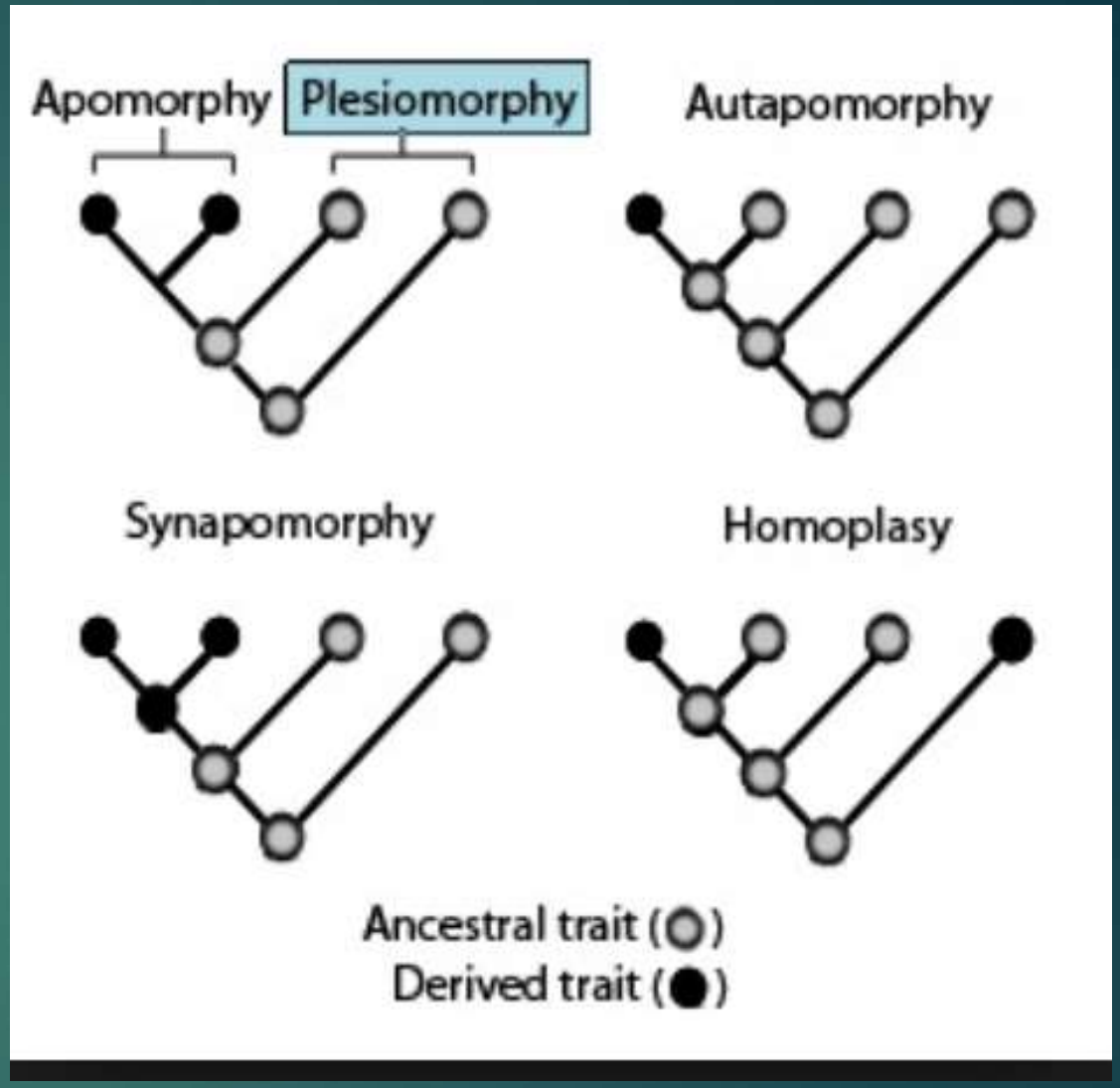
- Ancestral trait (plesiomorphic): a character that has been inherited from a common ancestor and has remained unchanged, i.e. for the genus *Homo* is an opposable thumb. All members of *Homo* have one, as do all other hominins and primates, suggesting that the groups inherited this trait from a common ancestor.

- When discussing apomorphies and plesiomorphies, it is important to keep context in mind. Whether a trait is ancestral or derived changes depending on the groups you are comparing. A small canine tooth is a synapomorphy for hominins, but it'd be considered a plesiomorphy for the genus *Homo* when compared to other hominin groups.

Quick cladistic lesson

Apomorphic: A novel evolutionary trait that is unique to a particular species and all its descendants and which can be used as a defining character for a species or group in phylogenetic terms.

Plesiomorphic: ancestral trait on its own, usually in reference to another, more derived trait.



Homoplasy: character shared by a set of species but not present in their common ancestor; i.e. eye

Ancestral (not “primitive”) vs “derived”

- In the case of *Homo naledi*, apomorphies (derived traits) that suggest its placement within the genus *Homo* include certain characteristics of its cranial structure and dentition, which appear derived from earlier hominin species.
- The hands suggest finely tuned motor skills, and the teeth suggest a diet of high-quality foods, such as meat and tubers.
- The feet are also apomorphic with other *Homo* species and suggest *Homo naledi* was capable of walking efficiently for long periods. In fact, they are so similar to that of modern humans one researcher commented that if you came across just a *Homo naledi* foot in a cave, you'd assume it was that of a recently deceased modern human.

Ancestral (not “primitive”) vs “derived”

- Ancestral: Other older characteristics, however, such as its small cranial capacity, short shoulder blades that sit high and wide on the trunk, and flared upper pelvis, appear ancestral to later hominin species. These traits are plesiomorphies (ancestral), and would suggest its placement outside of the *Homo* genus.

- Every species is a mix of ancestral and derived traits. The important point is not that it had a mix of traits, but that its particular mix of traits is different from all other known hominins.

Holotype of *Homo naledi:* DH1

Holotype: original specimen used to describe a new species for the first time.

H. naledi: a mosaic

- *H. naledi* exhibits:
  - anatomical features shared with Australopithecus,
  - other features shared with Homo,
  - with several features not otherwise known in any hominin species.
- This anatomical mosaic is reflected in different regions of the skeleton.
- The overall morphology of H. naledi places it within the genus Homo rather than Australopithecus or other early hominin genera.

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 similar to 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—ancestral above, modern below.
- The skull and teeth show a mix of traits.

A schizoid creature: a mix of ancestral & 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 similar to 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 & 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

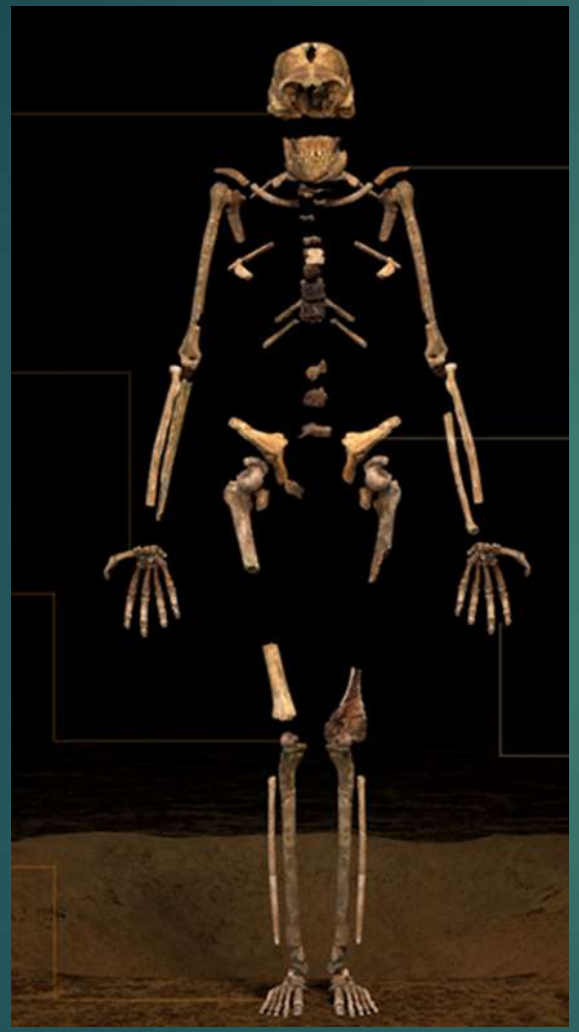
- The teeth have some ancestral features (such as increasing in size towards the back of the tooth row, larger molars & premolar roots) and humanlike features: small front teeth, molar crowns were small with five cusps, and set in lightly built, more curved jawbone.
- The teeth of this new species were relatively small, which is a modern trait. However, Homo naledi's back teeth were the largest, which is an ancestral trait.
- 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.
- Smaller teeth also improve language capability.
- No hyoid bone yet.

Homo naledi cranium

- The shape of the cranium is rounded — like those of other species within *Homo* (Australopithecines have almond-shaped craniums).
- Cranium lacks australopithecine 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
  - as well as larger body mass and stature
- *Homo naledi has all above traits.*

H. naledi vs. *A. sediba* skeletons: mirror reversal mosaics

H. naledi



A. sediba

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

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 ancestral; as if evolution was crafting it from outside in

Meet *Homo naledi* - our new human ancestor

Named after the Rising Star cave, "*naledi*" means "star" in Sesotho

Discovered: Rising Star cave, Cradle of Humankind, Gauteng in 2013/2014.

Age: Unknown

Height: 1.5 metres

Weight: 45 kgs

Characteristics: Small brain, human-like skull; teeth and hands, ape-like shoulders.

Skills: Climbing and walking long-distances

What makes it human?

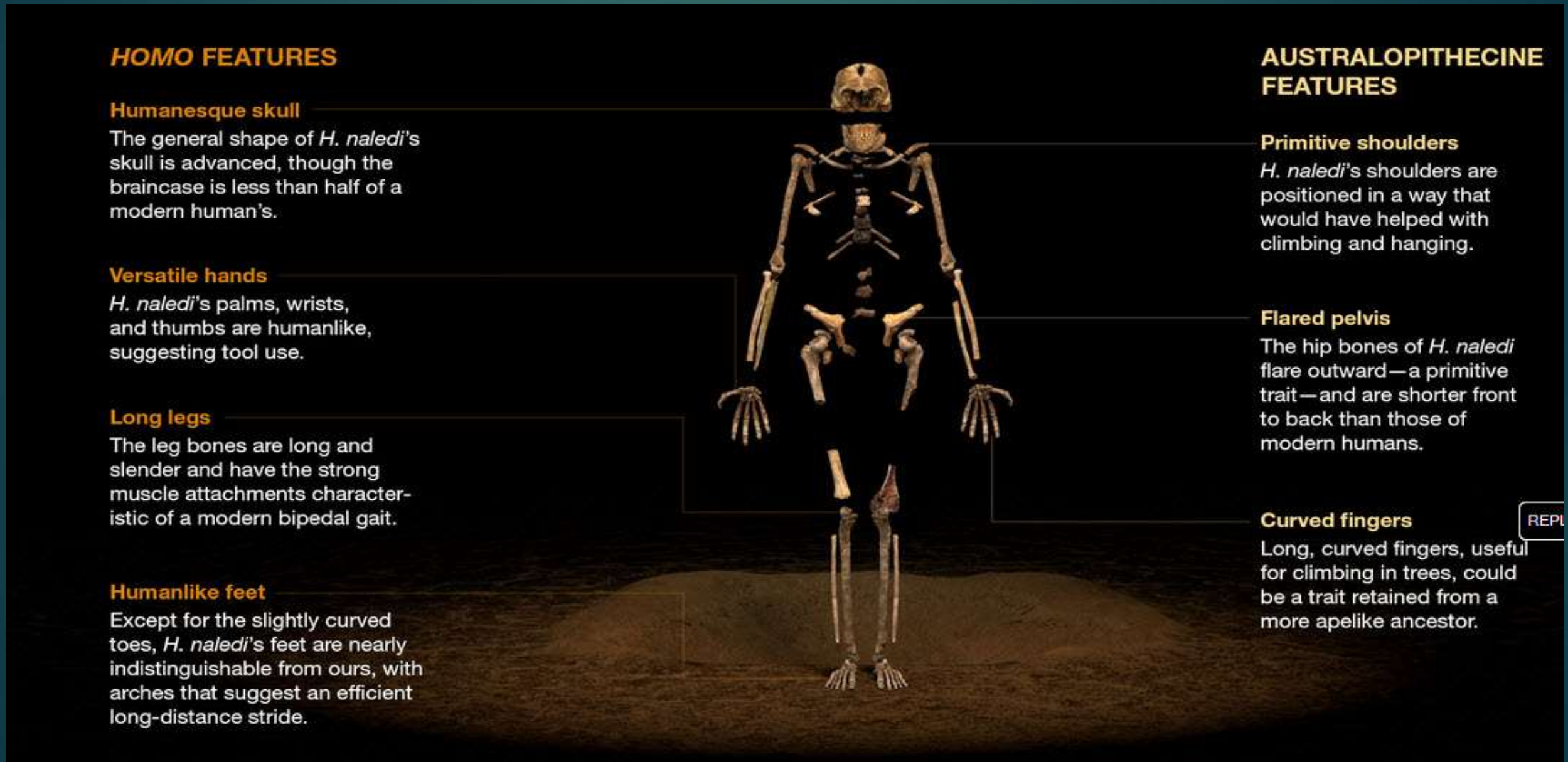
Scientists believe that *Homo naledi* intentionally buried its dead in the difficult to reach, isolated Dinaledi cave chamber.

eNCA.com

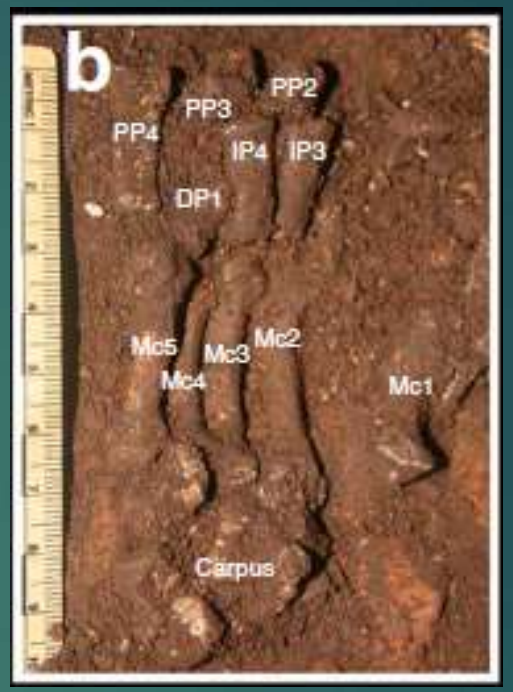
SOURCE: University of the Witwatersrand, National Geographic Society, Department of Science and Technolog/National Research Foundation

eNCA

Homo naledi: an anatomical mosaic



Homo naledi: Hand



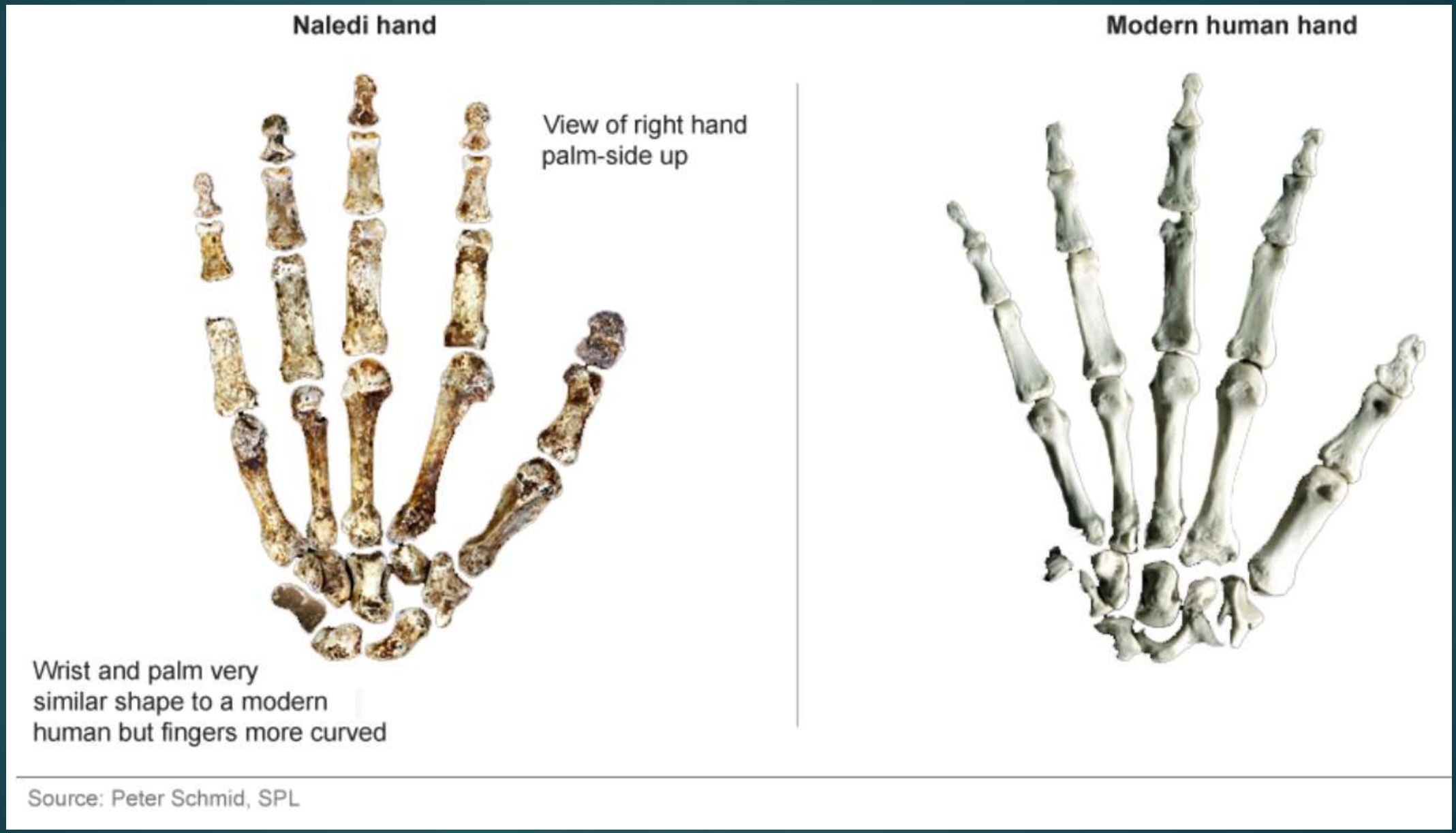
Found in situ in semi-articulation with the palm up and fingers flexed.

Australopithecine-like arboreal climbing capable, extremely curved fingers (joints are curved; more curved than almost any other species of early hominin; but longer thumb and wrist are stiffer like Homo, suggesting tool-using capabilities (Proportion of digits, distal apical tufts (broad finger), robust polical ray (broad thumb)

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

Naledi hand

Modern human hand



The *H. naledi* hand: strongly curved phalanges in association with an otherwise modern human/Neandertal-like hand

- 150 hand bone specimens; Hand1 is missing only 1 bone. It is part of the paratype of H. naledi and was recovered partially articulated with the palm up and fingers flexed
- Long, robust, muscularized (marks left on bone) thumb and derived wrist morphology that is shared with Neandertals and modern humans; capable of grasping objects tightly with their hands and using stone tools. No stone tools found.
- However, the finger bones are longer and more curved than those of nearly any other species of early hominin, indicating frequent use of the hand during life for strong grasping during locomotor climbing and suspension.
- Unique combination of features that have never been seen before in any other hominid.

Tracy L. Kivell, et al., 2015

Fingers were curved.

Burger: “They’re climbing, but I don’t know *what* they’re climbing.”

7 Metacarpals (lower finger bones) discovered

Seven first metacarpals (thumb bone closest to the base of the hand) of H. naledi were recovered so far. Here they are, along with the first metacarpal of a modern chimp and the 2-million-year old Australopithecus sediba. (Lee Roger Berger

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.

Scale bar = 10 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.

Muscle attachment marks on tibia (bumps that indicated activity) are unique; no other species has them.

Homo naledi: Foot – meant for walking - upright biped; the feet were “Nike-ready,” as *National Geographic* put it.

A

B

C

Found articulated as seen here

10 cm

Foot very similar to H. sapiens. It possessed some ancestral features: a flatter arch, curved toes and a heel less robust than ours

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. (digital reconstruction)

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 foot: different ways to be bipedal

- 107 pedal elements, including one nearly-complete adult foot. *Homo naledi's* foot is far more advanced than other parts of its body.
- Broadly similar to that of modern humans: The *H. naledi* foot is predominantly modern human-like in morphology and inferred function, with an adducted hallux, an elongated tarsus, and derived ankle and calcaneocuboid joints. In combination, these features indicate a foot well adapted for striding bipedalism.
- Foot morphology differed subtly from modern human foot: However, the *H. naledi* foot differs from modern humans in having more curved proximal pedal phalanges, and features suggestive of a reduced medial longitudinal arch
- Aside from that of H. sapiens and the Neanderthals, the Dinaledi foot possesses some of the most derived pedal morphologies in the hominin fossil record. Although there are members of the genus Homo known with earlier feet and relatively small brains (H. floresiensis) and with derived feet and larger brains than H. naledi (for example, early H. erectus), H. naledi is the first known hominin with this combination of such derived feet and legs and a small brain size.

W.E.H. Harcourt-Smith, et al., 2015

Full Foot Comparison

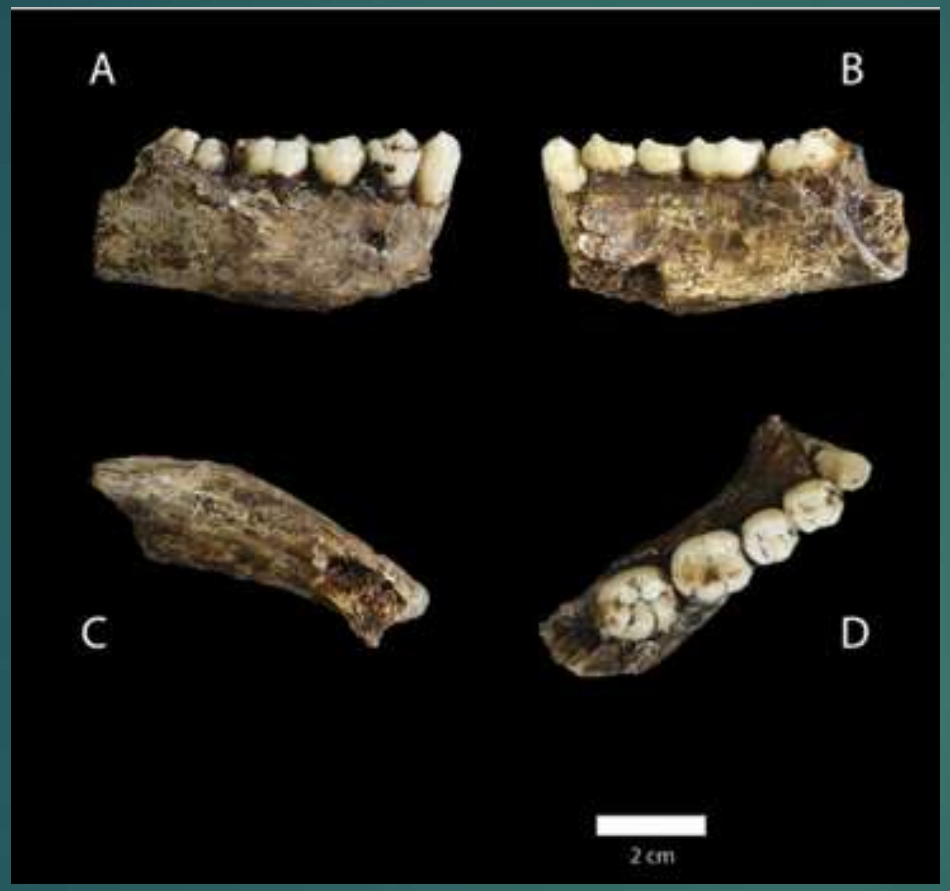
Table 1 | The mosaic foot of *Homo naledi*.

Modern human-like anatomy	Intermediate anatomy	Ape-like anatomy
Power arm/load arm ratio	Talar neck horizontal angle	Talar head/neck declination
Talar wedging	Flaring of talar malleolar facets	Sustentaculum tali orientation
Talar head and neck torsion	Calcaneal robusticity	
Talar trochlea margins even	Metatarsal 3 base height	
Low talonavicular range of motion	Proximal phalangeal curvature	
Small peroneal trochlea		
Lateral plantar process position		
Flat subtalar joint		
Locking calcaneocuboid joint		
Int. and lat. cuneiform elongation		
Adducted hallux		
Int. and med. cuneiform articulation L-shaped		
4th Metatarsal base DP flat		
Metatarsal length proportions		
Metatarsal head proportions		
Metatarsal torsion		
Metatarsal 4 base robusticity		
MT 1 head dorsally expanded		
Dorsally canted phalanges		

DP, dorsoplantar; Int., intermediate; lat., lateral; med., medial.

Homo naledi: Mandible

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.

190 Teeth: multiple 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.

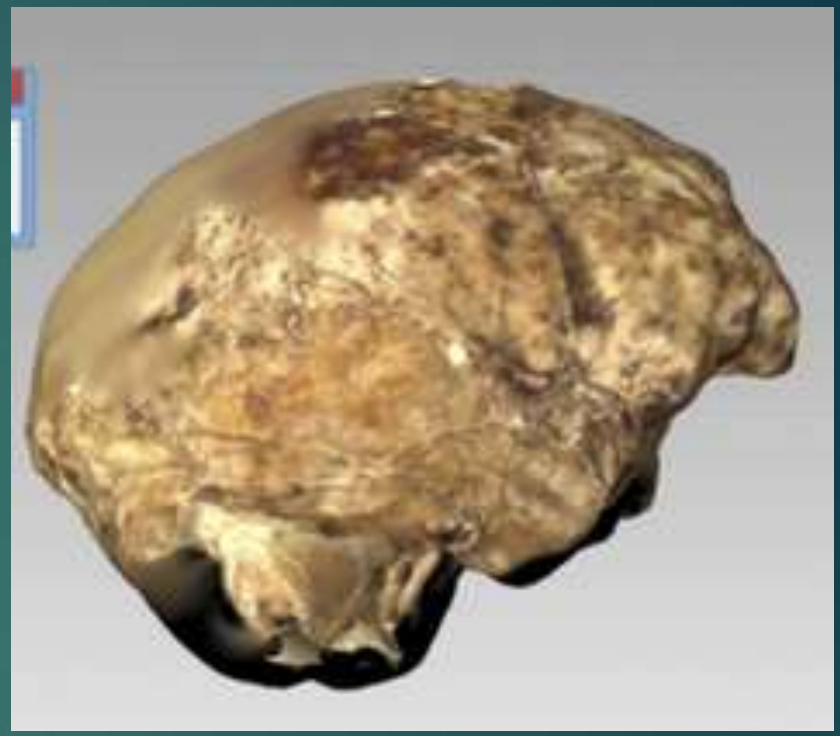
After *H. naledi*, a fossil part does not predict the whole anymore

- 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 earlier 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*



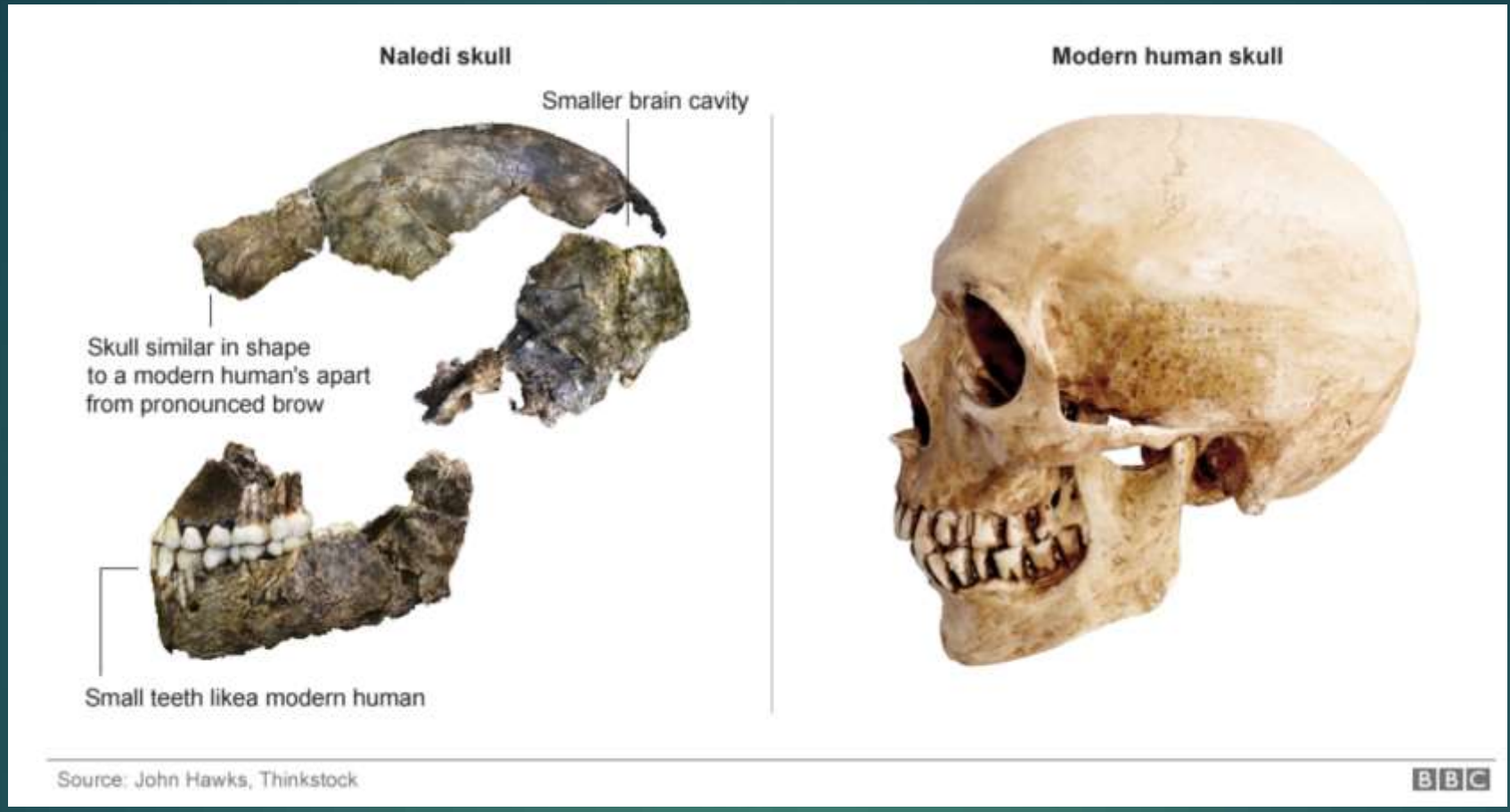
Five partial skulls had been found—two were likely male, two female. In their general morphology they clearly looked advanced enough to be called *Homo*. But the braincases were tiny—a mere 560 cubic centimeters for the males and 465 for the females. Overlaps entirely with the range of endocranial volumes known for Australopiths. Only the smallest specimens of H. habilis, one single H. erectus specimen, and H. floresiensis overlap with these values. Parietal bossing like Homo.
Australopiths = 285-550 cc

Homo naledi: cranial size comparisons

Cranial and mandibular measurements for *H. naledi*, early hominins, and modern humans

DOI: http://dx.doi.org/10.7554/eLife.09560.012

	Measurement definitions as in Wood (1991)	*P. aethiopicus*	*P. boisei*	*P. robustus*	*Au. afarensis*	*Au. africanus*	*Au. sediba*	*H. naledi*	*H. habilis*	*H. rudolfensis*	*H. erectus*	MP *Homo*	*H. sapiens*
Cranium													
Cranial capacity	–	410	485	493	457	467	420	513	610	776	865	1266	1330
Porion height	6	72	74	–	86	70	67	81	77	90	94	101	112
Posterior cranial length	3	58	47	54	60	44	–	65	60	70	79	99	81
Bi-parietal breadth	9	94	98	–	90	99	100	103	107	118	129	142	132
Bi-temporal breadth	10	110	109	108	115	104	101	107	112	126	131	146	127
Closest approach of temporal lines	–	crest*	crest*	crest*	crest*	21	56	52	35	51	72	101	96
Supraorbital height index	–	46	53	50	51	60	56	56	64	59	56	62	71
Minimum post-orbital breadth	–	62	66	70	77	67	70	68	75	78	89	96	97
Superior facial	49	100	107	109	–	95	86	86	97	113	110	124	107

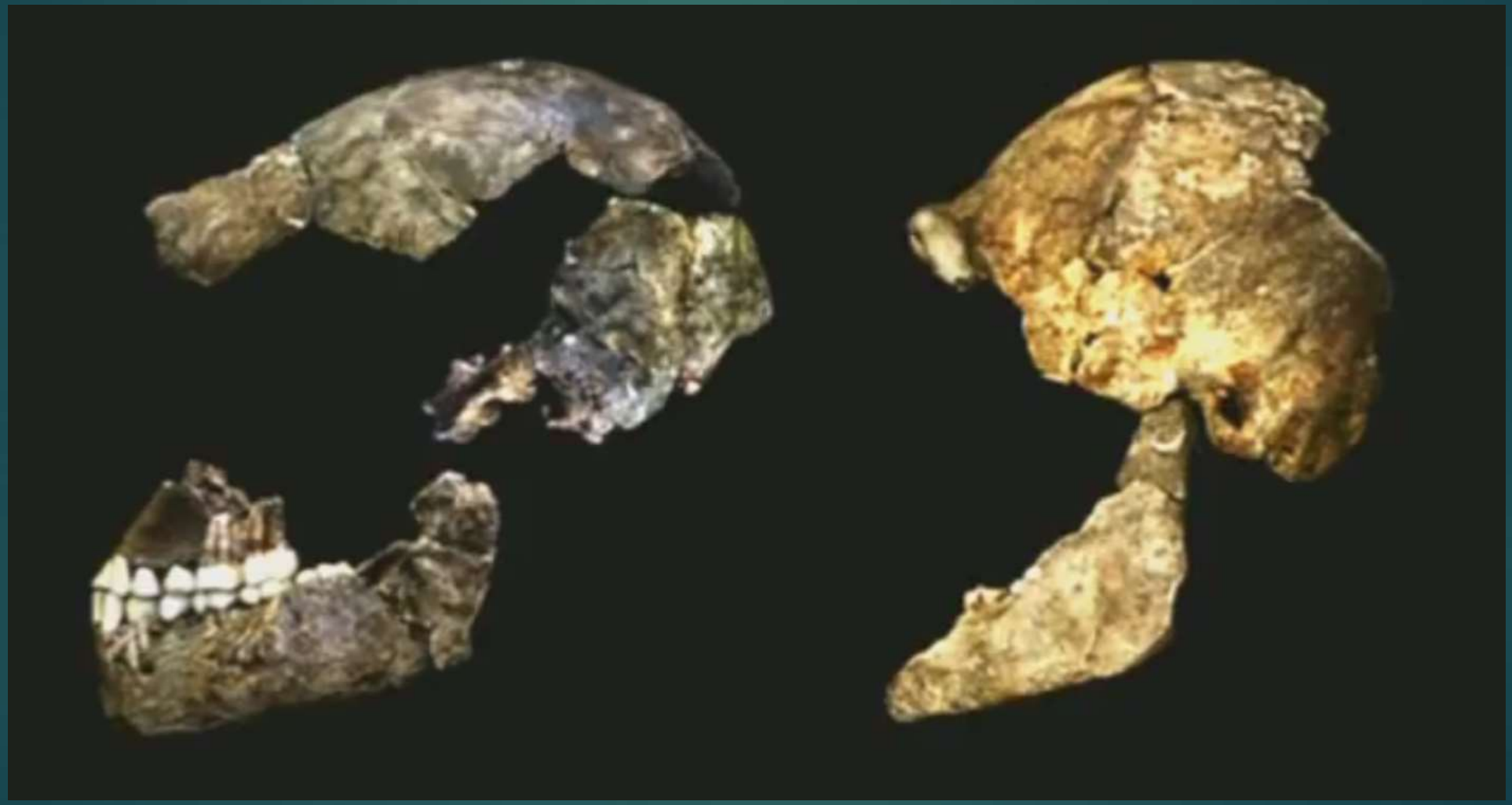


Jamie Shreeve, in his piece for *National Geographic*, described it this way: "These were pinheads, with some humanlike body parts." It seems we might have to give up on "big brains" being the hallmark of our genus

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

Note curved hand

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



Holotype

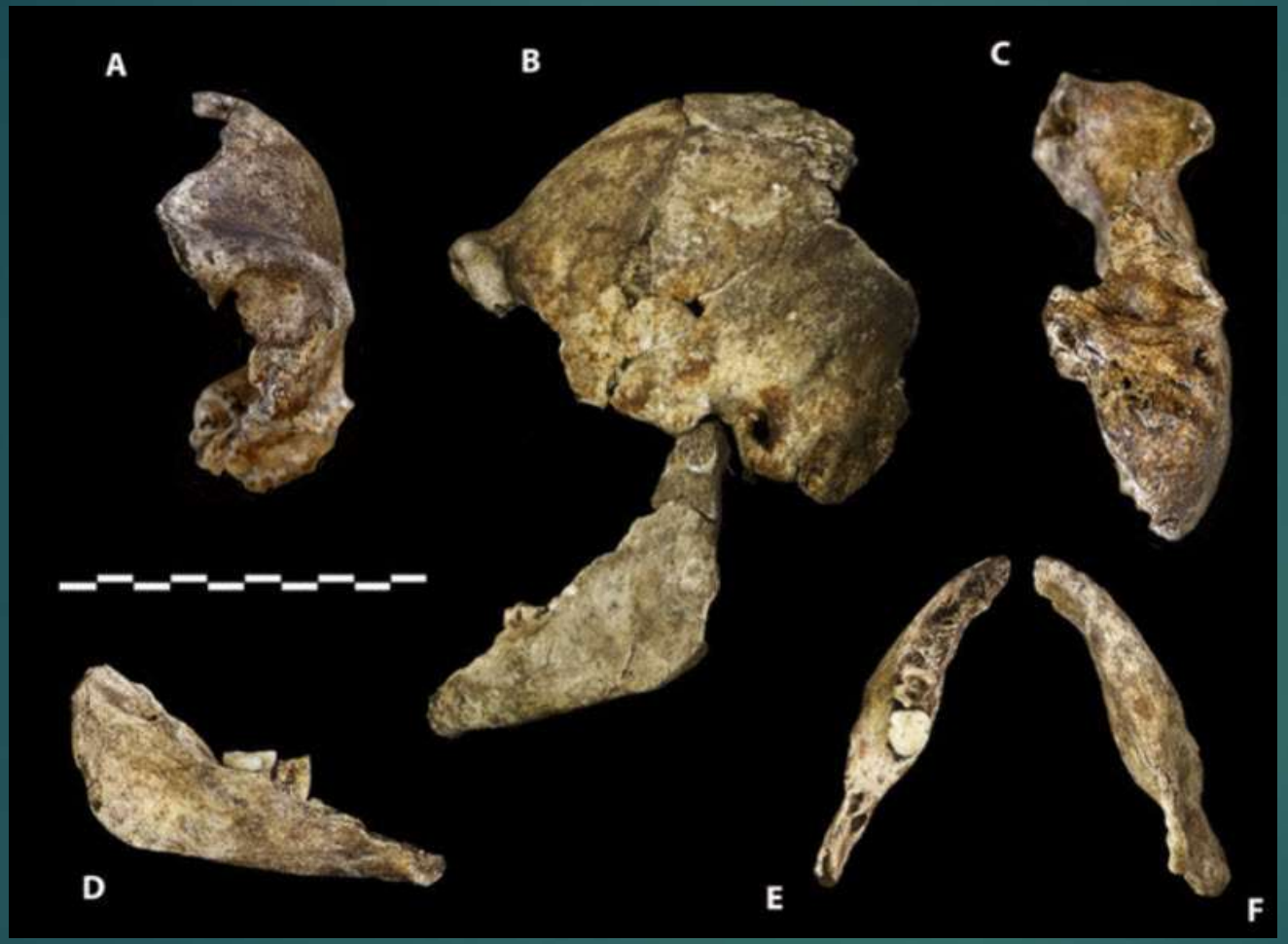
Homo naledi: Reconstructed Skull

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.

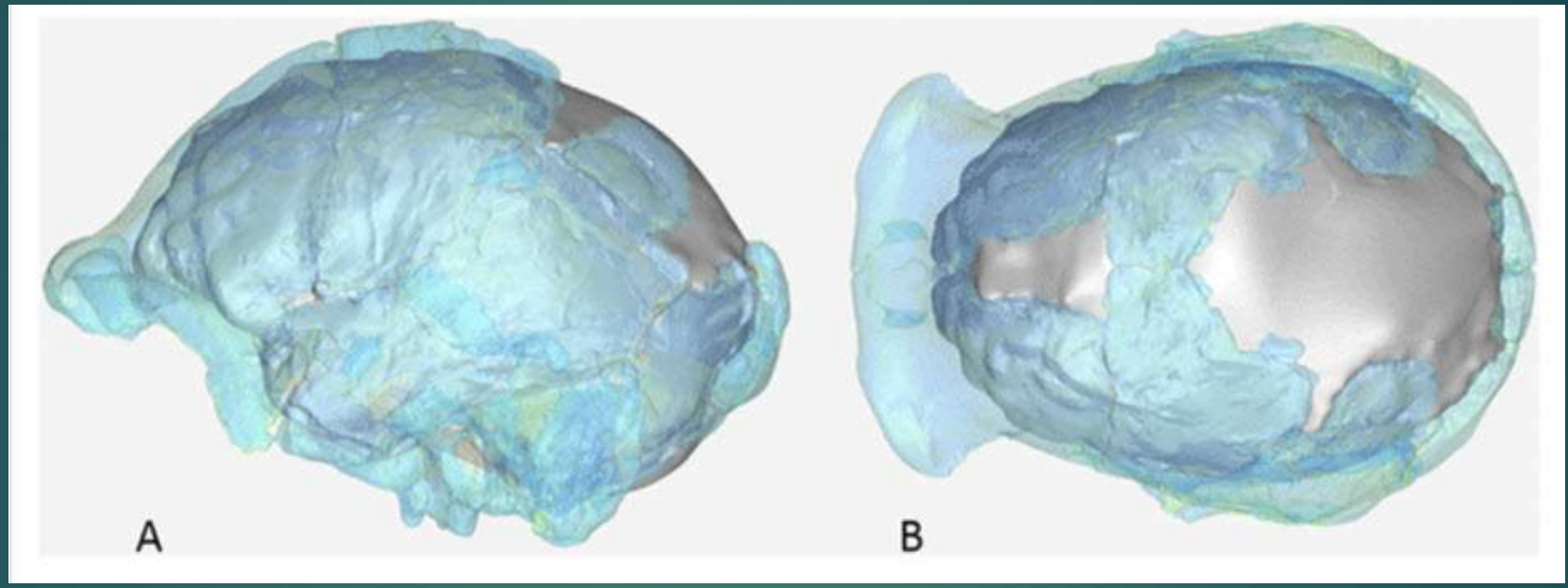
Homo naledi: DH3, an elder with worn teeth



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.. Scale bar = 10 cm.

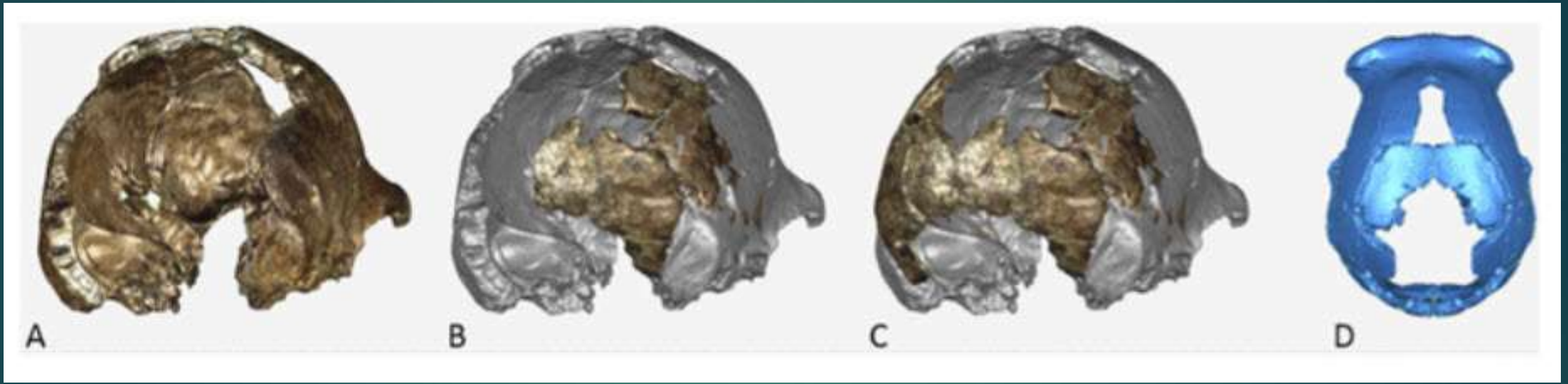
DH3 was a relatively old individual at time of death, with extreme tooth wear

Homo naledi: DH3 (female) & DH4 craniums



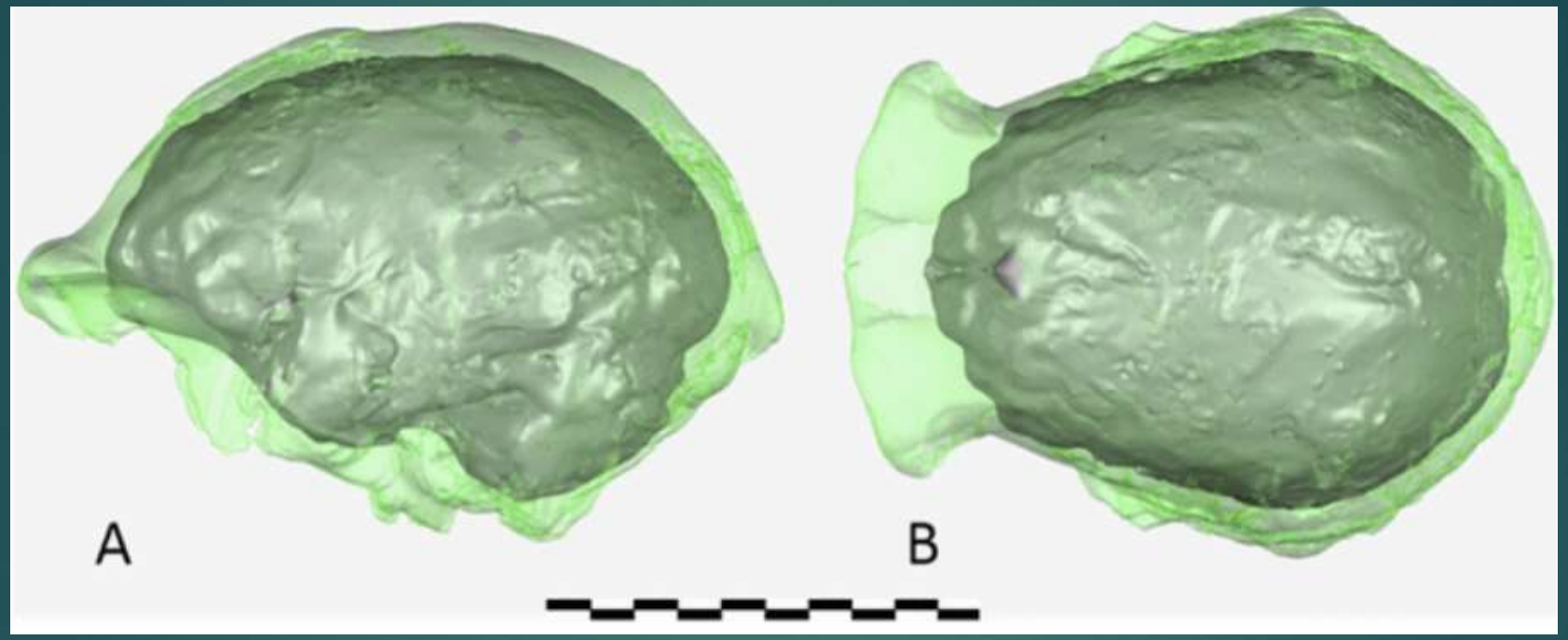
Reconstruction of DH3 & DH 4

Homo naledi: DH3 & DH4



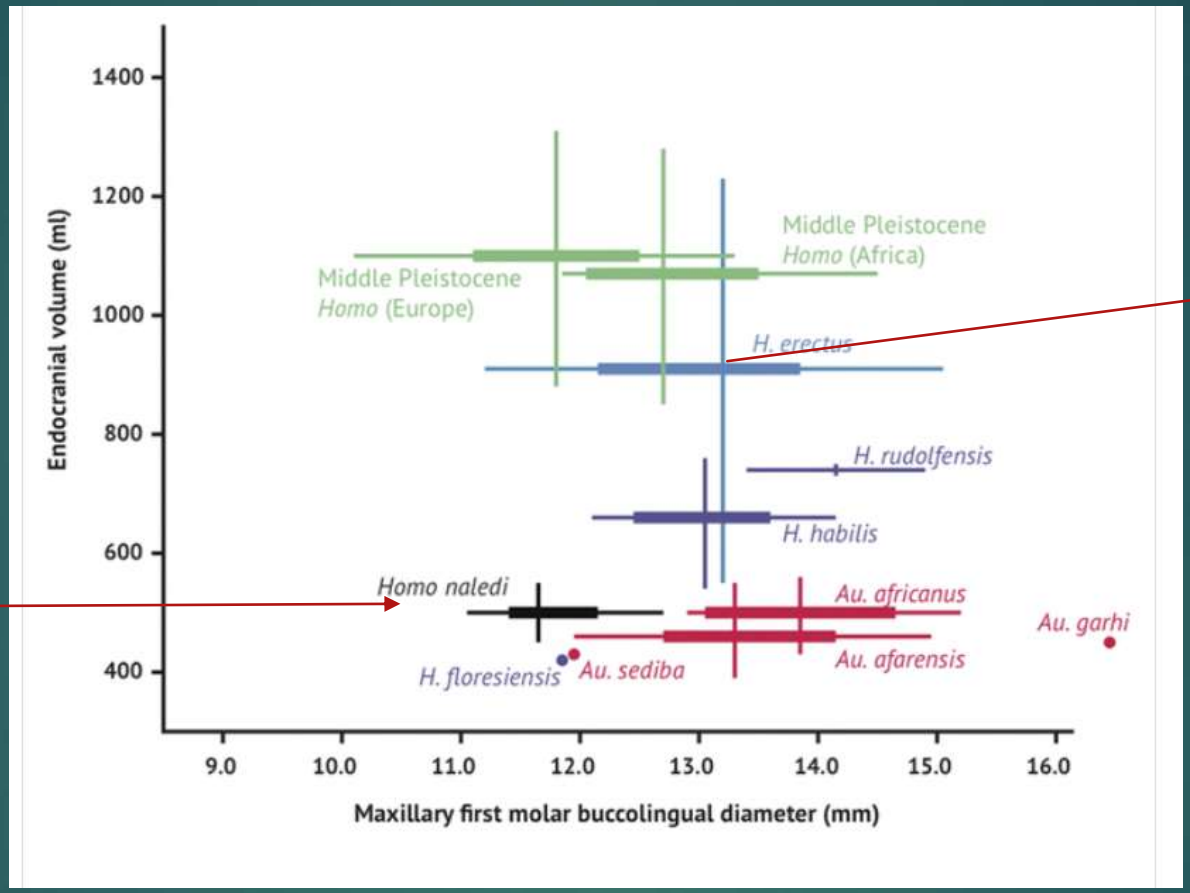
Postero-lateral view of the virtual reconstruction of a composite cranium from DH3 and DH4.

Homo naledi: DH1 & DH2 endocranium: 560 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.

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



H. erectus

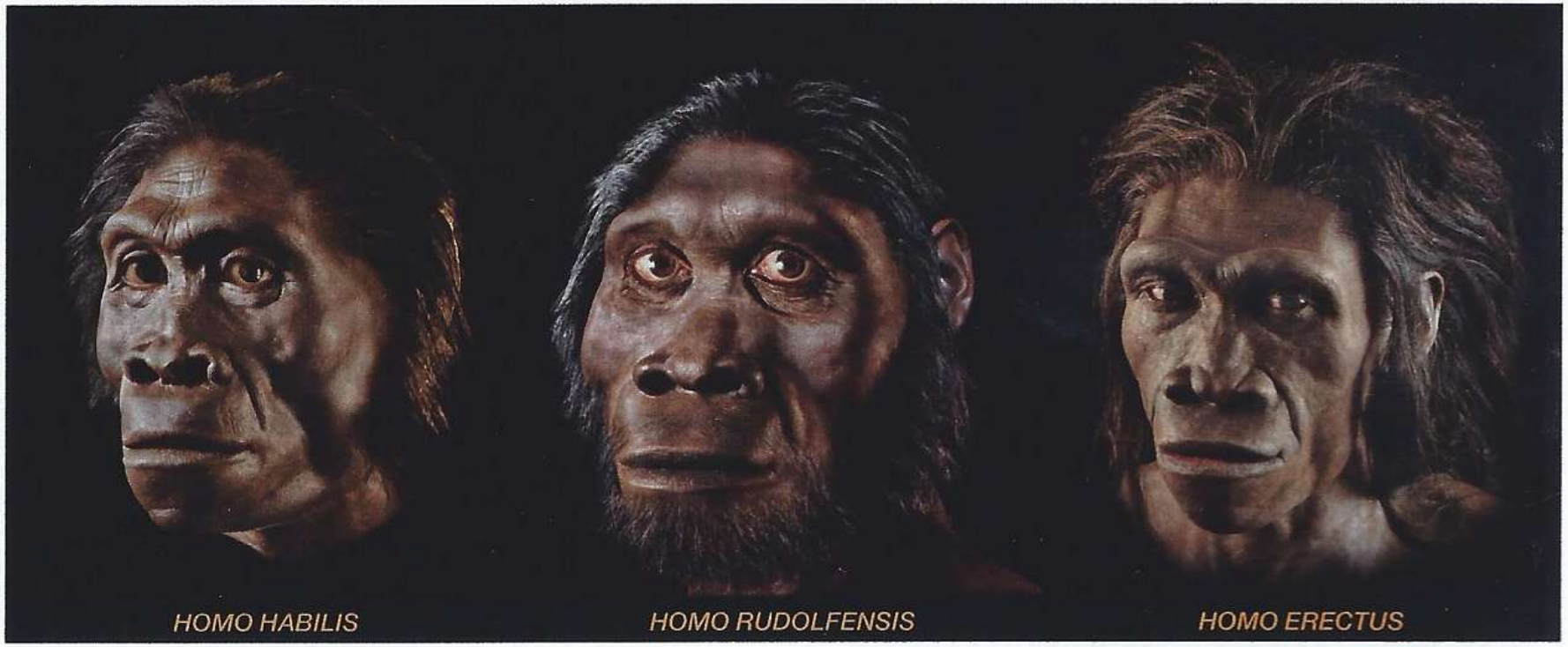
Homo naledi

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

5 feet vs. 6 foot +

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

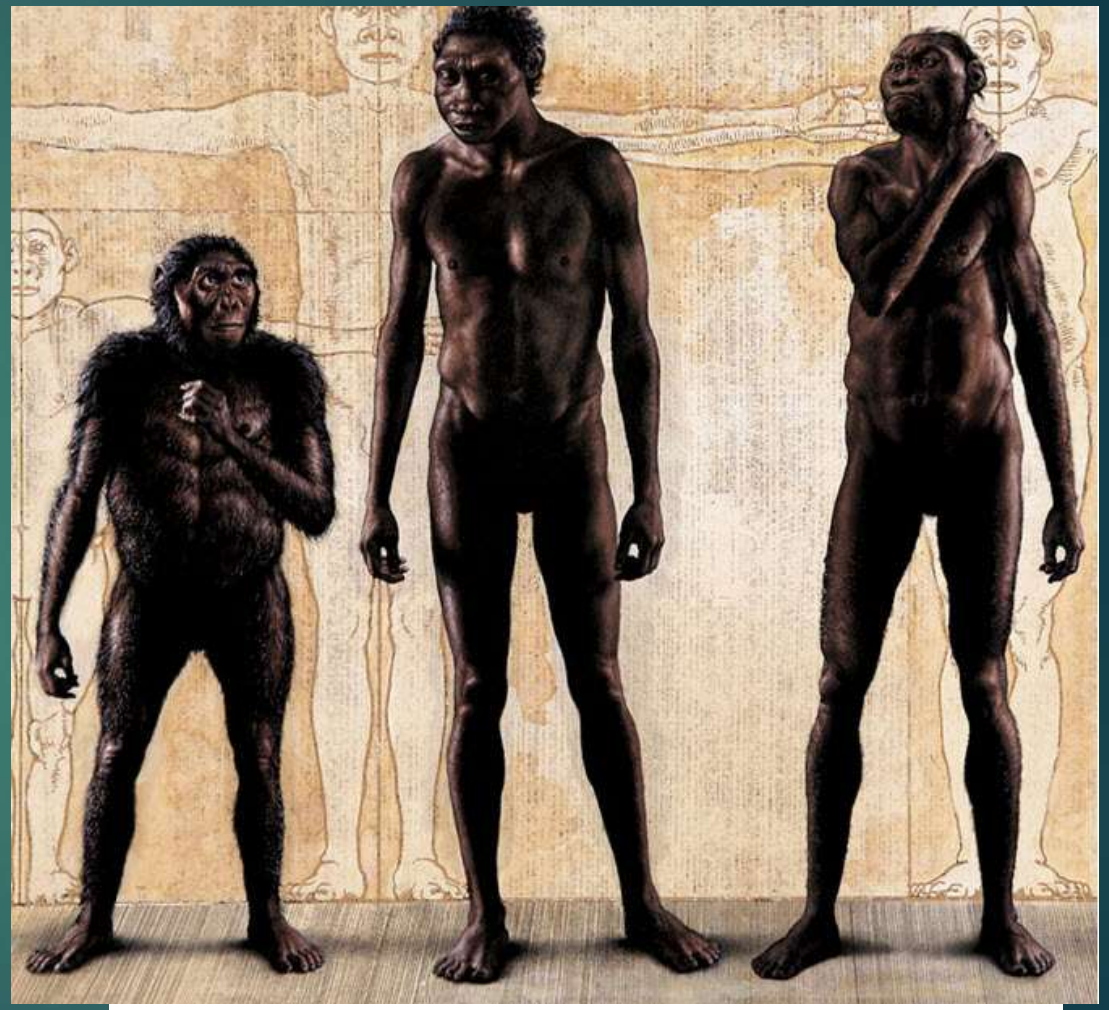


A trio of other *Homo* species, all first appearing in the fossil record around two million years ago, argues against a linear progression toward humanness—a message underscored by *H. naledi*’s unique blend of primitive and advanced traits.

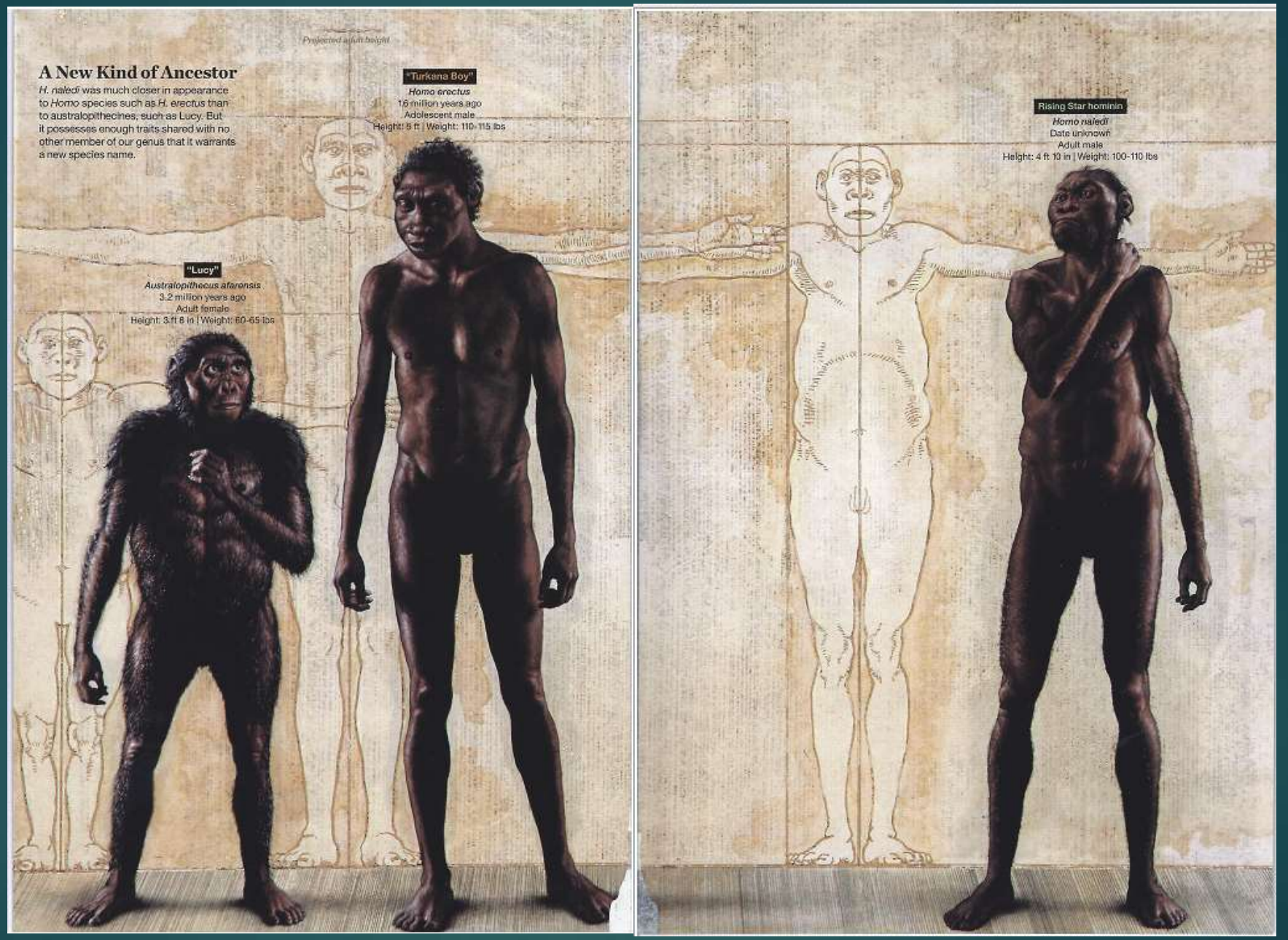
IMAGES NOT TO SCALE

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

Skinny, humanlike arms,
apelike thorax, more ancient pelvis,
long legs, humanlike feet

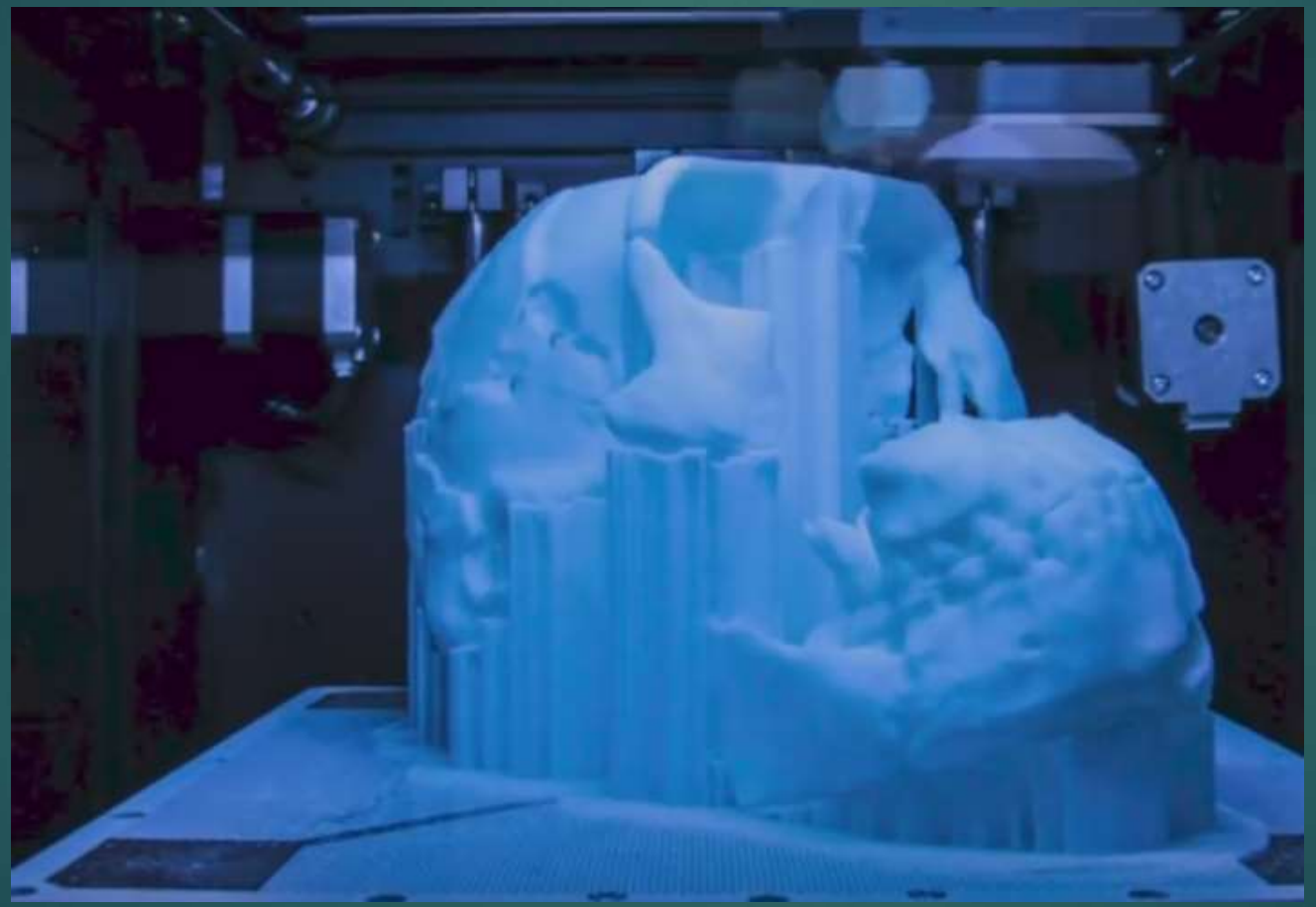


"Lucy"	"Turkana Boy"	"Rising Star Hominin"
Australopithecus afarensis	*Homo erectus*	*Homo naledi*
3.2 million years ago	1.6 million years ago	Date Unknown
Adult Female	Adolescent Male	Adult Male
3 ft 8 in	5 ft	4 ft 10 in
60-65 lbs	110-115 lbs	100-110 lbs



National Geographic comparison

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 by John Gurche

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

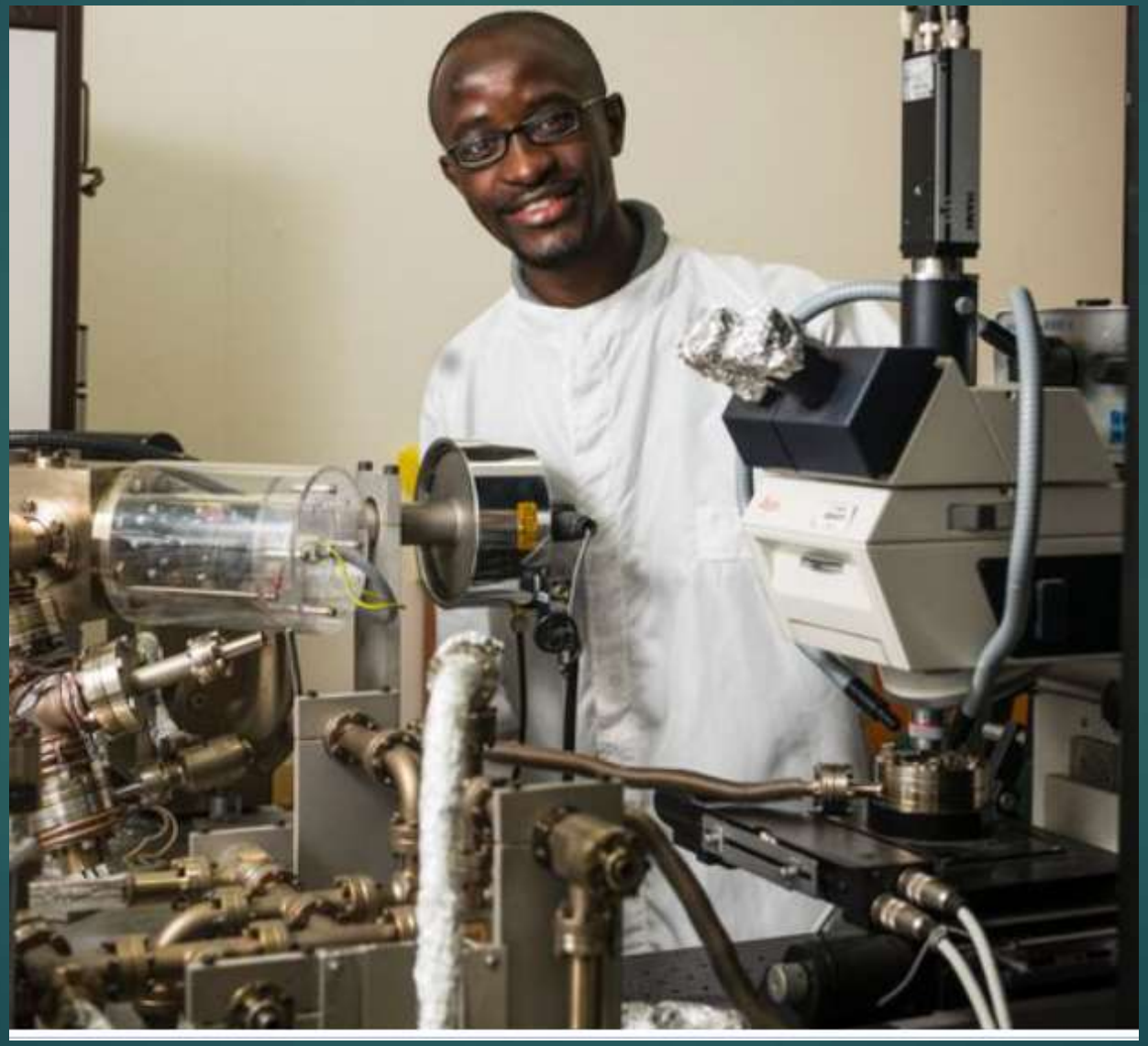
Image is from the 10/2015 issue of National Geographic


1 day ago

Undated

- No Current dating: fossils were not encased, or even adjacent to, any rocks that can be dated using radioactive isotopes.
- There were also no other extinct organisms in the cave that could help establish a date.
- No fauna, no upper/lower stone layers, no embedded flowstones to be able to date
- Geologists infer that Rising Star cave where *H. naledi* was found is less than 3 million years old, so there seems to be a firm “oldest possible” 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*.

Tebogo Makhubela dating *H. naledi*



Dating

- Tebogo Makhubela: *PhD student University of Johannesburg Department of Geology*; studying towards his PhD degree majoring in geochronology; Rising Star team as master's degree
- Manganese oxide crusts on bone (revised U-Thorium-Helium radioactive dating ((*U-Th*)/*He dating)* did not work); Swartkrans comparison sample, able to reproduce same age
- Now working on calcium carbonate flowstones using it;
- believe way older than carbon dating
- Different teams working on different methods
- DNA? No results yet
- Particles in sediment clay are 2 Billion YA via potassium dating
- (complex intruded)

Dating & Cladistics: morphological, not age-related, features

- It's important to note, however, that in terms of strict cladistical analysis, the age of the fossils does not matter.
- Cladistics establishes evolutionary relationships strictly by grouping organisms according to their shared-derived characteristics.
- In the case of paleontology, the characteristics are almost always morphological.
- What fossil age helps do is give a timeframe for splitting events already established by morphology.
- In other words, in some ways, it does not matter how old *Homo naledi* is — its morphology suggests that it is an early *Homo* species.

Dating is hard: Remember Little Foot

- Different teams have produced very different ages for the famous Little Foot skeleton from the Silberberg Grotto of Sterkfontein, ranging over more than a million years.

- Good news: certain flowstones over the *Homo naledi* fossils (now being dated), which should hint at their minimum age.
- Bad news: bones in softer sediment, so they may have shifted from their original locations with respect to the flowstones.
- Worse news: don't know if there are flowstones *under* the *H. naledi* fossils because they haven't dug down that far yet. Without such layers, they can’t estimate the *maximum* age of the fossils.

The geological age of the fossils is not yet known

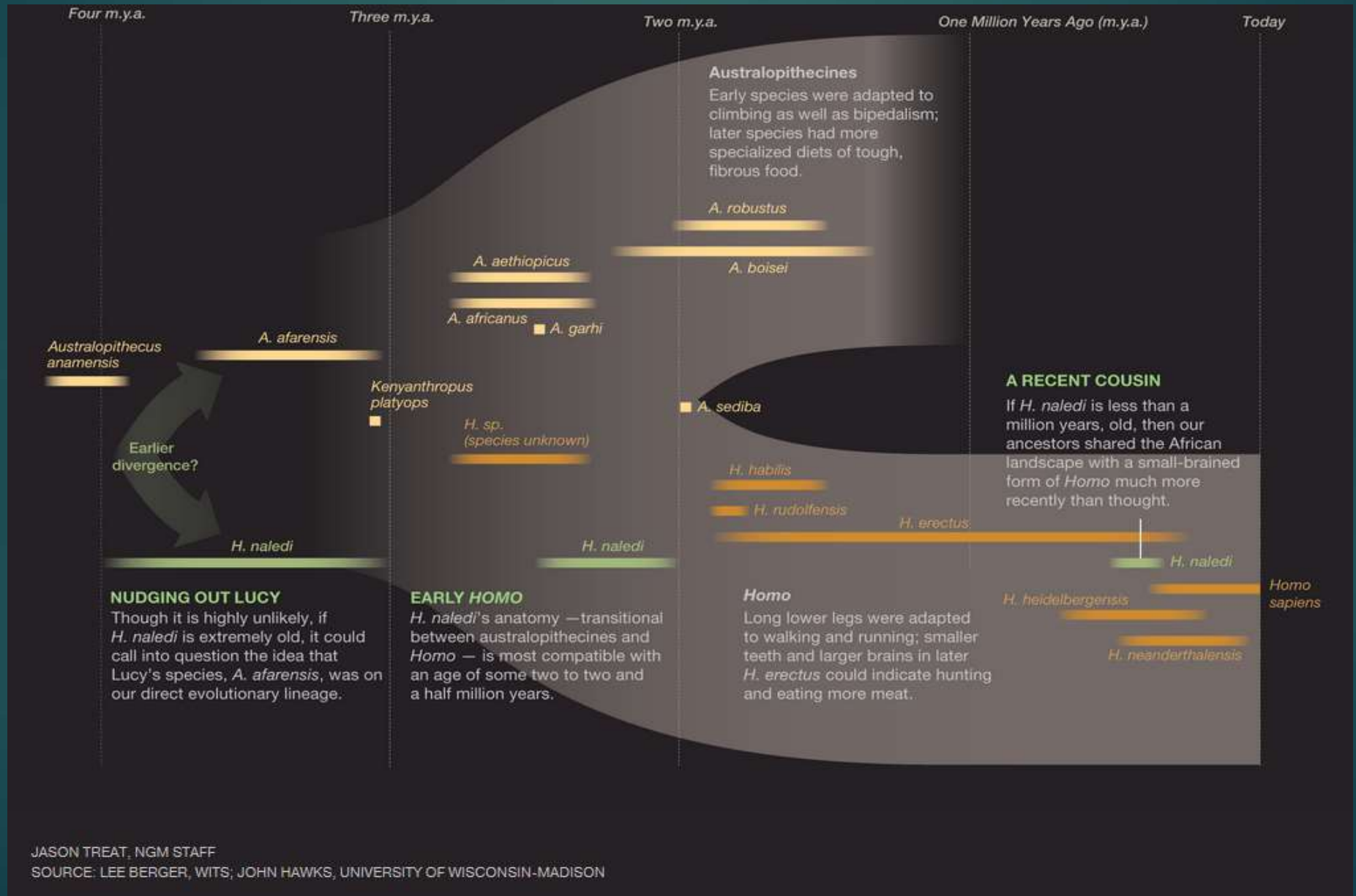
- No age estimates have been obtained for the *Homo naledi* fossils found on the cave floor and in the excavation.

- The fossils lay in soft sediments that have partly mixed together over time, obscuring the bones' original location.

- Berger believes that based on its anatomy, it sits near or at the root of the *Homo* genus.

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 years, then our ancestor *Homo erectus* lived with a small brained form of Homo

BRAIN DEVELOPMENT AND RANGE (in Cubic centimeters)

AUSTRALOPITHECUS

450 to 700

HOMO ERECTUS

775 to 1,235

SWANSCOMBE

About 1,200

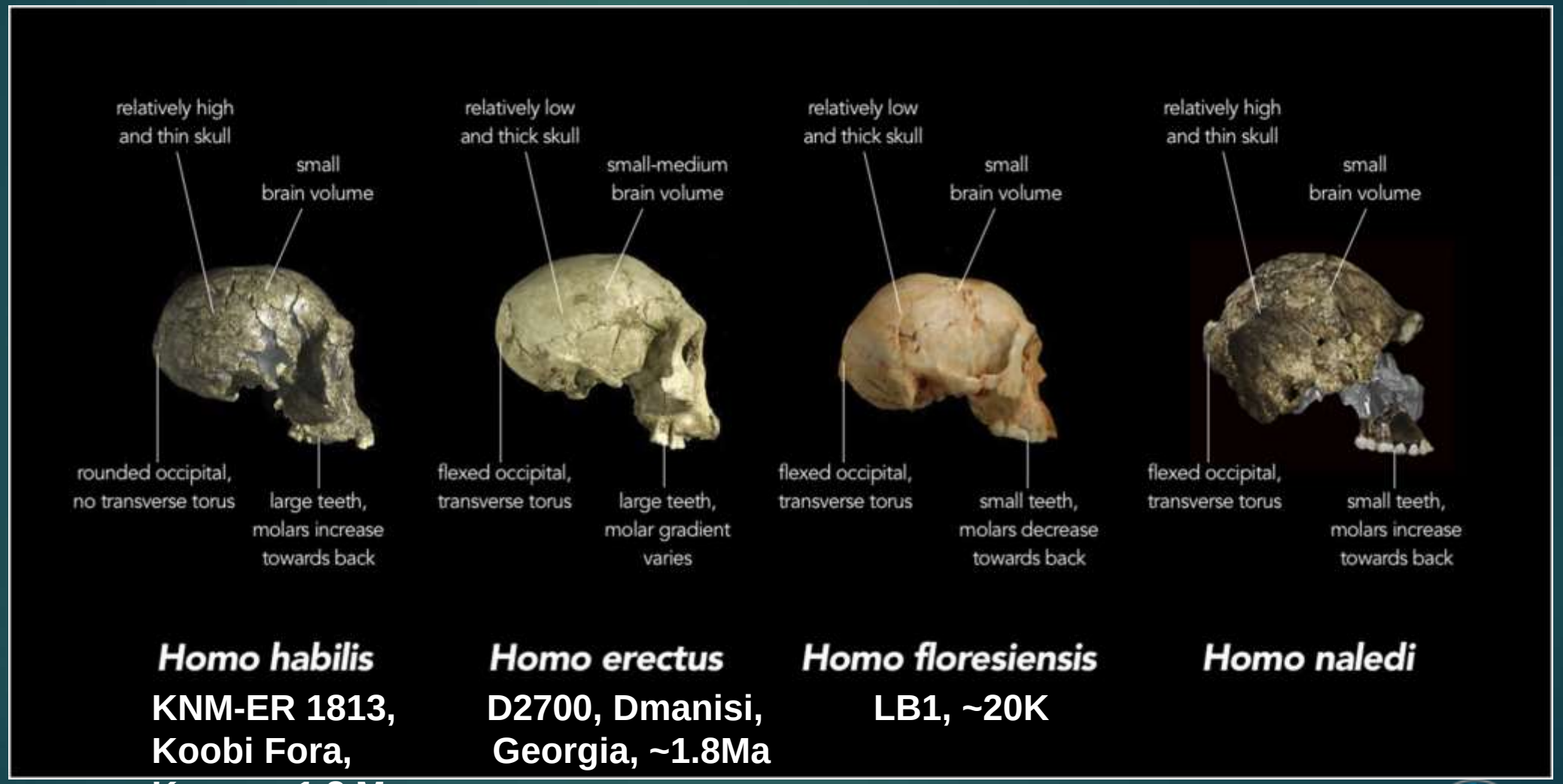
NEANDERTHAL

About 1,400

MODERN MAN

1,300 to 1,600

Comparison of skull features of Homo naledi & 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

Homo-like skull with Australopithecus sized brain

Differs from *H. sapiens:*
Small cranial capacity, not globular, megadont jaw, well defined supraorbital torus & sulcus (like *H. erectus*), less well defined chin, increasing molar size gradient, & primitive aspects of the postcrania

Differs from H. erectus:
Lacks long & low cranial vault, not metopic keeling, flat & square nasoalveolar clius (subnasal area is square & flat)

Differs from *Australopithecus*:
Lacks large jaws & dentition and associated musculature,
lack of postorbital constriction (depression behind eye sockets)

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.

Geological and taphonomic context for *Homo naledi*

- Hominins accumulated over time as older laminated mudstone units and sediment along the cave floor were eroded.
- It appears that the bodies were intact when they arrived in the chamber, and then started to decompose.
- Preliminary evidence is consistent with deliberate body disposal in a single location.

Taphonomic context

- 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.

- Not a single mark made by a tooth or a stone tool, or any trace of a fracture that happened when the individuals were still alive. “These were the healthiest dead things ever seen.”

Bodies were “deliberately disposed”: Burial ?

Homo naledi: Controversy! Was this a "burial" site?

- The individuals show signs of having been "deliberately disposed" of within the cave.

- Possible explanations:

  - 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;
    - Not any trace of carnivore remains or the remains of other likely prey animals. Thus, the predator would have had to select a single prey species--*H. naledi*--carrying into the chamber all age and size categories (Berger et al., 2015) without leaving a trace of its own presence. Considered this very unlikely.

  - No signs of hominid occupation/habitation debris

Deliberate disposition 2

- No green bone (pressure/trauma based) 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

- “An exhaustive search by a professional caving team and researchers has failed to find any other plausible access points into the Dinaledi Chamber, and there is no evidence to suggest that an older, now sealed, entrance to the chamber ever existed. Furthermore, detailed surface mapping of the landscape overlying the Rising Star cave system illustrates that no large flowstone-filled fractures occur in the region above the Dinaledi Chamber.”
- The roof of both the Dinaledi and Dragon’s Back chambers is formed by the capping chert.

Deliberate disposition

- Death trap scenario? Repeated death trap? Unlikely, but not ruled out.

- 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; but cannot be ruled out.

- Leaves hypothesis that they were put there deliberately

Deliberate body disposal

- “…our preferred explanation for the accumulation of H. naledi fossils in the Dinaledi Chamber is deliberate body disposal, in which bodies of the individuals found in the cave would either have entered the chamber, or were dropped through an entrance similar to, if not the same as, the one presently used to enter the Dinaledi Chamber.”

Alternative explanation

- Tegobo Makhubela:

  The UJ lecturer dispelled the notion by other scientist that Homo Naledi appears to have intentionally deposited bodies of its dead in a remote cave chamber, behavior previously thought limited to humans.

  "I think they went into the cave running away from danger of veld fires, heavy rainfalls with thunder or being chased away by predators and they were trapped down there unable to leave the place and ended up dying in the cave. I think they were alive because they do not have any indications of being attacked or killed."

Homo naledi

- Ants & bees have dispositional sites; but rare for mammals; Elephants, dolphins, giraffes, scrub jays and chimpanzees mourn their dead, but do not bury them.

- Intentional body disposal (which is different from burial, as some in the press are describing it — there is no sign that the remains were covered over) is thought to be a human behavior adopted only recently.

- 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.

- Or removal of stinking corpses from the places where they lived in order to avoid scavengers and predators having access to them.

Why?

- Briana Pobiner: “Dead people smell bad and attract predators. A cave would be a good place to keep them far away from where you hang out, too, so I can see chucking bodies into the cave so you wouldn’t be the next one eaten for dinner.”

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 earlier 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.”

Bones of Contention

- Questions raised:
- How old are they? Failure to date the find
- Rush to publish; research done hastily
- Is it a new species? Or Homo erectus
- Theory that species might have disposed of its dead
- Untrained eyes
- Too much media
- Was there damage done to fossils?

Bones of Contention: *H. naledi* contrarians

- Amid all the hoopla and confetti, however, a number of scientists are advising caution. They're not denying the importance of the find; the fossils, they say, are invaluable. But they contend that the bones may not represent a new species.
- Berger submitted twelve papers to *Nature*. One of them asserted that the cave fossils represented another new species—*Homo naledi*, or Star Man. After an anonymous peer-review process, the papers were not accepted. The editors asked Berger to heavily revise them. After several back-and-forths, he withdrew them. (but *eLife* is peer reviewed)
- Tim White, UCB, took 15 years to publish his findings on "Ardi.": Might be a variant of *H. erectus;* Berger maintains that 13 of the 83 characteristics he noted on *H. naledi's* skull differ from characteristics on known *H. erectus* skulls; White says many of these 13 characteristics are also present in *H. erectus*
- John Hawkes counters*:* body is unlike *H. 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*); Zeray Alemseged agrees that it is not *erectus.*
- Berger suggests that White should write a scientific rebuttal in peer reviewed journal.

Bones of Contention 2

- 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.

- Fred Spoor (U. College, London): despite small brain, this new species is clearly part of genus *Homo,* but doubts H. naledi was a direct ancestor of modern humans; burial hypothesis is controversial

Bones of Contention 3

- Christoph Zollikofer (U. of Zurich): fossils represent *Homo*, but strikingly similar to 1.8 My *Homo erectus* fossils of West Asia; may have belonged to *H. erectus* and evolved few skeletal innovations
- Susan Anton: doubts it is *Homo* because of *Australopithecus*-like features; fossils are “fabulous and a bit confusing.”

- Donald Johanson, the Lucy discoverer and an early mentor of Berger’s, told me that Rising Star was a “glaring example of how *not* to do fieldwork.” An excavation that took twenty-one days should have taken “more like twenty-one months.”

Bones of Contention 4

- *Journal of Human Evolution* published the critique by Val, the Wits postdoc who had questioned the body-disposal claim.
- Val wondered how the team could have made its radical conclusion without having established the bones' geological age or having excavated beyond a small fraction of the chamber.
- Only a third of the fossils had been "microscopically analysed," and the bone surface was intact on only six of five hundred and fifty-nine pieces, she noted. As a result, tooth marks, or cuts, or signs of trampling by predators "might not be preserved."
- Val added that the team had used an "unknown" method of analysis, making it hard for future researchers to check the findings.
- She urged a broader excavation and an "extensive geological assessment," using "established methods."

Bones of Contention 5

- The journal then published Berger's response to Val, in a paper whose lead author was Paul Dirks, an Australian geologist who led part of the *naledi* analysis. The researchers noted that Val had neither examined the *naledi* materials directly nor visited the fossil chamber before offering a "reinterpretation" of the data. Responding to her doubt that hominins with small brains could establish and maintain a complex funerary tradition, they said, "The closest living relative of *H. naledi* is our own species, which exhibits elaborate mortuary behavior in every culture."

Bones of Contention 6

- Another Wits colleague, Francis Thackeray, did examine the fossils, and he recently joined Val in disputing the disposal theory. Thackeray found what he calls evidence of lichen on the bones, and this suggested to him that the remains had been exposed to extensive daylight; this is hard to reconcile with the idea that the creatures lugged carcasses through narrow, pitch-black passageways and then left them to rot in a remote chamber. Thackeray thinks that maybe the creatures got trapped by rockfall. Berger has discounted this possibility; to him, the evidence suggests that the bodies came into the cave over time. In the press, he called Thackeray's hypothesis "flimsy" and said, "I am sticking with my theory."

Discourse

“Without a date, these fossils are more curiosities than game-changers,” said Jungers, “Where they fit in the family tree will be influenced by their age – they are a twig, looking for a trunk”

“Making sure you have got things right is of critical importance, particularly in a science in which there are so Few specimens left of any species. Rushing things, in particular to suit film-makers, is very dangerous.” White said.

“I need copies of key skulls to show my students,” Skinner said. ‘But casts of many of the most important skulls are still unavailable years after they were finally described in *Nature or Science*. I think it is a bit cheeky that researchers are able to push their careers forward by publishing about fossils like *Ardipithecus* but still do not make these finds available. My generation of academics is getting a bit fed up with that sort of thing. Hopefully things are now going to change.”

“A paleofantasy come true,” said Lucas Delezene, a newly appointed professor at the University of Arkansas. In grad school you dream of a pile of fossils no one has seen before, and you get to figure it out.”

Zeray Alemseged’ s Opinion

1550 fossils: Unprecedented, landmark find.

15 individual help understand variation within one species.

Supports hominid species diversity (like other animal species

Many evolutionary experiments

Naming a new species warranted by the mix of characters.

Early hominid evolution is a pan-African story

Zeray

- Knowing their age is important to appreciate their relationship but not to determine their taxonomic identity.

- East Africa offers more complete record, *but africanus, robustus, sediba, and naledi* probably speak to migrations and endemism (ecological state of a species being unique to a defined geographic location)

2016 comparison study: The evolutionary relationships and age of *Homo naledi*

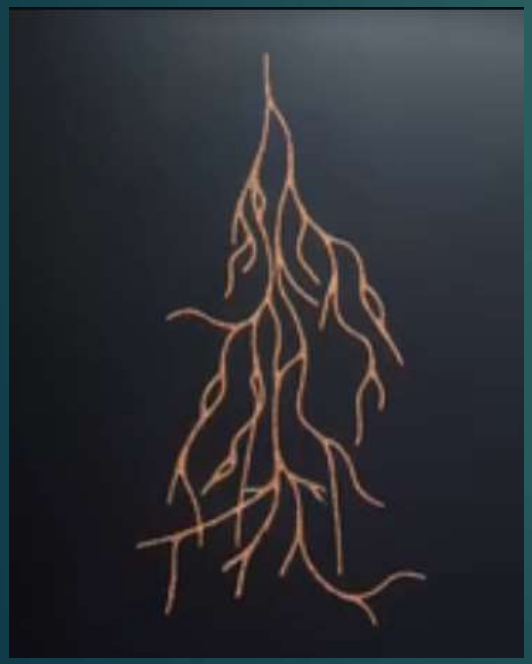
- a study that addressed two of them: “Where does *H. naledi* fit in the hominin evolutionary tree?” and “How old is it?”
- Used a large supermatrix of craniodental characters for both early and late hominin species and Bayesian phylogenetic techniques to carry out three analyses.
- The analyses strongly supported the hypothesis that *H. naledi* forms a clade with the other *Homo* species and *Australopithecus sediba*. The analyses were more ambiguous regarding the position of *H. naledi* within the (*Homo*, *Au. sediba*) clade. A number of hypotheses were rejected, but several others were not.
- Based on the available craniodental data, *Homo antecessor*, Asian *Homo erectus*, *Homo habilis*, *Homo floresiensis*, *Homo sapiens*, and *Au. sediba* could all be the sister taxon of *H. naledi*.
- According to the dated Bayesian analysis, the most likely age for *H. naledi* is 912 ka. This age estimate was supported by the resampling analysis.
- Our findings have a number of implications. Most notably, they support the assignment of the new specimens to *Homo*, cast doubt on the claim that *H. naledi* is simply a variant of *H. erectus*, and suggest *H. naledi* is younger than has been previously proposed.

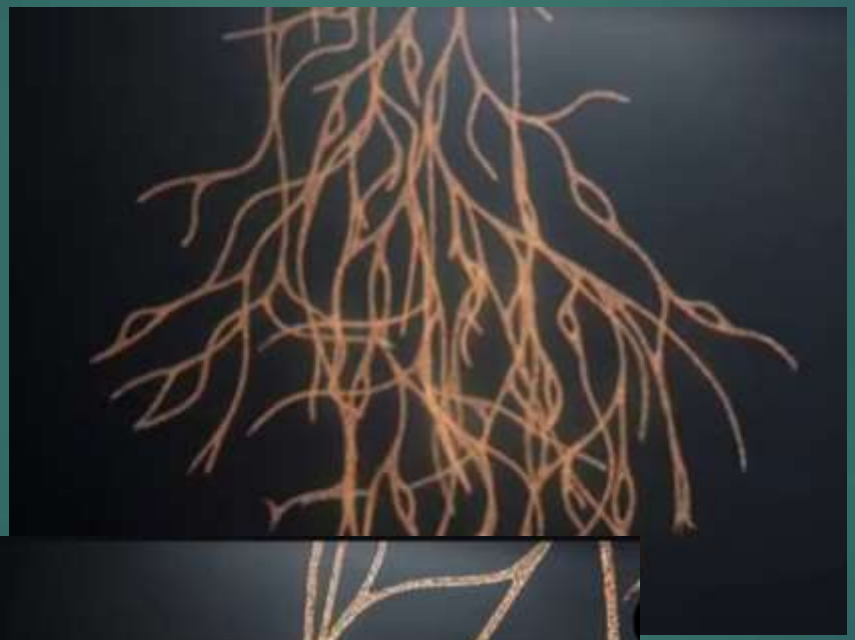
Mana Dembo, et al., 2016

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





Misunderstandings

- Recently provoked a backlash from a few influential South African national figures who associate the finding with five decades of apartheid governance.
- Trade unionist Zwelinzima Vavi tweeted: “No one will dig old monkey bones to back up a theory that I was once a baboon.” South African Council of Churches President Bishop Ziphozihle Siwa concurred: “To my brother Vavi, I would say that he is spot-on. It’s an insult to say that we come from baboons.”
- In responding to these remarks in press accounts, Lee Berger, lead researcher on the *H. naledi* study, explained that humans do not descend from baboons. Evolutionary biologist Richard Dawkins jumped in, tweeting back: “Whole point is we’re all African apes.”

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

- Rising Star cave is 800m from Swartkrans Cave, one of the most heavily explored caves in Africa; has been worked on continuously for 85 years; 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, paleomagnetic reversal data, electron spin resonance (max = 300K); South Africa has law that you can not destroy a fossil until published; "Further method development is underway to circumvent this problem"
  - Berger estimates 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 human 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.

Lessons to learn from *H. naledi*

- Some of the hallmarks of "being human" such as efficient bipedalism and fine motor skills are not dependent on a big brain.
- *Homo naledi* reaffirms that human evolution — like the evolution of all groups — is not patterned like a ladder, but rather a very deeply pruned bush, with many branching lineages, most of which have died out.
- We should never expect a new fossil find to have a predicted set of traits that perfectly "links" it between two other species.
- Nor should we use value-laden terms such as "primitive" to describe species, most of which successfully made their way on Earth for far longer than our own species has existed.

Rising Star is now a tour site

- andBeyond’s Human Origins Safari: $13,181
- Includes tour of Olduvai Gorge and tour of the Cradle of Humankind just outside Johannesburg, including the Rising Star cave where Homo naledi was unearthed

Bettina Hughes' Leakey Foundation Fellows Tour to South Africa in May, 2015

- Lee Berger did not show our group *H. naledi* at Rising Star , but in Johannesburg at the Evolutionary Studies Institute (ESI), added next door to the Center for Human Origin in Johannesburg. This is a brand new and among the largest of its kind paleoanthropological research institute.
- The room in which *H. sediba* and *H. naledi* were in is an air, temperature, and humidity regulated vault where all fossils are kept and locked up. We had three security people making sure we did not abscond with any of the materials - very tempting. Yes, Lee showed us *H. naledi*, one of 15 individuals collected in the cave, under the condition we not talk about this find until it is published.
- We then toured the building, and one of the most impressive things was a industrial-sized high resolution CT scanner that allows the researcher to determine what is inside the rock. As the rock (flowstone mostly) is so darn hard, it helps to know where you can whack off stone and where you have to work very carefully.

Evolutionary Studies Institute (ESI)

Bettina's trip 2

- We also went to Sterkfontein where Professor Ron Clarke gave us an extensive overview of human evolution in South Africa and then introduced us to his spectacular find of "Little Foot" that he has been working on over the last 13 years.
- It is estimated to be about 3 million years , maybe as much as 3.7, according to Ron Clark. The dating is difficult because of the flowstone that subsequently covered the fossil - no carbon, no volcano ash. It is a pretty much complete female *Australopithecus*, but what species is still to be determined. Clarke concludes that it is *A. prometheus*, the same species as the 1948 fossil found by Raymond Dart.
- He hopes to publish his big paper at the end of this year, but feels he still needs to remove the flowstone further. I hope he will as he is retiring at the end of this year and moving, I believe, to the UK. (You probably know Ron Clarke's name as he had uncovered the first bipedal footprints in Laetoli, Tanzania in the 1970ies. He was working with the Leakey's team at that time)
-

Ron Clarke and “Little Foot” Australopithecus

Ron Clarke and the Sterkfontein hominid

Bettina's Trip 3

- The 3.7 million years is an important date as it is around then that the oldest hominids were found in South Africa, and after that, there is a very good record of younger fossils, almost up to present day. S. Africa boasts that they have 10x more fossils than all the fossils outside of theirs, in the whole world. I think this is no exaggeration.
-
- The geologist Dominic Stratford then showed us some of the caves from above and up close (rickety stairs!!), and explained about the flowstone, but we did not pass either Malapa (where *A. sediba* was found), nor Rising Star (*H. naledi*), all within the Cradle of Humankind about 1 1/2 hrs NW of Johannesburg.

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- 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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Charlie's Downloable Evolution Talks

- www.charlesjvellaphd.com
  - A Brief Biographical History of Paleoanthropology 2012
  - What's New in Hominid Evolution 2015
  - What's New in Hominid Evolution 2015 - 2
  - Hominid Evolution 2015
  - Homo naledi, 2015
  - Human Brain Evolution 2016