*** OLLI Human Evolution Science Update

September 2024

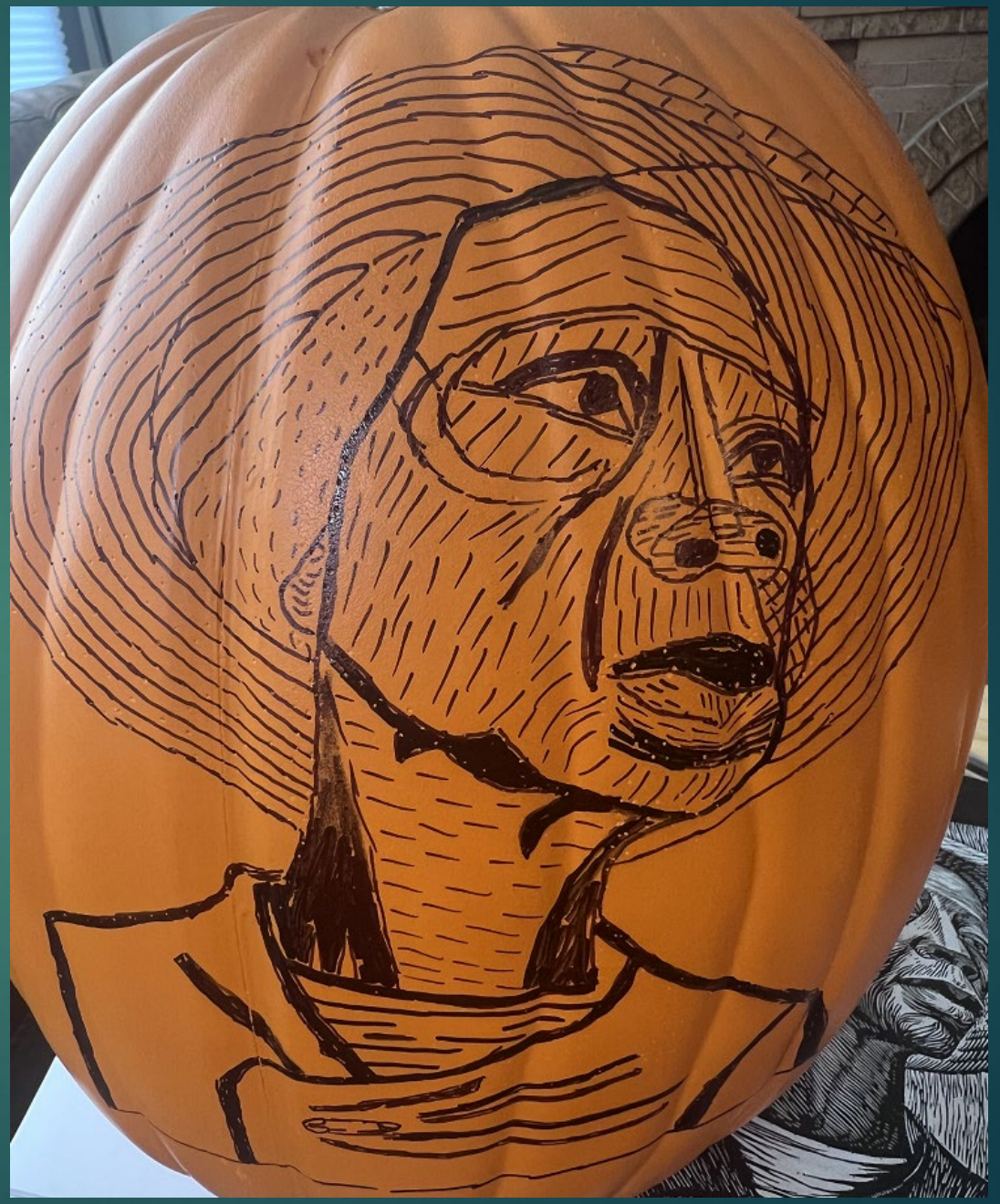
by

Charles J Vella PhD

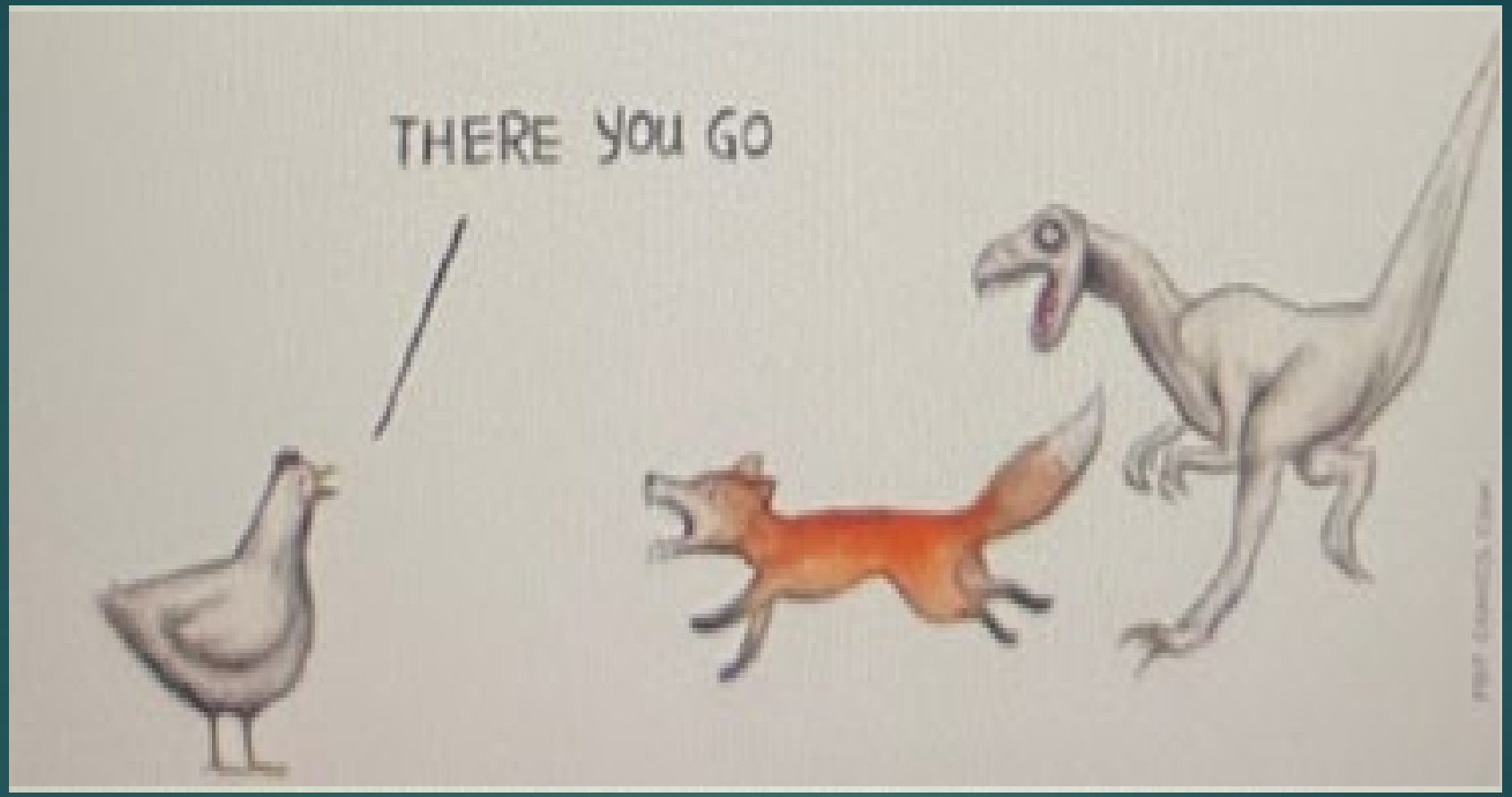
Pumpkin season
is here.

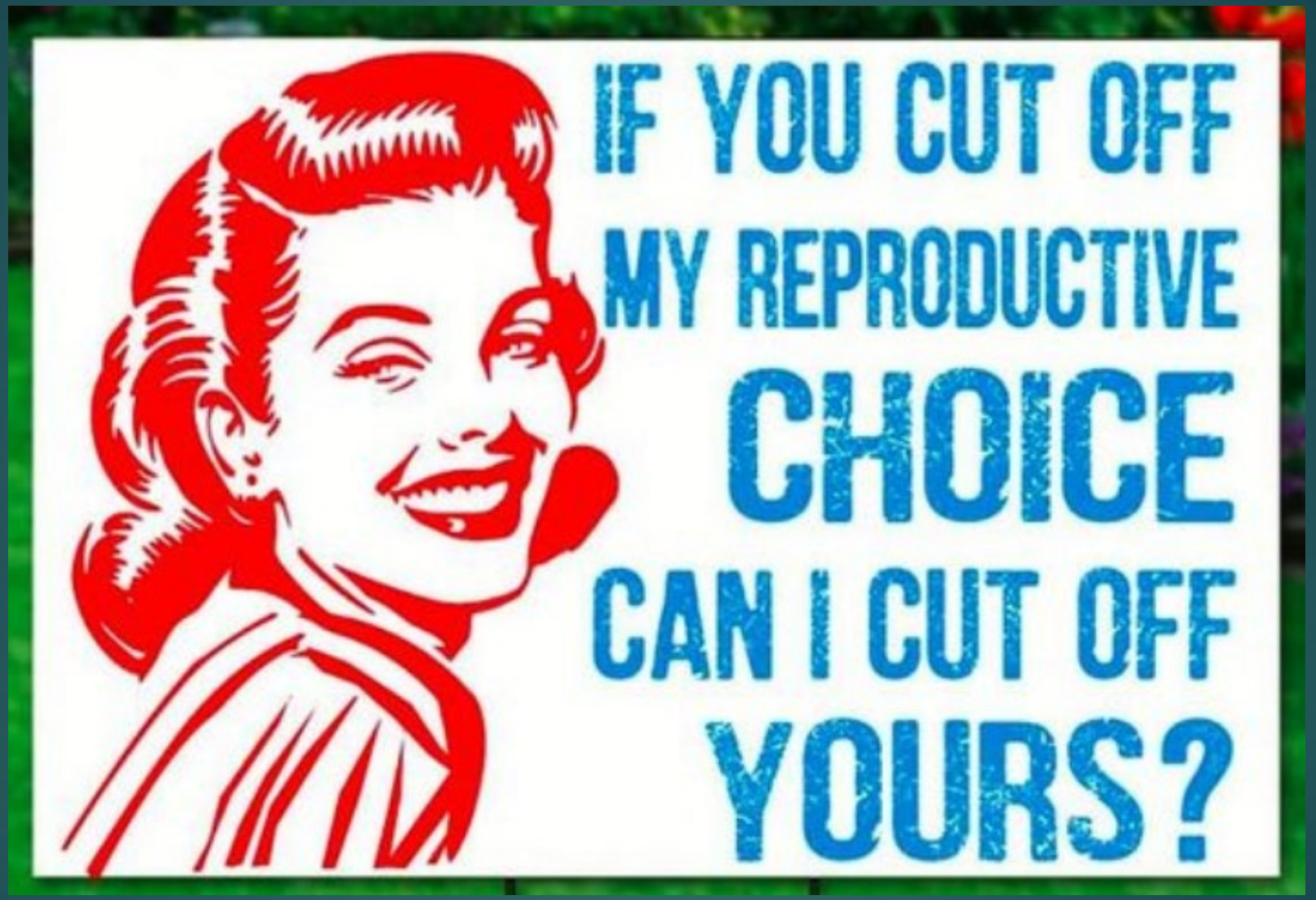
Original painting:
Sharecropper, 1952
By Elizabeth Catlett

Place on pumpkin;
pinprick outline;
dark pen outline;
then carve – Dremel
drill for foam pumpkins



Reverse evolution




IF YOU CUT OFF
MY REPRODUCTIVE
CHOICE
CAN I CUT OFF
YOURS?

Coming attractions

- Will try to continue our usual pattern of 1 hour of new science updates; then 1 hour of book we are reviewing (Myths in Human Evolution) – but not for nest 2 months

- Oct 23: science review, then Berger studies

- Nov 13 and 20: review of 2 new language evolution (esp. Ns)

A goliath birdeater spider = 11 inches across

CAS biologist Brad Balukjian:
a bright green, red,
and yellow plant bug
from Tahiti
will now be known as
Pseudoloxops kamalaharrisae.
A “bug” is a technical
term: belongs to
suborder
Heteroptera,
which have mouths
like a straw

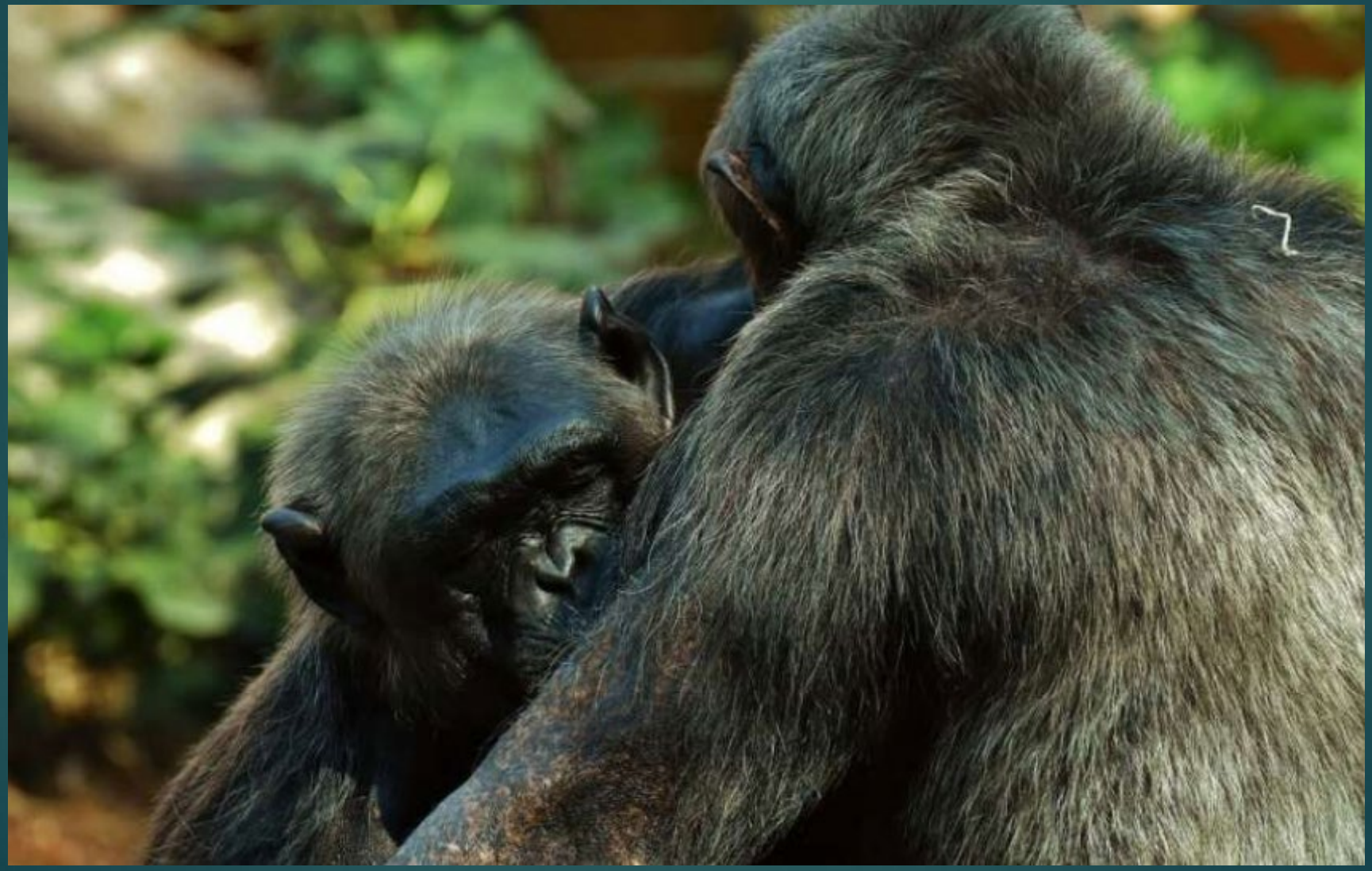
Can a multivitamin keep your brain healthy?

- Effect of multivitamin-mineral supplementation versus placebo on cognitive function: results from the clinic subcohort of the COcoa Supplement and Multivitamin Outcomes Study (COSMOS) randomized clinical trial and meta-analysis of 3 cognitive studies within COSMOS – C. M. Vyas, et al., 2024 = Harvard study, N=5000, RTC; used Pfizer Centrum Silver
- The meta-analysis showed clear evidence of MVM benefits on global cognition] and episodic memory; the magnitude of effect on global cognition was equivalent to reducing cognitive aging by 2 y.
- Daily MVM significantly benefits both global cognition and episodic memory. These findings within the COSMOS trial support the benefits of a daily MVM in preventing cognitive decline among older adults.

Or not?

- Or we might learn that the benefits reported here are too small to make much difference in real life, or wane over time, or have no effect on preventing common types of dementia.
- And it's hard to ignore an earlier randomized, placebo-controlled trial that was actually larger and longer-term: it found no improvement in brain function among male physicians ages 65 and older taking multivitamins.
- But it does mean that more study is warranted. We need to understand who is most likely to benefit from multivitamin use, what dose is optimal, and what parts of the multivitamin are most important.

Apes understand reasons behind each other's actions



The origin of great ape gestural forms

- Apes can understand the communicative goals behind each other's actions—a skill previously thought to be unique to humans.
- Study argues that apes use body language to show one another their communicative intentions.
- Apes understand what different parts of their bodies are used for. As a result, they can recruit these different body parts to use as gestures for communicative purposes.
- So, if a baby chimp has its arms outstretched towards its mother's back, the mother can understand it wants to be carried, as she knows she uses her back to carry.

Kirsty E. Graham,, et al., 2024

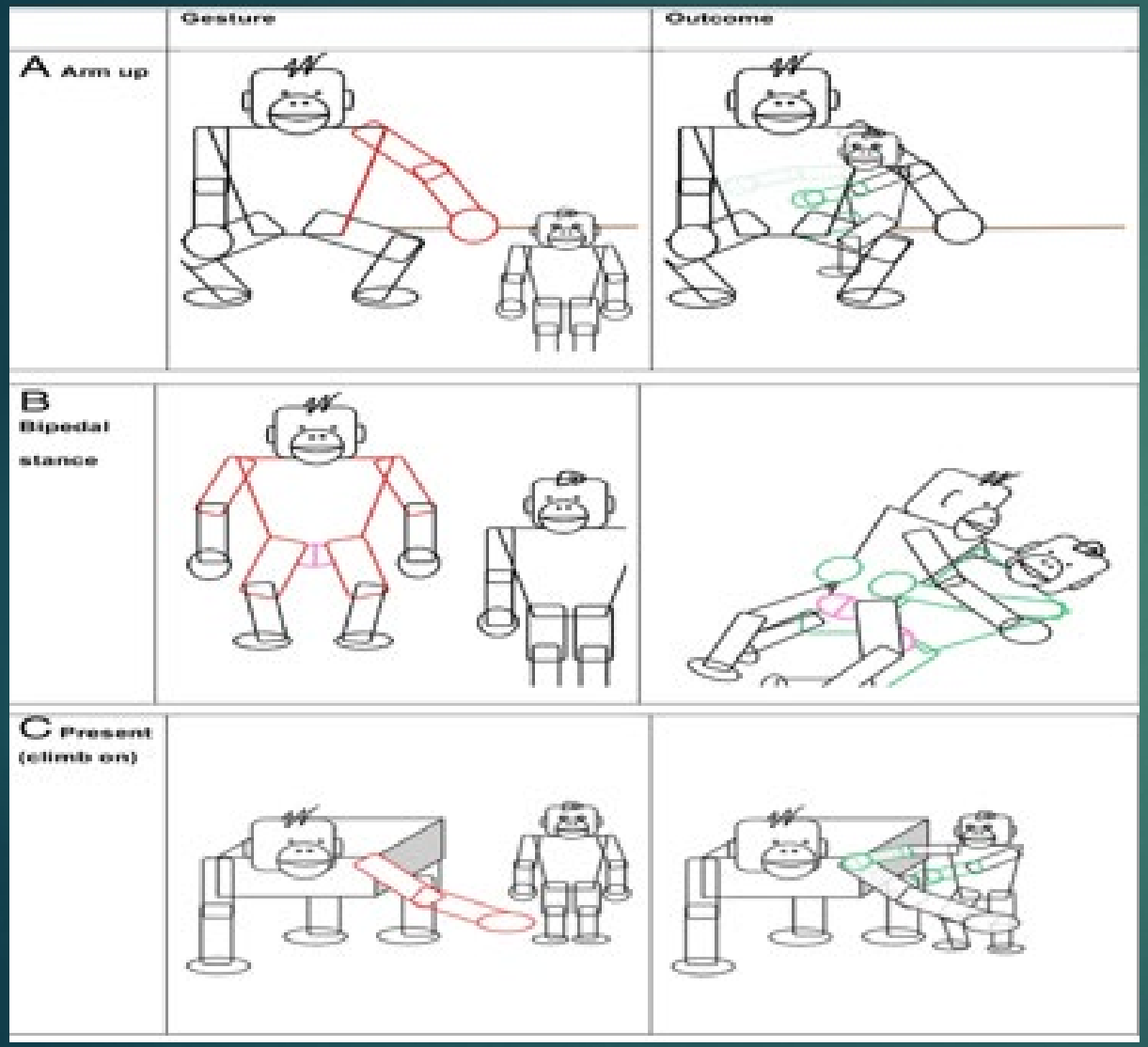
Historical views

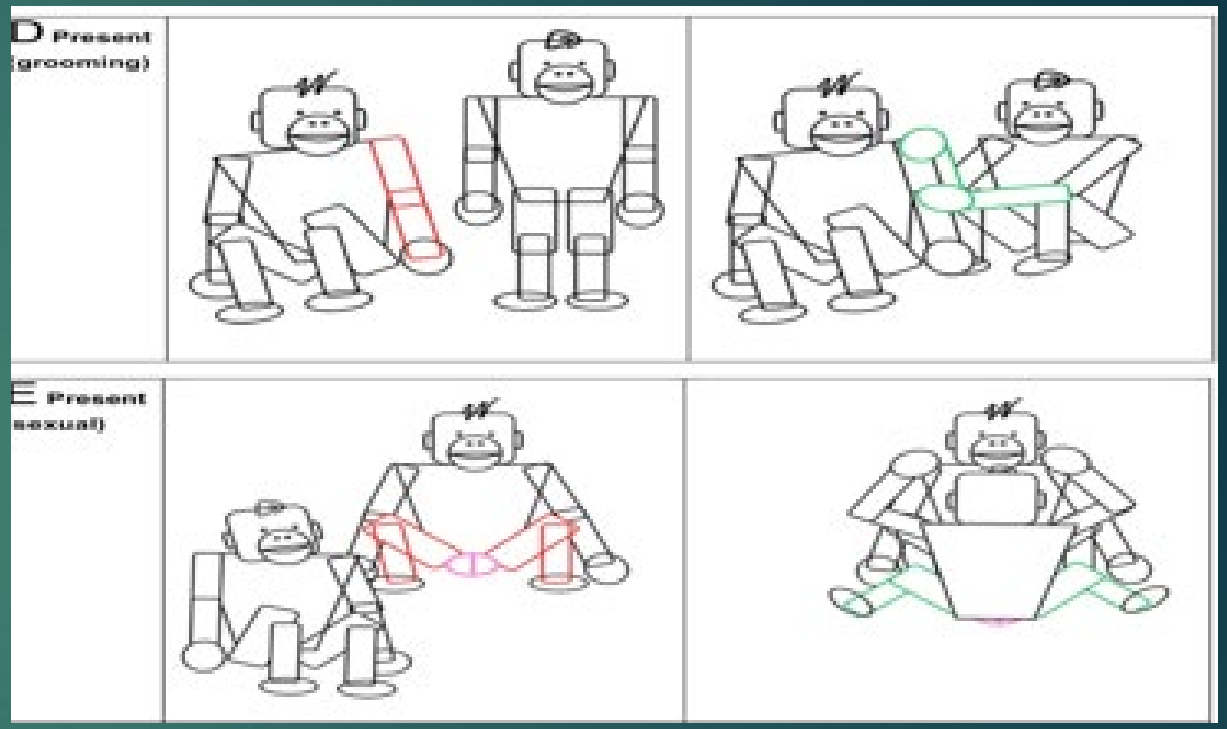
- This new "Recruitment view" of great ape gestures aims to replace two historically influential views.
  - One idea, the "Leipzig View," suggests that apes learn gestures through repeated interactions, leading to differences between groups.
  - Another theory, the "St Andrews View," argues that these gestures are universal across all great apes, meaning they don't need to be learned.
- New “recruitment view” of the origins of great ape gestures: apes use parts of their bodies or familiar actions to communicate.
- These gestures aren't taught or inherited; they arise naturally because all great apes have similar bodies and engage in similar activities.
- Imagine a chimpanzee showing another chimp its shoulder to be groomed, or making a motion like beckoning it to move closer.

Gestures

- However, unlike humans, apes rely heavily on clear physical cues, such as body movements or gestures, to interpret these intentions. "This theory offers a new perspective on how human language might have evolved," "We see a link between the gestures apes use and the early forms of communication that may have eventually developed into human language.
- Why do apes across different species and groups use such similar gestures? The answer, they suggest, lies in the shared actions and body parts that all apes have, making these gestures easily understood across species.

Some Gestures





A selection of gestures that show the part of the body with which the recipient should interact.

- (A) Th “Arm up” gesture deploys extended “straight arm(s) out to side and away from body” It is used by bonobos to request “Initiate contact” (80%) and “Climb on me” (20%)
- (B) In the “Bipedal stance” gesture, apes stand bipedally, arms out to the side, and with their back arched, to present their exposed genitalia. It is used by bonobos to request “Initiate copulation” (50%) and “Initiate genito-genital (GG) rubbing” (50%).
- (C) In the “Present (climb on)” gesture, an “arm or leg is extended to young recipient in order to facilitate them climbing onto the signaller's body (normally mother to infant)”. Both chimpanzees and bonobos use this gesture to request “Climb on me” (100% for both species).
- (D) In the “Present (grooming)” gesture, the body is moved to “deliberately expose an area to the recipient's attention which is immediately followed by grooming of the area. Bonobos and chimpanzees both use this to request “Initiate grooming” (100% for both species).
- (E) In the “Present (sexual)” gesture, the signaller “sits and spreads their limbs displaying their genital swelling or erect penis” . This gesture is used by bonobos to request “Initiate genito-genital (GG) rubbing” (64%) and “Initiate copulation” (36%), and by chimpanzees to request “Initiate copulation” .

Rare skeletons up to 30,000 years old reveal when ancient humans went through puberty

- An analysis of around a dozen teenagers who lived during the Paleolithic reveals that they hit puberty around the same time modern teens do.
- Most ice age teens started puberty around the same time as humans in modern times do, according to archaeologists who studied the skeletons of adolescents who died in Europe between 10,000 and 30,000 years ago. But physical maturity was delayed in some individuals, likely because of their challenging and hazardous lifestyles.
- Skeletons of 13 adolescents recovered from seven archaeological sites in Italy, Russia and Czechia (the Czech Republic); use of "maturation markers" on the skeletons to estimate different puberty stages in teens who died in the Upper Paleolithic period.

Mary E. Lewis, et al., 2024

Dozen skeletons from the last ice age, including those from Arene Candide in Italy to determine when teenagers hit major puberty milestones

Bones fusing

- Babies are born with about twice the number of bones as adults; during childhood, these bones grow and then fuse together by the time a person is 18 to 25 years old.
- Archaeologists can therefore use bones to identify several stages in the years-long process of puberty, including the major adolescent growth spurt, the beginning of menstruation when bones start fusing, and the time that sexual maturity is reached and all the bones are fully fused

Maturity at 16 to 21

- The researchers were able to determine the stage of puberty reached in 11 of the 13 ice age individuals.
- They discovered that these ancient adolescents had their growth spurt between the ages of 13 and 16, similar to the range of 12.5 to 14 years for modern foraging groups.
- Ice age teens also reached maturity between the ages of 16 and 21. This suggests that several ancient teens spent a longer time in adolescence than their counterparts in Western societies, who tend to reach maturity between 16 and 18 years old.

An artist's reconstruction of the 16-year-old Romito 2, a teenager who had a form of dwarfism about 11,000 years ago.

One individual from the Italian site of Romito represents the earliest known case of chrondroplastic (short limbed) dwarfism. The researchers found that he died around 16 years old, well into puberty. However, his development lagged somewhat behind other males from the period. His short stature of around 3.3 to 4.25 feet, along with his delayed puberty, may have meant his community viewed him as more child than adult — which may explain why he was uniquely buried in the arms of an older woman

Menarche/beginning of menstruation age

- However, one major difference between ice age adolescents and modern ones can be seen in the estimates for menarche, or the beginning of menstruation.
- Although the researchers' sample size is small — just five females from this time period — they concluded that the age of menarche was no earlier than 16 to 17 years old. In the modern U.S. population, the average age that menstruation begins is 11.9 years old. However, in modern hunter-gatherer populations, the range is later, around 13 to 17 years.
- This is the oldest application of peptide analysis for biological sex estimation.
- Would be interesting to do Ns next.

Ancient Rapanui genomes reveal resilience and pre-European contact with the Americas

- Rapa Nui (also known as Easter Island) is one of the most isolated inhabited places in the world, but has iconic megalithic statues called moai[1].

- Two prominent contentions have arisen from the extensive study of Rapa Nui. First, the history of the Rapanui has been presented as a warning tale of resource overexploitation that would have culminated in a major population collapse—the 'ecocide' theory.

- Second, the possibility of trans-Pacific voyages to the Americas pre-dating European contact is still debated.

J. Víctor Moreno-Mayar,, et al. 2024

Polynesian in origin

- Polynesian peoples from the west reached the island about 1250 ce; Europeans reached the island only in 1722 ce.

- In the 1860s, Peruvian slave raiders kidnapped a third of the population. Subsequently, a smallpox outbreak decimated the Rapanui population and it fell to an estimated 110 individuals.

- Reconstructed the genomic history of the Rapanui on the basis of 15 ancient Rapanui individuals that we radiocarbon dated (1670–1950 ce) and whole-genome sequenced. We find that these individuals are Polynesian in origin and most closely related to present-day Rapanui, a finding that will contribute to repatriation efforts.

No ecocide and Native American DNA

- Through effective population size reconstructions and extensive population genetics simulations, we reject a scenario involving a severe population bottleneck during the 1600s, as proposed by the ecocide theory.

- Furthermore, the ancient and present-day Rapanui carry similar proportions of Native American admixture (about 10%). Using a Bayesian approach integrating genetic and radiocarbon dates, we estimate that this admixture event occurred about 1250–1430 ce.

Conclusion

- In this work, we present high-quality ancient Polynesian genomes, which were found to be of Rapanui origin.
- Although these individuals— radiocarbon dated to the 1800s— postdate the first arrival of Europeans in Rapa Nui, they do not bear European admixture.
- More importantly, they pre-date the Peruvian slave raids and the devastating smallpox outbreak of the 1860s. As such, this dataset likely constitutes a close representation of Rapanui genomic diversity after the initial peopling of the island and before European contact.

Conclusion

- Were able to address two long-standing contentions on the Rapanui past: a highly publicized theory of a self-inflicted population collapse in Rapa Nui, and the extent of the Polynesian voyages across the Pacific and their early contacts with Native Americans.
- Using biological (genomic) data, we found no evidence that the Rapanui underwent a population collapse in the 1600s, originally proposed to be a consequence of deforestation, resource overexploitation and warfare.
- Although trees once covered Rapa Nui, it has been proposed that their decline is likely to be a compound consequence of direct human action and the proliferation of rats brought by Polynesian settlers, as observed in other Polynesian islands.

Rapanui

- According to some authors, the Rapanui census population size would have reached as many as 15,000 individuals. However, European records from the eighteenth and nineteenth centuries suggest that the Rapanui population was as small as about 3,000 individuals.

- Although such a small population could have been the result of the proposed population collapse, this estimate is also compatible with a population that would have steadily grown after the initial peopling when assuming pre-industrial growth rates.

- These accounts are consistent with our inference that the effective population size monotonously increased after the initial peopling of the island but remained low during the past 1,000 years.

10% Native American DNA

- Whereas anthropogenic impact is widespread in Polynesia, we specifically reject the hypothesis that such changes in Rapa Nui resulted in population collapse in the 1600s, before European contact.
- Instead, our results support that the Rapanui population was resilient despite a changing environment. We detected about 10% Native American admixture (and no European admixture) in all of the 15 Ancient Rapanui—a genomic diversity pattern not consistent with a post-European contact admixture event.
- We confidently dated this admixture event to about 1250–1430 ce (that is, well before Columbus arrived in the Americas and the 1722 European arrival in Rapa Nui) .

Native American DNA

- That we infer the Native American component in Ancient Rapanui to be most closely related to Pacific Coast South Americans and not North Americans or populations east of the Andes further substantiates trans-Pacific contacts between Polynesians and Native Americans.

Need for repatriation

- Suggests trans-Pacific contact could have occurred more than once across Polynesian populations. Notably, archaeological evidence and oral history attest that Polynesian peoples held the technology and know-how to embark on round trips to the Americas before Europeans reached South America.
- In addition to providing notable insights into Rapanui population history, the genomes presented here confirm that the 15 ancient individuals that we sampled are Rapanui in origin.
- When presenting this work to the Rapanui community and their representatives, the need to repatriate these ancestral remains to the island was discussed as a central goal for the community.

*** The nature of the last universal common ancestor and its impact on the early Earth system

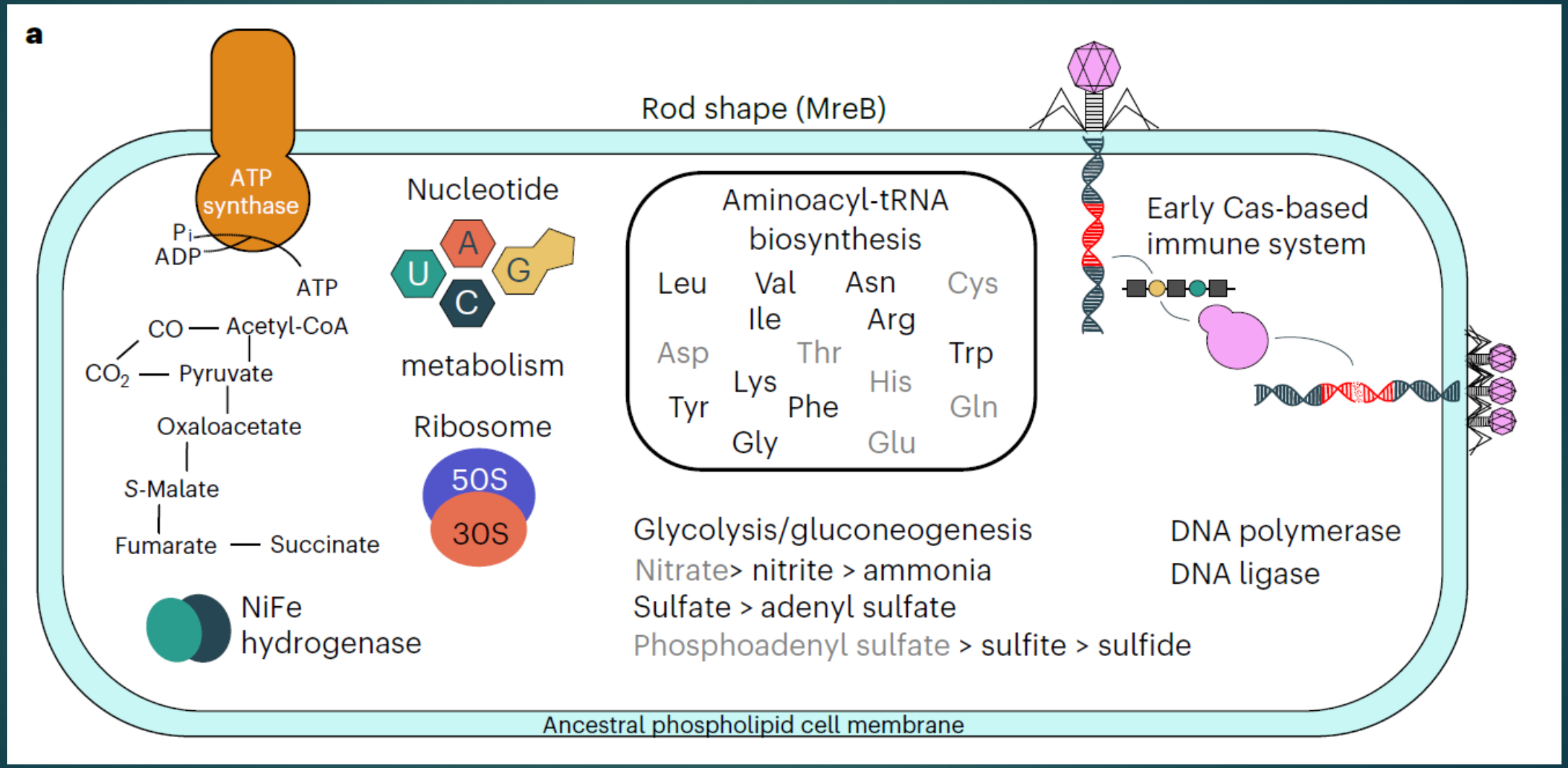
- The nature of the last universal common ancestor (LUCA), its age and its impact on the Earth system have been the subject of vigorous debate across diverse disciplines, often based on disparate data and methods. Age estimates for LUCA are usually based on the fossil record, varying with every reinterpretation. The nature of LUCA's metabolism has proven equally contentious, with some attributing all core metabolisms to LUCA, whereas others reconstruct a simpler life form dependent on geochemistry.
- Here we infer that LUCA lived ~4.2 Ga (4.09–4.33 Ga) through divergence time analysis of pre-LUCA gene duplicates, calibrated using microbial fossils and isotope records under a new cross-bracing implementation. Phylogenetic reconciliation suggests that LUCA had a genome of at least 2.5 Mb (2.49–2.99 Mb), encoding around 2,600 proteins, comparable to modern prokaryotes.

LUCA

- Our results suggest LUCA was a prokaryote-grade anaerobic acetogen that possessed an early immune system.
- Acetogen = bacteria and archaea that perform anaerobic respiration and carbon fixation simultaneously through the reductive acetyl coenzyme A (acetyl-CoA) pathway
- Although LUCA is sometimes perceived as living in isolation, we infer LUCA to have been part of an established ecological system.
- The metabolism of LUCA would have provided a niche for other microbial community members and hydrogen recycling by atmospheric photochemistry could have supported a modestly productive early ecosystem.

Edmond Moody, et al., 2024

A reconstruction of LUCA, within its evolutionary and ecological context.



Humpback Whales Create And Use Tools For Hunting

Bubble nets

- New research suggests that humpback whales engage in an even rarer behavior: *creating* tools for hunting. Study documents how whales blow bubbles to create nets to trap krill.
- In particular, much has been written about humpback whales working together to hunt fish.
- Study deployed underwater cameras on animal tags and aerial cameras on drones, researchers were able to see the exact structure of the bubble nets and the precise actions of the whales.


Humpback Whale Bubble-Net Feeding
DAILYMOTION PRO
UNIVERSITY of HAWAI'I
Alaska Whale
FOUNDATION
0:00

Bubble netting

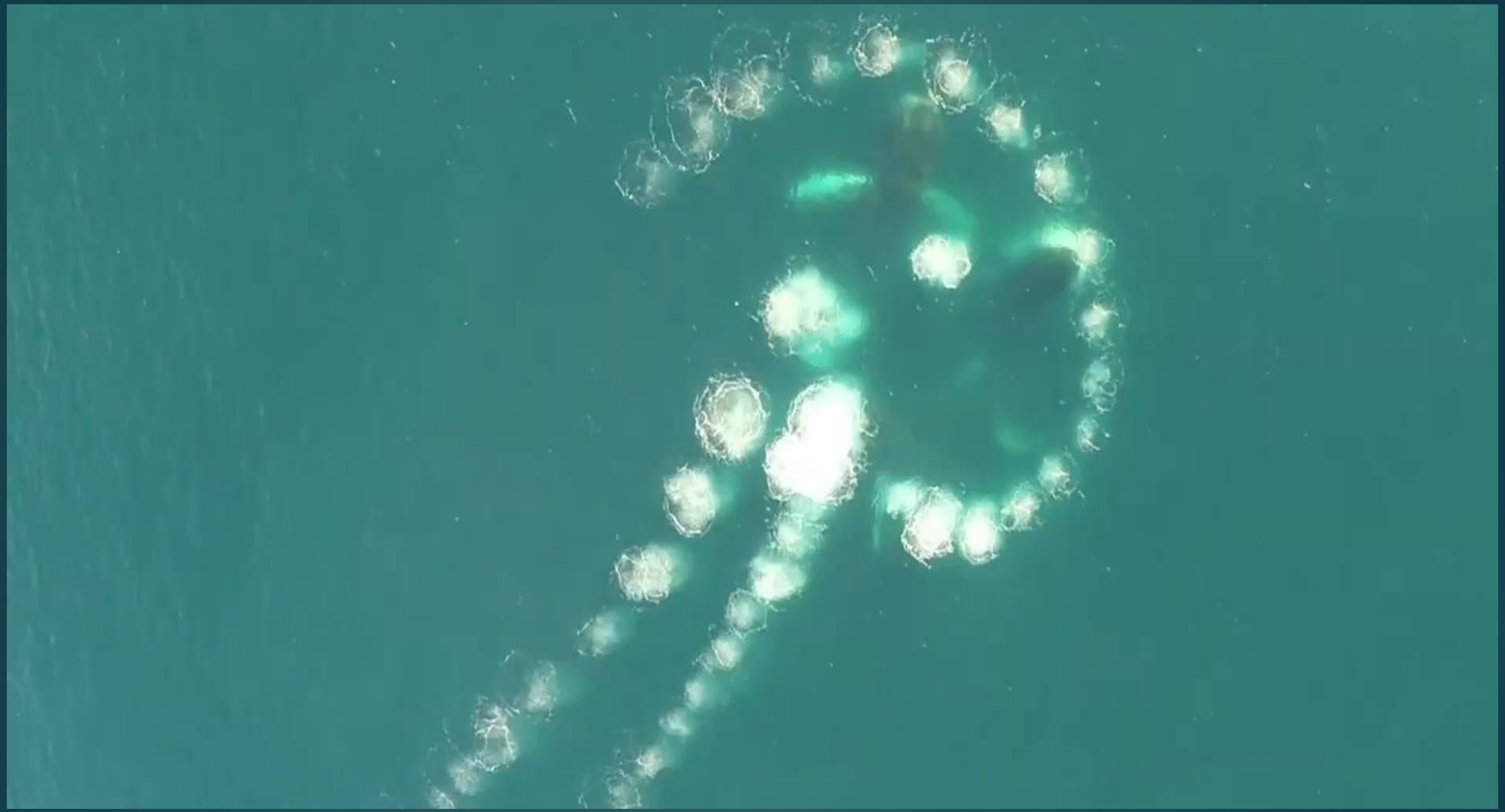
- Humpback whales hunt krill using rings of bubble nets. Although the krill are physically capable of swimming through the bubbles, they are reluctant to cross through them.

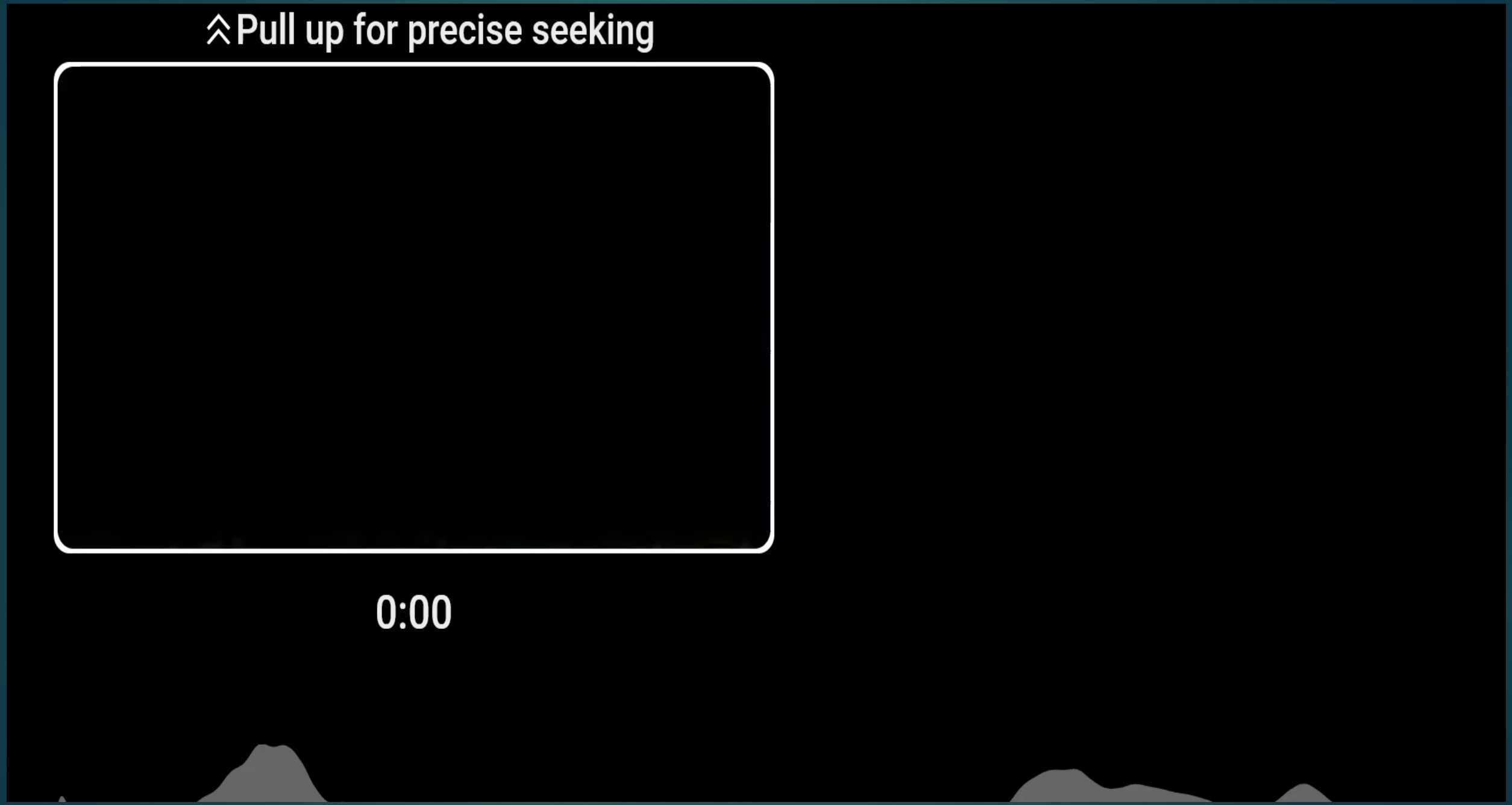
- As the nets get smaller and smaller, the groups of krill get denser and denser. On average, The whales increased krill density seven times by using the nets. This means a whale must take many fewer mouthfuls to eat.

Learn from each other

- The humpback whales also appeared to be learning from one another through observation. Whales are not born blowing bubble nets. Rather, they learn how to do it by practicing and by watching other whales. There is no evidence that the whales are intentionally teaching others.

- In study, there were at least 70 whales within two miles of the researchers' boat that were all creating bubble whales in the same way.




Pull up for precise seeking
0:00


Whales Team Up in Amazing Bubble-Net Hunt |...


Adobe Stock | #468011396

A “Kamakahe” *Neocapritermes taracua* termite

Kamikaze termites blow themselves up with 'explosive' backpacks

- Kamikaze termites in French Guiana carry highly volatile toxic "rucksacks" that are ready to be deployed in an instant, when the termite needs to defend its colony.
- Carry a toxic liquid that they can trigger to explode, poisoning their enemies in the process. Now, scientists have solved the mystery of how these deadly backpacks can be safely carried around then detonated on demand.
- The *N. taracua* workers have a specialized pair of glands in their abdomens that gradually secrete the enzyme blue laccase BP76 into pockets on their backs. As they age, the termites accumulate "rucksacks" filled with these blue, copper-containing blue crystals.

Older termites

- The mandibles of older termites dull over time, older termites may not be as effective at foraging or maintaining the nest as younger workers.
- With their exploding rucksacks, older workers may instead specialize in providing a final, deadly act to defend the colony.
- When faced with a threat, the aging workers rupture their bodies, mixing the enzyme with relatively benign secretions produced in their salivary glands. The result is a sticky liquid, rich in highly poisonous benzoquinones that can immobilize or kill predators.
- However, researchers were puzzled by how BP76 could remain in a solid state stored on the termites' backs, while still staying primed for an instant reaction upon rupture. They discovered how this happens

Marmosets

Marmosets are first non-human primate found that seem to call each other by name

- Marmosets can communicate with one another by name and know when they are being addressed, joining a very short list of species exhibiting such behavior, and a first for non-human primates.
- The monkeys use specific calls, known as “phee-calls,” to call each other, which scientists say is a “high cognitive” behavior pattern only previously observed in humans, dolphins and elephants.
- The tree-dwelling primates are highly social animals and live in small groups in South America but researchers collected data at an animal facility at the university in Israel.

7-inch primate

- Marmosets addressed specific individuals with the “phee calls.” Furthermore, the animals were able to discern when they were being called and responded more accurately in these instances.
- According to the study, marmosets are heavily reliant on vision but also display a “complex array of social calls” - of which the “phee call” is one. The calls are generally used to communicate when they are out of sight from each other.
- The sounds were used as “specific calls to label and address specific individuals.
- Interestingly, the learning pattern could also be seen with adult marmosets who were not blood relatives, suggesting that they learn vocal labels and dialects from other members of the same group.

The supercomputer known as Frontier at Oak Ridge, TN, covers an area larger than two basketball courts.

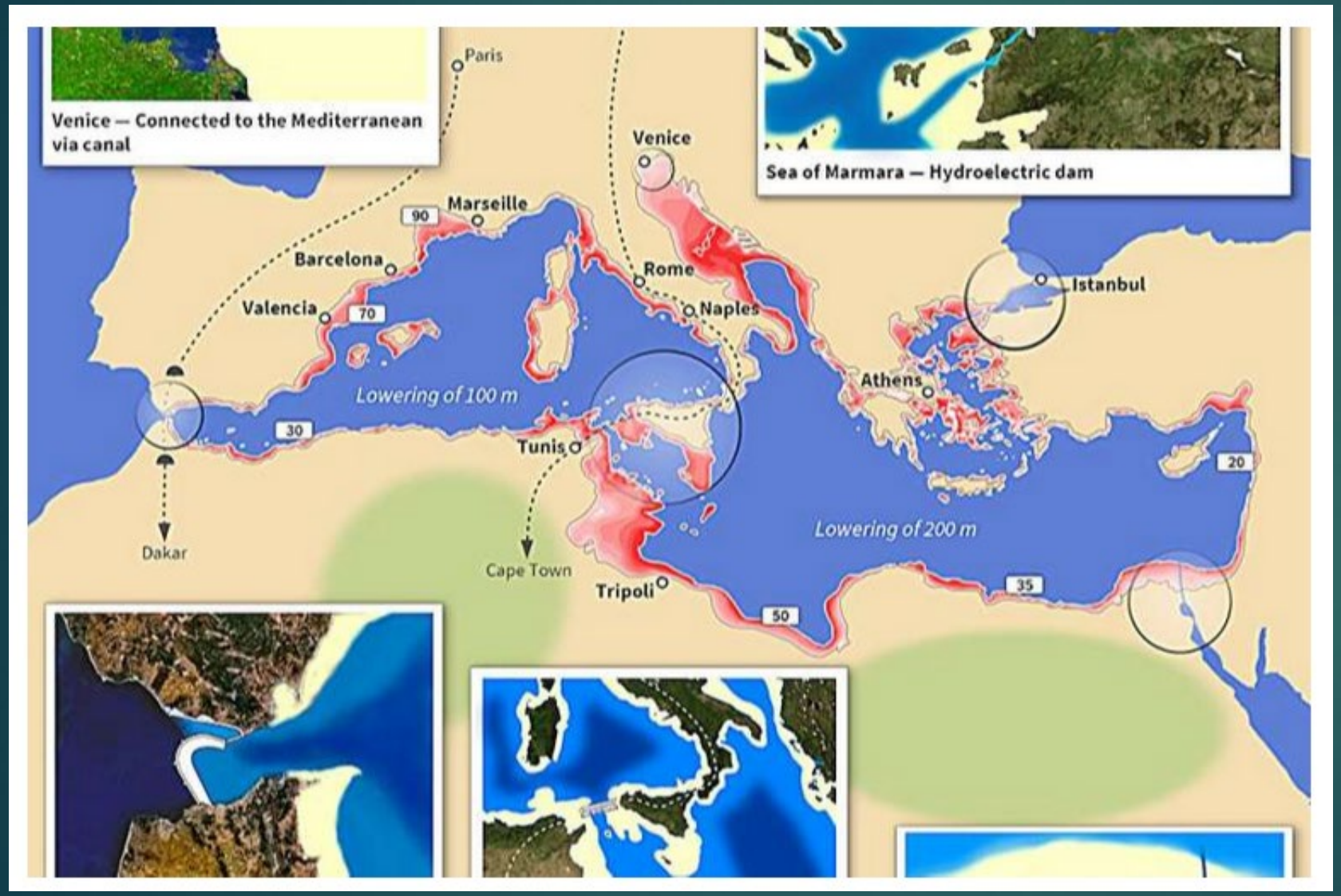
Frontier: use is free if project selected

- 50,000 processors; $280, 000, 000 cost
- The electricity demand peaks at around 27 megawatts, enough to power roughly 10,000 houses. 290 kilometers of fiber-optic cable and a cooling system = flow of 6000 gallons per minute
- Frontier churns through data at record speed, outpacing 100,000 laptops working simultaneously. When it debuted in 2022, it was the first to break through supercomputing's exascale speed barrier — the capability of executing an exaflop, or 10^{18} floating point operations per second.
- Each node consists of one CPU, 4 GPUs and 4 terabytes of flash memory. Each GPU has 128 GB of RAM soldered onto it, and each CPU has 512 GB of local DDR4 memory.
- New Summit is coming (also secret military labs?)

Colossus

- Elon Musk: brought our Colossus 100k H100 training cluster online. From start to finish, it was done in 122 days.
- Colossus is the most powerful AI training system in the world. Moreover, it will double in size to 200k (50k H200s) in a few months.
- Designed to train its large language model (LLM) known as Grok, a rival to Open AI's better known GPT-4.
- Located in Tennessee, the new xAI data center houses 100,000 Nvidia benchmark Hopper H100 processors, more than any other individual AI compute cluster.
- Japan to start building 1st 'zeta-class' supercomputer in 2025, 1,000 times more powerful than today's fastest machines; reach speeds on a zetaFLOPS scale (10^{21} operations per second.

The Mediterranean dried out 5.5 million years ago,



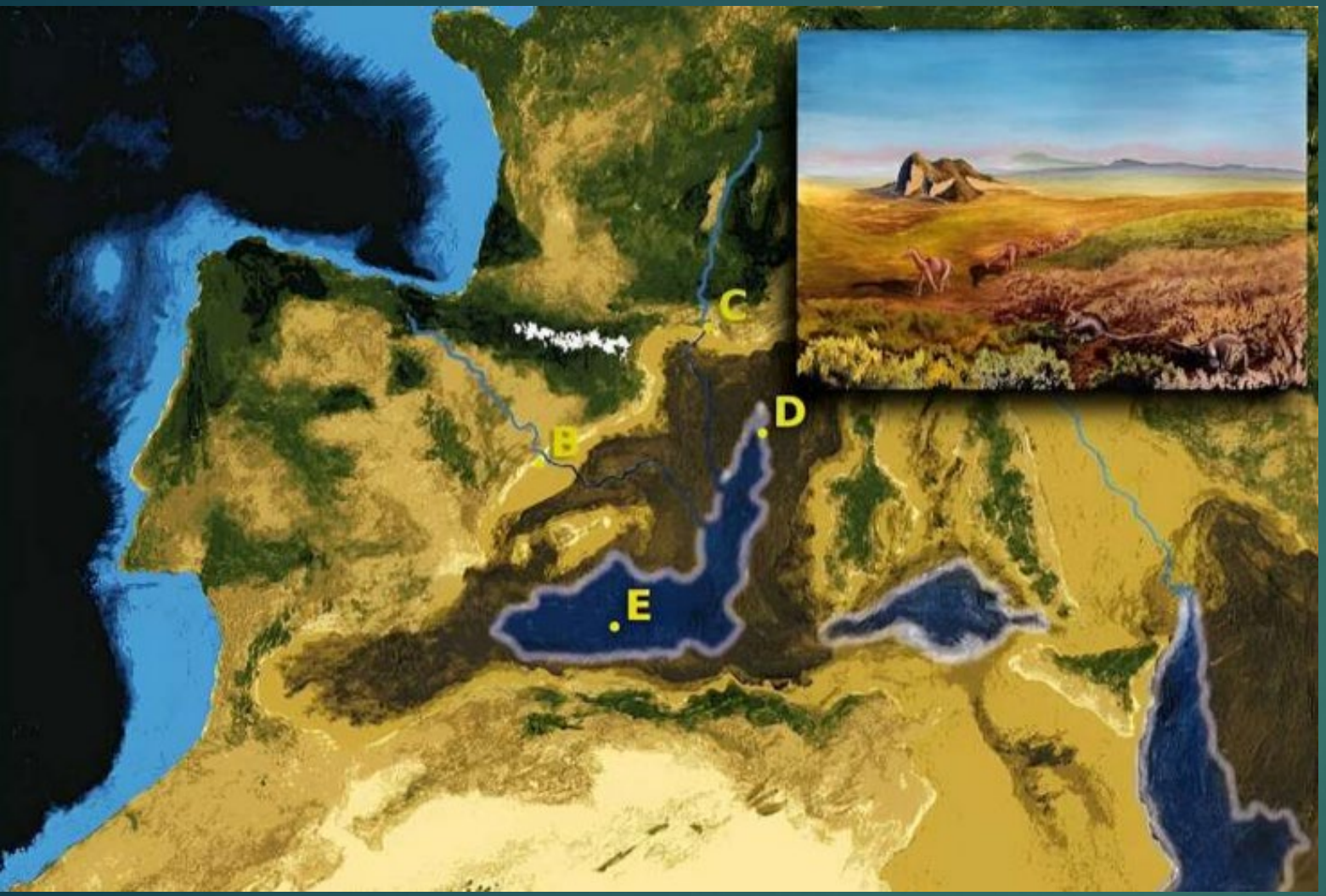
Map of Herman Sörgel's Atlantropa project, which aimed to partially empty the Mediterranean in order to gain more land in Europe, an extension of Nazi Germany's idea of Lebensraum.

by Daniel García-Castellanos and Konstantina Agiadi,, 2024

A 1950s project

- Herman Sörgel, a Bavarian architect who dedicated much of his life to this exact project: building a giant dam across the Strait of Gibraltar, letting the Mediterranean dry up, and colonizing the land reclaimed from the sea.

- What he did not know was that his dream had already come true at the end of the Miocene era, 5.5 million years ago, as a simple result of natural forces.



Closure of the last connecting channel between the Mediterranean and the Atlantic, leading to the Messinian salinity crisis 5.96 million years ago.
(D) evaporation caused salt saturation in the waters and the precipitation of salt layers more than a kilometer thick;
(E) lakes remained in the deepest parts of the sea.
This illustration show how mammals, such as camelids and gerbils, were able to move across the Strait of Gibraltar.

When the Mediterranean disappeared

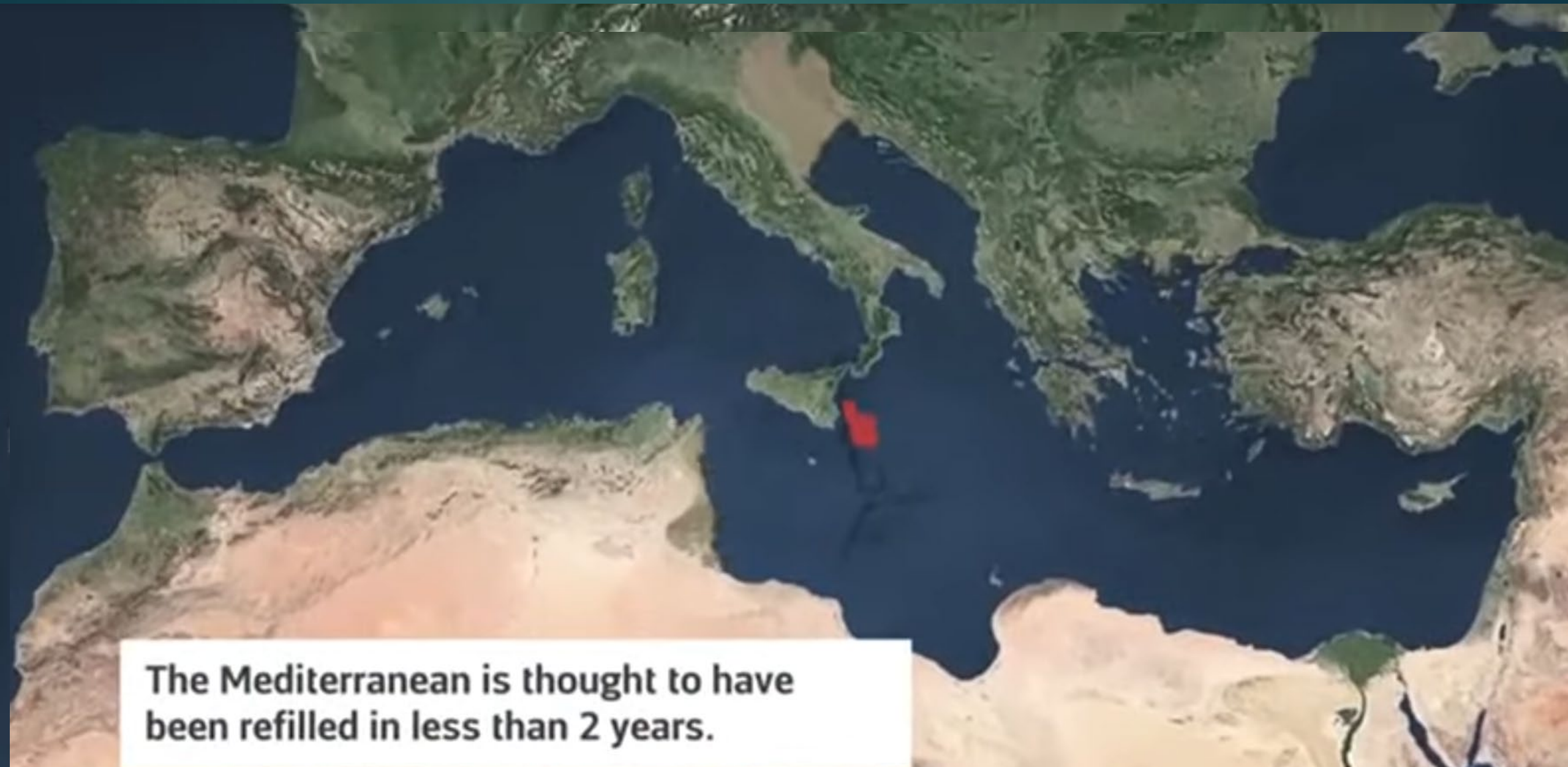
- The existence of a one to three kilometer thick layer of salt buried throughout most of the deeper parts of the Mediterranean Sea.

- This is almost a million cubic kilometers of salt that testify to a brief period when the Mediterranean was isolated from the rest of the world's oceans—brief in the geological sense, as the episode lasted about 190,000 years.

Plate tectonics: Messinian salinity crisis

- The culprit was plate tectonics. The Mediterranean basin, trapped between two continents that today continue to move closer by up to two centimeters every year, was cut off from the Atlantic. Its waters quickly evaporated due to the region's arid climate, leaving behind vast amounts of salt.
- This episode, known as the Messinian salinity crisis (the Messinian being the last period of the Miocene), is the biggest extinction event suffered by the Earth since the meteorite that wiped out the flightless dinosaurs and ended the Mesozoic era 65 million years ago.

Messinian Salinity Crisis



The marine biodiversity impact of the Late Miocene Mediterranean salinity crisis

- The disconnection of the Mediterranean Sea from the Atlantic in the late Miocene 5 to 6 million years ago led to the sea's nearly complete desiccation, leaving only a few hypersaline lakes similar to the present-day Dead Sea.
- Massive salt accumulations, or salt giants, have formed in highly restricted marine basins throughout geological history,.
- Only 86 endemic species of the original 2006 marine species survived the crisis, and that the present eastward-decreasing richness gradient in the Mediterranean was established after the MSC.

Repeated salinity crises

- Salinity crises have occurred repeatedly throughout geologic history in restricted evaporitic basins controlled by dynamic marine gateways that result from the formation and demise of oceans by tectonic motions and sea-level changes.
- Globally, at least 138 evaporitic basins have occurred from the Proterozoic until the Miocene. The Mediterranean salt giant is one of the most recent among the salt giants of the Neoproterozoic (Australia), Paleozoic (Siberia, United States, and northwestern Europe), Mesozoic (the Gulf of Mexico and the South Atlantic off of Brazil, Angola, and Gabon), and the Early (Iran), Middle (Red Sea), and Late Miocene (eastern Europe).

*** The marine biodiversity impact of the Late Miocene Mediterranean salinity crisis

- Native marine life was virtually extinct when the Mediterranean was cut off, and that subsequent recolonization by Atlantic species gave rise to a Mediterranean fauna more similar to the one we find there today.
- By statistically analyzing information from more than 750 scientific papers, we were able to document 22,932 presences of a total of 4,897 marine species living in the Mediterranean. Before the crisis, 779 species could be considered endemic species (i.e., documented only in the Mediterranean). Of those, only 86 were still present after the salinity crisis. All the tropical corals that were abundant in the Mediterranean before this cataclysmic environmental change disappeared.

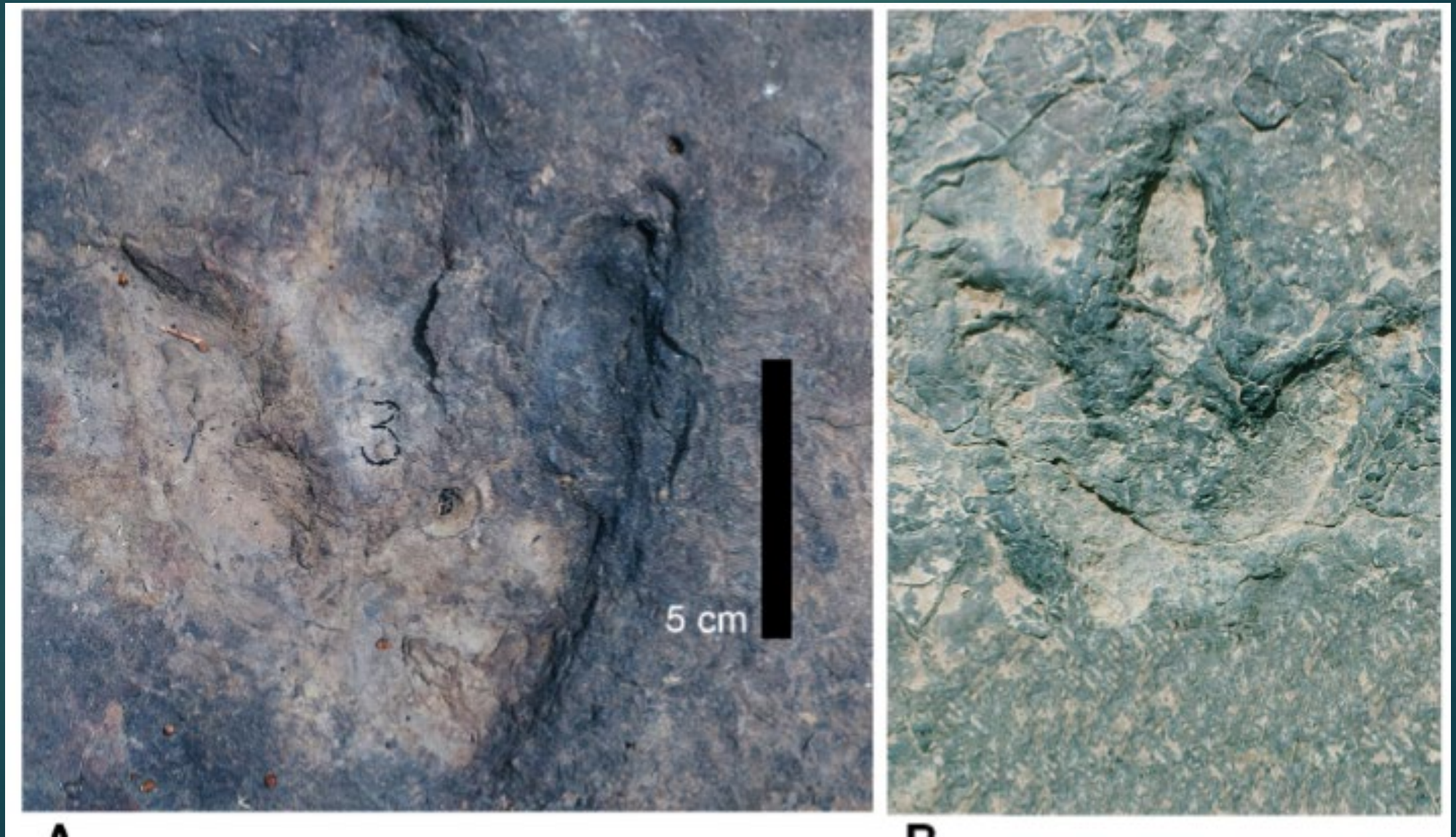
K Agiadi, et al., 2024

Effects of an extinction event

- Changes in populations are the result of replacement by Atlantic species after the Mediterranean's re-flooding, rather than rapid adaptation to the new hypersaline environment. In other words, life did not have enough time to adapt, and the extinct species were replaced by Atlantic species that migrated into the Mediterranean.

- The impact of the Mediterranean's isolation on its fauna and flora was catastrophic, destroying most of its ecosystems. Another significant finding from our research is that it took more than 1.7 million years for species numbers to recover.

Dinosaur fossils were created by three-toed theropod dinosaur; found 6000 miles apart



*** The early Cretaceous Borborema-Cameroon Dinosaur Dispersal Corridor

- Early Cretaceous (>120 Ma) dinosaur tracks occur on both sides of the Atlantic Ocean in sediments preserved in half grabens in Brazil, continued as the West and Central African Rift Zones in Nigeria and Cameroon.
- On both continents, the tracks are impressed on top of thin sandstone strata interbedded with silt and mud. The dinosaur tracks found in Brazil and Cameroon sediments were originally produced 1000 km apart on a single Gondwanan continent under similar paleoclimatic and sedimentological conditions in structurally similar basins formed by tectonic processes resulting in the formation of the South Atlantic Ocean. They now lie on opposite sides of that ocean some 3700 miles apart.

LOUIS L. JACOBS1, et al., 2024

Tracks 6000 miles apart

- They may be an ocean apart, but dinosaur footprints found in South America and Africa are so similar that their discovery suggests dinosaurs may have roamed a narrow corridor that connected the two continents before they split.

- Researchers found more than 260 footprints more than 3,700 miles apart in Brazil and Cameroon that were preserved in mud and silt where ancient rivers and lakes once stood.

L. Theropod footprint from Sousa Basin, Lower Cretaceous of Northeastern Brazil.
R. Theropod tracks from the Koum Basin in Cameroon.

Almost identical

- Study found matching sets of Early Cretaceous dinosaur footprints on what are now two different continents.

- More than 260 footprints were discovered in Brazil and in Cameroon, showing where land-dwelling dinosaurs were last able to freely cross between South America and Africa millions of years ago before the two continents split apart.

- “We determined that in terms of age, these footprints were similar,” Jacobs said. “In their geological and plate tectonic contexts, they were also similar. In terms of their shapes, they are almost identical.”

Footprints from 120 Ma

- The footprints, impressed into mud and silt along ancient rivers and lakes, were found more than 3,700 miles (or 6,000 kilometers), away from each other. Dinosaurs made the tracks 120 million years ago on a single supercontinent known as Gondwana– which broke off from the larger landmass of Pangea,
- One of the youngest and narrowest geological connections between Africa and South America was the elbow of northeastern Brazil nestled against what is now the coast of Cameroon along the Gulf of Guinea,". "The two continents were continuous along that narrow stretch, so that animals on either side of that connection could potentially move across it."

A long ornithopod trackway at Passagem das Pedra, Sousa Basin preserved in floodplain deposits of Lower Cretaceous

Continental drift

- Africa and South America started to split around 140 million years ago, causing gashes in Earth's crust called rifts to open up along pre-existing weaknesses.

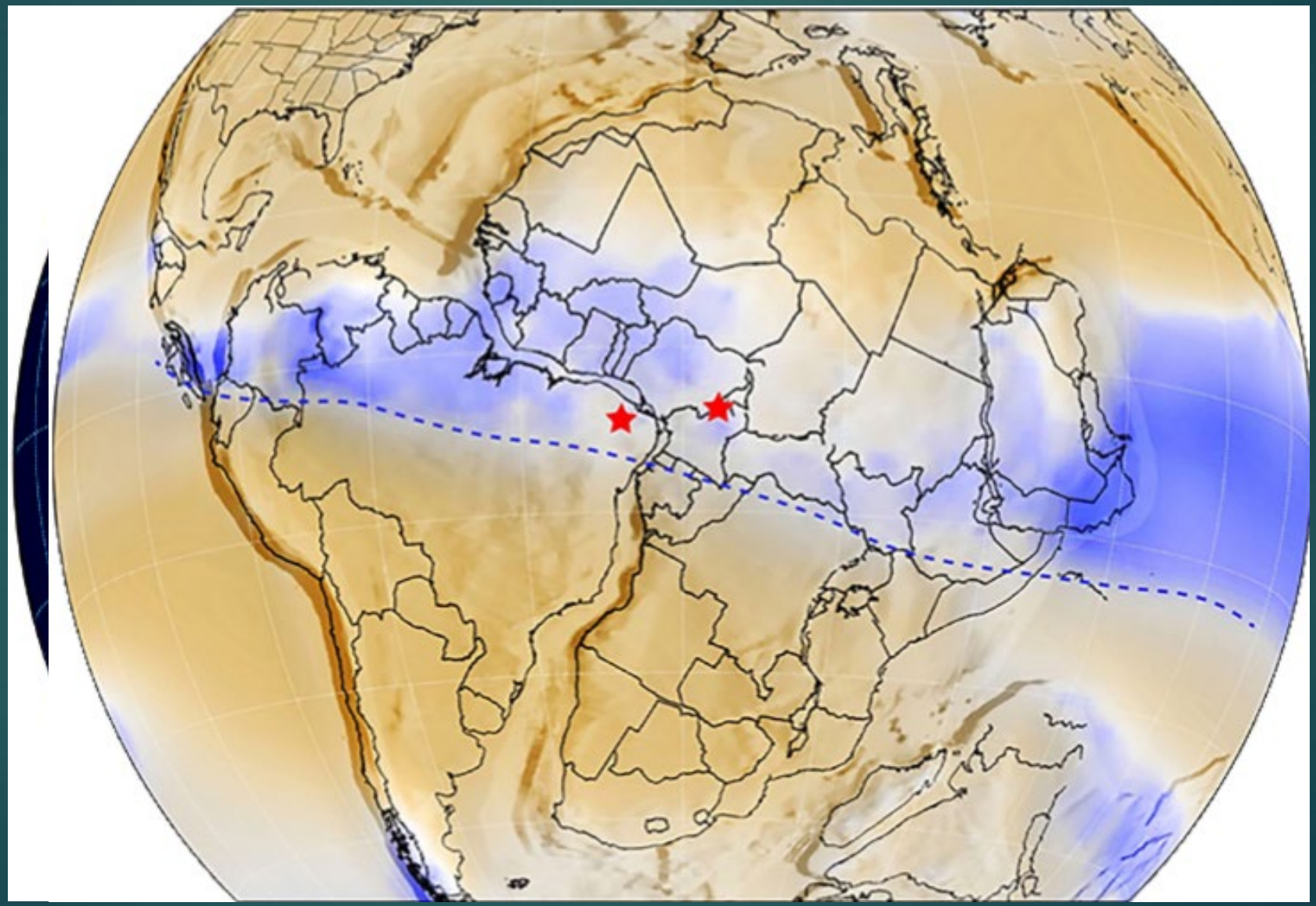
- As the tectonic plates beneath South America and Africa moved apart, magma from the Earth's mantle rose to the surface, creating new oceanic crust as the continents moved away from each other.

- And eventually, the South Atlantic Ocean filled the void between these two newly-shaped continents.

Rifting

- Half-graben basins -- geologic structures formed during rifting as the Earth's crust pulls apart and faults form -- are found in both areas and contain ancient river and lake sediments. Along with dinosaur tracks, these sediments contain fossil pollen that indicate an age of 120 million years.

Continental Drift separates SA from Africa



Similar Tracks on two continents

- According to the study, the Borborema Plateau in northeastern Brazil and the Koum Basin in northern Cameroon both contain similar geological structures that preserved dinosaur prints.

- The footprints discovered in those areas were similar in age, shape and geological context.

- The paper shows a “specific place at a specific time with specific climatic conditions and environmental conditions” that can help demonstrate how animals may have moved across the stretch of land between Cameroon and Brazil before Gondwana broke apart,

Matching geological structures: a corridor

Predominantly tridactyl theropod tracks

- Early Cretaceous dinosaur footprint occurrences in northeastern South America are quite similar to those in Cameroon, in their morphology and in their occurrence in the half-grabens of similar age developed on plutonic and metamorphic basement, filled with fluvial sediments.

- Predominantly tridactyl theropods, but with ornithopod and sauropod tracks as well

- "Corridor" = hypothesized path of dispersal defined more generally as the conjugate boundary of presumptive South America and Africa, which places minimal restriction to dispersal of terrestrial biota.

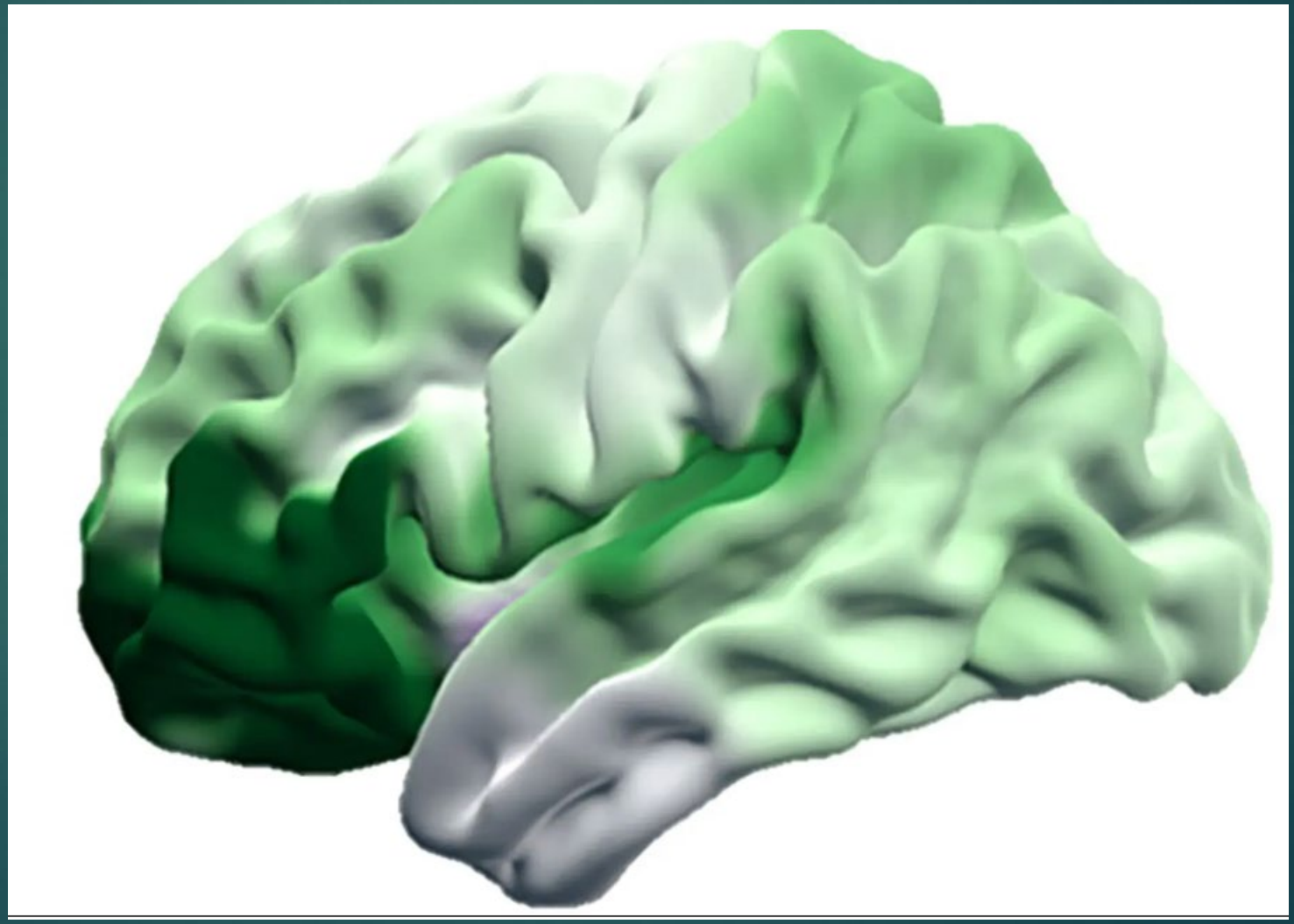
The Early Cretaceous Dinosaur Dispersal Corridor

- The Early Cretaceous Dinosaur Dispersal Corridor is essentially the last remnant of a larger South American-African corridor.

- Have tracked dinosaur footprints from the time they were impressed in mud along rivers and lakes over 120 million years ago, in localities originally contiguous and on a single landmass but some 600 miles apart.

- Today, these sites of fossil preservation are on two continents separated by 3700 miles and an ocean.

The darker green regions of the brain show the parts that have expanded the most during human evolution and shrink most during aging.



Most evolved brain areas are the fastest aging

- The regions that expanded the most in human evolution became exquisitely vulnerable to the ravages of old age.
- The human brain is three times as large as that of chimpanzees. But that doesn't mean all of our brain regions expanded at the same pace, like a map drawn on an inflating balloon. Some regions expanded only a little, while others grew a lot.
- Computer analysis of brain scans from 189 chimpanzees and 480 humans. Their program mapped each brain by recognizing clusters of neurons that formed distinct regions. Both species had 17 brain regions

Carl Zimmer, 2024

Larger areas

- In humans, they found the largest declines in the frontal cortex, including the prefrontal cortex, whereas chimps experienced the largest declines in the striatum, a central structure involved in habit-forming and reward behaviors.

- Visual processing and motor skills areas were less susceptible to ageing in both species.

- They found a number of regions that were roughly the same size in both species. But a few areas were much larger in people. One of them was the orbitofrontal cortex (prediction and decision making for emotional and reward-related behaviors)

Reason for correlation?

- Research has yet to show why recently expanded parts of the brain are so vulnerable to shrinking as we get older.

- One possibility, Dr. Vickery said, has to do with the fact that the fastest-expanding parts of our brain facilitate our most complex thinking. It's possible that the neurons that carry out this thought wear out quickly, causing the regions to shrink.

- What's more, the new study only found a modest link between expanded regions and rapid aging. "It's true for some of those regions, but we don't know if it is true for all of them," Dr. Gomez-Robles said.

The uniqueness of human vulnerability to brain aging in great ape evolution

- Aging is associated with progressive gray matter loss in the brain. This spatially specific, morphological change over the life span in humans is also found in chimpanzees, and the comparison between these great ape species provides a unique evolutionary perspective on human brain aging.

- Here, we present a data-driven, comparative framework to explore the relationship between gray matter atrophy with age and recent cerebral expansion in the phylogeny of chimpanzees and humans.

Sam Vickery, et al., 2024

Expansion related with aging

- In humans, we show a positive relationship between cerebral aging and cortical expansion, whereas no such relationship was found in chimpanzees.

- This human-specific association between strong aging effects and large relative cortical expansion is particularly present in higher-order cognitive regions of the ventral prefrontal cortex and supports the “last-in-first-out” hypothesis for brain maturation in recent evolutionary development of human faculties.

Aging

- With age, pronounced alterations occur in morphology and organization of the human brain with a distinct spatial pattern resulting in part from cellular atrophy in later life. This aging process may be further accelerated by age-mediated disorders such as Alzheimer's disease, Parkinson's disease, and other neurodegenerative conditions

- For humans, brain aging was compared with cortical expansion from chimpanzee to human, while for chimpanzees, aging was compared with expansion relative to both baboon and macaque.
- A strong positive correlation was found between cerebral expansion and age-mediated GM (grey matter) decline in humans. This relationship is particularly evident in the orbito-frontal cortex and insula, with considerable expansion and age-related GM decline, while low decline and expansion was found in the basal ganglia, occipital lobe, temporal pole, and medial temporal lobe.

Chimps and humans differed

- Found a human-specific positive relationship between age related GM decline and expansion in the human brain compared to chimpanzees. In chimpanzees, on the other hand, there was no such brain age association for cerebral expansion. This suggests that the extensive expansion of the PFC and other cortical association areas in recent human evolution since splitting from a common ancestor with chimpanzees comes at the price of increased age-related vulnerability.

VL, VM, Orbital Frontal

- Ventrolateral ventromedial, and orbital parts of the PFC, which shows the highest cross-species similarity as well greatest expansion in humans relative to chimpanzees. In previous studies, the PFC has been reported to be proportionally larger in humans compared to chimpanzees; this region showed an exceptionally large age-related GM decline in humans alongside the high degree of expansion.
- This suggests that the greater expansion of PFC, which has been instrumental in evolutionary development in primate cognition, comes with the detriment of severe age-related GM decrease in humans, where the PFC plays an important role in higher-order cognitive functions, such as executive control, working memory, and language..

Last-in-first-out

- The much greater ventral PFC expansion and age-mediated GM decline in humans compared to chimpanzees may be interpreted as additional dimension of the last-in-first-out hypothesis in the developmental maturation to aging trajectory.

- The relationship between human GM volume decline and cortical expansion indicates a link between the evolutionary development of specific cortical areas in humans and increased vulnerability to neurodegenerative processes. Such a relationship was not present in the expanded cortical regions of chimpanzee.

Multimodal association areas

- The main difference between humans and chimpanzees seems to be the more prominent expansion in sensorimotor regions in chimpanzees relative to the cercopithecoid monkeys, whereas regions of human cortical expansion is generally observed in more multimodal association regions.
- Human multimodal cortical areas are characterized by lower neuronal cell density, as well as higher dendritic branching and spine numbers of pyramidal neurons

Multimodal regions are vulnerable to faster aging

- The medial and orbito-frontal cortex and the insula that displayed large expansion and age-mediated GM decline have been previously found to have high deterioration of glucose metabolism and large accumulation uptake of β amyloid in human

- Aging regions with high cerebral expansion in humans relative to chimpanzees showed extensive GM decline.

- These findings suggest that recent evolutionary changes in human brain organization involving differential expansion of multimodal association regions may increase these regions' unique vulnerability to age-related neurodegenerative processes, in particular the ventral PFC.

*** Reconstructing the Neanderthal brain using computational anatomy – T. Kochiyama, et al., 2024

- *** The present study presents a detailed virtual reconstruction of the brains of NT and early Homo sapiens (EH) using computational anatomy, in order to infer possible morphological differences in the brain between the two species.

- *** We found that early Homo sapiens had relatively larger cerebellar hemispheres but a smaller occipital region in the cerebrum than Neanderthals long before the time that Neanderthals disappeared.

Takanori Kochiyama, et al., 2024

Cerebellum size has cognitive consequences

- Further, using behavioral and structural imaging data of living humans, the abilities such as cognitive flexibility, attention, the language processing, episodic and working memory capacity were positively correlated with size-adjusted cerebellar volume.

- As the cerebellar hemispheres are structured as a large array of uniform neural modules, a larger cerebellum may possess a larger capacity for cognitive information processing.

- Such a neuroanatomical difference in the cerebellum may have caused important differences in cognitive and social abilities between the two species and might have contributed to the replacement of Neanderthals by early Homo sapiens.

**** Study based on only 4 N skulls

- MH = population-averaged modern human brain or from one representative modern human brain
- Computed tomography (CT) scan data of:
  - four adult Neanderthals [Amud 1 (~50,000–70,000 years old), La Chapelle-aux-Saints 1 (~47,000–56,000 years old), La Ferrassie 1 (~43,000–45,000 years old) and Forbes' Quarry 1
  - four EH [Qafzeh 9 (~90,000–120,000 years old), Skhul 5, (~100,000–135,000 years old), Mladeč 1 (~35,000 years old) and Cro-Magnon 1 (about 32,000 years old)] were obtained.
- The cerebral and cerebellar volumes of the reconstructed NT and EH brains were 1304 and 182 cc for Amud 1; 1159 and 140 cc for La Chapelle-aux-Saints 1; 1268 and 166 cc for La Ferrassie 1; 912 and 106 cc for Forbes' Quarry 1; 1075 and 147 cc for Qafzeh 9; 1053 and 146 cc for Skhul 5; 1205 and 165 cc for Mladeč 1; and 1208 and 156 for Cro-Magnon 1, respectively.

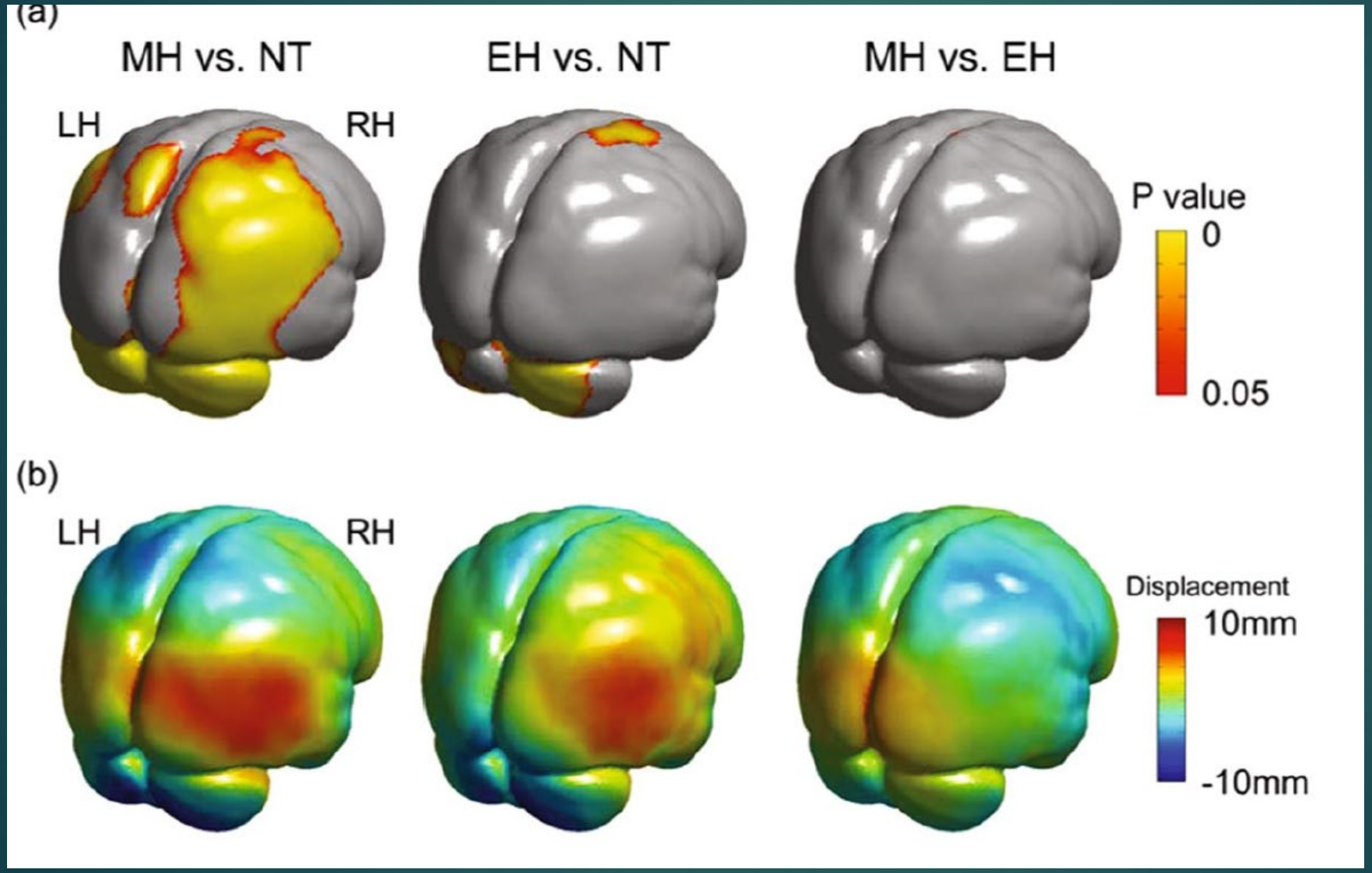
N had smaller cerebellums

- The mean (±sd) cerebral and cerebellar volumes of NT, EH and MH were 1161 ± 177 cc and 149 ± 33 cc, 1135 ± 83 cc and 153 ± 9 cc, and 1097 ± 115 cc and 149 ± 15 cc, respectively.

- *** No statistically significant between-group difference was detected in the total brain volume. However, the mean ratios of cerebellum to cerebrum in NT, EH and MH were 0.127 ± 0.010, 0.135 ± 0.004 and 0.136 ± 0.005, respectively.

- NT had significantly smaller relative cerebellar volume than EH and MH.

Comparisons of the brain surface morphology among Neanderthal, early Homo sapiens and modern Homo sapiens.



Surface areas where the differences are statistically significant

Significant differences

- There were significant morphological differences in the cerebellar, parietal, occipital and medial temporal regions, but no differences in the frontal regions between NT and MH.
- Between NT and EH, there were significant differences in the cerebellar and part of the right medial temporal and right somato-motor regions.
- Virtually no difference was observed between MH and EH, except for small part of the right somato-motor region.

MH had larger cerebellum at 100 Ka

- The largest morphological difference between NT and the EH-MH lineage was observed in the cerebellar hemisphere, which was significantly more inferiorly projected in EH and MH than in NT.

- The size-adjusted volume differences among the three groups were found in the superior and inferior region of parietal lobe, occipital regions, and cerebellum.

- This study clearly indicated that the cerebellum started to enlarge in the EH-MH lineage far before the time when NT disappeared because the relative cerebellar volume was much larger than NT not only in Mladeč 1 and Cro-Magnon 1, but also in Qafzeh 9 and Skhul 5.

Cerebellum in cognitive functioning

- There is now strong evidence that the cerebellar hemispheres are important for both motor-related function and higher cognition including language, working memory, social abilities and even thought.

- Further, whole cerebellar size is correlated with cognitive abilities, especially in the verbal and working memory domain.

Cognitive functions of Cerebellum

- Multiple regression analyses revealed that attention and inhibition task score was most strongly correlated with size-adjusted whole cerebellar volumes, followed by cognitive flexibility task score.

- There was also a significant correlation with speech comprehension speech production, working memory, episodic memory task scores, but not with processing speed task score.

Cerebellum and executive functions

- Note that the functions such as attention, inhibition, cognitive flexibility, working memory, are thought to be main components of executive functions.

- *** These results indicate that the cerebellar hemispheres are involved in the abilities of executive functions, language processing, and episodic memory function.

N = smaller right cerebellum

- Thus, Homo sapiens with relatively larger cerebellar hemispheres may possess higher cognitive and social functions.

- *** Found that the right side of anterior and posterior cerebellum was significantly smaller than that of the left in NT.

- Found that the relative volume of the right cerebellar hemisphere was significantly smaller in NT compared with that in EH

Smaller right side of N cerebellum: language difference

- *** Our finding of laterality in terms of the relatively small right cerebellar hemisphere of NT indicates minimal connection to the left prefrontal regions, which has one of the major role in language processing, potentially causing disparity of language ability between NT and Homo sapiens.

- ***** However, the preservation in the cerebellar region of the fossils is certainly not perfect and there might be asymmetry related to taphonomy in addition to the innate morphological asymmetry in the region.

- *** Therefore, morphological laterality of the Neanderthal cerebellum needs to be confirmed in future studies with a large number of cases.

Larger Parietal in MHs

- *** In the present study, the MHs had relatively larger parietal regions than the NT with significant difference, particularly in the superior medial and lateral areas.
- *** However, there were no differences in the relative size of the parietal region between NT and EH.

- In addition, the parietal regions have strong connections to the cerebellar hemispheres and the frontal cortex. These findings indicate that enlargement of this region in MH may have improved cognitive function in harmony with the cerebellar hemispheres and the frontal region.

Ns had larger Occipital regions

- *** Pearce et al. estimated that NT had larger visual cortices than EH based on the orbit size of fossil crania.
- *** In support, the occipital region was significantly larger in NT than in EH in the present study.
- There are also reported differences in the basicranial morphology between NT and EH, with NT having a relatively narrower orbitofrontal cortex, smaller olfactory bulbs and less increased and forward-projecting temporal lobe poles.

Conclusion

- *** In conclusion, we found that NT had significantly relatively smaller cerebellar hemispheres than Homo sapiens, particularly on the right side. Larger cerebellar hemispheres were related to higher cognitive and social functions including executive functions, language processing and episodic and working memory capacity.

- Based on archaeological records, Wynn and Coolidge suggested that NT had a smaller capacity of working memory, which is also related to the capacity for cognitive fluidity (from language processing) proposed by Mithen.
- Thus, the differences in neuroanatomical organization of the cerebellum may have resulted in a critical difference in cognitive and social ability between the two species.

Cognitive effects of size differences??

- Consequently, ability to adapt to changing environment by creating innovation may have been limited in NT and this difference possibly affected their chance of survival and drove the replacement process.

- CJV:
  - a) Data on size differences but no data on internal brain reorganization (& neuronal networks or connectomes)
  - b) note modern brain size differences (900 to 2000 ccs), with no significant cognitive differences
  - c) the difference may be an artifact of their Neandertal sample, which includes the very small Gibraltar Forbes female. The three male Neandertals do not appear to differ markedly from the moderns.

*** When European horses arrived on the American plains, they were coming home again.

- For 1000s of years before arrival of the Spanish in America in the 1500s, there were no horses.
- It was long theorized that Plains horses were descendants of horses set free during the Pueblo Indian Revolt of 1680. Fifty Puebloan groups in New Mexico expelled 2000+ Spaniards.
- In 2023 William Taylor's group analyzed 30 sets of horse remains: all the horses came from populations native to Europe & Asia and most came from Spanish bloodlines. Not related to Icelandic or Scandinavian horses (not from Norse voyages circa 1000), nor had any ancestral horses survived the Holocene extinction. Dispersal of Plains horses began in mid-1500s, a century before the Pueblo revolt.

Equus

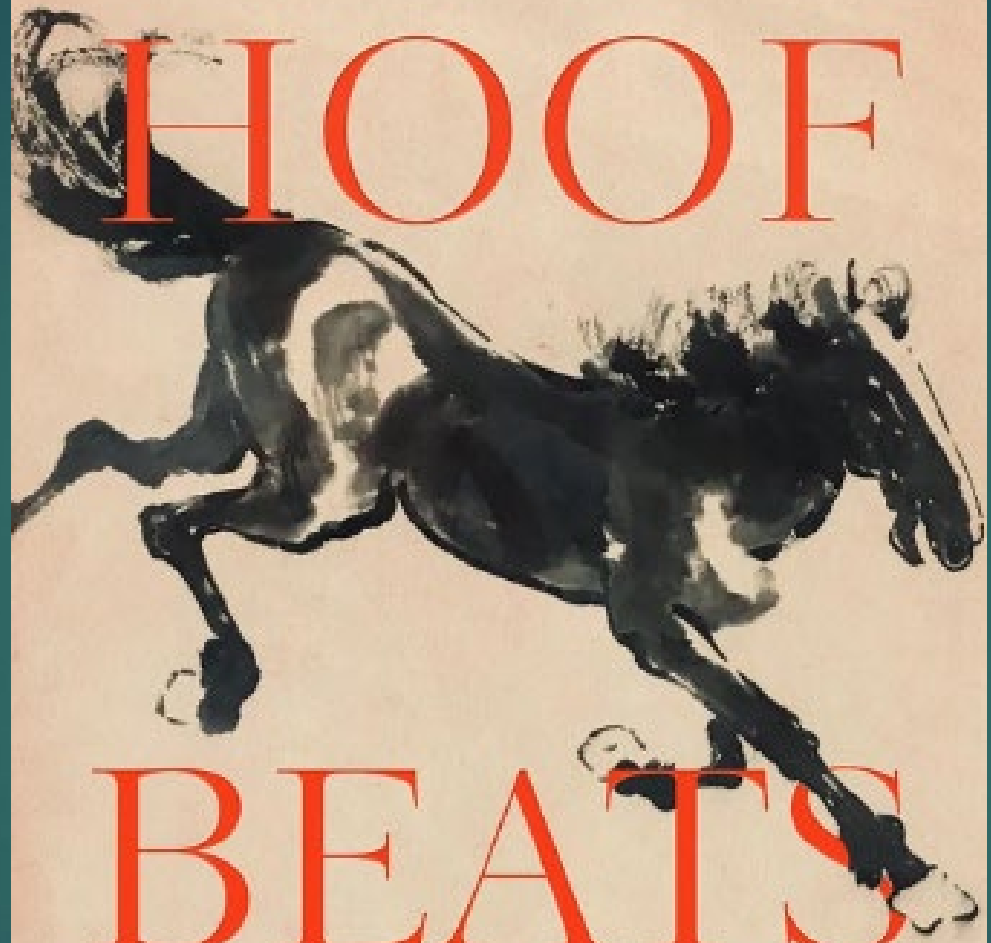
- The horses that came into the Plains were traded among indigenous groups; they did not become feral and then were re-domesticated. First horses in indigenous sites had skeletal attributes of horses that had been bridled and ridden.

- The genus *Equus* (all horses, asses, zebras) originated and evolved in the North American Great Plains around 3.5 Ma. They migrated into Asia, Siberia, and Europe when ice sheets allowed them. They were already here when the first Native Americans arrived circa 20 Ka. These arrivals hunted them to extinction in the great megafauna extinction.

- Europeans arrived 500 years ago with their domesticated horses, who then repopulated their ancestral home.

WILLIAM T. TAYLOR

HOOF BEATS



How Horses Shaped Human History

The Origins of Horse Domestication

- Throughout the annals of human history, no animal has had a more profound impact on the development of human societies than the horse. The story of how, when, and where horses were first domesticated has long been a topic of intense scientific inquiry
- New Book: "*Hoof Beats – How Horses Shaped Human History*“ by William T. Taylor: how horses played a pivotal role in the origins of globalization, trade, and social structures.
- Over half a million years ago, early human ancestors hunted horses with rudimentary wooden spears, using their bones for tools. By the late Paleolithic era, some 30,000 years ago, wild horses had become a common subject of ancient art, dominating the walls of Eurasian caves.

Kambiz Kamrani, 2024

Horses

- Following their domestication, horses became integral to the pastoral societies of Inner Asia's grasslands, transforming modes of travel, communication, agriculture, and warfare. The technological advancements of the chariot, saddle, and stirrup enabled horses to become the primary means of locomotion across much of the ancient world.

- The horse's impact was so significant that it persisted until the advent of industrial mechanization, which eventually supplanted their universal role in society.

Kurgen theory

- Among these, the most widely accepted has been the Indo-European or "Kurgan" hypothesis. This theory posits that around the fourth millennium B.C., the Yamnaya people of the western Asian steppes and the Black Sea region began riding horses, which in turn facilitated massive migrations and the spread of Indo-European languages and cultures across Eurasia.

- Over the past two decades, evidence appeared to converge on the notion that horses were first domesticated by the Botai culture in northern Kazakhstan around 3500 B.C. Archaeological finds, such as large quantities of horse bones, possible corral structures, and ceramic fragments containing horse milk residues, seemed to support this idea. Most compellingly, the teeth and jawbones of Botai horses showed signs of wear that suggested the use of a bridle, indicating that these animals might have been ridden.

Botai

- This evidence led many to believe that horse domestication began in the Botai culture, geographically close enough to the Yamnaya homeland to keep the Kurgan hypothesis largely intact. However, certain aspects of the Botai story did not align with what is known about the domestication of other animals.
- Despite the strong case for Botai as the origin of horse domestication, there were unresolved inconsistencies.
- Notably, the demographic profile of Botai horse remains—an even mix of males and females of reproductive age—was unusual for a domesticated herd. Killing healthy, breeding-age animals would have devastated any breeding program, yet this demographic is common among hunted animals. Some Botai horses also had projectile points embedded in their ribs, further suggesting they were hunted rather than domesticated.

Botai did not domesticate horses

- In 2018, nuclear genomic sequencing revealed that Botai horses were not the ancestors of modern domestic horses but were instead closely related to Przewalski's horses—a wild species native to the steppes, never domesticated in recorded history.

- Moreover, when researchers reexamined the skeletal features of Botai horses that had been linked to riding, they found similar traits in wild Ice Age horses from North America, which had never been ridden. This discovery suggested that the wear patterns observed on Botai horse teeth could be attributed to natural variation rather than evidence of domestication.

- Was horse transport even practiced at Botai? The evidence increasingly pointed away from the Botai culture as the birthplace of horse domestication.

Leaving the Kurgan Hypothesis Behind

- As the archaeological record becomes more complex, the Kurgan hypothesis is losing its dominance as the leading explanation for horse domestication. For instance, recent studies have shown that skeletal problems associated with mounted riding found in Yamnaya and early Eastern European burials could also result from other forms of animal transport, such as cattle carts, which were prevalent in Yamnaya-era sites.
- A clearer understanding of horse domestication may be emerging. A comprehensive genomic study of early Eurasian horses, published in 2024, indicates that Yamnaya horses were not the ancestors of the first truly domestic horses, known as the DOM2 lineage. Furthermore, Yamnaya horses showed no genetic signs of selective breeding, a key indicator of domestication.

First Domesticated horses ~2200 BC

- Instead, the first DOM2 horses appear just before 2200 B.C., long after the Yamnaya migrations and just before the widespread use of horses and chariots across Eurasia. This timeline suggests that horse domestication likely occurred in the Black Sea steppes but much later than the Kurgan hypothesis suggests. The explosive spread of horses and chariots across Eurasia in the early second millennium B.C. aligns more closely with the emergence of the DOM2 lineage.

- The latest research continues to challenge and refine our understanding of horse domestication. Some studies point to intriguing patterns in the Botai data, such as fluctuations in genetic estimates for generation time. These could imply that the Botai people may have raised Przewalski's horses in captivity for meat, without domesticating them for transport.

Widespread horse-based mobility arose around 2200 BCE in Eurasia

- An analysis of ancient genomes reveals an explosive geographical and demographic spread of modern domestic horses about 4,200 years ago. The findings counter the idea that horses accompanied and mobilized the mass migration of humans from the Eurasian steppes about 5,000 years ago.
- Here we assemble a collection of 475 ancient horse genomes to assess the period when these animals were first reshaped by human agency in Eurasia.
- We find that reproductive control of the modern domestic lineage emerged around 2200 BCE, through close-kin mating and shortened generation times.

Pablo Librado, et al. 2024

Horse domestication

- Reproductive control emerged following a severe domestication bottleneck starting no earlier than approximately 2700 BCE, and coincided with a sudden expansion across Eurasia that ultimately resulted in the replacement of nearly every local horse lineage..
- This expansion marked the rise of widespread horse-based mobility in human history, which refutes the commonly held narrative of large horse herds accompanying the massive migration of steppe peoples across Europe around 3000 BCE and earlier.

- Finally, we detect significantly shortened generation times at Botai around 3500 BCE, a settlement from central Asia associated with corrals and a subsistence economy centered on horses. This supports local horse husbandry before the rise of modern domestic bloodlines

Modern domestic horses (DOM2)

- This chronology implies that the spread of steppe-related ancestry that reshaped the human genetic landscape of nearly all regions of central and western Europe over the course of the third millennium BCE was not driven by DOM2 horseback riding.
- However, recent population models have claimed significant DOM2 genetic ancestry into European horses affiliated with the Corded Ware complex (CWC), a culture that developed from roughly 3000 BCE against the backdrop of the Yamnaya steppe migration. Bone pathologies potentially resulting from regular horseback riding also occur in about 5% of the human skeletons from the Carpathian Basin, mainly in steppe-related8 Yamnaya individuals, but also in pre-Yamnaya people, up to the fifth millennium BCE.

Horses

- Moreover, horse-related terminology commonly shared across Indo-European languages is often considered indicative of established equestrianism in the steppes, among Yamnaya-related proto-Indo-European speakers. These findings have revived theories associating horseback riding with the Yamnaya expansion, and possibly with earlier human steppe migrations into the Carpathian Basin after about 4500 BCE.
- It shows that the horse genomic make-up remained entirely local in central Europe and in the Carpathian and Transylvanian Basins until the end of the third millennium BCE.

Domestication before the Steppe migrations

- This timeline post-dates the period of steppe contact in the Carpathian and Transylvanian Basins starting around 4500 BCE, as well as the migrations potentially spreading proto-Indo-European languages into Europe with the Yamnaya phenomenon about 3000 BCE.
- The pronounced spread of DOM2 horses immediately followed the foundation of this new bloodline, and marked a new era of widespread horse-based mobility from about 2200 BCE, ushering in a monumental increase in connectivity and trade.
- It mirrors the archaeological record, which witnesses a massive spread of horses in the Near East and Asia during the transition between the third and second millennia (the 4.2 ka aridification event)

Equestrianism?

- Domestic horses and spoke-wheeled chariots may also have aided the conquest and defense of larger geographic areas in the face of uprising violence and social conflicts.
- Our work does not reject the possibility of equestrianism developing in the Pontic steppe or the Carpathian Basin before 2200 BCE.

- However, in such a scenario, the associated breeding practices would not have involved close-kin mating or accelerated generation times. The phenomenon would also have remained confined in scale, both demographically and geographically, excluding long-distance fast mobility as the primary domestication incentive..

Botai

- Our research strengthens the case for recognizing Botai as one such location in the central Asian steppe where horse husbandry developed before large-scale horse-based mobility.

- There, the domestication process did not aim at global production, but remained regional. It is aligned with the expectations of the prey pathway, in which a settled group of humans developed husbandry through corralling and reproductive control, in the form of shortened generation times, but not close-kin mating, to ensure access to an otherwise depleting meat resource

Creating new bloodlines

- Manipulating the animal life cycle by forcing earlier reproduction offers breeders enhanced productivity, especially for species with long gestational periods and/or small litter sizes.

- Our research demonstrates that this practice was integral to the array of breeding techniques developed to sustain the massive global demand for horses from the Early Bronze Age. The pressure for accelerated production relaxed quickly after around 1000 BCE, as a large enough horse breeding pool became available across extensive geographic areas.

Creating new bloodlines

- However, the development of modern breeds required the fast production of specific bloodlines from limited foundational stocks, which again shortened the horse generation time over the past few centuries. Apparently, this process affected Asian breeds more than racehorses, especially thoroughbreds, for which artificial insemination is forbidden. These findings align with stud book pedigrees recording increasingly faster generation times during the past three centuries, especially in cold blood horses.

Ancient Art Meets Modern Technology: The Nazca Glyphs – 303 new glyphs: a new theory: the glyphs were likely part of religious rituals and pilgrimages tied to the ceremonial center of Cahuachi.

hern Peru, in a 400 square mile area, the ng puzzled archaeologists. Etched into the arid plateau, these massive geoglyphs—visible only from the sky—are composed of intricate designs and symbols that span kilometers. Since their discovery in the 1940s, researchers have sought to decode their purpose and origins, with little concrete evidence as to why the ancient Nazca people created them.

- For decades, only 430 of these geoglyphs had been cataloged, leaving many questions unanswered. But a recent breakthrough[1] has uncovered 303 more glyphs in just six months—nearly doubling the known count.
- Of the 303 newly discovered glyphs, 178 were suggested by AI, highlighting the power of this tool to enhance human-led archaeological effort with drones

New theory

- The recent discoveries indicate that the geoglyphs were part of a sacred landscape, designed to be seen along specific paths, possibly during ritual pilgrimages to Cahuachi.

- This ceremonial center, perched on high mounds and overlooking many of the glyphs, served as a religious hub for the Nazca culture between 500 BCE and 500 CE. The placement of the geoglyphs along pathways leading to Cahuachi further supports this interpretation.

Orcas with knives!!

Orcas with knives. (Sakai et al., *PNAS*, 2024)

Glyphs meant to be seen along trails

- The newly identified glyphs, like those previously cataloged, belong to two distinct categories: relief-type and line-type.
- Relief-type geoglyphs, which make up the majority of the new findings, are smaller and more difficult to detect due to their subtle, carved outlines. These glyphs predominantly depict humans and domesticated animals, suggesting a connection to daily life and social activities. These geoglyphs were meant to be seen while walking along trails:
- In contrast, line-type geoglyphs are larger and more abstract, often representing wild animals. These designs are concentrated around starting and ending points of a network of linear geoglyphs, which connect sacred spaces like Cahuachi.

Punching Octopuses Lead Fish on Hunting Parties

- Octopuses and fish are routinely seen working together on the ocean floor, and now scientists say that the cephalopods are the leaders of the pack
- Study found that octopuses in mixed hunting groups would occasionally wind up one arm and wallop a fish. It wasn't clear which fish were the most punch-worthy, or whether the fish and the octopuses were really working together. Fish might have been simply taking advantage of a cephalopod by following behind while it flushed out prey.
- As a hunting pack traveled, the various types of fish fanned out around the octopus, essentially providing options for where the group might go next. From these options, the octopus would choose a direction.
- The octopus was the one stopping them from moving

Multidimensional social influence drives leadership and composition-dependent success in octopus–fish hunting groups

- The octopus's hunting was more efficient when it was traveling with fish partners: It checked out fewer crevices, but spent more time at each one, suggesting it was finding prey to slurp up. The most helpful partners were a species called blue goatfish.

- Some fish are good partners, but when others try to exploit the hunting party, then the octopus starts punching,

Leader of the pack

End Monday CAS

*** Schöningen, Germany, open-cast coal mine: spear site – 50 slides

The wooden artifacts from Schöningen's Spear Horizon and their place in human evolution -- *Leder, D. et al. (2024)*.

- In 1994, the Schöningen open-cast coal mine yielded an astonishing archaeological treasure: remarkably well-preserved wooden hunting weapons dating back 300,000 years.

- Spearheads and throwing sticks, discovered alongside animal bones, offered a glimpse into the sophisticated craftsmanship of early humans. Now, a collaborative effort led by researchers from the Universities of Göttingen and Reading, has unveiled groundbreaking insights into the woodworking techniques employed by our ancient ancestors.

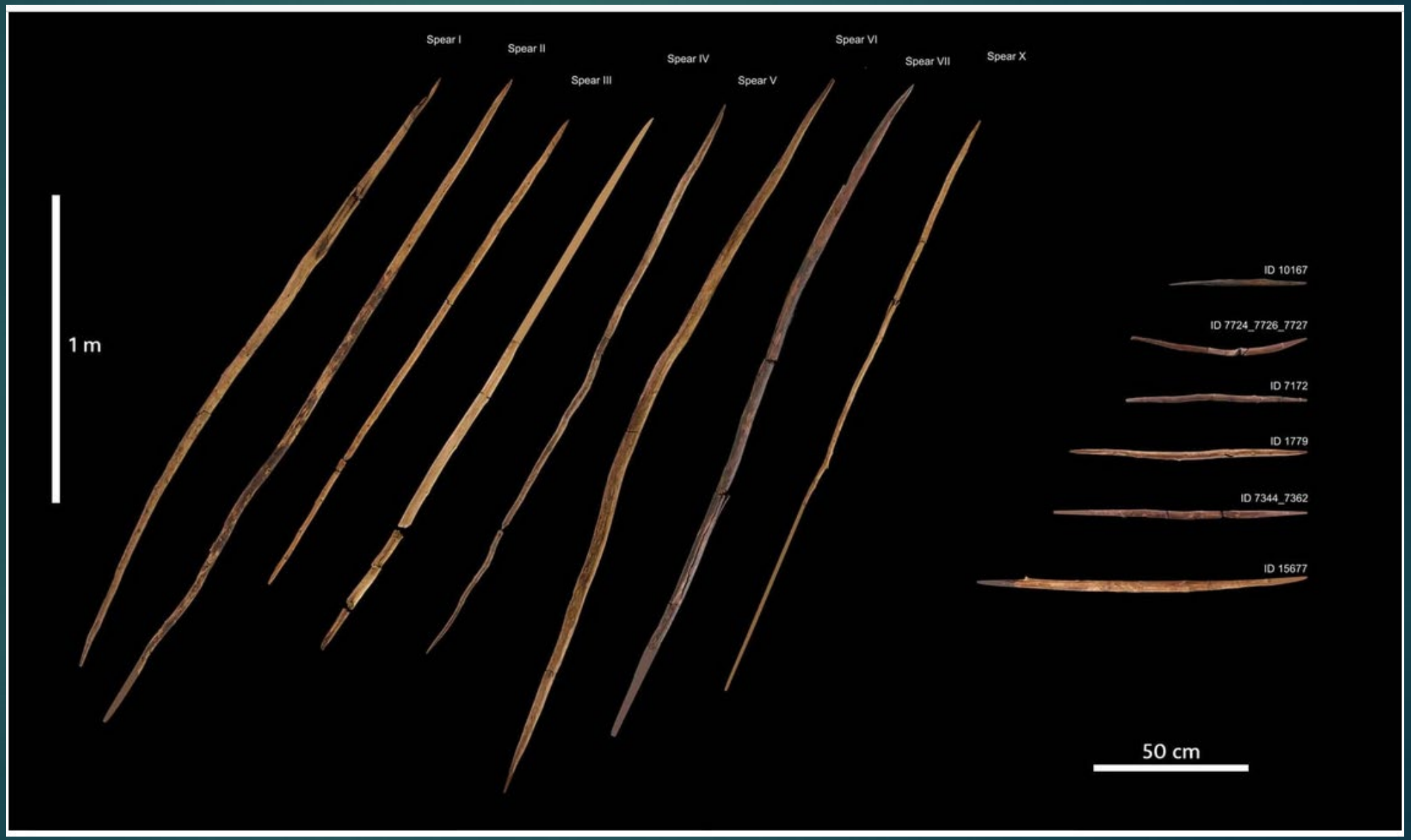
Leder, D. et al. (2024).

Woodworking

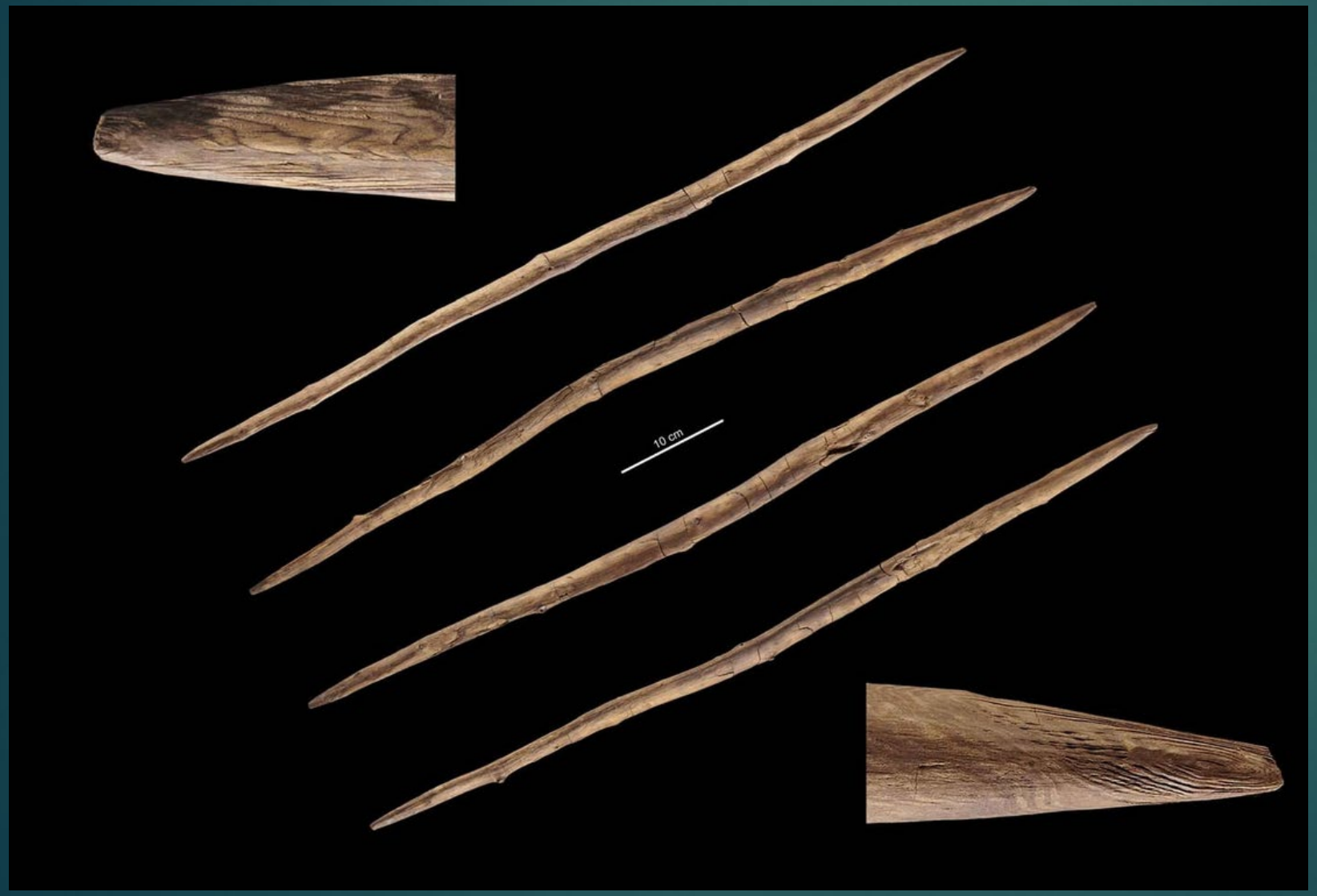
- State-of-the-art imaging techniques, including 3D microscopy and micro-CT scanners, have revealed a wealth of information about the handling and processing of wood at Schöningen.

- For the first time, researchers have documented innovative methods such as the "splitting technique," wherein small pieces of split wood were sharpened for various purposes, including the processing of hunted animals.

Eight spears and six double-pointed throwing sticks from Schöningen, Germany.

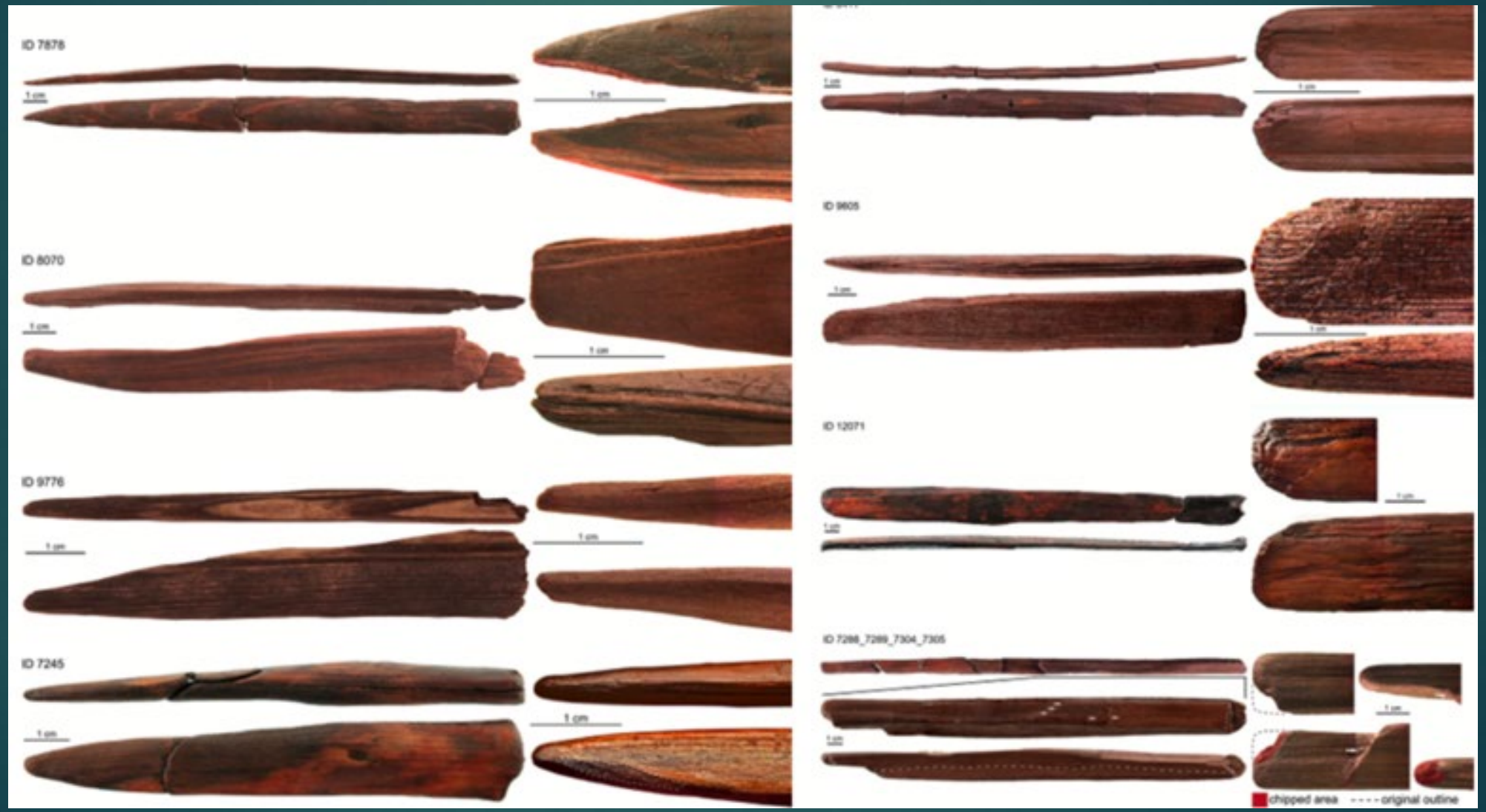


A double-pointed throwing stick from Schöningen, Germany, with detail views of the two sharpened points.



Hunters in some historic foraging societies used similar sticks to throw at game animals, boomerang-like, sometimes stunning or injuring the animals and other times tripping up their escape.

Examples of pointed and round-tipped cleft woods



Woodworking

- The meticulous examination of wooden artifacts has uncovered a sophisticated understanding of woodworking among early humans. Detailed analysis of spruce and pine wood has revealed the shaping of logs into spears and throwing sticks, as well as the repair and recycling of broken tools on-site.

- The discoveries at Schöningen underscore the paramount importance of wood in early human evolution

Schöningen: More than 50 wood supplies worked 300 Ka ago

- It is certain that wooden tools played a fundamental role in the daily life of the hunter-gatherers of the Pleistocene, both in hunting activities (launched spears, digging sticks), harvesting (bark peelers) and domestic (containers).

- However, the conservation of wood needs extraordinary freezing conditions, very arid climate, or a saturated water site where there is no oxygen or, therefore, microorganisms that degrade it.

Oldest wooden hunting tools

- The site of Schöningen 13 II-4 (known as Spear Horizon), in the center-north of Germany, has an imposing value.

- Examined the oldest complete hunting weapons known to humankind. The weapons, believed to be 300,000 years old, were found during archaeological excavations in Schöningen, Germany in 1994.

Schöningen, Germany in 1994.

- Identified how pre-Homo sapiens hunters re-sharpened broken points of spears and throwing sticks.
- Other tools were made by splitting wood, a behavior previously thought only to be practiced by our own species, Homo sapiens.
- Some tools made from split wood were likely used not for hunting, but to soften and smooth animal skins.
- Selected round woods were worked into spears and throwing sticks and brought to the site, while broken tools were repaired and recycled on-site.

Woodworking

- At least 20 spears and throwing sticks were among the weapons found at Schöningen three decades ago.
- The findings suggested a hunting ground on the lakeshore.
- The Schöningen finds bear witness to extensive experience in woodworking, technical know-how and sophisticated work processes.

The wooden artifacts from Schöningen' s Spear Horizon and their place in human evolution - *Leder, D. et al. (2024)*.

- However, wood rarely survives in the archeological record, especially in Pleistocene contexts and knowledge of prehistoric hunter-gatherer lifeways is strongly biased by the survivorship of more resilient materials such as lithics and bones.

- The recovery of complete wooden spears and throwing sticks at this 300,000-y-old site led to a paradigm shift in the hunter vs. scavenger debate.

Schöningen: proof of hunting

- Until the 1960s, stone tools associated with large mammal remains were routinely explained as only indicating the butchery of animals that had been hunted. By the early 1980s, there were few claims for big-game hunting. Scavenging by both carnivores and hominids seemed a more reasonable inference, and some even suggested that big-game hunting did not occur until the appearance of fully modern humans in the UP, about 40,000 years ago.

- To fit this picture, the Clacton and Lehringen spears were downgraded to digging-sticks. The 1985 discovery at Schoningen proved hunters at 300 ka were using spears and hunting big game.

187 wooden artifacts from Schöningen

- For the first time and almost 30 y after their discovery, this study introduces the complete wooden assemblage from Schöningen known as the Spear Horizon. In total, 187 wooden artifacts could be identified from the Spear Horizon demonstrating a broad spectrum of wood-working techniques, including the splitting technique

- A minimum of 20 hunting weapons is now recognized and two newly identified artifact types comprise 35 tools made on split woods, which were likely used in domestic activities.

- Schöningen 13 II-4 represents the largest Pleistocene wooden artifact assemblage worldwide and demonstrates the key role woodworking had in human evolution.

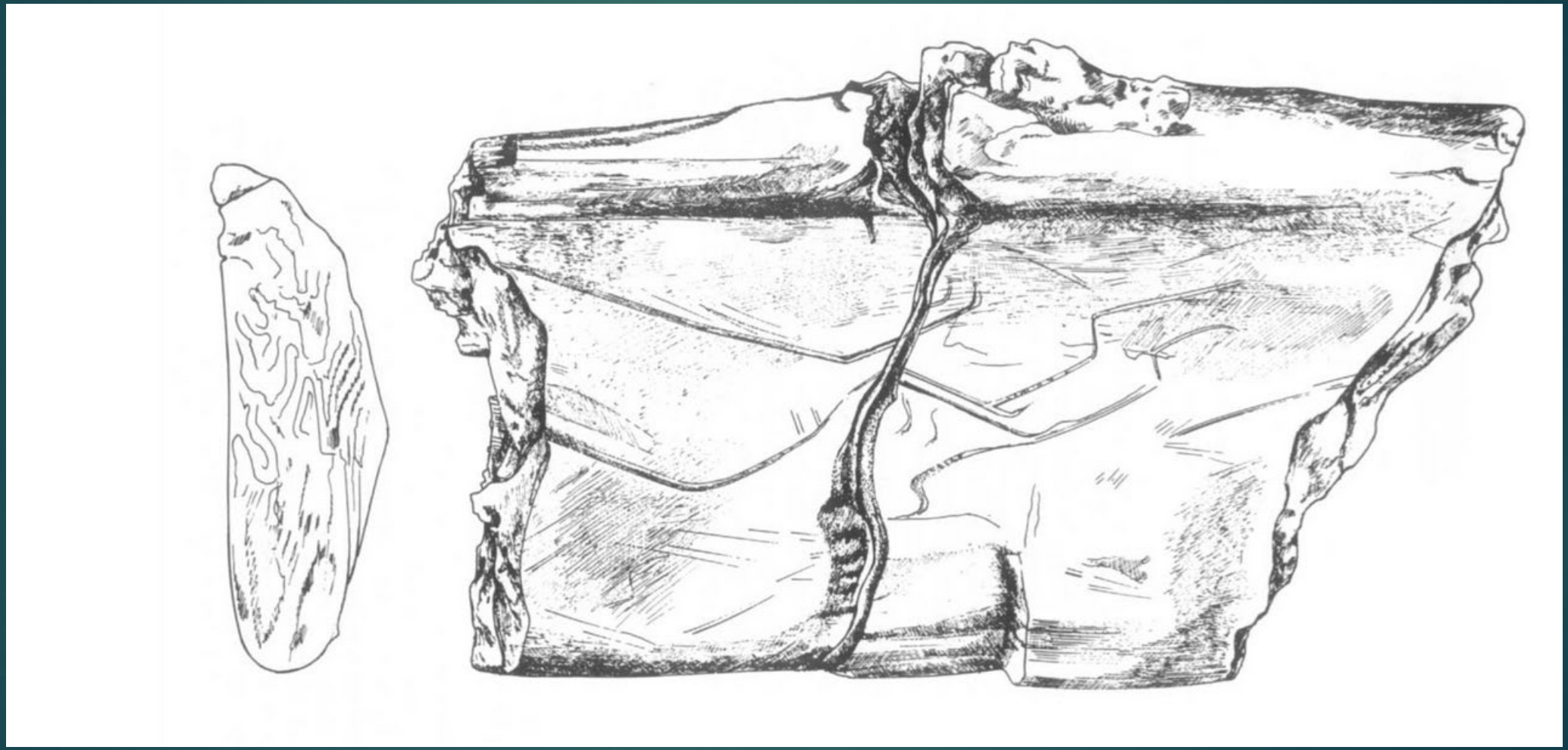
Wooden tools

- Wooden tools include at least 10 spears and seven throwing sticks used in hunting next to 35 newly recognized pointed and rounded split woods likely used in domestic activities

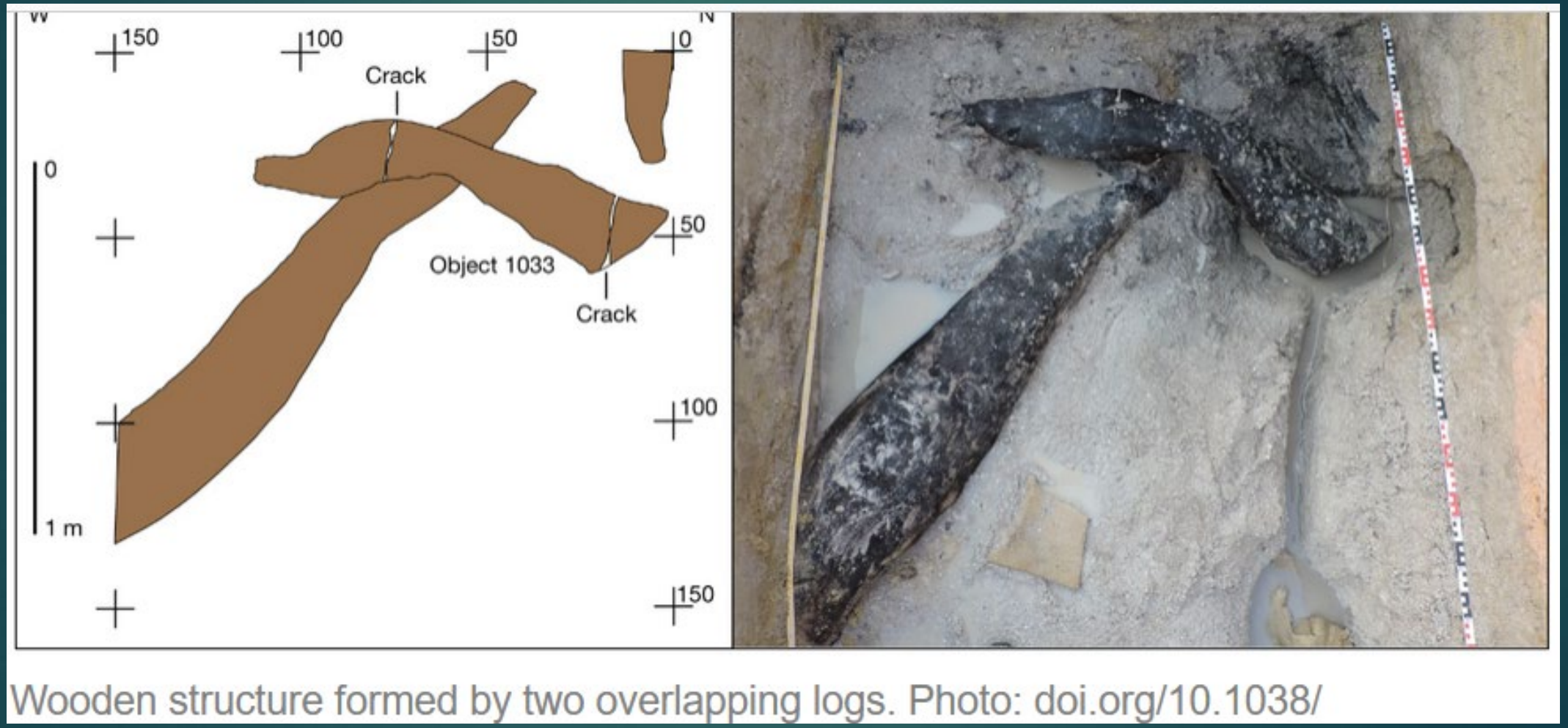
- The earliest indirect evidence for human woodworking dates back 2 to 1.5 Ma ago based on use-wear on lithics.

- The earliest known wood artefact with intentional shaping: a fragment of polished plank from the Acheulean site of Gesher Benot Ya'aqov, Israel, more than 780 ka

Worked wooden plank from Gesher Benot Ya'aqov, Israel.
Oldest modified wooden artifact in the archaeological record.



Zambia, pre-sapiens: two interlocking logs joined by a notch. 476 Ka



Wooden structure formed by two overlapping logs. Photo: doi.org/10.1038/

Schöningen

- The earliest wooden spears in Europe are 400 to 120 ka old, with an outstanding assemblage from Schöningen.
- The earliest throwing sticks are known from Schöningen, with later possible examples from Africa.
- The oldest arrows from the German site Stellmoor are of Late Glacial origin dating c. 11.6 ka.
- Digging sticks used in procuring underground storage organs (tubers) are preserved at few sites in Africa, Eurasia, and South America being 400 to 14.5 ka old

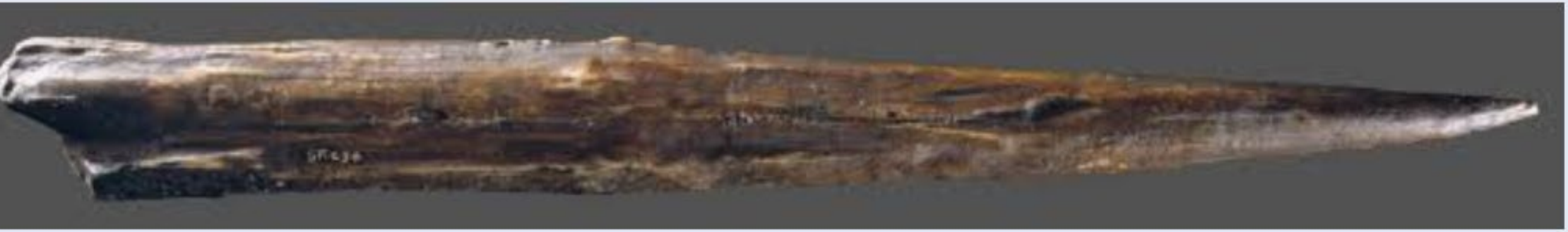
Wood came first, stone came later

- Early domestic wooden tools have been reported from a few sites in Eurasia and South America.

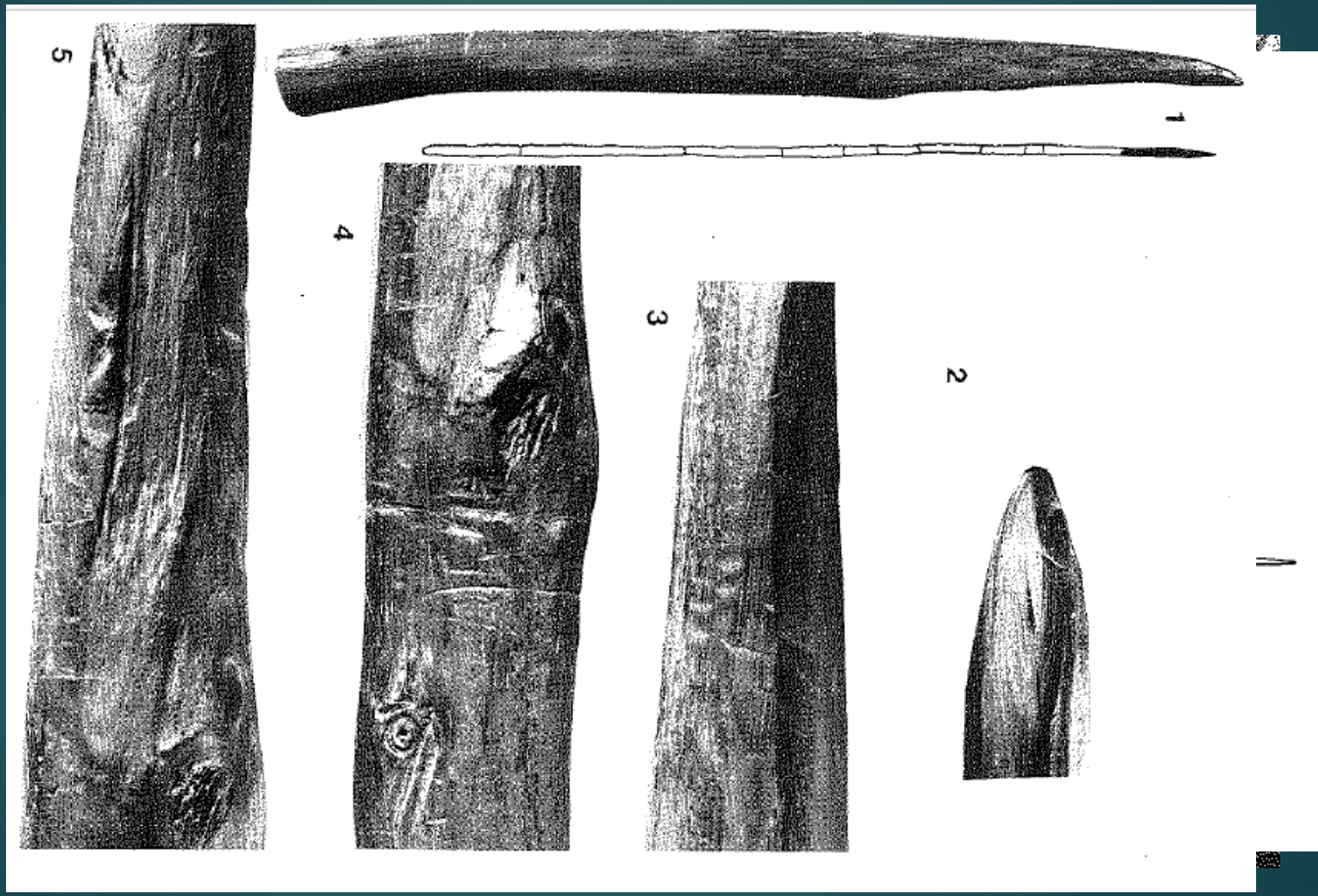
- Way earlier than any of these sites, some of the earliest Oldowan stone artifacts bear evidence that their sharp edges were used to shape wood. Many Acheulean handaxes and cleavers were used for wood shaping also. In other words, evidence for woodworking goes back long before any chance preservation of wood artifacts so far.

- Chimps use wooden implements. What that means is that the earliest hominins almost certainly used a wide range of wood tools before they routinely flaked stone.
- Bone digging tools found with *Paranthropus robustus* in South Africa

The Clacton-on-Sea spear: 400 Ka, fire hardened

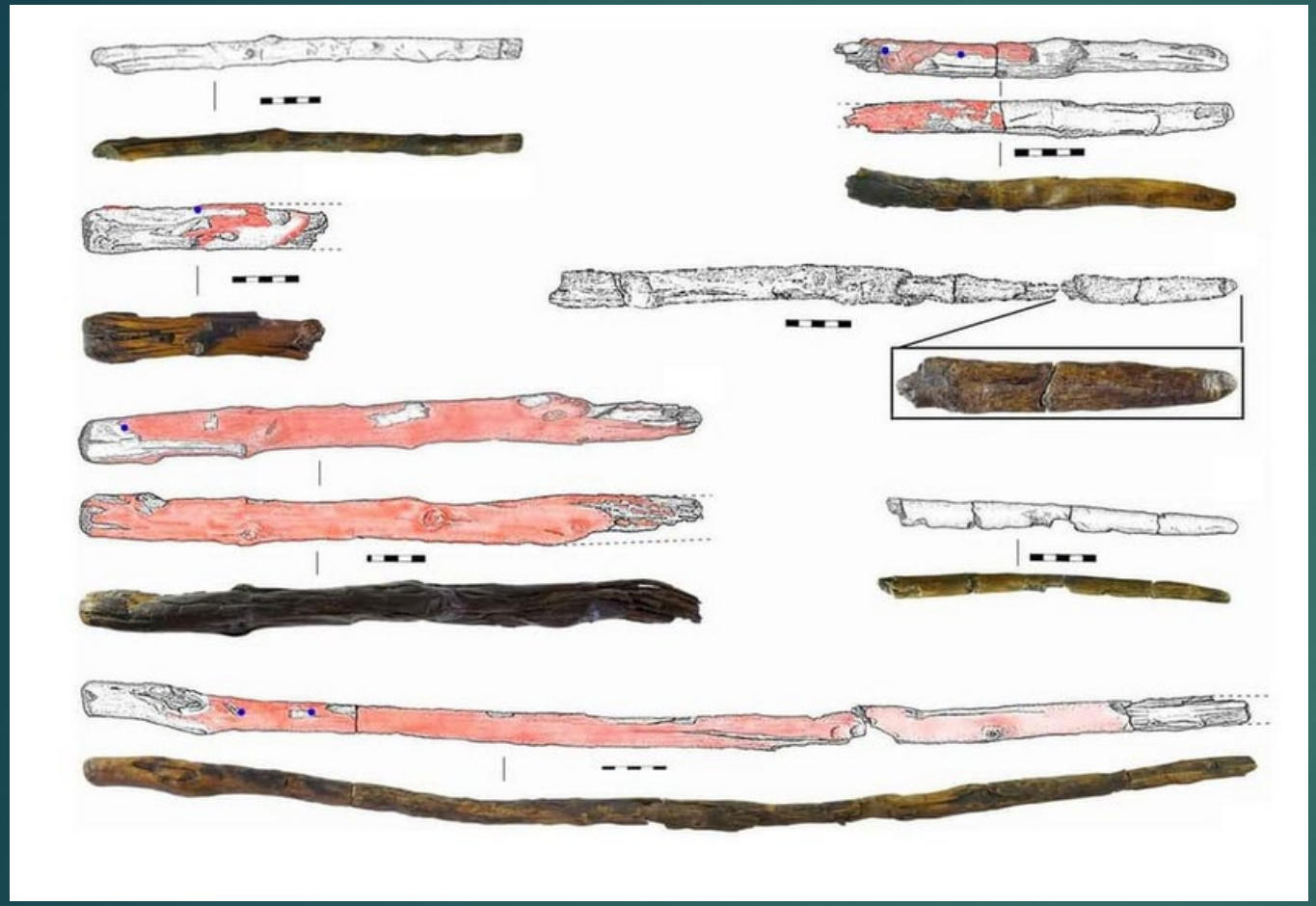


Lehringen, Germany spear: found in inside an elephant fossil in 1948: 115-125 Ka



Boxgrove: spear hole in a horse shoulder blade; 500 Ka

Poggetti Vecchi, Italy: 39 Digging sticks

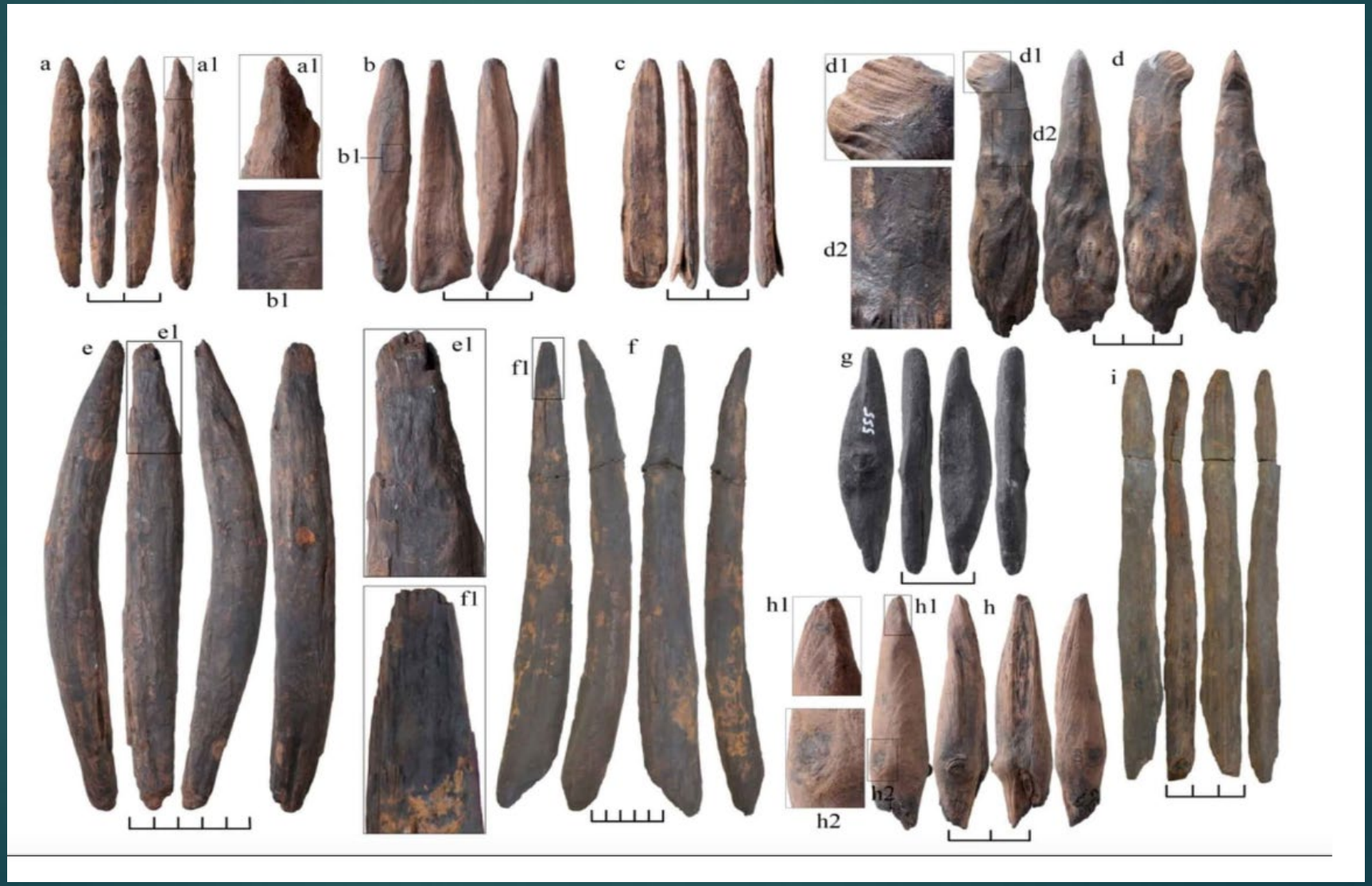


Made of boxwood: which is harder, denser, and more resistant to breaking than other species that were present in the ancient environment.
Many were fire hardened.
Some have a clearly rounded end forming a handle that the user could apply pressure to the pointed, working end of the stick.

Poggetti Vecchi, Italy: Neanderthals, 170 Ka

Poggetti Vecchi, Italy: The rounded “handles” and worn surfaces of wooden digging sticks: evidence of wood working and intentional shaping

Gantangqing, China: ancient lakeshore, 361-250 Ka, 35 wooden tools; starch grains on tips



Wood artifact from Aranbaltza III, Spain. The left panel shows the artifact just after excavation. After excavation and preservation, the artifact developed a distinct curve as depicted in the right panel. 140-50 Ka

Abric Romani, Spain; 45-75 Ka; Instead of direct survival of the organic wood, in a few sites imprints of wood are preserved in sediment or rock that formed around the wood before it decayed. Neanderthal.

A wood pseudomorph: An imprint at Abric Romani of a wooden tool, with fragments of organic wood present, and an experimental recreation of the tool by archaeologists.

The Late Glacial Shigir idol from Russia represents the earliest known monumental sculpture, at 11 Ka. 9 feet tall.

Importance of Schöningen.

- The oldest wooden tools come from sites Schöningen 12 II, 12 B, and 13 DB, and contain about 30 slotted handles.

- Most important are the ten spears and two double-pointed throwing sticks from Schöningen 13 II-4, which led to a paradigm shift in the hunter vs. scavenger debate.

- Schöningen 13 II-4 is located at a former interglacial lakeshore, which formed atop an Elsterian glacial till during MIS 9 (337 to 300 ka ago).

Schöningen

- The major occupation occurred in an open woodland landscape with alder, birch, and willow near river and lakeside locations, pine trees in lowland and hilly areas, and stands of pine, spruce, and larch at higher altitudes.
- Exceptional preservation led to the survival of hundreds of natural and worked wood remains making Schöningen 13 II-4 a prime location for the study of early wooden artifacts and human behavior connected to woodworking.
- Overview of Wood types:. Spruce, willow, and pine dominate the wooden assemblage followed by smaller numbers of birch, poplar, and larch, with few specimens of fir, alder, juniper, and oak.

Lakeshore

- Wood remains thus preserved under waterlogged conditions, mostly along the former lakeshore while few items were lost/tossed into the lake. The spears were deposited in the center of the excavated lakeshore in an area extending 25 m across

- Secure identification of eight spears, six double pointed sticks, and 17 point and 13 shaft fragments respectively, resulting in between ten and 18 reconstructed spears and between six and nine reconstructed DPSs; in a total of 20 to 25 hunting weapons present at Schöningen 13 II-4.

Wood sources

- All but 2 hunting weapons are manufactured most likely from tree trunks. The wooden artifacts are mainly shaped by carving/planning and tips by splitting away small wood chips from the point toward the shaft. Chopping was not applied in tool shaping. Thereafter, the entire artifact was smoothed via scraping and abrasion.

- Two formerly recognized tool types comprise 24 pointed split woods and 11 split woods with a rounded ends that are worked mainly by splitting, scraping, and abrasion.

- Besides tools and tool fragments, the wooden assemblage contains 109 split woods

Hunting weapons

- Hunting Weapons: Spears and double pointed sticks comprise the spectrum of the 20 to 25 hunting weapons at Schöningen.

- Spears were both thrusting and throwing weapons used in hunting medium-sized to large animals at Schöningen like horse, bovids, and cervids.

- Double pointed sticks are commonly interpreted as throwing sticks used in hunting small to medium-sized animals potentially including small–fast prey like birds and hare.

The Spears

- Compared to ethnographic spears, the Schöningen specimens are relatively short and thick. The location of the maximum diameter in Schöningen spears (median = 26.7) fits within the range of known ethnographic throwing spears.

- The spears are thoroughly worked and combined with the technological design speak for a fine workmanship. Most points bear dark discolorations, which might be connected to heat treatment in an attempt to dry and harden them, contact with soil, blood, or grease.

Spears

- Each is made from the trunk of a 30-year-old spruce tree; in each, the end with the tip comes from the base of the trunk, where the wood is hardest; and each has the same proportions, with the center of gravity a third of the way from the sharp end, as in modern javelins.

- Implies considerable depth of planning, sophistication of design, and patience in carving the wood, all of which had been previously attributed only to modern humans

Characteristics

- Longitudinal crushing on six points evidence usage as do six shaft breaks. Four broken front points are reworked by splitting and subsequent smoothing, which can be understood as a quick way to repair a broken spear point, possibly during a hunt.

- All DPSs are 45 to 88 cm long (median = 25 inches) with maximum diameters of 1.7 to 3.0 cm

- The two tool categories made on split woods likely represent domestic tools. These comprise 24 split woods with a single pointed tool end and 11 split woods with a rounded tool end

Uses of split woods

- Split woods: many had single tapering end others a round tool end.
- The split woods with a round tool end morphologically compare well with hide smoothers made from bone and ivory.
- However, other functions comparable to those of bone spatulas, e.g., sewing reed mats, scaling fish, and folding bark containers, cannot be excluded.
- Use-wear in the form of polish, micro-splintering, and crushing present on round-ended tools might be indicative of slightly abrasive tasks.

The securely identified eight spears and six DPSs from Schöningen 13 II-4 excavated until 2008

Pointed split woods and close-up images of the worked point.

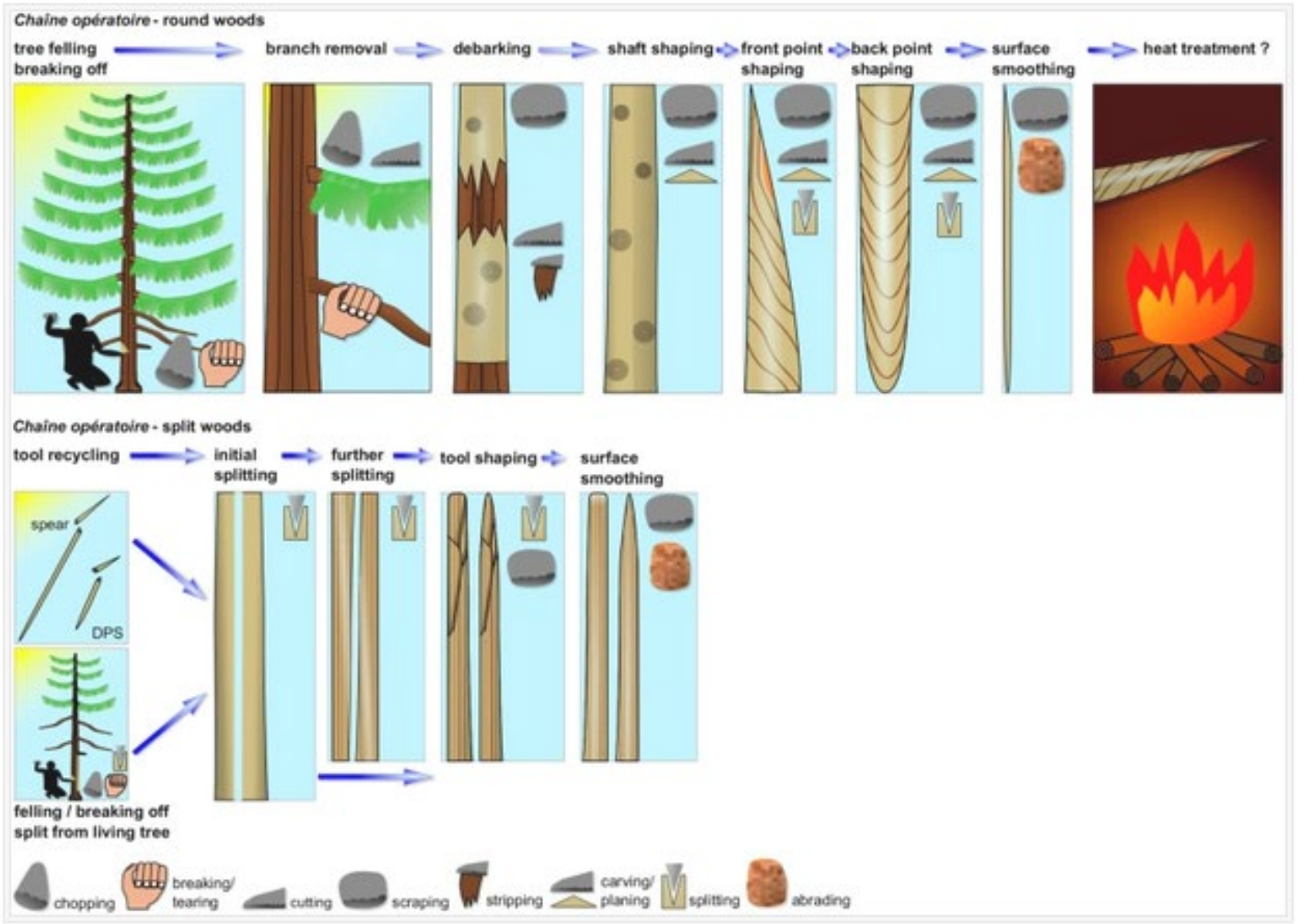
Fig. 2. Examples of pointed split woods and close-up images of the worked point. Photos: Matthias Vogel, Jens Lehmann, Dirk Leder, NLD.

Fig. 3. Examples of round-ended split woods and close-up images of the worked tool end. Photos: Matthias Vogel, Jens Lehmann, Dirk Leder, NLD.

Wood recycling

- The evidence shows wood recycling played a pivotal role in the formation of the wooden artifact assemblage from Schöningen.
- Spears, DPSs, and selected split woods were imported as finished tools to the site from afar.
- Upon use and breakage on-site, they were repaired and/or recycled.

The two operational chains observed in Schöningen: hunting tools and cleft wood tools for domestic use.



Round woods:

Tree felling/breaking off
Branch removal
Debarking
Shaft shaping
Front point shaping
Back point shaping
Surface smoothing
Fire treatment

Split Woods:

Tool recycling
Initial splitting
Further splitting
Tool shaping
Surface smoothing

Tool and Site Function

- Spears at Schöningen were likely used as thrusting and throwing weapons in hunting small to large prey.

- The DPSs likely functioned as throwing sticks in hunting medium-sized and potentially small-fast terrestrial prey as well as avian fauna, and according to ethnographic records, are tools that could be used by various members of the group including children.

- Single-pointed split woods could have been used in either vegetal working or processing of hides. In support of this is the evidence that skinning was one of the major features of the butchery sequence at the site

Knew their wood

- The split woods with a rounded tool end might have functioned as hide smoothers yet other functions are possible..

- It is striking that spruce, spruce/larch and pine woods were deliberately selected to fashion tools on roundwoods and split woods from them even though they had to be brought to the site from afar.

- Such behavior evidences a clear raw material selection strategy likely connected to the physical properties (hardness, elasticity, weight) of these coniferous woods.

Multipurpose site

- Schöningen functioned not only as a hunting/butchering site by a lakeshore, but equally as a site for domestic activities.

- Such activities comprised wood tool curation, artifact recycling, on-site production of expedient wood tools, and use of these tools for varying purposes, including hide preparation.

- The presence of 20 to 25 butchered herbivore

- Repeated human occupations mostly during the summer/autumn season.

Wood and Human Evolution

- Wood Artifacts and Human Evolution. Schöningen is pivotal in understanding early hunting strategies, hominin range expansion, technical and social skills, and human cognition.

- The first phase of human brain size increase between 2 and 1.5 Ma parallels the appearance of Homo erectus and the Acheulean technocomplex. Early indirect evidence of hunting might be just as old.

- The second phase begins with the Middle Pleistocene at 780 ka and ends around 200 ka after the first appearance of Homo sapiens and Homo neanderthalensis.

Human evolution

- Hominin expansion into colder parts of Europe and the earliest evidence for cooperative hunting fall into this later time slice, which is paralleled by the appearance of organic tools (wood, bone, and antler) and the introduction of multi-component tools, i.e., hafting and production of adhesive materials.

- With an age of c. 300,000 ka, Schöningen stands at the brink of the Lower and Middle Paleolithic and in the midst of the transitional phase from H. heidelbergensis/H. erectus to Neanderthals in Eurasia

Technological advances related to cognitive advances

- The more complex a tool, the more steps and quality controls to memorize.
- The Early and Middle Pleistocene archeological record shows an evolutionary trend of increasing technological complexity beginning with simple flake tools followed by handaxes, then sophisticated wooden hunting weapons, and finally hafted tools .
- Increasing technological complexity has been interpreted as a proxy of cognitive abilities and increasing reliance on social learning in Homo.

Technologically advanced tools: Planning ability

- Schöningen' s wooden artifacts play a key role in understanding early organic technologies. Hunting weapons were not simple sticks with points, but technologically advanced tools.
- The selected raw material was particularly suitable and the best option at the end of the interglacial due to its growth conditions providing hardness and elasticity at the same time.
- It was not available at the site but had to be procured elsewhere, which requires anticipation of an arising need and thus planning depth.
- The design of the spears (e.g., offset front point, point of balance) made them durable thrusting and throwing weapons.

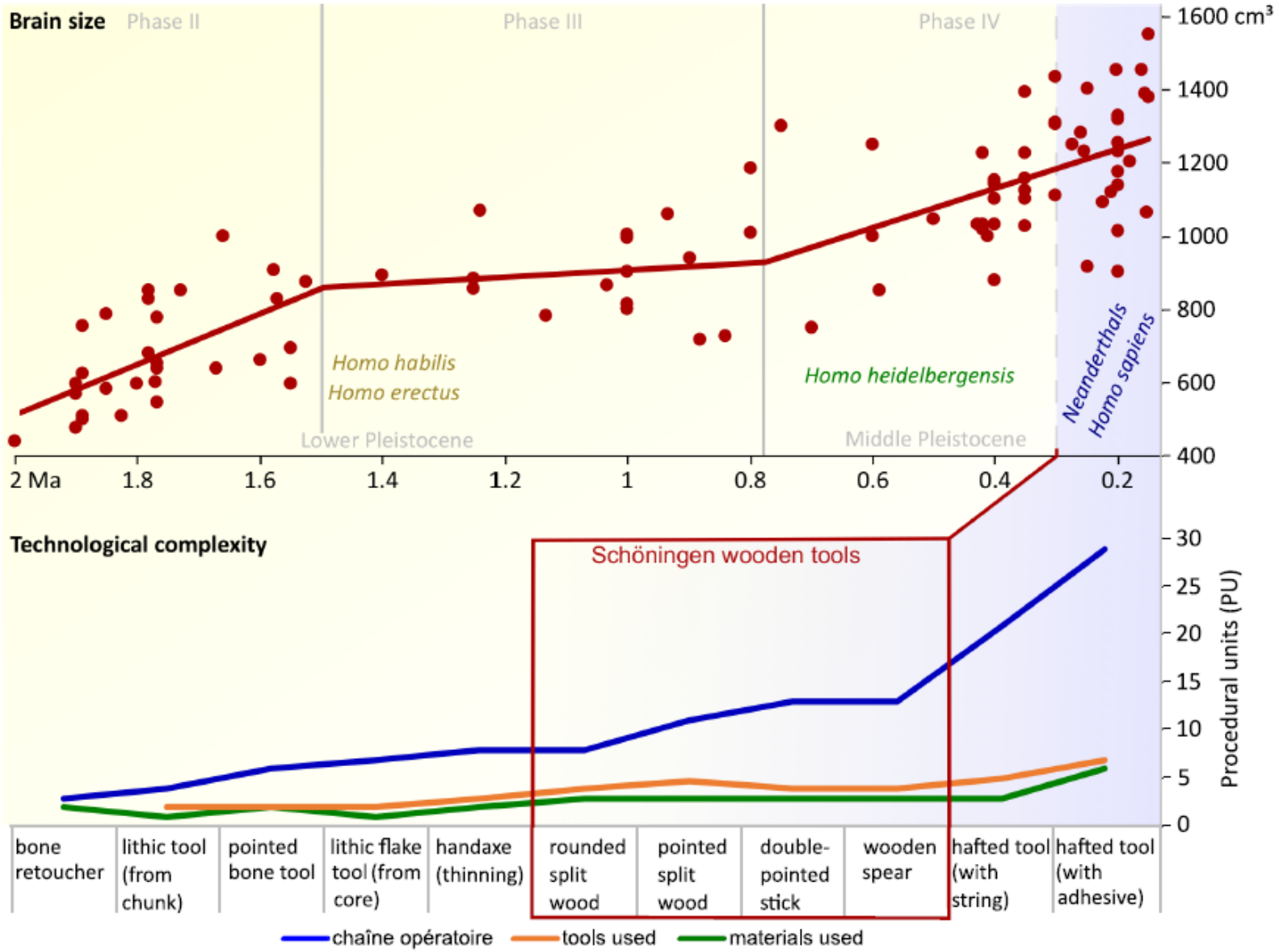


Fig. 6. Human brain size evolution and technological complexity development during the Early and Middle Pleistocene. Brain size data after Gingerich (46). Technological complexity according to multiple sources (*SI Appendix, SI-Text* and Table S23). Procedural units after Perreault et al. (61) (*SI Appendix, SI-Text*). Illustration Dirk Leder, NLD.

Human brain size correlates with Increased technological complexity.

What spears can tell us: Long term knowledge transfer

- Consequently, spears and DPSs can be viewed as two elements of a complementary hunting tool kit. Earlier and later wooden spears from Clacton-on-Sea and Lehringen bear similar technological features and despite the time gaps, these wooden spears may elucidate the successful knowledge transfer over many generations during the Pleistocene.

- Where wooden artifacts are not preserved, we might underestimate the cognitive abilities of prehistoric societies.

Hunting and Homo's success

- Brain growth significantly increased during the Middle Pleistocene connected to food diversification and reliable access to animal food sources.

- Hunting thus plays an essential role in the physical and cognitive evolution of hominins.

- The complex interplay of planning depth, social interaction, technological complexity, and secure food supply over many generations thus made a decisive contribution to the successful expansion of Homo from Africa to Eurasia and its persistence throughout the Pleistocene.

Milestones in human evolution

- Hunting is probably much older and primary access to high-quality food sources over generations would have benefited brain growth and human socio-cognitive abilities.
- Hunting would have ensured sustainable populations even in less favorable parts of Europe during the Pleistocene and contributed to human range expansion across the globe.
- Schöningen' s wooden hunting weapons are thus an excellent ambassador of these important milestones in human evolution.

*** The Dynamics of Early Human Dispersal Across Europe: A New Population Model

- Study: A Comprehensive Analysis of Human Migration During the Last Ice Age
- The Aurignacian is the first techno-complex related with certainty to Anatomically Modern Humans in Europe. Studies show that they appeared around 43-42 kyr cal BP and dispersed rapidly in Europe during the Upper Palaeolithic. However, human dispersal is a highly convoluted process which is until today not well understood.
- Here, we provide a reconstruction of the human dispersal during the Aurignacian on the pan-European scale using a human dispersal model, the Our Way Model, which combines archaeological with paleoclimate data and uses the human existence potential as a unifying driver of human population dynamics. Based on the reconstruction, we identify the different stages of the human dispersal and analyze how human demographic processes are influenced by climate change and topography.

Four phases

- The first phase, as revealed by the model, involved a slow westward expansion of human settlement from the Levant to the Balkans. This was followed by a rapid second phase of expansion into western Europe. The third phase saw a decline in human population, coinciding with a period of severe climatic conditions. Finally, the fourth phase was marked by a resurgence in population density and further advances into previously uninhabited regions, including Great Britain and the Iberian Peninsula.

Climate Change as a Driver of Human Dispersal

- During the late Last Glacial Period, the global climate was significantly cooler and drier than today, with frequent oscillations between colder and warmer periods. These climatic shifts played a crucial role in shaping the migration patterns of early humans, as they adapted to the changing environment.

- The model demonstrates that early human habitation in Europe was a highly complex process, characterized by cycles of advance, retreat, abandonment, and resettlement. These movements were driven not only by climatic changes but also by the adaptive capacities of early human populations.

Four key phases in the dispersal of early humans across Europe

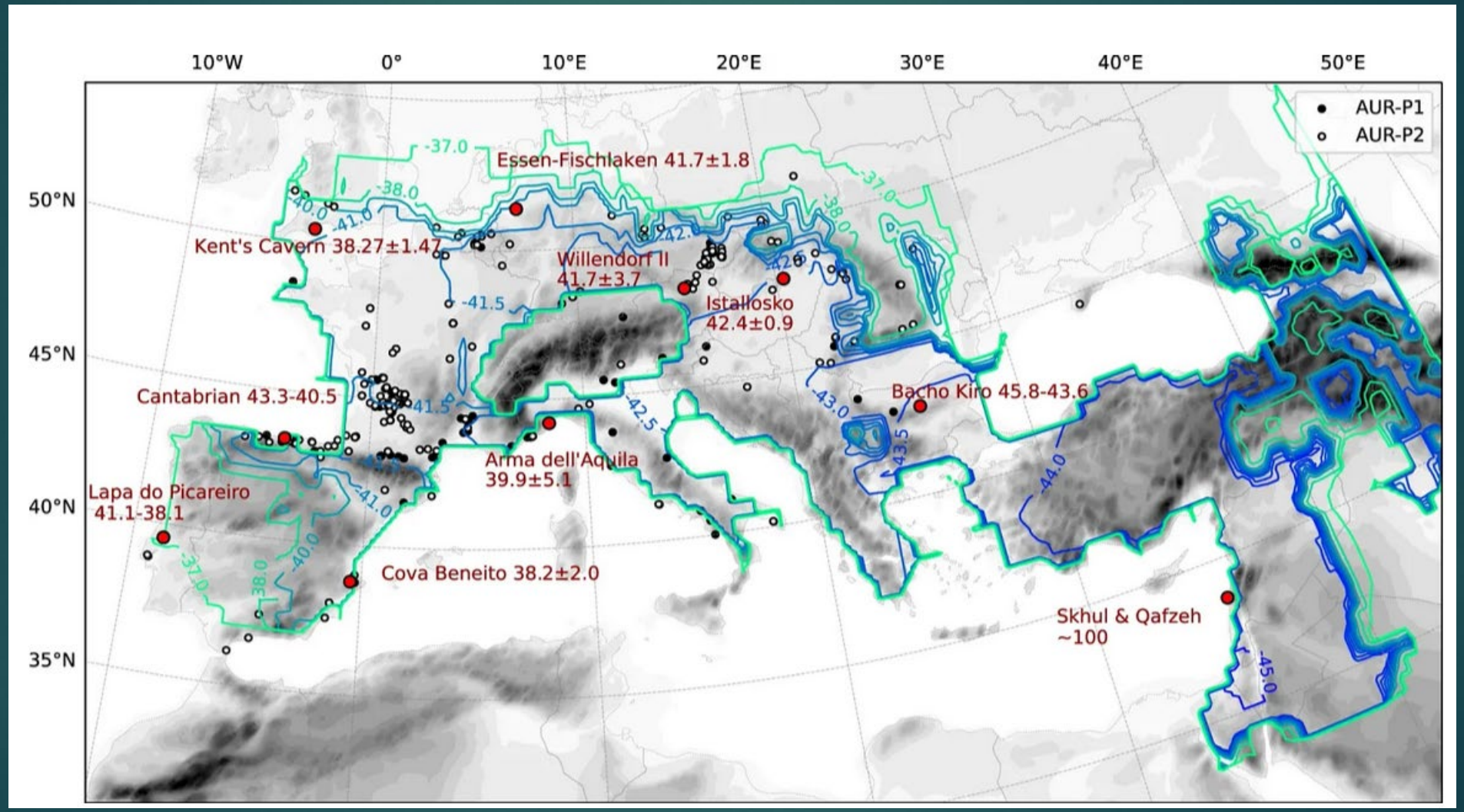
- **Phase 1: Slow Westward Expansion (45,000 to 43,000 years ago)**
  The initial phase involved a gradual westward movement of human populations from the Levant to the Balkans, laying the groundwork for future expansions.

- **Phase 2: Rapid Expansion into Western Europe (43,250 to 41,000 years ago)**
  This phase was marked by a rapid spread of *Homo sapiens* across western Europe, despite brief setbacks. The population reached an estimated 60,000 individuals, distributed across all known archaeological sites of the period.

Four key phases in the dispersal of early humans across Europe

- **Phase 3: Population Decline During Severe Cold (41,000 to 39,000 years ago)**
  A prolonged period of severe cold led to a significant decline in both the size and density of human populations. However, some groups survived in the "climate shadows" of large topographical features, such as the Alps.

- **Phase 4: Recovery and Further Expansion (Starting around 38,000 years ago)**
  As climatic conditions improved, human populations quickly recovered, leading to regional increases in population density and further migration into previously uninhabited areas, including Great Britain and the Iberian Peninsula.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AUR-P1
AUR-P2
Essen-Fischlaken 41.7±1.8
Kent's Cavern 38.27±1.47
Willendorf II
41.7±3.7
Istallosko
42.4±0.9
Cantabrian 43.3-40.5
Arma dell'Aquila
39.9±5.1
Bacho Kiro 45.8-43.6
Lapa do Picareiro
41.1-38.1
Cova Beneito 38.2±2.0
Skhul & Qafzeh
~100
-37.0
-38.0
-40.0
-41.0
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*** Hidden Lineage: New Insights into Neanderthal Evolution

- European Neanderthals consisted of at least two distinct populations, evolving in isolation for tens of thousands of years.
- Long regarded as a relatively homogenous group, Neanderthals may have had a much more complex evolutionary history, characterized by local extinctions and migrations.
- This new finding challenges long-held assumptions about their genetic uniformity and underscores the diversity of hominin populations in prehistoric Europe.

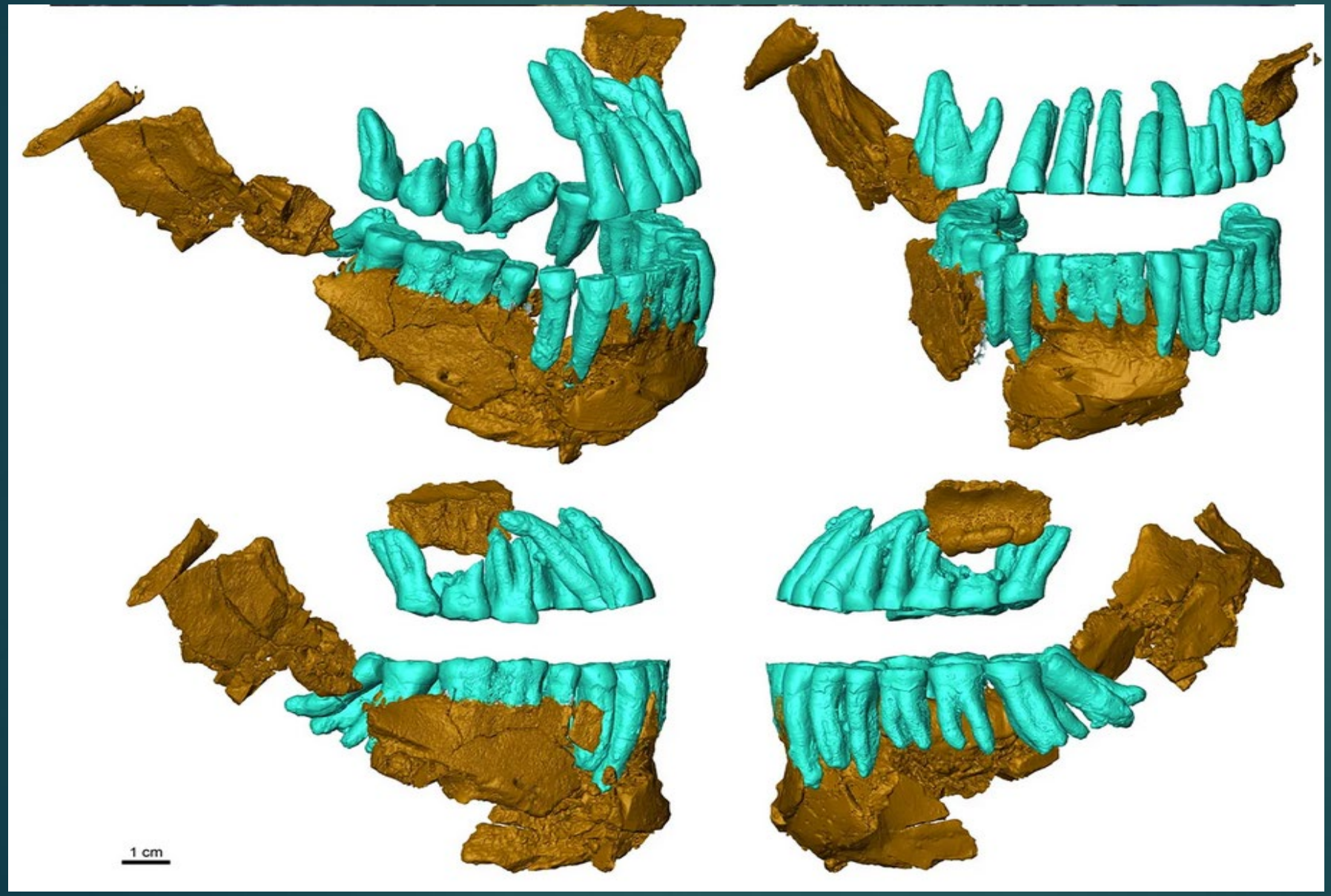
Thorin

- The key to this revelation lies in the remains of an adult male Neanderthal, dubbed “Thorin,” found in 2015 at the Grotte Mandrin rock shelter in France.

- Thorin’s partial skeleton, excavated by a team led by archaeologist Ludovic Slimak, holds genetic clues that point to a previously unknown lineage of Neanderthals.

- This lineage, it seems, had evolved separately from other European Neanderthals for around 50,000 years, almost until their extinction approximately 42,000 years ago

The Thorin Neanderthal: the mandible *in situ* when found in September 2019.
Virtual reconstruction of the jaw and dental elements of Thorin



Had two extra lower molars.

This trait is sometimes suggestive of an inbred population?

Thorin = 42 Ka

- Thorin lived between 50,000 and 42,000 years ago. Molecular analysis of his remains, including a molar, revealed that about 65% of Thorin's genome could be recovered. When compared to DNA from other Neanderthals, early *Homo sapiens*, and modern humans, Thorin's genetic profile stood out.

- The population of Thorin had spent 50 millennia without exchanging a single gene with the classical Neanderthal populations.

- "We thus have 50 millennia during which two Neanderthal populations, living about ten days' walk from each other, coexisted while completely ignoring each other."

High homozygosity = lots of inbreeding

- Thorin was found to have high genetic homozygosity — identical gene variants often indicative of recent inbreeding — and no evidence of interbreeding with modern humans.

- Results suggest small group sizes and long-term genetic isolation of the Thorin population from other late Neanderthal populations.

- Evidence newly uncovered in 2023 suggests Thorin is much more likely to be 42,000 years old and therefore is among the very last Neanderthals. 1 of only 5 late N skeletons

A Separate Line of Neanderthals in Southwestern Europe

- This newly identified lineage of Neanderthals, to which Thorin belonged, seems to have lived in small, closely related communities that exchanged mates only within their own group.

- Thorin's DNA shares similarities with that of a Neanderthal fossil found in Gibraltar, suggesting that this isolated population may have stretched across parts of southwestern Europe.