Scientific Updates
April 2024

by

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Vote for how to proceed with our HE sessions

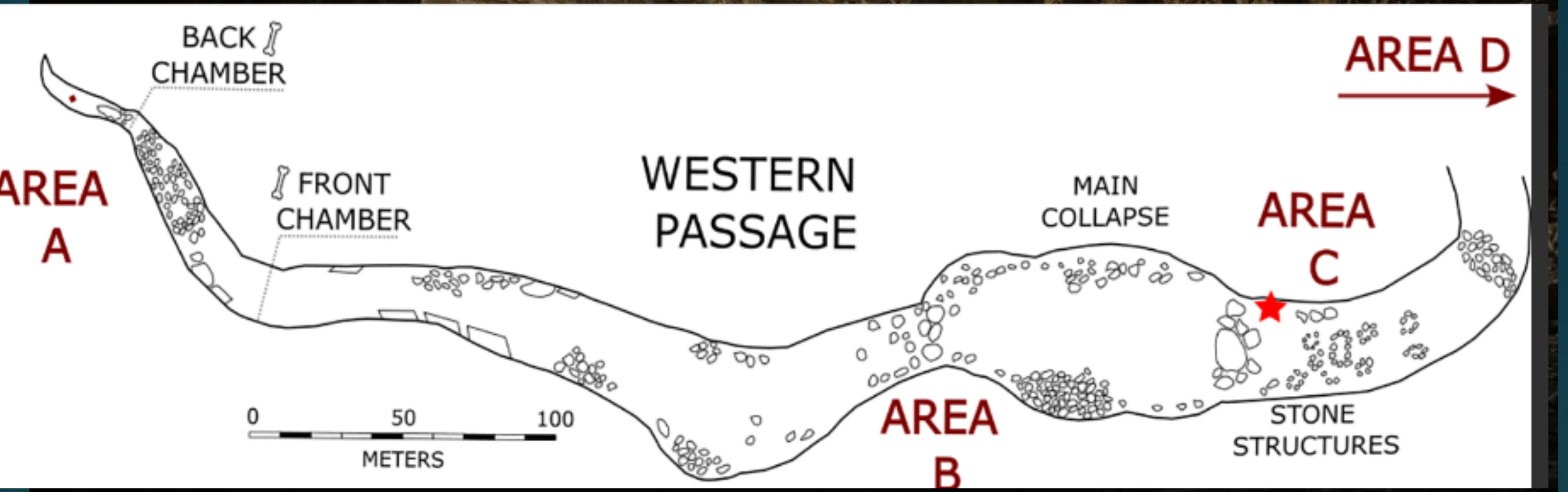
- Final Vote:
  - Do Scientific Updates for 1 hour,
  - Followed by 1 hour on our Continuing Topic (Myths in Evolution, then Pre-Homo Hominins)

Recent Arabian Archeology

Largely unexplored—the labyrinthine network of caves and lava tubes scattered across northern Arabia.

The Arabian Peninsula has been a site of human migration and occupation for hundreds of thousands of years. In extensive surveys in recent years, scientists have spied millions of archaeological features (like lakeside hearths) and structures (like tombs and ritual gathering sites) that those people left behind

The Umm Jirsan Lava Tube: first archaeological excavation of an Arabian Peninsula lava tube



The Umm Jirsan Lava Tube: An Ode to Subterranean Splendor

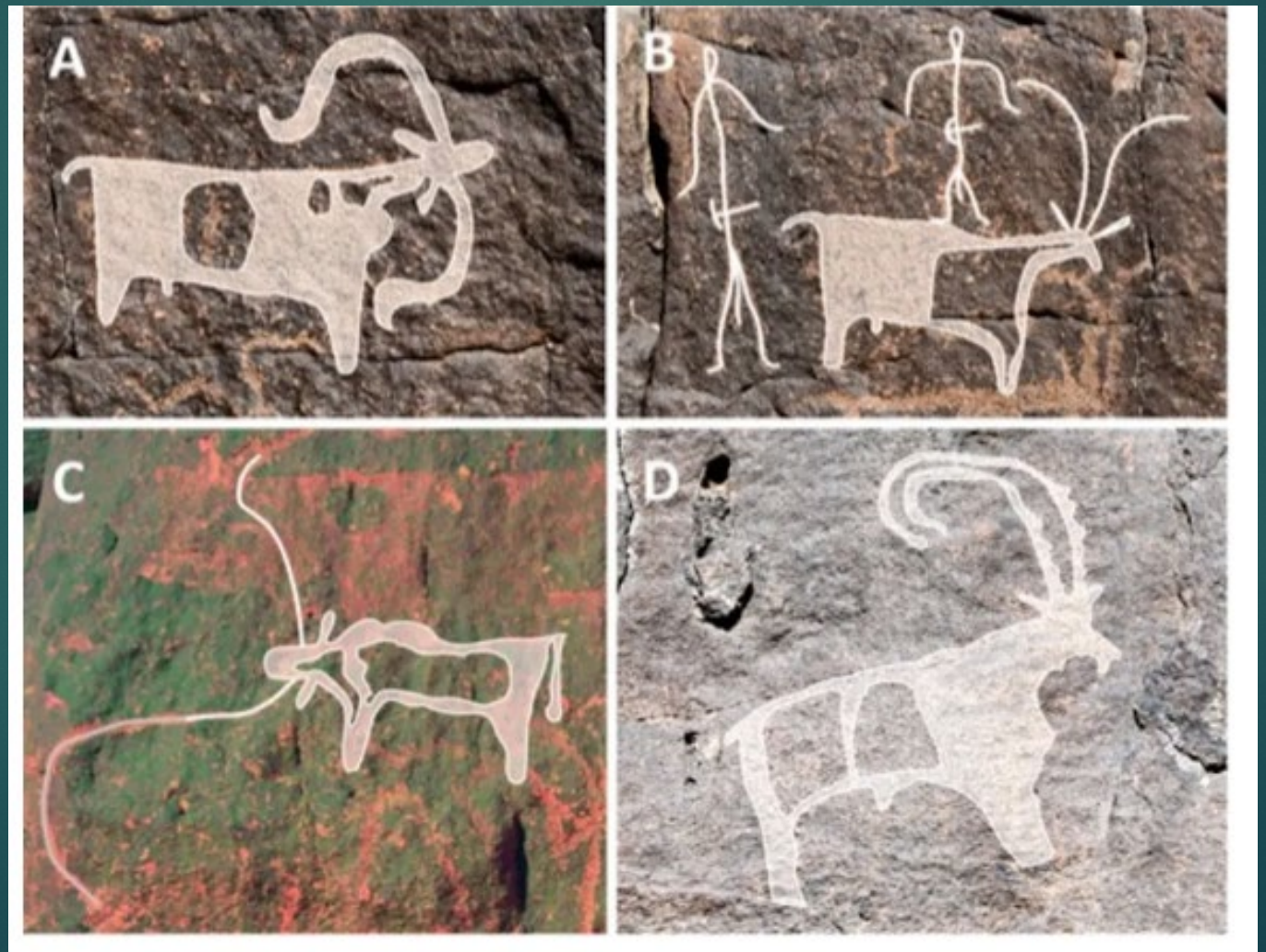
- Amidst the darkness, piles of bones lay testament to the relentless scavenging efforts of striped hyenas, who, over millennia, have transformed the caverns into massive bone collections. These fossil-rich deposits offer a tantalizing glimpse into the fauna that once roamed Arabia's ancient landscapes.
- 1.5 miles deep
- The excavation of the eastern passage that yielded the most remarkable discoveries—a trove of stone artifacts, animal bones, and charcoal, dating back millennia.
- Human occupation spanning from 7,000 to 10,000 years ago.

Stewart, M. et al. 2024

Pastoral resources

- Findings point to use of Umm Jirsan by predominantly pastoral populations that had increasing links through time with oasis settlements.
- The lava tube does not appear to have served as a permanent habitation location, but rather as a site that likely lay on herding routes and that allowed access to shade and water for passing herders and their animals.
- Prior to this, as well as during pastoral periods, the lava tube was likely also linked with hunting activities, which probably remained a cornerstone of local economies into the Bronze Age.

16 Rock Art panels in the entrance to another lava tube nearby. Some show people herding cattle, sheep and goats, sometimes with the aid of dogs; others depict people hunting gazelles and ibex.



Arabian lava tubes

- Results reveal repeated phases of human occupation of the site ranging from at least the Neolithic through to the Bronze Age. Pastoralist use of the lava tube and surrounding landscape is attested in rock art and faunal records, suggesting that Umm Jirsan was situated along a pastoral route linking key oases.
- For 7 to 10 Ma.
- Isotopic data indicates that herbivores primarily grazed on wild grasses and shrubs rather than being provided with fodder, while humans had a diet consistently high in protein but with increasing consumption of C_3 plants through-time, perhaps related to the emergence of oasis agriculture.

Samar Desert kite, southern Negev, Israel

Desert Kites

- Ancient Hunters Built Massive Death Traps for Animals
- Desert kites were originally identified in aerial images during the 1920s and were initially interpreted as animal traps. There were over 6,000 known kites in Asia and the Middle East, and in some parts of Syria there are as many as 1 kite every 2 square kilometers.
- A large collective hunting effort by ancient nomads.

Desert Kites

- Studies show that even low walls or linear structures like pipelines can effectively "guide" animals, which do not attempt to cross the lines even if they are physically able to do so, explaining the effectiveness of desert kites.

- The low visibility of the kite structures prevents the animals from recognizing the trap. The positioning of pits at the end of convergent enclosures and the presence of small walls delimitating pits from the enclosure would hide the pit from the animals until they are too close to change course in their panic

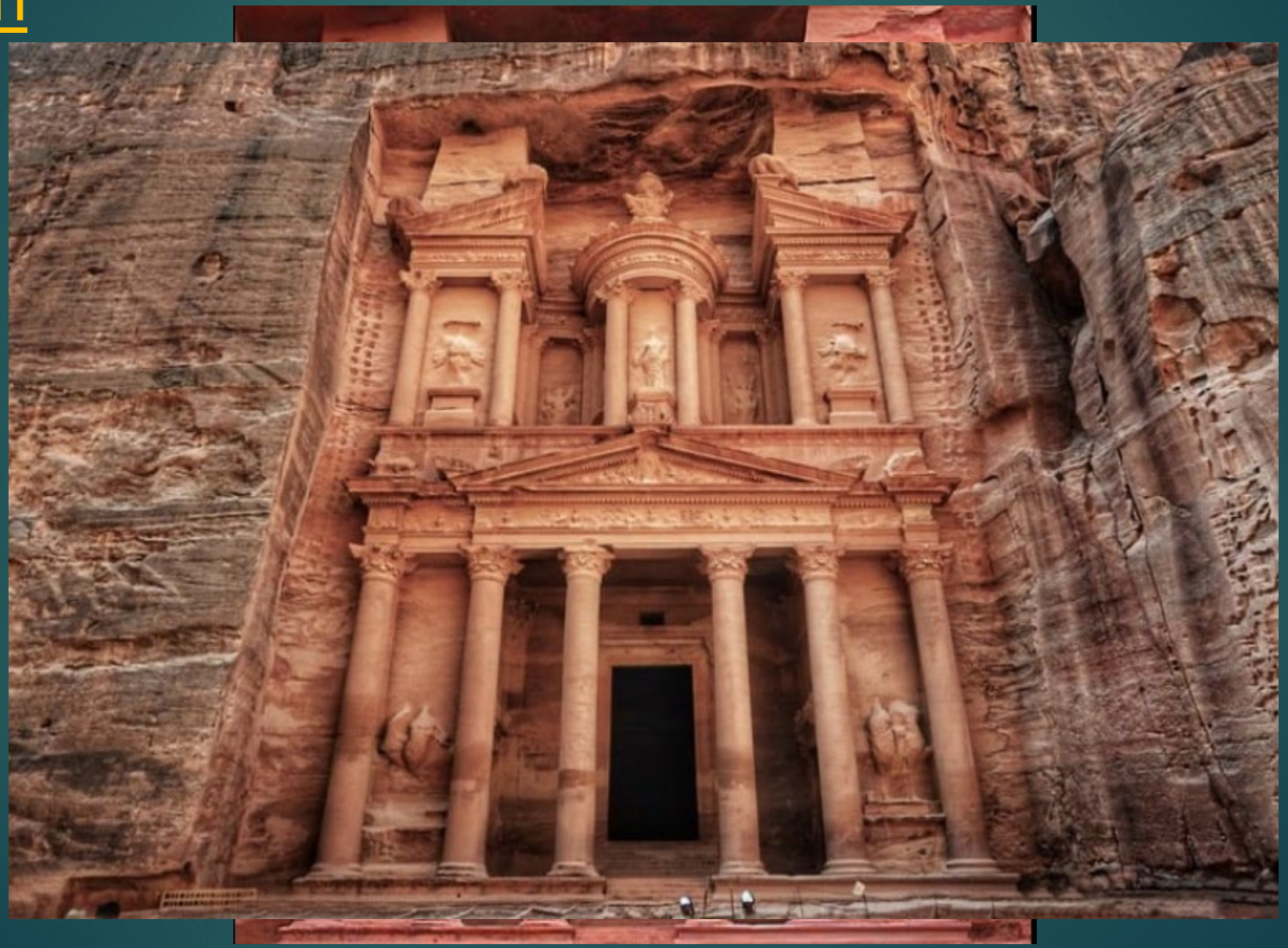
“Funerary avenues” spanning large distances in the northwestern Arabian counties of Al-‘Ula and Khaybar: Pendant tombs: 4,500 year-old avenues lined with ancient tombs

Petra, Jordan: a wonderous 1200 m canyon walk, the Siq

Aqueducts

And then at the end of the Siq, rays of light

Petra, Jordanian capitol of the Nabataean civilization: Al-Khazneh



The Treasury

At night

And in Raiders of the Lost Ark

Petra, 100 BC-400 AD

- A city on a central trade route
- Petra was one of the world's wealthiest, most eclectic and most remarkable cities.
- With its aqueduct system, Petra was a flourishing garden city of 30,000 people
- Not an arid desert, but a green oasis of gardens and orchards

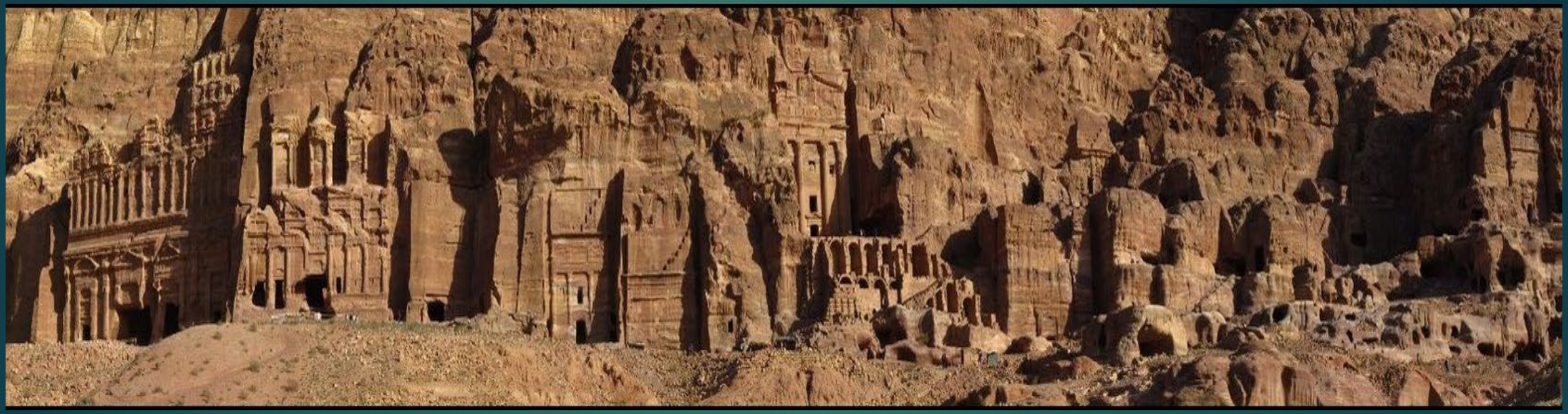
Garden Temple

Petra

The Urn Tomb

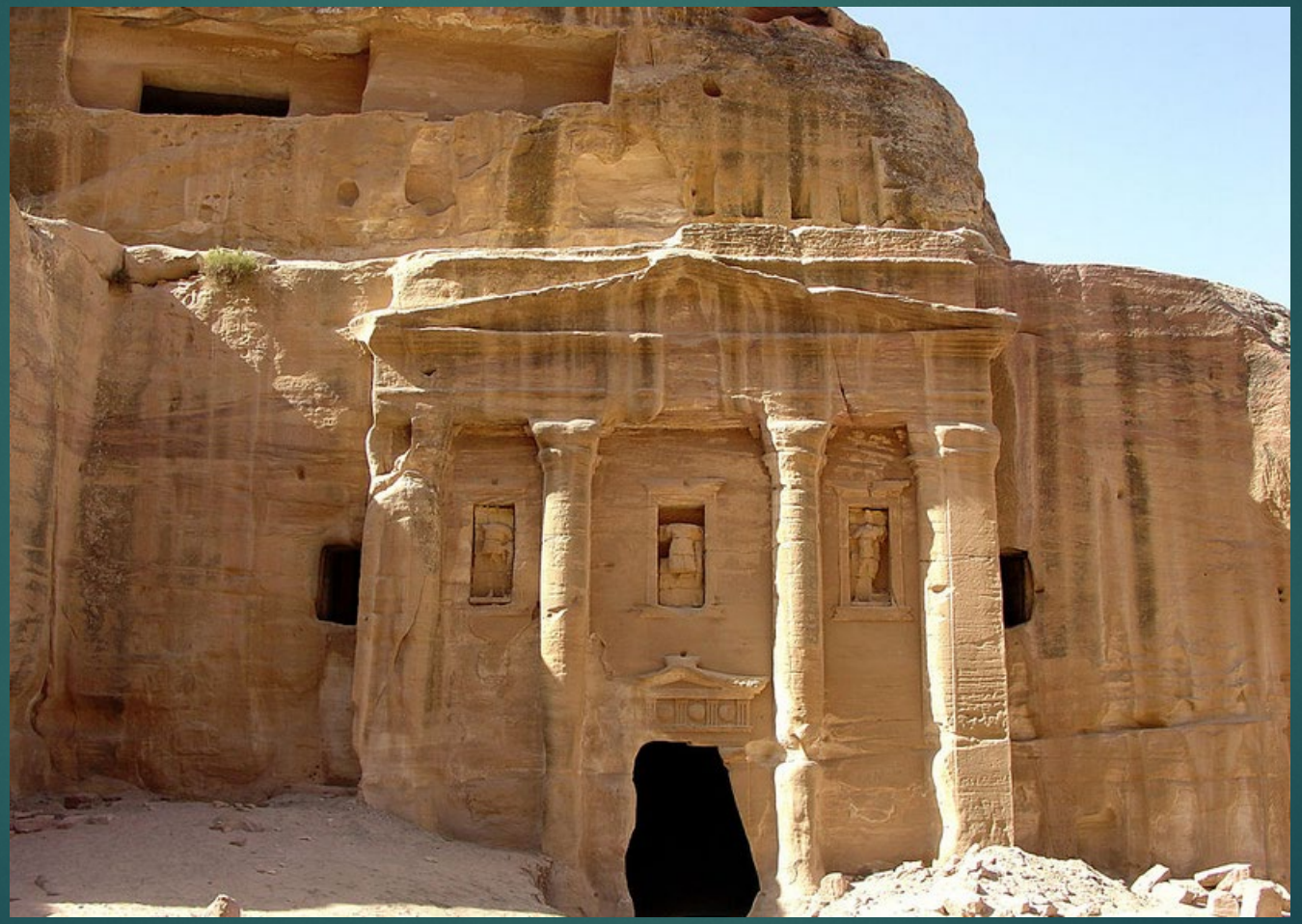
The valley of the tombs

The Royal Tombs in the southern part of the city



The Great Temple of Petra

Tomb of the Roman Soldier



The Palace Tomb

The 800-step stairway up to “The Monastery”

Ad Deir ("The Monastery") – reached by donkey ride up 10-foot-wide stairway up the side of the valley below


The other
Petra

Set in a stunning valley, this ancient desert oasis has birthed flourishing civilizations.

- Set in the AlUla Valley amid the soaring sandstone and granite mountains of north-western Saudi Arabia's Hijaz region, this ancient desert oasis has supported human life for the past 200,000 years.

- The area's fertile soil and access to water amid the arid, mountainous desert helped multiple civilizations blossom.

- The Dadan and Lihyan kingdoms that flourished here between 800 and 100 BCE were followed by Hegra, an important city in the Nabataean civilization whose capital, Petra, was located farther north, in modern-day Jordan.

Saudi Arabia’s counterpart to Jordan’s Petra, Mada’in Saleh is a fascinating Unesco-listed desert necropolis.

The Nabataean city of Hegra was Saudi Arabia's first Unesco World Heritage Site (Credit: Tuul & Bruno Morandi/Getty

AlUla: The Middle East's once-inaccessible ancient wonder

AlUla (sometimes written "al-Ula").

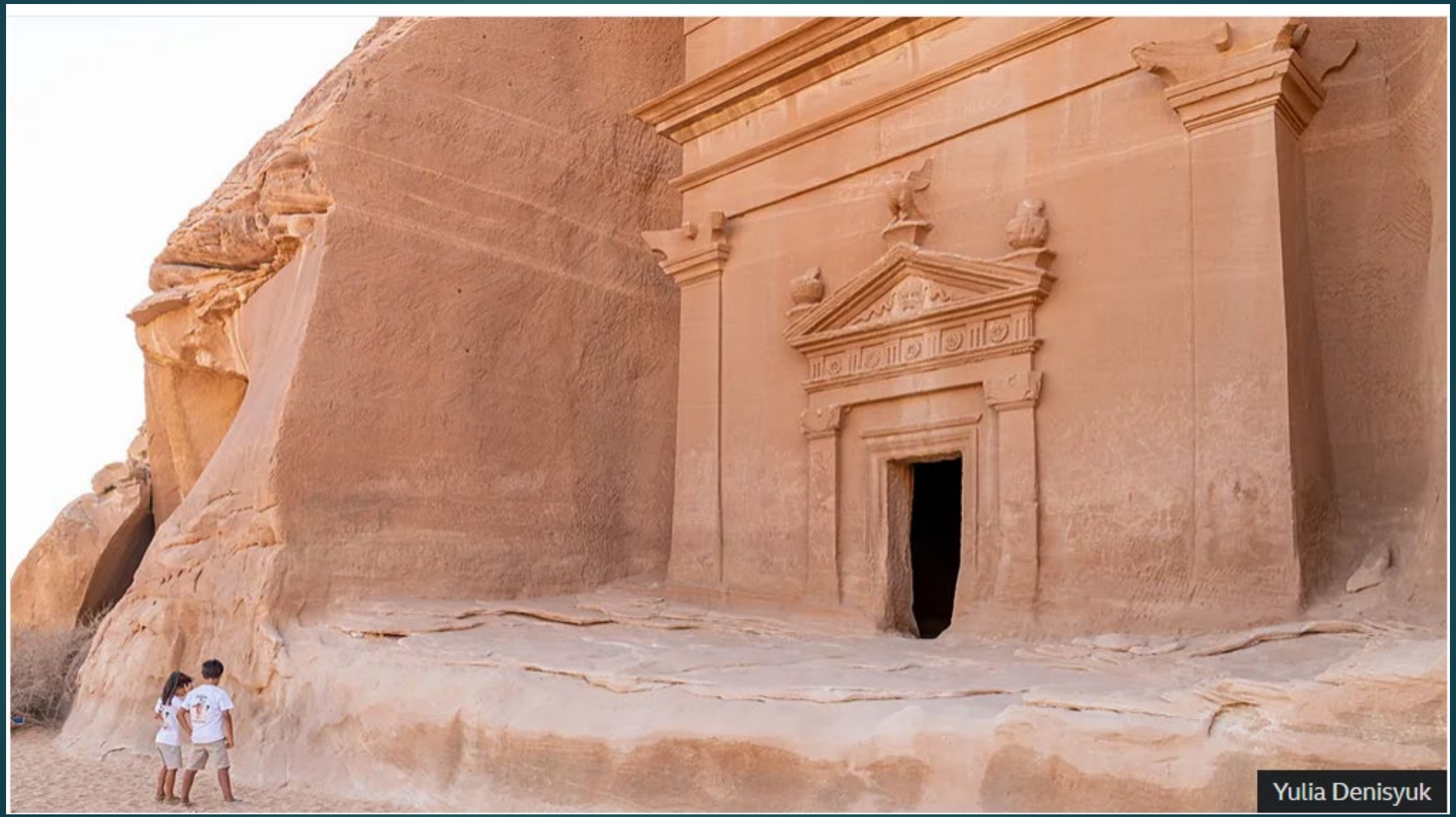
While Petra remained the kingdom's capital city, the Nabataeans' most important city to the south was Hegra – Saudi Arabia's first Unesco World Heritage Site.

Qasr al-Farid

Mustatils

- More than 1,600 Neolithic stone monuments called mustatils (rectangles in Arabic) have been uncovered in the AlUla region, revealing that people already thrived here some 7,000 years ago.

The Hegra area in south: once considered cursed by Mohammed


Yulia Denisyuk

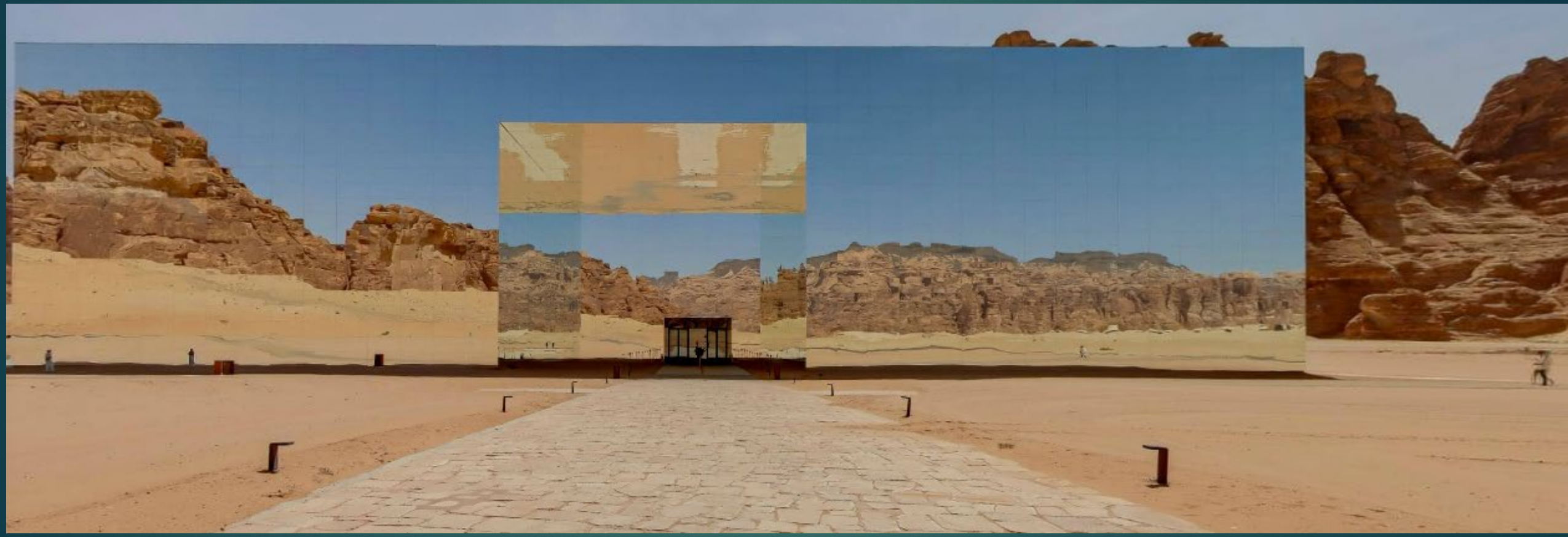
Elephant rock

Today: dates and citrus

Geological wonders

And modern resorts

Maraya: the world's largest mirrored building, covered with 9,740 glass panels that reflect the towering cliffs around it.



Where is the mirror?

Basal Cognition: What are farm animals thinking?

- There are an estimated 78 billion farm animals on Earth. and we have lived with them longer than any other creature save dogs. Yet in an era where researchers are modeling rat brains on computers and showing that our canine pals may be able to intuit our thoughts, livestock remain a black box.
- Pigs show signs of empathy, goats rival dogs in some tests of social intelligence, and cows can be potty trained, suggesting a self-awareness behind the blank stares and cud chewing that has shocked even some experts.
- Boars: 85% of the time, the animals freed a trapped companion within 20 minutes.

Empathic pigs

- Spontaneous helping in pigs is mediated by helper's social attention and distress signals of individuals in need

- The liberators were more likely to open the box when a pig was trapped inside than when it was empty, ruling out mere curiosity. Those that spent more time staring at their trapped companion were also more likely to help, especially if that companion squealed in distress.

- Experiments have also shown that both pigs and cows show signs of optimism and pessimism.

- Some cows were potty trained. And have best friends.

Goats prefer crunchy dried pasta in experiments

Goat smarts

- In an experiment known as the “impossible task,” dogs confronted with a food bowl they can’t access turn to humans for help, a behavior that’s been chalked up to their intensive coevolution with us.
- But goats did the same.
- This may be the only field of research where scientists eat their subjects when the study is over.
- Goats, like dogs, could distinguish between pictures of happy and angry people, suggesting they are tuned into our emotional states; that they could locate food behind an obstacle more quickly if they watched humans move the food there first.
- Goats seem to understand what we mean when we point at something, a complex reading of our social cues that eludes even chimpanzees.

Goats

- Observed in the wild: goats pulling down the branches of an apple tree so that a companion can reach the fruit. Altruism?
- Goats have learned the order of 28 symbols, and correctly recalled it weeks later—a performance comparable to that of primates and dolphins.
- Successfully complete visual “which one doesn’t belong?” game.
- Most money for livestock research still goes to studies aimed at improving milk or meat yields, not to figuring out how these creatures think.
- Many people may not want to know if the animals they think of as dinner turn out to have rich inner lives. “Some would prefer to keep them dumb.”

Decoding triancestral origins, archaic introgression, and natural selection in the Japanese population by whole-genome sequencing

- One of the largest non-European sequencing research efforts to date. They sequenced the genomes of more than 3,200 people living in seven regions in Japan and Okinawa to create the new Japanese Encyclopedia of Whole-Genome/Exome Sequencing Library (JEWEL).

- Modern Japanese people are descended from only three main ancestral groups:
  - Jomon hunter-gatherers of the Neolithic,
  - predecessors of the Han Chinese, and a
  - yet-to-be identified group of people from Northeast Asia.
- Their findings contradict theories that the Japanese people are descendants of the Jomon and later migrants from continental Asia.

Xiaoxi Liu, et al., 2024

Jōmon

- Jōmon people is the generic name of the indigenous hunter-gatherer population that lived in the Japanese archipelago during the Jomon period (c. 14,000 to 300 BC).

- They were united through a common Jōmon culture, which reached a considerable degree of sedentism and cultural complexity.

- The Jōmon people are characterized by a deeply diverged East Asian ancestry and contributed around 5-15% ancestry to modern Japanese people.

Also N and D DNA

- Modern Japanese people have 42 distinct DNA segments from Neanderthals and two from Denisovans, some of which have been associated with the development of certain diseases, such as diabetes type II, prostate cancer, coronary heart disease and rheumatoid arthritis.

- Current study and previous research indicate that Okinawa has a higher genetic affinity to Jomon, while West is genetically closer to the Chinese.

- Observed a reasonable fit of the tripartite model, involving Jomon, East Asians (EA), and Northeast Asian (NEA), across our dataset, with the exception of Northeast

Frans de Waal (1948–2024), primatologist who questioned the uniqueness of human minds

J. Hawks, 2024

Frans de Waal died earlier this month

- Widely known for his essays and books, he was one of the world's foremost researchers of nonhuman primates.
- De Waal's work helped both scientists and the public understand the sophistication and flexibility of social behavior in nonhuman primates. He approached all nonhuman animals with empathy and grace.
- His and others' research has progressively narrowed the perceived gap in cognitive ability between humans and non-human apes and other animals.

De Waal

- Many other people have reflected on the impact of his most famous book, Chimpanzee Politics: Power and Sex Among the Apes.

- First published in 1982, the book described the rich interactions of a group of around 25 captive chimpanzees at the Burger's Zoo in Arnhem, Netherlands

- Showed that the chimpanzees often acted in ways similar to social strategies devised by Renaissance diplomat Niccolò Machiavelli, as their alliances shifted in their pursuit of power.

Chimpanzee Politics: Power and Sex Among the Apes

- The book recounted episodes within the day-to-day lives of twenty-five chimpanzees, showing what led to aggressive conflicts, highlighting reconciliation, and pointing to moments of deliberate deception.

- No one could read the book without seeing the calculating minds behind these primates' interactions. De Waal did not describe apes as humanlike; he saw most of human behavior as a special case of ape behavior.

- Newt Gingrich gave a copy of the book to all new Republican House members

Newt Gingrich

- The 2007 reissue of Chimpanzee Politics includes this remarkable quote from Business Week:

- “Newt Gingrich has been an avid follower of de Waal's work for years. He has even placed de Waal's Chimpanzee Politics on his recommended reading list, along with better known texts such as the Declaration of Independence, the U.S. Constitution, and the Federalist Papers.

- What secrets has Gingrich gleaned from our simian cousins? In short, how to win power by forming tactical coalitions and mounting fierce psychological attacks on those blocking the way…It's a strategy Gingrich aped in his assault on former Speaker Jim Wright.

Prior studies of apes

- The study of primate social behavior had come a very long way in the two decades before de Waal began his work at the zoo in Arnhem in the 1970s.

- Until World War II, ethologists approached nonhuman primates with the idea that behavior was a result of instinct tempered by learning.

- Psychologists kept captive primates for experiments on operant conditioning, reinforcement, and other simple learning patterns. Not for observation.

Primate study

- Studies of wild primates were short, basic surveys of diet and social behavior carried out in expeditions of weeks or months. Such expeditions often ended by shooting the primates that were studied, bringing skins and skulls back to join museum collections.

- The groundbreaking work of Kinji Imanishi, who began field studies of Japanese macaques in 1948, began to change what scientists understood about primate behavior. By making careful records of individuals and their interactions, Imanishi and other researchers learned how day-to-day interactions were built from the complex intertwined histories of individuals.

Jane Goodall

- That project was followed by others, among the most well-known being Jane Goodall's work with wild chimpanzees at Gombe, Tanzania, Dian Fossey's research on mountain gorillas at Karisoke, Rwanda, and Jeanne and Stuart Altmann's work with baboons at Amboseli, Kenya.

- Such studies began to reveal how social interactions were shaped not only by mating systems and ecological surroundings, but also personalities, kinship relations, and reputation.

- Goodall had found that shifting alliances among the male chimpanzees were central to many interactions within the group. In a convergence of primatology with social science research in humans, such alliances became known as coalitions

Ape Machiavellianism

- By the 1970s, other researchers were documenting the centrality of such coalitions in social groups of other species. Maybe none were as impactful as Sarah Blaffer Hrdy's work with Hanuman langurs in India. She highlighted ways that male and female individuals had competing interests in mating, showing how their interactions, including aggression, coalition-building, and infanticide, were part of wider strategies to meet these competing demands.

- From these growing data emerged an understanding that nonhuman primates were in some ways Machiavellian. With his studies of the captive chimpanzee colony at Arnhem, de Waal teased apart some of the influences on their interactions. But even more important than de Waal's research results was his ability to translate this emerging scientific understanding for a broader public.

Bonobos vs chimps

▶ During the 1990s, de Waal himself shifted into another fascinating area: the study of bonobos.

▶ Chimpanzees and bonobos are sister species. Today we know that their common ancestors lived around two million years ago. The Congo River separates all bonobo populations from chimpanzees today, and likely was a barrier from the first separation of the two species.

▶ This history was not so clear in the 1990s. Still, it was clear that bonobos are equally close to humans as chimpanzees are. So, de Waal asked, why did so many anthropologists assume that humans had chimpanzee-like ancestors? Why not imagine a bonobo-like ancestor?

Chimps and Bonobos

- Looking at the anatomy of the two species, it might not seem to matter much. Their body plans are mostly similar, and even though bonobos were once called “pygmy chimpanzees”, the two species mostly overlap in body size.

- Both live in communities of 30 to 50 individuals with multiple male and multiple female adults. They knuckle-walk on the ground, climb trees easily and build nests at night, and their communities divide into smaller groups much of the time to find food, the “fission-fusion” organization.

Aggression vs Sex

- But with all these similarities, many social behaviors of the two species are starkly different. Chimpanzee groups are shaped by aggressive interactions among males. The male dominance hierarchy, sustained by coalitions that shift over time, determines access to favored foods and mating.

- Bonobo groups are shaped more by a female dominance hierarchy. Aggression is much more rare, and individuals often resolve potential disagreements with sexual interactions. Sexual contacts between adult females, between females and males, and among male individuals are all common.
- These basic differences in aggression and affiliation have many consequences across the social lives of each species.

Bonobo sexuality

- “Because the role of sex in society is such a loaded and controversial issue, scientists have tended to downplay this side of bonobo behavior, whereas the few journalists who have written about the species have naturally hyped it.

- Frans de Waal: “In this book, I hope to strike a balance: I intend to give the topic the attention it deserves, without reducing bonobos to the lustful satyrs that our closest relations once were considered to be. Sexual encounters of the bonobo kind are strikingly casual, almost more affectionate than erotic. If the apes themselves are so relaxed about it, it seems inappropriate for us to give in to typically human obsessions.”

Bonobo book

- De Waal's consideration of bonobos culminated in his 1997 book, *Bonobo: The Forgotten Ape*. He dived into the history of scientific study of these primates, and as in *Chimpanzee Politics*, he included some stories of his own research on the captive bonobos at the San Diego Zoo.

- De Waal recounted a history that I have told myself in many of my courses; how human evolution researchers once focused on hunting and aggression as roots of human behavior, leading to the idea of early hominins as “killer apes”. While the aggressive interactions of chimpanzees, with their occasional hunts of monkeys and other small mammals, might prompt such a comparison, nothing like this is apparent in the behavior of bonobos. Both species are equally close to humans, so why focus on one and not the other?

Cultural spread in primates

- His results demonstrated the cultural spread of novel tool use, generating local traditions and complementing the evidence for putative chimpanzee cultures in the wild.
- He returned to the theme of culture in his last work, *Different* (2022), in which he tackled the potentially treacherous topics of sex and gender. Noting evidence for primates culturally assimilating appropriate behavior for their sex, he argued that this is a manifestation of what we mean by gender — yet another phenomenon that is not unique to humans. Nor, as he showed, are homosexuality and gender transitions.
- The many puzzling contradictions of human behavior, from altruism and kindness to violence and genocide, become more comprehensible, de Waal argued, when viewed through the lens of the evolutionary ancestry that we can infer from all we have discovered about our contemporary primate cousins.

Who apes whom?

- He wrote an article on Homo naledi, “Who apes whom?”. The main idea of Frans' essay is that humans are not unique. We evolved from primate ancestors who share with us nearly everything once thought to be distinctive. “You name it”, he wrote, “tool use, tool making, culture, food sharing, theory of mind, planning, empathy, inferential reasoning—it has all been observed in wild primates or, better yet, many of these capacities have been demonstrated in carefully controlled experiments.”

- He ended his essay with a frank statement of human nonexceptionalism.

- “We are trying way too hard to deny that we are modified apes. The discovery of these fossils is a major paleontological breakthrough. Why not seize this moment to overcome our anthropocentrism and recognize the fuzziness of the distinctions within our extended family? We are one rich collection of mosaics, not only genetically and anatomically, but also mentally.”

Ape connections

- Most scientists readily accept the high degree of morphological and genetic continuity that connects us with ancient hominins. Yet many still resist the idea of mental continuity. They imagine a time that ancient humans suddenly transformed to “behavioral modernity”.

- According to this concept many behaviors and ways of thinking that humans share had emerged all together as a package: language, symbol recognition, creation of ornaments, use of pigments, and complex toolkits. This combination, the story goes, enabled our species to displace other hominins and ultimately drive them to extinction.

Connectedness to apes

- He regarded human uniqueness as a conceptional error. Ancestral hominins occupied the space between ape and human. If humans are more apelike than we usually admit, and apes more humanlike, then the space between apes and humans may be quite a lot smaller, easier for evolution to bridge.

- I think of one of the opening passages of *Bonobo*, which conveys the essential commonality between us and our close nonhuman relatives.

  - "When the lively, penetrating eyes lock with ours and challenge us to reveal who we are, we know right away that we are not looking at a "mere" animal, but at a creature of considerable intellect with a secure sense of its place in the world. We are meeting a member of the same tailless, flat-chested, long-armed primate family to which we ourselves and only a handful of other species belong. We feel the age-old connection before we can stop to think, as people are wont to do, how different we are."

His books

- All of his books reflect a broad engagement with culture and politics outside of academic research.
- *Peacemaking Among Primates* (1989) documented his discovery of reconciliatory behavior, in which two individuals would make up after a fight, embracing and grooming each other; he also researched consolation, in which a third party approached the loser to embrace or groom them. Both behaviors are similar to those seen in humans.
- Hawk's favorite of his books, which he has often assigned in courses, is The Ape and the Sushi Master: Cultural Reflections Of A Primatologist. Published in 2001, it was one of the first popular books to present the emerging science of cultures in nonhuman primates. The stories from the history of primatology that he shares in this book are part of the essential canon of primate behavioral ecology.

Epitaph

- He has many popular TED talks.

- A fitting epitaph might be the title of one of his books: *Good Natured* (1996). “One thing that I’ve seen often in my career is claims of human uniqueness that fall away and are never heard from again. We always end up overestimating the complexity of what we do … I’ve brought apes a little closer to humans but I’ve also brought humans down a bit.”

Primates

- The ancestors of the genus *Pan* split from the human line about 6-8 million years ago;

- Bonobos split from the common chimpanzee line about 2 million years ago

- As the two species are not proficient swimmers, the natural formation of the Congo River (around 1.5–2 million years ago) possibly led to the isolation and speciation of the bonobo. Bonobos live south of the river; Chimps on the north side.

Recent studies: Hunting

- Both bonobos and chimpanzees exhibit physical aggression more than 100 times as often as humans do

- Chimpanzees (*Pan troglodytes*) and bonobos (*P. paniscus*) hunt and consume the meat of various mammals.

- While primarily vegetarians, chimpanzees frequently hunt in groups for arboreal, group-living monkey species, bonobos focus on medium-sized terrestrial prey, such as forest antelopes (young duiker), flying squirrels and other rodents, which are caught opportunistically by single individuals

- The absence of monkey hunting by bonobos is often used to illustrate the divergent evolution of the two Pan species.

Bonobos

- Bonobos are omnivores: fruit (50% of diet; but not bananas), honey, eggs, soil, mushrooms, and insect larvae.

- Animal foods are only a small part of diet: beetles, bees, butterflies, snakes, shrews, earthworms, millipedes.

- But a recent study found: monkey hunting; catching of guenon and colobus monkeys, but not eating them, and bonobos and red colobus monkeys seen to engage in mutual grooming; At LuiKotale, both sexes were active in pursuing and hunting monkeys which confirms the active role of adult females in prey acquisition and meat sharing.

Differences in expression of male aggression between wild bonobos and chimpanzees - Maud Mouginot et al., 2024

- Classic view of bonobos (Pan paniscus) and chimpanzees (Pan troglodytes):
- Males in the two species exhibit contrasting patterns: male chimpanzees sexually coerce females and sometimes kill conspecifics, whereas male bonobos exhibit less sexual coercion and no reported killing.
- Among the various attempts to explain these species differences, the self-domestication hypothesis proposes negative fitness consequences of male aggression in bonobos.

Chimps vs “Hippie Chimps”

- Chimpanzee societies are dominated by males that kill other males, raid the territory of neighboring troops and defend their own ground with border patrols. Male chimpanzees also attack females to coerce them into mating, and sometimes even kill infants.

- Among bonobos, in contrast, females are dominant. Males do not go on patrols, form alliances or kill other bonobos. And bonobos usually resolve their disputes with sex — lots of it. They were “hippie” chimps.

- But these sweeping claims were not based on much data

Self-domestication theory

- In 2012, a trio of Harvard researchers proposed that bonobos evolved much like dogs did. Less aggressive wolves were not as likely to be killed by humans, which over time led to the emergence of dogs. In a similar fashion, the researchers argued, female bonobos preferred to mate with less aggressive males, giving birth to less aggressive offspring. The researchers called their idea the self-domestication hypothesis.

- Current study used 14 community-years of focal follow data—the gold standard for observational studies—to compare rates of male aggression in 3 bonobo communities at the Kokolopori Bonobo Reserve Democratic Republic of Congo, and 2 chimpanzee communities at Gombe National Park, Tanzania. Spent 9,300 hours of observations on 12 male bonobos and 14 male chimpanzees. Counted pushing and biting or simply chased their adversary.

Bonobo aggression: females like bad boy bonobos

- As expected, given that females commonly outrank males, we found that bonobos exhibited lower rates of male-female aggression and higher rates of female-male aggression than chimpanzees.
- Surprisingly, we found higher rates of male-male aggression among bonobos than chimpanzees even when limiting analyses to contact aggression. In both species, more aggressive males obtained higher mating success.
- Although our findings indicate that the frequency of male-male aggression does not parallel species difference in its intensity, they support the view that contrary to male chimpanzees, whose reproductive success depends on strong coalitions, male bonobos have more individualistic reproductive strategies.

Bonobos are more aggressive than previously thought

- Chimpanzees and bonobos are often thought to reflect two different sides of human nature—the conflict-ready chimpanzee versus the peaceful bonobo—but a new study published in *Current Biology* shows that, within their own communities, male bonobos are more frequently aggressive than male chimpanzees. For both species, more aggressive males had more mating opportunities.

- Though previous studies have investigated aggression in bonobos and chimpanzees, this is the first study to directly compare the species' behavior using the same field methods. The researchers focused on male aggression, which is often tied to reproduction

Male bonobos

- To their surprise, the researchers found that male bonobos were more frequently aggressive than chimpanzees.
- Overall, bonobos engaged in 2.8 times more aggressive interactions and three times as many physical aggressions.
- While male bonobos were almost exclusively aggressive toward other males, chimpanzees were more likely to act aggressively toward females.
- Chimpanzee aggression was also more likely to involve "coalitions" of males (13.2% vs. 1% of bonobo aggressions). The researchers think that these coalitions might be one reason why aggression is less frequent among chimpanzees.

Aggression differences

- Fights involving groups of males have the potential to cause more injuries, and within-community fighting could also weaken the group's ability to fight off other groups of chimpanzees.
- Bonobos don't have this issue because most of their disputes are one on one, they have never been observed to kill one another, and they are not thought to be territorial, which leaves their communities free to bicker among themselves.
- For both chimpanzees and bonobos, more aggressive males had greater mating success. The researchers were surprised to find this in bonobos, which have a co-dominant social dynamic in which females often outrank males, compared to chimpanzees, which have male-dominated hierarchies in which male coalitions coerce females into mating.

Chimpanzees murder, and bonobos don’t

- In their female-dominated society, male bonobos don’t face the risks that come with male alliances that characterize chimp society

- These findings partially contradict a prevailing hypothesis in primate and anthropological behavior—the self-domesticating hypothesis—which posits that aggression has been selected against in bonobos and humans but not chimpanzees.

- But the differences between the two species remain significant. Chimpanzees murder, and bonobos don’t.

Chimps and bonobos can recognize long-lost friends and family for decades

- UCB study: great apes and chimpanzees can recognize groupmates they haven't seen in over two decades—evidence of what's believed to be the longest-lasting nonhuman memory ever recorded.
- The findings also bolster the theory that long-term memory in humans, chimpanzees and bonobos likely comes from our shared common ancestor that lived between 6 million and 9 million years ago.
- The team used infrared eye-tracking cameras to record where bonobos and chimps gazed when they were shown side-by-side images of other bonobos or chimps.

L. Lewis, et al., 2023

Long term memory

- Participants' eyes lingered significantly longer on images of those with whom they had previously lived, suggesting some degree of recognition. In one case, a bonobo named Louise had not seen her sister, Loretta, or nephew, Erin, for over 26 years.
- What's more, participants looked longer at individuals with whom they had had more positive, as compared with antagonistic, relationships.
- Previous studies have shown that ravens, for example, remember people who tricked them and can recall social relationships in uncanny ways. Social memory beyond just a few years had previously been documented only in dolphins, which studies have found can recognize vocalizations for up to 20 years.

Trends in Intracranial and Cerebral Volumes of Framingham Heart Study Participants Born 1930 to 1970

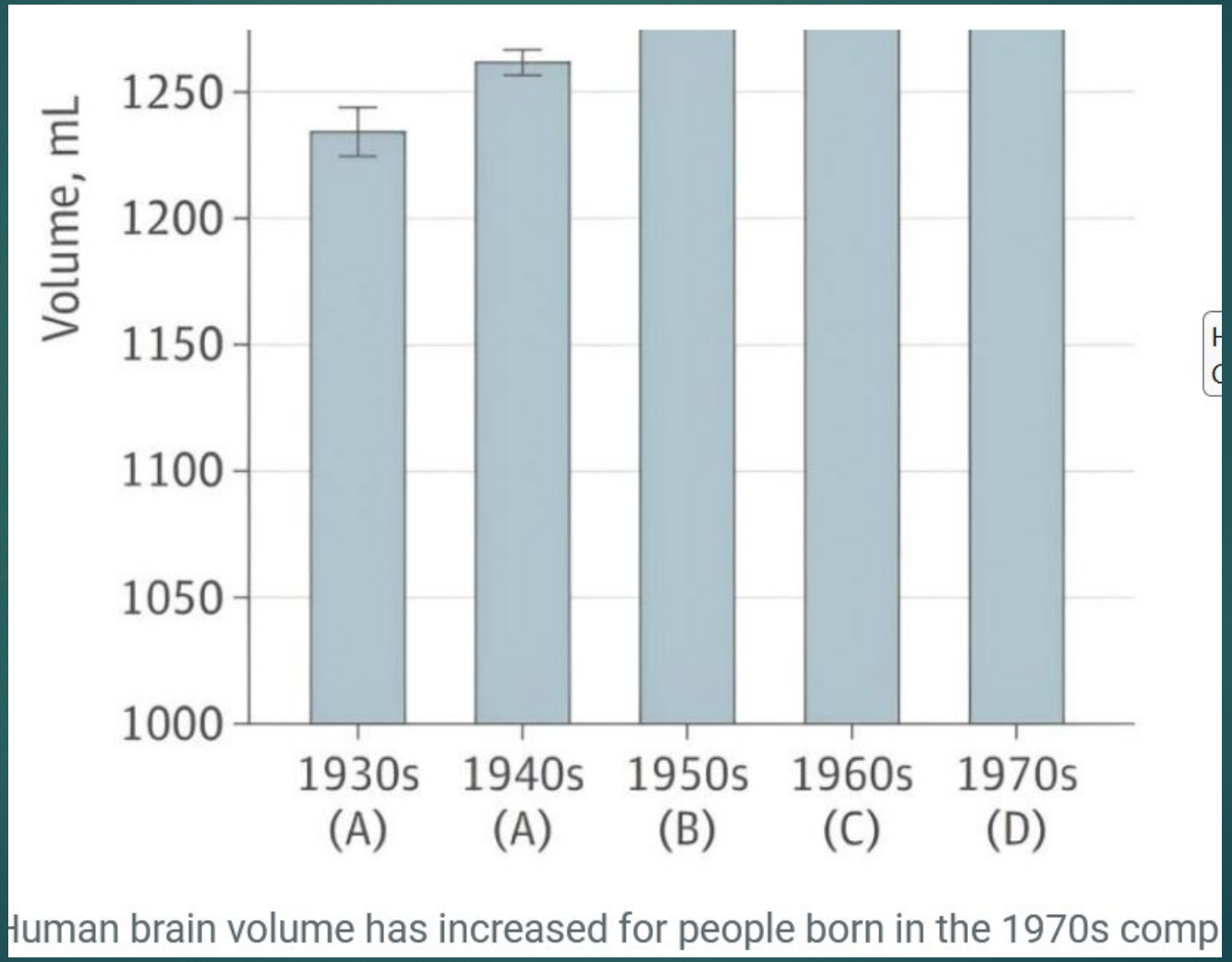
- A new study by researchers at UC Davis Health found human brains are getting larger.
- Study participants born in the 1970s had 6.6% larger brain volumes and almost 15% larger brain surface area than those born in the 1930s.
- Objective To examine environmental influences by testing whether time-dependent differences occurred in cranial and brain volumes and cortical thickness over birth decades spanning 1930 to 1970.

Charles DeCarli, MD, et al., 2024

Larger brains

- This cross-sectional study used data from the community-based Framingham Heart Study cohort for participants born in the decades 1930 to 1970.
- Participants did not have dementia or history of stroke and had magnetic resonance imaging (MRI) obtained from March 18, 1999, to November 15, 2019. The final analysis dataset was created in October 2023.
- Cross-sectional analysis of intracranial, cortical gray matter, white matter, and hippocampal volumes as well as cortical surface area and cortical thickness. The secular measure was the decade in which the participant was born. Covariates included age at MRI and sex.

Human brains are getting larger: That may be good news for dementia risk



Human brain volume has increased for people born in the 1970s comp

Larger brains

- Results The main study cohort consisted of 3226 participants with a mean age of 57.7 years at the time of their MRI. 53% women and 47% male. The birth decades ranged from the 1930s to 1970s.

- Significant trends for larger intracranial, hippocampal, and white matter volumes and cortical surface area were associated with progressive birth decades.
- ICV = Intracranial Volume
- Comparing the 1930s birth decade to the 1970s accounted for a 6.6% greater volume for ICV, 7.7% greater volume for white matter, 5.7% greater value for hippocampal volume, and a 14.9% greater value for cortical surface area.

Larger brains between 1930 to 1970s.

- **Conclusion:** In this study, trends for larger brain volumes suggested improved brain development among individuals born between 1930 and 1970.

- Early life environmental influences may explain these results and contribute to the declining dementia incidence previously reported in the Framingham Heart Study cohort.

Less dementia possible

- Data from the Framingham Heart Study (FHS), indicate that dementia incidence may be declining. While such factors as greater educational achievement[6] and medical management of vascular risk factors may explain part of this effect, early life environmental differences also likely contribute.
- Secular differences in ICV also remained significant after adjusting for height. We hypothesize that larger brain volumes indicate larger brain development and potentially greater "brain reserve" that could explain the declining incidence of dementia as previously reported.

Brain size issues

- How might these secular effects modify the likelihood of later life dementia? Brain growth begins in utero, increases throughout childhood, and reaches a maximum size in early adulthood. ICV is highly associated with brain growth during normal development, whereas aging or disease-related brain-volume decreases do not alter ICV.

- Thus, adult ICV is a stable and valid measure for maximal attained brain size, widely used as a proxy for brain reserve, and is an important predictor of cognition in old age.

Brain size

- Conversely, cross-sectional, and longitudinal age-related differences in brain volume measures are associated with cognitive performance in aging and disease.

- Hippocampal volume loss, in particular, is considered to be sensitive to early degenerative diseases such as Alzheimer disease.

- Although absolute volumes are not associated with cognitive ability per se, as illustrated by the fact that the women in this study had significantly smaller hippocampal volumes, but multiple studies show that cognitively normal women outperform men on tests of episodic memory.

Largeness

- However, loss of brain tissue within an individual is strongly indicative of pathological effects, which therefore may be buffered by larger structural brain development.
- Alternatively, larger structural brain development may be a surrogate for other processes ongoing during development and early adult life, such as increased brain connectivity.
- Increased connectivity is consistent with the radial unit lineage hypothesis that enables increased neuronal connectivity through cortical expansion and gyrification. Increased connectivity could explain our finding of increased white matter volume, could mitigate the impact of age-related diseases on cognitive performance, and fits well with the scaffolding hypothesis of cognitive reserve.

Conclusion

- In summary, our results indicate that ICV, white matter volume, and hippocampal volume as well as cortical surface area have increased over decades of birth ranging from 1930 to 1970.
- These findings likely reflect both secular improvements in early life environmental influences through health, social-cultural, and educational factors, as well as secular improvements in modifiable dementia risk factors leading to better “brain health” and reserve.
- While these effects are likely to be small at the level of the individual, they are likely to be substantial at the population level, adding to growing literature that suggests optimized brain development and ideal health through modification of risk factors could substantially modify the effect of common neurodegenerative diseases such as stroke and Alzheimer disease on dementia incidence.

The Most Mysterious Cells in Our Bodies Don't Belong to Us

- You carry literal pieces of your mom—and maybe your grandma, and your siblings, and your aunts and uncles.

- A XX woman with functional Y chromosomes in her thyroid example; had carried a male embryo

- Just about every time an embryo implants and begins to grow, it dispatches bits of itself into the body housing it. The depositions begin at least as early as four or five weeks into gestation. And they settle into just about every sliver of mother's anatomy

Katherine J. Wu, 2023

Microchimerism

- Cells might linger, grow, and divide for decades, or even, as many scientists suspect, for a lifetime. They can almost be thought of as evolution's original organ transplant.

- Microchimerism may be the most common way in which genetically identical cells mature and develop inside two bodies at once.

- These cross-generational transfers are bidirectional. Some researchers believe that people may be miniature mosaics of *many* of their relatives, via chains of pregnancy: their older siblings, perhaps, or their maternal grandmother

You carry your entire family in you.

- It's thought to affect every person who has carried an embryo, even if briefly, and anyone who has ever inhabited a womb.

- Other mammals—mice, cows, dogs, our fellow primates—seem to haul around these cellular heirlooms too.

- Hypotheses about what these cells do—if anything at all—remain "highly controversial; might help fine-tune their immune system, steeling the newborn body against viral infections

Microchimerism

- People are better at accepting organs from their mother than from their father

- Long-term, women with more fetal cells are also more likely to develop certain kinds of autoimmune disease; but also: fetal cells might sometimes protect against autoimmunity, leading a few conditions, such as rheumatoid arthritis, to actually abate during and shortly after pregnancy.

- Scientists aren't sure whether the foreign cells are causing damage, repairing it, or simply bystanders,

Have you ever wondered if your tendency to rise early might be linked to your genetic heritage?

- Remnants of Neanderthal DNA in some modern humans could play a role in determining whether individuals naturally lean towards being early risers.
- Neanderthal DNA associated with chronotype consistently increased the likelihood of individuals being morning people.
- Researchers found that individuals living at higher latitudes, experiencing more pronounced seasonal variations in light and darkness, tended to exhibit increased "morningness."
- Study uncovered a link between behavioral morningness and accelerated activity within the circadian gene network, which could confer an advantage in adapting to changing environments.

Morningness

- In this study, researchers analyzed 246 circadian-related genes and detected genetic variants potentially influencing the circadian clock. The study uncovered consistent evidence that certain genetic variants of Neanderthal origin consistently increased morningness among individuals.
- The study emphasized that while many aspects of Neanderthal DNA were not beneficial and were removed by natural selection, some traces have endured in human populations.
- Capra highlighted potential benefits such as enhancements in the immune system, metabolic processes, and hair and skin quality attributed to Neanderthal DNA.
- Note that there are many morning people who lack these specific Neanderthal variants, indicating the multifaceted nature of this trait.

The evolutionary drivers and correlates of viral host jumps

- Most emerging and re-emerging infectious diseases are caused by viruses circulating in animals.

- When these viruses cross over from animals into humans, a process known as zoonosis, they can cause disease outbreaks, epidemics and pandemics such as Ebola, flu or COVID-19.

- Given the enormous impact of zoonotic diseases on public health, humans have generally been considered as a sink for viruses rather than a source, with human-to-animal transmission of viruses receiving far less attention.

Cedric C. S. Tan, et al., 2024

Viruses

- Analyzed the nearly 12 million viral genomes that have been deposited on public databases to date. Leveraging this data, they reconstructed the evolutionary histories and past host jumps of viruses across 32 viral families, and looked for which parts of the viral genomes acquired mutations during host jumps.

- To investigate the relative frequency of anthroponotic (human to animal) and zoonotic (animal to human) host jumps, retrieved 58,657 quality-controlled viral genomes spanning 32 viral families, associated with 62 vertebrate host orders and representing 24% of all vertebrate viral species

Genome study shows humans pass more viruses to animals than we catch from them

- Roughly twice as many host jumps were inferred to be from humans to other animals (known as anthroponosis) rather than the other way round.

- This pattern was consistent throughout most viral families considered. Additionally, they found even more animal-to-animal host jumps, that did not involve humans.

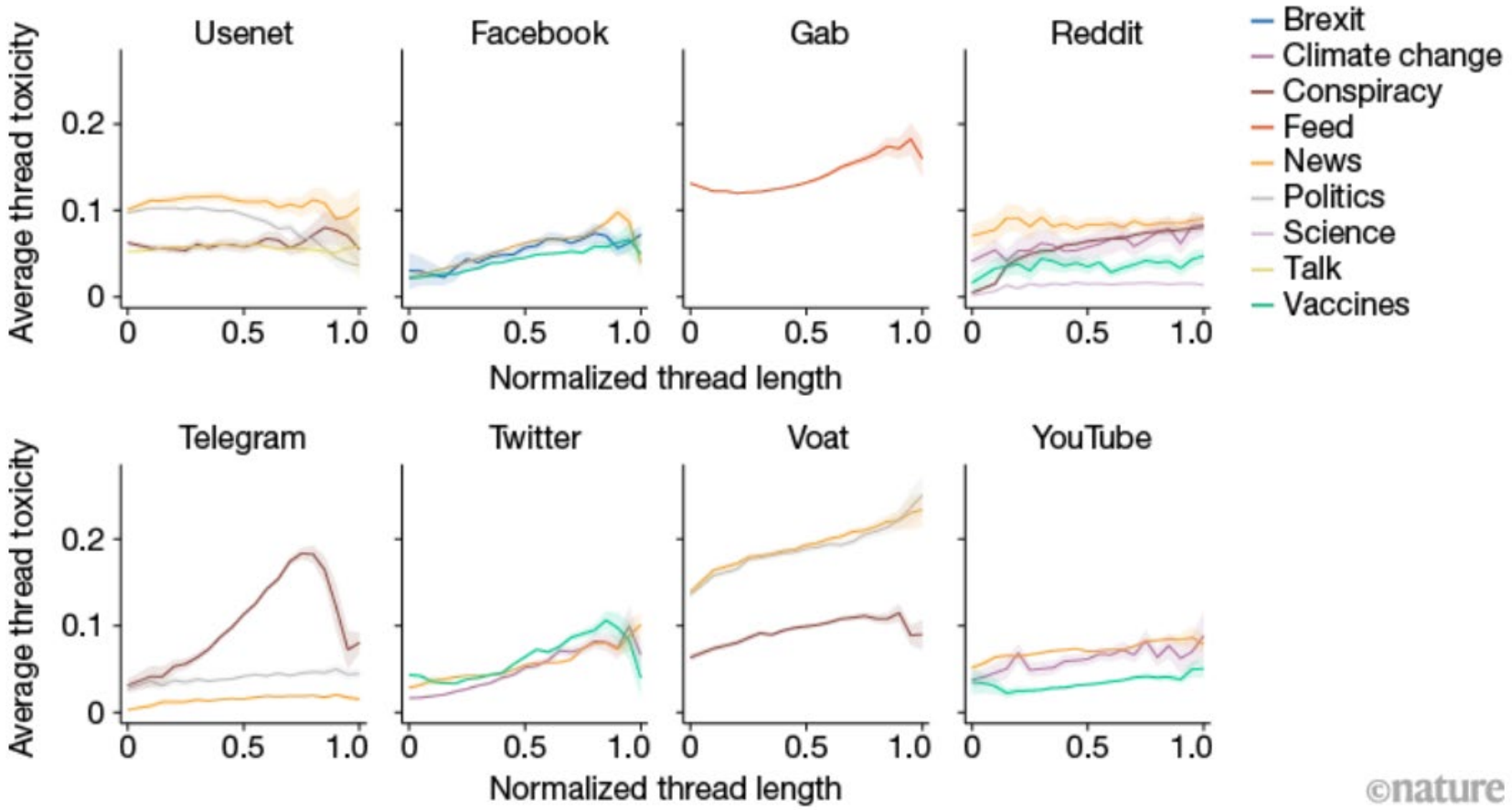
- The team's work highlights the high and largely underappreciated fact that human viruses frequently spread from humans into wild and domestic animals.

Increase in mutations in viruses

- On average, viral host jumps are associated with an increase in genetic changes, or mutations in viruses, relative to their continued evolution alongside just one host animal, reflecting how viruses must adapt to better exploit their new hosts.

- Further, viruses that already infect many different animals show weaker signals of this adaptive process, suggesting that viruses with broader host ranges may possess traits that make them inherently more capable of infecting a diverse range of hosts, whereas other viruses may require more extensive adaptations to infect a new host species.

Keep your online discusses short: Toxicity (a rude, disrespectful or unreasonable comment likely to make someone leave a discussion) increases with conversation length



Godwin's law: as the length of an online discussion increases, it becomes more likely that someone will make a comparison that mentions Nazis

Toxic discourse is inevitable in long online discussions.

Avalle, M. *et al.*, 2024

Evaluation of 34 years of 500 million online comments

- Conclusions: increased incivility in online discussions
  - Online conversations show a decrease in user participation over time but an increase in activity among participants.
  - Majority of active online users wrote at least one toxic comment,
  - Online users seek out and align with information that echoes their pre-existing beliefs, often ignoring contrasting views
  - People form opinions based on their beliefs rather than the information presented and this increases polarized perspectives,

Conclusions

- The longer the online conversation, the more toxic it tends to be; long conversations consistently exhibit higher toxicity,
- Toxic language does not invariably discourage people from participating in a conversation
- Debates and contrasting sentiments among users significantly contribute to more intense and hostile discussions

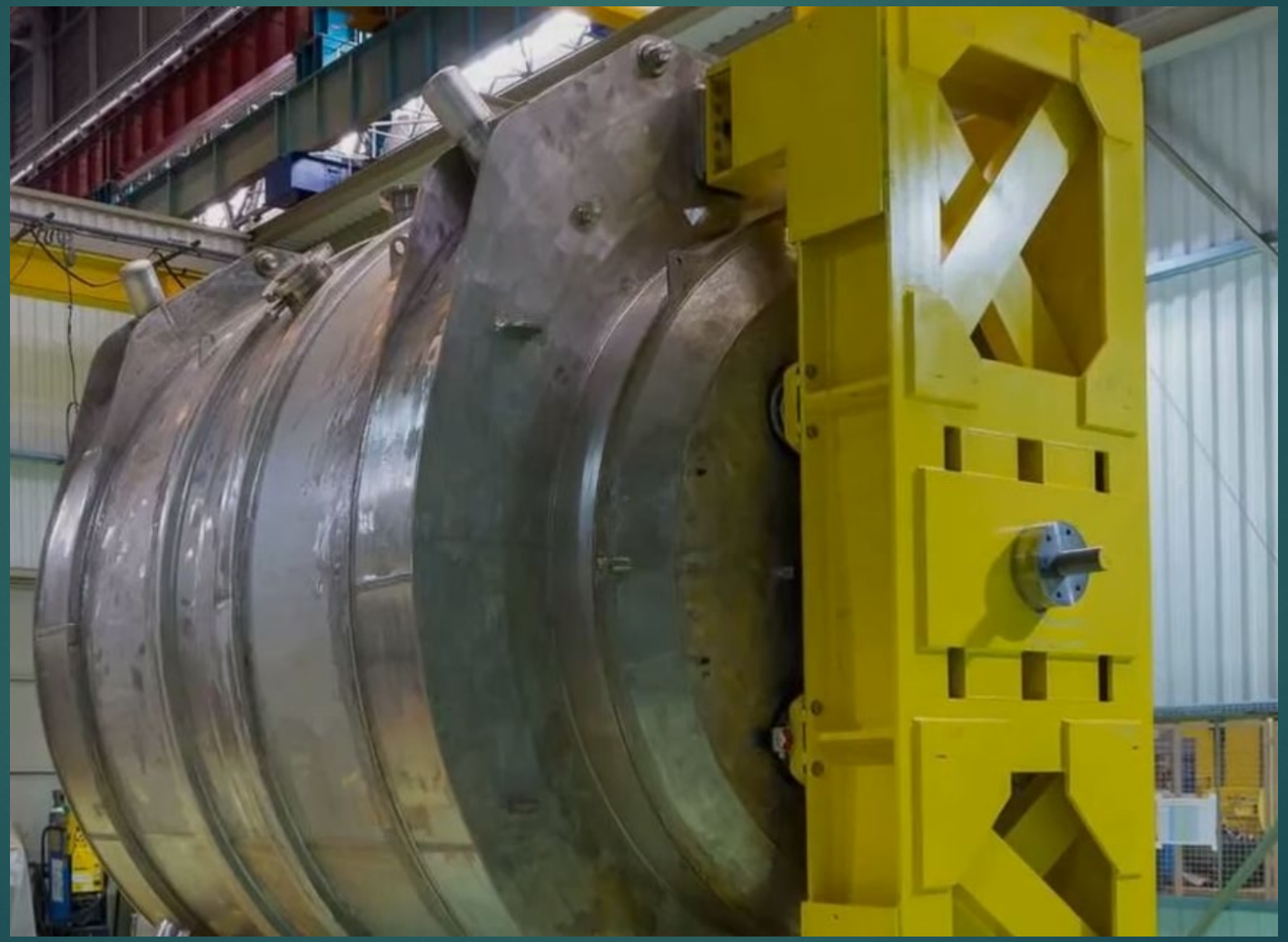
A floor tile made of Italian Travertine A Neandertal mandible

Reconstructed Florisbad skull, H. helmi, central S. Africa, 1280-1450 cc, 260-350 ka; part of the genetic soup from which emerged the probable Pan-African origin of *H. sapiens*

11.7 Teslas MRI Imaging: 20 years of R&D as part of the Iseult project

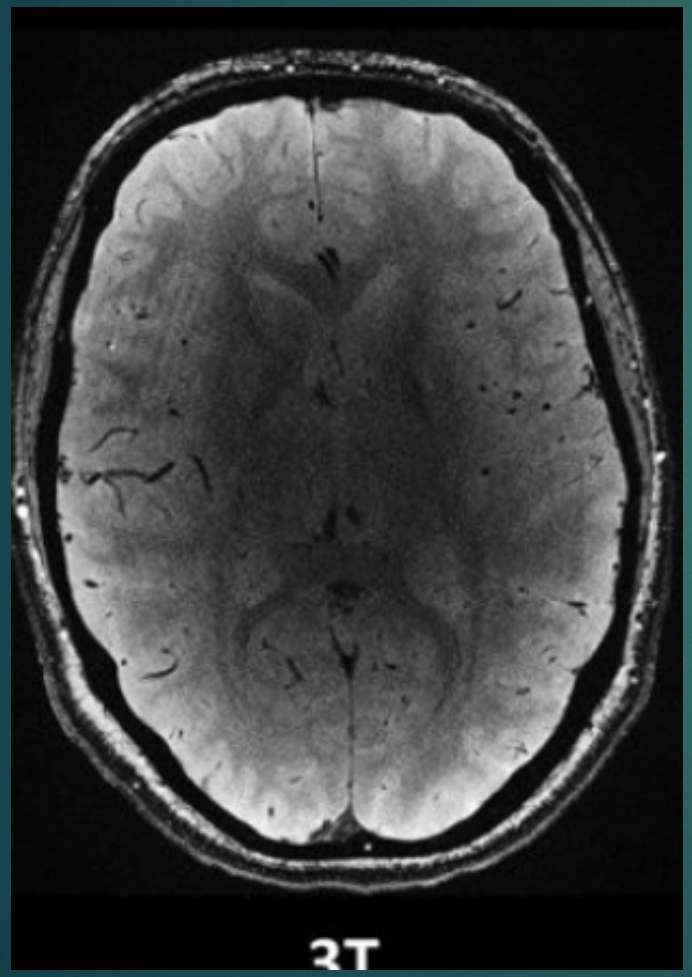
- 11.7 teslas (T) magnetic field strength MRI (vs 1.5 and 3 T for conventional MRI machines in hospitals)
- 132 tons, 5 m long and 5 m wide
- 182 km of superconducting wires
- 1 500 amperes running through the coil
- -271.35 °C: the temperature at which the magnet is cooled by using 7,500 liters of liquid helium
- 90 cm of central opening
- The images have an impressive resolution with 4 minute acquisition time – 0.2 mm in-plane resolution and 1 mm slice thickness, which represents a volume equivalent to a few thousand neurons

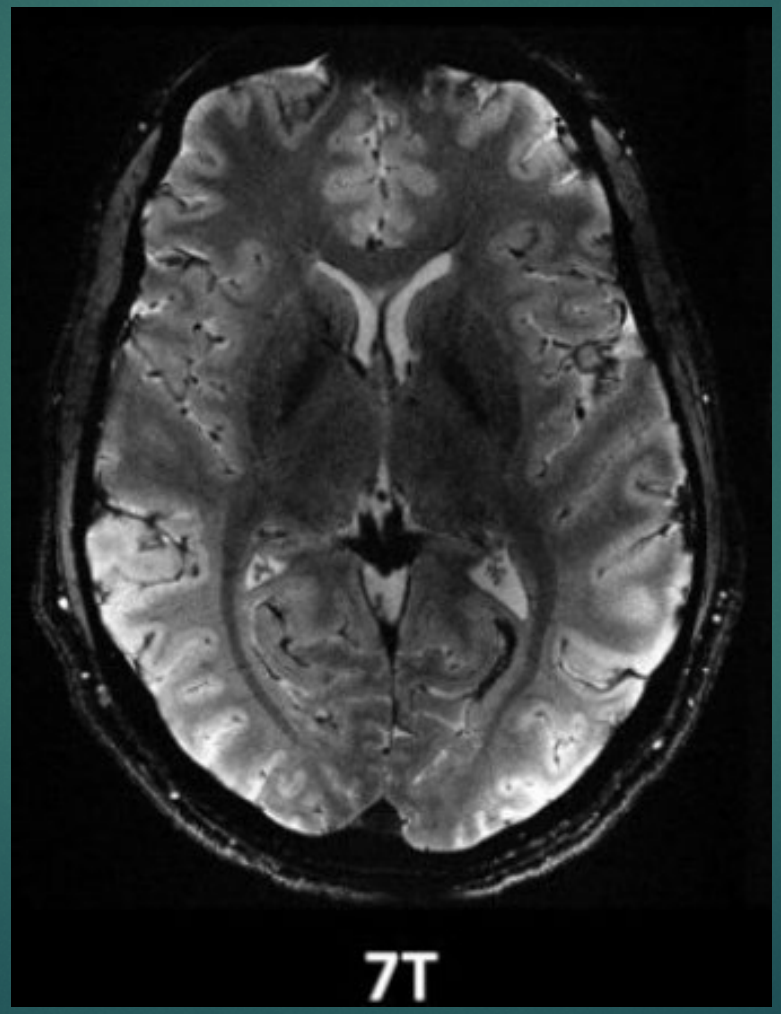
The Magnet

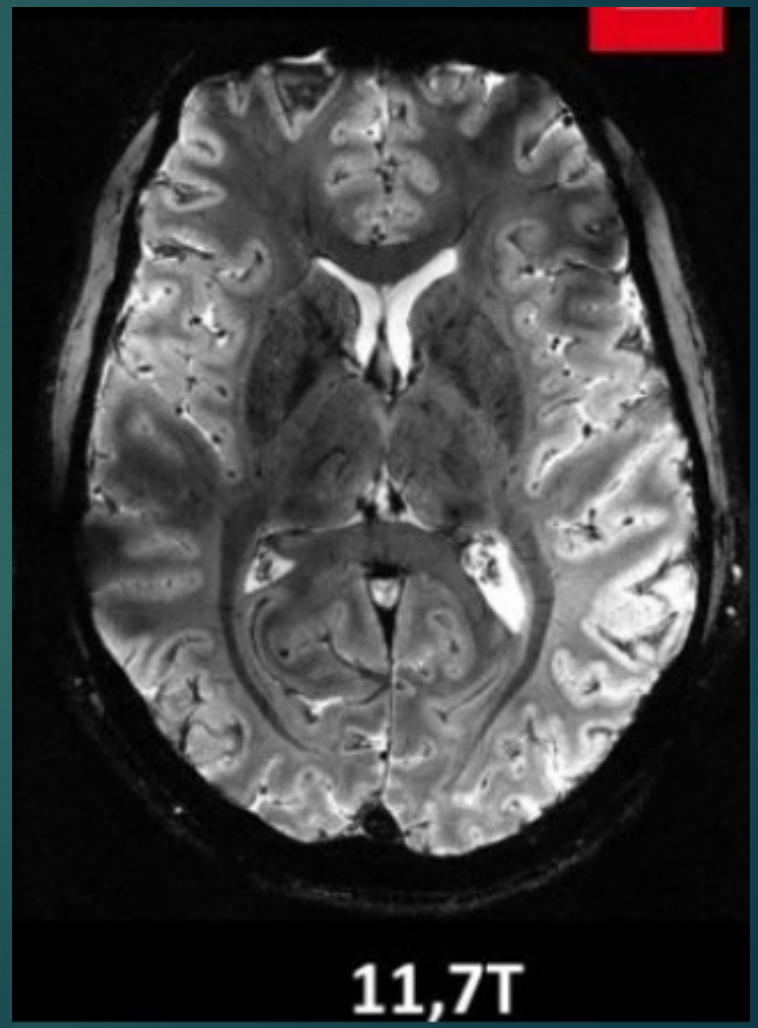


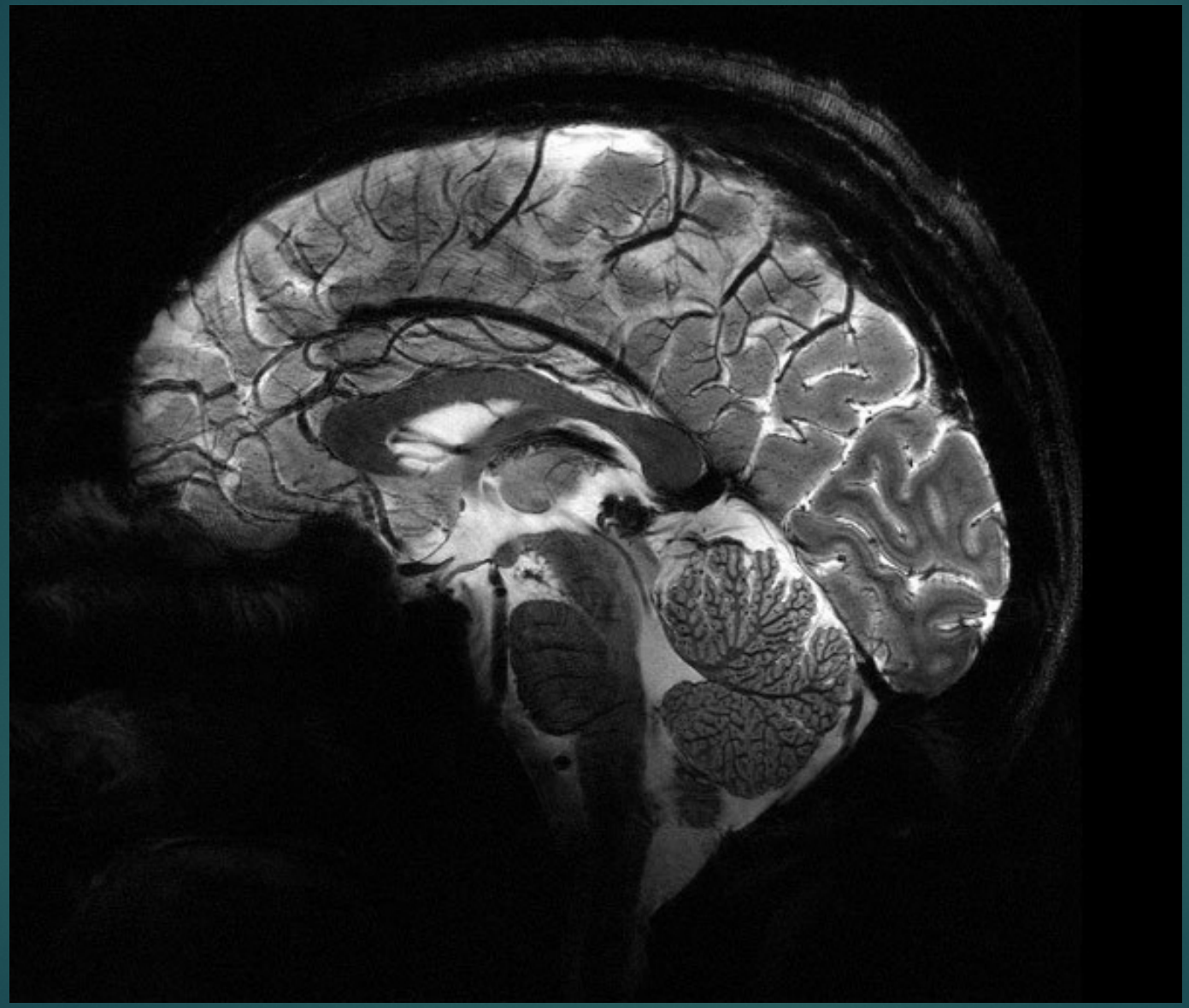
Resolution of 100-200 microns (5 large/50 small neurons)

MRI comparisons









Germany is working on a 14 T MRI system

Foxes as Prehistoric Pets

- Foxes may have been more than just wild animals to our ancestors.
- In Patagonia, Argentina, researchers1 uncovered a remarkable burial: a fox interred alongside a human, dating back 1,500 years. The analysis indicates that the fox shared meals with prehistoric hunter-gatherers, suggesting it held a cherished place within the community.
- Teeth of wild foxes have been found in ancient human burial sites across Argentina and Peru, hinting at the animal's symbolic significance. However, the discovery of a complete fox skeleton within a human grave is exceptionally rare in global archaeological records.

Cinthia C. Abbona, et al., 2024

Foxes as companions

- The fox, identified as *Dusicyon avus*, weighed between 10-15 kg and went extinct approximately 500 years ago, shortly after domestic dogs arrived in Patagonia. Its presence in human burials suggests a close bond that transcended mere symbolism.
- The findings indicate that a *Dusicyon avus* individual shared a similar diet and was probably buried alongside humans, suggesting a close relationship between the two species during their lives and deaths.
- The introduction of domestic dogs in South America from Mesoamerica by indigenous people *ca* 5000 years BP and their arrival in Patagonia *ca* 700–900 years BP may have also led to hybridization events between the two species, potentially further contributing to its extinction.

Fox burial

- It is possible that the fox was intentionally buried, becoming the first record of a complete skeleton of this fox species buried alongside humans.
- The most plausible explanation is that this fox was a valuable companion to the hunter-gatherer groups
- Examined isotopic signatures preserved in the fox's teeth. While most wild canids eat almost exclusively meat, a portion of the fox's diet was composed of maize-like plant material. This mirrors the amount of plant material that the humans buried at Cañada Seca were eating.
- The close association with human remains and shared dietary patterns suggests that this was a valuable individual, maybe even a companion or a pet for the hunter-gatherers during the late Holocene.

Remember Russian domesticated silver foxes

- The **domesticated silver fox** (*Vulpes Belyaev's* forma *amicus*) is a form of the silver fox that has been to some extent domesticated under laboratory conditions.
- Domesticated silver foxes are the result of a Russian experiment designed to demonstrate the power of selective breeding to transform species,
- Selection for behavior rather than morphology may have been the process that had produced dogs from wolves.
- By recording the changes in foxes when in each generation only the most tame foxes were allowed to breed

What is the domestication syndrome

- **Domestication syndrome** refers to two sets of phenotypic traits that are common to either domesticated plants or domesticated animals.

- Domesticated animals tend to be smaller and less aggressive than their wild counterparts, they may also have floppy ears, variations to coat color, a smaller brain, and a shorter muzzle . These animal traits have been claimed to emerge across the different species in response to selection for tameness,

1969: First floppy ears

Russian experiment

- After over 40 generations of breeding, Russian scientist Dmitry Belyayev produced "a group of friendly, domesticated foxes who 'displayed behavioral, physiological, and anatomical characteristics that were not found in the wild population, or were found in wild foxes but with much lower frequency. Described by *The New York Times* as "arguably the most extraordinary breeding experiment ever conducted."

- Many of the domesticated foxes had floppy ears, short or curly tails, extended reproductive seasons, changes in fur coloration, and changes in the shape of their skulls, jaws, and teeth. They also lost their 'musky fox smell'.

40 Years

- Believed "that after 40 years of the experiment, and the breeding of 45,000 foxes, a group of animals had emerged that were as tame and as eager to please as a dog.“

- “Siberian gray rats caught in the wild, bred separately for tameness and for ferocity have developed ... entirely different behaviors in only 60 or so generations". When geneticist Svante Pääbo was in Novosibirsk in 2003, he visited the institute, and "was stunned" by the two groups of rats

Critique: The History of Farm Foxes Undermines the Animal Domestication Syndrome - Kathryn A. Lord, et al., 2019

- The Russian Farm-Fox Experiment is the best known experimental study in animal domestication. By subjecting a population of foxes to selection for tameness alone, Dimitry Belyaev generated foxes that possessed a suite of characteristics that mimicked those found across domesticated species.
- Critique: widespread misconception maintains that the Farm-Fox Experiment started with wild foxes and recapitulated the entire process of domestication. Belyaev himself accurately described the founders as fur-farm foxes, but by referring to the unselected population as 'wild controls', contributed to this misconception.
- In reality, the experiment started with a fox population from eastern Canada that had been captive and purpose-bred since the late 1800s, something Belyaev and his colleagues may have been initially unaware of.

The original foxes were Canadian not Russian

- Wild foxes are generally monogamous, monstrous (having one estrous cycle per year), seasonal breeders and notorious escape artists. Whether wild or captive born, most foxes would not breed in captivity, and females often ate their young.
- From the start, the Canadian foxes were selected for both appearance and behavior. Dalton bred jet-black foxes, while Oulton favored white barring on guard hairs. While we found no reports of intentional selection for affiliative behavior, contemporary experts linked docility to improved fecundity. and the PEI farm foxes were unusually friendly. By 1913, breeding pairs sold for $30 000, equivalent to US $500 000 today.
- The overall weight of evidence, including data from other species, does not unambiguously support the existence of the domestication syndrome in animals.

Originally friendly foxes

- The Russian Farm-Fox Experiment started with foxes descended from a population of unusually friendly Canadian foxes – a phenomenon Belyaev accentuated by preferentially including exceptionally calm foxes. Mitochondrial DNA analyses of 24 Farm-Fox Experiment foxes showed 100% of haplotypes derived from Canadian foxes.
- The Canadian Farm-Fox population was initially established in the late 1800s with a small number of individuals (introducing a strong founder effect) and was subsequently subjected to strong selection for behavioral and morphological characteristics.
- The Farm-Fox Experiment selected for a behavioral trait that already existed in the population, essentially recapitulating a selection experiment performed on numerous occasions with dog breeds, i.e. dogs that don't kill livestock

Dogs and rats

- This Canadian history reframes the behavioral selection in the Farm-Fox Experiment as selection on standing genetic variation and explains the rapid behavioral change (within ten generations).

- A study in dogs saw change within just three generations after starting with founders exhibiting the trait of interest (nervousness).

- When Belyaev started a rat experiment with commensal rats living close to humans, significant behavioral changes occurred within 13 generations.

Chance alone?

- This history also makes it difficult to validate domestication syndrome. The Farm-Fox Experiment population experienced at least three major founder events at the founding of Canadian fox farms, the importation to Russia, and the inclusion in Belyaev's experiment.
- Like dog breeds, both the selected and unselected fox populations have small effective population sizes, making them susceptible to **genetic drift.** Thus, even large allele-frequency differences between the two populations can be explained by chance alone.
- The history of the Farm-Fox population undermines the commonly repeated narrative that a suite of domestication syndrome traits emerged solely as a result of selecting on tameness.

Chance alone

- There is no temporal link between most of the syndrome traits, which first appeared in the Canadian fur farms, and the later behavioral selection in Russia. The rate of behavioral change is consistent with selection on standing variation in the population.
- Finally, the small **effective population size** makes the experimental fox populations highly susceptible to large shifts in allele frequencies due to chance alone.
- Taken together, the results from the Farm-Fox Experiment offer little support for the existence of the domestication syndrome in animals. In addition to the uncertainty about whether the population can be referred to as domesticated, many of the purported domestication syndrome traits predate the experiment, making it impossible to infer a causal relationship with behavioral selection

Foxes

- While many canids (e.g., wolves) actively avoid human contact, wild foxes regularly live commensally with humans and have been known to use cat doors to access dens under homes, can be tamed, and may have been exploited in the earliest human settlements

- While the Russian study established a model system ideal for mapping genetic loci that shape complex behavioral traits, the Farm-Fox Experiment does not, however, validate the domestication syndrome.

Natural Selection in the Peppered Moth: Was the original experiment fraudulent?

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

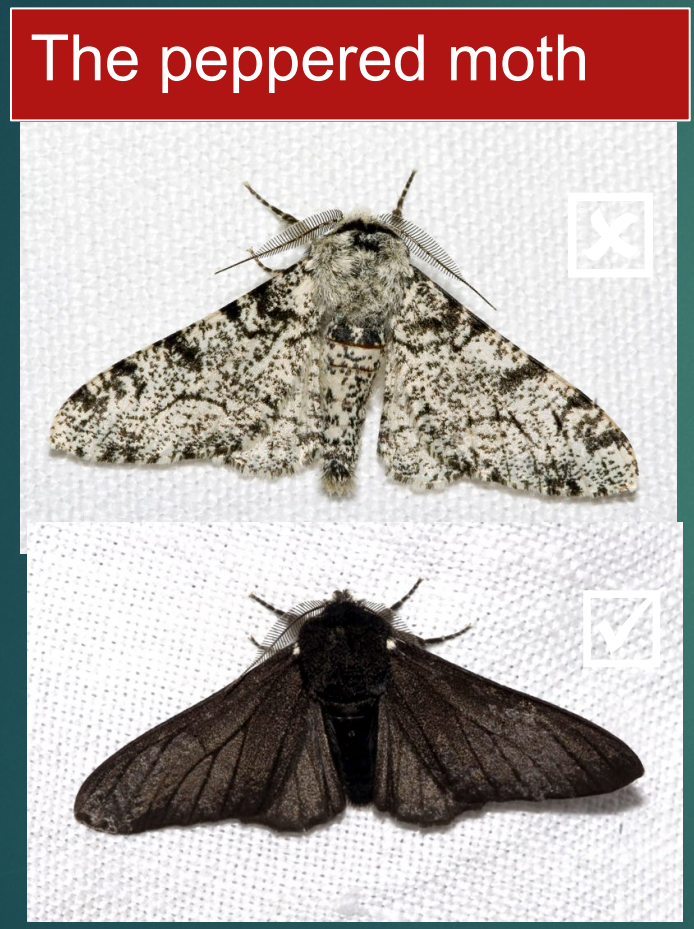
Peppered Moth

- Which moth will the bird catch?

A

B

Peppered Moth (*Biston betularia*)



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

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

History of the debate over reality of this proof of evolution

- The **evolution of the peppered moth** is an evolutionary instance of directional color change in the moth population as a consequence of air pollution during the Industrial Revolution.
- The frequency of dark-colored moths increased at that time, an example of industrial melanism. Later, when pollution was reduced, the light-colored form again predominated.
- Industrial melanism in the peppered moth was an early test of Charles Darwin's natural selection in action, and it remains a classic example in the teaching of evolution. In 1978, Sewall Wright described it as "the clearest case in which a conspicuous evolutionary process has actually been observed."

History

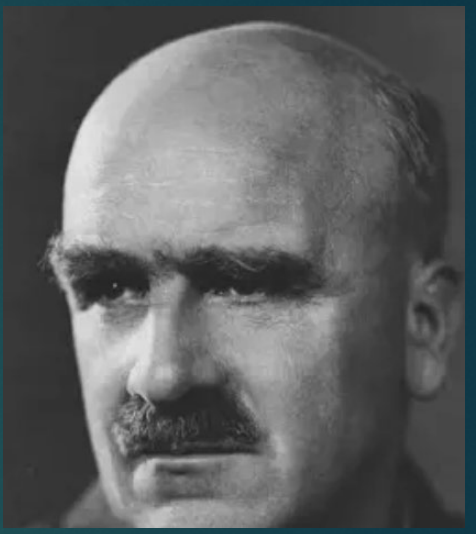
- The dark-colored or *melanic* form of the peppered moth (var. *carbonaria*) was rare After field collection in 1848 from Manchester, an industrial city in England, the frequency of the variety was found to have increased drastically. By the end of the 19th century, it almost completely outnumbered the original light-colored type (var. *typica*), with a record of 98% in 1895.

- It was 14 years after Darwin's death, in 1896, that J. W. Tutt presented it as a case of natural selection. Because of this, the idea spread widely, and more people came to believe in Darwin's theory.

Later research

- Bernard Kettlewell was the first to investigate the evolutionary mechanism behind peppered moth adaptation, between 1953 and 1956. He found that a light-colored body was an effective camouflage in a clean environment, such as in rural Dorset, while the dark color was beneficial in a polluted environment like industrial Birmingham.
- This selective survival was due to birds, which easily caught dark moths on clean trees and white moths on trees darkened with soot.
- The story, supported by Kettlewell's experiment, became the canonical example of Darwinian evolution and evidence for natural selection used in standard textbooks
- From around 1962 to the present, the phenotype frequency of *carbonaria* has steadily fallen in line with cleaner air around industrial cities. Its decline has been measured more accurately than its rise, through more rigorous scientific studies. Notably, Kettlewell conducted a national survey in 1956, Bruce Grant conducted a similar one in early 1996, and L.M. Cook in 2003

Haldane uses the peppered moth to create population genetics



- J.B.S Haldane's statistical analysis of selection for the melanic variant in peppered moths became a well-known part of his effort to demonstrate that mathematical models that combined natural selection with Mendelian genetics could explain evolution – an effort that played a key role in the foundation of the discipline of population genetics, and the beginnings of the modern synthesis of evolutionary theory with genetics.

Was the Peppered Mouth experiment a research fraud?

- Theodore David Sargent performed experiments between 1965 and 1969, from which he concluded that it was not possible to reproduce Kettlewell's results, and said that birds showed no preference for moths on either black or white tree trunks. He suggested that Kettlewell had trained the birds to pick moths on tree trunks to obtain the desired results.

- Failure to replicate the experiment and Theodore David Sargent's criticism of Kettlewell's methods in the late 1960s led to general skepticism.

- Jerry Coyne noted these points, and concluded that "for the time being we must discard *Biston* as a well-understood example of natural selection in action."

Of Moths and Men

- Judith Hooper's book *Of Moths and Men* (2002) severely criticized Kettlewell's experiment. Hooper argued that Kettlewell's field notes could not be found and suggested that his experiment was fraudulent, on the basis of Sargent's criticisms alleging that the photographs of the moths were taken of dead moths placed on a log.
- The book's reception led to demands that the peppered moth evolution story be deleted from textbooks.
- The criticism became a major anti-evolution argument made by creationists. Claimed peppered moths do not normally rest on tree trunks and that photos were staged.
- Scientists have examined the allegations made by Hooper, and found them to be without merit

6-year study proves original theory

- Michael Majerus was the principal defender of the original theory. His seven-year experiment beginning in 2001, the most elaborate of its kind in population biology, the results of which were published posthumously in 2012, vindicated Kettlewell's work in great detail.
- The experiment became the largest ever in the study of industrial melanism, involving 4,864 individuals in a six-year investigation, and it confirmed that melanism in moths is a genuine example of natural selection involving camouflage and predation
- He described his results as a complete vindication of the natural selection theory of peppered moth evolution; proved moths did land on tree trunks and that birds were the predators.
- This restored peppered moth evolution as "the most direct evidence", and "one of the clearest and most easily understood examples of Darwinian evolution in action"

May 2024
Monday CAS

Language at 1.6 Ma

- “The Language Puzzle: Piecing Together the Six-Million-Year Story of How Words Evolved,” written by British archaeologist Steven Mithen.
- Drawing upon insights from archaeology, paleo-anatomy, genetics, neuroscience, and linguistics, Mithen's meticulous analysis has unearthed evidence suggesting that the birth of language predates previous estimates by a staggering margin—ushering humanity's linguistic journey back to a momentous juncture approximately 1.6 million years ago.
- Traditionally, the narrative of human evolution had fixated on the emergence of speech around 200,000 years ago

- Central to Mithen's thesis is the notion that language did not arise in isolation but rather emerged as an integral component of a broader suite of evolutionary developments. From the expansion of the human brain and the reorganization of neural structures to the refinement of motor skills and the co-evolution of cultural practices, the birth of language reverberated across myriad facets of human existence.
- The emergence of Broca's area—an enigmatic region of the brain intricately linked to language production and comprehension—emerges as a linchpin in Mithen's narrative.
- Language, Mithen posits, catalyzed a revolution in social organization, facilitating collaborative endeavors, collective decision-making, and the transmission of knowledge across generations.

- From the proliferation of sophisticated stone tool technologies to the emergence of communal hunting strategies and coordinated group activities, the advent of language imbued humanity with a strategic advantage in navigating the complexities of the prehistoric landscape.
- Available on June 18, 2024.

G Factor (IQ) in humans and dogs

- In humans, success in various cognitive tests tends to correlate positively; for example, individuals who excel in math may also ace their literature essay.
- Human cognitive abilities are thus somewhat centralized, but also organized hierarchically, from specific task performances to broader cognitive domains.
- At the apex of this hierarchy lies the so-called general cognitive factor, or the g factor. This g factor is a fundamental component of intelligence; it encompasses and influences all underlying cognitive abilities, and is also closely related to academic, workplace, and career success.
- The g-factor is used to explain this positive statistical correlation among cognitive abilities and is considered to be a measure of general intelligence

Canine G factor

- To investigate this, researchers compiled a series of seven tasks to assess the cognitive performance of 129 family dogs aged between three and fifteen years, tracking them over two and a half years.
- Researchers identified two broad cognitive domains: independent problem-solving, which included tests of persistence, problem-solving, and memory, and learning ability, which encompassed associative learning and one-trial learning tests.
- These domains were interconnected, indicating that dogs with better problem-solving skills generally learned new tasks more quickly, confirming the existence of a higher-order, general cognitive factor that ties them together. Drawing from human literature, the authors referred to this as the "canine g factor."

G factor

- Tasks: pointing, Manipulative persistency, Clicker game, problem solving, attention, training for eye contact, memory, Exploration and box rustle, Novel object recognition, exploration, discrimination, reversal learning
- High explorative behavior and low neophobia have been consistently found to be positively related to cognitive performance in different tasks across a wide range of species. These behaviors are close to the openness to experience personality trait in humans, which has the strongest link to IQ among the Big Five traits (extroversion, agreeableness, openness, conscientiousness, and neuroticism.).
- 1st common factor = problem solving & memory
- External validation linked the common factor positively to discrimination and reversal learning performance, exploration, neophilia, activity/excitability, and training level while negatively to cognitive dysfunction symptoms, suggesting that it is a good candidate for a general cognitive factor (canine g).

G factor

- The results revealed that dogs with high g factor scores were more inclined to explore unfamiliar environments, showed greater interest in novelties, and performed better in new learning situations than dogs with lower scores. Moreover, the dogs' g scores were also related to their personalities, which were measured using a questionnaire filled out by the dog owners.
- A high g factor score was associated with higher levels of activity, training level, and trainability. These findings confirmed that the canine g factor resembles the human g factor not only in the structure but also in external correlations.
- The canine g factor score decreased with age. However, this decline was influenced by the health status of the dogs; dogs in poorer health exhibited a faster decline in the g factor value with age, whereas no significant change with age was observed in dogs in good health.

Did a "Sea-ice Highway" facilitate early human migration from Beringia into North America along the coastal route?

- Mounting evidence from archaeological sites in the Americas suggests humans had arrived in North America by at least 16 ka, and possibly as early the last glacial maximum (LGM; 26.5-19 ka). This time window would require populations stemming from Beringia or Northeast Asia arrived via the Pacific coast, as the interior route was blocked by the merged Laurentide and Cordilleran ice sheets between ~26 and 14 ka.

- We find that the cyclonic currents along the Alaskan margin would have been strengthened during the LGM and times of enhanced meltwater input, making southward transit by boat more difficult.

Summer Kate Praetorius, et al., 2023

Sea-Ice Highways

- Given the prevalence of seasonal sea ice throughout the LGM and early deglacial period, we suggest that stable winter sea ice may have acted as a platform that facilitated early coastal migrations into the Americas.

- Viable time periods for this scenario would likely have occurred intermittently between the Siku events when intermediate sea-ice conditions prevailed and unglaciated coastal refugia were available along the Alaskan margin.

- We identify 24.5-22 ka and 16.4-14.8 ka as the most likely time periods to accommodate early migration along the Alaskan coast, possibly aided by movement and subsistence on a “Sea-ice Highway.”

Sea ice highway to the Americas?

- During the last ice age, sea ice may have provided an ancient "highway" for the first humans to reach the Americas; trekked upon this highway in addition to boating alongside the coast

- Two main scenarios for how people may have first migrated to the Americas. The older idea suggested that people made this journey when Beringia was relatively free of ice.

- However, a growing body of evidence suggests that travelers made their way on watercraft along the Pacific coasts of Asia, Beringia and North America before 15,000 years ago, when giant ice sheets would have made an overland journey extremely difficult.

Walking on sea ice

- This "kelp highway" may have supplied bountiful goods in coastal waters. the most likely locations of human occupation during the migration are now underwater in the Bering Sea,

- The research team's climate models revealed that 20,000 years ago, ocean currents were more than twice as strong as they are today because of glacial winds and lower sea levels during the height of the Last Glacial Maximum, the coldest part of the last ice age.

- Although not impossible to paddle against, these conditions would have made traveling southward by boat very difficult. Such conditions may have lasted 1,000 to 2,000 years.

2 coastal periods

- The scientists also found that much of the region was home to sea ice during the winter until about 15,000 years ago. This opens up the possibility that instead of paddling against these powerful currents, ancient migrants to the Americas may have used sea ice as a platform to walk on

- In addition, the climate data suggested that conditions along the coastal route might have supported migration between 24,500 and 22,000 years ago, as well as between 16,400 and 14,800 years ago, possibly with the aid of winter sea ice.

- These open periods from the climate record do overlap well with footprints found in New Mexico [that are] about 23,000 years old

World's oldest known fort was constructed by hunter-gatherers 8,000 years ago in Siberia

- Hunter-gatherers built the oldest known fort in the world about 8,000 years ago in Siberia.
- Archaeologists have long associated fortresses with permanent agricultural settlements. However, this cluster of fortified structures reveals that prehistoric groups were constructing protective edifices much earlier than originally thought.
- These hunter-gatherers "defy conventional stereotypes that depict such societies as basic and nomadic, unveiling their capacity to construct intricate structures
- Located along the Amnya River in western Siberia, remains of the Amnya fort include roughly 20 pit-house depressions scattered across the site

An aerial view of some of the pit house depressions constructed by hunter-gatherers in Siberia. (Image

Ancient fort

- When constructed, each pit house would have been protected by earthen walls and wooden palisades — two construction elements that suggest advanced agricultural and defensive capabilities by the inhabitants

- This challenges traditional assumptions that monumental constructions were solely the work of agricultural communities.

- It's unknown what triggered the need for these fortified structures in the first place, but the strategic location overlooking the river would have not only been an ideal lookout point for potential threats but also allowed hunter-gatherers to keep tabs on their fishing and hunting grounds

1 mile wall built at 12 Ka for deer hunting

- Archaeologists have identified what may be Europe's oldest human-made megastructure, submerged 21 meters below the Baltic Sea in the Bay of Mecklenburg, Germany.
- This structure—which has been named the Blinkerwall—is a continuous low wall made from over 1,500 granite stones that runs for almost a kilometer. The evidence suggests it was constructed by Paleolithic people between 11,700 and 9,900 years ago, probably as an aid for hunting reindeer.
- Stands on a ridge running east to west, with a 5 km-wide lake basin a few meters below the ridge to the south. The resulting structure stands a little under a meter in height and up to two meters wide, with remarkable regularity over its 971-meter length. Sea levels were much lower then.

Fencing deer in during game drive hunting

- The identification of the Blinkerwall now demonstrates that Paleolithic hunters were managing their landscape to aid their hunting activities more deliberately than was previously thought.
- These structures are interpreted as having been built for the purpose of game drive hunting.
- In this strategy, hunters use landscape and built features to gain an advantage over their prey by directing its movements to a location where they are more vulnerable to attack by other hunters.
- It shows they recognized and understood the instincts of their prey so well that they were able to predict their movements—and how they would react when faced with an artificially created obstacle like the Blinkerwall.

Demise of *Gigantopithcus blacki, ~300 Ka*

- Giants once roamed the karst plains of southern China, three-meter tall apes weighing in at 551 lbs. These very distant human ancestors—Gigantopithcus blacki—went extinct before humans arrived in the region, with few clues to why, and so far leaving around 2,000 fossilized teeth and four jawbones as the only signs of their existence.

- New evidence from this region demonstrates beyond doubt that the largest primate to walk the earth went extinct between 295,000 and 215,000 years ago, unable to adapt its food preferences and behaviors, and vulnerable to the changing climates which sealed its fate.

H. sapiens, gorilla, G. blacki

The demise of the giant ape *Gigantopithecus blacki* – *Y. Zhang, et al., 2023*

- Six different dating techniques were applied to the cave sediments and fossils, producing 157 radiometric ages. These were combined with eight sources of environmental and behavioral evidence, and applied to 11 caves containing evidence of G blacki,
- Luminescence dating, which measures a light-sensitive signal found in the burial sediments that encased the G. blacki fossils, was the primary technique, supported by uranium series (US) and electron-spin resonance (US-ESR) dating of the G. blacki teeth themselves.
- The findings show G. blacki went extinct between 295,000 and 215,000 years ago, much earlier than previously assumed. Before this time, G. blacki flourished in a rich and diverse forest.

The extinction of the giant ape: A long-standing mystery solved

- The largest ever primate and one of the largest of the southeast Asian megafauna, *Gigantopithecus blacki*, persisted in China from about 2.0 million years until the late middle Pleistocene when it became extinct. Its demise is enigmatic considering that it was one of the few Asian great apes to go extinct in the last 2.6 million years, whereas others, including orangutan, survived until the present[5].

- The story of G. blacki is an enigma in paleontology—how could such a mighty creature go extinct at a time when other primates were adapting and surviving? The unresolved cause of its disappearance has become the Holy Grail in this discipline.

G. blacki could not adapt

- Orangutans (genus Pongo)—a close relative of G. blacki—adapted their size, behavior and habitat preferences as conditions changed.
- In comparison, G. blacki relied on a less nutritious backup food source when its preferences were unavailable, decreasing the diversity of its food. The ape became less mobile, had a reduced geographic range for foraging, and faced chronic stress and dwindling numbers.
- G. blacki was the ultimate specialist, compared to the more agile adapters like orangutans, and this ultimately led to its demise
- Increased seasonality, which caused changes in plant communities and an increase in open forest environments.

Change in landscape for early hominids may have led to the development of speech

- As the landscape in which ancient hominids lived transformed from dense forests to open plains during the Miocene era, between 5.3 million and 16 million years ago, the transformation may have prompted the hominids to develop language, switching from vowel-based calls to consonant-based calls.
- Hominids lived in treetops prior to a change in climate in the Middle and Late Miocene era that led to wide-open grasslands replacing forests in Africa, and hominids transitioning from living primarily in trees to moving onto the ground.
- Studied two types of orangutan calls by playing them in the savanna in South Africa, which is similar to the landscape in which the hominids would have lived as language developed.

C. Gannon, et al., 2023

Vowels vs consonants

- By playing the sounds in an open landscape, they found that the consonants traveled much farther than the vowels did.
- Researchers believe the development occurred so hominids could communicate in open spaces, when the physical distance between them was greater than when they were living in trees.
- The findings were significant because most modern languages have a heavy consonant-to-vowel ratio,
- The vowel-based calls were significantly less audible compared to consonant-based calls after distances of 125 meters, or about 410 feet, whereas consonant-based calls exhibited a modest decrease in audibility after 250 meters, or about 820 feet.
- Additionally, fewer than 20% of vowel-based calls were audible at 400 meters, compared to approximately 80% of consonant-based calls,

Fossil marks suggest hominids butchered one another around 1.45 million years ago

- Whether stone-tool marks on a leg bone are a sign of ancient cannibalism is up for debate

A roughly 1.45-million-year-old hominid leg fossil bears what a new study identifies as stone-tool incisions. Researchers suspect that this evidence points to hominids butchering one another, but that conclusion is controversial.

Stone cut marks

- An ancient individual used a stone tool to make nine incisions on the fossil, which preserves the shin and knee. Analyses of 3-D models of these marks peg them as resembling damage produced by stone tools rather than by large predators' bites or by animal trampling
- Those incisions are the oldest convincing example of such butchery and possibly cannibalism among ancient hominids
- Created 3-D scans of the bone marks and compared them with 898 bone marks known to have been made by stone cutting tools, stone pounding implements, the teeth of crocodiles, lions and other nonhuman predators, or cows trampling the ground. Nine marks closely matched stone-tool damage

Contentious conclusions

- No consensus exists on the species identity of the ancient leg fossil.
- It might represent *Homo erectus*, *H. habilis* or *Paranthropus boisei.* There is also no way to tell whether a hominid from the same species or a different species left stone-tool marks on the leg fossil.
- Stone-tool incisions on a partial leg bone do not provide enough evidence to determine whether hunger motivated flesh removal; therefore unclear if cannibalism was involved
- Tim White disagrees about the evidence

Can now identify species from DNA in bone, dirt, feces & air

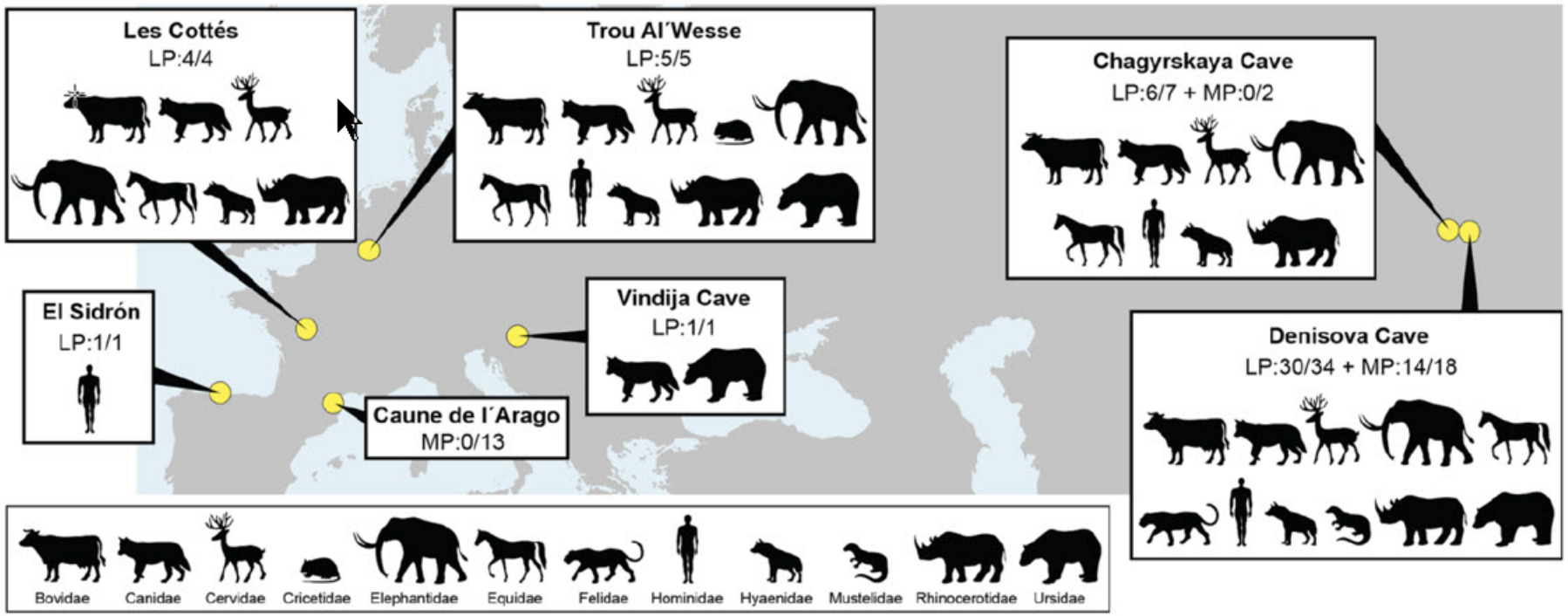
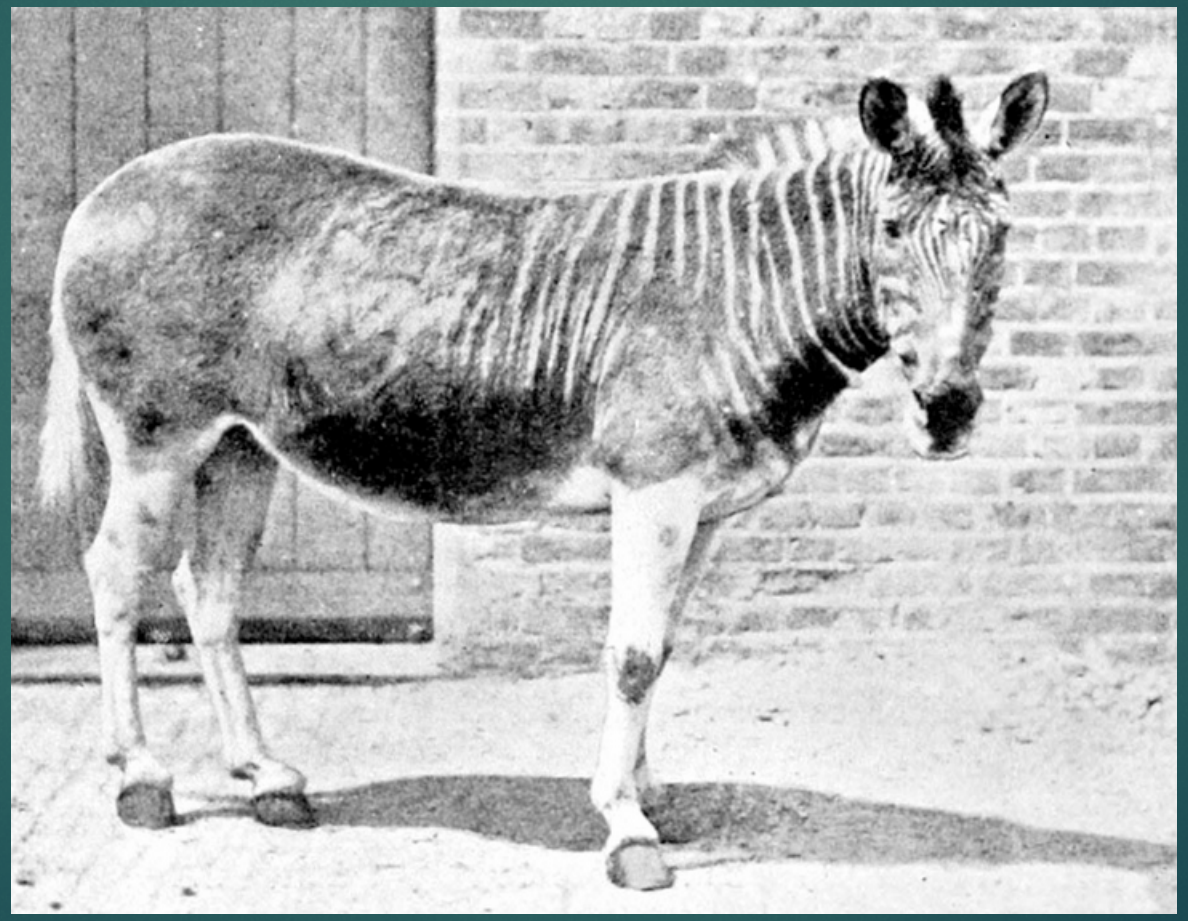


Fig. 1. Ancient taxa detected in Late Pleistocene (LP) and Middle Pleistocene (MP) sediment samples from seven sites. For each time period, the fraction of samples containing DNA fragments which could be assigned to a mammalian family and authenticated to be of ancient origin is indicated. The shaded symbols representing each family are not to scale.

Last Quagga: 1883 = a mere 229 base pairs of mitochondrial DNA



3 shovelfuls of dirt in 2006 from the Artic desert in northern Greenland

K. Kjaer, et al., 2022

15 year struggle to analyze that DNA

- See Nova Hunting for Ancient DNA episode – oldest DNA is coldest DNA
- Eske Willerslev Lab: it took 15 years and multiple postdoc researchers failures to ultimately analyze the ancient DNA in those 3 shovelfuls of dirt
- With the technology in hand at the time, the DNA was completely unreadable. In Eske's lab, students began calling the Greenland samples cursed. 5 students failed and left the field. Finally a student applied shotgun sequencing.

First to use shotgun sequencing on DNA in dirt

- Shotgun sequencing = DNA is broken apart and many many many many many sequence reads are generated from the DNA pieces. All of those data are analyzed by a computer program that looks for overlapping stretches of sequence and eventually puts that DNA puzzle back together. It takes immense computing power, billions of operations. And only now are computers powerful enough to work with fragments down to 30 base pairs.
- Matched these DNA barcodes to a reference catalog of known species

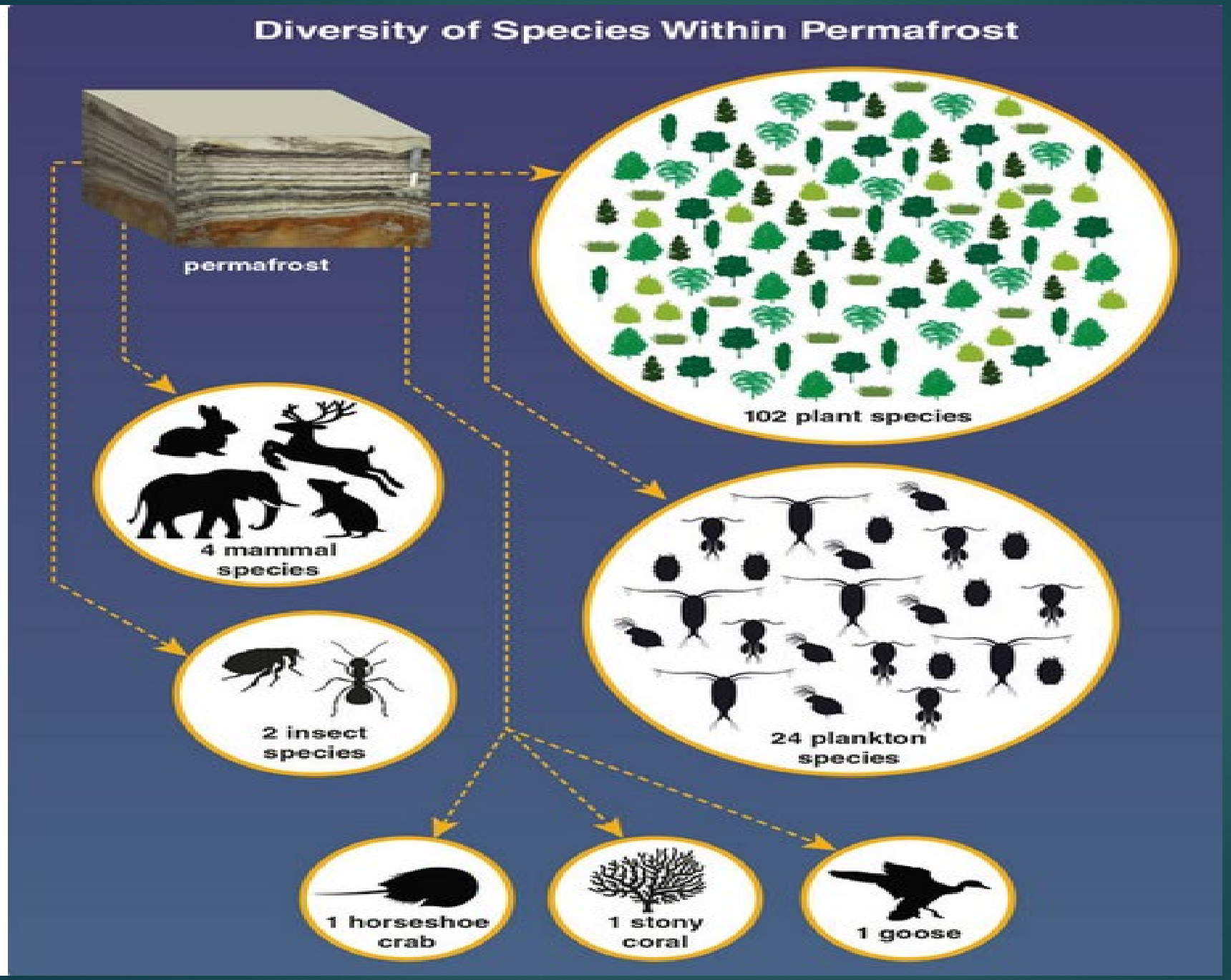
Greenland at 2 Ma: What Ancient DNA describes

- In 2022 a team of genetics experts and Earth scientists led by Kurt Kjær of the University of Copenhagen finally reconstructed a Pleistocene ecosystem from DNA extracted from permafrost (100 plant species, nine animal species, and *2,000 other organisms, from bacteria to plankton,*).
- The team collected permafrost samples from the Kap København Formation, a Pleistocene unit in northern Greenland where sediments from a boreal ecosystem, buried and frozen into permafrost, had lain undisturbed for 2.5 million years.
- We have entered an era in which an entire Pleistocene ecosystem can be reconstructed from analyzing the DNA preserved in long-frozen soil.

Daniel Ksepka, 2023

Why did the DNA survive?

- DNA survived such an incredible long time because of minerals in the soil.
- DNA is electrically charged. And many mineral particles that you find in the soil is also electrically charged.
- So, therefore, DNA fragments will basically bind itself around such sediment particles.
- And this reduces the rate of DNA degradation.
- Particularly with certain minerals of clay and quartz binds the DNA very strong. If bound to clay and quartz, DNA is basically frozen in time.
- His lab can now analyze 200 samples a week.



Another study:
evidence of camels too

Greenland at 2 Ma: half the year in darkness

Greenland at 2 Ma

- Greenland: Mastodons, horseshoe crabs, remarkably warm climate (water temp 5^0 C higher than today)

- Sequencing DNA from an entire ecosystem that existed millions of years ago is a dramatic showcase of what contemporary genetic analysis can do. But similar techniques are being applied in many other places.

Contamination

- Early Contamination issue: Many ancient DNA discoveries in the 1990s were actually artifacts of contamination that crumbled under closer scrutiny.
- Perhaps the most prominent case focused on DNA allegedly extracted from 80-million-year-old dinosaur bones, which ultimately turned out to be fragments of human DNA.
- Replication attempts failed.
- Modern sequencers map where short DNA fragments belong in the complete genome by comparing them to a reference genome from a closely related modern species

DNA proved elephant bird was related to kiwi of New Zealand, & not to ostriches; largest egg (12+') of any vertebrate (150x volume of chicken egg)

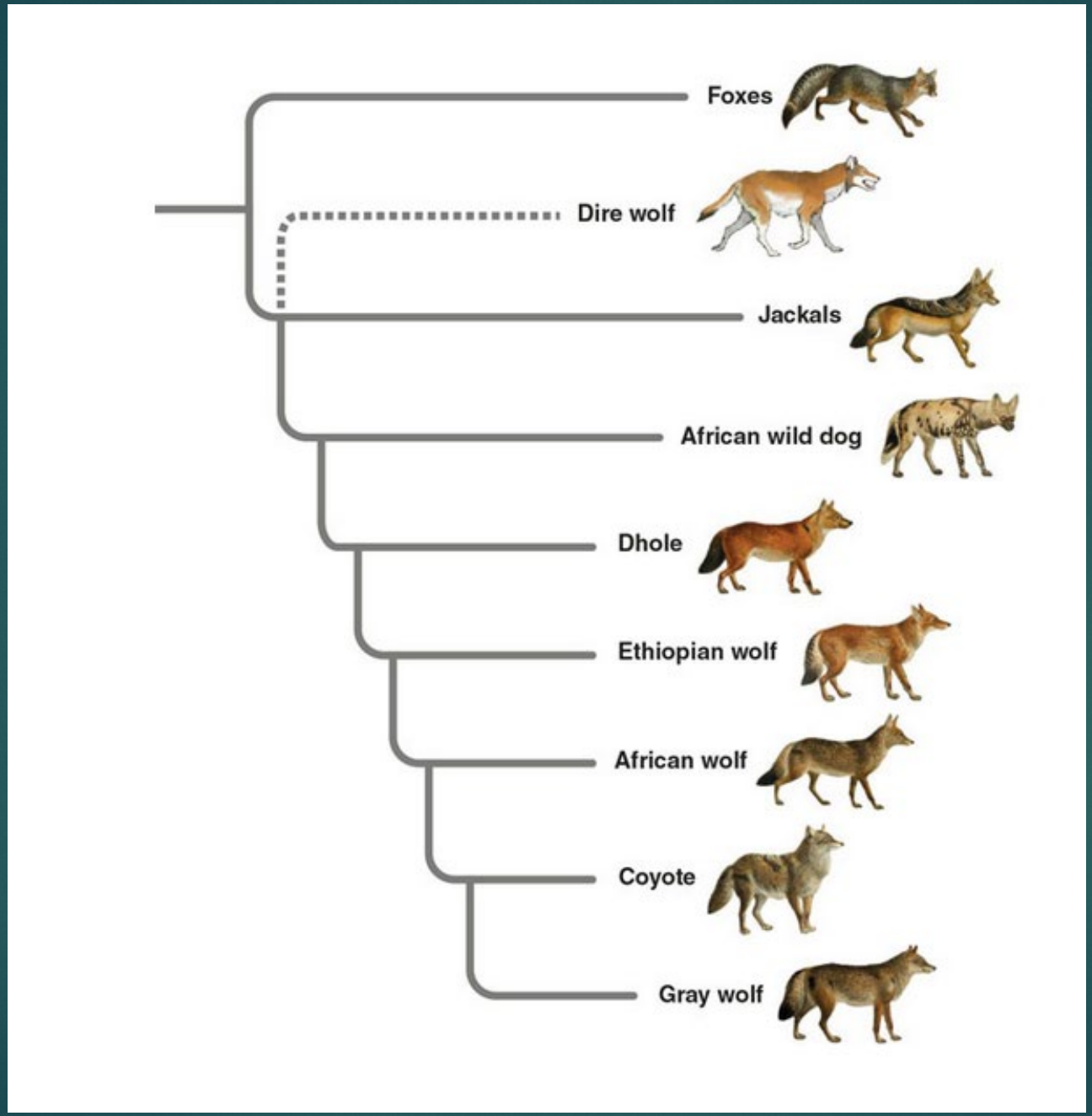
10 feet tall and weighed in at over 1,000 pounds, *Aepyornis maximus* was the largest bird ever to have lived. These flightless wonders towered over all other terrestrial animals in Madagascar until their demise at the hands of humans approximately 1,000 years ago.

Kiwi: 10 inches, 6 lbs

Dire Wolf Extinction: 2 x size of grey wolves; extinct at 10 Ka

Dire wolves

- Thousands of skeletons at La Brea tar pits
- Originally considered same genus as modern wolves (*Canis lupus*) and dogs (*Canis familiaris*); but DNA proved they branched off the canid family tree five million to six million years ago, before jackals, African wild dogs, dholes, coyotes, and wolves split from one another
- Removed dire wolves from the genus *Canis* and placed them in *Aenocyon* (Latin for “dreadful wolf”).


Foxes
Dire wolf
Jackals
African wild dog
Dhole
Ethiopian wolf
African wolf
Coyote
Gray wolf

Megafauna extinction

- This finding has major implications for understanding the Late Pleistocene megafaunal extinctions in North America, when more than 70 percent of the continent's megafauna died off, including sabertooth cats, ground sloths, and mammoths.

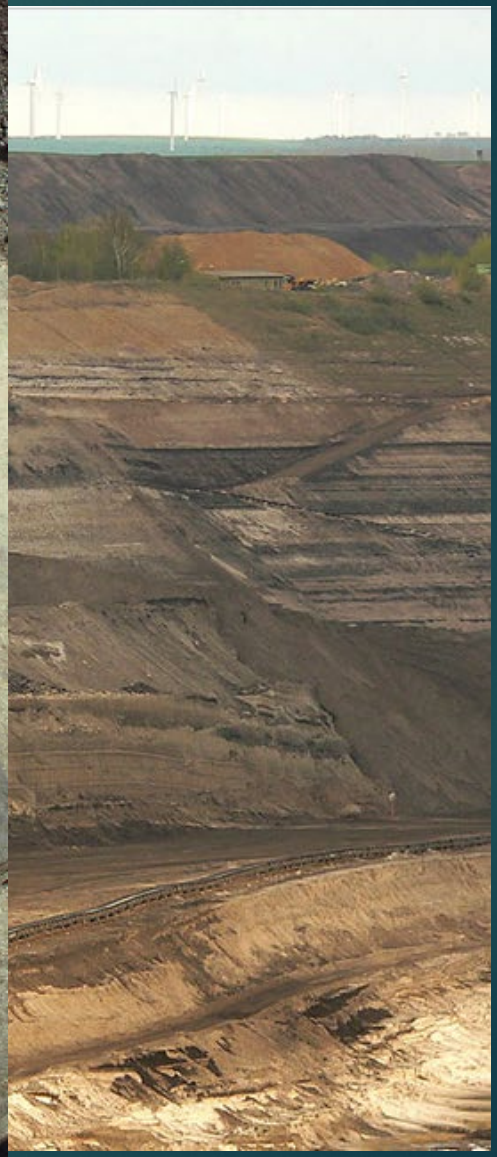
- Wolves and coyotes survived, but their archaic relatives perished. One possible explanation is dietary flexibility. Wolves and coyotes are known to hunt large prey but will also take rodents, birds, carrion, and in modern times are happy to raid human trash.

Megafauna

- Massive-headed dire wolves may have relied more heavily on large animals such as ground sloths and camels that perished as humans spread throughout the Americas.

- This explanation seems cut and dry. But ancient DNA suggests other factors could also be at play. The team speculated that new virulent diseases may have contributed to the extinction of dire wolves, whereas enhanced immunity gained by cross-breeding gave gray wolves more resistance.

Schöningen, Germany, open-cast coal mine: spear site



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.

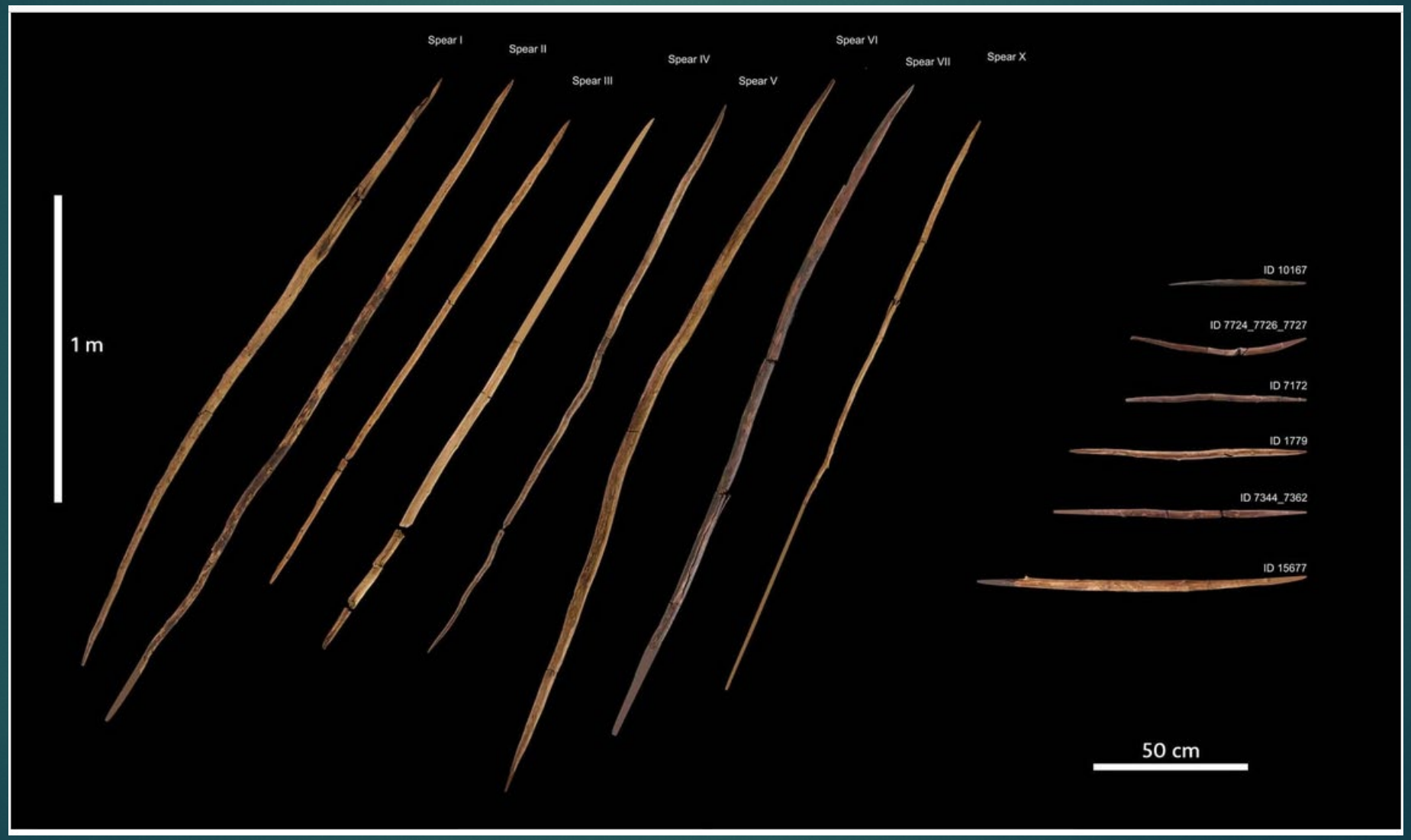
Leder, D. et al. (2024).

Woodworking

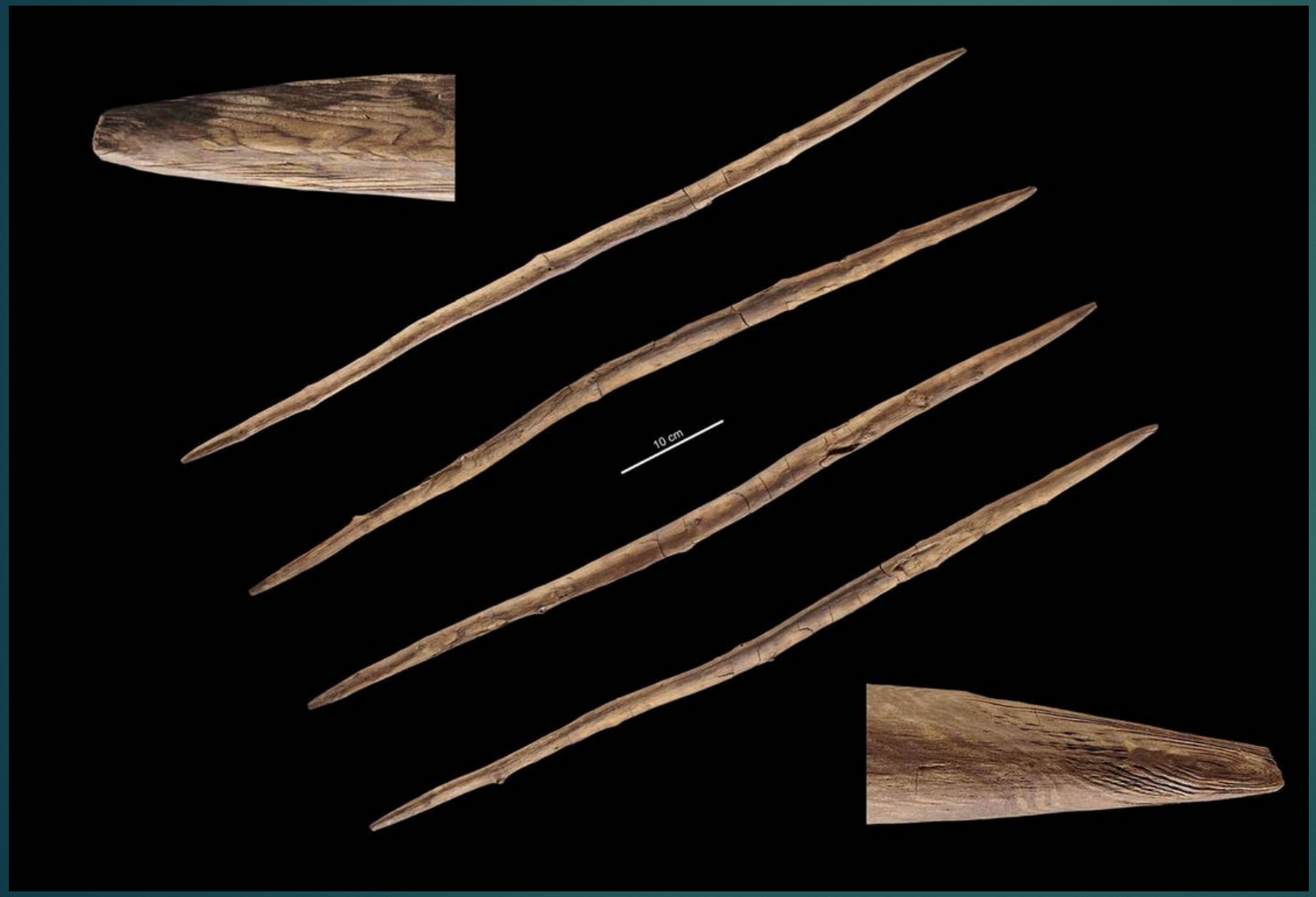
- State-of-the-art imaging techniques, including 3D microscopy and micro-CT scanners, have revealed a wealth of information about the handling and processing of wood at Schöningen.

- 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.

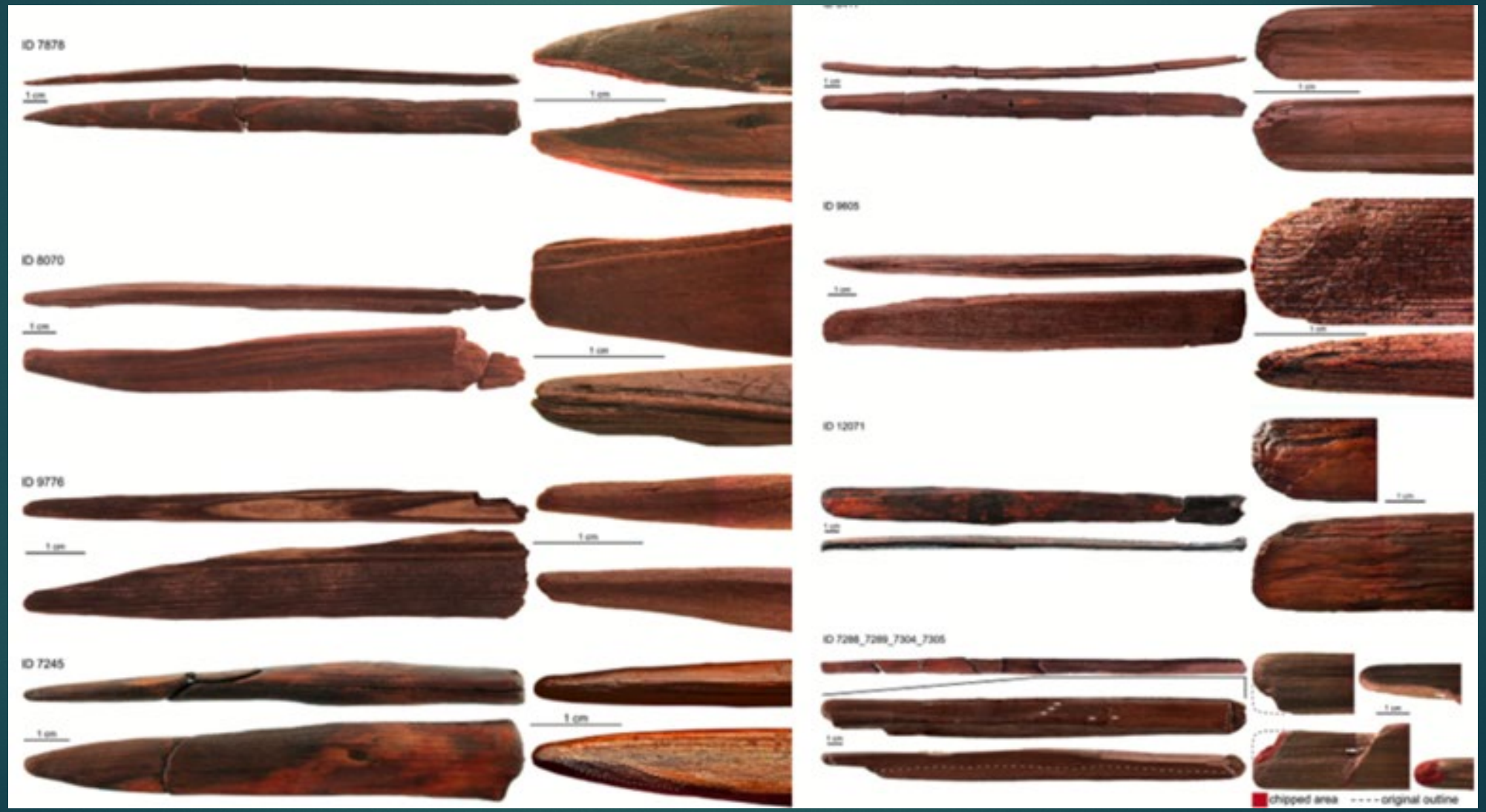


A double-pointed throwing stick from Schöningen, Germany, with detail views of the two sharpened points.



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. Despite its rarity in the archaeological record, the extensive range of woodworking techniques and the abundance of wooden weapons and tools emphasize wood's integral role in ancient societies.

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

- This rarely happens, so our interpretation of the ways of life of prehistoric hunter-gatherers is often biased by the survival of more resistant materials (lithic and bones) found in archaeological sites.

- Therefore, 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.

- In the years that followed, extensive excavations yielded numerous wooden objects dating from the end of a warm interglacial period 300,000 years ago. The findings suggested a hunting ground on the lakeshore.

- The wide range of woodworking techniques used on the weapons and tools show the importance of wood as a raw material 300,000 years ago. 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).*

- Wooden tools played a pivotal role in the daily lives of hunter-gatherers including food procurement tools used in hunting (e.g., spears, tools like handles, vessels).

- 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.

Schöningen

- Very few Paleolithic sites have produced wooden artifacts and among them, the site of Schöningen stands out due to its number and variety of wooden tools.

- 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.

- 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.

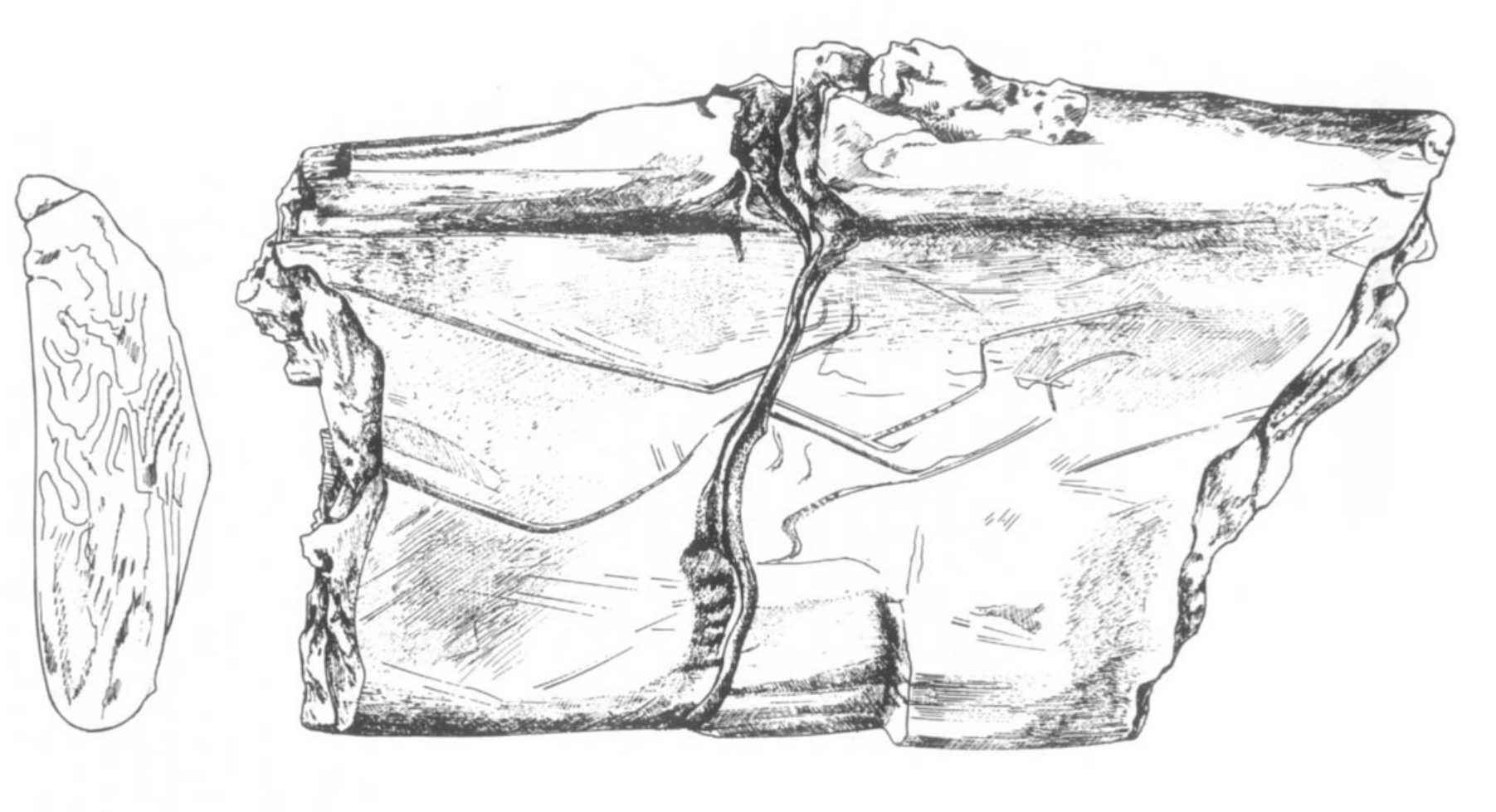
Wooden tools

- 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

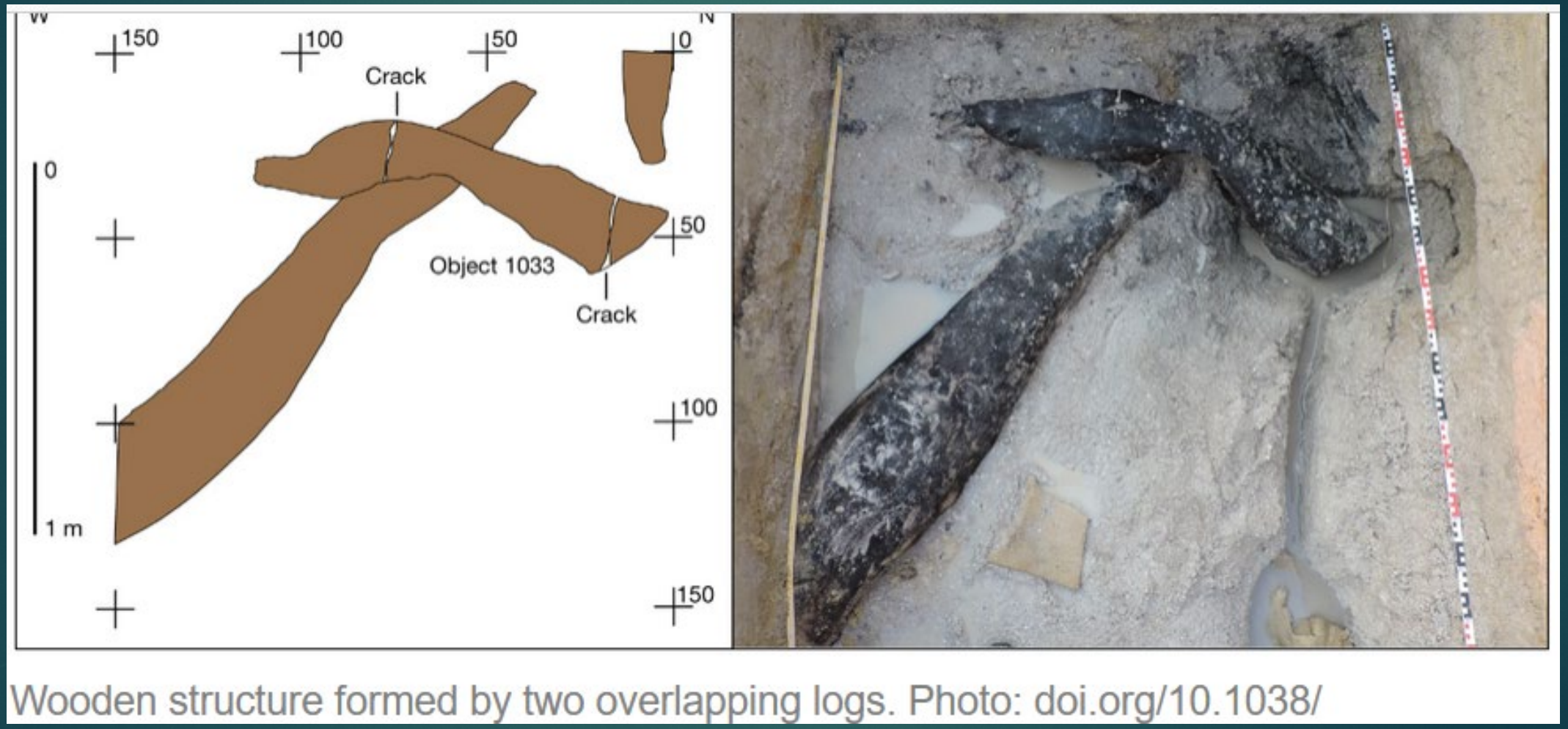
- The earliest indirect evidence for human woodworking dates back 2 to 1.5 Ma ago based on use-wear on lithics.

- 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.

Wood came first, stone came later

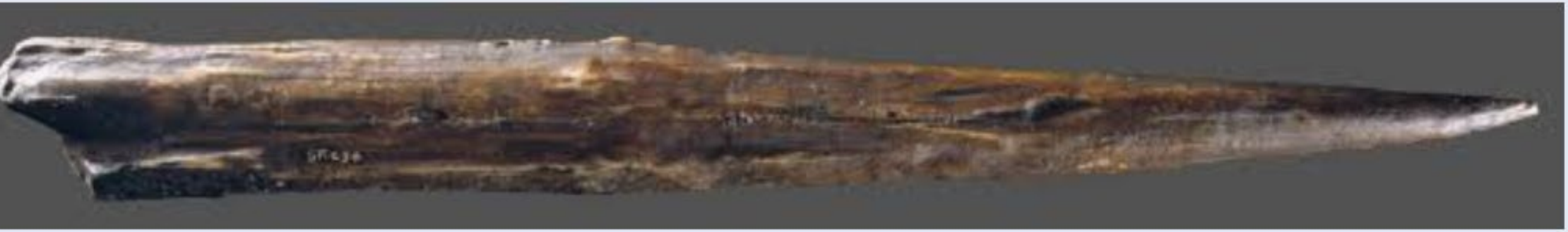
- Digging sticks used in procuring underground storage organs are preserved at few sites in Africa, Eurasia, and South America being 400 to 14.5 ka old.

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

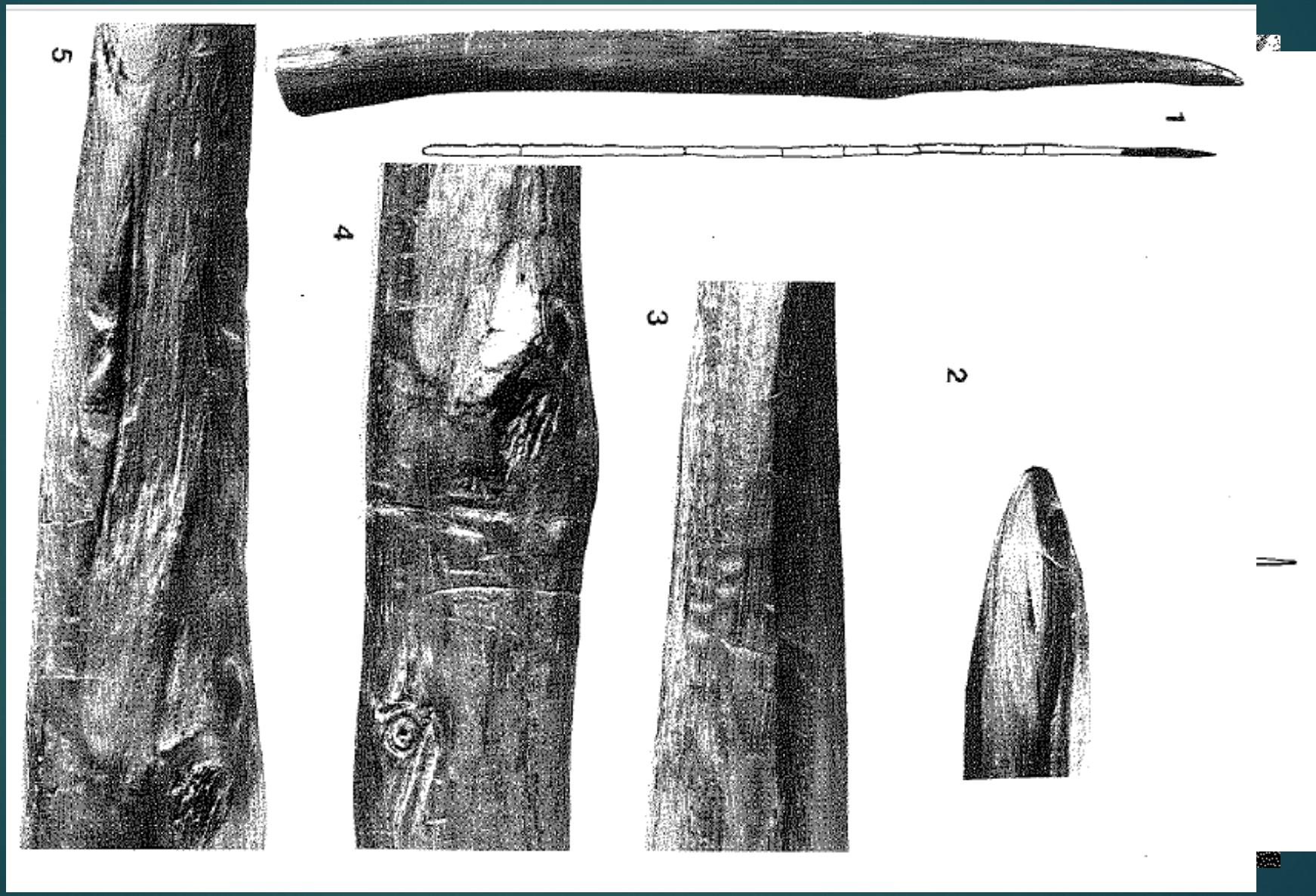
- Way earlier than any of these sites, some of the earliest Oldowan stone artifacts bear evidence that their sharp edges were used to shape wood. Many Acheulean handaxes and cleavers were used for wood shaping also. In other words, evidence for woodworking goes back long before any chance preservation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

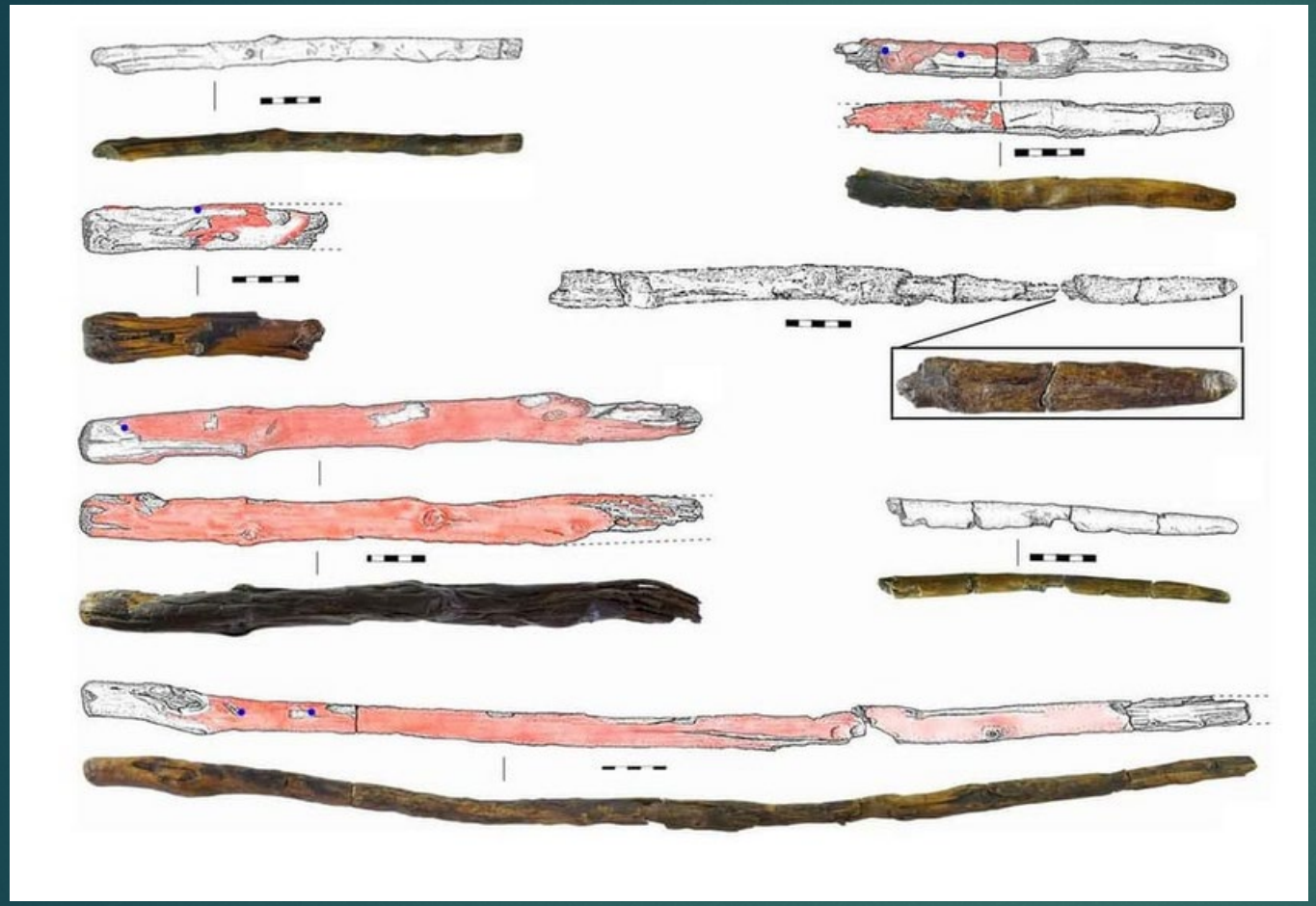


Lehringen, Germany spear: found in inside an elephant fossil in 1948: 115-125 Ka



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

Poggetti Vecchi, Italy: 39 Digging sticks

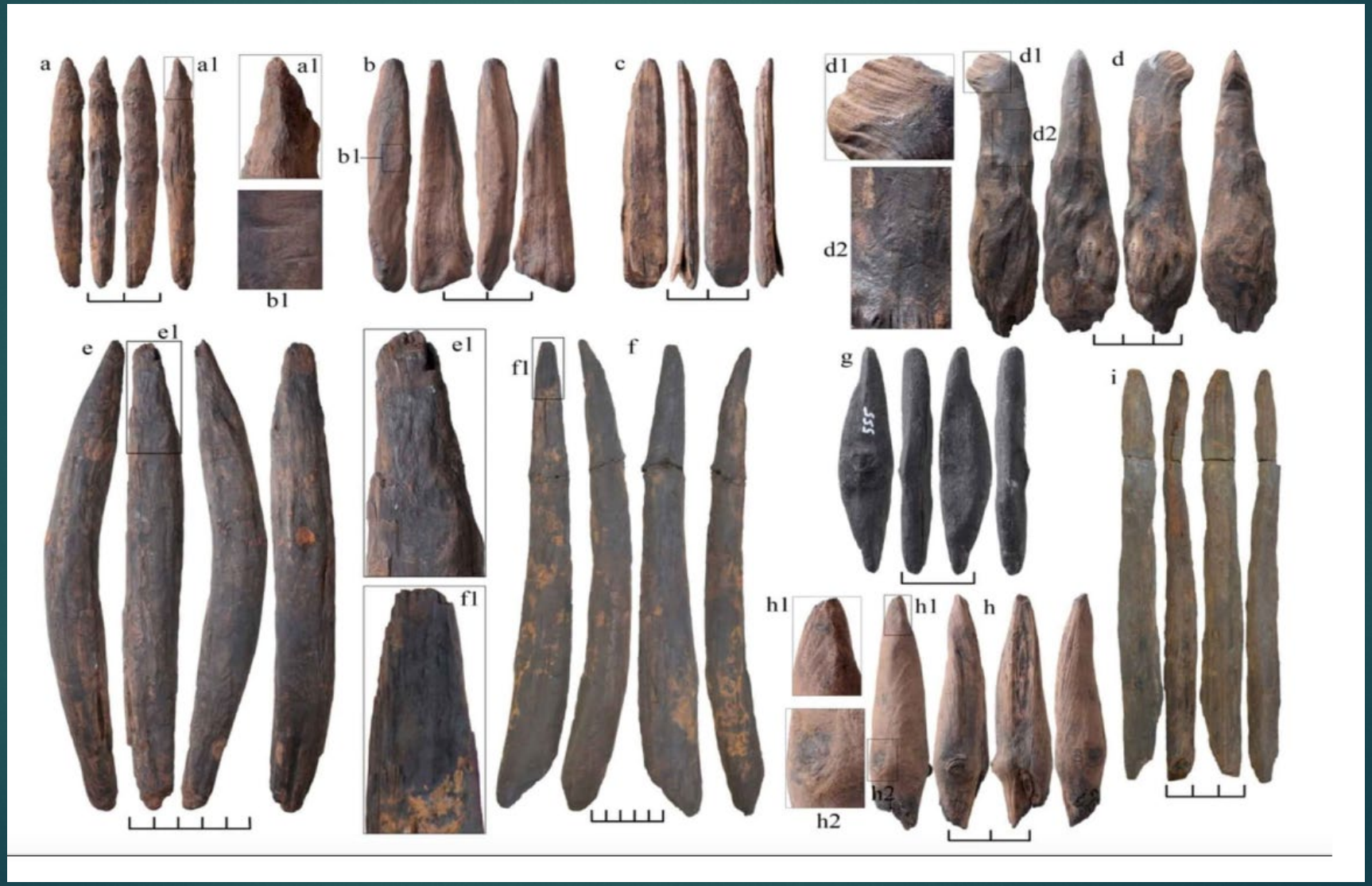


Made of boxwood: which is harder, denser, and more resistant to breaking than other species that were present in the ancient environment. Many were fire hardened. Some have a clearly rounded end forming a handle that the user could apply pressure to the pointed, working end of the stick.

Poggetti Vecchi, Italy: Neanderthals, 170 Ka

Poggetti Vecchi, Italy: The rounded “handles” and worn surfaces of wooden digging sticks: evidence of 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.

Importance of Schöningen.

- Schöningen is located in hilly terrain in the northern European Plains. Archeological excavations at this former opencast mine commenced in 1981 delivering multiple Middle Pleistocene sites.

- 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 Wooden Assemblage. 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
- The systematic study leads to the 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.
- 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.

Hunting weapons

- 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. 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.

Comparisons

- 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.

- 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. See considerable depth of planning, sophistication of design, and patience in carving the wood, all of which have been 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 45.0 to 87.7 cm long (median = 64.5 cm; 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

- The 24 pointed split woods are defined by their single tapering end.
- The assemblage also contains 11 split woods with 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. Oblique striations typical for digging sticks are absent.

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.

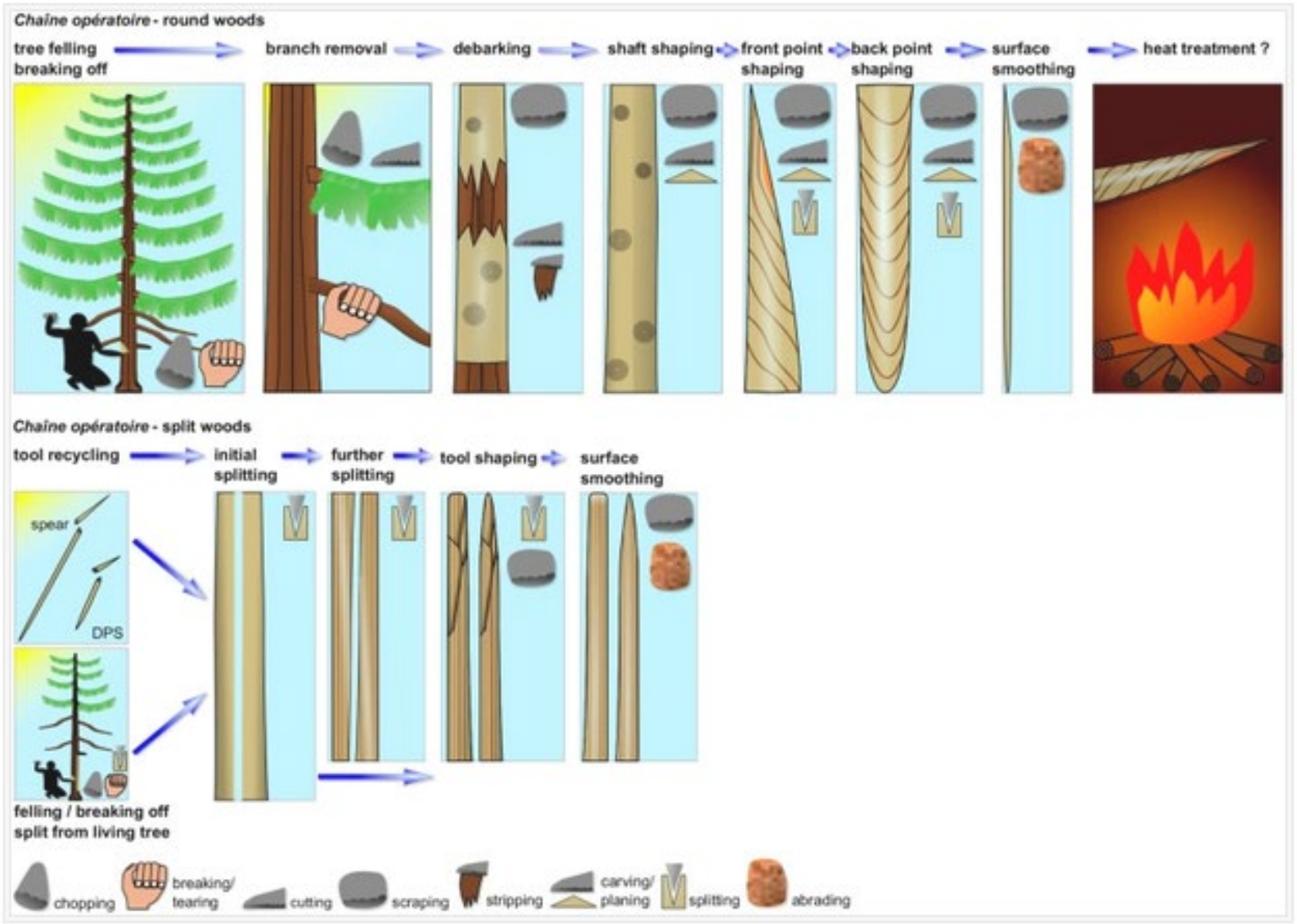
Fig. 2. Examples of pointed split woods and close-up images of the worked point. Photos: Matthias Vogel, Jens Lehmann, Dirk Leder, NLD.

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 or 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 large size of most of the spears makes use as fishing implements less likely and evidence of spear fishing or fish consumption is generally sparse at sites predating the Upper Paleolithic.
- 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

- 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.

Hunting weapons

- 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.

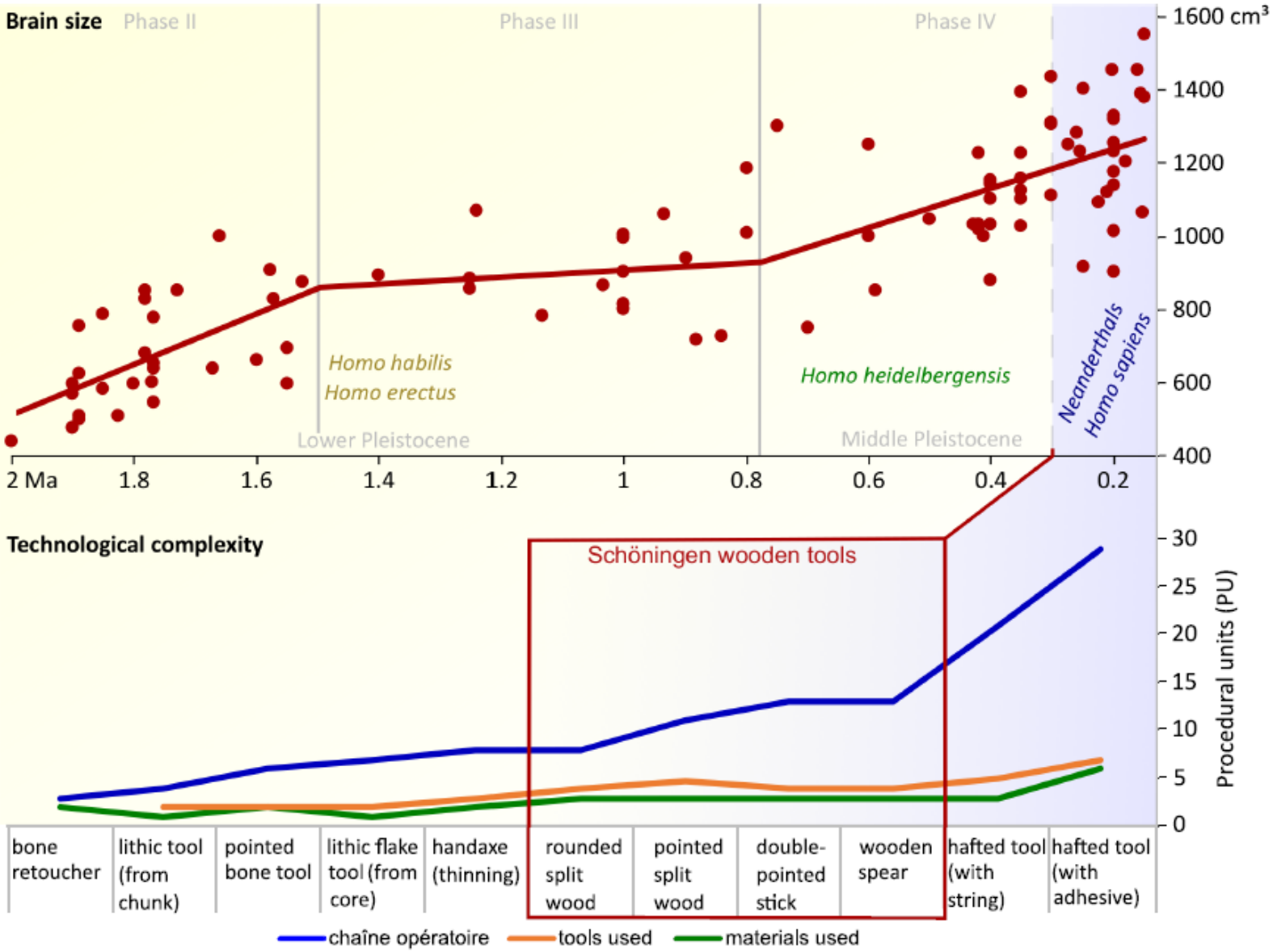


Fig. 6. Human brain size evolution and technological complexity development during the Early and Middle Pleistocene. Brain size data after Gingerich (46). Technological complexity according to multiple sources (*SI Appendix, SI-Text* and Table S23). Procedural units after Perreault et al. (61) (*SI Appendix,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