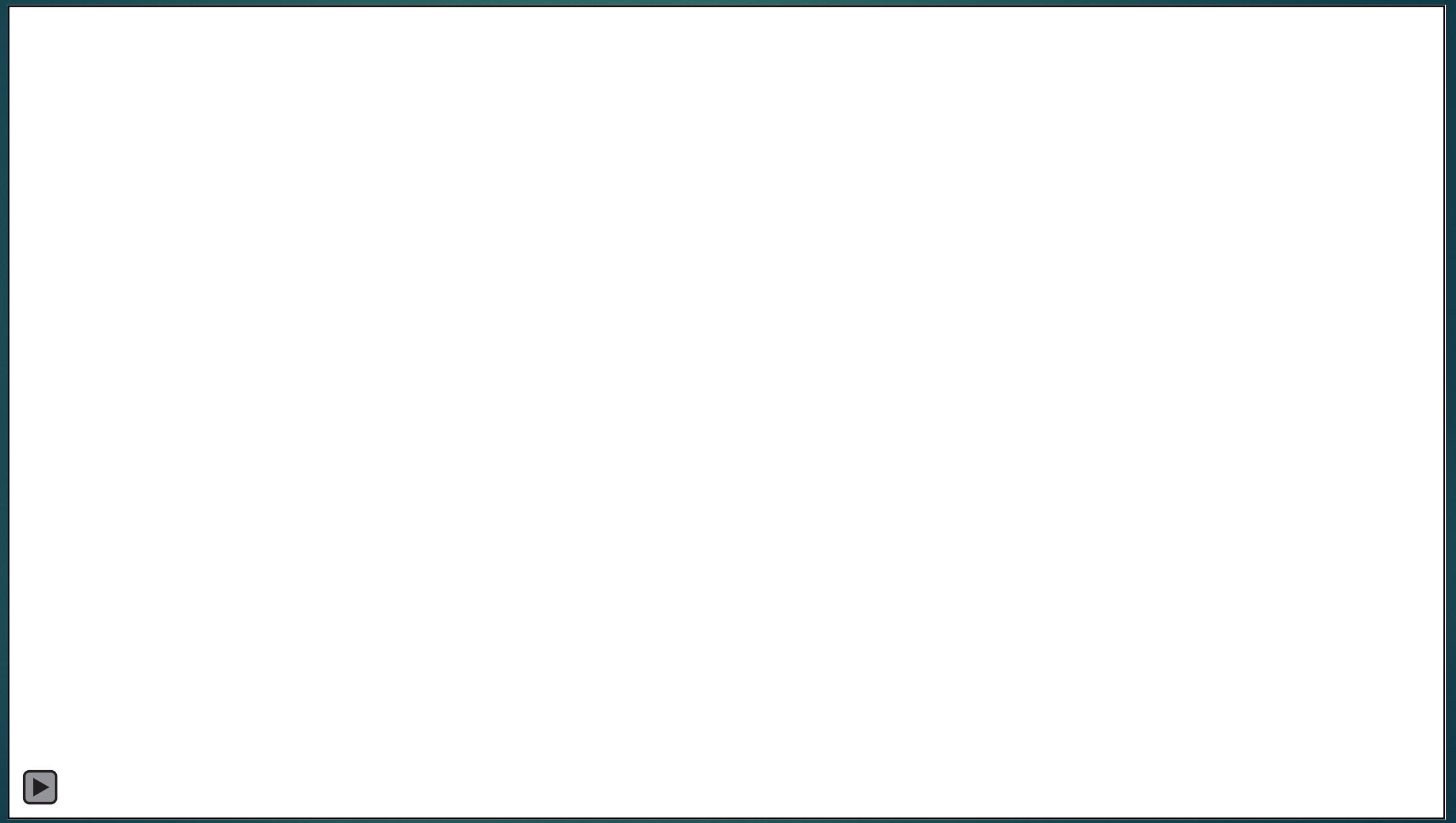
April 2025
OLLI Science Update
by Charles J Vella, PhD

Juvenile Colossal Squid, 1 foot long, at 2000 feet (can grow to 1000 lbs); deep ocean



World’s first Swiss Army knife: A Pfyn culture stone tool with a wooden handle from about 3800 B.C.

What it is: A flint tool with a wooden handle and birch tar
Where it is from: Öhningen, southern Germany

The sharp-edged flint blade was fastened to a wooden handle with birch tar, and a hole was drilled into the wood, likely so the tool could be hung.

** Scientists claim they have resurrected the dire wolf: two of three wolves genetically edited by scientists to have traits of a dire wolf, a prehistoric animal that went extinct about 12,500 years ago

Dire wolf hybrids: have resurrected the dire wolf phenotype (the observable traits of a species)

- Dire wolf lives again as the “world’s first successfully de-extincted animal,” according to Dallas-based biotech company Colossal Biosciences.

- Colossal scientists have created three dire wolf pups by using ancient DNA, cloning and gene-editing technology to alter the genes of a gray wolf, the prehistoric dire wolf’s closest living relative, the company announced Monday. The result is essentially a hybrid species similar in appearance to its extinct forerunner.

20 edits and 14 genes: Colossal's de-extincted 'dire wolf' isn't a dire wolf and it has not been de-extincted

- Team took DNA from a 13,000 year old tooth and a 72,000 year old skull and made healthy “dire wolf” puppies

- The company then used the information from the genetic analysis to alter gray wolf cells, making 20 edits in 14 genes before cloning the most promising cell lines and transferring them into donor eggs. Used domestic dogs — specifically large, mixed-breed hounds — as surrogates.

- This procedure did not bring back the dire wolf!

Two of the wolves were born on October 1, 2024. Colossal Biosciences

Not so fast

- But the announcement also drew howls of protest from scientists, many of whom were quick to point out that, despite Colossal's claims, the dire wolf remains as dead as ever.

- In reality, researchers at the company made 20 edits to 14 genes in the genome of the gray wolf—an animal that, despite physical similarities, isn't as closely related to the dire wolf as one might expect—in an attempt to imbue it with characteristics reminiscent of the long-lost species.

- These edited cells were then used to create embryos, which were implanted into surrogate dog mothers, ultimately producing three healthy pups with large bodies and snow-white fur: two males named Romulus and Remus and a female named Khaleesi (after a character from Game of Thrones who is famously known as the Mother of Dragons, not the Mother of Wolves).

1/100,000th dire wolf

- "Certainly, this involves advances in genetic technology and these might have applications for the conservation of existing species—but the return of dire wolves? No."
- Involved only a handful of edits focused on recapitulating obvious physical traits such as fur color and texture.
- " Would a chimpanzee with 20 gene edits be human?" geneticist Pontus Skoglund adding that the newly announced pups "seem optimistically 1/100,000th dire wolf."
- I have more than 14 Neanderthal genes in me, and we wouldn't call me a Neanderthal.

Better used for conserving currently endangered species

- Overall, these animals appear to have quite a lot in common with Colossal's woolly mice which were genetically engineered to have thick mammoth-like pelts. Neither represent a truly meaningful step on the road to de-extinction.

- Besides, as many conservationists have argued, trying to revive lost animals may ultimately be a fool's errand—one that diverts valuable resources and attention from endangered species living today.

Iran's folded rocks are a colorful formation that is part of the Greater Caucasus mountains, which formed when the Eurasian tectonic plate collided with the Arabian plate millions of years ago.

** Geological wonders: Rainbow Mountains, China's Zhangye Danxia National Geologic Park

Uplifted sedimentary rock uplifted when Indian plate hit Eurasian plate and also produced Mt. Everest

** Female Asian hermit spiders gobble up their partners after mating, so males detach their penises (it has 2) so they can leave it pumping sperm while they flee to safety and sometimes also offer up an amputated leg to escape.

** Satanic Leaf tailed gecko of Madagascar

**A male Denisovan mandible from Pleistocene Taiwan -- Takumi Tsutaya, et al., 2025

The Penghu 1 jawbone lay undiscovered on the seafloor off Taiwan until a fishing net dredged it up in 2010. The jawbone belonged to a Denisovan male. More evidence that Denisovans were also at home in humid lowland tropics.


a
2 cm

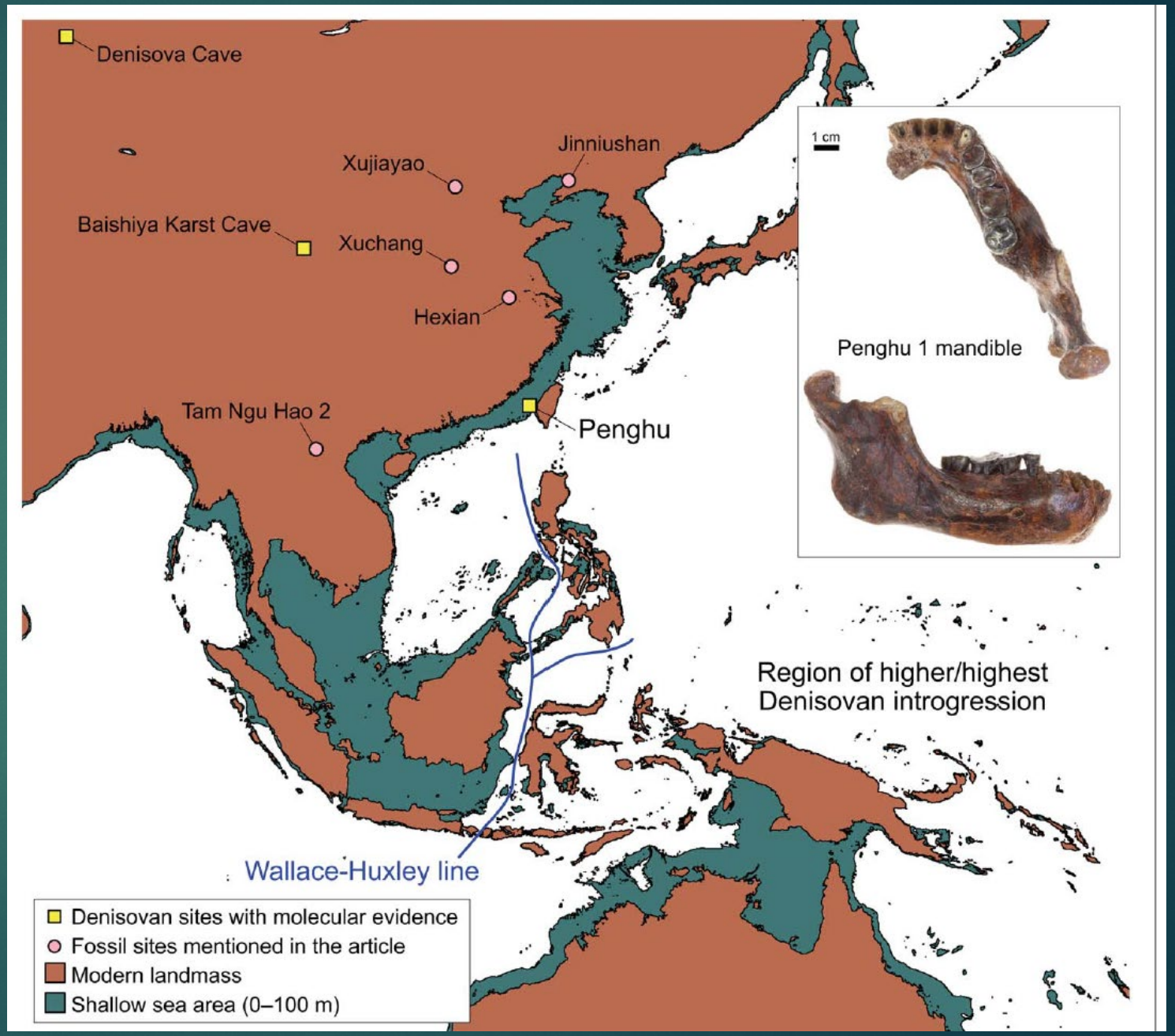
Jawbone

- A fossilized jawbone was found in an antiques market and was dredged up by a fishing net from the seafloor 60 to 120 m deep, 15 ½ miles off the coast of Taiwan in 2010 looked human, but for years scientists failed to nail down exactly where it fit in the human family tree. From when sea levels were lower and the ocean channel was a land bridge.
- Now, scientists have been able to confirm the identity of the mystery fossil, known as Penghu 1, through analyzing ancient protein fragments contained in teeth still attached to the jaw. The jawbone belonged to a Denisovan man.
- The identification of Penghu 1 as Denisovan is likely to prompt museum curators to take a new look at their collections, in case other Denisovan relics are waiting nameless in the drawers. There are 4,000 fossils from same area in the National Museum of Natural Science's collection.

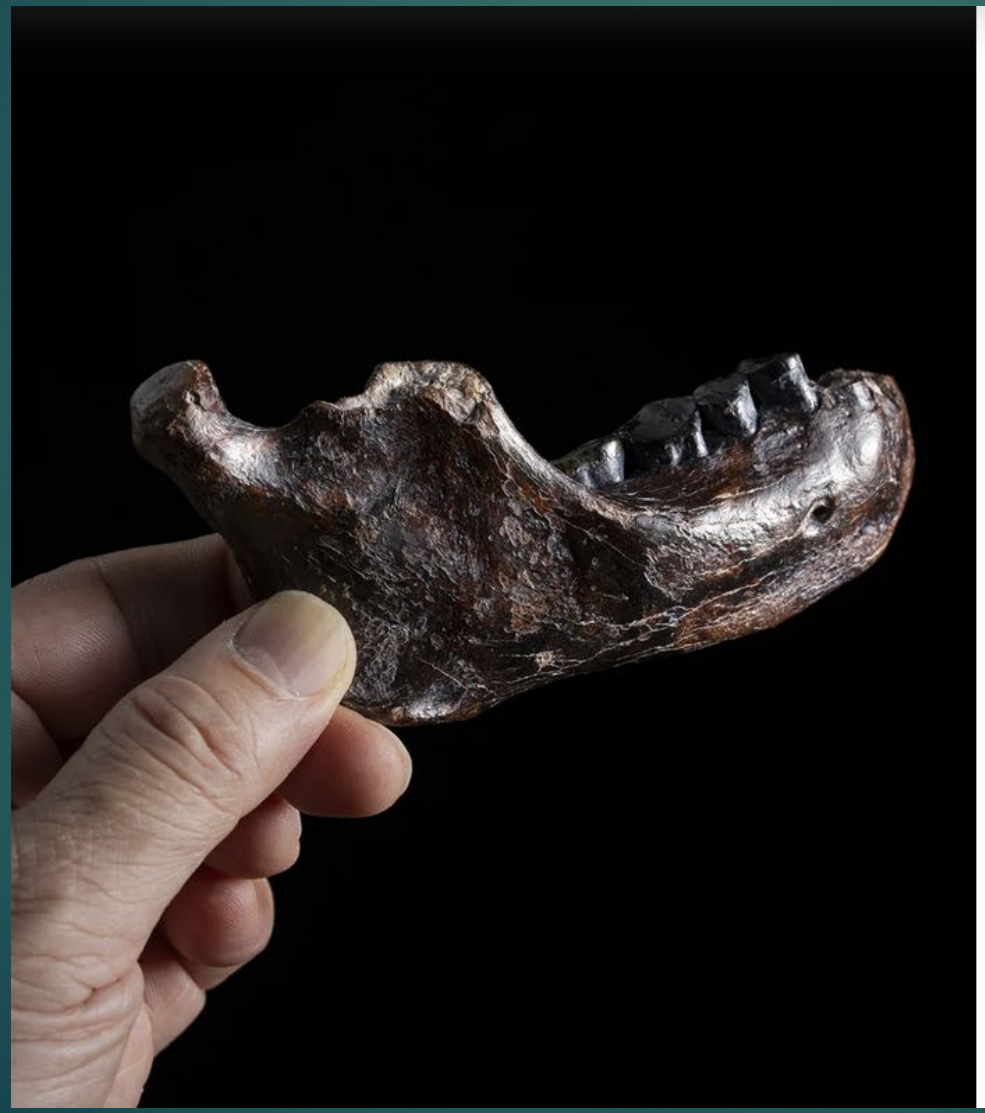
Hominin mandible (Penghu 1) from Taiwan

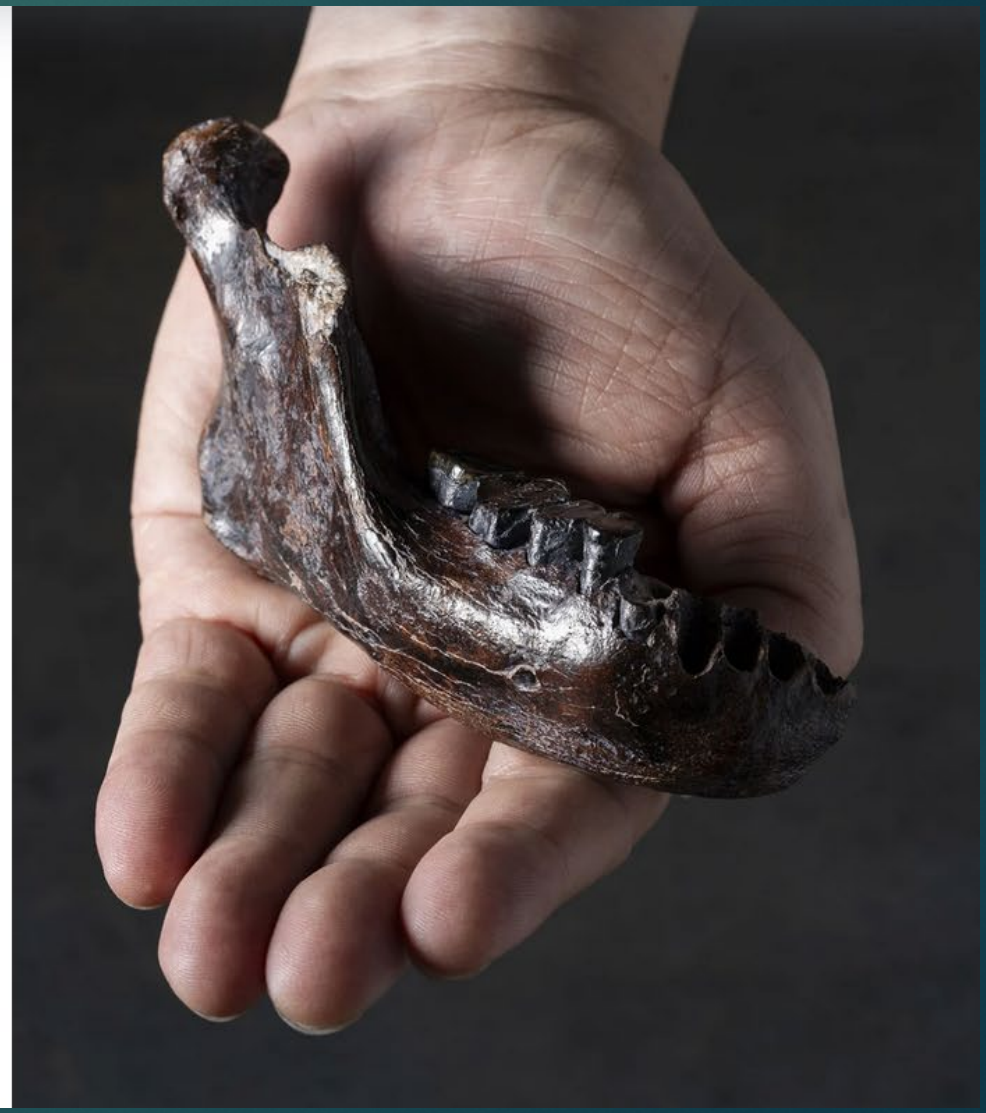
- Although genomic evidence suggests Denisovans had a widespread distribution throughout eastern Asia and Oceania, so far only a few fossils from the Altai and Tibet are confidently identified molecularly as Denisovan.
- We identified a hominin mandible (Penghu 1) from Taiwan (10 to 70 Ka or 130 to 190 Ka, when area was above water) as belonging to a male Denisovan by applying ancient protein analysis.
- We retrieved 4241 amino acid residues and identified two Denisovan-specific variants. The increased fossil sample of Denisovans demonstrates their wider distribution, including warm and humid regions, as well as their shared distinct robust dentognathic traits that markedly contrast with their sister group, Neanderthals.

Map showing the distribution of known, molecularly determined Denisovan fossils and photos of Penghu 1.



Penghu 1 hemimandible: Ds had “exceptionally large” molars.
The Penghu 1 and Xiahe mandibles did not have wisdom teeth, which could indicate that their jaws did not protrude forward in their face. Neither have chins.





Discussion

- The high-quality paleoproteomic data obtained from Penghu 1, enabled by relatively good fossil preservation and optimized protein extraction methods, indicates that Penghu 1 belonged to a male Denisovan. Two diagnostic positions in the Denisovan variant of AMBN and COL1A2 were covered with more than 19 D peptides.
- First, Penghu 1 expands the known geographic range of Denisovans with direct molecular evidence. Penghu is located ~4000 km southeast of Denisova Cave and ~2000 km southeast of Xiahe. The identification of Penghu 1 as a Denisovan mandible confirms that Denisovans were widely distributed in eastern Asia.
- The presence of Denisovans in diverse geographical and climatic zones—from a continental climate with long, cold winters (Denisova Cave; 51°N); to an alpine subarctic climate associated with a high altitude (3280 m above sea level) (Xiahe; 35°N); to the warmer, more humid climate of a low latitude (Penghu: 23°N)—demonstrates their adaptational flexibility.

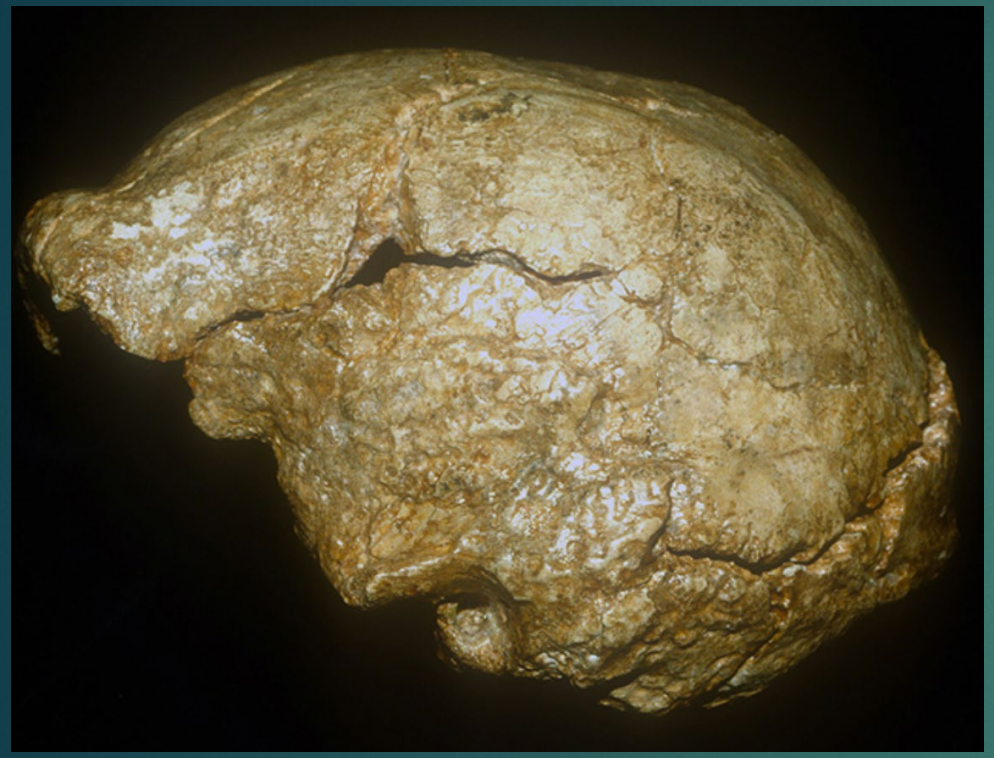
Denisovan Morphology

- Second, with the addition of molecular evidence for Penghu 1, there are now two mandibles with teeth (Xiahe 1 and Penghu 1) and two molars (Denisova 4 and 8) that allow for a confident discussion of the morphological characteristics of Denisovans.
- Together, these fossils suggest that Denisovans exhibited a thick but low mandibular body, a wide anterior dental arcade, large tooth size (particularly evident in the molars), robust premolar roots with a tendency of branching, an M2 root that is longer and more robust than the M1 root, a distinct extra root between the lingual aspects of the mesial and distal roots of M2, and a tendency for M3 agenesis (not only Penghu 1 and Xiahe 1 but also Denisova 4 and 8 follow this last trend, if these isolated teeth represent second rather than third molars).

Similar to Hexian

- Among existing hominin fossils, the mandible and teeth from Hexian, Anhui, East China, exhibit most or all of these characteristics, suggesting that the skull and dentognathic remains from this site also belong to the Denisovan clade.
- These characteristics seen in the Denisovan fossils differ from the reconstructed Denisovan skeletal morphology according to DNA methylation patterns, which suggested that the degrees of their mandibular protrusion, condylar size, and anteriormandibular width and height are greater than in modern humans and greater or comparable with those of Neanderthals. However, this reconstruction is derived from genomic data from Denisova Cave, where a Denisovan mandible has yet to be discovered.

Hexian fossils: Denisovan??



Female Denisovans?

- Third, the molecularly sexed Denisovan fossils now include the two large molars from Denisova Cave (Denisova 4 and 8) and the robust Penghu 1 mandible from this study, all identified as male. Only males, like all the other molecularly confirmed Denisovan fossils that have been sexed using this method.

- This raises the question of whether the robust characteristics are due to male sex, whereas some other Asian fossils with more gracile dentognathic characteristics (such as, Jinniushan from Northeast China, which is morphologically sexed as female) may be Denisovan females.

Denisovan Evidence

- The derived D variant of COL1A2 has so far been found only in Penghu 1, Xiahe 1, Xiahe 2, and Denisova 3.

- Penghu 1 clusters with Denisova 3, the only Denisovan individual with a sufficient reference genome sequence available. Both the Denisovan-specific variants and the overall phylogenetic results confirm that Penghu 1 is a Denisovan mandible.

*** Neandertal Quina stone tools – Did Ns get to China?

- In Europe, Neanderthals used Quina stone tools during a dry and cold period 60,000 to 50,000 years ago in a landscape of open woodland.
- Quina is not just a vague style. It's a craftsmanship signature. These tools — thick, sharp-edged scrapers with repeated retouch marks — were long considered an unmistakable calling card of Neanderthals in Europe.
- The tools would have helped Neanderthals hunt migrating herds of reindeer, giant deer, horses and bison.
- Quina tools typically had a long period of use and were often retouched and recycled — suggesting they were a response to patchy resources and a highly mobile lifestyle

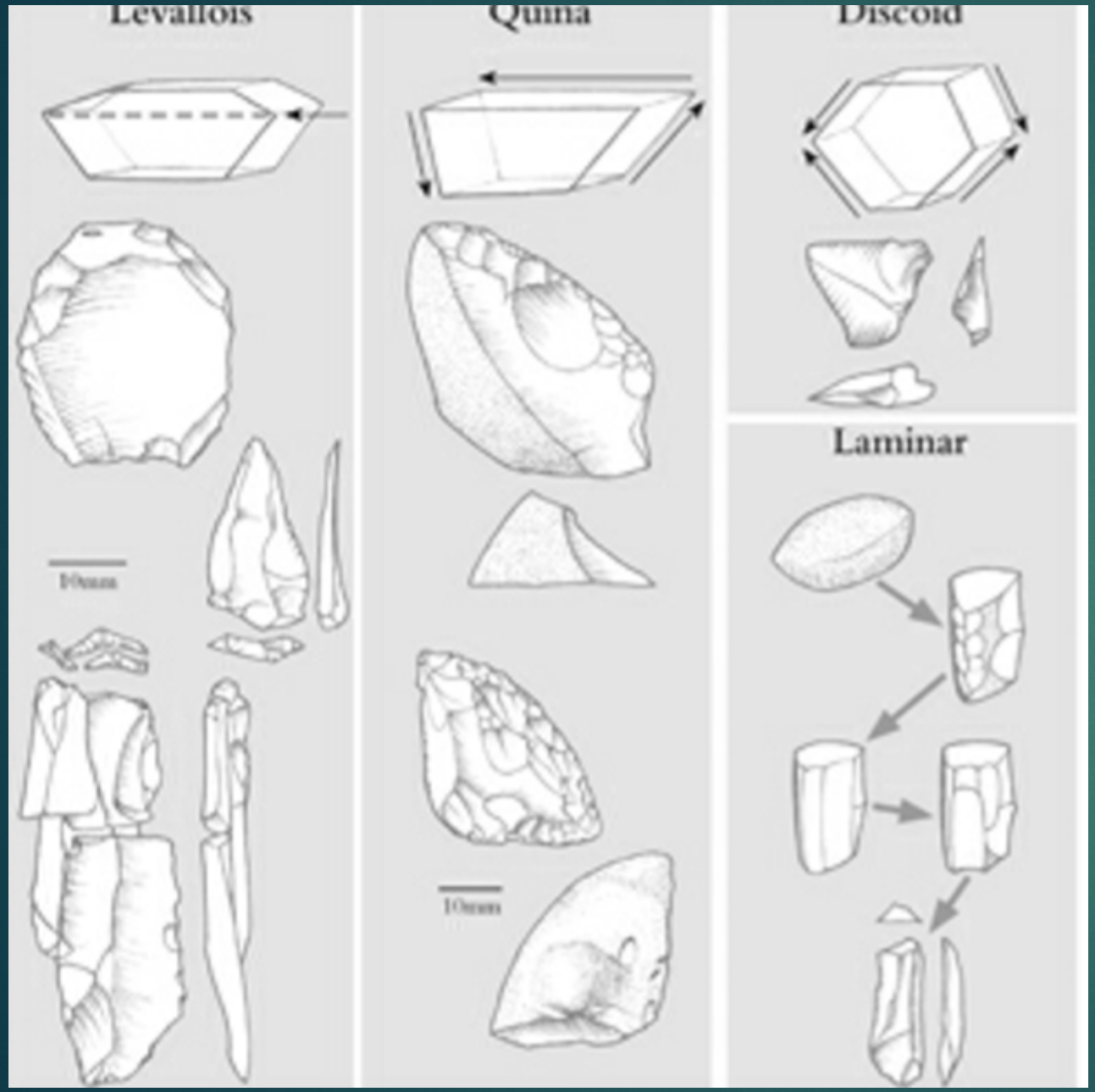
Original asymmetric scrappers from La Quina

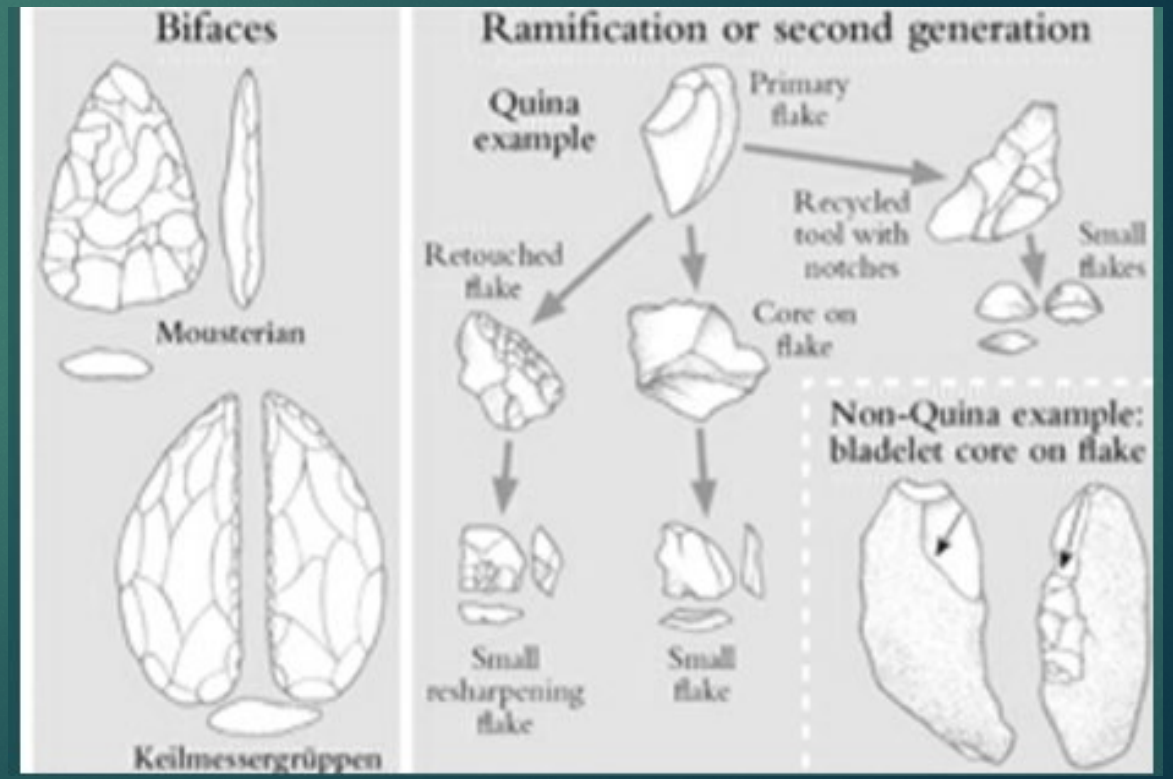
Quina

- The Quina package represents an adaptation to highly developed mobility strategies: these artifacts were designed to last a long time, as nomadic human groups were forced to search for resources that, due to increasingly harsh climatic conditions, were becoming scarcer.

- It was possible Neanderthals made it as far east as southwest China, or perhaps they encountered other human species in their home territory, an interaction that allowed their stone tool technology to spread eastward.

Quina: asymmetric shape





*** Quina lithic technology indicates diverse Late Pleistocene human dynamics in East Asia -- Qi-Jun Ruan, et al., 2025

- Stone tool discovery in China shows people in East Asia were innovating during the Middle Paleolithic (250 to 30 Ka ago), like in Europe and Middle East. Report of the discovery of the first complete example of a Middle Paleolithic technology previously seen only in Europe and the Middle East.

- The Neandertal Quina system of lithic production stands out being easily distinguishable from others.

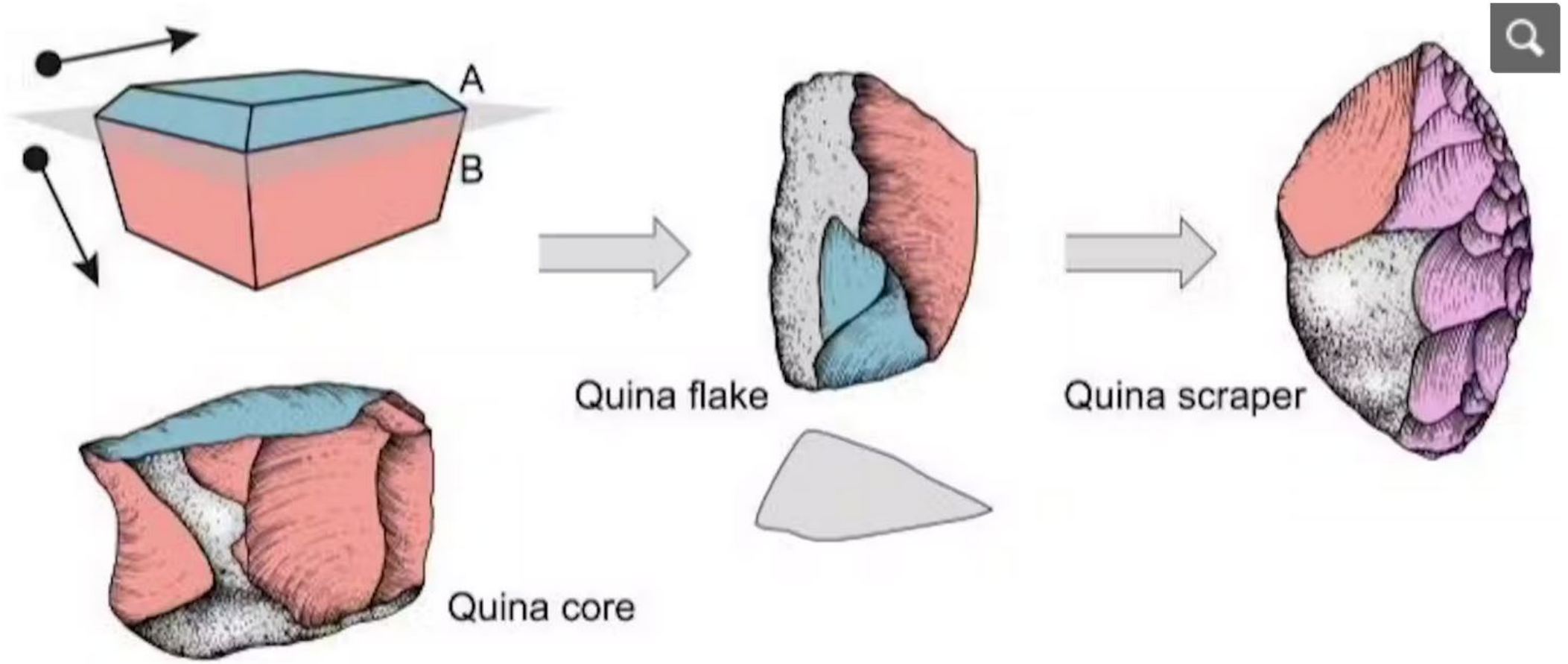


Illustration of a typical Quina scraper and related tools. The toolmaker would flake pieces of stone off the core to carefully shape the Quina scraper. Pei-Yuan Xiao

The Quina tool kit from Longtan. (A–D) Quina scrapers. (E–G) Quina cores. (H-J) Resharpening flakes showing Quina retouch at the near end of the top face. (K) Small tool made on resharpening flake.

Excavations at the Chinese site in 2019 and 2020 produced 3,487 stone artifacts. From that total, the investigators identified 53 Quina scrapers

MP lithics in China

- Archaeologists have thought that ancient people in East Asia completely skipped the Middle Paleolithic. Our discovery challenges the long-standing notion that while ancient people in Europe and Africa were inventing new tools during this period, people of East Asia stuck to only the most basic tools that remained unchanged for thousands of years.

- Quina lithic industries have been confined to European and western Asian countries. Hence, their discovery far outside Western Eurasia challenges the current scenario.

- The Quina technological system identified in Southwest China, dated to ~55 ka, is culturally in the European range, which challenges popular view that there is no “Middle Paleolithic” in this region.

Quina stone tools at Longtan, China

- Here, we report a complete Quina technological system identified from the study of the Longtan site in Southwest China.

- The site has been securely dated to ~60 to 50 thousand years ago (ka), with compelling evidence of core exploitation, production of large and thick flakes, shaping and maintenance of scrapers exhibiting the whole Quina concept, typical of contemporary European Middle Paleolithic technologies developed by Neanderthal groups adapted to climatic oscillations during Marine Isotope Stage (MIS) 4 and early MIS 3.

Quina scraper

- The tool we've identified is called a Quina scraper. This type of stone tool is well known from archaeological sites in Europe and the Middle East.

- Quina scrapers are typically quite thick and asymmetrical, with a broad and sharp working edge that shows clear signs of being used and resharpened multiple times. This shape results in durable cutting edges, ideal for long cycles of use followed by resharpening

- The layers containing the artifacts were 50,000 to 60,000 years old. This is roughly the same time Quina scrapers were being used in Europe at Neanderthal sites.

Neandertal territory

Map showing the location of the discovery of the Quina tool kit in China, at the southern margin of the Hengduan Mountains of the Tibetan Plateau. B. View of the landscape showing the Longtan archaeological site.

Quina and Levallois in China

- Our new discovery of Quina scrapers joins another recent find of a different kind of Middle Paleolithic technology in East Asia: Levallois tools from Guanyindong Cave in Guizhou Province in south-central China.

- Levallois tools result from a distinctive multistep sequence that efficiently produces lots of useful cutting tools, with minimal wasted stone. Taken together, these two finds make a strong case that Middle Paleolithic technologies were present in East Asia.

Quina lithics

- The finding of a Quina lithic assemblage in China not only demonstrates the existence of a Middle Paleolithic technology in the region but also shows large-scale analogies with Neanderthal behaviors in western Europe.

- Longtan substantially extends the geographic distribution of this technical behavior in East Asia. Although its origin remains unclear, implications for Pleistocene hominin dispersal and adaptation to diverse ecological settings are considered. The Longtan lithic evidence also provides perspectives for understanding the cultural evolutionary situation before the large-scale arrivals of early modern humans in East Asia predating ~45 ka.

Why now?

- But why are we only just finding this Quina tool kit now, when it has been known in Europe for such a long time?

- One reason is that archaeologists have been looking in Europe for longer than almost anywhere else in the world.

- Another reason Middle Paleolithic evidence appears rare in East Asia is because what now seem to be less typical variations of the Quina tool kit previously found in China had been overlooked, likely due to archaeologists' narrow definitions based on European examples.

Who made them?

- Was it introduced by visitors from Europe?
- Or did local people in East Asia independently invent it?
- If deeper geological layers have dissimilar tools, that suggests Quina technology was introduced from a neighboring group.
- It could have been modern humans. But it could also have been Neanderthals. Considering that the Quina technology in Europe is directly associated with Neanderthals, this seems likely. But it could also have been Denisovans,

*** Evidence for deliberate burial of the dead by *Homo naledi*

Lee R Berger, et al., 2025

- John Hawks: after two years of intense reviews and revision, the work on burial evidence from this ancient hominin finds acceptance.

- This week the journal *eLife* released a new editorial evaluation of our team's work on burial evidence from *Homo naledi.* The reviews and editorial assessment are remarkably positive. All of them accept that burial of remains by *Homo naledi* is a strong explanation for what we have found. They suggest some important lingering questions, which themselves are great suggestions for follow-up work.

The *eLife* process

The *eLife* model adopted in early 2023 differs from the model of review and editorial decisions in most academic journals. At *eLife*, submitted manuscripts are available to the public on bioRxiv preprints before they undergo any review, and the role of review is to provide expert assessment alongside the preprint, not to “accept” or “reject” it from publication. This is by design an iterative process. Authors can respond to reviews, provide more context, revise their manuscripts and release an updated preprint for evaluation.

- Since the whole review process unfolds in public, all the reviews and responses are part of the public record of the research. This is a remarkable strength of the model. Anyone who reads the research can see current evaluations by experts, even as the authors may continue to resolve questions that remain.

Revisions

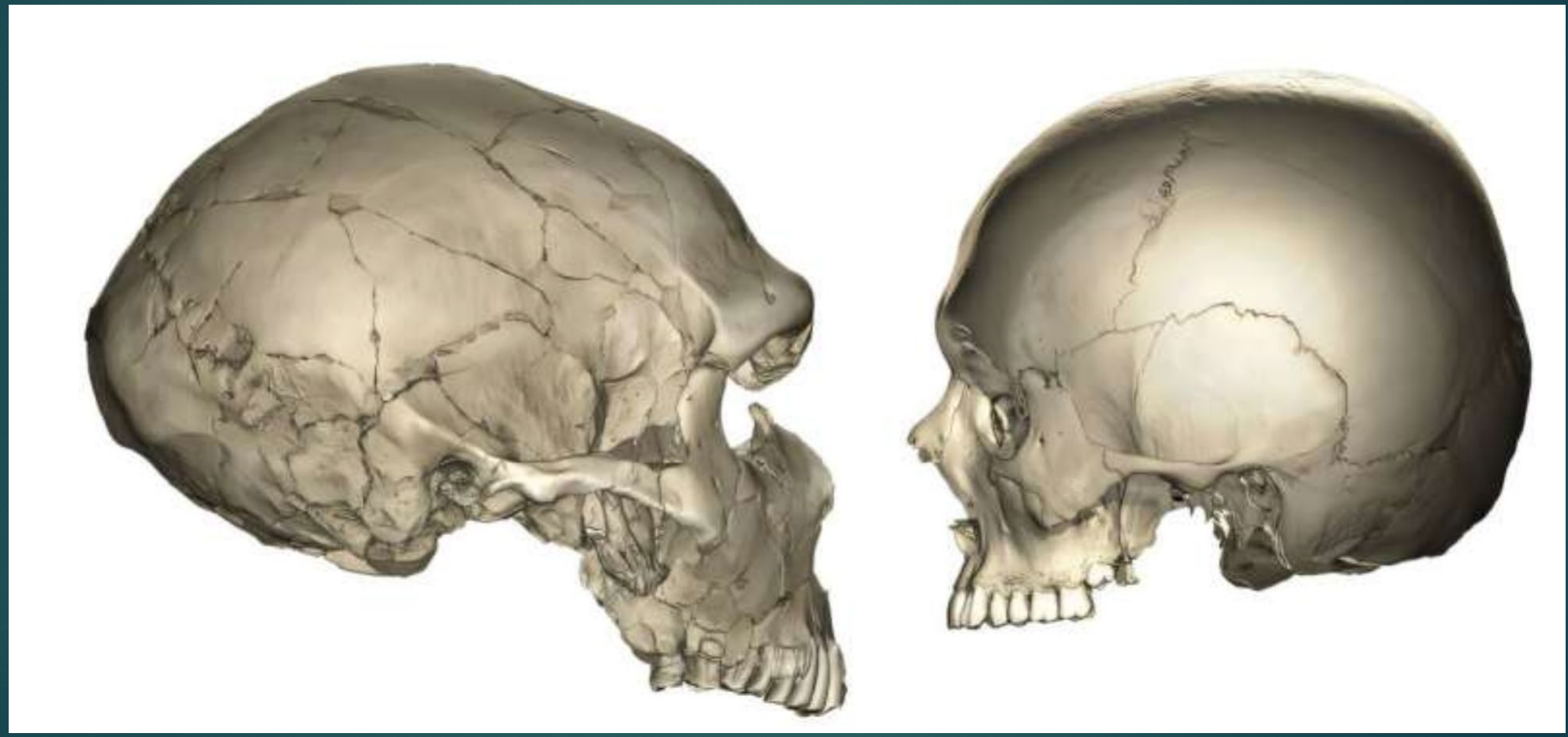
- The end result of this revision is a richly detailed presentation of the evidence. The main text and figures take up more than 150 manuscript pages, and the supplemental information added up to more than 100.
- ** Many people, including the *eLife* reviewers and editor, asked us to reframe the paper. They wanted us to present the hypothesis of a “natural” process of deposition, and then use the evidence to reject that hypothesis. The implication was that a “cultural” hypothesis was something extraordinary, only to be accepted after we excluded every noncultural alternative.
- The duality of “natural” versus “cultural” would lead us to many new insights as we built our revision. We discussed the reviews and comments, and we found that we could not agree with the idea that “natural process” is the right null hypothesis for this work. We checked the references we had cited, and we found that almost nobody else who has written about burial in modern humans or Neanderthals agreed with that idea, either.

Cultural burial conclusion

- The results of those earlier papers ruled out carnivore involvement, and water transport, and the idea that *Homo naledi* individuals had been trapped after falling into the cave.

- We were left with a cultural hypothesis: *Homo naledi* bodies were likely transported by other members of their group.

Differing midfaces in MHs and Ns



*** Human midfacial growth pattern differs from that of Neanderthals and chimpanzees -- Alexandra Schuh, et al., 2025

- Present-day humans have small and retracted midfaces, while Neanderthals possess large and forwardly projected midfaces.
- Study compared maxillary growth and development from birth to adulthood in present-day humans (*Homo sapiens*; *n* = 128), Neanderthals (*Homo neanderthalensis*; *n* = 13), and chimpanzees (*Pan troglodytes verus*; *n* = 33) using macroscopic (i.e., geometric morphometrics) and microscopic (i.e., surface histology) approaches.
- ** Found that the midfaces of present-day humans are on average already smaller at birth than those of Neanderthals and grow more slowly after birth. In particular, we find an early cessation of growth around adolescence, which is unique to our species

Midface differences

- Microscopically, this is reflected in reduced amounts of bone resorption, indicative of decreased cellular activities linked to bone development.

- Greater amounts of bone formation in the infraorbital and nasal regions and faster growth rates are responsible for the large Neanderthal midface.

- These results highlight the importance of postnatal ontogeny (especially in late stages) for explaining facial differences between Neanderthals and present-day humans, as well as part of the gracilization process characteristic of present-day

Midfacial development

- Our findings indicate key differences in midfacial developmental hx between Neanderthals, chimpanzees, and present-day humans that relate to the development of large and small faces, as well as to dental development.

- The characteristic midfacial prognathism of Neanderthals is already found at birth but is accentuated in the first years of life. They also exhibit an early growth spurt in childhood that contributes to the larger size of their midface. Moreover, throughout ontogeny, midfacial size increases are more pronounced in Neanderthals and chimpanzees than in present-day humans, even in later stages.

Genetically programmed facial growth pattern

- Thus, differences in midfacial morphology are due to prenatal and postnatal ontogenetic shifts, characterized by changes in the bone modeling patterns as well as in the rates and timings of the cellular activities.

- Although certain morphological differences are already present at birth, key midfacial shape differences between groups emerge postnatally.

- In present-day humans, maxillary growth ceases earlier and adult size is already attained around adolescence.

*** New discovery at Olduvai Gorge: excavations from 2015 and 2022

Bones of Innovation: discovery of bone tools at 1.5 Ma at Olduvai Gorge, Tanzania

- Before this study, most researchers believed that systematic bone tool production did not appear until the Middle Pleistocene, around 400,000 years ago, with early Homo sapiens and Neanderthals.

- Researchers have uncovered a collection of systematically shaped bone tools at Olduvai Gorge, dating back to 1.5 million years ago—an astonishing 1 million years earlier than previously known examples of knapped bone tools.

Bone tech

- Study argues that these tools represent a distinct technological tradition, not just an opportunistic or accidental use of bones.

- This study challenges the long-standing assumption that early hominin tool use was primarily limited to stone.

- The discovery joins other finds — such as a 1.4-million-year-old bone axe from Ethiopia — that suggest the human ancestor *Homo erectus* often used bones as tools.

27 bone tools

- The site, known as the T69 Complex, has yielded 27 bone tools made primarily from the limbs of elephants and hippopotamuses.

- These were not simply used fragments but carefully shaped artifacts, demonstrating intentional knapping—striking the bones with stone tools to modify their shape. This suggests that early Acheulean hominins had already begun transferring their stone-working knowledge to bone,

- The implications of this are profound. Not only does it show that early hominins were capable of complex technological thinking, but it also suggests that they were experimenting with different materials to expand their toolmaking repertoire—a trait that would later define Homo sapiens.

Advanced cognitive abilities

- Unlike the more commonly found stone tools, these bone tools were likely used for heavy-duty tasks. Their size and shape suggest they were designed for butchery—perhaps to process large animal carcasses.

- Some of the tools feature notched grips, hinting at ergonomic design choices made by their makers.

- Bone tools may have been the precursor to more advanced stone tool technologies; The ability to systematically create and use bone tools suggests advanced cognitive and social skills. They were capable of thinking beyond immediate survival needs.

Why did this technology disappear for 1 million years?

- One of the lingering questions is why this tradition of bone toolmaking seems to disappear for nearly a million years before reappearing in the Middle Pleistocene. The researchers propose two possibilities:

1. **Preservation bias**—Organic materials like bone degrade more easily than stone, meaning that many bone tools may have simply been lost to time.

2. **Technological shifts**—As hominins refined their stone tool technology, they may have abandoned bone tools in favor of more efficient alternatives.

If H. erectus had this level of sophisticated technology, what other cognitive abilities were present?

- This discovery argues for more advanced cognitive ability in H. erectus.

- Adds evidence for possibility of sophisticated language ability for social communication in service of this technology.

Importance of ancient horse hunting

40 slides

The Marsh Ambush: What a 300,000-Year-Old Horse Hunt Reveals About Early Human Cooperation

- A horse bone bed at Schöningen in northern Germany offers rare insight into the minds and methods of pre-modern humans—and how deep the roots of social intelligence may go.

- On the edge of a shallow lake in what is now Lower Saxony, Germany, a group of hunters closed in on a herd of wild horses. It was late summer, perhaps early autumn, 337 to 300 ka.

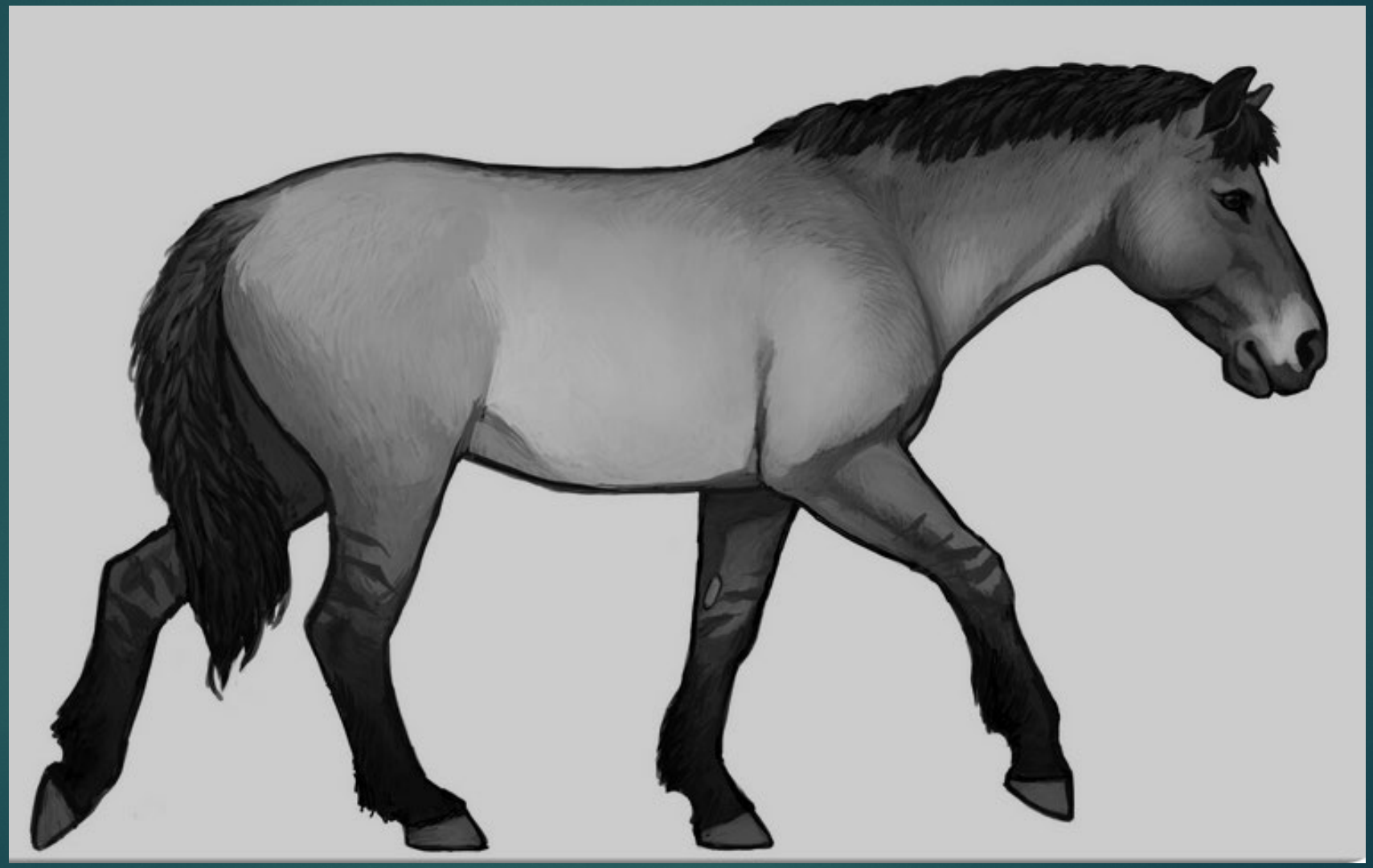
- The animals had followed a familiar path through floodplain grasses to drink at a vast paleolake edge. Hidden there, armed with wooden spears, the hunters waiting in the reeds. They were no longer wolf packs hunting by instinct.

Cooperative planning

- What unfolded next was no improvisation. It was a coordinated ambush—one requiring knowledge of terrain, animal behavior, and the actions of others. It may have ended in a moment of frenzy, with mares and foals brought down in muddy water, but it was conceived long before the herd reached the lake.

- This is the scene reconstructed by archaeologists from evidence at the site of Schöningen 13 II-4, where thousands of horse bones, butchered with precision and scattered in seasonal clusters, suggest that communal hunting—once considered a hallmark of *Homo sapiens*—was already well underway in the Middle Pleistocene.

Equus mosbachensis at Schöningen 13II-4



54 Horses at a shoreline

- Study based on 9,000 excavated bones, including lower jaws retaining teeth, that belonged to wild horses; at least 54 individual animals, the researchers found several families. Tooth size and the extent of tooth wear pegged 22 horses as juveniles up to 2 years old, 29 as adults mostly between 5 and 6 years old, and three as seniors older than 15.

- Tellingly, few signs of 3- to 5-year-old adolescent horses appear at Schöningen.

- Adolescent male horses leave their families to form bachelor groups or travel solo until they reach full maturity. Rather than queuing up family-style in response to threats, bachelor groups tend to disperse haphazardly. Communal hunting of horse families would leave behind limited evidence of slaughtered adolescents,

Ancient hunters used throwing spears 300,000 years ago

Discovery of 10 spears from Schöningen, Germany, dated to 300 Ka fostered a paradigm shift in Pleistocene archaeology = hunting, not scavenging. Wood spears could be thrown over medium distances of 19 meters, as well as used for thrusting. These spears have their point of balance in the front half. On this measurement, those from Schöningen were like modern javelins.

Adult horses in families

- The Schöningen horse site has been excavated for decades, but recent analysis of over 9,000 bones, including jaws, ribs, and long bones, has added depth to the story. The remains represent at least 54 wild horses, many killed in their prime and butchered for marrow, liver, and fat-rich tissue. Tool marks show deliberate dismemberment.

- Notably, there are few bones from adolescent horses—individuals who tend to break away from family groups and are harder to predict. This absence suggests that hunters intentionally targeted family herds, likely because of their consistent group behavior.

Coordinated hunters

- Hunters exploited topography and group structure. Herd behavior was used against the animals. Lake mud became a trap. Juveniles slowed the group. Sentinels likely redirected the herd from higher ground. Kill zones were selected and prepared. This was not the work of scattered foragers. It was an enterprise.

- The hunting party at Schöningen may have included dozens of individuals—possibly men, women, and children—each with a role. Some drove the herd. Others delivered the kill. Still others butchered and distributed meat.

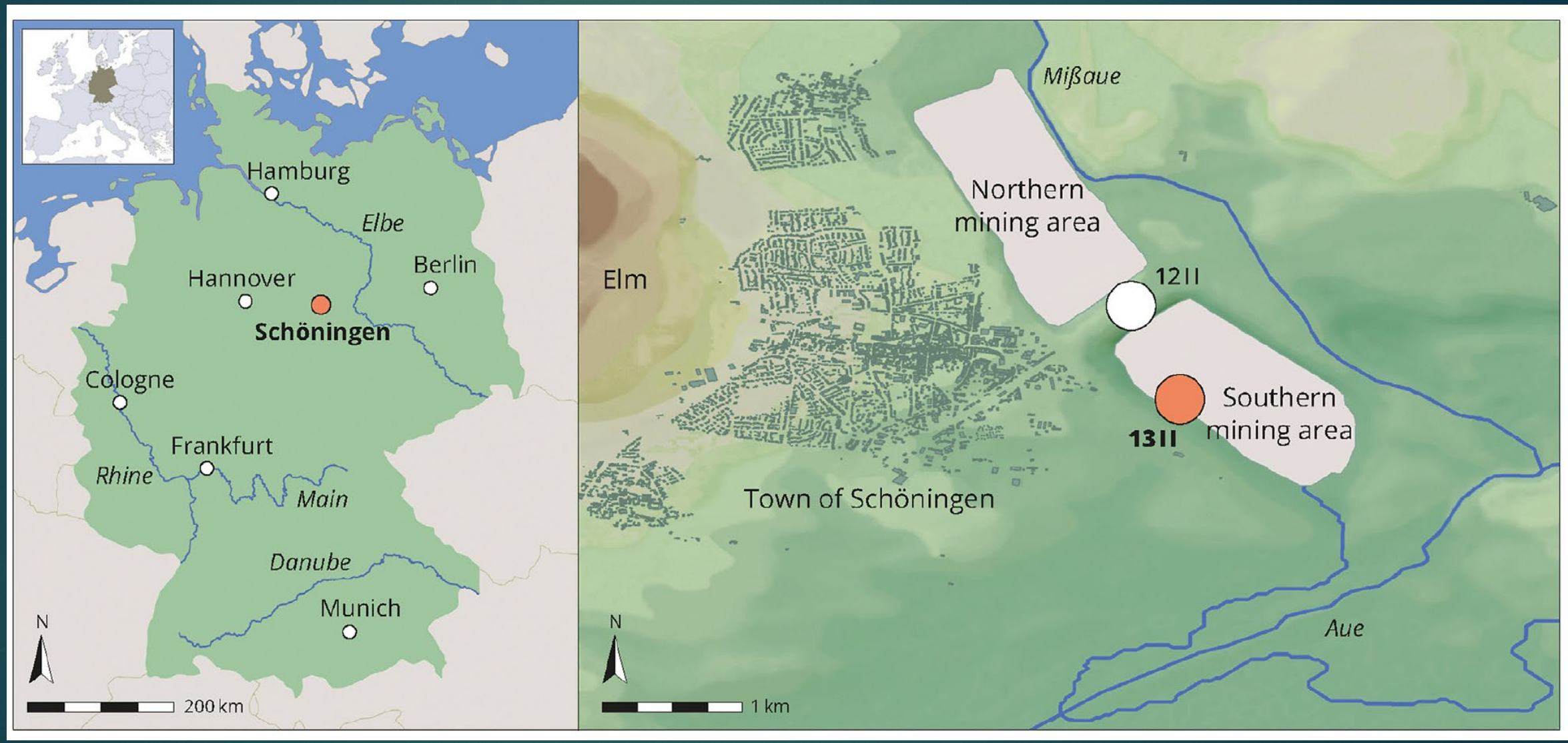
Like Plains Native Americans

- If this sounds familiar, it should: similar strategies were observed among 19th-century Plains societies in North America and forager groups in sub-Saharan Africa.

- "Communal hunting creates bonds," said Eugène Morin, who has studied cooperative hunting among Indigenous groups across continents. It's about food, but it's also about coordination, signaling, memory, and trust.

- Ten spears have now been recovered, along with dagger-like sticks, splitting tools, and over 1,500 stone implements. But there's no sign of fire. No hearths. No burned bones. If the hunters ate on-site, they likely consumed raw organ meats before transporting other parts elsewhere.

Schöningen


Hamburg
Elbe
Berlin
Hannover
Schöningen
Cologne
Frankfurt
Rhine
Main
Danube
Munich
N
200 km
Mißaue
Northern
mining area
Elm
1211
1311
Southern
mining area
Town of Schöningen
Aue
N
1 km

Excavations since 1990s

Excellent preservation: Studying aspects of horse teeth revealed the sex and age of hunted horses and even the timing of hunts. Based on the timing of modern horse births in late spring, juvenile horse deaths in the ancient sample occurred in every season but peaked in late summer and early autumn. Able to date exact month from July to May.

*** Persistent predators: Zooarchaeological evidence for specialized horsehunting at Schöningen 13II-4 -- Jarod M. Hutson, et al., 2024

- The Schoningen 13II-4 site is a marvel of Paleolithic archaeology. With the extraordinary preservation of complete wooden spears and butchered large mammal bones dating from the Middle Pleistocene, Schöningen maintains a prominent position in the halls of human origins worldwide.

- Present the first analysis of the complete large mammal faunal assemblage from Schöningen 13II-4, drawing on multiple lines of zooarchaeological and taphonomic evidence to expose the full spectrum of hominin activities at the sited before, during, and after the hunt.

Persistent predators

- Horse (Equus mosbachensis) remains dominate the assemblage and suggest a recurrent ambush hunting strategy along the margins of the Schöningen paleo-lake.

- Schöningen provides the first undisputed evidence for hunting of a single prey species that can be studied from an in-situ, open-air context.

- The Schöningen hominins likely relied on cooperative hunting strategy to target horse family groups, to the near exclusion of bachelor herds

Schöningen = Model of European MP hunting strategy

- Horse kills occurred during all seasons, implying a year-round presence of hominins on the Schöningen landscape. All portions of prey skeletons are represented in the assemblage, many complete and in semiarticulation, with little transport of skeletal parts away from the site.

- Butchery marks are abundant, and adult carcasses were processed more thoroughly than were juveniles. Numerous complete, unmodified bones indicated that lean meat and marrow were not always so highly prized, especially in events involving multiple kills when fat and animal hides may have received greater attention.

- Schöningen is considered the archetype for understanding hunting adaptations during the European Middle Pleistocene.

Conclusion

- The Schöningen 'Spear Horizon,' set against the backdrop of a lively Middle Pleistocene lakeshore environment, serves as a chronicle of Paleolithic hominin group activities before, during, and after the hunt.

- The lakeshore was a strategic location on the landscape, drawing in predator and prey alike, and the Schöningen hunters had little reason to stray far away.

- They returned time and again during the time of the 'Spear Horizon,' subsisting at or near the lakeshore year-round. This is the definitive example of how Middle Pleistocene hominins hunted, how they were knowledgeable about their environment, well equipped for the task, and organized communal pursuits of their prey.

Following the hunt

- Following the hunt, they were by no means frugal butchers and consumers, often leaving substantial portions of carcasses untouched.

- They ate or carried away only what they needed, at times favoring fat and hides over meat. Perhaps such a blithe attitude toward the availability of lean meat was commonplace up until much more recent times.

Schöningen: the model for MP hunting

- The timeline for communal hunting, crafting of spears, use of bone tools, and other sophisticated behaviors do not begin at Schöningen, nor do these behaviors and technologies end there.

- What makes truly unique is the appearance of all these behaviors as a unified and interrelated package.

- We propose that Schöningen best serves as a model for Middle Pleistocene hunting and subsistence behavior rather than an exception. Above all, Schöningen embodies more than just a 'Spear Horizon' or 'Horse Butchery Site;' it preserves a legacy of inherited behaviors from times past and lifeways handed down to future generations.

Schöningen

- There was a mosaic delta-plain landscape at Schöningen flanked by marshes, with open grassland and a nearby forest. The dominant feature was the Schöningen paleo-lake, which drew in a wide range of large mammalian species from across the region.
- Horses appear to have been particularly abundant, and the lake also played host to other large mammals, including ass, red deer, roe deer, giant deer, bison, aurochs, elephant, and rhinoceros. Much activity was centered around the shoreline,
- Data suggests a persistent hominin presence on the broader landscape during the Middle Pleistocene, but the sheer abundance of prey bones in the Schöningen deposit suggests this exact location offered an attractive suite of resources that was perhaps continually and closely monitored by the hominins.

Lithics and spears

- The lithic assemblage is rather unremarkable, with few formal tools and an abundance of retouching debris

- Prefabricated tools were brought to the lakeshore sites for use in various butchery tasks and possibly for woodworking and hide-working.

- The more interesting features of the Schöningen technological repertoire are the nonlithic implements and the wooden spears, of course, double-pointed sticks, split-wood implements, and the bone retouchers and hammers.

Bone retouchers

- The final elements of technology at Schöningen are the bone retouchers (lissoirs) and bone hammers used for resharpening the dulled edges of stone tools and for breaking long bones for marrow.

- Combined, there are 200 bone retouchers in the assemblages, far more than the number of formal lithic tools.

- The complete technological repertoire organized around a diverse set of raw materials (stone, wood, bone) reflects a strategy of individual provisioning, with a combination of expedient and curated tools.

Bone tools

- The bone retouchers and bone hammers fall at the expediency end of the technological continuum, whereas the carefully crafted spears, double-pointed sticks, and split-wood implements represent the opposite: thoughtfully curated, maintained, and recycled tools.

- The lithics fall somewhere in the middle, imported to the site as finished tools, rejuvenated on site and discarded when their uselife was exhausted.

How did the Schöningen hominins execute their hunts?

- Clearly, hunting efforts were directed at horse populations inhabiting the Schöningen paleo-lake environment.
- The Schöningen hominins engaged a number of tactics to increase the chances of a successful hunt, especially the local geography and particularities of horse social behavior, that the hunters were able to exploit.
- The 'Spear Horizon' was particularly well suited as an ambush site.

Ideal geography

- Upland areas on the flanks of the nearby Elm ridge offered commanding views of the vast grassland and open woodland descending down to the Schöningen lakeshore. From here, hominins could view herds of potential prey or solitary game meandering through the lowland meadow and across braided streams of the delta-plain on approach to the lake.

- Marsh, swamp, raised-bog, and shallow-water areas close to the lakeshore may have offered wary herds a safe haven from some predators, but the Schöningen hominins could use these wetland areas to their advantage, waiting in ambush among the tall reed and sedge beds, with any chance of their prey escaping slowed by the narrow pathways of uneven and unfirm ground.

Behavioral predictability of horses

- The Schöningen hunters also could exploit characteristics of horse behavior in order to target certain segments of the horse population. Behaviorally, when confronted with a distant (i.e., not immediate) threat, horse family groups often take flight in a single file along an established direction initiated by the most nervous mares; antipredator responses of bachelor groups are more random and leaderless, with individuals regularly fleeing in any direction.
- Essentially, the collective behaviors of horse family groups were probably more predictable and therefore easier to influence. Armed with knowledge of horse flight behavior and the ability to manipulate that behavior, together with the understanding of horse movements tethered around water, the Schöningen hominins would have greatly profited from a game drive and ambush-hunting strategy.

A horse trap

- Observing and tracking a horse family group from a distance, the Schöningen hunters could drive the animals toward the lake and position sentries at strategic places on the grassy and wet-meadow landscape to direct their potential prey along a predetermined course.

- The trap could be sprung as the horses approached the lakeshore, where allied hunters, armed with spears and concealed amid tall reeds and sedges, lay in wait to dispatch the entire horse family group. The final death blows likely came at close range with spears thrown over a short distance or with thrusting spears.

- Deer and bovid prey species were scarcer, less predictable, and the latter more dangerous.

Neandertals formed teams that effectively hunted a range of herd animals.

- The ability to kill multiple prey individuals during a hunting event at Schöningen may have involved greater reliance on cooperative hunting strategies.

- Other similar N hunting sites from later periods:
- Aurochs were killed in large numbers at Biache-Saint-Vaast (France, MIS 7),
- Red deer dominate the faunal assemblage at Lazaret Cave (France, MIS 6);
- Reindeer at Salzgitter Lebenstedt, Germany, MIS3

Neandertal hunting strategies

- Bison at Mauran (France, MIS 5). Estimated that several thousand Bison died at the hands of Neanderthals over the course of a thousand years.
- Several thousand horse remains dominate the faunal assemblages at Zwolen (MIS 5-4, Poland). During the winter months at Zwolen, Neanderthals drove horse harem groups into a narrow, steep-sided ravine, where they were easily ambushed and killed.
- Evidence of 70+ straight-tusked elephant hunting and butchery by large groups of Neandertals at Neumark-Nord, Germany.
-

N team hunting strategies

- Neanderthal hunting involved superb tactical planning, using the landscape to disadvantage prey.
- Their prey's avoidance and flight behaviors were exploited in the hunt.
- They did not target specific individuals during the hunt, but killed indiscriminately from whole herds.
- After the kill only the ‘prime’ animals were chosen to butcher.
- In sum Neanderthals were “careful tacticians, casual executioners and picky diners”.

N planning ability is evidence of symbolic ability.

- CJV note: These hunting strategies required advanced cognitive ability.

- Planning ability is one of the multi-domain, difficulty-related, functional systems in the brain's prefrontal and parietal systems. It is the forward projection of something you hold in present memory; it is the creating steps from now to the future.

- It is utterly dependent on a functional memory system and intact hippocampus.

Cognitive capacities

- Working memory is the ability to hold and manipulate information in mind, and it's crucial for creating mental representations of the situation, the goal, and the steps needed to reach the goal.

- Interestingly, Alzheimer's patients who lose function of their hippocampus and parietal lobes, are utterly unable to image a future or to plan. Clearly memory is the foundation of future planning ability

- Neanderthal hunting/planning ability is evidence of symbolic ability and likely the need for language.

How about after the hunt?

- All evidence points to hominins as the primary accumulator of the Schöningen faunal assemblage.

- Traces of hominin butchery are considerably more abundant than carnivore-gnawed bones from horse and Bison, and in cases where cut marks. and tooth pits co-occur, hominin butchery always precedes damage by other carnivores.

After the hunt

- Based on the arrangement of cut marks and impact damage, the Schöningen hominins sought out the easily accessible, meaty, and marrow-rich portions of animal carcasses for consumption.

- Carnivore damage is largely restricted to the ends of long bones and ribs, as well as vertebrae. These patterns indicate primary accumulation by hominins and secondary scavenging by other carnivores, likely wolves.

'Shoot first, ask questions later'

- In terms of horse mortality profiles, it seems that the Schöningen hominins adopted an indiscriminate 'shoot first, ask questions later' mentality, targeting entire horse family groups, young and adult individuals alike; bachelor herds were largely ignored.

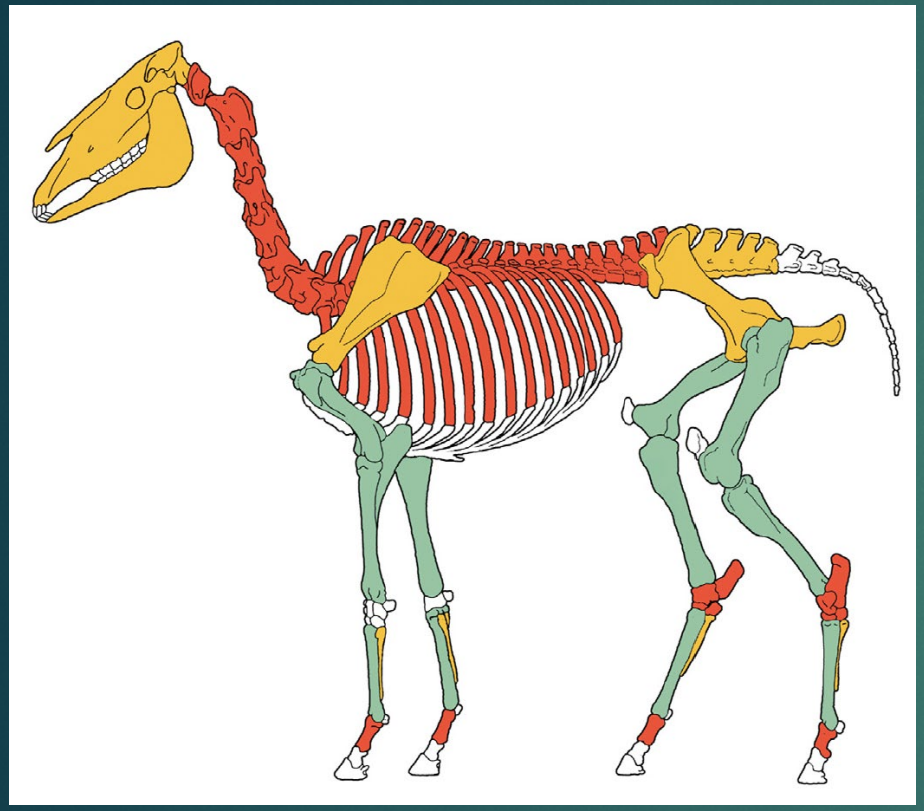
- Thereafter, the Schöningen hunters took up an approach to butchery that may be considered suboptimal or even wasteful, butchering substantial portions of many carcasses, while leaving others only minimally processed. Clearly, subadult (and young juvenile) horses were not exploited in the same manner as adult individuals.

Cut marks

- The ratios of carnivore-damaged bones to cut-marked bones across the horse skeleton show that adult animals were frequently stripped of meat, but subadult carcasses were not so intensively butchered.

- Scraping marks are often found in conjunction with cut marks (and with bone tools use) in the adult-horse assemblage, but only seven bones from subadult horses show scraping damage.

Cutmarks



Hunters limited the amount of protein-rich lean meat consumed at kill sites,

- Standardized cut-mark frequencies on the horse skeleton, with
- high (green),
- medium (orange),
- low (red), and unmodified (white)
-
- Cut marks produced during filleting are numerous for nearly all bones with significant amounts of meaty tissues, especially on the long bones.
- Cut marks on mandibles correspond to the removal of the large chewing muscles and the tongue.
- Filleting marks on long bones and mandibles served double duty, primarily for meat removal and secondarily as the first step in marrow processing.

Cutmarks

- Anatomically, the greatest concentration of meat in the horse skeleton resides in the cervical vertebrae, thorax (thoracic vertebra and ribs), and pelvis, yet cut marks appear on these skeletal portions in low proportions relative to the long bones. Similarly, the limbs below the humerus and femur are of lesser value in horse, but these bones are heavily cut-marked overall.
- Many of the marrow-bearing bones of horse have been intentionally broken.
- To date, 200 remains of horse, red deer, and bison bearing traces of use in lithic manufacture and maintenance, commonly known as 'retouchers,' or for heavy pounding activities, referred to as 'bone hammers,' have been identified. 7% of bones had carnivore tooth marks; but these are after human modifications

Suboptimal processing of meat

- The limb bones of subadults were also not as intensively processed for marrow and only 28 subadult limb-bone fragments show impact fractures as compared to 603 adult bones with impact damage.

- Subadult horse bones were similarly avoided for use as tools, with only three bones in the entire bone retoucher assemblage definitively from subadults.

- From any angle, the treatment of subadult horses in terms of food-resource potential at Schöningen was decidedly less than optimal.

Not conservationists in butchery

- Overall, it appears that meat from these portions was underutilized despite high-utility rankings. Many horse long bones also were recovered unmodified and unbroken, indicating marrow, too, was not always fully exploited.

- This restricted manner of butchery opposes the thrifty ideals of prehistoric subsistence, always maximizing returns and never leaving anything to waste.

- The Schöningen hunters were far from conservationists, but rather opportunists, whose subsistence strategy would be most practical when multiple horses were killed during a single event, with some horses fully butchered and others processed on a more limited basis.

Why leave good food behind?

- Why, then, would a hunting party kill entire horse family groups instead of one or two healthy, prime-aged adults, only to repeatedly leave significant portions of the carcasses unconsumed? Perhaps to address this question, we must understand what portions of carcasses held value to the Schöningen hunters.

- Based on butchery evidence, lean meat and marrow were undoubtedly valued but possibly less than objectively measured by various utility indices. The fact that utility indices consistently rank lean meat by weight above all probably reflects modern (and Western) preferences rather than the nutritional requirements of Paleolithic hunter-gatherers

Dangers of too much lean meat

- While lean meat was an important component of Middle Pleistocene hominin diets, there is an upper limit to the amount of protein an individual can safely consume on a daily basis (~300 g).

- Sustained consumption of excess protein over the course of weeks or longer runs the risk of protein poisoning and fatigue, weakness, and eventual death.

- Fats and carbohydrates were likely the easiest sources of supplementary calories available to hunter-gatherers. Additionally, internal organs, hides, and other nonconsumables were surely highly valued items, but whose utility is difficult to quantify and standardize alongside lean meat and marrow.

Fat was a prize

- Fat rather than meat and marrow could have been the highest prize. As fat can be processed and consumed with little disturbance to the skeleton, its consumption may be somewhat invisible archaeologically. Horses are generally quite lean, but fat is most accessible at the neck (crest), down the back to the tail head, behind the shoulder, over the ribs, and within the abdominal cavity.

- Cutting fat from along the vertebra, especially at the neck, and the ribs would not necessarily leave any butchery traces, and meat beneath the fat on the vertebrae and ribs would be left for scavenging carnivores. The few cut marks on the medial sides of rib shafts may be evidence for consumption of internal organs and associated fat within the abdominal cavity.

Internal organs and hides and lissoirs

- Similar to fat, internal organs contain vital nutrients not present in lean meat. In particular, the liver provides necessary vitamins (especially vitamin C) to maintain basic bodily functions and promote disease prevention in a diet otherwise heavy in meat and fat.

- To explain the many unbroken horse long bones, marrow, as lean meat, may not have been so highly valued and sometimes ignored in favor of more easily accessible stores of fat.

Horse hide

- Beyond dietary considerations, horse hide was also likely a high ranking element of carcass utility, albeit difficult to measure, and a small number of skinning cut marks on the Schöningen horse bones suggest hides were procured from carcasses at the site.

- Split-wood pieces from the site may have been used as hide smoothers (lissoirs) or for other hide-processing tasks. Several bones with utilized, rounded tips from the contemporary Schöningen 12II-4 site resemble hide smoothers from later Paleolithic contexts, suggesting that regular hide-working may have been a widespread activity at Schöningen.

Not a habitation site

- Based on the setting and overall archaeological signature, Schöningen bears little resemblance to a habitation site.
- Following a successful hunt, some degree of hide-working was likely as much a part of the processing routine as butchering a carcass for meat, fat, marrow, and other edible tissues to meet the situational needs of the forger group.
- Why the Schöningen hunters abandoned their spears and double-pointed sticks at the site is still shrouded in mystery, but the remainder of the archaeological remains at the site can be directly traced back to carcass processing activities and regular tool maintenance without invoking any reference to domestic activities or a habitation site.

For how long did the Schöningen hominins occupy the 'Spear Horizon' site?

- The site can be regarded as a palimpsest of kill/butchery episodes.

- For seasonality, evidence from the timing of juvenile horse deaths at Schöningen suggest a sustained hominin presence throughout all seasons of the year, with some brief gaps and peaks in the age distribution.

- The May-June gap overlaps with a main birth pulse that is prevalent among modern equids in the Northern Hemisphere, suggesting some segment of the horse population may have moved away from the Schöningen area during the birthing and breeding seasons with an 11-month gestation period

Rapid site burial

- Based on the associated archaeological remains, much of the zooarchaeological record at Schöningen detailed here plausibly could have been created during several successive hominin generations.

- Excellent preservation of bone, wood, and other botanical remains in an undisturbed depositional context, bolsters the argument for a short period of accumulation and rapid burial.

- Targeted hunting of horse family bands and exclusion of bachelor herds, differential treatment of adults and subadult horse carcasses, the lack of bone transport to or from the site, and the high frequency of butchered horse bones relative to carnivore-damaged bones may altogether represent the cooperative behaviors of a single hominin group or closely related groups.

Rapid burial of bone material

- Noteworthy is the lack of bone weathering, which indicates limited subaerial (air) exposure time for the bulk of the 'Spear Horizon' deposit.

- Rapid burial thereafter is implied by the presence of dark staining on many bones from decaying vegetation that otherwise would have faded quickly with extended exposure to the elements.

- These features provide solid evidence that the 'Spear Horizon' deposit accumulated over a very short period of time and was buried even quicker.

Rethinking the ‘Modern’ in Human Behavior

- For decades, archaeologists framed the emergence of modern human behavior as a sudden cognitive shift around 50,000 years ago. Art, ritual, language—all seemed to bloom at once. But the record now suggests a more gradual evolution, one that began hundreds of thousands of years earlier.
- At Schöningen, no art has been found. No graves. No beads. But there is strategy, collaboration, and memory—a set of behaviors that, in many ways, define our species.
- The idea that planning, cooperation, and innovation belong only to *Homo sapiens* doesn’t hold anymore. We’re seeing tactical, discerning, highly effective hunters in much earlier periods.

Tools and animals present

- On-site lithic maintenance and breaking bones for marrow were carried out using a variety of bone tools and retouchers, metapodial hammers, and possibly anvils rather than hard stone hammers.

- Use-wear and residue analysis shows evidence of wood and hide working as well as cutting meat.

- Bone retouchers, used for modifying flint tools (90% small flakes), predate the Mousterian period and are associated with a Lower Paleolithic flake industry. The retouchers are found in close association with the skeleton of an extinct straight-tusked Eurasian elephant, which was probably scavenged.

- There is no evidence for the controlled use of fire at the site, and no burned bones have been reported.

Animals

- Hunters targeted the family group of horses, consisting of one mature male over 5-6 years, two to six breeding mares, and their young; and the bachelor group, comprised of 2-15 males aged 2-4.5 years; not bachelor horses

- The Schöningen hominins potentially ranged over the lakeshore and vicinity on a year-round basis

- There is a clear signature of heightened hunting and butchery activities at the 'Spear Horizon' high-water shoreline during the warmest months of the year, from July to October.

Lithics

Straight-tusked Eurasian elephant at Schöningen; and elephant footprints 100 meters away; they walked parallel to the lake shore.

Who were the hunters at Schöningen?

- Dated at 337-300 Ka
- ~1500 stone artifacts of local flint and lacks hand axes and Levallois technology. Approximately 90% of the lithic assemblage consists of small flakes, chips, and retouching debris
- Homo heidelbergensis or early Homo neanderthalensis
- Homo heidelbergensis is now considered the ancestor of H. neanderthalensis.

Planning ability = symbolic thought

- Schöningen isn't alone. Sites like Gesher Benot Ya'aqov in Israel (780,000 years ago) and Gran Dolina in Spain (400,000 years ago) also show evidence of systematic, group-based hunting.
- In Spain, Neanderthal ancestors drove bison off ledges.
- In Israel, prime-aged deer were repeatedly harvested from lakeshores.
- In Germany, more recent Neanderthal groups left behind evidence of hunting elephants at Neumark-Nord—massive undertakings that required teamwork and foresight.
- Across these contexts, a pattern is emerging: early humans and their relatives hunted not as scattered opportunists, but as organized, tactical cooperators. They were planning, strategizing. That kind of behavior demands symbolic thought. And almost certainly even language.

Malta

** Mediterranean hunter-gatherers voyaged across the open sea 8500 years ago

New discoveries on Malta show people settled remote islands before the rise of farming

- Archaeologists thought they knew how Malta was first settled: by ancient farmers who reached the remote Mediterranean archipelago some 7400 years ago, crossing the open sea from Sicily with pottery, crops, and domesticated animals in tow.
- Now, an analysis reveals a previously unknown coastal site brimming with stone tools, hearths, shells, and animal bones that turns the old view on its head. Not only does the site push back the settlement of Malta by more than 1000 years, but it also suggests seafaring hunter-gatherers, rather than farmers, were the first to arrive.
- The discovery implies the longest known sea voyage made by Mediterranean hunter-gatherers—and raises provocative questions about the seafaring abilities of preagricultural people.

Isolated Maltese Archipelago

- Maltese Archipelago is among the most remote groups of islands in the Mediterranean, the world's largest inland sea.

- Sea-level rise rapidly submerged the low-lying, now around 95 m deep, hypothesized land bridge from Malta to Sicily around 13 ka. Over the next few thousand years, both Sicily and the Maltese islands reached their current configurations, with Malta now having a combined landmass of just 316 km^2.

- Evidence suggesting that the first people to reach Malta were Neolithic farmers, associated with impressed ware pottery, stemming from the Sicilian 'Stentinello' phase of the Neolithic.

Original theory: farmers arrived

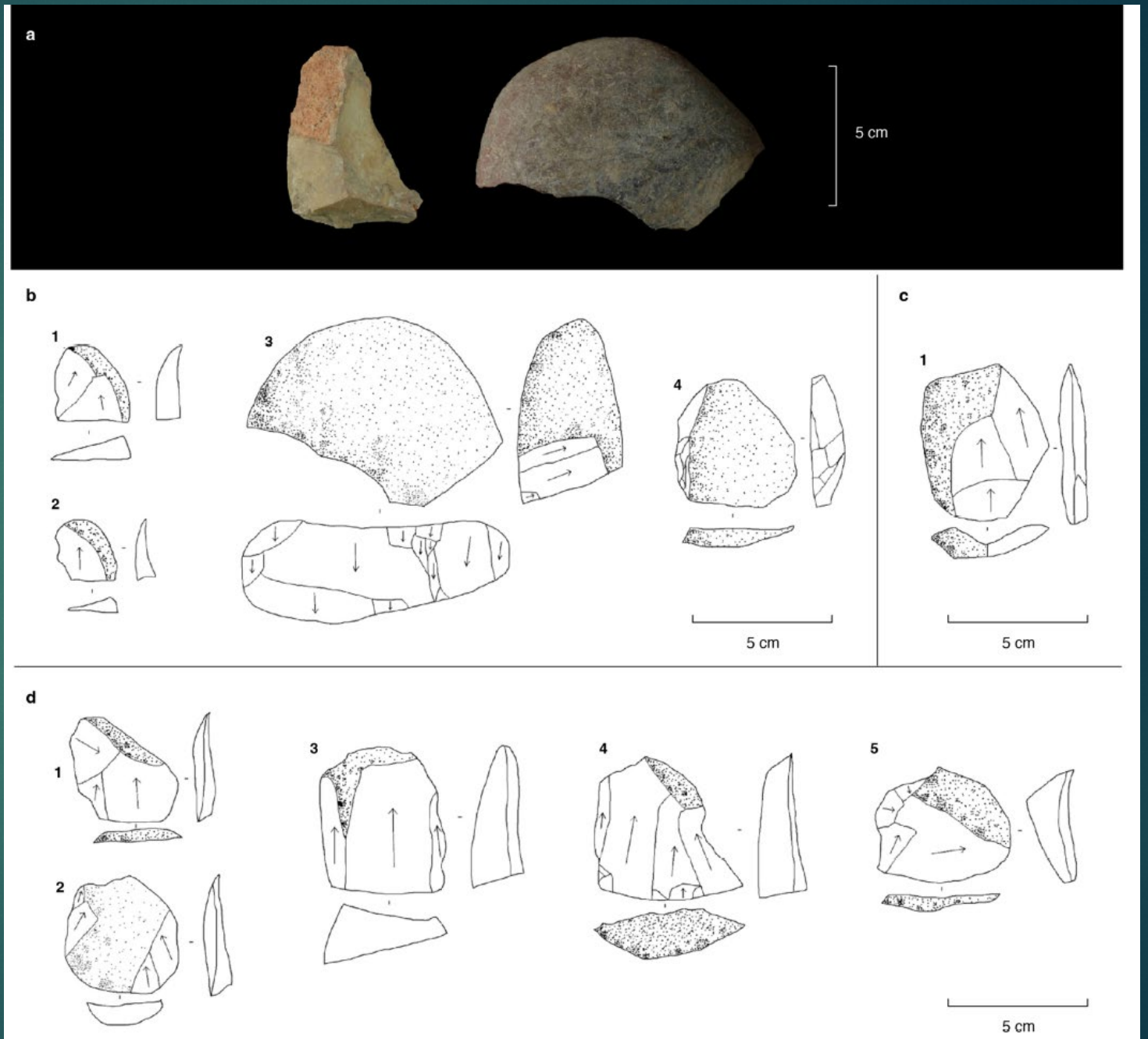
- These farmers were assumed to have introduced crops and domesticated and commensal fauna into a pristine island ecosystem. The directly dated and secure evidence for the start of the Neolithic in Malta indicates an age of around 7.4 ka.
- Study: provide decisive evidence for a pre-Neolithic human presence on the Maltese islands, in the form of a previously unknown Mesolithic phase characterized by the presence of Holocene hunter-gatherers.
- This discovery casts new light on the age and extent of Mesolithic sea crossings in the Mediterranean, and on hunter-gatherer interactions with endemic island fauna. Description of an archaeological sequence at the site of Latnija (Lat-nee-yuh). The site is located in a large doline (natural enclosed depression) in the Mellieħa area of northern Malta

64 lithics

- 64 limestone lithics; flakes produced by hard hammer percussion.
- In addition to hunting wild deer, the earliest occupants of Malta ate shellfish, birds, fish, tortoises, and seals. “They are exploiting everything the sea has to offer and everything they can get from the air,” Scerri says.
- Their wild food sources and stone tool technologies were distinct from those of later farmers, who introduced domesticated plants and animals, such as wheat and goats. There’s a clear coastal hunting and foraging economy happening here, and it’s very different from the later Neolithic settlement of these islands, supporting the idea that the hunter-gatherers of Malta were a separate, earlier group.

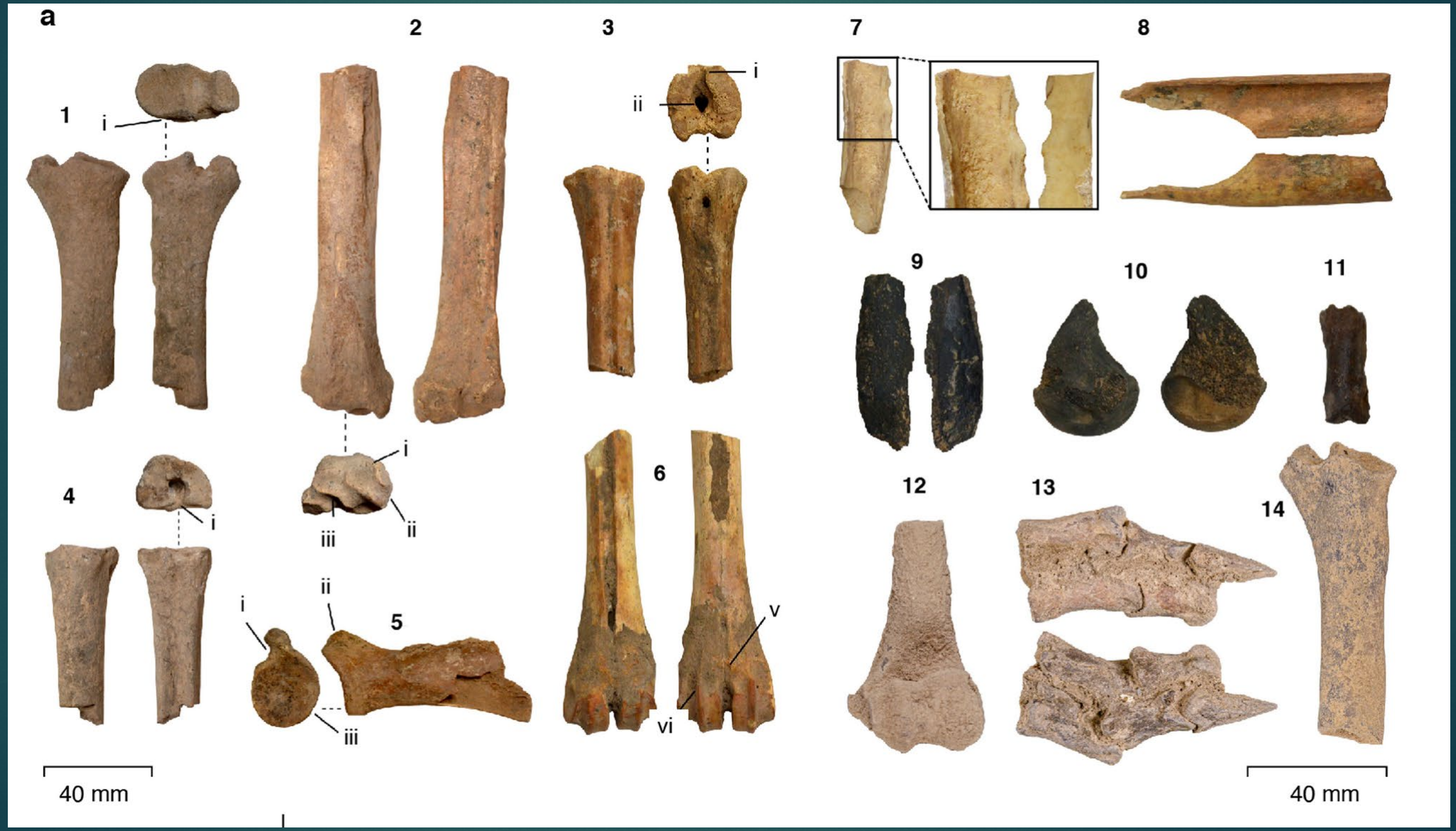
Fig. 4: Fauna and lithics from the Mesolithic Horizon.

Maltese Mesolithic limestone lithics



Extended Data Fig. 10 | Lithics from the Maltese Mesolithic. a, Photographs of lithics from Phase III (left) and Phase V (right) showing terrestrial and coastal raw material forms. **b–d**, Illustrations of lithics from Phases V (**b**), IV (**c**) and III (**d**). All are flakes except b3 (core) and b4 (retouched flake). All limestone.

Red deer remains, taphonomic modifications



*** Hunter-gatherer sea voyages extended to remotest Mediterranean islands – E. Scerri...Nicholas Vella, et al. 2025

- The Maltese archipelago is a small island chain that is among the most remote in the Mediterranean. Humans were not thought to have reached and inhabited such small and isolated islands until the regional shift to Neolithic lifeways, around 7.5 thousand years ago.

- Here we describe chronological, archaeological, faunal and botanical data that support the presence of Holocene hunter-gatherers on the Maltese islands.

Occupation by sea voyagers circa 8.5 Ka

- At this time, Malta's geographical configuration and sea levels approximated those of the present day, necessitating seafaring distances of around 100 km from Sicily, the closest landmass.

- Occupations began at around 8.5 ka and are likely to have lasted until around 7.5 ka. These hunter-gatherers exploited land animals, but were also able to take advantage of marine resources and avifauna, helping to sustain these groups on a small island.

- Our discoveries document the longest yet-known hunter-gatherer sea crossings in the Mediterranean, raising the possibility of unknown, precocious connections across the wider region.

Mesolithic occupation of Malta from 8.5 to 7.5 Ka

- The evidence from Latnija confirms a Mesolithic occupation of the Maltese islands spanning from around 8.5 ka to 7.5 ka.

- Today Malta has a minimum straight-line distance of around 85 km to Sicily.

- However, sea surface currents and prevailing winds, as well as the use of landmarks, stars and other wayfinding practices, mean that the distances traversed by hunter-gatherers to Malta could have been considerably longer, and a crossing of about 100 km has been proposed for the Neolithic.

Long-distance, open-water sea journeys

- These findings therefore provide evidence of long-distance, open-water sea journeys that were far longer than any previously documented in the Mediterranean, before the Neolithic and Bronze Age.

- The motivation for these long sea crossings remains ambiguous. It might be that movement to Malta was driven by the availability of (perhaps seasonal) subsistence resources, catalyzed by the slightly improved climate of the Early Holocene. It is also possible that the Maltese Mesolithic reflects social rather than environmental factors; namely, the potential regional demographic shockwaves through hunter-gatherer societies associated with the transition to the Neolithic in the Mediterranean.

Hunter-gathers at sea

- The ability of Mesolithic hunter-gatherers to reach small and remote Mediterranean islands forces a re-evaluation of the capabilities and strategies of the last hunter-gatherers of the region.

- Finally, the presence of Mesolithic hunter-gatherers on Malta raises the possibility of other long-distance connections.

Oldest seafaring in the Mediterranean

- The oldest evidence of seafaring in the Mediterranean dates back to at least 130 Ka (to 45 Ka), with stone tools found on the Greek island of Crete suggesting Neanderthals or other pre-Sapiens hominins may have been early seafarers.

- **La Marmotta Dugout Canoes**: Neolithic dugout canoes at La Marmotta, a lakeshore village near Rome, dated between 5700 and 5100 BC,

- **Malta Hunter-Gatherers**: at 8500 ya crossed 100 kms of open water

Oldest seafaring

- Pesse Canoe: The Pesse canoe, discovered in the Netherlands, is considered the world's oldest boat, dating back around 10,000 years.

- Ancient Egypt: Iconographic evidence of sails in Egypt dates to the late fourth millennium BC,

- Minoans and Mycenaeans: Minoans from Crete were likely the first "professional" seafarers sailing internationally in the Mediterranean area, spanning the period between 2000 BC and 1500 BC. From 1500 BC to 1200 BC, the Mycenaeans ruled the Aegean Sea and eastern Mediterranean.

Oldest seafaring

- The oldest established evidence of seafaring, the sea-crossing migration of anatomically modern Homo sapiens to Australia, began around 60,000 years ago.
- The migration of humans to Australia, a landmass only reachable by sea, provides the strongest evidence of early seafaring.

- Homo erectus probably reached island of Flores at 1 MA.