The Power of Deciduous Teeth in Diagnosing Taxa: Case Study of a Late Surviving Neandertal in the Caucasus

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The deciduous teeth of fossil hominins are fairly well represented but comparatively understudied. This is unfortunate because in some cases they are the only teeth represented at important paleoanthropological sites (e.g., Blombos, Cavallo). The deciduous teeth are thought to strongly reflect an individual's underlying genotype since they develop early during ontogeny and their final expression is influenced even less by environment than are the permanent teeth. The crown and cervical outlines of deciduous upper first and second and lower second molars have been shown to be diagnostically different between *Homo sapiens* and *H. neanderthalensis*, but the lower first molar (dm1) has yet to be studied in this context. This study used elliptical fourier and linear discriminant analyses to examine the discriminatory power of the lower dm1 outline of Neandertals (n=13), fossil (n=13) and recent *H. sapiens* (n=189). Of particular interest is a child from Barakai Cave (Caucasus) represented by a mandible with a complete deciduous dentition. The mandible was previously assigned to *H. neanderthalensis* (Faerman et al. 1994) based on the sizes of the corpus and the teeth, as well as the possession of thin enamel and taurodont roots. However, the occlusal morphology of the deciduous second molar (dm2) is ambiguous, possessing an interrupted, rather than continuous, middle trigonid crest. Our results show that lower dm1 outline discriminates even better between *H. neanderthalensis* and *H. sapiens* than does that of the lower dm2. Our analysis of the Barakai deciduous molar outlines confirm its status as *H. neanderthalensis*: a discriminant analysis shows a 92% posterior probability of belonging to *H. neanderthalensis* based on dm1 and 88% based on dm2. Rent radiocarbon dating of fauna associated with the mandible place it between 38–40 Ka. Thus, the Barakai child joins Mezmaiskaya as a late surviving member of *H. neanderthalensis* in this region.

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Paleoenvironments of the Omo Shungura Formation: Synthesizing Multiple Lines of Evidence Using Bovid Ecomorphology

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This study reconstructs past environments of the Shungura Formation (Plio-Pleistocene, Ethiopia) using mesowear of bovid molar teeth and locomotor ecomorphology of bovid astragali. These elements are among the most frequently preserved elements in the fossil record, and therefore provide a robust statistical sample for inferring adaptations of past bovid communities. Astragalar morphology is functionally related to habitat-specific modes of predator avoidance. Bovids occupying structurally distinct habitat types differ in their astragalar anatomy, and these differences are significant after controlling for body size and phylogenetic signal (Barr 2013). In total, 234 astragali from Shungura were analyzed using measurements previously shown to relate to habitat preference. Mesowear was scored for 559 molars following published protocols. Mesowear is a predictor of diet, differentiating between abrasion-dominated grazers with low-blunt cusps and attrition-dominated browsers with high-sharp cusps. Carbon isotope values for some Shungura Tragaphines are higher than in any known extant relatives (Bibi et al. 2013). The mesowear data in the present study shows no evidence for any significant grazing adaptation in any Shungura Tragelaphines, which may suggest that there was a significant source of C_4 browse available to explain the isotopic data. Previous work reconstructed a large ecological shift between Members B and C (ca. 2.85 Ma). The present study, based on analyses at the level of submember, finds that this shift was not completed until submember C-08 (<2.58 Ma). Furthermore, the ecological differences between Member E and Member F (ca. 2.36 Ma) appear similar in magnitude to the earlier shift. The astragalar data reveals a statistically significant increase in the number of bovids from habitats with light vegetation cover through time. Overall, these results demonstrate that hominins in the Lower Omo Valley were faced by continuously shifting environmental conditions.

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The Lumbar Spine of *Australopithecus sediba* Indicates Two Hominid Taxa

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In a recent issue of *Science*, researchers reported the discovery of two partial skeletons from a single site, Malapa, in South Africa. After a thorough investigation, the researchers assigned both skeletons to a new species, which they named *Australopithecus sediba*. According to our analysis, the spinal columns of the two skeletons represent two different hominid genera—*Australopithecus* and *Homo*. Unlike *Homo*, australopiths exhibit a ventrodorsal length of the vertebral bodies that is relatively short when compared to the height of the vertebrae (their craniocaudal length); the vertebral canal is large in relation to the AP dimension of the vertebral bodies; and, the articular processes are relatively large. We compared these ratios in the four lumbar vertebrae from Malapa to the ratios that characterize the lumbar elements of 75 modern humans, two *Homo erectus* specimens, and four australopiths. Our measurements indicate that the lumbar vertebrae attributed to the Malapa specimen MH-1 (UW88-92 and UW88-152) fall well within the range of *Homo*, whereas the lumbar vertebrae attributed to the Malapa specimen MH-2 (UW88 127/153 and UW88 126/138) are similar to those found in australopiths. These findings are in perfect agreement with the mandibular evidence provided by the Malapa specimens and again suggest that the hypodigm of "*Australopithecus sediba*" consists of a typical *Homo* mandible and an australopith. The claim that *A. sediba* represents a transitional species between *Australopithecus africanus* and *Homo* stems from this mixture. The coexistence of *Homo* and *Australopithecus* in early South African sites is not unusual, as seen in fossils from the Swartkrans Cave and the nearby Sterkfontein Cave.

Preliminary Results from the Renewed Excavations from Peshcka Cave: A Stratified Middle and Upper Paleolithic Cave in the Lori Plateau, Armenia

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The Middle Paleolithic (MP) - Upper Paleolithic (UP) transitional period in the Southern Caucasus is a critical period in understanding this pivotal process in human evolution. The Lori Plateau in Northern Armenia has not yielded any sites from this time period. Moreover, stratified sites including MP-UP strata are rare in Armenia as in the Caucasus in general. A 2003 survey uncovered a cave, Peshcka, excavated by Dolukhanov and colleagues in 2004–2005. In the initial publication, it was suggested that the site included a Mesolithic assemblage with a Levallois component. Dolukhanov passed away in 2007 and the research in the cave was halted. We resumed excavation in the cave in 2013 under a joint American-Armenian expedition. Here we present the preliminary results from this study. The cave is formed by a lava tube and is believed to be a unique structure in its environment. The pedogenesis within the cave is shallow, but includes four different soil layers in a depth of ca. 70cm. A large UP lithics assemblage found in strata C, prepared solely on obsidian, is similar to Dzudzuana. The assemblage consisted mostly of debitage with a complete *chain opératoire*, but no tools. Tools were identified in the assemblages collected by Dolukhanov, which indicates that their absence is a product of sample size. A MP assemblage was uncovered from stratum D. The assemblage was made entirely from basalt, with mostly non-diagnostic tools. Tools were indicative of Levallois technique on blades. Unfortunately, no carbon material was available for ^{14}C and current research is focusing on other dating methods, obsidian sourcing and regional GPR. These results point to the presence of a stratified MP-UP site in Northern Armenia and its potential to shed light on the Middle to Upper Paleolithic transition in this critical time in human evolution.

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ESR Dating Tooth Enamel from the Mousterian Layers in Pešturina Cave, Serbia

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Often ^{14}C ages fail to accurately date Middle Paleolithic sites. Electron spin resonance (ESR), however, can date tooth enamel from 10 ka to 2 Ma with 2–5% precision. In southern Serbia, on a migration route from the Levant to southern Europe, Pešturina Cave overlooks a tributary to the Nišava River east of Niš. A series of matrix-supported conglomerates house a Charentian Mousterian industry, a Denticulate Mousterian, and a blade-rich Gravettian in Layers 4, 3, and 2 respectively. Fauna in all three layers suggest a mixed environment with temperate forest, rocky cliffs, and steppe within walking distance of the cave. Although hyenas likely contributed some bone to the site, especially in Layer 3, the fragmentation patterns and butchering marks, plus the many lithic tools, suggests that some faunal remains were human kills. The predominance of horse in the lower layers suggests a warmer and drier climate during the deposition of Layer 4, than during later phrases. Although tools from all production stages occurred, the scarcity of cores suggests that their

initial manufacture happened elsewhere. Until now, this site was undated. From five herbivore teeth found in the Mousterian Layers 3–4b, 24 enamel subsamples were independently dated with ESR. Multiple sediment samples were analyzed by NAA to calculate volumetrically averaged sedimentary dose rates. Although rodents apparently reworked some teeth in Layer 4b, three teeth appear to be stratigraphic succession and likely date the layers in which they occurred. If the teeth accurately reflect the ages for the tools in Layers 3–4b, this represents the first site in the Central Balkans with quasi-continuous occupation from 95 ka to 38 ka. The latter is one of the latest Middle Paleolithic dates in Serbia, while the former is one of the few Middle Paleolithic dates in the central Balkans correlating with MIS 5.

ESR Dating the Mousterian Layer J at Grotte du Bison, Arcy-sur-Cure, France

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A partially collapsed cave with an extant gallery and another 30m^2 of archaeological deposits out front, Grotte du Bison opens south 6m above the modern Cure River. A sequence of clast- and matrix-supported conglomerates house at least 10 archaeological layers, some of which correlate with layers found next door at the Grotte du Renne. In Grotte du Bison, Mousterian and Châtelperronian layers have produced hearths, ochre, manuports, and lithics, including bifaces, scrapers, cortical, and retouched flakes. Levallois technology dominated the Charentian Mousterian industry, made mainly on flint and chert. Most cores and tools, mainly sidescrapers and endscrapers, were found in the main gallery or outside. Roughly equal numbers of reindeer, horse, and bovid fossils occur, plus cave bear, mammoth, roe deer, red deer, birds, fish, lemmings, susliks, some larger herbivores, and carnivores. Faunal analyses from >8,000 bones, including ~100 bird bones, suggest a cold steppe with some forest. Pollen analyses suggest very few trees, only scattered willow and pine, with many cold steppe grasses and chenopods. The Mousterian layers have yielded 20 Neanderthal remains, including a partial adult maxilla, 13 isolated permanent and deciduous teeth from at least five individuals, ranging in age from an infant 2–4 years to adults. From Couche J in the Mousterian layers, 28 independent subsamples from four *Equus* teeth were ESR dated to enable isochron analyses. The external dose rates for each tooth were determined by measuring the radioactivity in associated sediment samples, and by assuming a time-averaged cosmic dose given the sample's varying roof cover since its deposition. U in the enamel ranged from 0.06–0.50ppm, while dentinal U ranged from 2.6–20.6ppm. Isochron analyses suggest that some recent U remobilization has affected the teeth. Nonetheless, the mean LU ages correlate well with early Marine (Oxygen) Isotope Stage 3.

Tephrostratigraphy and Middle Stone Age Archaeology of the Eastern Lake Victoria Basin, Kenya: A Refined Stratigraphic Context for Late Pleistocene Human Evolution in East Africa

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Here we present correlations of distal tephras from the eastern Lake Victoria Basin (eLVB), Kenya, and their relevance to Late Pleistocene Middle Stone Age (MSA) archaeology of equatorial East Africa. The eLVB preserves discontinuous, <1m – >9m thick exposures of Pleistocene deposits across ~60km^2 on Rusinga and Mfangano Islands and Karungu on the Kenyan mainland. Over 900 volcanic glass shards from 65 tuffs at 21 stratigraphic sections across these exposures have been analyzed for major element oxide geochemistry with an electron microprobe at the University of Utah. Results show four distinct tephras in the eLVB. Three tephras are sequentially exposed at multiple locations, defining two successive artifact and fossil bearing intervals. These tephrostratigraphically-defined intervals allow reconstructions of a semi-arid landscape based on fossil fauna and paleosol data from individual localities located up to 60km apart. Four archaeological sites have also been identified: Nyamita and Aringo North from the upper interval, and Aringo-1 and Aringo-2 from the lower. Nyamita and Aringo-1 are both associated with spring deposits, documenting persistent human use of these resources. Nyamita excavations (47m^2) have produced abundant fauna and 328 lithic artifacts including four Levallois points (lava and chert), six obsidian flake fragments, and evidence for on-site knapping of chert nodules. Test excavations (5m^2) at Aringo-1 produced 56 *in situ* artifacts, including Levallois and radial cores, a Levallois point, and an obsidian flake fragment. The nearest known obsidian source is >200km away in the Rift Valley, indicating persistent contact with the eastern rift. Tephrostratigraphy of the eLVB thus allows us to target MSA archaeological sites in two discrete, time successive intervals, and to better understand variability in Late Pleistocene environments and hominin behavior, particularly raw material use and technological variability across the landscape.

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Craniometric Analysis of European Upper Paleolithic and Mesolithic Samples Supports Discontinuity at the Late Glacial Maximum

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The Last Glacial Maximum (LGM) represents the most significant climatic event since the emergence of anatomically modern humans (AMH). In Europe, the LGM affected the distribution, size, and density of AMH populations and may have also played a role in the microevolution of morphological features as a result of adaptive and stochastic processes. We use craniometric data to examine morphological diversity in pre- and post-LGM samples. Craniometric variation was assessed across four periods—pre-LGM, late glacial, Early Holocene, and Middle Holocene—using a large, comprehensive, and well-dated dataset. In compiling the dataset, particular attention was paid to the comparability of measurement protocols employed by different researchers, the archaeological ascription of sites, and new information regarding the dating of particular sites and/or specimens. We employed size-adjustment via the geometric mean to remove scaling effects due to sexual dimorphism and potential differences in robusticity. We then applied multivariate statistical methods to assess the degree and nature of any differences among the four groups. A MANOVA on size-adjusted cranial measurements found significant differences across the four periods. A linear discriminant analysis showed the major separation to be between pre-LGM and later groups along the first discriminant function. Post-LGM groups were all clustered together and were substantially distant from pre-LGM specimens as measured using Mahalanobis distances. The pre- and post-LGM discrepancy was driven mostly by facial measurements, which is consistent with hypotheses of climatically driven selection. However, we cannot rule out the possibility of stochastic evolutionary forces due to glacial refugia, population fragmentation, and genetic drift. These results suggest that the LGM had a major impact on the microevolution of AMH populations in Europe prior to the Neolithic.

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A Taphonomic Assessment of the Bovids from Malapa, South Africa, and Its Implications for the Accumulation of *Australopithecus sediba* Fossils

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This study addresses the faunal taphonomy at Malapa, a hominin-bearing vertical cave opening in South Africa. Specifically, these analyses assess the site's bovid assemblage and consider its implications for the associated *Australopithecus sediba* material. The assemblage is noteworthy in two important ways: 1) extraordinary preservation characterized by partially articulated skeletons; and, 2) remarkable absence of accumulator tooth marks and/or hammerstone percussion breakage. The lack of taphonomically distinct marks suggests that there was no systematic collection of bones by a biotic, bone-accumulating agent. Only approximately 10% of the assemblage exhibits trauma, which may be consistent with a low energy fall or impact; none of the bovid remains have perimortem trauma consistent with a fall from significant height. Moreover, a majority of the bovid long bone remains demonstrate breakages consistent with dry fractures such as right fracture angles and transverse outlines. Finally, the bones exhibit post mortem and post fossilization fractures including crushing, splintering, and cracking; these breakage patterns suggest that there was sediment loading consistent with movement of the surrounding matrix. These observations suggest that the bovids, and likely the hominins, entered the cave on their own, whether by accident or of their own volition, and were unable to escape.

Gastrophagy in the Hadza and Its Implications for Hominin Diets

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Accounts of gastrophagy (the consumption of stomachs and/or stomach contents of prey species by human hunters) are widespread in the ethnographic record. The practice is recorded among people from different latitudes (Greenland[1–4] to Kenya[5] to Australia[6]), with different subsistence strategies (hunter gatherers[1–4,6] and pastoralists[5]), and with a wide variety of prey (birds, mammals, herbivores, omnivores, and carnivores[3–4,7]). However, many of these reports are anecdotal, typically the stories of Western travellers and explorers in the nineteenth century or early twentieth[1–2, 8]. These sources can be unreliable as they may tend towards the sensationalist, and to be tinged with prejudice against what were considered 'savage' practices[1]. Conversely, where recent authors mention gastrophagy it is typically as an aside, an observation marginal to the main aim of the research e.g.,[9]. Little detail is therefore provided in terms of frequency, seasonality, demographic factors, species composition, and relative dietary contribution. With these factors unclear, the real importance of gastrophagy to human groups remains uncertain. Here we discuss gastrophagy in a group of contemporary East African

foragers (the Hadza of Tanzania) with a very well studied diet in order to put gastrophagy into context. We then consider the implications of gastrophagy in hominin evolution. It was recently suggested that, given the prevalence of gastrophagy in non-farming groups, and the clear nutritional advantages of herbivore chyme in a vegetation-poor environment, gastrophagy may have been practiced by Neanderthals[10]. Given evidence from the Hadza that gastrophagy also occurs amongst recent humans living in warm climates, we consider the implications of the practice in earlier hominins living in Africa. If gastrophagy occurred at a significant level in meat-eating *Australopithecus* or *Homo species*, plant remains from their (hunted or scavenged) herbivorous prey could potentially confound hominin dietary interpretations based on evidence such as toothwear, calculus, lithic residues, trace, and isotope analyses.

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Developmental Simulation of the Adult Cranial Morphology of *Australopithecus sediba*

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Subsequent to the announcement of the new species *Australopithecus sediba*, several commentators expressed the concern that because the type specimen (MH1) was a juvenile, it might have undergone a significant amount of morphological change between its present stage of growth and development and full adulthood. They maintained that such transformations could potentially alter the original phylogenetic hypotheses concerning *Au. sediba*, including its status as a distinct species. Here we present a reconstruction and developmental simulation of the MH1 cranium using 3D geometric morphometric techniques. First, damage to the fossil was corrected using a synchrotron scan of MH1. To estimate growth trajectories for comparative ape species, scans were obtained from male and female individuals with second molars erupted, and from male and female individuals with third molars erupted, from the following: chimpanzees (*Pan troglodytes*), gorillas (*Gorilla gorilla*), and humans (*Homo sapiens*). All scans were used to place an array of 3D landmarks and semilandmarks. Growth vectors for each species were then applied to the original coordinates collected from MH1, to produce coordinates for the simulated adult cranium. Using thin-plate spline transformations in Landmark Editor® software, the MH1 cranium was morphed into these coordinates to produce a rendering of the adult specimen. The majority of morphological changes expected to occur between second and third molar eruption appear to be related to the development of secondary sexual characteristics. Most significant changes are observed in the male gorilla growth vector, in which we see increased development of the glabella and supraorbital torus, combined with thickening of the zygomatic. This was also observed, to a lesser extent, using the chimpanzee growth vector. However, changes observed for that of the human growth vector were minimal. Informed by taxon- and sex-specific models of craniofacial ontogeny, these results extend our knowledge of the evolutionary significance of *Au. sediba*.

The Early Upper Paleolithic Fauna from Mughr el-Hamamah (Jordan): An Initial Report on Species Representation and Gazelle Exploitation Based on the Dental Remains

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Initial excavations at Mughr el-Hamamah (MHM; Ajlun District, Jordan) uncovered a single Upper Pleistocene occupational horizon dated to the initial millennia of the Early Upper Paleolithic (EUP, ca. 45–30 ka; Stutz et al. under review). The site is noteworthy for its large and well-preserved faunal assemblage; more than 40,000 fragments were recovered from ~1 cubic meter of intact deposits, of which ~10,000 are identifiable. Analysis of the total assemblage is ongoing; we report here on the teeth and associated cranial/mandibular fragments (NISP=825). The range of identified species is comparable to that from other Middle and Upper Paleolithic sites in the region and includes gazelle, goat, roe deer, fallow deer, red deer, and wild boar, as well as smaller animals such as rock hyrax and red fox. Gazelle dominates the assemblage (NISP=521; MNI>30). Notably, these fragments have been assigned to *Gazella* sp. because

a preliminary analysis of the horn cores indicated the presence of both *Gazella gazella* (mountain gazelle) and *Gazella subguttarosa* (goitered gazelle). Wear stages for the lower fourth premolars and lower molars were assigned based on the scheme in Munro et al. (2009). Estimated ages were then calculated for complete/partial tooth rows (n=23) and isolated teeth (n=62). Juveniles (<18 months) account for ~40% of the MHM assemblage. This is a high frequency of juveniles, particularly as compared to other MP and EUP assemblages from the region (Stiner 2005), although it is similar to the percentage of juveniles identified in the EUP at Kebara (Speth, unpublished data). These data raise new questions about geographic variation in food resource availability and gazelle exploitation patterns within the Levant and are relevant to our broader understanding of human behavioral change through the MP-EUP transition.

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New Stone Age Localities Near the Knysna Heads, Western Cape, South Africa

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The Knysna estuary and coastal environment (Western Cape, South Africa) presented Stone Age foragers with an attractive diversity of resources, resulting in a potentially rich Late Pleistocene archaeological record. Despite earlier reports of Stone Age sites in this area (Goodwin and Van Riet Lowe 1929; Deacon 1979), none have been systematically studied. We present several previously undocumented Stone Age localities near the Knysna headlands, where the estuary meets the Indian Ocean. An open-air Earlier Stone Age site on top of the Western Head (~200m asl) includes large bifaces and casual cores made on local quartzite. Later sites, with deposits typical of the Middle Stone Age (MSA) and Later Stone Age (LSA), are located in caves on both sides of the Heads. On the Western Head, we surveyed three low-lying caves that face the straits. In two of these caves, MSA material is eroding out beneath a partially cemented aeolian layer. Preserved hearth features include lithic, shell, and bone finds. The third cave preserves a shell midden (likely LSA). The Eastern Head holds an equally rich Stone Age record. We recently initiated test excavations at Knysna Eastern Heads Cave 1 (KEH-1), a sea cave at ~23m asl. This deposit is above the last interglacial high sea stand and thus could potentially contain a record older than 125,000 years BP. KEH-1 has an upper shell midden component (likely LSA). Underlying this, a deep non-shelly deposit includes a rich sequence of hearth features with ochre, lithic artifacts, and processed faunal remains. Here we report initial technological observations of the Western Heads caves and KEH-1, as well as preliminary age estimates for the latter. At Knysna, we have a unique opportunity to investigate a long record of early human adaptation at the intersection of three very different habitats—marine, riverine, and terrestrial.

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Paleohabitat Reconstruction of the Middle Pliocene Site, Woranso-Mille, Ethiopia, Using a Multiproxy Approach

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Woranso-Mille is a paleoanthropological site in Ethiopia sampling a critically important and under-represented time period in human evolution (3.8–3.6 Ma). Specimens of cf. *Australopithecus anamensis*, *Au. afarenis*, and an unidentified taxon of hominin with an abducted hallux (BRT-VP-2/73) have been recovered from this site. Using multiple habitat proxies, this study provides a preliminary paleoecological reconstruction of two fossiliferous collection areas from Woranso-Mille (Aralee Issie and Mesgid Dora). Previous reconstructions based on faunal assemblages have pointed to the presence of both open (due to the presence of aepycerotines, alcelaphines, and proboscideans) and more closed (cercopithecids, giraffids, and traglephines) habitats. Analysis of the community structure (proportions of locomotor and dietary adaptations) at the Aralee Issie and Mesgid Dora localities indicates a predomiannce of open habitat, such as a shrubland. Mesowear analysis reveals that ungulates with all dietary types (grazers, leaf and fruit browsers, and mixed feed-

ers) were present in nearly equal proportions. Ecomorphological analyses using linear measurements of the astragalus and phalanges indicate that bovids utilizing locomotor behaviors associated with all habitat types were present, though lighter cover habitats are better represented in the sample (57% open and light cover specimens versus 38% closed and heavy cover specimens). Ecomorphological analyses using geometric morphometrics of astragli and metatarsals support this conclusion. Geometric morphometric analysis of the plantar margin of the third phalanx demonstrates that bovids adapted to all substrate conditions less mountainous are represented. These results suggest that the Aralee Issie and Mesgid Dora localities were heterogenous habitats with dense vegetative areas along the paleo-river and more open regions (woodlands, grasslands) grading away from the river.

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Size and Scaling in the Chest and Pelvis of Modern Humans and Earlier *Homo*

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The wide bodies of Neandertals, characterized by broad, voluminous chests, and medio-laterally (M-L) wide pelves, are commonly considered a derived condition that arose primarily as an adaptation to a strenuous lifestyle in cold, high-latitude environments. The designation of a morphological pattern as apomorphic relies on a correct assessment of the character states of hominins that came before and those that came after; i.e., other archaic hominins and modern humans. Given recent fossil hominin discoveries, the autapomorphic status of the Neandertal body pattern perhaps requires some revision. The present study first examined the degree to which Plio-Pleistocene hominins, including Neandertals, possess body plans that consist of trunks and pelves that were both absolutely wide (i.e., the dimensions of the trunk and pelvis scaled together tightly). Then, a sample of modern humans (n=98) was used to investigate the relationships and patterns of scaling between body size and variables related to the size and shape of the chest and pelvis, in order to determine whether the modern human pattern differs from that of fossil hominins. Results suggest that modern humans, instead of Neandertals, possess a derived pattern that is more variable in terms of how the dimensions of the upper and lower trunk scale with one another, as well as with body size. Finally, the current study explored possible adaptive scenarios that contextualize the development of the derived modern human morphological pattern.

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Quantifying the Tempo and Mode of Hominin Cranial Capacity Evolution Including Taking into Account Dating and Measurement Error

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The dramatic increase in hominin cranial capacity during the Pliocene-Pleistocene is often cited as a hallmark event in our clade, and elucidating the tempo and mode of this increase is an important goal in paleoanthropology. Apparent saltation events (rapid cranial capacity increases) have been linked to changes in hominin ecology and behavior mediated by variables that include climate, stone tool morphology, diet, language, sociality, etc. However, the existence of these saltation events has not been rigorously demonstrated. Most studies investigating the rate and pattern of hominin cranial capacity evolution are qualitative and neglect the error associated with radiometric dating and measurement of cranial capacity. We address these issues by presenting a novel quantitative approach in which three evolutionary models (random walk, phyletic gradualism, and punctuated equilibria/stasis) are fit to the data via maximum likelihood; the relative merit of each model is then assessed using the modified Akaike Information Criterion. Monte Carlo methods are used to incorporate radiometric dating errors in the model selection procedure, while ANOVA is used to partition variance in replicate cranial capacity measurements to attain specimen measurement error. We focus on the period from 3.5 to 0.5 million years ago, encompassing the emergence of *Homo* and other key grade shifts within the hominin clade. The phyletic gradualism model is overwhelmingly supported by our analyses. This suggests that the correlation of external events with "saltations" in hominin cranial capacity evolution are likely to be spurious. Among geographic regions, there is mixed support for the random walk, phyletic gradualism, and punctuated equilibria/stasis models, which suggests different evolutionary dynamics across lineages and regions. This novel analysis provides a rigorous quantitative approach to this long-standing question and offers new insight into the patterns of hominin cranial capacity evolution at different spatial (global vs. regional) and evolutionary (within vs. among lineages) scales.

The Role of Raw Material Differences in Handaxe Shape Variation: An Experimental Assessment

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Lithic raw material differences are widely assumed to be a major determining factor of stone tool morphology, but this assumption remains largely untested. Two different sets of toolstone properties are thought to influence artefact form. The first set is internal, and related to mechanical flaking properties. The second set is external, namely the form (size, shape, presence of cortex) of the initial nodule or blank from which flakes are struck. We conducted a replication experiment under controlled conditions to determine whether handaxe morphology was influenced by raw materials of significantly different internal and external properties—flint, basalt, and obsidian. The knapper was instructed to copy a model handaxe, produced by a different knapper, 35 times in each toolstone type (n=105 handaxes). To ensure that learning over time did not confound results in any one raw material, the knapper produced one flint, basalt, and obsidian handaxe, in turn, each day for 35 days. The same set of knapping tools was used throughout. On each experimental handaxe, 29 size-adjusted (scale-free) morphometric variables were recorded to capture the shape of each handaxe in order to compare them to the model. Both Principal Components Analysis (PCA) and a Multivariate Analysis of Variance (MANOVA) were used to determine if raw material properties were a primary determinate of patterns of overall shape differences across the toolstone groups. The PCA results demonstrated that variation in all three toolstones was distributed evenly around the model "target" form. The MANOVA of all 29 size-adjusted variables, using two different tests (Pillai's Trace and Wilks' Lambda), showed no statistically significant differences in overall shape between the three groups of raw material. In sum, our results show that assuming the primacy of raw material differences as the predominant explanatory factor in stone tool morphology, or variation between assemblages, is unwarranted.

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Late Pleistocene Archaeology and Paleoenvironments of Karungu in the Lake Victoria Basin, Kenya

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New investigations of Late Pleistocene (≤100 ka) sediments from Karungu along the northeastern margin of Lake Victoria (Kenya) have uncovered Middle Stone Age (MSA) archaeological sites associated with detailed paleoenvironmental records. Here we review our ongoing archaeological, paleontological, and geological fieldwork at Karungu, with an emphasis on their implications for past environments and the biogeographic histories of plant and animal communities, including MSA human populations. The Pleistocene deposits at Karungu include >9 meters of fluvial and alluvial sediments with well-developed vertic (Vertisol-like) paleosols and three chemically distinct tephras, the basal-most of which probably derived from East African Rift System volcanoes that began erupting ~100,000 years ago. Paleosol morphologies and bulk geochemical proxies, together with faunal community composition, indicate a seasonal, semi-arid climate (precipitation = ~700mm/year to 900mm/year) that was drier than today (~1200mm/year), likely driving a substantial reduction in the surface area of Lake Victoria. The reduction in precipitation was associated with an expansion of C_4 grasslands, as evidenced by the dominance of grassland species in the micro- and macro-mammalian fossil assemblages and by stable isotopic analysis of tooth enamel, which demonstrates that mammalian herbivores primarily consumed C_4 vegetation. Several ungulate species with historically allopatric ranges co-occur at Karungu, suggesting that the expansion of grasslands and the reduction in Lake Victoria facilitated mammalian dispersals across equatorial East Africa, consistent with predictions from genetic evidence. Regional archaeological evidence further suggests that vegetation shifts played a role in mediating the dispersal of MSA technological markers across the Lake Victoria Basin, perhaps indicating past human dispersals. Taken together, our results indicate that the Late Pleistocene of the Lake Victoria region experienced a dry climate phase that was associated with C_4 grasses and the dispersal of grassland-adapted faunas and human technological markers.

Bone Mineral Density in Habitual Climbers: An Analogue for Early Hominins?

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The assumption that functional loading over an organism's lifespan has positive dose-dependent effects on bone structure provides a window onto hominin locomotor behavior and general physical capabilities. Identifying if, and then when, during human evolutionary history habitual climbing was an important part of the early hominin locomotor repertoire is key to conceptualizing the transition to obligate bipedalism. The present study examines a small sample of living modern humans (n=32) to test the hypothesis that those who practice frequent recreational climbing are more robust at specific entheses locations when compared to individuals who do not climb for recreation. The sample of habitual climbers to non-climbers were asked to participate in a survey and self-assessment of physical activity that included climbing abilities, a push up test and a bone density scan (Dual-energy X-ray Absorptiometry, DEXA). It was found that the climbers maintained larger arm musculature and an increased bone mineral density of the arms and shoulders when compared to non-climbers. Higher bone mineral density at the humerus and shoulder was seen among the practiced climbers when compared to the non-climbers. Among modern humans, recreational climbing is a habitual locomotor alteration that can be observed in the skeleton. This pattern may serve as a model for addressing the extent of climbing behaviors among early hominins.

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Chronology of the Early Hominin Settlement of Iberia: Vallparadís (Barcelona, Spain)

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Vallparadís is one of the best calibrated and most accurately dated archaeological sites from the European Early Pleistocene regarding the first human occupation of Europe. The comparison of the mandibular first molar (m1) of individual adult specimens of *Mimomys savini* recovered from level 10 (EVT7) at Vallparadís with specimens from Gran Dolina TD3, TD4, and TD5 (Atapuerca) and Fuente Nueva 3, and Barranco León D (Orce) allows us to chronostratigraphically relate level 10 with level TD5 (Cuenca-Bescós et al. 2011) and to fix the former's chronology to around 0.98–0.95 Ma (MIS 27) and, therefore, prior to level TD6 in which fossil remains of *Homo antecessor* were recovered. This age is fully consistent with the available chronological proxies from magnetostratigraphy, ESR-U/series, and OSL radiometric dating (0.83±0.13 Ma) and the biochronology of macro and microfauna (Duval et al. 2011, 2012; Martínez et al. 2010) and situate level 10 just above the upper limit of the Jaramillo subchron. The chronology of Vallparadís and the set of contemporary palaeoclimatic proxies regarding the Iberian Peninsula strengthen the hypothesis that there was a continuous population, at least in Iberia, during the late Early Pleistocene (Agustí et al. 2010; Bermúdez de Castro et al. 2013; Duval et al. 2012; Garcia et al. 2011, 2012, in press a; Martínez et al. in press), rather than the intermittent populations conditioned by climatic fluctuations (Agustí et al. 2009; Bermúdez de Castro and Martinón-Torres 2013; Dennell 2003, 2010; Dennell et al. 2011; Martinón-Torres et al. 2007; Moncel 2010). The hominin adaptations to higher latitude continental environments during the late Early Pleistocene between Jaramillo and the Matuyama-Brunhes boundary (Garcia et al. in press b) entailed cultural and biological advances that expanded the human range in Europe, overcoming the climatic fluctuations and changes to the landscape that occurred during this period.

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A Large and Varied Bone Tool Assemblage from Contrebandiers Cave (Atlantic coast of Morocco) Dated Between ~122 ka–96 ka

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The origin and use of bone tool technology in the Middle Stone Age (MSA) figures prominently in modern human origins research, as formal tools systematically manufactured on material other than stone are thought to be a hallmark of modern humans and a proxy for complex cognition. There is consensus that modern humans recognized bone as a raw material for tool manufacture by at least ~70,000 years ago (ka) in Africa during the MSA (Henshilwood et al. 2001), although this record is patchy and bone does not appear to be frequently and systematically utilized until the Later Stone Age in Africa and the Upper Paleolithic in Europe. Here we describe a previously unrecognized formal and informal bone tool assemblage from recent excavations by Dibble et al. (2012) at Contrebandiers Cave on the Atlantic coast of Morocco, originating approximately 100 ka during the MSA, that extends the earliest appearance of formal bone tools by ~30,000 years. Sixty-five bone tools from 11 levels securely dated to 122 ka–96 ka and associated with the Aterian/Moroccan Mousterian industry are described. Identification of the raw material selected to manufacture each bone tool includes, when possible, taxonomic identification, size class, age class, and skeletal element. Shaping techniques and use-wear were recorded for each piece using bright incident light coupled with an Olympus binocular 10x–40x zoom microscope, as well as a Leica EZ4 HD stereo 8x–35x zoom microscope with an integrated high definition digital camera for photography. The bone tools described here include spatulates, possible points, and scaled pieces that were systematically manufactured through scraping with a lithic edge and grinding to produce recurrent morphologies that were likely used for specific tasks. The bone tools from Contrebandiers Cave represent the largest bone tool sample from a single MSA locality yet described.

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Herolds Bay Cave: New Evidence for Middle Stone Age Coastal Adaptations in Cape Province, South Africa

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We present the results of our investigation of Herolds Bay Cave (HBC), a Middle Stone Age (MSA) site on the south coast of South Africa. Excavations performed by Brink and Deacon (1982) revealed MSA deposits including a lithic assemblage and molluscan remains stratified just above beach sediments thought to date to Marine Isotope Stage 5e (MIS 5e, ca. 130–125 ka). There are currently only three documented MSA shell middens that have numeric age estimates that confirm a MIS 5e age (Marean in press). Given the significance

of coastal adaptations, the paucity of such deposits makes HBC a key site in the study of modern human origins. The purpose of this report is to provide improved stratigraphic control of the HBC sediments and to provide new age estimates for the deposits. Uranium-thorium (U-Th) dating of detritus-free flowstone that formed on top of the sediment stack provides a minimum age of 91.9±3.8 ka for all archaeological and fossiliferous material in the cave. Micromorphological analysis of the speleothem confirms the formation of speleothem directly on the deposits overlying the cave sediments, precluding the post-depositional reworking of these deposits. Further, our results suggest the cave was sealed through roofspall and colluvium ca. 92 ka, around the same time the nearby Pinnacle Point caves (13B and Crevice cave) were sealed by dune formation (Karkanas and Goldberg 2010). In this report we also include optically stimulated luminescence (OSL) measurements for single grains of quartz from sedimentary deposits within HBC. These results confirm the MIS 5 age of the human occupation horizon, which is rich in mollusk remains and lithics, and documents that HBC is another of a small sample of sites providing evidence for early coastal adaptations on the South African coast.

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Monkey Archaeology

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Until the early twenty-first century, paleoanthropologists who looked to living wild primates to help model the emergence of hominin lithic technology had only one option, the Western chimpanzee. Now the choice has tripled, with the discovery of stone tool use by wild capuchin monkeys in Brazil, and wild macaques in Thailand. These animal groups show some similarities to known chimpanzee lithic behavior, including a focus on pounding activities, selective transport and accumulation of natural materials, and group-level adoption of technological traditions. However, there are also striking differences—the macaques use stone tools primarily to exploit shellfish instead of plant foods, and they live on intertidal coasts, while the capuchins use stones for digging and have been observed deliberately fracturing pebbles. In this paper I discuss ongoing results from the inter-disciplinary Primate Archaeology project, which investigates the evolution of primate tool use to provide comparative data for hominin evolution. These results include the identification and excavation of monkey archaeological evidence, studies of skilled tool manipulation and use-wear formation, and the suggestion, based on emerging genetic data, that extant chimpanzee and capuchin monkey lithic technology may have first arisen in the Middle Pleistocene.

Seasonal and Habitat Variation in Nutritional and Antifeedant Properties of South African Plants

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Early hominins, like living hominoids, likely ate predominantly plant foods. Despite the importance of plant foods, we know surprisingly little about the wild edible plant species in the areas relevant to human evolution. Habitat reconstructions of fossil-bearing sites suggest that early hominins lived in a variety of habitats, from forest to wetland. We assume that certain habitats may have been more welcoming to a hominin with an ape-like diet, but have little information about the edible foods, particularly their nutritional and mechanical properties, present in these environments. Without this information, it is difficult to accurately reconstruct aspects of early hominin behavioral ecology, such as patch choice, diet breadth, and habitat preference. We have explored this question by documenting the availability and abundance of potential plant foods in several South African microhabitats within the Cradle of Humankind World Heritage Site, including wetland, woodland, and open grassland, and have compared the nutritional properties and abundance of antifeedants of these plants across habitats and between seasons. We collected the dominant grass, sedge, tree, and forb species from each habitat and have measured their mechanical properties, phytolith abundance, and percentages of crude protein, fiber, lipids, and lignins. Preliminary results suggest that phytolith content is highest in the wetlands, probably due to the abundance of sedges in this habitat. Among grasses, those with the highest nutritional value also have the highest phytolith content, thus increasing the mechanical cost of consumption and digestion of these plants. Plants in the open woodland have highest protein levels, while those in the riverside habitat have highest lignin. These results suggest that differences in plants among various habitats would have had a strong influence on the overall quality of those habitats for early hominins.

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The Fauna of Feiliang: A Preliminary Analysis from the Nihewan Basin of China

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The Nihewan Basin of China is an ancient, down-faulted lake basin located approximately 120km west of Beijing in northwestern Hebei Province of China. The Paleolithic site of Feiliang is located on the eastern margin of the Nihewan Basin in the Nihewan Formation, and it is dated to approximately 1.2 million years ago. This area is of great importance in human evolution because it contains evidence of early hominin behavior as they migrated out of Africa and into this new climate and geographic region over one million years ago. At the present time, no *Homo erectus* fossils have been found in the Nihewan Basin, but their presence is known at Feiliang based on the discovery of stone tools in association with the analyzed faunal remains. An analysis of the faunal material from this site includes 383 total specimens, including over 150 identifiable specimens and 125 long bone fragments. The ungulate families Equidae, Bovidae, and Cervidae dominate the collection, although carnivore, fish, bird, and bivalve specimens are also present. An analysis of the surface damage of these bones shows both carnivore- and hominin-imparted damage, including toothmarks, tooth pits, hammerstone percussion marks, and cutmarks, the latter of which was the most common type of damage observed. Additionally, there are possible bone flakes that could indicate a new technology not previously seen in this region.

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Out of Beringia: Genetics, Paleo-ecology, and Archaeology

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Many human geneticists argue that most Native Americans are derived from a population isolated from its source in Asia for thousands of years before dispersing in the Americas. Some of them suggest that the isolated population was located in Beringia during the Last Glacial Maximum [LGM] (i.e., "Out of Beringia" or "Beringian Standstill" model) (e.g., Tamm et al. 2007). Although archaeological traces of LGM occupation in NE Asia and Alaska/Yukon (i.e., accessible remnants of Beringia) are lacking, pre-LGM settlement of northwestern Beringia is documented at sites near the mouth of the Yana River (Pitulko et al. 2012). Several lines of evidence indicate a mesic tundra refugium on the Bering Land Bridge (BLB) that may have provided the only substantive source of wood above latitude 55° North during the LGM (e.g., Brubaker et al. 2005; Elias and Crocker 2008). The presence of mesic tundra habitat in central Beringia presumably reflects its geographic position relative to the North Pacific circulation and sources of moisture during the LGM, and may be contrasted with the aridity of unglaciated areas of northern Eurasia ~28–18 ka. Experimental studies indicate that some wood is necessary to render fresh bone practical for regular use as a fuel (Théry-Parisot 2001), and archaeological sites that contain evidence of heavy bone fuel use consistently yield some traces of wood (e.g., Mezhyrich [Marquer et al. 2012]). The post-LGM archaeological record of Beringia contains an industry derived from NE Asia (Dyuktai) after 15,000 cal BP, but also contains an industry that has no clear antecedent outside Beringia (e.g., Ushki-Layer VII in Kamchatka). The latter is plausibly derived from the industry that would have been produced by the occupants of the LGM mesic tundra refugium on the BLB, which now is submerged.

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Edge Angle as a Variably Influential Factor in Flake Cutting Efficiency: An Experimental Investigation of Its Relationship with Tool Size and Loading

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The onset of the Oldowan is marked by the appearance of the first recognizable stone cutting tools, with these basic flake utensils formally inaugurating the entire "Palaeolithic." Simple flake cutting tools were, however, utilized across broad chronological and geographical ranges up until historical times. Factors affecting the utility of such tools would, therefore, have been of concern to hominin populations over the entire timescale of human evolution. Fundamental to the functional utility of simple flake tools is the presence of a relatively acute working edge. The acuteness of this "edge angle" is widely hypothesized to be a primary determinant of cutting ef-

ficiency and, subsequently, of potential consequence to hominins. However, there have been no controlled experimental investigations specifically testing the link between working edge angle and cutting efficiency. Moreover, no consideration has been given to whether this relationship is dependent upon the size of the tool. Here, the functional effects of edge angle are examined under controlled experimental conditions, with its relationship to cutting efficiency, loading (i.e., force applied), and overall flake size investigated. Results demonstrate that there is a highly significant relationship between more acute working edges and increased cutting efficiency in the smallest flake tools in our sample. Above a certain flake-size threshold, however, working edge angle had no influence on cutting efficiency because larger flakes facilitate the application of greater working loads. These results have important implications for flake selection criteria by hominin populations, especially in relation to utility, function, and the changing effects of edge angle through a sequence of retouch.

Explaining the Effective Size of Modern Humans: Integrating Genetic, Skeletal and Archaeological Data

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It has long been suggested that the low allelic diversity of modern humans is explainable by specific demographic events within the history of our Genus. Various hypotheses have been presented to explain this peculiar nature of human genetic diversity, including models that suggest a significantly low amount of gene flow between small regional populations of early humans during the Pleistocene. While these models may work in principal, they are rarely tested against the anthropological record. Here, I test models that attempt to explain the low genetic diversity and low effective population size of *Homo sapiens*. I show how the ethnographic & fossil data can help geneticists test their models. I derive expectations as to how the anthropological data should pattern if these genetic models are an accurate depiction for human behavior. I show that the archaeological data is slightly patterned in the expected way: information follows between populations in ways expected based upon mediated migration. However, neither the skeletal data nor the ethnographic record support the tested hypothesis. Instead, it is argued that models predicated on effective population size often misuse this genetic parameter. This study is unique in its use of multiple lines of anthropological data to test a genetic model of human evolution. This work has implications both for the understanding of human evolution and for the renewed relevance of the intersection of cultural and biological anthropology as it tests the paleoanthropological record against ethnographic reality in an informative way. It is shown that low human genetic diversity is symptomatic of the early human population as a whole and models explicating this genetic anomaly must take into account all of these factors.

Foot Length in *Australopithecus afarensis*

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The bony evidence of the foot of *Australopithecus afarensis* consists only of isolated pedal elements from the Afar Locality, including two tali (AL–288–1as and AL–333–147) and a 4th metatarsal (AL–333–160). The Laetoli footprint trail provides functional evidence of the foot of a biped, but no osseous elements are available to provide a unequivocal tie to a species. The function of the pedal elements from the Afar Locality has been interpreted to be consistent with the Laetoli footprints, but these interpretations remain contentious. We provide an additional line of evidence linking the Afar Locality fossils to the Laetoli footprints—foot length. Weight-bearing radiographs of 50 people from an urban US Level 1 trauma center were used to measure the lengths of the talus, 1st through 5th metatarsals, and fleshy-foot (posterior border of skin to the crease between the metatarsal head and proximal phalanx). We chose to not include the lengths of the toes in fleshy-foot length. Linear regression was used to determine the predictive ability of the lengths of the elements in determining fleshy-foot length. All elements are predictive of both fleshy-foot length (all p's <0.001), with r^2=0.61–0.85. The lengths of the fossil tali (37.4mm and 47.1mm) and 4th metatarsal (59.9mm) were taken from published sources. We also measured the lengths of the G1 (144mm) and G2 (205mm) trails (posterior edge to the distal edge of the ball of the foot) from reconstructions. The predicted fleshy-foot length of the fossil elements are: AL–288–1as = 153mm; AL–333–147 = 177mm; AL–333–160 = 166mm. The predicted fleshy-foot lengths from the fossil pedal elements is within the variation seen in the Laetoli footprint trail, providing further evidence that *A. afarensis* made the trail.

Populational Variability in Size Using the Sima de los Huesos Tali

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Pleistocene hominins are generally believed to have exhibited degrees of sexual dimorphism in the range of modern humans and substantially less than Pliocene hominins. Most of the evidence has, of necessity, either been acquired across multiple sites or has been limited to cranial elements. The fossil remains of the hominins from Sima de los Huesos, Atapuerca, Spain provide an opportunity, however, to evaluate the variation in size of post cranial elements in a pseudo-population. Toward this end, we compare the variation in length (M1A) of the 16 recently described adult tali from Sima de los Huesos with those of 50 modern humans (25 men and 25 women). Weight-bearing radiographs, obtained from an urban US Level 1 trauma center, were used to measure the length of the modern human

tali. The mean lengths of the modern human tali is 57.2mm (range=55.6–58.8mm), while that of the humans from Sima de los Huesos is 55.4mm (range=53.3–57.4mm), a difference that is not statistically significant (p=0.123). The distributions of the 2 pseudo-populations is also not different (Kolmogorov-Smirnov test, combined corrected p=0.35). The hominin tali from Sima de los Huesos indicate that the degree of sexual dimorphism in this group was similar to that of modern humans. Whether or not this result is applicable to Middle Pleistocene hominins in general, or just to this group, remains to be determined. Sima de los Huesos continues to provide an invaluable opportunity to evaluate pseudo-populational variability.

Diet Breadth and Dental Calculus: Starch Grains and Phytoliths in Calculus from Ovatwe Forager-Horticulturalists

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Starch granules and phytoliths recovered from dental calculus are increasingly used as markers of diet in ancient human populations (Boyadjian et al. 2007; Henry et al. 2011; Henry and Piperno 2008; Piperno and Dillehay 2008), but it is not clear how well these plant microremains reflect diet breadth. This project examines how well plant microremains in dental calculus from Ovatwe forager-horticulturalists of Northwestern Namibia record the range of plant foods consumed. We generated data on starch and phytolith content of Ovatwe plant foods in order to predict their representation in Ovatwe dental calculus. Preliminary analysis suggests that very few of the starchy plants in Ovatwe diet are represented by starch granules in dental calculus. Even fewer phytoliths from Ovatwe foods are observed. On an individual basis, starch granules and phytoliths in dental calculus are a poor predictor for the range of plant foods eaten by the Ovatwe. They may better reflect diet breadth at the population level. This is the first study to quantify how well plant microremains in dental calculus record the plant portion of diet in a population with a known diet. Results from this project have implications for interpreting plant microremain data from archaeological dental calculus samples.

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Enamel Thickness Topography and Molar Wear Pattern in European Early Agriculturalists

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Enamel thickness (ET) has been demonstrated to be an evolutionary plastic trait, selectively responsive to dietary changes, wear, and tooth function (e.g., Hlusko et al. 2004; Lucas et al. 2008; Schwartz 2000). European Late Paleolithic and Mesolithic hunter-gatherers mainly show flat wear pattern, while oblique molar wear has been reported as characteristic of early agriculturalists from the Neolithic (e.g., Smith 1984). Here we quantify molar wear patterns and ET topographic distributions in the French Neolithic necropolis from Gurgy, with the expectation that high masticatory forces on tooth location will lead to selection for greater ET. Gurgy was used continuously around thousand years (ca. 5000–4000 cal. BC) and is situated at the crossroads of multiple cultural influences. As a comparative population having experienced other masticatory and/or dietary conditions, we used a French medieval sample. Occlusal wear was recorded in second upper permanent molars (UM2) of 64 Neolithic individuals and 311 comparative medieval UM2s. Using a microtomographic-based record (Skyscan 1076 X-ray microtomograph; voxel size: 17.93–36.18µm^3), we virtually assess ET topographic distribution in sub-samples of 17 Neolithic and 25 medieval UM2s. Differences in wear patterns and ET topography were found between the Neolithic and medieval samples. Oblique wear is largely dominant in the Neolithic sample (87%), while medieval UM2s show greater variation and only 41% of oblique wear. For the Neolithic population, maximal ET is precisely localized where occlusal wear is the most important, whereas medieval ET topography is more homogeneously distributed. These results suggest that ET could be affected by a selective pressure caused by functional dietary changes, notably by those reported for the transition to agriculture. Particularly, thick molar enamel may have evolved as a means to resist wear. In this context, it is noteworthy that preliminary results in a small Mesolithic sample show relatively thin ET distributed homogeneously.

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Evidence for the Use-Life of Percussive Technology in Bed I, Olduvai Gorge, Tanzania

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Experimental work into the use-life of spheroids or chopper forms with dihedral battered ridges have suggested that they are the results of percussive activities such as the extraction of marrow from large mammal bones. A recent study of Oldowan assemblage from the Upper Bed I at Olduvai Gorge revealed an assemblage strongly supporting this interpretation of percussor use-life. We sampled a Developed Oldowan assemblage from HWK W site comprised of 59 lithic artifacts in association with large mammal bones from an intact stratigraphy. The majority of artifacts and faunal remains rested on the surface of an earthy clay layer above Tuff IE (1.83 Mya; see Deino 2012) at the contact with an overlaying volcaniclastic sandstone. This, together with the composition of the assemblage, may suggest that a single behavioral episode is represented at this level. Technologically, the assemblage is percussive in character. Percussors were identified based on the criteria of Schick and Toth (1994) or on the presence of dihedral battered ridges per de la Torre and Mora (2004). Only two cores and two useable flakes were present (7% of the assemblage). Except for a few unmodifed lava cobbles (7%), the rest of the assemblage is composed of quartzite percussors (10%), igneous percussors (10%), or the byproducts of their use (chunks or debitage) (66%). These byproducts indicate that tools were produced onsite during use. The percussive component of the assemblage suggests that hominid activities at the site involved breakage of large mammal bones. The lack of usable cutting stone knives (flakes) suggests that slicing meat off bones was not an important hominin behavior activity at this site.

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Revisiting the Early Stone Age of the Namib Sand Sea

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The vast Sand Sea of the Namib Desert in western Namibia preserves substantial evidence of Middle Pleistocene hominin occupation and was recently declared a UNESCO World Heritage Site. In 2013, as part of an ongoing project, our group led an expedition that was the first archaeological team to visit the northern erg of the Sand Sea in over 30 years. In this paper, we present the preliminary results of our work. We documented one previously unreported Early Stone Age (ESA) site, known as "Ms. Chicky's Vlei," as well as re-located and re-assessed the previously reported site Namib IV, the only known Middle Pleistocene site in Namibia that preserves ESA stone implements and fossilized faunal remains in probable association (Shackley 1980). While the remote locations and the substantial difficulties in access limited our time at the sites, we were able to gather data from lithic artifacts and faunal remains that allow us to draw some new conclusions about hominin technological organization in the Namib Sand Sea. Additionally, geological sourcing of handaxes and other lithic implements using portable X-Ray Fluorescence (pXRF) trace-element characterization gives insights into the mobility patterns of mid-Pleistocene populations across the mosaic of environments that characterize the hyper-arid Namib Desert. While the research we discuss here can only be considered as preliminary, our ongoing program on the archaeology of the Sand Sea will expand our understanding of mid-Pleistocene hominin behavior and adaptive variability to a broader range of environmental conditions.

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Middle Stone Age Ostrich Eggshell Beads from Magubike, Tanzania

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This paper presents new radiocarbon dates on ostrich eggshell (OES) beads from Magubike rockshelter in Tanzania. These are the old-

est known direct radiocarbon dates on artifacts of this type. This research was carried out as part of an ongoing project to explore the archaeology and cultural heritage of the Iringa region of southern Tanzania. During the 2012 field season, seven units were excavated under the modern roof of the shelter. The top 50cm of deposits in this area were dominated by historic or Iron Age material. Beneath this, the artifacts change abruptly to a Middle Stone Age (MSA) sequence which continued until reaching bedrock at 180–200cm below surface. Overall, a total of 93 OES beads and blanks were recovered; three of these were found in the MSA levels. It is unusual to find OES beads in MSA contexts and only a handful of sites in Africa have reported such associations. To help rule out taphonomic factors, a sample of OES beads was sent to the Oxford Radiocarbon Accelerator Unit for direct dating. The dates confirm that the three beads found in association with the MSA occupation indeed belong to that era. The uncalibrated ages for the MSA beads are 31,810±180 BP (OxA-27627), 47,750±750 (OxA-27626), and >50,100 BP (OxA-27628). Previously the oldest directly dated OES beads were reported from Border Cave, South Africa, in a Later Stone Age context approximately 38,020±1240 BP. The new dates from Magubike suggest that the tradition of OES beadmaking began at least 50,000 years ago, during the terminal stages of the MSA.

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Competitive Interaction Model for Modern Human Dispersals: Tropical Adapted versus Temperate Adapted Populations

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Today African populations are the most genetically diverse and all populations living outside of Africa are related to a single branch of Africans (Oppenheimer 2012). Non Africans also have varying degrees of admixture with at least two archaic populations, Neanderthals and Denisovans (Green et al 2010; Meyer 2012; Reich et al 2011) . Although modern human fossils are found by 200 ka in Africa (White et al 2003), archaic populations continued to occupy Europe until 30–40 ka (Finlayson 2008), almost 150 ka later. Thus human populations were much more diverse in the past and the present low diversity is quite recent. The Indian Subcontinent plays a pivotal role in the dispersal of modern humans. It has a subtropical climate and has been continuously occupied since at least 1 myr. In relation to India, the debate has been simplified into two alternative models, either an early dispersal (MIS 5) of modern humans into the Indian Subcontinent without blade technology or a late dispersal (MIS 4) with microblade technology (Mellars 2013). The Indian data is not in conformity with either of these models. It is suggested that diversified hominin populations expanded at the expense of differently adapted hominins when conditions were favorable but expanded at the expanse of similarly adapted hominins when conditions were unfavorable. Thus modern humans expanded into temperate regions during interglacial periods and into tropical regions during glacial periods, while Neanderthals expanded at the expense of modern humans during glacial periods and probably replaced Denisovans during an interglacial phase.

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Virtual Ancestor Reconstruction: Revealing the Last Common Ancestor of Modern Humans and Neandertals

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In the context of a limited fossil record, new approaches to study human evolution are essential. This study presents a predictive method combining cladistics and geometric morphometrics that computes 3D morphotypes of possible last common ancestors (LCA) of a phylogeny. Here we focus on the genus *Homo* and on the Middle Pleistocene divergence between *H. sapiens* and *H. neanderthalensis*. A simple structural phylogenetic pattern is used to distribute terminal taxa represented by 3D models of crania described by 420 semi-landmarks. The landmarks are aligned and scaled using a Generalized Procruste Analysis (EVAN Toolbox v. 1.63) before being used as continuous variables presenting three components: the spatial coordinates (x,y,z). We use the squared-change parsimony principle (maximum parsimony method which minimizes the total number of evolutionary transformations to reconstruct cladograms) to compute the ancestral state of the 420 semi-landmarks at all nodes in the tree; that is, the coordinates of each landmark for the hypothetical ancestor (Mesquite, v. 2.75). From this 3D shape we reconstruct the putative LCA of *H. sapiens* and *H. neanderthalensis* as a fully-

rendered virtual 3D model (landmark-guided surface warping). Using 3D geometric morphometrics, we compare the virtual LCA to a dataset of 3D landmarks of Pleistocene hominin fossils including Middle Pleistocene specimens that could represent the ancestral population of modern humans and Neandertals. Our results show that the virtual LCA is similar to Middle Pleistocene fossils and especially to African specimens such as Kabwe and Bodo, suggesting that the Middle Pleistocene population ancestral to modern humans and Neandertals may have been African. Additionally, we demonstrate that this method can be successfully applied to simulate ancestral nodes in human evolutionary phylogenies. The Virtual Ancestor Reconstruction method offers a new means to generate and test hypotheses about morphological change in the past, and contributes towards resolving long-standing debates in paleoanthropology.

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Using Geometric Morphometrics to Sex Hand Stencils: Implications for Investigating Paleolithic Rock Art

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Accurate determination of the sex of the makers of Paleolithic hand stencils would provide a significant step forward for interpretations of rock art. Several methods employing measurements from stencils have been developed, often with conflicting results. Here we present a methodologically and statistically robust means of predicting sex using geometric morphometrics to quantify sexually dimorphic shape variation reflected in hand stencils. Experimental replication of hand stencils comparable with Paleolithic homologues was carried out leading to 264 hand outlines (106 males; 158 females). Digital images were captured, with 19 landmarks applied to each stencil. Following the methodology of Randolph-Quinney et al. (2010), landmark configurations were subjected to Generalized Procrustes Analysis and post-hoc tests using R. Shape variation was investigated, with discriminant function analysis being used to investigate patterns of sexual dimorphism. Exact randomization and partial least squares tests were further applied in order to examine covariation and modularity in hand shape. The results indicate that when both shape and size are factored into the analysis this method can predict the sex of an individual, with successful classification ranging between 85% and 91%, depending on which anatomical region is sampled. The technique allows sex-assessment based on stencils of the whole hand, the digits, the palm, or isolated parts of each. This integrated approach offers significant discriminating power in predicting the sex of individuals from hand stencils, exceeding the predictive power of other methods. Furthermore, preliminary analysis indicates that this approach is also able to accommodate incomplete stencils (i.e., when digits are missing or bent-over). We discuss the potential advantages of this technique for investigating ancient rock art, particularly in the light of recent analyses of Paleolithic cave stencils (Pike et al. 2012; Snow 2013).

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Quantifying Morphological Variation in the Nasal Floor of Extant and Fossil *Homo*

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Nasal floor configuration has been shown to vary in frequency between populations of extant and fossil *Homo*. Three nasal floor configurations have been documented in the literature—flat, sloped, and depressed (Franciscus 2003). However, this morphology has been visually scored and has never been analyzed quantitatively, and there is reason to believe that this trait may manifest along a continuum. The category of a sloped nasal floor has also been discussed as being potentially problematic (Franciscus 2003), and is not included in all analyses of this trait. Quantification of nasal floor configuration was previously limited by a lack of technology for landmarking internal surfaces and a lack of a methodology for quantifying curves or surfaces. This project quantifies nasal floor shape using 2D and 3D sliding semi-landmark analyses using clinical CT scans of extant humans (n=80) and 3D surface renderings taken from a sample of original fossil *Homo* specimens. Canonical variates analysis revealed that while individuals visually coded as flat or depressed grouped separately from each other (p=0.0127), individuals coded as sloped fell intermediate to both groups (sloped vs. flat p=0.2759, sloped vs. depressed p=0.2801). Sloped nasal floors (which were correctly classified only 60% of the time) showed a greater tendency to be misclassified as flat than as depressed. A 2D relative warps analysis (RWA) focused exclusively on nasal floor shape showed variation in topography that focused on mid-floor curvature (or lack thereof) and only RW3 (which represented 14.6% of the total variation) was correlated (p=0.0171) with the visually coded nasal floor scores, implying that some nasal floor shape variation is not captured by the traditional assessment method. A morphometric approach is therefore beneficial in capturing the full range of variation in nasal floor topography.

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Neandertal Metacarpal 5 Base Shape: A 3D Geometric Morphometric Analysis

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Metacarpal (MC) 5 base-shape is quantified with a 3D geometric morphometric analysis to detect between-sample shape differences when Neandertals (n=6) are compared to Middle Paleolithic early modern humans (n=1), Early Upper Paleolithic (n=6), Late Upper Paleolithic (n=5), and recent human males (n=15), and females (n=13). Seventy-one procrustes superimposed semilandmarks are used in a principal component (PC) analysis. Between-sample shape differences are assessed with a canonical discriminant function of PC scores and regressions of PC scores on ln centroid size tests for allometry. Reclassification is used to illustrate the degree of between-sample overlap of base-shapes. Two PCs (5 and 8) are not significantly correlated with ln centroid size. These two PCs represent MC5 bases with hamate facets that are flat-to-condyloid with symmetrical dorsopalmar curvature, and with tall, radially facing MC4 facets; this includes Neandertals and the Middle Paleolithic early modern human Qafzeh 9. The extremes of Neandertal MC5 base-shape are distinct from the other samples, but ranges of variation overlap. Further research may determine which between-sample contrasts in hand morphology are indicative of Late Pleistocene technological and behavioral transitions.

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The Vertebrate Assemblage from HWK EE, Bed II, Olduvai Gorge

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The consumption of larger mammal carcasses by early *Homo* marks an important adaptive shift that substantially increased the amount and quality of resources available to our ancestors. The increase in brain size that began over 2 million years ago and continued through the appearance of modern humans is often associated with our increasing carnivory. However, the significance of this niche expansion cannot be appreciated without an understanding of the nature of hominin carcass acquisition capabilities, which at some point after 1.8 mya began to include hunting. Whether this behavioral shift occurred before or after the emergence of the Acheulean remains unclear due to the inadequate sample of fossil assemblages that have been studied from this time period. The Olduvai Geochronology and Archaeology Project (OGAP) is addressing this deficiency by examining archaeological sites deposited before and after the Oldowan/Acheulean transition at Olduvai Gorge, Tanzania. The HWK EE site comprises part of this sample and represents a period just prior to the appearance of Acheulean technology at Olduvai. HWK EE is an Oldowan site that lies on top of Tuff IIA, indicating it was deposited roughly 1.7 mya. Mary Leakey excavated HWK EE in the early 1970's, but never studied the well-preserved collections recovered from the site. OGAP reopened HWK EE in 2009 and extended Leakey's trench where we continue to expose large concentrations of artifacts and fossils. Here we report results for the first taxonomic and taphonomic study of the vertebrate assemblage recovered by Mary Leakey's original excavations of HWK EE and provide an interpretation of hominin and carnivore feeding activities at the site. Butchery marks and carnivore tooth marks are both well represented in the assemblage suggesting hominins were consuming at least some flesh and marrow, while competing with carnivores for animal food resources at the site.

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Did *Homo* and *Paranthropus* Differ in Ecology? Evidence from East Turkana, Kenya

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The ecological context of adaptation is paramount to our understanding of the evolutionary history of human anatomy and behavior. However, current interpretations about hominin ecology are confounded by taphonomic biases as well as discrepancies in the temporal and geographic scale of analyses. In this study, we use both published and new primary data derived directly from 10 hominin localities and 5 archeological sites within the Okote Member (1.52–1.38 million years ago) of the Koobi Fora Formation, East Turkana,

Kenya, to test hypotheses related to the ecological and behavioral patterns of *Homo* and *Paranthropus*. Our analyses suggest that *Homo* and *Paranthropus* were associated with similar subsets of the larger mammalian community at East Turkana during this critical period of our evolutionary history. This is particularly interesting given that the end of this interval may witness the local extinction of *Paranthropus* at ~1.4 million years ago. Relative to the earlier two geologic members (i.e., Upper Burgi and KBS), this period documents a significant carbon enrichment and oxygen depletion in the isotopic signature of *Homo* that is not observed in other contemporary mammalian taxa, including *Paranthropus*. In addition, archeological sites within the Okote Member possess unusually high proportions of size class 3 grazing mammals relative to their overall abundance in this member. Thus, it is our hypothesis that the change in the isotopic signature of *Homo* ca 1.5 million years ago is the consequence of consuming significant amounts of meat obtained from large-bodied C_4 grass-eating herbivores.

Building the Climate Context of the Acheulean and Middle Stone Age of East Africa: The Olorgesailie Drilling Project

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In September 2012, drill cores reaching the local basement of the East African Rift were obtained from the southern Olorgesailie Basin, Kenya. Sediments totaling 216m were obtained from two drilling locations where the basin's depocenter occurred periodically over the past 500,000 years. The cores were acquired to build a detailed environmental record associated with the Acheulean to Middle Stone Age transition and extensive mammal turnover documented in nearby excavations. The project seeks precise tests of how climate dynamics and tectonic events were associated with these transitions and, in concert with other drill cores, to test hypotheses of environmental events preceding and connected with the first appearance of *Homo sapiens*. The cores were sampled in April 2013 at the National Lacustrine Core Facility. Multi-sensor logging indicates variation potentially related to precessional cycles. Numerous tephra were sampled, enabling high-precision $^{40}Ar/^{39}Ar$ chronology coupled with correlations to nearby archeological and faunal sites. The cores show intervals of varve-like lake strata interspersed with regressive phases in a near-shore setting. More than two dozen proxy records are in development, including diatoms, phytoliths, palynomorphs, leaf-wax biomarkers, ostrocodes, charcoal, organics, carbonates, and other geochemical indicators. Initial datasets will assess seasonal-to-orbital-scale climate variability, and test a recently proposed model of high- and low-climate variability and its influence on hominin evolution. A unique challenge is to integrate the core and outcrop data to model resource landscapes, ecological variability, hominin responses, and factors that affected selection, extinction, and population divergence in a region where important evolutionary events are documented. Project members: R. Potts, A.K. Behrensmeyer, K. Brady, J. Bright, A.S. Brooks, E. Brown, D. Cares, J. Clark, A. Cohen, A. Deino, P. deMenocal, D. Deocampo, R. Dommain, V. Gelorini, J. King, R. Kinyanjui, N. Levin, A. Noren, R. O'Grady, R.B. Owen, R. Renaut, S. Rucina, J. Russell, K. Uno, and J. Yellen.

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Testing Environmentally-Based Hypotheses of *Homo* sp. Evolution with Pedogenic Carbonate Stable Isotopes in the Turkana Basin

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Environmentally-based models of Plio-Pleistocene human evolution identify aridity upturns, humid pulses, or high climatic variability as causal mechanisms for behavioral and morphological change. In order to test the prediction that key human evolutionary events occurred during intervals of high global/regional climatic variability or in response to significantly increased aridity or humidity, I utilize climate proxy records from terrestrial hominin environments in the Turkana Basin from 2.4–1.4 Ma. The Nachukui and Koobi Fora formations in the Turkana Basin during the study interval encompass several significant events in the human lineage presently known, including *H. rudolfensis* FAD, *H. habilis* LAD, *H. erectus* FAD, and the earliest Acheulian technologies. In this study I 1) contribute new pedogenic carbonates $\delta^{18}O$ values (analyses=730) of sampled target intervals; 2) conduct time-series analyses of new and previously published $\delta^{18}O$ values and previously published $\delta^{13}C$ values of pedogenic carbonates sampled within the Nachukui and Koobi Fora formations and temporally compare to key evolutionary events; and, 3) measure intranodular variation and nodular population distribution within target intervals of global/regional climatic variability (high/low) derived from the early Pleistocene African dust records. Results demonstrate that high global/regional climatic variability corresponds to basinal-scale variability in soil water parameters.

Two Hominid Taxa at Malapa: The Mandibular Evidence

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A report on two individuals from the Malapa site in South Africa attributes them both to the new hominid species *Australopithecus sediba*. However, the mandibles (as well as elements of the vertebral column) of these specimens indicate that two separate genera are represented. One specimen, indeed, represents *Australopithecus*, and the other, *Homo*. Each genus is characterized by a distinct, diagnostic ramal morphology, which can be easily observed, quantified, and statistically analyzed. *A. sediba*, therefore, is not a transitional species between *Australopithecus africanus* and *Homo*, as claimed by the researchers who proposed this new species; rather, it represents a mixture of two different taxa. The coexistence of representatives of *Australopithecus* and *Homo* at one site is seen in some other early South African caves, and the Malapa cave seems to fit into that category. Hence, the Malapa researchers' reluctance to recognize early *Homo* specimens, such A.L. 666, as contemporaneous with *A. sediba* is clearly unjustified.

Genetic and Developmental Basis for Parallel Evolution and Its Significance for Understanding Hominoid Evolution

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African apes have served as primary models for the *Pan-Homo* last common ancestor of late due to their close phylogentic relationships with humans. However, recent comparative and fossil evidence suggests that African ape locomotor specializations may have evolved in parallel arguing against a suspensory, knuckle-walking LCA. The existence of such substantial homoplasy may seem unlikely. Yet, when compared to other adaptive radiations, in anole lizards, stickleback fish, and even fruit flies, this degree of recurrent evolution is unremarkable. In addition, recent advances in evo-devo have begun to identify the genetic and developmental mechanisms underlying evolutionary change in numerous species including humans. In many cases the independent evolution of similar phenotypes commonly involves the reuse of a narrow set of genes and developmental pathways. Genetic and developmental biases such as the topology of gene regulatory networks, co-option of regulatory modules, and shared standing genetic variation can facilitate repeated phenotypic evolution. Thus, consideration of the role these factors have played in other adaptive radiations are crucial to understanding hominoid evolution. Preexisting mammalian regulatory architecture in the form of Hox's role in determining skeletal growth and vertebral segment identity, and the identification of individual genetic enhancers modulating rib curvature, shows that key hominoid features such as elongated forelimbs, shortened lumbar spine, and broadened thorax can be highly evolvable. Thus, extensive genetic diversity combined with homologous genetic makeup and organizational biases in ancestral hominoids could foster parallel phenotypic evolution in the face of similar selective pressures across multiple lineages. These results indicate that despite involving appreciable homoplasy, models proposing parallel evolution in African apes are feasible when considered within larger developmental, ecological, and paleontological contexts.

Evidence for Curated Fire During the Late Early Pleistocene in Southeastern Spain: A Micromammalian Taphonomic Approach

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Cueva Negra, an upland rock-shelter overlooking the Río Quípar, contains a rich paleontological, paleopalynological, and Paleolithic record. The 5m-deep undisturbed sediment is dated by magnetostratigraphy to >0.78 Ma (Matuyama magnetochron). Excavation has uncovered thermally-altered chert and calcined bone from a deep, sealed layer of sediment showing micromorphological features consistent with thermal alteration. Analysis of heat-altered micromammalian bone from the layer substantiates claims of cultivated fire-use well inside the cave. Taphonomic analysis conducted on micromammalian remains (individuals <5kg in weight) from within, above, and below the thermally-altered layer indicates that in this layer the temperature reached 550–600°C (unlikely to have been caused by a bush fire encroaching on the cave). The intensity of heating is evidenced by drastic discolouration of small-mammal bones. Five grades of heat-induced discolouration were recognized through the sample, with only 3% of category 5 (calcined) bone occurring outside the burnt layer. Electron microscopy of bone fragments attributes this discolouration to burning rather than post-depositional mineral staining (however, a distinctive form of manganese staining has been recognized throughout the sample). Interpretation of the agent responsible for the micromammal sample accumulation, based on element representation, breakage patterning, and acid etching, suggests that these bones were deposited by avian predators prior to the burning event. Human intervention is demonstrated by presence of thermally-altered struck flakes and cores of chert excavated in the same layer, and human curation of fire can be inferred. There is little evidence of post-depositional movement or dispersal, and limited weathering and root-etching on the bones sampled. This form of research represents a novel line of evidence in identifying pyrotechnological capabilities at Early Paleolithic occupation sites.

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Force Production During Stone Tool Knapping

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Recent archaeological finds demonstrate that stone tool behaviors predate *Homo* by more than half a million years. However, these early assemblages are scarce and some have low tool and flake accumulations. Only after the appearance of *Homo* are increases in site and artifact density evident. While these archaeological data indirectly support the hypothesis that efficient tool production and use are linked to adaptive changes seen in the genus *Homo*, these links remain tenuous. Understanding the functional consequences of shifts in hominin forelimb anatomy on knapping performance may provide a means of evaluating this hypothesis and can further illuminate the mechanics of early tool production. This study tests a biomechanical model for the manner in which power is generated during knapping. Kinematic data were collected from six experienced knappers making simple Oldowan flakes with raw flint. These un-restricted data were compared to kinematic data collected from the same subjects wearing motion-limiting braces on their shoulder and wrist to mimic aspects of the ancestral condition. Inverse dynamics analysis was performed to calculate joint velocities and torques at each major joint in the forelimb. Results suggest the largest contributions to force production come from the elbow extensors and internal rotation of the shoulder. Other power contributions from the shoulder and wrist are highly variable between subjects. The anatomical shifts in wrist hyperextension, humeral torsion, and shoulder orientation between *Australopithecus* and *Homo* have important consequences for the production of power and accuracy in stone tool knapping performance.

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Analyzing a Paleoenvironmental Context for Middle and Late Stone Age Behavioral Transitions

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Characterizing the tempo and mode of Middle Stone Age (MSA) and Late Stone Age (LSA) behavioral change is integral to understanding the evolution of modern human behavior. An understanding of the links between behavior and ecology requires well developed environmental contexts. Carbon and oxygen isotopic characterization of fossil tooth enamel of faunal communities from five equatorial African MSA and LSA sites is reported here to: (1) demonstrate the extent to which regional climatic proxies (East African megadroughts, Kalahari expansion, and Congo rainforest cycles) calibrate with site-level ecological signals; and, (2) develop robust, high-resolution environmental databases for these key sites. This research provides a comprehensive "ground-up" approach with long-term diachronic data. The five sites selected for analysis are: Lukenya Hill, Kenya, Porc Epic and Kibish Formation, Ethiopia, and Makwe Caves and Kalemba, Zambia. Isotopic results suggest that the last glacial maximum was the most significant continent level event in Africa during the Late Pleistocene. Oxygen profiles for all taxa at all sites indicate a sharp enrichment in O^{18} (signaling aridity) in the time period of 28–14 kya. In Zambia, a concurrent transition to C_3 grasslands is evidenced in the carbon profiles of traditional grazers, particularly equids. Earlier aridity events, such as East African megadroughts, may have been localized to large lake basins. Contrary to expectations, Member III in the Kibish Formation (~130–75 kya) reveals the greatest O^{16} enrichment in the sequence. It is cautioned, though, that similar time intervals from other East African sites are required to properly characterize the local effects of the megadrought events. Results of this study provide a more complete picture of regional environmental diversity for contextualizing local habitats in which humans evolved across Africa.

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Direct Evidence for the Intensive Exploitation of Marine Resources from the Paleolithic to the Neolithic Periods at the Site of Nerja Cave (Málaga, Spain)

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Paleolithic and Mesolithic archaeological sites from southern Iberia (along the coast of the Alborán Sea) have ample zooarchaeological and archaeological evidence for the use of marine foods by humans. In addition there are artistic representations of marine fauna representations in Paleolithic art from this region. However, until now, there has been no direct evidence for the importance of marine foods in human diets. We here present carbon and nitrogen isotopic results carried out on human and animal remains from Paleolithic, Mesolithic, and Neolithic humans from the site of Cueva de Nerja (Málaga, Andalucía). Our results clearly show that marine foods were not only intensively exploited, but also intensively consumed, by humans dating to the Upper Paleolithic and Mesolithic periods from this site. However, in the Neolithic period diet changed, as the isotope evidence instead shows that the diets were mainly terrestrial.

The Impact of Imitative versus Emulative Social Learning Mechanisms on Artifactual Variation: Implications for the Acheulean

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It is often assumed that artifacts such as "handaxes" comprising the so-called "Acheulean" have the potential to tell us about issues such as social learning mechanisms in fossil hominin populations. But what mechanism of social learning underpinned traditions of handaxe manufacture? It has been proposed that "imitation," i.e., the copying of actions leading to a specific "result," generate relatively low rates of copying error required in order to sustain long-term cultural traditions in the face of cumulative copying errors. Conversely, "emulation," i.e., the copying of a result but not the behaviors that have led to that result ("end-state copying"), is allegedly associated with the production of relatively higher rates of copying error. However, to what extent these different social learning mechanisms generate distinct patterns of variation in the archaeological record remains largely unexplored empirically. Here, a controlled experiment was implemented using 60 participants who copied the 3D shape of a "target handaxe form" from a standardized foam block. In an "imitation condition," 30 participants were shown manufacturing techniques employed in the production of the target form and the target form itself. Conversely, in an "emulation condition," 30 participants were shown only the target form. Morphometrically, copying error rates were statistically different, being significantly lower in the "imitation" condition compared to the "emulation" condition. Moreover, the imitation condition matched the demonstrated behaviors with significantly higher copying fidelity than the alternative condition. These results illustrate that imitation may be imperative for the long-term perpetuation of visibly distinct archaeological traditions, especially in the case of lithic (reductive) traditions, where copying error rates can reasonably be expected to be relatively high (Schillinger et al. 2014). These findings suggest that imitation may be required to explain the prolonged continuity of broad shape fidelity such as that seen in traditions of "handaxe" manufacture during the Pleistocene.

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They Don't Make Them Like They Used To: Unifacial Point Production and Maintenance at the Kenya Middle Stone Age Site of Marmonet Drift

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The Marmonet Drift archaeological site in Kenya's Central Rift Valley has over 26 meters of naturally exposed paleosols containing six Middle Stone Age archaeological horizons and thirteen volcanic ashes. Four volcanic layers have been dated, with ages ranging from 244 to 94 thousand years ago (ka). A new excavation in 2013 collected almost 8,000 *in situ* obsidian artifacts from two distinct archaeological horizons; one directly above the 94 ka volcanic ash and one bracketed between two ashes dated to 110 ka and 94 ka. The younger horizon is dominated by extremely thin unifacial points and bifacial knives while the older horizon has no points, but is characterized by bifacial knives, large endscrapers, and burins. Both assemblages contain significant percentages of thin shaping and resharpening flakes with large, lipped platforms, very low external platform angles, and radial scar patterns on dorsal surfaces indicating shallow invasive trimming of thin, but large, flake tools. The large and well-preserved assemblages allow for robust interpretations of the or-

ganization of technology, specifically in relation to tool production, shaping, maintenance, and discard at this critical period of human evolutionary history. Finally, the significance of the Marmonet Drift site and its lithic assemblages to the African MSA and evolution of *Homo sapiens* behavior are discussed.

An Early Upper Paleolithic Modern Human Femur From Central Siberia

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In 2008, N.V. Peristov, an ivory carver from the city of Omsk (Russian Federation) found a fossil femur on the banks of the Irtysh River in Omsk Province, Russian Federation (Russia), which one of us (A.B.) recognized as a hominin femur in 2010. Sadly, Peristov did not record the exact locality of the specimen, but based on his recollections he found it in alluvial deposits of the Irtysh, north of the town of Ust-Ishim. Here, a thick succession of Middle and Late Pleistocene deposits rich in vertebrate fossils is eroded by the river. The hominin femur most likely comes from the OIS 3 Buginka and Zagvozdino strata that constitute the second terrace of the Irtysh River. This assignment is supported by a direct ^{14}C date of 41,200±1,300 yrs BP on the fossil. The specimen is an incomplete left femur, preserving the shaft between the lesser trochanter proximally and the popliteal surface distally. The articular ends are missing, and parts of the surface are damaged, most likely by fluvial transport. The specimen has a marked gluteal buttress and a strong anterposterior bending of the shaft. The two lips of the Linea aspera are well separated, and are on a strong pilaster that is delimited by sulci medially and laterally. The cross-section of the shaft at the midshaft is teardrop shaped. These last characters are typical of modern humans, and not seen in Neanderthals. The presence of modern humans in Siberia in early OIS 3 has been proposed previously based on the Initial Upper Paleolithic artifacts from Kara-Bom (Altai Mountains, Russian Federation) dated to about 43,000 years BP. The Ust-Ishim femur, though about 1,200km further northwest supports the early colonization of the area by modern humans.

Developmental Disruptions in the Teeth of Primates of Known Histories

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Developmental defects on the outer and inner aspects of tooth crowns and roots are known as hypoplasias and accentuated lines, respectively. These features are frequently examined for insights into human and nonhuman primate childhood disease, nutrition, environmental variation, early mortality, and weaning. While precise records of developmental defects may provide key insights into human evolution, very few studies have examined the teeth of individuals of known histories. In this study we determined the timing of developmental defects on casts and in histological sections of nine captive juvenile rhesus macaques (*Macaca mulatta*), two captive juvenile pig-tailed macaques (*Macaca nemestrina*), and three juvenile wild chimpanzees (*Pan troglodytes verus*), which where compared to medical and/or behavioral records of potential developmental stressors. Hypoplasias are uncommon in the permanent molar crowns of these individuals, but internal accentuated lines are common in postnatal enamel and dentine. We find that teeth are particularly sensitive recorders of diarrheal illnesses, as well as medical procedures. It does not appear that the normative cessation of lactation leaves a consistent or marked developmental defect in molar crowns. Finally, a ten-year record of developmental defects in the Taï Forest wild chimpanzees does not correspond to local patterns of rainfall, fruit availability, or epidemic illnesses observed in this community. While human and nonhuman primate teeth do show events such as birth, severe illnesses, and poor nutrition under certain conditions, we caution against specifically inferring weaning, malnutrition, disease, and/or environmental variation from hypoplasias or accentuated lines in fossilized dentitions.

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Cryptotephra Possibly from the 74 ka Eruption of Toba Discovered at Pinnacle Point, South Africa: Implications for Resolving the Dating Controversy for Middle Stone Age Sites in Southern Africa

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Cryptotephra has been discovered in the Shelly Ashy Dark Brown Sand unit (SADBS) within the sediment section of a Middle Stone Age (MSA) rock shelter (site PP5-6) at Pinnacle Point, South Africa. This tephra occurs as bubble wall glass shards less than 80μm in size and has a high probability of being distal ash from the 73.88±0.32 ka super-eruption of Toba in Indonesia. Shards are high silica rhyolite (73–78 wt. % SiO2) and fall within the compositional range of Young Toba tephra (YTT) for all major elements. The weighted mean OSL age estimate for the unit containing the tephra is 70.6±2.3 ka (Brown et al 2012). The first discovery of YTT tephra in Africa was in a Lake Malawi core (Lane et al. 2013). The occurrence of YTT at Pinnacle Point extends the area covered by distal tephra and suggests that YTT may be found at other MSA sites in southern Africa. This discovery is important in that it may help resolve the dating controversy arising from substantially different age estimates provided by different luminescence researchers for MSA sites in South Africa. The Toba tephra provides a widespread isochronous marker that can be used to independently test age estimates from luminescence techniques. At PP5-6, the location of the tephra suggests an age concordant with that from the published OSL chronology (Brown et al. 2012). Our documentation of cryptotephra in an MSA context in South Africa provides an exciting new addition to our geochronological toolbox, and we propose application of cryptotephra studies to all the relevant MSA sites in South Africa so as to quickly resolve this dating debate.

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Electron Spin Resonance (ESR) Dating and Human Evolution

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In 2012 several *Homo sapiens* teeth were found in the Magubike rockshelter, Iringa region, Tanzania, with hundreds of flaked stone tools. Also in the site were other mammalian teeth and numerous samples of the land snail *Achatina* sp. Both materials are in principle suitable for electron spin resonance (ESR) dating, although *Achatina* has not been fully tested for this purpose. ESR dating measures the accumulation of radiation-induced damage and can date materials as young as 30 ka and as old as several million years with a precision of 10–15%. In the summer of 2013 additional shells and teeth were collected from the MSA levels. The teeth ages show good stratigraphic consistency, with those 50–60cm below the surface dating to around 100 ka, and those from depths conforming to the *H. sapiens* finds dating around 200 ka. The *Achatina* shells yield similar ages, but with less precision. These ages suggest strongly that the Iringa specimens are among the oldest known examples of *Homo sapiens*.

Starch Taphonomy on Stone Tools: Considering Anthropogenic Alterations, Climate, and Soil Chemistry

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Starch grains recovered from archaeological contexts have been targeted in various research projects aimed at reconstructing the dietary patterns of ancient communities. They are known to survive over long timescales in protective archaeological contexts, such as within the cracks and crevices on the surfaces of stone tools (e.g., Piperno et al. 2004), and in the matrix of dental calculus (Hardy et al. 2012; Henry et al. 2011). Starch grains can become damaged and destroyed by several physical and chemical processes, in particular, due to cooking and processing (e.g., Crowther 2012; Henry et al. 2009), and are therefore especially vulnerable to post-depositional taphonomic processes. We are currently carrying out experimental work to study changes to the morphology of starch as a factor of time, as well as quantitative variation as a result of decay during burial. For this purpose, we have seeded flint tools with three varieties

of starches (wheat, potato and cattail), using both native and cooked starches, and buried them in different environmental and climatic contexts that mimic those found at archaeological sites for a period of three years. Our main research question is to determine how different parameters in soil chemistry, including temperature, pH, nutrient and mineral content, water availability and movement, and bacterial load, affect the preservation of starches under different climatic conditions. The results from this project will help indicate environments in which we should expect to see good starch preservation. Here we present the results obtained after one year of burial.

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Take Me to the River: The Orange-Senqu Corridor and Late Pleistocene Population Dynamics in Inland Southern Africa

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South Africa's 2,798km coastline hosted key developments in modern human evolution. During times of resource stress, the coasts acted as refugia to earlier members of our species by providing stable supplies. But the subcontinent has another major aquatic feature that, despite stretching 2200km across virtually the entire country, has received far less attention: the Orange-Senqu River. Rising from the subcontinent's highest peaks and coursing through some of its most arid regions, the Orange-Senqu would have oscillated with Late Pleistocene climate changes between a useful corridor and a vital lifeline. Our project targets opposite ends of this inland fluvial artery—highland Lesotho where its headwaters rise, and the Namaqualand desert where it empties into the Atlantic. In this paper, we employ radiometric, geoarchaeological, and paleoenvironmental data to generate a hypothesis of how the Orange-Senqu River variably influenced Late Pleistocene population dynamics. Specifically, during glacial periods conditions were relatively humid in Namaqualand due to westward shifts of the arid coastal belt, but dry and cold in highland Lesotho. We predict that Namaqualand groups would have been untethered from the river and ranged widely over a relatively productive landscape, whereas Lesotho would have been largely abandoned due to lowered temperatures. Our findings indicate dense occupation of Namaqualand during MIS 4 and 2, whereas exploitation of Lesotho is only ephemeral, particularly during the extreme cold of the LGM. MIS 3, on the other hand, is a period of great instability with rapid humid/arid oscillations throughout the subcontinent. This may have tethered people to the river in both regions in order to reduce the risk of losing access to fresh water and dependent resources. This is largely corroborated by our data, although MIS 3 occupations in Lesotho were more dense and continuous while in Namaqualand ephemeral occupation pulses coincide with brief humid phases.

Angling in on Bone Breakage: A Controlled Study of Hammerstone and Hyena (*Crocuta crocuta*) Long Bone Breakage

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Bone breakage forms important evidence for interpreting taphonomic history and hominin behaviors at paleoanthropological sites. Bone breakage analysis usually can determine the timing of breakage (as fresh, dry, or fossil bone) and aims at identifying agents of breakage (e.g., hominins, carnivores, trampling, compaction in sediments). Crenulated breaks associated with tooth pits on spongy bone/ long bone epiphyses indicate carnivore breakage, but identifying causes of breakage on long bone shafts is more problematic if tooth or hammerstone pits are not preserved or are covered by matrix. Studies of notches and breaks on shaft fragments have suggested that carnivore tooth loading results in more perpendicular break angles, while hammerstone dynamic loading leads to more oblique breakage angles (Alcántara-Garcia et al. 2006; Capaldo and Blumenschine 1994), but variation due to variables such as size class, shapes and thickness of skeletal elements, location of impact, degree of force applied, and even taxonomic group (de Juana and Domínguez-Rodrigo 2011) means that large scale controlled studies are required. We present experiments of hammerstone and carnivore broken long bones controlling for body size and taxon by using only *Cervus canadensis* long bones. We chose North American elk because it represents a size class commonly found at Pleistocene sites. The breaks were classified as oblique, longitudinal, or transverse after (Villa and Mahieu1991 and Pickering et al. 2005) and angles measured following the protocol of (Alcántara-Garcia et al. 2006). The hammerstone sample consists of 39 long bones, 219 measured fragments, and 669 measureable breaks; the hyena broken sample consists of 11 femora, 60 fragments, and 111 breaks. We compare angles measured using goniometers between skeletal elements and to previously published data. Intra- and inter-observer error estimates are made and measurements are compared to 3D models in Rapidform. Carnivore and hammerstone oblique break angle distributions overlap strongly; at the assemblage level carnivore break angles are slightly

more oblique than those of hammerstones; and there were significant differences between break angles on different skeletal elements.

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Were Neanderthals Biting Off More Than They Could Chew? Evidence from the Temporomandibular Joint of Middle and Late Pleistocene Hominins

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One hypothesis for the distinctive form of the Neanderthal cranium is the anterior dental loading hypothesis (ADLH). However, both support for and against this hypothesis has been generated by biomechanical analyses of the Neanderthal cranium, and it therefore remains unclear what, if any, the adaptive significance of the Neanderthal face for masticatory (or paramasticatory) purposes may have been. As the joint connecting the mandible to the cranium, the temporomandibular joint (TMJ) plays an important role in dissipating masticatory forces and governing mandibular range of motion. Here I present an analysis of the TMJ in *H. heidelbergenis*, *H. neanderthalensis*, and *H. sapiens* with the goal of further evaluating the ADLH. Three-dimensional landmarks describing craniofacial and TMJ shape were collected on a sample of Middle and Late Pleistocene fossil hominins, as well as archaeological samples of modern *H. sapiens* that are known to have varied in their masticatory behaviors. Standard geometric morphometric techniques were employed to compare TMJ form among taxa (e.g., *H. heidelbergensis*, *H. neanderthalensis*, and *H. sapiens*), and linear measurements describing aspects of TMJ and masticatory shape were extracted to test a series of biomechanical hypotheses. Results revealed few significant differences in linear measures of masticatory and/or TMJ form among *H. heidelbergensis* and *H. neanderthalensis*; these results were further mirrored by the geometric morphometric analyses of glenoid fossa form. The shape analyses did, however, successfully distinguish fossil hominins (including fossil *H. sapiens*) from more recent *H. sapiens*, potentially suggesting important differences in masticatory function between these groups. Finally, a high occurrence of TMJ pathologies was noted in the Neanderthal sample, with 30% (6/20) of the individuals examined showing signs of TMJ osteoarthritis. This relatively high prevalence of TMJ pathology represents another potential line of evidence for evaluating masticatory function in this fossil species.

Revised Age and Context of the Middle and Later Stone Age Strata and Associated Hominin From GvJm-22, Lukenya Hill, Kenya

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GvJm-22 is a rockshelter on an inselberg overlooking large game migratory pathways on the Athi-Kapiti plains of south-central Kenya. Excavations by R.M. Gramly in the 1970s revealed a >2-m-thick Late Pleistocene-to-Holocene sequence rich in Later Stone Age (LSA) and pastoral Neolithic artifacts and fossil fauna, including hominin remains. The Pleistocene deposits are dominated by the extinct alcelaphine bovid *Damaliscus hypsodon*, and at ≥19 ka, GvJm-22 has been interpreted as a Last Glacial Maximum site occupied seasonally, to target these and other migratory game, by hominin populations moving from the central Kenyan uplands, based on obsidian source data. Our renewed investigations of the site focus on: (1) generating a suite of new age estimates using multiple radiometric methods; (2) a re-examination of LH-1, the only fossil hominin from East Africa associated with Pleistocene-aged LSA artifacts; (3) new analyses of the artifact assemblages; and, (4) constructing more accurate paleoenvironmental reconstructions through the analysis of previously unreported faunal collections. Our results indicate an extension of the site's age to near or beyond the limits of the radiocarbon method, emphasize variability within Late Pleistocene East African hominin populations, demonstrate the presence of Levallois technology and a formerly unrecognized Middle Stone Age (MSA) archaeological component, as well as early LSA components with ochre, grindstones, and ostrich eggshell beads, and provide the first detailed analysis of the site's microfauna. GvJm-22 therefore provides one of the few well-dated sites in East Africa that span the MSA-LSA transition, and the presence of associated *in situ* hominin remains make the site particularly important for understanding the age, context, mode, and tempo of human behavioral change in the Late Pleistocene.

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Postcranial Functional Anatomy of the Endemic Rats from Liang Bua, Flores, Indonesia

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Liang Bua, an Indonesian site on the island of Flores, is best known as the type site of endemic hominin, *Homo floresiensis*. Excavations at Liang Bua have recovered an overwhelming amount of vertebrate remains, including more than 200,000 bone fragments identified to the Muridae family (i.e., rats). These rat remains have the potential to reveal important information about the ecology, environment, and small mammal biodiversity surrounding Liang Bua during the past 100,000 years. Previous work on the rats of Liang Bua indicates at least five genera are represented (*Papagomys*, *Spelaeomys*, *Komodomys*, *Paulamys*, and *Rattus*), including species of small, medium, and giant body size. Here we use a suite of twelve metric and nonmetric measures to analyze the calcaneus (n=370) and humerus (n=450) in order to address questions about Liang Bua rat functional morphology, taxonomy, and taphonomy. Multivariate analysis suggests that there is at least one arboreally-adapted and one terrestrially-adapted species present among each size class, based on consistent differences in the size and shape of the heel. Similar clusters are observed based on the humeral measurements, but the expected functional correlation with arboreality or terrestriality of humeral features is less clear. Taphonomic analysis of the bones suggests that an owl (*Tyto* sp.) is the likely primary accumulating agent based on characteristic digestive etchings and breakage patterns observed. However, some elements range outside the digestive capacity for owls, suggesting an additional, large avian predator is responsible, probably either the vulture or Marabou stork known from the late Pleistocene deposits. In total, these analyses of two postcranial elements indicates that considerable morphological variation is present among the Liang Bua rats, suggesting a diverse array of species that differ not only in body size, but also in shape and ecological adaptation, coexisted with *H. floresiensis* during the late Pleistocene.

Ecological Change at Koobi Fora in Northern Kenya Circa 3.4 Million Years Ago: Implications for Hominin Biogeography in East Africa

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Global scale climate change over thousands to millions of years is often posited as a driver of hominin evolution; however, less attention has been focused on shorter time intervals and at the local level of spatial resolution. It is more likely that hominins and other species would have responded to climatic variability on shorter temporal and smaller spatial scales. To address the issue of scale, multiple proxies from a local paleoenvironment, including stable isotope signals from pedogenic carbonates (n=86), the abundance of fossil mammals (n=951), and facies context, are used to quantify the extent of ecological change between the periods above and below the Tulu Bor Tuff (3.44 Ma) in the East Turkana region, northern Kenya. Global climate records suggest that the period below the Tulu Bor (~3.7–3.44 Ma) is more humid than the younger period above the Tulu Bor Tuff (~3.44–3.2 Ma). Data from this study demonstrate a significant difference in mammalian community structure across the Tulu Bor Tuff in East Turkana, where mammalian diversity decreases in the younger sediments corresponding to the less humid global climate regime. However, the carbon isotopes signals demonstrate no significant differences in mean or variance between the two periods, whereas oxygen isotope means do differ significantly. Though the results from these proxies demonstrate a correlation between mammalian diversity and global humid and dry periods, they also correspond with local events such as the extended volcanic activity that resulted in the deposition of the Tulu Bor Tuff, and may have affected the local ecology of the region. We use the Koobi Fora example to discuss the broader biogeographic implications of local hominin environments in East Africa at about 3.4 million years ago and their influence on hominin dispersals in relation to climatic changes.

New Teeth from Denisova Cave and the Dental Morphology of the Denisovans

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Genetic analyses of a manual phalanx fragment from Layer 11 of Denisova cave (Altai Mountains, Russian Federation) showed that it originates from a previously unknown hominin group, the Denisovans. Based on their nuclear DNA, the Denisovans were found to be an Asian sister group of Neandertals, having separated from them in the Middle Pleistocene. Our knowledge of their morphology

is extremely limited, as the material known until now only consists of a proximal fragment of a juvenile distal phalanx and an upper second or third molar of a different individual, linked to the phalanx by its mtDNA. The molar is very large, lacks the expanded hypocone seen in Neandertals and has massive and strongly flaring roots. Ancient DNA from another hominin specimen, a toe phalanx, found in a lower sublayer (11.4) is similar to that seen in Neandertals, showing that the cave has been occupied by both Denisovans and Neandertals. New hominin material recovered since 2010 also includes two teeth, a naturally exfoliated left lower di2 from layer 11.4 and an incomplete upper M3 crown from the border of 11.4 and of the underlying Layer 12. The molar is a Denisovan based on its mitochondrial and nuclear DNA, but the affinities of the di2 are unclear. The di2 is not very diagnostic, with slight marginal ridges and strong labial convexity. It is very small, close to the lower limit of the Neandertal range of variation. The molar is even larger than the previously described specimen, and is morphologically rather different. The crown is very low with little relief, and the cusp pattern is unusual, with one large and several small accessory cusps between the hypocone and metacone, resulting in a pentagonal crown outline. We will discuss the morphology of these specimens in a comparative context, and their implications for our understanding of the enigmatic Denisovans.

Return Rate Estimates for Inter-Tidal Foraging From Experiments on the South Coast of South Africa: Implications for Debates Over the Significance of Early Marine Resource Use

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The origins and significance of coastal foraging has gained increasing interest in discussions of modern human origins research. The south coast of South Africa has the oldest and best studied evidence for early use of coastal resources, and various researchers have argued that coastal resource use was significant for cognition (Broadhurst et al. 2002), social complexity, and the maintenance of population refugia (Marean 2010). To date there has been little consensus, and even less empirical evidence, on the foraging returns for inter-tidal resources in this coastal environment. Here we present the first net return rate estimates for inter-tidal foraging in the varied south coast of South Africa. Foraging experiments were conducted with Khoe-San descendants in the area and hourly caloric net return rates were recorded over 35 low tides and through the seasons. Net return rates varied as a function of gender, tidal range, marine habitat types, and condition of surf. The mean net return rate (kcal/hour) in some instances equals or exceeds that recorded for hunting of large mammals, and shows that under the right conditions the south coast provides an extraordinarily rich protein resource. Our results show that strategic coastal foraging along the south coast could have been a highly productive foraging strategy for emerging modern humans. We relate these results to recent analyses and discussions of Middle Stone Age coastal foraging.

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Experimental Determination of Butcher Experience Using Cutmark Patterning

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The evolution of hominin brain and body size is often associated with the increasingly carnivorous diet of early *Homo*. Cutmarks are the most direct evidence of hominin flesh consumption and have been used to investigate the relative timing of hominin and carnivore access to carcasses (Dominguez-Rodrigo 1997). However, the potential for linking behavior and ecology to cutmarks is currently limited due to our poor understanding of cutmark patterning as measured by the frequency, orientation, and distribution of cutmarks over larger mammal skeletons. This may be the result of our lack of knowledge of the effect of butcher skill and experience on resulting cutmark patterns. This study provides a method for the evaluation of butcher skill and experience using the patterning of cutmarks on limb bones. Experiments were designed to test the effect of butcher skill and experience on the frequency, orientation, and distribution of cutmarks across the larger mammal appendicular skeleton. Ungulate limbs were defleshed with stone tools by both experienced and inexperienced butchers and the resulting cutmark patterns were analyzed using an established GIS-based protocol for the evaluation of feeding trace patterns (Parkinson 2013). The results of these data have implications for researcher's choices of analogous participants in experimental butchery events and further have the capacity to shed light on the cognitive evolution of hominins inferred from their knowledge of anatomy.

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Modern Human Behavior in the East African MSA: A Preliminary Evaluation of Lithic Artifacts from Magubike Rockshelter, Tanzania

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This poster presents preliminary findings on an assemblage of lithic artefacts recovered during the 2012 excavations at Magubike Rockshelter, Tanzania. From under the main roof of the shelter, these cultural deposits represent approximately 50cm of recent and Iron Age material, and up to 1.5 meters of Middle Stone Age (MSA) occupation at the base of the sequence. The MSA materials are particularly significant as they coincide with the anatomical and behavioral appearance of modern *Homo sapiens*, 200,000 years ago. The abundance of lithic artifacts, in association with faunal remains and symbolic items such as ostrich eggshell beads, provides an excellent opportunity to test assumptions concerning the emergence of behavioral modernity during the MSA.

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A High-Resolution Late Pleistocene (~90–50 ka) Middle Stone Age Lithic Technological Sequence at Pinnacle Point Site 5-6, South Africa

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Pinnacle Point Site 5-6 (PP5-6) on the south coast of South Africa provides a high resolution and nearly continuous record of Late Pleistocene occupation between ~90 and 50 ka. Fourteen meters of stacked occupation layers have been excavated with total station plotting and dated by 81 optically stimulated luminescence age estimates. We present the results of the analysis of more than 14,000 lithic artifacts from the sequence to examine aspects of change and continuity in raw material selection and heat-treatment, core reduction strategies, and tool types through time. At PP5-6, fine-grained raw materials (i.e., silcrete, quartz, chalcedony) dominate the assemblage after ~70 ka. Quartzite is more common ~90–70 ka, though some stratigraphic units during this period are silcrete-dominant. Quartz use peaks between ~70–63 ka. Based on the size-variability of lithic artifacts with remnant pre-heat treatment scars, silcrete nodules of various sizes and morphologies were heat-treated. Diverse core reduction methods were used throughout the sequence for blade, bladelet, and flake production, and these methods included the use of minimally-crested blades, pyramidal blade cores, and bipolar percussion. Backed pieces occur from ~70–50 ka, but with fluctuating frequencies and morphologies. Unretouched points are most common between ~90–80 ka and again at ~50 ka, and are rare between ~70 and 50 ka. These results are situated within the context of the African Middle and Later Stone Age to consider the nature of technological change and adaptation in the Late Pleistocene. Our comparative framework includes contemporary MSA sequences at Diepkloof Cave, Klasies River, Sibudu Cave, Border Cave, and younger Later Stone Age assemblages. The presented sequence is critical for understanding Late Pleistocene technological variability and how environmental change influenced the technological decisions of early modern humans.

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Dental Fluctuating Asymmetry Among Early Modern Humans and Neandertals

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Studies of development stress in Neandertals, and to a lesser extent early modern humans, have largely focused on the analysis of episodic stress evident in dental enamel hypoplasias (DEH). However, cumulative stress during crown development is also discernible through the analysis of dental fluctuating asymmetry (DFA), and a study by Barrett and colleagues (2012) demonstrated that DFA was highest among Neandertals when compared to several recent human groups (Inupiat, Ohio Late Archaic and Protohistoric groups, and modern Ohioans). The present study aims to contextualize these results within the context of the Middle to Upper Paleolithic transition by providing a further comparison with 22 early modern humans (~40–20 ka cal BP). Following Barrett et al. (2012), DFA index values were calculated for the early modern human sample and converted to z-scores. DFA index values were then compared to the published values for Neandertals and recent humans. Results show that DFA index values are highest among the Neandertals (absolutely highest for 7 of 16 tooth positions), but early modern humans did have the highest overall values for 3 of 16 tooth positions. When compared directly, Neandertal DFA index values are higher in 10 of 16 tooth positions compared to early modern humans. Excluding the limited

modern Ohioan sample, early modern human z-scores had the least significant differences from the Protohistoric (7.8%) followed by the Neandertals (9.7%), Late Archaic (9.8%), and Inupiat (10.4%) at P<0.05. These results support previous DEH and DFA research suggesting that Neandertals were under considerably more developmental stress than anatomically modern humans. These results should be taken with caution as larger sample sizes are needed to confront issues raised by temporospatial averaging of the Late Pleistocene sample.

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Middle and Later Stone Age Technology and Adaptation in Southern Tanzania

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The Magubike rockshelter in the highlands of southern Tanzania contains a more or less continuous archaeological record beginning with the earliest Middle Stone Age (MSA) at least 200,000 years ago and extending up to and including historic times. In addition to numerous faunal remains, six modern *Homo sapiens* teeth have been recovered from the earliest MSA deposits. Three separate MSA occupations have been uncovered, each of which shows selection of different stone raw materials for tool production. Two areas of the site have Later Stone Age (LSA) occupations. Magubike also appears to contain evidence of human occupation over the genetic bottleneck which occurred sometime before the Middle to Later Stone Age (LSA) transition. Along with other open air and rockshelter sites in the same region, the cultural sequence at Magubike can be used to test models of the emergence of modern human technology and behavior, both before and after the Out of Africa 2 dispersal.

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"Learning to Live with Missing Data"

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Paleoanthropologists appear to have a compulsion to generate comprehensive hypotheses about human evolutionary history. We do this despite several lines of evidence that suggest we are unlikely to have enough data to complete such an exercise with any realistic chance of success. We make several assumptions that experience would suggest are unreasonable. First, we make the assumption that we 'know' all of the taxa that need to be integrated into a comprehensive reconstruction of human evolutionary history. This is an assumption that has been made since paleoanthropologists began reconstructing evolutionary history, but in nearly every decade since the 1960s, new taxa have been added. Yet prior to their addition, at each iteration of this process, practitioners were confident that all we needed to know was known. Unless we are determined that history can teach us nothing, then it would be rash to assume we have identified all the actors in the hominin evolutionary play. Second, we seem to lose sight of the fact that the hominin fossil record prior to 2 million years ago provides us with two main regional geographical windows, one from part of East Africa and the other from part of southern Africa, plus a miniscule and temporally limited window into what is happening in Central Africa. This communication will argue that we need to model what effect these geographical and temporal restrictions are likely to have on attempts to reconstruct hominin evolutionary history.

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A Reconsideration of the Ochre Artifact Assemblage from J.D. Clark's Excavation of Twin Rivers Kopje, Zambia

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Twin Rivers Kopje is a Middle Stone Age site located 24km southwest of Lusaka, Zambia, and, along with Kalambo Falls, is one of two Zambian archaeological sites which preserve evidence of the Lupemban Industry. The site was first excavated by J. Desmond Clark in 1954–56; more recent excavations by Lawrence Barham (1990s) yielded evidence of extensive collection and utilization of mineral pigments from Middle Pleistocene Lupemban and later contexts. Although Clark's publications on Twin Rivers acknowledged the

presence of ochre, little consideration was given to ochre modification type and mineralogical identity. In the study presented here, we examined all examples of ochreous minerals preserved in the J.D. Clark Twin Rivers collection at the Stone Age Institute (Bloomington, Indiana). A total of 195 pieces of putative ochre were identified by visual inspection, and their dimensions, mass, mineralogy, color, Mohs hardness, and modification type were recorded. Each piece also was assigned a score for the criteria 'Pigment Probability' and 'Modification Probability.' This study confirms Barham's conclusion that the visually striking mineral specularite is an important element of the ochre assemblage at Twin Rivers. However, our results also indicate that non-specular iron ore was the most common component of the ochre assemblage from Clark's excavation and was utilized differently from specularite. Artifacts classified as Definitely Pigment, Definitely Modified, and made of non-specular iron ore outnumbered (n=29) outnumbered those classified as Definitely Pigment, Definitely Modified, and made of specularite (n=20). Non-specular iron ore was predominantly knapped into flakes while specularite was ground or scraped as frequently as it was flaked, calling into question the common interpretation that any streakable, iron-rich mineral can be equated with pigment. Putative ochre made of weathered mafic rock was also common but may represent post-depositional weathering of an iron-rich rock originally collected and modified for non-pigment purposes.

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