Limb Bone Lengths and Diaphyses, But Not Joints, Reflect Neutral Among-Population Relationships

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Limb bones are more sensitive to environment and behavior than are crania, which presumably limits their utility to detect neutral evolutionary trends (e.g., gene flow). However, prior studies typically focus on overall patterns of limb variation, combining traits governed by different developmental and physiological mechanisms (e.g., joints, lengths, diaphyses). This study compared the ability of various limb bone properties to detect among-population relationships relative to the crania for 11 diverse, sympatric populations. Data were collected on 14 craniofacial and 83 limb bone properties for 626 Europeans, South Africans, and North Americans. Diaphyseal, length, and joint data were collected for the humerus, radius, femur, and tibia. All data were z-score transformed and mass standardized where appropriate. Coefficients of Variation (CV) and minimum QSTs were used to investigate how differences in trait variation/plasticity affected among-population similarity. The Relethford-Blangero model was used to compare the abilities of craniofacial, length, joint and diaphyseal variation to independently detect among-population relationships. Results show diaphyses and joints have higher variation than do lengths or crania. This increases within-population variation and lowers among-population differentiation as indicated by lower QSTs (crania=0.08, lengths=0.12, joints=0.07, diaphysis=0.05). Despite this, diaphyseal and length data predict among-population relationships similar to those produced by the crania. Furthermore, predicted relationships are consistent with documented historical migrations. Mantel tests confirm high, significant correlations between genetic distance matrices produced using limb bone lengths and diaphyses (correlation=0.79), lengths and crania (correlation=0.76), and diaphyses and crania (correlation=0.65). No Mantel test involving joints was significant. These results suggest aspects of limb bone variation do detect broad population structure or neutral evolutionary trends. Results do not support prior hypotheses that stronger intrinsic constraints make joints more suitable for inferring phylogeny than diaphyses.

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Estimating the Timing of and Placing Confidence Intervals on the Origination and Extinction of the *Australopithecus anamensis-afarensis* Lineage

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The *Australopithecus anamensis-afarensis* lineage is well-documented at several sites in eastern Africa and has an observed temporal range of ~4.15 to 3 million years ago (Ma). However, the temporal range of a fossil species is never completely sampled and thus species' true durations are systematically underestimated. We analyzed published site ages (specifically, their midpoints) to estimate probabilistic origination and extinction ages for this lineage along with their 95% confidence intervals (CI). This was first done using a method that assumes the probability of recovering fossils through time is uniformly distributed (Marshall 1990; Strauss and Sadler 1989). Because this is a strong assumption, we validated its veracity using probability plots. Using this method, the estimated true ages of origination and extinction are 4.2 Ma (95% CI: 4.35 Ma) and 2.95 Ma (95% CI: 2.8 Ma), respectively. We then corroborated these results using a recently published Bayesian method (Wang et al. 2016), which gave the same estimated origination and extinction ages of 4.2 Ma (95% CI: 4.44 Ma) and 2.95 Ma (95% CI: 2.72 Ma), respectively, but longer CIs. Our results extend the observed temporal range of this lineage by ~50 ka in either direction, but generally support its observed origination and extinction dates. More importantly, however, these methods allow us to place CIs on origination and extinction times, providing an objective assessment of their uncertainty. Because we used age midpoints in our analyses, we also explore the effect of dating uncertainty on our results. Since documenting hominin species origination and extinction is the basis for answering many of paleoanthropology's most pressing questions (e.g., temporal correlations of climate change with speciation and extinction events, time-scaling of the hominin phylogenetic tree, and corroborating or undermining proposed ancestor-descendant relationships), we have started to apply this method to other lineages.

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Calibrating the Chronology of Late Pleistocene Modern Human Dispersals, Climate Change, and Archaeology with Geochemical Isochrons

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Chronometric dating of Late Pleistocene modern human dispersals from Africa, environmental changes, and archaeological sites can be refined by correlations with precisely dated volcanic isochrons, stalagmites, and marine isotope stages (MIS). Qafzeh Cave burials are usually dated ~92 ka, within cold MIS-5b. However, carbon and oxygen isotopes of caprine teeth from Level XXI (Hallin et al. 2012) show C_4 grasses and summer rainfall. Soreq Cave stalagmite isotopes show C_4 grasslands and summer rainfall only during MIS-5e, 128–119 ka (Bar-Mathews et al. 2000). If Qafzeh Level XXI dates to MIS-5e, then African modern humans expanded into the Levant during an era of least environmental resistance. Lake Malawi cores have volcanic ash from the Toba super-eruption ~74 ka (Lane et al. 2013), in a level with a modeled date of ~62.5 ka. Megadroughts previously dated ~95–115 ka thus become >130 ka, within cold MIS-6. Several types of core data show the coldest, driest period after 74 ka spans ~2000 years, directly above the Toba ash. This is consistent with Greenland ice core evidence for 18 centuries of extreme cold after Toba. A sand layer on the South African coast contains Toba ash at Pinnacle Point and elsewhere (Smith et al. 2017), reflecting an abrupt drop in sea level ~74 ka. This is consistent with Malawi and Greenland core evidence for severe climate after Toba. The age for the Howiesons Poort MSA overlying this sand at Pinnacle point is likely ~72 ka. If Blombos and Pinnacle Point sand beds correlate, then the Stillbay MSA dates no later than 74 ka. OSL chronologies should be recalibrated. If the molecular genetic date for the dispersal of modern humans out of Africa is ~55–65ka (Nielsen et al. 2017), then MIS-5e Levantine "moderns" are too old to be the ancestors of extant non-Africans. Advanced MSA technologies after 74 ka suggest that modern socio-territorial organization strategies may have evolved in response to severe climate after Toba, and may have facilitated modern human dispersals out of Africa during MIS-4.

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Developing a Geospatial Paleoanthropology: An Example from Vertebrate Paleontology

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Paleoanthropology has long been an interdisciplinary science whose practitioners rely on analytical methods and conceptual approaches borrowed from related scientific fields. Much recent work demonstrates that the location, collection, and analysis of fossils in different field settings can benefit from the current and ongoing revolution in the geospatial sciences. Our fieldwork in Paleocene and Eocene deposits in Wyoming's Great Divide Basin has utilized tools, techniques, methods, and datasets from the GISciences to develop a new, geospatially informed vertebrate paleontology that is of direct relevance to paleoanthropology. We utilized different remote sensing sampling strategies (e.g., medium and high-resolution satellite imagery, drone based photogrammetry, terrestrial LiDAR, spectral radiometry) to visualize sediments and predict the presence of fossil-bearing deposits. Our approaches are multiscalar, ranging from supervised and unsupervised classifications of basin-wide Landsat imagery, to a more local approach involving high resolution commercial satellite imagery, to highly-local, low elevation reconnaissance flights using unmanned aerial vehicles (UAVs) equipped with an HD video camera, and terrestrial LiDAR scans of a single locality. We developed artificial intelligence based predictive models to guide the ongoing search for new localities in the field, and ground-truthed several resulting models. We surveyed 40 predicted locations over two field seasons and collected vertebrate fossils at 20, resulting in 30 new fossil vertebrate localities, a significantly higher rate of success than standard prospecting techniques have yielded in the past. We developed 3D virtual models of a particularly rich fossil bearing sandstone locality using photogrammetry derived from drone-based photography, and from a terrestrial LiDAR scan—both virtual models reveal intriguing aspects of microstratigraphy, geomorphology, and taphonomy. These approaches from the geospatial sciences can help us locate additional fossil resources, share spatial and fossil data with colleagues and the public, and better understand the geomorphological nature and taphonomic history of individual fossil localities.

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Absolute and Relative Diaphyseal Long Bone Lengths of Juvenile Neanderthals Suggest that Neanderthal Growth and Development Closely Resembles that of Modern Arctic Populations

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Previous studies have generally concluded that Neanderthals grew more rapidly than modern humans. The Denver Growth Study has primarily been used to represent modern humans in these investigations. However, a sample of healthy middle-class children from Denver, Colorado, does not accurately represent the considerable developmental variation seen across modern human populations today. With a diverse comparative sample, we hypothesize that Neanderthals grew more similarly to humans than previous analyses suggest. We evaluate the growth tempo of seven juvenile Neanderthals by assessing the fractional stages of tooth development, absolute long bone diaphyseal lengths of the humerus, ulna, radius, femur and tibia, and percentage of adult size at death. We use four modern comparative samples: the Denver Growth Study, a combined sample of four past Arctic populations, the North African Kulubnarti sample, and the early medieval Central European Mikulćice population. We found that the absolute diaphyseal long bone lengths of the Neanderthal sample are much more similar to modern Arctic populations than any other human sample. In general, there is a much smaller difference in the percentage of adult size at death between the Neanderthal and modern Arctic populations than other modern human samples. This sample, in general, seems to offer the best analogy to Neanderthals. It indicates that developmental differences between Neanderthals and modern humans may be more related to other variables, such as climate, ecology, and health status, than interspecies differences. For both absolute and relative diaphyseal long bone length, the Denver Growth Study plots separate from the other modern human and Neanderthal samples. Therefore, we caution against using the Denver Growth Study when working with non-recent samples to investigate such questions.

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Hominin Cranial Fragments from Milner Hall, Sterkfontein, South Africa

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The Sterkfontein Caves site is one of the richest early hominin fossil localities in Africa. In addition to significant fossil assemblages from Members 2 and 4, recent excavations have revealed the potential of the Milner Hall (MH) deposits to contribute to the South African hominin fossil record (Stratford et al. 2016). In particular, the description and metrical analyses of the manual proximal phalanx (StW 668) and the upper molar (StW 669) from the T1 depositional unit of the Central Underground Deposits excavation site (STK-MH1) suggest enigmatic mix of unique, primitive, and derived morphological traits. The complex stratigraphic context of the MH fossiliferous depositional sequence, in which an early distal accumulation of the 3.67 Ma old Member 2 (T3) and 2.18 Ma Oldowan artifact-bearing sediments from Member 5 (T2) contribute to the formation of T1 (Stratford et al. 2014), affords potential early *Australopithecus*, *Paranthropus*, and early *Homo* representation in the deposit. Here we describe two hominin cranial fragments excavated from STK-MH1 in 2015 and apply high-resolution microtomography to explore potential taxonomically diagnostic features (Beaudet et al. 2017). Based on external morphology, StW 671 and StW 672 are tentatively identified as parietal fragments. Our non-invasive bi-dimensional quantitative investigation of the two cranial fragments provides a mean cranial thickness of 8.8mm (range: 7.0–9.8mm) and 5.6mm (range: 4.6–7.1mm) for StW 671 and StW 672, respectively. Additionally, the diploic layer constitutes less than 50% of the cumulative cranial thickness. While the mean thickness falls within the range of *Homo* (Copes and Kimbel 2016), the relative proportion of the diploë is lower than in *Australopithecus* (>60%) and extant humans (>50%) (Beaudet et al. 2017). Accordingly, in terms of both cranial thickness and inner structural organization, the MH hominins combine derived and primitive traits, consistent with the published postcranial and dental material (Stratford et al. 2016).

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The First Paleoecological Analysis Derived from Small Mammal Remains from the Late Pleistocene of South China: Results from Yahuai Cave and Implications for Modern Human Dispersal into East Asia

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Modern human dispersal from Africa in the Late Pleistocene is one of the most important events in human evolution. The first modern humans in China have been dated to ca. 100 ka in Southern China. The role of rainforest ecologies in this dispersal has been debated. However, paleoecological studies in this region and time period are rare. To our knowledge, there have been no studies of small mammal paleoecology in Late Pleistocene contexts in Southern China. Here we present for the first time, results of a small mammal paleoecological reconstruction from the archaeological site of Yahuai cave located in Long'an County, Guangxi Zhuang Autonomous Region, South China, and discuss its relationship to modern human dispersal into the region. The site consists of a rock shelter and an inner cave, covering an area of more than 100m^2. Deposits are over 7m thick, with 55 stratigraphic layers identified in four excavation areas. Upper levels of Area A have been dated to 44,000 years and provide a *terminus ante quem* for the lower levels of the site. Over ten thousand cultural artifacts, including lithics and bones, were uncovered throughout the sequence. In addition, Area A revealed a rich small mammal assemblage. Taxonomic and taphonomic analysis was conducted following procedures outlined in the literature. Results suggest that the assemblage includes a high diversity of species which includes at least five species of flying squirrels, seven species of murids, as well as several species of shrews, bats, and insectivores. Paleoecological analysis suggests that all are indicative of a close, forested, warm, and humid environment. The reconstructed environment is more humid than suggested for the contemporaneous Indochinese peninsula and provides evidence for the presence of modern humans in highly forested environments during the Late Pleistocene.

Taphonomic and Fossil Reconstructive Analyses of the Ngaloba (LH 18) Skull

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The Ngaloba specimen (LH18) from Lateoli, Tanzania, includes a partial maxilla and largely intact cranial vault. LH18 represents an important stage in the Mid-Pleistocene *Homo* fossil record (205±17 ka or 290±25 ka) and expresses a number of primitive and derived craniofacial features. Although the cranium was found in several pieces and experienced post-mortem deformation, reconstructions have allowed for numerous morphological comparisons. Some researchers argue that Ngaloba's general maxillary shape, reduced prognathism, and reduced robusticity align the specimen with modern humans, while others argue that intermediate alveolar prognathism and a short maxilla place it in the archaic grade. Taxonomic placement of LH18 is further complicated by the ever-changing shape of the specimen. Here, we demonstrate four events in which a portion of the right zygomaticoalveolar crest is attached, re-attached incorrectly, goes missing, then is re-attached and further rotated. The left portion of the maxilla also demonstrates wear and breakage, with palate expansion. Through analyses of 3D surface and CT scans in Geomagic Design X, we qualitatively and quantitatively assess the various shapes the maxilla has taken. Implications for comparative studies utilizing this specimen also are discussed. While this research highlights changes in LH 18, it also demonstrates the importance in scanning original specimens, potential risks in using other researchers' data, and need for supporting proper curation techniques. Three of the restorative efforts of LH 18 have taken place due to inadequate storage causing the specimen to break. As such, this research also demonstrates the needs of the National Museum of Tanzania (NMT). As researchers, it is partially our responsibility to ensure museums and other storage facilities are properly equipped with secure temperature and humidity controlled rooms, casting programs, and supplies for fossil reconstruction and curation. These cooperative measures serve to safeguard both fossil specimens, as well as future-generation research.

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Hominins on the Western Periphery of the Red Sea: New Acheulean Occurrence in Coastal Sudan and Associated Implications

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The western coastal zone of the Red Sea basin occupies a pivotal geographic location for investigating the routes hominins took during

their expansion out of Africa. However, with a few exceptions [1, 2], the region had seen little Stone Age-focused research in the past, hindering well-informed assessment of its contribution to hominin survival and dispersal. A recent archaeological reconnaissance in the Red Sea coastal region of the Republic of Sudan documented two Acheulean sites (Hayna 01 and 02) and numerous isolated scatters of stone artifacts representing different technotypological features, such as points and prepared core products. The launching of this pioneering project was aimed at finding Paleolithic (Stone Age) sites that can inform us about Pleistocene hominin adaptations in the western peripheries of the Red Sea. Hayna 01 (HY01) will be the focus of this presentation. The site is located c. 35km from the coast (18.130N, 37.820E) on an elongated outcrop of alluvial fan breccia at the mouth of a fault-bound valley adjoining the Red Sea Hills. It has produced a lithic assemblage characterized by a classic bifacial technology referable to the Acheulean technocomplex [3] or Mode 2 technology [4]. Based on a preliminary technotypological analysis of a biface sample collected from the HY01 site in a systematic manner, this paper will discuss raw material selectivity, blank choice, manner of bifacial shaping, and size variability in the Acheulean industry there. The Hayna discovery represents the first characteristic and richest-known Acheulean occurrence in the western periphery of the Red Sea basin north of the Danakil Depression, and offers a critically needed baseline to establish the region as a viable destination and dispersal conduit for hominins.

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Least Cost Path and Agent Based Models for Hominin Dispersal Routes Out of East Africa into the Levant

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When and through which geographic routes did early humans leave Africa? Answers to these questions remain incomplete. The Nile basin and the Strait of Bab-al-Mandab (on the southern end of the Red Sea) are often cited as the likely pathways of early human expansion out of Africa [1–3]. However, the role of other geographic regions in hominin dispersal remains unclear. Our collaborative research seeks to identify areas that would have served as viable pathways for hominin dispersal from the Afar Basin (Ethiopia) toward the Levant. The study employed analytical tools in the Geographic Information System (GIS) and computational statistics (in R) to construct models, namely Least Cost Path (LCP) and Agent Based Model (ABM) that would find the least-resistance pathways (in terms of energy cost and resource scarcity) from the Ethiopian-Afar basins to Sinai. Elevation, slope, stream flow, and Net Primary Productivity for the present time were used as input variables in constructing the models. Our models demonstrate that multiple paths would have existed for hominins to follow during their expansion out of the Ethiopian-Afar rift basins toward the Levant, including the western littoral of the Red Sea basin. The study sheds light on the geographic areas that may have facilitated hominin dispersal out of Africa, and lends support to the notion that coastal landscapes may have served as dispersal conduits during global expansion of hominins. Furthermore, the models identify key target areas for Paleolithic survey.

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Regional Differences in Faunal Communities around Lake Lorenyang Between ~2.0 and 1.4 Ma

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Fossil faunal abundance data from Plio-Pleistocene deposits are useful for understanding the spatial and temporal dynamics of the environments inhabited by hominins. Here, we synthesize faunal abundance records from the Koobi Fora, Nachukui, and Shungura formations of the Turkana Basin in northern Kenya and southern Ethiopia to better understand environmental trends related to the regression of paleolake Lorenyang between ~2.0 and 1.4 Ma. The geographic locations of these Formations (to the east, west, and north of Lake Lorenyang) are ideally positioned to record the potential ecosystem restructuring associated with this geomorphic

change. Specifically, the paleoenvironments of the Shungura Formation have been hypothesized as a refugium for mesic-adapted taxa during cycles of increased aridity in the basin. We test this idea by investigating the relative abundance of mesic-adapted fauna in the Shungura Formation between 1.8–1.5 Ma period during Lake Lorenyang regression. Our faunal sample consists of both mesic- and xeric-adapted mammal taxa (n=6,117) and is dominated by material from the families Bovidae (n=3,977) and Suidae (n=1,628), but also includes material from the family Equidae (n=512). From ~1.8–1.5 Ma, there was a significant sharp increase in the relative proportion of mesic-adapted Reduncini fossils collected from the Shungura Formation, with a coincident increase in xeric-adapted Alcelaphini fossils from the Nachukui Formation. In the subsequent time slice (~1.5–1.4), the relative abundance of bovid tribes begins to covary with no significant difference between formations. Our data also indicate that the genera *Notochoerus* and *Eurygnathohippus* existed in the Shungura Formation during periods of decline and even extirpation in the Koobi Fora and Nachukui Formations. This could indicate that these taxa were more mesically-adapted than previously thought. Overall, our results indicate that the Shungura Formation could have acted as a refugium during this period of fluctuating lake size and aridity.

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The Rise and Expansion of Anatomically Modern Humans Out of Africa in the Context of Climate Variability Using New Quantifying Methods and a Multi-Regional Approach

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Numerous hypotheses have attempted to correlate key periods of human evolution and migration with climate and landscape changes. Many of these hypotheses operate within a unidirectional backdrop of decreasing tree cover and increasing aridity, trends evident in offshore dust flux, soil carbonate isotope, and fossil faunal records. While others, like the variability selection hypothesis, focus on alternating climate extremes which would have required early humans to adapt to climatic variability and a changing mosaic of habitat types. The more recent accumulated plasticity hypothesis states that a species which experiences increased temporal variation within their environment is naturally selected to have more adaptive strategies while being less fit for any one particular type of environment. These adaptive strategies would equip a species for dispersal into new habitats. Direct comparisons between climate variability and human evolution have been difficult due to the lack of well-dated, long-term, regionally specific climate records. Aside from generalized insolation variability, climate variability has not adequately been defined and quantified for paleo-records in any testable manner. We use two different methods to quantify and define climate variability through over 30 climate/environmental records developed using different techniques and timescales. The new methods allow direct comparisons between different records offering insight into complex, multi-regional climate dynamics of the last 400,000 years. Furthermore, the records span the African continent, as well as the Levant and Southern Europe, offering an unparalleled spatial understanding of how multiple regions relevant to the rise and expansion of *Homo sapiens* responded to global climatic events. The new methods indicate that between 120 ka and 130 ka, most of these regions experienced periods of high climate variability. This suggests that climate instability may have been a driving factor in dispersals out of Africa during MIS 5.

ESR Dating Teeth from Šalitrena Pećina, Serbia: Implications for the Middle/Late Paleolithic Transition

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Anatomically modern *Homo sapiens* (am*Hs*) first arrived in Europe during latter half of Marine Isotope Stage (MIS) 3. Despite >150 years research on the relationship between Neanderthals and am*Hs*, if or how these two species interacted remains uncertain. Šalitrena Pećina is the only Serbian site south of the Danube, where a continuous sedimentary sequence records the Middle/Upper Paleolithic (MP/UP) transition. Šalitrena sits in a cave near Breždje in central Serbia in the Dinaric Mountains. The cave opens about 20m overlooking the Ribnica River. In the cave entrance, six sediment layers reach ~1.5m thick. Layer 1's loose gray surficial sediment contains mixed artifacts from several time periods. Layer 2, a compact gray-brown sediment, has Neolithic tools. In Layers 3–4, fine yellow silty sand

with large *éboulis* and loose dark brown sediment with soot and scree, respectively, contain Gravettian artifacts and flint. Layer 5, a grey-brown sandy silt with *éboulis*, contains Aurignacian artifacts. Layer 6 contains brown, sandy silt with 20% *éboulis*. Layers 6a-c has Mousterian tools made by Levallois and discoid reduction methods. Layer 6d had one Central European bifacial scraper. AMS ^{14}C has dated Layers 3–4 at ~24–25 ka, Layer 5 at ~31 ka, and Layer 6 at ~38–39 ka. Since its ^{14}C ages approach the ^{14}C dating limit, five herbivore teeth from Layer 6 have been dated by standard and isochron ESR. ESR can date tooth enamel from ~5 ka to > 2 Ma, with ~2–5% precision. For the volumetrically averaged sedimentary dose rates, >25 sediment samples from six layers within 30cm of the teeth were analyzed by NAA. Cosmic dose rates were calculated by ramped box averaging, using the geology about sedimentary cover. Three teeth from Layer 6d correlated with MIS 5b to earliest MIS 4.

New Excavations of the Late Pleistocene Sediments at "Gramly's Site" (GvJm-22), Lukenya Hill, southeastern Kenya.

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We report new excavations of Late Pleistocene sediments at the rockshelter (GvJm-22), here named Gramly's Site at Lukenya Hill, Kenya. R.M. Gramly excavated two layers of artifacts and bones in 1970–1973, 'Occurrence E' and the underlying 'Occurrence F.' Gramly identified microlithic tools in both layers and referred them to the Later Stone Age (LSA). His radiocarbon dates on these layers (19–11 ka) fall within the age-range of the LSA, but these dates yielded stratigraphically inverted ages. Tryon et al. (2015) reanalyzed Gramly's layer 'F' material and documented Levallois cores and bifacial points (Middle Stone Age [MSA] technologies), with new dates suggesting an age of >46 ka. However, without re-excavation, the reanalysis could not distinguish a 'transitional' industry reflecting gradual behavioral change from an assemblage resulting from post-depositional mixing or inadequate lateral and vertical control of artifact positions during Gramly's excavations. Our new excavations and piece-plotting of 6,337 stone artifacts and 537 bones has revealed distinct sloping geometries of layers 'E' and 'F.' Materials from our corrected stratigraphy show Gramly's original designation of layer 'E' as LSA is valid, but new material from 'F' is typically MSA. Obsidian sourcing data from the updated stratigraphy supports the distinction between 'E' and 'F.' Distant (120km) high-quality Naivasha sources (Sonanchi and South Naivasha) account for 50% of Layer 'E' obsidians, but are absent from the lower Layer 'F.' New excavations (2m^2) have dug >2m below the base of Gramly's trench (~4.5m below surface datum) and have produced older MSA stone tools and bones. These deposits continue deeper confirming that Gramly's Site preserves an important MSA and LSA archaeological sequence. Continued excavations, dating, and analysis at Gramly's Site as well as several other undated and understudied sites of Lukenya Hill can provide valuable and robust archaeological information on human behavior throughout the Late Pleistocene, if not earlier.

Acknowledgements: We would like to thank R.M. Gramly for initiating the work on this site at Lukenya Hill and generously donating his personal photos of his original excavations of GvJm-22. Our renewed excavations at Gramly's Site, Lukenya Hill, were supported by an Australian Research Council Discovery Early Career Researcher Award (DE160100030) to JTF

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The MIS 3 Occupation at Erfkroon and the Early Later Stone Age in Southern Africa

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At Erfkroon along the Modder River in South Africa four locales with *in situ* Early LSA artifacts are eroding out of the Red Paleosol in the Orangia Terrace. Only one, the Upper F Locality, has been excavated. Dating to ~34 ka, this excavated and surface assemblage consists of equilateral flakes, non-microlithic bipolar wedges, and grinding stones. Replications and ethnobotanical studies suggest unique uses for the latter two artifact types. This Early LSA assemblage can be easily distinguished from the Late MSA and the Robberg components at Erfkroon, as can Early LSA components at other sites, so we argue the Early LSA is a separate cultural tradition. The earliest occurrence of this tradition starts at Border Cave between ~47–44 ka, then it spreads into the Interior Plateau perhaps as early as ~38 ka at Kathu Pan, and a few thousand years later at other sites, including Erfkroon, in the middle Orange and Vaal basins. However it is possible that MSA groups continued in isolated areas as late as ~21 ka. The latest appearance of Early LSA in Southern Africa is in the winter and year-round rainfall regions in the south and west, recorded no earlier than ~27 ka. The Early LSA was rapidly replaced by Robberg groups at many sites across Southern Africa between ~25–23 ka, but the final Early LSA may have persisted until ~20 ka in the Western Cape. In addition to the distinctive assemblages, the duration of the tradition, the pattern of its spread, as well as the nature of its replacement, all support the assertion that the Early LSA is a distinct cultural tradition. We conclude by exploring an intriguing link between the emergence and termination of the Early LSA, and demographic events recorded in mtDNA L0 haplogroup bifurcation

ages during MIS 3, which may have paleoenvironmental correlations.

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A Paleoenvironmental Reconstruction Using Stable Isotopes of Red Deer (*Cervus elaphus*) Enamel at Lapa do Picareiro (Portugal)

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Neanderthals and anatomically modern humans (AMH) adapted to a series of environmental changes during the Late Pleistocene that affected their subsistence strategies, technology, mobility, and settlement patterns. Explanatory models such as the Ebro Frontier Model propose that Neanderthals were adapted to woodland environments while AMHs preferred open landscapes. Late Neanderthal survival in southern Iberia may have been possible due to relatively mild conditions during MIS 3. Heinrich Events, especially H4, created harsh climatic conditions that may have reduced Neanderthal populations below survival thresholds. Thus, reconstructions of paleoenvironmental conditions to which Neanderthals and AMHs were subjected are key to understanding the adaptive behavior of both groups. This poster presents additional preliminary stable isotope results from intra-tooth enamel samples to assess paleoenvironmental changes during the Late Pleistocene using red deer (*Cervus elaphus*) teeth recovered from Lapa do Picareiro, located in central Portugal. Picareiro is a cave site in Portuguese Estremadura that contains evidence of late Neanderthal survival after H4, and AMH occupations dated after 34 ka cal BP. These occupations are encountered in deposits with large archaeofaunal assemblages that provide adequate samples of ungulate teeth. Using carbonate carbon and oxygen isotope values, we offer an initial assessment of shifting environmental context of red deer diet, a significant prey species at the site, and compare these results with other paleoclimate indicators such as magnetic susceptibility and sediment particle size for paleoenvironmental reconstruction. As a ubiquitous species among western European Paleolithic archaeofaunas, isotopic analyses of red deer tooth enamel present the opportunity for comparison with similar paleoenvironmental studies conducted in other Paleolithic sites. We then use these results to consider implications for both Neanderthal and AMH adaptation.

Misgrot Cave: An Actualistic Model of a Modern Baboon Sleeping Site

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Current taphonomic hypotheses suggest that many early hominins may have ended up in caves as the discarded remains of a carnivore's meal (Brain 1981). However, the accumulation patterns of several sites in the 'Cradle of Humankind' have overlooked the possibility of caves as primate sleeping sites. Misgrot is a dolomitic cave in Northam, Limpopo Province, South Africa, that is a confirmed baboon sleeping site (through camera trap footage) with a large amount of skeletal material. The assemblage, some of it mummified, is the first taphonomic model of a cave used as a baboon sleeping site. The Misgrot material was quantified using taphonomic counts (e.g., NISP, MNI, MNE, MAU %) and analyzed to determine the representation of age cohorts, sex distribution, and taphonomic modification. Across all species, a total of 1,761 skeletal elements were collected and analyzed. Among the sample, Chacma baboons (*Papio ursinus*) comprise 95.1% of the entire assemblage. Within the primate sample, the most prevalent age cohort is 'Old Adult' individuals which comprise 29.1%. Yet, all age ranges are represented, even infants (i.e., a single indeterminable infant/juvenile specimen). When considering the isolated material (a subset within the greater assemblage), 'bone breakages' (49%) and 'burnt material' (47%) constitute a significant part of the taphonomic patterns observed; in some instances these patterns even overlap. By quantifying patterns within a natural primate sleeping site, we may contribute to teasing apart the mode of deposition (e.g., predation, death-trap, and/or sleeping site) within the fossiliferous 'Cradle of Humankind' sites. This model is compared to other South African Plio-Pleistocene cave sites, especially those with high percentages of primates (e.g., Drimolen and Sterkfontein, Member 2), to determine if habitual use of the sites (by primates) may have contributed to their accumulation.

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Assessing the Development of Societal Complexity at the Middle to Later Stone Age Transition in the Context of the Economic Defensibility Model: Evidence from Knysna, Coastal South Africa

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The Economic Defensibility (ED) model posits increases in social and technological complexity in populations with access to rich, dense, and predictable resources. The model is therefore relevant to the appearance and evolution of complex forager strategies during the Late Pleistocene, and ultimately to the diversification of human adaptations, the biogeographic expansion of the global population, and the increased ratcheting of cultural technology that now define the human population. This project investigates technological and social change within coastal and near coastal societies during a critical but poorly documented period of the Late Pleistocene (~55 to 25 ka). Archaeological evidence provides a means to assess the degree to which models such as the ED and others successfully explain the development of complexity within forager society. On the southern coast of South Africa, shifts in coastal position of 75km or more would have impacted foraging territory location, potentially bringing groups into conflict. The juxtaposition of groups committed to different foraging strategies is a source of potential tension and social complexity (in terms of exchange of people and information). Thus, shifting coastlines would have shaped the evolution of the larger social landscape, possibly stimulating the growth of territory management and defense within early modern humans. At the archaeological site of Knysna Eastern Heads Cave 1 (KEH-1), we have documented a dense, long-term period of site use that not only spans a significant technological transition (the Middle to Later Stone Age, ~ 46ka through 18ka), but also records changing foraging strategies during a very rapid sea level rise and fall at about 32ka. At KEH-1, we seek to understand the impact of environmentally forced changes in foraging territory on the evolution of human landscape use in a broad social context.

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Renewed Explorations of the Mid-Pleistocene Site, Isimila, Tanzania

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Isimila, located in central Tanzania, is well-known for its vast assemblage of Acheulean tools, where handaxes exist in densities similar to Olorgesailie, Kenya. Most of the work conducted at Isimila occurred in the 1960s and 70s and though the site currently exists as a tourist destination, there has been little archaeological work there in the past few decades. Originally dated to 260,000 years ago (Howell 1972), there are indications that Isimila may be older. Here we report on the findings from two brief field seasons in 2016. Our primary goals in these expeditions were: 1) assess the likelihood of finding additional fossil specimens and/or deposits; and, 2) reconstruction of taphonomic histories for new specimens. Fossils were found in both *in* and *ex situ* contexts. *In situ* fossils are very well preserved and include a partial pelvis, vertebrae, and dental remains, including a large tusk. *Ex situ* fossils in variable stages of preservation numbered in the hundreds. *In situ* fossils had very little bone surface modification, while *ex situ* specimens were in weathering stages 0–4, had limited carnivore damage, and exhibited some polishing, suggesting that they may have been deposited in fluvial or lacustrine contexts. Most fossils were assigned to *Hippopotamus*, although specimens of turtle and crocodile (both previously unreported), suid (*Kolpochoerus*), and bovid were recovered. Thus, the potential for finding further fossil material is high. Further, preliminary taphonomic assessment of new fossils revealed two specimens with likely cut-marks. Despite the abundance of stone tools at the site, these are the first reported cut-marks on fossils from Isimila.

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Taphonomy and Early Human Foraging Behavior at SM1, a Late Middle Stone Age Site in Northwestern Ethiopia

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Research along the Shinfa River, a major tributary of the Blue Nile in the lowlands of NW Ethiopia, documents an extensive MSA record. Excavations at site SM1 (late MSA, >50 ka) reveal well-preserved stratified open-air occupations with abundant chipped stone artifacts. SM1 is unusual for the MSA because its fauna includes both terrestrial and abundant aquatic taxa. Analyses of faunal remains (n=2,993) allows investigations into aspects of site formation, including which species were collected by humans and how they were processed. The majority of specimens (n=2,164) are non-identifiable bone and dental fragments. Terrestrial fauna are dominated by size classes I and II, and include multiple bovid taxa, warthog, vervet monkey, porcupine, gerbil, lizard, snake, frog, guinea fowl, and ostrich. Aquatic fauna include crocodile, bivalve mollusks, and fish, with *Clarias* and *Synodontis* the most abundant genera (56% and 30% of MNI, respectively), while *Bagrus*, *Schilbe*, and *Heterobranchus* also are present but less common. Taphonomic analyses document minimal damage from weathering, erosion, exfoliation, and other postdepositional processes. Fracture angle/outline frequencies indicate fresh breaks for many bones. However, high proportions of transverse outlines (38%) and specimens with angles/outlines indicative of both fresh and dry breaks (~10%) suggest a more complex postdepositional history. Frequencies of human cut/percussion (6%) and carnivore tooth furrow/puncture (7%) marks are similar, and human and carnivore modification occur on both terrestrial and aquatic fauna. Analyses indicate that MSA humans focused their hunting and foraging activities on smaller terrestrial mammals and birds and also exploited fish and mollusks. This combination of riverine resource use and a restricted body-size focus may represent a seasonal facet of foraging behavior at SM1. Although humans are the primary agent of faunal accumulation, the site preserves a complex taphonomic history, the effects of which must be accounted for in future analyses of human foraging behavior.

Implications for Interpreting Time-Averaged Fossil Assemblages from an Analysis of Spatiotemporal Scaling Relationships in Species Richness for the Amboseli Large Mammal Fauna, Southern Kenya

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Most fossil assemblages are time-averaged over coarser temporal scales than modern ecological communities. It is well established in the literature, however, that ecological patterns and process change across both temporal and spatial scales. This calls into question the uncritical use of modern ecological theory and methods in paleoanthropological studies (e.g., inferring interspecific interactions and habitat selection from co-occurrence patterns in fossil faunas). One way to assess the comparability of ecological phenomena across orders of magnitude of scale is to study scaling relationships in ecological patterns. Here, we examined spatiotemporal scaling of species richness (i.e., number of species) in the large mammal (>1kg) skeletal assemblage from Amboseli National Park, Kenya. We find diversity scales positively with spatial and temporal scale but with a negative statistical interaction between the two. Extrapolating this relationship to the time scales of a Koobi Fora Pleistocene large mammal community (i.e., 10^4–5 years), shows that fossil species richness is under-predicted. A model that includes speciation during the time-averaged interval can account for a large proportion but not all of the deficit. Our study of richness scaling shows that time-averaging affects communities in much the same way as spatial averaging. This provides a first-order explanation for why many hominin environments are reconstructed as "mosaics"—most fossil assemblages are capturing a signal from multiple contemporaneous habitats. On fossil time scales, speciation and other rare, large-magnitude events not observed on modern time scales (e.g., large-scale migrations, Milankovitch-driven climate change) strongly influence fossil community structure. Thus, "co-occurrence" of species within time-averaged samples should not be used on its own to infer interspecific interactions (e.g., competition, predator-prey relationships) and habitat associations. We view this research as the first step in developing a theoretical framework for assessing the effects of time-averaging, which should facilitate more accurate paleoecological inferences from fossil assemblages.

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Continuity and Change: A Diachronic Technological Analysis of the Earliest Acheulean at Kokiselei in Turkana, Kenya (1.8–1.76 Ma)

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Paleoanthropological and paleoecological data show changes in eastern Africa 2 million years ago (Ma). Hominin species diversity,

morphology, and ecological niches shifted as environments opened up and foraging ranges expanded. The concurrent appearances of bifaces (a.k.a., "handaxes") in the archaeological record coincide with these changes. The earliest known bifaces were found in the Kokiselei Site Complex (KS), west of the Lake Turkana in northern Kenya, which is comprised of several sites spanning ~1.8–1.76 Ma. Existing theories interpret bifaces as intentionally shaped tools, signaling developments in hominin cognitive abilities, including forward planning and advanced social learning. Bifaces are generally accepted as key artifacts of the 'Acheulean Industry,' representing a divergence from previous core-and-flake technologies. The theoretical assumptions connecting bifaces, shaping abilities, and the Acheulean influenced initial interpretations of Kokiselei lithic assemblages. These interpretations described a technological evolution from 'simple Oldowan' (KS6) to more 'complex Acheulean' (KS4). However, holistic technological data from the entire Kokiselei sequence was not yet available to determine whether biface production required new knapping techniques or if hominins instead continued existing bifacial flaking strategies and selected different raw materials (e.g., elongated rather than round/subangular cobbles). Renewed analyses of the Kokiselei lithic assemblages suggest that diachronic technological change in the sequence is complex. These data show that the oldest site (KS6) differs from the younger sites (KS5 and KS4) in some respects, but that there is significant technological consistency throughout all sites in the sequence, particularly for previously undescribed larger artifacts. KS5 and KS4 have more technological similarities than differences, and Kokiselei assemblages demonstrate a high level of variability in technological processes which may result from a flexible repertoire of knapping methods and techniques. Further research can tease apart these methods and techniques to determine what factors (e.g., raw material characteristics) drove this variability.

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Australopithecus anamensis Paleoecology in the Omo-Turkana Basin Using Fossil Suidae (Mammalia, Artiodactyla)

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Australopithecus anamensis lived in eastern Africa c. 4 million years ago. The abundance of hominin fossils at c. 4 Ma sites in the Omo-Turkana Basin is extremely variable—the majority of *A. anamensis* fossils have been found at Kanapoi (c. 70%), some have been discovered at Allia Bay (c. 30%), and no hominin remains have been found so far at Mursi. The site of Kanapoi has been reconstructed in published literature as a relatively open environment, and Mursi as a wetter environment. We hypothesize that *A. anamensis* were the least abundant in the wetter environments. We focus our study on fossils from the family Suidae because multiple lines of evidence have shown the association of the genera *Nyanzachoerus* and *Notochoerus* with closed and humid environments during the East African mid-Pliocene. We analyzed Suidae fossils for faunal abundance patterns, stable isotope ratios (published and new values), and surface modification patterns on postcranial remains. We expected the distribution of carbon isotope compositions in dental enamel of all suid taxa to be generally more ^{13}C-depleted at Mursi relative to the same taxon at Kanapoi, with samples from Allia Bay intermediate between these endmembers. Instead, we found overlapping values at Kanapoi and Allia Bay, and more ^{13}C-depleted isotopic ratios at Mursi. In addition, the grazing suid *Notochoerus* is proportionally rarer at Mursi than at the other two sites. Our analysis of the surface modification patterns on the three collections also supported the important presence of humid settings at Mursi (higher abrasion levels, larger variety of weathering levels, etc.) comparatively to Allia Bay and Kanapoi. In sum, our analyses revealed similarities between the sites of Allia Bay and Kanapoi, with the results from Mursi differing from the two former sites, which may explain why the site did not seem to be inhabited by hominins.

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Non-Random Variation in Human Mandibular Molars: Implications for Selection of Analogue Species for Fossil Hominin Taxonomic Assessments

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Mandibular molars have been found to be successful in delineating between extant species, subspecies, and populations (e.g., Pilbrow 2006, 2010), and they are useful for investigating questions of variability within and between species in the fossil record. Dental anthropologists typically assess size-shape variability ranges in neontological species, as "analog" species for extinct hominin species. One such species, *Homo sapiens*, has undergone tooth size reduction, molar shape changes, and cusp simplification in some societies worldwide but not in others. The exact mechanisms for this change are currently not perfectly known, but there is no doubt that a transition to wide-scale farming and the adoption of high-starch, heavily processed soft foods in some areas, while other communities have continued with a hunter-gatherer lifestyle, have driven this non-random dental variability within our species. To test this non-random shape and size variation between groups, 240 lower second molars of *Homo sapiens* from populations around the world are compared in morphospace, using Procrustes superimposition and principal compnents analyses, and are found to vary in both size and shape, largely based on the individual's subsistence lifestyle strategy—hunter-gatherer or long-term agriculturalist. Further, a

time-series analysis of lower second molars from individuals living in different periods in Great Britain showed a general tendency for teeth to reduce in size over time, which would support research showing that historical decreases in masticatory stress have caused craniofacial reduction, particularly in the lower jaw (von Cramon-Taubadel 2011). Other factors (dietary differences, population sizes, globalization, etc.) are not comparable with Plio-Pleistocene hominin species' presumed subsistence strategies, ranges, and population sizes. Consequently, it is concluded that caution should be exercised before using modern *Homo sapiens* as an analog species for extinct hominin dental variability studies.

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Size and Shape Variation among Femora Attributed to Early *Homo*

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At least two species of early *Homo* are represented by cranio-dental remains from the Upper Burgi member at Koobi Fora, Kenya (2.0–1.88 mya). Due to the fragmentary nature of post-cranial remains and their lack of association with cranio-dental remains, little is known about the extent of post-cranial diversity from these deposits. Here, methods are employed for reconstructing missing portions of fossil femora (n=35). Proxies for femoral head size are derived from fossil acetabula and used to predict femoral neck variables using standard least squares regression (n=10). A large sample size allows for robust statistical comparisons using the standard deviation and coefficient of variation, instead of max/min ratios. 3D geometric morphometric techniques are used to capture size and shape variation on polygonal models derived from surface scans of the original fossils. Fossils from Koobi Fora, Olduvai Gorge, Sterkfontein, and Swartkrans are compared. Estimates of variation are compared among fossil groups, as well as between fossil groups and equal-sex reference samples (*Homo sapiens*, *Gorilla gorilla*, *Gorilla beringei*, *Pan troglodytes*, and *Pongo pygmaeus*). Estimates are iteratively compared using resampling procedures. Results reveal that the degree of shape variation among Upper Burgi femora is less than that of some single-sex reference samples. However, when comparing the coefficient of variation, size variation among femora attributed to early *Homo* is greater than that of *Pongo* and *Gorilla*, which are the most size-dimorphic species among hominoids. Like previous studies, these results suggest that at least two species of *Homo* are represented in the Upper Burgi member. Additional pairwise comparisons suggest that there may be more than two species of early *Homo* from the deposits. Alternatively, some specimens may be incorrectly assigned to early *Homo*. A potential limit to these interpretations is our lack of understanding of temporal dynamics of size among hominin skeletal elements.

Estimating Interproximal Wear in Upper First Molars

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Fossil hominin dental remains are often relied upon to determine taxonomic affinity or to investigate differences between species when the taxonomy is known. Frequently metrics such as mesiodistal diameter and crown area are reported in the literature. However, both of these metrics are affected by interproximal wear, which reduces the mesial and distal sections of the tooth. It is often unclear if researchers account for interproximal wear when interpreting dental remains, and how accurate their reconstructions are when they do compensate for it. One method relies upon estimating the missing sections of the original crown outline by using photographs oriented in the occlusal plane. The researcher follows the curvature of the remaining unworn tooth and estimates the sections that are missing. Here, the accuracy of this method was tested by recreating mesial and distal crown outlines on photographs of artificially worn upper first molars. The author completed two sets of recreations, the first of which differed significantly from the actual crown areas, the second of which did not. Interobserver error was explored by comparing the reconstructions of an additional two researchers to those of the author. The results were mixed, but overall indicate that caution should be used when utilizing this method.

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Emergence of the Functionally Modern Ungulate Community in Eastern Africa

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A goal of paleoecological research on late Cenozoic African faunas is to shed light on the environmental and ecological context of hominin evolution. This research is largely informed by modern ecosystems, though a growing body of evidence from eastern Africa highlights intriguing differences between past faunal communities and those of the present. There is little understanding of when

or why eastern African mammal communities came to resemble their modern counterparts, particularly in terms of their functional ecology. Not only is this relevant to the evolutionary history of what are today the most species-rich communities on the continent, but changes in the functional structure of mammal communities can have important effects on the composition of plant communities, and in turn on the environments in which hominins lived. Here we document changes in the functional ecology of eastern African ungulate communities using 100+ fossil assemblages spanning the last 7 Ma. We compare body size classes, digestive strategy, and dietary habits to more than 200 modern ungulate communities across Africa, allowing for an evaluation of when the functional structure of fossil communities approached that of their modern counterparts. Functionally non-analog communities are pervasive from 7 Ma to ~ 700 ka, and this is driven to a large extent by a greater number of megaherbivore (>1000kg) and non-ruminant species. Long-term changes in functional structure closely parallel independent proxies for terrestrial environments (soil carbonate $\delta^{13}C$), though distinguishing cause from effect remains an important challenge. These results cast doubt on the extent to which modern African ecosystems can serve as analogs for the past. Rather than emphasizing how ancient ecosystems relate to modern ones, there is exciting potential to better understand the paleoecological context of hominin evolution by shifting the focus to examining how and why the past differed from the present.

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Geometric Morphometric Reassessment of the Omo 323-78-898 Talus with a Large Catarrhine Sample

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The enigmatic hominin talus Omo 323 '76 898 was collected in 1976 by the International Omo Research Expedition from lower Member G (Unit 8, approximately 2.1 Ma, but possibly as old as 2.3 Ma) of the Shungura Formation. Omo 323 '76 898 is not directly associated with cranial material, and at least two hominins are known from Member G—*Paranthropus* aff. *boisei* and early *Homo*. The fragmentary partial cranium Omo 323 '76 896, from the same locality as the talus, is also clearly allocated to *Paranthropus boisei* (Alemseged et al. 2002). The specimen was first described by Deloison (1997) and tentatively allocated to early *Homo*. Gebo and Schwartz (2006) also thought the talus was most likely that of early *Homo*. If this is correct, then Omo 323 '76 898 represents some of the earliest postcrania allocated to *Homo*. We conducted a geometric morphometric analysis of 228 catarrhine tali, nine of which are fossil hominins including the Omo specimen. Using Landmark Editor software, 30 landmark points were collected on each talus covering all articular facets. Generalized Procrustes analysis was performed in Morpheus, which allows for the superimposition of specimens with missing data. We performed a principal components analysis and assessed the shape transformations associated with each component in Morphologika. Results demonstrate clear separation between humans and all other primates. The Omo specimen is large, comparable to modern human tali, and, morphologically, falls within the *Homo* range along with KNM-ER 813, and 1464. The six remaining fossil hominins, including OH8 (*Homo habilis*) fall outside the *H. sapiens* range and within that of all great apes. These findings imply increased pedal diversity in the Early Pleistocene hominin fossil record. This is important as Omo is significantly older than specimens from Olduvai and Koobi Fora, yet is more human-like in both size and shape.

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Alternatives to Neanderthal Hypercarnivory - Experimental Study of the $\delta^{15}N$ Values of Meat during Putrefaction

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Nitrogen isotope ratios are used frequently in paleoanthropology and archaeology as an indicator of dietary composition. When applied to collagen preserved in Neanderthal long bones, results show a highly enriched $\delta^{15}N$ signal across multiple individuals and sites. Traditionally, paleoanthropologists have interpreted this result as demonstrating Neanderthal hypercarnivory, in line with

or even exceeding the $\delta^{15}N$ values of contemporaneous carnivores in the same sites. However, recent work on Neanderthal dental calculus has indicated that the Neanderthal dietary repertoire is much more varied than previously thought, including a number of plant foods. It is difficult to reconcile the $\delta^{15}N$ isotopic results with other dietary indicators without conceding that there must be an alternative explanation for the highly enriched $\delta^{15}N$ signal. This study explores an alternative dietary mechanism from which a $\delta^{15}N$ signal akin to those seen in Neanderthals could result. We hypothesize that the microbial activity involved in both early-stage natural meat decomposition and deliberate putrefaction processes will cause the $\delta^{15}N$ value of the meat to become more enriched. If Neanderthals were to then consume meat that had been subject to these processes, their $\delta^{15}N$ values would also be enriched. A study was designed to test relative $\delta^{15}N$ enrichment in different kinds of meat over the length of both natural decomposition in a controlled setting and deliberate putrefaction. Putrefaction and meat-drying techniques were replicated from ethnographic studies of high-arctic indigenous populations. Samples were analyzed by isotope ratio mass spectrometry (IRMS) at the Smithsonian Institution Museum Conservation Institute, and initial results show step-wise enrichment of $\delta^{15}N$ over time. This result lends support to an alternative mechanism for the observed $\delta^{15}N$ values in Neanderthal collagen.

A Modern Human-Like One Million-Year-Old Partial Pelvis from Buia, Eritrea

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The debate surrounding modern human pelvic morphology has focused on concomitant directional selection for obstetrics and bipedal locomotion, although these factors were undoubtedly shaping pelvic morphology in genus *Homo* well before the earliest modern humans appeared. *Homo erectus sensu lato* (~1.9 Ma–27 ka) is recognized as being the first species having fairly modern human-like postcranial features, proportions, and stature. There are several Pleistocene ossa coxae that are known (KNM-WT 15000, KNM-ER 1808) or assumed to be *Homo erectus* (KNM-ER 3228, BSN49/P27, OH 28). The picture that has emerged from these fossils is that there may have been considerable morphological variation in the pelves of Pleistocene hominins, perhaps even within a single species, but that no Early Pleistocene hominin displays a modern human-like pelvis. Here we analyze 1.07–0.99 million-year-old (Ma) pelvic remains UA 173/405 from Buia, Eritrea. UA 173/405 is likely associated with cranium UA 31, which displays a blend of *Homo erectus*-like features and derived features more commonly found in Middle Pleistocene specimens. We assessed morphology using traditional linear pelvimetrics as well as 3D geometric morphometrics (3DGM) of the ischium, using a broad fossil and extant modern human comparative sample. UA 173/405 is within the range of modern human variation for all metrics examined. Moreover, the 3DGM analyses find the ischium to be the only non-sapiens fossil to fall within modern human shape space, being even more similar to modern humans than are Neandertals (Kebara 2, Neandertal 1). The discovery of UA 173/405 adds to the increasing number of fossils which suggests that the morphology of *Homo erectus sensu lato* was variable and, in some cases, nearly indistinguishable from modern human morphology. This Eritrean fossil demonstrates that a more modern human-like pelvic morphology had origins in the Early Pleistocene, potentially within later African *Homo erectus*.

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Human Adaptive Responses to Abrupt Climate Change during the Late Pleistocene

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During the Upper Pleistocene (MIS 5–2), human populations adapted to abrupt climate changes that created highly variable paleoenvironments across the Iberian Peninsula. Our understanding of human responses to environmental change derives from multi-scale spatio-temporal archaeological, paleoenvironmental, and paleoclimatic records. Artifact assemblages from archaeological palimpsests and high-resolution sites reflect human-environment interactions during this period. Polar ice cores record global scale temperature and sea-level changes on annual time scales for the entire Upper Pleistocene. Deep-sea sediment cores off Iberia record regional and continental scale climate and environmental changes at centennial and millennial time scales. Terrestrial sediment traps, including lakes, bogs, and caves, record local and regional scale records at similar temporal scales. For western Iberia, Lapa do Picareiro, a cave site in central Portugal, provides a diachronic record for MIS 3 and 2 human occupation and environmental change. The cave contains a continuous, 10.5m stratified sequence of minimally-disturbed sediments spanning 60,000 years of the Upper Pleistocene, making it an ideal locale to track long-term changes in paleoenvironments and human ecodynamics. The sedimentary sequence of Picareiro contains Middle and Upper Paleolithic occupations, extremely rich faunal assemblages, and subtle variations in particle size and geochemistry that record changes in the climate, hydrology, and morphology of the cave environment. Age control is provided by over 50 radiocarbon dates. Stratified lithic artifact assemblages fit regional and local patterns of technological change during the Middle and Upper Paleolithic. Taphonomic analyses of the faunal remains inform on local paleoenvironments and human diet choice

during MIS 3 and 2. Sedimentological analyses including magnetic susceptibility link the cave deposits with global scale records of Upper Pleistocene climate from the Greenland ice cores and regional-scale ones from deep-sea cores off Portugal. We use these data to synchronize abrupt climate changes and human ecodynamics during the Upper Pleistocene.

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Tubers in Winter: Implications for Early Hominin Seasonal Migrations

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Early Pleistocene hominins faced with the harsh winter conditions of northern Europe could overwinter in place, or migrate long distances to more amicable habitats. Evidence at sites in coastal England has been interpreted to mean that they stayed in place (Parfitt et al. 2010), but these studies did not fully account for the potential role of plant foods. Plants are vital in that they can stave off protein poisoning (Speth and Spielmann 1983), and can provide essential nutrients like vitamin C, which are limited in animal foods (Hockett 2012). We propose that the underground storage organs (USOs) of biennial or perennial plants would have been a necessary food during winter, because they provided vitamin C and necessary carbohydrates. Our survey of available literature on wild edible plants in mid latitude habitats indicates that USOs are available in the winter months (December-February) when almost no other plant resources are available. Analysis of the starch grains preserved in the USOs of a variety of wild edible plants indicates that many species contain abundant starch, and would therefore have been a valuable source of carbohydrates during the winter. Many of these plants also contain abundant vitamin C. However, most of these tuber-bearing species are cryptic in the winter. The need to locate these carbohydrate and vitamin-rich foods implies that hominins who had spent spring and summer in one area might be better able to survive the winter. However, we cannot rule out the possibility of long-distance migrations, since several important species are easily recognizable year-round. In particular, shallow water or near-water habitats might have been preferred habitats, given their large numbers of visible taxa. This lends support to the proposal that early hominins migrated and lived along coasts and rivers (Cohen et al. 2012).

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Variability among African and Eurasian *Homo erectus* Sites

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Most early hominins were geographically restricted to the continent of Africa, but members of *Homo erectus* were the first to expand their range to new areas across Eurasia. It has been suggested that this was possible as a result of their ability to survive in a variety of different climates and environments; this variability selection hypothesis is based on data that indicate diverse and unstable climates and environments in East Africa prior to the expansion of *H. erectus* out of Africa. This hypothesis is tested and evaluated here by comparing climates, prey composition, prey utilization, and predator composition/competition at nine *H. erectus* sites across Africa and Eurasia. Paleoprecipitation estimates, based on hypsodonty indices for large, herbivorous mammals, show the virtual loss of a wet season at northeastern Asian sites and high degree of variability in precipitation among all sites across annual, driest quarter, and wettest quarter estimates. Prey composition is also found to be variable among sites as there are fewer total potential prey species at Eurasian sites, especially for Bovidae and Suidae. Hominins at African and Eurasian sites are found to have been utilizing prey differently with larger taxa more commonly processed at African sites, and cervids, though absent at African sites, processed at Asian sites. Lastly, predator competition was similarly inconsistent among *H. erectus* sites. Eurasian sites are found to have both more total carnivore species and more large carnivore species. These results, highlighting a high degree of variation in multiple variables at *H. erectus* sites, are consistent with the Variability Selection Hypothesis.

Trinil's Main Bonebed (Java) and *Homo erectus* Paleobiogeography

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Trinil's Main Bonebed (MB; Hauptknochenschicht), the 1891–1892 *Homo erectus* (*H.e.*) discovery context, is still central to understanding hominin paleobiogeography in Sundaland. The MB was mostly well-lithified, volcaniclastic, very poorly sorted sandstone and pebbly

conglomerate of fluvial origin, as remnant outcrops help establish. The stratum produced thousands of well-preserved, disarticulated skeletal bioclasts. Many were greatly oversized relative to lithic components. The taphonomy, lithology and setting indicate accumulation in a lowland river during long-runout-lahar flooding. This followed mass deaths in the drainages of a high-standing, active stratovolcano. Small-sized (*Axis*) deer, large-bodied bovids (*Bibos*; *Bubalus*), *Stegodon*, and the tiny boselaphine *Duboisia* were most abundant as fossils. Crocodylians, turtles, pig, and rhinoceros were common. Other documented MB remains were tiger, muntjac, macaque, porcupine, river-fishes, and -mollusks, and trees and sedges. Trinil specimens of dog, leopard cat, langur, gibbon, lizard, python, rat, and birds are credible additional MB components. Femur I is a reasonably uncontestable MB discovery (as II, III and IV probably are), based on firsthand accounts and site geology. Mussel shells from the MB reveal possible *H.e.* use, but no lithic artifacts or hominin-damaged bones have been identified. The diversity of taxa in the MB is greater than in any other individual *H.e.*-discovery bed. The MB fauna anchors Java's long-lasting *Stegodon-Homo erectus* (land-vertebrate) biostratigraphic sequence (*S.-H.e.*). *H.e.* was secure enough ecologically to withstand the associated Siva-Malayan large-mammal immigrations, endemic faunal developments, and glacioeustatic changes of the Early and Middle Pleistocene. Certain *S.-H.e.* species went extinct, but relatives of others (e.g., MB cervids, large bovids, rhinoceros, pig, primates, tiger, turtles, crocodile, fishes, and mollusks) survived into the Late Pleistocene-Holocene, when they occupied dispersed parts of the region extending from Java to Indochina. These biogeographic patterns support the proposition that *S.-H.e.*-like ecological communities, hominins included, were broadly present across Sundaland in the time of *H.e*.

A Novel Method for Reconstructing Habitual Manual Activity Based on Human Hand Muscle Attachments

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Reconstructing habitual behavior based on human skeletal remains comprises one of the most fundamental objectives of biological anthropology. Entheses, the areas of the bones where muscles attach, have been widely utilized as occupational stress markers (Wilczak et al. 2017). However, the exact effect of activity on entheseal form is not yet clear, while most previous methodologies involved low repeatability, reference samples with inadequate documentation for the individuals' long-term physical activities, and absence of multivariate statistical analysis (Alves Cardoso and Henderson 2012; Milella et al. 2015; Wilczak et al. 2017). A recent research by one of us put forth a new and precise multivariate method for the three-dimensional analysis of human hand entheses, identifying two morphometric patterns among entheses which reflect fundamental synergistic muscle groups (Karakostis and Lorenzo 2016). More recently, we applied this method on a sample with a uniquely extensive documentation regarding the specimens' lifelong occupational activities, medical record, as well as socioeconomic background (Karakostis et al. 2017). Our results revealed a close statistical association between hand entheseal patterns and the nature of habitual manual activity. Particularly, individuals with highly intense manual activities showed a pattern associated with the application of high grip force. At the same time, individuals involved in precise and/or less strenuous manual activities showed an entheseal pattern associated with precision grasping. Based on the sampling strategy as well as the correlation tests of this study, the observed entheseal patterns were not significantly associated with population, sex, biological age, body mass, bone length, entheseal overall size, pathologies, direct relatedness, or socioeconomic characteristics. The method and reference sample used in this work can comprise a unique basis for reconstructing habitual manual activities in the fossil record, enabling a greater understanding of the evolution of human manipulative capabilities.

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Where are All the Neanderthals? An Archaeological and Paleoanthropological Survey of Paleolithic Cave Sites in Britain

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There are only a few known Neanderthal sites in Britain, ranging in age from 230–100kya. Mousterian artifacts are recorded at many more sites, but well-documented and appropriately dated occurrences also are rare. This scarcity of "Neanderthal" sites and fossils raises many questions about the presence, geographic range, and evolution of Middle Paleolithic hominins in Britain. The initial aim of this project was to compile a data base of recorded occurrences of Neanderthal and Mousterian sites using a range of sources including published reports, Sites and Monuments Records, grey literature, university theses, and online archives of public interest groups involved in archaeology and caving. Additionally we have initiated a field survey and mapping project to locate cave and other sites that have potential to document these same periods. This fieldwork has focused on the Limestone Heritage Area of the Magnesian Limestone—a region of limestone geology in the Derbyshire-Nottinghamshire area that includes Creswell Crags and a number of additional limestone vale and gorge localities that have not yet been systematically surveyed for archaeological or paleoanthropological sites. We report on our project to develop a collaboration between academics, commercial archaeologists, and the heritage sector to produce a UK database of Paleolithic cave sites, and to establish criteria to identify and prioritize sites with high potential to produce Mousterian artifacts and/or Neanderthal fossils. Our fieldwork to date has focused on two regions with such potential, and on development of a GIS 'cave landscape model' in the study areas.

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Dietary Ecology of Pliocene Suids and Hominins in Kanapoi and Hadar

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The carbon isotopic data evidences an increase in dietary breadth from the C_3-dominated Kanapoi sample of *Australopithecus anamensis* to the Hadar sample of *Australopithecus afarensis*, which included both C_3 and C_4 resources. On the other hand, dental microwear analysis has found no significant differences in the dietary signal between Kanapoi and Hadar hominins. Although most mammalian species are too specialized to provide an appropriate contrast to the hominin pattern, suids are relatively generalized in their dietary preferences. In fact, the combined analysis of carbon and oxygen stable isotopes in Hadar showed that the suid, *Nyanzachoerus pattersoni* was closest in the dietary niche space to *A. afarensis*. Here we use dental microwear analyses to examine if the dietary differences between the two *Australopithecus* species is mirrored by changes in suid diets. A total of 178 lower third molars were molded, cast, and analyzed using 3D confocal microscopy. The sample includes four extant African suid species (n=50) and four extinct suid species, including *Ny. pattersoni* (n=29), *Ny. jaegeri* (n=4), *Notochoerus euilus* (n=61), and *Kolpochoerus afarensis* (n=34). The mean values of anisotropy in *Ny. jaegeri* (Kanapoi) and *No. euilus* (Hadar) overlap with those of the grazing warthog, suggesting the presence of grasslands at both sites. Hadar is marked by high values of complexity associated with *Ko. afarensis*, indicating hard-object consumption as in modern bush pigs. The lower values of complexity of suids at Kanapoi are mainly due to the absence of *Kolpochoerus*, opening the possibility that the main foods consumed by this suid were not present at this site. As in hominins, the microwear of *Ny. pattersoni* is very similar between Hadar and Kanapoi, suggesting that this suid may be a good analog in terms of dietary adaptations to early hominins.

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Differences in Bilateral Asymmetry of the Femur Between Recent and Archaeological Human Populations Using Multivariate Measures

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Levels of asymmetry in human limbs vary between populations, indicating differences in division of labor, nutrition, or activity patterns. Recent studies suggest that asymmetry levels decrease in temporally recent populations as opposed to older populations. However, previous studies comparing archeological and recent populations have included specific and possibly biased samples, such as samples from athletes or small, isolated groups. No study yet has evaluated larger samples with wider representations of recent humans, which is necessary to gain a broader understanding of these relationships. Furthermore, past studies have relied solely on univariate measures. Multivariate statistics have the potential to capture information about the shape of the bone, offering a more comprehensive evaluation of bilateral asymmetry. Livshits and Smouse (1993) showed how the difference between linear measurements on both sides of the body can be used in studies of multivariate asymmetry. These measures have yet to be applied to an analysis of this nature. This study explores the difference in femoral asymmetry between a recent and archaeological sample using multivariate measures. The

data used here are from the Forensic Data Bank (n=660) and the Goldman Osteometric Data Set (n=1,248) with three measurements on both femora. Mahalanobis distances between the vectors of differences were used to compare the two samples. The F-test between the two samples' centroids for right minus left measurements was significant (p=0.00301), indicating that the samples have dissimilar directional asymmetry. These results have implications for interpreting societal and biological differences in populations over time.

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Women in Human Evolution Redux

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For decades, gender and feminist critiques have influenced anthropology, especially cultural anthropology, archaeology, and bioarchaeology, from framing questions to interpretation of results. Twenty years after the influential anthology Women in Human Evolution (1997), edited by Lori D. Hager, biological anthropology, and paleoanthropology in particular, lags behind other subfields of anthropology in terms of efforts to incorporate feminist perspectives. What may explain the resistance against gender and feminist perspectives in biological anthropology is the predominant positioning of the field around the traditional concept of scientific process as somehow outside the realm of social issues. Scientific process, however, is undertaken by scientists who belong to a dynamic sociocultural system. Human evolution research utilizes models, and models are based on our knowledge and experience. Our knowledge and experience, in turn, is shaped and informed by the larger sociocultural community that we belong to. Therefore, the feminist-turn in the sciences obligates us to reconsider the assumptions and biases that scientists have held implicitly and explicitly about gender in human evolution. Questioning the biases that have informed our evolutionary framework is an important step toward a new paleoanthropology of the 21st century. New perspectives and data will help us gain a fuller and richer understanding of ourselves. In this paper, we explore the state of affairs in paleoanthropology as a field. In particular, we examine the biases in the questions asked, body of evidence accepted as valid, and the interpretation of the results.

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Termite-Associated Hydrocarbons and the Detection of C_4 Resources within the *Zinjanthropus* Horizon at Oludvai Gorge, Tanzania

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Termites are an important food resource for a number of living mammalian clades, including primates. Among the termites regularly consumed by some populations of chimpanzees and humans are those of the genus *Macrotermes*. Explanations for termite consumption by extant hominoids focus on termites' nutritional value, and dietary reconstructions suggest that these insects would have offered similar nutritional benefits to extinct hominins. Evidence of mound-building termites in association with hominin occupied landscapes has been limited to a preserved nest at Laeotoli, Tanzania, that is architecturally similar to *Macrotermes* today. Here we report the presence of termite mound-like deposits at the iconic FLK *Zinjanthropus* archaeological (Level 22) horizon at Olduavi Gorge, dated to about 1.785 million years ago, as well as the results of focused biomarker and isotopic analyses of hydrocarbons extracted from this feature compared to extant termites and recent termitaria. Biomarker analyses of termite soldiers and termite workers in dominant East African species of *Macrotermes* show indistinguishable intraspecific saturated hydrocarbon distribution patterns dominated by odd, longer chain-length homologues (n-C21 to n-C27). In contrast, there are consistent interspecific differences in relative saturated hydrocarbon abundances. Observed biomarker distributions of termite soldiers/workers also are apparent in associated termitarium sediments, and distinctive as compared to surrounding plant tissues or soil. With this in mind, *in situ* termite mound-like sediment features uncovered from around FLK *Zinj* show near-identical hydrocarbon distributions vis-à-vis edible extant *Macrotermes* species. Stable carbon isotopic analyses of termite-associated hydrocarbons extracted from inferred termitaria at Olduvai Gorge show increased $\delta^{13}C$ values as compare to surrounding plants, which—based on associated $\delta^{13}C$ values of hominin molars at FLK *Zinj*—is consistent with the incorporation of C_4 plant-like invertebrate resources in our ancestors' diets.

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An Ecomorphological Analysis of the Metacarpal of Extant African Antelopes Using Photogrammetry

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Ecomorphological analyses explore the interactions between specific anatomical features of organisms and their ecology. Fossil antelopes (Mammalia: Bovidae) are commonly used for ecomorphological analyses as they dominate faunas at numerous African Pliocene and Pleistocene paleoanthropological sites. Traditional ecomorphological analyses using linear measurements have provided good results in reconstructing past habitats available to our hominin ancestors. Recent improvements in digital imaging techniques have dramatically reduced the costs and time constraints associated with three-dimensional methods, positioning them as attractive and reliable alternatives to traditional ecomorphological approaches. Photogrammetry has recently gained much attention as an inexpensive and fast method to generate three-dimensional models of bones from which shape data can be extracted. In this analysis, we used photogrammetry to generate three-dimensional models of the metacarpals of 33 extant African antelope species of known habitat affinities. We collected three-dimensional shape data from these photogrammetric models and performed DFA to estimate the percentage of specimens which were correctly classified to their known habitat category. We further compared the performance of the three-dimensional shape data and linear data collected with calipers. Our results indicate that the three-dimensional data obtained from photogrammetric models are excellent alternatives that outperform traditional linear measurements for ecomorphological analyses of the metacarpal. Similar to other 3D GM approaches, photogrammetry facilitates examination of the articular topography of the bovid metacarpal that is not possible using traditional caliper measurements. Photogrammetry and laser scanning have the advantage of providing a shape archive of bones that can be easily retrieved for future analyses. Photogrammetric models also reduce costs and time constraints compared to conventional laser scanning techniques. Photogrammetric models allow robust ecomorphological analyses even when fossil remains are fragmentary, as is common in African Pliocene and Pleistocene paleoanthropological sites, increasing sample sizes available for analysis and improving the accuracy of environmental reconstructions.

Multivariate Analyses of Lithic Variability in the MSA of Kenya and Ethiopia Prior to 100 ka

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Behavioral variability during the Middle Stone Age (MSA) provides an important framework for research on *Homo sapiens* origins and their interactions with contemporary Pleistocene hominins. As many of the earliest MSA assemblages are found in East Africa, this is a focal region for investigating precocious technological behaviors in the middle-to-later Pleistocene. Yet despite a long history of research, the regional pattern of technological variability in the East African MSA remains poorly understood. Identifying underlying technological structures is an essential first step before exploring the role of lithic variability in modern human origins. This presentation reports the results of an attribute-based multivariate analysis of lithic flakes from six MSA assemblages, older than 100 ka, from Kenya and Ethiopia. Flakes are suitable for exploring diversity in knapping behaviors as they are the most numerous constituent of lithic assemblages and preserve observable traces of different flaking techniques, technologies, and behaviors. This study uses principal component analysis and multiple correspondence analysis to identify the main components (attribute clusters) shaping variability in early East African MSA flakes. These analyses show that the exploitation of dorsal convexities, scar numbers and directions, and flake size all contributed to MSA lithic variability. The technological clusters identified in the multivariate analyses were then explored for relationships with raw material constraints, reduction intensity, and site contexts. Intra-site variability contributes to overall lithic diversity, but both the pattern of inter-site differences and relationships with drivers of lithic behaviors vary across technological clusters. This study has resulted in a structured and nuanced model of early East African MSA flaking behaviors that supports multi-causal explanations of lithic variability. It also illustrates the potential of attribute analyses, which go beyond presence/absence comparisons of lithic types, for testing technological patterning in the MSA and emerging behavioral flexibility.

Reassessing the Ursid Hypothesis for the Laetoli "A" Bipedal Trackway

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The 3.66 Ma Laetoli "G" bipedal trackway represent one of the most famous paleoanthropological discoveries. These prints, made by at least three individuals, unequivocally demonstrate the antiquity of upright walking and are attributed by most to *Australopithecus afarensis*. While the prints from Footprint Site G have received the most scholarly attention, a mysterious set of four bipedal prints from Laetoli Footprint Site A were discovered first. These prints were originally classified as hominin, but it was later hypothesized that they may have been produced by an ursid. Here, we used photogrammetry to digitally recover the now eroded Laetoli "A" trackway and retest the ursid hypothesis. We collected bipedal footprints (n=47) from four juvenile semi-wild American black bears (*Ursus americanus*) walking through deformable mud to produce tracks similar in depth to the Laetoli "A" sample. These data were compared against footprints (n=45) made by bipedally walking chimpanzees, and the "G" and "A" Laetoli prints. Relative step length and ball width of the Laetoli "A" prints were similar to those produced by bipedally walking bears and chimpanzees. However, Laetoli "A" possessed a relatively wider heel, similar to that found in the Laetoli "G" hominins (and in modern human tracks). Perhaps more importantly, the stride width of Laetoli "A" is far narrower than that observed during chimpanzee or bear bipedalism. We regard this as potential evidence that the maker of the Laetoli "A" prints possessed a lateral pelvic stabilizing mechanism and/or a valgus knee—key, early adaptations for hominin bipedalism. Given the growing fossil evidence for taxonomic and locomotor diversity in Pliocene hominins and the continued absence of ursid fossils at Laetoli, we suggest that the Laetoli "A" trackway, while somewhat different from the "G" trackway, is more likely hominin than ursid.

U-Series Dating Calcrete: A New Paleo-Hydrological Tracer for Middle Stone Age Archaeological Sites in the Northern Cape, South Africa

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Calcrete, in the form of soil and ground water carbonates, is a ubiquitous feature on the landscape in South Africa and often associated with archaeological sites. This study is focused both on the new site of Gamohana Hill, in the Northern Cape of South Africa, where excavations at a stratified rockshelter are providing a detailed Middle Stone Age record, and a regional survey of archaeological occurrences and carbonate formations. This project is in its early phases, but a variety of carbonate material has already been recovered, ranging from tufa on the sides of the rockshelter, to stalagmite-like mounds along the drip lines, and brecciated, calcreterized slope terraces with stone tools preserved in rare instances. These terraces consist of lenses of what appears to be ground water calcrete following paleo-drainage channels down the talus slope away from the rockshelter. Careful and detailed micromorphological work on the textures of these various carbonates will help to determine their origins. U-series dating, in particular U-Th dating, has already yielded preliminary ages of ~40 ka for the terraces and will ultimately be used to date as much of the calcrete as possible to produce a detailed landscape-scale picture of the past hydrological balance and effective precipitation. A deeper understanding of how this calcrete forms and the paleohydrological conditions it represents will be a huge contribution to understanding the expression of Quaternary climate variation in South Africa and will inform on the behavioral adaptation of hominins in this southern Kalahari Basin region during the Pleistocene.

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Size Doesn't Matter: OES Bead Diameter in the Stone Age of Eastern and Southern Africa

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Ostrich eggshell (OES) beads are commonly found yet chronically understudied artifacts from Later Stone Age (LSA) sites in sub-Saharan Africa. The most commonly recorded characteristic of these artifacts is external diameter. Much of the discussion surrounding

bead diameter pertains to whether it changes throughout time, and if this can be used to distinguish older and younger archaeological occupations. Jacobson first proposed a link between average bead diameter and age in the 1980s, suggesting that older beads tended to be smaller than younger ones based on his observations at early herding sites in Namibia. He described the change as a reduction in the variability of diameters in older levels; younger deposits had a wide range of bead sizes, older beads had a more limited size range. Subsequent work found diameter shifts present at numerous sites from 3000–100 BP in South Africa. Although this proposed size change is not well understood nor has it been widely tested, it is often informally applied to estimate the age of archaeological deposits during fieldwork. This study tests the hypotheses that bead size increases through time and that younger beads are more variable by comparing bead diameters across large temporal and geographic ranges within eastern and southern Africa. Combining new data with published bead diameters reveals two major findings. First, average bead diameter actually increases towards the beginning of the LSA, i.e., beads from 30,000 years ago are larger, on average, than beads from 5,000 years ago. Second, the data reveal regionally distinct trajectories of bead diameter change. This includes both intra-regional site differences as well as larger distinctions between eastern and southern Africa. With little evidence that bead diameter universally increases through time (undermining the use of OES beads as a relative dating measure), geographic variability and distinctions may contribute to other discourses such as exchange networks or population movements in the LSA.

Investigating Raw Material Properties: Interaction between Knapper Skill and Rock Mechanical Properties

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Previous studies on experimental knapping have provided some insights on determining the qualities of stone. However, given the variability in rock properties it is sometimes difficult to relate these to archaeological materials. Visual inspection of rocks has often been used to identify key features related to stone knapping ability. These visual inspections are usually related to the size and variation of crystals, especially in igneous rocks. This is particularly evident in igneous rocks that make up the majority of Earlier Stone Age assemblages in East Africa. Visual properties of stones that are relevant to artifact manufacture can be quantified using image analysis (ImageJ 4.x). We investigated the relationship between mechanical properties of specific raw materials (as measured by Leeb hardness and Young's elastic modulus) and visual features related to the size, shape and frequency of phenocrysts in a variety of igneous rock types. Sixty-six sections of six lithologies used by hominins at the ca. 2 million year old Oldowan site of Kanjera South (western Kenya) were prepared and 1,986 images (40–150x magnification) of these sections were analyzed with Image J 4.x to document phenocryst size and frequency. Results indicate that these visual properties covary more strongly with raw material elasticity than hardness. To further test these relationships 30 cobbles with known elasticity values were knapped by individuals with varying skill levels, to investigate the impact of elasticity on various archaeologically visible measures. Expert knappers produced larger and thinner flakes with higher frequencies of feather termination using raw materials having higher elasticity values. Intermediate and novice knappers can make large flakes with low quality raw materials but see little improvement with more elastic lithologies. These experiments suggest that the impact of raw material quality on archaeological assemblages is interrelated with knapper skill.

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A New Reconstruction of the Forearm of A.L. 288-1 ("Lucy") and Functional Interpretations

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A long running debate in human evolution concerns the degree to which early hominins combined arboreal behaviors with terrestrial bipedalism. The argument in favor of obligate terrestrial bipedalism considers the arboreal-linked traits (e.g., curved phalanges) to be retained primitive features inherited from an arboreal ancestor that had no adaptive value in the descendant, whereas the opposing argument holds that these traits were adaptations for arboreal locomotion. A new approach by Ruff et al. (2016) examined long bone cross-sectional geometry, a feature that responds dynamically to loading during the life, and showed that Lucy is intermediate between humans and chimpanzees in having high humeral strength, most likely produced by frequent climbing. If Lucy climbed by using her arms to pull herself up, forearm traits for climbing should be shared with chimpanzees. Lucy preserves partial ulnae and radii. We used high-resolution X-ray CT scans of Lucy for the reconstruction by mirroring right and left portions, and using 3D cross-sections of humans, chimpanzees, and australopiths to construct and evaluate scaled models. Lucy's ulna is more similar to chimpanzees in

being anteroposteriorly curved and laterally bowed proximally, and straight distally; and differs from humans in lacking a concave, deeply furrowed and sharply keeled interosseous margin, and a triangular shaft cross-section. Lucy's radius more closely resembles the chimpanzee and again differs from humans in lacking a sharply keeled interosseous margin. Unlike earlier studies that quantify curvature in 2D only, we apply measures of tortuosity to evaluate curvature in 3D. In chimpanzees, these traits combine to produce a stable pronated forearm for knuckle-walking, and powerful pronation and supination when climbing; since Lucy was not a knuckle-walker, it appears that these traits facilitated powerful pronation and supination, behaviors that align with her high humeral strength and together underscore the importance of climbing in her species.

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Vegetation Structure Study in Gorongosa National Park, Implications for Hominin Ecospace

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Understanding paleoenvironmental conditions that prevailed in the Pliocene and the Pleistocene and how these environments changed through time is crucial to infer how these changes affected the course of human evolution. However, most paleoenvironmental reconstructions from this time period indicate a mosaic environment (i.e., a variety of different types of habitats). Therefore, to be able to make more refined reconstructions of the habitat occupied by early hominins, a more detailed understanding of mosaic environments in undisturbed modern ecosystems, at a high spatial resolution, using proxies that can be preserved in the fossil record is crucial. Here we report on a preliminary study from one such site in Gorongosa National Park in Mozambique, located at the southern extreme of the East African Rift System. Surface soil samples were collected from different habitat types (i.e., woodlands, shrublands, wooded grasslands, and grasslands) and hemispherical photographs were taken at each sampling site to help quantify the associated woody cover. The phytolith composition of samples collected from the grasslands indicates a high proportion of bilobate and bulliform morphotypes with a calculated tree cover index (D/p ratio) of 0.2. Samples collected from sedge wetlands with a D/p ratio of 0.5 show a higher proportion of bilobates, with bulliforms being less abundant. Samples from the woodlands and shrublands have a relatively low phytolith yield which was dominated by blocky and elongate morphotypes, and very few globular granulate phytoliths. Some discrepancy between phytolith assemblages and observed tree cover is expected from previous works. However, in combination with results from similar ongoing studies from other sites, a calibration model will be developed to quantify tree cover by combining phytolith assemblages and carbon isotopic data along with woody cover estimations from aerial and hemispherical photographs. This approach is likely to improve habitat reconstructions from paleosols.

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A Newly (Re)discovered Paleoamerican Cranium from Catlow Cave, Southeastern Oregon

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Paleoindian skeletal remains (>8000 BP) are rare in North America and determining their population affinities can be difficult. In 1935 and 1937, a team led by Luther Cressman excavated the scattered skeletal remains of an aged adult female—dubbed Catlow 1—from Late Pleistocene beach gravels in the back of Catlow Cave (Cressman et al. 1940, 1942). These gravels, deposited during a late Pleistocene highstand of pluvial Lake Catlow, lay stratigraphically below cultural levels in other areas of the cave that produced Fort Rock style sandals dated to ~9400 cal BP (Connolly et al. 2016). All the known Catlow 1 skeletal remains (including some cranial fragments) were repatriated by the BLM under NAGPRA in 1998. However, the vast majority of the fragmented skull was recently rediscovered among materials stored after the closure of the UCLA radiocarbon laboratory. Although it was previously reconstructed (by Hrdlička) and is missing the basicranium, the fragmented bones of the cranium are in relatively good condition though in need of further reconstruction. Therefore, we manually and digitally reconstructed the skull, with the goal of determining its morphological affinities and approximate temporal placement. Portions of the face are too fragmentary to reconstruct *in vivo* but were scanned and

digitally added to the skull. Principal components and discriminant analyses on raw and size-standardized measurements consistently group Catlow 1 with other Paleoamerican crania, distinct from archaic and modern groups. When combined with the stratigraphic position of the cranium and the presence of Early Holocene artifacts in overlying strata, our results suggest that Catlow 1 may be another rare example of a late Pleistocene human skeleton from North America.

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Early Aurignacian Coloring Materials in Evolutionary Context

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Coloring materials, commonly referred to as ochre, are rocks, powders, and clays with sufficient concentrations of manganese or iron oxides to leave a characteristic streak (Bernatchez 2008; Watts 2002). These strikingly colored materials are a ubiquitous medium of human symbolic expression in both the ethnographic and archaeological record, with exploitation in the latter spanning at least three hominin species (including Neandertals and modern humans) and over 100,000 years. Consequently, these minerals are key elements of heavily debated models of the Mid-to-Late Pleistocene development of "fully symbolic sapiens behavior" (Henshilwood and Marean 2003). Research in the last 20 years has radically advanced our picture of this period and the innovations to which it gave rise, particularly the role coloring material exploitation played in Middle Stone Age (MSA) and Neandertal societies. Models built on comparisons of only these two datasets, however, neglect a crucial control sample, the modern humans that successfully colonized Eurasia. Addressing this gap, this paper details recently reconstructed operational chains for coloring material exploitation at four Early Aurignacian sites in France's Vézère Valley. Combining use-wear, digital colorimetry, and geochemical analyses, this study goes beyond simplistic presence/absence checklists to address the specific behaviors associated with coloring material collections. These findings are then compared to currently available data on Neandertal and MSA coloring materials to test, keeping expressive medium constant, the hypothesized equivalency in symbolic behaviors across cultural and biological categories.

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Early Pleistocene Grassland Dynamics at East Turkana: Indications from Shifting Patterns of Mesic- and Xeric-Adapted Ungulates and New Insights into Ungulate Niche Preference

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Fossil sediments of the Upper Burgi (1.98–1.87 Ma), KBS (1.87–1.54 Ma), and Okote (1.54–1.38 Ma) Members of the Koobi Fora Formation in northern Kenya have yielded extensive evidence for the evolution of *Paranthropus* and *Homo*. However, the complex dynamics of the ecosystems inhabited by these hominins remain somewhat unclear. To investigate paleolandscape dynamics at East Turkana during this period, we examine the spatial and temporal heterogeneity in the relative proportions of xeric- and mesic-adapted grazing ungulate taxa from a total sample size of nearly 5,000 specimens. We find that the Karari subregion at East Turkana experienced significant faunal turnover during this period, primarily between the Upper Burgi and KBS Members. This turnover may be the result of aridification during the regression of Lake Lorenyang, as the dominant mesic-adapted taxa, such as the bovid tribe Reduncini, were

replaced with xeric-adapted taxa including Alcelaphini, *Equus*, and *Metridiochoerus*. Finally, we find that the suid genus *Kolpochoerus* tracks the abundance pattern of Reduncini, supporting existing assertions that these suids were mesic-adapted in the Turkana basin. Similar patterns are evident in the relative abundance of the equid genus *Eurygnathohippus*. Correspondence analyses of abundance indicate a covariation in the presence of these taxa as graphically represented through multivariate ordination. The Karari subregion has the highest frequency of known archaeological localities, suggesting hominins discarded stone tools in these xeric habitats. Further analyses are needed to understand the relationship between habitat heterogeneity, hominin behavior, and sources of stone to make tools.

Quantitative Analysis of the Micromorphology of Trampling-Induced Abrasion and Stone Tool Cut Marks on Bone Surfaces

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Bone surface modifications are a primary indicator of the processes that contribute to site formation and are essential to reconstructing the paleoecological contexts of archaeological sites. Despite the significance of bone surface modification, the reliability of inferences based on these traces is hindered by equifinalities in mark morphology between actors. In particular, trampling-induced abrasion has been shown to resemble stone tool cut marks, leading to on-going debates concerning claims of hominin activity in fossil assemblages, as seen with the Dikika specimens from Ethiopia. Previous research has relied on examination of qualitative features of mark morphology using 2-D microscopic analysis to distinguish agents. Yet, these studies have yielded inconclusive results due to methodology that is difficult to replicate and vulnerable to subjectivity. This study uses high-resolution 3-D laser scanning to distinguish between individual trample and cut marks and provides a new understanding of the quantitative differences between these superficially similar bone surface modifications. Trampling marks were induced by cows and heifers repeatedly stepping on defleshed and demarrowed limb bone midshaft fragments. Cut marks were collected by slicing defleshed and demarrowed bones with stone flakes and bifaces of various raw materials. Bones were cleaned of debris and scanned using a Nanovea white-light confocal profilometer to collect 3-D data from surface modifications. Multivariate statistics were used to quantitatively discriminate between trample and cut marks based on measurements collected from both the 3-D models and cross-sectional profiles. Our results indicate that trampling and stone tool cut marks can be distinguished with over 90% accuracy using this methodology, suggesting the refined analyses offered by implementing high-resolution 3-D technology can break the perceived equifinality between these bone surface modifications. Application of this method to the fossil record has the potential to resolve debates about the origins of bone surface modifications.

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GUImorph: A User-Friendly R Package With a Graphical User Interface to Digitize and Conduct Geometric Morphometric Analyses of 2D and 3D Landmark, Curve and Surface Data

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Analysis of shape and size of fossilized hominin anatomical structures and archaeological artifacts is a common practice in paleoanthropological research. Landmark-based Geometric Morphometrics (GM) is a prominent approach used to quantify shape variation and its covariation with other variables. Current theoretical and methodological approaches allow not only the GM analyses of traditional 2D and 3D landmarks, but also of important 3D curves and surface configurations representing anatomical and archaeological structures of interest. Moreover, recent 3D scanning and photogrammetry technology now make high quality 3D point, curve, and surface data easily available. Despite these advances, many paleoanthropological studies that use 3D GM methods only evaluate hypotheses about landmark configurations, leaving out crucial shape information derived from 3D surfaces and curves. This may occur because most user-friendly morphometric software are designed to conduct only GM analyses of 2D landmarks, sliding semilandmarks and 3D landmarks, ignoring 3D surfaces and curves. Here I present GUImorph, the first user-friendly R package featuring a Graphical User Interface (GUI) to 1) digitize 2D landmarks and sliding semilandmarks, as well as 3D landmarks and sliding curve and surface semilandmarks; and, 2) conduct 2D and 3D GM analyses on landmarks and sliding curve and surface semilandmarks. GUImorph is easy to use and provides needed tools for paleoanthropologists interested in quantifying the complete shape variation of objects, and in evaluating hypotheses regarding shape co-variation with other variables of interest.

Differentiating between Cutting Actions on Bone Using Geometric Morphometric and Bayesian Analysis of Complete 3D Cut Mark Surfaces

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Cut marks and other bone surface modifications (BSM) on archaeological faunal assemblages provide critical evidence about human evolution and hominin subsistence behavior. However, aspects of BSM identification and classification are contentious. There is little consensus regarding the most accurate methods to identify human-made BSM, and how to differentiate them from marks created by other taphonomic agents. This has been particularly problematic when identifying the earliest instances of hominin butchery. Most BSM studies rely on morphological characteristics to identify butchery marks and understand their patterning. This approach extends to the analysis of cut marks, one of the most evolutionarily significant human-made BSM. To discriminate cut marks from other types of marks, researchers use techniques ranging from naked-eye, qualitative assessments of cut mark morphology, to scanning electron microscopy, micro-photogrammetry, and 3D scanning. Recent studies have employed 3D scanning technologies that generate detailed morphological information to interpret marks found in the fossil record. Although 3D methods open promising new avenues for investigation, most studies rely on cross-sectional slices of 3D scans as proxies for overall BSM shape. Such analyses, unfortunately, fail to take advantage of complete 3D surface morphology. Here, we demonstrate that geometric morphometric analyses of complete 3D BSM surfaces, in conjunction with Bayesian statistics, can discriminate with 88% success between marks created by different butchery behaviors. Our results help strengthen statistical confidence in cut mark identification and offer a novel method to distinguish subtle differences between cut marks in the fossil record. This study provides a nascent digital library from which to make quantitative comparisons to archaeological examples, particularly controversial specimens that are key to understanding the earliest date of hominin butchery.

The Past, Present, and Future of Bone Surface Modification Research

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The increasing reliance of our ancestors on animal source foods is often linked to the evolution of the genus *Homo* and the characteristics that define the lineage, such as more human-like body proportions and increasing brain size. The best method for investigating the timing and significance of hominin carnivory continues to be the study of traces found on fossils that were left by the feeding of both hominins and the carnivores with which they were competing. However, there is a long history of debate between researchers concerning the identification of feeding traces on fossils, which has resulted in a reassessment of traditional taphonomic methods that were, until recently, limited to low-power microscopic observation of qualitative criteria. In 2016, we demonstrated the potential of a new quantitative method of bone surface modification identification using measurements collected from high-resolution 3-D models of these traces. While several new methods of taphonomic investigation have since been proposed, ours remains the only technique that is completely objective and shown to be replicable between researchers. Here, we report on the two years of progress since our introduction of this method and describe a robust actualistic database that allows for high-confidence identification of bone surface modifications. 3-D data were collected from more than 500 modern bone surface modifications created in controlled settings including cut marks, percussion marks, mammalian carnivore tooth marks, crocodile tooth marks, and trample marks. 3-D models were created using a Nanovea white-light confocal profilometer and were measured for volume, maximum depth, average depth, length, width, and surface roughness of the mark. Quadratic discriminant analysis that employs Bayes' theorem to estimate posterior class probabilities allows distinction between these commonly seen bone surface modifications with high-confidence. These newly improved statistical models are applied to bone surface modifications on fossils specimens from Olduvai Gorge, Tanzania.

Drone Mapping of Isimila, Tanzania: The Implications for Future Research into Mid-Pleistocene *Homo* Behavior

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Located in the southern highlands of Tanzania, the Middle Pleistocene site of Isimila contains one of the most abundant Acheulean stone assemblages in Africa, if not the world. Although the extensive riverine erosional beds are littered with innumerable artifacts which include hand-axes, hammerstones, and flaked tools, few faunal remains have been discovered. The sheer density of artifacts, exceeding that of Olorgesaille in Kenya, has made it difficult to ascertain the behavioral patterns and site formation processes that led to their accumulation. Dated at ~260 ka, Isimila represents an important juncture in the evolution of the genus *Homo* and the emergence of our species; therefore, understanding Isimila as a product of Mid-Pleistocene *Homo* behavior remains crucial. To the best of our knowledge, there have not been any extensive excavation projects conducted at the site in decades; instead smaller excavations have taken place. Recent advances in technology have allowed for fresh approaches to survey of large sites such as Isimila, allowing for greater ease when establishing large-scale research questions. Through the use of a remote-controlled aerial drone and photogrammetry, a high-resolution map of the entire Isimila Korongo system was created. This includes a southern section that does not appear on earlier maps, where *in situ* stone tools were discovered during pedestrian survey. This map allows for an absolute visualization of stone tool deposits, aids in determining future excavation locations and identifies outlier deposits. The map presented here serves as an important tool in determining the roles of natural processes versus *Homo* behavior, determines possible usage patterns of the site, examines the distribution of artifacts, and enables future large-scale excavation at Isimila.

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Frequency and Duration of U-Pb Dated Flowstone Growth Intervals in South African Early Hominin Caves Reflect Early Pleistocene Climate Variability

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The Cradle of Humankind (CoH) in South Africa is home to a rich collection of early human (hominin) fossils, preserved in dolomite caves. Flowstones, horizontally bedded layers of calcium carbonate, are ubiquitous features at all the sites. The flowstones serve the dual purpose of providing ages for the fossilferous sediments sandwiched between them (via uranium-lead dating) and as indicators of past climate regimes by their presence alone, being associated with increased effective precipitation. Massive flowstones of several meters thick are not uncommon and hint at prolonged periods of significantly increased precipitation. Uranium-lead (U-Pb) dating of cave carbonates has reached a level of maturity where it can be applied with ease and precision. Flowstones from eight caves across the CoH has produced a total of twenty eight U-Pb ages. To solve the problem of necessarily large uncertainties on individual ages, a kernel density estimate is used to sum together the U-Pb age data into a single record of flowstone growth intervals (FGIs). This record spans from 3.2–1.3 Ma with four major FGIs identified, with flowstone forming in at least two caves during the same time interval. These intervals are interpreted as major wet phases, during which caves were most likely sealed closed and not receiving sediments/bones from outside, allowing for massive flowstone development. The interceding times are interpreted as drier phases, during which the fossiliferous sediments accumulated in the caves. These new data suggest that these fossil bearing deposits carry an inherent 'dry phase' bias, implying that the South African hominin and faunal record is only sampling these drier intervals, and that large periods of time (during wetter phases) are under represented, if not completely missing, from the fossil record.

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Testing the Hypothesis of Multiple Genera in *Proconsul*

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Proconsul from the early Miocene (17–23 Ma) in Kenya and Uganda occupies a key position in our understanding of human, ape, and monkey evolution. Possessing a mosaic of primitive and derived morphological characters, *Proconsul* has inconsistently been regarded as stem taxon in catarrhine, hominoid, and hominid phylogeny. The taxonomy of *Proconsul* has similarly been subject to multiple interpretations, with debates centering on issues of sexual dimorphism, single or multiple species, or multiple genera represented in the fossil material. The purpose of this paper is to test the hypothesis that variation in canine dimensions in *Proconsul* is greater than

can be encountered in a single genus of present-day *Pan*, *Gorilla*, *Pongo*, or *Hylobate*s. Length, breadth, and height dimensions of upper and lower canines of 24 *Proconsul* specimens combined from all fossil localities were compared with similar measurements in samples of 342 *Pan*, 357 *Gorilla*, 173 *Pongo*, and 356 *Hylobates*. Samples of 24 were drawn randomly in 1000 repetitions from the extant hominoid samples. The coefficient of variation (CV) was used to compare the fossil and extant ranges of variation. For most canine dimensions the CV in *Proconsul* was within the range generated in *Pan*, *Gorilla*, and *Pongo*, but with less than 0.05 probability of occurrence. The height of the canines, however, had higher than 0.05 probability of falling within the range of CV for the extant hominoids. Except for the height of the upper canine, the CV for *Proconsul* canine dimensions was higher than the range of CV for *Hylobates*. Based on size variation in the most dimorphic tooth in the dentition, this study finds some support for more than one genus represented within the fossil sample for *Proconsul*. The study highlights the differences in patterns of variation between *Proconsul* and modern hominoids.

Identification of Possible Cut Marks on an Early Pleistocene Hominin Tibia from Turkana, Kenya

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Butchery marks left by hominins on fauna beginning by at least the early Pleistocene point to increasing meat and marrow acquisition during the evolution of the genus *Homo*, but identification of butchery marks on hominin fossils from this time period is rare. A recent taphonomic investigation by Pobiner of published hominin fossils from the Turkana region of Kenya dated to ~1.8–1.5 Ma revealed possible cut marks on KNM-ER 741, a proximal shaft of a left tibia found by Mary Leakey in 1970 in the Okote Member of the Koobi Fora Formation. Originally identified as *Australopithecus boisei*, it was subsequently revised to *Homo erectus* and is now sometimes labeled *Homo* sp. Molds of the marks were taken with dental molding material and sent to M. Pante for analysis without any contextual information. Several impressions that were preserved in the molds were scanned with a Nanovea white-light confocal profilometer and the resulting 3-D model was measured and compared with an actualistic database of over 500 individual tooth, butchery, and trample marks created through controlled experiments. Results show multiple cut marks that are consistent with those produced experimentally by both bifaces and flakes, and tooth marks that are most similar to those made by modern lions. There are also several abrasive marks that may have been induced by trampling. While hundreds of cut marked fossils of other animals have been identified from the Okote Member of the Koobi Fora Formation, these are (to our knowledge) the first possible cut marks identified on an early Pleistocene hominin fossil from Kenya.

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A Single-Event Middle Stone Age Occupation Site in the Lowlands of Northwestern Ethiopia

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Investigations of late MSA sites in the Horn of Africa can offer important insights into the behaviors of modern humans around the time when our species left the continent to populate the rest of the world. The majority of both cave and open air sites consist of stratified sediments that, depending upon post-depositional processes, are often time-averaged, thus potentially obscuring evidence of discrete activities. We here describe SM66, an MSA site that appears to represent a single-event open air occupation surface. Limited testing in 2015 was followed in 2016 by an ~10m^2 controlled excavation. SM66 occurs on the upper surface of an overbank flood deposit, and all mapped items were found encased within the uppermost 1–2cm of this finely-bedded siltstone unit. Although the bone was highly deteriorated, most fragments appear to be from large mammals only, a finding in contrast to the much higher faunal diversity seen at other nearby MSA sites. Of note are three discrete, perhaps near-synchronous activity loci concentrated around probable anvil stones, each with very different associated debris. Materials adjacent to the first anvil are predominately cryptocrystalline quartz, most of which seems to have originated from a single nodule or identical source. Chipped stone also predominates near the second anvil but is primarily basalt. The third anvil has far less chipped stone and instead is surrounded by the highest density of bone. We suggest that three or more task-focused activity types are represented—three basalt blocks were transported nearly 2km to the site for use as anvils; two discrete knapping episodes occurred, each using different raw materials; and faunal remains were processed. SM66 appears to preserve evidence for coordinated behavior in the MSA. The occupation surface continues into overlying terrace deposits and will be the focus of future excavations.

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High-Resolution Environmental Record of the Acheulean-to-Middle Stone Age Transition in the Southern Kenya Rift

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Environmental drivers of African hominin evolution are hypothesized to include heightened aridity, intensified moisture, or changes in habitat variability. Establishing a direct impact of environment on evolution demands high-resolution climatic and ecological evidence that precisely connects novel hominin behaviors in time with local changes in landscapes, biota, and potential selective benefits and costs. The 2012 Olorgesailie Drilling Project recovered 216m of sediment from two drill sites located 22–24km from outcrops documenting the oldest well-calibrated replacement of the Acheulean by the MSA in eastern Africa during an interval associated in the southern Kenya rift with an ~85% turnover in mammalian taxa. $^{40}Ar/^{39}Ar$ dates and the Brunhes-Matuyama magnetic reversal are the basis for a 1-cm-scale Bayesian age model for the 166-m-long core designated OLO12-1A. The interval ~500 ka to 250 ka provides an especially high-resolution (sub-decadal- to millennial-scale) record of diverse lithologies, diatom assemblages, plant phytoliths, stable isotopes, and other measured environmental proxies. Regional demise of the Acheulean, development of the MSA by at least ~320–305 ka, and the faunal shift took place following a marked change at ~460 ka in the drill core record from generally deep freshwater lake phases with infrequent desiccation, to highly variable lake levels and frequent, short-duration dry episodes. Grassland expansion is also documented both in the drill core and in outcrop and faunal records of the adjacent Olorgesailie Basin by 325–250 ka. The sediment core data point to (1) reliable freshwater supply 850–490 ka when Acheulean hominins occupied the region, and (2) increasingly unreliable freshwater availability and frequent dry episodes 450–70 ka, as MSA innovations took root. MSA behavioral strategies are hypothesized to have succeeded in the southern Kenya rift in response to habitat/resource unpredictability and episodes of resource scarcity favoring wider hominin ranges, technological change, and social networking and communication.

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Vultures Moving In: Fossil Birds Suggest A More-Open and Heterogeneous Landscape During the Oldowan-Acheulean Transition (Middle Bed II) at Olduvai

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Fossil bird data from Olduvai Gorge, Tanzania, have been previously used to better understand the environmental context of hominin land use during the Oldowan (Bed I and Lowermost Bed II). Here, fossil birds help provide an ecological framework from which to address the causalities behind the Oldowan-Acheulean transition of Middle Bed II. These birds include fossils excavated by the Olduvai Geochronology and Archaeology Project (OGAP) between 2009 and 2015 and previously undescribed fossils collected by Mary Leakey in the 1970's. No major environmental/faunal turnover is evident across the Oldowan-Acheulean transition, but these birds do show a notable shift away from the extensive wetlands of Lowermost Bed II with a decline in taxa associated with thick, emergent vegetation and the appearance of more open-grassland and woodland birds such as crane, ibis, owl, raptor, crow, and vulture. The Middle Bed II landscape is interpreted from our avifaunal data as more open and potentially drier, with matured wetlands, scattered trees, and a greater expansion of grasslands than what occurred during Lowermost Bed II times. The ecologically-diverse avifauna suggests greater landscape heterogeneity (patchiness) across the Middle Bed II landscape. Increased heterogeneity would have led to more-dispersed resource, increased predation risk, and potentially the need for tools that could be more readily carried across less ideal patches of habitat. Increased patchiness, rather than large scale environmental change, may have selectively favored the increased portability and utility usually attributed to Acheulean handaxes.

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ESR Dating of Teeth from Medzhibozh, Ukraine, a Middle Pleistocene Paleolithic Open-air Site

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In the Ukraine, Medzhibozh includes two multi-layers open-air sites at 49°35′ N 27°42′ E, 270m amsl. Since ESR can date mammalian enamel up to 2–4 Ma with 2-5% precision, four cervid teeth from Layer 16a at Medzhibozh I and Layers 1 and 2 in Medzhibozh A were dated by standard ESR and by isochron analyses to assess the U uptake rates, *p*. In Medzhibozh I's lower alluvial cycle, Layer 16a yielded Paleolithic artifacts, mainly choppers, chopping tools, and flakes with little secondary modification, associated with bones with cutmarks left by early hominins inhabiting an ancient lake shoreline. *Ursus deningeri* and other Middle Pleistocene fossils suggest that Layers 13–16 must predate 200 ka. About 500m away, Medzhibozh A's six archaeological layers were intercalated with sterile gravels. To measure time- and volumetrically averaged sedimentary dose rates, sediment samples were analyzed geochemically. Using geological criteria, a ramped box model calculated time-averaged cosmic dose rates. From Medzhibozh A, AT29's LU age agreed best with ages estimated from the faunal analyses, but the isochron showed extensive secondary U uptake. At Medzhibozh I, all teeth had >100ppm U in the dentine and the isochrons indicated that secondary U uptake. Thus, their standard ESR ages overestimated their true ages. Using U uptake rates at *p*=2–6, ages for AT41, AT44, and AT45 agreed best with the estimates from faunal analyses, but coupled ESR-^{230}Th/^{234}U analyses must confirm *p*'s. Since this estimate comes from few teeth, however, more teeth must be dated to confirm these results. If correct, these ages makes Medzhibozh's hearths the oldest in the Ukraine. Medzhibozh is the first site analyzed by isochron analyses to show the same type of secondary U uptake in multiple teeth, hinting that one secondary U uptake event may have affected the whole site.

Turkana's Return to Woody Cover during the Mid-Pleistocene Climate Transition and the Extinction of *Paranthropus boisei*

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Plio-Pleistocene global climate change, linked to increased aridity in eastern African habitats, is thought to have mediated hominin evolution. Historically, the extinction of *Paranthropus boisei* during the mid-Pleistocene climate transition (MPCT; 1.25–0.70 Ma) was explained as competitive exclusion by our technologically flexible and dietary generalist forbearers as a consequence of the species' behavioral and dietary inflexibility amid grassland spread and increasing environmental perturbations. Recent archaeological finds predating the earliest *Homo* fossils further supports speculation that genus *Homo* was not the only toolmaker. Moreover, the plausibility of direct competition is called into question by dietary reconstructions that reveal substantial niche separation between *Homo* as a mixed feeder and *P. boisei* as a C_4 specialist. Here we demonstrate a significant decrease of C_4 vegetation in the Turkana Basin, Kenya, during the MPCT, which traditionally was considered one of the driest periods in eastern Africa due to an intensification of Northern Hemisphere glaciation. Our stable isotopic record of paleosol carbonates (nodules=53, analyses=95) sampled between 1.4–0.7 Ma from the Nachukui and Koobi Fora formations shows that woody cover steadily increased after 1.4 Ma, reaching a C_3-dominated vegetation structure by 1 Ma; after which, grassy environments returned gradually. Faunal assemblages during the *P. boise*i extinction circa 1 Ma indicate increasing speciosity of C_4-feeding herbivores. Abundant C_4-grazing fauna framed within our record of diminishing C_4 vegetation suggest heightened competition between C_4-grazers and the C_4 niche hominin. These factors in concert may have influenced the extinction of *P. boisei*.

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Community Archaeology in Kondoa: New Excavations from the Late Pleistocene-Holocene Sequence at Kisese II Rock Shelter, Tanzania

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The eastern African Late Pleistocene and Holocene record provides evidence to reconstruct human landscape use and demographic patterns prior to and during dispersals from Africa. However, current uses of this record have been severely limited by poor chronological resolution and reliance on stone tool technology as the only behavioral proxy. Here we present on new excavations from Kisese II, a painted rock shelter with a 6-meter stratified deposit in the Kondoa UNESCO World Heritage Centre in central Tanzania. Spanning the Middle Stone Age, Late Stone Age, and Iron Age, Kisese II was first excavated by Leakey in 1951 and later by Inskeep in 1956. The Inskeep collections, spanning over 60 cubic meters, yielded chronological, technological, and faunal data recently analyzed by Tryon et al (2018). Building on these data, our excavations targeted *in situ* archaeological sediments in addition to bisecting the Leakey and Inskeep trenches. Geoarchaeological approaches and piece-plotting were used to capture a high-resolution sample and to better contextualize the Inskeep 1956 collection, which had been excavated in arbitrary ~15-cm-thick levels that may have crosscut sedimentary units. Our excavation significantly increased the sample of ostrich eggshell beads, pottery, ochre, obsidian, fossil fauna, and stone artifacts, and documented the first bone pendant from the site. We present a model for site formation processes at Kisese II, coupling new micromorphological and sedimentological data with archaeological evidence, and present a model for managing community archaeology projects in eastern Africa. Following Schmidt (2014), we demonstrate how archaeologists can move beyond colonial legacies such that archaeological research is collaborative, incorporating all stakeholders, and can be used as a vehicle for sustainable development and conservation of tangible and intangible cultural heritage.

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Homo floresiensis: Where Does It Stand?

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The exact placement of *Homo floresiensis* in hominin phylogeny has been vigorously debated ever since the first fossils were discovered on the island of Flores more than a decade ago. The most commonly accepted hypothesis for its evolutionary placement describe it as a member of early *Homo* that migrated out of Africa to southeast Asia, became isolated on Flores, and subsequently underwent a process of dwarfism due to the selective pressures of island life. Recently, a cladistic analysis by Argue et al. (2017) suggested that this diminutive species most likely belonged to a sister group of *H. habilis*. This hypothesis has several important implications for early hominin evolution, including a possibly earlier *Homo* migration event out of Africa. I have examined the physical traits of *Homo floresiensis* to determine the effects that isolation is hypothesized to have had on an early species of *Homo*, specifically focused on the manual and pedal elements. This analysis is based on a comparison of *H. floresiensis* with other *Homo* taxa, centered on what has been described as its ape-like condition and, specifically, its closer similarity to the chimpanzee in contrast to the derived features seen in other contemporary species of *Homo*. Understanding the polarities of these traits within the context of their functional morphology will help to clarify the evolutionary standing of this species, assess where it belongs within early *Homo*, and potentially help to determine when the lineage originated.

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Robust Australopith Paleobiology: The Biogeography and Paleoenvironments of Eastern and Southern African *Paranthropus*

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Paranthropus boisei and *Paranthropus robustus* overlapped in time and shared derived morphology associated with heavy chewing.

Their different geographic distributions, however, may have been concomitant with differing diets, niche spaces, and ecological contexts. Here, we combine paleocommunity analyses of *Paranthropus* faunal assemblages with biogeographic analyses to investigate the paleoecological contexts of these species, and how broad-scale African biogeographic patterns likely influenced their diverging habitats. To compare paleoecological contexts, associated assemblages of large mammals from 11 South African and 6 east African *Paranthropus* sites were analyzed using a community approach. Multivariate correspondence analyses compared fossil communities to 191 extant communities in modern African habitats with known climatic variables. Using presence/absence data of 243 extant large mammal species and their locomotor and dietary adaptations, modern communities were described in terms of abiotic data, and this variability was used to retrodict ecological parameters for *P. boisei* and *P. robustus*. Biogeographic analyses included genus-level calculations of Dice and Simpson's faunal resemblance indices of >75 eastern and southern African fossil assemblages spanning the last 7+ million years. Multivariate analyses suggest that while *P. boisei* sites were likely wetter over the course of the year, *P. robustus* sites were influenced more by seasonality in temperature and rainfall. Further, pan-African biogeographic patterns indicate that habitats, seasonality, and lineages began diverging between eastern and southern Africa ~3 million years ago leaving very little faunal interchange between the biogeographic regions. *Paranthropus boisei* and *Paranthropus robustus*, while both able to take advantage of a limited range of seasonal habitats, in fact existed in significantly different ecological and biogeographic contexts.

Giant African Land Snails: Their Relevance to Archaeological Contexts.

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Across the eastern African landscape, genera of giant African land snails (i.e., *Lissachatina fulica*) have been prevalent since the early Pleistocene. In ecological studies, their abundance and invasiveness have been closely related to discussions of species diversity and habitat sustainability, especially throughout the Eastern Arc Mountain refugia. In paleoarchaeological research however, land snail shell (LSS) use as proxies have been poorly documented because their assemblages are assumed to be natural occurrences, i.e., death assemblages and/or burrowing behaviors. LSS growth rates and shell mineralization are important indicators of environmental conditions and can be used to infer past temperatures and moisture conditions in local terrestrial sites where proxies for conventional paleoenvironmental methods are lacking. Culturally, LSS have been used during the Iron Age to produce perforated shell beads similar in form to the ostrich eggshell beads of the Middle Stone Age. LSS shells may also have been used as materials for shamanic rituals and as water vessels. Ethnographic discussions have described giant African land snail fauna as food resources, particularly in Nigeria and on the west African coast. This poster presentation describes LSS data from the rockshelter site of Magubike in the southern highlands of Tanzania and indicates how the archaeological contexts uncovered there contain LSS assemblages that culturally relate to the numerous human occupations of the site and how their presence in the past may not be entirely due to the natural invasiveness of these species.

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Divergent Diversification Histories of Large Mammals across Two Sedimentary Basins in Eastern Africa over the Last 7 Myr

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Eastern Africa's rich paleontological record of late Cenozoic mammals, including hominins, has been extensively used in studies of regional-level turnover (origination and extinction) in the context of global climate and environmental change. The spatially hierarchical nature of biodiversity, however, implies that important insights into the potentially independent diversification histories of communities, ecosystems, and subregions are effectively lost when aggregated and homogenized at regional scales. Here, we use a 7-Myr record of large-bodied fossil mammals in eastern Africa to test for distinct turnover patterns in two highly fossiliferous sedimentary basins, the Awash Valley (Afar), Ethiopia, and the Turkana Basin, Ethiopia and Kenya. We analyzed taxonomic rates of turnover following Foote (2000) from a database of 107 fossil assemblages using 0.5 Ma temporal bins. Foote's rate measures assume exponential survivorship dynamics and are calculated using information on lineages originating in, going extinct in, or ranging through a given bin. We show that neither basin mirrors regional patterns of turnover over the last 7 Myr and that turnover patterns in these basins are widely divergent. Awash origination rates are highest near the Mio-Pliocene boundary (~5.25 Ma), whereas those of Turkana peak during the early to mid-Pliocene (~3.75 Ma). The only similarity between both basins is a relatively low and stable rate of extinction from ~5 to 2 Ma, after which many taxonomically-modern components of eastern Africa's present-day mammal communities first emerge. Intrabasinal turnover patterns between herbivore and carnivore clades differ significantly both in rate and the timing of turnover events, suggesting fundamental differences in the underlying processes driving diversity dynamics across ecological guilds. Our analyses highlight the importance of careful consideration of multiple spatial- and ecological- scales when addressing macroevolutionary questions, including those related to human evolution.

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Testing the Methodological Utility of Trace Element Analysis for Detecting Dietary Differences in Fossil Fauna from Turkana

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Direct measures of hominin diet with stable isotopic analyses have revealed exploitation of C_4 resources in the Pliocene coincident with the earliest finds of lithic artifacts. Whether this diet shift included an increase in faunivory remains unknown. Trace element analysis (e.g., Sr/Ca, Ba/Ca) has been used to infer dietary differences in modern and fossil fauna in South African hominin ecosystems. We conducted a pilot study in a modern and fossil eastern African context. Here we compare enamel Sr/Ca and Ba/Ca ratios of 30 extant mammalian species from Laikipia, Kenya to those of fossil fauna from the Nachukui Formation, Turkana Basin (specimens=84) collected by the West Turkana Archaeological Project. In the South African modern and fossil fauna, Sr/Ca separated C_3-browsers/carnivores from C_4-grazers, but did not differentiate trophic level; Ba/Ca differentiated carnivores from herbivores. We found variability across taxa in both modern and fossil eastern African ecosystems. Sr/Ca did not differentiate between C_3-browsers and C_4-grazers. Carnivores, however, show significantly lower Sr/Ca and Ba/Ca ratios than those of herbivores at Laikipia. Only one Turkana fossil carnivore (*Panthera* sp.) was analyzed in the study which hindered Sr/Ca and Ba/Ca analysis. Laikipia papionins and suids demonstrated relatively lower Sr/Ca ratios than Laikipia herbivores. Papionins in the modern period have lower Ba/Ca ratios than those of their fossil relatives. We found good agreement between fossil and modern Sr/Ca (R2=.96) and Ba/Ca (R2=.89) ratios of tragelaphines, antilopines, reduncines and equids. We gauged diagenesis in the Turkana fossil enamel samples by measuring Mn, Zn, Rb, Y, La, Sm, Yb, Th, and U. Although the concentrations of Mn, Rb, U, Th are higher in the fossil enamel samples compared to the modern assemblage, alteration may be element-specific, which suggests promise for the utility of trace element analysis in Turkana fossil enamel.

Digitally-Empowered Learning: Teaching Archaeology through Virtual Reality and Game-Based Learning

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Like many natural sciences, a critical component of archaeology is field work. Despite its importance, field opportunities are available to few students for financial and logistical reasons. With little exposure to archaeological research, fewer students are entering archaeology, particularly minority students (Smith 2004; Wilson 2015). To counter these trends, we have leveraged the ongoing revolution in consumer electronics for the current, digitally-empowered generation by creating a game-based, virtual archaeology curriculum to 1) teach foundational principles of a discipline that is challenging to present in a traditional classroom by using sensory and cognitive immersion; and, 2) allow wider access to a field science that has previously been limited to only select students. Virtual reality (VR) is computer technology that creates a simulated three-dimensional world for a user to experience in a bodily way, thereby transforming data analysis into a sensory and cognitive experience. Using a widely-available, room-scale, VR platform, we have created a virtual archaeological excavation experience that conveys two overarching classroom objectives: 1) teach the physical methods of archaeological excavation by providing the setting and tools for a student to actively engage in field work; and, 2) teach archaeological concepts using a scientific approach to problem solving by couching them within a role-playing game. The current prototype was developed with the HTC Vive VR platform, which includes a headset, hand controllers, and two base stations to track the position and orientation of the user's head and hands within a 4x4 meter area. Environments were developed using Unreal Engine 4, an open source gaming engine, to maximize usability for different audiences, learning objectives, and skill levels. Given the inherent fun of games and widespread interest in archaeology and cultural heritage, the results of this research are adaptable and applicable to learners of all ages in formal and informal educational settings.

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Biomechanics of the Sloping Supraorbital Torus of *Paranthropus boisei*

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Among the more conspicuous attributes of the bony visage of *Paranthropus boisei* are its curiously shaped orbits. The supraorbital torus of *P. boisei* descends steeply from a high glabella towards the inferolateral margin of the orbits. This descent has the effect of pulling the entire orbital profile downwards, giving the orbits the appearance of sloping parallelograms. Rak hypothesized that this circumorbital form serves as a structural buttress against deformation caused by powerful masticatory musculature, insofar as it would decrease bending moments in the supra- and lateral orbital frame. If this is true, *P. boisei* should experience lower tensile stresses at: 1) the inner aspect of the superolateral angle of the orbit; and, 2) the outer aspect of the superomedial angle of the orbit. This study examines the mechanics of orbital profile shape related to mastication using a series of finite element models based on specimen OH5. Supraorbital and lateral orbital margin morphology was modified to test the hypothesis that the sloping orbital profile found in OH5 offers a structural advantage over a more box-like "generalized primate" orbital (GPO) profile. Overall, little difference was found between models for either strain magnitude or pattern. Slightly higher strains are found at the outer aspect of the superomedial angle in the GPO model during premolar loads, but slightly lower strains are found at the inner aspect of the superolateral angle. One notable difference in strain pattern is observed at the outer aspect of the superolateral orbit, where changes in the ratio of maximum to minimum principal strain causes a shift from tensile dominance in OH5 to compression dominance in GPO. This is, in fact, opposite the condition predicted by Rak. These results are inconsistent with the prediction of Rak's model and suggest that this aspect of morphology is not functionally significant during feeding.

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Rhyolite Cryptotephra Identified in Mousterian Deposits at Arma Veirana, Italy

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Cryptotephra are small glass volcanic shards (<80micron) that occur invisibly in sediments and can be used to create precise isochrons (time datums) in archaeological sites. We identified cryptotephra at Arma Veirana (AV), a Middle and Upper Paleolithic archaeological site approximately 14km from the Mediterranean coast in Liguria, Italy. The shards are found within a 15-cm interval within the lowest stratigraphic unit at Arma Veirana; the Black Mousterian (BM). AMS radiocarbon dates on charcoal samples from BM range from 43,781 to 43,121 (68.2%) cal BP. Shards are abundant (5–10 shards/gram of sample) in the lower part of the BM but are found in samples up to the contact with the overlying "Granular" layer dated by AMS radiocarbon between 41,721 and 41,174 (68.2%) cal BP. Work is in progress for samples above this stratigraphic level. At AV, cryptotephra analysis was used to refine dates and potentially document the presence of the Campanian Ignimbrite dated to ~40 ka. Major element chemistry obtained by electron microprobe indicates that the shards are high silica rhyolite (>75 wt. %) with FeO <1 wt. %—a unique geochemical signature rare for volcanoes in the Mediterranean region. Trace elements by LA-ICP-MS provide a unique signature and show depletion in Ba, Sr, and Eu and enrichment in Th, U, and Pb when normalized to primitive mantle. The rare-earth elements (REE) are also excellent for chemical fingerprinting and have relatively flat patterns with deep negative Eu anomalies. An unusual characteristic is that the heavy REE increase in abundance with mass number. The source volcano for the shards is under investigation. The unique chemistry eliminates sources in Iceland, Canaries or Azores, Aeolian Islands, and volcanoes in Italy and Greece. Source volcanoes in Turkey and the Carpathian Mountains cannot be ruled out.

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Tick Shells, Personal Ornamentation, and Marine Resource Exploitation during the Late Pleistocene at Contrebandiers Cave (Temara, Morocco)

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Increasingly, researchers have considered the role of coastal marine resource exploitation in influencing the trajectory of human behavioral and biological evolution, specifically relating to modern human origins. However, these models have focused almost exclusively on the relatively rich and well-documented record from the Middle Stone Age (MSA) of coastal South Africa. Here, we present data on coastal marine resource exploitation during the Late Pleistocene at Contrebandiers Cave [La Grotte des Contrebandiers, Smugglers' Cave] (Temara, Morocco). Contrebandiers' sequence includes the MSA, which spans ~126,000–95,000 years ago at the site, and the Iberomaurusian, which elsewhere is ~22,000–11,000 years ago. Today the site is only 270m from the Atlantic shore; during the MSA and Iberomaurusian, inhabitants appeared to have had consistent access to a nearby rocky coast, where they gathered mainly marine mollusks (limpets, mussels, and marine snails) for subsistence, but also other marine fauna in small proportions (birds, fish, crabs, goose barnacles, and sea urchins). The Contrebandiers occupants also collected during both the MSA and Ibeuromaurusian shells for non-dietary reasons; these include triton (*Charonia lampas*), but above all tick shells (n=136). Most of the tick shells belong to two different species of the Nassariidae Family: *Tritia* [*Nassarius*] *gibbosulus* and *Tritia* [*Nassarius*] *circumcinctus*. Neither of these two gastropods lives along the Moroccan coasts today. The large majority of these tick shells preserve perforations, inviting us to ask if they had been used as personal ornaments, as has been argued for similar shells found elsewhere in northern Africa, as well as in South Africa. Each tick shell was subject to a macroscopic and microscopic analysis, looking for traces of use-wear and residues. Here we discuss the Contrebandiers tick shells through a taphonomic approach that is integrated with the analysis of the mollusks exploited for subsistence, focusing on their potential use as ornaments.

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Origins of the Human Predatory Pattern: The Transition to Large Animal Exploitation by Early Hominins

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The habitual consumption of large animal resources (e.g., similar-sized or larger than the consumer) separates human and non-human primate behavior. Flaked stone tool use, another important hominin behavior, often is portrayed as being functionally related to this by the necessity of a sharp edge for cutting animal tissue. However, the empirical evidence for this emphasizes sites that post-date ca. 2.0 million years ago. Claims of earlier stone tools and butchery marks that pre-date the emergence of *Homo* further confound what once appeared to be a simple relationship between stone tool use, large animal exploitation, encephalization, and changes in foraging behavior and life history strategies. Here we summarize our paper in press in *Current Anthropology* where we critically deconstruct the theoretical significance of an earlier origin for flaked stone tool use and meat-eating, their proposed inter-relationship, and the nature of the empirical record. We demonstrate that from an optimal foraging perspective these concepts are too loosely defined: outside-bone nutrients (e.g., meat) and inside-bone nutrients (e.g., marrow and brains) have different macro-nutrient characteristics (protein versus fat), mechanical requirements for access (cutting versus percussion), search, handling and competitive costs, encounter rates, and net returns. Thus, they would have demanded distinct technological and behavioral solutions that do not always place them together in space and time. We propose that the regular exploitation of large animal resources—the "human predatory pattern"—began with an emphasis on percussion-based scavenging of inside-bone nutrients, independently of the emergence of flaked stone tool use. We then provide a series of test implications for deposits that pre-date the emergence of *Homo*.

A Quantitative Assessment of Percussion-Induced Modification to Bone Surfaces

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The presence of percussion marks on faunal remains demonstrates that hominins used a hammerstone-on-anvil technique to process animal carcasses with the intention of extracting and consuming fat-rich bone marrow. The analysis of such marks holds important implications for both the evolution of stone tool technologies, as well as hominin encephalization, which roughly coincides with the appearance of percussion marks in the archaeological record. Zooarchaeologists have typically utilized low-power hand lenses or 2D microscopic techniques to discern percussion marks on faunal remains, but these methods are difficult to reproduce between researchers and are limited in the behavioral inferences they can produce. The use of high-resolution 3-D scanning has demonstrated potential to enhance interpretations of stone tool cut marks and carnivore tooth marks. Here, we provide a new approach that applies high-resolution 3-D scanning to identify the unique characteristics and quantify the micromorphology of percussion marks inflicted on limb bones. Experimental percussion marks were produced with raw materials from Olduvai Gorge, Tanzania, using a hammerstone-on-anvil technique controlling for animal species, bone type, and raw material of the lithics used to break the bones. 3-D reconstructions of these marks were produced using a Nanovea ST400 white-light confocal profilometer, which were processed using Digital Surf's Mountains software. Measurements recorded from the 3-D models include volume, surface area, maximum depth, maximum width, and length. Additional measurements collected from 2D cross-sectional profiles include cross-sectional area, width, depth, and roughness. Results characterize variability in the micromorphology of percussion marks related to the position of the bone during breakage, as well as type of raw material used in the experiments. When applied to the fossil record, these quantitative measurements may allow percussion marks to be identified and analyzed with greater accuracy, which would provide a better understanding of hominin behavior and evolution during the Early Stone Age.

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Excavating the Archives: The 1947 Campaign at Ksar Akil (Lebanon)

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The ~23-m-thick deposits at Ksar Akil rockshelter near Beirut preserve a key archaeological sequence for the Levant, that, unusually for the region, includes both a series of Upper Paleolithic strata as well as underlying Middle Paleolithic deposits. The site was excavated in two major excavation campaigns interrupted by the Second World War, resulting in the recovery of several million lithic and faunal remains, including multiple hominin fossils ('Egbert' and 'Ethelruda') attributed to *Homo sapiens* and associated with Initial Upper Paleolithic artifacts. The stone tool assemblages from the 1937–1938 excavations are stored in the UK and have been the subject of extensive analyses and publications, as have non-hominin fossil fauna in Leiden. This is not the case for the >38,000 lithic artifacts from the 1947 fieldwork that are housed at Harvard University's Peabody Museum of Archaeology and Ethnology (PMAE). The PMAE collections remain understudied, but unlike collections in the UK, sample both Middle and Upper Paleolithic strata and are thus unique in preserving the majority of the site's stratigraphic sequence. We report here our ongoing archival research and reexamination of the lithic material excavated in 1947. The extensive written and photographic archives at the PMAE have not been integrated into current understandings of Ksar Akil, yet these materials provide a more robust understanding of the nature of the assemblages and their curation history, specifically, the kinds of material that have been lost or retained. Building on the archival studies, examination of the artifacts has focused initially on technological changes related to the origin and development of projectile technology across the Middle/Upper Paleolithic transition, indicating more complex patterns of behavioral variability than recognized elsewhere in the Levant.

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New Excavations at Sel'ungur Cave, Kyrgyzstan

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One of the most important sites for understanding the Central Asian Middle Paleolithic is the cave of Sel'ungur in the Fergana Valley of Kyrgyzstan, as this is the only stratified site containing a lithic industry, in combination with faunal and hominin remains. Excavations in the 1980s revealed an at least 8m thick sequence of Holocene, Late Upper Pleistocene, and probably Middle Pleistocene deposits. The upper part of the deposits contains several Middle and Upper Paleolithic horizons, while the lower cultural layers were interpreted as Acheulean by the excavators. The hominin status of six teeth from the site is doubtful, but a child humerus is Neanderthal-like. The dating of the site is problematic, but based on a U-series date and the fauna the lower layers could date to OIS 5e or before. Since 2014, we are re-excavating this crucial locality with a focus on recovering a well-documented and stratigraphically constrained faunal and archaeological assemblage, in combination with new samples for dating, site formation, and paleoenvironmental studies. In the course of the excavations, we recovered over 2,500 lithics from seven cultural horizons, and over 6,000 faunal remains. The identifiable faunal remains belong mostly to argali (*Ovis ammon*) and Siberian ibex (*Capra sibirica*), but isolated remains of steppe bison, equids, rhinoceratids, and cervids also occur. Carnivores are represented by *Panthera* cf. *spelaea* and small canids. In contrast to the previous interpretations of the Sel'ungur lithic material, we do not see any evidence for the presence of Acheulean technology or typology. Rather, this seems to be a Middle Paleolithic industry in a broader context, as evidenced by the developed core reduction, plano-convex blanks, dominance of sidescrapers, and the highly standardized toolkit. We will discuss the implications of the reassessment of the industry for our understanding of the Central Asian Middle and Lower Paleolithic.

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To Walk or To Run: Derived Skeletal Traits in Early *Homo* and the Transition to Endurance Locomotion

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Early members of the genus *Homo* shifted to a hunting and gathering lifestyle around two million years ago which led to an increase in aerobic physical activity levels compared to earlier hominins. Many derived musculoskeletal traits appeared during this transition and have been linked specifically to the hypothesized adoption of endurance running (ER) behaviors, which may have improved hunting and scavenging success. ER increases the magnitude of initial foot-ground contact reaction forces and may have led to impact-resisting skeletal adaptations (IRSA). In general, the researchers have tested the ER hypothesis by comparing IRSA performance during running and walking (often at slow speeds). However, few studies have explored alternative explanations for these IRSA. Ethnographic literature suggests ER is relatively rare in extant hunter-gatherer groups, and instead, individuals in these groups tend to walk both at high-speeds and while carrying heavy loads. In this study, we examine high-speed and loaded walking as possible alternative explanations for two specific IRSA that have been linked to the ER hypothesis: enlarged semi-circular canals to accommodate high head pitch velocities and enlarged lower limb joints to manage high impact forces. We measured head kinematics using a high-speed motion capture system and estimated vertical knee forces using 3d accelerometers of subjects while unloaded and loaded during walking and running. Head pitch (HP) and estimated vertical knee forces (KF) were not significantly different between running and walking at high speeds (2.0m/s) with a light (15% bodyweight) or heavy (30% bodyweight) load (HP walking vs. running: light $p=0.95$, heavy $p=0.99$; KF walking vs. running: light $p=0.99$, heavy $p=0.22$). These results strongly support the hypothesis that high-speed and loaded walking may be an alternative explanation for the derived IRSA seen in *Homo*.

Laser Scanning Confocal Microscopy as a Tool to Distinguish Use-wear Traces

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Some recent efforts to determine the function of stone tools have employed quantitative descriptions of use-wear. This approach arguably has the benefit of increasing reproducibility and reducing subjectivity. This paper describes a new quantitative use-wear method, which relies on a statistical analysis of 3D data generated by a laser scanning confocal microscope. The method presented here was also "stress tested" to explore the impact of post-depositional damage on its findings. Experimental use-wear specimens

were shaken in a sediment sieve shaker in thirty minute increments before being reassessed with the model. The results reveal that the method is still viable for use with lightly and moderately damaged specimens. This experiment demonstrates that the method is no more vulnerable to post-depositional damage than more conventional methods and thus can be confidently applied to archaeological specimens.

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Comparative Taphonomy of Two Landscape Bone Assemblages in the Ngorongoro Conservation Area, Tanzania

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Identifying the variables that influence the deposition, preservation, and spatial distribution of faunal material across landscapes remains a key goal of taphonomic research. Here, we report on the results of pedestrian surveys for faunal material between 2015 and 2017 across two 250m x 250m areas within the Ngorongoro Conservation Area (NCA). The survey areas are separated by approximately one kilometer and represent two microhabitats within the eastern Serengeti ecosystem—a treeless grassland and a seasonal waterhole surrounded by woodland. Within each survey area, all visible faunal material was plotted with a laser total station and collected. Analyses reveal significant differences in skeletal part representation, bone surface modifications, and spatial patterning between the two microhabitats. In line with previous studies, our results suggest that ecological characteristics, including most prominently vegetation regime and water availability, heavily influence the dynamics of bone deposition. We apply the findings from the NCA bone scatters to the paleoecology and taphonomy of Olduvai Gorge's well-known early Pleistocene faunal assemblages.

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Sexual Dimorphism in the Lower Back of *Australopithecus sediba* and *Homo naledi*

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Sexual dimorphism—in body size, canine size, and a host of secondary sexual characteristics—is associated with social organization and mating systems in extant primates. In the fossil record, inferences into species' social behavior often are limited to what can be interpreted from skeletal remains. The discovery and virtual recovery of new lumbar and lower thoracic vertebrae from Malapa and the Lesedi Chamber of the Rising Star Cave system allows for the estimation of sexual dimorphism in *Australopithecus sediba* and *Homo naledi*. Malapa Hominin 1 (MH1; juvenile male) and MH2 (adult female) both preserve lower thoracic and lumbar vertebrae, as do individuals from Rising Star Dinaledi (101; adult female) and Lesedi (102; adult male) chambers. We analyze the shape and size of vertebrae in males and females of these species in a comparative context of extant hominoids and available fossil hominins. Measures of sexual dimorphism indicate that *H. naledi* male vertebral bodies are approximately 20% larger than females, comparable to *H. erectus* and *H. sapiens* (males ~30–40% larger) and lower than *Paranthropus robustus* (males ~60% larger), *Au. africanus* (males ~70% larger), and *Au. afarensis* (males ~110% larger). Although a direct measure of sexual dimorphism in *Au. sediba* cannot be taken due to the subadult status of MH1, sexual dimorphism is likely to have been low to moderate in this species, as previous estimates of body mass have suggested. Additionally, we find no support for the hypothesis proposed by Been and Rak (2014) that MH1 and MH2 lumbar vertebrae represent different species. Sexual dimorphism of other vertebral morphologies (e.g., transverse process robustness and orientation) also are discussed, as are the implications of vertebral sexual dimorphism for overall body size dimorphism, locomotion, and possible socio-sexual differences among species.

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The Iringa Region Archaeological Project: Recent Results and Future Plans

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The Iringa Region in southern Tanzania has a long, relatively continuous record of human occupation, which starts in the Acheulean. Located in the Southern Highlands, Iringa has enormous potential for the resolution of key questions about the biological and cultural evolution of our own species, *Homo sapiens*, at the end of the Acheulean and during the Middle and Later Stone Age (MSA and LSA). Paleoenvironmental sequences in many East African lakes have demonstrated that the MSA was associated with repeated episodes of catastrophic cooling and droughts, which might have led to demographic stress and to technological innovation. Our current and future fieldwork will be focused on the following questions. Did climate change and/or social, cultural, or demographic factors underlie the evolution of the earliest modern people in this part of Africa? What does the archaeological record of Iringa Region illustrate about the behavior of the earliest members of our species? Can a landscape archaeological approach help to answer such questions? The Iringa Region Archaeological Project (IRAP) and its parallel cultural heritage program CHIRP, or the Cultural Heritage in Iringa Region, were organized in order to study the Pleistocene and more recent history of this part of Tanzania. This poster summarizes recent field research results by members of both research teams, and outlines plans for the next field season (in 2018). We plan to continue to document the cultural heritage of Iringa through academic and popular publications, to produce posters and museum displays for local communities in Tanzania, and to work with the recently formed Fahari Yetu (Southern Highlands Culture Solutions), a locally based group, in order to enhance both the academic and the cultural heritage components of our research.

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Large-Scale Anthropogenic Landscape Change in the Middle Stone Age of Malawi

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Human agency is implicated in many recent environmental changes, some of which have resulted in permanent crossing of ecological thresholds. However, researchers rarely consider anthropogenic effects to extend back in a detectable way more than a few thousand years. There are exceptions in regions such as Australia, where the hominin record begins with modern humans, and where landscape burning as a management strategy likely extended into the Pleistocene. In Africa, anthropogenically-driven ecological change is not as straightforward to detect, because of long co-evolutionary histories of humans and landscapes. To overcome these challenges, we have dated extensive Middle Stone Age (MSA) occupations in alluvial fan deposits at 24 localities in the Karonga District of northern Malawi, southernmost Rift Valley, and paired them with paleoenvironmental data from the Lake Malawi drill cores. Fan activation co-occurs with MSA artifact assemblages, beginning ~92 ka, immediately after lake levels rose following a major lowstand with semi-arid conditions. As the first sites appear, lake core data reveal a simultaneous six-fold increase in macrocharcoal input in the central basin of Lake Malawi, accompanied by collapse in vegetation species richness and an increase in fire tolerant taxa. Other dated sites cluster after ca. 60 ka, coinciding with stabilization of lake levels and major vegetation turnover with further expansion of fire-resistant trees. Macrocharcoal from the northern basin, <40km from the dated sites, rises in frequency as MSA sites become more abundant. We argue that these patterns are the signature of ancient feedback between early human behavior (large-scale burning), landscape denudation, alluvial fan activation, and vegetation response that resulted in permanent landscape alteration. Previous cycles of semi-arid to forest transitions do not have the same effect, suggesting fundamental differences in human population sizes and/or behavioral strategies in the latter part of the MSA of this part of Africa.

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Intratooth Isotope Profiles of Fossil Suids: Environmental Variability in the Pleistocene Deposits of the Koobi Fora Formation

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Previous studies investigating the changing environment in eastern Africa have employed stable light isotope analysis in tooth enamel for paleoenvironmental reconstruction. Despite an extensive isotopic record of the Pleistocene fossil fauna, most studies have utilized a single sample from each tooth, which usually averages the animal's diet over an uncertain period of time. Intratooth isotope profiles can reveal seasonal changes in diet and body water, which can serve as a proxy for environmental variability. Most suids in the Early Pleistocene have high-crown molars or long canines (tusks), both of which are ideal for intratooth profiles. We selected three canines of *Kolpochoerus* and three M3s of *Metridiochoerus* from Upper Burgi, KBS, and Okote members of the Koobi Fora Formation (2.1–1.38 Ma). We investigated their dietary response to seasonality by examining carbon and oxygen isotopes in enamel that was sequentially sampled along the growth axis of each tooth. The $\delta^{13}C$ values of all six individuals indicate that they were predominantly C4 grazers. All six show some degree of intra-individual variation in both $\delta^{13}C$ (Δ ranging from ~1‰ to 2‰) and $\delta^{18}O$ (Δ ranging from ~1‰ to 7‰). Data from some individuals indicate extreme rainfall seasonality but with little change in diet. Others indicate relatively stable hydroclimate and diet. The $\delta^{13}C$ and $\delta^{18}O$ values in 4 out of 6 intratooth profiles are positively correlated, suggesting similar dietary response to rainfall seasonality. Intratooth profiles of fossil suids can provide insights into vegetation and hydroclimate variations of hominin fossil sites. This preliminary dataset allows for limited interpretation of long term trends, but additional samples will be analyzed, which we anticipate will shed light on paleoenvironments across space and time in the Koobi Fora Formation. Similar methods can be extended to other fossil mammals, particularly those with hypsodont or continuously growing teeth/tusks.

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Cold Adaptation and the Neandertal Face

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Despite extensive investigation, the combination of evolutionary forces that shaped Neandertal craniofacial anatomy remains elusive. Here we present the results of a reanalysis of a classic evolutionary hypothesis for the Neandertal face—adaptation to cold climate. Our analysis incorporates multiple sources of evidence, much of which has not been considered previously in combination. We examine differences in the overall craniofacial architecture of archaic and modern humans, the physiological parameters that govern nasal heat and moisture exchange, the relationship between body mass and oxygen demands, and the role of the nasal complex in craniofacial growth. From this evidence, we make the following conclusions. First, due to larger body mass and greater energetic demands than modern humans, Neandertals maintained a large nose to facilitate greater oxygen consumption. As a result, Neandertals had broader noses than cold-adapted modern humans—a fact several scholars have used to reject cold adaptation as a selective force on Neandertals. As a result of energetic constraints, the Neandertal nose required a different adaptive solution to cold climate demands. Second, due to pleisiomorphic retention of a prognathic midface, Neandertals had longer nasal passages than those of orthognathic modern humans, which translates to greater mucosa surface area and an increased capacity for nasal heat and moisture exchange. In response to cold climate, the Neandertal nasal complex further lengthened relative to sub-Saharan archaic humans via increased external nasal projection, which further increased the air conditioning capacity of the Neandertal nose. Third, given that nasal heat and moisture exchange is governed by multiple physiological parameters and that Neandertals and modern humans start with different craniofacial architecture, we should not expect Neandertals and modern humans to exhibit the same morphological responses to cold climate conditions. Instead, there are likely different adaptive solutions to accommodate the needs of cold climate conditions.

Ecological Niche Models of Human Land Use at the Last Glacial Maximum in Southeast Asia: A Comparison of GARP and MaxEnt

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Ecological niche models (ENM) of species distributions and dispersal patterns are well established in the biological sciences. However, their use in paleoanthropological reconstructions of hominin niches and mobility patterns is relatively recent, and has focused on out of Africa dispersals and human land use in Europe and Central Asia (Glantz et al. 2018). These studies have shown that the most important variables in regard to predicting human site use are moderate temperature, rainfall, and access to fresh-water. We take these predictors of human land use and apply them to Southeast Asian landscapes during the climatically tumultuous Last Glacial Maximum, validating ENM using known fossil human occupation sites (n=20) to construct human land use maps in an area where glacial climate likely facilitated human movement across islands. We compare human land-use outputs from two popular ENM programs, GARP and

MaxEnt, to determine which program shows the least error when hindcasting human land use from known fossil sites. Though both models suggest much of Southeast Asia to be used by humans at this time, fitting suggests that GARP may overestimate the actual distribution based on the input parameters, therefore increasing accuracy, but reducing precision. Whereas MaxEnt suggests less overall land use, but is also more focused than GARP on the distribution attributed to humans (moderate accuracy, high precision). Further analysis will include additional environmental variables (vegetation, terrain, species interactions, etc.) to examine how humans may have dispersed through Australasia throughout the Late Pleistocene. Beyond increasing our knowledge of past human dispersals, this type of modeling has been shown to greatly increase the probability of new fossil finds (Block et al. 2016). This suggests this type of work may be greatly beneficial to future fossil prospecting in Southeast Asian landscapes.

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Constructing Strontium Isoscapes to Test Models of Terminal Pleistocene and Early Holocene Forager Social and Territorial Organization in Northern Malawi

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Understanding the environmental circumstances that promote contingent strategies of risk reduction is an enduring area of anthropological investigation with significant implications for the evolution of human adaptability. As part of the Malawi Ancient Lifeways and Peoples Project (MALAPP), we are using strontium isotope ratio provenance analysis to investigate variation in mobility, residential life history, and social exchange network scale during the Later Stone Age (LSA). The initial phase of this project involves constructing a bioavailable strontium isoscape for a ~2700km^2 study area in Mzimba District, Malawi, centered on three LSA sites dating between 28 and 5 ka. Sourcing skeletal or shell remains and artifacts with strontium isotopes is predicated on measuring systematic spatial variation of bioavailable $^{87}Sr/^{86}Sr$ in the foodweb. Plants are the most reliable proxy for local foodweb strontium because they integrate all sources of bioavailable strontium unfractionated [1]. Preliminary analysis of 51 plant samples yielded an $^{87}Sr/^{86}Sr$ range of 0.72475–0.79628. This extraordinarily large range is consistent with whole rock $^{87}Sr/^{86}Sr$ reported for the Nyika Plateau (0.7256–0.7926) ~60km north [2]. The isoscape predicts high Sr ratios (~0.76–0.79) across the northern half of the surveyed area, and lower ratios (~0.72–0.75) in the south, based on ordinary spherical kriging interpolation of non-riparian samples from those areas. The north-flowing Kasitu River bisects the study area, with sites arranged in the valley and adjacent mountains. Plants from its riparian zone yielded an $^{87}Sr/^{86}Sr$ range of 0.75055–0.75593, implying strontium transport from lower Sr isotope ratio sources upstream. The large range of bioavailable $^{87}Sr/^{86}Sr$ in this study area indicates that studying provenance diversity for archaeological faunal remains, human teeth, and ostrich and mollusk shells, and shell artifacts, will be effective for testing hypotheses about strategic variation in social and territorial organization in late Pleistocene arid and Holocene humid environments [3].

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