The Role of Paleosol Carbon Isotopes in Reconstructing the Aramis *Ardipithecus ramidus* habitat: Woodland or Grassland?

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Paleosols (fossil soils) were sampled across a 9km west to east curvilinear transect of the Aramis Member of the Sagantole Formation in the Middle Awash Valley. Paleosol carbon isotope ratios are interpreted as reflecting floral habitats with 30% to 70% C_4 grass biomass, representing woodlands to wooded grasslands (WoldeGabriel et al. Science 326: 65e1–5, 2009). Pedogenic carbonate carbon and oxygen isotope ratios increase from west to east, reflecting grassier, drier habitats on the east, where *Ardipithecus ramidus* fossils are absent. These data are consistent with diverse lines of geological, paleontological, anatomical, and dental isotopic evidence for the character and distribution of floral habitats associated with *Ardipithecus* 4.4 Ma (White et al. *Science* 326: 87–93, 2009). Cerling et al. (*Science* 328: 1105-d, 2010) presented a new model for interpreting soil carbon isotopes from Aramis. They concluded that *Ardipithecus* occupied mainly wooded to open grasslands with less than 25% trees and shrubs and narrow strips of riparian woodlands. Geological and paleontological evidence for fluviatile deposition and riparian habitats is absent at Aramis. Their isotopic model contradicts all previously published paleosol carbon isotope-based reconstructions of tropical fossil sites, including all previous publications by six coauthors of Cerling et al. (2010). However, rejection of nearly three decades of research is premature. Their modern reference set for estimating tree:grass biomass is heavily dominated by soils formed on Kalahari sands, and on Australian sands that have demonstrably biased preservation against C_4 grass carbon (Wynn and Bird, *Global Change Biology* 13: 2208, 2007; Tellus 60b: 610, 615–617, 2008). Therefore, their model is inapplicable to fine-grained soils formed on volcanic parent materials including those of most hominid sites in African Rift Valley settings. We stand by our conclusion, corroborated by other lines of evidence, that the carbon isotope ratios of Aramis Member paleosols reflect woodland to wooded grassland habitats.

Springs and Groundwater-Fed Woodlands: A Fresh Look at Bed I Archaeological Sites, Olduvai Gorge, Tanzania

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Localized dense concentrations of fossils and stone tools in the lake margin flats of paleo Lake Olduvai (Bed I) have never been reasonably explained. Lake sediments recorded saline and alkaline conditions. Recent excavations at FLK-Zinj and FLK-North produced new paleoecological data (spring tufas and phytoliths) that support paleolandscape reconstruction centered on groundwater-fed environments. The proposed hydrologic model describes precipitation that is trapped by the Ngorongoro Highland and moves down slope into the Olduvai basin. In the sub-surface, water is protected from evaporation and thus buffered from droughts. Groundwater moves slowly (~meters/year) with the flow path determined by geology (structure and lithology). Olduvai basin is dissected by rift-parallel faults that acted as conduits bringing groundwater to the surface. FLK-Zinj: A 0.5-m-thick tufa draped by Tuff IC (1.839 Ma) was excavated 200m from the FLK Zinj site, in the same stratigraphic horizon as Level 22 in which hominin remains, stone tools, and cut-marked bones are concentrated. Stable isotope data of the tufa indicate deposition from fresh water. Phytolith analysis of the waxy clay in Level 22 revealed abundant woody dicotyledon and palm phytoliths, indicating that the site was densely wooded. The temporal/spatial proximity of these two groundwater-fed environments suggests that they are genetically related. FLK-North: Excavations under Tuff IF (1.785 Ma) revealed thick tufa deposits located ~100m southeast of FLK north. The archeological site was situated on a low-relief ridge where dense woody vegetation (a thicket-woodland or forest) flourished. The ridge was better drained than the surrounding low area with ground water-supported environments. Phytolith data indicate that the greater environs had grass with scattered trees and shrubs. This landscape reconstruction of FLK north time suggests an "oasis" in a savannah grassland offering both freshwater and shelter for the consumption of meat by either carnivores or hominins, or both.

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Virtual Anthropology Meets Field Archaeology: Using Handheld 3D Surface Scanner in Excavations

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One of the most important aspects in archeological digs is to accurately document excavated items both in terms of location and context to other objects. In recent years the use of computational GIS systems has become common, coupled with the use of digital photography. The introduction of laser and light based surface scanners also were incorporated into archeological work. Unfortunately, these systems still pose major shortcomings for field work as they are large, heavy, require specific working environments, and can only be used after elaborate settings. Scanning is also time consuming and can halt excavation in that area for a few days. In our project we used a new system by Z-Corporation that features a handheld 3D surface scanner. This scanner is very light, accurate, portable, and can be set up in minutes. In order to test the scanner, two experiments were undertaken. First, we simulated bone burial and excavation. The bones were scanned several times throughout the "excavation," each time revealing more parts. The scans were then merged to create a complete model. In the second experiment, we scanned the cast of the Kebara burial, emphasizing the delicate bony structures such as ribs, phalanges, and vertebra. On this surface scan we superimposed CT scans of the original bones. This was done in order to have a firsthand view of what the burial looked like *in situ*. We believe that this instrument can become widely used in excavations, not only as a method for acquiring archeological objects in their original context but also as an important tool for further spatial and temporal analysis throughout the process of the excavation. It also can eliminate the need to create rubber molds in the case of important osteological finds, a process that is sometimes destructive for fragile fossilized bony structures.

GIS Modeling of Paleolithic Hominin Landscape Exploitation Strategies in Central Asia

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Although the Paleolithic occupation of Central Asia is well documented, explanatory models that rely on multiple lines of evidence in order to characterize late Pleistocene hominin landscape exploitation strategies are currently lacking. The timing and intensity of paleoclimatic fluctuations in Central Asia are different from those experienced in western and central Europe. An increasingly cold and aridified region may have directly influenced hominin site distribution. As part of a broader investigation into the paleobiogeographical context of late Pleistocene hominin colonization of Central Asian landscapes, the present study identifies those variables that best predict site location preference with regard to Middle and Upper Paleolithic cave and open air sites in Uzbekistan and Tajikistan. Additionally, it is hoped that the methods used in this study will aid in creating a predictive model useful to archaeological surveys in greater Central Asia. The working hypothesis here is that proximity to water (<2km) represents the best predictor for site location. To test this hypothesis, we employed GIS techniques to explore how biophysical features such as elevation, slope, aspect, terrestrial biomes, and water proximity correspond to site location. Cave (n=7) and open air sites (n=15) were analyzed independently of one another. Sites were ranked (1–9) based on the number of distinguishable cultural layers as well as relative lithic and faunal densities. Ranking for each category then served as dependent variables in regression analyses. Preliminary results indicate that the working hypothesis should be overturned as proximity to water does not appear to be a reliable indicator of either open air or cave site location. The pitfalls of reconstructing paleolandscapes in a GIS environment will be discussed. Additionally, climatic trends and their impact on site location in Central Asia will be explored.

Preliminary Results From a New Lower Paleolithic Locality in Kurtan, Lori Plateau, Armenia: Evidence for an Early Pleistocene Cultural and Biogeographic Corridor Between the Levant and the Lesser Caucasus

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The earliest dispersal of hominins from Africa is attested to at the site of Dmanisi, Georgia, dated to ca. 1.85–1.77 Ma. However, other sites along the Levantine corridor remain scarce. While several sites are known from 1.6–1.0 Ma in the southern Levant ('Ubeidiya, Evron, Latamne), no sites older the Late Acheulean ca. 0.4–0.3 Ma are known from Armenia. Here we present preliminary results from a new locality, Kurtan, with evidence for the earliest human occupation in Armenia. Situated in the Lori Plateau of Armenia, this site comprises 3–4 meters of fine-grained sediments. The fossil and artifact bearing sediments contain pedogenic carbonate and overlie a

pumiceous volcanic ash bed containing plagioclase, sanidine, biotite, and magnetite. At its base, this ash bed is in erosional contact with a vesicular basalt. Basaltic volcanism in the region ceased ~2 Ma and the ash bed can be dated to 1.49±0.01 based on $^{40}Ar/^{39}Ar$ laser total fusion of single sanidine crystal, which provides a lower age boundary for the deposits. The site yielded ca. 200 lithic artifacts, including choppers, picks, core scrapers, and primitive small tools, as well as a rather large unique handaxe. Lithic artifacts are made from a variety of volcanic source materials, presumably locally derived, and are attributed to the Early-Middle Acheulian tradition. Fauna recovered from the sediments provided a biochronological date for the lithic material. Specifically, two teeth were identified as *Stephanorhinus* cf. *hundsheimensis*, similar to specimens from Pietrafitta, Italy, which are dated from 1.4 to 1.0 Ma. The stratigraphy, biochronology, and lithic typo-technology point to an Early Pleistocene date for the Kurtan locality and suggest that Kurtan presents the earliest hominin *in situ* site in Armenia to date. This locality illuminates Early Pleistocene cultural and biogeographic connections between the Caucasus and the southern Levant and serves to fill in the gap in our knowledge of early hominin presence in the region during the Early Paleolithic.

Early Middle Stone Age Technology at the New Site of Loc 305 in the Kapthurin Formation, Kenya

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The emergence of Middle Stone Age (MSA) technology signals an important shift in the human behavioral repertoire, which now included hafted tools, carved bone implements, aquatic resource procurement, transport of water and raw materials, and symbolic expression (Clark 1988; McBrearty and Brooks 2000; Henshilwood and Marean 2003). MSA artifacts are associated with *Homo sapiens* fossils at a number of sites, suggesting that the initial appearance of MSA technology coincides with the origin of our species (McBrearty and Brooks 2000). Yet the nature of the earliest MSA lithic technology and the precise timing of its appearance remain incompletely understood. Prior research in the Middle Pleistocene Kapthurin Formation near Lake Baringo, Kenya, has contributed to our understanding of late Acheulian (Johnson and McBrearty 2010) and early MSA technology (Tryon 2006), as well as demonstrating interstratification between them (Tryon and McBrearty 2002). Here we present preliminary results of the lithic technology, summary stratigraphy, and depositional environment of MSA artifacts at Loc 305, a new site in the Kapthurin Formation. Excavation in June and July 2009, of an area of $17m^2$ at Loc 305, yielded 2,231 artifacts, including *in situ* Levallois cores, blades, and points, as well as other retouched tools typologically and technologically characteristic of the MSA. Surface collection over an area of $74m^2$ produced over 4,000 additional artifacts. The *in situ* artifacts lie below a tuff which has been dated by $^{40}Ar/^{39}Ar$ to 285–235 ka (Deino and McBrearty 2002), and preliminary artifact refitting shows a high degree of spatial integrity at the site. Excavated specimens are primarily in basalt, but surface finds also include artifacts in chert and obsidian. These results will help to clarify the nature of early MSA technology in East Africa.

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Cross-Sectional Morphology and Mechanical Loading in Plio-Pleistocene Hominin Femora: Implications for Locomotion

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Homo erectus was the first hominin to display anatomical traits consistent with the modern human form of obligate terrestrial bipedalism nearly 1.8 mya. Pre-*H. erectus* hominins retain some anatomical evidence of ancestral adaptations to arborealism with increasing adaptations to terrestrial bipedalism over time. The amalgamation of ancestral and derived traits, and the mosaic nature of human evolution have complicated reconstructions of fossil hominin locomotor behavior. A biomechanical approach may help elucidate the locomotor behavior of early hominin groups. This study investigates femoral cross-sectional properties in Plio-Pleistocene hominins to determine if mechanical loading patterns are consistent with modern human-like locomotion, *Pan*-like locomotion or intermediate locomotor behavior. Mechanical loading patterns in the proximal and midshaft femur of fossil *Homo* sp. and *H. erectus* are generally commensurate with modern human-like patterns. Mechanical loading patterns in the proximal femur of *Paranthropus* are more similar to modern human-like patterns than to *Pan*-like patterns, which suggests a mode of locomotion kinematically more akin to *Homo* than to *Pan*. Mechanical loading patterns in the midshaft femur of *Paranthropus* (KNM-ER 1592) are similar to modern and fossil *Homo*,

which either indicates that paranthropine locomotion was similar to *Homo*, or that KNM-ER 1592 is not representative of *Paranthropus*. OH 34 and OH 62 are more similar to *Pan* than to modern humans in cortical area (CA) versus average bending and torsional strength (J0.73). Preservation bias in the Olduvai femora may be influencing the results, or locomotor variability was present in fossil *Homo*. The relationship between M-L and A-P bending strength is similar in modern humans and *Pan* despite obvious locomotor differences between the two groups. It is possible that different mechanical demands could potentially yield similarities in diaphyseal shape, which further complicates interpretations of this property.

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An Examination of Hominin Tooth Morphology Using EFFA

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Hominin dental occlusal morphology has been of particular interest in discussions on the origins of the genus *Homo*. This study involves obtaining the outline of the crown of hominin molar teeth by employing Elliptical Fourier Function Analysis (EFFA), a curve-fitting function particularly suited for the characterization of boundary outline data of complex irregular morphologies. The analysis includes images of teeth classified as *Australopithecus robustus*, *A. africanus*, *A. sediba*, and specimens assigned to early *Homo*. The digitization process involves creating two-dimensional bounded outline tracings of the occlusal surface of the same tooth type across hominin specimens via digital photographs, and computing harmonics and amplitudes using EFFA. The EFFA results are used as variables in multivariate statistical analyses, including principal components analysis, cluster analysis, and discriminant function analysis. The results of the study indicate that no discernible pattern is evident that distinguishes the occlusal surface shape of teeth of the various taxa after a moderate level of occlusal attrition has occurred. These results suggest that australopith and early *Homo* teeth have overall similar occlusal shapes and are therefore difficult to discriminate. Alternatively, the similarities in shape between the hominin specimens could indicate misclassification of the a priori groups, as discriminant function analysis indicates that several specimens typically attributed to early *Homo* classify with a higher probability as australopiths. Thus, the occlusal morphology is likely more variable than has been suggested and, therefore is a less robust method for distinguishing between hominin teeth and for establishing phylogenetic relationships.

A Pre-Howiesons Poort Small Backed Blade MSA Occurrence at Pinnacle Point

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Features most commonly identified with the Howiesons Poort (HP) are: 1) utilization of more fine-grained raw materials; and, 2) retouched tools that include backed and notched pieces. Jacobs et al. 2008 demonstrated that HP assemblages across southern Africa date to between 60-65 ka and represent one of two 'marker horizons' in the southern African MSA. The other is the Still Bay (SB) at 71 ka. At PP5-6 there are at least two small blade entities that meet criteria 1) and 2) above. The more recent occurrence has been OSL dated to 65-60 ka. The second small blade entity, in Layer SADBS, is capped and separated from the PP5-6 HP by a thick sand dune dated to 69 ± 3 ka (Brown et al. 2009). This ~70 ka dune is similar in appearance and chronology to the dune layer that marks the end of the SB sequence at Blombos Cave (Jacobs et al. 2003a,b). OSL ages for the SADBS layer (c. 71-72 ka) are approximately contemporary with the SB, the age of which is centered at ~71 ka (Jacobs et al. 2008). The PP5-6 SADBS assemblage and SB, though similar in age and close in proximity, are technologically distinct. There are now a series of occupations within recently excavated sites that are 'Howieson's Poort looking' but do not necessarily meet the 'classic' definition of the HP (Porraz et al. 2008). Rather than trying to fit these assemblages into large stratigraphic blocks that obscure subtle but potentially important regional and temporal variation, the MSA might best be viewed occupation to occupation along a chronological continuum rather than as replacement (e.g., MSA I replaced by MSA II which is replaced by HP, etc.). Obviously this type of approach requires that all sites be carefully excavated and systematically dated by comparable techniques that can stand up to scrutiny.

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A Preliminary Paleoneurological Survey of the Endocast From Buia (UA-31)

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A fossil cranium (UA-31) was recovered in 1995 near Buia, in the Northern Danakil Depression of Eritrea, and dated ca 1 Ma. The neurocranium is nearly complete, allowing the reconstruction of a high-quality resin model of the endocranium. The cranial capacity is 995 cc. The braincase is undeformed, and general endocranial morphological feature can be recognized and described. The endocast is elongated antero-posteriorly, appearing long and narrow when compared with the endocranial variability of archaic humans belonging to the Lower and Middle Pleistocene fossil record. The occipital lobes are strongly projecting posteriorly and the cerebellar lobes lie under the occipital lobes, separated from the temporal lobes. The frontal lobes are narrow with respect to the maximum endocranial width, which is positioned on the lower parietal areas. Although the upper parietal surface is depressed, its lower parts show a marked bossing at the supramarginal gyrus. The endocast exhibits the basic pattern of asymmetries commonly described for the genus *Homo* and correlated with right-handedness: the Broca's cap is more shaped on the left side, the frontal lobes are wider on the right side, and the occipital volumes are larger and most posteriorly projected on the left hemisphere. Venous channels are not easily identified, while the arterial network can be recognised, showing scarce reticulation and definite dominance of the posterior branches. Apart from very low values for the latero-lateral diameters (frontal width, maximum width, parietal arc widths), bivariate and multivariate morphometrics suggest a general phenotypic affinity with archaic humans (*H. ergaster/erectus*). Hence, in terms of endocranial morphology UA-31 can be interpreted as a very dolichocephalic archaic hominin. It remains to be considered whether the marked lower parietal bossing is a structural consequence of dolichocephaly, a normal individual/geographical trait, or a feature with possible phylogenetic relevance.

Testing the Stratigraphic Integrity of Middle and Upper Paleolithic Deposits at Vindija Cave

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Vindija Cave in northwest Croatia is a stratified cave containing cultural materials and archaic human fossils significant for understanding the Middle to Upper Paleolithic transition in Central Europe. Excavations carried out in the 1970's and 1980's revealed an association of Neandertal remains with Upper Paleolithic bone and stone tool types in Level G1. The typological designation of this assemblage remains ambiguous due to the presence of both Middle and Upper Paleolithic stone tool types and the potential for these deposits to be mixed by post-depositional processes has been suggested as an explanation. A recent archaeological study was undertaken with the aim of testing the stratigraphic integrity of these deposits and to determine to what extent the cultural assemblages are intact or undisturbed. Systematic refitting of the chipped stone artifacts within and between all stratigraphic levels was carried out and five percent of the assemblage was successfully refit. The vertical distribution of refitting artifacts throughout the Middle and Upper Paleolithic deposits demonstrates that post-depositional movement of artifacts has occurred between discrete sedimentary deposits and strongly suggests that the stratigraphic integrity of these materials is compromised. This paper presents the results of the study and discusses the role that vertical displacement of cultural materials and fossil remains may have played in the composition of artifact assemblages.

New Reconstructions of Hominin Foraging Behavior on Olduvai Paleolandscapes

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Since 2006, research by The Olduvai Paleoanthropology and Paleoecology Project (TOPPP) has produced high-resolution reconstructions of the foraging behavior of Early Pleistocene hominins at Olduvai Gorge, Tanzania. TOPPPs approach is to focus renewed excavation at key anthropogenic sites known from the Leakeys' work and to work laterally from these known locations of hominin activity into equivalent deposits representing the surrounding paleolandscape placing hominin activities in paleoecological context (Dominguez-Rodrigo et al. 2010). Several examples illustrate the notable success of this approach for clarifying hominin foraging strategies. Excavating trenches around the accessible periphery of FLK Zinj (1.835 Ma) in Middle Bed I reveals a previously unrecognized freshwater spring 200 meters away at FLK NN creating a wooded "oasis" setting in an otherwise unappealing grassy landscape.

This natural magnet attracted herbivores, and the carnivores and hominins preying on them. The combined evidence of the spring, skeletal profiles, defleshing cut marks, and bovid mortality profiles indicates why early *Homo* focused on the location and that they were probably capable hunters with significant access to meat. In Upper Bed I at FLK North (1.785 Ma), new taphonomic analysis of another classic "living floor," indicates a bone assemblage produced predominantly by felid predation/feeding and hyena scavenging (Dominguez-Rodrigo et al. 2007). Again, there is an associated freshwater spring providing another oasis-like setting partially surrounding FLK North. Hominin butchery evidence is minimal but notable in that limb bones defleshed by hominins were not then broken with hammerstones for accessing marrow. Hominins used the location as an extractive site for obtaining meat and other food resources (plants?) before departing for secure destinations elsewhere. In Upper Bed II, BK (1.2 Ma) is a rich, multi-level site in proximal floodplain sediments adjacent to a larger stream, with abundant butchery evidence of macro- and megafaunal remains and two hominin limb elements discovered in 2010.

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Interpretations of the Endocast of *Australopithecus sediba* (MH1)

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In 2008, a Plio-Pleistocene site in the Cradle of Humankind known as Malapa was discovered. Hominin remains from the site include two partial skeletons both with associated craniodental and postcranial remains (Berger et al. 2010). The site has been dated to between 1.95 and 1.78 my, with the hominin partial skeletons originating from Facies D (approximately 1.90 my) (Dirks et al. 2010). The Malapa hominin specimens represent a new australopithecine species from southern Africa, *Australopithecus sediba* (Berger et al. 2010). One of these partial skeletons (MH1) represents a juvenile male, and includes much of an undeformed skull (UW88-50). The facial skeleton, frontal bone, and left parietal bone of this specimen are intact, while right parietal and left temporal bones are fragmentary. The right temporal and occipital bones appear completely absent, leaving no evidence of the cranial base. Thus, anterior and middle cranial fossae are present, while the posterior cranial fossa is absent. An in silico preparation approach was used to produce a preliminary endocast from medical CT images, from which the initial cranial capacity estimate of 420cc was derived (Berger et al. 2010). Here we evaluate a new MH1 endocast produced in silico using high resolution synchrotron-acquired images (voxel size=91 microns) and provide an updated cranial capacity estimate. We also assess hemispheric asymmetry for the first time, and compare MH1 endocranial morphology to that of specimens attributed to *Au. africanus* (e.g., Sts 5 and Stw 505). We comment on implications that the MH1 endocast has for interpretations of brain expansion and reorganization in human evolution, particularly with regards to the emerging Genus *Homo*.

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Sacroacetabular Load Transfer and Sacral Stabilization in the Pelvis of *Australopithecus sediba*

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The pelvis of the Plio-Pleistocene hominin *Australopithecus sediba* represents an intermediate form between that of the small-brained, facultative bipeds of the earlier Pliocene and the large-brained, obligate bipeds of the later Pleistocene. As such it presents a mosaic of primitive and derived features, clustering with Australopiths in some aspects of its morphology and with early *Homo* in others. One apparent synapomorphy shared with *Homo* involves enhanced robusticity of the auricular-to-acetabular load transfer region of the iliac body, and reinforcement of the sacroiliac joint through hypertrophy of the posterior sacroiliac ligaments, relative to the condition seen

in Australopiths. To evaluate this possibility, we collected data on acetabulosacral buttress thickness, acetabulosacral weight transfer moment arm, auricular surface area, and anteroinferior-posterosuperior diameter of the postauricular surface of the iliac blade from original fossils and casts representing *Australopithecus afarensis*, *Au. africanus*, *Au. robustus*, *Au. sediba*, *Homo erectus*, *H. heidelbergensis*, *H. neanderthalensis*, and early Pleistocene African *Homo* sp. indet. Data also were obtained on a sample of 107 modern human skeletons from the Raymond Dart collection at the University of the Witwatersrand. In measures of iliac body robusticity and relative expansion of the postauricular surface of the ilium, *Au. sediba* clusters with early and recent *Homo*, while absolute and relative auricular surface area is more similar to that seen in *Australopithecus*. These findings, in conjunction with an apparent increase in the thickness of the sacral alae, belie a pelvis adapted to withstand higher magnitude forces in locomotion than those incurred by earlier Australopiths, perhaps related to a change in bipedal kinematics (involving reduced force damping along the kinematic chain) or an enhanced role of running (and the production of high magnitude ground reaction forces) in the locomotor repertoire of *Au. sediba*.

A Techno-Typological Reassessment of an Alleged Upper Paleolithic Assemblage from Visadi (Northwestern India)

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Evidence of the Upper Paleolithic in northwestern India is scarce and comes from very few sites. A quartz-dominated lithic assemblage from Visadi is the only Upper or Late Paleolithic site from Gujarat, a state in northwestern India roughly equivalent in size to Nebraska. The Visadi assemblage came from a fossil sand dune located during a Cambridge-University of Baroda expedition in the 1970s. The Visadi lithics were attributed to the Upper Paleolithic due to: 1) a lack of geometric microliths, 2) presence of burins; and, 3) the overall larger size of artifacts relative to Mesolithic industries in the area (Allchin et al. 1978). However, recent data on the distribution of Paleolithic sites in the region (Ajithprasad, 2005) and the geochronology of the fossil dunes of southern Gujarat (Juyal et al. 2003) make previous assessments questionable. New analysis of the Visadi lithics was done to test the hypothesis that the assemblage exhibits stronger affinities with Mesolithic than Upper Paleolithic technology. The Visadi sample was reevaluated and compared to quartz-dominated collections from Gujarat and Upper Paleolithic sites in the broader region of northwestern India. This study found few types in the Visadi sample that support an Upper Paleolithic attribution. Moreover, the assemblage cannot be ruled out as Mesolithic from a technological perspective. Several lines of evidence suggest that Visadi represents an Early Holocene, Mesolithic site. This revision underscores a massive gap in the Late Pleistocene prehistory of northwestern India stretching from Middle Paleolithic to Chalcolithic /Harappan times. Although microblade-based Late Paleolithic industries are known from ~40,000 BP in mainland India, the state of Gujarat has not yielded evidence for pre-Holocene microliths. There are no known Upper or Late Paleolithic sites in Gujarat State. This suggests that there is little archaeological support for the southern dispersal hypothesis (*sensu* Mellars 2009) in coastal northwestern India.

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The Relative Efficacy of Functional-Developmental Cranial Modules for Reconstructing Hominoid Phylogeny: Implications for the Reconstruction of Hominin Phylogeny

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Reconstructing hominin taxonomy and phylogeny are fundamentally important endeavors within paleoanthropology yet, in the absence of direct genetic evidence, are largely reliant on assessments of morphological affinities within and between paleospecies. Moreover, inferences of hominin phylogeny are often dependent on craniodental data given the prevalence of preserved crania in the fossil record. Recent comparisons of human craniometric and neutral genetic affinities (Harvati and Weaver 2006; Roseman 2004; Smith 2009; von Cramon-Taubadel 2009) have overwhelmingly supported a neutral model of evolution for the human cranium, although some cranial regions have been found to be more reliable for reconstructing population history than others. In order to extend these results to make accurate inferences regarding hominin affinities, it is necessary to test the extent to which genetic and craniometric congruence patterns in other primate taxa match those found in modern humans. Here we present a study which assesses the reliability of four functional-developmental cranial modules (FDMs)—the basicranium, splanchnocranium, neurocranium, and mandible - for

reconstructing the phylogeny of hominoid taxa. The data comprise 129 cranial and 33 mandibular landmarks digitized for 15 hominoid taxa. Mahalanobis distances among taxa were calculated based on each FDM as well as for the entire cranium. Neighbor-joining phenograms were generated and compared to the hominoid consensus molecular phylogeny. Although none of the phenetic datasets could recover the molecular topology correctly, the relationships of taxa within genera were generally accurately assigned. An analysis of topological differences between the consensus phylogeny and each phenogram found that the entire skull most accurately recovered the hominoid phylogeny, followed by the neurocranium, chondrocranium, splanchnocranium, and mandible. These results mirror those found in previous studies of human FDMs, suggesting that some regions of the primate cranium may be more phylogenetically informative in general. These results have important implications for inferring phylogeny in the fossil record.

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Expanding Ecomorphological Methods: Geometric Morphometric Analysis of Artiodactyl Post-Crania

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While there is currently a robust group of caliper-based ecomorphological methods for reconstructing paleoenvironments, geometric morphometrics (GM) is still under-utilized in ecomorphology. GM substantially augments ecomorphological studies by evaluating the skeletal region of interest as a whole and allowing for visualizations of shape difference between different morphotypes, which is important for extinct species. This study evaluates the functional morphology of the rear limb of artiodactyls in an ecological context. Four morphological units of analysis from the femur, tibia, calcaneus, and third phalanx are analyzed using both landmark-based and outline-based GM procedures. The order Artiodactyla was selected due to its frequent dominance in paleoanthropological assemblages in Africa and Eurasia. The Bovidae have been shown to be good proxies for paleoenvironments in past studies utilizing caliper-based methods. This study analyzes bovid ecomorphology using GM methods established for cervids (Curran 2009). In CVAs of the four different morphological units, extant bovid specimens had 67.6–70.3% correct reclassification into their known habitat groups with resubstitution and 32.2–41.7% with cross-validation. In combination with cervid data, correct rates of reclassification were 41.9–79.1% (resubstitution) and 40–66.3% (cross-validation). Specimens also were scored along a single canonical variate (Habitat Score in Scott 2004), wherein the calcaneus and third phalanx had continuous distribution from Open/Dry to Closed/Wet habitat conditions, while femoral and tibial specimens had a more discrete distribution (Closed or Not-Closed). Using GM visualizations along each axis, functional interpretations are provided for each skeletal unit of analysis. The methods presented here provide a new proxy for reconstructing habitats of paleoanthropological sites, elucidating the range of habitats utilized by large mammals associated with hominins.

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Lakeshores, Hydrology, and Topography of Holocene Lake Turkana Basin: Models of Early, Mid, and Late Holocene Landscapes

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The Lake Turkana Basin is an important area for understanding changes in food production and subsistence. Studies by the co-authors focus on 1) the role that the acquisition and use of obsidian raw material had on the mobility of mid-Holocene pastoralists, and 2) the ecology and lifeways of early Holocene fishing peoples. Fundamental to both authors' research is the creation of topographically informed landscape scale models of the Lake Turkana Basin. The present Lake Turkana is surrounded by remnant paleoshore features. These features indicate that in the early and mid-Holocene Lake Turkana had a greater extant. Digital terrain models, landscape, and shoreline reconstructions help us to understand and interpret archaeological evidence. Such models underpin analyses of site distribution, raw material source utilization, mobility patterns, and land use. The reconstruction of paleo lake shorelines is an intricate meeting of techniques from geology, climate, lacustrine, and hydrology modeling, geospatial technologies, and archaeology. Remnant lacustrine landforms were identified using satellite imagery and aerial photography. Although these markers of the previous extant of Lake Turkana can be identified, the sediments are discontinuous. Digital terrain models derived from differential GPS measurements and satellite imagery can be used to fill in the gaps. Maps of Holocene lake extant contours for early, mid, and later Holocene periods have been delineated. Additionally various hydrological and geomorphological features for each lake extant period have been projected on

to the lake extant maps. A discussion of the results of using an automated lacustrine modeling tool will also be presented. Lastly major changes in the extant of the modern Lake Turkana are anticipated due to the construction of dams along the Omo River and a model of the changes to Lake Turkana that may result from this development is presented.

Making Tracks Into the Pleistocene: Gait Analyses of Unshod Daasanach Provide Stature and Speed Estimates for Fossil Footprints

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Recently discovered fossil footprints from 1.5 million year old sediments at Ileret, Kenya (Bennett et al. 2009), raise questions about the hominins who made the prints, as well as broader questions about the evolution of modern human gait. However, detailed interpretations of these and other fossil footprints are hampered by the lack of information regarding the relationship, in unshod populations, between the gait, speed, and size of the footprint maker and how these factors influence the formation of prints. In this study, we report results from controlled experiments using habitually unshod and minimally shod male (N=10) and female (N=10) Daasanach subjects living in the vicinity of Ileret, near the northeast shore of Lake Turkana, Kenya. Biometric data including foot length, lower limb length, stature, and weight were recorded for each subject. 2D kinematic data were captured on video, and later digitized and analyzed using Peak Motus software. Each subject used three walking and two running speeds across an open-ended trackway, with a 125x50x15cm section of rehydrated sediment taken directly from the fossil footprint layer at the FwJj14E site. Results show that Daasanach male mean stature (162cm), lower limb length (96cm) and foot length (26.2cm) exceeded those of females (174, 87, and 24.2cm, respectively). Analyses of the experimental data show significant relationships between stride length and speed across walking speeds (r^2=0.82, $p<0.01$), running speeds (r^2=0.87, $p<0.01$), and the full range of speeds (r^2=0.91, $p<0.01$). These data are used to estimate speeds from several partial trackways at the FwJj14E site, and provide stature estimates from the lengths of footprints of multiple individuals. The stature estimates range from 146cm to 174cm, providing evidence of relatively large body size in these 1.5 Ma hominins.

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Flint Acquisition and Transport in the Caucasian Eastern Micoquian

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Studies of raw material exploitation through the Paleolithic allow us to define human adaptation strategies and to obtain new data on mobility and social networking of ancient populations in different regions and ecological niches (Demars 1982; Geneste 1985; Féblot-Augustins 1997; Gregoire 2000; Andrefsky 2009). The authors of this paper obtained petrography data and carried out research on lithic collections from four Eastern Micoquian sites in the Northern Caucasus: Mezmaiskaya and Matuzka caves, the Baranaha 4 open-air site, and the Hadjoh-2 workshop. Data for Gubs gorge (Monasheskaya and Barakaevskaya caves and Gubs I Rockshelter) and Ilskaya I–II sites were obtained from published reports; petrography analysis had never been done for them. Regional flint outcrops were examined by us during field surveys in 2007–2010; a series of samples were collected from all of them. These studies are on-going. Our research so far shows that Neanderthals preferentially exploited local (0–5km) flint sources. Except for Matuzka cave, Eastern Micoquian sites in the Northern Caucasus were always located near raw material sources. In addition to these local resources, Neanderthals actively used high-quality flints transported into the sites from distant sources (30km and more), mostly as retouched tools or flakes; cores made on these flints are rare. High-quality Belsleneevskaya flints were brought in to almost all Eastern Micoquian sites in the region. An especially important finding is the discovery of long-distant (up to 200–300km) movements northward, into the steppe areas of the Eastern coast of the Sea of Azov, to procure high quality flints. Near those outcrops, several Eastern Micoquian sites are known (examples are the open-air sites of Rojok and Nosovo). In addition to high-quality flints, obsidians found in the Middle Paleolithic layers at Mezmaiskaya were derived from sources located near Zayukovo village in the North-central Caucasus (approximately 200km eastward from the cave; Golovanova et al. 2010).

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Landscape Neotaphonomic Studies and East African Carnivore Guild Structure: Modeling Hominin Scavenging Opportunities

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Landscape-scale bone assemblage structure and the amount of carcass resources available for hominin consumption are determined in part by population densities of carnivores and by carnivore guild structure. Because of hyenid bone-cracking adaptations, their population density compared to that of other carnivores such as meat-slicing large felids has a large impact on what animal resources remain on the landscape after the initial predation event. Based on his observations in the Serengeti National Park/Ngorongoro Conservation Area (Tanzania) ecosystem, Blumenschine (1989) argued that in a single landscape, areas with large numbers of hyenas, particularly spotted hyenas (*Crocuta crocuta*), will present fewer scavenging opportunities for hominins. Neotaphonomic surveys (Faith and Behrensmeyer 2006) document the effects of changing spotted hyena densities over time on bone survival and carcass fragmentation in the Amboseli National Park (Kenya) ecosystem. In this study, we compare data on carcass fragmentation and bone destruction from Blumenschine's Serengeti/Ngorongoro study with long-term data from Amboseli and new data from the Shompole Conservation Area in southern Kenya. We test the generality of the relationship between spotted hyena density and carcass fragmentation across different habitats and through time. In environments with the highest spotted hyena density, we find the lowest MNE/MNI ratios (an index of carcass completeness), depressed axial skeletal element frequencies, and high levels of damage to individual skeletal elements. Based on our observations in modern ecosystems, it is clear that past hominin meat-eating opportunities must be considered in the context of dynamic ecosystems in which the abundance of bone-cracking carnivores can change over time and across habitat boundaries. Past scavenging opportunities would be expected to increase in times and places where bone-cracking members of the carnivore guild were relatively rare, suggesting that the abundance and paleolandscape distribution patterns of associated stone artifacts and hominin-modified vertebrate remains could reflect varying Plio-Pleistocene carnivore guild structures.

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Taphonomy of the Large Mammals From Boomplaas Cave and its Implications for Middle and Later Stone Age Subsistence and Settlement Patterns in the Cape Floral Region, South Africa

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Excavations at Boomplaas Cave uncovered Middle Stone Age (MSA) and Later Stone Age (LSA) artifacts and faunal remains spanning the last ~80,000 years. Boomplaas Cave is located 80km from the present coastline in southern Africa's Cape Floral Region (CFR), and presents an opportunity to examine human activities in an inland setting. Taphonomic analysis of the large mammals indicates differential bone accumulation by humans and carnivores through time. Bone surface modifications indicate that carnivores accumulated the majority of the Pleistocene fauna associated with MSA artifacts. This is consistent with low densities of artifacts and hearths, suggesting ephemeral human occupation. Carnivores remain an important accumulator of the faunal remains in the LSA deposits during the Last Glacial Maximum (LGM), and there is an increasingly strong anthropogenic signal at the end of the LGM, leveling out at the initial Holocene. This trend matches temporal frequency curves derived from radiocarbon dates that indicate increasing human population densities following the LGM. Recent dates from coastal MSA CFR sites, including Pinnacle Point and Blombos Cave, indicate that these sites were primarily occupied during high sea-level stands that brought the coastline within the vicinity of the caves. This may reflect an MSA adaptation geared toward the exploitation of coastal resources. At Boomplaas Cave, where coastal resources were not available, the evidence suggests low-level human occupation throughout the MSA. This is consistent with the hypothesis that coastal resources played a determining role in mediating MSA settlement patterns within the CFR. Rich MSA sequences outside the CFR (e.g., Sibudu and Border Cave), combined with intermittent occupation of CFR localities suggest the CFR was a relatively impoverished terrestrial habitat for hunter-gatherers in the absence of coastal resources. Substantial human occupation of inland CFR localities may have only taken place within the last 18,000 years by LSA humans.

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Ecomorphological Analysis of the Bovid Mandible Using 3D Geometric Morphometrics, With Application to Middle Pleistocene Paleoecology at Elandsfontein, South Africa

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Ecomorphological analysis is a method of determining an animal's habitat or dietary preference by examining the relationship between these ecological parameters and functional morphology. Bovids inhabit a wide range of habitats and are often well-represented at hominin localities, so are particularly well-suited for ecomorphic analysis. Traditionally such analyses have been performed using either qualitative assessment or multivariate statistical analysis of linear (2-dimensional) caliper measurements of morphologically variable aspects of the skeleton. These measurements have been useful in determining an animal's habitat preference, but they can be improved upon by using methods that reflect shape variation and exhibit how landmarks relate spatially to one another (Adams et al. 2004; Rohlf and Marcus 1993). Here we expand ecomorphological methods beyond two-dimensional morphometrics (Spencer 1997; Sponheimer et al. 1999) by presenting a three-dimensional geometric morphometric (GM) analysis of the bovid mandible. GM maintains relational geometric information of 3D data, treating objects as whole units and thus providing a more accurate quantification of shape. GM analysis of extant taxa, using a 40 landmark protocol, clearly distinguishes between mandibles of modern bovids with various dietary preferences including obligate browsers, mixed feeders preferring browse, mixed feeders preferring grass, obligate grazers, and fresh grass eaters (after Sponheimer et al. 1999). We applied these methods to fossilized mandibles from the Acheulean site of Elandsfontein, South Africa (EFTM deposits, ca. ~1 Ma–600 Ka). Using an 18 landmark protocol, there was still a clear separation between purely grazing and purely browsing taxa although specimens in the mixed feeding and FG categories were less clearly separated. Five taxa (tribes) were sampled from the EFTM fauna including Neotragini (n=5), Reduncini (n=4) Antilopini (n=2), Alcelaphini (n=2), and Bovini (n=1). The fossil Alcelaphini and Reduncini cluster with the modern taxa eating mainly grass and fresh grass while the fossil Antilopini cluster with the extant browsers and mixed-feeding browsers. The one Bovini specimen (*Pelorovis antiquus*) examined falls between the grazing and browsing taxa. The Neotragini cluster most closely with the browsers and mixed-feeding browsers although one of the specimens (*Raphicerus*) overlaps with the fresh grass eating taxa. The results of this pilot study show that this method has promise for the investigation of the feeding ecology of extinct Bovidae.

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Middle Pleistocene *Homo* and the Origin of Neandertals—A 3D Morphometric Analysis

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The morphological variation of hominins falling somewhere between *H. erectus* and *H. sapiens* is the subject of a longstanding debate on taxonomy and phylogeny and has recently regained attention, though several aspects remain without consensus. One question relates to the presence of Neandertal vs. modern human features in Middle Pleistocene hominins, now often assigned to *H. heidelbergensis*. A number of characters discussed in the literature, such as globularity, concern overall cranial shape and proportions, for which few specimens are available. Others, such as parietal expansion, occipital bunning, or midfacial prognathism are not easy to quantify with linear or standard landmark-based geometric morphometrics. Yet, the increasing availability of 3D surface models allows for an extension of quantitative analyses to entire cranial surfaces, thus increasing our ability to re-assess morphometric affinities. For this study, a large number of landmarks and semilandmarks was extracted from surface scans of the braincase and the face, in order to quantify the entire calvarial shape differences between species and key fossils. Analyses of the overall shape and of parietal expansion were conducted on a sample comprising 12 to 30 fossil hominins, depending on preservation. A random sample of modern humans was also included. The results confirm that Neandertals and modern humans share evolutionary trends that separate them from earlier hominin groups such as *H. erectus* and *H. rhodesiensis*. These results provide some support for an Afro-European definition of *H. heidelbergensis*, but emphasize the more ancestral morphology of *H. rhodesiensis*.

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Lower Pleistocene Hominid Settlement in Northeastern Spain: Vallparadís (Barcelona)

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The Vallparadís site has recently become one of the most important Lower Pleistocene sites in Europe. The ESR/U-series method has given age of 0.83±0.07 Ma for archaeological Level 10. This date agrees with the palaeomagnetic data, which situate this level in a magneto-zone of inverse polarity between the Matuyama-Brunhes limit and the Jaramillo subchron (0.98–0.78 Ma). The biochronological information is consistent and contains the following rodent species: *Mimomys savini*, *Ungaromys* sp., *Eliomys quercinus*, *Sciurus* sp., and *Iberomys huescarensis*. The fauna includes *Pseudodama vallonetensis*, *Sus* cf. *scrofa*, *Equus altidens*, *Premegaceros verticornis*, *Bison* sp., *Stephanorhinus hundsheimensis*, *Hippopotamus antiquus*, *Elephas antiquus*, *Lynx* sp., *Canis mosbachensis*, *Ursus deningeri*, *Panthera gombaszoegensis*, *Pachycrocuta brevirostris*, and *Macaca sylvanus* cf. *florentina*. Twelve elements (1.6%) have cut marks and others elements show anthropic fractures (0.6%). The high index of hyena bite marks (42.7%) suggests competition between carnivores and humans for the same resources (Martínez et al. 2010). The lithic industry is Oldowan and is basically characterized by its use of local raw materials, the short development of the *chaîne opératoires*, small-size artifacts, orthogonal-hard-hammer-on-anvil technique, retouched denticulate and notched tools, and other more specific instruments such as becs. The Vallparadís site means that the Iberian Peninsula now has a demonstrated complete archeological sequence starting at 1.4–1.2 Ma with the sites of Atapuerca (Carbonell et al. 1995, 2008) and Orce (Martínez-Navarro et al. 1997; Oms et al. 2000), and continuing up to the Matuyama-Brunhes limit. Analyses of the pollen found in the Vallparadís sequence and the neighbouring Cal Guardiola site and of the herpetofauna in Level 10 show important changes in climate and landscape throughout this chronological period. Despite these environmental changes, the archaeological evidence found in the Vallparadís, Atapuerca, and Orce sites seems to confirm that humans populated continuously the southern regions of Europe throughout the Late Lower Pleistocene.

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Early Acheulean Technology Excavated From Pre-Victoria West Levels at the Site of Canteen Kopje, South Africa, Dated With Cosmogenic Nuclides

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Earlier Stone Age artifacts from the site of Canteen Kopje, near the town of Barkly West in the Northern Cape province of South Africa, have been discussed and debated since stone tools were discovered there by early diamond miners. The majority of these works have focused on the Victoria West prepared core industry found in the calcretized alluvial deposit. The pre-Victoria West levels have received significantly less focus. Our ongoing study has so far recovered several thousand artifacts excavated from these older levels. Cosmogenic nuclide burial dating was undertaken at the site to determine the age of these artifacts. Four samples were taken within the pre-Victoria West deposit for dating using a profile method. This approach is used to date shallow deposits by analyzing multiple samples from different depths in a vertical profile. The age of these samples was solved for simultaneously, yielding a burial age of 1.53 ±0.09 Ma for this package. This age is consistent with our other cosmogenic dating work in the Vaal River Basin (Gibbon et al. 2009) indicating the widespread distribution of the Early Acheulean in the region by ca 1.6 Ma.

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Does Antemortem Tooth Loss in *Homo neanderthalensis* Indicate Human-Like Behavior? Evidence From a Comparative Approach

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Since 1979 anthropologists have explained the survival of *Homo neanderthalensis* individuals with severe antemortem tooth loss (AMTL) as a result of human-like behavior in this extinct species; the behaviors implicated range from conspecific care to cooking but are all currently unique to *Homo sapiens* and would imply more ancient evolutionary roots if also practiced by Neandertals. The purpose of this study is to test one prediction of these explanations-that modern humans and *Homo neanderthalensis* differ in their frequency of AMTL from non-human primates. This study tests the above prediction by investigating AMTL in a sample of 590 recent hunter-gatherers, *Homo neanderthalensis*, *Pan troglodytes*, *Pongo pygmaeus*, and *Papio* sp. The results of this data collection show that the average proportion of teeth remaining at death in humans is lower than any other species; Mann-Whitney U and Kolmogorov-Smirnov two-sample tests of the data indicate that the human distribution has a significantly lower central tendency and is significantly more dispersed than any other sample. None of the Neandertal and non-human primate central tendencies and distribution shapes are significantly different from each other. These preliminary results suggest that humans have a higher frequency of AMTL than non-human primates and therefore support hypotheses that link AMTL to uniquely human behaviors or biology. However, the Neandertal AMTL frequencies observed are significantly smaller than humans and not unlike those recorded in non-human primates; this tentatively suggests that behavioral innovation is not necessary to explain the survival of Neandertals with AMTL. Ongoing analyses of this data will consider age and other variables, but if they do not identify similarities in the patterns of AMTL between Neandertals and humans, they will support the conclusion that behaviors linked to AMTL may instead have evolved after the split between Neandertal and human lineages and be truly unique to *Homo sapiens*.

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The Paleobiogeography of Central Asia: Testing the Validity of the Neandertal Range

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Neandertal features are widely regarded as appearing first in Europe during the middle Pleistocene. The hypothesized expansion of this group into the Near East, Central Asia, and southern Siberia during the late middle and late Pleistocene is documented by multiple lines of evidence, including the archaeological record, hominin fossil morphology, and genetics. However, the array of factors that functioned to maintain isolation between western Eurasian and East Asian hominin populations during this period of time is poorly resolved. The present study is primarily concerned with outlining the possible biogeographical limits of the Neandertal range. The working hypothesis is that the region due east of Okladnikov and Teshik-Tash Caves expresses biogeographical factors that significantly differ from the region due west of these Neandertal sites. The contiguous areas compared here are delimited by creating two polygons that share one side (a line drawn between Teshik-Tash in the southwest and Okladnikov Cave in the northeast). The area of the west and east polygons is 15 degrees by 15 degrees, respectively. The spatial and temporal distribution of geo-referenced Paleolithic sites within the polygons was examined in a global information systems (GIS) environment. Using ArcGIS 9, layers were creating that represent 1) fluctuating biome distributions during glacial and interglacial periods (OIS 5-2), 2) the extent and chronology of Quaternary mountain glaciers, 3) digital elevation models and corresponding measures of elevation variatio; and, 4) faunal and palynological sequences. Paleoanthropological data bearing on the validity of a Neandertal 'territory' during the late Pleistocene also were examined. Results indicate that the biogeography of the region and the existing archaeological and hominin fossil records contain no clear evidence of separation between Neandertal territory and that of East Asian hominins. The implications of these results with regard to Neandertal population ecology will be discussed.

Strengths, Weaknesses, and Advances in Cosmogenic Nuclide Burial Dating

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Cosmogenic nuclide burial dating is increasingly being used to date sites in paleoanthropology and archaeology. The method is based on the radioactive decay of ^{26}Al and ^{10}Be in the mineral quartz. These nuclides are produced by secondary cosmic rays near the ground surface; they subsequently decay after the sediment has been buried by several meters, thereby slowing cosmogenic nuclide production. There are two key issues that must be considered for burial dating to be accurate. 1) Quartz sediment must be buried deeply and quickly, and must be buried only once over the past 10 million years. These assumptions are sometimes violated as sediment is reworked from older deposits. 2) It is important to understand in detail the production of ^{26}Al and ^{10}Be at depth. This has previously made it difficult to date sediment buried by less than about 5–10 meters. Here I will discuss a new burial dating method that uses multiple samples to form an isochron. Isochron methods have been very powerful in many other types of geochronology as a method

to identify and account for contamination. An isochron approach proves equally useful in cosmogenic nuclide methods to identify reworking within sedimentary deposits and to explicitly account for complications due to postburial production. I will present a variety of cases documenting both successes and failures of the burial dating method applied to paleoanthropological sites (e.g., Dali, Atapuerca, Sterkfontein). I will also present isochron burial ages for a suite of three tool-bearing terraces along the Sundays River in South Africa. The Sundays River valley terraces contain abundant artifacts, previously studied by Breuil and Ruddock. We have dated three of these terraces to 0.65±0.07 My, 1.36± 0.21 My, and 1.14±0.20 My.

Exoticism of Portable Art and Ornaments: A Study of Social Networks Around the Last Glacial Maximum

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This research aims to test the hypothesis that portable art objects and ornaments were used to create and maintain social networks in periods of climatic insecurity around the Last Glacial Maximum. In contrast to previous studies that focused on regional iconographic similarities, I identify and source artifacts and raw materials to calculate the distance traveled. This permits an exploration of correlation between the movement of goods and climatic changes. This study includes 1,522 osseous and shell artifacts found in France, Spain, and Italy dated to between 26,000 and 14,000 calibrated years BP. Using precise reconstructions of sea level changes and interpolations of faunal assemblages through GIS, I identify the minimum distance value traveled by each artifact. Statistical tests suggest that distance varies greatly over time, but correlates neither with mean temperature, nor with climate variability. Generally however, the distance traveled by materials increases significantly around 18,000–17,500 cal BP. This coincides with Gamble et al's (2006) initial demic expansion event associated with initial glaciers' retreat. In addition to exploring the connection between distance and population movement, this research compliments the previous studies on portable art and ornaments, as it employs GIS spatial analysis to explore how the artifacts' material can give us information on their role during the Last Glacial Maximum.

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The Primitive Shoulder Blade of *Australopithecus*

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Fragmentary remains have limited our understanding of *Australopithecus* shoulder morphology, but recent discoveries from Dikika (Ethiopia) as well as Malapa (South Africa) and Woranso-Mille (Ethiopia), have greatly expanded the shoulder fossil record. These fossils all share primitive characteristics, but the functional relevance of these traits has been the subject of considerable debate. While some researchers hold that only derived features (e.g., adaptations for bipedal locomotion) merit consideration, others maintain that functional interpretations of early hominin fossils should also include considerations of primitive characteristics. To date, there has been little consensus on how to meaningfully interpret phylogenetically primitive traits in the fossil record. Here, we present new data from the complete scapula of the 3.3 million-year-old juvenile *Au. afarensis* specimen from Dikika (Selam), including considerations of blade characteristics that were previously unavailable for study in earlier reports. We analyzed this specimen in conjunction with an ontogenetic sample of extant great apes and humans and found that certain regions of the shoulder (e.g., infraspinous fossa) reliably distinguished taxa with different locomotor habits and were also modified during ontogeny in line with known locomotor shifts. This suggests that these features are particularly reliable for making functional interpretations of fossils. Notably, the morphology of the Dikika scapula is apelike for many of these characteristics, bolstering the hypothesis that—in addition to bipedal capabilities inferred from the lower limb and foot—this individual was adapted to arboreal locomotor behaviors. This ontogenetic approach also facilitates consideration of the Dikika child's morphology alongside more mature, yet fragmentary *Australopithecus* individuals in a broader comparative context. A consistent picture of a primitive, apelike australopith shoulder is beginning to emerge. Most significantly, the apelike traits seen in *Australopithecus* can be linked with locomotor function in extant hominoids, both across taxa and within groups through ontogeny.

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Body Mass Estimation Using the First Metatarsal in Upper Paleolithic Populations

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Accurate estimation of body size is fundamental to the interpretation of adaptive strategy and life history of fossil hominins. Because fossil hominins are often fragmentary, this paper explores the use of the first metatarsal for the estimation of body mass and stature. Consistent relationships between first metatarsal dimensions and femoral length and head diameter (FHD), recognized as the most

suitable measurements for body mass and stature estimation, were demonstrated by the authors on a series of recent modern humans with varying body sizes and body proportions. The proximal dorso-plantar diameter (DPP) is a good predictor of FHD and therefore body mass. Femur length and hence stature was predicted well by DPP and by metatarsal length. In this paper we test these regressions on a sample of Paleolithic hominins (Neanderthals and early *Homo sapiens*), and a sample of Epipalaeolithic Iberomaurusians from the sites of Taforalt and Afalou. The results show that the Paleolithic groups have a similar relationship between DPP and femoral head diameter as modern humans. There is no significant difference between actual FHD and FHD estimated from DPP. The difference between actual and predicted FHD is significant for the Iberomaurusians. This group exhibits a similar relationship between femur length and FHD to modern humans, but a low DPP relative to metatarsal length indicating a relatively low DPP and normal FHD. To test whether this is the result of genetic drift or environmental differences, a genetically close North African Holocene sample also was analyzed and showed the typical modern human pattern. The difference between the Iberomaurusians and other humans is therefore a result of differences in habitual behavior or physical environment. The environment at Taforalt is characterized by an uneven mountainous substrate and could result in a different force distribution and therefore smaller proximal articulation of the first metatarsal.

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Early *Australopithecus* Taxonomy in Light of New Hominid Fossils From Woranso-Mille (Central Afar, Ethiopia)

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The earliest *Australopithecus* species, *Australopithecus anamensis*, is hypothesized to have descended from *Ardipithecus ramidus* around 4.2 million years ago. *Australopithecus anamensis* is known from Kenya, in deposits dated to between 4.2 and 3.9 million years ago, and in the Middle Awash of Ethiopia in sediments of similar age. Its phyletic descendant *Australopithecus afarensis*, is well-documented from Hadar and Laetoli dating between ca. 3.7 and 2.9 Ma. *Australopithecus afarensis* is a presumed direct descendant of *Australopithecus anamensis*. However, the lack of hominid fossils from the time between 3.6 and 3.9 million years ago remained a major hurdle to explain the apparent gradual transformation. Recent discoveries from Woranso-Mille, a new paleontological site in the Afar region of Ethiopia, have started to fill this gap in the fossil record and to yield new information on the paleobiology of early *Australopithecus*. Preliminary results from the study of the Woranso-Mille fossil hominids indicated that while the proposed ancestor-descendant relationship cannot be falsified, *Australopithecus anamensis* and *Australopithecus afarensis* might represent two ends of a single evolving species. The new Woranso-Mille fossil specimens, combined with the Laetoli specimens, further reduce the amount of morphological and dimensional differences between *Australopithecus anamensis* and *Australopithecus afarensis* although the Kanapoi specimens stand out as more primitive. The Woranso-Mille hominid fossils definitely pose a significant challenge to the taxonomic integrity and current hypodigm of *Au. anamensis*. The Allia Bay specimens appear to share more derived characters of the dentition (particularly the P3) with specimens from the Woranso-Mille and Laetoli. The more primitive dental and mandibular features of *Au. anamensis* from Kanapoi could only be quantitatively and qualitatively enumerated less the Allia Bay specimens. This would require splitting the initial *Au. anamensis* paratype into two taxa. However, it appears to be the most plausible solution to retain *Au. anamensis* as a valid species name.

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Distribution of Mammalian Fauna During the Early Pleistocene of the Koobi Fora Formation, East Turkana, Kenya

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The Plio-Pleistocene boundary marks the beginning of a significant period of climatic, environmental, and faunal change within the Lake Turkana Basin with the expansion of C_4 grasslands. Open savanna environments increased even though mosaic conditions persisted. Coinciding with the changing landscape was the coexistence of four hominin species, and fossil remains from these species are documented from the Koobi Fora Formation on the eastern side of Lake Turkana. In addition to hominins, the Koobi Fora Formation, representing 4 Myr of deposits, yields a diverse record of over 90 species of larger mammals. This study presents a mammalian faunal analysis among three members (Upper Burgi, KBS, and Okote Members) of the Koobi Fora Formation that date from 2.0 Ma to 1.39 Ma, encompassing the period when C4 grasslands came to dominate the local vegetation and when hominins were diversifying. The Turkana Paleontology Database, containing a record of over 11,000 specimens from Koobi Fora, is used to analyze temporal differences in faunal proportions among the three members. Taxa included in the study are Cercopithecidae, Bovidae, Suidae, Equidae, Rhinocerotidae, Deinotheriidae, and Giraffidae. Tribal level abundance analysis is performed for Bovidae, and genus and species level analyses are performed for Suidae, Equidae, and Cercopithecidae. Tests of significance and correspondence are presented. Results show a predominance of Bovidae, Suidae, and Cercopithecidae followed by Equidae, but these taxa are responding differently to the environmental changes. Distribution of bovid tribes indicates certain stability to the environment with species adapted to both closed and open habitats remaining relatively constant. Suid and equid genera show increases in relative abundance of grazing and hypsodont taxa

with dramatic shifts occurring in suid genera between the Upper Burgi and KBS Members and in *Metridiochoerus* species between the KBS and Okote Members. These shifts represent increases in taxa further adapted to grassland habitats.

Multivariate Analysis and Classification of the Apidima 2 Cranium From Mani, Southern Greece

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The Apidima fossil human crania were discovered in 1978 in a karstic cave complex (Apidima A-E) in the Mani peninsula, Southern Greece. Two individuals, Apidima 1 and 2, recovered from a breccia block in Cave A, have been considered as pre-Neanderthals of likely Middle Pleistocene age. Apidima 2 has been considered a female possibly belonging to the same taxon as the Petralona cranium. Together with the Petralona cranium, the two Apidima specimens are among the most significant human fossil discoveries in South-East Europe. Despite their importance, however, little information exists about them in the international literature. Here we re-examine nine published osteometric measurements for Apidima 2, the more complete specimen of the two. We tested these measurements for possible error associated with distortion using row standardization in order to control for outlier values. This procedure resulted in the removal of two variables affected by distortion and/or breakage. We adjusted the remaining variables for size by subtracting the log geometric mean of each variable for each individual from each log-transformed measurement, and conducted a canonical variates and discriminant analysis in order to shed light on the specimen's classification. Results suggest close affinities with Neanderthals, and, contrary to our expectations, not a strong relationship with our Middle Pleistocene sample or with the Petralona specimen in particular. While a review of the site's geology gives a large chronological bracket (400-105 ka) for the Apidima specimens, our findings suggest that the later part of this period fits better with the observed morphology. They further place the Apidima site and specimens among the Middle Paleolithic localities known from the immediate geographic vicinity in the Mani.

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New Explorations and Preliminary Magnetobiostratigraphical Analysis of the Kilombe Acheulian Locality, Central Rift, Kenya

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New excavations and geological analysis have been undertaken at the Acheulian localities of Kilombe in the Central Rift of Kenya. The aims were to increase the faunal sample from the site and refine the stratigraphy and chronology. New fossils recovered from the locality include *Syncerus antiquus*, *Hippotragus* sp., *Hippopotamus* sp., and *Aepyceros melampus* (impala). Early fossils of *A. melampus* are extremely rare and are first found in the Okote Member at Koobi Fora between 1.6 and 1.4 Ma. *S. antiquus* occurs in Olduvai Bed IV at slightly older than 1.1 Ma and a number of southern African sites after 1.1 Ma. The base of the sequence consists of reddish, followed by dark brown clays which contain these faunal remains. The fauna occurs at the interface between the two units and represents an ancient landscape surface. These layers have a normal magnetic polarity and are interpreted as representing the Jaramillo Subchron between 1.07 and 0.99 Ma. The main Acheulian bearing layers record reversed magnetic polarities and date to the end of the Matuyama Chron between 0.99 and 0.78 Ma. The results are compared with recent studies at the hominin and Acheulian bearing Cornelia-Uitzoek locality in South Africa that also has been dated to between 1.07 and 0.78 Ma.

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Tracking Climate-Driven Changes in Neandertal Subsistence Behaviors

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A recent model to explain Neandertal extinction (and replacement by modern humans) holds that four late Pleistocene global cold events reduced the carrying capacity of Neandertal environments, stressed the populations, and never allowed recovery. The current study tests one of this model's assumptions that cold climates in general stressed Neandertal populations. If cold climates stressed

Neandertals, their subsistence behaviors may have changed-requiring intensified use of prey. To test whether intensified nutrient extraction occurred during glacial periods, an analysis of Neandertal butchering was conducted on red deer, reindeer, and roe deer bones deposited during global warm and cold phases from two French sites: Pech de l'Azé IV (Bordes' excavation) and Roc de Marsal (RDM). Analysis of surface modification on all marrow-yielding long bones, demonstrates that bones excavated from the cold levels at each cave have more cut marks (Wald X^2= 51.33, p=<0.001) and percussion marks (Wald X^2= 4.92, p= 0.02) than bones from the warm levels after controlling for fragment size. The proportion of percussion marks on long bones at both sites (RDM cold=20.5% warm=13.14%; Pech cold=38.2%, warm=34.8%) show hominids were accessing internal bone nutrients. At Pech, the proportion of percussion marked bones matches patterns from actualistic studies (27-49.2% percussed) where 100% of marrow was extracted. At both sites, epiphyseal fragments are rare (RDM cold=2.5%, warm=1.9%; Pech IV cold and warm levels=5.1%), but carnivore marks are almost nonexistent (<0.1%). Processing epiphyseal ends for bone grease may have been a Neandertal survival strategy, and interestingly, 15% of the epiphyses from RDM's cold-period level are percussed versus 7.1% in the warm level. The pattern is similar at Pech: 17.1% in cold and 7.1% in warm. Thus, this analysis is consistent with the hypothesis that Neandertals were processing bones more heavily during glacial periods.

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Rivers Draining Stratovolcanoes in Eastern Java—The Paleoenvironmental and Taphonomic Sweet Spot for *Homo erectus* Discovery in Indonesia

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Indonesian *Homo erectus* skeletal fossils have been found exclusively in a sector of eastern Java, <1% of Indonesia's land area. What accounts for the discovery sweet spot? Andesitic conglomerate and sandstone dominate the *Homo erectus* formations, and comprise discovery beds at Mojokerto, Ngandong, Sangiran Dome, and Trinil. The lithofacies represents lowland rivers draining stratovolcanoes. The mountains presumably concentrated rainfall orographically, supporting perennial river flow, as they do today in Java, and produced large pyroclastic eruptions and volcaniclastic pulses, including long-run-out lahars (LLs). LLs originate as debris flows and extend 15–120$^+$ km downriver as slurries and sandy-gravelly floods. The Ngandong *Homo erectus* bonebed evidently was deposited during an LL flood on Java's largest river, Bengawan Solo, ~50km from a stratovolcano, following mass death in a population aggregation of large mammals. Moreover, LL deposits are widespread in the ~200-km-long Mojokerto-Trinil outcrop belt, where LL members cumulatively reach 275m in thickness. The Trinil bonebed itself was probably LL deposition in wet lowlands. The Mojokerto hominin bed formed as a fluvial-gravel bar in a river-dominated delta where the ancestral Brantas River, subject to LLs, entered the sea ~100km from the source stratovolcano. Most Sangiran contexts likewise are coarsely volcaniclastic. Cattle, deer, *Stegodon,* and other large herbivores--generally found at the sites as transported bioclasts--inhabited the stratovolcano basins with *Homo erectus* for over a million years. Aquatic-, forest-, and large-mammal dietary resources evidently fostered recurring or continuous hominin occupation, while rapid volcaniclastic deposition, sometimes following eruption-related deaths, favored skeletal preservation. No *Homo erectus* fossils have been discovered in nearby non-volcanic districts, yet 1000km east on Flores, million-year-old artifacts occur. Varying paleoenvironmental and taphonomic conditions would help explain how *Homo erectus* populations that ranged broadly across the region could be represented by fossil discoveries in the eastern Java sweet spot alone.

A Survey of Recent Bone Accumulations at Ngamo Pan, Hwange National Park, Zimbabwe

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Determining the relative impacts of humans and non-human carnivores on archaeological assemblages through actualistic studies has largely been the purview of those engaged in the debate of hunting vs. scavenging at Plio-Pleistocene sites in East Africa. Here I present new data on the Recent bone accumulations at Ngamo Pan, an open, grassy plain in Hwange National Park, Zimbabwe, intended to serve as a modern analogue for interpreting open-air Middle Stone Age sites in southern Africa where human association is implied by the presence of stone tools, but can be questioned due to widespread indications of non-human carnivore impacts to the bones. The more than 3,000 bones scattered across an area of roughly 1.5km2 surrounding numerous seasonal water holes, represent the serial predation activities of non-human carnivores and natural deaths. Although the distribution of bones at Ngamo Pan is less spatially restricted than the discrete concentrations of most open-air fossil sites, they are potentially useful in that more carcasses were documented nearest the water holes, and the cumulative effects of repeated carcass deposition clearly will mimic archaeological sites over longer time scales. When treated as a single assemblage, the bones at Ngamo Pan show taphonomic similarities to the late Pleistocene carnivore serial predation assemblage at Kalkbank, located in Limpopo Province, South Africa: both show low incidences of carnivore tooth marks in relation to carnivore den locations; their comparable patterns of bone survival cannot be explained by differential burial or density alone; and, they have mortality profiles tending toward prime-aged adults that overlap with the typical age structure of

lion prey. In addition to highlighting the role of non-human carnivores at open-air settings, the patterns documented here also can be useful in assessing the scavenging opportunities available to Middle Stone Age hominins in open savanna settings of southern Africa.

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Morphological Variability in Aterian Tanged Tools and Its Implications for the Origins of Projectile Technology

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Tanged tools from the Middle Stone Age Aterian technocomplex in North Africa have a particular importance in the debate surrounding the origins of modern human behavior, because they are often interpreted as offering a dual evidence of hafting and use as projectiles. Unfortunately, proper data that could address the validity of these interpretations contextually is missing, because most of the extant collections date to the early part of the 20th century and are suspected of curation bias. Further, this affects the potential of usewear for establishing function. In order to work around some of these problems, this study examines function by identifying the loci of greatest and least morphological variability in comparatively large samples. This can suggest the general locations of active/resharpened parts vs. hafted/prehensile/standardized parts of tools. These patterns are investigated with the aid of classical morphometrics and elliptical Fourier Analysis (EFA) on a sample of 455 complete Aterian tanged tools from museum collections in Rabat and Paris, alongside 52 specimens from controlled modern excavations in Morocco (Contrebandiers and el-Mnasra). The results show that Aterian tanged tools exhibit several allometries that are consistent with hafted use and with reduction from the tip down to the base, which are known from North American projectile tips as well as from Australian hafted scrapers. Finally, the variability of 36 tanged certain arrow points from the Final Paleolithic site of Stellmoor (Germany) is quantified for comparison. The study concludes that Aterian tanged tools were probably hafted, but are unlikely to have been real projectile tips.

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Craniofacial Evidence for the Evolution of *Homo erectus* and *Homo floresiensis*

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Homo erectus (*sensu lato*) is the first hominid group that achieved great range expansion from Africa into Eurasia. However, the process of resultant regional morphological diversification of the group still remains unclear, inviting a long-time debate whether the taxon actually represents single or multiple species. We approach this question by morphometrically examining their spatiotemporal variation, using many of the existing craniofacial specimens of *H. erectus* and their foregoing and succeeding populations in Africa, Georgia, China, and Indonesia (N=54). In order to minimize errors in the metric data set used, we measured a large number of original fossil specimens (N=37) with help from micro-CT imagery in some cases. The results showed the following remarkable trends: The most marked changes from *H. habilis* to *H. erectus* (*s. l.*) are neurocranial size increase and transverse vault expansion; Regionally distinct patterns of craniofacial forms in *H. erectus* (*s. l.*) are evident from the earliest documented stages of their fossil records in Africa, Java, and northern China; A small face and a thick cranial bone at the mastoid portion are among important characteristic features of Asian as compared to African *H. erectus*; African and Javanese *H. erectus* exhibit mutually different patterns of temporal morphological changes; These and many other regional/chronological differences within *H. erectus* or between *H. habilis* and *H. erectus* are not allometric cranial size-related variations; and, When the cranial form of *H. floresiensis* is interpreted in the framework of morphological variation documented in this study, it shows affinities with Asian, particularly early Javanese *H. erectus*. By integrating time and space factors of variation, this study highlights the presence of regional differences within *H. erectus* (*s. l.*) that would not be visible if one focuses only on one of these factors. Taxonomic and evolutionary implications emanating from these observations are discussed.

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Blue Highways: MSA Foraging Behaviors along the Blue Nile Tributaries in NW Ethiopia

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Questions about where our species, modern *Homo sapiens*, originated on the Africa continent, the migratory route taken when the species left Africa to populate the rest of the world, and its behavioral adaptations that facilitated this expansion, are some of today's mostly actively investigated research topics within the field of human evolution. It remains the case that additional data from the ground, gathered from different geographical settings that sample diverse habitats, are required to develop a better understanding of the full range of the behavioral adaptations and foraging technologies of early humans. We present here new data for MSA humans living along the upper reaches of the Blue Nile tributaries on the lowland slope of Ethiopia's northwestern plateau. The trunk tributaries are somewhat unique in that their headwaters are in the highlands and their flows are concentrated in only a few months of the year. These factors combine to produce extreme hydraulic conditions that erode deep bends in the channels that in turn become isolated waterholes during the long dry season. We have documented numerous surface sites in close proximity to the ancient channels that contain abundant aquatic and terrestrial animal remains, and have also recovered limited plant remains from some of the cut-off meander lakes. These data suggest that the MSA humans were adapted to a riverine-based foraging lifestyle focused on the exploitation of abundant food resources that were seasonally concentrated around isolated waterholes during the dry season. Once local foods were depleted, longer distance foraging forays along the channel to new waterholes functioned as a dry season "pump" to siphon MSA populations out along the rivers. Not only would these "blue highways" have provided highly predictable foods and water during an otherwise challenging dry season, but movements from one waterhole to another would have affected population movements northward.

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Jacovec Cavern: a Taxonomic, Taphonomic and Paleoenvironmental Appraisal of a Lesser Known Hominind Bearing Cave in South Africa

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The Jacovec Cavern is the deepest fossil bearing deposit within the Sterkfontein Cave System, South Africa. Located approximately 30m below the ground surface, it has been suggested to contain the oldest fossils by one school of thought, while the other argues for the youngest date within the cave system. The recovery of *Australopithecus* fossils, as well as other extinct fauna, coupled with a cosmogenic nuclide date of ca. 4 myrs render support that the cave may contain the oldest fossil deposit at Sterkfontein. However, the cyclical processes of deposition, collapse, erosion, and re-deposition evident in the two breccia deposits within the cave, and a recovery of fauna thought to have migrated into Africa from Asia at a later date calls for a re-assessment to this interpretation. The cave has yielded faunal species from the families Hominidae, Cercopithecidae, Aves, Suidae, Machairodontinae, Felidae, Canidae, Viverridae, Hyaenidae, Bovidae, Equidae, Pedetidae, Lagomorpha, and Chelonia. The taxonomic analysis of the faunal assemblage reveals an abundance of carnivores in relation to other faunal species. Taphonomically, the fossil assemblage was accumulated through a combination of processes including carnivore action and fluvial activity. Palaeoenvironmental reconstruction suggests a mosaic of gallery forest, equivalent of today's African tropical forest, and open grassland.

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Lithic Technologies and Information Transfer Among Early Human Groups in the Middle Pleistocene

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Recent studies have suggested that the low effective population size of *Homo sapiens* is the result of a significant lack of gene flow between small groups of early humans (Premo and Hublin 2009). If this model is correct, the low Ne of modern humans could be explained as a result of hunter-gatherer groups competing for resources yet not exchanging genes. This, however, does not match with what we know about hunter-gatherer behavior, as the group sizes necessary for these models to work are smaller than those known from ethnographic record. The archaeological record may better fit such a process. Specific stone tool technologies may have been passed down in such a way that only a handful of individuals had access to the *chaîne opératoire* for constructing a toolkit. If, for example, specific hunting technologies are only taught to adult males (a behavior seen in the ethnographic record) then this technology will not spread easily, as individuals leaving the group (females and young males) may not have had the time or access to learn the technique. Thus only a small group of individuals in a population knows how to make the technology and, since they do not leave the group, the technology is not spread unless the population itself expands. Over time there may be some modifications to the technol-

ogy, but we expect to see a general pattern of descent. Here, we model this process using Python and then compare the model to the archaeological record from Middle Pleistocene sites of Europe. While a number of assumptions are made, we show how such a model may be treated as a simple hypothesis to explain information transfer and exchange over time. Simulating lithic technologies in such a way allows us to test hypotheses regarding the exchange of information between and among groups.

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Velocity Consequences of Leg Length Dimorphism in *Australopithecus afarensis*

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The estimate of leg length (femoral + tibial length=0.773–0.793m) of the recently described partial skeleton of *Australopithecus afarensis* from Woranso-Mille (KSD-VP-1/1) is substantially outside the previously-known range for *Australopithecus* and within the range of modern humans. The leg length of KDS-VP-1/1 is particularly intriguing when juxtaposed against leg length estimate of the other partial skeleton of *A. afarensis*, AL 288-1 (0.525m). This dimorphism between the two specimens could be attributed to a number of causes, including sexual dimorphism in body size and/or temporal or populational responses to ecological conditions. Even without understanding the cause of the variation between the two partial skeletons, the difference in leg length has implications for mobility. Using a sample of 48 children (age>7 years, trochanteric height=0.56–0.765m) and 24 adults (trochanteric height=0.77–1.00m), who walked at their self-selected slow, preferred, and fast walking velocities, the relationship between leg length and velocity was established. Leg length was correlated with slow ($p<0.001$, $r^2=0.29$), preferred ($p<0.001$, $r^2=0.42$) and fast ($p<0.001$, $r^2=0.57$) walking velocity. Using these relationships to predict velocity for the two specimens yields a velocity profile for KDS-VP-1/1 (slow=0.71-0.73m/s, preferred=1.04–1.06m/s, fast=1.41–1.44m/s) that is 25–35% higher than that of AL 288-1 (slow=0.54m/s, preferred=0.82m/s, fast=1.08m/s). Differences in walking velocities raise important questions regarding mobility patterns. For instance, the preferred velocity of an individual like KDS-VP-1/1 is equal to the fast velocity of an individual like AL 288-1. If the familiar concave up relationship between cost of transport and velocity is appropriate for *Australopithecus*, then this degree of dimorphism could have substantial energetic consequences for group mobility.

Thoracic Shape in *Australopithecus*

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The partial skeleton KSD-VP-1/1 from Korsi Dora vertebrate locality 1 (KSD-VP-1) in the Woranso-Mille area of the Afar region, Ethiopia, preserves previously unknown portions of the Pliocene hominid thoracic cage. Five ribs, a clavicle, a nearly complete scapula, and an os coxa allow, for the first time, an accurate assessment of the thoracic form in a 3.58 Ma *Australopithecus*. It does, moreover, shed light on the evolutionary development and function of the African ape thoracic form. The ribs of KSD-VP-1/1 show declination from their vertebral origins, flexed costal angles, and axial torsion - all of which indicate craniocaudal elongation of the thorax and lumbar column and a deep spinal column invagination. The second rib and clavicle indicate that the upper thorax did not have the marked cupular constriction like that seen in the African apes. The presence in KSD-VP-1/1 of an expanded thoracic cupula, significant rib declination, and highly flexed costal angles all negate a knucklewalking phase in early hominids. This further indicates that the thoracic form of KSD-VP-1/1 is primitive among hominoids. That early *Australopithecus* fails to show the adaptive suite of African ape thoracic anatomies: cupular constriction, reduced rib obliquity, reduced iliocostal space, and a reduced lumbar column indicates that knucklewalking and its associated thoracic anatomies are derived and were never part of early hominid anatomy or locomotor repertoire.

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Hominin Carcass Acquisition and Processing Behavior During the Middle and Early Late Pleistocene: New Data From Orgnac 3 and Le Grand Abri aux Puces.

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Paleoanthropologists continue to debate how hominin subsistence strategies have changed over time and, more specifically, when hominins increased their focus on acquiring meat and other animal tissues, and whether they had early or late access to carcasses in comparison with other carnivores. It is further important to know whether different populations of hominins foraged or hunted differently, and what the evolutionary import of any differences might be. This is especially true when considering the Middle and Late Pleistocene, when different species of hominids lived on different continents, but only *Homo sapiens* survived to the end of the Pleistocene. Here I present a complete paleontological, zooarchaeological, and taphonomic analysis of the fossil faunal assemblages of the

Middle Pleistocene site of Orgnac 3, and for comparison, from the late Middle/early Late Pleistocene layers of Le Grand Abri aux Puces (GAP), both located in the Rhône valley of southeastern France. Orgnac 3 is a cave/sink hole site most likely dating to OIS 11, 10, 9, and 8, whereas GAP is a cave site most likely dating to OIS 5e. First I show how sedimentological, geological, and zooarchaeological data allow control for taphonomic factors affecting the interpretability of the faunal assemblages, such as post-depositional compaction, chemical alteration, and carnivore contributions to the system. Then I show how the Orgnac 3 hominins (probably *Homo heidelbergensis*) changed their carcass acquisition and processing behavior through the sequence, comprising ten archaeological levels and different climatic phases, and I will compare this to the carcass acquisition and processing behaviors of the GAP hominins (probable *Homo neanderthalensis*) during the last interglacial. Overall, the Orgnac and GAP hominins' carcass acquisition and processing behavior was advanced over that in preceding Acheulean sites, but not as developed as in later Middle Paleolithic sites.

Iliac and Ischiopubic Modularity: Implications for the Evolution of the Hominin Pelvis

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The morphological rearrangement of the pelvic girdle in hominins is one of the most notable developments in human evolution, but even after decades of research, understanding of which features of the pelvis are adaptive is still limited. Because the ilium, ischium, and pubis develop from three separate cartilage anlagen and likely serve different biomechanical functions, it is possible that the pelvis is morphologically integrated and that its bony components are modular (i.e., aspects of each component are correlated and covariation among components is low). If pelvic features are morphologically integrated, they will evolve together; in that case, regarding individual traits as structurally or functionally independent may profoundly obscure understanding of the functional significance and evolution of primate pelvic shape. To test for modularity in the pelvis, 27 three-dimensional landmarks were collected from 829 specimens representing 67 extant primate species. Landmarks were adjusted for non-shape effects using Generalized Procrustes Analysis and a matrix of pooled within-species covariances generated. Because of the disparity in the numbers of landmarks collected on the ilium compared to the ischium and pubis, landmarks were divided into only two groups-those on the ilium and those on the ischiopubis. The RV coefficient, a measure of covariance between groups, was calculated and compared to the distribution of RVs derived from all possible permutations of landmark sets. The results support the hypothesis of modularity of the ilium and ischiopubis (RV=0.26, $p<0.005$); care should be taken in evaluating fine-grained discrete pelvic traits, but broad scale shape analysis of its bony components may be useful. Although a clear understanding of pelvic adaptation has been elusive, the perspective from integration might offer a solution to this seemingly intractable problem. Furthermore, this approach may ultimately shed light on the constraints and selective pressures acting on the hominin pelvis.

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The Effects of Core Surface Morphology and Hammer on Flake Attributes

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It has become axiomatic in lithic studies that the preparation of a core's exterior surface and choice of material used as a hammer are two of the most significant variables that influence particular attributes of flakes. These effects have largely been studied through either replicative experiments (flintknapping) or the refitting of prehistoric assemblages. As described here, a new experimental design allows for the testing of these effects in a more objective and quantified manner, by using molded glass cores that are struck with hammers of different materials. We present the results of two separate experiments. The first is designed to test the effects of core surface morphology: five different cores types were designed, each of which has ridges arranged in different patterns on the exterior surface, but in ways that mimic common prehistoric core types. The second experiment, limited to one core design, investigates the influence of several hammer attributes, including the size and shape of the tip that strikes the core, and the material used to construct the hammer tip. The results of these experiments confirm some influence of these independent variables on certain aspects of flake morphology, but in many cases these effects are much less than would traditionally be expected. Where possible to extend these analyses to archaeological lithic assemblages, these experimental results are confirmed.

Dento-Alveolar Abnormalities of the Early Modern Humans from Zhirendong, South China

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The early modern human remains from Zhirendong, south China, consist of two right LM3s (Zhiren 1 and 2), one with the LM2 and LM3 partial alveoli (Zhiren 1), plus an edentulous anterior mandible from mid-LP4 to mid-LP4 alveoli (Zhiren 3). They are dated by U-series and associated faunal remains to early MIS 5 (100^{+} ka BP). In addition to documenting the earliest derived modern human mandibular morphology in east Asia, they present a series of dental and alveolar pathological lesions. The Zhiren 1 LM3 and alveolar fragment indicate pronounced alveolar resorption around the LM2 and LM3 (and not merely supereruption), with LM3 cervical-alveolar crest (CAC) heights of 6 to 10mm. The Zhiren 2 LM3 possessed a large carious lesion, 8.4mm wide and 8.7mm high, which removed the distal halves of the crown and of the adjacent root. It also exhibits hypercementosis of the apical halves of the roots. The Zhiren 3 mandible exhibits bilateral labial-mesial rotation of the LI1s, but the incisor, canine, and LP4 alveoli are otherwise normal. More importantly, Zhiren 3 had bilateral abscesses around the LP3 roots. LP3 alveoli are apically expanded 7 and 8mm wide and buccally open. The sockets are resorbed to the underlying trabeculae, and both have distal septal bony deposition. The lack of porosity suggests that they healed antemortem. It is unclear whether the LP3s were lost antemortem. The LP3 abscesses are unusual for their bilateral symmetry and lack of associated incisor, canine, or LP4 involvement. The Zhiren 2 lesion adds to a small sample of principally lower latitude Late Pleistocene dental caries. The Zhiren 1 alveolar resorption is marked for a Late Pleistocene human. Together these remains augment the record of dento-alveolar lesions among earlier Late Pleistocene humans, which otherwise remains relatively uncommon.

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The Bony Labyrinth of the Middle Pleistocene Sima de los Huesos Hominids (Sierra de Atapuerca, Spain)

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The primate bony labyrinth has been studied across a range of taxa to provide insight into locomotor behavior and to assess the phylogenetic affinities in fossil hominid temporal bones. Compared with *Homo sapiens*, several morphological differences have been identified in the Neandertal bony labyrinth. In particular, the absolute and relative sizes of the anterior and posterior semicircular canals are smaller, while the lateral canal is larger. In addition, the posterior canal is more circular in shape, and is positioned more inferiorly relative to the plane of the lateral canal. This latter feature appears to be a derived characteristic of Neandertals. To evaluate when this combination of features appeared during the course of Neandertal evolution, we have studied the bony labyrinth morphology in the Middle Pleistocene hominids from the Sima de los Huesos (SH) site in the Sierra de Atapuerca (Spain). The fossils recovered here date to at least 530 kya and represent some of the earliest specimens in the fossil record to show derived Neandertal features. The SH bony labyrinths were virtually reconstructed in thirteen individuals, and the dimensions were compared with several samples of Pleistocene and recent humans. Our results show that the SH hominids were more variable in their morphology than were the Neandertals. Although some of the SH individuals exhibit a morphology similar to the Neandertals, the sample as a whole shows smaller dimensions of the lateral and posterior semicircular canals and a slightly different shape to the basal turn of the cochlea. Perhaps most relevant, the SH hominids do not show the relatively inferior placement of the posterior semicircular canal seen in Neandertals, suggesting this Neandertal apomorphy evolved at a later time during their evolutionary history. The SH hominids thus help clarify the phylogenetic polarity and evolutionary emergence of several features in the Neandertal bony labyrinth.

Morphological Analysis of the Elbow Joint of *Australopithecus sediba*

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The postcranial skeleton of *Australopithecus sediba* is characterized by a mosaic of primitive and derived features, with a hindlimb exhibiting relatively more derived *Homo*-like features and a forelimb morphologically more similar to other Australopiths. Hominin elbow articular morphology has been perceived as highly conserved, and thus largely uninformative in taxonomic or functional analyses. However, most comparative morphometric analyses of the individual bones making up the joint complex have found species-level distinctions in articular morphology among Plio-Pleistocene and later Pleistocene hominin groups. These distinctions likely reflect species-level variation in loading regimes associated with differential forelimb use, including perhaps the degree to which the upper limb was used in locomotion. We hypothesize that, within hominins, functionally relevant differences in elbow joint morphology are attributable to genus-level differences in the degree of arboreal locomotion and tool use behavior. The morphology of the distal humerus and proximal radius and ulna of *Au. sediba* was compared with that of other Australopiths, and with samples of early and

modern *Homo*. Univariate and bivariate analyses of linear elbow joint dimensions show that, in most features, *Au. sediba* does not differ significantly from the other Australopiths, but is typically significantly different from both early and modern *Homo*. These results suggest parity in upper limb use between *Au. sediba* and earlier Australopiths, with a change in habitual elbow loading regimes in the *Homo* lineage. While the degree of arboreality of Australopiths remains a matter of contention, the overall morphology of the elbow joint of *Au. sediba* is consistent with the retention of a significant arboreal component to its locomotor repertoire.

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Middle Stone Age Desert Occupations in the Central Namib, Namibia: Results of the 2010 Survey of Surface Lithic Materials

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The Middle Stone Age (MSA) in Southern Africa is a period that brackets substantial changes in hominin behavioral repertoires. During this period, hominins developed complex lithic technology, exploited a more diverse set of resources, and possibly began to use complex symbols. Many of these changes also were likely to have manifested themselves in the spatial patterning of behavior at landscape-level (as opposed to site-level) scales; as, for example, changes in mobility patterns, occupational intensity, and raw material procurement strategies. However, relatively few attempts have been made by archaeologists to understand and characterize the landscape-level spatial patterning of hominin behavior during the MSA and how it changed in subsequent periods. This poster presents results of a 2010 survey of surface lithic materials from the Central Namib Desert in Namibia. This area preserves abundant MSA artifacts in an arid low-energy depositional environment, thus making it an exceptionally good region for studying spatial patterning in hominin behavior at landscape scales. Using a "siteless" survey methodology coupled with GIS analysis of spatial patterning in artifact density, refits, and flake morphology, I demonstrate that MSA hominin occupation of the Central Namib region can be characterized as low-intensity and highly sensitive to climatic fluctuations in humidity during the Middle and Late Pleistocene. Additionally, through analysis of landscape-scale spatial patterning of flake retouch, I show that certain activities were focused on points in the survey area that more frequently retained relatively high soil moisture in the past, likely reflecting points of relatively high vegetation density and animal activity. Finally, utilizing the small component of diagnostically Late Stone Age (LSA) materials also present in the survey area, I demonstrate changes in raw material procurement strategies that occurred in the Central Namib over the transition from the MSA to the LSA approximately 30 kya.

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Does Size Matter? Re-evaluating the Species Designation of the PU-198 Premolar

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Storm and colleagues (2005) have assigned PU-198, a left maxillary third premolar dated to 128 Ka from the Indonesian island of Java, to the species *Homo sapiens*. This taxonomic assignment was based on an analysis of buccolingual and mesiodistal dimensions from 55 Holocene *H. sapiens* and 7 *H. erectus* maxillary third premolars. The PU-198 premolar, with relatively small buccolingual and mesiodistal dimensions, was found to group with the *H. sapiens* sample in bivariate space, and was thus assigned to this species. However, there are published dates for *H. erectus* on Java as recent as 50 Ka, presupposing the presence of *H. erectus* on Java at the time of PU-198, with descendants later inhabiting the sites of Ngandong and Sambungmacan. Given this apparent incongruence, we re-evaluated the efficacy of P3 size in delineating the *H. erectus* to *H. sapiens* transition on Java with an analysis of buccolingual and mesiodistal dimensions in a large sample of *H. erectus* (n=25) and *H. sapiens* (n=69) premolars. Importantly, our *H. sapiens* sample includes early *H. sapiens* from the sites of Skhul and Qafzeh, which would have been contemporaneous with the PU-198 specimen. Our results support a *Homo*-wide trend of P3 size reduction through time, with early *H. sapiens* premolar dimensions overlapping completely with those of *H. erectus*. These results suggest that PU-198, while small, cannot be precluded from a *H. erectus* designation based exclusively on size, especially when considering the diachronic trend in posterior dental size reduction reported for *H. erectus* on Java between 1.6 and 1 Ma (Kaifu 2006). We conclude that, while the non-metric morphology of PU-198 may further clarify a species designation for PU-198, without contemporaneous Javan teeth for comparative analysis, a species designation of *H. erectus* cannot be ruled out at this time.

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New Paleoenvironmental and Paleoclimatic Interpretations From Fossil Leaves for the Early Miocene Faunas of Rusinga Island (Lake Victoria, Kenya)

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Nearly one hundred years of field work has established Rusinga Island, Kenya, as one of the most important Early Miocene (17–20 Ma) primate sites in Africa. In order to fully understand the patterns of Early Miocene primate evolution, it is critical to understand the paleoenvironment and paleoclimate in which they lived. In spite of the amount of paleontological work that has been conducted on Rusinga Island, there have been relatively few paleoenvironmental or paleoclimatic studies. Those that have been done are contradictory. Furthermore, although there are abundant fossil plant remains on Rusinga, there have not been any studies that have attempted to reconstruct paleoclimate directly from fossil leaves. The correlation of the size and shape of woody dicot leaves with temperature and rainfall has been used to develop proxies for reconstructing mean annual temperature (MAT) and mean annual precipitation (MAP) from fossil leaves. Thus the fossil leaves from Rusinga can be used to directly reconstruct the paleoclimate and paleoenvironment that existed during the evolution of Early Miocene primates, including the stem hominoid *Proconsul*. A preliminary collection of 91 fossil leaves representing 28 distinct morphotypes (26 woody dicotyledonous (dicot) angiosperms and 2 monocotyledonous angiosperms) was made from a fossiliferous deposit near the top of the Grit Bed Member of the Hiwegi Formation at Kaswanga Point on Rusinga Island. We used the dicot morphotypes to estimate MAT and MAP using both univariate and multivariate methods. These analyses demonstrate that the Early Miocene MAT and MAP on Rusinga Island were near or above 30°C and ~100–160cm respectively. These estimates suggest that the Early Miocene faunas from Rusinga Island lived in a tropical-seasonal forest or tropical woodland paleoenvironment.

Scapula Morphology of *Australopithecus afarensis*: New Insights from KSD-VP-1/1g

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The current understanding of the *Australopithecus* shoulder girdle is based on data from a small number of fragmentary fossils. These specimens suggest that the *Australopithecus* glenoid was oriented more cranially than in *Homo*, supporting the traditionally held view that the *Australopithecus* scapula resembled that of *Pan* or *Gorilla*. The scapula of the new 3.58 Ma *Au. afarensis* partial skeleton from Woranso-Mille (KSD-VP-1/1g) preserves anatomical regions that were not previously known from adult specimens; including the spine, blade, and medial border. In addition, the glenoid and lateral border are present, making this specimen the first of its kind to preserve all major structural components of the scapula. Preliminary analysis of KSD-VP-1/1g showed that it is morphologically more similar to humans than it is to African apes (Haile-Selassie et al. 2010). I conducted further analyses, using both traditional and 3D GM methods and an expanded comparative sample. The results show that the adult *Australopithecus* scapula is unique, but most similar to *Pongo* among the non-human apes. Both genera exhibit a cranially oriented glenoid in association with a horizontal spine. Despite these similarities, clustering algorithms group *Australopithecus* with *Homo*, indicating that the total morphological pattern of the specimen is clearly derived along the human lineage. If the hominine primitive condition resembled an African ape, then KSD-VP-1/1g demonstrates that the evolution of the human scapula occurred in at least two independent stages. *Australopithecus* exhibits the derived condition of the first stage, where the spine changed from being cranially to horizontally oriented. Reconstructions of the positional behavior of *Australopithecus* modeled on African apes may thus require revision, although the adaptive significance of the change in spinal position is unclear. I discuss alternative possibilities.

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Using Experimental Methods to Improve the Behavioral Resolution of Archaeological Butchery Interpretations

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Oldowan cut-marked bone assemblages encode the behavioral contexts of tool-assisted carnivory, but reconstructing the tool type

used during butchery or the amount of meat defleshed from a carcass with cut mark data is confounded by behavioral equifinality. The debate over 3.4 Ma pre-Oldowan butchered bones at Dikika highlights the weak inferential link between bone modification and behavioral interpretations of hominin carnivory (Dominguez-Rodrigo et al. 2010; McPherron et al. 2010). Recent actualistic experiments report success in distinguishing experimental cut marks produced by different classes of Early Stone Age effectors (Bello et al. 2009; Dominguez-Rodrigo et al. 2009; de Juana et al. 2010), but butchery experiments described here indicate that abstract experimental contexts neglect confounding factors inherent to realistic butchery and minimize the variability of experimental cut mark morphology. Trials on goat and cow carcasses explore the effect of two experimental factors: (1) replicated Oldowan tool type (unmodified flake, bifacially flaked core) and, (2) butchery action (skinning, disarticulation, bulk defleshing, scrap defleshing) on cut mark size and cut mark cluster geometry. Response variables include cut mark cross-sectional width and depth, the number of marks in a sub-parallel cut mark cluster, cluster area, median mark length per cluster, and standard deviation of mark length and angular orientation per cluster. Analysis indicates that flakes and cores are equally efficient butchery tools, but neither cut mark size nor cluster geometry variables reliably discriminate tool type. However, cut mark size is significantly negatively correlated with long bone portion density. The dispersion of cut mark length and angle per cluster is not related to tool type or the amount of flesh removed but positively correlates with cluster area. It is argued that butchery trials conducted in a realistic behavioral context capture a wider range of cut mark morphology and provide a more secure archaeological interpretive framework.

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Trinil Femora: *Homo sapiens* or *Homo erectus*?

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The six femora of Trinil, discovered in 1892 in Java by Eugene Dubois, are quite unknown in the paleoanthropologist community. In fact, the first femur (official name Trinil 3) is very famous because of its pathological morphology, but researchers often ignore the existence of five other femora, also associated to *Homo erectus*. Today, there is a controversy about them: are they really *H. erectus*? This work suggests a new study of this material. By means of a traditional morphological description, but also statistical analysis (Principal Components Analysis and probalistic distance, a method developed by F. Hoüet (Maureille, et al. 2001)) and comparisons with a modern pool and numerous fossil femora, we would like to discuss the position of the Trinil femora in human evolution. Our description and our analysis do not show real differences between modern and Trinil femora. These analysis allowed us to call into question the description of Trinil femora as *H. erectus* and the morphological differences in modern and *H. erectus* femora.

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A New Hominin Mandible From the Middle Pleistocene, Discovered at the Site of Payre (South-Eastern France)

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Although there is a general agreement that Neandertals represent a hominin lineage rooted in in Europe during MP times, the involved evolutionary processes and taxonomic affiliation of these Middle Pleistocene specimens are the subject of debate. As such, one com-

mon difficulty when addressing these questions relates to the scarcity of European fossils attributed to MIS 10 to 6. We present a new hominin mandible from the Middle Pleistocene deposits of the site of Payre (Rhône Valley, South-East France). To date, the site has yielded twelve human teeth and a parietal fragment belonging to young adults and juveniles. The mandible was discovered in 2010 in Level Ga, which radiometrically dates back to the end of MIS 8 or to the beginning of MIS 7. It was associated with the faunal remains of equids, cervids, and bovids, and an Early Middle Palaeolithic assemblage. This mandibular fragment retains three teeth *in situ*, the complete symphyseal region, and the right part of the body. As indicated by heavy occlusal wear, it belonged to an elderly adult. Discrete morphological features and 2D measurements are compared to samples of Middle Pleistocene hominins and Neandertals. CT data allowed for virtual reconstruction of the mandibular body and investigation of the internal anatomy of the specimen. This specimen shows a combination of primitive and Neandertal-like features and is characterized in particular by a robust mandibular body, a receding symphyseal profile, and a posterior and inferior location of a single mental foramen. The comparative analysis of this specimen enhances our understanding of European Middle Pleistocene hominin mandibular variability. Our results are discussed in the light of recent debates regarding the tempo and mode of evolution in the Neandertal lineage and the taxonomy of late Middle Pleistocene European hominins.

Taphonomic Study of Bone Surface Modification From a Pliocene Fossil Assemblage at Laetoli, Tanzania

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Bone surface modification features provide insightful depositional environment and peri- and post-mortem histories of vertebrate fossil faunal assemblages. Insect-induced bone modification features in fossil assemblages from hominin sites in East Africa is well documented and its utility in paleoecological reconstructions has increased tremendously. A detailed taphonomic study for surface modification on 1,448 bones from the Upper Laetolil Bed fossil faunal assemblage at Localities 7, 8, and 9 was visually and microscopically carried out in order to establish their damage patterns. The following components were investigated for this study of bone surface modification including: (a) breakage pattern (including trampling), cracking; (b) insect damage, weathering; (c) abrasion, polishing, and surface marks (carnivore and rodent teeth marks); and (d) bioturbation. Results from our preliminary analysis identified taphonomic signatures helpful in establishing depositional environments at Laetoli 3.56 million years ago, where over 13% of the analyzed bones bear insect-related surface modification (star-shaped, U-, and V-shaped marks and grooving), 10% rounding and polishing, 49% pitting and etching, and 29% desquamation. This study also considered other taphonomic variables such as bone breakage pattern and orientation and skeletal parts representation in the assemblage, which provided important information on fossil preservation at Laetoli.

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Is the Neandertal Opponens Pollicis Insertion a Flange or Just a Large Crest?

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Neandertal first metacarpals are remarkable for their large opponens pollicis (OP) insertion which is described as a fin-like (Vlček 1975) or a flange-like (Trinkaus 2006, 2007) radially projecting ridge. The OP flange arises just proximal to the metacarpal head where it usually projects beyond the radial margin of the metacarpophalangeal articular surface and then remains as a distinct, but progressively less projecting ridge as it courses to the metacarpal base. An incipient OP flange is even apparent in young Neandertals such as the infant Kiik-Koba 2 and the subadult Zaskalnaya VI (Vlček 1975). Neandertals, it is argued, exhibit the derived form of the OP insertion while all Late Pleistocene and Holocene modern humans, except the European early modern Sunghir 1, exhibit the ancestral pattern of a variably expressed, non-flange-like OP crest. Sunghir 1's flange-like OP insertion is explained as partial evidence for Neandertal admixture (Trinkaus 2007). The admixture explanation requires that OP insertion morphology is not a developmentally plastic reflection of habitual behavior. Alternately, if OP insertion morphology is developmentally plastic, one would expect to find flange-like OP insertions on Holocene human metacarpals from populations that are ethnographically or archeologically documented to have engaged in habitual behaviors that require elevated hand strength. Prehistoric Native Indians from the Pender Canal sites (Pender Island, B.C., Canada) are one such population. Two of seven male hand remains dated to ca. 4,000 years BP have radially projecting flange-like OP crests. Associated archaeological evidence indicates the production of flaked stone points and extensive woodworking activities during this time-period (Carlson and Hobler 1993). These OP flanges, though not precisely identical to the Neandertal morphology, represent the intermediate form of a developmentally plastic morphology. The Neandertal OP flange is an extremely large OP crest.

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Leaving It to Chance? A Statistical Method for Evaluating the Symbolic Properties of Stone Age Markings and Implications for the Origins of Symbolism

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The appearance of symbolic expressions and its use to organize behaviors and social interactions are key markers in the evolution of modern *Homo sapiens*. Symbolism is a fundamental component of all modern societies, mediating relationships between human behavior and cultural constructs. Symbols have shared conventions which are central for conveying a person's social identity, indicating group membership, gender, and individual life-history characteristics such as age or marital status. Semiotic and Information Theory provide a quantitative framework within which to study information transmitted through symbolic systems. To transmit meaning, and differentiate from random background markings, symbols are expected to be non-randomly organized, minimizing the degree of Entropy (information loss) within a system (Shannon 1948). Information transmitted within higher fidelity systems should be expected to be 'selected for' within a cultural framework (Boyd and Richerson 1985). Currently however, attributing symbolic meaning to prehistoric artifacts is a subjective endeavor. This is clearly a problem. Expert opinions, or arguments from authority, are not conducive to reproducibility, a fundamental scientific principle. Here, we develop a probabilistic method to quantitatively and more objectively discriminate between anthropogenic configurations more likely to contribute to symbolic systems and those undifferentiated by chance. As examples, we use engraved markings proposed as evidence of symbolism across the Earlier, Middle, and Later Stone Age in Africa where archaeological and genetic evidence suggests modern human populations first emerged. Results show that most engraved markings are easily achieved by random-chance alone and would function poorly as symbolic media, suggesting that these configurations do not result from behavior embedded within symbolic systems. By quantitatively differentiating engraving configurations, researchers can begin to ascribe statistical confidence to inferences regarding the emergence of symbolism. Furthermore, statistical analyses may eventually be useful in developing a hierarchical classification system for the development of a more concise and comparative symbolic theory.

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The Larger Mammal Fossil Assemblage from JK2, Bed III, Olduvai Gorge: Implications for the Feeding Behavior of *Homo erectus*

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One of the most important events in human evolution was the dietary shift towards carnivory that for the first time put our ancestors in competition with large carnivores. Evidence based upon the fossil assemblage from the roughly 1.8 million year old, Bed I, FLK *Zinjanthropus* site at Olduvai Gorge indicates that the initial encroachment by *Homo habilis* on the larger carnivore guild during the Oldowan was likely in the role of a scavenger (Blumenschine, 1995). However, virtually nothing is known about the carnivorous component of the diet of *Homo erectus*, a species that is characterized by its more human-like brain and body proportions and association with more advanced stone tool technology. Here I present an interpretation of the feeding behavior of *Homo erectus* based upon the first taphonomic analysis of the Bed III, JK2 site, Olduvai Gorge. Results indicate that both hominins and carnivores acquired early access to carcasses at the site. A relatively low incidence of percussion marking suggests hominins did not break all long bones in the assemblage. Tooth and cut mark frequencies independently suggest that both hominins and carnivores had access to flesh, but neither indicate hominins or carnivores as the dominant consumers of flesh. The presence of specimens that are both tooth- and butchery-marked demonstrates occasional hominin and carnivore feeding from the same carcass. Together the bone surface modification data suggests a mixed taphonomic history for the assemblage with at least some carcasses accessed by hominins early in the consumption sequence and others only by carnivores. The evolutionary significance of these results lies in the indication that *Homo erectus* may have acquired earlier access to carcasses than its Oldowan hominin ancestors.

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"Muddying the Water:" Doubts about the Oldest Purported Butchery Marks from Dikika, Ethiopia

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Our recent critique of claims for hominin butchery from the ~3.4 Ma Dikika (Ethiopia) site (McPherron et al. 2010) concluded that the published evidence did not, in fact, support the identification of bone surface marks on two fossils as unequivocal stone tool butchery damage (Domínguez-Rodrigo et al. 2010). We further asserted that any equivocation surrounding butchery claims of this great antiquity (~800 ka older than oldest known butchery marks from Gona, where marked animal bones are derived from fine-grained sediments and in spatial association with hominin-flaked stone tools) should lead to rejection of such claims. This assertion is not equivalent to contending the impossibility of pre-2.6 Ma butchery by hominins, but charges of bias were leveled. Our skepticism also was branded as "unfortunate…[because it] just muddies the water." Clearly, neither retort is a legitimately scientific counter-argument to our contentions: (1) that the Dikika fossils derived from a potentially abrasive sedimentary context, and (2) that the Dikika fossils show surface damage that is indistinguishable from that imparted randomly (by trampling and/or other incidental movement) in such deposits. More substantively, the Dikika team eluded to the as-yet unpublished results of experiments that they claim will corroborate their inference that the Dikika bone surface marks were imparted by hominins butchering with unmodified rocks. Here, we reiterate our reasons to reject the Dikika claims and also present the results of our own experiments using unmodified stones to deflesh ungulate limbs. These results indicate that although it is possible to impart butchery marks with similar morphology to some of those on the Dikika fossils, this in no way nullifies the fact that randomly imparted striae can also mimic the Dikika marks, nor does it change the abrasive sedimentary context of the fossils. Thus, the null hypothesis of non-anthropogenic origin(s) for the marks remains unfalsified.

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Transition to Large Cutting Tool Production at the Koobi Fora Formation, Kenya

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The earliest evidence of Acheulean technology appears during a time of great biological diversity in the hominin lineage. The correlation between technological and biological evolution in the Early Pleistocene is poorly defined. However, the appearance of Acheulean artifact forms throughout the Old World after the expansion of the *Homo* lineage from Africa suggests this technology was related to the success of these populations. Despite recent analyses that document the technological prowess of Oldowan toolmakers, this technology remains relatively simple in comparison to techniques observed in Acheulean industries. Experimental work suggests these differences may be linked to complex cognitive functions among Acheulean toolmakers. However, the definitive aspects of Acheulean technology are extremely variable. Some studies emphasize the ability to produce large standardized flake blanks as integral to the production of large cutting tools (LCTs). Others focus on the appearance of systematic bifacial tool shaping. Few Early Pleistocene assemblages provide evidence for the complete suite of technological traits by which the Acheulean is generally characterized. Here we report on a recently excavated Early Pleistocene locality from the Koobi Fora Formation. FxJj 65 is located on the eastern margin of the Karari Ridge within the Upper Okote/Lower Chari Member (~1.4 Ma). We compare technological attributes of this industry with those from previously reported Oldowan (2) and early Acheulean sites (3) from Koobi Fora. Using a combination of morphometric and *chaîne opératoire* approaches we describe the production of LCTs. Data suggest that sites in the Upper Okote Member contain the full sequence of LCT production. We document evidence of both bifacial shaping and LCT flake blank production processes. Quantitative assessments of the byproducts of core reduction distinguish between these different processes in Oldowan and Acheulean contexts. We document similarities between FxJj 65 artifacts and typical Acheulean materials, yet call attention to significant quantitative differences.

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Derived Characters Shared Uniquely by Sima de los Huesos Mandible Sample and *Homo neanderthalensis*

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The study of mandibles from Sima de los Huesos reveals an identical morphology to that of the corresponding and unique region in the *Homo neanderthalensis* mandible (a resemblance that has previously been noted by others). This likeness is the outcome of a constellation of characters, the most salient of which are the very low position of the mandibular condyle (compared to the "normal" height of the coronoid process) and its anterior location, which brings the condyle closer to the deepest point of the mandibular notch. This constellation of characters is absent in other early and late hominins, including the type specimen *Homo heidelbergensis* (the Mauer mandible). Through a quantification of the mandibular anatomy and statistical analyses, we have verified these observations. We conclude that the mandibles of the Sima sample are virtually identical to the Neandertal mandible. Thus, we regard this morphology as a synapomorphy that the Sima fossils share only with *H. neanderthalensis*. In some other cranial morphologies, the Sima sample does not resemble Neandertals; hence, we place the Sima specimens within the Neandertal clade-as a sister group to Neandertals. This conclusion is inevitable regardless of whether one advocates a cladogenetic or anagenetic model.

Community Paleoecology and Habitat Variability During Middle Stone Age Occupation of the Cape Floral Region, South Africa

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The effects of Pleistocene glacial cycling on coastal terrestrial habitats of South Africa's Cape Floral Region (CFR) are debated, as multiple lines of evidence suggest differing levels of aridification and ecological changes associated with climatic extremes. More is understood about the exposure of the coastal plain resulting from cold glacial periods and this shift in land form may have drastically changed habitats available for coastal Middle Stone Age (MSA) humans. This study explores the shifting nature and variability of paleohabitats and allied large mammal communities associated with coastal MSA sites in the CFR through time. Minimum numbers of individuals of large mammal species from more than 50 levels of Quaternary archaeological and paleontological localities across the CFR were included in a meta-analysis designed to identify and compare patterns and shifts in taxonomic and ecological frequency distributions through time. Together with a model of glacial sea coast regressions (Fisher et al. 2010) and climate and environment reconstructions from speleothems (Bar-Matthews et al. 2010), these comparisons suggest likely paleohabitat affinities and mammalian community structures for assemblages during interglacial, glacial, and transitional time periods. Results suggest that during all climatic regimes, MSA humans occupied habitats distinctly dissimilar and more speciose than CFR habitats today, and that interglacials and glacials were characterized by differing ecology. Specifically, glacial periods were typified not by pure grasslands or mixed mosaics, but rather a unique pattern resulting from sampling both neocoastal habitats and habitats developing on exposed Agulhas coastal plain. This habitat heterogeneity suggests that while shrubby vegetation was maintained along the rockier, topographically diverse current coastline, exposed coastal plain represented a mixed grass-dominated ecosystem populated by a community of animals resembling a possible migratory unit analogous to those in eastern Africa. This novel interpretation can help clarify previously conflicting ecological signals used to reconstruct MSA paleoecology.

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Lateral Iliac Flare in Hominins

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The orientation and degree of lateral extension of the iliac blades is often mentioned in descriptions of the pelvic remains of Plio-Pleistocene hominins and in biomechanical inferences drawn from those remains. Laterally flared ilia are considered by some to be a plesiomorphic character shared by Australopiths and pre-modern *Homo*, which suggests parity in gluteal abductor muscle function between these groups. However, iliac flare is generally treated as a qualitative trait, and its definition appears to vary among researchers (meaning to some the absolute or relative lateral extent of the ilium, to others the degree of medial-ward curvature of the anterior portion of the blade). Therefore, we assessed differences between hominin groups in measurements that both quantify the overall lateral breadth of the os coxae and that capture the amount of anterior curvature of the iliac blade (that is, the degree to which the anterior superior iliac spine is displaced medially). Data was collected from original fossils and casts representing *Australopithecus afarensis*, *Au. africanus*, *Au. sediba*, *Homo erectus*, *H. neanderthalensis*, and early Pleistocene African *Homo* sp. indet. Measurements were also taken on a

sample of 107 modern human skeletons from the Raymond Dart collection at the University of the Witwatersrand. We found significant differences in iliac flare between species when comparing the anterior curvature of the iliac blade, which generally is expressed as a generic level difference between *Australopithecus* and *Homo*. We failed to detect significant differences between groups when only comparing the lateral breadth of the os coxae. These results suggest that evolutionary changes in pelvic architecture with the emergence of the genus *Homo* involved an accentuation of sigmoid curvature of the iliac blade, perhaps related to repositioning of the small gluteal muscles, repositioning of the abdominal oblique muscles, or overall changes in thoracopelvic bauplan.

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Quantifying Time Expenditure Associated with Neanderthal Burials and Its Implications

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The meaning and function of Neanderthal burials has been debated since their discovery. Some have argued for a symbolic interpretation, while others have advocated a purely functional use of burial. These arguments are often based on the absence or ambiguity of grave offerings in combination with little other archaeological evidence suggesting symbolic thought among the Neanderthals. Nevertheless, Mellars (1996) has argued that to create a Neanderthal burial would require a great investment of time and energy. Through experimental archaeology, I have attempted to quantify time expenditure associated with the act of digging inhumation pits using Middle Paleolithic stone tools to help understand the role of burials within Neanderthal society. Results from the experiment suggest the act of burying an individual would have required a great deal of time or manpower. As expected, there was an inverse relationship between the amount of time invested in the digging act and the number of individuals participating in the process. By contextualizing this data within our current understanding of the size, compassion, and site utilization among hominin groups, I argue that Neanderthal burials represent a social act beyond the simple disposal of an individual. The investment of time or manpower required for such burials supports the idea that Neanderthals possessed social or emotional bonds with each other and their dead.

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Reconstruction of *Australopithecus afarensis* Sexual Dispersal Demonstrates That Males Were More Closely Related Than Females at the "First Family" Site (A.L. 333, Hadar, Ethiopia)

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Reconstructions of australopithecine social organization are based on examining sexual dimorphism: high body mass and canine size dimorphism reflect high male-male competition, indicating polygyny, while low body mass and canine size dimorphism denote low male-male competition, indicating monogamy. *Australopithecus afarensis* is paradoxical, exhibiting high body mass dimorphism, yet low canine size dimorphism. Previous literature focuses on levels of male-male competition, but neglects other traits relevant to *A. afarensis* social organization, such as sexual dispersal pattern. This study reconstructs *A. afarensis* sexual dispersal pattern by establishing whether males or females were more closely related. Mandibular first and second molars from the "First Family" site, A.L. 333, were sexed and rated for five dental traits in two models. In Model 1, molars smaller than the mean were female, while molars larger than the mean were male. Model 2 involved random assignment assuming gorilla-like sexual dimorphism. Dental trait ratings were employed to assess intrasexual relatedness levels in A.L. 333 molars compared to all Hadar molars. In Model 1, A.L. 333 female variation was 91% that of all Hadar females, while male variation was 42% that of all Hadar males. In Model 2, A.L. 333 female variation was 67% that of all Hadar females, while male variation was 54% that of all Hadar males. Both models indicate that A.L. 333 males were more closely related than females. *A. afarensis* likely practiced a sexual dispersal pattern with considerable female transfer and only a moderate degree of male transfer. Although this sexual dispersal pattern is gorilla-like, canine size sexual dimorphism precludes the male-male competition that corresponds with uni-male groups. *A. afarensis* individuals of both sexes appear to have relocated at sexual maturity, much like modern humans in foraging societies. Hence, *A. afarensis* social organization may have formed the evolutionary beginnings of modern human society.

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Examining the Accumulation of Different Components of Fine Artifact Fraction Using Geographical Regression: An Example from the Mousterian and Aterian from the Grotte des Contrebandiers (Morocco)

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In most Middle Paleolithic research, larger-sized lithic and faunal remains have been studied using standard research methods, while fractions smaller than 5mm have been analyzed less extensively and usually only through the application of geological techniques. In this presentation, I show the results of geographically weighted regression analysis (Fotheringham et al. 2002) between the distribution of different components of fine fraction of 5-2mm size from one Aterian and one Moroccan Mousterian layer, derived from the recent excavations of the Middle Paleolithic site of Grotte des Contrebandiers (Morocco). Fine fraction material was provenienced as bucket aggregates, and it consists of lithic particles, bone fragments, as well as of geologically derived granules. Here, I model the relationship between vertical and horizontal distribution of those components within a layer, revealing more precisely their potential association and comparing the nature of their accumulation. The purpose of this is to detect potential patterns in the formation of layers, and, thus, to get insights into some aspects of taphonomy and behavior. At the same time, my aim is to contribute to the existing methods for extracting information from fine fraction material. The results show that there is a similarity in the input of different raw materials during the occupations of both of these two layers, where one of the raw materials is more closely related with the input of the very fine gravel in the sediment, indicating that its accumulation was due to geological agents rather than hominin behavior. In both of the layers there is a geographical correlation between the amount of burned bone fragments and the total amount of bone fragments, suggesting that either this distribution was affected by some postdepositional agent or that there were combustion events that were not induced anthropogenically.

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Early Modern Human Footprint Assemblage from Engare Sero, Tanzania

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Footprint assemblages provide us with unique information about the behavior and anatomy of our extinct relatives. Here we report on the oldest substantial assemblage of early modern human footprints, dating to c.120,000 years ago at Engare Sero, Tanzania, on the southern shore of Lake Natron. We uncovered over 350 hominin footprints, formed in a wet volcanic ash that subsequently lithified, in an area of approximately 150m^2 near the shore of paleo-Lake Natron. No prints of any other animals are present. Impressions of grass blade fragments and an acacia thorn suggest that these fragments were blown onto the ash surface from plants nearby. To examine the Engare Sero hominin prints, we compared them to an experimental sample of footprints made at various speeds by habitually unshod and minimally-shod adult Dassenach females (N=10) and males (N=10) from Ileret, northeastern Lake Turkana. The footprint assemblage consists of trails and a few isolated prints made by several dozen human individuals. Preliminary analyses of footprint shape suggest that the Engare Sero prints represent anatomically modern feet and gait. Several trails head in an easterly direction with stride lengths indicating that some of the individuals were running. The majority of the trails head in the opposite direction with stride lengths consistent with a walking speed and with similar preservation, suggesting that the prints were made within a relatively short time period. The diversity of footprint sizes (heel-hallux length range: 14.5–29cm) indicates that they represent individuals ranging from adult males and females to children. The Engare Sero print assemblage provides a snapshot, potentially including information about group composition, of what could be a traveling group of early modern humans 120,000 years ago.

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Mousterian and Proto-Aurignacian Spatial Organization at Riparo Bombrini, Italy

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Aurignacian sites are often claimed to differ from Mousterian ones on the basis of their showing clear evidence for spatially discrete activity areas and, by extension, where various types of discarded archaeological remains cluster within them. On the other hand, with a few notable exceptions, Mousterian sites have been generally argued not to show clearly separated activity areas. Assessing the true significance of these differences is difficult, however, when site size, shape, and functions cannot be controlled for. This highlights the need to conduct spatial analyses at sites that contain levels accumulated by both modern humans and Neanderthals to directly compare their degree of intrasite organization. To this end, this study uses piece-plotted finds (lithics, bones, shells, ochre) to contrast hominin use of space in proto-Aurignacian and late Mousterian levels from Riparo Bombrini (Liguria, Italy), where only a few hundred years separate the two types of occupations. While some spatial variability is evident in both periods, our results underscore that only the artifact distribution patterns in the site's two proto-Aurignacian levels can be interpreted as indicating different activity areas. Specifically, lithic manufacture, shellworking, and butchering activities appear to have been concentrated in different areas when the site was occupied by logistically- vs. residentially-organized *Homo sapiens*. In contrast, there does not appear to be a clear separation of activity areas in any of the Mousterian levels at the site, which suggests that Neanderthals and modern humans organized their use of Riparo Bombrini quite distinctly. Finally, by using artifact distribution patterns more broadly, we infer the position of the rockshelter's dripline before its collapse, indicating how spatial analysis might be a useful tool to reconstruct missing geomorphological features in other collapsed caves and rockshelters.

Seasonality in the Middle and Later Stone Age of Coastal Southern Africa From Comparative Cape Fur Seal (*Arctocephalus pusillus*) Assemblages: Reassessment and Future Directions

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Archaeological evidence for modern behavior-marked by inferred increases in cognitive ability, including use of symbols, complicated technologies, and advanced subsistence strategies-may be apparent as early as 160 ka, but seems to become more widespread after 100 ka. Disagreement regarding the timing of modern human behavioral complexity is based in large part on the perceived differences between MSA and LSA assemblages. Seasonal exploitation of coastal resources has been important to this debate. For example, comparisons of archaeological samples of Cape fur seal at coastal sites in southern South Africa have been used to suggest that LSA hunter gatherers, unlike MSA populations, strategically-targeted coastal sites during seasons when seals were more abundant (Klein and Cruz-Uribe 1996). Although methods for establishing seasonality from archaeological seal mandibles have been evaluated by previous researchers (e.g., Woodborne et al. 1995; Marean and Assefa 1999; Lam 2002), specific predictions for differences in MSA and LSA seal assemblages have not been rigorously tested using appropriate statistical methods. The current study readdresses the utility of using seal remains to infer patterns of seasonality in the African Stone Age. Specifically, we address two questions: (1) Are comparative samples of seal remains adequate to address the question of seasonality?; and, (2) Do comparisons of archaeological and comparative samples demonstrate the predicted differences between LSA and MSA suggested by prior research? These questions are evaluated using resampling techniques and mortality assemblage simulation modeling. Our results indicate the comparative samples may be useful for questions of site seasonality. However, the predictions of LSA strategic seasonal targeting of young seals and MSA non-seasonally patterned visitation of coastal sites are not supported. The results are discussed in terms of the emergence of behavioral modernity in southern Africa, particularly in relation to the evolution of seasonal variation in foraging.

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Classifying Sex in Early *Homo sapiens* Using Fragmentary Os Coxae

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Developing methods to classify sex in fossils is problematic given the poor preservation typical of ancient specimens and the possibility of evolutionary changes in the expression of sexual dimorphism. Here, discriminant analysis is employed to identify variables from the more durable portions of the pelvis that enable an accurate classification of sex in a modern African sample comprised of Zulu and Kikuyu individuals. The reliable discriminant functions are then employed to determine the sex of several early *Homo sapiens* fos-

sils, including the first formal classification of sex for Omo I. The best-performing function in the modern African sample achieves an accuracy of 92.8%. This function uses two variables (sciatic notch width and sciatic notch depth) rendered dimensionless by scaling using the geometric mean of acetabular width and posterior acetabular ischial length. Because this method emphasizes shape rather than size differences, it may be reliably applied to populations of different body size and robusticity. Furthermore, since it relies on few measurements from durable portions of the pelvis, this approach can be productively applied in archaeological and paleontological contexts. Using this function, Omo I, Grotte des Enfants 5, and Nazlet Khater 2 are classified as female, while Qafzeh 9, Skhūl 4, Grotte des Enfants 4, and Paviland are classified as male. Depending on the preservation of each fossil, additional discriminant functions developed independently for the Zulu and Kikuyu samples were also employed. The classification of female sex for Omo I and Grotte des Enfants 5 remains relatively stable across all functions, while the other early *H. sapiens* fossils are classified as male in most instances. Furthermore, sex classification of these early *H. sapiens* tends to be characterized by moderate to high typicality probabilities, suggesting that these specimens generally conform to the pattern of pelvic dimorphism exhibited by modern Africans.

The Context of Early Middle Stone Age Occupations in the Main Ethiopian Rift: Renewed Excavations at Gademotta.

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The majority of evidence surrounding the origin of modern human populations suggests an African origin. The interplay between modern human behavior and the biology of these early human populations is complex. The archaeology of the Middle Pleistocene in Africa is therefore pivotal in understanding the behavioral evolution in those populations that predate the expansion from the African continent. These Middle Pleistocene assemblages are often associated with the term Early Middle Stone Age and span the technological boundaries of the Acheulean and later MSA industries. There are very few Early Middle Stone Age assemblages that are associated with high quality geochronological information. The assemblages from the Gademotta Formation represent one of the few instances where Early Middle Stone Age assemblages are associated with a well studied tephrochronology. The Gademotta Formation records a cultural sequence that spans ages between >280 ka and <183 Ka. This allows a fine-grained interpretation of hominin adaptive behavior and paleoenvironmental contexts. Previous research interpreted assemblages from the oldest EMSA occupation as representative of precocious technological capabilities. However, little has been described on the actual stratigraphic details of this site. This hinders the incorporation of this locality into current debates surrounding the topic. Here we report on renewed excavation and survey that suggest that the Gademotta Formation contains laterally extensive cultural sequences, including *in situ* Middle Stone Age (MSA) artifacts conspicuously overlain by Unit 10 (~280 Ka). However, further work is needed to better understand the microstratigraphy of the oldest MSA section. The complexities of the geological context of the Gademotta Ridge suggest some of the previously excavated materials actually post-date the volcanic ashes. The present study also explores the potential of the locality to provide an important setting for the investigation of the still largely unclear timing of the Acheulean-to-MSA transition and the appearance of modern humans.

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A Re-Evaluation of Mandibular Variation in Early *Homo*

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The rather ambiguous and exceptionally diverse Plio-Pleistocene early *Homo* fossil record continues to be an area of ongoing debate. The recent discovery of *Au. sediba* in South Africa and its link to early *Homo* has fuelled a growing number of questions surrounding the phylogenetic relationships among early members of our genus. However, the different taxonomic viewpoints and related studies of early *Homo* are complicated by our limited understanding of the cause and effect of inter- and intra-specific variation in this lineage, fundamental in determining specific evolutionary scenarios of adaptation. In this paper we evaluate the morphological variation in early *Homo* mandibular specimens, with a key focus on the cause of diversity in the hypodigm. The mandible is an appropriate indicator of phylogenetic significance, reflecting selective pressures related to the masticatory system, and is therefore useful to our objectives. 3D scanner and conventional morphometric data are collected from early *Homo* specimens from southern and eastern Africa, as well as numerous robust and gracile australopith mandibles, incorporated because of their temporal/spatial correspondence. Extant variance/covariance matrices from hominoids are used to calculate inter-individual scaled Mahalanobis' Distances between these specimens to determine their morphological relationships. These data also are analyzed using quantitative genetic statistical tests developed from neutral evolutionary theory in order to estimate the causal factors behind morphological divergence - i.e., whether divergence was likely to result from selection versus drift. Our results suggest that, for the most part, genetic drift can explain the diversity seen in early *Homo* mandibular morphology. However, results indicate that some southern African specimens are unusual relative to other early *Homo* material, and that genetic drift is unlikely to be responsible for the divergence of these specimens, implying an adaptation to different diet/environments and possibly warranting taxonomic separation.

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Evaluating *Paranthropus* Monophyly Through an Inhibitory Cascade Model of Postcanine Development

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Molarization of the postcanines has been argued to be a synapomorphy of *Paranthropus*, but it may also be the product of homoplasy. Evolutionary developmental models may provide predictive frameworks for understanding the origins of adaptive morphologies such as molarization. Kavanagh et al.'s inhibitory cascade model, developed in extant rodent postcanines, is here applied to the molar row and to P3-M1 sequence in *Paranthropus* taxa in order to evaluate whether molarization follows the same developmental pattern in the two sequences examples. Total crown areas of *Paranthropus* maxillary and mandibular postcanines were collected from precision casts and the literature. Analysis of the molar row (i.e., M1-M3) demonstrates similar developmental patterning in both *P. robustus* and *P. boisei*, with the morphology of *P. boisei* molars being an "extreme" form of the pattern seen in *P. robustus*. Analysis of the P3-M1 sequences demonstrates that they are not the same in the two taxa. The pattern of P3-M1 development in *P. boisei* resembles that of the molar sequence. The P3-M1 sequence in *P. robustus* is different in that there is a significant step between the P4 and M1, unlike the pattern seen in *P. boisei*. This application of the inhibitory cascade model suggests that it has potential for evaluating the hypotheses that have been generated to explain the evolutionary relationship between *P. boisei* and *P. robustus*.

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The First Evidence of Cultural Modernity in Early Upper Paleolithic of Iran and Implications for the Initial Dispersal of Aurignacian

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Despite the considerable amount of work which has been carried out on the debate of origin(s) of Aurignacian, the first known cultural entity attributed to anatomically modern human in Europe and Western Asia, this topic has still remained an unsolved issue and requires additional data from related geographical regions. In this respect, new, important evidence from Iran, particularly the Zagros Mountains region, which is located almost on the south eastern border of Aurignacian technocomplex expansion, has a definite potential to answer some of our questions regarding the aforementioned problematic debate. The earliest known upper Paleolithic culture of Iran, which was called the Baradostian, shares certain similarities with some phases of the Aurignacian and plays the key role in this discussion. The presence of symbolic behaviors accompanying advanced techno-economical procedures signals the Baradostian as the first Paleolithic culture in Iran possessing the indicators of behavioral modernity in the time span of the transition between the Middle to Upper Paleolithic. This paper examines all major evidence of known symbolic behavior indicators of the Baradostian from sites such as Yafteh and Pa Sangar and attempts to interpret them in their cultural context on the basis of available data and, in broader sense, defines their contribution to the current debate of the Aurignacian in Eurasia.

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The Greater Sciatic Notch Index as a Designator of Sex: Implications for LB1/7 (*Homo floresiensis*)

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Although the greater sciatic notch (GSN) is commonly cited in the literature as the basis for sex determination of both modern humans and fossil hominins, there is no standard, easily replicable method to follow when using this feature to sex interspecific, ecogeographically dispersed remains. The GSN index, a proportion of the posterior chord of the notch to the overall width, is a simple metric method that was widely used in the first half of the 20th century and is only intermittently employed in recent research. To use this index diagnostically, the value calculated from the unknown sample must be compared to the mean GSN index value of a reference population, and ecogeographic origins of both sample and reference must be taken into account. In addition, Ruff (2010) cited equal accuracy in calculating the GSN index from measuring either posterolateral photographs of fossil pelves or directly from casts. The present study systematically tests the accuracy of the GSN index in assigning sex, from both direct measurements and photographs, based on GSN dimensions of known-sex Terry Black pelves (males n=46, females n=47). The Terry GSN index mean and sectioning point were determined to be 0.41, with a female mean of 0.50 (95% CI±0.02) and a significantly different ($p<0.0001$) male mean of 0.31 (95% CI±0.03).

Index values calculated from measurements of the LB1/7 (*Homo floresiensis*) GSN from the two published photographs available (Brown et al. 2004; Jungers et al. 2009) and from a high-quality cast fall within the 95% CI of Terry Black females, lending evidence to support previous claims that LB1 is female. These data reinforce the utility of the GSN index as a metric method to designate sex without immediate access to fossil materials.

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The Aurignacian Rock Engravings of Abri Castanet: 3D Documentation and Analysis

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The site of Abri Castanet (Dordogne, France) preserves a single Aurignacian occupation resting directly on bedrock and sealed by a collapsed rock shelter. In addition to a rich archaeological assemblage, some fragments of this collapsed ceiling preserve traces of engraved and painted surfaces. In many cases these artistic representations are fragmentary, either from taphonomic factors or the process of extracting large blocks. Using total stations, structured light 3D scanners, and gigapixel imaging techniques these blocks can be very precisely digitally recorded. Here we present about two large blocks from the Aurignacian of Abri Castanet. The first was discovered in the spoil of earlier excavations and preserves traces of animal forms and *anneaux* (suspension holes). While out of direct context, it is certainly of Early Aurignacian age. The second block was discovered *in situ* with its engraved surface in contact with the underlying archaeological layer. It preserves one distinct engraving (of a roughly vulvar form) and traces of several others. The associated archaeological material has been radiocarbon dated to 32,400 BP, making this find the current oldest dated parietal representation in Eurasia. This second block was fragmented both in place and during extraction, but in the 3D environment the disparate pieces can be digitally refit. The digital scans and imagery of the block are used to reveal the clear anthropogenic nature of the engraving, its placement on the collapsed shelter, and the direct association of the engraving with the well-dated archaeological material. These techniques and results yield important insight into the nature, chronology, and context of some of the earliest known graphic representations.

Results of Experimental Obsidian Microwear Analyses Using a Scanning Electron Microscope and Its Applicability to the Archaeological Record

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Traditional lithic microwear studies use light microscopy to determine chert and flint artifact functions. Applying this technique to obsidian is problematic because light reflects off its naturally glassy surface hindering observation of microwear features such as flake scars, edge rounding, striations, and polishes. Obsidian is an extremely brittle raw material and generates patterns of use damage that differ from those on chert and flint artifacts. Because obsidian is too reflective for light microscopy and its brittleness generates unique damage patterns, it requires a different set of analytical methods for microwear analysis. Scanning electron microscopy (SEM) negates light reflection and permits clear, high magnification imaging of microwear features on obsidian artifacts. I present results of experiments and blind tests showing that differences in worked material hardness and different use-actions produce diagnostic patterns of modification on obsidian artifacts that are observable with a SEM. The development of obsidian microwear methods is important for research on stone tool function and applicable to areas of the world where this raw material was abundant and virtually the only material used for flaked stone tools. Preliminary microwear analysis of obsidian artifacts from the Middle Stone Age site of Marmonet Drift (GtJi15) in the central Kenya Rift Valley identified characteristic wear patterns on some artifacts and highlights the applicability of this technique to the archaeological record.

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Orgnac 3: New Perspectives on an Old Site and Directions for Future Research

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A critical goal of current paleoanthropological research is to clarify "the muddle in the middle," (Isaac 1975), that is, the poorly resolved record of the behavioral and biological evolution of Middle Pleistocene (MP) hominin populations in Europe that included Neanderthals and their ancestors. Orgnac 3 (OR3) in southeastern France is especially well suited to addressing the paleoecological, behavioral, and morphological changes that were taking place during the MP, though it has received relatively little attention. We will introduce the site to a wider audience, summarize the previous results, offer some new views that they suggest, and propose directions for future research. A review of previous work and the inferences it allows show that OR3 remains relatively misunderstood and understudied. We will show that the OR3 archaeological deposits most likely date to OIS 11, 10, 9, and 8, rather than just to OIS 9 and 8, putting the initial occupation of the site ~100,000 years earlier than previously accepted. This bears directly on when Levallois technology appeared in Europe, as OR3 is one of the few early sites to reveal its development. The shorter chronology was based on Uranium-series dates from post-depositionally altered travertine samples, and contradicts biochronological and sedimentological chronologies. The fossil fauna most likely represents a combination of both carnivore and hominin activity and not simply hominin hunting and butchering. The hominin remains have not been photographed, described in detail, or assigned to a taxon. The site itself, of which only ~12% of the currently known deposit has been excavated, has been left in a state of disrepair and, despite having a building and a fence protecting it, has been frequently vandalized by intruders over the last 20 years. We hope that continuing research at OR3 will help clarify the "muddle" in our understanding of hominin evolution during the MP.

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Occlusal Fingerprint Analysis in Early Hominid Molars and its Meaning for Dietary Reconstruction

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The morphology of teeth has always been essential for research on phylogeny, diet, and palaeoenvironment. Occlusal wear patterns, which develop during the processing of food, are an important aspect for the understanding of the functional morphology of teeth, as these structures provide direct evidence for an individual's diet. However, the complexity of the configuration of these facets has been a challenge in dental research. The Occlusal Fingerprint Analysis (OFA) applied in this study provides a mean to quantify and compare these wear patterns. By measuring the dip direction and the inclination angle of every facet on a tooth, we generated a 3D occlusal compass. This compass enabled us to get a clear picture of an individual's dental wear. Lower molars of *Australopithecus afarensis* from the three Ethiopian sites of Hadar, Omo, and Maka were surface scanned and the resulting 3D models were analysed using the software package PolyWorks®. Our preliminary results indicate that this early hominid sample is extremely uniform, independent of wear stage, geological age and place of discovery. These results are remarkable considering the wide range of habitat reconstructions for the investigated sites, covering open woodland and grassland to rather closed vegetation.

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3D Digitization of the Excavation Site of a Fossil Hominid (StW 573 / "Little Foot," Sterkfontein, South Africa)

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During more than 10 years of careful excavation, Ron Clarke and his colleagues exposed a virtually complete skeleton of *Australo-*

pithecus (StW 573, nicknamed "Little Foot") at Sterkfontein in South Africa. It is estimated to be around 3 million years old. This is somewhat older than recently published U-Pb dates for the skeleton, which, in fact, date a younger flowstone that filled gaps created by subsidence of the breccias containing the skeleton. This specimen is exceptional in its completeness and represents a second species of *Australopithecus* to *A. africanus*, for which Sterkfontein is well known. Most of the elements of the skeleton are undistorted and preserve anatomical association. However, a few anatomical parts show crushing, fragmentation, scattering, and disarticulation, caused by collapse of portions of the deposit. It has been important to record the details of the skeleton's position and any displacement within the strata so that the orientation and location of the bony elements are carefully archived prior to removal of the bones from the cave. For this purpose, we scanned the excavation site with two 3D laser scanners. High resolution 3D models also provide a memory of the geological context to assist interpretation of the skeleton in relation to the detailed stratigraphy. With the 3D digital models, it will be possible to come back to an interactive and non-interpretative view of the context. We used a Konica-Minolta VIVID 910 scanner which is widely used in industrial metrology and a NextEngine HD scanner which is a low-cost desktop device used to digitize small archaeological objects. Post-processing of the 3D views consists in a pipeline of computer graphics procedures: selection of 3D views, global registration, fusion, and simplification, "beautifying" the resulting 3D reconstruction and rendering. One author used only open-source software whereas another author combined the functionalities of several commercial softwares.

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The ESRF Virtual Database: A New Resource for Paleoanthropologists

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Paleoanthropological studies increasingly employ micro-computed tomography (micro-CT) for studies of skeletal anatomy and development. This non-destructive method allows precise quantification of internal structures and three-dimensional morphology at increasingly finer resolutions. For example, recent micro-CT studies of the primate dentition have provided insights into enamel thickness, enamel-dentine junction shape, root and pulp morphology, and developing tooth calcification. However, limited access to requisite scanning equipment and fossil material has prohibited widespread study of these characters. Although there have been discussions about making hominin data accessible (Weber 2001; Delson et al. 2007), the only fossil that is available for free and with open access is the Skhul V scan (on the Harvard University Peabody Museum website), and just a few scans are available for a nominal fee (e.g., NESPOS Society, University of Vienna's Digital Archive of Fossil Hominids). Recently, the European Synchrotron Radiation Facility (ESRF) created a free open access online database from micro-CT studies performed at the ESRF (<http://paleo.esrf.eu>). We are currently working to upload synchrotron micro-CT scans employed in publications on hominin dental remains (Smith et al. 2006, 2009, 2010), and other material scanned at the ESRF in collaboration with numerous scholars and repositories (who may retain copyrights). The ESRF is committed to the long-term maintenance of this database as a means of increasing global research infrastructure and promoting awareness of synchrotron imaging. Given the recent publication of newly discovered fossil insects in opaque amber (e.g., Lak et al. 2008), digital data may even represent the primary evidence of new species in some cases. Moreover, virtual models of skeletal remains may serve as a mean of safekeeping fossils, can be used to produce scaled replicas, and reduce the need for repeated measurements on actual fossils. By making these data available we also hope to promote more open scholarly exchange.

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Carnivore Ecomorphology in Plio-Pleistocene East Asia and East Africa: Implications for Hominins

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Hominins interacted with the carnivore guild by scavenging carcasses and competing with carnivores for those carcasses. Feeding adaptations and body mass are among the traits that differentiate members of the carnivore guild and influence the outcome of interspecific competition. Early Pleistocene hominins colonizing East Asia would have encountered different species of predators. Obtaining animal resources would have been important at higher latitudes due to seasonal differences in plant availability. Here, Plio-Pleistocene

East Asian and East African large carnivore communities were analyzed to show how they compared ecomorphologically and how differences may have affected hominins. Ecomorphological indices related to body mass and feeding adaptations, such as bone-cracking, flesh-slicing, and grinding, were derived from craniodental measurements of fossil Felidae, Canidae, Ursidae, and Hyaenidae. Specimens were compared from Olduvai Gorge and Lake Turkana in East Africa and hominin and non-hominin faunas in East Asia. The results show that hominins may have faced differences in the availability of scavengeable remains in East Asia. East African faunas had more species of hyaenids. African *Crocuta* and Asian *Pachycrocuta* had some similarities in the feeding traits measured here, but *Pachycrocuta* was larger and may have been a more formidable competitor. Hominins also may have interacted with larger and more carnivorous canids in East Asia compared with East Africa. Though East Asia and East Africa shared many genera of large felids during this time period, *Homotherium* and *Megantereon* survived longer in East Asia and may have been sources of scavengeable resources. This study implies that early Pleistocene hominins adapted to carnivore guild differences, in particular co-existing with *Pachycrocuta*. The ability to utilize a variety of resources, group sociality, and other behaviors may have enabled hominins to better compete with East Asian carnivores and may have affected the carnivore guild structure over time.

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Experimental Definition of Bone Surface Signatures From Natural Unmodified Stones and Implications for Early Hominin Subsistence

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The early exploitation of large ungulate resources by our hominin ancestors is commonly considered to have begun in concert with the advent of flaked stone technology. Recently-reported fossils from Dikika, Ethiopia predate the earliest documented stone tools by more than 800 thousand years, yet they bear marks characteristic of butchery damage (McPherron et al. 2010). In addition to the implications this has for early hominin subsistence and tool use, there are several attributes of the Dikika damage that appear qualitatively different from that inflicted by a dual toolkit consisting of a flaked stone cutting edge and a rounded hammerstone for marrow extraction. We present the results of experimental meat and marrow removal from ungulate long bones using such a dual flake/hammerstone toolkit and then replicated using only unmodified, naturally sharp-edged stones (NSES). These experiments show that: 1) carcasses can be butchered using only NSES; 2) NSES effecters leave bone surface modification that can be classified morphologically as both cut and percussion marks; 3) several variables within the butchery signature of NSES can be separated statistically from the signature of a dual flake/hammerstone toolkit; and, 4) the damage signature on the Dikika fossils resembles damage caused by NSES. The experiments provide a referential framework for interpretation of early fossils that bear butchery damage but which are not associated with flaked stone tools. They also illustrate a new method for quantifying the damage signatures of different effecters, increase the experimentally-produced range of variability in the morphology of butchery damage, and suggest how further archaeological traces might be expected to be found in Pliocene sediments that pre-date flaked stone technology.

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New Archaeological Research on the Origins of the Acheulean at Olduvai Gorge, Tanzania

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This paper summarizes recent archaeological research in Middle and Upper Bed II at Olduvai Gorge by OGAP (Olduvai Geochronology and Archaeology Project). Integrating geochronological, paleoecological, zooarchaeological, and technological perspectives, the archaeological objective of our current work is to address the demise of the Oldowan and the dynamics that led to the emergence of the Acheulean at Olduvai in Middle Bed II, and to explore inter-assemblage variability between the so-called Developed Oldowan and the Acheulean in Upper Bed II. Our recent fieldwork has combined surveys in search of new assemblages with excavations at sites previously investigated by Mary Leakey (1971), including HWKEE, EFHR, MNK, and FC West. HWKEE, located in lower Middle Bed II, has revealed a large bone and lithic assemblage that, together with new fieldwork at MNK, is allowing us to characterise the technology and subsistence strategies of Olduvai hominins just before the emergence of the Acheulean. Ongoing excavations at EFHR aim to refine the stratigraphic position of this site, which Leakey (1971) believed to be the earliest Acheulean at Olduvai. We are also investigating the sedimentary context of the archaeological assemblage in more detail, which indicates a more complex picture than suggested by Leakey's (1971) original environmental reconstruction. Fieldwork at EFHR is also extending the fossil and lithic sample, which is vital for understanding the character of the earliest Olduvai Acheulean. Resumed excavations at FC West are unearthing a dense bone and lithic assemblage, which will help us to investigate subsistence and technological adaptations of Olduvai hominins after the emergence

of the Acheulean, and will contribute new data to help assess the validity of the Developed Oldowan as a lithic technology separate from the Acheulean.

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Middle Stone Age Hominin Occupation of Arid Environments in the Lake Victoria Basin: New Evidence From Rusinga and Mfangano Islands, Kenya

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Lake Victoria, presently the largest water source in Africa, has a complex ~400 kyr history of contraction and expansion linked to orbitally forced changes in humidity that have significantly altered bordering plant and animal communities. Our research on Rusinga and Mfangano islands in Lake Victoria provides the first terrestrial evidence for pre-Last Glacial Maximum periods of aridity in the Lake Victoria basin. Increased aridity would have caused lake contraction and replacement of local scrub vegetation with open grassland habitats and associated fauna. The Pleistocene expansion of grasslands may have served as an important mechanism for the range shifts and dispersal of taxa, including hominins, within and out of eastern and central Africa. Both islands contain Middle Stone Age (MSA) artifacts and fossil fauna in primarily reworked, tuffaceous, alluvial sediments and rare associated ancient spring deposits. Artifacts include Levallois flakes, cores, and small unifacial and bifacial projectile points with typo-technological affinities with Rift Valley MSA sites also from grassland environments. The fossil assemblages are dominated by alcelaphine bovids, contain extant arid-adapted taxa beyond their present range (*Equus grevyi* and *Oryx gazella*), and include extinct taxa (e.g., *Syncerus antiquus*, *Rusingoryx atopocranion*, *Megalotragus*, and a small alcelaphine) with fossil associations or adaptations consistent with an arid grassland setting. These large ungulates likely required home ranges greater than that of Rusinga (40.5km^2) or Mfangano (64km^2), suggesting a connection to mainland Kenya. The co-occurrence of artifacts and fossils, rare tooth- and cut-marked specimens, sedimentological evidence, and stable isotopic analyses of pedogenic carbonates, soil organics, and fossil tooth enamel suggest that the deposits on both islands sample well-watered areas within an open, arid, grassland setting very different from the present. These deposits may have served as focal points for local herbivores, carnivores, and hominins during the late Pleistocene in the Lake Victoria Basin.

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The Effects of Seasonality and Aridity on Horn size and Sexual Dimorphism in Extant *Aepyceros melampus*: Implications for Interpreting Trends in the Fossil Record in the Hadar Formation, Ethiopia

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The Pliocene Hadar Formation, Ethiopia, is well known for its 400 ka record of mammalian (including hominin) evolution. Independent lines of evidence indicate that the youngest part of the formation, the Kada Hadar 2 (KH-2) submember, is the most arid and seasonal environment recorded at Hadar. A significant turnover in the faunal assemblage is noted and, additionally, anagenetic changes in the size of the KH-2 fauna have been suggested. For example, impalas, *Aepyceros* sp. nov., from the KH-2 have the largest basal horn size observed in the Hadar Formation. To determine if horn size increase in the Hadar impalas reflects changing environmental conditions, this study examines the relationship between horn size, aridity, and seasonality in the geographically and ecologically widespread extant impala, *Aepyceros melampus*. Male horn size and body size (estimated from cranio-dental variables) from four subspecies of *Aepyceros melampus* (n=59) were measured. The specimens were grouped based on their collection locality and data on monthly rainfall, used to quantify aridity and seasonality, for each collection locality was acquired. Correlations between environmental predictors and horn size were analyzed, as were multiple regressions (forward and backward step-wise). The relationship between rainfall modality, a categorical predictor, and horn size was determined using an ANOVA and Tukey's post-hoc tests. Specimens from localities with a bimodal rainfall distribution (i.e., two rainy seasons) are significantly larger than those from localities with a unimodal distribution ($p<.01$). A significant positive correlation ($p=0.025$) is observed for horn size and annual rainfall; that is, specimens from drier habitats have a smaller horn size than those from wetter climates. Additionally, body size did not correlate with any rainfall predictor. The results suggest that increases in seasonality and not aridity drove the increase in horn size observed in the youngest impala specimens from the Hadar Formation.

A New and Free Database About Teeth

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This communication introduces a new web site, <http://anthropologicaldata.free.fr/> (without www), which allows anyone to download free metric tooth data. The aim of this web site is to provide comprehensive, standard dental metrics for most, if not all, of the permanent teeth of the earliest hominins to modern humans. Much of the human fossil record is made up of dental remains and these descriptions are scattered in different journals—some old and hard to get. For many researchers it is difficult to assemble a data set for comparative studies and there is always the problem of inter-observer error. Our attempt here is to provide a data repository for comparative dental data using standard length/breadth crown metrics and root measurements when available. A large sample from the European Upper Paleolithic and Mesolithic are now available and we plan to add (soon) data for late Paleolithic North African samples and for the Krapina Neandertals. We encourage scholars to contribute their data sets to our website. In this web site, fossil teeth are grouped together in tables (Excel 2003 files) where each line corresponds to one tooth and contains metric data, bibliographic references of the first or more recent important description of these remains, etc. To avoid huge files, samples are divided as following: Lower Paleolithic, Middle Paleolithic, Upper Paleolithic, Mesolithic, Neolithic, and extant and/or recently extant groups. All teeth are listed by site and the measurements include standard mesial-distal and buccal (labial)-lingual measurements. Today, more than 3,500 teeth are available and this number will continue to growth, especially when lower and middle Paleolithic are included.

A Statistical Analysis of Incision Patterns at Wonderwerk Cave, South Africa: Towards an Evaluation of Early Symbolic Behaviors

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Development of the capacity for symbolically-mediated behavior was an important milestone in the evolution of *Homo sapiens*, but acceptance of most markings as symbolic media is based on subjective/expert opinion (argument from authority) rather than objective testing. The statistical method advanced here tests whether line configurations engraved on the surface of objects differ from randomly-generated line configurations. Pattern significance is calculated from the observed frequency with which a single line configuration may be generated from a distribution of 9,999 randomized line configurations. Line configurations that are significantly different from random are more likely to be part of a patterned system of shared meaning and to have served as symbols intended to transfer information. Two control samples were analyzed here to test the feasibility and reliability of the method; (1) Later Stone Age incised stones from Wonderwerk Cave, Northern Cape, South Africa, and (2) "natural" pieces of stone collected from outside Wonderwerk Cave that exhibit lines due to the geological processes of cleavage and abrasion. The results conform fairly well to expectation. One of 10 of the natural pieces and 5 out of the 12 of the LSA pieces exhibit line configurations that differ significantly from a randomly generated pattern. This analysis reveals that natural processes can occasionally result in non-random configurations and that not all unequivocally engraved objects yield line configurations that are significantly different from random. The intent of this research is to expand on a method grounded in entropy information theory and move towards a more objective approach to exploring the origins of symbolic communication.

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Experimental Evaluation of Ochre-Containing Mastic in the Hafting of Hunting Armatures

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The use of ochre by humans prior to the Upper Paleolithic and Later Stone Age has often been cited in studies addressing the origins of symbolic behavior. Minerals such as hematite, specularite, and goethite are all considered ochreous and are functionally united by the unique and vibrantly colored streak produced by each. Analyses of the Middle Stone Age (MSA) assemblage from Twin Rivers, Zambia, dated to 270–170 kya have concluded that humans preferentially acquired specularite from more distant sources when other ochreous minerals were available locally. Some researchers have interpreted this evidence as indicative of MSA humans following an ochre acquisition strategy mediated by visual properties and suggestive of a symbolic application. However, experimental archaeology and residue analysis of 50–60 kya points from Sibudu Cave, South Africa, indicate that ochre possessed utilitarian value during the MSA, specifically as a component of adhesive used to haft lithic tools. Here we report the findings of a study addressing the hypothesis that ochreous minerals were used primarily in non-symbolic capacities and that such a role may explain the patterns observed in the Twin Rivers assemblage. Specifically, this experiment evaluated three ochreous minerals as an ingredient of mastic for hafting projec-

tile points. Using *Acacia senegal* tree resin and finely ground hematite, specularite, and goethite, three recipes of mastic were produced and used to haft stone points on commercially available arrow shafts. Completed arrows were divided into groups and stored under variable humidity in order to study the hydroscopic properties of each adhesive. Following storage, the arrows were tested as hunting weapons through launching into a goat carcass with a recurve bow. Preliminary analysis suggests that mastic recipes containing hematite form the most effective adhesive when compared with specularite and goethite-containing mastics and can haft projectile points without any reinforcing materials.

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