Overview of Paleolithic Archaeology

Nicholas Toth and Kathy Schick

Contents

Abstract

The Paleolithic, or Old Stone Age, comprises over 99 % of human technological history and spans a time range from 2.6 Ma (the earliest recognizable stone tools and archaeological record) to 10,000 years ago (the end of the last ice age). There are three major stages of the Paleolithic: (1) The Early Paleolithic which includes the following: (a) the Oldowan, from 2.6 to about 1.0 Ma, characterized by simple core forms on cobbles and chunks (choppers, discoids, polyhedrons), battered percussors (hammerstones and spheroids), flakes and fragments, and retouched forms such as flake scrapers. Cut marks and fracture patterns on animal bones indicate meat and marrow processing, with the use of simple stone knives and hammers. This stage is associated with the later australopithecines and the earliest forms of the larger-brained genus *Homo* and documents the first hominid dispersal out of Africa and into Eurasia, (b) The Acheulean, which lasted from approximately 1.7 Ma to 250,000 years ago and was

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characterized by large bifaces such as handaxes, cleavers, and picks. The early Acheulean is associated with *Homo erectus/ergaster*, while the later Acheulean (by ca. 500,000 years ago) is associated with the even larger-brained *Homo heidelbergensis*. (2) The Middle Paleolithic/Middle Stone Age, from about 250,000 to 30,000 years ago, characterized by a focus on retouched flake tools, such as scrapers, points, and backed knives, and prepared core technologies such as the Levallois method. The controlled production and use of fire appears to be widespread for the first time. This stage is especially associated with archaic forms of *Homo sapiens* (having modern-size brains but more robust faces and postcranial skeletons), including the Neanderthals (see chapter "▶ Neanderthals and Their Contemporaries," Vol. 3) and the earliest anatomically modern humans (see chapter "▶ Origin of Modern Humans," Vol. 3). (3) The Late Paleolithic, from 40,000 until 10,000 years ago, characterized by blade tool industries; a proliferation of artifacts in bone, antler, and ivory; and the emergence of rich symbolic art in the form of paintings, engravings, sculpture, and personal body adornment (see chapters "▶ Modeling the Past: Archaeology," Vol. 1, "▶ Cultural Evolution During the Middle and Late Pleistocene in Africa and Eurasia," and "▶ Dispersals of Early Humans: Adaptations, Frontiers, and New Territories," Vol. 3). Early examples of clear architectural structures, musical instruments, and mechanical devices (spear-throwers and bows and arrows) appear during this time. This stage is especially associated with anatomically modern humans, *Homo sapiens sapiens*.

Introduction

The Paleolithic is the term applied to a very broad, early period of human prehistory beginning with the first archaeological evidence of stone toolmaking approximately 2.6 Ma, through to the end of the Pleistocene epoch about 10,000 years ago, when the last continental glaciation receded. It documents the emergence of a wide range of new technological, behavioral, and adaptive traits through time (Toth and Schick 2010). It is important to appreciate that over 99 % of human technological development took place during the Paleolithic. The Paleolithic thus constitutes the bulk of the time span of human technological development and human prehistory and documents the emergence and evolution of the genus *Homo*. The term is applied primarily to prehistoric developments in the Old World, as the New World's earliest archaeological evidence appears only toward the very end of Paleolithic times, during the last phases of the terminal Pleistocene glaciation. In the New World, however, the period of Late Ice Age hunter-gatherers is often referred to as "Paleo-Indian" and is contemporaneous with the last few thousand years of the Paleolithic in the Old World. For overviews of human evolution and the Paleolithic, see also Boyd and Silk (2012), Burenhult (2003), Clark (1982), Ciochon and Fleagle (2006), Delson et al. (2000), Gamble (1986), Johanson and Edgar (1996), Jones et al. (1992), Klein (2009), Lewin and Foley (2004), Mithen (1996), Noble and Davidson (1996), Renfrew and Bahn (1996), Roberts (2011), Scarre (2013),

Schick and Toth (1993), Stringer and Andrews (2005), Tattersall (1999), Tattersall and Schwartz (2000), and Toth and Schick (2010).

"Paleolithic" literally means the "Old Stone" (paleo = old, lithic = stone) Age, as it represents the earliest phases of human technological development when the vast majority of the tools represented in the archaeological record were made of stone. At the end of the Pleistocene, the Paleolithic is followed by the later phases of the Stone Age, the Mesolithic and then the Neolithic. During the Mesolithic (in some regions referred to as the "Epipaleolithic"), stone technologies continued to evolve as stone tool-using hunter-gatherers adapted to changing environments of the current (Holocene) epoch, sometimes characterized by small (microlithic) stone tools. During the last phase of the Stone Age, often referred to as the Neolithic (or "New Stone" Age), a transition occurred from hunting-gathering to a more settled way of life based on food production (agriculture and herding), but stone continued for some time to be used for tools (such as ground axes, projectile points, and sickles).

The Paleolithic is traditionally divided into three major subdivisions: (1) the Early Paleolithic (also sometimes called the Lower Paleolithic) or Early Stone Age (ca. 2.6 Ma to 250,000 years ago); (2) the Middle Paleolithic or Middle Stone Age (ca. 250,000–30,000 years ago); and the Late Paleolithic (also Upper Paleolithic) or Later Stone Age (ca. 40,000–10,000 years ago). The "Lower"/"Middle"/"Upper" designations for the Paleolithic stages were developed in Europe in the late nineteenth and earlier twentieth centuries, based primarily on diagnostic artifact types and technological patterns observed in the stratigraphic and cultural sequences in various regions of Europe. More recently, with the appreciation that other parts of the world did not follow the precise cultural-historical sequence of Europe, many researchers have put less formal emphasis on these designations in favor of the more neutral terms "Early"/"Middle"/"Late" on a worldwide scale. This latter terminology will be used here.

For the first hundred years of Paleolithic research, these Paleolithic subdivisions were used to express a general chronological sequence (a relative chronology) without a firm sense of how many years ago each phase began or ended (an absolute chronology). During the past half-century, however, radiometric dating techniques have allowed the development of a more precise chronological framework for this Paleolithic sequence worldwide (see chapter "▶ Chronometric Methods in Paleoanthropology," Vol. 1), with approximate times for the beginning and end of each phase.

Change from one stage of the Paleolithic to the next, however, does not always entail an immediate or complete turnover in artifact types, though it does generally represent an obvious and perceptible shift in the types of artifacts dominating the archaeological tool assemblages and often a corresponding shift in the dominant methods used in making these tools. For instance, while modified flake tools are present at a number of Lower Paleolithic sites, they become the dominant artifact form, often with consistent or repeated shapes, at many Middle Paleolithic sites. There is also some regional variation in the absolute chronology of the sequence, with evident technological transitions in some regions occurring earlier or later than

in other regions. For instance, the transition from the Middle Paleolithic/Middle Stone Age to the Late Paleolithic/Later Stone Age happens somewhat earlier in some regions than in others.

Perspectives on Early Stone Tools

The earliest prehistoric archaeological record is now approximately 2.6 Myr old, based on the recognition of flaked stone artifacts in securely dated deposits in East Africa. The fossil record of bipedal hominids, however, goes back at least 6 Ma, several Myr before the first appearance of stone tools (see chapter "▶ Role of Environmental Stimuli in Hominid Origins," Vol. 3). On the basis of modern primate analogs, especially from chimpanzees, a range of tools and tool-using behaviors might be postulated for hominid populations prior to 2.6 Ma. Such hypothetical early tool use likely involved highly perishable, organic raw materials that provide no enduring, visible archaeological record.

A handful of nonhuman species have been documented to show some minimal use of tools in the wild, including sea otters, birds (such as crows, finches, and Egyptian vultures), and even mud wasps (Shumaker et al. 2011). Aside from humans, however, the only other animals showing habitual use of a variety of tools for a variety of purposes are our closest living relatives, the chimpanzees (McGrew 1992). What is more, chimpanzee toolmaking and tool-using skills appear to be learned over several years, suggesting a simple culturally transmitted system.

We now know that there is variability among different chimpanzee groups in the sets of tools (see chapters "▶ Great Ape Social Systems", "▶ Evolutionary Biology of Ape and Monkey Feeding and Nutrition", "▶ The Hunting Behavior and Carnivory of Wild Chimpanzees," Vol. 2, and "▶ Modeling the Past: Archaeology," Vol. 1) they commonly use, showing cultural variation among chimpanzees in their tool kits. Modern chimpanzee tool use includes nut cracking with stone and wood hammers and anvils, termite fishing, ant dipping with sticks or grass stems, and using chewed-up wads of leaves as sponges to obtain water or for self-cleaning. Although some chimpanzee tools consist of unmodified objects used for a particular task, chimpanzees do intentionally modify or shape some of their tools, such as the sticks and grasses used for termite fishing or ant dipping and the chewed leaves used as sponges.

Deliberately manufactured stone artifacts in the early archaeological record represent the earliest evidence of tool production by early hominids. As such, they reveal the development of a reliance on stone tool use in early hominid adaptation by at least 2.6 Ma. Although stone tool use may have been affected by seasonal, environmental, or other opportunities, the archaeological record reveals a consistent manufacture of stone tools that persisted from this time onward until recent times.

Early stone artifacts clearly indicate a number of interesting behavioral characteristics of these early hominids: they selected stone raw materials at specific

locations, transported manufactured artifacts and unmodified stone from one place to another on the paleolandscape, and discarded artifacts (and sometimes parts of animal carcasses) in distinct concentrations at many localities some distance from the raw material sources. Moreover, the manufacturing process used to produce early stone artifacts is one that is not observed in any nonhuman animal, even among chimpanzees, highlighting the novelty of behavioral innovation in the early stone toolmakers. Although early stone tools are admittedly simple and do not show elaborate shaping, they represent clear evidence of a new and unusual behavior pattern: the deliberate, controlled fracture of rock through percussive blows.

Technological patterns seen in early stone artifacts indicate they were produced primarily through a technique sometimes called "free hand, hard hammer percussion." This involves hitting one rock (the hammer) against another (the core) to bring about controlled fracture of the core (called conchoidal fracture, as the shock waves can produce radiating, shell-like ripples in finer-grained materials) and produce numbers of sharp pieces called flakes, a process called flaking or knapping. Experiments have shown that the main objective of early stone tool making was likely the production of such sharp flakes to use as cutting tools. Thus, a primary tool in the early hominid tool kit was likely the sharp-edged flake, and many of the cores found at early sites were likely by-products of the toolmaking process (see chapter "► Modeling the Past: Archaeology," Vol. 1).

Early stone toolmaking hominids were consistently producing such fractured stones at a number of early site localities. Early Paleolithic sites often involve dozens of flaked cores and thousands of flake products. Analysis of early archaeological materials often reveals extensive, controlled flaking of cores, involving rotation and manipulation to produce a series of flakes from the same piece of stone. Such fine core manipulation and exploitation is observable at even the very earliest Stone Age sites at Gona in Ethiopia, showing consistent, controlled, and skillful flaking of cores by 2.6 Ma.

With such skillful flaking observable among early hominid toolmakers on the one hand and the diverse tool-using and toolmaking cultures observable in chimpanzees (McGrew 1992) on the other, a natural question is whether the production of early stone tools represents skills beyond those seen in other apes. Wild chimpanzees are known to have ca. 40 cultural traits, which can pattern geographically (Whiten et al. 1999). At the subspecies level, chimpanzee groups in closer proximity tend to share more of these cultural traits (Toth and Schick 2009; Whiten et al. 2009). Although chimpanzees are known to use stones as hammers and anvils in nut-cracking activities in West Africa, wild chimpanzee tool manufacture does not involve the intentional percussive flaking of stone, and wild chimpanzees have not developed sharp-edged tools for cutting in their assorted tool kits. It has been possible, however, to explore through experiments how comparable toolmaking skills of early hominids are to those of apes in captivity. An essential question in such experiments is whether the toolmaking skills of early hominids represent a significant departure from an ape "substrate" of toolmaking ability and what insights we might gain regarding early hominid cognitive abilities. Do early hominid toolmakers exhibit special cognitive or biomechanical skills or abilities,

Fig. 1 Kanzi, a bonobo (*Pan paniscus* or "pygmy chimpanzee"), flaking stone. Kanzi learned stone tool manufacture by modeling or imitation followed by years of trial and error, and he uses his tools to cut open a container to obtain food. His stone toolmaking skills have improved since the start of this experiment in 1990. Many of his artifacts resemble those found at Oldowan sites, although overall his flakes and cores still show some important differences from those found at Early Paleolithic sites

or do these emerge only much later in human biological and technological evolution? (see chapter "► Theory of Mind: A Primatological Perspective," Vol. 2).

Experiments were begun in 1990 teaching a bonobo (see chapters "► Great Ape Social Systems" and "► Primate Intelligence," Vol. 2) (pygmy chimpanzee), Kanzi (Savage-Rumbaugh and Lewin 1994), to make and use stone tools (Fig. 1) (Toth et al. 1993; Schick et al. 1999). The experiment involved introducing the use of a stone tool for cutting and retrieving a foodstuff, initial demonstrating (modeling) stone tool manufacture, and a subsequent period of trial-and-error learning on Kanzi's part in both the toolmaking and tool-using operations. This experiment has clearly shown that apes can become adept at some aspects of stone toolmaking. However, after more than 15 years of this experiment, some distinct technological differences have persisted in the bonobos' artifacts compared to artifact assemblages found at early Paleolithic sites (Toth et al. 2006; Toth and Schick 2009). Some of these differences appear to reflect lesser skill in the bonobo toolmaker, perhaps reflecting lesser cognitive appreciation of particular facets of the toolmaking process (such as flaking sharper edges of the core), although others are likely related to biomechanical differences in the hand and arm of the apes.

This experiment highlights how skilled and adept early stone hominids were in their stone toolmaking by the time of the earliest known archaeological

occurrences 2.6 Ma. The skillfulness reflected in the earliest stone tools might suggest that even earlier stone technologies existed, yet undiscovered and perhaps rare on the paleolandscape, whose makers were not quite as proficient in flaking stone and who did not produce such a readily recognizable product. Or it may be that hominids were "preadapted" to efficiently flaking stone because of selection for other manipulative skills that were later transferred to stone knapping when the need arose. The ape stone tool making experiments give important clues as to what technological characteristics might be found in such hypothetical "Pre-Oldowan" technologies.

Early Paleolithic

The Early Paleolithic comprises a long time interval, between 2.6 Ma and approximately 250,000 years ago. It not only includes this extremely large span of human prehistory but also encompasses, over time, sites across huge geographical distances, from southern Africa to eastern Asia. During this period of more than 2.25 Myr, profound evolutionary changes occurred among hominids, and some marked changes are observed in the archaeological record in multiple parts of the Old World.

In Africa, where the Early Paleolithic is often referred to as the Early Stone Age, two industries have been recognized: (1) The first to appear, starting 2.6 Ma, the Oldowan industry (named after Olduvai Gorge in Tanzania), consists of stone industries containing simple cores and flaked pieces, along with some battered artifacts such as hammerstones and (2) starting between 1.7 and 1.5 Ma, or approximately 1 Myr after the onset of Oldowan technology, the Acheulean industry (named after the locality of St. Acheul in France) appears, with new distinctive artifact forms in the form of relatively large bifacial tools (handaxes, cleavers, and picks).

Oldowan

The Oldowan is the first recognizable archaeological record, with simple flaked and battered stone artifacts, sometimes found with cut-marked and broken animal bones, emerging around 2.6 Ma. Although similar types of simple lithic industries are found throughout time, archaeologists usually use a cutoff of around 1 Ma when referring to the Oldowan Industrial Complex. The Oldowan coexisted for several hundred thousand years with the Acheulean handaxes industries, starting about 1.76 Ma. Oldowan sites are known first from Africa and subsequently document the spread of hominids outside of Africa into parts of Eurasia, notably producing archaeological sites in the Near East, the Republic of Georgia, and eastern Asia. These sites are found especially in tropical and subtropical climatic regimes, in particular grassland/woodland environments.

At Dikika, Ethiopia, it has been argued that marks on surface bovid bones believed to date to 3.3 Ma were produced by stone tool-wielding hominids,

in this case the contemporary *Australopithecus afarensis* (McPherron et al. 2010). Others, however, have argued that these marks could be produced by crocodile teeth (Njau 2012) or by trampling (Domínguez-Rodrigo et al. 2010). No stone tools have been found at this locality. Until new evidence comes to light, the claim of stone cutting tools from this time period should be regarded as unsubstantiated.

In East and North Africa, most Oldowan sites are open-air occurrences that are located along stream courses, in deltaic settings, or on lake margins. These were areas of close proximity to water and were depositional settings where sediments could build up over time. In South Africa, Oldowan artifacts are found in karstic limestone cave deposits and may have been carried there by hominids or brought in by natural forces such as slope wash or gravity. The high incidence of hominid bones in South African cave deposits (especially robust australopithecines) may be the result of predation and/or scavenging by carnivore such as leopards and hyenas.

Oldowan industries are contemporaneous with a number of bipedal hominid forms, including later australopithecines (see chapter "► The Species and Diversity of Australopiths," Vol. 3) (*Australopithecus garhi*, *A. aethiopicus*, *A. robustus*, and *A. boisei*), whose cranial capacities ranged from about 400 to 550 cm^3, and early forms of the more encephalized genus *Homo* (see chapter "► Evolution of the Primate Brain," Vol. 2) (*H. rudolfensis*, *H. habilis*, *H. ergaster/erectus*), whose cranial capacities ranged from about 600 to 850 cm^3. Although it is possible that all of these hominids used stone technology to a greater or lesser extent, many anthropologists believe that the genus *Homo* was probably the more habitual toolmaker and tool user, as its brain size almost doubles in the first million years of the Oldowan, while its jaws and teeth tend to diminish in robusticity. By 1 Ma, only *Homo ergaster/erectus* was known in the human paleontological record, while the australopithecines became extinct. Interestingly, *Homo ergaster/erectus* appears to have much more modern limb proportions and stature relative to earlier hominids and is the first form clearly identified outside of Africa (see chapters "► *Homo ergaster* and Its Contemporaries," "► Later Middle Pleistocene *Homo*," and "► Defining *Homo erectus*," Vol. 3).

Oldowan industries are characterized by simple technologies (sometimes called Mode 1) consisting of cores made on pebbles or chunks (choppers, discoids, polyhedrons, heavy-duty scrapers, facetted spheroids), battered percussors (hammerstones and battered spheroids), debitage (flakes and fragments), and retouched pieces (scrapers, awls, etc.) (Fig. 2) (Hovers and Braun 2009; Isaac 1989; Leakey 1971; Schick and Toth 2010; Toth and Schick 2006, 2009). Common raw materials include volcanic lavas, quartz, and quartzite. The most common techniques for producing Oldowan artifacts were hard hammer percussion and bipolar technique (in which the core to be flaked is set on a stone anvil and hit with a stone hammer). At Olduvai Gorge, some technological trends have been observed through time, with later Oldowan sites showing higher frequencies of such artifact classes as scrapers and battered spheroids and lower frequencies of choppers. These sites are sometimes assigned to a "Developed Oldowan," but this designation is more difficult to apply elsewhere.

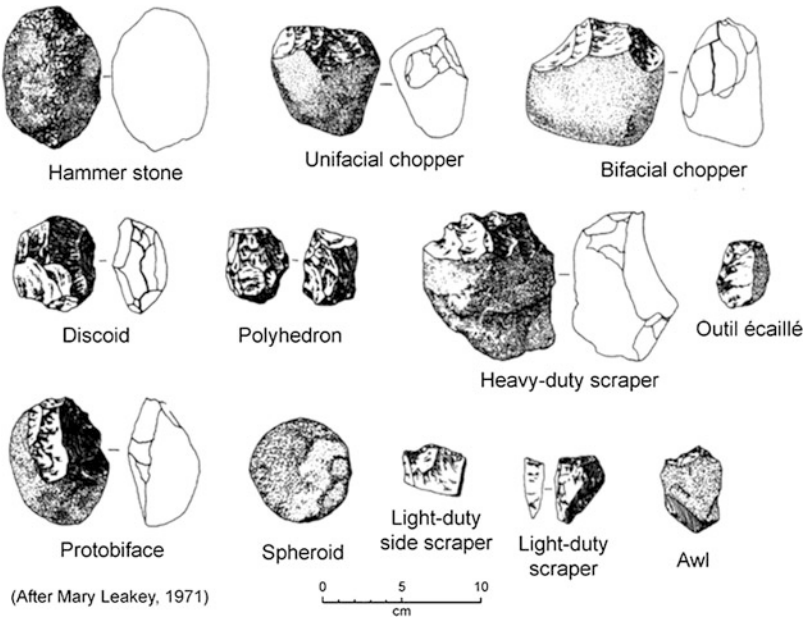

Fig. 2 Typical Oldowan artifacts found at Early Paleolithic sites. These are examples of flaked and battered stone artifacts found at Olduvai Gorge, with their common or conventional designations ("types") noted

Microwear patterns on a small sample of Oldowan tools suggest that flakes were used for animal butchery, woodworking, and cutting soft plant matter. Experiments in using stone tools (Fig. 3) have shown that Oldowan flakes can be used to efficiently process the carcasses of animals from the size of small mammals to elephants (Fig. 4) and stone hammers could easily break bones for access to nutritious marrow and skulls for brain tissue. Choppers could have been used to chop branches to make spears or digging sticks, although many such Oldowan core forms were probably by-products of flake production. It is likely that a rich range of perishable organic material cultures were also used, including containers of shell, horn, skin, or bark; wooden clubs and/or throwing sticks; wooden spears or digging sticks (Fig. 5); and horn or bone fragments as digging tools. In addition, a small sample of bone specimens from South African caves are polished and striated on their pointed end, suggesting that these may have been used as opportunistic digging tools to gain access to underground vegetable resources or insects such as termites.

Although evidence of fire has been found at a few Oldowan sites (in the form of reddened, baked sediments, burnt bones, or fire-cracked stone), it cannot be ruled out that natural agents, such as lightning strikes and brushfires, may have produced these fires. No clear architectural structures have been found at Oldowan sites, and it is possible that Oldowan hominids could have been sleeping in trees at night (perhaps building nests like chimpanzees) rather than on the ground, in order to

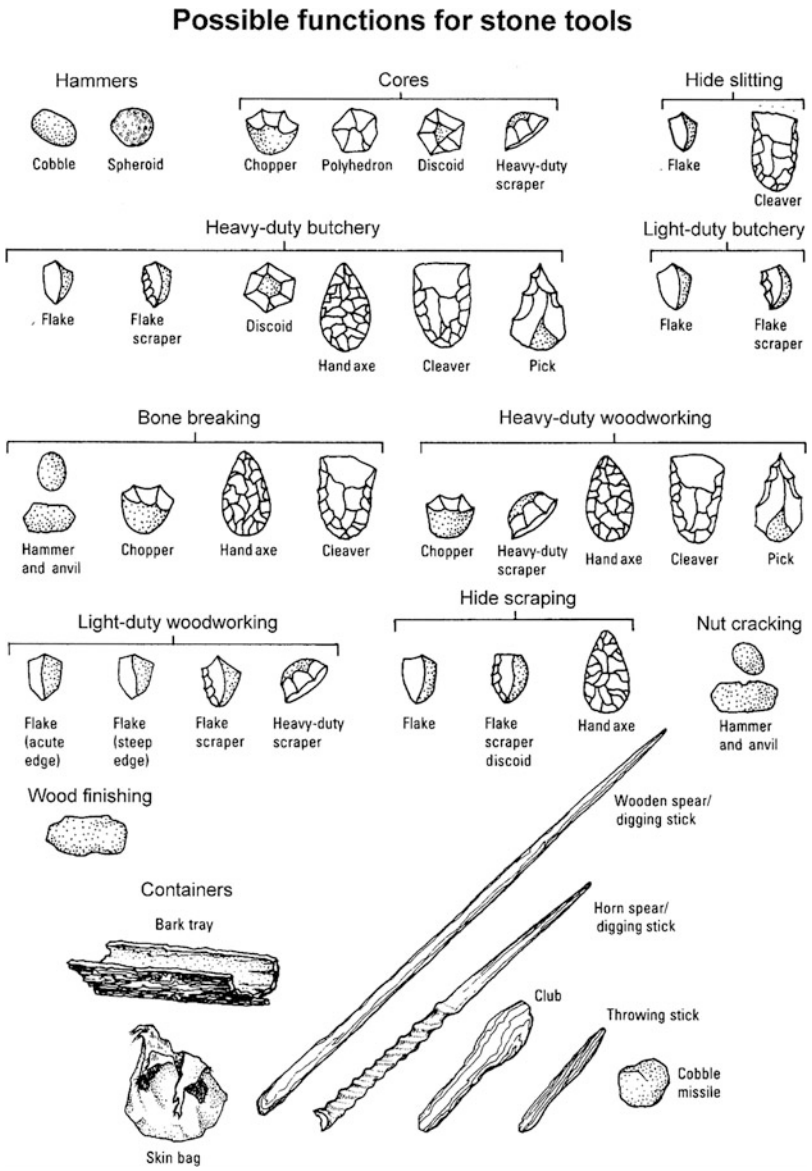

Fig. 3 Potential functions of Early Paleolithic artifacts, both Oldowan and Acheulean forms, based on experiments using tool replicas for various purposes

avoid predation by nocturnal carnivores (see chapters "▶ Evolutionary Biology of Ape and Monkey Feeding and Nutrition," "▶ Great Ape Social Systems," and "▶ The Hunting Behavior and Carnivory of Wild Chimpanzees," Vol. 2).

It seems clear that these Oldowan hominids were concentrating lithic material and animal bones at favored locations on the landscape (a pattern not seen in

Fig. 4 Butchery of an elephant, the world's largest terrestrial mammal, using simple Oldowan flakes (The elephant had died of natural causes)

Fig. 5 Sharpening a wooden branch with a simple stone flake. Such implements could have been used as spears, digging sticks, or skewers to carry meat resources

nonhuman primates today), but the precise behavioral patterns that formed these concentrations are still debated. Interpretations for these concentrations include home bases or central foraging places; favored places due to proximity to shade, water, or food resources; intentional stone caches; and scavenged carnivore accumulations. It is also possible that Oldowan sites formed through more than one behavioral pattern. Cut marks and percussion marks/fractures on bones show that hominids were accessing meat and marrow resources from animal carcasses obtained through scavenging or hunting. The modified bones at Oldowan sites typically come from animals ranging in size from small mammals to those weighing hundreds of pounds. This is a scale of carnivory that is not seen in the nonhuman primate world and was most likely greatly facilitated through the use of stone tools.

At present, there is debate as to whether hominids accessed larger animals through more marginal scavenging (getting the ravaged leftovers of carnivore kills) or, rather, had access to more complete carcasses through hunting or confrontational scavenging. In any case, the processing of larger animal carcasses could have significantly increased the dietary breadth (and thus survivorship and reproductive success) of Oldowan hominids, although the majority of Oldowan hominid diet was likely derived from plant foods such as fruits, berries, nuts, edible leaves, and underground storage organs (roots, tubers, corms, and rhizomes). Carrying devices may have facilitated the collection and transport of dietary items that could be consumed at a later time.

Important Oldowan localities include Gona, Fejej, and the Omo Valley in Ethiopia; East and West Turkana in Kenya; Olduvai Gorge in Tanzania; Sterkfontein and Swartkrans Caves in South Africa; Ain Hanech and El Kherba in Algeria; the lowest levels at 'Ubeidiya in Israel; and Dmanisi in the Republic of Georgia.

Acheulean

The Acheulean Industrial Complex is characterized by the presence of large bifacial handaxes, cleavers, and picks (sometimes called Mode 2 technologies), which are found from approximately 1.76 Ma to 250,000 years ago. The earliest known Acheulean sites are Kokiselei 4, West Turkana, Kenya, dated to 1.76 million years ago (Lepre et al. 2011), and Konso in Ethiopia, dated to 1.76 million years ago (Beyene et al. 2013). At Kokiselei four large cobbles of phonolite lava were flaked into crude handaxes and picks, while at Konso-Gardula, similar large picks and bifaces and unifaces were manufactured primarily from large flakes. Such handaxe/cleaver industries are contemporaneous and sometimes regionally co-occurring with the simpler Oldowan-like (Mode 1) industries. Acheulean and contemporaneous Mode 1 industries are found throughout Africa and Eurasia, but classic handaxe and cleaver assemblages are especially characteristic of Africa, the Near East, the Indian subcontinent, and Western Europe. Elsewhere, notably Eastern Europe and most of eastern Asia, simpler Mode 1, Oldowan-like technologies are found. This was a period of major climatic change, with numerous cold/warm oscillations that would have especially affected northern latitudes of Eurasia. For most of this period, hominids would have flourished only during the warmer periods in these northern latitudes. Hominids extended their range from grasslands and woodlands of tropical and subtropical regions to cooler, more temperate climates during this period (Fleagle 2010; Gamble 2005; Norton and Braun 2010; Shipton and Petraglia 2010).

Contemporaneous hominid forms (see chapter "► *Homo ergaster* and Its Contemporaries," Vol. 3) include *Homo ergaster*/*erectus* and the later, larger-brained *Homo heidelbergensis* (sometimes referred to as "early archaic *Homo sapiens*"). Cranial capacities range from about 800 to 1,400 cm^3, generally increasing over the time span of this period. In the early Acheulean, robust australopithecines (see chapters "► Analyzing Hominin Phylogeny: Cladistic Approach" and

"► The Species and Diversity of Australopiths," Vol. 3) (*A. robustus* and *A. boisei*) still existed, but most anthropologists do not regard these forms as plausible Acheulean toolmakers, and in any case they appear to have gone extinct by 1 Ma.

New elements in Acheulean industries (in addition to Mode 1, Oldowan-like artifacts that continue to be found) include handaxes, cleavers, picks, and knives (generically called "bifaces") made either on large flakes struck from boulder cores or on larger cobbles and nodules. A range of well-made retouched tools, such as side scrapers, awls, and backed knives, are also common. Frequently used raw materials include fine-grained lavas, quartzites, and flints. Earlier, cruder bifaces were produced by hard hammer percussion (Fig. 6), while later more refined bifaces

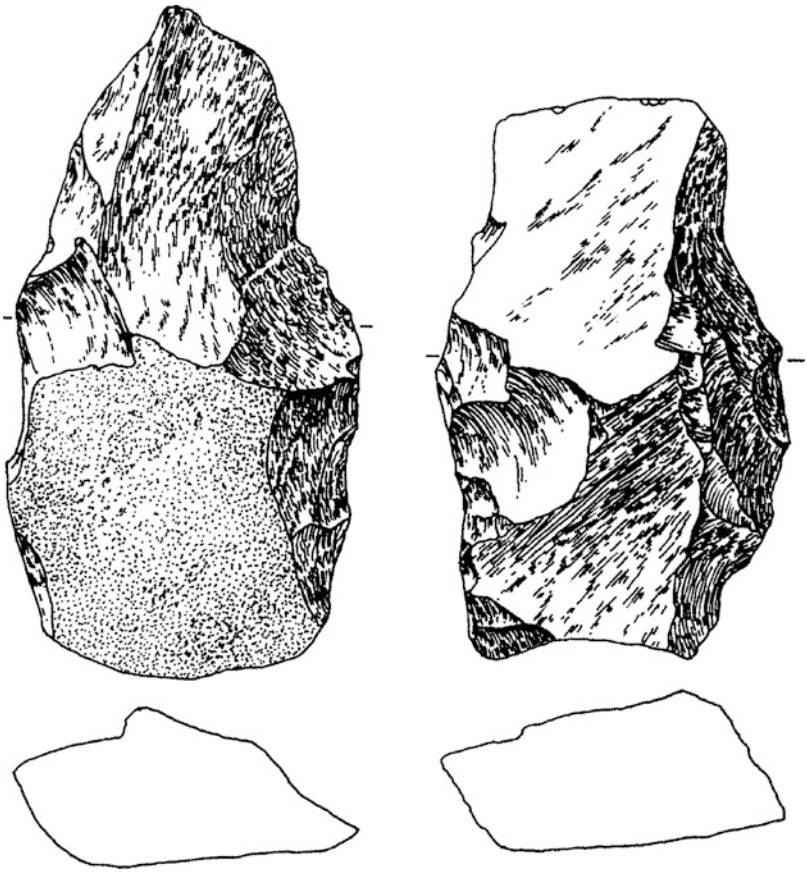

Fig. 6 Early Acheulean tools: relatively crude handaxe (*left*) and cleaver (*right*), approximately 1.4 Myr old. These artifact forms, made on large flakes or cobbles, show definite shaping to leave a sharp working edge, especially toward the tip end of the handaxe and the bit of the cleaver, with the lower part of the tool shaped or left natural to serve as a handle. They usually show some, though relatively low, degree of symmetry in their plan view and their cross-section and were made by hard hammer percussion

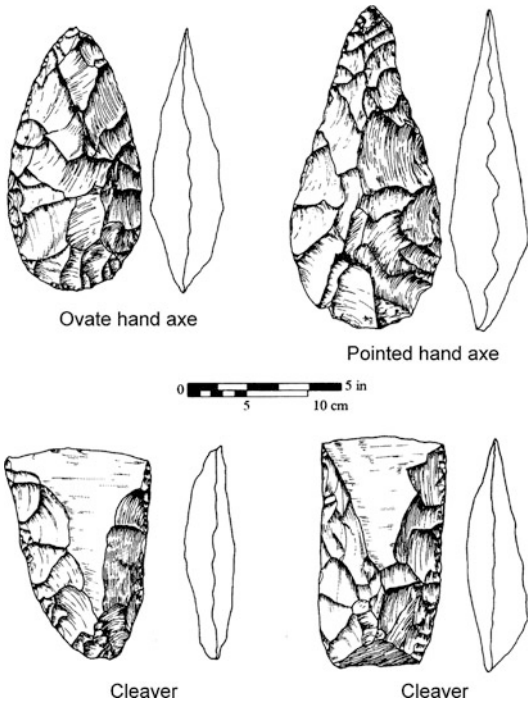

Fig. 7 Late Acheulean tools: beautifully made, highly symmetrical handaxes and cleavers typical of the latter part of the Acheulean, approximately 400,000 years old. These forms clearly show more cognitive complexity, craftsmanship, and probably an aesthetic sense hundreds of thousands of years before the first representational art

were probably finished by the soft hammer technique, in which a softer material, such as wood, bone, ivory, antler, or even soft stone, was used as a percussor, producing thinner, more invasive flakes (Fig. 7). Prepared core techniques, notably the Levallois tortoise core technique (in which a large, predetermined flake is removed from the upper surface of a discoidal core) and, more rarely, early blade production, are found in some later Acheulean industries. Sharpened wooden spears are known from later Acheulean times, as at Schöningen in Germany (see chapter "► Modeling the Past: Archaeology," Vol. 1) and Clacton in England, suggesting that more formal hunting weaponry was established as part of a regular subsistence pattern by at least this time if not earlier.

The fact that Acheulean and contemporaneous hominids successfully occupied cooler, more temperate latitudes suggests that they were better adapted to such cooler conditions. Use-wear patterns on side scrapers indicate that many of these tools were used to scrape hides, strongly suggesting that animal skins were being used for simple clothing, blankets, and/or tent or hut coverings. Evidence of fire in the form of charcoal or ash layers is occasionally seen in later Acheulean times but is by no means widespread in the archaeological record during this period. There is no definitive evidence of architectural structures during Acheulean times, although arguments have been made in this regard. Sites are found in numerous caves and rock shelters as well as many open-air sites.

Handaxes and cleavers, in particular, indicate the ability to impose bilateral symmetry on lithic materials. This clearly shows higher cognitive abilities and motor skills than are manifested in the Oldowan. Even modern humans who learn to make stone tools normally require considerable apprenticeship before they can produce well-made handaxes and cleavers. Although there is a wide range of handaxe forms through time and space, it is common that at certain Acheulean sites, there are recurrent shapes and sizes, as if there were stylistic norms of production among their makers. Presence of ocher at some sites and, occasionally, incised bone may indicate the emergence of proto-symbolic behavior as well.

Important Acheulean sites/localities include Konso-Gardula, Middle Awash, Melka Kunture, and Gadeb in Ethiopia; Olduvai Gorge and Peninj in Tanzania; Olorgesailie and Isenya in Kenya; Kalambo Falls in Zambia; Elandsfontein and Montagu Cave in South Africa; Ternifine in Algeria; 'Ubeidiya and Gesher Benot Ya'aqov in Israel; Swanscombe, Hoxne, and Boxgrove in England; Saint-Acheul and Terra Amata in France; and Torralba and Ambrona in Spain. Important contemporaneous Mode 1 localities include Atapuerca (TD6) in Spain, Arago Cave in France, Clacton in England, Bilzingsleben and Schöningen in Germany, Vértesszölös in Hungary, Isernia in Italy, and the Nihewan Basin and Zhoukoudian ("Peking Man") cave in China.

It has recently been argued (Wilkins et al. 2012) that stone points from Kathu Pan 1, South Africa, believed to date to ca. 500,000 years ago, could have functioned as hafted spear points, based upon the morphology of the artifacts and edge damage. These artifacts are associated with a stone tool industry, often referred to as the "Fauresmith" that includes handaxes and is considered by some to be transitional between the Acheulean and the Middle Stone Age. If this argument is valid, this would put the origins of hafted technologies several hundred thousand years before the first widely accepted evidence of hafting (see chapters "► Modeling the Past: Archaeology," Vol. 1, and "► Dispersals of Early Humans: Adaptations, Frontiers, and New Territories," Vol. 3). Kathu Pan 1 also shows evidence of systematic blade production, another trait which tends to appear in the archaeological record in later times (Wilkins and Chazan 2012).

Middle Paleolithic/Middle Stone Age

The Middle Paleolithic industries of Europe, the Near East, and North Africa (sometimes called the "Mousterian" after the site of Le Moustier in France) and Middle Stone Age industries of sub-Saharan Africa are found between approximately 250,000 and 30,000 years ago. They are found in tropical, subtropical, temperate, and even periglacial climatic regimes. During this time, hominids extended their ranges to most environmental zones of Africa and Eurasia except harsh deserts, the densest tropical forests, and extreme northern or arctic tundras.

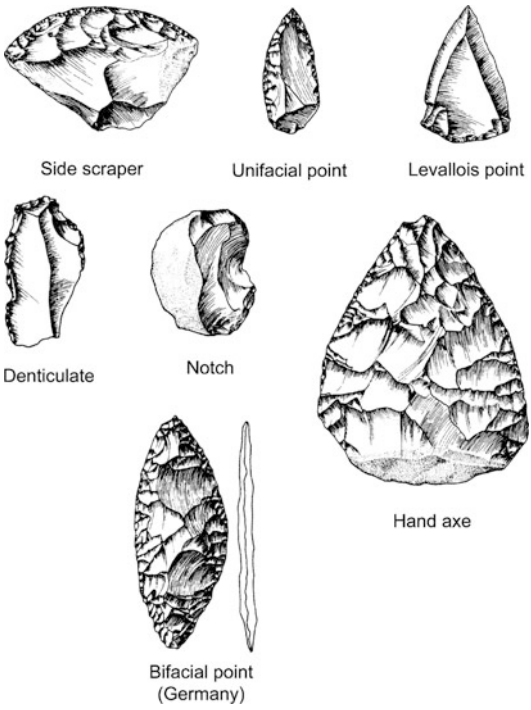

Fig. 8 Middle Paleolithic tools: numerous retouched flake tools, such as side scrapers, points, and denticulates, were made on flake blanks, some struck from prepared cores. It is possible that some of these points were hafted to wooden shafts as thrusting or throwing spears

It appears that hominids were somehow able to cross the water between Southeast Asia and Australia and then attached to New Guinea and Tasmania, by late in this period. Contemporary hominid forms include those often designated as archaic *Homo sapiens* (including the Neanderthals of Europe and the Near East) and anatomically modern humans.

Handaxes and cleavers tend to be less common (although toward the end of the Middle Paleolithic of Western Europe, smaller, well-made handaxes are found), and the emphasis in these stone industries is on retouched forms made on flakes (such as side scrapers, denticulates, and points) that become numerous in many of these assemblages (Fig. 8). Hard hammer and soft hammer techniques were common during this period. Many of these industries exhibit prepared core methods, notably the Levallois technique for more controlled production of flakes, points, and sometimes blades. Wooden spear technology continues from the Acheulean (as seen at Lehringen, Germany, where a spear with a fire-hardened tip was associated with an elephant carcass), and stone points with tangs or thinned bases suggest that these forms may have been hafted onto spear shafts, suggesting the development of composite tools. Rare bone points are also known from this time.

Fire and hearth structures are much more common during this period, although clear architectural features outlined by stones or bones are rare. Sites are numerous in caves and rock-shelters, as well as open-air sites on plateaus and along river floodplains.

Occasional perforated and grooved shells and teeth at a few sites imply the emergence of some personal adornment and, along with the infrequent presence of ocher as well as a number of well-documented burials, suggest at least some symbolic component to hominid behavior during this period of the Paleolithic (McBrearty and Brooks 2000).

Important Middle Paleolithic/Middle Stone Age sites include Combe Grenal, Pech de L'Azé, Le Moustier, La Quina, and La Ferrassie in France; Krapina in Croatia; Cueva Morin in Spain; Tabun, Skhūl, Kebara, Amud, and Qafzeh in Israel; Shanidar in Iraq; Dar es-Soltan in Morocco; Bir el Ater in Algeria; Haua Fteah in Libya; Kharga Oasis in Egypt; Diré-Dawa, Omo-Kibish, and Middle Awash in Ethiopia; Enkapune Ya Muto, Prospect Farm, and Kapthurin in Kenya; Kalambo Falls and Twin Rivers in Zambia; and Florisbad, Border Cave, Klasies River Mouth Cave, and Die Kelders Cave in South Africa.

Late Paleolithic

The Late Paleolithic (often called Upper Paleolithic in Europe and Later Stone Age in Africa) is found between 40,000 and 10,000 years ago, at which time the last glaciation receded. This period of human prehistory overlaps and is contemporaneous with the end of the Middle Paleolithic/Middle Stone Age in some regions. During this time, humans inhabited tropical, subtropical, temperate, desert, and arctic climates; occupied present-day Australia, New Guinea, and Tasmania after crossing significant bodies of water; and, late in this period, spread to the Americas via the Bering Straits (see chapters "► The Dentition of American Indians: Evolutionary Results and Demographic Implications Following Colonization from Siberia" and "► Dispersals of Early Humans: Adaptations, Frontiers, and New Territories," Vol. 3). Late Paleolithic industries are almost always associated with anatomically modern humans (*Homo sapiens sapiens*), but some early Upper Paleolithic sites in Europe are also contemporaneous with the last populations of Neanderthals (see chapter "► Neanderthals and Their Contemporaries," Vol. 3) there.

Late Paleolithic stone industries are often characterized by blade technologies, elongated flakes produced by soft hammer or indirect percussion, in which a punch is placed on the edge of a blade core and struck with a percussor. These blades were then made into a variety of tool forms, including end scrapers, burins, and backed knives (Fig. 9). Some Late Paleolithic technologies emphasized bifacial points, such as the Solutrean of Spain and France and the Paleo-Indian occurrences of the New World (Clovis and Folsom) (see chapter "► The Dentition of American Indians: Evolutionary Results and Demographic Implications Following Colonization from Siberia," Vol. 3). Such points may have been produced by soft hammer technique or by pressure flaking, in which small flakes are detached by directed pressure rather than by percussion. Some raw materials appear to have been heat treated to make them easier to work. Other Late Paleolithic technologies emphasized bladelets (small blades) and geometric microliths, which were hafted as composite tools into a range of projectiles and cutting tools. These microlithic

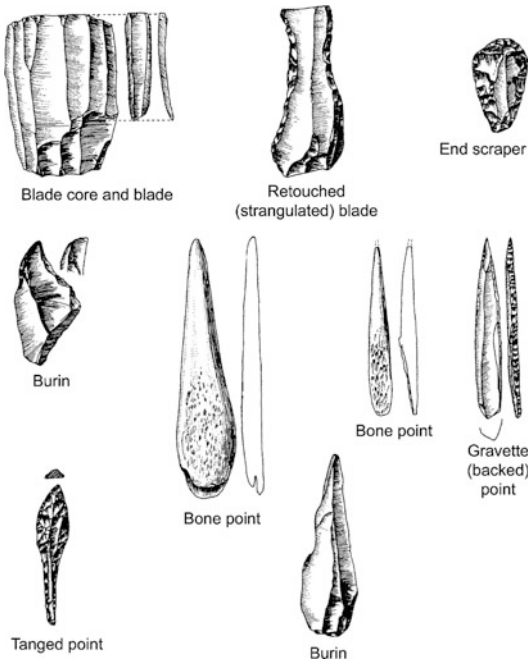

Fig. 9 Late Paleolithic tools: tools made on blades struck from prepared cores were important components of these technologies, made into such forms as end scrapers, burins, and points, as were formal tools shaped from bone, antler, and ivory

technologies are characteristic of the Later Stone Age of Africa as well as some parts of central and eastern Asia.

A diagnostic element of many Late Paleolithic industries is an emphasis on nonlithic materials for tools, including bone, antler, and ivory, made into a range of artifact forms such as points, needles, spear-throwers, shaft straighteners, and harpoons. Hooked spear-throwers are essentially mechanical devices to increase the velocity and/or distance of a projectile, and thus represent a significant advance in hunting technology or weaponry. The small size of some points and microliths toward the end of the Late Paleolithic suggest the development of bow and arrow technology, and arrows are preserved at Stellmoor, Germany.

Several human sculptures from the Late Paleolithic suggest clothing such as hooded parkas, headdresses, and aprons. The development of bone and antler needles also suggests that sewed clothing was common after 20,000 years ago, and recently discovered impressions on fired clay fragments from the Czech Republic indicate woven textiles, presumably of plant material.

Controlled use of fire appears to be a universal trait during this period, with hearths sometimes lined with stones. Architectural features are much more common than in earlier periods, with hut structures delineated by stone or bone patterns, by postholes, and sometimes with hearth structures and other apparent activity areas within (such as toolmaking or tool-using). Sites tend to be more numerous and have denser concentrations of materials, suggesting larger populations and more regular habitation of sites.

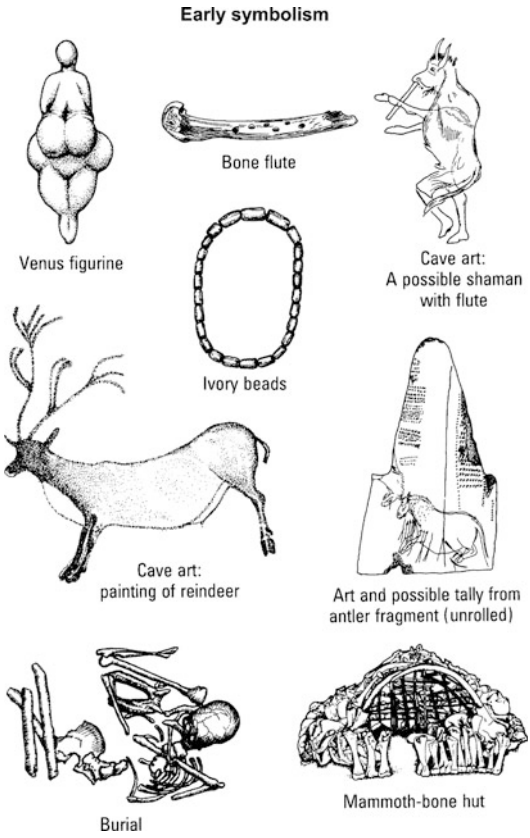

Fig. 10 Examples of probable symbolic behavior in Late Paleolithic times, expressed in art, personal adornment, music, notation, burial, and possibly more formal architecture

Relatively late in the time span of the Late Paleolithic, the first evidence of human occupation of the Americas appears. The most widespread evidence is attributed to the Clovis culture, characterized normally by fluted spear points and often associated with mammoth remains, dating to ca. 13,500–13,000 years ago. Several sites may predate the Clovis in the Americas by several thousand years (Meltzer 2010).

One of the most distinctive characteristics of the Late Paleolithic is the proliferation of symbolic expression in art and personal adornment (Fig. 10). This can be seen in the naturalistic representation of animals and, more rarely, humans in painting and sculpture as well as in the more abstract geometric designs. A variety of media were employed for artistic expression, including use of charcoal, pigment paints, antler, bone and ivory, and clay, as well as a diversity of techniques, including drawing, painting, engraving, carving, and modeling. Personal adornments are sometimes numerous, manifested in beads or pendants of shell, bone, tooth, antler, ivory, and stone. This proliferation of symbolic expression, best seen in the European Upper Paleolithic, has sometimes been referred to as the "Creative Explosion." Some of these artistic manifestations, particularly paintings, drawings,

and engravings, are located in deep, hard-to-access recesses of caves, suggesting a ritualistic and religious aspect to this symbolism. In view of the complexity of the material culture of this period and its well-developed symbolic component, it is likely that modern human language abilities were fully developed by this time, if not before.

Late Paleolithic burials are more common and more elaborate than in the Middle Paleolithic. Men, women, and children were sometimes interred with rich grave goods, including stone tools, jewelry, and bone/antler/ivory artifacts. Again, this suggests an important symbolic component and a probable belief in an afterlife, in other words, something akin to a spiritual belief and a religion.

Important sites include Lascaux, Pincevent, La Madeleine, Abri Pataud, Cro-Magnon, Solutré, Chauvet, and Laugerie Haute in France; El Castillo, Altamira, and Parpalló in Spain; Dolní Věstonice in the Czech Republic; Vogelherd in Germany; Istállóskö in Hungary; Willendorf in Austria; Kebara Cave in Israel; Ksar Akil in Lebanon; Kostienki and Sungir in Russia; Mezin and Mezhirich in Ukraine; Mal'ta in Siberia; Zhoukoudian Upper Cave in China; Lukenya Hill in Kenya; Mumba Cave in Tanzania; Nelson Bay Cave, Die Kelders, Elands Bay Cave, and Wilton, in South Africa; Haua Fteah in Libya; Lake Mungo in Australia; and Blackwater Draw in New Mexico (North America).

Conclusion

The earliest evidence of hominid technology dates to between 2.6 and 2.5 Ma in the Ethiopian Rift Valley. The Oldowan, characterized by simple cobble cores, flakes, retouched flakes, and battered percussors, is associated in time with later australopithecines and early forms of larger-brained hominids assigned to the genus *Homo*. Cut marks on fossil mammalian bones and hammerstone fracture of long bones indicate that one aspect of these early technologies was the processing of animal carcasses.

By 1.8–1.7 Ma, the prehistoric record documents the emergence of *Homo ergaster/erectus* and the early Acheulean, characterized by new artifact forms such as handaxes, cleavers, and picks. The first hominid migrations out of Africa and into Eurasia are documented at the same time. Later Acheulean sites, ca. 500–250 Ka, are often characterized by better-made and more symmetrical handaxes and cleavers and are associated with *Homo heidelbergensis*. Handaxe industries are known for much of Africa, the Near East, Western Europe, and the Indian subcontinent. In much of Eastern Europe and East Asia, contemporary hominid populations were producing simpler cobble cores and a range of retouched flake tools.

The Middle Stone Age/Middle Paleolithic emerges around 250 Ka, usually characterized by prepared core technologies (e.g., Levallois cores, flakes, and points), side scrapers, denticulates, and retouched points. In Africa these industries are associated with larger-brained archaic forms (sometimes assigned to *Homo helmei*) and early anatomically modern humans. In the Near East, such industries

are associated with Neanderthals and modern humans. In Europe the Middle Paleolithic appears to be exclusively associated with Neanderthals. In East Asia during this time, the lithic industries are usually simpler core/flake/retouched flake industries, associated with archaic forms of hominids. Evidence of fire becomes very common during this period.

The Late Paleolithic (Upper Paleolithic, Later Stone Age) emerges in the Old World in the last 50,000 years. Industries are often characterized by blade production, blade tools such as backed knives, end scrapers, and burins, and a range of unifacial and bifacial point styles. For the first time, materials such as bone, antler, and ivory (and presumably a very rich wood technology) became major raw materials for tools. Architectural features such as hut structures and well-made hearths became common for the first time. The first representational artwork was produced on cave walls in the forms of paintings and engravings as well as mobiliary sculpture and engraving.

During the last glaciation, modern humans reached Australia by 40 Ka and the Americas by at least 15 Ka. Around the world, stone industries document a greater variability over time and space, suggesting stronger regional cultural rules regarding material culture and more innovation and technological change over time. With more complex technologies and adaptive patterns, humans were able to occupy extreme environments such as dense tropical forests, arid deserts, and frigid tundras. In a number of places in the Near East, Africa, East Asia, Oceania, and North and South America, these Paleolithic foraging societies slowly emerged as sedentary farmers, and then in some of these places, complex societies emerged as "civilizations" with urban centers.

The Paleolithic lasted over two-and-a-half million years and, in terms of duration, covers well over 99 % of human technological history. It is no exaggeration to say that the human lineage is a product of its Paleolithic past and that the modern human condition, characterized by industrialization, farming, urban life, and ever-increasing networks of communication and globalization, is firmly rooted in its Stone Age past.

Cross-References

- ▶ Chronometric Methods in Paleoanthropology
- ▶ Cultural Evolution During the Middle and Late Pleistocene in Africa and Eurasia
- ▶ Defining *Homo erectus*
- ▶ Defining the Genus *Homo*
- ▶ Dispersals of Early Humans: Adaptations, Frontiers, and New Territories
- ▶ Geological Background of Early Hominid Sites in Africa
- ▶ *Homo ergaster* and Its Contemporaries
- ▶ Later Middle Pleistocene *Homo*
- ▶ Modeling the Past: Archaeology
- ▶ Neanderthals and Their Contemporaries

▶ Origin of Modern Humans
▶ Primate Intelligence
▶ Quaternary Deposits and Paleosites
▶ Quaternary Geology and Paleoenvironments
▶ Role of Environmental Stimuli in Hominid Origins
▶ The Earliest Putative *Homo* Fossils
▶ The Evolution of the Hominid Brain
▶ The Evolution of Speech and Language
▶ The Paleodemography of Extinct Hominin Populations
▶ The Species and Diversity of Australopiths
▶ Zoogeography: Primate and Early Hominin Distribution and Migration Patterns

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