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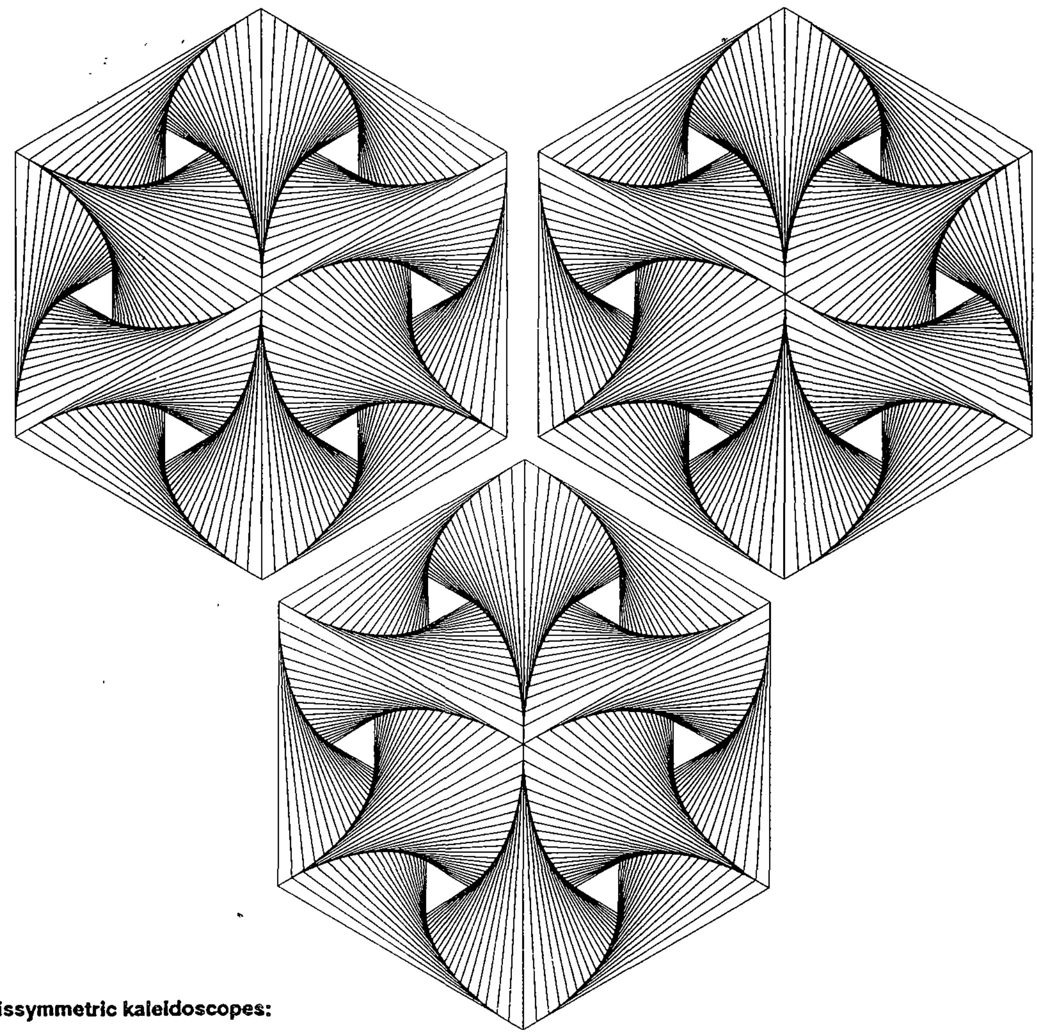

Dissymmetric kaleidoscopes:
Hommage à Pasteur

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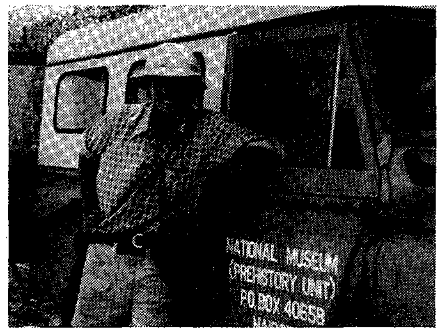
SYMMETRY: CULTURE & SCIENCE

THE PREHISTORIC ROOTS OF A HUMAN CONCEPT OF SYMMETRY

Nicholas Toth



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Publications: The Oldowan reassessed: A close look at early stone artifacts, *Journal of Archaeological Science*, 12 (1985), 101-120; Archaeological evidence for preferential right-handedness in the Lower and Middle Pleistocene, and its possible implications, *Journal of Human Evolution*, 14 (1985), 607-614; The first million years: The archaeology of proto-human culture, *Advances in Archaeological Method and Theory*, 9 (1986), 1-96 (with Schick, K.); The first technology, *Scientific American*, 255 (1987), No. 4, 112-121; Behavioural inferences from early stone artifact assemblages: An experimental model, *Journal of Human Evolution*, 16 (1987), 763-787.
Shows: *The Quest for Our Ancestors*, [International Conference on Human Origins], Indiana University, 1987; *The Rise of Humankind*, [Museum exhibit of human evolution], Mathers Museum of Anthropology, Indiana University, 1987; *Masterpieces of the Early Stone Age*, [Museum exhibit of early palaeolithic artifacts], Indiana University Art Museum, 1987; *Before and After Darwin*, [Book exhibit of important works on human evolution], Lilly Library of Rare Books, Indiana University, 1987.

QUESTION 1

what is symmetry?

Introduction

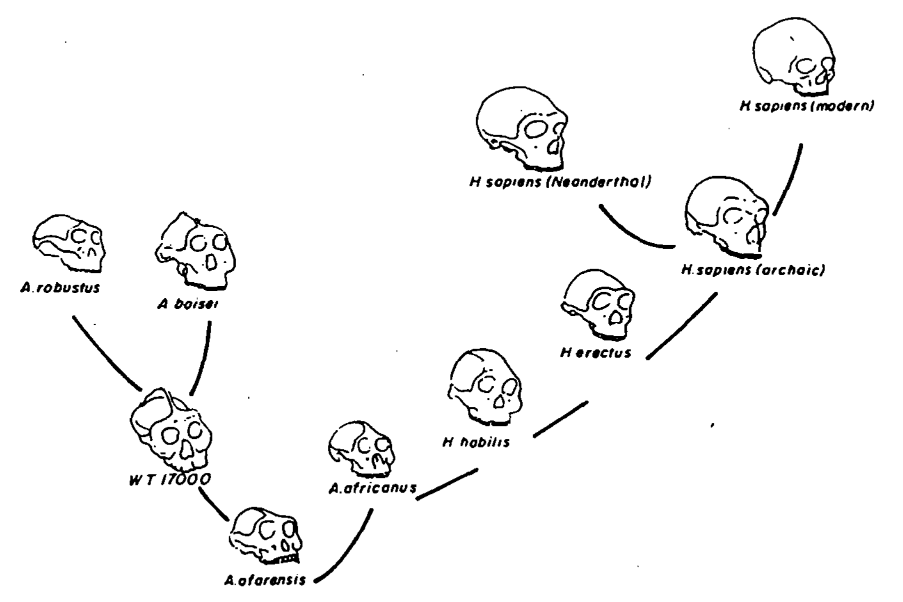
Symmetry can be defined as:

(1) "A relationship of characteristic correspondence, equivalence, or identity among constituents of a system or between different systems"
(2) "Exact correspondence of form and constituent configuration on opposite sides of a dividing line or plane or about a center or axis"
(3) "Structural or functional independence of direction; isotropy"
(4) "Beauty as a result of balance or harmonious arrangement"

(*The American Heritage Dictionary*, 1971, p. 1303).

Although geometric symmetry (correspondence of form on opposite sides of a line, plane, center, or axis) can be easily identified in nature (e.g. crystal structures, celestial bodies, the structure of biological organisms), it is worth inquiring *when* in the course of human evolution can we see a cognitive sense of such symmetry (or asymmetry) in our ancestors or near-ancestors. If we assume that human cognition and symbolism evolved from a more primitive, ape-like form to the present condition characterizing modern humans (*Homo sapiens sapiens*), it should be possible to document, at least in an imperfect way, the physical manifestations of such abilities in the prehistoric archaeological record in the form of *artifacts*, objects that have been modified by human or proto-human forces.

This presentation will focus upon the palaeolithic archaeological evidence to assess the developmental patterns of the concept of symmetry as it is manifested in the human evolutionary record. This evidence includes prehistoric stone, bone, antler, ivory, and wooden artifacts/tools, architectural features, and artworks. Studies of the palaeoneurological evidence for the evolution of the human brain, including studies of lateralization, handedness, and speculations on the origins of language are also included.



Evolution of hominid skulls. Two or three broadly defined phylogenetic trends are indicated by the fossil record. From a pattern similar to that of *Australopithecus afarensis* increasingly large masticatory muscles and chewing teeth produced the strongly buttressed, deep faces of the *A. robustus/A. boisei* lineage, which became extinct. A general decrease in tooth size, musculature, and face size, coupled with a dramatic increase in size of the braincase, marked the *A. africanus/Homo sapiens* lineage, although the intervening details of phylogenetic and morphologic evolution are unresolved. The development of large browridges, low-slung heads, and keeled vaults, for example, may have been a specialization of an *erectus/neanderthalensis* line.

Figure 1: From *Encyclopedia of Human Evolution and Prehistory*, edited by Ian Tattersall, Eric Delson and John Van Couvering, New York: Garland Press, 1988, p. 529.

By examining the material cultural prehistoric record in this way, several important points must be kept in mind. First of all, the palaeolithic archaeological record is imperfect, and many types of artifacts would not be expected to survive, especially those of wood, other vegetable materials, horn, and hide. Secondly, it must be assumed that the archaeological record can give (at least) minimal indications of cognitive abilities (including a sense of symmetry), but not necessarily maximum indications. There may have been no need or desire to produce such symmetrical forms in the everyday lives of these hunter-gatherer societies, even if the cognitive abilities, motor skills, and technological wherewithal existed. It must be asked whether such evidence of symmetry in the artifactual record is intentional or could simply be a by-product of a raw material or a given technological operation. A final point to stress is that throughout most of the palaeolithic, the artifacts that show a sense of symmetry are first and foremost *utilitarian* objects, manufactured for some functional end (animal butchery, woodworking, hide scraping, hunting, etc.) so that certain attributes, such as size, shape, edge angle, and sharpness may be critical variables for effective use.

Current anthropological evidence suggests that the hominid lineage leading to modern humans (which includes the bipedal genera *Australopithecus*, and *Homo*) separated from that leading to the African apes between five and ten million years ago, and is characterized by a suite of new traits, most significant of which are adaptations to bipedal locomotion (Howell, 1982). Figure 1 shows one possible evolutionary chart of the relationships of the hominid fossil forms.

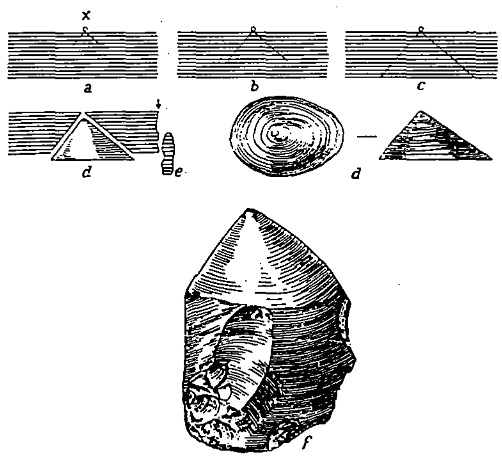
From about 4.0 until 2.5 million years ago, there is no definitive evidence of hominid modification or use of natural materials (i.e. *artifacts*, objects modified by hominids, and *tools*, objects used by hominids). It is likely, however, that the hominids of this time period (*Australopithecus afarensis* and *Australopithecus africanus*) made and used simple stone tools, perhaps on a scale similar to that observed in extant common chimpanzees, *Pan troglodytes*.

Chimpanzees are one of the few nonhuman animals that use tools, and the only nonhuman animal to actually manufacture them. Chimpanzees have been observed stripping twigs or grass to "fish" for termites, will chew leaves into wads for sponges, and use stone and wooden hammers and anvils to crack open hard-shelled nuts and fruits (Goodall, 1986). Wear-pits on hammers and anvils that are used for nut-cracking show that chimpanzees can center a nut on an anvil and hit it cleanly with a hammer (summarized in Toth and Schick, 1986).

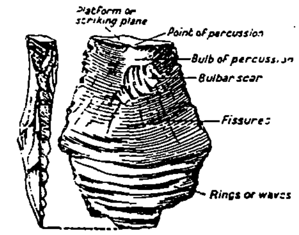
Chimpanzees raised in captivity have learned to paint, an occupation they sometimes take up zealously. Scientists examining this art have argued that this art shows that even the chimpanzee brain has a sense of composition and balance, which occasionally includes drawing roughly parallel lines and crude circles (Morris, 1962; Sebeok, 1981). These manifestations of what may be a very rudimentary sense of symmetry have not been observed in the wild, however.

The earliest definite evidence of human modification of materials is in the form of stone artifacts (M. Leakey, 1973; Isaac, 1984; Toth and Schick, 1986). The earliest prehistoric sites that exhibit such traces date back as early as 2.5 million years ago, and continue for over a million years thereafter. All of these sites, as well as hominid (proto-human) fossils prior to 1.0 million years ago, have been found on the African continent, where these early stages of human evolution appear to have been restricted.

Interestingly, the mechanic of fractured stone has an inherent symmetrical patterning to it. The ideal types of rock for making flaked stone tools are normally hard, fine-grained, and isotropic (no preferential cleavage structure, fracturing equally well in any direction). Force applied by percussion produces a semi-cone of percussion that is normally bilaterally symmetrical in structure. This type of fracture is called *conchoidal* (Figs. 2a and 2b).



Cones of percussion. (*Scale* 2/3.)
(*a*—*d*) Theoretical stages in the fracture. (*e*) A flake removed with incomplete conical fracture. (*f*) An actual cone preserved intact (i.e. corresponding to *d*).

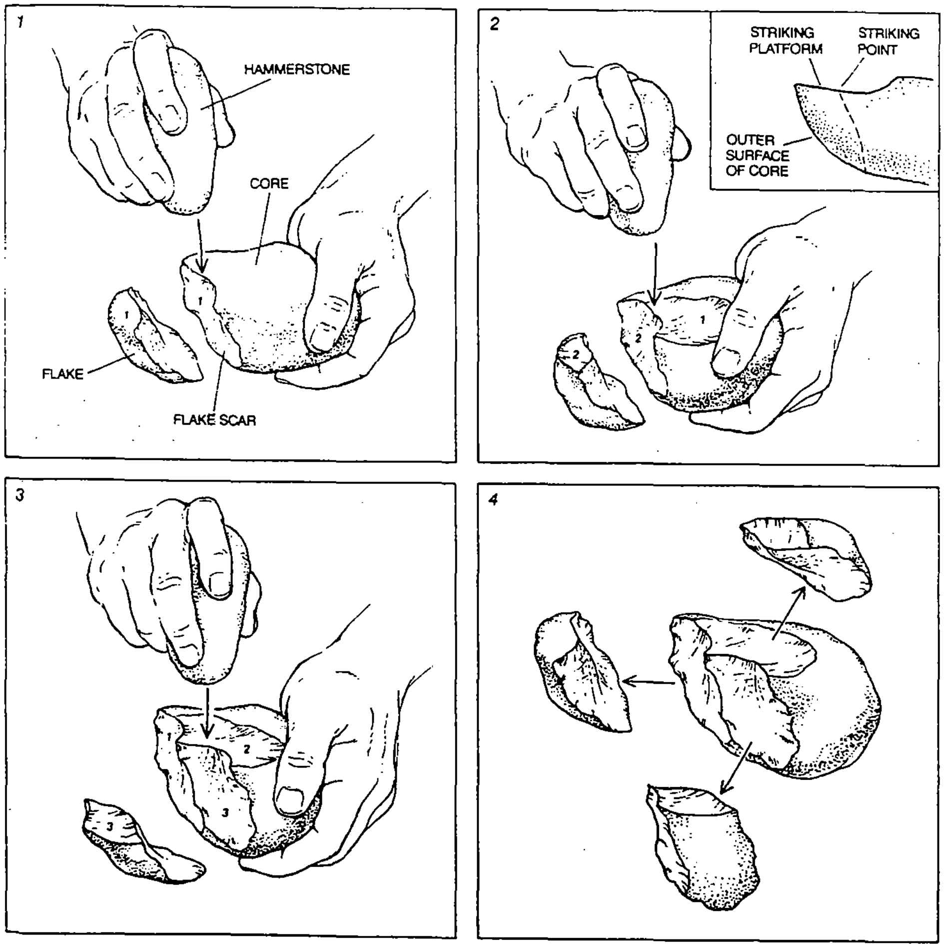


The ideal flake, in which all the conchoidal features are clearly visible. (*Scale* 2/3.)

Figures 2a and 2b: From *Flint Implements: An Account of Stone Age Techniques and Cultures*, Cambridge: British Museum Publications Limited, 1968, pp. 27 and 28, Figures 1 and 2.

These early lithic assemblages are called *Oldowan* industries after the famous site of Olduvai Gorge in Tanzania where they were first discovered (M. Leakey, 1971; Isaac 1984; Toth and Schick, 1986). These occurrences include the Omo sites of Ethiopia, probably the Gona (Hadar) sites of Ethiopia, the Koobi Fora of Kenya, the Olduvai Gorge sites of Tanzania, and the South African cave sites of Sterkfontein and Swartkrans. These stone industries are characterized by *cores*, pieces of rock from which sizable *flakes* and fragments have been removed by percussion with *hammerstones* (Figs. 3 and 4). Flakes were sometimes trimmed along their edges by removing even smaller flakes and fragments into *retouched* forms such as scrapers.

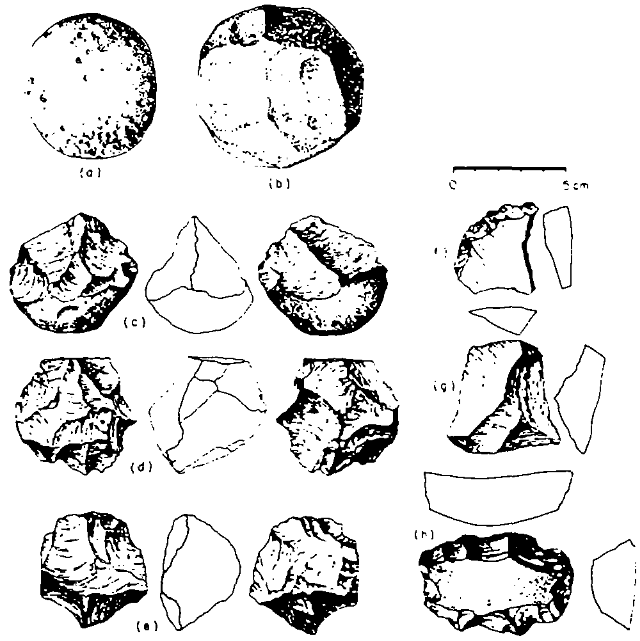
These artifact forms are typical of many palaeolithic occurrences dated to between 2.5 and 1.5 million years ago. Contemporary hominid forms in this time period include *Homo habilis* (2.0-1.5 million years ago), early *Homo erectus* (beginning 1.6 million years ago), and the smaller brained, large molar teeth forms of the later australopithecines (*A. robustus* of South Africa and *A. boisei* in East Africa). It cannot be demonstrated with certainty which hominid forms were responsible for which palaeolithic occurrences. Most anthropologists, however, suspect that the larger-brained forms of *Homo* were more habitual stone tool-makers and users; the *Australopithecus* lineage goes extinct about one million years ago, while the *Homo* lineage continues without a major disruption in the palaeolithic archaeological record.



BIFACIAL FLAKING was one of the chief methods employed by early toolmakers. It was generally carried out by means of the technique called hard-hammer percussion. A stone serving as a hammer was held in one hand and the core, or rock to be flaked, was held in the other (*1*). After a flake had been struck off, the core was turned so that the flake scar (here numbered to match the flake) could serve as a platform for striking off the next flake (*2*). For effective flaking the angle between the striking platform and the core's outer surface must be less than 90 degrees (*inset*). Striking off more flakes (*3, 4*) yields a core with a bifacial edge.

Figure 3: From "The first technology", by N. Toth, *Scientific American*, 255 (1987), No. 4, p. 115.

These Oldowan sites represent the most rudimentary systems of hominid technology that are presently known. Wynn (1981) using a Piagetian approach of analysis, has rightly pointed out their low level of standardization and style, and probably low level of operational procedures as well. Nonetheless, these hominids had a good intuitive grasp of how to fracture stone, which requires angles of less than ninety degrees (acute angles) and a glancing blow from a stone hammer. Just how good this sense of reducing stone was can be observed by examining the products of a beginning student (*Homo sapiens sapiens*) today; normally it takes at least a few hours of practice to replicate Oldowan skill in flintknapping.



A range of Oldowan forms and their traditional classificatory designations (a) Hammerstone. (b) subspheroid. (c) bifacial chopper. (d) polyhedron. (e) discoid. (f) flake scraper. (g) flake. (h) core scraper (Parts (c)-(h) after Barbara Isaac) Drawn by J. Ogden.

Figure 4: From "The Oldowan reassessed: A close look at early stone artifacts", by N. Toth, *Journal of Archeological Science*, 12 (1985), p. 102, Figure 1.

Toth (1985a) has pointed out that, based upon experimentation, many of the Oldowan "core-tool" forms (choppers, discoids, polyhedrons, core scrapers) can be best-explained as by-products of producing sharp flakes, and that much of the technology exhibited in this period is an opportunistic one, the end product largely due to the type of stone, shape, and size of the raw material. This view is shared by Wynn (1981). Some of these "core-tool" forms, however, were likely used as implements as well, for such activities as chopping or bone breaking, so that in some cases the attributes of morphology, weight, edge angle, and edge freshness (sharpness) may have been important considerations for the hominid tool-makers.

Some core forms, especially bifacial discoids, may show a rudimentary sense of symmetry as they are often roughly circular in shape and lens-shaped (biconvex) in cross-section (Fig. 5). Whether this morphology is intentional or accidental is difficult to ascertain, but such forms do allow for easy production of successive generations of flakes, and similar types of cores can be found in palaeolithic sites of recent time periods. Gowlett (1984, 1986) uses the bifacial discoid as the key to the transition to the bifacial handaxe, which will be discussed in the next section. The same may be the case with core scrapers (heavy duty scrapers), usually made on thick flakes or plano-convex cobbles and have flakes removed around much of their circumference. There may be a simple sense of intentional form to these artifacts as well.

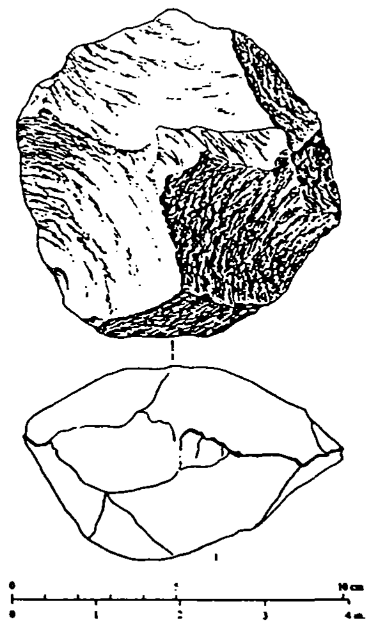


Figure 5: A bifacial discoid. From *Olduvai Gorge, Vol. 3: Excavations in Beds I and II, 1960-1963*, by Mary D. Leakey, Cambridge: Cambridge University Press, 1971, p. 33, Figure 14.

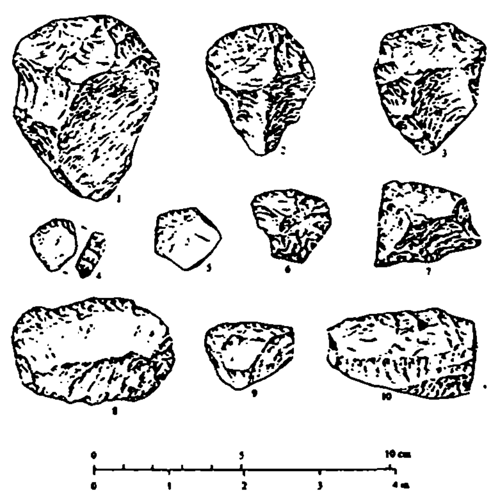


Figure 6: Scrapers. From M. D. Leakey, 1971, p. 180, Figure 83.

Toth (1985a) has pointed out that when hominids exploited unmodified stream or beach cobbles, common forms of raw material used by Oldowan hominids, it would have been difficult to impose a strong symmetric morphology to the core being flaked because of the often irregular nature of the rock as well as the tenacity of some raw materials, such as lavas or coarser-grained quartzites. When such materials were used by later hominids, they sometimes also made core forms similar to those seen in the Oldowan.

Retouched flakes are another clue to the cognitive abilities of Oldowan hominids. These forms often exhibit small flake removals along one or more edges (scrapers, Fig. 6) or converging edges to form a point (awl, Fig. 7). Presumably these pointed forms were used in some sort of perforating or gouging mode; the morphology of these specimens is clearly imposed on the piece of rock, and I would argue *does* require a pre-conceived notion of form as well as an intuitive notion of a sharp, angular point.

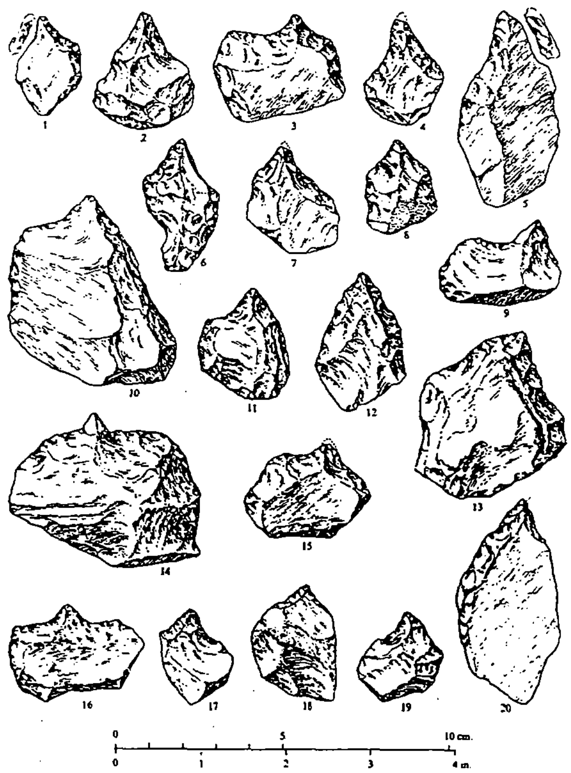


Figure 7: Awls. From M. D. Leakey, 1971, p. 195, Figure 91.

The most symmetrical forms that are occasionally found during this period are "spheroids": spherical stones that are battered over much or all of their surface (Fig. 8). A recent study by Toth (in prep.) shows that these forms can be arrived at by prolonged use of an angular stone as a hammer in flaking. Very spherical forms can be arrived at in several hours duration, without premeditation.

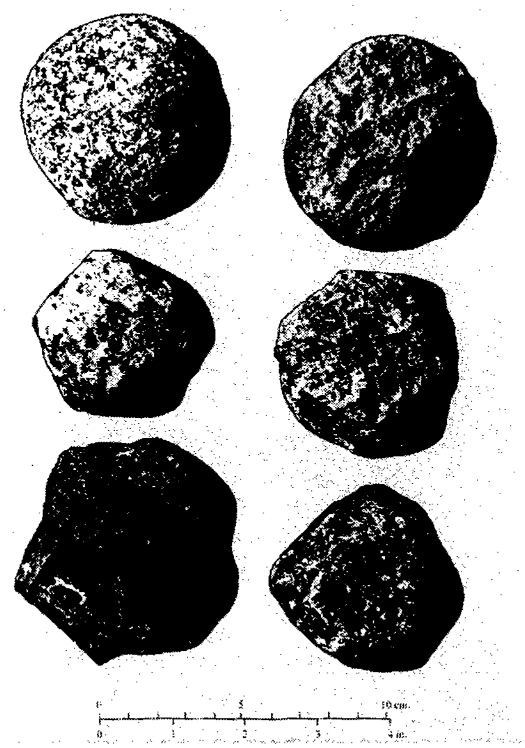


Figure 8: Spheroids (top) and subspheroids. From M. D. Leakey, 1971, Plate 16.

Another possible piece of evidence to suggest an early sense of symmetry among these early stone age hominids was found in Bed I at Olduvai Gorge in Tanzania. At site DK I, Mary Leakey (1971) uncovered a stone circle, approximately 4 to 4.5 meters in diameter, made up of cobbles of unmodified lava rubble (averaging 15-20 cm in maximum dimension, the largest specimens about 30 cm in size) that outcropped locally at that time (Fig. 9). Non-hominid forces that could have produced such a feature cannot be discounted, but based on the density of stone artifacts and broken animal bones with butchery marks on them, it does not seem unreasonable to think that hominids were the agent that organized these rocks into a circular pattern.

This feature at Olduvai site DK 1 may be the remains of a crude windbreak or protective enclosure, with the lava stones helping to anchor branches or other vegetation. Similar structures are still built by African pastoralists today to protect their livestock from predators. If this is truly a hominid-fabricated structure, it is certainly precocious, as no other such feature exists in the palaeolithic record for the next 1.5 million years. It should be pointed out, however, that preservation at this site is excellent, with the fossil bone some of the best-preserved in all of the Early Stone Age.

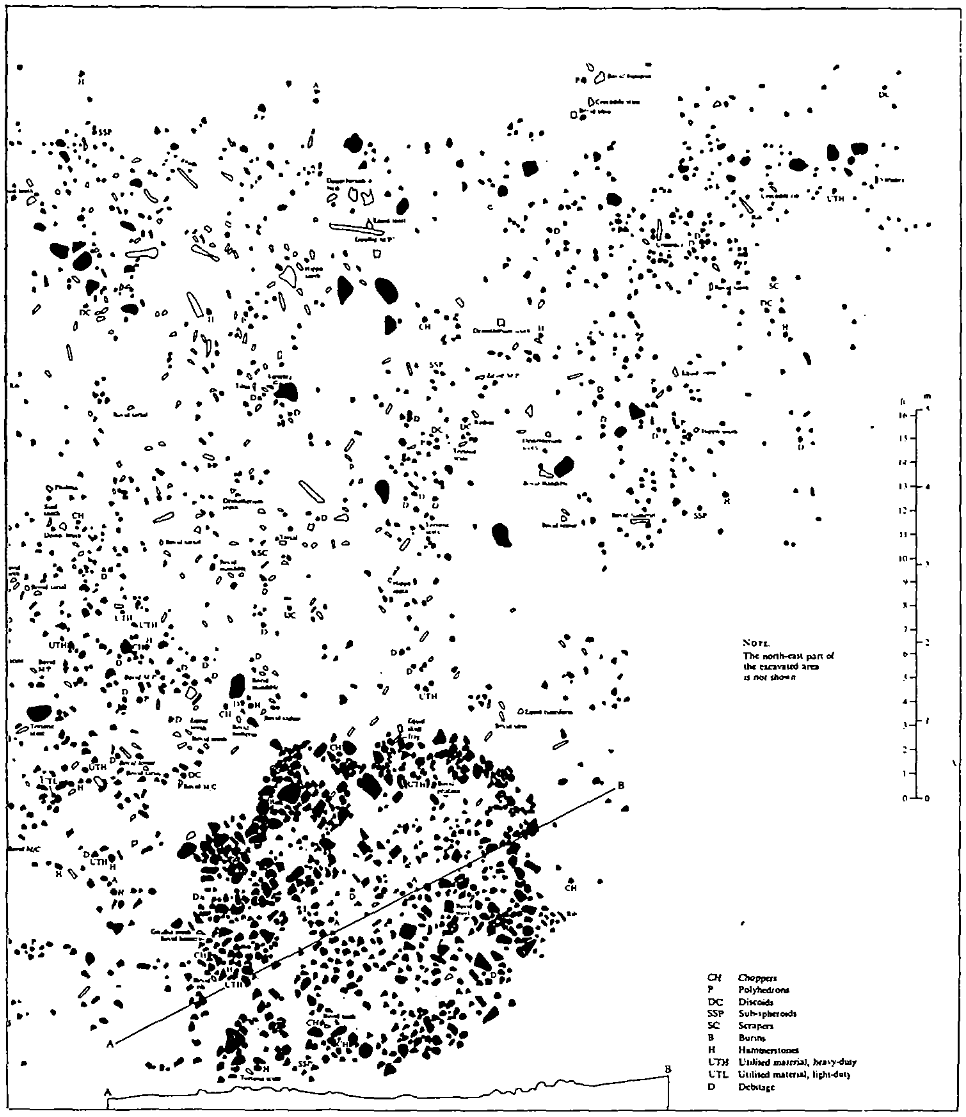
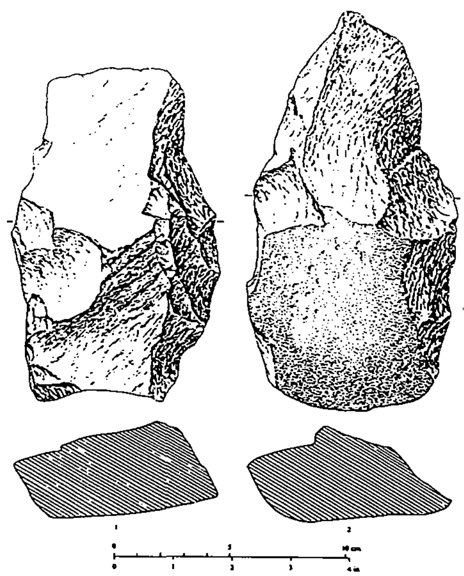


Figure 9: Stone circle at site DK. From M. D. Leakey, 1971, Figure 7.

The formation of stones is strikingly symmetrical, fairly circular in form, and may represent the earliest evidence of an early hominid architectural form that also shows a functional sense of geometry. Unlike stone tools, which is a subtractive process, such a stone circle is an additive process, in essence, a composition of natural rocks.

The Acheulean industrial stage: *Homo erectus*, early archaic *Homo sapiens*

Beginning approximately 1.5 million years ago, early hominids began producing larger artifact forms called *handaxes* and *cleavers*, (Figs. 10, 11, 12, and 13), often on large flakes that were struck from boulder cores. These forms are the hallmark of the *Acheulean* industrial phase, named after a site on the Somme River of France that was discovered in the last century. Often simpler, Oldowan-like artifacts are also found with these new forms. Hominids of the early Acheulean include *Homo erectus* and *Australopithecus*. The *Australopithecus* lineage goes extinct about one million years ago, and *Homo erectus* populations are believed to have spread about this time out of Africa and into Eurasia.



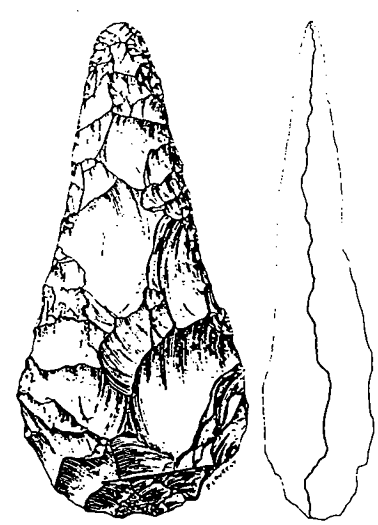


Figure 10: Early Acheulean cleaver and handaxe. From M. D. Leakey, 1971, p. 133, Figure 66.
Figure 11: Late Acheulean handaxe. From *Typologie du Paleolithique ancien et moyen*, Planches, by Francois Bordes, Paris: Centre National de la Recherche Scientifique, Cahiers du Quaternaire I, 1981, Planche 54.

Acheulean handaxes often exhibit a remarkable sense of symmetry in platform and cross-section (Wynn, 1979). It has been argued by many anthropologists that these forms are more carefully made than their functions would have required, suggesting an early sense of aesthetic concern. Based upon my own experience in experimentally producing such forms, I would agree. The production of these forms is no mean feat, and can only be accomplished by a skilled modern stone-knapper after considerable practice. Preparation of striking platforms is necessary in order to create an edge that is steep and regular enough to sustain enough force from a percussor (a stone, bone, wood or antler hammer) to detach thinning flakes which travel at least halfway across the face of a specimen. Such preparation requires the removal on numerous small flakes along the angle of the striking edge, the force and direction of the blow, are critical factors here.

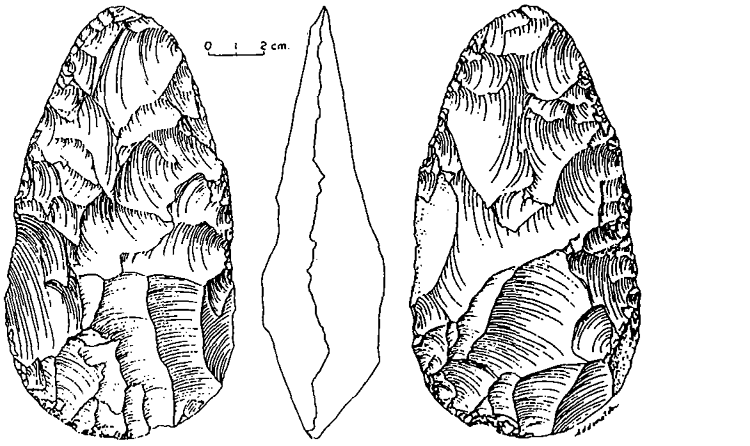
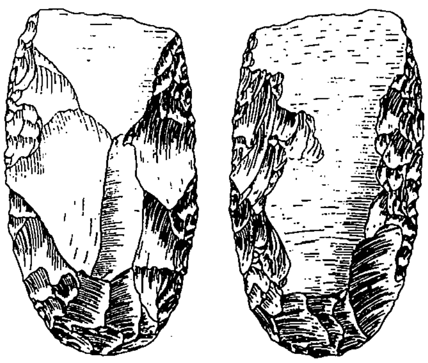


Figure 12: Late Acheulean handaxe. From *Lithic Illustration: Drawing Flaked Stone Artifacts for Publication*, by Lucile R. Addington, Chicago: University of Chicago Press, 1986, Figure 48.



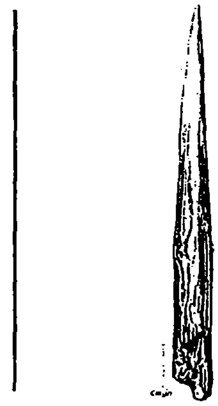


Figure 13: Late Acheulean cleaver. From Bordes, 1981, Planche 78.
Figure 14: Wooden spearpoint from Clacton. From *Man the Toolmaker*, 6th edition, by Kenneth P. Oakley, Chicago: University of Chicago Press, 1972, p. 15, Figure 5.

One of the few three-dimensionally carved objects of wood is the Clacton spearpoint, found at a Lower Palaeolithic site in southern England (Oakley et al., 1977). This artifact, representing one of the few pieces of worked fossil wood from the Lower Palaeolithic, is made of yew wood and is the pointed tip of a probable spear (Fig. 14). Stone tool marks from whittling or scraping are still visible on the specimen. Although this specimen has warped a bit through time, the original shape would have almost certainly been a conical one, symmetrical in cross section around a central axis. One can postulate that spearpoints and digging sticks may have been quite common during this period of time.

At Bilzingsleben in East Germany, estimated to be approximately 300,000 years old, a large fragment of elephant bone had multiple diagonal strokes, roughly parallel and equidistant from one another (D. Mania, pers. comm., 1986). These marks do not appear to be butchery-related (cut-marks from butchery can produce parallel marks from skinning, cutting at joints, or defleshing), but their significance is not known. The interesting point here is that the hominid who made them possessed a concept of parallelism and equidistant spacing.

At the site of Pech de l'Aze in France (Marshack, 1976) in an Acheulean horizon estimated to be approximately 300,000 years old, an ox rib fragment had irregular lines engraved on them. While they do not appear to be clearly representational, they are very interesting because the individual who created them attempted to make two parallel, roughly curvilinear lines in several areas of the bones, again keeping the lines approximately the same distance apart (Fig. 15).

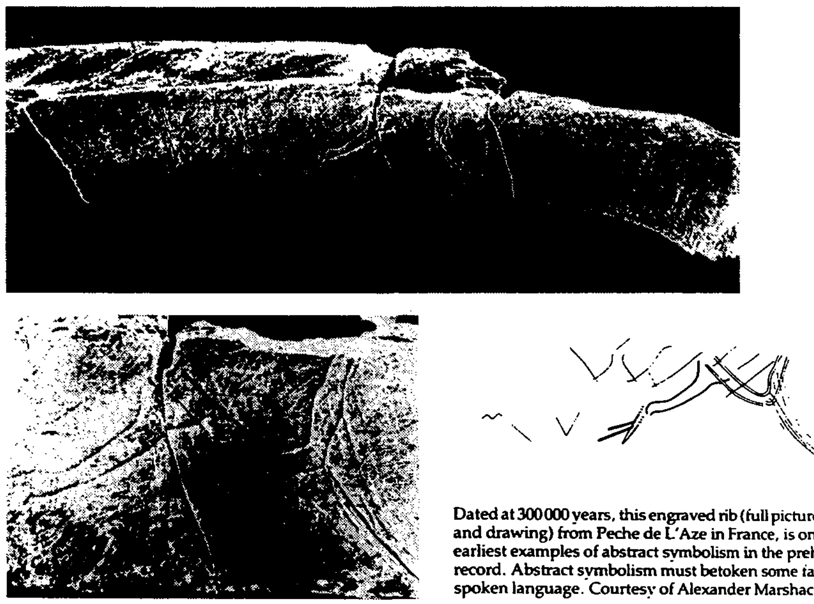
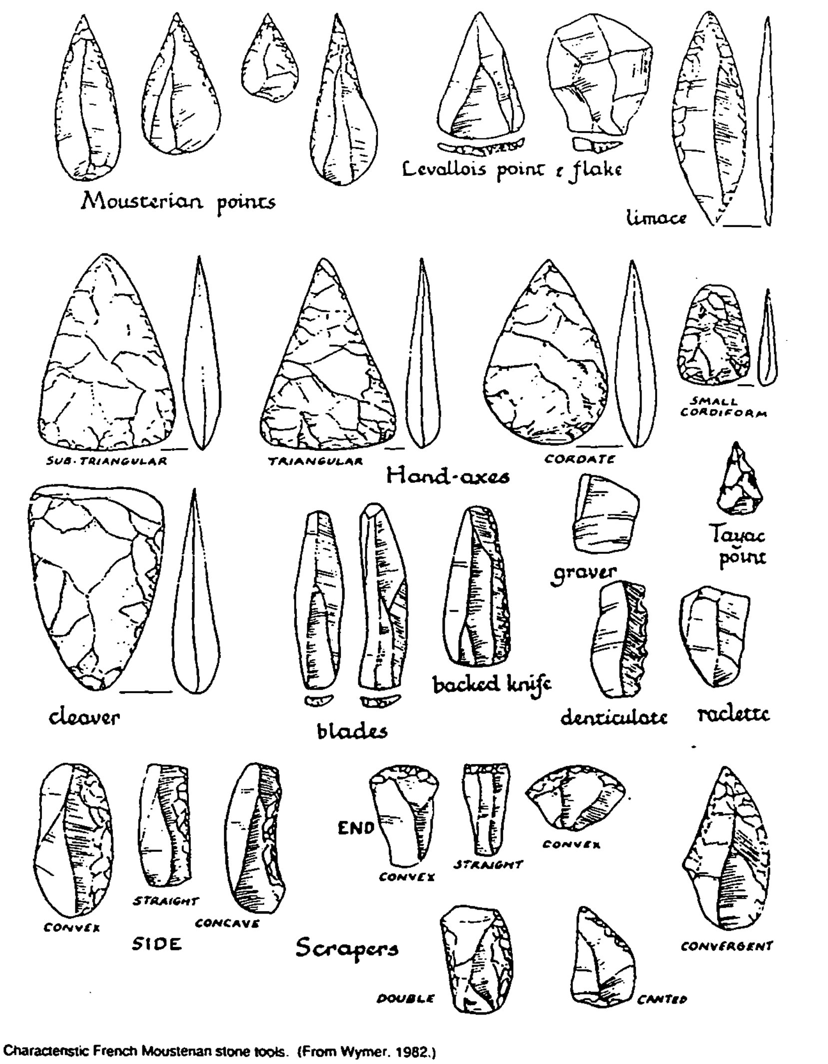


Figure 15: From *Human Evolution: An Illustrated Introduction*, by Roger Lewin, Oxford: Blackwell Scientific Publications, 1986, p. 86.

At the famous "Peking Man" cave site of Zhoukoudien in China, a deep sequence of fossiliferous and artifactual deposits were uncovered, including a number of *Homo erectus* specimens. At one archaeological level, a quartz crystal, not occurring geologically near the cave, was uncovered. It has been suggested that this object, because of its unusual (symmetrical) shape and its transparency, may have been collected and transported as a curiosity or trinket. While this is hard to verify, it is nonetheless interesting to note the cult resurgence of interest in "crystal power" in the 1980's!

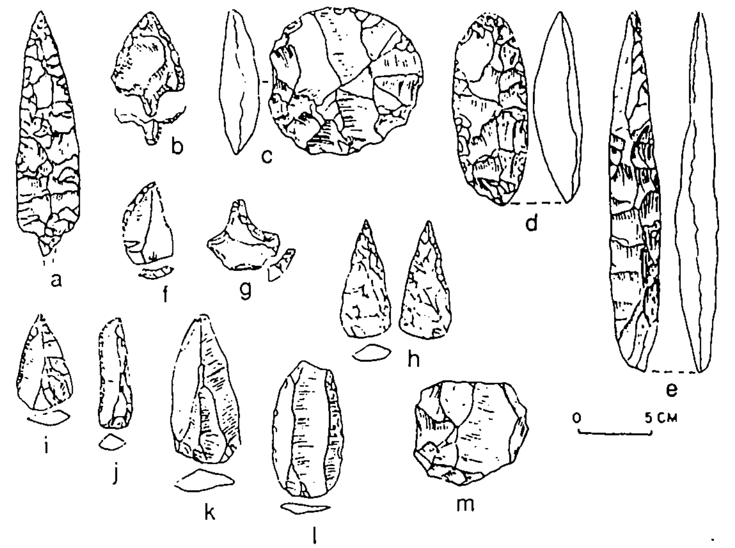
The Middle Palaeolithic/Middle Stone Age stage: Later archaic *Homo sapiens*, including the Neanderthals

Between approximately 200,000 and 100,000 years ago, there was a gradual shift in many parts of the Old World from the large cutting tools (handaxes, cleavers) of the Acheulean to technologies stressing smaller tools, often made on flakes. These occurrences are normally assigned to the *Middle Palaeolithic* (*Mousterian*) in Europe, North Africa, and the Middle East, and *Middle Stone Age* elsewhere.



Characteristic French Mousterian stone tools. (From Wymer. 1982.)

Figure 16: From Tattersall, Delson and Van Couvering, 1988, p. 359.



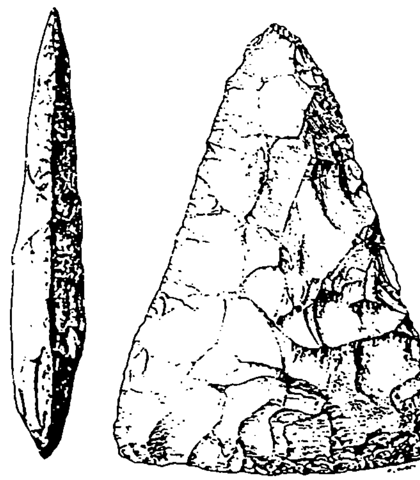
Middle Stone Age artifacts. Aterian industry (Algeria): a–b) tanged points. Lupemban industry (Zaire): c) disk; d) end- and side-scraper; e) bifacial lanceolate. Bambata industry (Zimbabwe): f) backed flake with concave marginal retouch on working edge; g) borer; h) bifacial point. Pietersburg industry (South Africa): i) unifacial point; j) double side-scraper; k) triangular flake from prepared core; l) Levallois-type flake; m) disk core. After J.D. Clark, The Prehistory of Africa, 1970, and Phillipson, © 1985 by Cambridge University Press.

Figure 17: From Tattersall, Delson and Van Couvering, 1988, p. 347.

In general, stone artifacts of this industrial phase are carefully made, with much emphasis on retouched flakes (probably serving such purposes as scrapers knifes, saws, and projectile points, Figs. 16 and 17). These retouched forms tend to be asymmetrical, with the unretouched side serving as a convenient grip during use. Bilaterally symmetrical forms include unifacial points (possibly the first hafted spearheads), bifacial points in Eastern Europe and parts of Africa, and in some cases small, well-made triangular or cordiform handaxes (Fig. 18).

A new technique is found in many Middle Palaeolithic and Middle Stone age contexts: the *Levallois* technique, named after the suburb of Paris where such forms were first described in the 19th century. With this technique, a core is shaped to a prescribed form for the removal of a bilaterally symmetrical flake. These flakes are either oval or circular in form (called Levallois "tortoise core" flakes), or pointed (Levallois points). It can be argued that the production of such forms require more foresight and ability to work with three-dimensional forms than that required for handaxe manufacture (Fig. 19).

At the Mousterian site of Tata in Hungary are two interesting and unusual objects (Marshack, 1976). (Fig. 20.) One is a nummulite pebble engraved, presumably by a stone tool, with a cross-shaped design. The significance of this marking is unknown. The intersection of these two lines is almost a perfect right angle, each line divided neatly into nearly equal halves by the intersecting line. This suggests a strong sense of symmetry as well as an intuitive sense of the concept of right (90 degrees) angles.



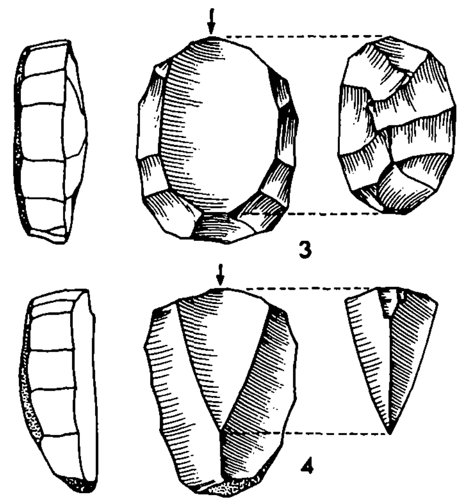


Figure 18: Refined triangular handaxe from the Mousterian period. From Bordes, 1981, Planche 59.
Figure 19: Levallois tortoise core and flake (top) and Levallois point core and point (bottom). From *The Old Stone Age*, by Francois Bordes, New York: McGraw Hill Book Company, 1968, p. 30, Figure 8(3).

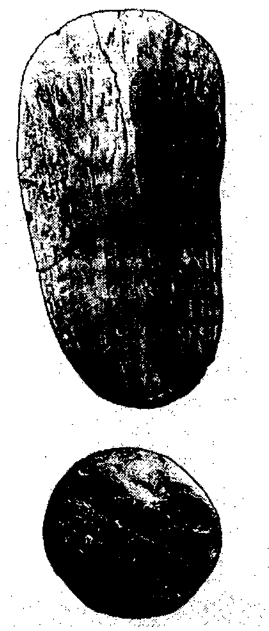


Figure 20: Artifacts from the Tata site in Hungary. From *Historical Atlas of World Mythology, Vol. I: The Way of the Animal Powers*, Part 1, "Mythologies of the Primitive Hunters and Gatherers", by Joseph Campbell, New York: Harper and Row, 1988, p. 57, Figures 86 and 87.

Other examples of Mousterian geometric marks include a bone from the site of La Ferrassie, France, with evenly-spaced, parallel linear incisions, and a bone fragment from Bacho Kiro in Bulgaria, with a series of chevrons ("zigzags") engraved upon it (Marshack, 1976).

From the "Micoqian" site of Bocksteinschmiede, Germany (estimated to be approximately 110,000 years old) a wolf footbone and tailbone have carefully drilled holes in them (Marshack, in press). These bored holes are carefully centered at one end of the bone in line with the longitudinal axis of the bone. The Mousterian site of Molodova in the Ukraine revealed a circular structure (Jelinek, 1975), believed to be the foundation of a hut (Fig. 21). This compositional feature was constructed primarily of mammoth bones, and appears to show clear intent of producing this shape.

Figure 21: Plan of circular hut from Mousterian times, Molodova in Ukraine, U.S.S.R. From the *Pictorial Encyclopedia of The Evolution of Man*, by J. Jelinek, New York: Hamlyn, 1975, p. 236, Figure 368.

Another compositional feature was discovered at the Neanderthal cemetery at the rockshelter of La Ferrassie; nine evenly-spaced mounds of earth had been constructed in three rows, one with a burial associated with it. The significance of this pattern is not known, but if the field reports of these features are accurate, it represents the most organized compositional feature associated with archaic hominid forms.

The Later/Upper Palaeolithic stage: Anatomically modern humans, *Homo sapiens sapiens* ("Cro-Magnon")

In Western Europe, the Neanderthals are replaced by anatomically modern humans, *Homo sapiens sapiens* ("Cro-Magnon") and dramatically new technologies about 35,000 years ago. Evidence from the Near East and Africa suggests that anatomically modern humans may have emerged as early or earlier than 100,000 years ago (Clark, in press). Between 100,000 years ago and 35,000 years ago is a technological shift (the transition period varying widely geographically) away from typical Middle Palaeolithic/Middle Stone Age technologies and towards *Upper Palaeolithic/Later Stone Age* industries.

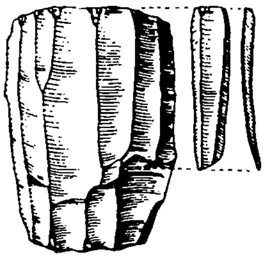


Figure 22: Upper Palaeolithic blade core and prismatic blade. From Bordes, 1968, p. 30, Figure 8(1).

These new industries tend to be characterized by *blade* industries (flakes struck from prismatic cores) with end scrapers, burins (engraving tools), and awls (piercers) being numerous (Figs. 22 and 23). After 35,000 years, these technologies tend to be much more varied geographically and change more rapidly through time than earlier technologies.

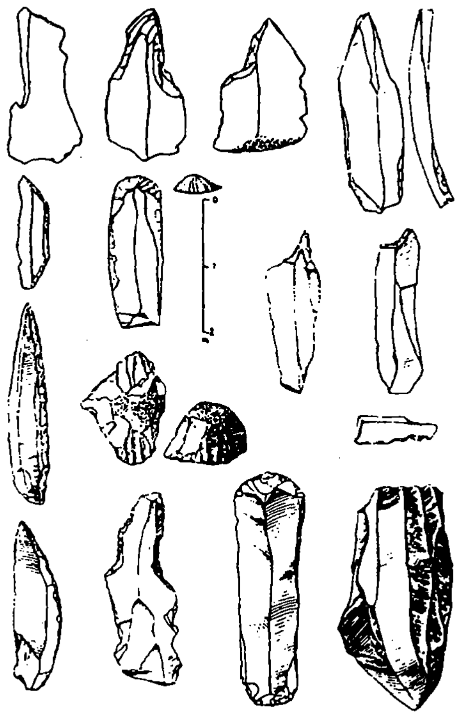
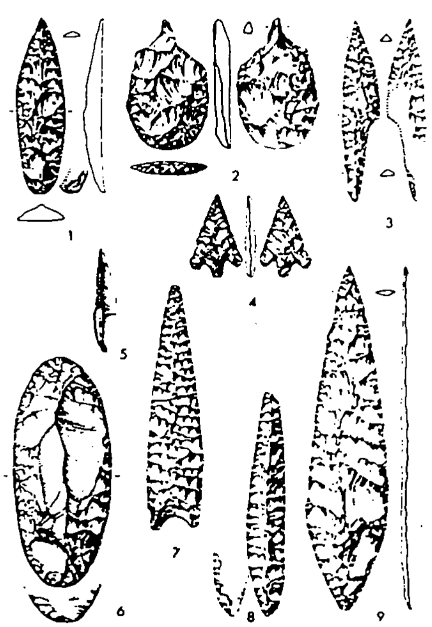


Figure 23: Upper Palaeolithic flint tools. From Oakley, 1972, p. 60, Figure 24.

A great deal of technological innovation, probable advances in hunting and gathering procurement strategies, and the emergence of a strong artistic sense emerges during this time, which has prompted a number of anthropologists as well as experts in semiotics and linguistics to suggest that the emergence of fully human language capabilities may have also emerged concurrently.



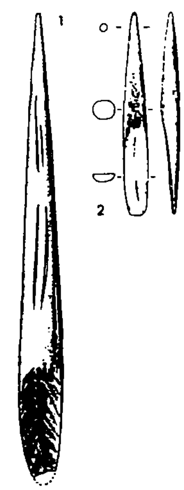


Figure 24: Upper Palaeolithic (Solutrean) stone artifact forms, including bilaterally symmetrical points. From Bordes, 1968, p. 160, Figure 57.
Figure 25: Upper Palaeolithic bone points. From Bordes, 1968, p. 162, Figure 58(1,2).

There is a great diversity of lithic forms during this period of time, including, in some places and time periods, highly stylized bilaterally symmetrical points (Fig. 24), as well as artifacts in bone and antler, including projectile points (Fig. 25), and harpoons, as well as needles and awls. The first representational art is seen in the industrial stage called the Upper Palaeolithic in Eurasia, beginning between 40-35,000 years ago in Western Europe. This artwork is manifested in monochrome and polychrome paintings on cave walls, engravings on cave walls and pieces of stone, antler, or ivory; bas relief carvings on rockshelter walls and fragments of stone; and full-relief carving in antler, ivory, bone, and stone.

The majority of this Upper Palaeolithic art portrays animal figures, usually seen in side view. A strong sense of bilateral symmetry can be seen in the "Venus" figurines and other human carvings of the Gravettian (Upper Perigordian) industry of Western Europe, dated to approximately 30,000 to 20,000 years ago. Anthropologist Leroi-Gourhan (1967) has pointed out the striking symmetry and proportionality of these forms (Fig. 26), which has been corroborated metrically recently by Alexander Marshack (pers. comm., 1989).

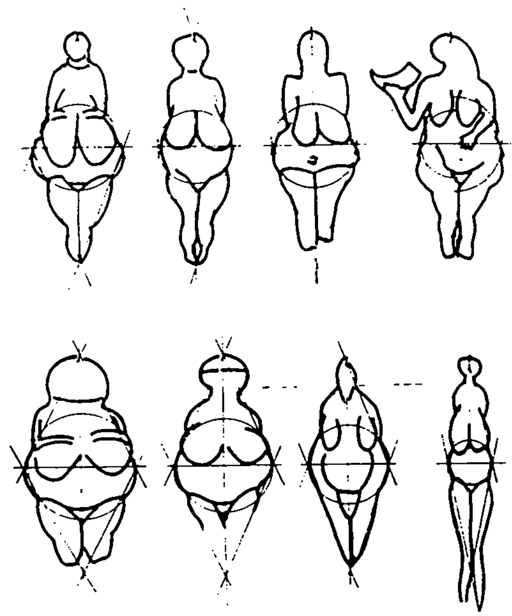


Figure 26: Upper Palaeolithic "Venus" figurines. *Art et civilization des chasseurs de la Prehistoire, 34000-8000 ans av. J.-C.*, Paris: Laboratoire de Prehistoire du Musée de l'Homme et Musée des Antiquites de Saint-Germain-En-Laye, 1984, p. 116, Figure 53.

Three-dimensional carvings, often of zoomorphic forms, are characteristic of the Upper/Later Palaeolithic in some areas, and often have a strong sense of bilateral symmetry that reflects the biological structure of these Pleistocene species. One especially striking example of such a carving is an antler spear-thrower from the Magdalenian site of Mas d'Azil in France (Fig. 27). An ibex is portrayed on this implement, which can only be viewed properly from a face-on (as opposed to profile) view; only the front legs are represented, and the entire piece exhibits incredibly precise bilateral symmetry.

It should be remembered that even with anatomically modern human hunter-gatherer societies of the last 35,000 years, there is an incredible range of variation in the degree in which symmetry is presented in the material cultural record; the absence of such symmetrical artifacts is obviously not a reflection of the innate cognitive skills of these populations, but rather the cultural and stylistic norms of their makers. It is assumed that in some of these prehistoric groups such a system of symmetry and proportion could well have been made in or on perishable materials, such as wood or hides, rather than stone or bone/antler.

Figure 27: Upper Palaeolithic spear thrower fragment engraved with the body of an ibex. From *Men of the Old Stone Age*, by Henry Fairfield Osborn, New York: Charles Scribner's Sons, 1916, p. 449, Figure 245.

Architectural features found at open-air occupation sites in Europe during this period tend to be more numerous, and often in a circular or rectangular shape (Jelinek, 1975). (Fig. 28.)

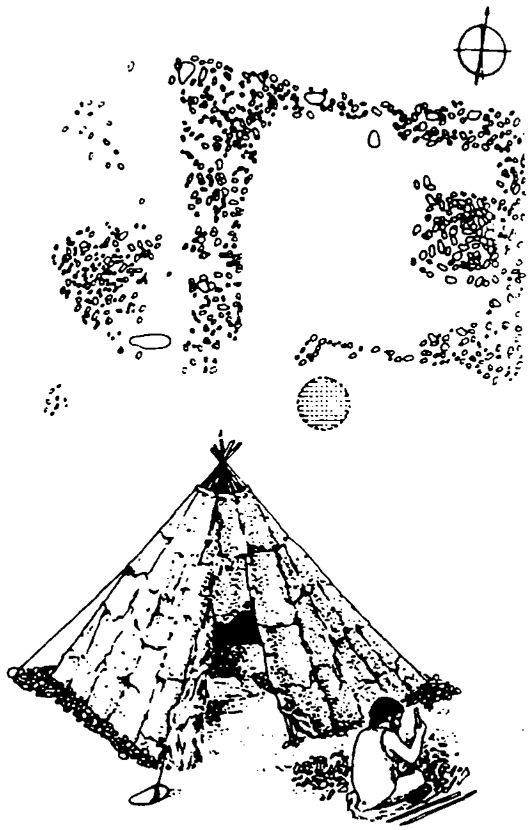
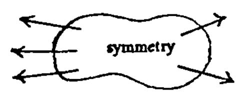


Figure 28: Outline and reconstruction of a square shelter from late Upper Paleolithic times, Plateau Parain, France. From Jelinek, 1975, p. 219, Figure 337.

QUESTION 2



The discussion in the first section concentrated on the prehistoric archaeological evidence for a sense of symmetry in early hominid populations, notably in the form of stone and bone artifacts, architectural patterns, and artwork.

Other disciplines that interface with archaeology in the study of symmetry/asymmetry include palaeontology, palaeoneurology, neurology, and cognitive psychology.

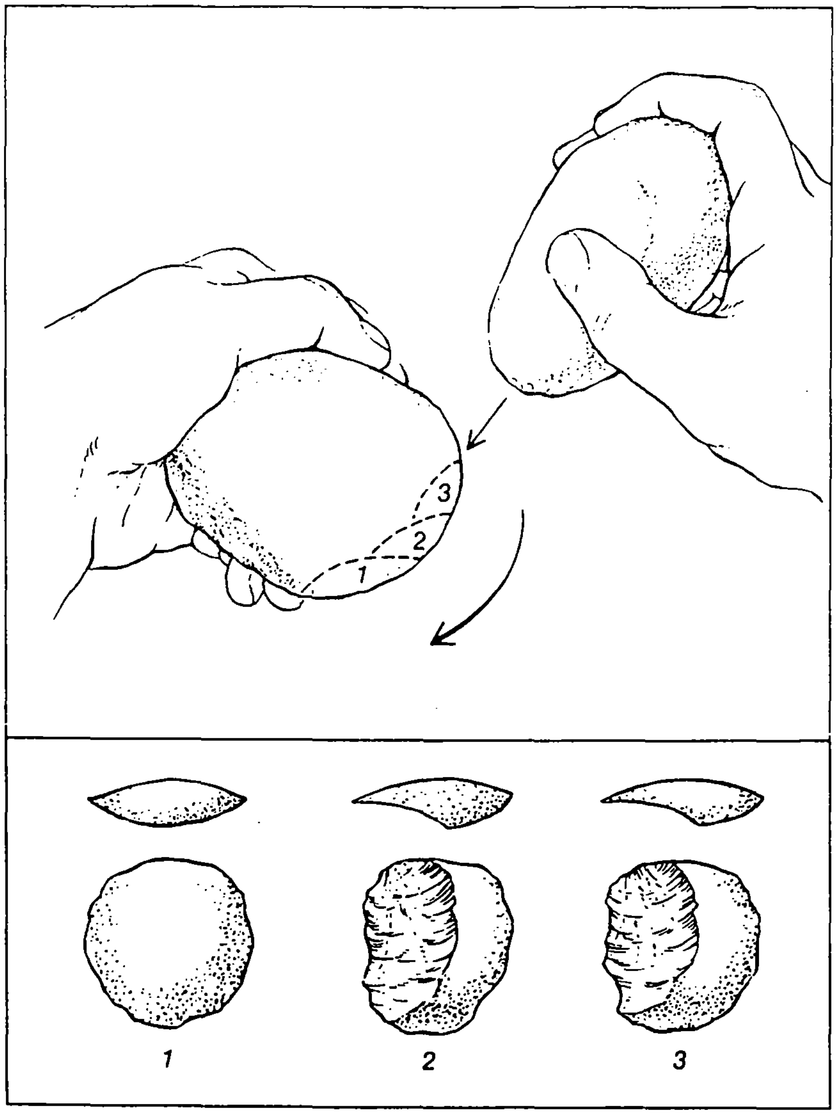
Although there is a growing realization that many animals exhibit some asymmetric lateralization to their brains (Falk, 1987), many researchers would argue that the human brain has evolved to a degree that it now exhibits an exaggerated lateralization that is more profound neurologically and behaviourally than is observed in non-human species. This can be studied on modern and fossil humans by examining asymmetric structure of the brain (or endocranial casts) and the skull (summarized in Falk, 1986). There appears to be a stronger asymmetric pattern in the genus *Homo* than in *Australopithecus* specimens, as well as a development in certain parts of the brain, including Broca's area which is associated with language ability.

Although there may be some asymmetric patterns of handedness in non-human primates (Falk, 1986), modern human populations are anomalous in the animal world with regard to handedness: approximately 90% of humans being right-handed, and there appears to be a strong genetic basis for this asymmetrical pattern in humans. This phenomena has puzzled scientists for well over a century, since neither the adaptive significance (if any) of such an asymmetry is known, nor is the evolutionary history of this asymmetry. Many researchers believe that this strong emphasis on right-handedness may be associated with the development of a strongly lateralized brain during the course of human evolution, with the left hemisphere emphasizing time sequencing, language ability, and control of the dominant right hand, while the right hemisphere more specialized for spatial perception.

My own experimental studies of manufacturing early stone tools shows that early hominid populations appear to have had a higher percentage of right-handed individuals then left-handed individuals, based upon preferential rotation of cores during flaking. As a right-handed knapper, I hold the stone hammer in my right hand and the core to be flaked in my left. When removing a series of flakes from the core, the core is often rotated in a clockwise direction, producing flakes with cortex (the weathered portion of the cobble) on the *right* side of the flake; the left side of the flake is normally a scar previous flake removal (Toth, 1985b). I assigned these flakes to "left-oriented" and "right-oriented" categories (Fig. 29).

As a right-handed tool-maker, I generated right/left oriented flakes in a 53/47 ratio, almost identical to that found at Oldowan sites at Koobi Fora in Kenya. This slight but statistically significant patterning of asymmetry and possible preferential right-handedness between 1.9 and 1.5 million years ago may indicate a more profound specialization (lateralization) of the left and right hemispheres of the hominid brain by the early stone age. The flaking of stone tools is, in fact, an *asymmetric* process, since the dominant hand normally holds the percussor while the left hand holds and orients the piece of stone to be worked (Toth, 1985b; Marshack, 1984).

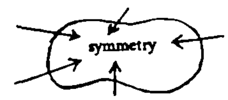
As mentioned earlier, anthropologist Thomas Wynn (1979; 1981) has approached stone tools using Piagetian cognitive psychological theory. Criteria for evaluating the cognitive sophistication of early Oldowan and Acheulean hominids includes symmetry of platform, symmetry of cross-section, and the ability to produce a straight edge. Wynn argues that the operational skills required to produce later Acheulean forms were of a higher order than those required to produce Oldowan artifacts.



UNIFACIAL FLAKING ***yields flakes that can indicate which hand was favored by the toolmaker.*** **A right-handed individual holds the hammerstone in the dominant right hand and the core in the left hand; the core tends to be rotated clockwise as a sequence of flakes is struck off one face. Left-handers reverse the arrangement and generally turn the core counterclockwise. The pattern of cortex, or weathered rind, on the flakes can show which hand held the hammerstone. The flakes numbered *2* and *3* in the lower panel are "right-oriented," suggesting a right-handed toolmaker. (On left-oriented flakes, made by left-handers, the crescent of cortex has the opposite orientation.) Analysis of large populations of prehistoric flakes enabled the author to determine that early hominids appear to have become preferentially right-handed by between 1.9 and 1.4 million years ago.**

Figure 29: From Toth, 1987, p. 120.

QUESTION 3



Western Civilization has emphasized the concept of geometric symmetry in both the arts and the sciences. To what extent this system is analytically imposed upon non-Western cultures as well as prehistoric societies is difficult to gauge. According to some anthropologists, notably Claude Lévi-Strauss (1963), there is an innate structure to the human mind, which is manifested in all aspects of human behaviour in all societies. This theoretical perspective, called *structuralism*, posits that the human mind orders the world into opposable parts (e.g. raw vs. cooked, life vs. death, male vs. female), and that much of the observed cultural patterns of human groups is the symbolic result of this imposed dichotomy.

Linguist Noam Chomsky (1975) has postulated that the human mind has an innate propensity for language and an internal system of rules for ordering vocalizations into meaningful patterns. In a similar way, semiotician Thomas Sebeok (1968; 1972; 1977; 1986) believes that human language is a modeling system: an internal framework for ordering the observable world in a manner that can generate alternative, imaginary possibilities for the future. This modeling system (which includes speech) in unique to the modern human condition and not shared by any extant animals, including the great apes.

If such a biological basis for cognitive ordering is a part of the human condition, could a sense of geometric symmetry be a part of this system? Could the manifestation of this sense of symmetry in technology and art be partially a desire to symbolize a sense of balance or harmony? This researcher believes that this may be the case in recent as well as ancient times. If so, then a strong sense of symmetry in the human condition is *not* primarily influenced by culture, but is a part of the "web of fabric" in the organization of the human brain. Culture would impose a secondary set of rules upon this innate sense of symmetry (which might even include prescriptions by which asymmetric symbolism would be an appropriate cultural response).

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