Behavioral Differences between Archaic and Modern Humans in the Levantine Mousterian

Early modern and archaic humans are associated with similar lithic industries in the Middle Paleolithic of the southern Levant, but new data suggest that they used the environment in different ways. Evidence from analyses of seasonally deposited increments of the teeth of the animals they hunted suggests that modern humans primarily practiced a strategy of circulating seasonal mobility, while archaic humans in the same region 30,000 years later were more residentially mobile. Analyses of their lithic hunting technology further suggest that archaic humans hunted more frequently than did modern humans. We argue that this greater hunting intensity may have been a strategy for coping with the consequences of resource biodepletion resulting from long-term, multiseasonal occupation of sites. These behavioral contrasts may be related to some of the morphological differences between early modern and archaic humans.

Until recently, the Western European paleoanthropological record suggested a simple and straightforward correlation between Upper Pleistocene hominid taxa and Paleolithic industries. Anatomically modern humans were associated with the Upper Paleolithic, and archaic humans (such as the Neanderthals) were associated with the earlier Middle Paleolithic. However, exciting new evidence from the Middle East and Europe has demonstrated this correlation to be false. In particular, new radiometric dates, (summarized in Bar-Yosef 1992) combined with recent excavations at the Kebara Cave in Israel (Bar-Yosef et al. 1992), have refocused attention on the significance of the occurrence of fossil specimens of at least two morphologically distinct hominid taxa—archaic and early anatomically modern humans—with similar Middle Paleolithic assemblages in the Levant, known as the Levantine Mousterian. In addition, recent excavations in western Europe demonstrate that Neanderthals are associated with the Upper Paleolithic Chatelperronian industry (Lévéque and Vandermeersch 1981). These discoveries have spurred an intense reevaluation of theories of modern human origins (Clark and Lindly 1989; Klein 1992; Stringer and Gamble 1993; Wilson and Cann 1992; Wolpoff and Thorne 1992).

The association between Levantine Mousterian assemblages and both early modern humans and archaic humans in the Near East actually has been recognized since the 1990s (Garrod and Bate 1937; Howell 1952; McCown and Keith 1989). However, the Levantine picture has become more clear as a result of recent excavations at Qafzeh (Vandermeersch 1981), Amud (Suzuki and Takai 1970), and Kebara (Bar-Yosef et al. 1992) and new dates from these and earlier excavations (see Bar-Yosef 1992; Grün and Stringer 1991). Archaic Homo sapiens have been uncovered at the Tabun, Amud, and Kebara Caves, and early modern Homo sapiens have been excavated at the Skhul and Qafzeh Caves. All these sites contain broadly similar archaeological residues, which
means that different Late Pleistocene hominids were producing the same Levantine Mousterian stone tools, using these tools in similar ways (Shea 1991), hunting the same medium-to-large-sized animals, and behaving in other similar ways, such as burying some of their dead and building hearths. In addition, it seems clear that archaic humans at Kebara and Amud (and perhaps Tabun) arrived in the Levant roughly 30,000 years after the deposition of sediments containing modern humans at Qafzeh and Skhul (McDermott et al. 1993; Valladas et al. 1987).

The Levantine evidence seems to contradict long-standing models of hominin biocultural evolution developed from the western European record, prompting many paleoanthropologists to question the existence of any meaningful correlations between the Middle Paleolithic archeological record and the hominin fossil record. For some researchers the lack of a demonstrable correlation between change in the archeological record and change in the hominin fossil record presents a paradox, because numerous studies of the hominins' anatomic differences have suggested that there must have been some behavioral differences between archaic and early modern humans (Smith et al. 1989; Trinkaus 1992). For others (e.g., Clark and Lindly 1989; Wolpoff 1989) the Levantine Mousterian evidence suggests that there were few behavioral differences between these taxa in the Levant. These researchers suggest that the apparent lack of evidence for behavioral differences between archaic and modern humans implies that they must have been variants of the same species that evolved gradually and locally in the Levant.

While the question of the evolutionary relationships between archaic and modern humans is important and in need of resolution, this article focuses solely on evidence for behavioral similarities and differences between the morphologically distinct hominin taxa known from the Levant. Rather than attempting to evaluate preexisting models of human origins based on the western European record, we propose new models that address the relationship between the southern Levantine archeological and hominin fossil records.

We contend that detailed analyses of the archeofaunal and lithic evidence from the Upper Pleistocene southern Levant, specifically at the Qafzeh and Kebara Caves, demonstrate that there were behavioral differences between modern and archaic Homo sapiens in this region that we consider significant; but these are not the kinds of differences that most researchers have been looking for. While modern and archaic humans lived in the same region, hunted the same animals, and made similar stone tools, the behavioral contexts in which they performed these tasks may have been markedly different. In particular, evidence from cementum increment analysis for seasonal site occupation associated with modern humans at the Qafzeh Cave suggests that they had a circulating residential mobility strategy; this evidence contrasts with evidence supporting a more locally intensive radiating mobility pattern perhaps practiced by archaic humans at the Kebara Cave. These alternative seasonal mobility strategies are correlated with lithic evidence that suggests that archaic humans hunted more often than early modern humans. These differences in hominins' use of the environment may be related to some of the anatomic contrasts between Neanderthals and early modern humans. These behavioral differences could also be caused by or related to environmental changes during the Upper Pleistocene.

After a brief review of the relevant archeological and paleontological record, we summarize new information on the season of occupation and the intensity of hunting activity from Levantine Mousterian archeological sites. We concentrate on the evidence from the Kebara and Qafzeh Caves because they are the only two sites from the southern Levant for which there are clear stratigraphic associations between hominin fossils, plentiful faunal remains, and well-described lithic industries. Although the stratigraphic position and morphological affinities of the hominin fossils from the Tabun Cave are less clear, we have included data from this site because the Middle Paleolithic sequence from Tabun is generally accepted as a model for the Levant. We believe the evidence
for significant behavioral contrasts between archaic and early modern humans in the Levant must be taken into account in models of the evolutionary relationships of these hominids.

Background

Archaic and early modern humans are found to have existed in the Levant during the Upper Pleistocene under broadly similar climatic and environmental conditions. This makes the southern Levant a valuable region for helping us to understand the behavioral similarities and differences between these taxa. In effect, this region presents us with an approximation of a controlled experiment for investigating the nature of any behavioral differences between archaic and modern humans.

Geography and Climate

The Levant consists of four major geographic zones between the Arabian Desert and the eastern Mediterranean Sea (see Figure 1): a coastal plain, a central mountainous backbone, the Jordan Valley, and the Transjordanian Plateau (Horowitz 1979). Because the Levant lies at the crossroads between Eurasia and Africa, the plant and animal species that live there are a unique combination of Palearctic, Asiatic, and Ethiopian biota (Tchernov 1988). Throughout the Upper Pleistocene and Holocene, the region has been covered by three major phytochoric regions: the Mediterranean woodland, the Irano-Turanian steppe, and the Saharo-Arabian desert (Zohary 1962). Human occupation of the southern Levant has been confined mostly to the Mediterranean woodland and to the margins of the steppic zone. Periodic increases in rainfall resulting from Late Quaternary climatic fluctuations caused shifts of the woodland zone southward and eastward of its present coastal refugia into those parts of the Levant that are today more steppe and desertic (Horowitz 1988; Jaffe 1988; Rognon 1987; Wigley and Farmer 1982).

It is important to note that these changes in climate may be correlated with the presence of different human groups in the Levant. Archaic humans may have occupied the region during a relatively cool period between 60,000 and 80,000 years ago, and early modern humans may have occupied the region during a warmer phase between 80,000 and 120,000 years ago (but see McDermott et al. 1993). Changes in temperature and rainfall quantity notwithstanding, it is likely that the southern Levant during the Pleistocene was subject to the same highly seasonal distribution of rainfall that occurs in the region today (Bar-Yosef 1992).

Archaeology

Recently published radiometric dates and correlations between the terrestrial and marine records suggest that the Levantine Mousterian and its associated hominin fossils date to between 45,000 and more than 150,000 years ago, a period that encompasses oxygen isotope stages (OIS) 4 to 6. The Levantine Mousterian record is best documented from a number of large cave/rockshelters, including Ksar Akil, Yabrud, Tabun, Skhul, Kebara, Qafzeh, and Amud; a few open-air sites also are known, including Biq'at Quneitra, Tirat Carmel, Rosh Ein Mor, and Nahal Aqev (see Bar-Yosef 1989). Levantine Mousterian lithic assemblages are characterized by relatively high percentages of Levallois debitage products, low percentages of retouched tools, and a variable frequency of pointed artifacts (Crew 1975; Marks 1990; Meignen and Bar-Yosef 1989; Skinner 1965).

The general chronology and classification of Levantine Mousterian assemblages has traditionally been based on the sequence of archaeological assemblages from the Tabun Cave, Mount Carmel (Copeland 1975; Garrod and Bate 1937; Jelinek 1982; Meignen and Bar-Yosef 1988).

Most researchers recognize three major lithic industrial variants within the Levantine Mousterian: the youngest, the Tabun B variant, is characterized by unidirectional core
preparation and both large and small isosceles points; the Tabun C variant is characterized by radial core preparation, low percentages of points, and numerous retouched tools; and the oldest, the Tabun D variant, is characterized by unidirectional and bidirectional core preparation, large numbers of blades, and elongated points (Meignen and Bar-Yosef 1988). The chronology of these variants is not yet resolved, but the Tabun B variant is generally dated to between 50,000 and 90,000 years ago, the Tabun C variant to between 80,000 and 120,000 years ago, and the Tabun D variant to between 120,000 and 160,000 years ago (Bar-Yosef 1992).

The medium-to-large-sized fauna present at most Levantine Mousterian sites include mountain gazelle (Gazella gazella), red deer (Cervus elephas), fallow deer (Dama mesopo
Hominid Paleontological Evidence

Archaic human fossil remains have been recovered from the Tabun, Kebbara, and Amud Caves. At Tabun the fragmentary remains of a female (Tabun I) were discovered in a shallow pit near the contact between levels C and B. Garrod provisionally assigned the fossil to level C, but she noted that it may have been intrusive from level B (Garrod and Bate 1937:166). In addition, a mandible of questionable taxonomic affiliation was excavated from within level C. During the 1960s a largely complete archaic human skeleton and several other fragmentary remains were excavated from Amud Cave level B by Suzuki and Takai (1970), and a fragmentary human juvenile (Kebara Hominid 1) was uncovered in Kebara Cave level F by Stekelis (Smith and Arensburg 1977). Subsequent excavations at Kebara between 1982 and 1990 by a team led by Bar-Yosef and Vandermeersch (Bar-Yosef et al. 1992) recovered an almost complete postcranial skeleton of an adult male archaic human from unit XII. Of these archaic human fossils, secure radiometric dates—using both thermoluminescence (TL) and electron-spin resonance (ESR) methods—are available only for the Kebara hominids, which are dated to between 48,000 and 62,000 years ago (Valladas et al. 1987).

Early modern human fossils have been recovered from only two sites, Skhul and Qafzeh. At the Skhul Cave, the remains of at least 16 individuals were excavated by McCown, under the supervision of Garrod (Garrod and Bate 1937), from levels B1 and B2 (McCown and Keith 1939). These levels have been dated by ESR and TL methods to between approximately 80,000 and 110,000 years ago (Grün and Stringer 1991; Schwarz et al. 1988). Another large sample of 16 early modern human remains was uncovered at Qafzeh, first by Neuville (1951) on the terrace in front of Qafzeh and more recently by Vandermeersch (1981) from levels XVI to XXI. These levels have also been dated to between 80,000 and 120,000 years ago by ESR and TL methods (Schwarz et al. 1988; Valladas et al. 1988).

The morphologies of these archaic and early modern humans have been summarized in detail by Suzuki and Takai (1970); Trinkaus (1984, 1992); Vandermeersch (1981); and Arensburg, Rak, and Tillier (in Bar-Yosef and Vandermeersch 1991). Cranially, the archaic Homo specimens from the Levant, which are represented only by Amud and Tabun I, are characterized by a number of features that are regarded by most paleoanthropologists as plesiomorphic (primitive) relative to the apomorphic (derived) character states observed in modern humans. These features, which are shared with other populations of archaic Homo sapiens, include a relatively low frontal angle; a longer, lower cranial vault with more pronounced supraorbital tori; thick cortical development of the cranial vault; and relatively robust facial architecture. While features shared between these Levantine fossils and Neanderthals have often been emphasized (Sant Luca 1978; Suzuki and Takai 1970), it is not clear if Amud and Tabun I share the same degree of midfacial prognathism or occipital bunning that characterizes the classic Neanderthals of western Europe. On the basis of the cranial and postcranial evidence, the Levantine sample most likely represents a population of archaic humans with some Neanderthal affinities.

Significant anatomic differences exist between the archaic and modern human fossils from the Levantine Mousterian. In contrast to the specimens from Tabun and Amud,
the early modern humans from Qafzeh and Skhul share numerous derived cranial and postcranial characters with other modern humans, such as a high-domed cranium, a rounded occiput, and a highly flexed basicranium. As Trinkaus (1992) has pointed out, the early modern humans also differ from the archaic samples in the Levant in their reduced postcranial robusticity, reduced anterior dental wear, more gracile muscular development of the rotator cuff (including a narrower scapula), less bowed radii, higher femoral neck angle, and more anteroposteriorly elongated femoral shaft dimensions. Many of these morphological differences (which are discussed below) imply that there were some behavioral differences between these hominid taxa.

Behavioral Similarities and Differences

These morphological contrasts notwithstanding, many overviews of the Levantine Mousterian record have emphasized the significance of the formal similarities between the lithic and faunal records associated with archaic and early modern humans (S. Binford 1968; Brace 1967; Clark and Lindly 1969; Howell 1957; Jelinek 1982; Trinkaus 1984; Wolpoff 1989). For example, Wolpoff (1989:136) has recently argued:

It is difficult to understand how the presumably earlier Qafzeh folk of the Levant were able to coexist with the possibly intrusive Neanderthals, given that they lived at the same time in the same places, manufactured the same tool industries, utilized the same technology, and adapted with the same subsistence patterns unless they became the same people (just as McCown and Keith [1939] suggested might have been the case).

These archæological similarities have received much attention, but the apparent similarities between the archaic and early modern humans associated with the Levantine Mousterian require careful analysis. There are three reasons for this:

1) Gross similarities in the archæological record have been taken to imply overall behavioral similarity, limiting the search for important behavioral differences between these hominid taxa. Such differences are suggested by functional anatomic comparisons (Trinkaus 1986), and their correlates should be sought in relevant aspects of the archæological record.

2) The similarities that have been identified and emphasized by recent studies are the kinds of basic shared behavioral characteristics that are to be expected between closely related hominid taxa living in the same region and under comparable environmental conditions. Indeed, it would be surprising if archaic and early modern humans in the Upper Pleistocene Levant made completely different lithic industries, used the tools in strikingly different ways, or hunted different medium-to-large-sized mammals. These similarities could reflect some important shared constraints on hominid behavior (there are only a limited number of ways to use stone tools and a limited number of animal species to hunt).

3) It is wrong to use the perceived lack of archæological contrasts between the Kebara and Qafzeh data sets as support for either a close biological relationship or behavioral similarity between Neanderthals and early modern humans. Such an approach is flawed because it can easily lead one to accept a false null hypothesis on the basis of insufficient contrary evidence—what Sokal and Rohlf (1969) term a type II error or what Popper (1959) refers to as the problem of falsifiability. Similarity can be tested only by looking for differences.

If there are any significant behavioral differences between these hominid taxa, examining the behavioral processes that created aspects of the Levantine Mousterian archæological record may reveal them. Truly important behavioral differences between archaic and early modern humans may be less apparent in the formal aspects of the archæological record than they are in the formation processes by which the record was created. Seasonal mobility and resource acquisition strategies and the use of tools to buffer hominids from environmental stresses are important factors that have a profound effect on the character of the archæological record. An examination of these dimensions
of hominid behavior using the faunal and lithic records from the Kehara, Qafzeh, and Tabun Caves indicates to us that there may have been some meaningful behavioral differences in the archeological formation processes at these sites.

The Kehara, Qafzeh, and Tabun Caves

Before presenting data on behavioral contrasts inferred from the lithic and faunal evidence from the Kehara, Qafzeh, and Tabun Caves, it is useful to review the context of these deposits.

The Kehara Cave

The Kehara Cave is located on the southwestern escarpment of Mt. Carmel 60 meters above sea-level on the headland facing west and overlooking the coastal plain at the conjunction of two valleys. The Mousterian occupations in the cave were first excavated by Turville-Petre (1932) and then by Stekelis (Schick and Stekelis 1977). Recent excavations (1982–1990) at the Kehara Cave have been conducted by Bar-Yosef et al. (1992). TL and ESR assays date the Kehara Mousterian to between 48,000 and 63,000 years ago (Schwarz et al. 1989; Valladas et al. 1987), which is in general accordance with the biostratigraphy (Tchernov 1989). In addition to approximately 5 meters of Mousterian deposits, the cave also contains levels of mixed (units VI–IV), Upper Paleolithic (units III–I), Kebaran (Layer C), and Natufian (Layer B) cultural material. The early Upper Paleolithic (unit VI) is dated by TL to between 44,000 and 53,000 years ago (Valladas et al. 1989).

During the Mousterian spring, activity and subsidence eroded and redeposited some of the sediments, but this disturbance appears to have been localized. One of the most striking characteristics of the Kehara Mousterian sediments is the deep sequence of hearths and ashy lenses, which indicates prolonged and repeated intentional burning by the hominids that lived there (Meignen et al. 1989). Meignen and Bar-Yosef (1988:85; Bar-Yosef and Meignen 1992) describe the lithic industry from Kehara units VII–XIII as a “Tabun B variant” of the Levantine Mousterian with a high percentage of cores and blanks produced by unidirectional convergent flaking. The faunal remains from the site (which have been only partially studied) are dominated by G. gazella, although there are also remains of Dama mesopotamica as well as Capreolus capreolus, Cervus elaphus, Sus scrofa, Alcelaphus sp., Bos primigenius, and Equus spp. (Bar-Yosef et al. 1992; Davis 1977; Saxon 1974). Gazelle constitute at least 75 percent of the bones in all levels, with the exception of the Upper Paleolithic, where they are about 63 percent (Davis 1977; Saxon 1974). Some carnivore remains (including hyena coprolites) have been identified (Horwitz and Goldberg 1989), along with bones with carnivore chewing marks, but detailed taphonomic studies indicate that the accumulation of bones in the cave results mostly from human activities, and that carnivore modification of bone was subsequent to their discard by humans (Bar-Yosef et al. 1992). More carnivore modification is evident in the Upper Paleolithic than in the Middle Paleolithic.

Hominid remains have been found throughout units VII–XII of Kehara, but the most complete remains are from two grave sites, those of an infant (Kehara Hominid 1) buried at a depth of 6.83 to 6.9 meters (Smith and Arensburg 1977) and an adult male (Kehara Hominid 2) from unit XII (Bar-Yosef et al. 1986, 1988; see Bar-Yosef and Vandermeersch 1991).

The Qafzeh Cave

The Qafzeh Cave faces southeast overlooking the Esdraelon Plain, on a steep promontory of the Wadi el-Haadj south of Nazareth at an elevation of 220 meters above sea level. The Mousterian levels in the Qafzeh Cave were first excavated by Neuville and Stekelis (Neuville 1951:179–184). Later excavations by Vandermeersch (1981) focused on the terrace in front of the cave. Although the interior of Qafzeh contains numerous
artifacts and faunal remains embedded in fine-grained sediments, Mousterian hominin fossils were recovered only from the terrace, where the sediments consist of alternating beds of silt and rock scree (Goldberg 1980) with variable faunal preservation (Vandermeersch 1981).

The Mousterian levels on the Qafzeh terrace that are associated with modern human remains (units XV–XVII) are dated by TL and ESR assays to between 92,000 and 115,000 years ago (Schwarzc et al. 1988; Valladas et al. 1988). The lithic assemblage from those levels of Qafzeh associated with most of the hominin fossils, units XVII–XXIV, resembles that of Tabun C, with a relatively high percentage of Levallois flakes and cores with radial/centripetal preparation (Boule 1989). Unit XV, which is associated only with an infant cranial fragment, contains a large lithic assemblage with more pointed artifacts than in the lower levels. According to Bouchud’s (1974) analysis of the fauna, C. gazella comprise 22 percent of the elements of medium-to-large-sized mammals from units XVI–XXVI, but other large mammals are present in similar proportions: B. primigenius account for 20 percent, Equus maurusianicus account for 17 percent, and Cervus elephas and Dama mesopotamica constitute 16 percent and 13 percent of the fauna, respectively. In contrast to the lower levels of the terrace, Cervus elephas constitutes roughly 40 percent of the fauna from units XI–XV (Bouchud 1974).

The Tabun Cave

The Tabun Cave is located 4 kilometers from the present coast at the Wadi el-Mughara, 63 meters above sea level on the western face of Mt. Carmel. Tabun was originally excavated by Garrod in the 1930s (Garrod and Bate 1937) and reexcavated between 1967 and 1975 by Jelinek (1981, 1982, Jelinek et al. 1973). The Tabun sequence spans the final Acheulian (Layers G and F), the Acheulo-Yabrudian (Layer E), and the Mousterian (Layers D, C, and B) (Jelinek 1982). 26Th/234U and ESR dates for these levels (Bar-Yosef 1992; Grün and Stringer 1991; McDermott et al. 1993) indicate that Tabun B dates to OIS 4 and/or late OIS 5, Tabun C dates to between early OIS 5 and/or late OIS 6, and Tabun D dates to OIS 6 or possibly OIS 7. A partial skeleton of an archaic Homo sapiens female was recovered from either Layer C or Layer B, and a damaged mandible of indeterminate taxonomic affinity was found in Layer C (McCown and Keith 1939).

Seasonality

Data are now available for the first time on the season of occupation of the Kebara and Qafzeh Caves, allowing us to estimate the seasonal mobility strategies of the hominids associated with these sites. Seasonality data are important because the temporal and spatial limitations on foraging and hunting imposed by the restricted seasonal availability of most resources constitute a primary constraint on hunter-gatherer behavior (L. Binford 1980; Kelly 1983, 1992; Speth 1987; Speth and Spielmann 1983). Seasonal mobility strategies are one of the most important adaptations available to hunter-gatherers for coping with the problems imposed by their environments. Differences in seasonal mobility and resource acquisition strategies could account for some of the variability seen in some late Pleistocene Levantine faunal assemblages, such as the change in proportion of male to female gazelle observed by Speth between the Middle and Upper Paleolithic levels at the Kebara Cave (Bar-Yosef et al. 1992). In addition, seasonality data from fauna provide clues about other seasonally available plant resources that probably constituted the primary component of early human diets, but which remain archeologically invisible.

Unfortunately, information on seasonality from Paleolithic sites in the Levant and elsewhere has not been readily available. This lack of information is partly because of the poor preservation of plant remains in Levantine soils, and partly because most hominin sites were excavated before adequate recovery techniques were used. Never-
theless, there have been some attempts (discussed below) to relate Levantine Mousterian industrial variability and site distributions to differences in seasonal mobility strategies (S. Binford 1968; Coinman et al. 1986; Henry 1992; Marks 1988; Marks and Friedel 1977). All these studies, however, assume a dependent relationship between some aspect of human behavior reflected in the archeological record (e.g., group size, flintknapping intensity, hunting patterns) and seasonal fluctuations in resources. Archeological correlates of seasonality and mobility (which include site size, site location, and lithic density) are problematic because they can vary as the result of factors other than the season or duration of site occupation. Estimates of seasonality based on a priori biological indicators of the season of death of animals are an improvement over previous approaches because they are based on a known biological processes (i.e., the formation of acellular cementum in animal teeth) that cannot be altered by human activity (except under highly controlled laboratory conditions).

**Cementum Increment Analysis**

Seasonally deposited incremental structures in cementum, a tissue that surrounds mammalian teeth, can provide valuable data on the season of death of fauna from archeological sites (see Figure 2) (Burke 1992; Gordon 1988; Grue and Jensen 1979; Klevezal and Kleinenberg 1967; Lieberman et al. 1990; Lieberman 1991, 1993a, 1993b, 1994; Pike-Tay 1991; Spiess 1979). Cementum is a bone-like tissue that is continually laid down around the roots of teeth from the onset of occlusion until death or until the tooth falls out. Cementum can be divided into two categories, cellular and acellular. Cementum at the apical end of tooth roots and between the furcation of tooth roots tends be cellular in nature and is rapidly laid down in large quantities during periods

---

**Figure 2**

A, schematic cross section of a lower first molar of a mountain gazelle (*Gazella gazella*) showing the location of cellular and acellular cementum as well as other dental tissues. B, photomicrograph of acellular cementum increments from an archeological sample from the Mousterian of Kiebara. C, graph (luminance profile) of the cementum increments demonstrating that this animal has eight alternating translucent (T) and opaque (O) increments, indicating that the animal died during the fall or winter of its fourth year of life.
of tooth eruption, thus filling voids between the gum (periodontal ligament) and the tooth root. The extremely narrow cementum bands laid down between periods of tooth movement—sometimes termed lines of arrested growth (Castanet 1981)—are acellular and hypermineralized. Given the high rate of variation of cellular cementum growth at the end of the tooth root, the cellular cementum bands in this region are primarily useful in most species for determining the age at death (for a detailed discussion of the histology and physiology of cementum, see Lieberman 1994; Lieberman and Meadow 1992).

Acellular cementum bands, which cover the rest of the tooth root up to the enamel crown, are useful for estimating season of death. These bands function to attach the tooth root to the mandible or maxilla by mineralizing around collagen fiber bundles (Sharpey's fibers) that originate in the periodontal ligament. Acellular cementum grows slowly and constantly throughout the year in bands whose optical quality varies under polarized transmitted light microscopy (Figure 2). In most mammals, acellular cementum bands deposited during seasons of growth tend to be translucent, and bands deposited during seasons of reduced growth tend to be opaque. Controlled laboratory experiments demonstrate that these seasonal bands result from two processes caused by seasonal changes in diets (Lieberman 1993b). First, changes in the frequency and/or magnitude of force required to chew different diets results in variations in the orientation of Sharpey's fibers (causing variations in the birefringence of bands deposited in different seasons). Second, seasonal variations in the nutritional content of diets affect the rate of mineralization of cementum, resulting in bands with different mineral densities. Consequently, the outermost acellular cementum band in a tooth indicates the season of death of an individual.

The season of occupation of archeological levels from the southern Levant can be estimated by determining the seasons during which these hominids hunted mountain gazelle (Gazella gazella) and other ungulate species. Gazelle were obviously attractive prey for human hunters: until recently they were available in large numbers in both Mediterranean woodland and steppic phytogeographic zones. They breed rapidly, are nonmigratory and territorial, and are easy to hunt because they tend to run in semicircles when attacked (Baharav 1974, 1981, 1983; Simmons and Illany 1977). Gazelle are a valuable indicator of seasonality because there is a strong correlation between the nature of acellular cementum bands of mountain gazelle in the Levant and their seasonal diet, which consists primarily of grazing during the winter rain season and browsing during the summer dry season (Baharav 1981). In modern gazelle, acellular cementum bands grown during the wet season are optically opaque under transmitted polarized light, and bands grown during the dry season are optically translucent; opaque bands and translucent bands grow at a constant rate of about 2.7 micrometers per month and 4.6 micrometers per month, respectively (Lieberman 1993c, 1994). Therefore, measurement of the width of the outermost cementum band of gazelle can yield relatively precise (within two months) and accurate estimates of month of death.

Mandibles of gazelle (as well as a few samples of Capra, Ovis, and Bos) from the Kebara, Qafzeh, and Tabun Caves were examined to estimate the season of occupation of sites. To prevent false estimates of season of death from the loss of outermost increments, only teeth still embedded in bone were studied. All teeth were analyzed using computer image analysis techniques to quantify objectively the number of increments and the optical nature of the outermost increment (for a complete explanation of the sample preparation techniques and the method of computer image analysis, see Lieberman et al. 1990 and Lieberman and Meadow 1992).

Table 1 summarizes the samples analyzed in this study. Thirty of the mandibles studied were from Kebara: 20 from the Stékelis excavation in the center of the cave, corresponding roughly to units VII–X, and 10 from a single stratum of the descapanese excavation in unit X in which layers demarcated by hearths were carefully "peeled away" to expose ancient living floors. At Qafzeh, limited faunal remains were found associated
Table 1
Season of occupation of sites.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Age (ka)</th>
<th>Industry</th>
<th>N</th>
<th>% outer opaque</th>
<th>% outer translucent</th>
<th>Season of occupation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kebara VII–X</td>
<td>50–60</td>
<td>Tabun B</td>
<td>30</td>
<td>52</td>
<td>48</td>
<td>Multiseasonal</td>
</tr>
<tr>
<td>Tabun B</td>
<td>60–90</td>
<td>Tabun B</td>
<td>12</td>
<td>50</td>
<td>50</td>
<td>Multiseasonal</td>
</tr>
<tr>
<td>Tabun C</td>
<td>80–130</td>
<td>Tabun C</td>
<td>10</td>
<td>90</td>
<td>10</td>
<td>Fall/winter</td>
</tr>
<tr>
<td>Qafzeh XVI–XXI</td>
<td>92–115</td>
<td>Tabun C</td>
<td>15</td>
<td>0</td>
<td>100</td>
<td>Spring/summer</td>
</tr>
</tbody>
</table>

Source: Lieberman 1993a

with the early modern humans between levels XVI and XXIII: a total of 15 mandibular or maxillary fragments are preserved below level XVI (of which 73 percent are *Gazella gazella*, 13 percent are *Capra ibex*, 7 percent are *Dama mesopotamica*, and 7 percent are *Bos primigenius*). In addition the sample of teeth from levels XVI and below can be augmented with 14 specimens from levels XV–IV. The majority of the faunal assemblage excavated by Garrod from the Wadi Mughara caves were not saved, but a small sample remains in the Natural History Museum in London. Of these, 12 mandibular fragments of *G. gazella* from Tabun level B and ten mandibular fragments of *G. gazella* from Tabun level C were analyzed.

The pattern of seasonal gazelle use from these sites (summarized in Table 1) reveals two different patterns. In the Kebara Mousterian levels (units VII–X), 52 percent of the gazelle were hunted during the dry season, and 48 percent were hunted during the wet season. It should be stressed that evidence for multiseasonal hunting of gazelle in the Kebara Mousterian is documented not only with specimens from the original Stekelis excavations comprising three units (VI–IX), but also from a single level (unit X) of the 1987 excavation of the décapage.

It is likely that the multiseasonal pattern evidenced at Kebara is not the result of the mixing of very chronologically separated single-seasonal occupations. (It should be noted that we do not wish to imply that multiseasonal occupation is the same as sedentism: multiseasonal occupation refers to a site that was inhabited for more than one season during a year, unlike sedentism, which refers to the relatively continuous occupation of a site throughout the year). The mandibles from the décapage originate from 4 square meters of a single horizon (all within 10 centimeters of each other vertically), are closely associated with hearths and other cultural material, and probably do not result from other nonanthropogenic site-formation processes (Bar-Yosef et al. 1992). Moreover, the multiseasonal signature of the teeth from the Mousterian levels of Kebara contrast with the single-seasonal signature of the gazelle from the Upper Paleolithic levels (*n = 30*) and with almost every other level from every other Levantine Middle Paleolithic, Upper Paleolithic, and Epipaleolithic sites (with the exception of Tabun B and the upper layers of Qafzeh, which are discussed below). In other words, the multiseasonal signature at Kebara does not appear to be a result of time-averaging of several very disparate single-seasonal events (although such a possibility cannot be ruled out).

At Qafzeh, in contrast, there is evidence for only single-seasonal hunting of gazelle and site-use. In layers XVI and below, which are associated with early modern humans, all the gazelle and other ungulates present were killed only during the dry season.

The different patterns of seasonal site use at Kebara and Qafzeh are paralleled in the Tabun Mousterian sequence. Level B in Tabun not only has the same industrial facies of the Levantine Mousterian as Kebara VII–XII but also has the same multiseasonal signature as the Kebara Tabun-B type assemblage. In Tabun B, 50 percent of the gazelle were hunted during the dry season and 50 percent during the wet season. Tabun level
C, which has a Levantine Mousterian assemblage similar to Qafzeh XVI-XXI, preserves evidence for gazelle hunting during just one season. The only difference between the Tabun C and Qafzeh XVI-XXI samples is that all the gazelle from Qafzeh XVI-XXI were killed during the dry season, while 90 percent of the gazelle from Tabun C appear to have been hunted in the wet season. The correlation between the estimated season of occupation at the Kebara, Qafzeh, and Tabun Caves with the lithic typology suggests a link between seasonal mobility strategies and patterns of Levantine Mousterian lithic industrial variability.

Lithic Technology

Information on behavioral diversity in the Levantine Mousterian is also available from combined formal and functional analyses of lithic artifacts. To date, most analyses of Middle Paleolithic industrial variability have been more concerned with the overall pattern of techno-typological variability than with the issue of how to relate such variability to behavioral contrasts among the hominids who produced the assemblages. However, several recent analyses of Middle Paleolithic industrial variability have emphasized the role that hominin mobility and resource acquisition strategies may have played in the formation of lithic assemblages (Jelinek 1988; Rolland and Dibble 1990). Because stone tools are the most durable residues of Pleistocene hominids' adaptive strategies, it seems reasonable to look for aspects of lithic technological variability that parallel the behavioral differences between archaic and early modern humans suggested by the faunal data.

Kebara, Qafzeh and Tabun Compared

Techno-typological analyses of the Kebara IX-XII assemblages (Meignen and Bar-Yosef 1988, 1989, Bar-Yosef and Meignen 1992), and preliminary analyses of the Mousterian assemblages from Tabun (Jelinek 1982), and Qafzeh (Bouyé 1989) have emphasized a few basic similarities between these assemblages. The Kebara, Qafzeh and Tabun assemblages are made of high-quality flint that appears to have been procured from sources within a few kilometers of each site. Both assemblages contain a similar suite of artifact types, including isosceles Levalllois points, blades, and oval flakes, various kinds of retouched flakes, and abundant unretouched debitage. As with most Levantine Mousterian assemblages, the differences between the Kebara and Qafzeh assemblages are not so much distinctions of different kinds of tools as they are of differing relative frequencies of the same basic artifact categories.

Table 2 compares the lithic inventories from Qafzeh XV, XVII-XXIV and Kebara IX-XII, and the assemblages from recent excavations in Tabun equivalent with Garrod’s levels B and C (Jelinek 1982), highlighting several points of similarity. The Kebara sample is the largest, but all three assemblages feature roughly the same percentages of retouched tools (3–6 percent) and comparable percentages of Levalllois debitage (11–17 percent). On the whole, the Kebara assemblages are most like that from Tabun B, while the Qafzeh assemblages are most like that from Tabun C, except that Qafzeh XV has a higher percentage of points among its debitage.

There are also important contrasts between the Kebara, Qafzeh, and Tabun lithic assemblages that may have important behavioral implications. The most obvious of these contrasts is the relative frequency of pointed artifacts. Pointed artifacts are significantly more common in Kebara IX-XII (7.0 percent), in Qafzeh XV (3.7 percent), and in Tabun B (7.0 percent) than they are in Qafzeh XVII-XXIV (0.5 percent) or in Tabun C (1.4 percent). Because the same kinds of pointed artifacts (mainly Levalllois points) are present in both lithic samples, this contrast between Kebara and Qafzeh is less likely to be from differences in the abilities of the hominids to make pointed tools than from differences in the frequency with which points were made, used, and
Table 2
Lithic inventories from Kebara, Qafzeh, and Tabun.

<table>
<thead>
<tr>
<th>Site</th>
<th>No. Artifacts</th>
<th>Retouched Tools</th>
<th>Levallois Debitage</th>
<th>Pointed Artifacts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>Kebara IX–XII</td>
<td>10,269</td>
<td>100</td>
<td>316</td>
<td>12.5</td>
</tr>
<tr>
<td>Tabun B</td>
<td>451</td>
<td>100</td>
<td>54</td>
<td>12.5</td>
</tr>
<tr>
<td>Qafzeh XV</td>
<td>5,872</td>
<td>100</td>
<td>383</td>
<td>6.9</td>
</tr>
<tr>
<td>Tabun C</td>
<td>3,985</td>
<td>100</td>
<td>176</td>
<td>4.4</td>
</tr>
<tr>
<td>Qafzeh XVI–XXIV</td>
<td>2,397</td>
<td>100</td>
<td>131</td>
<td>5.5</td>
</tr>
</tbody>
</table>


discarded at these sites. Lithic microwear analysis provides some clues about the behavioral factors affecting Levantine Mousterian tool discard patterns.

Lithic Microwear Analysis


Under microscopic examination, the tips of many pointed artifacts from Levantine Mousterian sites preserve breakage patterns, microfracturing damage, and abrasive wear (scourings and polishing) that suggest they were used as hafted stone spear points (Shea 1989, 1991, 1993). Distal breakage patterns similar to those described here, and those present on Levantine Mousterian tools, have been observed on a variety of experimental projectile points (lances, javelins, atlatl darts, and arrows) and on pointed artifacts from a wide range of Late Pleistocene and Holocene archeological contexts (Ahler 1970; Bergman and Newcomer 1983; Fisher et al. 1984; Moss 1983; Odell and Cowan 1986).

When pointed artifacts like those found in Levantine Mousterian contexts are lashed to wooden shafts and either thrust or thrown into animal targets, one of four main kinds of breakage pattern will eventually occur: macrofracturing, pseudo-burination, comminution, and lateral snapping.

Macrofracturing is the most important of these breakage patterns because it is the most diagnostic of spear-point use in the Levantine Mousterian sample. Macrofracturing typically involves a single large bending fracture that is initiated along a broad front within a few millimeters of the tip of the tool and propagates onto the ventral surface of the tool. Single small fractures or clusters of small fractures can also result from the use of pointed artifacts in other tasks, or from non-use-related wear vectors (such as trampling and soil compaction), but macrofractures large enough to impede the performance of a projectile point (those more than 3 to 5 millimeters long) appear to result only from the use of stone spear points or arrows (Shea 1991). Evidence for comminution and burination on Levantine Mousterian points are much less frequent than microfracturing. Comminution, which results from the structural collapse of the edge under dynamic loading (usually from impact against a rigid material such as bone), is marked by multiple incompletely propagated shear and bending fractures that radiate outward from the impact-damaged part of the tool. Comminution is not a common result of spear impact on animal targets, but can result from high-speed impact against bone, or from a collision with some other hard object (such as rocks, trees, or soil). Burination is a large fracture that propagates on a tangent to one of the point's lateral edges, creating a fracture similar to a coup de burn. Pseudo-burination occurs infrequently in projectile experiments. Truncations from lateral snapping com-
commonly result from experimental spear-point use, but are not used here as an indicator of hafted spear points because such snaps can occur from other processes.6

Wear traces other than impact damage are also related to the use of stone tool points as projectiles. In particular, some points worn from impact also feature polishing and striation concentrated on the distal part of the tool. Such abrasion is caused either by forceful contact between the surface of the tool and the target and/or by "auto-abrasion" from lithic material dislodged by impact-fracturing being dragged across the surface of the tool. Beyries (1987) and Anderson-Gerlaud (1990) have found such "hafting wear" among western European Mousterian assemblages. Many impact-damaged Levantine Mousterian points also feature bifacial patterns of microfracturing, striation, and polish on their lateral edges, suggesting use as knives for cutting a variety of materials (Figure 3).

The presence of impact-damaged artifacts in Levantine Mousterian contexts is important because it suggests that the hominids who produced these industries invested significant effort and planning into the design of effective hunting equipment. Spears with sharpened wooden tips were used for hunting medium-to-large-sized mammals in many parts of the world (Oswalt 1976), and there is archeological evidence (e.g., from Clacton and Lehringen) suggesting similar implements were being used by at least some late Middle Pleistocene hominids (Movius 1950). Such sharpened wooden spears would probably have been sufficient to kill all but a few of the larger mammals represented in Levantine Mousterian archeofaunas.

But stone-tipped points are a significant technological improvement. The main advantage that a stone spear point provides is a larger wound that will more rapidly kill or immobilize the target animal. A sharpened wooden spear point will pierce all but the thickest animal hides and may puncture some internal organs, but such a spear can easily be dislodged by the thrashing of the wounded animal. A spear tipped with a sharp piece of stone, however, will not only cut through most animal hides, it will also create a large slashing wound that aids in the formation of a blood trail (important for tracking wounded game). Moreover, once the stone spear point is inside the body of an animal, subsequent movement causes the edges of the spear point to lacerate internal organs, immobilizing the animal more quickly. All in all, a wooden spear with a stone point attached to it is a more effective, reliable hunting weapon than a simple sharpened wooden spear. Stone points, even if damaged by impact, can also be used as knives for butchering the animal carcass in which they are embedded.

There are, however, some disadvantages involved in making and using hafted stone spear points. First, it takes time to produce suitable stone points, to obtain resin and lashing fibers, to carve a receptacle for the point on the spear shaft, and to secure the point to its haft. Secondly, if a lithic point is damaged accidentally, the amount of effort that must be expended to repair it is considerably greater than would be the case if one had to whittle a new point on a wooden spear. If we view the hafting of stone spear points as a technological strategy, one with costs and benefits, then it seems reasonable to expect a correlation between the frequency of hominid predatory activity (particularly the hunting of medium-to-large-sized mammals) and the frequency with which hafted stone spear points were made, used, and discarded. Thus, one should not expect stone spear points to occur everywhere hominids hunted with spears, but rather only at locations where opportunities for large mammal hunting were exceptionally high or alternative low-risk food sources (such as plants and small animals) were especially scarce.

**Worn Pointed Artifacts from Kebara, Qafzeh, and Tabun**

All artifacts larger than 2.5 centimeters from Kebara IX–XII, Qafzeh XV–XXIV, and those levels of Jelinek's Tabun excavations equivalent to Tabun B (unit I, levels 1–17) and Tabun C (unit I, levels 18–26) were examined for lithic microwear traces at
Figure 3
Levallois point from the Kebara Cave showing the lithic microwear patterns attributable to the use of stone-tipped spear points in the Levantine Mousterian: a, large fracture located on the ventral face of a tool referable to impact with a hard surface (bone?) during a piercing motion; b, a continuous row of overlapping fractures referable to a forceful longitudinal cutting or sawing motion; c, detail of edge in b showing matte-reflecting polish and striations, which indicate prolonged contact with nonsiliceous material such as meat, skin, or cartilage; d, clusters of small fractures near the base of the tool, possibly from contact with fibers used to secure the point to a wooden handle; e, bright spot on a ridge near the base of the tool, possibly the result of sliding contact against wooden handle during use (such bright spots are rare on impact-damaged points). Scale: This point is 70.5 mm from tip to base.
magnifications between 5 and 160X. 1,607 artifacts from these assemblages featured the discrete concentrations of microfracturing, striations, and polish suggesting they had been worn from use. Impact-damaged points were present in nearly all these assemblages, but the abundance of impact-damaged points (measured in comparison to the total number of tools exhibiting use-wear traces) varies widely. Impact-damaged points account for between 14 and 21 percent of the worn artifacts from Kebara IX–XI, Qafzeh XV, and Tabun B. Points are far less common in the Tabun C and Qafzeh XVII–XXIV samples.

Impact damage is not the only kind of wear that occurs on pointed artifacts from Levantine Mousterian contexts (Shea 1988, 1993), but it is a kind of wear that is associated only with points and with no other kinds of artifacts. If the use of stone-tipped spears played a major role in the kinds of lithic artifacts deposited at Levantine Mousterian sites, then one would expect the frequency of impact damage to be correlated with the frequency of points in an assemblage. This expectation is met by the microwear record from Kebara, Qafzeh, and Tabun. Table 3 compares the frequency of impact damage among visibly worn tools to the frequency of points among Levallois debitage for the Kebara, Qafzeh, and Tabun assemblages. The correlation between these variables is strong and highly significant ($r = .96, p = .010$). Assemblages with large proportions of points among their Levallois debitage, such as those from Tabun B, Kebara IX–XI, and Qafzeh XV, also feature large proportions of impact wear among their use-worn tools. Assemblages with relatively low percentages of points among Levallois debitage, such as Tabun C and Qafzeh units XVII–XXIV, feature a correspondingly lower proportion of impact-damaged tools. These observations suggest that the percentage of Levallois points among Levallois debitage is a strong indicator of the intensity of technologically assisted hunting that coincided with the formation of Levantine Mousterian assemblages.

It is also interesting to note that assemblages with the highest percentages of artifacts worn from impact and highest percentages of points among Levallois debitage, namely Kebara IX–XII, Tabun B, and Qafzeh XV, all come from the strata for which cementsum-increment analyses indicate multiseasonal occupation. Both of the sites for which single-season occupations are indicated, Tabun C (wet season) and Qafzeh XVII–XXIV (dry season), feature the lowest percentages of points and the least evidence for the use of hafted stone spear points.

The faunal evidence for variation in season of occupation and the lithic evidence for hunting intensity at Kebara, Qafzeh, and Tabun are correlated with each other, but is this correlation meaningful? We believe it is, and that these patterns in the faunal and lithic evidence result from the dynamic relationship between seasonal mobility and subsistence strategies.

### Table 3

<table>
<thead>
<tr>
<th>Assemblage</th>
<th>From impact</th>
<th>Total worn</th>
<th>Impact/total</th>
<th>Points</th>
<th>Total</th>
<th>Points/total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kebara IX–XII</td>
<td>137</td>
<td>958</td>
<td>0.14</td>
<td>182</td>
<td>1,459</td>
<td>0.13</td>
</tr>
<tr>
<td>Tabun B</td>
<td>4</td>
<td>19</td>
<td>0.21</td>
<td>30</td>
<td>127</td>
<td>0.24</td>
</tr>
<tr>
<td>Qafzeh XV</td>
<td>62</td>
<td>334</td>
<td>0.19</td>
<td>225</td>
<td>1,003</td>
<td>0.22</td>
</tr>
<tr>
<td>Tabun C</td>
<td>4</td>
<td>139</td>
<td>0.03</td>
<td>54</td>
<td>687</td>
<td>0.08</td>
</tr>
<tr>
<td>Qafzeh XVII–XXIV</td>
<td>4</td>
<td>157</td>
<td>0.03</td>
<td>6</td>
<td>269</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Seasonal Mobility and Hominid Subsistence Strategies

Most hunter-gatherers rely on resources that are temporally and spatially restricted (Kelly 1983, 1992), requiring them to adopt mobile range utilization strategies to acquire those resources. Mobility allows hunter-gatherers to avoid foraging deficits caused by overhunting and other effects of long-term habitation on local ecology (Hamilton and Watt 1970). Other benefits of mobility include group size flexibility and the ability to relocate settlements near periodically abundant resources (Perlman 1985; E. Smith 1981), a reduction in social stress and conflict by fission/fusion of co-resident groups (Lee 1972, 1979; Woodburn 1972, 1980), and exposure to a wider range of potentially exploitable resources.

Yet there are also incentives for hunter-gatherers to remain in one place for prolonged periods of time. Some of the benefits of reduced residential mobility include an increased capability for storage (Testart 1982; Woodburn 1980), greater return on investment in material culture (especially site facilities and other hard-to-transport items), and an improved ability to monitor high-quality resources (Dyson-Hudson and Smith 1978). Larger group sizes are also a major asset in resolving intergroup conflicts over access to high-quality resources.

However, any strategy that decreases residential mobility may also increase the possibility of infection and disease; increase the likelihood of intragroup conflict; and, most significantly, accelerate the depletion of local resources. Hamilton and Watt (1970) have demonstrated that the core zone around human camps becomes depleted in plant and animal resources in proportion to the duration of occupation of the site. Hunter-gatherers living in one camp inevitably lower the density of exploitable resources by collecting plants and killing off game in the vicinity of the camp. This causes shifts in the natural distribution of many plants and animals: edible plants become scarcer and the number of large animals decreases (Hames and Vickers 1983; Tchernov 1991). In essence, the longer a group stays in one site, the more time and energy its members will have to spend to maintain constant levels of food intake (Halstead and O'Shea 1989; Speth and Scott 1989; Vickers 1983, 1988).

All hunter-gatherer groups face the problem of diminishing foraging returns, the point at which the energetic rate of return of gathering and hunting falls below the average return rate for their habitat (Charnov 1976; Winterhalder 1981). The solutions they find to this problem point to important differences between circulating and radiating mobility strategies (Mortensen 1972). Circulating strategies involve seasonal movements by hunter-gatherer bands from one temporary residential camp to another in a recurrent annual cycle. Radiating strategies involve movements between a more permanent (multiseasonal) residential base-camp and less permanent (highly seasonal) logistic camps positioned near important resources (Figure 4).

These contrasts between circulating and radiating mobility strategies parallel L. Binford's (1980) categorization of hunter-gatherers as either "foragers" or "collectors," respectively. According to Binford, foragers acquire food on a daily basis, do not store food, and move frequently from residential camp to residential camp (residential mobility). Collectors, in contrast, concentrate their settlements for longer periods of time near long-term stable resources that can be stored and consumed later; collectors move less frequently, often to special activity sites for the acquisition of specific resources (logistic mobility). In general, residential mobility tends to be more efficient in environments with evenly distributed patches of resources, while logistic mobility is more efficient in environments with dispersed but dense patches of resources (L. Binford 1980; Kelly 1992).

Hunter-gatherers practicing a circulating mobility strategy (which we infer for Qafzeh and Tabun C) need to develop methods for monitoring local resources and for anticipating the point of diminished foraging returns. For example, San hunter-gatherers tend to move camp when they have to spend more than 3 to 6 hours a day in search
Schematic diagram of the differences between circulating and radiating mobility strategies (see text for explanation).

of food (Lee 1972; Silberbauer 1981). Such a strategy puts a premium on a group’s ability to monitor the availability of distant resources. Circulating mobility strategies incur a number of significant costs, such as limitations on property and nontransportable resources and increased foraging time in less well-monitored environments (O’Connell and Hawkes 1981), but it is generally assumed that these costs are counterbalanced by an ability to position the groups near the highest-quality resources at the most advantageous time to collect them.

Hunter-gatherers practicing radiating mobility (which we infer for Kebra II–XII and Tabun B) attempt to prolong the time between residential movements by responding to diminishing foraging returns with novel subsistence strategies that often emphasize low-yield over high-yield resources. Examples of such strategies might include collection of previously unused plant resources and/or increased dependence on hunting. This phenomenon is well documented in the ethnographic record. Saffirio and Scaglion’s (1982) study of the effects of increased residential stability among the Yanomamo demonstrated that as the number of plants and animals became depleted near their camps over time, the rate of hunting to provide calories and protein increased. Eventually, there was a threefold increase in the frequency of hunting trips, which were 1.5 times longer than previous trips in order to maintain adequate yields. In this situation, it becomes more advantageous to hunt larger animals because the return per unit effort declines more rapidly for small items than large items (Pulliam 1981). Also, the energetic returns for developing specialized hunting equipment increase.

We believe these considerations explain some of the patterns we have observed in the Levantine Mousterian archeological record. As mentioned above, there have been several previous attempts to examine the seasonal mobility of hunter-gatherers in the southern Levantine Mousterian. Most importantly, Marks and Friedel (1977) argued, on the basis of extensive surveys, that the early Mousterian in the Aqvat/Aqev region in the Negev was characterized by a radiating settlement pattern with large, diverse
"sedentary" sites connected to peripheral specialized sites with extractive technology and undiverse assemblages; but, as the environment became drier during the late Mousterian and early Upper Paleolithic, hunter-gatherers in the region shifted to a strategy of residential, circulating mobility. Coinman et al. (1986), however, argued that a radiating settlement system remained relatively constant throughout the Upper Pleistocene in the Wadi Hasa, where large sites with diverse lithic assemblages occur only at lower elevations and smaller sites with more limited assemblages are found at higher elevations. Unfortunately, the above studies relied on lithic evidence and site location to estimate seasonality, and there are no associated hominids at any of these sites.

Application to the Levantine Evidence

When the cementum-increment data on seasonality data are considered together with the lithic data on hunting intensity at the Kebara, Qafzeh, and Tabun Caves, these two independent lines of evidence suggest that archaic humans at Kebara and Tabun B were less seasonally mobile and therefore hunted more frequently than early modern humans at Qafzeh and Tabun C. This suggests that archaic humans predominantly practiced a radiating mobility strategy and that modern humans predominantly practiced a circulating mobility strategy.

Kebara IX–XII, Tabun B, and Qafzeh XV feature roughly equal proportions of opaque and translucent outer cementum increments. This indicates that hominids brought gazelle to these sites during more than one season of the year. Moreover, the high variance and range of the width of the outermost bands of these gazelle, particularly at Kebara, indicate that they were hunted for many different months throughout the year. These same levels also feature lithic assemblages with relatively high percentages of points among Levallois debitage. This suggests that the intensity of hominid predatory activity near these sites was especially high when stone tools and faunal remains were deposited there. Both the faunal and the lithic evidence match the expectations of a radiating mobility strategy. During the formation of Kebara units IX–XII, Tabun level B, and Qafzeh units VI–XV, hominids appear to have been present at different seasons. We cannot (yet) tell if this "multiseasonal" occupation involved a sustained year-round occupation by a single group (which is unlikely) or many short-term visits by one or more groups throughout the year (which is more likely). However, the evidence for frequent spear-point use suggests that the hominid presence was of sufficient duration for low-cost food sources to have become depleted and for hominids to respond by hunting large game more often and by producing more reliable hunting equipment.

Qafzeh XVI–XXIV and Tabun C feature highly seasonal cementum-increment profiles. On the strength of this evidence, hominids appear to have occupied Tabun C only during the fall/winter and Qafzeh XVI–XXIV only during the spring/summer. If this is an accurate indication of when hominids visited Tabun and Qafzeh, then the relatively low frequencies of pointed artifacts in these levels may reflect the abandonment of these sites before resource depletion required increased investment in the production of hunting equipment.

The faunal record provides other indications of a more permanent hominid presence during the formation of Kebara IX–XII and Qafzeh VI–XV and a more ephemeral/seasonal hominid presence during the formation of Qafzeh XVI–XXIV. Sustained human presence at Levantine cave sites would likely have created substantial bone accumulations from which scavengers would have been deterred for substantial periods of time. The faunal residues of more limited seasonal occupations, on the other hand, would probably have been attacked by carnivores shortly after the site was abandoned. The density of fauna remains in the Mousterian levels of Kebara is several orders of magnitude higher than at Qafzeh, which is particularly poor in nonhuman fauna below
level XVI, the strata containing the burials of modern humans (Bar-Yosef et al. 1992; Bouchud 1974). The inferred contrasts in hunting intensity between these sites and levels should also be reflected in the composition of the faunal assemblages from Kebara, Qafzeh, and other Levantine Mousterian sites, but these data are not yet available for most of the sites under consideration here. Interestingly, Stiner (1990, 1991) has argued that significant differences characterize the mortality and skeletal element profiles of animals hunted by archaic humans and modern humans in western Europe, in spite of similarity in species representation.

It should be mentioned that there is no reason to assume that radiating (logistic) and circulating (residential) mobility strategies are mutually exclusive; rather, they represent two contrasting mobility strategies within what were undoubtedly complex settlement systems. Henry (1992), for example, has recently argued that two contemporary late Mousterian sites in the Negev, Tor Faraj and Tor Sabiha, reflect logistic and residential mobility strategies, respectively, that were part of a single settlement system. However, the evidence for multiseasonal site use at Kebara and Tabun B contrasts with the single-seasonal pattern at every other southern Levantine site (including the other levels of Kebara) from the rest of the Upper Paleolithic and Epipaleolithic until the Natufian period, just prior to the origins of agriculture (Lieberman 1993d). With the exception of the Tabun B and Natufian periods, southern Levantine hunter-gatherers appear to have always migrated from highlands to lowlands on a seasonal basis during the Upper Pleistocene. We acknowledge that more data from these and other sites are needed to test this hypothesis (e.g., information on flint sources, butchery strategies, carnivore activities), but we believe that the implications are interesting enough to warrant further investigation.

Anatomic Correlates of Radiating and Circulating Mobility

Further support for the hypothesis that archaic and early modern humans were characterized by different resource acquisition strategies is provided by some of the morphological contrasts between these taxa. If, as we suggest, less-mobile radiating resource acquisition strategies require significantly higher daily expenditures of effort to acquire less predictable resources such as game, then this difference should be reflected in the hominids' anatomy. Skeletal morphology is primarily determined by genetic factors, but certain aspects of bone morphology, such as the distribution of cortical bone around shafts, contain considerable information about habitual behaviors because bone is a dynamic tissue that responds in shape and composition to many of the strains (deformations) that occur during activity (Lanyon 1992).

Considerable research over the last few years has demonstrated that deformations caused by repeated dynamic strains of sufficient magnitude are known to result in modeling and remodeling of bone, which causes changes in the shape and size of skeletal elements, presumably to provide better architectural response to strain (Biewener et al. 1986; Lanyon 1992; Lanyon and Rubin 1984; Meade 1989; Rubin and Lanyon 1985; Woo et al. 1981). For example, the cortical bone of the humerus in a professional tennis player's or baseball pitcher's playing arm tends to be 30 percent thicker than in the other arm (Jones et al. 1977; King et al. 1969). Such differences in degree of cortical bone hypertrophy have also been documented between the lower limbs of hunter-gatherers and those of agriculturalists (Ruff and Hayes 1983).

Trinkaus's (1992) analysis of the morphological differences between modern humans from the Levant (represented by the fossils from Qafzeh and Skhul) and archaic Levantine humans (represented by Amud, Kebara, Shanidar, and the Tabun female) suggests that the archaic humans placed much higher habitual levels of strain on many of their bones, which is consistent with our hypothesis that modern humans and archaic humans had different solutions to the problem of ranging. In comparison with their early modern human counterparts, the archaic Levantine hominids have much broader
scapulae relative to the length of their humeri, which indicates a more muscular
development of the shoulder region (Churchill and Trinkaus 1990); also, they have
significantly more lateral curvature of the radius, which indicates greater axial loading
of the upper limb (Trinkaus 1992).

The muscular hypertrophy of the archaic Homo upper limb is matched by similar
differences in the lower limb. The midshaft cross sections of the Levantine early modern
human femurs are relatively teardrop-shaped in comparison with the more laterally
expanded, ovoid cross sections of the archaic human sample (Trinkaus 1992). This
suggests that modern humans placed primarily anterior-posterior strains on their legs
that were much lower than the frequency and magnitude of femoral strain reflected in
the robusticity of archaic human upper legs (Ruff and Hayes 1983). Indeed, the early
modern humans from the Levant have much thinner cortical bone in their femoral and
tibial diaphyses than the Neanderthals (Ben-Itzak et al. 1988; P. Smith et al. 1983, 1984).
Finally, Trinkaus (1983, 1984, 1992) has also documented that the archaic humans from
the Levant have a much higher degree of anterior dental paramasticatory wear relative
to posterior dental wear, which suggests that they were using their front teeth considerably
more than early modern humans to "manipulate" objects.

Trinkaus (1986, 1992) has argued for years that the archaic humans from Europe and
the Levant consistently display morphologies that indicate that they placed more stress
on their bodies than contemporary modern human populations:

Unless some of these hominids were burying their kin in the sites of others, there should be a
better correlation between these biological indicators of habitual behavior levels and the
indicators of behavioral patterns in the contemporaneous archaeological record. [1992:290]

We propose that archaic Levantine hominids' muscular hypertrophy—implying not
only greater musculoskeletal strength but also "more extensive use of human anatomy
to accomplish habitual tasks" (Trinkaus 1992:280)—is related to the different mobility
and resource-acquisition strategies outlined above. The more-circulating pattern of
residential mobility typical of modern humans is more energetically efficient than the
more-radiating mobility pattern that characterized the archaic humans of the Levant.
The multiseasonal occupation of sites such as Kebara probably required the archaic human occupants to forage for considerably longer than did their modern human
counterparts, who were more residentially mobile. (This is not to imply that archaic human mobility strategies were always less efficient than the modern human strategy; they were obviously just as efficient as they needed to be in certain ecological contexts
for tens of thousands of years.) The major problem that remains to be addressed is
whether archaic human skeletal morphology reflects elevated stress because of physiological responses to habitual strains incurred through high levels of hunting-gathering
activity, or whether these archaic humans adopted a more intensive radiating mobility
pattern because they were better adapted physiologically for such a strategy.

Climatic Factors

There is probably no simple relationship between mobility patterns—especially as
perceived in the Levantine archeological record—and changes in climatic and environ-
mental conditions over time and space. In particular, some of the contrasts between
Kebara and Qafzeh outlined above could be attributable to their different lowland and
highland locations, to regional climatic differences during their time of occupation, or
to different archaic and early modern human resource acquisition strategies. At present,
the limited available data suggest that environmental change was not the only determin-
ant of behavioral differences. Environmental and climatic differences, for example,
cannot explain the contrasts between Kebara and Tabun. Moreover, it should be
pointed out that the Kebara Cave was occupied only on a single-season basis during the
relatively cold and wet conditions of OIS 3 during the Upper Paleolithic (Lieberman
1993c), conditions that were not very different from those of the Middle Paleolithic (Bar Yosef et al. 1992).

More data are needed to resolve the issue of the influence of climate and environment on mobility patterns. Climatic change cannot be ruled out as a major factor in the mobility contrasts we infer between archaic and modern humans at Kebara and Qafzeh. The total faunal assemblages from Kebara, Tabun, and Qafzeh suggest that the environments around these sites were relatively similar during Levantine Mousterian times (Tchernov 1988). Yet it is probable that OIS 4 and late OIS 3, when Tabun B and Kebara VII–XII were probably occupied, were cooler than OIS 5, when Qafzeh XVI–XXI and Tabun C were probably occupied. Thus the Mediterranean woodlands may have been more widely distributed at the time when archaic humans were present in the Levant, allowing them to forage within a relatively small region throughout the year. In contrast, the warmer and drier episodes of OIS 5 may have restricted the distribution of the Mediterranean phytogeographic zone, resulting in more seasonal constraints on resource availability in any given region and requiring a higher level of mobility between regions. Indeed, numerous researchers (e.g., Trinkaus 1984) have suggested that archaic and modern humans may have been physiologically adapted to somewhat different environmental conditions. However, in order to ascertain whether or not archaic and modern humans were ever present in the Levant at the same time or under the same climatic conditions, we need to resolve the location of the Tabun I archaic female.

Conclusions

The different pattern of environmental use by archaic and modern humans that we hypothesize can account for not only the similarities but also some of the differences in the Levantine Mousterian archeological and paleontological records. The many and significant similarities between these two taxa are important, reflecting the close evolutionary relationship and overall behavioral similarity between them that are often overlooked by researchers using paradigms, based on the western European record, in which the taxa are quite dissimilar. These hominids were clearly alike in many ways, so important differences that distinguished them may not be readily apparent in the archeological record. However, we must remember that the sources of behavioral data available to us through the analysis of artifacts are often superficial manifestations of complicated behavioral processes; we are currently limited to characterizing the behavior of most early hominids by the animals they hunted (or scavenged), the tool types they made, and a small number of other characteristics that we can discern, such as the degree of intrasite patterning. Because of their close evolutionary relationship and therefore overall behavioral similarity, we should expect the archeological residues associated with archaic and modern humans to be similar in many of these respects.

Models of recent human evolution must therefore look beyond mere formal similarities in the archeological record and focus on the processes by which artifacts and food residues were acquired, modified, and discarded at different locations. Differences in ranging patterns and in the use of the environment are important behavioral categories that can provide clues to some of the behavioral processes that may have distinguished modern and archaic humans. Contrasts in hominin functional morphology (see Trinkaus 1983, 1984, 1992) provide some of the best nonarcheological evidence for the behavioral capacities and habitual activities of the hominids themselves. Other behavioral differences between archaic and early modern humans that have been suggested include language capabilities (P. Lieberman 1984), social organization (L. Binford 1983; S. Binford 1968), and reproductive strategies and life histories (Foley 1989; Trinkaus 1992; Zubrow 1989).

Further sources of data are needed to evaluate more adequately our hypothesis that early modern and archaic humans practiced different mobility strategies. With the
exception of Kebara, the faunal remains of southern Levantine sites associated with
either modern or archaic humans have been studied only on a preliminary basis. More
information is needed than just the relative abundance of various species present; for
example, information on the age and sex structure of prey species such as gazelle and
deer (Klein 1987) and on the distribution of skeletal elements and cut marks could help
indicate the relative proportion of hunting versus scavenging and strategies for trans-
porting meat (e.g., Stiner 1990). In addition, nonanthropogenic taphonomic processes,
such as the introduction of bones by hyenas during periods of hominin absence, must
be evaluated to understand the processes by which the faunal assemblages were created
and transformed (Bär-Yosef et al. 1992).

Our approaches to investigating Middle Paleolithic industrial variability also are in
dire need of change. While most faunal analysts recognize that faunal assemblages are
not so much snapshots of living assemblages as they are aggregate residues of many
behavioral and taphonomic factors, this perspective is all too rare in studies of Middle
Paleolithic lithic variability. Much attention has recently been devoted to the Middle
Paleolithic, resulting in new insights into the behavioral sources of industrial variability
(see Rolland and Dibble 1990); but all too many studies of Middle Paleolithic variability
continue to be structured by the traditional technotypological classifications and indus-
trial systematics, developed by Bordes and others nearly four decades ago, to address
questions that these typologies were never designed to answer. In addition to the
traditional typological emphasis on tool morphology, we need to consider the effects of
raw material procurement, tool use, and discard behavior on Middle Paleolithic indus-
trial variability. Meaningful answers to behavioral questions will be forthcoming from
the lithic record only when our characterizations of that record include testable
hypotheses about the relationship between specific archeological phenomena and
inferred patterns of hominin behavior.

In this study we have tried to single out a few key interrelated variables: season and
duration of occupation of sites, intensity of hunting, and morphology of the associated
hominids. Without any question, this hypothesis needs to be subjected to further
examination both in the Levant and elsewhere. The small sample size available is a major
problem, but one that is currently unavoidable. There are only a handful of sites in the
southern Levant that preserve either early modern humans or archaic humans. Modern
and archaic humans appear to have been present at around the same time in parts of
Europe during OIS 3, and it would be interesting to see if the Levantine pattern is
replicated there.

We are at an exciting stage in paleoanthropology because we are beginning to make
better inferences about behavioral contrasts and similarities of Pleistocene hominids
instead of just drawing correlations between formal similarities between the archeolog-
ical and fossil records. The debate over the origins of modern humans and over the
behavioral differences between archaic and modern humans is particularly interesting
because of the prospects for testing the relationships between evolutionary change and
hominid behavior on a finer scale than is possible for earlier periods in human
evolution. While we feel that the evidence for higher intensity of hunting at Kebara and
Tabun B than at Qafzeh and Tabun C may be a result of different mobility strategies,
this does not explain why the archaic humans associated with these sites practiced a
different strategy from that of their early modern human neighbors. More evidence
from other regions and more interdisciplinary studies that combine independent
analyses of the faunal and lithic records will undoubtedly shed more light on the nature
of the behavioral differences between archaic and early modern humans.

Daniel E. Lieberman is Junior Fellow, Society of Fellows, Department of Anthropology, Harvard University, Cambridge, MA 02138. John J. Shea is Assistant Professor, Department of Anthropology, State University of New York, Stony Brook, NY 11794.
Notes

Acknowledgments. We would like to thank O. Bar-Yosef, D. Haig, D. Pilbeam, J. Speth, and our reviewers for their helpful and insightful comments on this article. This research was supported by grants from the Harvard University Department of Anthropology, the L. S. B. Leakey Foundation, the Irene Levi-Sala CARE Foundation, the National Science Foundation, and the Wenner-Gren Foundation. We also would like to thank O. Bar-Yosef, E. Tchernov, B. Vandermeersch, and the other directors of the Kebara excavations, as well as A. Jelinek, the Israel Antiquities Authority, and the Natural History Museum (London), for generously allowing us to analyze faunal and lithic material.

1. Although many researchers have tended to classify the archaic fossil hominids from Tabun, Amud, and Kebara as Neanderthals, Arosbouy (1991) has recently argued that it is inappropriate to classify these specimens as Neanderthals because they do not exhibit all the derived features that typify classic Neanderthals specimens from Europe.

2. The location of the Tabun I fossil will never be resolved. The lithic industry associated with the Amud fossil has not yet been fully described. Almost no fauna was saved from the cave of Skhul, for which the stratigraphic information is poor; and so far there is only a rudimentary description of the lithic industry.

3. Many of the sites in question are caves whose size is determined by the erosion of bedrock and not by human activity. Almost all the known open-air Levantine Mousterian sites were discovered after an unknown period of erosion, leaving their actual extent an open question. Information about the density of lithic artifacts in a sedimentary deposit is of questionable value because (even if sedimentation rates could somehow be held constant) a few brief episodes of intensive lithic reduction can easily produce as dense a lithic concentration as more numerous episodes of low-intensity flintknapping.

4. Use of teeth that were still embedded in the alveolar bony of the mandible or maxilla ensured that the outermost band of cementum was still present in all samples; cementum is fragile and laminar and can thus be stripped from the roots, yielding a false estimate of season of death. Almost all the samples analyzed were mandibules, and all samples were carefully checked for marks attributable to carnivore damage.

5. Lateral lapping is a common result of experimental spear-point use; however, this wear pattern can also be caused by many other wear vectors (end-shock during flintknapping, torsion during use, trampling, and even soil pressure), and is therefore not treated as diagnostic evidence for the use of hafted stone spear points. Lateral lapping usually involves a bending fracture that truncates the point at some distance from its tip. It should be mentioned that evidence for lateral lapping is frequently observed on Levantine Mousterian tools, which means that the actual number of Levantine Mousterian tools that are worn from impact is probably underestimated in this analysis.

6. The term worn tools refers to those artifacts that preserve concentrations of microfracturing, striations, and polish on their edges that are more invasive than the "background" wear on other parts of the same tool and that are morphologically similar to wear patterns observed on experimentally utilized stone tools. We recognize that this is a subjective characterization and no substitute for a wholly parametric approach to lithic microwear analysis, but progress toward the latter has thus far been slow (see Shea 1992). Because microwear patterns form at different rates in different kinds of tasks, it is likely that many tools that were used briefly and/or to cut yielding materials did not preserve distinctive wear traces and may have been overlooked by microwear analysis. As such, these figures should be taken as a minimum estimate of the number of tools in these assemblages preserving wear traces referable to use.

The frequency of points is measured in terms of Levallois debitage rather than in terms of all artifacts present in an assemblage because (1) most pointed artifacts in these samples are also Levallois points; (2) the special degree of preparation involved in the production of Levallois debitage suggests that this quantity more accurately reflects the toolmaking efforts of Levantine Mousterian flintknapper; and (3) this eliminates the effect of the widely variable amounts of primary core-reduction debitage at these sites, a quantity that more likely reflects the local availability of lithic raw materials than the toolmakers' intentions.

7. However, in some cases the number of small animals increases through alteration of the local biomass from predator depletion, gardening, and other activities (Laden 1992; Linares 1976).

8. This could explain why Kebara has a much higher percentage of gazelle.
References Cited

Ahler, Stanley A.

Anderson-Gerfaud, Patricia

Arensburg, Baruch
1991 From sapiens to Neanderthals: Rethinking the Middle East. American Journal of Physical Anthropology (Suppl. 12):44.

Baharav, D.

Bar-Yosef, Ofer

Bar-Yosef, Ofer, and Liliane Meignen

Bar-Yosef, Ofer, and Bernard Vandermeersch, eds.

Bar-Yosef, Ofer, Bernard Vandermeersch, Baruch Arensberg, Paul Goldberg, Henri Laville, Liliane Meignen, Yoel Rak, Eitan Tchernov, and Anne-Marie Tillier

Bar-Yosef, Ofer, Henri Laville, Liliane Meignen, Anne-Marie Tillier, Bernard Vandermeersch, Baruch Arensberg, Anna Belfer-Cohen, Paul Goldberg, Yoel Rak, and Paul Goldberg


Ben-Izhak, S., P. Smith, and R. A. Bloom

Bergman, Christopher A., and M. H. Newcomer

Béry, Sylvie

Biewener, A. A., S. M. Swartz, and J. E. A. Bertram
Binford, Lewis R.
Binford, Sally R.
Bouchud, Jean
Boutié, Paul
Brace, C. Loring
Bucke, Ariane
Castanet, J.
Charnov, Eric L.
Churchill, Steven E., and Erik Trinkaus
Clark, Geoffrey, and John Lindly
Cohnman, N., Geoffrey Clark, and John Lindly
Copeland, Lorraine
Cotterell, Brian, and Johan Kaminga
Crew, Harvey
Davis, Simon J. M.
Dyson-Hudson, Rada, and Eric A. Smith
Fischer, Anders, P. V. Hansen, and P. Rasmussen
Foley, R.
Garrard, Andrew N.

Garrod, Dorothy A. E., and D. M. A. Bate

Goldberg, Paul

Gordon, Brian C.

Grue, H., and B. Jensen

Grin, Rainer, and Christopher B. Stringer

Halstead, P., and J. O’Shea

Hames, R. B., and W. T. Vickers

Hamilton, W. J., and K. E. F. Watt

Henry, Donald O.

Horowitz, Aharon


Horovitz, Liora K., and Paul Goldberg

Howell, F. Clark


Jaffe, S.

Jelinek, Arthur J.


Jones, H. H., J. D. Priest, W. C. Hayes, C. C. Tichenor, and D. A. Nagel

Keeley, Lawrence H.

Kelly, Robert L.

King, J. W., H. J. Brelsford, and H. S. Tullos

Klein, Richard G.


Klevezal, G. A., and S. E. Kleinenberg
1967 Age Determination of Mammals by Layered Structure in Teeth and Bone. Moscow: NAUK.

Laden, Gregory T.

Lanyon, L. E.

Lanyon, L. E., and C. T. Rubin

Lévêque, F., and B. Vandermeersch
1981 Le néandertalien de Saint-Césaire. La Recherche 12:242–244.

Lee, Richard B.


Lieberman, Daniel E.


Lieberman, Daniel E., T. W. Deacon, and R. H. Meadow
Lieberman, Daniel E., and R. H. Meadow

Linares, Olga

Marks, Anthony E.

Meade, J. B.

Meignen, Lilliane, and Ofer Bar-Yosef

McDermott, F., R. Grün, C. B. Stringer, and C. J. Hawkesworth

Mortensen, P.

Moss, Emily

Morris, Hallam L., Jr.

Neuville, René

O’Connell, James F., and Kirsten Hawkes

Odell, George H.
Odell, George, and Frank Cowan


Oswalt, Wendell H.


Perlman, S. M.


Pike-Tay, Anne


Pisson, Hughes


Popper, Karl


Pulliam, H. R.


Rogoff, P.


Rolland, Nicholas, and Harold Dibble


Rubin, C. T., and J. E. Lanyon


Ruff, Chris, and W. C. Hayes


Saffiro, G., and R. Scaglion


Santa-Luca, A. P.


Saxen, E. C.


Schick, Tamar, and Moshe Stekelis


Semenov, S. A.


Shea, John J.


1989 A Functional Study of the Lithic Industries Associated with Hominid Fossils in the Kebara and Qafzeh Caves, Israel. In The Human Revolution: Behavioral and Biological


Silberbauer, G.

1981 Hunter and Habitat in the Central Kalahari Desert. Cambridge: Cambridge University Press

Simmons, Alan, and G. Ilany


Skinner, James


Smith, Eric A.


Smith, Fred H., A. B. Falsetti, and S. M. Donnelly


Smith, Patricia, and Baruch Arensburg


Smith, Patricia, R. A. Bloom, and J. Berkowitz


Sokal, Robert R., and F. J. Rohlf


Speth, John D.


Speth, John D., and S. L. Scott


Speth, John D., and K. Spielmann


Spess, Arthur E.


Stiner, Mary C.


Stringer, Christopher, and Clive Gamble

1993 In Search of the Neanderthals. London: Thames and Hudson.

Suzuki, Hiroshi, and F. Takai


Tchernov, Eitan


1989 The Middle Palaeolithic Mammalian Sequence and Its Bearing on the Origin of Modern Homo sapiens in the Southern Levant. In Investigations in Southern Levantine Prehis-
Differences Between Archaic and Modern Humans

Lieberman & Shea


Testart, Alan


Trinkaus, Erik


Turner-Petrie, Francis


Valladas, Helène, J. L. Joron, and G. Valladas


Vandermeersch, Bernard


Vickers, W. T.


1988 Game Depletion Hypothesis of Amazonian Adaptation: Data from a Native Community Science 239:1521–1522.

Wigley, T., and G. Farmer


Wilson, Alan C., and R. Cann


Winterhalder, Bruce


Wolpoff, Milford H.


Wolpoff, Milford H., and Alan G. Thorne


Woodburn, James

Zohary, Michael

Zubrow, Ezra