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The Tabun Cave and Paleolithic Man in the Levant

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Summary. Recent excavations at the deeply stratified Late Pleistocene cave site of Tabun on Mount Carmel have yielded a long sequence of Middle and Lower Paleolithic industries and associated geological and environmental evidence that has important implications for the understanding of man's cultural and biological development in that period. An analysis of these materials strongly supports a continuity in cultural development at this site from about 130,000 to 50,000 years ago and suggests that a continuous biological evolution from Neanderthal to anatomically modern *Homo sapiens* took place in the southern Levant.

As new discoveries continue to extend our knowledge of man's ancestry into the remote past (*1*) several fundamental questions about later human development remain unanswered. One of the most interesting of these problems concerns the events that led to the emergence of anatomically and culturally modern man in the Late Pleistocene. Here the role of the Neanderthals, the latest of fossil men, and the significance of their Middle Paleolithic stone tool industries are important factors. At present there are two conflicting interpretations of the role of Neanderthals in human development: (i) populations of anatomically modern man (referred to below as modern man or modern *Homo sapiens*) were present at least as early as the last interglacial period, about 100,000 years before present (B.P.), and were contemporary with populations of Neanderthals and similar fossil hominids in some regions until about 40,000 B.P. or (ii) a general gradual transition took place, perhaps at about 50,000 to 40,000 B.P., from Neanderthal to modern man. At issue here is whether in at least some areas of the world there is evidence for the development of modern *Homo sapiens* from essentially Neanderthal ancestors or whether the early and middle Late Pleistocene populations of modern man and Neanderthals represent two divergent lines of descent from a common ancestor. The latter view would see the Neanderthals and their culture as an evolutionary "dead end" that contributed little to the cultural and biological heritage of modern man. In the following discussion I will attempt to show how recent archeological findings can contribute to the further understanding of this basic problem in human evolution.

Our best evidence pertinent to these questions has been derived largely from archeological excavations in two separate areas of the Old World, southwestern Europe and the Near Eastern Levant. The Middle Paleolithic stone tool assemblages contemporary with Neanderthal remains in these two areas have been separated into distinctive industries on the basis of consistent patterns in the relative frequency of different kinds of retouched tools and in the frequency of the specialized Levallois technique of flake production (*2*). The significance of this kind of Middle Paleolithic industrial variability has been the subject of considerable recent controversy in archeology. This controversy concerns the extent to which typologically distinct industries reflect distinct ethnic (and genetic) populations as opposed to task-specific emphases in tool manufacture in a single society (*3*). The underlying issue here relates to fundamental questions of stylistic versus functional explanations in archeological interpretation (*4*).

Within southwestern Europe and the Levant there are a few key sites with deep stratified sections that have long served as major points of reference for the interpretation of artifactual variability through time. The cave of Tabun, on the western margin of Mount Carmel in the southern Levant, is one of these rare sites. The excavations of Dorothy A. E. Garrod at this site between 1929 and 1934 revealed a section about 25 meters in depth that includes the most extensive Lower and Middle Paleolithic industrial succession discovered in the Near East to date. The discovery of Neanderthal remains in the upper levels of the Tabun excavation and remains of *Homo sapiens* more robust than modern man, but more "modern" than the Tabun remains in the nearby shelter of Skhul, in association with similar industries, added to the importance of the Tabun section (*5*).

The cave overlooks a narrow coastal plain from the south side of the Wadi Mughara, about 3 kilometers east of the present Mediterranean shore. Between the cave and the shore lie several ridges of fossil dune sand (*kurkar*), paralleling the present coast and interrupting the drainage from Mount Carmel to the sea. The cave itself, as revealed by the original excavation, consists of a large unroofed outer chamber in front of a high arch in the limestone cliff that separates it from an inner chamber. The roof of the inner chamber has also collapsed, leaving a wide chimney that opens on the hill slope above the cave.

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The Earlier Excavations

Garrod's excavations showed a paleolithic cultural succession in six layers from a basal Tayacian (layer G), through Late Acheulian (F), Acheuleo-Yabrudian (E), Lower Levalloiso-Mousterian (D, C), and Upper Levalloiso-Mousterian (B) (*6*). The Neanderthal burial (Tabun I) and mandible (Tabun II) were found in layer C. Between Tabun and Skhul was the site of el-Wad, in which Garrod found a sequence beginning with Levalloiso-Mousterian similar to Tabun layer B and continuing through a succession of Upper Paleolithic and Epipaleolithic cultures. This relatively complete sequence of Lower, Middle, and Upper Paleolithic cultures in the Wadi Mughara formed a chronological and typological baseline for subsequent interpretations of Levantine prehistory. The contemporary work of Alfred Rust at the Yabrud I shelter in southeastern Syria resulted in a more refined sequence (for instance, the separation of Yabrudian and Acheulian layers and the isolation of the Pre-Aurignacian) (*7*), but in general confirmed Garrod's Lower and Middle Paleolithic sequence. The sequences described at the Levantine sites of Abou Sif (*8*), Jerf Ajla (*9*), Abri Zumoffen (*10*), and the Bezez cave (*11*) also conform to Garrod's succession at Tabun, and to date no stratigraphic exception to this sequence has been described.

The hominids from the Wadi Mughara sites of Skhul and Tabun differ morphologically, with the Tabun I burial similar in many respects to the Neanderthals of western Europe, while the Skhul remains, though very robust, more closely approximate modern man (*12*). Thus the Skhul hominids can be seen as lying morphologically between the Neanderthals and fully modern *Homo sapiens*. Subsequent to Garrod's work the remains of modern *Homo sapiens* were reported from the Qafzeh cave near Nazareth in association with an industry similar to that found with the Wadi Mughara remains (*13*). Thus there is a basic problem in the interpretation of the fossil hominids from these sites in that a full range of variation from Neanderthal to modern *Homo sapiens* has been reported in association with similar lithic industries, implying rough equivalence in time.

The Recent Excavation

Between 1967 and 1972 a new series of excavations at the Tabun cave was undertaken in an attempt to recover information that might permit a better understanding of the chronological relationships between the long Tabun sequence and other sites with more abbreviated sections such as Skhul and Qafzeh. The new excavations were also designed to clarify the position of the "Amudian" industry (*14*) at Tabun, which appeared to be stratigraphically and typologically similar to Rust's Pre-Aurignacian at Yabrud I, and to determine whether distinct Acheulian and Yabrudian occupations were present at Tabun as at Yabrud I. Another goal was the clarification of problems of chronology and cultural adaptation through the recovery of environmental evidence in association with the different industries at Tabun.

The more refined stratigraphic controls employed in the recent excavation have resulted in the definition of more than 85 geological beds in a 10-meter section at the center of the old profile (*15*). Within this geological sequence more than 300 contextual associations of artifacts have been defined. The total number of artifacts recorded (including flakes) is in excess of 44,000 and the total volume excavated was about 90 cubic meters (*16*).

The new stratigraphy is contrasted with Garrod's section in Fig. 1. The complexity of the deposits reflects a series of episodes of accumulation, nondeposition, and occasional collapse of sediments into underlying karstic solution cavities. Garrod recognized one such collapse following the deposition of her layer E, but it is clear that several additional episodes took place as the cave was filled. The most important of these, for the purpose of chronological reconstruction, took place following the deposition of the industry that Garrod termed layer D (the earlier portion of her Lower Levalloiso-Mousterian). At this time a massive collapse of sediments took place in the inner chamber of the cave and it was only after that great pit had filled that Garrod's layer C was deposited. This means that there is a significant time gap between the layer D and layer C industries of her Lower Lavalloiso-Mousterian. Both were originally classified as "Lower" Levalloiso-Mousterian, despite marked typological differences, because they preceded a dramatic change in the faunal assemblage in the cave (primarily characterized by an earlier emphasis on *Gazella* and a later emphasis on *Dama*). This shift was thought to reflect a significant environmental change that was important for chronological correlation (*17*). The layer B industry following this shift was, in most respects, typologically similar to layer C.

At a deeper level there is a sequence of deposits (unit XIV) truncated by a disconformity that equates with the post–layer F collapse noted by Garrod. These beds appear to have remained in place, perhaps due to an underlying supporting ledge, while adjacent deposits were drawn downward into the "swallow hole." They appear to represent an early period of deposition in the cave.

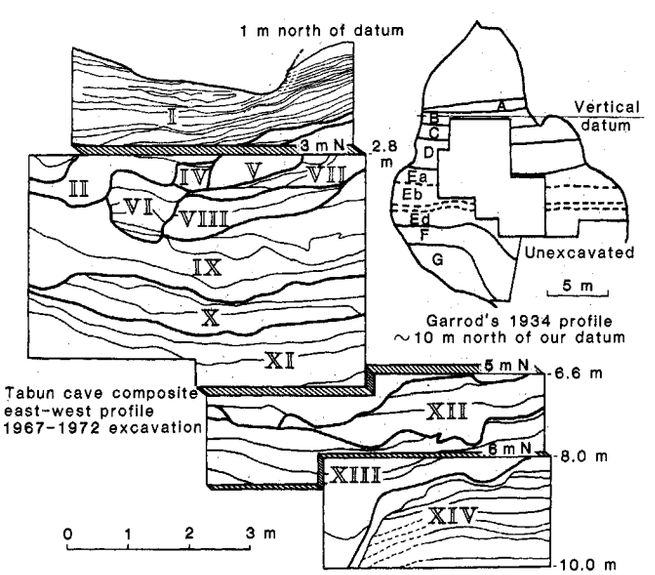

Fig. 1. Comparison of the stratigraphic section reported by Garrod with that revealed by the recent excavation. Roman numerals designate major stratigraphic units separated by periods of nondeposition or erosion. The regularity of the layers defined by Garrod resulted from her technique of excavating in arbitrary horizontal levels.

Environmental Evidence

A sedimentological analysis of material from Garrod's profile by Farrand and Goldberg (*18*) shows differences through time that probably relate both to changes

in the local geomorphology that resulted from global climatic change and to changes in the structure of the cave itself. The deepest sediments, corresponding to Garrod's layer F and lower E (units XIV to XII), are quite sandy, with increasing amounts of silt in upper E (units XI and X) and predominantly silt in layer D (units IX and VIII). Beginning with layer C (lower unit I) increasing amounts of clay are present, and in layer B (uppermost unit I) clay is dominant in the sediments, mixed with numerous blocks of roof fall. Farrand (*19*) recently interpreted these data as evidence for the near proximity of the sea during the deposition of the lower sandy layers and a gradual retreat of the sea as the sand is replaced by silt. These events are seen as corresponding to the highest sea stand of the last interglacial and the gradual marine retreat as the glacial cycle progressed. The clays and roof fall of layers C and B resulted from the opening of the chimney and a rapid accumulation of terra rossa from the hillside above. This masks the relatively slow wind-blown sedimentation that accounts for most of the previous fill in the cave. Farrand sees the withdrawal of ground water as a primary mechanism responsible for the karstic collapses and resulting sedimentary disconformities as the cave filled. Thus the sedimentology suggests that the earliest habitation in the cave corresponds to the last interglacial and that successive cycles of advance and retreat of the sea may be responsible for the major hiatuses between our depositional units. The great collapse of sediments in the interior chamber follows the silty accumulation of layer D, whose sediments suggest a maximum sea retreat up to that time.

This correlation is supported by recent palynological and paleontological evidence that suggests markedly cool conditions during the deposition of layer D (*20*). This evidence suggests that in the Mousterian levels at Tabun, major environmental changes take place between layers D and C rather than between layers C and B, where Garrod's coworker D. Bate postulated a "great faunal break" (*21*). I have suggested (*22*) that the faunal changes observed by Bate resulted from a change in the use of the cave as the chimney opened on the hillside above. The nature of the bone and artifact associations reported by Garrod suggests that after the chimney opened the cave was employed primarily for butchering *Dama* driven into the chimney from the wooded slopes above the opening. With these structural changes the cave was no longer suitable for habitation and the remains of *Gazella* as well as larger animals butchered on the coastal plain were no longer left at the site. Vaufrey, Hooijer, and others postulated many years ago that the *Dama-Gazella* ratio was largely the result of human preferences in hunting (*23*); this interpretation supports their views and provides an explanation of why this was so.

Artifactual Evidence

Both the typological and technological analyses of the artifacts from the recent excavation have provided some surprising insights into questions of chronological development and industrial variability at Tabun.

Unit XIV, which appears to precede the post–layer F collapse, has yielded a Late Acheulian industry that is remarkably uniform within our limited excavation and remarkably heterogeneous in the range of tool types that are represented, including consistent "Upper Paleolithic" elements. This diversity of tool types, associated with relatively infrequent bifaces and high ratios of cores, compares favorably with collections from Garrod's layer G, suggesting that the two contexts may have the same industry (*24*). In this industry, as in succeeding levels well up into unit XI, there are occasional examples of manuports in the form of characteristic well-rounded beach pebbles of flint. The frequency of these pebbles supports Farrand's hypothesis that the beach was not far from the mouth of the Wadi Mughara during the deposition of these sandy layers.

The 15 geological beds in units XIII to X (corresponding to Garrod's layer E) have been subdivided, on the basis of artifact distribution, into over 95 contextual loci ("sub-beds"). The several disconformities in this sequence suggest a somewhat discontinuous deposition following, by some significant interval, the deposition of Garrod's layer F. A primary problem in the artifactual analysis of this sequence was whether the distinct Acheulian, Yabrudian, and Pre-Aurignacian/Amudian industries that Rust (*7*) and Bordes (*25*) had described at Yabrud I could also be isolated at Tabun. Since the Yabrudian had been defined as having high frequencies of *déjeté* (asymmetrically convergent) scrapers, the frequency (counts) of this type of scraper with respect to all other scrapers was examined for all of the sub-beds in which this type occurred regardless of whether the industries would conventionally have been classified as Acheulian (that is, had many bifaces) or Yabrudian. A linear regression analysis yielded a correlation coefficient of .817 for the 82 samples ($P < .001$), indicating that the frequency of *déjeté* scrapers very closely approximates that of all other scrapers in all of these industries. A similar analysis incorporating *déjeté* scrapers and transverse scrapers and *limaces*, tools characteristic of the western European Quina Mousterian with which the Yabrudian has sometimes been equated (*25*), yielded an even higher correlation coefficient (.918 for 86 samples). Thus there does not seem to be a specialized "kit" of these kinds of scrapers that can be used to distinguish one group of industries from another in this series (*26*). This means that a distinction between Yabrudian and Acheulian industries here must be based primarily on the relative abundance of bifaces in one industry (Acheulian) as opposed to all scrapers in the other (Yabrudian).

An examination of the relative frequency of bifaces and scrapers through time is shown in Fig. 2. It is clear that this relationship does not fluctuate randomly; it begins with a relatively uniform pattern in unit XIV and then shows two cyclical progressions prior to the disappearance of bifaces at the base of unit IX (layer D). The continuity exhibited in this sequence is, with the demonstrated uniformity of the scraper assemblage, strong evidence for the presence of a single cultural tradition through this portion of the sequence at Tabun. The consistent position of the relatively small samples of bifaces and scrapers from loci with high frequencies of Amudian elements (prismatic blades and blade tools) suggests that the enigmatic "Upper Paleolithic–like" Amudian industry might also lie within this single cultural tradition. I have proposed (*27*) that the name Mugharan Tradition (after the Wadi Mughara) be applied to these industries, and that within this tradition we can distinguish Yabrudian, Acheulian, and Amudian facies, respectively characterized by relatively high frequencies of scrapers, bifaces, and Upper Paleolithic elements.

Evidence of continuity from the Mugharan Tradition into the following Mousterian levels is provided by the artifact assemblages of unit X. Here our technological analysis (Table 1) shows a gradual increase in the Levallois elements that characterize the Early Mousterian from the top of unit XI (sub-bed 73S) to the two lowest samples from unit IX (bed 68 and sub-bed 67D). Two major

Table 1. Frequency (percent) of particular flake types in the transition from the Mugharan Tradition to the Early (Tabun D type) Mousterian.

Sub-bed and (unit)	Levallois		Prismatic blades	Complete flakes	*N*
	Flakes	Points			
67D (IX)	6.1	18.2	29.3	53.6	99
68 (IX)	11.7	10.2	14.5	38.3	290
70 (X)	12.6	5.4	11.9	30.5	277
71S (X)	6.8	5.1	10.2	25.7	176
71I (X)	7.1	3.0	7.1	21.0	168
72S (X)	5.5	.8	4.4	21.8	476
72I (X)	5.4	.5	1.7	20.9	591
73S (XI)	4.4	.2	1.7	19.2	637

trends characterize this transition. One is a gradual increase in the flakes and blades resulting from the specialized Levallois core preparation techniques; the other is a gradual increase in the frequency of unbroken flakes (as opposed to retouched tools, broken flakes, and cores) in the assemblage. While the latter trend suggests some increasing selection on the part of the aboriginal inhabitants as to what was brought into the cave, the former indicates a dramatic reorientation in lithic manufacture from the heavy bifaces and scrapers that dominate the earlier industries to the thin-edged Levallois products that characterize the entire later portion of the sequence. It is likely that the Levallois emphasis that we see in our samples is to some degree exaggerated by the selection for complete flakes from a manufacturing area located elsewhere, but the virtual absence of bifaces and heavy scrapers from unit IX onward is indicative of a dramatic overriding change in the technology. It is possible that the high frequencies of prismatic blades and complete flakes in the Amudian levels of unit XI mark a similar, though temporary, technological shift at an earlier point in the sequence.

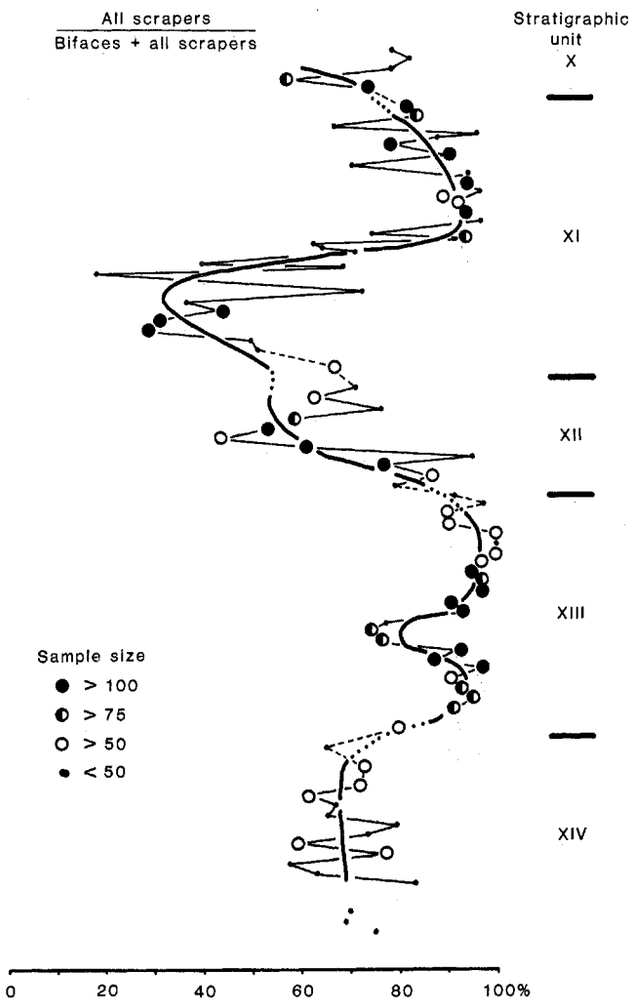

Fig. 2. Relative frequency of scrapers and bifaces through time in units X to XIV. Higher frequencies of scrapers lie to the left. The time scale is not calibrated.

While we have no direct evidence of a transition from the Early Mousterian of "Tabun D" type to the "Tabun C" type Mousterian in units I and II (*28*), such a transition is supported by stratigraphic evidence at Abou Sif (*8*) and Yabrud I (*7*), where increasing frequencies of broad Levallois flakes with respect to points and blades are evident in Mousterian sequences.

One additional and most striking line of evidence supporting continuity in the Tabun sequence has been derived from a metric study of the flakes produced in lithic manufacture. When samples from the major depositional units are arranged in stratigraphic order, lumping the mixed material of units VIII to III that fills the collapse in the interior chamber, a consistent progression can be seen in the statistical parameters of the ratio of width to thickness for complete flakes (Table 2). Complete (unbroken) flakes were employed to ensure that width and thickness were consistently measured at the midpoint of flake length (*29*). The regular progression through time of the mean, median, and variance for this ratio indicates a continuing proportional decrease in the thickness of the flakes with respect to their width. The increase in variance reflects a relative increase in the numbers of proportionately thinner flakes in samples that also retain a full range of thicker flakes through time. The regularity of the increase in variance suggests that this is the best expression of the trend.

This continuous change in flake shape through time is one of the most remarkable findings to emerge from the analysis of the Tabun collections. A question of great importance is whether this trend represents a purely local phenomenon, related to such factors as the exploitation of the flint sources near the Wadi Mughara, or a fundamental underlying pattern of increasing manual dexterity and control arising from the conceptual development of the hominids that were responsible for the succession of lithic industries. If the latter is the case, then it may be possible to temporally correlate isolated collections from the Levantine region by calculating the width-to-thickness ratios of samples of complete flakes. At the very least this progression provides further strong evidence for the continuity of cultural development at Tabun.

Taken altogether, the evidence from Tabun and other Levantine sites strongly supports a continuous sequence of cultural development from the Late Acheulian of Tabun unit XIV to the latest Levantine Mousterian.

The Tabun Sequence in a Broader Setting

It is now possible to consider all of the structural and artifactual evidence from Tabun against a general chronology of climatic change during the time when this long record was accumulating. As a general calibrated indicator of paleoclimatic conditions I have employed the deep-sea oxygen isotope ratios of Emiliani and Shackleton (*30*). The continuing confirmation of this sequence (*31*) suggests that it has general applicability in the temperate and tropical latitudes. The correlation with Tabun is based on Farrand's equation of the beginning of the section (that is, unit XIV) with (or shortly after) the peak warm episode at the beginning of the last interglacial (stage 5e) and the termination of unit I at about 50,000 B.P. (*32*).

The correlation of our evidence is summarized in Fig. 3. If we assume that a progression from warmer to cooler sea temperatures correlates with a marine retreat and that marine advances correlate with the opposite trend, and if the withdrawal of ground water following marine retreats was responsible for karstic collapse in the cave, we can correlate the two major episodes of collapse of sediments in the cave with the major cool peaks of stage 5d (following unit XIV and Garrod's layer F) and stage 4 (following unit IX and Garrod's layer D). These two intervals have recently been interpreted as the most dramatic periods of ice growth in the last glacial cycle (*33*). The paleontological and palynological evidence for cool conditions in layer D (*20*) lends strong support to this correlation, as does the sedimentological analysis of Farrand and Goldberg (*18*).

If this correlation is valid, it appears that there are some consistent associations of industrial variability with variations in the isotope data. Specifically, the cyclical pattern of variation in the ratio of bifaces to scrapers can be seen to correspond to stages Ec through Ea, with Yabrudian facies associated with warmer periods and Acheulian facies with cooler intervals. Here the blade-producing Amudian and Early (Tabun D) Mousterian, both also characterized by high ratios of complete flakes, correspond to cool peaks. It is interesting to note that the latest Mousterian in our sequence (unit I) would correlate with a relatively warm phase (stage 3) and has a retouched tool inventory almost entirely confined to scrapers, as is the case with the warm-correlated Yabrudian facies.

While these correlations are preliminary, they are consistent with the current evidence from Tabun. They suggest a conservative cultural tradition that maintained narrowly circumscribed traditions of lithic manufacture through long periods of time, with slow fluctuations in the emphasis on particular groups of tools, probably in response to shifting resources. Although we cannot at this time link particular tools with particular resources, this interpretation is consistent with the view that the typological variability in these industries was the result of task-specific shifts in the technology.

When the technological evidence of changes in flake shape through time is scaled to the time intervals suggested by the oxygen isotope correlation, the regularity of the resulting curve is most striking (Fig. 4). We see a gradual regular progression through unit IX and an acceleration in the trend following the mixed deposits of units VIII to III.

At this point it may be interesting to consider comparable data on complete flakes from other sites in the Levant that have yielded hominid remains and artifact samples pertinent to chronological relationships of the sites. If the width/thickness trend at Tabun has regional temporal significance, these data will be of considerable importance in assessing the temporal relationships of the various associated human fossils. It should be noted that the flakes in all the samples in Table 3 were selected to some degree by the particular excavator from the full range of materials present, except for those from B. Vandermeersch and O. Bar Yosef's recent excavations at Qafzeh and possibly Rust's Pre-Aurignacian (layer 15) from Yabrud I and Garrod's layer G from Tabun. It can be demonstrated that this selection tends to preserve generally thinner flakes; therefore, the indices for the selected samples are probably somewhat higher than would be the case had the samples been collected objectively. The effects of this selection are most clearly seen at Tabun. Garrod's sample from layer G (where an attempt was made to save all material) is very similar to unit XIV; however, the chimney–layer B sample values (where Garrod saved only a small and highly selected sample of flakes) are markedly higher than the values for our unit I, which directly underlies them.

In relating Tabun to other sites with similar industries, the earliest sample available is Rust's layer 15 from Yabrud I, where the Pre-Aurignacian industry can be equated with the Amudian facies of unit XI at Tabun. The mean and the median of the width-to-thickness ratio for this sample fall between the values

Table 2. Statistical parameters, by major stratigraphic unit, of the ratio of width to thickness for complete flakes with maximum dimension > 2.5 centimeters.

Unit	Mean	Median	Variance	*N*
I	4.638	4.249	5.146	1346
II	4.550	4.182	4.057	331
III–VIII	4.361	4.000	3.977	1263
IX	4.256	3.998	3.127	745
X	3.947	3.626	2.901	446
XI	3.453	3.125	2.670	2342
XII	3.545	3.250	2.558	959
XIII	3.520	3.250	2.390	1897
XIV	3.212	2.917	1.947	761

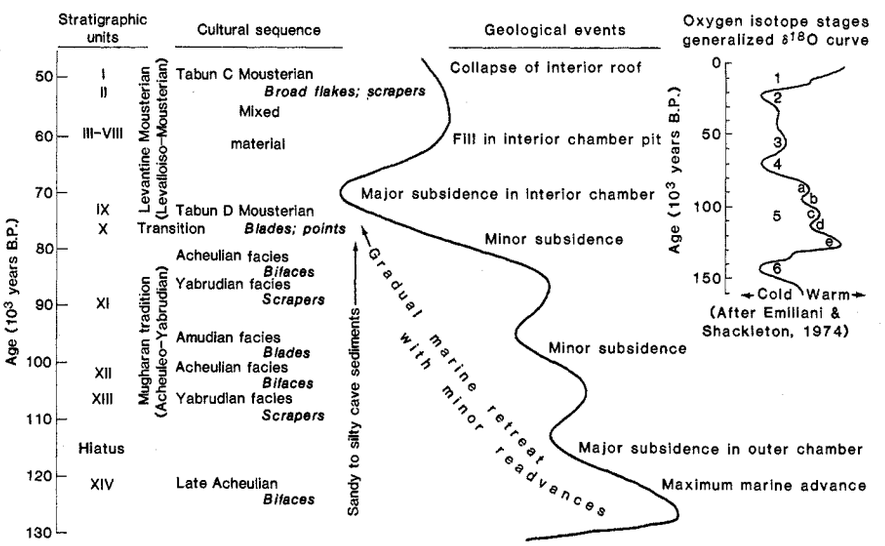

Fig. 3. Proposed correlation of geological and archeological evidence from Tabun with a paleoclimatic curve based on oxygen isotope variation (stages 5e to 3). Diagnostic artifacts for each industry are shown in italics. Garrod's industrial designations are shown in parentheses.

Table 3. Statistical parameters of the ratio of width to thickness for complete flakes with maximum dimension > 2.5 centimeters for samples from Garrod's Tabun excavation and from other sites in the Levant.

Site	Layer	Mean	Median	Variance	*N*
Qafzeh	VII–XV	5.970	5.399	8.924	2188
Qafzeh	XVI–XXIV	6.389	5.712	9.080	599
Qafzeh	I+L	6.735	6.166	8.757	1234
Skhul	B	6.500	5.999	8.669	532
Kebara	F	6.039	5.499	7.638	1770
Tabun	Chimney+B	6.199	5.665	7.102	338
Abou Sif	B	4.510	4.002	3.342	214
Abou Sif	C	4.126	3.875	1.732	173
Yabrud I	15	3.744	3.428	2.972	361
Tabun	G	3.223	2.998	1.553	153

for units XI and X at Tabun, and the variance falls between the values for units X and IX. Given the nature of the data (that is, the limited stratigraphic context represented by the Yabrud I sample), these values appear to support the correlation.

The Abou Sif samples are typologically most similar to Tabun unit IX, and all their values approximate those of unit IX except the low value for variance in Abou Sif C. Here the highly selected sample consists almost entirely of points and prismatic blades with very similar midsection dimensions; this tends to minimize the variance of the width-to-thickness ratio in the sample. The data that are present support the correlation here as well.

If we assume that roughly the same degree of selection was practiced in the recovery of the Tabun chimney–layer B, Skhul, and Kebara (*34*) samples, the age of the Neanderthal infant burial at Kebara (*35*) is roughly equivalent to that of the chimney deposits at Tabun, and the more modern Skhul hominids postdate both of those contexts. If we compare the selected Skhul sample with Neuville's selected sample from Qafzeh layers I and L (*13*), we find that they are quite similar, with the latter showing somewhat higher values for all parameters. The Qafzeh values are markedly higher than those for the Tabun chimney. The unbiased sample from the deepest layers of the recent excavation at Qafzeh (XVI to XXIV) is most similar to the (selected) Skhul B sample. It is interesting to note that the upper sample from this excavation (layers VII to XV) shows somewhat lower values than samples from the lower levels. However, all the objectively retained Qafzeh material shows values markedly higher than the comparable Tabun unit I sample. The temporal scale suggested by these relationships would place the Tabun Neanderthal earliest on the time scale, followed by the Kebara Neanderthal infant, the more modern Skhul individuals, and the fully modern Qafzeh hominids in that order. Thus our current evidence from Tabun suggests an orderly and continuous progression of industries in the southern Levant, paralleled by a morphological progression from Neanderthal to modern man.

A developmental scheme that conflicts with this interpretation has been proposed by Vandermeersch, based in part on his recent excavations at Qafzeh (*36*). Vandermeersch sees the Levantine Neanderthals as relative latecomers in the Near East, derived from a Neanderthal population that had developed in western Europe after fully modern man was already present in the Levant (as evidenced by the Qafzeh hominids, for which he estimates a date near the end of the last interglacial, that is, about 75,000 B.P.). The major evidence for this date is the presence of two archaic rodents at Qafzeh (*37*) that are not present in units I and II at Tabun and the presence in those beds at Tabun of a more modern form (*38*) that does not appear with the hominids at Qafzeh. Given the quite different habitats of the two sites and the closer proximity of Qafzeh to the refugium of the Jordan Valley, such evidence seems far from definitive. Other recent claims that the Tabun C (units I and II) type of Mousterian occurs as early as the last interglacial on the Lebanese coast (*39*) are dependent on the interpretation of beach associations of the industries and correlations of past high sea levels and absolute chronology that also seem highly tenuous in view of our present knowledge of these circumstances and events. Acceptance of these interpretations would mean acceptance of a late (about 60,000 to 50,000 B.P.) migration from western Europe of Neanderthals (for which there is no intervening evidence), who arrived to find a population of modern *Homo sapiens* using an industry that would have continued unchanged for about 35,000 years (Tabun C Mousterian).

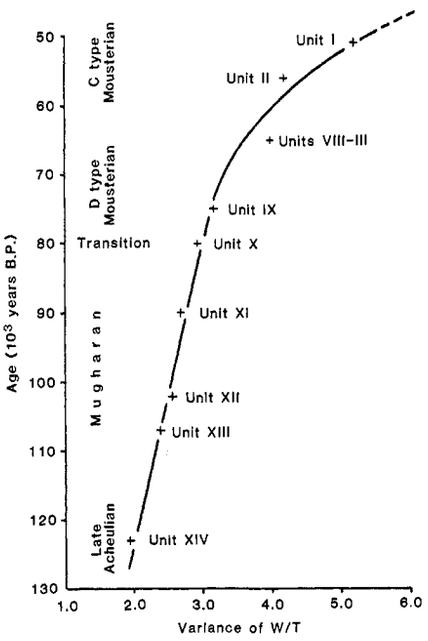

Fig. 4. Changes in the variance of the width to thickness ratio (*W/T*) of complete flakes through time. The time scale was derived from the correlation in Fig. 3.

The questions that these interpretations leave unanswered are (i) How and where did this postulated early Tabun C type industry develop? (ii) Why did it exist unchanged side by side with an industry that slowly evolved from a late Mugharan Tradition, through Tabun D Mousterian, into an identical Tabun C Mousterian (as evidenced at Tabun, Yabrud I, Abou Sif, and the Bezez cave)? (iii) If modern man existed through this period with a Tabun C type industry and the Neanderthals were late arrivals in the Levant, who was responsible for the industrial developments at such sites as Yabrud I and Tabun? (iv) Where is there evidence of a Neanderthal intrusion in the cultural sequence in the Levant?

The continuous sequence of cultural and biological development supported by the Tabun sequence appears to be a more economical and firmly based interpretation.

Significance of the Industrial Sequence at Tabun

Beyond questions of the development of the Levantine Mousterian, the industrial sequence at Tabun has implications for the interpretation of the place of Middle Paleolithic man in human development. The most striking feature of the sequence at Tabun is the conservatism in typology and technology over prolonged time intervals. In particular, the slow

oscillation of the facies of the Mugharan Tradition, representing gradual shifts in emphasis on the manufacture of different elements in a continuing uniform tool kit, and the very gradual change in the production of flakes through time seem to show a lack of the kind of innovative behavior that has characterized modern man for the last 35,000 years. I have suggested (*40*) that this pattern of technological stability reflects a distinctive *paleocultural* behavior that contrasts with the fully cultural behavior seen in the archeological record following the Middle Paleolithic. The apparent acceleration in the width/thickness trend in flake manufacture toward the end of the sequence (which is also compatible with the evidence from Skhul and Qafzeh, assuming an in situ progression) suggests the beginning of a qualitatively different regime. It is possible that this difference in rate is connected with the development of modern man and that it may help us to comprehend the nature of the differences in behavior between modern man and the latest of his fossil progenitors. A primary goal of archeological research is the development of analytical and interpretive techniques that will enable us to understand what the artifactual record can reveal about the cognitive activities of the hominids that produced it. Interpretations of these archeological data make it possible to pose questions for biological anthropologists concerning the ways in which human osteological evidence associated with artifactual materials may be linked to behavioral changes in man. Thus it may be that the human remains from Qafzeh show us the full development in biological potential of modern man, on the threshold of breaking away from the long tradition of slow and limited innovation that characterized the paleocultural behavior of the Lower and Middle Paleolithic. Clearly the biological potential for such a cognitive difference would have to be present before the change would be evident in the artifactual record. It may be that an application of the new kinds of information that have emerged from the excavations at Tabun to earlier and later time horizons and to other regions can help to provide additional insights into those vital differences that exist between ourselves and our immediate fossil antecedents.

References and Notes

1. D. C. Johanson and M. A. Edey, *Lucy: The Beginnings of Humankind* (Simon & Schuster, New York, 1981); R. Lewin, *Science* **211**, 806 (1981).
2. F. Bordes, *Science* **134**, 803 (1961).
3. L. R. Binford, in *The Explanation of Culture Change*, C. Renfrew, Ed. (Duckworth, London, 1973), pp. 227–254.
4. J. R. Sackett, in *ibid.*, pp. 317–325; A. J. Jelinek, in *Cultural Change and Continuity*, C. Cleland, Ed. (Academic Press, New York, 1976), pp. 19–33.
5. D. A. E. Garrod and D. Bate, *The Stone Age of Mount Carmel* (Oxford Univ. Press, Oxford, 1937), vol. 1.
6. Garrod revised her terminology for the layer E industries following the publication of Rust's work on the Yabrud I shelter in 1950. The term "Acheuleo-Yabrudian" replaced "Micoqian" and "Final Acheulian" in D. A. E. Garrod, *Quaternaria* **3**, 39 (1956).
7. A. Rust, *Die Hohlenfunde von Jabrud (Syrien)* (Wachholtz, Neumünster, Federal Republic of Germany, 1950).
8. R. Neuville, *Arch. Inst. Paleontol. Hum. Mem.* **24** (1951), pp. 47–60.
9. C. S. Coon, *The Seven Caves* (Knopf, New York, 1957), pp. 290–316; H. B. Schroeder, thesis, Columbia University (1969).
10. D. A. E. Garrod and D. Kirkbride, *Bull. Mus. Beyrouth* **16**, 7 (1961).
11. D. A. E. Garrod, *ibid.* **19**, 5 (1966).
12. W. W. Howells, *Evolution of the Genus Homo* (Addison-Wesley, Reading, Mass., 1973), p. 124.
13. R. Neuville, *Arch. Inst. Paleontol. Hum. Mem.* **24** (1951), pp. 179–184.
14. The term "Amudian" was suggested by Garrod and Kirkbride (*10*, p. 11) as a replacement for Rust's Pre-Aurignacian, which he had applied to an industry of Upper Paleolithic type sandwiched between layers of Yabrudian and Acheulian at Yabrud I. Amudian is generally used at present to refer to those industries at Tabun, Abri Zumoffen, and Zuttiyeh that are rich in backed blades; Pre-Aurignacian continues to be applied to Rust's industries from layers 15 and 13 at Yabrud I that are rich in burins and have few backed blades.
15. The recent excavation was designed to penetrate 2 meters into the center of the old profile on a front that expanded from 5 meters wide at the top (in layers B and C) to 6 meters wide at lower levels. The excavation front was shifted 3 meters to the west in the lowest portion of the excavation to avoid an unstable surface on the profile and to sample deposits that appeared to have been protected from the first karstic collapse in the cave. The particular techniques of excavation are detailed in A. J. Jelinek, W. R. Ferrand, G. Haas, A. Horowitz, P. Goldberg, *Paleorient* **1**, 124 (1973).
16. It has been estimated by one of her co-workers that Garrod's excavation at Tabun removed about 4800 cubic meters of deposit during the five seasons of work [T. D. McCown, *Kroeber Anthropol. Soc. Pap.* **25**, 228 (1961)]. In her final report (*5*), Garrod records 55,550 artifacts recovered.
17. The reduction in frequency of *Gazella* was accompanied by the disappearance of hippopotamus and rhinoceros from the fauna. This led Bate, who carried out the paleontological analysis, to postulate the existence of a "great faunal break" that reflected a regional climatic shift. It was anticipated that this event would be a useful chronological referent throughout the Levant.
18. W. R. Farrand and P. Goldberg, in A. J. Jelinek *et al.*, *Paleorient* **1**, 155 (1973).
19. W. R. Farrand, *J. Archaeol. Sci.* **6**, 369 (1979).
20. G. Haas and A. Horowitz, in A. J. Jelinek *et al.*, *Paleorient* **1**, 164 (1973).
21. While there is a marked discontinuity in sedimentation between Garrod's layers D and C, the deposition between layers C and B is continuous and apparently rapid. Had a general faunal shift of the magnitude postulated by Bate taken place at the junction between layers C and B it would call for a "catastrophic" explanation.
22. A. J. Jelinek, in A. J. Jelinek *et al.*, *Paleorient* **1**, 179 (1973).
23. R. Vaufrey, *Rev. Sci.* **77**, 390 (1939); D. A. Hooijer, *Zool. Verh. Rijksmus. Nat. Hist. Leiden* **49**, 61 (1961).
24. Garrod defined the industry of layer G as "Tayacian" on the basis of the absence of bifaces; however, a recent examination of the collections from Tabun in the Museum of Archaeology and Ethnology at Cambridge University revealed two bifaces (one quite crude and the other with a large flake struck from it) in the layer G material, suggesting that it is, in fact, Acheulian.
25. F. Bordes, *Anthropologie (Paris)* **59**, 486 (1955).
26. Since Bordes and others have on occasion suggested that the Yabrudian was a Near Eastern "Quina Mousterian," the frequency of Quina retouch was compared for the three best Yabrudian samples (those with highest ratios of scrapers) and three best Acheulian samples (highest ratios of bifaces). The results were virtually identical, with about 8 percent demi-Quina and 4 percent Quina retouch in both industries (402 Acheulian scraper edges and 1938 Yabrudian).
27. A. J. Jelinek, "The Middle Paleolithic in the southern Levant," paper presented at CNRS Colloque No. 598, Lyon (1980).
28. It appears that by this time the Tabun C type Mousterian was fully developed. The beds of units VIII to III fill the pit caused by the subsidence in the inner chamber and are assumed to contain a mixture of artifacts contemporary with the infilling with older materials that fell from the sides of the pit. While some of the industries from these beds appear to be transitional from D to C, this may be a result of the mixture of artifacts of different ages.
29. The techniques of measurement employed in this study are discussed in A. J. Jelinek, *Eretz-Israel* **13**, 87 (1977).
30. C. Emiliani and N. J. Shackleton, *Science* **183**, 511 (1974).
31. S. C. Porter, M. Stuiver, I. C. Yang, *ibid.* **195**, 61 (1977); N. J. Shackleton, "The oxygen-isotope record as an ice-volume monitor," paper presented at the American Quaternary Association meeting, Orono, Maine (1980).
32. Three recent ^{14}C dates on material from unit I (GrN-7408, > 47,900; GrN-7409, $51{,}000^{+4800}_{-3000}$, and GrN-7410, $45{,}800^{+2100}_{-1600}$ B.P.) suggest an age of about 50,000 years for Garrod's layer C.
33. W. F. Ruddiman, A. McIntyre, V. Niebler-Hunt, J. T. Durazzi, *Quat. Res. (N.Y.)* **13**, 33 (1980).
34. T. Shick and M. Stekelis, *Eretz-Israel* **13**, 97 (1977).
35. P Smith and B. Arensburg, *ibid.*, p. 164.
36. B. Vandermeersch, in *Les Origines Humaines et les Epoques de l'Intelligence* (Masson, Paris, 1979), pp. 251–260.
37. *Mastomys batei* and *Avicanthis ectos*.
38. *Cricetulus migratorius*.
39. L. Copeland and F. Hours, paper presented at CNRS Colloque No. 598, Lyon (1980).
40. A. J. Jelinek, *Annu. Rev. Anthropol.* **6**, 28 (1977).

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