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PENAN HUNTER-GATHERERS OF SARAWAK, EAST MALAYSIA

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Splitting section of sago palm trunk for processing.

Throughout the interior of central Borneo are groups of hunter-gatherers variously known as Penan or Punan. From September 1984 to October 1987 I conducted field research among one group, the Penan Gang, who inhabit the Usun Apau plateau between the Balui and Baram rivers in the Malaysian state of Sarawak.

The majority of the population in the interior districts of Sarawak-Kayan, Kenyah, and other longhouse-dwelling agricultural groups are settled along the banks of major rivers. In contrast, hunter-gatherers like the Penan are found mostly in upper tributaries, areas characterized by mountainous terrain and still largely forest-covered except where extensive logging has occurred. Prior to 1960, as much as 80 percent of Penan were still nomadic; today, nearly all have been settled. Despite the present reliance on agriculture, for most Penan communities during at least certain parts of the year, the forest has been, and remains, the primary focus of life, both economically and culturally.

The term Penan applies to two primary populations of people defined as Eastern and Western. The Western Penan, of which the Penan Gang are included, are all those in the Belaga District, as well as communities in the Silat river watershed and at Long Beku. The Eastern Penan is a separate population. The two populations, though recognizing each other as commonly Penan, consider themselves of different or at best of vague, very distant ancestry. They have little interaction with each other and marriage between them is rare. The dialects of Eastern and Western Penan, though closely related, are quite different but mutually intelligible. Both Eastern and Western

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PRESIDENT'S MESSAGE

Dear Fellows and Members of the Leakey Foundation:

Are we a misfit in nature's grand scheme of things, destined to destroy a perfectly good Eden in our brief span of occupancy at the top of the heap? Is wanton waste the best we can do for planet Earth and, incidentally, for our fellow man?

I don't think so.

Slow learners perhaps we may be, but not hopeless.

The way forward starts with willingness. Willingness to wake up, look around and share the upside of our bountiful know-how and apply it to a struggling humanity worldwide. Traces from the memory of early mankind and their battles with hostile environments still linger in each and every one of us. Through some tangled skein of accident or purpose, we did inherit, did endure, and will prevail.

Ancient echoes from distant unrecorded times ripple through our daily lives stirring our common concerns, asking what are we doing here, where did we come from and where are we going. For, no matter how civilized our label, we shall never quite escape from our beginnings.

From the shadows of the past fall the fossilized bits of a great mosaic stretching along a timeless wall. Each precious fragment of the big picture passes in review for scholars to share and make of it what they will.

Along the way, laymen too grasp the outlines of the features which have helped to make or break kindred species and we rediscover ancient myths and mysteries that have long lay in some hidden backwater.

There are countless paradoxes and contradictions on the incomplete road map leading to and from our ancestry. There are surely many side paths to follow as we progress to a better understanding of either ancient or modern mankind.

Leakey Foundation grantees search along many avenues for answers. Their achievement and your sponsorship go hand in hand. We invite you to be a part of the adventure and check the record of grants ready and waiting. Goals that begin with vision and persistence are only sustained by funding.

Some of our grantees may be among the last to witness corners of this planet's remaining tribal groups. Time is of the essence before they are swept into the next century under the heel of progress.

Why not concentrate on the Here and Now? Why burden ourselves with minute features of the dead and dusty past or be concerned with backward societies? Because, with ever increasing certainty we know that the thrust of our success is centered on the ability to adjust to change. What better challenge for modern man than that we should better understand ourselves.

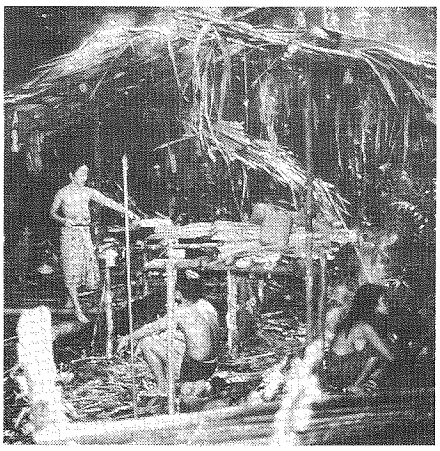
Even as we consider the unique miracle of a human being, we can develop an increasing respect for life itself. That too, when you think about it, is not such a bad start to make on problems of the Here and Now.

Thoughtful men and women brought the Leakey Foundation into being. More of the same are needed to join a distinguished list of members and patrons whose sponsorship helps unmask the fascinating past and grasp a bountiful future.

Mason Phelps

Please see AnthroQuest reader survey on inside back page.

(Penan Hunter-Gatherers cont.)



Penan sago camp ***(Lamin tana).***

Penan depend on the processing of hill sago *(Eugeissona utilis)* to provide their primary carbohydrate staple, and all rely heavily on hunting, though there is some variation in the technology employed. With regard to the size of these two populations, Eastern Penan number some 4294, while Western Penan number 2251. Of this total, only 360 Penan in eight bands remain fully nomadic, all of them Eastern Penan in the vicinity of the Tutoh and upper Limbang rivers. (The last nomadic Western Penan settled twenty years ago.)

Although both groups are traditionally forest-dwelling and nomadic, and despite similarities between these two populations, there are significant differences between them. They represent two distinct responses to living in the Bornean rain forest. Certain features of Western Penan subsistence, settlement and social organization make them unique among recently documented foragers. My main focus was the Penan Gang community of Long Jek, situated along the Seping river in the Belaga District.

The Penan Landscape. Conspicuous features of Penan environment range from large, navigable rivers to small rivulets with scarcely any flow. The importance of rivers to Penan can scarcely be overestimated. In an environment where visibility seldom exceeds 200 feet, rivers and streams form the skeleton around which environmental knowledge is organized. When travelling in the forest, Penan are always cognizant of their exact location relative to various rivers. This keen sense of spatial relationships derives from an awareness of the rivers' relative sizes and the angle of flow of one to another, the topography between particular rivers, and the proximity of different headwaters as well as other environmental cues. Not only are rivers named, but so are the various places along them: rapids, slow-flowing sections, distinctive rocks, and minor river forks. To Penan however, the landscape is more than simply a vast, complex river network; it is a reservoir of detailed ecological knowledge and a repository for the memory of past events.

Over a period of three years I identified some 2000 named rivers and streams. The value of this is twofold. First, a knowledge of these rivers is necessary to make sense of Penan historical and genealogical accounts. Rivers are the paradigm around which spatial, historical and genealogical information is organized. Secondly, learning the waters known to a particular band serves to provide a wealth of historical and ecological background, since a great deal of information is actually encoded in the river names.

Rivers are often named for a particular type of tree or fruit occurring either near the river mouth or growing in abundance along its course.

There is a significant degree of microenvironmental variation occurring in the forests of Sarawak; plants may be abundant in one watershed and absent in another. This is the sort of information encoded in many Penan river names. Rivers may also be named for some natural feature, such as the occurrence of a particular type of stone. Also common are river names chosen for some particular event such as the killing of a rhinoceros, the loss of a favorite dog or an exceptionally abundant fruit season. Finally, there are a large number of rivers named for particular individuals, both living and dead. These may signify the birth or death of a person or their fondness for hunting there. This relationship between individuals and rivers is reciprocal.

The Penan have a strong prohibition against mentioning the names of deceased persons, particularly those who have died recently. When a person dies they are referred to by the name of the river where they died and are buried, prefaced by either *Lake'* (male) or *Redu* (female). Thus a man who died while camped near the Uten river would be known as Lake' Uten. Significantly, the memory of ancestors by this device often reaches back some six generations. The burial place of the Penan Gang apical ancestor, Poven, who lived in the Seping river area sometime prior to 1800 is only a short distance upriver from the present settlement of Long Jek and establishes for this community their relationship to the surrounding area. The result is that the landscape itself serves as an idiom for the maintenance of historical and genealogical information. This idiom is an important mnemonic device for the maintenance of social relationships, particularly between distant kin in different communities. At the same time it serves to establish the rights of Penan communities to exploit the resources of a given area.

The "cultural density" of the Penan landscape is manifested in still other ways. Weaving throughout the landscape is a vast network of well-maintained trails. When the Penan travel in the forest they are constantly cutting away saplings, branches and vines. Such trails are followed repeatedly: hunters do not travel through the forest randomly, but rather follow one of these established routes. While these trails themselves are not named, numerous waypoints along them are.

Finally, the Penan landscape is filled with particular trees which are either the property of the whole community or which are recognized as belonging to specific individuals. Of significance here is the concept of *molong,* to preserve or foster. This generally applies to fruit trees of various types, to sago clumps, or, for instance, to large trees which are suitable for boat building. Frequently when traveling in the forest a person will spot a tree which has not been claimed, and will then mark it in some manner, thus reserving it for future harvest or use. Even young children actively claim trees, and by adulthood may have accumulated several dozen fruit trees and sago clumps. Significantly, there are a large number of fruit trees which are specifically named. Such names may refer to the person who first spotted it, to a deceased individual buried

near it, or to the river near which it occurs. Many of these trees are recognized as having been molong by long-dead ancestors and are thus a further source of continuity between past generations and present.

Settlement. Western Penan communities tend to be much larger than those of Eastern Penan, ranging in size from 60 to 200 individuals. Penan bands are essentially kin- based groupings, with most individuals being closely related. In addition, every Penan band has a number of individuals who have married in from other communities and may be only distantly related.

One striking feature of Western Penan band composition is its long-term stability. G. Arnold censused five Penan bands in the Plieran river area in 1955, and I recensused these in 1987. If one allows for births, deaths, and marriages, the degree of stability in band composition is remarkable. These are thus enduring social aggregates, not at all like the fluid bands characteristic of many other hunter-gatherer societies.

Western Penan bands have continually fissioned since at least the early part of this century. This is an ongoing process. There are a number of reasons why bands may fission. Perhaps the most important is that a group becomes too large to allow sufficient amounts of meat to be distributed to each household. Also, above a certain size, it becomes difficult to provision the band, given that task groups must travel farther to reach sago groves and may easier deplete them. Thus there is a maximum band size above which provisioning becomes difficult. A second major factor is disputes, generally but not always due to considerations of leadership.

The Western Penan traditionally maintained a two-tier settlement system. The first level was the central base camp *(lamin jau)* in which all families maintained a shelter. These settlements were apparently quite large, often with over 20 shelters. These no longer exist, since all Western Penan are now settled: they have been replaced by village or longhouse types of settlement. The period for which *lamin jau* were occupied varied, depending on the availability of sago in an area, but often they were occupied for considerably more than one year. The second level of settlement were satellite camps *(lamin tana)*, occupied mainly for the production of sago or for the collection and processing of forest products. These camps were generally not more than a days travel distant from the *lamin jau,* and were occupied for shorter amounts of time, from one week to three or four months, depending on the abundance of sago in a particular area. From these, *lamin tana* sago was transported to the main settlement every few days. Approximately one third of the community would be resident at these *lamin tana* at any given time. In particular, it was younger families or individuals who could more efficiently carry out the difficult task of processing sago who were present at sago camps, as is still the case. The elderly remained mostly at the *lamin jau.*

Despite the recent adoption of agriculture, this system is still maintained in the more traditional communities, except during those periods of the year when agricultural products are being consumed. The settlement has merely taken the place of the *lamin jau.* In Long Jek, during the time of year when sago is being exploited, generally about 25-30 people (from a population of 78) will be resident at a particular sago camp. The distance of sago camps from the main settlement of Long Jek is variable. Some camps, occupied for only a few days, may be only 3-4 hours walk from the main settlement in areas where most of the sago has been depleted but where there are a few clumps which are worth harvesting. Most of the more substantial, longer-occupied sago camps are at a minimum distance of six hours walking and/or paddling. The maximum distance between the main settlement and outlying sago camps is no more than two days travel.

Genealogical and Historical Accounts. For Western Penan, genealogical and historical knowledge are in large part coextensive. During fieldwork, a considerable amount of genealogical and historical information was collected both in Long Jek and at other Western Penan settlements. The quantity of information that resulted far exceeded expectations. Based on this, I anticipate eventually producing a comprehensive ethnohistory of Western Penan.

Among Western Penan, the Penan Gang possess the most complete genealogical/historical accounts. This is not to say that everyone possesses such knowledge. Rather, certain individuals are recognized as holders of this knowledge. Two informants proved to be particularly rich sources: Sugun Uwing of Long Jek and Tingang Banjang of Long Tangau. Individuals such as Sugun and Tingang were able to trace genealogies back some five or seven generations to the apical ancestor Poven and even slightly beyond. Interestingly, Sugun and Tingang knew genealogies of Penn in distant watersheds who did not know their own genealogies. Sugun Uwing died in May 1987 and Tingang Bajang in August 1987. These two men were able to trace the genealogical relations of all Penan Gang and a large percentage of other Western Penan. What was remarkable is not just the depth of these genealogies, but the breadth incorporating many hundreds of names.

The population of Penan in the Belaga District has been growing steadily since at least the turn of the century and is nothing short of remarkable. The present Penan Gang are derived from a single band which in the early 1900s was comprised of only four households. There has been some immigration from other Penan groups, but most increases appear to have been internal. One clear piece of evidence for population increase is the comparison of past and present censuses. Guy Arnold took a census in 1955 of five Penan communities in the Plieran river area. These bands comprise the core of their communities. Comparing population figures from then to 1987, the high rate of population growth is evident (160%-276%).

Social Organization. There are a number of features of Western Penan social organization which are both of general ethnographic interest and of particular interest to those concerned with hunter-gatherers. Among the most significant, if problematical, is the question of Penan social stratification.

One of the critical features of Western Penan society which differentiates it from that of Eastern Penan is a strong institution of leadership. What makes Western Penan particularly interesting is that they claim to

be ranked, to have *maren* (aristocrats) in the manner of surrounding longhouse peoples such as Kayan and Kenyah. This is somewhat problematical, and it is certainly arguable whether Western Penan society is in fact ranked. Certainly, within particular communities, egalitarian principles simultaneously exert a powerful influence. Nevertheless, the fact that this claim is made and that Penan back this up with reference to genealogies is significant.

More than any other factor, the basis of headmanship in Penan society is that of being recognized as a *maren*. This is a matter of general consensus within a community, though often not between different communities. Recognition of marenship by others is derived from the medium of genealogies and, as noted, it is with respect to this knowledge that Western Penan are so remarkable. For example, the Penan Gang link present headmen to longhouse aristocrats through marriages that occurred over many generations. Sugun, for instance, was able to trace direct links between himself, Lirong and Seping *maren* in marriages probably occurring in the early 19th century. This is important in and of itself, as conferring *maren* status, and because it validates claims to land and resources such as fruit trees. However, this cannot be said to explain fully the Penan interest in the maintenance of genealogical knowledge. Certainly one aspect of these genealogies is that they allow distantly related people to establish kin ties. Regardless of other functions it may have, it is this genealogical knowledge which provides certain individuals with authoritative knowledge and allows them to act as effective arbiters of relationships between communities. These individuals also have a vested interest in that the knowledge also validates their own status. Headmanship is an important institution among Western Penan.

Sago Production. Sago starch, derived from the palm *Eugeissona utilis*, has traditionally been the primary source of carbohydrates for Penan. It is a resource which under nomadic conditions determines the location of Penan camps and the frequency of their movement. It remains a seasonally important part of the diet.

Penan woman washing sago pulp in basket over settling mat.

The *Eugeissona* palm has a wide elevational range and occurs throughout interior Sarawak. In the upper Balui watershed it is found in greatest concentration on steep ridges and slopes above 2500 feet where it is generally found in dispersed groves interspersed with other forest vegetation. It grows in dense clumps of 3-6 trunks per clump, elevated on aerial roots.

The processing of *Eugeissona* for starch appears to be a relatively efficient mode of subsistence. Though yields do vary somewhat, the amount of starch derived from any given episode of processing appears to be fairly consistent: slightly above one part starch to every four parts of chopped pith. Generally a minimum of two men will chop pith on a given day, working for an average of six hours. Each can process 50-65 pounds (wet weight) of starch per day, resulting in a total yield of 100-130 pounds of starch.

When the sago in one area has been depleted, it is left to recover over a period of years. The Penan attitude with regard to *Eugeissona* is one of explicit stewardship.

Hunting. The meat and fat provided by hunting makes up a high percentage of the Penan diet, and hunting is the predominant forest-related activity engaged in by Penan men. In three years of research, I collected data on over 300 hunts, including such variables as participants (human and canine), encounter locations and rates, routes followed, success rates, and species, sex, weight and fat content of animals killed.

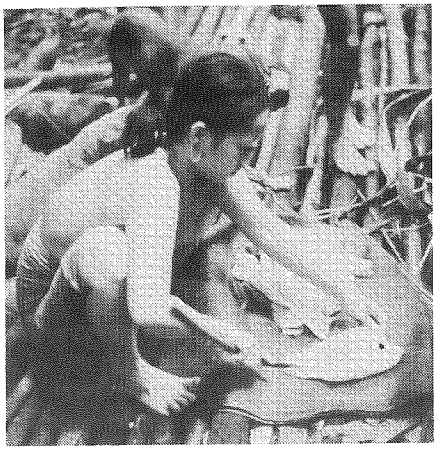
The game preferred by Penan is bearded pig *(Sus barbatus)*. It provides large amounts of meat, has high fat content, and is the most common type of game procured. Other prey species are sambar deer and barking deer. Less common game include bear and porcupine which are considered distinctly inferior and is usually discarded.

There are three primary hunting methods employed by Western Penan: hunting with spears and dogs, blowpipe hunting, and hunting with shotguns. Most of the hunting in Long Jek today is done with spears and dogs, which can account for success rates as high as 85-90 percent.

However, this rate varies throughout the year depending on pig densities. Hunts generally take place on average every other day and consist of two or three hunters going out with four to six dogs. The hunt will generally cover a distance of five to eight miles in the course of a day. On most hunts at least one pig is killed, often two, and weigh between 60-120 pounds. Sometimes, one of 160 pounds is killed, but this is rare.

Though almost all Penan men in the Belaga District own blowpipes, these are used only occasionally. Unlike Eastern Penan, among whom this type of hunting is the dominant form, for Western Penan it is only supplementary and used only when there are no dogs or, even if there are dogs, if there are no pigs in the forest. Blowpipes are most effective against smaller types of game such as gibbons, monkeys and squirrels which Western Penan have little interest in unless no other meat is available. Hunting with a blowpipe is generally a solitary activity.

Butchering bearded pig for distribution to each household.



Slicing pig fat prior to cooking over fire.

Shotguns are today highly prized by the Penan and almost every community possesses one. Many derive a major portion of the meat they consume from hunting with shotguns. Long Jek is one of the few communities in the Belaga District which does not have a shotgun.

The Penan derive a relatively small percentage of their non-carbohydrate subsistence needs from fishing. Unlike longhouse peoples such as Kayan and Kenyah, the Penan do not value fish highly. They eat it, but it is a food of last resort. The Penan employ a number of fishing methods: hook and line, poisonous tuba root *(Derris elliptica)*, fish traps and harpoons. Recently fish nets have been introduced and today this method provides a significant percentage of the catch.

In Borneo there is a relationship between (1) periodic fruiting of forest flora and (2) bearded pig migrations, and thus their relative densities in particular areas through time, (3) fat deposits found on pigs, and (4) pig reproduction. An important characteristic of pigs is that they are highly mobile, traveling great distances in search of fruit or other items both daily and seasonally. Thus there is no single, stable pig population which stays permanently in a given area. Concomitant to this, pig densities vary constantly in any particular area. There are periods of abundance and periods when they disappear. Furthermore, fat deposits on bearded pigs vary seasonally and yearly. It is clear that the animal plays a key role in the Penan diet, accounting for a high percentage of overall caloric intake.

Trade. Trade with surrounding longhouse communities has long been a major component of the Penan economy. Traditionally, it has been based on the collection of forest products and weaving of rattan by Penan who exchange these for items such as metal, cloth, salt and tobacco. The actual range of products collected has varied considerably through time. Camphor, jelutong and damar were important trade products at various times in the past. Garu wood collection was an especially prominent activity in the 1970s, but this resource has now been largely depleted. The Penan have always been known for the fine woven rattan mats and baskets which they produce, and this continues to be the primary source of cash for them in the Balaga District today. Among contemporary Penan, patterns of trade vary considerably in different communities and watersheds.

In regional perspective, the Penan have long occupied a specific niche in the economies of interior Borneo. Trade with Penan and other hunter-gatherers has certainly been a feature of central Bornean economies for many hundreds of years. Such peoples have been a major source of forest products which are traded to longhouses and thence to the coast for consumption or export. This trade has had a decisive influence on certain features of riverine longhouse society. It can plausibly be suggested that one of the primary determinants of longhouse locations at the mouths of major rivers is the control or monitoring of trade with hunter-gatherers. The trade in forest products was an important factor in the development of coastal sultanates in previous centuries.

The issue of trade is particularly significant in light of the recent publication of Hoffman's *The Punan: Hunters and Gatherers of Borneo* (1986), where the issue of the ethnogenesis of Bornean hunter-gatherers is addressed. Hoffman contends that the existence of peoples such as Penan in Borneo is explained exclusively with reference to their role as providers of forest products in local trade networks. Clearly, for Penan, trade has long played a key role in their lives. But, Hoffman takes the argument to great lengths in claiming that Penan/Punan exist primarily to trade, that trade is their *raison d'etre*. We need not deal with the particulars of this debate here except to say that these contentions are faulty. Trade is critically important to the Penan, and presumably has been for thousands of years, yet trade alone does not explain their existence.

Traditionally, Penan depended on longhouse peoples, particularly aristocrats, to act as mediators with the outside world and to serve as the conduit by which both information and material goods reached them. The traditional type of relationship existing between Penan and longhouse aristocrats was multi-dimensional in that longhouse peoples provided not just trade goods to Penan but other types of "service" as well. One function was protecting Penan from raiders *(ayau)*. In past generations when raiding was still occurring, the locations of their camps was not information that Penan shared freely. This meant that longhouse traders who knew their whereabouts could essentially control access to Penan and, conversely, Penan depended on them not to reveal camp locations or to bring people with hostile intentions. This worked well for all parties concerned: traders were able to maintain a monopoly, and the Penan were not raided.

The length of time which Penan maintain relationships with particular longhouse communities is highly variable: some for many decades or generations, and others for just a few years. Just how long such relationships persist seems to be a matter of how well Penan get along with their longhouse trade partners and how good and friendly their aristocrat/patrons are.

Among Penan, women are the exclusive processors and weavers of rattan. As such, they play a key role in the making of mats and baskets, products which are in great demand by longhouse peoples, primarily for trade with Chinese merchants. To generalize, one could say that whereas subsistence is largely the domain of men, the production of trade goods is the domain of women. This is particularly so in the contemporary trade economy, where unprocessed forest products collected by men are of less importance than in the past.

The Western Penan are skilled metal-smiths and today produce large numbers of bush knives. Their forges use either the traditional bamboo bellows or, increasingly, manufactured hand-operated bellows. In the Belaga District, bush knife production is applied largely for Penan's own use. This contrasts markedly with Western Penan communities in the Baram District.

Another trade item of considerable importance to Penan is the aromatic wood, *kayu garu*. It still provides cash income, though it is not as important as it once was. During the 1970s and early 1980s, the garu economy throughout Sarawak boomed due to increased demand. It was a time when both Penan and their longhouse neighbors scoured the forests for whatever garu they could find. Many thousands of dollars could be earned on a single extended collecting trip that usually lasted several weeks. The Penan describe this period in glowing terms, saying they were much richer then, than they are at present. Since the decline in garu trade, not only have prices dropped, but garu itself has been drastically depleted.

Another product that was of considerable importance to Penan in past decades was damar, the resin of the massive tree *Agathis borneensis*. Used in the manufacture of varnish, it formerly constituted a considerable percentage of total trade volume. The task of collecting damar is time-consuming but, more importantly, the job of transporting it to market is exceedingly difficult. In bringing it down to trade, groups of men would carry baskets weighing about 100 pounds. The trip to where it could be loaded onto boats took from two to five days of arduous overland hiking. Damar is no longer an important item of trade because of a fall in prices.

One point should be stressed with respect to trade; unlike groups such as Semang, Agta, or Mbuti, business does not involve the exchange of forest products for food. It involves items such as tobacco, metal, cloth, salt and flashlight batteries, but not food items such as rice, corn, cassava or the like. With regard to food, Penan are wholly self-sufficient and do not require supplements from trade with longhouse peoples.

Feature	Western Penan	Eastern Penan
Group Size	Large groups with a range of 60 to 200 members.	Small groups with a range of 20 to 40 members.
Av. Household Size	6-10 persons.	4-5 persons.
Settlement Location	Built adjacent to rivers and streams.	Built on ridgetops, generally at some distance from sources of water.
Settlement System	Two-tiered settlement system with large, central base camps inhabited for up to 1 year and dispersed short duration sago camps.	Camps of short duration, ca. 1-3 weeks.
Foraging Area Size	Large foraging areas with little overlap of areas used by separate groups.	Smaller foraging areas with frequent overlap of areas used by different bands.
Hunting	Primary use of dogs and spears, with pig being the primary game. Blowpipe hunting of subsidiary importance.	Primary reliance on blowpipe hunting with reliance on a wider range of game.
Leadership Institutions	Strong institutions of leadership with recognition of aristocratic status for some individuals.	Less developed institutions of leadership.
Genealogical Knowledge	Extensive genealogical knowledge extending to more than seven generations.	Shallow genealogies.

Eastern and Western Penan. The foregoing discussion has concerned Western Penan. It may be useful now to briefly compare Eastern and Western Penan. As noted, the contrast between these two populations represents two different responses to life in the Bornean rainforest. In some sense, Eastern Penan conform more closely to generalizations made about recently documented foraging societies with regard to features such as group size, settlement patterns and the like. I would note that my information on Eastern Penan must be considered preliminary since I have visited Eastern Penan on only two brief occasions. Nevertheless, even in this short period it was possible to observe several features which markedly differentiate Eastern and Western Penan and get some hint at factors which may be of significance in understanding this variation. The following is a very preliminary list of some of the more important though tentative points of comparison between Eastern and Western Penan. Further observation will be required to establish with certainty the salient features of Eastern Penan society.

In addition to the above, there seem to be interesting points of variation in the production and processing of sago between Eastern and Western Penan. Whereas Western Penan tend to work sago in large task groups, Eastern Penan tend to process it in much smaller groups, perhaps just one or two nuclear families.

After analysis of my data on Western Penan, I hope to return to Sarawak to carry out a comparative study of nomadic Eastern Penan in the Tutoh river area. ■

GRANT SPOTLIGHT

GRANT GUIDELINES

The Foundation was formed to further research into human origins, behavior, and survival. Recent priorities have included research into the environments, archeology, and human paleontology of the Miocene, Pliocene and Pleistocene; into the behavior of the Great Apes and other Old World primate species; and into the ecology and adaptations of living hunter-gatherer peoples. Other areas of study related to human evolution have been funded occasionally.

The majority of the Foundation's general grants have been between $3,000-$5,000. Priority is normally given to the exploratory phase of promising new projects. Doctoral students and post-doctoral researchers are encouraged to apply.

Deadlines for submission of the formal applications are: General Grants: September 1, December 1, and March 1. Baldwin Fellowship: September 1, or December 1 for following academic year. Fellowship for Great Ape: May 1. Fellowship for the Study of Foraging Peoples: May 1.

For further information and application forms, contact the L.S.B. Leakey Foundation, 77 Jack London Square, Oakland, CA 94607-3750.

Caroline E.G. Tutin *$4,800 funded*

HABITUATION OF LOWLAND GORILLAS AND CHIMPANZEES

This on-going project will utilize "spy microphones" or transponders. This device, once placed in the fields, suspended at a height to avoid damage, can be activated from camp to transmit all sounds from its area. The system allows monitoring visits of up to five fruiting trees at any time and is particularly valuable in the evenings and early mornings because when gorillas or chimpanzees are heard, observers know exactly where to go at the beginning of each day.

The grant program, the major purpose of the L.S.B. Leakey Foundation under the guidance of the distinguished Science and Grants Committee, depends upon public support for its success. Every penny of your contribution dollar directly supports the grant awards.

Russell D. Greaves *$5,030 funded*

DISSERTATION RESEARCH-SUBSISTENCE AND TECHNOLOGICAL ORGANIZATION AMONG MACHIGUENGA FORAGERS

Russell Greaves' objective is to determine how the organization of subsistence choices effect use contexts, production and maintenance of exploitive technology. Behavioral data generated from this research will be comparable to other hunter-gatherer studies, particularly the work of the Manu Park Project. The data on the relationship of the technology to subsistence activities will be a substantial contribution to archeological understanding of how technical systems are organized.

John Kelley *$3,911 funded*

ANATOMICAL ANALYSIS OF HOMINOID CRANIAL SPECIMENS FROM LUFENG, CHINA

Dr. Kelley's project included a detailed anatomical analysis of cranio-dental specimens of the Lufeng large hominoid, brought to the U.S. by Dr. Xu Qinghua of the Institute of Vertebrate Paleontology and Paleoanthropology, Beijing. From thoroughly computed tomography, computer assisted laser surface imaging, and digitized 3-D surface contouring, Kelley hopes the badly deformed Lufeng crania can be reconstructed. This will lead to a more reliable description of features which are critical to understanding the position of *Lufengpithecus* within hominoid phylogeny.

Nubi Bernard Mbae *$8,000 funded*

GRADUATE TRAINING IN AFRICAN ARCHEOLOGY AND HUMAN EVOLUTIONARY ECOLOGY/ GRADUATE STUDIES AT UNIVERSITY OF ILLINOIS-URBANA-CHAMPAIGN

This Baldwin Fellowship supported project provides for completion of graduate studies. Mbae will undertake ethnoarcheological observations in the field which will aid in the interpretation of archeological faunal assemblages. Field research will involve ethnographic observations on the Okiek/Dorobo hunter-gatherers on the Mau Escarpment and the Nyahururu area. The Okiek adaptation has much to offer modeling of prehistoric hunting and gathering. The ethnoarcheological data will be used as a source of insight in the inter-subsistence adaptations of hunter-gatherers to complex Savanna and forest mosaic environments in the Central Rift Valley.

Amal Abu Mohamed *$5,751 funded*

THE IDFUAN INDUSTRY: LITHIC VARIABILITY, SUBSISTENCE PATTERNS AND SEASONALITY

The project is a continuation of an international multidisciplinary investigation of the development of the Upper and Late Paleolithic industries between ca. 33,000 to 17,000 B.P. and their evolutionary technological relationship from the earlier Middle Paleolithic industries in the Nile Valley and adjacent areas in Egypt and Sudan. The analytical framework was designed to consider types of variability such as: 1) subsistence analysis and settlement patterns and 2) lithic assemblages; i.e., use-wear analysis, typological analysis, technological and stylistic analyses and quantitative analysis.

Sibanyama Mudenda *$8,000 funded*

PREHISTORIC INVESTIGATIONS IN ZAMBIA/GRADUATE STUDIES AT INDIANA UNIVERSITY

This Baldwin Fellowship supported project contributes to graduate training in prehistoric archeology (Ph.D. program). Mudenda's dissertation topic will deal with prehistoric hunter-gatherer subsistence patterns in Central Zambia, in collaboration with Drs. Nicholas Toth and Kathy Schick. The plan is to combine studies of early technology, human ecology, taphonomy and geoarcheology.

Robin W. Dennell *$9,770 funded*

LATE PLEISTOCENE ARTIFACTS IN THE SOAN VALLEY, NORTHERN PAKISTAN

Dr. Dennell, working with other scientists and the British Archeological Mission to Pakistan will make an independent assessment of the paleolithic stone artifacts and fossils (dated 1.9 million years old) discovered in the Soan Syncline near Riwat. If these artifacts are as old as they were originally dated, significant revisions of current hypotheses of hominid evolution will be necessary.

Y. Fernandez-Jalvo *$4,500 funded*

TAPHONOMY OF ATAPUERCA/IBEAS CAVE DEPOSIT (MIDDLE PLEISTOCENE)

The project aims to understand the taphonomic processes in caves, especially in Atapuerca/Ibeas caves. Thus far, most extensive work has been done in open-air sites, despite the many archeological and paleontological sites belonging to cave systems. For that lack, this project has to be extended to recent cave infillings, to study physical aspects of sedimentation, bone accumulation, etc. Human behavioral, environmental and local paleoecological interpretations will be attempted as conclusions.

John F. Hoffecker *$4,050 funded*

SOVIET PARTICIPATION IN THE SIXTH INTERNATIONAL CONFERENCE OF ICAZ (MAY 1990)

This grant provided for participation of four Soviet scientists at the Sixth International Conference of the International Council for Archeozoology. The group included three researchers from the Zoological Institute, USSR Academy of Sciences, and one researcher from the Institute of Archeology, Leningrad. The project provided an opportunity for these scholars to present some of their important results to their colleagues in the West. The collaboration will facilitate Dr. Hoffecker's continuing research on the Mousterian and early Upper Paleolithic sites of the European USSR.

Russell L. Ciochon *$6,500 funded*

ANALYSIS OF PALEOANTHROPOLOGICAL DISCOVERIES FROM LANG TRANG CAVES, A NEW MIDDLE PLEISTOCENE HOMINID SITE FROM VIETNAM

This study by Dr. Ciochon and co-investigator John Olsen will begin the laboratory analysis phase of the joint Vietnamese-American Paleoanthropological Field Research Project. The most recent expedition (January 1989) resulted in the discovery of a new middle Pleistocene hominid site, Lang Trang Caves, which yielded five specimens attributed to *Homo erectus,* as well as orangutan, gibbon, cercopithecoid monkey and mammalian specimens. A breccia/bone sample has been dated to 500,000 years B.P. which should make Lang Trang Caves the oldest dated hominid site in Southeast Asia. Two Vietnamese scientists, Prof. Kha and Prof. Hao, will bring representative samples of the primate and other mammalian fauna and artifacts recovered from Lang Trang Caves to the U.S. for comparative study and publication.

David J. Daegling *$4,834 funded*

BIOMECHANICS OF EARLY HOMINID MANDIBLES

David Daegling will apply computed tomography to determine compact bone contours in the mandibles of fossil hominids. From information on the amount and distribution of cortical bone in mandibular cross-sections, their biomechanical properties can be determined with unprecedented precision. They will be related to the types of stresses that have been demonstrated to occur *in vivo* in extant higher primates. Thus, the functional significance of mandibular corpus size and shape variation in the hominid fossil record may be more confidently assessed.

Daris R. Swindler *$1,785 funded*

TO INVESTIGATE DENTAL DEVELOPMENT IN *THEROPITHECUS GELADA*

Dr. Nina Jablonski (University of Hong Kong), invited Dr. Swindler to study tooth formation in a sample of *Theropithecus gelada.* Swindler plans to work in Dr. Jablonski's laboratory, X-ray the heads and remove the tooth germs from appropriately aged specimens in her collection for further study.

Shaily Menon *$3,900 funded*

THE ECOLOGY AND CONSERVATION OF LION-TAILED MACAQUES IN A SOUTH INDIAN RAINFOREST

Shaily Menon will carry out a two-part study of the lion-tailed macaque and its rainforest ecosystem for her Ph.D. dissertation research. Part one will test hypotheses about habitat selection by the lion-tailed macaques and obtain data on land use by an indigenous tribe of hunter-gatherers and shifting agriculturists. Part two will use the predictive power of a Geographic Information System to suggest conservation strategies for a newly established Tiger Reserve in India.

Sylvia Ann Hixson *$7,500 funded*

PALEOHABITAT RECONSTRUCTION OF FOSSIL HOMINOID SITES USING MODERN MAMMALIAN COMMUNITY ANALOGS

This, the first of a two-phase project, will develop a new approach to reconstructing the paleohabitats of fossil hominoids. The method involves comparison of extant mammalian faunas powerfully discriminating variables. The second phase (for which funds will be requested at a later date) will use the patterns derived from the analysis of extant communities to examine several fossil assemblages containing hominoids. Environmental change is often postulated as an explanation for aspects of hominoid/hominid evolution and the project is designed to establish a method to assess these propositions. Specimens are housed at the British Museum of Natural History. Morphological data will be collected from these extant species and will form the data set for the discriminant analysis.

Amy L. Campbell *$4,998 funded*

AN ANALYSIS AND SYNTHESIS OF THE EGYPTIAN MIDDLE PALEOLITHIC

Amy Campbell will analyze Middle Paleolithic data from Egypt with respect to controlling two variables: the differences and/or similarities apparent between sites in the Western Desert and sites along the Nile Valley; and the significance played by raw material availability and variation between these areas. Campbell hopes the site will provide an opportunity to examine the spatial patterning of fauna and lithics for a Middle Paleolithic occupation site in the region, and provide material for obtaining much needed absolute dates for this period. This analysis of the Egyptian Middle Paleolithic will contribute to a greater understanding of the similarity and variability represented by the period.

David S. Reese *$3,000 funded*

ANALYSIS OF 1988 BONES AND SHELLS FROM AKROTIRI-*AETOKREMNOS*, CYPRUS

Dr. Reese spent two months on Cyprus completing a study of the 1988 fauna of bones and shells from the ca. 8000 B.C. site of Akrotiri-*Aetokremnos*. Careful analysis is necessary to work out an ageing pattern for these extinct species, the elements preserved, and the study of butchered and burnt bones.

Kate Baker *$8,000 funded*

HIERARCHY FORMATION AMONG FEMALE CHIMPANZEES

Kate Baker will examine female behavior in dominance interactions, and will test hypotheses concerning the significance of sex differences in such relationships. Observations of the formation of a social group of captive chimpanzees will be done at the Detroit Zoo. Data will be collected on patterns of reconciliation and coalitionary behavior as well as videotaped data of aggressive interactions. Baker hopes to distinguish between the relative importance of two explanations for sex differences in investment in aggressive and dominance related behaviors.

Frederick E. Grine *$9,000 funded*

EXPLORATION FOR POTENTIAL PLIO-PLEISTOCENE HOMINID SITES IN SOUTH AFRICA

Dr. C.K. Brain, Director of the Transvaal Museum, South Africa, has invited Dr. Grine to join in a cooperative, systematic exploration for new hominid bearing cave deposits at sites in South Africa. These sites are breccia filled karst caves in Dolomite Series limestones that cover extensive areas of the Cape and Transvaal. They will be identified and mapped, and samples of a fossiliferous breccia will be taken to the Transvaal Museum for preparation and faunal identification.

John Kappelman *$4,000 funded*

A SURVEY OF PLEISTOCENE SEDIMENTS IN THE LOWER INDUS BASIN, PAKISTAN

This project made a survey of sediments in order to assess the feasibility of locating and recovering Pleistocene fossils, including *Homo*, and stone tool artifacts from this part of south Asia. Kappelman proposed the work because this region presents a geological setting in strong contrast to the active tectonism of northern Pakistan.

BOOKS

The following is a list of books of possible interest to AnthroQuest readers. While they are not sold by or available through the Leakey Foundation office, they can be ordered from local or specialty bookstores.

CONFORMITY AND CONFLICT Readings In Cultural Anthropology edited by James P. Spradley/David W. McCurdy, Macalester College. Seventh edition. Scott, Foresman/Little, Brown, Glenview, IL, 1989. pp 491, $12.00 paper.

The broad range of topics covered by this textbook suits the needs of the student and general reader alike. The twin themes of conformity and conflict are treated in ten distinct segments, each of which is a unit in itself. For example, "Language and Communication" comprise four separate readings dealing with disparate avenues of this field, such as nonverbal communication (The Sounds of Silence) or the complex cross-cultural bridges encountered when translating the meaning of Shakespeare's Hamlet to an African bible group.

Some papers have particular significance in understanding the problems of introducing technology to alien social structures. A typical article, "Steel Axes for Stone-Age Australians" by Lauriston Sharp, demonstrates how the *"introduction of an apparently insignificant, hatchet-*

sized steel axe to Australian aborigines altered the relationship among family members, changed patterns of economic exchange, and threatened the very meaning of life itself." The conviction, on the part of the providers, that a steel axe is preferable to a stone axe, is the beginning of a thread of events that leads to a series of misunderstandings and changes in values that provide a strong lesson in the negative effects of Western influence.

Each of the thirty-six papers, complete with review questions, stands alone as a well-rounded sample of explanation dealing with a special aspect of cultural anthropology.

ENCYCLOPEDIA OF HUMAN EVOLUTION AND PREHISTORY edited by Ian Tattersall, Eric Delson, and John Van Couvering. Garland Publishing, New York, 1988. pp 640, $87.50

Reviewed by: John G. Fleagle

From Acheulean handaxes and Africa to Zhoukoudian (Choukoutien) and *Zinjanthropus,* if it is relevant to human evolution you can find out about it in this excellent encyclopedia. The 1200 entries vary in length from a single paragraph up to 10 pages, and were all written by current authorities in the field. The range of topics covers almost every aspect of human evolution and prehistory, including geography (e.g. Africa, Ethiopia, Olduvai Gorge), geology (e.g. glaciation, Miocene, Paleomagnetism), taxonomy (e.g. *Australopithecus,* catarrhines, hominids), anatomy (teeth, skeleton, skull) archeology (e.g. handaxe, Olduwan) as well as biographies of noted paleontologists and archeologists (e.g. Raymond Dart, L.S.B. Leakey, Mary Leakey). The entries are clearly written and well-illustrated with maps, photographs and figures, with supplementary taxonomic charts and geological timetables. Individual entries are extensively cross-referenced to encourage browsing from one topic to another. Overall it is a very impressive book. Anyone interested in human evolution and prehistory should own a copy. ■

Left to right: Gordon Getty, Chairman of the Board; Roy Eisenhardt, Executive Director of the California Academy of Sciences; Leslie Fox, Executive Director; Philip Leakey.

ALLEN O'BRIEN LECTURE 1990

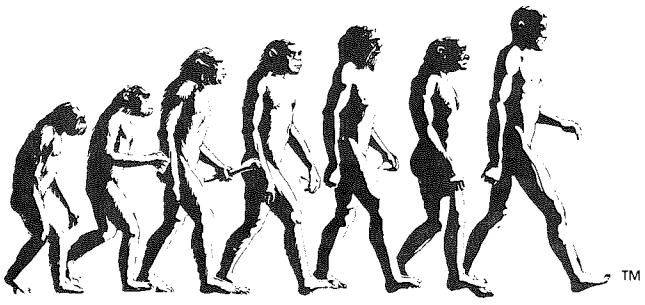
Philip E. Leakey, youngest son of Louis and Mary Leakey, was the Allen O'Brien Lecturer for 1990, sponsored by the L.S.B. Leakey Foundation.

On May 19th at the Natural History Museum of Los Angeles County, and again on May 22nd at the California Academy of Sciences in San Francisco, the Honorable Philip E. Leakey spoke as the Allen O'Brien Lecturer for 1990. Mr. Leakey, who serves as the only white member among the 200 member Kenyan Parliament, focused his remarks on man's need to halt the destruction of the world's environmental resources. "Nature is a very intricate system, and we are stretching its ability to take care of us," said Leakey. "We have to put away our arrogance, and realize that he is not the only species that counts."

Global warming and the geometric increase in our world's population are the two issues confronting us at present. "The people of the world must work together for our survival and think of ourselves as one big family." Leakey said, "The United States is very insular to problems in other countries because everything is available in this country." He suggested that the only success man has had in renewing a resource is our food supply. "This probably accounts for the success of our species. But we are not only dependent on food. We require other resources as well."

In speaking of his experience as a politician in Kenya, Mr. Leakey described a society which is daily becoming more environmentally conscious. He pointed out that the citizens of his country have become concerned and dedicated to the preservation of their wildlife, and that under the direction of President Moi, the issue of conservation is politically viable. Adults and children alike have established a tradition of planting a tree at any ceremony of importance, and the children sing about such topics as soil conservation.

Mr. Leakey answered questions about the banning of the ivory trade and the severity of treatment now given to poachers. Drastic measures have become necessary, he insisted, in order to save this endangered species from total extinction. ■



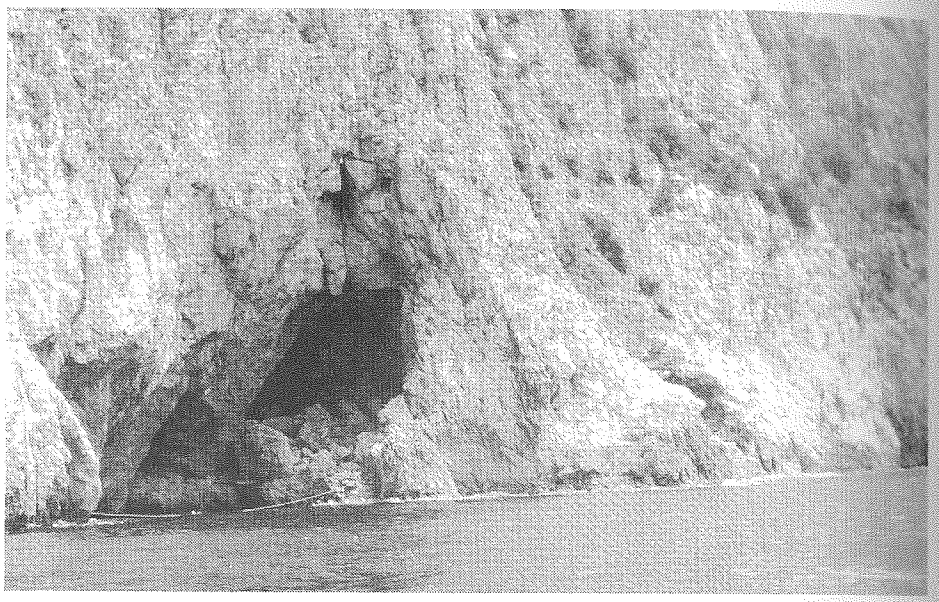
LATE MOUSTERIAN TECHNOLOGY AND FORAGING PATTERNS AT GROTTA BREUIL, ITALY

Steven L. Kuhn
University of New Mexico

Grotta Breuil is one of a half dozen Middle Paleolithic cave sites located in the region of Latium, on the Tyrrhenian coast of Italy (see map). The largest concentration of sites in this area (including Grotta Breuil) is found on Monte Circeo, the mythical home of the siren Circe. The best known site is Grotta Guattari, where, in 1939, vineyard workers discovered a nearly intact Neandertal cranium lying amid a jumble of stones and animal bones.

The Mousterian assemblages from the sites of coastal Latium are quite distinctive, falling within the so-called 'Pontinian' facies, found only in west-central Italy. Finds of human fossils at Grotta Guattari and Grotta Breuil confirm that the 'Pontinian' Mousterian assemblages are the product of Neandertals (*Homo sapiens neandertalensis*) (Manzi and Passarello 1988). 'Pontinian' assemblages are remarkable for the small size of the tools (most are less than 3cm in maximum dimension), as well as for their typological monotony. With a very few exceptions, different types of side-scrapers make up 70% or more of the tool assemblages. Many of the unique characteristics of the 'Pontinian' are attributable to the nature of the local flint raw materials. The only high quality stone found within 50 or 60km of the coast consists of small, heavily abraded flint pebbles which are found mainly in scattered exposures of Pleistocene beach deposits. The small size and scarcity of raw materials sets the region around Monte Circeo apart from many other places with extensive Mousterian records (e.g., southwest France and the Levant), and makes it an excellent natural laboratory for studying aspects of Middle Paleolithic technology.

The most intense period of research on the Mousterian of coastal Latium occurred between the mid-1930's and late 1950's, primarily due to the energetic efforts of A.C. Blanc and co-workers from the Istituto Italiano di Paleontologia Umana. A number of Mousterian sites, including Grotta Guattari, Grotta Breuil, and Grotta di S. Agostino, located to the south near Gaeta, were either tested or extensively excavated during this period.



In 1985, Mary Stiner (University of New Mexico) and I began coordinated studies of the collections of animal bones and stone artifacts, respectively, derived from previous excavations. We were well aware of the limitations for modern studies imposed by the collection procedures common earlier in the century. However, by combining technological and faunal data, we hoped to maximize the behavioral information we could extract from the older collections.

In contrast to the typological monotony of the 'Pontinian' assemblages, our studies of older collections revealed that both technology and faunal remains varied considerably from site to site and level to level. Variation in the use of large game and the techniques used to make and maintain stone tools seem to be closely linked in a number of interesting ways. One of the most surprising observations has to do with apparent changes in both technology and the exploitation of game during the Mousterian.

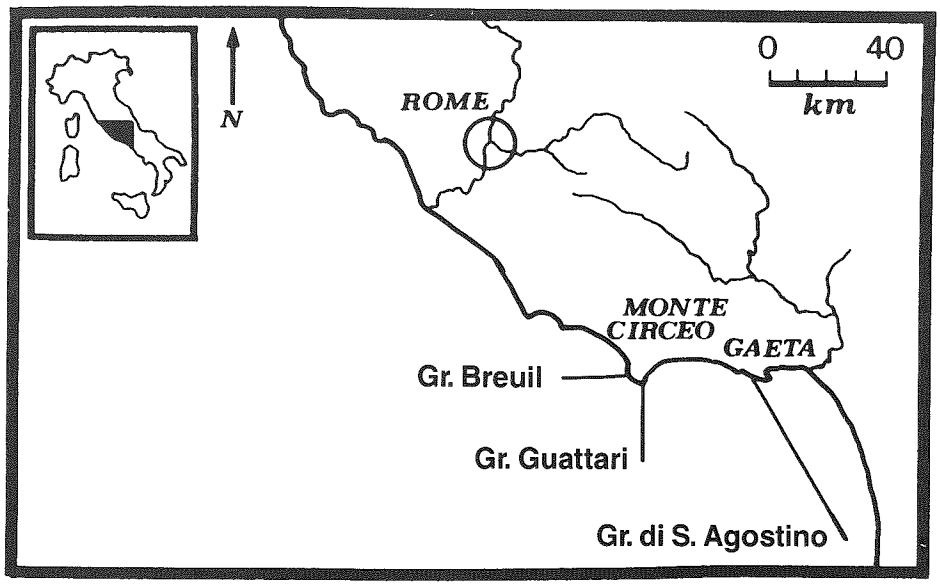
The assemblages from older excavations can be divided into two chronological groups. One group consists of assemblages dating to sometime between 120,000 and 55,000 years ago. Artifact collections are dominated by heavily used and resharpened tools, some of which were probably transported from outside the coastal pebble raw material zone. Flake production techniques, primarily bipolar and centripetal or disc-core techniques, maximized the size of tool blanks produced from small pebbles (Kuhn 1990). The heavily-used tools appear to have been deposited in the context of relatively brief cave occupations. The frequency of faunal remains is often quite low, and there is evidence for repeated and prolonged use of the caves by hyaenas in some levels. The faunas associated with exclusively human use of caves are dominated by cranial elements from

relatively old animals, and scavenging of natural deaths may have been an important means of procuring ungulate resources (Stiner 1990).

The second group contains faunal and lithic assemblages dating to between 55,000 and 40,000 years ago. In these more recent levels, flakes are much less frequently retouched and tools were less extensively renewed. The use of novel types of platform cores enabled the production of relatively large numbers of sharp, 'naturally-backed' flakes from small pebble cores. Raw materials are almost entirely of local origin. These technological developments are argued to represent an increasing emphasis on bringing large quantities of local raw materials to cave sites to 'provision' relatively prolonged occupations (Kuhn 1990). The associated faunal assemblages are dominated by prime-age individuals, suggesting that Neandertals used some form of ambush hunting to obtain them (Stiner 1990). Since virtually the whole range of anatomical elements is represented, it also appears that entire carcasses were carried to and consumed at the cave, an observation consistent with the idea that the later Mousterian occupations were more substantial and prolonged.

Researchers working in other parts of the world have tended to emphasize the stable, unchanging character of the Mousterian, an observation consistent with the widely held notion of Neandertals as an evolutionary dead end, a specialized offshoot of the hominid line. Yet in coastal Italy, important changes in hunting patterns, cave use, and strategies of tool production and use first appear well before the end of the Middle Paleolithic. The evolutionary significance of these developments is not entirely clear, however. The novel character of the later (post-55,000) Mousterian could represent directional, evolutionary change. It might also simply reflect shifts in how this particular group of coastal caves was used within a single adaptive pattern, perhaps related to climatic changes.

In order to investigate the apparent differences between the early and late Mousterian in greater detail, more precise, "high resolution" archaeological data produced by modern excavation techniques, as well as better control over paleoenvironmental variables are needed. Excavations currently underway at Grotta Breuil represent an important opportunity to see if observed patterns of technology and game procurement were in fact constant during the late Mousterian, and if the trajectory of change continues into even more recent Mousterian deposits.



Map of west-central Italy, with sites referred to in text.

The site of Grotta Breuil is located at the base of a high cliff on the western edge of Monte Circeo, directly on the sea. In bad weather, waves break in the rocks at the mouth of the cave. The site can be reached only by boat, and only when the sea is calm. While the spectacular location can greatly complicate the jobs of archaeologists excavating the site, it has also protected the deposits from the looters (*clandestini*) who have severely damaged so many other Paleolithic sites in the region.

Grotta Breuil preserves a long sequence of intact archaeological deposits, which form a steep, wave-cut face approximately 7m high. Much of the *in situ* deposit is covered by an unstable blanket of loose organic soil created by decomposition of the limestone bedrock. Virtually the entire sequence yields Mousterian industry and faunas: there are only ephemeral traces of later occupations. Geological evidence and radiometric dates suggest that the stratigraphic sequence begins with deposits dating to about 90,000 BP and ends with strata formed about 35,000 BP. The entire sequence thus falls within the later part of the Mousterian period, conventionally thought to extend from around 150,000 to 40,000 years ago, but it spans the period of apparent adaptive change noted in our earlier studies.

Although preliminary *sondages* were excavated at Grotta Breuil several times during the 1940's and 1950's, systematic excavation did not begin until 1985. Mary Stiner and I joined the project in 1987. Prof. A. Bietti (University of Rome), director of the excavation, heads an international team of human and animal paleontologists, geologists, palynologists, and specialists in a variety of archaeological topics (lithic technology, use-wear analysis, faunal studies). The central aim of the excavation project is to document Neandertal adaptive behavior in its environmental context during the later half of the Mousterian period, until just before the appearance of modern humans.

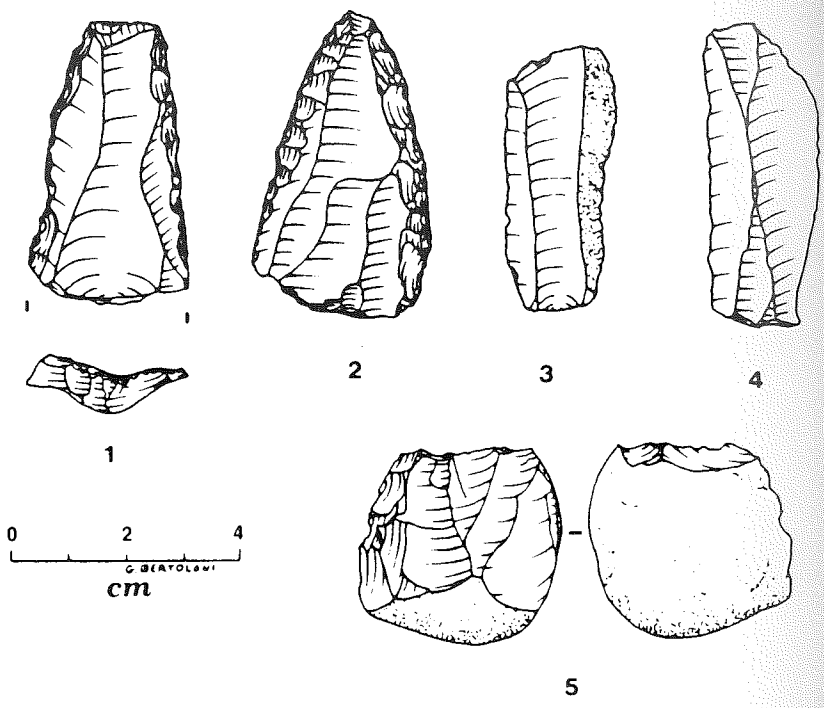
The first three years of excavation were devoted to sampling and removing the blanket of redeposited soils in order to determine the extent of intact strata beneath. It was not until 1988 that we began systematic excavation of intact strata. The most intriguing results from the 1988/89 seasons relate to assemblages coming from the series of thin, heavily

concreted layers, termed stratum 3, at the very top of the sequence. Dr. Henry Schwarcz (McMaster University) has obtained an ESR (Electron Spin Resonance) date of 37,000 BP (± 3000 years) from a sample of ungulate teeth from this level. The assemblages from stratum 3 at Breuil are thus the most recent dated Mousterian materials from west-central Italy.

Excavation in stratum 3 has thus far been limited to a few square meters. Data recovery proceeds slowly due to the heavy concretion of the archaeological deposits and the laborious procedure of plotting all finds in three dimensions. In spite of the small sample size, however, it is clear that the most recent Mousterian assemblages from Grotta Breuil exhibit a combination of features not documented for any other Mousterian assemblage from this region.

The retouched tools from stratum 3 at Grotta Breuil are clearly Mousterian in character (illustration 1-2), although a few very atypical Upper Paleolithic tool forms are present. Flakes and tool-blanks are often elongated and blade-like (illustration 3-4). Levallois technique, a marker of the Mousterian in Europe, is well represented in the flakes and tools, but many large pieces are actually Levallois blades rather than flakes. There are also many platform cores (illustration 5), somewhat reminiscent of blade cores found in Upper Paleolithic assemblages. Although platform cores are common in other recent (post-55,000 BP) 'Pontinian' assemblages, they are particularly abundant in the upper strata at Grotta Breuil. Retouched tools are even less extensively resharpened or reduced than tools from other relatively late Mousterian assemblages.

In contrast to Mousterian assemblages dating between 55,000 and 40,000 BP, a relatively large number of tools found in stratum 3 at Grotta Breuil lack pebble cortex, and may have been made on 'exotic', non-pebble raw materials obtained from outside the coastal zone. The assemblage also contains a conjoinable series of small, unretouched flakes made of an unusual raw material and bearing no traces of typical pebble cortex. The conjoining flakes appear to have been struck in the cave from a



Artifacts from stratum 3 at Grotta Breuil: (1) double scraper; (2) Mousterian point; (3, 4) blade-like flakes; (5) platform core.

core of 'exotic' stone. They represent virtually the only good evidence for the use of cores of non-pebble flint in any Mousterian assemblage from this region.

The association between technological patterns and faunal remains also differs from what has been observed for other Mousterian assemblages. Faunal remains are unusually abundant compared with lithic debris. Like the other relatively recent Mousterian faunas, the assemblage from stratum 3 at Grotta Breuil is dominated by animals killed in their prime, and contains a nearly complete range of anatomical elements (Stiner 1989). The association between this faunal pattern and relatively abundant evidence for the transport of tools (and even raw materials) is precisely the opposite of what was observed in other Mousterian assemblages, however, and is in fact more reminiscent of later Upper Paleolithic assemblages from nearby rockshelter sites.

There is also evidence of a marked change in the local environment within the thin layers which make up stratum 3 at Grotta Breuil. The uppermost layers are dominated by ibex (*Capra ibex*), with smaller quantities of wild ass (*Equus hydruntinus*). The presence of ibex and wild ass is thought to mark relatively cold, dry conditions. Fauna from the layers directly below (but still within stratum 3) is dominated by red deer (*Cervus elaphus*), aurochs (*Bos primagenius*) and horse (*Equus caballus*). This trio of species is common in Mousterian levels in other sites, and is characteristic of somewhat wetter, forested conditions. Interestingly, anatomical part representation, the age structure of the prey populations, and basic patterns of artifact manufacture, resharpening and transport do not appear to vary among the various layers within stratum 3. These findings suggest that the relatively late developments in Mousterian technology, hunting patterns and the use of cave sites were not simply responses to new sets of prey species or environmental conditions. Instead, the observed changes may well mark a fundamental realignment in Mousterian foraging and technology.

The findings from excavations at Grotta Breuil described here are only preliminary. In subsequent seasons, we hope to enlarge our samples from the top of the sequence so that the relationship between technology, hunting patterns, cave use and environment can be explored in greater detail. We will also investigate

deposits lower in the sequence in order to examine the critical period around 55,000 BP. Continued work at the site clearly has the potential to yield valuable insights into the nature of Neandertal foraging and technological adaptations, and to cast some light on that crucial period immediately pre-dating the appearance of modern humans in Europe. ■

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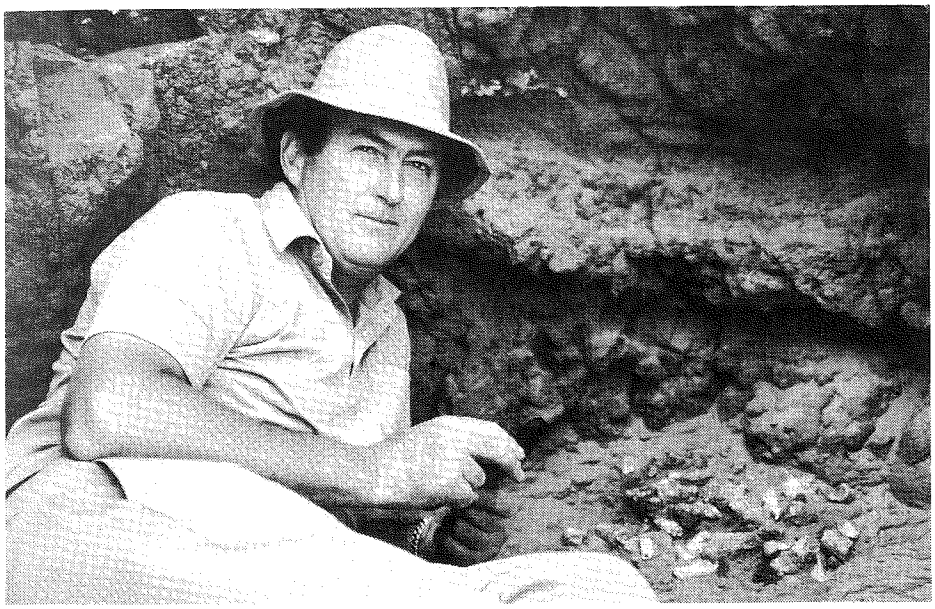
Manzi, G. and Passarello, P. 1988: From Casal de'Pazzi to Grotta Breuil: fossil evidence from Latium before the appearance of modern humans. *Animal and Human Biology* Vol 1: 111-144.

Stiner M. 1990: *The Ecology of Choice: Procurement and Transport of Animal Resources in Upper Pleistocene West-Central Italy.* PhD Dissertation, Dept. of Anthropology, University of New Mexico.

1990 FIELD EXPEDITION TO THE WEST SIDE OF LAKE TURKANA



Dr. Richard E. Leakey

The Leakey Foundation is seeking additional funding to the sum of $15,000 –which will be added to $25,000 already raised for this important work.

This is an exciting time for those interested in the search to understand man's origins and the nature of evolution. Where once theories were based on isolated teeth and skull fragments, they are now based on the steady recovery of fossils which boast nearly complete skeletons for interpretation.

One of the most significant locations under investigation for such discoveries is the Turkana Basin in Kenya, where Richard and Meave Leakey bring together teams of international scientists to discover new evidence of the kind that often fuels debate and challenges our perspective on man's origins and ultimately on his survival and possible extinction.

Background. The well-known paleontological site at Lothagam Hill in West Turkana, Kenya, has been explored intermittently since 1967 when a team from Harvard University, led by Professor Brian Patterson, recovered numerous fossils, including hominids. The geology was studied in detail at the time and it was determined that the site was between 5 and 5.5 million years old. The "youngest" site at Lothagam is older than 3 million years and possibly between 4 and 4.5 million years.

Careful exploration of sediments in the Turkana Basin, Kenya, has continued to reveal the importance of these exposures for the discovery of hominid fossils. In 1989, surveys carried out in West Turkana indicated the presence of extensive exposures of Pliocene and Pleistocene sediments which justified further investigation. In particular, a number of primate and other mammalian fossils were discovered at Lothagam which suggested a field season devoted to this site might be very rewarding.

Importance of the project. Lothagam is primarily important because of its age. Fossiliferous sediments between 4 and 5.5 million years are of particular interest because they document a time when several mammalian groups including the Hominidae were diversifying. Two major questions could be answered by the discovery of a partial or complete hominid skeleton from this period. *The first would be to identify the precise date at which the human and ape lineage diverged. The second would be to identify how and when our own ancestors evolved a bipedal gait.* Both of these "events" must have taken place between 4 and 10 million years B.P. Hominid fossils dating between 4 and 4.5 million years are therefore important because they may record this event, or if not, they will certainly shed light on the timing.

Importance of the site. *Few sites of this age are known and there are very few which yield fossils of such high quality.* Lothagam is known to be richly fossiliferous, and although it has been extensively worked in the past, the number of fossils discovered in 1989 indicate that many more remain to be found in the future. The discovery of a large number of *Primate* fossils suggests a high probability that additional *Hominid* fossils may be found as well.

Field work accomplished in 1989 and planned for summer 1990. During the 1989 field season a number of fossils were found both at Lothagam and in the surrounding areas. These will be collected and their positions recorded on aerial photographs. At Lothagam a number of important non-hominid primate fossils and other mammalian fossils were located. These included a partial skeleton of a carnivore which was eroding from a cliff forming the bank of the river running through the site. As the fossilized hindquarters had become exposed they had dropped into the river bed. These were excavated since there was a danger that some might be swept away and lost in the following rainy season. The excavation revealed the almost complete hindlimbs, and several caudal and lumbar vertebrae. The forelimbs, trunk and possibly also the skull remain in the hard clays of the approximately 15 foot high cliff. Extraction of this important specimen is planned, and an intensive paleontological survey will also be carried out to locate additional fossils.

The camp was closed at the end of September concluding a very exciting and productive field season. Aerial photos are to be taken shortly and then a more intensive season can be planned for next year. This will include geological studies and the collections of samples for dating. Several months will be spent at Lothagam and the two sites near Loperot will be sieved. An excavation of an important 17 million year site at Kalodirr which has yielded a number of skeletal elements of the large ape Afropithecus (Leakey & Leakey 1976) also has to be extended. In the longer term many months will need to be spent working the extensive sediments to the south of Loperot.

In addition to Pliocene sediments, many Holocene sediments are found in the Lothagam area. These contain a wealth of information on the people occupying the lake approximately 4,000 years ago. Numerous graves, cairns and burial sites containing pottery, animal figurines, stone tools, harpoons and other artifacts occur. Some of these sites have already been investigated but the numerous sites in the Turkana Basin warrant an intensive long term investigation. A Kenyan archaeology student at Oxford University, UK will record the sites in the Lothagam area.

The principal personnel active in the expedition to the west side of Lake Turkana are: **Dr. Meave Leaky**–Paleontologist, National Museums of Kenya; **Dr. Alan Walker**–Anthropologist and Human Anatomist, Johns Hopkins University, Baltimore; **Mr. Patrick Nganga**–Geologist, National Museums of Kenya; **Joseph Murugah**–Zoology graduate, Nairobi University; **Christine Kenyatta** –Anthropology student, Oxford University, U.K.; **Robert Mutegi**–Zoology student, Nairobi University; **Kamoya Kimeui**–Coordinator and leader of field crew.

Footnote: *The Hominid Gang,* by Delta Willis makes useful companion reading to this expedition project. In particular, chapters 6-9 provide a fine introduction to the discoveries and personalities involved in work at the Lake Turkana site. Though not readily available at most bookstores, it may be ordered from Discount Buyers Service, (800) 833-0720. ■

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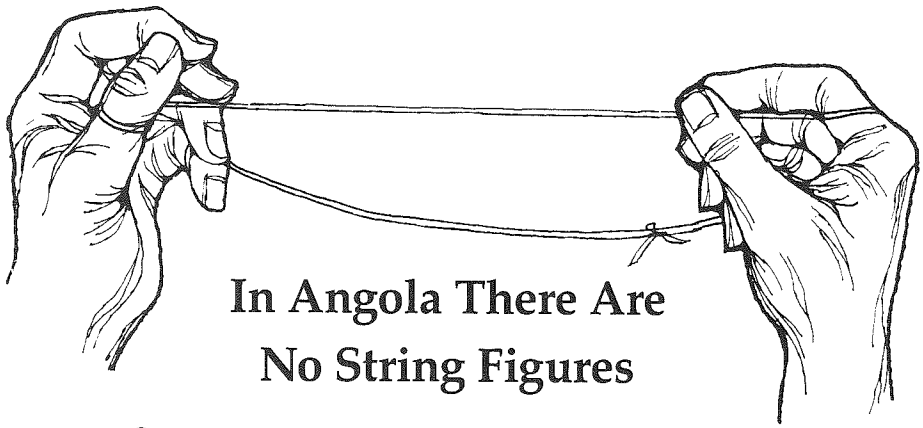
The L.S.B. Leakey Foundation Prize for Multidisciplinary Research on Ape and Human Evolution

Nominations are solicited for the first award, planned for August 1991, of the *L.S.B. Leakey Foundation Prize for Multidisciplinary Research on Ape and Human Evolution.* The Prize is intended to reward intellectual achievement and express appreciation for research performed with courage and perseverance in the fields of Ape and Human Evolution. It will honor a scientist (scientists) for achievement transcending the boundaries of his/her discipline and linking widely differing branches of science. The donor of the Prize expressly wishes to encourage the multidisciplinarian, as well as to stimulate research that gives evidence of broad interests and ingenuity.

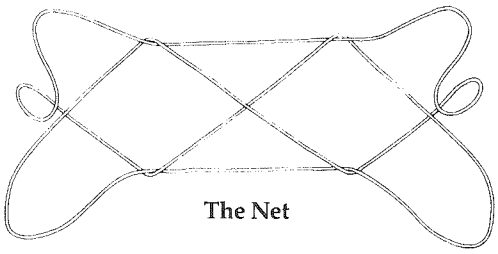
The Prize shall consist of a cash award of $25,000 and a medal commemorating the achievement. While intended to honor the achievement of one person, the Prize may, in exceptional circumstances, be awarded to a team that meets the relevant criteria.

Nominations for the Prize are due on, or before, January 1, 1991 and should be addressed to the Executive Director of the L.S.B. Leakey Foundation, 77 Jack London Square, Oakland, California 94607-3750. The nominating document must be a letter of no more than 1,000 words containing an evaluation of the nominee's accomplishments and specific identification of the work to be recognized. A biographical sketch and a list of publications authored by the nominee must also be supplied. No more than *two seconding letters,* containing factual information not given in the letter of nomination, may be included, or sent separately. It is recommended that all documents be letter size and unbound. ■



In Angola There Are No String Figures

Some personal reminiscences by Louis Leakey



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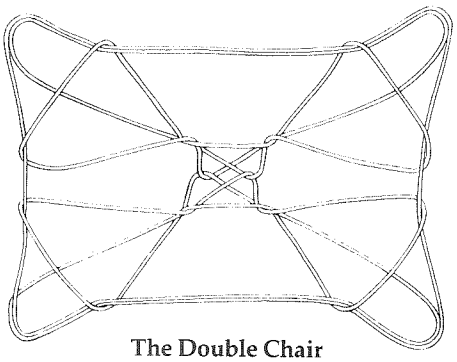
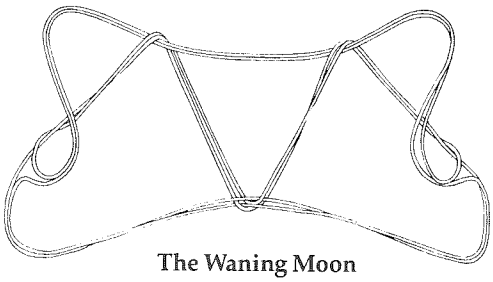
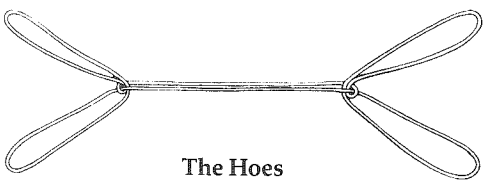


The Double Chair



The Waning Moon



The Hoes

We are indebted to Dr. Edwin S. Munger, Professor of Geography, California Institute of Technology and a past president of the Leakey Foundation, for this charming segment of a "lost" study that was first brought to light about a decade ago.

The following is an extract from Vol. #57, Jan., 1981 of the Munger Africana Library Notes, which featured, "Some String Figures from North East Angola" by M.D. and L.S.B. Leakey following their visit in 1948 to what was then Portuguese territory.

Louis Leakey had a wide repertoire of string figures, each with its own story and a source of delight to children of all ages everywhere.

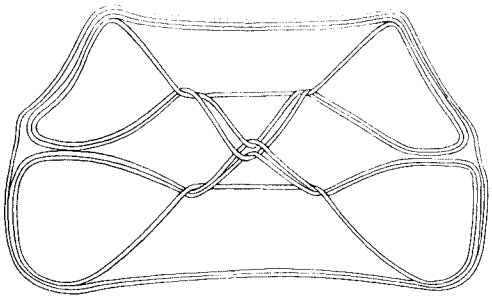
Years ago, towards the end of the last century, anthropologists and travelers in Melanesia, Australia, and the Far East had recorded a large number of string figures. One of my professors at Cambridge, Dr. A.C. Haddon, was foremost among the recorders, and he devised a special nomenclature for the task. Studies in the United States followed, and in 1906 Jayne published a monumental book on all of the then known string figures of the world. In the preface he wrote for this book, Dr. Haddon noted: *"So far no string figures from Africa have been recorded, but recently my friend Cunningham has written to me that he has found some at the south end of Lake Tanganyika."*

Today, probably more string figures are known from the African continent than from any other. One of the strange things, however, is that a few tribes, like my own, the Kikuyu, do string tricks rather than figures. Some of these, which I learned as a child, I discovered were being performed on the stage in England in the early 1920s by British conjurers.

Another interesting fact about string figures is that although there are a few in Great Britain and Ireland that are almost certainly indigenous, the best known, such as "the cat's cradle," originated in China and Korea and were most probably brought to Europe long ago by those who sailed the China seas. From Great Britain they were taken by the Pilgrim Fathers to America; in the United States today these were commonly referred to as "English string figures," to differentiate them from the native Indian ones.

I've found string figures exceedingly useful in Africa. They may have saved my life in 1929. I had been invited to a conference in Johannesburg. It was a long journey by lorry and car and we got stuck in what is now Zambia with a broken axle. People kept moving up and down the road and I kept addressing them in Swahili, *"Jambo...havari?"* But nobody understood a word.

Finally, a well dressed young man came along and I said, *"Good Morning. Can you help me, please?"* He didn't understand a word I was saying. Then I remembered what my Cambridge mentor, Dr. Haddon, had said and I took out a string and made a figure. A big crowd was standing around and they smiled at the figure. So I did another one–a string figure which in the Congo is a password for a secret society. If you can do that in the Congo no one will ever murder or hurt you. You will immediately be persona grata and people will help you.



The Brooms

The people in Zambia smiled at the figure and quite suddenly a shriveled old woman of about 70 put her finger into her waist belt, pulled out a bit of string, and began doing a string figure. I moved up close to her and when she did a figure very, very quickly, I made signs for her to repeat it. I started to follow her. She hadn't started the ordinary way and used an opening I had never seen in Africa before. She went so fast I couldn't get it. Finally, she took notice of my distress and did it a third time slowly. After about five attempts on my part, I was able to reproduce a figure I had never seen before. When I finally got it just right with a flourish the crowd around me went, *"Aaaaaaaaaaah."*

Then the young man who had pretended not to hear a word I had said in English spoke up:

"Oh Sir, I think you were wanting some help."

I thought to myself that he damn well knew I wanted help–some kind of transport to go for a spare wheel and axle. He went on:

"I think the chief has a lorry, I will go and see."

So off he went and by that time the whole crowd had come around and was doing string figures as hard as we could go. The chief came back with his lorry and said:

"If you want the lorry you can take the lorry, sir, to go and get a spare axle."

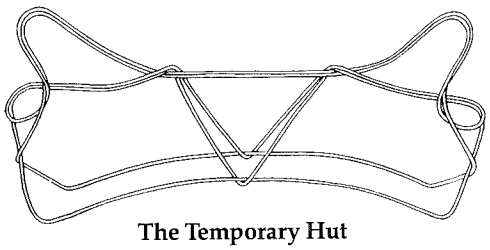
I thanked him and told my traveling companions, *"You stay here and I'll be back as quick as I can with the spare parts. Meanwhile you can make a camp."*

I would have hesitated to leave the women in a place where they couldn't speak a word of the local languages, but once they had string figures, they had friends. When I got back they'd been given eggs, chickens, and other food. Every possible help had been given to them. They had been accepted as fellow Africans and friends and not as beastly white people. The difference was string figures.

A strange thing happened when we went to Angola in 1947. Mary and I had dinner with Dr. J. Redinha, who had studied the tribes there for thirty years and had published books on seven of them. I told him that although string figures are common in East Africa, my own tribe, the Kikuyu, had only a small repertoire of them and asked him:

"What string figures do your people do here?"

He replied: *"My people do not do string figures. There are no string figures in Angola."*



The Temporary Hut

I was astonished with Redinha's reply. To me, this was almost beyond belief. The biggest ethnic groups north of Angola and in Northern Rhodesia, to the east, all had particularly large repertoires of string figures and tricks. Since there were so many cultural resemblances in other respects between these groups and those of northeast Angola, I found it hard to believe that no Angolan tribe practiced this art. However, I did not wish to argue with my host, since he seemed so sure of his facts.

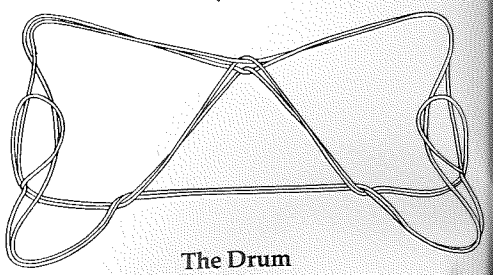
But after dinner when we had retired to his sitting room, I pulled out a string from my pocket. I almost always carry a suitable piece of string wherever I go in Africa. As I sat on the sofa waiting for the coffee and liqueurs to be brought in, I proceeded to demonstrate some of our East African string figures. I was in the middle of a very complicated figure known as "the bed," which is very common in Africa and is known in the United States as "the tent flap," when a servant came through the door carrying a tray loaded with coffee cups, a silver coffeepot, brandy glasses, brandy, and cigars. When he saw me his face turned to utter consternation. A white man doing string figures! He virtually dropped the tray on the table and fled as though in fear of his life.

My host was, naturally, shocked by this display of uncontrolled behavior in one of his highly trained house servants. Redinha was about to rush after the man when I stopped him to explain that I was sure the poor servant had suffered a terrible shock and had better be left alone. He had just seen a foreigner engaged in doing something he probably regarded as sacred and known only to his own people. I also sensed that there was a strong taboo against performing in front of strangers. But I couldn't resist asking my host,

"Are you sure that people here don't know string figures?"

"Yes," Redinha replied, *"I'm quite sure. I've been here thirty years now and there are no string figures in Angola."*

I said, *"Wait. We will see."* Then Mary, who is adept at string figures, and I began to show our host and his other guests a large number of string figures from Melanesia, Alaska, Canada, and Australia, as well as from Africa. As I was doing an Eskimo one and then a South Seas one called "kite (the bird) flying," I noticed the door at the far end of the room open very slowly, to admit the head of the African waiter. Next, at the level of his waist, his wife's face appeared, and below her the faces of three children. A few minutes later the door opened wider, and the cook and his family and a whole bevy of servants were watching. I watched them in silence. Then I asked my host, *"You won't mind if they come in?"*



The Drum

He looked distressed. An African invasion of his sitting room! And by menial staff at that! I motioned the staff to come in and began doing more figures, beginning with the bed again. The Africans watched in

silence for a while. They were wide-eyed as I showed them more figures, especially from the adjoining territories of the Congo and Northern Rhodesia.

Finally, I tossed my string to one of the men, and Mary gave hers to one of the women. They hesitated a few minutes and then, as one took the lead from the other, we were given a fascinating display of Angolan string figures, many of them absolutely new to us.

I turned to my anthropologist friend, *"No string figures in Angola –Sir?"*

Redinha's face was an absolute mask. Neither surprise nor anger showed–just blank, staring amazement. Finally he relaxed and began to question the members of his staff in their own language. He was completely at a loss to know how he could have lived in the country for so long without ever having seen the people he was studying making such figures.

The reason he hadn't seen them was that in Angola string figures can only be done at night. One is forbidden to do them in the day time, possibly because they have religious or magical properties. Or it could be because once you start doing them neither you nor your fascinated audience does any work.

Everyone in the traditional society has to work by day but after supper, sitting by a fire, string figures are done. Often they illustrate stories. Western people might take out a writing pad for a drawing or use a photograph to illustrate a story. In societies without them a string figure does the trick. In parts of New Guinea, for example, many houses are built on poles sticking out of the water. To get away from mosquitos and to give ventilation in the steamy climate, houses are open at both ends. I could illustrate a story about such a house using string figures with my elbows as the stilts.

After the evening with the string figures, Africans were also consternated by us. The news that there were two visiting white "men" who knew how to do string figures spread rapidly through the district. In many places thereafter we were referred to as "white gods." Again and again, as we sat down under a tree to have a quiet smoke or eat our sandwiches, people would appear suddenly from nowhere and stand around staring at us. At first they would be a little apprehensive, but as they gained confidence they would shyly produce strings that had been tucked into their belts and do some string figures for us, to which we in our turn would respond by doing some for them. In this way Mary and I learned many new string figures.

On our last day in Dundo, the president of the diamond company held a dinner party in our honor. I described how the people all over the area had been showing us string figures. After dinner we were asked to demonstrate some of these, and before long we had about sixteen people, including our host, sitting on the carpet with pieces of string learning some elementary African string figures! ■

LEAKEY FOUNDATION NAMED FUNDS

The Foundation is seeking support in several areas of human origins research. These "named" funds honor a special individual and provide support in perpetuity for knowledge of our earliest ancestors. We would like to ask you to consider adding your name to the list of donors by making a contribution to any of the following named funds.

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The goals of the Leakey Foundation in studying human origins are the discovery and recognition of sites, the intense and appropriate study of those sites, and the preservation of this knowledge for posterity. Mary Leakey has made extraordinary contributions to each of these levels of research.

The support generated by the fund for scientific research will continue that legacy.

DIAN FOSSEY MEMORIAL FUND FOR GORILLA RESEARCH

Dian Fossey's twenty years of research changed the world's perception of this endangered species. The work continues at the Karisoke research site in Rwanda, but research must be expanded and efforts must be accelerated to protect this threatened species.

The support generated by this fund will continue Dian Fossey's work.

MARGARET GELL-MANN FUND

Named to honor the late wife of Dr. Murray Gell-Mann, this fund will be used to finance research relevant to the preservation of the great apes or to the preservation of the physical existence or cultural continuity of hunting and gathering peoples. These are the two classes of living beings of greatest interest to the Leakey Foundation and both are in grave danger of extermination.

GLYNN L. ISAAC FELLOWSHIP FUND

During the twenty years that span the period of his work, Glynn Isaac was an acknowledged leader in the most significant advances in the understanding of human behavior from study of prehistoric cultural residues. With a deep and genuine love of teaching, Glynn was interested in training nationals from African countries in various branches of paleoanthropology.

This fellowship will enable young researchers to continue and expand the new approaches to the study of human origins that Glynn Isaac so successfully developed in Africa.

THE LATE NATUFIAN SITE OF SALIBIYA I IN THE JORDAN VALLEY: PRELIMINARY INVESTIGATIONS

Pam J. Crabtree and Douglas V. Campana
Princeton University

Pam J. Crabtree

The transition from hunting and gathering to agriculture is one of the most significant changes in human prehistory. It was accompanied by profound changes in population, settlement, and technology which laid the foundations for the subsequent development of complex societies in the Levant. The Natufian culture of the Levant, conventionally dated between 10,500 B.C. and 8,500 B.C., marks a period of social and technological transition during which both economy and lifeways were radically remodeled. Chronologically, the Natufians lie between the mobile hunter-gatherers of the preceding period (known as the Kebaran) and the later sedentary village farmers of the pre-pottery Neolithic. The Natufian culture is critical to our understanding of the development from foraging to farming, since the Natufians appear to be sedentary hunter-gatherers who relied on the intensive collection of wild cereals and the hunting of gazelles.

The precise details of the Natufian economic adaptation remain unclear, but indirect evidence, such as the presence of grinders and of flint blades bearing a distinctive gloss left by silica in plant stems, suggests that the gathering of wild grain had become a major element in the diet. The trend toward a greater dependence upon cereals appears to have begun in the preceding Kebaran period, when the climatic changes that accompanied the close of the Pleistocene led to the expansion of the oak-pistachio parklands, with associated wild cereals, throughout the Levant.

Many of the larger Natufian sites, which appear to be base camps, are situated on the boundaries of the oak-pistachio region. In these locations the Natufians could make use of the parkland resources of grain and nuts, as well as the abundant wild gazelle on the adjacent grasslands. Larger sites such as Mallaha and Nahal Oren indicate that at least some Natufians were becoming sedentary. Other smaller sites probably served as specialized exploitation camps. Base camps differ from smaller encampments both in size and in their possession of permanent architecture. Excavations at Mallaha, for example, revealed substantial architectural remains including stone foundations and plaster floors. The Natufians also possessed a much broader artifact inventory than was present in the preceding Kebaran period, including a variety of bone tools, many decorative items such as beads, and art objects which reflect a considerably richer technology than had existed previously.

It is clear that the study of Natufian subsistence and technology can contribute to our understanding of the economic, social, and demographic changes that accompanied the transition from hunting and gathering to agriculture. A wide variety of models has been proposed to explain the shift from foraging to farming. In order to assess these various models we need to answer several important questions. These include: (1) the nature of the Natufian settlement system, (2) the size and degree of permanence of the Natufian settlements, and (3) the nature of the environment surrounding the Natufian settlements during the terminal Pleistocene.

It was with these aims in mind that we undertook the excavation of the site of Salibiya I, a late Natufian site located in the Lower Jordan Valley about 230m below sea level and about 17km north of Jericho. The site was initially discovered about ten years ago as part of a survey of the area directed by Professor Ofer Bar-Yosef. Our group, which included Anna Belfer-Cohen of the Hebrew University of Jerusalem, began excavations during the summer of 1987. The initial phase of the project being funded by grants from the National Geographic Society, the L.S.B. Leakey Foundation, and Princeton University, and subsequent study of the fauna through a grant from the National Science Foundation.

Salibiya I is located near the settlement of Netiv Hagdud, where an early Pre-Pottery Neolithic (PPNA) site is also located. Another PPNA site, Gilgal is also nearby. The site area is an open grassland in the winter, completely dry in summer. Today Salibiya I is surrounded by a highly dissected badlands topography, cut by many wadis which are wet only in the winter, but all this erosion is post-Neolithic in date. During Natufian times the site appears to have lain in a somewhat low-lying marshy area fed by a number of springs. Pollen analyses suggest that the surrounding environment supported a steppic vegetation with few trees. The site would not have been very far from the shores of Lake Lisan, which during the Pleistocene took the place of today's Dead Sea and filled much

of the Lower Jordan Valley. The site is underlain by the Lisan Marl deposit, the result of an early formative stage of the Lisan Lake, which by the time the site was occupied had withdrawn from its greatest Pleistocene extent. Black marsh clays, in which the Natufian site is found, directly overlie the Lisan Marls. Superimposed upon this layer are redeposited reddish silts, known as terra rossa. It is in this upper layer that the pre-pottery neolithic sites are found. At Salibiya, this layer, which ranges up to 50cm in thickness, contains few artifacts, and protects the site.

Most Natufian sites are located upon terra rossa soils, where much of the wild grain of the Levant grows. Unfortunately these soils do not preserve organics and charcoal well. As a result, although substantial quantites of grain have been found at the contemporary site of Abu Hureyra in Syria, there is little direct evidence for the use of grain within the central Natufian area. In contrast, Salibiya I offered the potential for excellent organic and charcoal preservation. Quantities of grain and other organics had been found in the adjacent neolithic sites of Gilgal and Netiv Hagdud, and a high organic presence had been noted in the initial testing of the site itself. The possibility of obtaining direct evidence of the nature of the cereal resources used by the Natufians within the core cultural area was one of our principal reasons for undertaking the excavation. This is of particular importance because Salibiya I lies within the area native to wild emmer wheat, of the type later domesticated in the neolithic of the region. The wheat found at Abu Hureyra, by contrast, was of a different type, known as einkorn.

A second motivation lay in the location of the site at the periphery of the core area; an ecotone between the Mediterranean and steppe-desert vegetation zones. This environment may favor the growth of wild grasses including cereals, although small environmental changes may have a marked effect on the flora and fauna of the region. Recent thinking has suggested that a postulated environmental deterioration (a dry phase) at the end of the Natufian period may have placed a stress upon the Natufian resource base, and led to a shift in their food procurement strategy. As Salibiya I would have been in an ecotonal zone, such a stress would have been felt most strongly there, and a shift in settlement pattern or food collection strategy may have been reflected in the archaeological remains.

The immediate goals of the first season's excavation were modest. We needed to determine the extent, depth, and complexity of the site, and to verify whether the organic, floral, and faunal remains were likely to provide the information we desired. The excavated area is still small, consisting of a two by two meter trench excavated to the top of the first minimally disturbed Natufian level and a one meter trench excavated to the bottom of the deposit. A rapid survey of the area indicated that the site was larger than we had anticipated, with about 1200m^2 remaining to be excavated.

The original site must have been considerably larger, but it has been eroded away by the surrounding wadis. Exposures of black clay occur at the same level as the site in numerous places on the wadi banks. Many of these exposures contain flints, bone, and charcoal, indicating that the original occupation must have been extensive. Our stratigraphic test trench indicated that the total depth of the Natufian deposit at Salibiya I is about 95cm. It is probable that the whole of the Salibiya Depression, about a square kilometer in extent, was dotted with Natufian encampments during late Natufian times. The Natufians must have camped there soon after the first formation of the depression, as their artifacts penetrate almost to the bottom of the meter of black deposit.

Our initial excavations indicate that the deposit is sub-divided into several distinct strata or interdigitated lenses, but it will require additional survey and excavation to verify the stratigraphy. It appears, however, that the most intensive occupation falls in one of the lower strata, as can be seen from the distribution of point-provenienced animal bone remains. This lower stratum also produced an abundance of artifactual material and fire-cracked rock. It lies approximately 20-30cm below the area that has been excavated in our 2m by 2m trench, and we hope to expose this stratum in our next field season. It appears that the initial intensive occupation was followed by a series of less intensive visits, as evidenced by decreased quantities of animal bones, artifacts, and fire-cracked rock in the upper strata.

Permanent Natufian dwellings have not yet been found in the Jordan Valley. While there may have been structures at Salibiya I, perhaps of an ephemeral nature, not enough area has been exposed to determine their exact form. A stone feature associated with some clay deposits in the uppermost layer suggests a possible hut floor, but this is uncertain and requires further investigation. The point-provenienced animal bones lie within this putative structure. Deposits of clay which may have been puddled for flooring or walls were found, as were several fragments of plaster, but not enough has yet been recovered to be sure if these represent any permanent structure. All these questions should be answered by the close of our next field season. On the basis of the current evidence it seems reasonable to classify Salibiya I as a seasonal camp, using Bar-Yosef's terminology, based on the flimsy architecture, scarce heavy-duty tools, and the absence of graves. Two small fragments of human bone were recovered from the excavations, but there is as yet no clear evidence for burials.

Salibiya I contains the full range of artifacts usually associated with the Natufian. The lithic are currently being analyzed by Anna Belfer-Cohen. The site is characterized by many small, unifacially retouched lunate microliths, which are characteristic of the late Natufian. This is in line with a radiocarbon date of 11530 ± 1550 (RT-505A) (ca. 9500 B.C.) by Joseph Schuldenrein for a nearby associated deposit. Other finds include bone tools, many beads made from dentalium shells, bone and stone, and an inscribed limestone fragment. Many fragments of wood charcoal were recovered in well-preserved condition, suggesting that carbonized grain, if it existed, will have also been well-preserved and awaits recovery. We are very encouraged that plant remains will be found in following years.

Replica of a leopard phalanx, a magnified view showing cut marks left from skinning the animal.

Our most valuable source of information from the first excavation season was the abundant faunal material. The analysis of the animal bones, which was carried out during the summer of 1988, reveals that a wide range of animal species was exploited by the Natufians at Salibiya, including gazelle, wild pig, fallow deer, wild goat, wild cattle, fox, hare, common badger, leopard and other smaller wild felids, ducks, raptorial birds, and tortoises. This wide range of animal species which were used, at least on an occasional basis, by the Natufians at Salibiya would provide some support for the "broad spectrum revolution" hypothesis, a proposed widening of the range of food resources utilized in the later Pleistocene. As is the case for most other Natufian sites, however, the vast majority (nearly 90%) of the large mammal remains are those of gazelles. Wild pigs are a poor second, while the other large mammals are represented by only small numbers of fragments.

The gazelle remains include substantial numbers of juvenile individuals, especially those between 8 and 18 months of age. This pattern is apparent in both the upper and lower levels of Salibiya I, and at a number of other Natufian sites. The causes of this mortality pattern are as yet unclear. Increased hunting pressure and changes in hunting techniques may have led to the slaughter of larger numbers of immature animals. The next step in our analysis will be to prepare thin-sections of the teeth and to examine the cementum annuli, which can provide indications of the season of death for the gazelles.

The Salibiya I faunal assemblage also included substantial numbers of smaller mammals, and, in particular, of hare and fox. Many of the small mammals are carnivores, and it also seems reasonable to suggest that many were slaughtered for their pelts. This suggestion is supported by the discovery of a leopard second phalanx showing cut marks on the plantar surface which could have resulted from skinning (see illustration). Cut marks provide other evidence for the use of secondary animal products. For example, the radius of a fox shows cut marks which would have resulted from the removal of sinew.

One of the most striking features of the Salibiya I faunal assemblage is the presence of large numbers (115 identified so far) of phalanges, primarily terminal phalanges, of raptorial birds. Very few other body parts of raptorial birds are present in the collection. The distribution of the point provenienced raptorial bird phalanges is identical to that of the gazelle fragments, indicating that these bird phalanges entered the faunal assemblage as a result of human activity. It is a distinct possibility that the Natufians collected the talons of raptorial birds and used them for decorative purposes.

Previous analyses of fauna from Natufian sites have focused on the role of animals in the diet, and from this perspective, the Salibiya I faunal assemblage provides no surprises. The large mammal remains are predominantly those of gazelles. If we view the small mammal and bird remains from Natufian sites simply as food remains however, we will underestimate their economic importance. The real value of the Salibiya I faunal assemblage is that it illustrates the importance of *non-food* uses of mammals and birds for the Natufians. Pelts, hides, sinew, talons, and feathers may have been as important as meat and marrow.

The size, integrity, and excellent preservation conditions for this site indicate that a much more extensive excavation will be warranted. A broader excavation should clarify the nature of the settlement pattern. We have high hopes of recovering floral remains, and perhaps the faunal materials have further surprises in store.

While the first season of excavation at Salibiya I may have raised more questions than it answered, several conclusions can be drawn which shed light upon the nature of Natufian subsistence and settlement in the Jordan Valley. The presence of deer, pig, and waterfowl indicates that the area around Salibiya I would have been a favorable environment even during the relatively dry late Natufian period. The faunal evidence supports the geological reconstructions which suggest that the area around the site was a seasonally inundated marshy environment fed by freshwater springs. The depth of the cultural deposit and the density of the artifactual and faunal materials suggest that Salibiya I was occupied intensively for a relatively long period of time. While Salibiya I lacks the permanent stone architecture seen at sites such as Mallaha, it should not be seen as a temporary exploitation camp. Even if the site was not permanently occupied on a year round basis, it might perhaps be seen as a seasonal encampment, perhaps for the intensive collection of resources such as gazelles, pigs, birds, and deer. Moreover, the Salibiya data suggest that regional and continental models of climatic change are not sufficiently finescale to explain changes in subsistence practice on the local level. ■

DEVELOPMENTAL BIOLOGY OF EARLY HOMINIDS: NEW PERSPECTIVES FOR PALEOANTHROPOLOGY

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GLOSSARY

Circadian. This word means "around a day". Seven to eight cross-striations, on average, occur between adjacent stria of Retzius (see Perikymata). Each cross-striation represents one 24-hour increment of enamel formed and is hence the result of a circadian rhythm of enamel formation.

Nasoalveolar. The nasoalveolar contour of the face is seen in the skull profile. This contour is formed by the tooth bearing portion of the upper jaw below the nasal cavity. In *A. afarensis* and *Homo* one can see a more or less convex contour while in *Paranthropus* and *A. africanus* this contour is normally straight.

Nasocanine. The nasocanine contour of the face is seen in the skull profile. This contour is formed by the lateral margins of the nasal cavity and/or robust roots of the canine tooth that extend upward into this vicinity. In *A. afarensis* and *Homo* one can see this contour but in *Paranthropus* and sometimes in *A. africanus* this contour is hidden from view by the forward positioning of lateral parts of the facial skeleton.

Ontogeny. Ontogeny may be generally defined as the course of growth and development from conception to the attainment of adult characteristics. Some authors define ontogeny further to include changing features and life history characteristics during adulthood until death. Alterations to the characteristic ontogeny of a species over evolutionary time is *phylogeny.*

Orthognathism. This refers to the relative extent to which the jaws remain significantly below the upper facial region, or the most forward aspect of the braincase.

Perikymata. This word means "wave around". Perikymata are often visible on human and hominid permanent incisors over the forward-facing surface of the tooth crown. They are the surface manifestations of striae of Retzius which are a systemic defect in tooth enamel production that occurs, on average, every 7 or 8 days. Perikymata are gross incremental features often visible by eye that appear continuously around the tooth as a low trough and ridge or as a sharper imbrication line (like the edge of overlapping tiles).

Prognathism. This refers to the relative extent to which the jaws protrude significantly in front of the upper facial region, or the most forward aspect of the braincase.

Pterygoid. The pterygoid complex is part of the bony base of the skull that meets the upper jaws behind. The pterygoid complex is often considered a 'buttress' against which the upper jaws grow. This is a very important architectural point in the developing skull whereby the remodeling direction of the pterygoid complex will determine to some extent the direction of growth of the jaws.

Remodeling. All bone developing (forming) and resorbing cell activity concerned with the growth, maintenance and adaptation of bone. The term remodeling is qualified here to include 'bone growth remodeling', meaning the processes responsible for the development of the sizes and shapes of bones.

Taphonomy. This term means "the laws of burial". It incorporates the study of the death, decay and modification of organic and mineralized tissues. The result is a sampling of the living community in geological context. The study of taphonomy can thus aid in paleoecological reconstruction and descriptions of other physical and biological agents acting on fossil materials.

Researches on the developmental biology of early hominids have been progressing at a phenomenal rate these last several years. In particular, one branch of the biological sciences, "mineralized tissue biology", concerned as it is with the developmental biology of bones and teeth, is contributing much to our understanding of human evolutionary history and is briefly summarized here.

Paleoanthropologists have mainly the fossilized bones and teeth (the hard parts) of our early hominid ancestors through which to reconstruct hominid biology and behavior. Archeologists and **taphonomists** recover other important evidence of early hominid behavior (e.g., stone tools and cutmarks, fossil footprints, site formation processes, etc.), but only the bones and teeth of hominids can demonstrate to us their morphology, which then may reveal function, and more general interpretations of their biology and systematics. To date, descriptive and functional morphological studies at the whole bone level characterize the overwhelming volume of research on early hominid skeletal material.

Recently, however, paleoanthropologists have looked more intently at the developmental and functional biology of early hominid skeletal and dental *tissues* (mineralized tissue biology). In the main, these studies have focused on mechanisms/processes of growth (ie., the secretory activities of bone and tooth forming cells) and hence the developmental dynamics of fossil hominid teeth and bone. The development of these tissues are patterned into the growth period with other maturational events and so their comparative study enables us to say more about early hominid life history than has been known or appreciated before.

Approaches to fossil hominid skeletal and dental development prior to the 1980's concerned themselves with "patterns" of **ontogenetic** change. Skeletal studies compared juvenile to adult skeletal parts of the same species (or to a comparative primate sample) and inferred the growth necessary to accommodate the difference between them. Dental studies compared the pattern of development, eruption and wear of early hominid teeth to human and chimpanzee developing dentitions. One particularly influential study by Alan Mann on four *Paranthropus* mandibular fragments led to the conclusion that early hominids demonstrated a *Homo*-like, rather than primitive pattern of growth and development, despite the criticism by Mark Skinner that to compare the worn teeth of hominids to those of chimpanzees suffers from many unknown factors, not the least of which was the unknown duration of tooth wear for each specimen compared.

With these beginnings, and notably the encouragement and help from Becky Sigmon, Alan Walker, Alan Mann, Mark Skinner and others, the L.S.B. Leakey Foundation supported my proposal in 1982 to investigate actual growth mechanisms (ie., bone growth remodeling) responsible for the facial development in early hominid species of *Australopithecus, Paranthropus,* and early *Homo.*

Methods appropriate to the proposed study employed high-resolution replication materials by which the microanatomy of both forming and resorbing surfaces, characteristic of the bone growth **remodeling** mechanism, could be examined by scanning electron microscopy (SEM). And so, for one year I researched replication techniques in the Materials Science Laboratory of the Dental School (University of Toronto) directed by Dennis Smith. Amply satisfied with the 0.1 of one micron resolution, I collected facial skeleton replicas of 60 modern human children, 40 immature chimpanzees, and virtually the entire sample of immature African Plio-Pleistocene hominid craniofacial specimens; about 40 specimens.

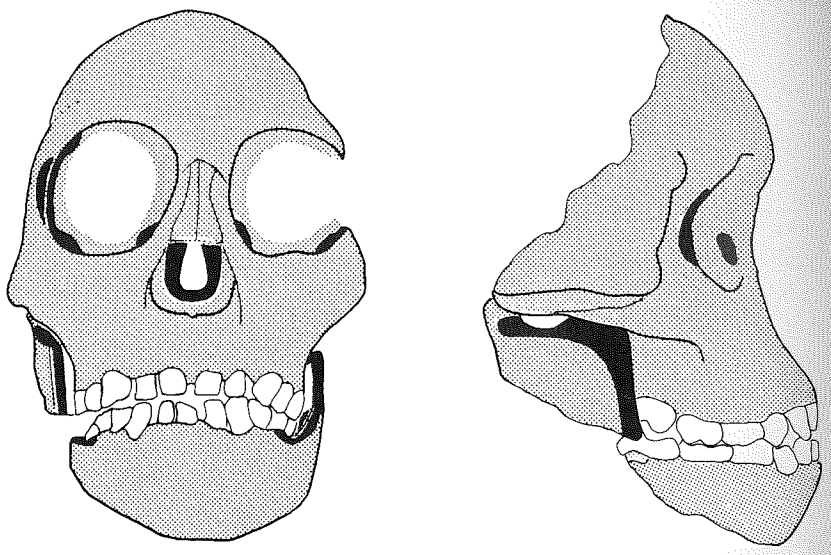

Figure 1. Frontal and lateral views of *Australopithecus* facial remodeling, superimposed onto the Taung child (*A. africanus*) about 3.3 years old (Bromage, 1987). Black represents resorption and grey represents deposition.

After nearly two years of travelling, I stopped through London to visit Alan Boyde (University College London). Boyde, together with Sheila Jones, pioneered SEM interpretations of developing bone and teeth. My bag of hominid facial replicas titillated their interest and I was invited back to London for three months. Others working with Boyde when I returned were Lawrence Martin who was just finishing his doctoral dissertation on aspects of enamel thickness and development in ancient apes and hominids, and Chris Dean who had just finished his dissertation on aspects of ape and hominid cranial bases. Indeed, Boyde's unit, while distinguished for many other reasons, became *the* center for mineralized tissue research in paleoanthropology.

Upon my arrival in London I took my first peek at the 'life' of an early hominid face on the SEM, only to find it was nothing remotely like the remodeling surfaces I had been taught to recognize. It became clear that a considerable research endeavor on experimental taphonomic studies of bone microdamage was essential to this work. In this case it was not as relevant to know what taphonomic processes damaged the bone surface, but simply to know that the surface had been damaged. By experimentally abrading developing bone surfaces it was possible to begin to "understand" that (1) the surface was indeed altered, (2) that this damage was distinct from the appearance of normal bone surfaces and that (3) once the damage was understood in this way it was possible to "read through" the damage, as if it were "noise" in the system, to see the biological information underneath. The importance of this research in microscopic taphonomy cannot be underestimated.

The results of the bone growth remodeling research were acquired after an estimated 900 hours of SEM time and years after my three months had expired. Six years later, these results and interpretations, published in the *Journal of Human Evolution* and summarized here, indicated that *Australopithecus* (often referred to as the gracile australopithecine) was characterized by bone deposits on forward-facing aspects of the face. This was combined with a forward-drifting **pterygoid** complex, emphasizing the forward growth of the midfacial region. *Paranthropus* (often referred to as the robust australopithecine) was characterized by resorption over some forward-facing aspects of the face and the lower jaw. Curiously, this, together with a downward-drifting pterygoid complex, was similar to that seen in modern humans. Thus specimens attributed to *Australopithecus* retained the primitive ape-like facial

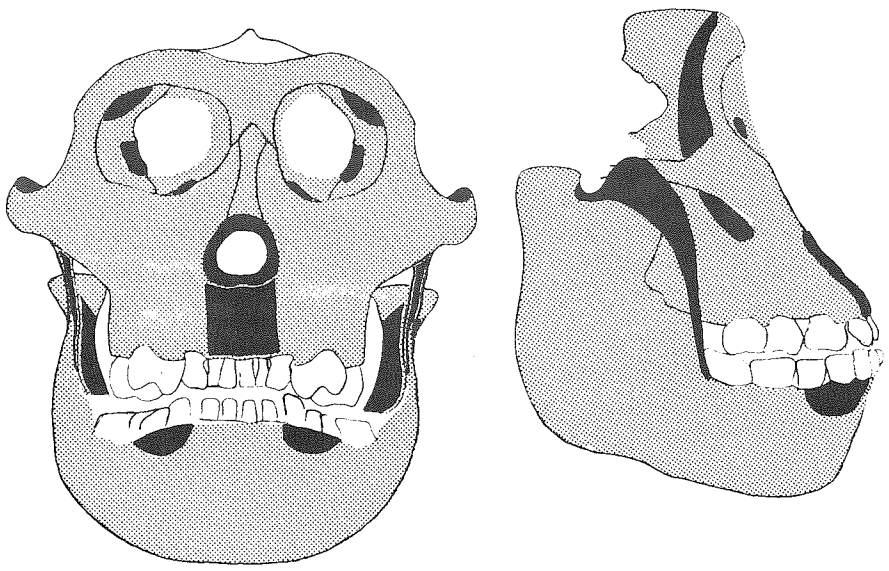

Figure 2. Frontal and lateral views of *Paranthropus* facial remodeling, superimposed on a construct largely based on the Swartkrans 52 facial skeleton (about 11.3 years old: Bromage, 1987) and the Swartkrans 23 mandible (note that in lateral view the ascending ramus of the mandible is drawn and superimposed over the rear of the upper jaw which is showing through). Black represents resorption and grey represents deposition.

remodeling pattern, reflecting their relative facial **prognathy** compared to modern *Homo*. *Paranthropus* exhibited a unique facial remodeling pattern somewhat paralleling modern *Homo*, accounting for the relative **orthognathy** of this taxon. Early *Homo* facial remodeling could not be as satisfactorily appraised, but lower jaw and midfacial remodeling was demonstrably like that of *Australopithecus*.

There is a relation between phylogeny and ontogeny and, indeed, phylogeny can be defined on the basis of shifts of ontogenies through time. Thus ontogenetic data may inform us about and test claimed morphological transformations over evolutionary time. For instance, research during the last decade has suggested that *Australopithecus africanus* shares many derived features with *Paranthropus* and that *Australopithecus afarensis* shares many primitive features with *Homo*. These morphological studies have been used to support a view that because *Australopithecus africanus* is already derived in the direction of *Paranthropus*, *Australopithecus afarensis* currently represents the best last common ancestor of all later hominids. We may now test this hypothesis with ontogenetic "characters"– the ontogenies of early hominids.

One of the many features that can now be evaluated for their *ontogenetic* character states in these taxa is the exposure of the **nasocanine** and **nasoalveolar** contours of the face when looking in side view. *Australopithecus afarensis* is figured to share this "primitive" feature with *Homo*. We now know that this feature in *Australopithecus afarensis* is the result of bone deposits over all forward-facing aspects of the face that serve to emphasize the forward growth vector of the midface. However, in modern *Homo* we know that bone resorption over much or most of the forward-facing aspects of the midface serves to emphasize the downward growth vector of the face. Thus, different ontogenetic mechanisms characterize the morphological similarity between *Australopithecus afarensis* and *Homo*. From the ontogenetic point of view this suggests that *Homo* facial remodeling may represent the uniquely derived character state while the morphological similarity represents a convergence. This convergence would be due either to the reacquiring of the primitive condition found in *Australopithecus afarensis* or be due to the maintenance of this primitive trait but with new underlying principles (e.g., new function). Alternatively, it may be that a change in ontogeny (from *A. afarensis* to *Homo*) was required to maintain some architectural relationship (and morphological similarity) or function, and that this ontogenetic change represents an appropriate transformation series. While this latter alternative is a possibility, it has yet to be demonstrated.

I originally embarked on studies of early hominid dental development with Chris Dean because the age in chronological years, at which bone growth remodeling and morphogenetic events actually occur, is the dependent base on which to assess, for instance, differences in *rates* of bone growth remodeling between modern humans, early hominids and the apes. And so in 1985 Dean and I published the first of a generation of studies on early hominid developing dentitions that challenged the prevailing view on which hominid studies were based. We noted that coarse incremental growth markings in enamel, called striae of Retzius, could be seen passing obliquely from the enamel-dentine junction to the tooth surface where they became visible as perikymata (particularly on human and hominid permanent incisors). Whereas the amount of enamel between stria of Retzius can and does vary, there is an average of 7-8 daily increments (cross-striations) between adjacent stria of Retzius. Cross-striations occur along the lengths of enamel prisms and it has been generally accepted that they result from a circadian variation in the rate of matrix secretion by enamel forming cells. This suggests that, in turn, perikymata occur with the same near-7 day, weekly, or circaseptan periodicity.

Hominoid lower incisor and upper central incisor crowns begin to calcify around birth up to about 3 months of age. In addition, studies show that up to 6 months worth of enamel increments formed do not reach the tooth surface (these are sometimes called hidden increments). Thus by counting the number of perikymata on incomplete or nearly complete incisor crowns and adding a quite liberal 9 months for these two estimated variables, crown formation times could be obtained. But as these crowns begin to form around birth, these times also represent age at death. Dean and I had no preconception, no vested interest in

any one particular result. We were exploring.

Finally, we obtained chronological ages at death for several early hominid specimens which was interesting but not important in and of itself. What was important was that specimens aged at something like 3 to 3.5 years on the basis of incisor crowns with little or no root development also had first permanent molars coming into occlusion. In humans the central incisors erupt into the mouth about the time of the eruption of the first permanent molars, at around 6 years of age. In living apes the first permanent molars erupt at around 3 to 3.5 years of age during which time their central incisor crowns are formed and have little or no root; their central incisors erupt into closer proximity to the second permanent molar. Thus the *pattern* of incisor development and eruption in *Australopithecus,* for instance, was demonstrably like that of the living apes. But, in addition, the *rate* of dental development was demonstrably like that of the living apes as well, inasmuch as their first permanent molars had erupted at around 3 years of age. *Paranthropus* on the other hand was clearly human-like in its *pattern* of incisor eruption (ie., coincident with the first permanent molar) but their first permanent molars were erupting at an early age (ie., around 3 years instead of 6 years as in humans), illustrating the ape-like maturation period in which these events were taking place. These results represent a new perspective through which we may interpret aspects of early hominid biology and lifestyles.

Within the last three or four years, more than a dozen contributions by Chris Dean, David Beynon, Glen Conroy, Holly Smith, myself and colleagues, employing a variety of independent methods (e.g., enamel incremental periodicity, rate of enamel formation, radiographic imaging, computerized tomography, dental developmental pattern, and life history correlation) have indicated that Plio-Pleistocene hominid growth and maturation periods were more like those of modern apes than humans.

However, while there has yet to emerge a coherent objection to this new perspective, critics have noted in the lay press that incremental features of enamel employed in a few of these studies, were *assumed* to represent daily and circa-septan rhythms. There has been much circumstantial evidence collated over the last 75 years to demonstrate this. For instance, in the early 1960's Alan Boyde counted every cross-striation from the neonatal line through the developing dentition of a child and obtained an age at death consistent with conventional age determinations.

An *experimental* study of enamel incremental periodicity was required to test this assumption. I was drawn to such a study because at the most fundamental level of investigation, that is the enumeration of enamel circadian increments, it represents a method of determining the duration of life history periods over which enamel is formed that is *not* dependent on intra or interspecific developmental *variation.* With this confirmation would come additional objective support to dental developmental studies employing enamel incremental features in the data base. And so with help from the L.S.B. Leakey Trust, in England, I examined developing teeth of macaques which were sequentially labeled at recorded intervals with fluorescent substances. At the 1989 annual American Association of Physical Anthropologists meeting in San Diego I was able to confirm, for those who had any doubt, that indeed cross-striations represented daily incremental events.

The importance of experimental research as a complement to mineralized tissue research on anthropological problems is paramount. Experimental research in microscopic taphonomy is necessary for all microscopal applications. Experimental research on mineralized tissue development and morphology are important for a more complete understanding of the processes acting on bone and teeth in the fossil record and over evolutionary time.

It is clear that mineralized tissue biology has a great deal to contribute to our understanding of human and animal evolution. Where fossils were once dead lumps of bone, teeth and morphology, they now reflect many important aspects of the lives of their owners. We can translate the *cellular* behavior of these fossils' bone and tooth forming cells into ontogenetic and phylogenetic data, and even now begin to characterize aspects of early hominid life history. For instance, Holly Smith recently collated primate life history data (e.g., gestation length, age at sexual maturity, etc.) from Harvey and Clutton-Brock and noted that age at eruption of the first permanent molar correlated generally as well or better with all the life history variables than did any other variable such as lifespan or brain weight. As an example, age at eruption of the mandibular first permanent molar and adult brain weight have a high correlation coefficient of 0.98 in primates. Thus the early age at which we now know early hominids to erupt their first molars is, indeed, what we would expect given their small cranial capacities.

Most of the research that has spun from our original researches on early hominid mineralized tissue biology owe their thanks to pioneering support from the L.S.B. Leakey Foundation and the L.S.B. Leakey Trust. Phillip Tobias, C.K. Brain, Elizabeth Vrba, Richard Leakey, Mary Leakey, D.C. Johanson, Laura Newell-Morris, and the Governments of Kenya and Tanzania kindly made specimens available to me. This research has also accumulated a long history of support from Alan Boyde. ■

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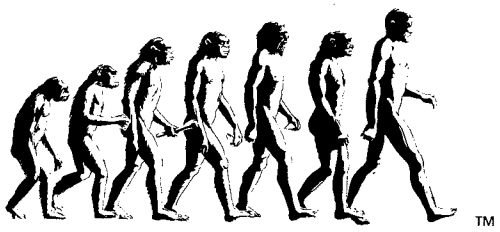

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