11 Who Were They? What Were They Like?

The Archaeology of People

Introductory books on archaeology generally say little or nothing about the archaeology of people themselves – about their physical characteristics and evolution. This seems a strange omission, and one we hope to rectify in this chapter. One of archaeology's principal aims is to recreate the lives of the people who produced the archaeological record, and what more direct evidence can there be than the physical remains of past humanity? Certainly, it is the specialist physical anthropologist rather than the archaeologist who initially analyzes the relevant evidence. But archaeology draws on the skills of a great variety of scientists, from radiocarbon experts to botanists, and the role of the modern archaeologist is to learn how best to use and interpret all this information from the archaeological point of view. Physical anthropology yields a wealth of evidence to enrich the archaeologist's understanding of the past.

A major reason for the lack of integration between archaeology and physical anthropology in the decades immediately after World War II was the question of race. During the 19th and early 20th centuries some scholars (and many politicians) attempted to use physical anthropology to help prove their theories of white racial superiority. This stemmed from their belief that local, indigenous people were incapable of constructing impressive monuments, for instance the burial mounds of the eastern United States. As recently as the 1970s, the white government of Rhodesia maintained that the great monument that today gives the nation its name – Zimbabwe – could not have been the unaided work of the indigenous black population (box, pp. 464–65).

Today, physical anthropologists are much less willing to recognize supposedly different human populations on the basis of a few skeletal measurements. That does not mean that racial distinctions cannot be looked for and studied, but a more robust methodology is needed, supported by well-conceived statistical methods to ensure that any variations observed are not simply of a random nature.

The main thrust of the work today is to use the human remains to show the age and sex of the deceased, to examine the state of health during life, and sometimes to establish family resemblances. In the future, developments in biochemistry and genetics may soon allow much more work to be done at the molecular level, instead of relying mainly on the osteology – the study of bones. There is real hope of approaching once again the whole question of racial distinctions, and how these may correlate with ethnic groups: social groups which regard themselves as separate and distinct.

Perhaps the most interesting field of study, however, is in the origins of the human species. When and how did the uniquely human abilities emerge? What were the processes that led to the development of the first hominids, and then of successive forms up to the emergence of our own species? And what changes have there been in the physical form and in the innate abilities of the human individual since that time?

The Variety of Human Remains

The initial step is to establish that human remains are present, and in what number. This is relatively easy where intact bodies, complete skeletons, or skulls are available. Individual bones and large fragments should be recognizable to competent archaeologists (except for ribs which resemble those of other animals and may therefore require identification by a specialist). Even small fragments may include diagnostic pieces by which human beings can be recognized. In some recent, careful excavations, individual hairs have been recovered which can be identified under the microscope as human. In cases of fragmentary multiple burials or cremations, the minimum number of individuals (see box, pp. 288–89) can be assessed from the part of the body that is most abundant.

As we saw in Chapter 2, purposely made mummies are by no means the only bodies to have survived intact: others have become naturally desiccated, freeze-

The variety of human remains. (Left) At Sutton Hoo, eastern England, the early medieval burials could be recovered only as outlines in the acid sandy soil. (Right) The well-preserved body of a blindfolded girl, drowned in a bog pool at Windeby, north Germany, about 2000 years ago.

dried, or preserved in peat. Since so much of our appearance lies in the soft tissues, such corpses can reveal what mere skeletons cannot, namely features such as the length, style, and color of hair, skin color, and marks on the skin such as wrinkles and scars; tattoos (some very clear, as in the 5th-century BC frozen body of a Scythian chieftain); and details such as whether the penis is circumcized. In exceptional circumstances the lines on fingertips that produce fingerprints, and the corresponding lines on the soles of the feet, may survive – the most famous example being the Iron Age Grauballe Man from Denmark. Sometimes chemical action will alter original hair color, but for mummies fluorescence analysis can often help to establish what that original color was.

Even where the body has disappeared, evidence may sometimes survive. The best-known examples are the hollows left by the bodies of the people of Pompeii as they disintegrated inside their hardened casing of volcanic ash (see box, pp. 22–23). Modern plaster casts of these bodies show not only the general physical appearance, hairstyles, clothing, and posture, but even such fine and moving detail as the facial expression at the moment of death. Foot- and hand-prints are a different kind of "hollow" in the archaeological record, and will be examined later.

Disappeared bodies can also be detected by other means. At Sutton Hoo, England, the acid sandy soil has destroyed most remains, usually leaving only a shadowy stain in the soil – a kind of sand silhouette. If such traces are flooded with ultraviolet light, the "bone" in them fluoresces, and can be recorded photographically. Amino acids and other products of organic decay in the soil may help identify the sex and blood groups of such "invisible" corpses.

In Germany, numerous intact empty pots, buried in the cellars of houses between the 16th and 19th centuries AD, were tested by archaeologist Dietmar Waidelich; samples of sediment from inside them were found, through chromatography, to contain cholesterol which pointed to human or animal tissue, and steroid hormones such as oestrone and oestradiol, so it is virtually certain that the pots had been used to bury human placenta (afterbirth) – according to local folklore, this ensured the children's healthy growth.

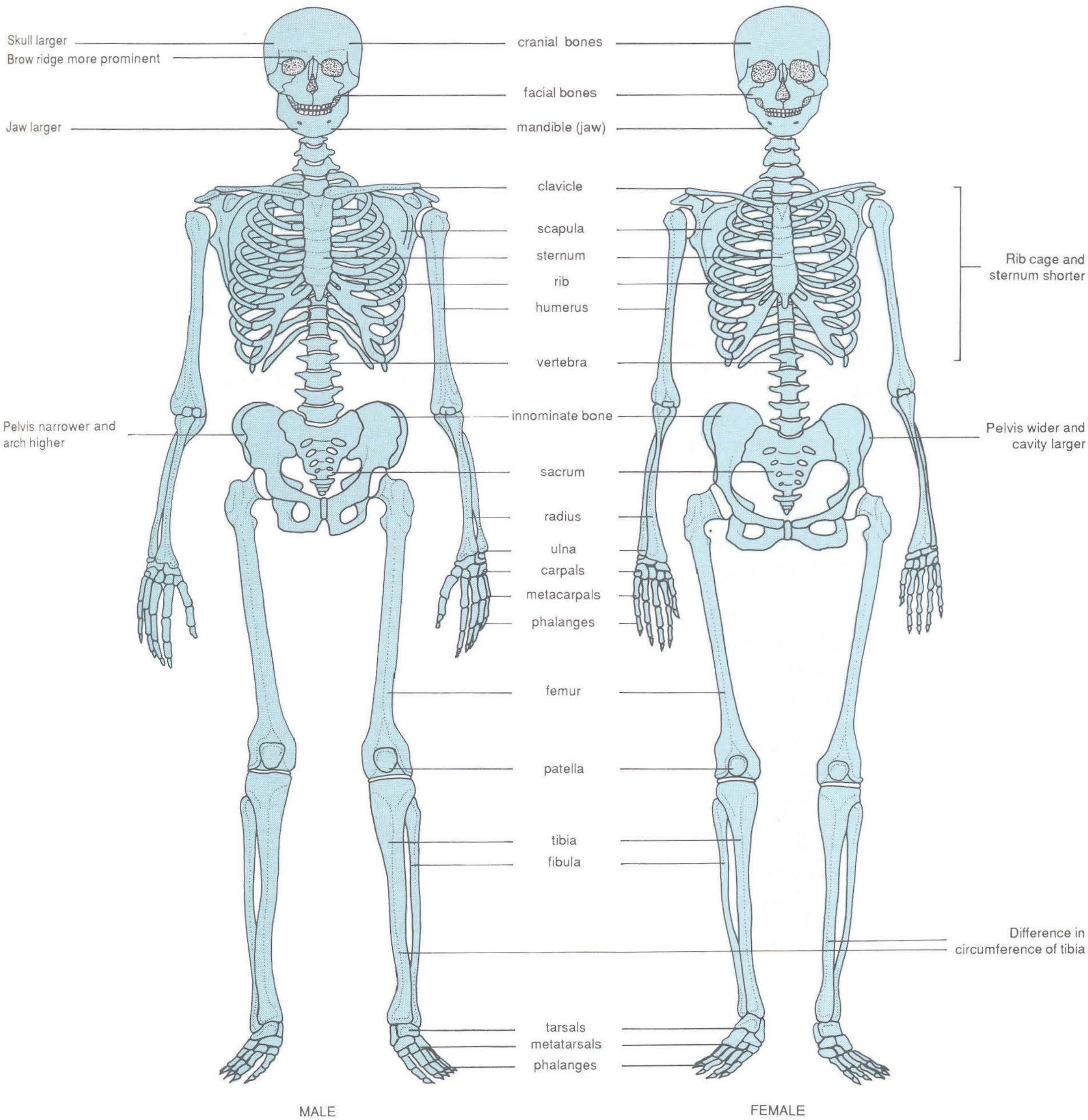
Nevertheless the vast majority of human remains are in the form of actual skeletons and bone fragments, which yield a wide range of information, as we shall see. Indirect physical evidence about people also comes from ancient art, and assumes great importance when we try to reconstruct what people looked like.

IDENTIFYING PHYSICAL ATTRIBUTES

Once the presence and abundance of human remains have been established, how can we attempt to reconstruct physical characteristics – sex, age at death, build, appearance, and relationships?

Which Sex?

Where *intact bodies* and *artistic depictions* are concerned, sexing is usually straightforward from the genitalia. If these are not present, secondary characteristics such as breasts and beards and moustaches provide fairly reliable indicators. Without such features, the task is more of a challenge – length of hair is no guide, but associated clothing or artifacts may be of help in making a decision. With depictions, one can go no further – for example, in the late Ice Age human figures from La Marche, France, the only definite females have vulvas or breasts, the definite males



Bones of the human skeleton, with salient differences between the sexes.

have male genitalia or beards/moustaches, and the rest of the figures have to be left unsexed.

Where ***human skeletons*** and ***bone remains*** without soft tissue are concerned, however, one can go a great deal further. The best indicator of sex is the shape of the pelvis, since males and females have different biological requirements (see diagram, previous page). Not all populations display the same degree of difference between the sexes – for example, it is much less marked in pelvises of Bantu than in those of the San (Bushmen) or Europeans.

Other parts of the skeleton can also be used in sex differentiation. Male bones are generally bigger, longer, more robust, and have more developed muscle markings than those of females, which are slighter and more gracile. The proximal ends of male arm and thigh bones have bigger articular surfaces; females have a shorter chest bone (sternum); and males have bigger skulls, with more prominent brow-ridges and mastoid processes (the bump behind the ear), a sloping forehead, a more massive jaw and teeth, and in some populations a bigger cranial capacity (in Europeans, above 1450 cc tends to indicate a male, below 1300 cc a female). These criteria, used in blind tests on modern specimens, can achieve 85 percent accuracy – but females in certain parts of the world, such as some Polynesians and Australian Aborigines, often have very large skulls.

Anthropologists Yasar Iscan and Patricia Miller-Shaivitz have found that measurement of the circumference of the shin-bone (tibia), about a third of the way down from the knee, can accurately predict sex in 80 percent of samples. But the method is much more accurate for blacks than for whites; the length of bones seems more useful for sexing whites, and thus the method requires prior knowledge of the population involved and, to some extent, of its nutritional level. One should not therefore place too much faith in measurements of any one bone, but combine results from as many sources as possible.

For *children* it is worth noting that, with the exception of preserved bodies and artistic depictions showing genitalia, their remains cannot be sexed with the same degree of reliability as adults, although dental measurements have had some success. Faced with subadult skeletal remains one can often only guess – though the odds of being right are 50:50. Progress has been made in sexing them using discriminant function analysis of measurements of juveniles from Spitalfields, London (see box overleaf), whose sex and age are known from coffin labels. Helgar Schutkowski was able to predict sex with 85 percent accuracy, and found the mandible particularly revealing.

Recently, a new technique has been developed of determining the sex of fragmentary or infant skeletal remains from DNA analysis (see below, p. 432). For example, skeletons of 100 neonates have been recovered in a sewer beneath a Roman bath-house (and probable brothel) at Ashkelon, Israel, most likely the victims of infanticide. Out of 43 left femurs tested for DNA, 19 produced results: 14 were male and 5 female. DNA can also be extracted from coprolites, thanks to cells being sloughed off from the intestines during defecation, and can thus determine the sex of the person who produced them – information which could eventually elucidate gender-based differences in diet. For instance, four coprolites from the La Quinta site, California, and Lovelock Cave, Nevada, were analyzed, and the originators of two were identified as female, one as male, and one remained indeterminate. Experiments on sex determination in coprolites have also been carried out through an analysis of hormones and steroids such as estradiol and testosterone in feces from Salts Cave and Mammoth Cave in Kentucky, which, it turned out, had all been left by men.

How Long Did They Live?

However confidently some scholars may indicate the exact age at death of particular deceased human beings, it should be stressed that what we can usually establish with any certainty is biological age at death – young, adult, old – rather than any accurate chronometric measurement in years and months. The best indicators of age, as with fauna, are the ***teeth***. Here one studies the eruption and replacement of the milk teeth; the sequence of eruption of the permanent dentition; and finally the degree of wear, allowing as best one can for the effects of diet and method of food preparation.

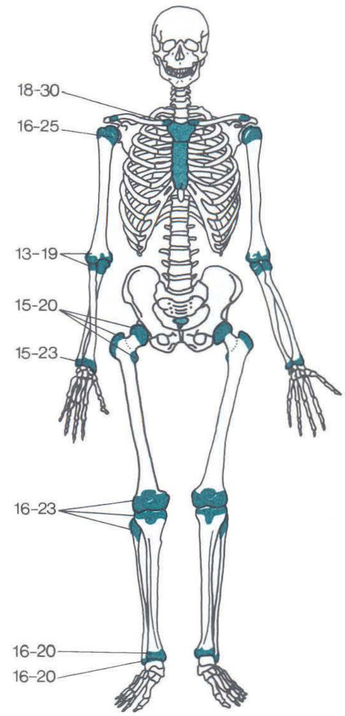
A timescale for age at death derived from this kind of dental information in modern people works reasonably well for recent periods, despite much individual variation. But can it be applied to the dentition of our remote ancestors? New work on the microstructure of teeth suggests that old assumptions need to be tested afresh. Tooth enamel grows at a regular, measurable rate, and its microscopic growth lines form ridges that can be counted from epoxy resin replicas of the tooth placed in a scanning electron microscope. In modern populations a new ridge grows approximately each week, and a similar rate of growth has to be assumed in analyses of our hominid ancestors. The method has been shown to be accurate on the Spitalfields juveniles (see box overleaf).

By measuring tooth growth ridges in fossil specimens, Tim Bromage and Christopher Dean have concluded that previous investigators overestimated the age at death of many early hominids. The famous 1–2 million-year-old australopithecine skull from Taung, South Africa, for example, belonged to a child who probably died at just over 3 years of age, not at 5 or 6 as had been believed. These conclusions have been confirmed by analyses of root growth patterns and by independent studies of dental development patterns in early hominids by Holly Smith, and by a recent investigation of the Taung skull's dental development using computerized tomography (see below). All this suggests that our earliest ancestors grew up more quickly than we do, and that their development into maturity was more like that of the modern great apes. This is supported by the biologically known fact that smaller creatures reach maturity sooner than larger ones (our earliest ancestors were considerably shorter than we are – see below).

Bromage and Dean, together with Chris Stringer, have also studied the Neanderthal child from Devil's Tower Cave, Gibraltar, dating to perhaps 50,000 years ago, and changed its age at death from about 5 years to 3 years, a result confirmed by analysis of the temporal bone. Other researchers, however, remain skeptical of this method of aging – tooth ridges are no longer seen as strict indicators of growth, and it is thought there was great variation in Neanderthal populations, making it impossible to generalize from one individual.

Other aspects of teeth can also provide clues to age. After a tooth's crown has erupted fully, its root is still immature and takes months to become fully grown – its stage of development can be assessed by X-ray – and thus, up to the age of about 20, results can be obtained with some accuracy by this means. The fully grown roots of a young adult's teeth have sharp tips, but they gradually become rounded. Old teeth develop dentine in the pulp cavities, and the roots gradually become translucent from the tip upwards. Measurement of the transparent root dentine of an 8000-year-old skeleton from Bleivik, Norway, suggested an age at death of about 60. Accumulated layers of cement around the roots can also be counted to give an age since the tooth erupted.

Bones are also used in age assessment. The fixed sequence in which the articulating ends (epiphyses) of bones become fused to the shafts provides a timescale that can be applied to the remains of young people. One of the last bones to fuse is the inner end of the clavicle (collar bone) at about 26; after that age, different criteria are needed to age bones. Synostosis, the joining of separate pieces of bone, can also indicate age: for instance, the sacrum (base of the spine) unifies between 16 and 23.



Assessing age: the years at which bone epiphyses fuse (darker color). Areas in lighter color indicate synostosis, the joining of a group of bones (e.g. the sacrum at 16–23 years).

The degree of fusion of the sutures between the plates of the cranial vault (top of the skull) can be an important indicator of age, but the presence of open sutures should not necessarily be taken as an indication of youth: open sutures often persist in old individuals, perhaps because they have a selective advantage. Skull thickness in immature individuals on the other hand does bear a rough relationship to age – the thicker the skull the older the specimen – and in old age all bones usually get thinner and lighter, although skull bones actually get thicker in about 10 percent of elderly people. Ribs can also be used to provide an age at death for adults, since their sternal end becomes increasingly irregular and ragged with advancing age, as the bone thins and extends over the cartilage: this method has been used on the man thought to be Philip of Macedon (Alexander the Great's father) found in a tomb at Vergina, northern Greece (box, p. 430): it suggests he was closer to 45 than 35 (historical evidence indicates that Philip was 46 when murdered).

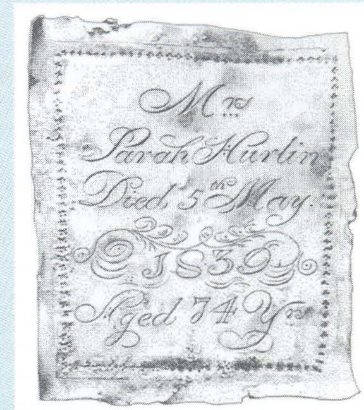
But what if the bone remains are small fragments? The answer lies under the microscope, in ***bone microstructure***. As we get older, the architecture of our

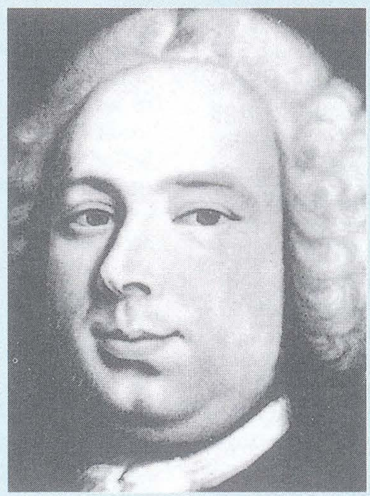
SPITALFIELDS: DETERMINING BIOLOGICAL AGE AT DEATH

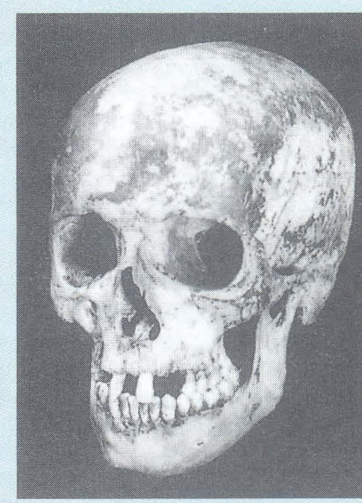
A rare opportunity to test the accuracy of different methods of aging skeletal material came in 1984–86 with the clearance by archaeologists of almost 1000 inhumations in the crypt of Christ Church, Spitalfields, in east London. No fewer than 396 of the coffins had plates attached giving information on the name, age, and date of death of the occupants, who were all born between 1646 and 1852, and died between 1729 and 1852. Females and males were equally represented, and one third were juveniles. The mean age at death of the adults was 56 for both sexes and the oldest was aged 92.

A range of techniques was used on the material to evaluate apparent age at death, including the closure of cranial sutures, involution of the pubic symphisis, the study of thin-sections of bone tissue, and amino acid racemization in teeth. The results were then compared with the true ages as documented on the coffin plates. It was found that traditional methods of determining age at death are inaccurate. All the methods applied to the Spitalfields skeletons tended to underestimate the age of the old, and overestimate the age of the young, a result that reflects the bias inherent in cemetery material composed of individuals who died of natural causes. Those who die young have presumably failed to achieve their potential and already have "old bones," while those who live to a great age are survivors and have "young" bones at death.

In the Spitalfields population, children were small for their age compared to children today, but the material helped analysts develop and test methods that can give a fairly precise assessment of juvenile age. The Spitalfields adults began aging later (after 50) and at a slower rate than people today, which should make one cautious in applying data from modern reference samples to skeletal material from the past. As a result of the findings from Spitalfields, it would be rash to try to age an adult more precisely than as biologically young, middle-aged, or old.

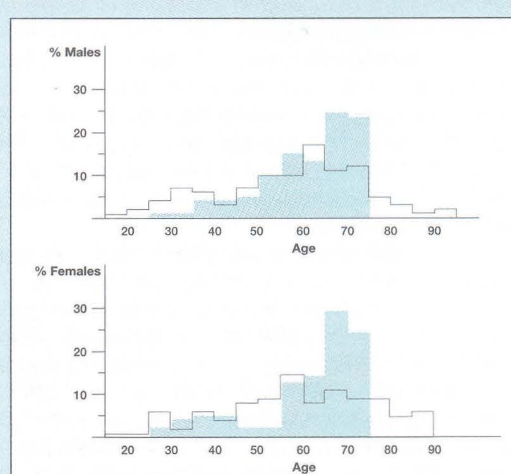




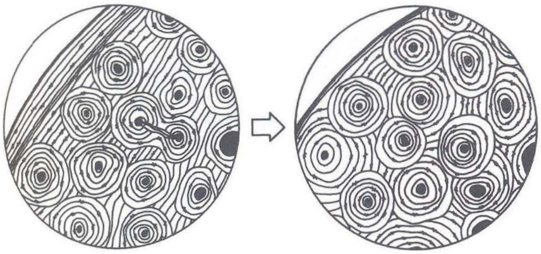


Coffin plate (top) of Sarah Hurlin, giving her name, age, and date of death.

***Peter Ogier** (1711–75), a master silk weaver, in life and death (above): a portrait compared with his actual skull.*



***Comparison of** the ages at death estimated from bone analysis (shaded) with real ages reveals that many mature adults had been given too high an age because they have "old bones." The cut-off at 75 years old is due to the scale used for the reference population.*



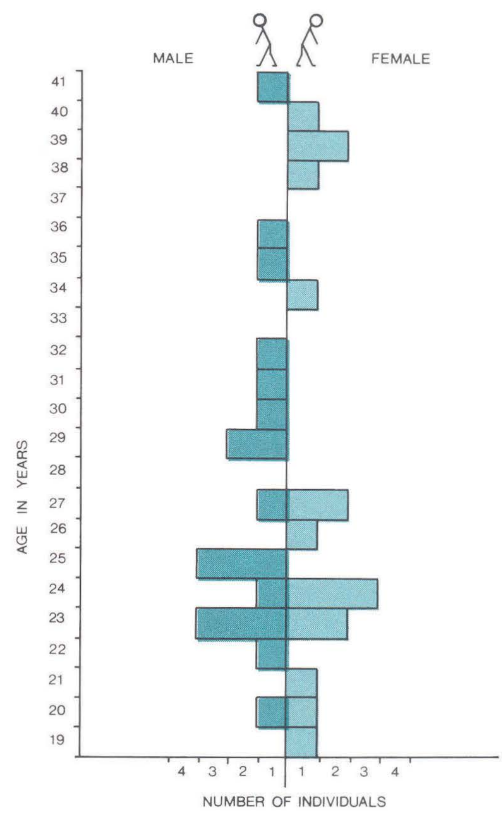
Assessing age: changes in bone structure are visible under the microscope as humans grow older. The circular osteons become more numerous and extend to the edge of the bone.

bones changes in a distinct and measurable way. A young longbone, at about 20, has rings around its circumference, and a relatively small number of circular structures called osteons. With age the rings disappear, and more and smaller osteons appear. By this method, even a fragment can provide an age. Putting a thin section of a femur (thigh bone) under the microscope and studying the stage of development is a technique which, in blind tests with modern specimens, has achieved accuracy to within 5 years. However, on material from Spitalfields (see box) it proved no more accurate than using rib ends or the pubic symphisis.

Akira Shimoyama and Kaoru Harada have applied a new chemical method to a skeleton from a 7th-century AD burial mound in Narita, Japan. They measured the ratio of two sorts of aspartic acid in its dentine. This amino acid has two forms or isomers which are mirror images of each other. The L-isomer is used in building teeth, but converts slowly to the D-isomer during life through the process of racemization (Chapter 4). The D/L ratio increases steadily from the age of 8 to 83, and is therefore directly proportional to one's age. In this case, it was shown that the skeleton was that of a 50-year-old. Since the L-isomer continues to convert to the D-isomer after death, depending on temperature, the burial conditions have to be taken into account in the calculation.

Interpreting Age at Death. Once the ages of a sample of remains have been estimated, one can calculate the average and maximum lifespan within that sample. (It should be realized that calculating these lifespans will not indicate what percentages of people in a particular population lived to those average and maximum ages – if most deaths occur in childhood and old age, this would give an average age at death of around 30, even though few people actually die at that age.) It has been calculated, for instance, that few Neanderthalers reached 50, and most died before 40. By combining age information with sexing results, one can also see whether men or women lived longer. For example, it seems that women in prehistory were more likely to die before the age of 40 than men, no doubt because of the stresses and dangers of childbirth. Among the prehistoric Chinchorro mummies of Arica, Chile (see p. 64), dating back 4000–7800 years, few individuals lived beyond 50, and the birth-scarred women seem to have died on average two or three years before the men. In 450 skeletons from Roman Cirencester, studied by Calvin Wells, the average male age was 40.8, the female 37.8; both sexes did reach 65 occasionally. In a sample of 40 adults from Wairau Bar, New Zealand, of AD 1150–1450, however, women slightly outlived men on average, although members of both sexes tended to die in their early 20s, and the oldest only reached their 40s.

It must be stressed that one can only calculate average age at death for the bodies and skeletons that have survived and been discovered. Many scholars used erroneously to believe that to dig up a cemetery,



Ages at death of the people of Wairau Bar, New Zealand. Out of a sample of 40 adults dating from AD 1150–1450, the majority died in their early 20s.

and assess the age and sex of its occupants, provided an accurate guide to the life expectancy and mortality pattern of a particular culture. This entails the considerable assumption that the cemetery contains all members of the community who died during the period of its use – that everyone was buried there regardless of age, sex, or status; that nobody died elsewhere; and that the cemetery was not reused at another time. This assumption cannot realistically be made. A cemetery provides a sample of the population, but we do not know how representative that sample might be. Figures on life expectancy and average age in the literature should therefore be looked at critically before they are accepted and used by archaeologists.

But it is not sufficient to have a population broken down by age and sex. We also want to know something of their build and appearance.

What Was Their Height and Weight?

Height is easy to calculate if a body is preserved whole – as long as one allows for the shrinkage caused by mummification or desiccation. But it is also possible to assess stature from the lengths of some individual longbones, especially the leg bones. Tutankhamun's height, for example, was estimated from the mummy and from his intact longbones as 1.69 m (5 ft 6½ in), which corresponded to that of the two wooden guardian statues standing on either side of the burial chamber door.

The formula for obtaining a rough indication of height from the length of longbones is called a regression equation – the metrical relationship of bone length to full body length. However, different populations require different equations because they have differing body proportions. Australian Aborigines and many Africans have very long legs that constitute 54 percent of their stature; but the legs of some Asian people may represent only 45 percent of their height. Consequently, people of the same height can have leg bones of very different lengths. The answer, in cases where the source population of the skeletal material is unknown, is to use a mean femoral stature (an average of the different equations), which will provide an adequate estimate of height, probably accurate to within 5 cm or a couple of inches, which is good enough for archaeological purposes. In Roman Cirencester, people seem to have been a little shorter than today: the average female height was 1.57 m (5 ft 2 in), and the tallest woman was equivalent in height to the average man (1.69 m or 5 ft 6½ in).

Arm bones can also be used where necessary to estimate stature, as in the legless Lindow Man (see box, pp. 448–49); hand stencils have also occasionally been used. And footprints also give a good indication, since foot length in adult males is reckoned to be equivalent to 15.5 percent of total height; in children under 12 it is thought to be 16 or 17 percent. The Laetoli footprints in Tanzania, which date to 3.6–3.75 million years ago, are 18.5 and 21.5 cm (7.3 and 8.5 in) in length, and were therefore probably made by hominids of about 1.2 and 1.4 m (3 ft 11 in and 4 ft 7 in) in height, assuming that the same calculation is equally valid for premodern people.

Tutankhamun's mummy was unwrapped in 1923, revealing within the bandages a shrunken body. The young king's original height was estimated by measuring the longbones.

Weight is also easy to calculate from intact bodies, since it is known that dry weight is about 25 to 30 percent of live weight. An Egyptian mummy of 835 BC at Pennsylvania University Museum (designated PUM III) was thus reckoned to have weighed between 37.8 and 45.4 kg (83–100 lb) when alive. Simply knowing the height can also be a guide, since from modern data we know the normal range of weight for people of either sex at given heights, who are neither obese nor unusually thin. Therefore, armed with the sex, stature, and age at death of human remains, one can make a reasonable estimate of weight. A single leg bone could thus indicate not only the height but also the sex, age, and bulk of its owner. Where early hominids are concerned, body size is more a matter of conjecture. Nevertheless, because the skeleton of the australopithecine nicknamed "Lucy" (see section on walking, p. 433) is 40 percent complete, it has been possible to reckon that this hominid was about 1.06 m (3 ft 6 in) tall, and weighed about 27 kg (60 lb).

So far, we have a sexed body of known age and size; but it is the human face that really serves to identify and differentiate individuals. How, therefore, can we pull faces out of the past?

What Did They Look Like?

Once again, it is preserved bodies that provide us with our clearest glimpses of faces. Tollund Man, one of the remarkable Iron Age bog bodies from Denmark, is the best-known prehistoric example. Another finely preserved face belongs to the 50-year-old man from Tomb 168 near Jinzhou in China, who was buried in the 2nd century BC and perfectly preserved by a mysterious dark red liquid. Discoveries at Thebes in Egypt in 1881 and 1898 of two royal burial caches have given us a veritable gallery of mummified pharaohs, their faces still vivid, even if some shrinkage and distortion has taken place.

Thanks to artists from the Upper Paleolithic onward, we also have a huge array of portraits. Some of them, such as images painted on mummy cases, are directly associated with the remains of their subject. Others, such as Greek and Roman busts, are accurate likenesses of well-known figures whose remains may be lost for ever. The extraordinary life-size terracotta army found near Xi'an, China, is made up of thousands of different likenesses of soldiers of the 3rd century BC. Even though only the general features of each are represented, they constitute an unprecedented "library" of individuals, as well as providing invaluable information on hairstyles, armor, and weaponry. From later periods we have many life- or death-masks, sometimes used as the basis for life-size funerary effigies or tomb-figures, such as those of European royalty and other notables from medieval times onward.

Occasionally, one can identify historical individuals by juxtaposing bones and portraits. Belgian scholar Paul Janssens developed a method of superimposing photographs of skulls and portraits. By this means one can confirm the identity of skeletons during the restoration of tombs. For instance, a photo of the skull thought to belong to Marie de Bourgogne, a French duchess of the 15th century AD, was superimposed on a picture of the head from her tomb's sculpture and the match proved to be perfect. Superimposition of photos and skulls was also used to help identify the skulls of Tsar Nicholas II, his wife Alexandra, and their children, murdered in 1918 and excavated a few years ago from the pit in a Russian forest where they had been buried.

There are other ways of proving identity. X-ray investigations in the 1970s of the mummy of an important but unknown Egyptian lady, found in the 1898 royal burial cache at Thebes, showed that her skull resembled that of a woman called Thuya. Thuya was the mother of Queen Tiye who was the wife of Amenophis III and mother of Akhenaten, and probably also Tutankhamun's grandmother – a locket in his tomb was inscribed with Tiye's name and contained a lock of hair. A sample of this hair and a sample from that of the unidentified female mummy were subjected to

Faces from the past. (Far left) Bronze head of the Roman emperor Hadrian (reigned AD 117–138), from the Thames river. (Second left) Moche portrait vase, c. 6th century AD, from Peru. (Second right) Head of Tollund man, the Iron Age bog body from Denmark. (Far right) Mummified head of a man, perhaps the pharaoh Tuthmosis I (1504–1492 BC), from Deir el-Bahri, Egypt.

HOW TO RECONSTRUCT THE FACE

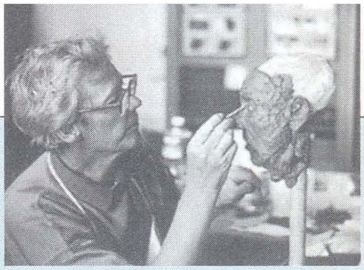
Attempts to reconstruct faces were already being carried out in the 19th century by German anatomists in order to produce likenesses from the skulls of celebrities such as Schiller, Kant, and Bach. But the best-known exponent of the technique in the 20th century was the Russian Mikhail Gerasimov, who worked on specimens ranging from fossil humans to Ivan the Terrible. It is now felt that much of his work represented "inspired interpretation," rather than factual reconstruction. Currently, the process has reached a higher degree of accuracy.

One of the most successful recent reconstructions has been of human remains from Tomb II at Vergina, northern Greece. It was suspected that these remains belonged to Philip II of Macedon, assassinated in 336 BC, who was the father of Alexander the Great. Small family portrait figures in the tomb seemed to support the suspicion.

Richard Neave, John Prag, and their colleagues in Manchester, England, first took casts of the cremated fragments of skull, and fitted them together – a difficult task owing to shrinkage of some of the parts, injury and congenital deformity: the left side of the face proved to be markedly underdeveloped, with compensating overdevelopment of the right. An injury to the right eye socket (a healed fracture, and a notch on the upper edge of the orbit) implied a blow by a missile from above, and tallied with hints from portrait heads as well as with an account by a 1st-century BC author who stated that Philip was hit in the right eye by an arrow at the siege of Methone.

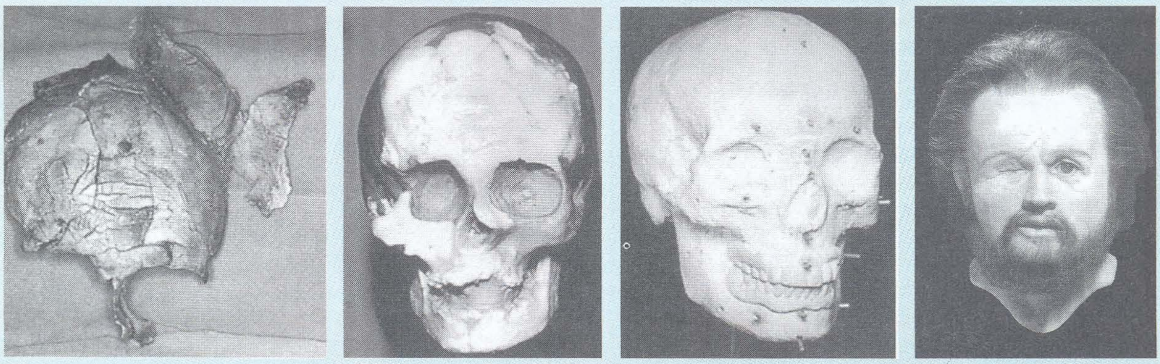
The next step was to insert measuring pegs at 23 key points in the skull: the thickness of soft tissue at these points was known from modern specimens. The size and distribution of facial features were largely determined by the skull's structure, and therefore the major muscles could be modeled on. Finally, the superficial layers of muscle and skin were added, though their degree of development was far less accurately determined.

***Miniature** ivory head thought to represent Philip II, from Tomb II at Vergina.*



***Richard Neave** reconstructs a face, perhaps of King Midas, from skull remains found at Gordion, Turkey, where Midas ruled (738–696 BC).*

Normally this is as far as the skull will allow one to go, though in the case of Philip a detailed scar was originally added to the right eye based on the study of an almost identical injury received by a present-day Canadian lumberjack! Only after the reconstruction was made was it discovered from reading Pliny's *Natural History* that Philip had received treatment that would have prevented or at least reduced scarring. Other details – hair type/color/style/length, skin color and condition, facial hair, eye color, and the shape and configuration of nose, lips, and ears – were not totally unknown, and were broadly determined by racial type. Facial hair depends on ethnic type (some lack it); configuration of nose, lips, and position of ears are determined within broad limits by the shape of the skull. In Philip's case, the confirmation of his identity meant that certain of these characteristics could be copied from family portraits (for example, the typical nose shape).



***Reconstruction** in progress (left to right): the frontal bone of the skull from the Vergina tomb; the skull after laboratory reconstruction; a plaster cast with marker pegs in position for the addition of soft tissue; a wax cast of the reconstructed head, with the eye wound rendered to give the impression of Philip's having received some medical treatment.*

scanning electron microprobe analysis by James Harris and his colleagues at the University of Michigan. The almost identical X-ray scatters from these two samples suggested that the lady is indeed Tiye, although more recent work in Germany has cast some doubt on the validity of these results.

A different method has proved to some, if not all, scholars' satisfaction the identity of Philip of Macedon's remains (see box opposite). It involved the reconstruction of the skull, and then the building up of facial tissue. The resulting head was compared with a portrait assumed to be of Philip found in the tomb and with written descriptions of his wounds. Some facial reconstructions are now done with a laser-scanning camera connected to a computer containing information about the skull's muscle-group thickness, and a computer-controlled machine then cuts a 3-D model out of hard foam: this method has been used, for example, to recreate the face of a Viking fisherman at York.

Stereolithography, a technique used for surgical reconstructions, has been used to replicate the skull of Italy's 5300-year-old Iceman (see box, pp. 66–67). Multiple scans (see box, pp. 440–41) enabled a computer to record electronic "slices" of the skull; a second computer then used these data to construct replica skulls by carving plastic with a laser, as in the case of the York Viking. The technique recreates not only the outside of the skull but also its inner surfaces. A complete facsimile skeleton of the Iceman is planned, which will aid its investigation since the actual body can only be examined for 20 minutes every two weeks to avoid deterioration. Fragmentary fossil skulls can also now be restored, measured, and replicated without physical contact through a similar technique. Using a combination of computerized tomography (see box pp. 440–41), computer-assisted reconstruction, and stereolithography, Swiss researchers have turned five fossil fragments of the Neanderthal child from Devil's Tower Cave, Gibraltar (see p. 425), into a solid model of an intact skull; missing areas were restored with mirror images from opposite sides.

Any jewelry or clothing found associated with bodies or skeletons are also invaluable in assessing how these people looked during life. And footprints provide clues about footwear. Nearly all Ice Age prints are barefoot, but one of those in the French late Upper Paleolithic cave of Fontanet seems to have been made by a soft moccasin.

How Were They Related?

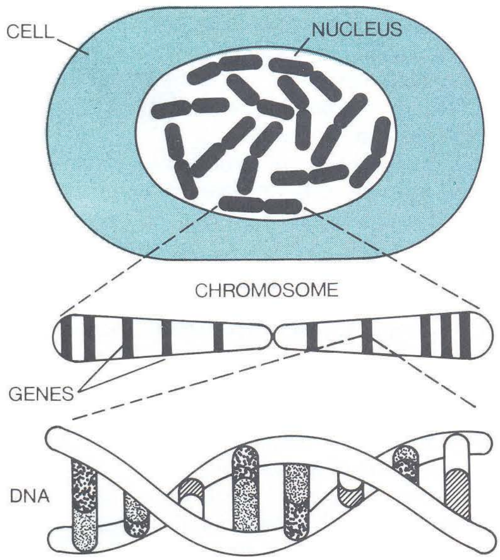
We have seen that in certain cases it is possible to assess the relationship between two individuals by comparing skull shape or analyzing the hair. There are other methods of achieving the same result, primarily by study of dental morphology. Some dental anomalies (such as enlarged or extra teeth, and especially missing wisdom teeth) run in families.

Blood groups can be determined from soft tissue, bone, and even from tooth dentine up to more than 30,000 years old, since the polysaccharides responsible for blood groups are found in all tissues, not just in red blood cells, and survive well. Indeed, protein analysis by radioimmunoassay (the detection of reaction to antibodies) can now identify protein molecules surviving in fossils which are thousands or even millions of years old, and can decipher taxonomic relationships of fossil, extinct, and living organisms. In the near future we may obtain useful information on the genetic relationships of early hominids.

One potentially major advance in this direction has emerged from the Canadian Thomas Loy's still somewhat controversial analysis of blood residues on stone tools (see Chapter 7). In cases where identification points to human blood, he uses an immunological testing procedure that gives a positive reaction for the presence of human immunoglobulin. One tool, from the site of Barda Balka in Iraq, dates to 100,000 years ago, and the human blood on it is almost certainly Neanderthal. In Britain, blood has also been detected in Saxon bones more than 1000 years old.

Since blood groups are inherited in a simple fashion from parents, different systems – of which the best known is the A-B-O system in which people are divided into those with blood types A, B, O, AB etc. – can sometimes help clarify physical relationships between different bodies. For example, it was suspected that Tutankhamun was somehow related to the unidentified body discovered in Tomb 55 at Thebes in 1907. The shape and diameter of the skulls were very similar, and when X-rays of the two crania were superimposed there was almost complete conformity. Robert Connolly and his colleagues therefore analyzed tissue from the two mummies, which showed that both had blood of group A, subgroup 2 with antigens M and N, a type relatively rare in ancient Egypt. This fact, together with the skeletal similarities, makes it almost certain that the two were closely related. The exact identity of the mysterious Tomb 55 body is still unresolved, however, some scholars holding that it is Tutankhamun's possible father, Akhenaten, others that it is his possible brother, Smenkhkare.

New work in genetics means that it is now possible to work out family relationships through analysis of DNA (see illustration overleaf). The Swedish scientist Svante Pääbo first succeeded in extracting and cloning



Genes, the organizers of inheritance, are composed of DNA (deoxyribonucleic acid), which carries the hereditary instructions needed to build a body and make it work. Genes are copied or "replicated" with every new generation of living cells; nuclear DNA forms the blueprint for the cells, and is copied every time a new cell is produced. Thus, when cells are cultured in the laboratory, DNA is being grown. Sometimes a segment of nuclear DNA from humans or other animals can be inserted into bacteria and grown in the laboratory. This is called "cloning." The mitochondria (small organelles) within the cell contain relatively small loops of DNA (mitochondrial DNA; abbreviated mtDNA) which have been intensively studied.

mitochondrial DNA from the 2400-year-old mummy of an Egyptian boy. Over such a long time period, the DNA molecules are broken up by chemical action, so there is no question of reconstituting a functioning gene, far less a living body. But information on the DNA sequences of, for example, Egyptian mummies may indicate the relationships between members of royal families, and determine whether members of a dynasty did practice incest, as is commonly believed: an analysis of DNA from six mummies of 2200 BC found at Hagasa, Egypt, has proved that they were a family group. Currently, a databank of thousands of tissue samples is being compiled from mummies all over the world, for future research into everything from the spread of diseases to human migrations.

Genetic material has also been removed from ancient human brain cells in Florida by Glen Doran and his colleagues. Brain material has been recovered from 91 of 177 individuals buried in Windover Pond, a peat bog near Titusville, between 7000 and 8000 years ago. Some of the skulls, when placed in a scanner, proved to contain well-preserved and largely undamaged brains. DNA extracted from them may make it possible to discover whether there are any survivors from this particular Indian group.

Pääbo has also retrieved some DNA molecules from the brain of an Archaic period American Indian (over 7000 years old) preserved in a skull found in 1988 in Little Salt Spring Bog, Florida. The molecules contained a previously unknown mitochondrial DNA sequence which suggests that an additional group of humans entered America (i.e. separate from the three lineages known to have migrated there – see below), but that they died out sometime after their arrival.

It is now possible also to extract the tiny amounts of DNA left in bones and teeth. Researchers at Oxford, using a technique invented in California known as "polymerase chain reaction," have been able to amplify minute amounts of DNA for study. The team has already extracted and copied DNA from fossils over 5000 years old such as a human femur from Wadi Mamed in the Judaean desert, and from the 4000-year-old skull of a child from Maiden Castle, England.

A highly significant breakthrough has been achieved by Matthias Krings, Svante Pääbo, and their colleagues with the extraction of DNA (in this case mtDNA) from hominid fossil remains more than 40,000 years old. As discussed below, this has changed current thinking about the Neanderthals and opens a new era in biological anthropology.

The recent advances in genetic engineering thus open up fascinating possibilities for future work in human evolution and past human relationships.

So far in this chapter we have learnt how one can deduce a great deal about our ancestors' physical characteristics; but the picture is still a static one. The next step is to learn how one reconstructs the way these bodies worked and what they could do.

ASSESSING HUMAN ABILITIES

The human body is a superb machine, capable of performing a great variety of actions, some requiring strength and force, and others involving fine control and specialized skills, but it has not always been able to perform these tasks. How then do we trace the development of various human abilities?

Walking

One of the most basic uniquely human features is the ability to walk habitually on two legs – bipedalism. A number of methods provide insights into the evolution of this trait. Analysis of certain parts of the skeleton, and of body proportions, is the most straightforward method, but skulls are often the only parts of our early ancestors to have survived. One exception is the 40 percent complete australopithecine skeleton nick-named "Lucy," dating from around 3.18 million years ago and found by Donald Johanson and his colleagues at Hadar in the Afar region of Ethiopia – hence its scientific name, *Australopithecus afarensis*. Much attention has been focused on the lower half of Lucy's skeleton. The American paleoanthropologists Jack Stern and Randall Susman believe that it could walk, but still needed trees for food and protection – their evidence consists of the long, curved, and very muscular hands and feet, features that suggest grasping.

Another American researcher, Bruce Latimer, and his colleagues, think that Lucy was a fully adapted biped. They doubt that curved finger and toe bones are proof of a life in trees, and find that the lower limbs were "totally reorganized for upright walking": the orientation of the ankle is similar to that in a modern human, implying that the foot was less flexible in its sideways movements than an ape's. Lucy's proportions are not incompatible with bipedalism, but it had not yet achieved the gait of modern humans, since the pelvis was still somewhat like that of a chimpanzee.

Recently, the debate has been exacerbated by analysis of "Little Foot", four articulating footbones from a probable *Australopithecus africanus* from Sterkfontein, South Africa, up to 3.5 million years old. Some specialists believe that, while clearly adapted for bipedalism, the foot also has apelike traits which make it perfect for tree-life. Other specialists insist that these are simply relict anatomical traits, and that these australopithecines spent all their time on two legs on the ground.

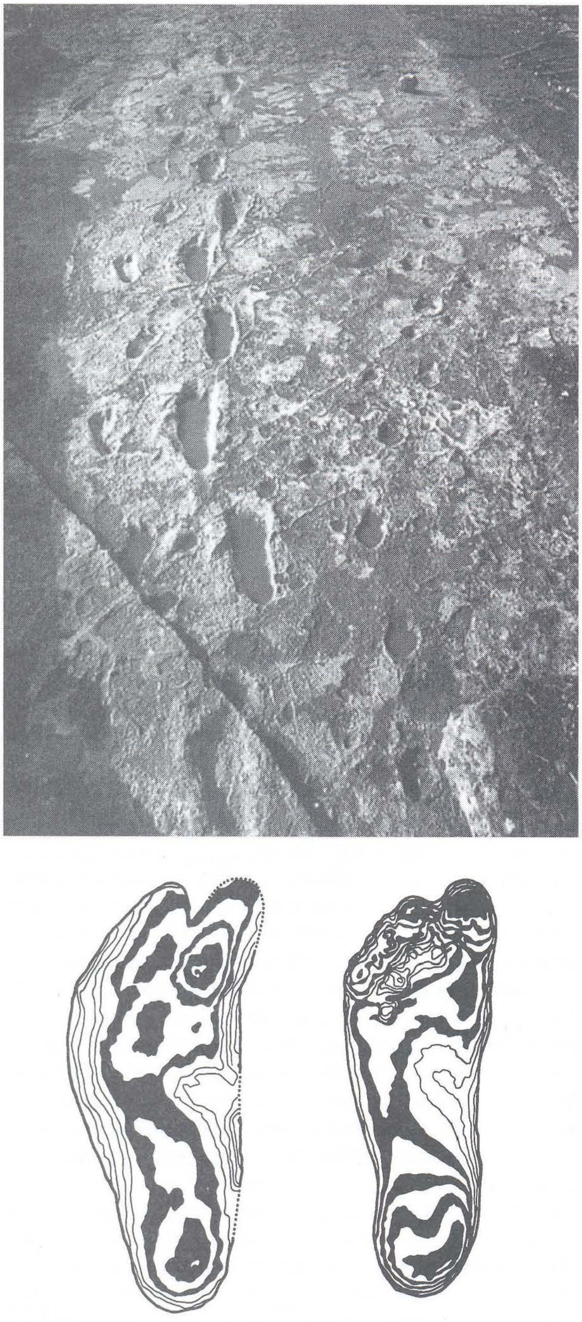
A different type of evidence for upright walking can be found in ***skulls***. The position of the hole at their base, for example, where the spinal column enters, tells a great deal about the position of the body during locomotion. Even fossil skulls trapped inside a rock-hard matrix can now be examined through the technique of computerized axial tomography (CAT or CT), in which X-ray scans made at 5-mm intervals produce a series of cross-sections that the computer can reformat to create vertical or oblique images as required. A skull can therefore be seen from any angle. The technique is also useful for studying mummies without unwrapping them, and for revealing which organs still remain inside them (see box, pp. 440–41).

Dutch scientists Frans Zonneveld and Jan Wind have used the CAT-scan technique on the very complete skull of *Australopithecus africanus*, 2–3 million years old, from Sterkfontein, South Africa, known as "Mrs Ples." The scans revealed the semicircular canals of the inner ear, entombed inside the solid fossil cranium. This feature is of special interest because it provides an indication of the carriage of the head: the horizontal canal has a relationship with the angle of the head in upright-walking humans. The angle in "Mrs Ples" suggested that she walked with her head at a greater forward-sloping angle than in modern humans. Dutch anatomist Fred Spoor and his colleagues have recently studied the canals in a series of different hominids, and found that in australopithecines this feature is decidedly apelike – supporting the view that they mixed tree-climbing with bipedalism – while *Homo erectus* was similar to modern humans in this respect.

Footprints in Time. A great deal can be learned from the actual traces of human locomotion: the footprints of early hominids. The best known specimens are the remarkable trails discovered at Laetoli, Tanzania, by Mary Leakey. These were left by small hominids around 3.6–3.75 million years ago, according to potassium-argon dates of the volcanic tuffs above and below this level. They walked across a stretch of moist volcanic ash, which was subsequently turned to mud by rain, and then set like concrete.

Observation of the prints' shape revealed to Mary Leakey and her colleagues that the feet had a raised arch, a rounded heel, a pronounced ball, and a big toe which pointed forward. These features, together with the weight-bearing pressure patterns, resembled the prints of upright-walking humans. The pressures exerted along the foot, together with the length of stride (average 87 cm, or 34 in), indicated that the hominids (probably early australopithecines) had been walking slowly. In short, all the detectable morphological features implied that the feet which did the walking were very little different from our own.

A detailed study has been made of the prints using photogrammetry (Chapter 3), which created a drawing showing all the curves and contours of the prints. The result emphasized that there were at least seven points of similarity with modern prints, such as the depth of the heel impression, and the deep imprint of the big toe. Michael Day and E. Wickens also took stereo-photographs of the Laetoli prints, and compared them with modern prints made by men and women in similar soil conditions. Once again, the results furnished



The Laetoli footprints. (Top) One of the remarkable footprint trails left by early hominids 3.6–3.75 million years ago at this East African site. (Above) The contour pattern of one of the Laetoli footprints, left, is strikingly similar to that of a modern male foot impression made in soft ground, right.

possible evidence of bipedalism. Footprints thus provide us not merely with rare traces of the soft tissue of our remote ancestors, but evidence of upright walking that in many ways is clearer than can be obtained from analysis of bones.

The study of fossil prints is by no means restricted to such remote periods. Hundreds of prints are known, for example, in French caves, dating from the end of the last Ice Age. Research by Léon Pales, using detailed silicone resin molds, has revealed details of behavior in these caves: we have already mentioned that most of these prints are barefoot. Many of the prints were made by children, who seem to have had no fear of exploring the dark depths of caves. In the cave of Fontanet one can follow the track of a child who was chasing a puppy or a fox. In the cave of Niaux, the prints show that children's feet were narrower and more arched than today.

More recent prints are known from the surface of ancient Japanese paddy fields, from early Holocene surfaces on the Argentine seashore, and especially from 3600-year-old mud-flats in England's Mersey estuary where 145 footprint trails show a mean adult male height of 1.66 m (5 ft 5 in) and a female height of 1.45 m (4 ft 9 in). Many children are present, moving slowly like the women (perhaps gathering shellfish), while the men moved rapidly. Some of the prints show abnormalities such as toes missing or fused, providing information on medical conditions.

Which Hand Did They Use?

We all know that many more people today are right-handed than left-handed. Can one trace this same pattern far back in prehistory? Much of the evidence comes from stencils and prints found in Australian rockshelters and elsewhere, and in many Ice Age caves in France, Spain, and Tasmania. Where a left hand has been stenciled, this implies that the artist was right-handed, and vice versa. Even though the paint was often sprayed on by mouth, one can assume that the dominant hand assisted in the operation. One also has to make the assumption that hands were stenciled palm-downward – a left hand stenciled palm-upward might of course look as if it were a *right* hand. Of 158 stencils in the French cave of Gargas, to which we shall return later, 136 have been identified as left, and only 22 as right: right-handedness was therefore heavily predominant.

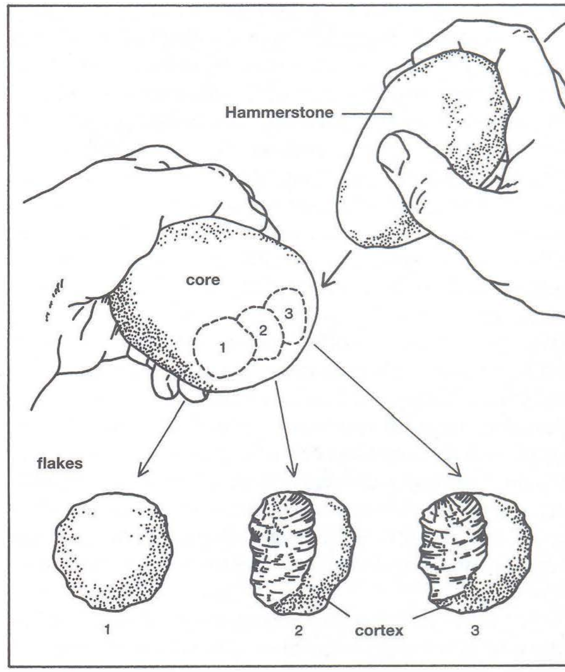
Cave art furnishes other types of evidence of this phenomenon. Most engravings, for example, are best lit from the left, as befits the work of right-handed artists, who generally prefer to have the light source on the left so that the shadow of their hand does not fall on the tip of the engraving tool or brush. In the few cases where an Ice Age figure is depicted holding something, it is mostly, though not always, in the right hand.

Clues to right-handedness can also be found by other methods. Right-handers tend to have longer, stronger, and more muscular bones on the right side, and Marcellin Boule as long ago as 1911 noted that the La Chapelle aux Saints Neanderthal skeleton had a right upper arm bone that was noticeably stronger than the left. Similar observations have been made on other Neanderthal skeletons such as La Ferrassie I and Neanderthal itself, while skeletons of the 11th to 16th centuries AD from the English medieval village of Wharram Percy have been found to have right arms longer than the left in 81 percent of specimens, and the left longer in 16 percent.

Fractures and cutmarks are another source of evidence. Right-handed soldiers tend to be wounded on the left. The skeleton of a 40- or 50-year-old Nabataean warrior, buried 2000 years ago in the Negev Desert, Israel, had multiple healed fractures to the skull, the left arm, and ribs. Pierre-François Puech, in his study of scratches on the teeth of fossil humans (Chapter 7), noted that the Mauer (Heidelberg) jaw of *c.* 500,000 years ago has marks on six front teeth; these were made by a stone tool, and their direction indicates that the jaw's owner was right-handed.

Tools themselves can be revealing. Long-handled Neolithic spoons of yew wood, preserved in Alpine lake villages dating to 3000 BC, have survived; the signs of rubbing on their left side indicate that their users were right-handed. The late Ice Age rope found in the French cave of Lascaux consisted of fibers spiraling to the right, and was therefore tressed by a right-hander.

Occasionally one can determine whether stone tools were used in the right hand or the left, and it is even possible to assess how far back this feature can be traced. In stone toolmaking experiments, Nick Toth, a right-hander, held the core in his left hand and the hammerstone in his right. As the tool was made, the core was rotated clockwise, and the flakes, removed in sequence, had a little crescent of cortex (the core's outer surface) on the side. Toth's knapping produced 56 percent flakes with the cortex on the right, and 44 percent left-orientated flakes. A left-handed toolmaker would produce the opposite pattern. Toth has applied these criteria to the similarly made pebble tools from a number of early sites (before 1.5 million years) at Koobi Fora, Kenya, probably made by *Homo habilis*. At seven sites, he found that 57 percent of the flakes were right-orientated, and 43 percent left, a pattern almost identical to that produced today.



Nick Toth's experiments showed that a right-handed stone toolmaker will typically produce flakes 56 percent of which have the cortex on the right, as here. Tools over 1.5 million years old from Koobi Fora, Kenya, display an almost identical ratio.

About 90 percent of modern humans are right-handed: we are the only mammal with a preferential use of one hand. The part of the brain responsible for fine control and movement is located in the left cerebral hemisphere, and the above findings suggest that the hominid brain was already asymmetrical in its structure and function not long after 2 million years ago. Among Neanderthalers of 70,000–35,000 years ago, Marcellin Boule noted that the La Chapelle aux Saints individual had a left hemisphere slightly bigger than the right, and the same was found for brains of specimens from Neanderthal, Gibraltar, and La Quina.

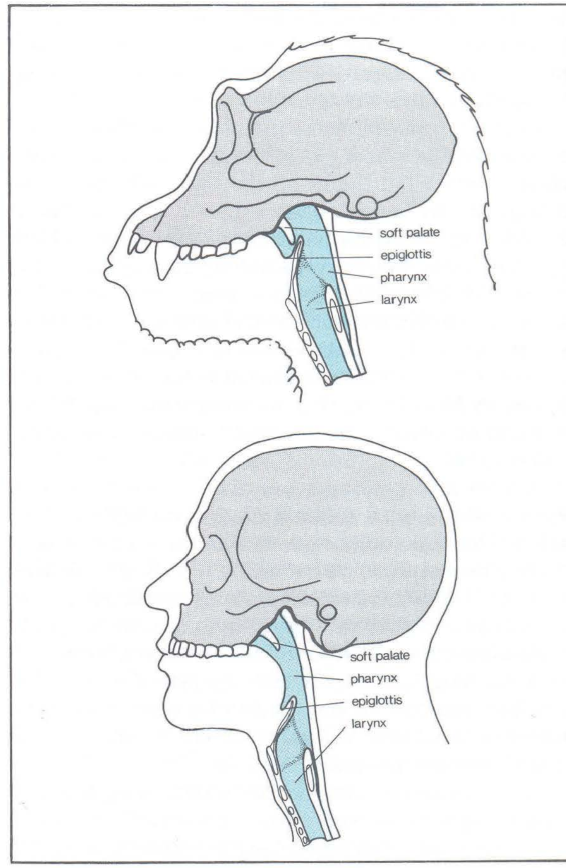
When Did Speech Develop?

Like fine control and movement, speech is also controlled in the left part of the brain. Some scholars believe we can learn something about early language abilities from ***brain endocasts***. These are made by pouring latex rubber into a skull; when set the latex forms an accurate image of the inner surface of the cranium, on which the outer shape of the brain leaves faint impressions. The method gives an estimate of cranial capacity – thus Ralph Holloway has examined two reconstructed skulls from Koobi Fora (KNM-ER 1470 and 1805), and calculated their brain volumes. Skull 1470, dating to about 1.89 million years and usually attributed to *Homo habilis*, had a capacity of either 752 cc or about 775 cc, while 1805, dating to about 1.65 million years and belonging to either *Homo* or *Australopithecus*, had a brain of australopithecine size (582 cc). According to American scholar Dean Falk, 1470's brain endocast shows clearly human features, while 1805 had a brain more like that of a gorilla or chimpanzee.

The speech center of the brain is a bump protruding on the surface of the left hemisphere, which an endocast should theoretically record. Certainly Dean Falk, following on from analyses done by Phillip Tobias, argues that this area of 1470's brain is already specialized for language, and that this hominid was perhaps capable of articulate speech. But by no means all scholars are convinced that features of this type in fossil hominids are ever sufficiently clear for reliable interpretation.

Since fine control and movement are located in the same part of the brain as speech, some scholars go on to argue that the two may be interconnected. From this they develop the thesis that symmetry in tools could be a sign of the sort of intellectual skill needed to understand language. The increasing abundance and perfection of form of the Acheulian hand-axe, or an increase in the number of tool categories, might imply an elevation in intellectual – and therefore language – capacity.

Others, however, deny any correlation between spatial (technological) abilities and linguistic behavior, arguing that toolmaking and language are not conceived or learned in the same way. Much of the apparent standardization of tools, they say, is probably the result of technological constraints in the material and manufacturing process, as well as in our archaeological classifications. Stone tools alone, these scholars conclude, cannot tell us much about language.



Vocal tracts of a chimpanzee (top) and a modern human (above) compared. The human larynx is lower, and the base of the skull is also more arched – a trait whose origins can be studied in the fossil record.

Reconstructing the Vocal Tract. Another approach to assessing speech ability is to try to reconstruct the vocal tract in the throat. Philip Lieberman and Edmund Crelin compared the vocal tract of Neanderthalers, chimpanzees, and modern newborn and adult humans, and claimed that the adult Neanderthal upper throat most closely resembles that of modern infants. Neanderthalers, they argue, lacked a modern pharynx (the cavity above the larynx or voice box) and therefore could make only a narrow range of vowel sounds, not fully articulated speech. This claim rests on fragile evidence and has not been widely accepted.

However, the vocal tract work has received support from Jeffrey Laitman using a different method. He noted that the shape of the base of the skull, which forms a "ceiling" to the throat, is linked to the position of the larynx. In mammals and human infants, the base is flat, and the larynx high, below a small pharynx, but in adult humans the base is curved and the larynx low, with a large pharynx allowing greater modulation of vocal sounds.

Turning to fossil hominids, Laitman found that in australopithecines the base of the skull was flat, and the pharynx therefore small – albeit slightly bigger than in apes. Australopithecines could vocalize more than apes, but probably could not manage vowels. Moreover, like apes and unlike humans, they could still breathe and swallow liquids at the same time. In skulls of *Homo erectus* (1.6 million to 300,000 years ago), the skull-base is becoming curved, indicating that the larynx was probably descending. According to Laitman, full curvature of modern type probably coincides with the appearance of *Homo sapiens*, though he agrees that Neanderthalers (*H. sapiens neanderthalensis*) probably had a more restricted vocal range than modern humans.

Debate about Neanderthal speech abilities was rekindled by the find, at Kebara Cave, Israel, of a 60,000-year-old human hyoid, a small U-shaped bone whose movement affects the position and movement of the larynx to which it is attached. The size, shape, and muscle-attachment marks put the find within the range of modern humans, thus casting more doubt on Lieberman's view and suggesting that Neanderthalers were indeed capable of speaking a language. However, several scholars have pointed out that language is a function of the brain and of mental capacity, and the simple presence of a hyoid is not involved so much as the level of the larynx in the neck.

Recently, however, analysis of the hypoglossal canal, a perforation at the bottom of the skull, where the spinal cord links to the brain, has shown that as long ago as 400,000 years ago these canals were comparable in size to those of modern humans, which suggests that they contained a similar complement of nerves leading to the tongue, and thus that humanlike speech capabilities may have evolved far earlier than had been thought, and certainly long before the Neanderthals.

Identifying Other Kinds of Behavior

Use of Teeth. As we saw in Chapter 7, marks on the teeth of our early ancestors can sometimes suggest that they often used their mouths as a sort of third hand to grip and cut things. In Neanderthalers this is indicated by the extreme wear on the teeth even of fairly young adults, and by the very high incidence of enamel chipping and microfractures.

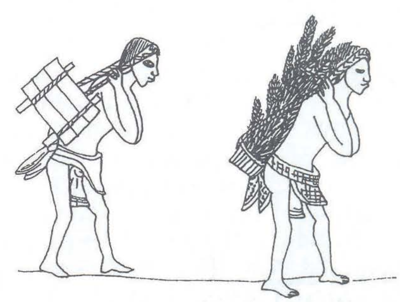
The history of dental hygiene may seem of remote interest to archaeologists, but it is certainly intriguing to know that science can now indicate use of toothpicks of some kind by our early ancestors. David Frayer and Mary Russell found grooves and striations on the cheek teeth of Neanderthalers from Krapina, Croatia, consistent with regular probing by a small, sharp-pointed instrument. Such marks have been observed on the teeth of *Homo erectus* and *Homo habilis* as well. For a much more recent period, the 16th century AD, analysis in the scanning electron microscope of the front teeth of King Christian III of Denmark revealed striations whose form and direction indicated that the king had cleaned his teeth with a damp cloth impregnated with abrasive powder.

Use of Hands and Fingers. One can study surviving hands and fingers to assess manual dexterity and labor. Randall Susman has shown that the first (thumb) metacarpal bone has a broad head in relation to its length in humans but not in chimpanzees, and since this bone has a similar configuration in *Homo erectus*, it follows that this hominid must have had a well-muscled thumb capable of generating the force needed for tool use and manufacture; conversely, the thumb of *Australopithecus afarensis* did not have this potential – it could not have grasped a hammer stone with all five fingers, but its hands were still better adapted to tool use than those of apes. Jonathan Musgrave likewise analyzed the hand bones of Neanderthalers and concluded that they gave a somewhat less precise grip than we have between thumb and index finger. The manicured fingernails of Lindow Man (see box, pp. 448–49) suggested that he did not undertake any heavy or rough work.

Stresses on the Skeleton. Human beings repeat many actions and tasks endlessly through their lives, and these often have effects on the skeleton that physical anthropologists can analyze and try to interpret.

Squatting has been suggested by Erik Trinkaus as a habitual trait among Neanderthalers, on the basis of a high frequency of slight flattening of the ends of the thigh bone and other evidence. Squatting facets on the bones of the ankle joints of the female prehistoric Chinchorro mummies from Arica, on the Chilean coast, are also thought to have been caused by working crouched, perhaps opening shellfish on the beach.

Load-carrying can lead to degenerative changes in the lower spine. In New Zealand such changes have been found in both sexes, but in other regions of the world they are predominantly associated with men. On



In Mesoamerica, without beasts of burden, porters like these Aztecs carried loads using straps around the forehead.

the other hand, females seem to have done most of the carrying in Neolithic Orkney. In his analysis of the skeletons from the Orkney chambered tomb of Isbister, Judson Chesterman noted that several skulls had a visible depression running across the top of the cranium; it was associated with a markedly increased attachment of neck muscles to the back of the skull. These features are known from the Congo, Africa, where women get them from carrying loads on their back, held by a strap or rope over the head. In parts of Central and South America, northern Japan, and other regions, the strap goes across the forehead, and can leave a similar depression there. Numerous Aztec codices depict porters carrying goods in this way in pre-Columbian times.

Theya Molleson's analysis of human remains from the early farming settlement of Tell Abu Hureyra, Syria (box, pp. 296–97), reveals that bones in the foot and big toe bore facets attributable to kneeling and pushing with the toes while grinding grain. Arthritic growths around the joints of the big toes would seem to be the consequence of injuries sustained by over-shooting the end of the saddle-quern – an early version of Repetitive Strain Injury. The deformed bones are found predominantly in females, indicating a division of roles.

Hunting activities may also be detectable from human remains. Neolithic skeletons from a hunter-gatherer site in Niger, some 6000–7000 years old, displayed lesions (the technical term for injuries) representing hyperactivity of certain muscles – in this case, an inflammation of the arms and feet probably caused by the use of bows, throwing weapons, and long runs over hard ground. No such traces were found on females at the site.

Midwives assisting at the birth of a child: a scene from a Peruvian vase produced during the Moche period.

Sexual Behavior and Childbirth. Art and literature provide evidence for innumerable human activities in the past, some of which, such as sex, may not be detectable from any other source. The abundant and finely modeled pre-Columbian Moche pottery of Peru gives us a vivid and detailed display of sexual behavior in the period between AD 200 and 700. If it can be taken as an accurate record, it appears that there was a strong predominance of anal and oral sex, with occasional homosexuality and bestiality – were these methods perhaps adopted as a means of contraception rather than out of preference? We also learn from pottery representations the position that Moche women adopted for childbirth.

DISEASE, DEFORMITY, AND DEATH

So far, we have reconstructed human bodies and assessed human abilities. But it is necessary to look at the other, often more negative aspect of the picture: What was people's quality of life? What was their state of health? Did they have any inherited variations? We may know how long they lived, but how did they die?

Where we have intact bodies, the precise cause of death can sometimes be deduced – indeed, in some cases such as the asphyxiated people of Pompeii and Herculaneum it is obvious from the circumstances (the effect of the eruption of the volcano Vesuvius). For the more numerous skeletal remains that come down to us, however, cause of death can be ascertained only rarely, since most afflictions leading to death leave no trace on bone. Paleopathology (the study of ancient disease) tells us far more about life than about death, a fact of great benefit to the archaeologist.

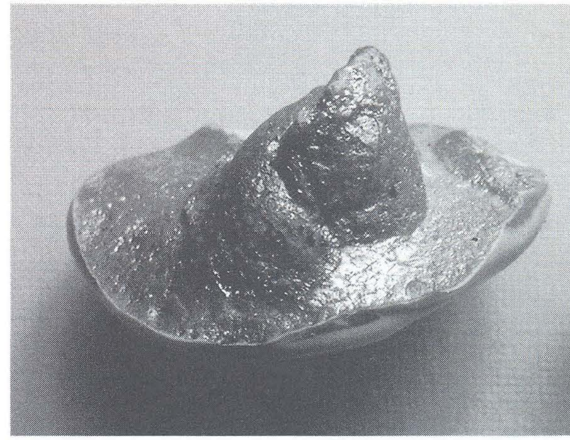
In parallel, physical and forensic anthropologists are increasingly using techniques developed within archaeology to assist them with the recovery and study of human remains. Indeed, a new sub-discipline is now appearing – forensic archaeology – which helps in the recovery and interpretation of murder victims, as well as trying to identify individuals within mass burials, as encountered in Rwanda and former Yugoslavia.

Evidence in Soft Tissue

Since most infectious diseases rarely leave detectable traces in bones, a comprehensive analysis of ancient diseases can only be carried out on bodies with surviving soft tissue. The *surface tissue* can sometimes reveal evidence of illness, such as eczema or similar conditions. It can also reveal certain causes of violent death, such as the slit throats of several bog bodies.

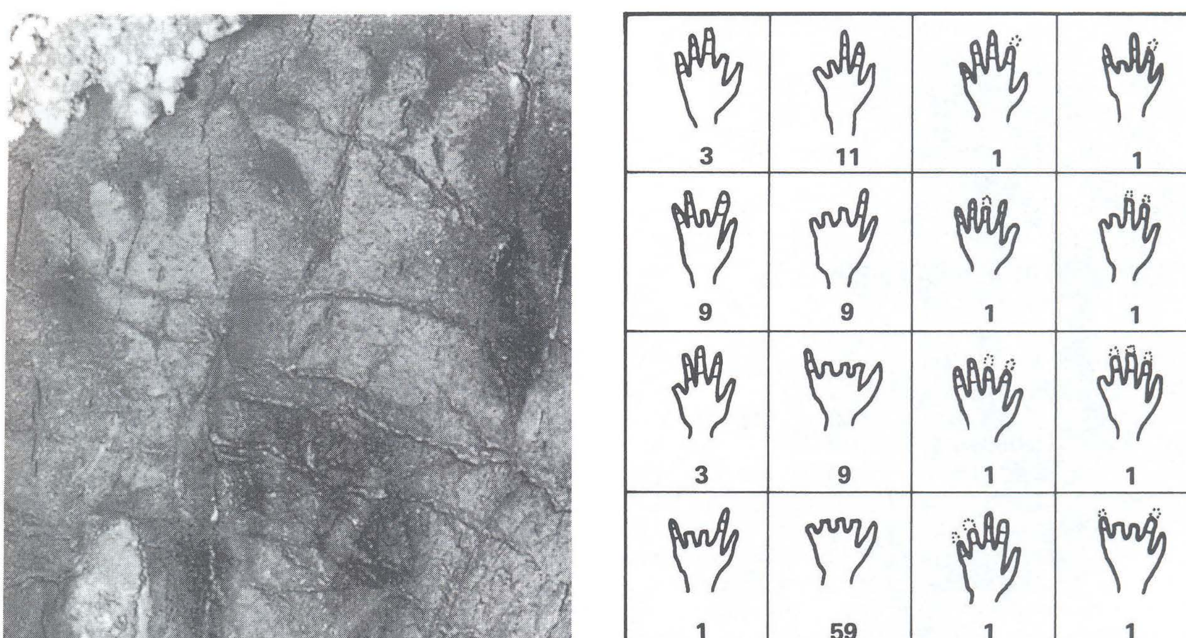
Where *inner tissue* is involved, a number of methods are at the analyst's disposal. X-rays can provide much information, and have been used on Egyptian mummies, but newer, more powerful methods are now available (see box overleaf). Occasionally, one can study soft tissue that is no longer there: the *footprints*, *handprints*, and *hand stencils* mentioned in an earlier section. *Fingerprints* have survived on pieces of fired loess from the Upper Paleolithic site of Dolní Věstonice, the Czech Republic, and on artifacts from many other periods such as Babylonian clay disks and cuneiform tablets from Nineveh (3000 BC), and on ancient Greek vases and sherds, helping to identify different potters.

Some handprints and stencils may supply intriguing pathological evidence. In three or four caves, most notably that of Gargas, France, there are hundreds of late Ice Age hand stencils with apparently severe damage. Some have all four fingers missing. Debate still continues as to whether the stencils were made with the fingers folded, as a kind of sign language, or whether the damage is real but caused by mutilation or disease.



A cast of a finger-end produced by the City of London Police from a hole in a 5000-year-old pot from the Thames, London.

Other forms of art from all periods yield evidence for illnesses. The small figures carved in medieval churches and cathedrals in western Europe illustrate various maladies and ills. The Mexican Monte Albán *danzante* figures carved on stone slabs have sometimes been interpreted as a kind of early medical dictionary, with symptoms and internal organs displayed,



Hand stencils from the late Ice Age cave of Gargas, France. (Left) Photograph of some of the stencils. (Right) Chart showing the numbers of hands found with particular types of "mutilation." Debate still continues as to whether the hands were indeed mutilated, or were shown with the fingers folded.

LOOKING INSIDE BODIES

When examining human remains it is essential to extract the maximum information while causing minimum damage to the remains themselves. In some cases, such as the mummies of the Egyptian pharaohs, the authorities permit examination only under exceptional circumstances. But a considerable amount of knowledge can be gained by simply "seeing" into a body, and modern technology has placed several effective methods at scientists' disposal.

Non-destructive Techniques

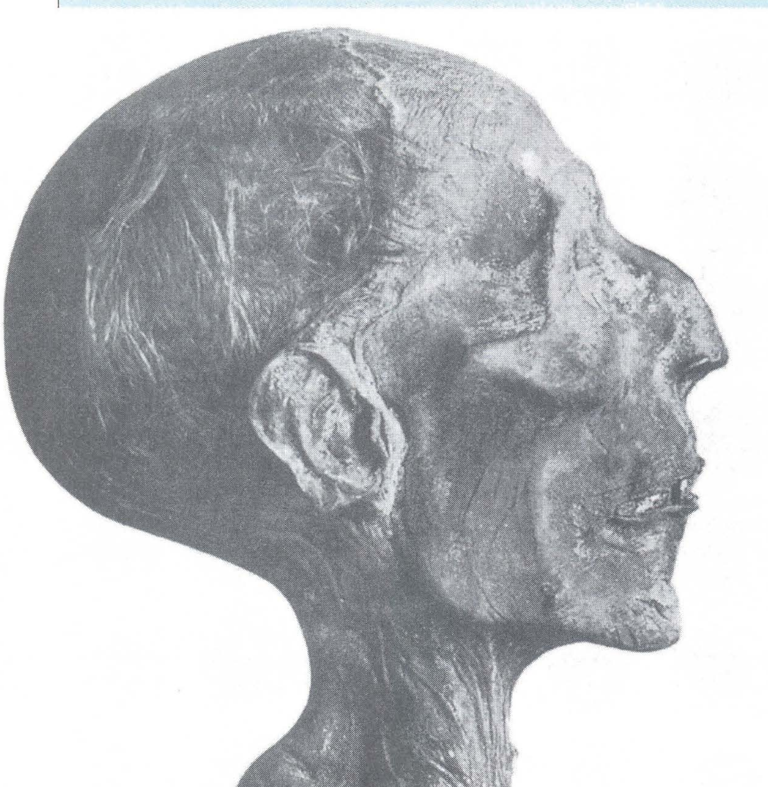
Archaeologists are often surprised by what **X-rays** of coffins and wrapped mummies reveal – animal bodies where human remains were anticipated, additional bodies in one coffin, or a mass of unexpected jewelry. **Xeroradiography** goes a step further. This technique is rather like a cross between X-rays and a photocopy, in that it produces electrostatic images through colored powder being blown onto a selenium plate. The result is a much sharper definition than that produced by normal X-rays; and the wide exposure latitude allows both soft and hard tissue to show clearly on the same image. With "edge enhancement," features are outlined like a pencil drawing. The technique can be used on mummies, either wrapped or in their coffins. When used on the head of the pharaoh Ramesses II, xeroradiography revealed a tiny animal bone inserted by the embalmer to support the nose; and in cavities behind the nose a cluster of tiny beads became apparent.

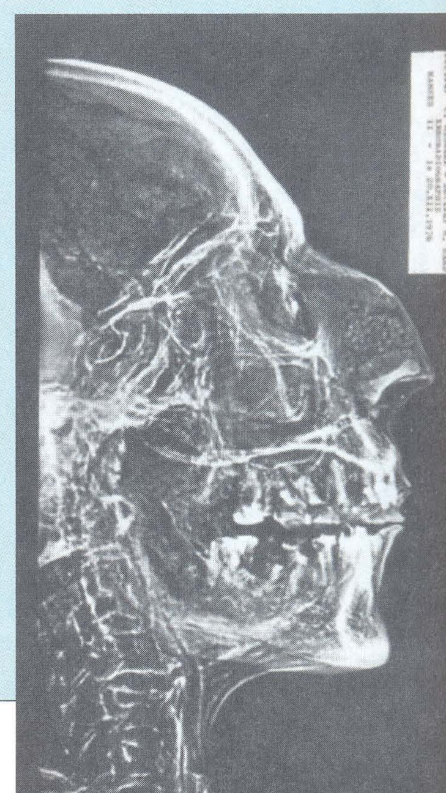
***When the mummy** of Ramesses II was taken to Paris for specialized medical treatment in the 1970s, it was subjected to xeroradiography. Revealed for the first time was a tiny animal bone at the front of the king's nose; in the nasal cavities were clusters of tiny beads.*

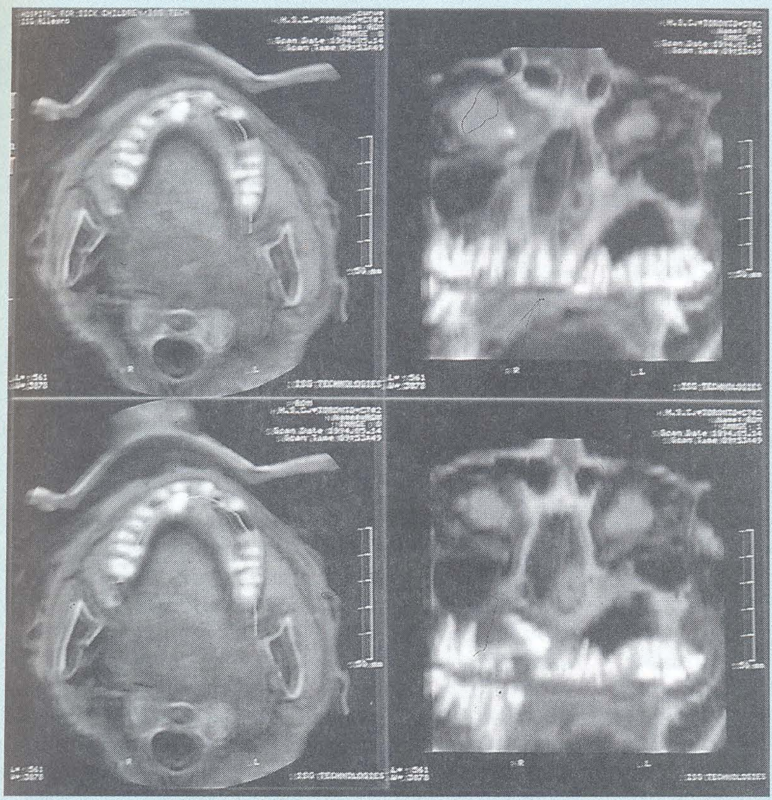
Computed axial tomography using a scanner (hence the abbreviation CT or CAT scanner) is an important method that also allows wrapped mummies and other bodies to be examined in some detail non-destructively. The body is passed into the machine and images produced of cross-sectional "slices" through the body. CAT scanners are more effective at dealing with tissues of different density, enabling soft organs to be viewed as well. New helical scanners move spirally around the body and produce continuous images rather than slices, a much quicker method.

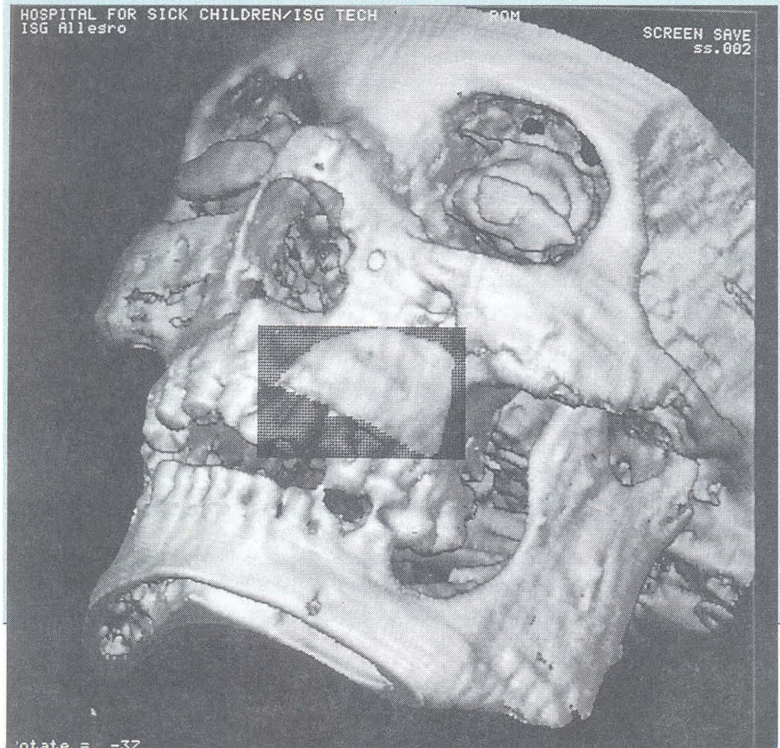
Another technique for looking at internal organs is ***Magnetic Resonance Imaging*** (MRI), which lines up the body's hydrogen atoms in a strong magnetic field, and causes them to resonate by radio waves. The resulting measurements are fed into a computer which produces a cross-sectional image of the body. However, this method is only suitable for objects containing water, and is thus of limited use in studying desiccated mummies.

By using a **fiber-optic endoscope** –









a narrow, flexible tube with a light source – analysts can look inside a body, see what has survived, and in what condition (see box, Lindow Man, pp. 448–49). Endoscopy occasionally reveals details of the mummification process. When inserted into the head of Ramesses V, for example, the fibroscope showed an unexpected hole at the base of the skull through which the brain had been removed (the brain was often broken up and removed through the nose); a cloth had later been put inside the empty skull.

Destructive Techniques

In cases where it is acceptable for the body to have samples taken from it for analysis, there are several techniques at the disposal of the scientist. (It is worth noting that fiber-optic endoscopy (above) is also used in some cases for removing tissue.)

When tissue samples are removed, they are rehydrated in a solution of bicarbonate of soda (becoming very fragile in the process). They are then dehydrated, placed in paraffin wax, and sliced into thin sections which are stained for greater clarity under a microscope. Using this technique on Egyptian mummies, analysts have detected both red and white corpuscles, and have even been able to diagnose arterial disease.

Finally, **analytical electron microscopy** (similar to scanning electron microscopy) permits elements in tissue to be analyzed and quantified. When Rosalie David's Manchester mummy team applied it to one Egyptian specimen, they found that particles in the lung contained a high proportion of silica and were probably sand – evidence of pneumoconiosis in ancient Egypt, where this lung disease was evidently quite a common hazard.

***Computed axial tomography** scanners allow scientists detailed views of mummies without the need to unwrap them. These CT scan images are of an Egyptian female mummy in the Royal Ontario Museum, Toronto examined by Dr Peter Lewin at the Hospital for Sick Children in Toronto. The unfortunate woman had a huge tooth abscess, visible in the scan.*

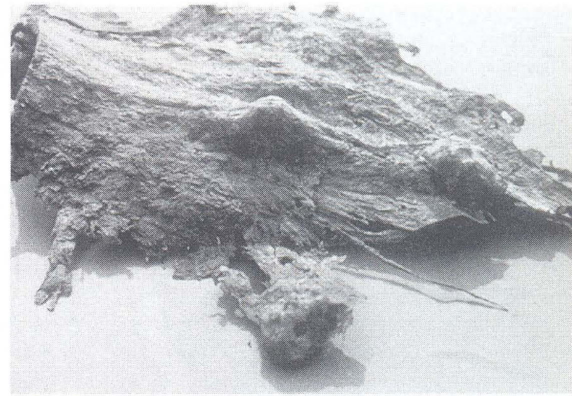
although the current view is that these figures represent slain or sacrificed captives (see Chapters 10 and 13).

Parasites and Viruses

Where soft tissue survives, one can usually find ***parasites*** of some sort. The first place to look is in the bodies themselves, and principally in the guts, although body and head lice can also be detected. Parasites can be identified from their morphology by a specialist. A huge diversity of such infestations has been found in Egyptian mummies – indeed, almost all have them, no doubt because of inadequate sanitation, and an ignorance of the causes and means of transmission of diseases. The Egyptians had parasites that caused amoebic dysentery and bilharzia, and they had many intestinal occupants. Pre-Columbian mummies in the New World have eggs of the whipworm, and the roundworm. Grauballe Man in Denmark must have had more or less continuous stomach ache through the activities of the whipworm *Trichuris*, since he had millions of its eggs inside him (see also the Lindow Man box, pp. 448–49).

Another important source of information about parasites is human coprolites (Chapter 7). The parasite eggs pass out in the feces encased in hard shells, and thus survive very successfully. Parasites are known in prehistoric dung from Israel, Colorado, and coastal Peru – but it is worth noting that 50 coprolites from Lovelock Cave, Nevada, proved to have none at all. It is not uncommon for hunter-gatherers in temperate latitudes and open country to be parasite-free. On the other hand some 6000-year-old samples from Los Gavilanes, Peru, analyzed by Raul Patrucco and his colleagues, had eggs from the tapeworm *Diphyllobothrium*, with which one becomes infested from eating raw or partially cooked sea-fish. Coprolites in other parts of the New World have yielded eggs of the tapeworm, pinworm, and thorny-headed worm, as well as traces of ticks, mites, and lice. Parasites can also be detected in medieval cesspits, while sediments from a French Upper Paleolithic cave at Arcy-sur-Cure, dating to between 25,000 and 30,000 years ago, have been found to contain concentrations of the eggs of parasitic intestinal worms, *Ascaris*, that are almost certainly from human excrement.

Certain parasites cause medical conditions that can be recognized if soft tissue survives. Some prehistoric mummies from the Chilean desert, dating from 475 BC to AD 600, had clinical traces of Chagas' disease – notably an inflamed and enlarged heart and gut. The muscles of these organs are invaded by parasites left on the skin in the feces of bloodsucking bugs.



A lump on the lung of a 900-year-old Peruvian mummy was caused by tuberculosis, ascertained by isolating DNA of the disease in the lesion. It proves that TB was not brought to the Americas by the European colonists.

Scabs and ***viruses*** can also survive in recognizable form in soft tissue, and may possibly even pose problems for the unwary archaeologist. We do not know for certain how long microbes can lie dormant in the ground. Most experts doubt that they pose any danger after a century or two, but there is a claim that anthrax spores survived in an Egyptian pyramid, and infectious micro-organisms may also persist in bodies buried in the Arctic, preserved by the permafrost. The dangers in decaying bone and tissue may be very real – especially as our immunity to vanished or rare diseases has now declined.

A safer approach is provided by genetics, since some diseases leave traces in DNA. Smallpox and polio, for example, are caused by viruses, and a virus is simply DNA, or closely related RNA, in a "protective overcoat" of protein. A virus infects by releasing its DNA into the unfortunate host, and some of the host's cells are then converted to the production of viruses. In this way viral infections can leave traces of the DNA of the virus. Analysis of ancient genetic material may therefore help to trace the history of certain diseases. For example, American pathologist Arthur Aufderheide and his colleagues have isolated fragments of DNA of the tuberculosis bacterium from lesions in the lungs of a 900-year-old Peruvian mummy, thus proving that this microbe was not brought to the Americas by European colonists.

Skeletal Evidence for Deformity and Disease

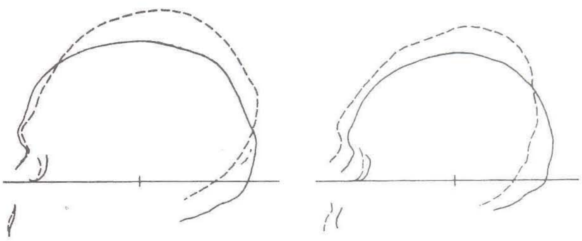
Skeletal material, as we have seen, is far more abundant than preserved soft tissue, and can reveal a great deal of paleopathological information. Effects on the outer surface of bone can be divided into those caused by violence or accident, and those caused by disease or congenital deformity.

Violent Damage. Where violence or accidents – known as traumas – are concerned, straightforward observation by an expert can often reveal how the damage was caused, and how serious its consequences were for the victim. For example, one of the Upper Paleolithic skeletons of children from Grimaldi, Italy, had an arrowhead buried in its backbone, a wound that was very probably mortal – as was the famous Roman ballista bolt found by Mortimer Wheeler in the spine of an ancient Briton at the Iron Age hillfort of Maiden Castle, southern England. A study by Douglas Scott and Melissa Connor of the skeletal remains at the famous battle of the Little Big Horn, Montana – where General Custer and his entire force of 265 men were wiped out by the Sioux in 1876 – showed the extensive use of clubs and hatchets to deliver a *coup de grâce*. One poor soldier, about 25 years old, had been wounded in the chest by a .44 bullet, then shot in the head with a Colt revolver, and finally had his skull crushed with a war club.

In cases where the bones are masked by soft tissue, X-ray analysis is necessary (see box previous pages).

Individual wounds and fractures, however compelling the personal stories they reveal, are nevertheless of limited interest to medical history. It is their frequency and type that are more useful. A community of hunter-gatherers will have encountered different dangers from those faced by a community of farmers, and their skeletal traumas should therefore be different. The aim should be to study the pathologies of entire groups and communities wherever possible.

As with other kinds of archaeological evidence, one has to be alert to the possibility that changes (in this case damage such as broken or deformed skulls) may have been caused by physical or chemical action after burial in the soil. Some human communities have even deformed skulls deliberately, by binding the brow of growing infants, with or without a board, or by applying pressure at regular intervals to produce a frontal flattening. Analysis of two of the Neanderthalers of Shanidar Cave, Iraq, has led Erik Trinkaus to claim that skull deformation was already practiced at this early date. It also seems to have existed in Pleistocene or early Holocene Australia. Peter Brown compared deliberately deformed Melanesian skulls with normal specimens, in order to identify the changes caused by deformation. He then applied his results to skulls from early Australian sites in Victoria, including Kow Swamp, and established beyond doubt that they had



Skull deformation. (Right) Skull outlines of an artificially deformed Melanesian male – dashed line – and a normal male. (Left) A 13,000-year-old skull from Kow Swamp, Australia – dashed line – compared with that of a modern male Aborigine, suggesting that the Kow skull was deformed deliberately.

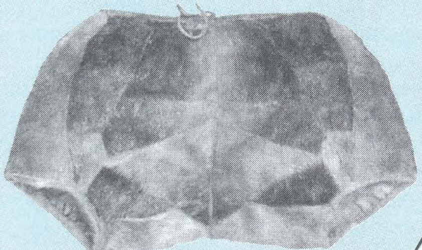
been artificially deformed. The oldest specimen, Kow Swamp 5, is 13,000 years old.

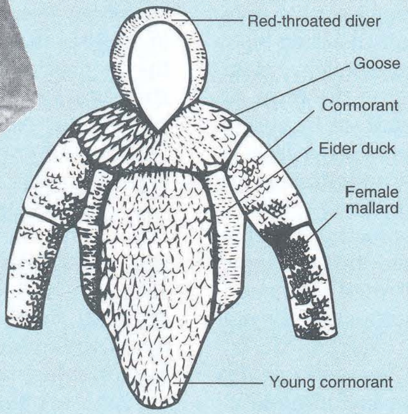
One of the Shanidar Neanderthalers, a man aged about 40, had suffered a blow to the left eye, making him partially blind. He also had a useless, withered right arm, caused by a childhood injury, a fracture in one foot bone, and arthritis in the knee and ankle. Individuals such as this could only have survived through the help of their fellows.

Other practices besides skull deformation are detectable. Tim White used a scanning electron microscope to analyze the skull of "Bodo," a large male *Homo erectus* or archaic *Homo sapiens* from Ethiopia, about 300,000 years old, and came to the conclusion that it had been scalped. Analysis revealed two series of cutmarks, one on the left cheek under the eye socket, and the other across the forehead. These were made before the bone had hardened and fossilized, and therefore just before or just after death. Pre-Columbian Indian skulls that were scalped – for ritual reasons prior to burial – have similar marks in the same positions.

Identifying Disease from Human Bone. The small number of diseases that affect bone do so in three basic ways – they can bring about erosion, growths, or an altered structure. Each of these phenomena has many possible causes, but some afflictions leave quite clear signs. *Leprosy*, for example, erodes the bones of the face and the extremities in a distinctive manner, and there are clear specimens from medieval Denmark. Recently, DNA from the leprosy bacterium has been isolated from a 1400-year-old skeleton in Israel. Certain cancers also have a noticeable effect on bone (see box overleaf), such as the pathological changes to the leg bones of the elderly Neanderthal man of La Ferrassie 1, France, which are likely to have been caused by lung cancer. Australian archaeologist Dan Potts and his colleagues have discovered the world's earliest known

LIFE AND DEATH AMONG THE INUIT





***Cold, dry** conditions resulted in remarkable finds at Qilakitsoq. This six-month-old child (top right) was the best preserved of all the mummies. Leather clothing likewise survived, as in the boot and shorts above. The drawing is of a woman's garment made from feathers carefully chosen from different birds, and worn next to the skin for extra warmth.*

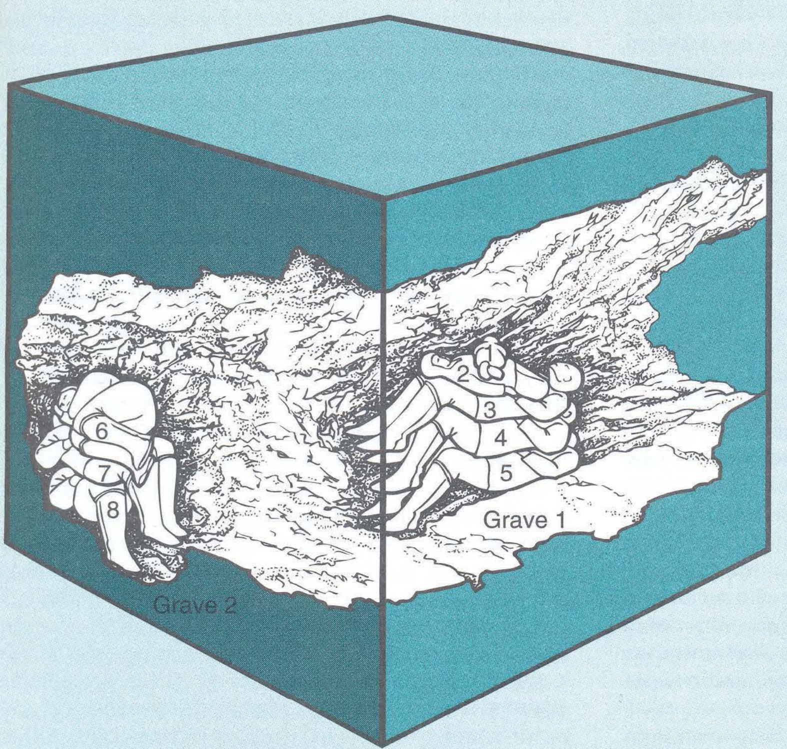
Among the most interesting aspects of the study of human remains are the assessment of the state of health, the quality of life, and the cause of death of the individuals concerned.

In 1972, two collective burials were discovered under an overhanging rock at Qilakitsoq, a small Inuit settlement on the west coast of Greenland dating to about AD 1475. The eight bodies had all been mummified naturally by a combination of low temperature and lack of moisture. In one grave were 4 women and a six-month-old infant; in the other, 2 women and a four-year-old boy. The over- and under-clothing (a total of 78 items including trousers, anoraks, boots) had also survived in perfect condition.

The bodies were sexed by the genitalia of those that were unwrapped, and from X-ray examination of the pelvis and other bones of the mummies left intact; in addition, facial tattoos were usually restricted to adult women in this society.

Aging was done from dental development and other physical features. Three of the women died in their late teens/early 20s, but the other three had reached about 50 – a good age, since even at the turn of this century the average age of death for women in Greenland was only 29.

The young boy and one woman may have been in much pain. X-rays of the boy showed that he had a misshapen pelvis of a kind often associated with Down's Syndrome children. A disorder known as Calvé-Perthe's disease was also destroying the head of a thigh bone, and he may have had to move around on all fours. The woman, one of those aged 50, had broken her left collarbone at some stage; it had never



The eight bodies, layers of animal skins between them, lay protected by overhanging rock. Their frozen, moistureless grave resulted in natural mummification.

knitted, which perhaps impaired the function of her left arm. In addition, she had naso-pharyngeal cancer (cancer at the back of her nasal passage) which had spread to surrounding areas, causing blindness in the left eye, and some deafness.

Some of her features could be attributed to particular activities: her left thumbnail had fresh grooves on it, caused by cutting sinew against it with a knife (and, incidentally, showing that she was right-handed). She had also lost her lower front teeth, no doubt from chewing skins and using her teeth as a vice, like the Barrow Inuit in Alaska (box, p. 65).

Another similarity with the Alaskan case is that the youngest woman's lungs contained high levels of soot, probably from seal-blubber lamps. On the other hand, hair samples from the mummies showed low levels of mercury and lead, far lower than in the region today.

How these people met their deaths remains a mystery. At any rate, they did not die of starvation. The woman with cancer had Harris lines showing arrested bone growth as a child caused by illness or malnutrition, but she was well nourished when she died. The youngest woman had a sizeable quantity of digested food in her lower intestine. Isotopic analysis of the young boy's skin collagen (p. 307) revealed that 75 percent of his diet came from marine products (seals, whales, fish) and only 25 percent from the land (reindeer, hare, plants).

Finally, analysis was carried out to ascertain the possible relationships among these individuals. Tissue typing established that some were not related at all, while others might have been. Either of two of the younger women could have been the mother of the four-year-old boy buried above them; while two of the women aged about 50 (including the one with cancer) may have been sisters. They also had identical facial tattoos, perhaps by the same artist, which were just like those on the earliest known portrait from this area (*c.* AD 1654). Another woman had a tattoo so different in style and workmanship that she probably came from a different region and had married into the group.

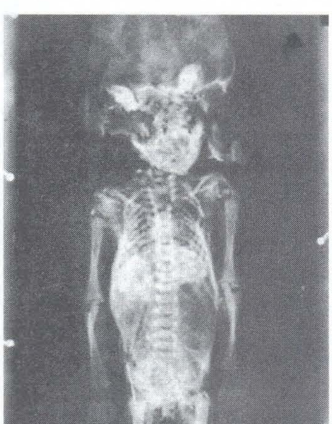
Infrared photography has made the tattoo design on this woman's face clearly visible.

polio victim in a 4000-year-old grave in the United Arab Emirates; the skeleton of an 18- to 20-year-old girl showed classic symptoms of the condition, such as the small size and inflammation of muscle attachments, thinness of all long bones, one leg 4 cm (1.6 in) shorter than the other, a curved sacrum, and asymmetrical pelvis.

In some diseases, the body produces hard structures distinct from bone – calcium compounds, which form stones in the gallbladder or kidney – and these often survive. Straightforward observation or X-ray analysis is sufficient for most studies of this kind.

Deformity in bone often reveals a congenital abnormality. The tiny mummified fetus of a female, one of two found in the tomb of Tutankhamun, was shown by X-ray analysis to have ***Sprengel's deformity*** – where the left shoulder blade is congenitally high, and spina bifida is present – which probably explains why the infant, perhaps Tutankhamun's own child, was stillborn. Egypt also provides skeletal evidence of ***dwarfism***, a congenital birth condition, and the same has been found among Paleo-Indians in Alabama. However, the earliest known example of a dwarf is a male from the 10th millennium BC, no more than 1.1–1.2 m (3 ft 7 in–3 ft 11 in) tall, who died at the age of about 17 and was buried in the decorated cave of Riparo del Romito, Calabria, Italy.

Calvin Wells' analysis of the 450 skeletons from Roman Cirencester, England, revealed a number of congenital defects in the spine, and five skeletons with evidence of *Spina bifida occulta*. However, the most common ailment was ***arthritis***, in most joints of the body, which was found in about half the males. At Mesa Verde, Colorado, in the period AD 550 to 1300, every known individual over 35 suffered from osteoarthritis.



A tiny mummified fetus from Tutankhamun's tomb was shown by X-ray analysis to have Sprengel's deformity, probably explaining why the child, a female, was stillborn.

Art may also provide evidence of congenital deformities. The most common motif in the Olmec art of Mexico is an anthropomorphic figure, a child with feline facial features known as the "were-jaguar motif." It often displays a cleft forehead, and a downturned, open mouth, with canine teeth protruding; the body is usually obese and sexless. Carson Murdy suggests that the motif represents congenital deformities, and Michael Coe has argued that the cleft forehead represents spina bifida, which is associated with a number of cranial deformities. Such conditions usually occur only about once in every thousand live births and may therefore have been restricted to a certain social group, or even to a single extended family. Carson Murdy hypothesizes that a chief's family may have used the phenomenon in art and religion to reinforce their status, identifying their children's deformities with the characteristics of the supernatural jaguar. If "jaguar blood" ran in the family, it would be only natural to produce "were-jaguar" offspring.

X-ray analysis of bone may reveal lines of arrested growth known as ***Harris lines*** (see box pp. 444–45 for a study that detected these lines). These are opaque calcified formations, a few micromillimeters thick, that occur when growth is interrupted during childhood or adolescence because of illness or malnutrition. They are usually clearest in the lower tibia (shin-bone). The number of lines can provide a rough guide to the frequency of difficult periods during growth. If the lines are found in whole groups of skeletons of the same age group and period, they can indicate crises of subsistence, or, in other cases, some social inequality of the sexes. Similarly, ***Beau's lines*** on finger- and toenails are shallow grooves indicating slowed growth caused by disease or malnourishment; the one surviving fingernail of the Alpine Iceman of 3300 BC has 3 such grooves, suggesting that he had been subject to bouts of crippling disease 4, 3, and 2 months before he died (see box, pp. 66–67).

Lead Poisoning. Analysis of bone can show that the danger of poisoning from toxic substances is by no means confined to our own times. Some of the Roman inhabitants of Poundbury, England, had a remarkably high concentration of lead in their bones, probably thanks to their diet. Lead has also been found in face-powder from a 3000-year-old Mycenaean tomb in Greece, probably used as a cosmetic.

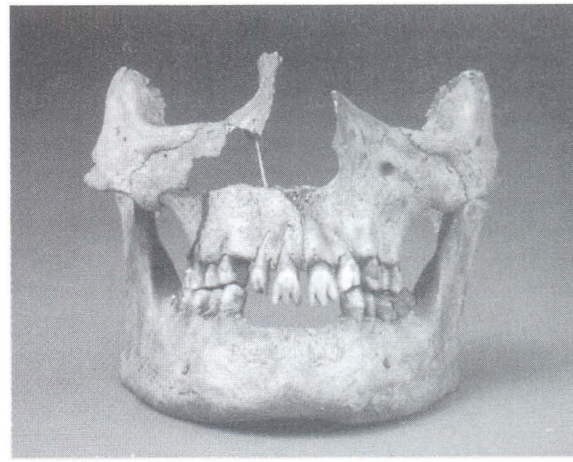
Three British sailors, who died and were buried 140 years ago on Canada's Beechey Island, Northwest Territories, had been crew members of the 1845 Franklin expedition attempting to find a navigable Northwest Passage. Their bodies, well preserved in permafrost, were exhumed by the Canadian anthropologist Owen Beattie and his colleagues. Analysis of bone samples revealed an enormously high lead content, enough to cause poisoning if ingested during the expedition. The poisoning probably came from the lead-soldered tins of food, lead-glazed pottery, and containers lined with lead foil. Combined with other conditions such as scurvy, this could have been lethal.

Lead in skeletons has also provided insights into the lives of Colonial Americans. Arthur Aufderheide analyzed bones from burial grounds in Maryland, Virginia, and Georgia, dating from the 17th to 19th centuries. He found that the people there had been exposed to lead from the glaze in their ceramics, and also from pewter containers, which they used for storing, preparing, and serving food and drink. However, only the affluent could afford to poison themselves in this way, and this is the key to obtaining social data from the lead content. In two populations from plantations in Georgia and Virginia, white tenant farmers tended to have more lead than free blacks or slaves, but less than the wealthier plantation owners. On the other hand, white servants usually had low levels, especially those working for white tenant farmers. This suggests sharp segregation from their employers.

Teeth

Food not only affects bones, it also has a direct impact on the teeth, so that study of the condition of the dentition can provide much varied information. Analysis of the teeth of ancient Egyptians such as Ramesses II, for example, shows that the frequently heavy wear and appalling decay was caused not just by sand entering the food, but by the consistency of the food and the presence of hard material in plants. X-ray analysis can in addition reveal dental caries and lesions. The skeletons from Roman Herculaneum had an average of only 3.1 dental lesions each, which indicates a low sugar intake compared with today, as in ancient Egypt, probably helped by a water supply with lots of fluoride.

When analyzing dentitions one needs to remember that healthy teeth were sometimes extracted for ceremonial or aesthetic reasons. This practice was very common in the Jomon period in Japan (especially around 4000 years ago), and was applied to both sexes over the age of 14 or 15. Certain incisors, and occasionally premolars, were removed. Indeed, in the later Jomon (3000–2200 years ago), three different regional styles developed.



Part of an adult female skull and jawbone from a Jomon-period site in Fujiidera City, Osaka, Japan, with teeth extracted and decorated – presumably for ceremonial or decorative reasons.

In Australia the Aboriginal custom of tooth avulsion – the knocking out of one or two upper incisors as part of a male initiation ceremony – has been found in a burial at Nitchie, New South Wales, dating to around 7000 years ago, while the skull from Cossack, Western Australia, some 6500 years old, also seems to have had a tooth removed long before death.

Finally, there is early evidence of dentistry. The world's oldest filling has been found in Israel, in the tooth of the Nabataean warrior buried 2000 years ago in the Negev Desert, mentioned in an earlier section. Investigation by Joe Zias found that one of his teeth was green because it had been filled with a wire that had oxidized. It is likely that the dentist had cheated him. Instead of inserting a gold wire, he had installed one in bronze, which is corrosive and poisonous. The oldest known false tooth is an iron specimen, precisely fitted to the jaw of a 1900-year-old Gaul from Chantambre, near Paris.

The examination of the skull of Isabella d'Aragona (1470–1524), an Italian noblewoman and possible inspiration for Leonardo da Vinci's Mona Lisa, revealed that her teeth were coated with a black layer which she had tried so desperately to remove that the enamel on her incisors was rubbed away. Analysis of the black layer showed that it was caused by mercury intoxication: inhalation of mercury fumes was common in that period as a treatment for syphilis and other complaints, especially skin conditions. The result of protracted treatment was a serious inflammation of the teeth, and it is probable that Isabella's death was caused by mercury rather than the syphilis.

LINDOW MAN: THE BODY IN THE BOG

In 1984, part of a human leg was found by workers at a peat-shredding mill in northwest England. Subsequent investigation of the site at Lindow Moss, Cheshire, where the peat had been cut revealed the top half of a human body still embedded in the ground. This complete section of peat was removed and later "excavated" in the laboratory by a multi-disciplinary team led by British Museum scientists. The various studies made of the body have yielded remarkable insights into the life and death of this ancient individual, now dated to the late Iron Age or Roman period – perhaps the 1st century AD – although results from radiocarbon have been conflicting.

Age and Sex

Despite the missing lower half, it was obvious from the beard, sideburns, and moustache that this was the body of a male. The age of Lindow Man (as he is now called) has been estimated at around the mid–20s.

Physique

Lindow Man appears to have been well-built, and probably weighed around 60 kg (132 lb or nearly 10 stone). His height, calculated from the length of his humerus (upper arm bone), was estimated to be between 1.68 and 1.73 m (5 ft 6 in to 5 ft 8 in) – average today, but fairly tall for the period.

Appearance

Lindow Man wore no clothing apart from an armband of fox fur. His brown/ginger hair and whiskers were cut, and analysis by scanning electron microscopy indicated that their ends had a stepped surface, implying that they had probably been cut by scissors or shears. His manicured fingernails indicate that he did not do any heavy or rough work – he was clearly not a laborer.

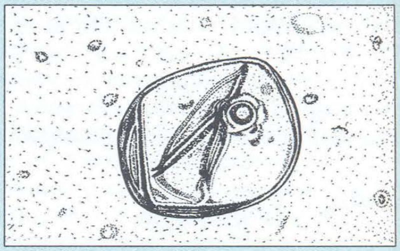
Bright green fluorescence in his hair was thought to be caused by the use of copper-based pigments for body decoration, but in fact is due to a natural reaction of hair keratin with acid in the peat.

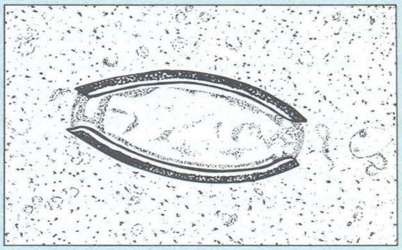
The bog acid had removed the enamel from his teeth, but what survived seemed normal and quite healthy – there were no visible cavities.

State of Health

Lindow Man appears to have had very slight osteoarthritis; and computed axial tomography (see box, pp. 440–41) revealed changes in some vertebrae caused by stresses and strains. Parasite eggs show that he had a relatively high infestation of whipworm and maw worm, but these would have caused him little inconvenience. Overall, therefore, he was fairly healthy.

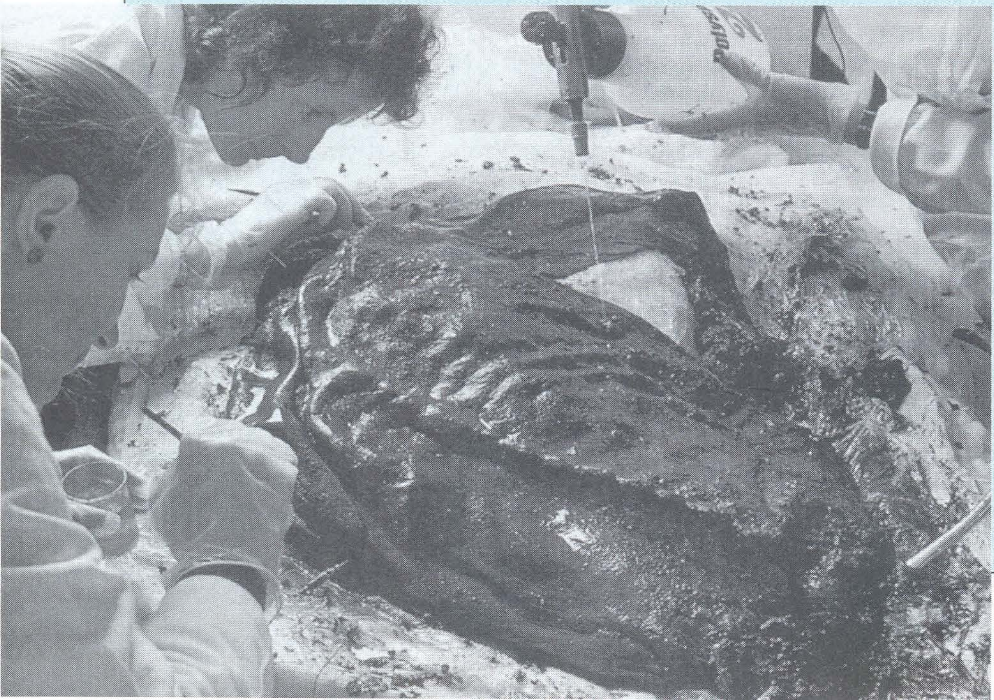
His blood group was found to be O, like the majority of modern Britons. Computed tomography scans showed





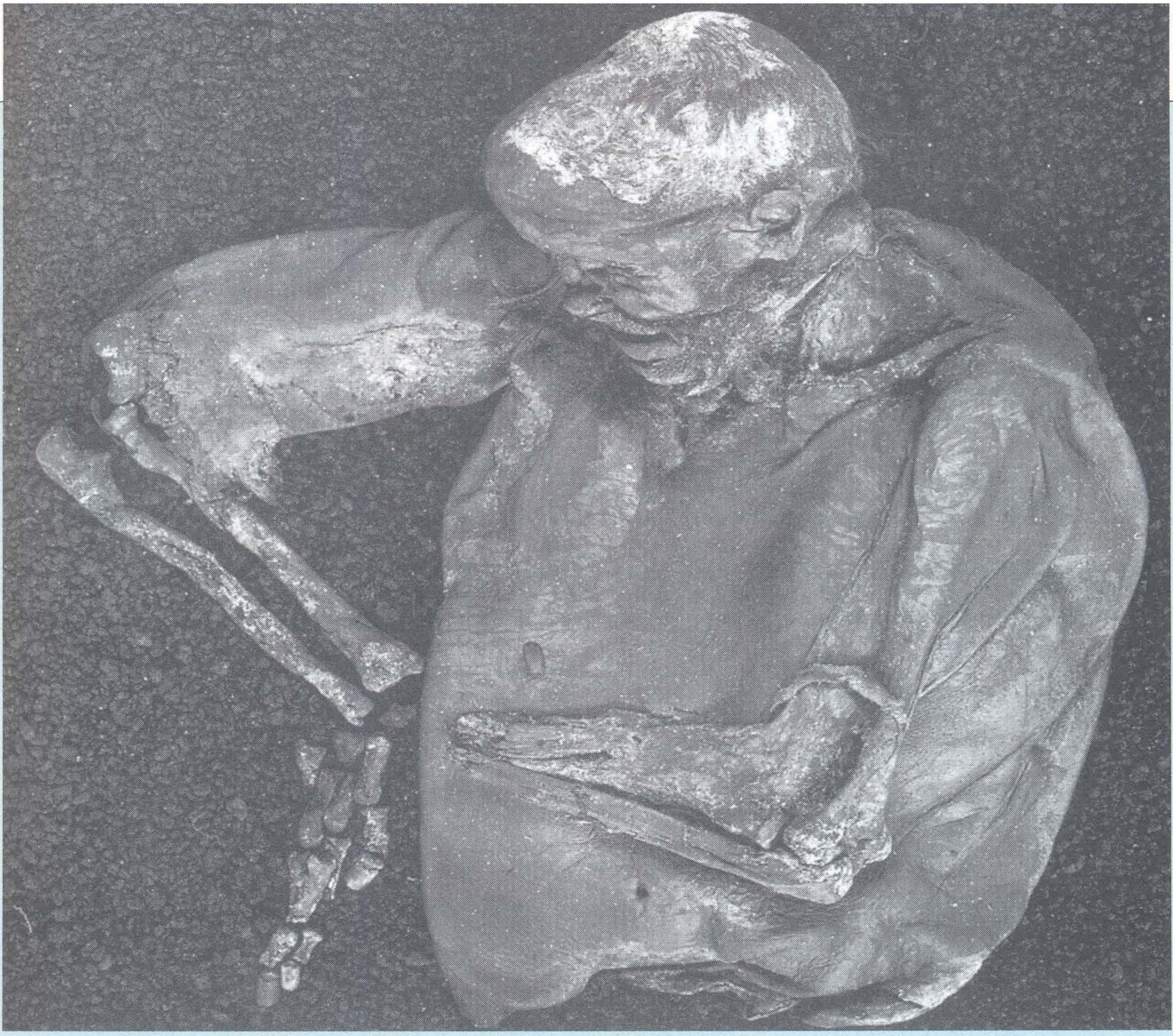
***Cereal pollen** grain (top) from the small intestine.*

***Egg of the** intestinal worm Trichuris trichiura (above) from Lindow Man.*



***Cleaning the back** of Lindow Man in the laboratory. Distilled water is being sprayed to keep the skin moist.*

that the brain was still present, but when an endoscope (box, pp. 440–41) was inserted to explore the interior of his skull it became clear that no brain structure remained, only a mass of putty-like tissue. As explained in Chapter 7, the food residues in the part of his upper alimentary tract that survived revealed that his last meal had consisted of a griddle cake.



Fully conserved *remains of Lindow Man photographed in ultra-violet light to enhance the details.*

How Did He Die?

Xeroradiography (box, pp. 440–41) confirmed that his head had been fractured from behind – it revealed splinters of bone in the vault of the skull. A forensic scientist deduced from the two lacerated wounds joined together that the skull had been driven in twice by a narrow-bladed weapon. There may also have been a blow (from a knee?) to his back, because xeroradiography showed a broken rib.

The blows to the head would have rendered him unconscious, if not killed him outright, so that he cannot have felt the subsequent garotting or the knife in his throat. A knotted thong of sinew, 1.5 mm thick, around his throat had broken his neck and strangled him, and his throat had been slit with a short, deep cut at the side of the neck that severed the jugular. Once he had been bled in this way, he was dropped face-down into a pool in the bog.

We do not know why he died – perhaps as a sacrifice, or as an executed criminal – but we have been able to learn a great deal about the life and death of Lindow Man, who has been subjected to perhaps the most extensive battery of tests and analyses ever applied to an ancient human being.

Medical Knowledge

Documentary sources are important to our understanding of early medicine. Egyptian literature mentions the use of wire to prevent loss of teeth by holding them together. Roman texts also tell us something about dental treatment. Where general medicine is concerned, there are medical papyri from Egypt, and ample documentary and artistic evidence from Greece and Rome, as well as from later cultures.

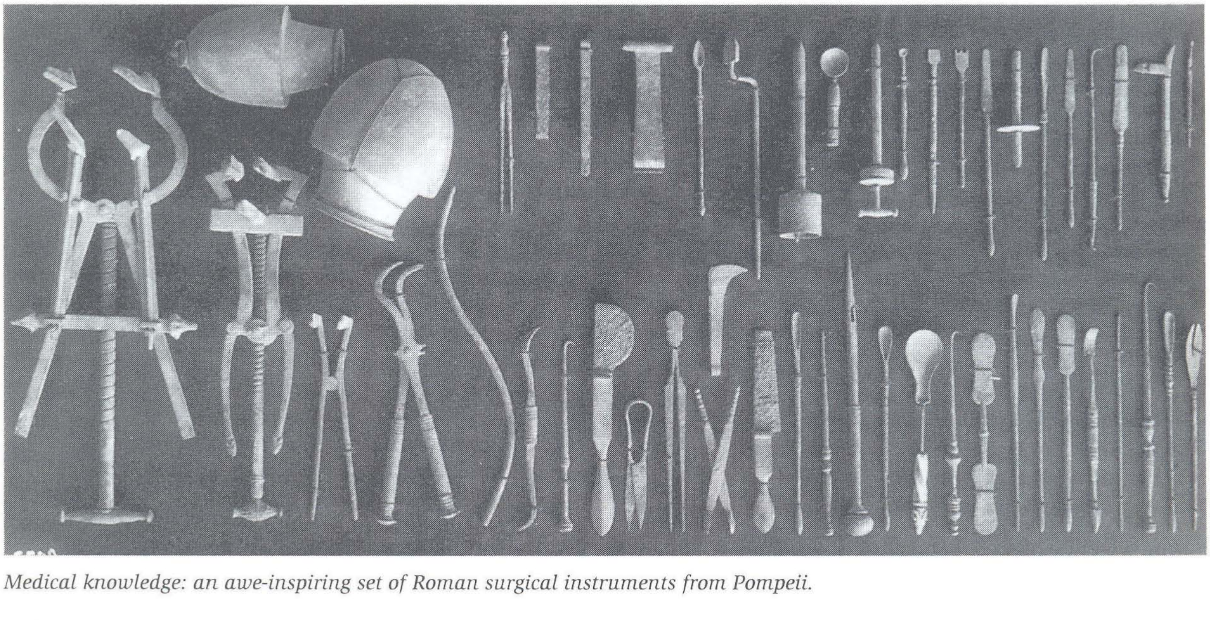
The most common and impressive archaeological evidence for medical skill is the phenomenon of trepanation, or trephination, the cutting out of a piece of bone from the skull, probably to alleviate pressure on the brain caused by skull fracture, or to combat headaches or epilepsy. Over 1000 cases are known, and more than half had healed completely – indeed, some skulls have up to seven pieces cut out. Amazingly, this practice dates back at least 7000 or 8000 years.

Other evidence for early medical expertise includes bark splints found with broken forearms dating to the 3rd-millennium BC in Egypt, and the dismembered skeleton of a fetus from the 4th-century AD Romano-British cemetery at Poundbury Camp, Dorset, whose cutmarks correspond precisely to the operation described by Soranus, a Roman doctor, for removing a dead infant from the womb to the save the mother.

Actual examples of surgeons' equipment include large sets of instruments unearthed at Pompeii and a full Roman medical chest with intact contents (including wooden lidded cylinders of medicines) recovered from a shipwreck off Tuscany, Italy. A similar kit was discovered in the wreck of the *Mary Rose*, the 16th-century British ship, and included flasks, jars, razors, a urethral syringe, and knives and saws.

The remains of an 11th-century AD hospital attached to a Buddhist monastery outside the city of Polonnaruva in Sri Lanka contained medical and surgical instruments, and glazed storage vessels, suggesting a sophisticated level of medical care. A set of surgical instruments has also been found in Peru, from the Chimú period, AD 450–750. It consists of scalpels, forceps, bandages of wool and cotton, and, most interesting of all, some metal implements closely resembling modern instruments used to scrape a uterus in order to induce an abortion. It comes as no surprise that the ancient Peruvians had achieved this level of skill – we know from other evidence that they routinely did trepanation, and added artificial parts to support faulty limbs. Their pottery displays detailed medical knowledge, including the different stages of pregnancy and labor. It is also clear from Maya codices and Spanish records of the Aztecs that other peoples of the New World had sophisticated medical know-how, including the use of hallucinogenic fungi.

Archaeologists and paleopathologists thus use a wide variety of methods to provide insights into the health of past peoples. By combining these approaches with data on subsistence (Chapter 7), we can now go on to examine the quality of diet of our ancestors and the likely character and size of their populations.



Medical knowledge: an awe-inspiring set of Roman surgical instruments from Pompeii.

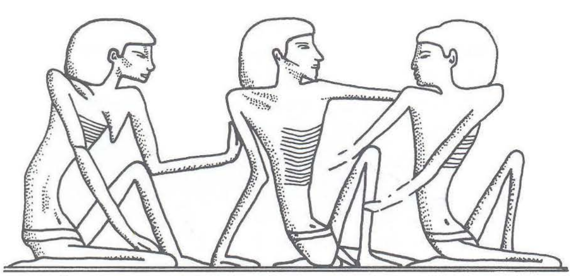
ASSESSING NUTRITION

Nutrition can be described as the measure of a diet's ability to maintain the human body in its physical and social environment. We are of course interested to be able to learn that a particular group of people in the past enjoyed good nutrition. In his investigations in northeast Thailand, the archaeologist Charles Higham found that the prehistoric people of 1500–100 BC had abundant food at their disposal, and displayed no signs of ill health or malnutrition; some of them lived to over 50. But in many ways what is more informative is to discover that the diet was deficient in some respect, which may have affected bone thickness and skeletal growth. Furthermore, comparison of nutrition at different periods may significantly add to our understanding of fundamental changes to the pattern of life, as in the transition from hunting and gathering to farming.

Malnutrition

What are the skeletal signs of malnutrition? In the previous section, we mentioned the Harris lines that indicate periods of arrested growth during development, and that are sometimes caused by malnutrition. A similar phenomenon occurs in *teeth*, where patches of poorly mineralized dentine, which a specialist can detect in a tooth-section, reflect growth disturbance brought about by a diet deficient in milk, fish, oil, or animal fats. A lack of vitamin C produces scurvy, an affliction that causes changes in the palate and gums, and has been identified in an Anglo-Saxon individual from Norfolk, England. Scurvy was also common among sailors until the 19th century because of their poor diet.

The general size and condition of a skeleton's bones can provide an indication of aspects of diet. The adult skeletons found at Roman Herculaneum, for example, had leg bones flatter than the modern average, an indication of a diet poorer in protein than ours. As mentioned earlier, sand in food, or the grit from grindstones, can have drastic effects on teeth. The excessive abrasion of teeth among certain California Indians can be linked to their habit of leaching the tannins out of acorns (their staple food) through a bed of sand, leaving a residue in the food.



Evidence for malnutrition: detail of a wall relief at Saqqara in Egypt depicting famine victims, c. 2350 BC.

Additional evidence for malnutrition can be obtained from ***art and literature***. Vitamin B deficiency (beriberi) is mentioned in the *Su Wen*, a Chinese text of the 3rd millennium BC, and Strabo also refers to a case among Roman troops. Egyptian art provides scenes such as the well-known "famine" depicted at Saqqara, dating to around 2350 BC.

Comparing Diets: the Rise of Agriculture

Chemical analysis of bone allows further insights. After bone has been burnt to ash, atomic absorption spectroscopy can reveal the amounts of various elements (strontium, zinc, calcium, sodium, etc.) present in it. Two burial populations from the eastern United States have been compared using this method. One was a group of hunter-gatherers of the Middle Woodland period (AD 400), while the other was a group of maize farmers of the Late Woodland (AD 1200). In the first group, males and females had statistically identical bone composition for every element. Among the maize farmers, on the other hand, there were significant differences between the sexes, in that males had less strontium and calcium, and more zinc, than females.

All of these are diet-related elements, and it therefore appears that there existed dietary differences between the sexes by this period, with perhaps a greater differentiation of roles which may be linked to maize cultivation. The lower concentration of strontium in males indicates that they had more animal protein in their diet than the females, who presumably ate more maize than the men (see also section on analysis of bone collagen, p. 307).

A maize diet can have other effects on the body. In a similar study of two eastern North American populations from a single site, Dickson Mounds in Illinois, John Lallo and Jerome Rose found that through time, from AD 1050 to 1300, there was a growing dependence on maize. This seems to have been accompanied by a rise in population density and hence in social contacts, associated with a marked increase in the frequency and severity of damage from disease in bones. They also found skeletal evidence for a deficiency of iron, and an increase in dental defects reflecting nutritional stress or an increase in disease. In short, the skeletons showed how economic and social changes can be linked in this case to an increase in disease and nutritional problems.

These findings are supported by Clark Larsen's comparison of some 269 hunter-gatherer skeletons (2200 BC–AD 1150) and 342 agricultural community skeletons (AD 1150–1550) from 33 sites on the Georgia coast (see also Chapter 7). Larsen discovered that through time there was a decline in dental and skeletal health, but also a decrease in the sort of joint disease related to the mechanical stress of being a hunter (men of both periods suffered from this osteoarthritis much more than women).

There was also a reduction in the size of the face and jaws – but only females had a decrease in tooth-size, and it was females who had the greater increase in dental decay and the most marked decrease in cranial and overall skeletal size (probably related to a reduction in protein intake and an increase in carbohydrates). These results suggest that the shift to agriculture affected women more than men, who perhaps carried on hunting and fishing while the women did the field preparation, planting, harvesting, and cooking. Taken together, therefore, the eastern North American data are quite consistent in highlighting the differential effects of maize agriculture on males and females.

At a broader level of analysis, it is difficult to distinguish the effects of different aspects of the adoption of agriculture – not merely a changed diet, but a settled way of life, greater concentrations of population, differential access to resources, and so on. Nevertheless studies of skeletal pathology in many areas are beginning to form a pattern, suggesting that the adoption of agriculture (and its accompanying effects on group size and permanence of settlement) commonly led to increased rates of chronic stress, including infection and malnutrition. As in the case of Georgia, a decrease in mechanical stress was replaced by an increase in nutritional stress.

POPULATION STUDIES

In the preceding sections of this chapter we have looked at individuals or at small groups of people. The time has now come to extend the discussion to larger groups and to entire populations, a field of research known as ***demographic archaeology***, which is concerned with estimates from archaeological data of various aspects of populations such as size, density, and growth rates. It is also concerned with the role of population in culture change. Simulation models based on archaeological and demographic data can be used to gain an understanding of the link between population, resources, technology, and society, and have helped clarify the peopling of North America and Australia, and the spread of agriculture into Europe.

An allied field is ***paleodemography***, which is primarily concerned with the study of skeletal remains to estimate population parameters such as fertility rates and mortality rates, population structure, and life expectancy. All the techniques mentioned so far can be of assistance here, by helping us to investigate the life-span of both sexes in different periods, or to assess fertility through the number of births. Study of disease or malnutrition can be combined with sex and age data to cast light on differential quality of life. But there remains one fundamental question: how can one estimate the size of population, and hence population densities, from archaeological evidence?

There are two basic approaches. The first is to derive figures from settlement data, based on the relationship between group size and total site area, roofed area, site length, site volume, or number of dwellings. The second is to try to assess the richness of a particular environment in terms of its animal and plant resources for each season, and therefore how many people that environment might have supported at a certain level of technology (the environment's "carrying capacity"). For our purposes the first approach is the most fruitful. In a single site, it is necessary to establish, as best one can, how many dwellings were occupied at a particular time, and then one can proceed to the calculation. (On waterlogged, or very dry sites as in the American Southwest, remains of timber dwellings can often be tree-ring dated to the exact years when they were built, occupied, and then abandoned. Usually such results indicate that fewer buildings were lived in during a particular phase than archaeologists had previously imagined.) Assessments of occupied floor area are potentially the most accurate means of achieving population figures. The most famous equation is that proposed by the demographer Raoul Naroll. Using data derived from an examination of 18 modern cultures, he suggested that the population of a prehistoric site is equal to one tenth of the total floor area in square meters.

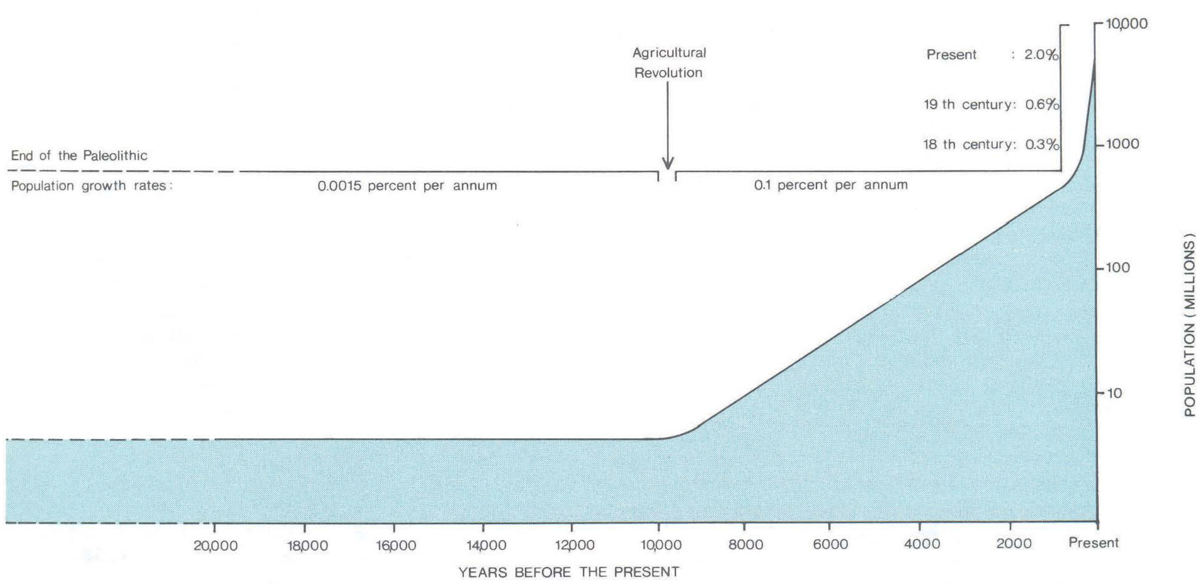
This claim was later refined and modified by a number of archaeologists, who found that it was necessary to take into account the variation in dwelling environments. But just as Naroll's original formula was overgeneralized, some more recent equations have perhaps been too narrowly focused on a particular area – for example, "Pueblo population = one third of total floor area in square meters." One useful rule of thumb developed by S.F. Cook and R.F. Heizer, if one is starting with non-metric measurements, is to allow 25 sq. ft (2.325 sq. m) for each of the first 6 people, and then 100 sq. ft (9.3 sq. m) for every other person.

In the case of long houses of the Neolithic *Linearbandkeramik* (LBK) culture in Poland, Sarunas Milisauskas first applied Naroll's formula and obtained a figure of 117 people for a total of 10 houses. He then tried using a colleague's ethnographic evidence, which assumes one family for every hearth in a long house, and thus one family for every 4 or 5 m (13–16 ft) of house length, and he obtained a figure of 200 people for the same houses.

Samuel Casselberry further refined the procedure for multi-family dwellings of this sort. Using data from ethnography he established a formula for New World multi-family houses, claiming that "population = one sixth of the floor area in square meters." Applying this to the Polish LBK houses, he reached a figure of 192 people for the 10 dwellings, which is close enough to Milisauskas' second result to suggest that methods of this type are steadily achieving greater reliability. The important factor is that the ethnographic data used are from types of dwelling similar to those under investigation in the archaeological record.

Other techniques are possible. For example, in her attempt to assess the population of a *pa* (hillfort) in Auckland, New Zealand, Aileen Fox used ethnographic data which showed that Maori nuclear families were relatively small in the late 18th and early 19th centuries AD. Archaeological evidence indicated an average of one household utilizing two storage pits on the *pa* terraces. A combination of both sets of data led to a formula of six adults to every two storage pits; thus the site's 36 pits indicated 18 households, and 108 people – a far smaller figure than had previously been believed. Population estimates may also be made from the frequency of artifacts or the amount of food remains, though these calculations depend on many assumptions.

It is also ethnography (primarily the !Kung San of the Kalahari Desert and the Australian Aborigines) that has given us the generalized totals of about 25 people in a hunter-gatherer local group or band, and about 500 people in a tribe. Since bands in Australia and elsewhere vary considerably in size through time and with the seasons, often numbering less than 25, it follows that such figures provide only a rough guide. Nevertheless, given that we can never establish exact



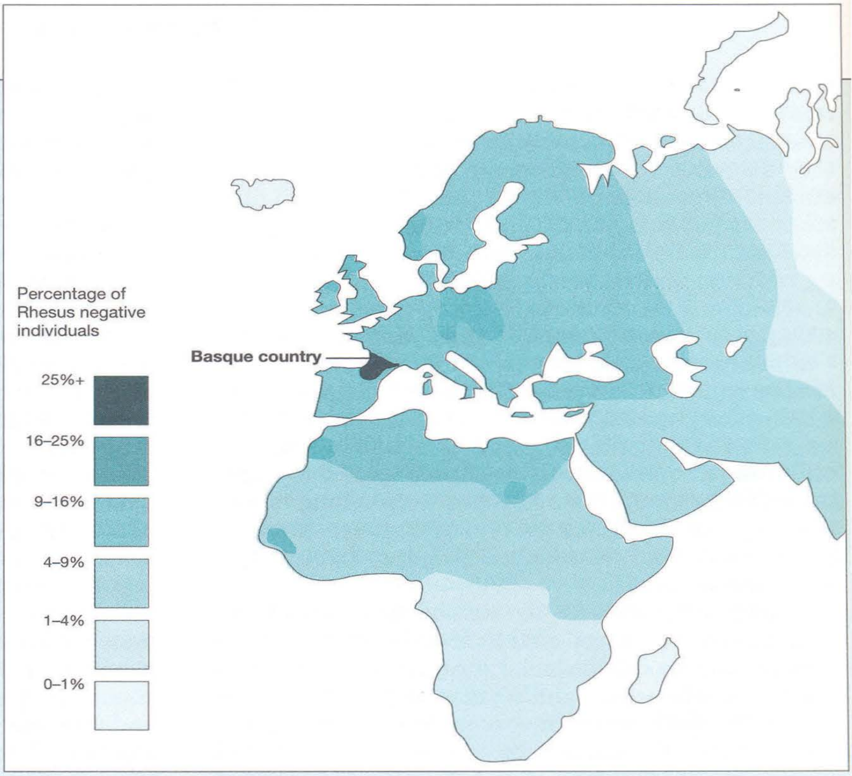
Trends in world population: the rate of growth increased considerably after the farming revolution, and has accelerated dramatically in the last two centuries.

GENETICS AND LANGUAGES

Genetic methods are increasingly being used in conjunction with linguistics to investigate population history. In many parts of the world, the language spoken by a human community is the best predictor of the genetic characteristics (as seen e.g. in blood groups) that community will have. Laurent Excoffier and his colleagues have studied African populations, measuring the frequencies of the varieties of gammaglobulin in the blood of different populations. The frequencies were used to compute similarities and differences between the various populations which were then plotted in tree form. It was found that this classification, based on genetic evidence, actually arranges the populations of Africa into their language families. The genetic classification (based on gammaglobulin frequencies) for example classes together the Bantu-speaking populations. The Afroasiatic speakers of north Africa form another group, and the pygmies, with languages of the Khoisan family, another group again. So striking a correlation between genetic composition and language is impressive.

Luca Cavalli-Sforza and his colleagues have suggested a very widespread correlation between genetic and linguistic classifications, arguing that both are the products of similar evolutionary processes. But language change takes place much more quickly than genetic change, which is governed by the mutation rate for individual genes. Instead, the correlation is partly explained by the processes underlying language replacement (see box, Language Families and Language Change, p. 467).

If a farming dispersal introduces large numbers of a new human population speaking a language new to the territory, language replacement may be accompanied by genetic replacement also.



***A map showing** the distribution of the Rhesus negative blood group reveals a high concentration in the Basque region of Spain, coinciding impressively with the distinctive language spoken there.*

The Basques

Many of the studies so far conducted employ classical genetic markers (blood groups etc.). One such study highlights the Basque country of northern Spain as distinctive, on the basis of the high incidence here of the rare Rhesus negative gene. Interestingly the Basques are also distinctive in speaking one of the very few non-Indo-European languages now remaining in Europe. The Basque language is generally thought to be a relic of a language family more widely spoken before the coming of Indo-European to Europe. Mitochondrial DNA and Y-chromosome DNA studies have now confirmed the special genetic status of the Basque population (see box Molecular Genetics and Population Dynamics: Europe, pp. 468–69).

DNA and Languages

Increasingly mtDNA (mitochondrial) and Y-chromosome studies are being used to study the affinity of populations defined by the languages they speak. The situation is more complicated when language replacement has taken place by the mechanism of elite dominance (see box, p. 467), since if the immigrant population is small in number the gene flow may not be significant, and in such cases the genetic and the linguistic pictures will no longer correlate.

The application of molecular genetics to population studies and to historical linguistics is still in its early stages, but the information potentially available is vast in quantity, and this is certain to be an expanding field.

There is some evidence from mtDNA studies in the Americas that the speakers of a particular language may have different haplogroup frequencies from those of their neighbors, and indeed that specific haplotypes may be seen to be characteristic of the speakers of a particular language. This phenomenon of "population specific polymorphism" and its relation to specific languages remains to be explored further (see p. 223), but, as we have seen, it seems clear for the Basques and among African populations (where it is language families rather than specific languages which are being contrasted).

Macrofamilies

Russian and Israeli linguists have made the controversial proposal that a number of major language families in the western part of the Old World (namely the Indo-European, Afroasiatic, Uralic, Altaic, Dravidian, and Kartvelian families) can be classified in a single, more embracing (and more ancient) macrofamily, to which the term "Nostratic" has been given. The American linguist Joseph Greenberg has proposed an analogous "Eurasiatic" macrofamily, although he would draw the boundaries differently. In 1963 he classified the various languages of Africa into just four macrofamilies, a proposal which has been widely accepted, but his similar proposal for just three macrofamilies among the native languages of the Americas (Eskimo-Aleut, Na-Dene and "Amerind") has been widely criticized by historical linguists.

Despite this, there is some evidence from molecular genetics which has been taken as support of the Greenberg view, and as we have seen there is a correlation in Africa between his classification and the molecular genetic data there. The whole question is also caught up with that of the peopling of the Americas (see box p. 456) and other continents. At present it is probably wise for the archaeologist to treat concepts such as "Amerind" or "Nostratic" with considerable caution, in view of the reservations of many linguists. Even if the genetic data favor a classification which might correlate well with the linguistic "lumpers" (who favor long-range linguistic connections and macrofamilies, as against the "splitters" who are skeptical of both), there might be other explanations. Caution is in order until the linguistic picture is clearer.

population figures for prehistoric peoples, figures of this sort do provide useful estimates that are certainly of the right order of magnitude.

But what of the population of large areas? Where archaeological evidence is concerned, one can only count the number of sites for each region, assume how many in each cultural phase were occupied at the same time, estimate the population of each relevant site, and then arrive at a rough figure for population density. For historical periods, it is sometimes possible to use written evidence. On the basis of censuses and grain imports and other data, for example, it has been estimated that the population of Classical Attica, Greece, was 315,000 in 431 BC and 258,000 in 323 BC. In another Classical example, this time of a city rather than a region, the population of ancient Rome was recently estimated to be about 450,000 on the basis of the population densities of Pompeii and Ostia, as well as of hundreds of pre-industrial and modern cities.

However, population estimates for wide areas during prehistory are no more than guesses. Estimates for world population in the Paleolithic and Mesolithic vary from 5 million to over 20 million. Perhaps in the future, with improved knowledge of the population densities of different economic groups and the carrying capacities of past environments, we may be able to achieve a more informed guess for the tantalizing question of world population.

ETHNICITY AND EVOLUTION

Finally, we come to the question of identifying the origins and distribution of human populations from human remains. Modern techniques have ensured that such studies are on a sounder and more objective footing than they were before World War II.

Studying Genes: Our Past within Ourselves

Much the best information on early population movements is now being obtained from the "archaeology of the living body," the clues to be found in genetic material. For example, light has recently been cast on the old problem of when people first entered the Americas, and it has come not from archaeological or fossil evidence but from the distribution of genetic markers in modern Native Americans (box overleaf).

It is proving possible to compare ancient DNA, such as that extracted from ancient brains in Florida (see above), with that of modern Native Americans. If the ancient DNA has patterns that no longer exist, this might indicate that the ancient group in question had

STUDYING THE ORIGINS OF NEW WORLD POPULATIONS

Northeast Asia and Siberia have long been accepted as the launching ground for the first human colonizers of the New World. But was there one major wave of migration across the Bering Strait into the Americas, or several? And when did this event or events take place? In recent years new clues have come from research into linguistics, teeth, and genetics.

Evidence from Linguistics

The linguist Joseph Greenberg has since the 1950s argued that all native American languages belong to just three major macrofamilies: Amerind, Na-Dene, and Eskimo-Aleut – a view that has given rise to the idea of three main migrations.

The glottochronologies of the individual macrofamilies might suggest that Eskimo-Aleut languages began to diverge from their ancestral form about 4000 years ago, with the Na-Dene divergence beginning sometime between 9000 and 5000 years ago. These dates for first divergence are thought to time the entry into the Americas of population groups who spoke the proto-language of each macrofamily. The time depth of the Amerind macrofamily is too great for glottochronology to be of any real value, but a date in excess of 11,000 years ago is indicated.

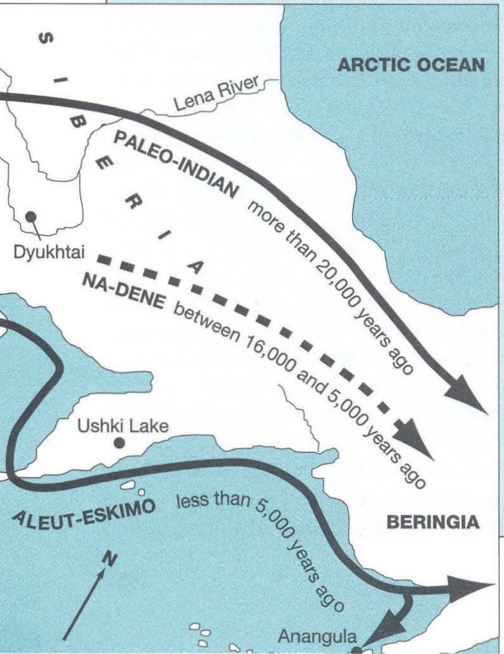
Greenberg is in a minority among fellow linguists, however, most of whom favor the notion of a great many waves of migration to account for the more than 1000 languages spoken at one time or another by American Indians.

The historical linguist Johanna Nichols has used the high degree of linguistic diversity in the Americas to produce a colonization date of 35,000 years ago, but the assumptions underlying her work have been robustly questioned by Daniel Nettle. In the last analysis it is for the archaeologist, using standard radiometric methods, to establish the date of the first human settlement and it is not realistic to expect a more reliable chronology from linguistic arguments.

Evidence from Teeth

Studies of teeth claim to support the hypothesis of three waves of migration. The biological anthropologist Christy Turner is an expert in the analysis of changing physical characteristics in human teeth. He argues that tooth crowns and roots have a high genetic component, minimally affected by environmental and other factors.

According to Turner, the dental evidence ties in with the idea of a Paleo-Indian migration out of northeast Asia which he sets at before 14,000 years ago by calibrating rates of dental microevolution, followed by two later migrations which he equates with Na-Dene and Eskimo-Aleut.



Three possible waves of migration from Siberia to North America using dates initially suggested by Wallace, Torroni and their colleagues: but this is already seen as too simple an account which further research is modifying.

Evidence from Genetics

Antonio Torroni, Douglas Wallace, and their colleagues have examined the mitochondrial DNA (mtDNA) from American Indians belonging to widely separated Native American groups. By analyzing divergences in the sequence variation of mtDNA within and between the groups, they were able to suggest that the first Amerind speakers had entered the Americas sometime between 42,000 and 21,000 years ago, while a population ancestral to the present-day Na-Dene arrived between 16,000 and 5000 years ago. Interestingly, the date for the Amerind migration of 20,000 years ago or more suggests an occupation phase earlier than that attested by the widespread Clovis points, generally dated to about 14,000 years ago.

Their initial picture of four founding female (mtDNA) lineages has however been complicated by the discovery of further haplogroups, and recently by data from Y-chromosomes. Indeed it has now been shown that up to 85 percent of Native American males share a common Y-chromosome marker, leading to talk of a "Native American Adam" living around 20,000 years ago, and to the suggestion that many of the first Americans arrived in a single migration from an ancestral Siberian home. Andrew Merriwether has concluded (1999, 126): "It is much more parsimonious with a single wave of migration with all these types, followed by linguistic and cultural diversification after or during entry." So it can no longer be claimed that the genetic data give clear-cut support for the "three waves" hypothesis initially supported by the mtDNA: the Y-chromosome data currently favors a single migration view. But the pace of research is considerable and matters may be clearer in a few years.

disappeared or greatly changed. The discovery of "Kennewick Man," dated to some 7000 years ago, and according to some anthropologists very different from modern American Indian populations, has underlined that possibility (see p. 541). Adrian Hill has established that certain mutations in DNA occurred in Polynesians, Melanesians, and Southeast Asians, but nowhere else, a fact which supports archaeological and linguistic evidence in casting considerable doubt on theories that Polynesians came from South America. Further work by Erika Hagelberg and John Clegg on this problem, involving mitochondrial DNA (see below) from modern populations and skeletal remains in the Pacific, has helped to trace the migration route of the proto-Polynesian voyagers. Their preliminary results suggest that the earliest inhabitants of the central Pacific may have come from Melanesia rather than Southeast Asia.

Other population movements in the distant past have been reassessed through genetic evidence, as a result of which it appears that Africans were the ancestors of modern humans. This has been deduced by James Wainscoat and his colleagues from mapping part of a human chromosome in eight different populations around the world. Members of the same population all tend to carry similar mutations, and populations that are geographically close have very similar patterns; but African samples differ markedly from non-African. Africans have two unique patterns, and only 5 percent of African samples have the pattern most common among Eurasians. It seems, therefore, that the more "recent" Eurasians have lost, or never had, the predominant patterns of African people, a fact which suggests that the founder population of anatomically modern people was small and highly inbred; that there is a big genetic distance between African groups and the others, interpreted as a mark of great age; and that the strong genetic homogeneity among various non-African peoples points to a common center of origin. So does the origin of *Homo sapiens sapiens* lie in Africa? If so, the founder population could have been as small as 1000 people.

A very similar conclusion was reached by Rebecca Cann, Mark Stoneking, and Allan Wilson by using very different genes. Most of our genetic information in the form of DNA is stored in the nuclei of our cells, but other bodies in our cells (mitochondria) also contain such information. However, mitochondrial DNA (mtDNA) is passed on only by females, because the male sperm's mitochondria do not survive fertilization intact. Since mtDNA is thus inherited solely through the mother, unlike nuclear DNA which is a mixture of both parents' genes, it preserves a family record that is altered over the generations only by mutations.

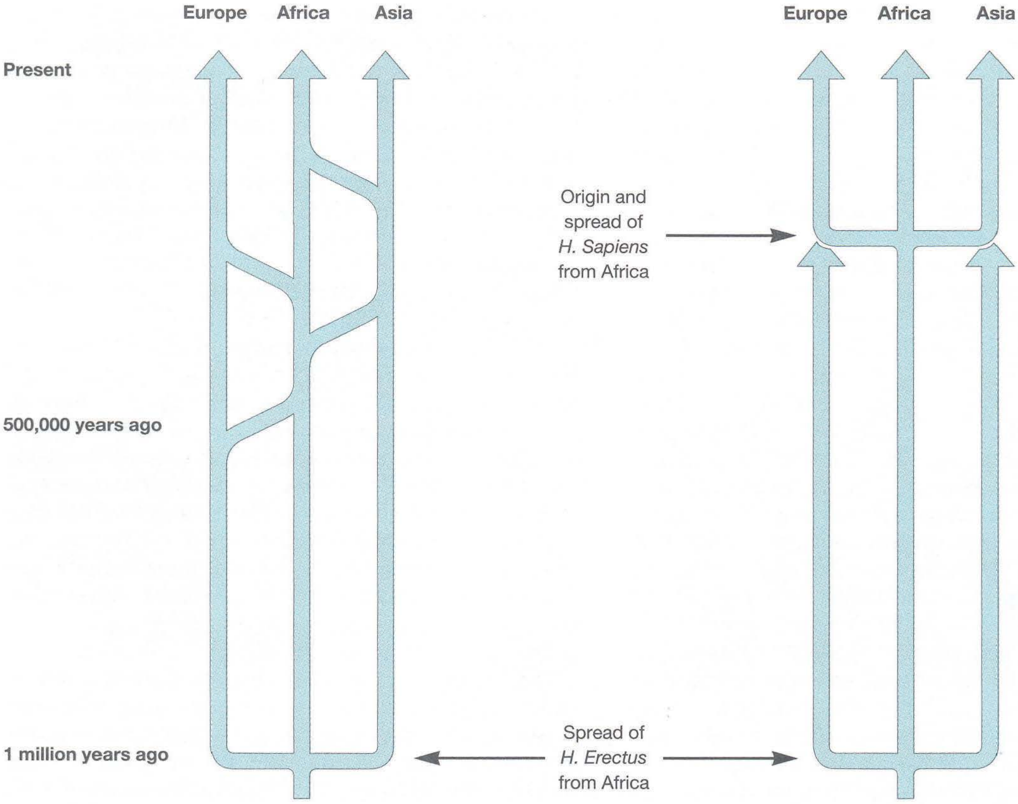
In a comparable way, Y-chromosome DNA (which is part of the nuclear DNA) is inherited in the male line and likewise does not recombine as the genetic material is passed on to the next generation. Most nuclear DNA does of course recombine, with contributions from the male and female parents, making the inheritance of DNA a complex process: the possibility of studying female (mitochondrial) and male (Y-chromosome) non-recombining DNA is therefore of great importance.

Consequently mtDNA can be used to study the movements of women, and thus provide more information on the origins of modern people. Cann and her colleagues believed that mtDNA mutates at a known and steady rate (about 2–4 percent per million years), so that one can calculate the dates of these movements; and they claimed that we are all descended from one woman who lived in Africa about 200,000 years ago: she was nicknamed "Eve," although it was stressed that she not only had a mother herself but lived at the same time as other people. Indeed, many other males and females must have contributed to her or her children's offspring in order to account for the genetic variability we possess in nuclear DNA.

The important point about Eve, in Cann's formulation, was that she was *not* the first woman, but the ancestor of everyone on earth today. Other females alive at the same time also had descendants, but Eve was the only one who still appears in everyone's genealogy. Some of the other females' descendants will have included generations that produced no children or only males, thus halting the propagation of their mtDNA. This process can still be seen today – it is reckoned that of the French people alive in 1789, only 14 percent have descendants today.

Cann, Stoneking, and Wilson analyzed mtDNA from 147 present-day women from five different geographical populations (Africa, Asia, Europe, Australia, and New Guinea), and concluded that the people of sub-Saharan African descent showed the most differences among themselves, which implied that their mtDNA has had the most time to mutate – hence their ancestors must be the earliest.

To the glee of researchers who support the alternative "Multiregional Hypothesis" (the theory, based primarily on fossils and tools, that *Homo erectus*, having left Africa, evolved separately in different parts of the Old World, and was not simply replaced by a much later migration of anatomically modern humans from Africa), geneticist Alan Templeton subsequently pointed out crucial flaws in the "Mitochondrial Eve Hypothesis." In his view, the analysis was invalid, since it used inappropriate statistical tests and sampling



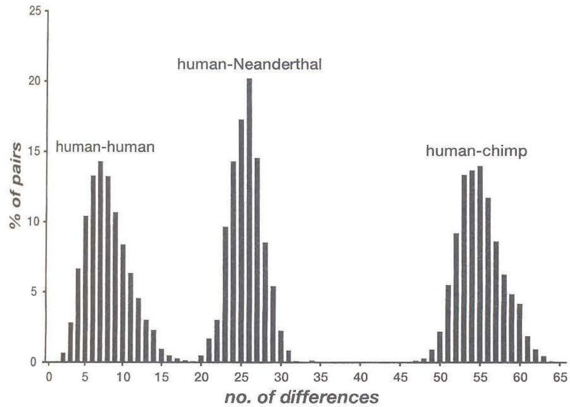
Two views of the origins of modern humans. (Left) The "Multiregional Hypothesis": according to this view, after the migration of Homo erectus *out of Africa around 1 million years ago, people evolved into modern humans independently in different parts of the world. (Right) "Out of Africa": others believe the genetic evidence indicates that modern humans evolved first in Africa, migrating from there into other continents around 100,000 years ago and replacing earlier* Homo erectus *populations.*

methods biased in favor of an African root; its results were dictated by the order in which the information was fed into the computer. Instead of one "family tree" leading back to Africa 200,000 years ago, these data can produce thousands of simpler trees, some of which do not have African roots. Moreover, variation in population sizes may help explain the greater genetic divergence of Africa. Templeton instead argued that a model in which modern humans evolved from many centers would fit all the evidence.

Opinions differ sharply about the reliability of "molecular clocks," and the rate of mutational change in human DNA, in calculating Eve's date. There have also recently been disquieting suggestions that there may sometimes be a male contribution to the inherited mitochondrial DNA which, if confirmed, would invalidate much recent work in this field.

Supporters of the "Out of Africa" model, however, maintain that other lines of fossil and nuclear DNA evidence still point to Africa as the birthplace of modern humans. For example, analysis of part of the Y chromosome in men around the world shows limited variation in its DNA, suggesting a common male ancestor less than 200,000 years ago.

This polarization of views is currently one of the hottest debates in the whole of anthropology, though many believe the truth is likely to lie somewhere between the two extremes, and to be more complex, for example with more than one migration out of Africa, as well as movements in the other direction. With time, the disputes will no doubt be resolved, and the human relationships that modern DNA studies are only just beginning to reveal will be determined with much greater precision. Genetics are also being combined with the study of languages to produce interesting results (see box, pp. 454–55).



Distributions of pairwise sequence differences among humans, the Neanderthals, and chimpanzees (X axis: number of sequence differences; Y axis: the percentage of pairwise comparisons) showing human-Neanderthal differences to be much more numerous than had been imagined and hence the Neanderthals to be much more remote cousins of the human species.

So far most of the running in the application of molecular genetics has come from the study of samples from living populations. But the contribution of ancient DNA, from the remains of ancient burials and other human remains, will soon prove highly important. The most striking example comes from the study of Neanderthal DNA from one of the original fossils found in the Neander Valley in western Germany in 1856, which gave its name to "Neanderthal Man." Mathias Krings and Svante Pääbo in Munich, with Anne Stone and Mark Stoneking at Pennsylvania State University, were able to extract genetic material and then amplify segments of mtDNA. By using overlapping amplifications they recovered mitochondrial DNA sequences over 360 base pairs in length. When these were compared with the comparable sequences in humans, 27 differences were found. Taking an estimated divergence date between humans and chimpanzees of 4 to 5 million years, and assuming constant mutation rates, a date of 550,000 to 690,000 years ago for the divergence of Neanderthal mtDNA and contemporary human mtDNA was obtained (compared with a divergence date among humans of 120,000 to 150,000 years).

The divergence date for humans corresponds well with current thinking and the Out of Africa hypothesis for human origins. The surprise is that the human-Neanderthal divergence date is so much earlier. The Neanderthals may still just be considered our "cousins," but they are very much more remote cousins than had previously been thought. This conclusion also appears to rule out any direct Neanderthal input to the human genome. It therefore makes a fundamental contribution to the debates concerning human origins.

Genetic research techniques are thus revealing a good deal more about our past than we ever thought possible. This is proving of major assistance to archaeologists and anthropologists. Even the best fossil beds preserve only about one skeleton in every million, but we all carry a record of our history in some of the cells of our bodies. The archaeology of our cells has started to tell us much about ourselves. It must be noted, however, that genetics can only tell us about past populations which left descendants; it can tell us nothing about people who died out.

SUMMARY

Since archaeology studies the relics of the human past, it follows that the archaeologist's ultimate interest must lie in the remains of the very people who produced the archaeological record. Much of the material in this chapter lies within the realm of physical anthropologists, but it is usually archaeologists who provide them with the specimens for study and who derive great benefit from their findings.

A huge range of very varied information can now be extracted from even minor fragments of humanity. We can assess age, sex, height, weight, appearance, inter-relationships; abilities such as walking, talking, and left- or right-handedness; stresses, traumas, and disease; and whether nutritional level was good or inadequate.

Finally, the newest field of inquiry – molecular genetics, forming a genetic history – is "archaeology within the human body," a kind of ethnoarchaeology where observations made in the present can have tremendous influence on our interpretation of the past. Most information comes at present from samples taken from modern populations, but the study of ancient DNA from preserved human remains (and plant and animal residues) is also developing as extraction techniques improve. DNA studies have been adding amazing new insights into our understanding of the history of human populations. In modern archaeology, human remains have thus reached center stage, and rightly so since they were, so to speak, the actors in the play we are trying to reconstruct.

FURTHER READING

The following provide good general introductions to the study of human remains:

Brothwell, D. 1981. *Digging up Bones. The Excavation, Treatment and Study of Human Skeletal Remains.* (3rd ed.) British Museum (Natural History): London; Oxford University Press: Oxford.
Brothwell, D. 1986. *The Bog Man and the Archaeology of People.* British Museum Publications: London; Harvard University Press: Cambridge, Mass.
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Ubelaker, D.H. 1984. *Human Skeletal Remains.* (Revised ed.) Taraxacum: Washington.
White, T. 1991. *Human Osteology.* Academic Press: New York.

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The standard work on population studies is:

Hassan, F.A. 1981. *Demographic Archaeology.* Academic Press: New York & London.

For the evolution of modern humans see:

Johanson, D. & Edgar, B. 1996. *From Lucy to Language.* Simon & Schuster: New York.
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For the application of molecular genetics see:

Cavalli-Sforza, L.L., Menozzi, P., & Piazza, A. 1994. *The History and Geography of Human Genes.* Princeton University Press: Princeton.
Sykes, B. (ed.) 1999. *The Human Inheritance: Genes, Languages and Evolution.* Oxford Univ. Press.