Understanding The Past:
Archaeological and Paleoanthropological Methods

OUTLINE

Introduction
Biocultural Evolution: The Human Capacity for Culture
Paleoanthropology
Archaeology
Goals of Archaeology
Archaeological Research Projects
Piecing Together the Past
Artifacts, Features, and Contexts
Ethnoarchaeology
Experimental Archaeology
Dating Methods
Relative Dating
Chronometric Dating
Paleoanthropology and Archaeology at Olduvai Gorge
What are the central aspects of paleoanthropology in general? Of archaeology in particular? Why, from a biocultural perspective, do we want to learn about both the behavior and the anatomy of ancient hominins?

Introduction

A portion of a pig’s tusk, a small sample of volcanic sediment, a battered cobbler, a primate’s molar tooth: What do these seemingly unremarkable remains have in common, and more to the point, why are they of interest to paleoanthropologists and archaeologists? First of all, if they are all discovered at certain sites in Africa or Eurasia, they may be quite ancient—perhaps millions of years old. Further, some of these materials actually inform scientists directly of accurate and precise dating of the finds. Last, and most exciting, some of these finds may have been modified, used, and discarded by creatures who looked and behaved in some ways like us, but were, in other respects, very different. And what of that molar tooth? Is it a fossilized remnant of an ancient hominin? These are the kinds of questions asked by paleoanthropologists and archaeologists, and to answer them, these researchers travel to remote locales in the Old World.

How do we identify possible hominins from other types of animals, especially when all we may have to study are fragmentary fossil remains from just a small portion of a skeleton? How do humans and our most distant ancestors compare with other animals? In the last three chapters, we’ve seen how humans are classified as primates, both structurally and behaviorally, and how our evolutionary history coincides with that of other mammals and, specifically, other primates. But we are a unique kind of primate, and our ancestors have been adapted to a particular lifestyle for several million years. Some primitive hominoid probably began this process close to 7 mya, but with better-preserved fossil discoveries, scientists now have more definitive evidence of hominins shortly after 5 mya.

The hominin nature of these remains is revealed by more than the structure of teeth and bones; we know that these animals are hominins also because of the way they behaved—emphasizing once again the biocultural nature of human evolution. Most of our understanding of these events and changes is the result of paleoanthropological, and especially archaeological, research. In this chapter, we describe the basic concepts of these interrelated lines of investigation so that you can approach the rest of the book with a solid grounding in the research methods on which reconstruction of the human past is based.

We’ll begin with the broader aspects of paleoanthropology, which, in addition to archaeology, examines early hominin behavior and ecology through the study of fossil remains. This sets the stage for Chapters 9 through 12, in which we examine the fossil evidence of human ancestors and near relatives.

As part of paleoanthropology, some archaeologists specialize in studying the early phases of human biocultural development. This work certainly makes archaeology a major component of paleoanthropological research, but in this chapter we’ll also cover a variety of research perspectives and methods that are practiced by all archaeologists (including those investigating later phases of prehistory as well as historical contexts). Our more specific focus on archaeology emphasizes it as a body of methods related to those used by other paleoanthropologists. But while archaeology explores similar questions about the human past, it does so primarily through examination of material remains. The importance of archaeological methods increases gradually throughout Chapters 9 through 12 and becomes the dominant source of information in Chapters 13 through 15. Toward the
end of this chapter, you’ll be able to appreciate the close partnership of paleoanthropology and archaeology in the study of the early human past by reading about the best-known early hominin site locality in the world: Olduvai Gorge, in East Africa.

**Biocultural Evolution: The Human Capacity for Culture**

One of the most distinctive behavioral features of humans is our extraordinary elaboration of and dependence on culture. Certainly other primates, and many other animals, for that matter, modify their environments. As we saw in Chapter 7, chimpanzees especially are known for such behaviors as using termite sticks, and some even carry rocks to use for crushing nuts. Because of such observations, we’re on tenuous ground when it comes to drawing a sharp line between early hominin toolmaking behavior and that exhibited by other animals.

Another point to remember is that human culture, at least as it’s defined in contemporary contexts, involves much more than toolmaking capacity. For humans, culture integrates an entire adaptive strategy involving cognitive, political, social, and economic components. The *material culture*, the tools humans use, is but a small portion of this cultural complex.

Nevertheless, when we examine the archaeological record of earlier hominins, what is available for study is almost exclusively limited to material culture, especially residues of stone tool manufacture. So it’s extremely difficult to learn anything about the earliest stages of hominin cultural development before the regular manufacture of stone tools. As you will see, this most crucial cultural development has been traced to approximately 2.6 mya (Semaw et al., 2003). Yet, hominins were undoubtedly using other kinds of tools (made of perishable materials) and displaying a whole array of other cultural behaviors long before then. However, without any “hard” evidence preserved in the archaeological record, our understanding of the early development of these nonmaterial cultural components remains elusive.

The fundamental basis for human cultural success relates directly to cognitive abilities. Again, we’re not dealing with an absolute distinction, but a relative one. As you have already learned, other primates, as documented in chimpanzees and bonobos, have some of the language capabilities exhibited by humans. Even so, modern humans display these abilities in a complexity several orders of magnitude beyond that of any other animal. And only humans are so completely dependent on symbolic communication and its cultural by-products that contemporary *Homo sapiens* could not survive without them.

At this point, you may be wondering just when the unique combination of cognitive, social, and material cultural adaptations become prominent in human evolution. In answering that question, we must be careful to recognize the manifold nature of culture; we can’t expect it to always contain the same elements across species (as when comparing ourselves with nonhuman primates) or through time (when trying to reconstruct ancient hominin behavior). Richard Potts (1993) has critiqued such overly simplistic perspectives and suggests instead a more dynamic approach, one that incorporates many subcomponents (including aspects of behavior, cognition, and social interaction).

We know that the earliest hominins almost certainly did not regularly manufacture stone tools (at least, none that have been found and identified as such). These earliest members of the hominin lineage, dating back to approximately 7–5 mya, could be referred to as *protohominins*. These protohominins may have carried objects such as naturally sharp stones or stone flakes, parts of carcasses, and pieces of wood around their home ranges. At the very least, we would expect them to have displayed these behaviors to at least the same degree as that exhibited in living chimpanzees.
As you’ll soon see, by at least 5 mya and perhaps even by 7 mya, hominins had developed one crucial advantage: They were bipedal and could therefore much more easily carry all manner of objects from place to place.

What we know for sure is that over a period of several million years, during the formative stages of hominin emergence, many components interacted, but not all of them developed simultaneously. As cognitive abilities developed, more efficient means of communication and learning resulted. Largely because of consequent neurological reorganization, more elaborate tools and social relationships also emerged. These, in turn, selected for greater intelligence, which in turn selected for further neural elaboration. Quite clearly, then, these mutual dynamic interactions are at the very heart of what we call hominin biocultural evolution.

**Paleoanthropology**

To adequately understand human evolution, we obviously need a broad base of information. It’s the paleoanthropologist’s task to recover and interpret all the clues left by early hominins. Paleoanthropology is defined as the overall study of fossil hominins. As such, it’s a diverse multidisciplinary pursuit seeking to reconstruct every possible bit of information concerning the dating, structure, behavior, and ecology of our hominin ancestors. In the last few decades, the study of early humans has marshaled the specialized skills of many different kinds of scientists. Included in this growing and exciting adventure are geologists, archaeologists, physical anthropologists, and paleoecologists (Table 8-1).

Geologists, usually working with anthropologists, do the initial surveys to locate potential early hominin sites. Many sophisticated techniques aid in this search, including the analysis of aerial and satellite imagery (Fig. 8-1). Paleontologists are usually involved in this early survey work, for they can help find fossil beds containing faunal remains. Where conditions are favorable for the preservation of bone from such species as pigs and elephants, hominin remains may also be preserved. In addition, paleontologists can (through comparison with known faunal sequences) give approximate age estimates of fossil sites without having to wait for the results of more time-consuming analyses.

Fossil beds likely to contain hominin finds are subjected to extensive field surveying. For some sites, generally those postdating 2.6 mya (roughly the age of the oldest identified human artifacts), archaeologists take over in the search for hominin material traces. We don’t necessarily have to find remains of early hominins themselves to know that they consistently occupied a particular area. Such material clues as artifacts also inform us directly about early hominin activities. Modifying rocks according to a consistent plan or simply carrying them around from one place to another over fairly long distances (assuming the

---

**Table 8-1 Contributing Scientific Fields to Paleoanthropology**

<table>
<thead>
<tr>
<th>Physical Sciences</th>
<th>Biological Sciences</th>
<th>Social Sciences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geology</td>
<td>Physical anthropology</td>
<td>Archaeology</td>
</tr>
<tr>
<td>Stratigraphy</td>
<td>Ecology</td>
<td>Ethnology</td>
</tr>
<tr>
<td>Petrology (rocks, minerals)</td>
<td>Paleontology (fossil animals)</td>
<td>Cultural anthropology</td>
</tr>
<tr>
<td>Pedology (soils)</td>
<td>Palynology (fossil pollen)</td>
<td>Ethnography</td>
</tr>
<tr>
<td>Geomorphology</td>
<td>Primatology</td>
<td>Psychology</td>
</tr>
<tr>
<td>Geophysics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemistry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taphonomy</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**multidisciplinary** Pertaining to research that involves the mutual contributions and cooperation of experts from various scientific fields (i.e., disciplines)

**artifacts** Objects or materials made or modified for use by hominins. The earliest artifacts are usually made of stone or, occasionally, bone.
action can’t be explained by natural means, such as streams or glaciers) is characteristic of no other animal but a hominin. So, when we see such material evidence at a site, we know absolutely that hominins were present.

Because organic materials such as wooden and bone tools aren’t usually preserved in the archaeological record of the oldest hominins, we have no solid evidence of the earliest stages of hominin cultural modifications. On the other hand, our ancestors at some point showed a veritable fascination with stones, because they provided not only easily accessible and transportable materials (to use as convenient objects for throwing or for holding down other objects, such as skins and windbreaks) but also the most durable and sharpest cutting edges available at that time. Luckily for us, stone is almost indestructible, and some early hominin sites are strewn with thousands of stone artifacts. The earliest artifact sites now documented are from the Gona and Bouri areas in northeastern Ethiopia, dating to close to 2.6 mya (Semaw et al., 1997; de Heinzelin et al., 1999). Other contenders for the “earliest” stone assemblage come from the adjacent Hadar and Middle Awash areas, immediately to the south in Ethiopia, dated 2.5–2 mya.

If an area is clearly demonstrated to be a hominin site, much more concentrated research will then begin. We should point out that a more mundane but very significant aspect of paleoanthropology not reflected in Table 8-1 is the financial one. But once the financial hurdle has been cleared, a coordinated research project can begin. Usually headed by an archaeologist or physical anthropologist, the field crew continues to survey and map the target area in great detail (Fig. 8-2). In addition, field crew members begin searching carefully for bones and artifacts eroding out of the soil, taking pollen and soil samples for ecological analysis, and carefully collecting rock samples for use in various dating techniques. If, in this early stage of exploration, members of the field crew find fossil hominin remains, they will feel very lucky indeed. The international press usually considers human fossils the most exciting kind of discovery, a situation that produces wide publicity and often ensures future financial support. More likely, the crew will accumulate much information on geological setting, ecological data (particularly faunal remains), and, with some luck, artifacts and other archaeological traces.

Although paleoanthropological fieldwork is typically a long and arduous process, the detailed analyses of collected samples and other data back in the laboratory are even more time-consuming. Archaeologists must clean, sort, label, and identify all artifacts, and
taphonomy (taphos, meaning “grave”) The study of how bones and other materials came to be buried in the earth and preserved as fossils. A taphonomist studies the processes of sedimentation, the action of streams, preservation properties of bone, and carnivore disturbance factors.

context The environmental setting where an archaeological trace is found. A primary context is the setting in which the archaeological trace was originally deposited. A secondary context is one to which it has been moved (e.g., by the action of a stream).

paleontologists must do the same for all faunal remains. Knowing the kinds of animals represented—whether forest browsers, woodland species, or open-country forms—greatly helps in reconstructing the local paleoecological settings in which early hominins lived. Analyzing the fossil pollen collected from hominin sites by a palynologist further aids in developing a detailed environmental reconstruction. All these paleoecological analyses can assist in reconstructing the diet of early humans. Also, the taphonomy of the site must be worked out in order to understand its depositional history—that is, how the site formed over time and if its present state is in a primary or secondary context.

In the concluding stages of interpretation, the paleoanthropologist draws together the following essentials:

1. Dating
   - geological
   - paleontological
   - geophysical

2. Paleoecology
   - paleontology
   - palynology
   - geomorphology
   - taphonomy

3. Archaeological traces of behavior

4. Anatomical evidence from hominin remains

By analyzing all this information, scientists try to “flesh out” the kind of animal that may have been our direct ancestor, or at least a very close relative. Primatologists may assist here by showing the detailed relationships between the anatomical structure and behavior of humans and that of contemporary nonhuman primates (see Chapters 6 and 7). Cultural anthropologists and ethnoarchaeologists (see p. 186) may contribute ethnographic information concerning the varied nature of human behavior, particularly the cultural adaptations of those contemporary hunter-gatherer groups exploiting roughly similar environmental settings as those reconstructed for a hominin site.

The end result of years of research by dozens of scientists will (we hope) produce a more complete and accurate understanding of human evolution—how we came to be the way we are. Both biological and cultural aspects of our ancestors contribute to this investigation, each process developing in relation to the other.
Archaeology

As we noted in Chapter 1, archaeology is a body of methods designed to understand the human past through the examination and study of its material remains. Archaeologists use basically the same methods and techniques to research early hominin sites in the Old World as they do to study the prehistory of modern humans and their cultures. The big differences are, first, that the archaeological record holds much less material evidence of the lifeways of early hominins than of modern humans and, second, that the oldest archaeological data are difficult to interpret accurately because early hominins were physically and culturally quite different from modern humans. As we move closer in time to modern humans, the archaeological record becomes more extensive, more diverse, and more readily interpreted.

GOALS OF ARCHAEOLOGY

In its study of the human past, anthropological archaeology has at least four main goals, several of which play a role in virtually every research project. The first goal, a very basic one, is to reconstruct the chronicle of past human events as they were played out across space and through time. This goal is essentially that of providing order to the archaeological record, an order that implicitly answers the fundamental “when” and “where” questions. When did plant domestication arise in the Near East? What sustained contacts existed between the people of western Mexico and northern Peru in 800–400 B.C.? Does the distribution of hand axes (a type of stone tool discussed in Chapter 10) extend into Southeast Asia? Descriptive questions such as these, anchored as they are in time and space, are essential to the successful examination of more challenging questions about the human past.

Archaeology’s second main goal is to reconstruct past human lifeways. Using clues from recovered artifacts, archaeological features, sites, and contexts, archaeologists try to understand how people actually created and used those cultural products to interact with each other and their surroundings. How did they use these tools? How were people treated in death? What did their huts or shelters look like? Think of this area of research as the archaeological equivalent of the ethnographies of cultural anthropology.

Third, archaeologists want to explain how and why the past happened as it did. Why does the earliest evidence of farming occur after the end of the last Ice Age and not before? Are social inequalities inevitable correlates of the development of the earliest civilizations? Such questions are tough to answer because of their general nature and because the answers can sometimes require that we come to understand more about the past than anyone has yet learned.

Theoretical changes in archaeology over the past two decades also yielded what many researchers now regard as a fourth main goal, which can be loosely described as interpreting the cognitive and symbolic aspects of past cultures. This research complements the search for general explanations of past cultural patterns and explores questions that reflect archaeology’s roots in the humanities. What can changing representational conventions of clothing in medieval Hindu art tell us about changes in the nature of kingship and the relations between kings? To what extent is the current scientific understanding of Russian prehistory biased by the values, beliefs, and social history of past generations of archaeologists? Such questions defy general explanation but are just as important to our understanding of the human past.

ARCHAEOLOGICAL RESEARCH PROJECTS

Modern archaeology, like paleoanthropology, is a complex undertaking that often draws on the expertise of specialists from many fields. Field projects range in scale from relatively
simple tasks that can be completed in a few days (Fig. 8-3) to major undertakings that may take decades to complete (Fig. 8-4). The justification for allocating resources to such research also varies greatly, from cultural resource management (CRM) projects intended to meet legal guidelines for conserving historical sites and monuments to public or private agency-sponsored projects designed to answer specific questions about the past.

Given an important question or problem to motivate research, archaeological fieldwork assumes a fairly common pattern. First, an appropriate location is chosen for the research, and the archaeological resources of that region are identified and inventoried. Second, sites selected from the region’s known sites are carefully examined, often using methods that cause minimal disturbance to the archaeological record. Finally, some sites may be wholly or partially excavated.

Modern archaeologists and other paleoanthropologists can (and do) turn to an extraordinary array of high-tech tools to help them discover the location of sites, including aerial and satellite imagery and remote sensing technologies with such obscure-sounding names as ground-penetrating radar, side-scan sonar, proton magnetometers, and subbottom profilers, to name only a few (Fig. 8-5). Even so, fieldworkers on foot who look for artifacts and other telltale material evidence on the ground surface probably still discover most sites.

As they identify sites in the field, archaeologists record information about the local terrain, including the kinds of artifacts and other cultural debris that may be present on the surface, the area covered by this scatter of debris, and other basic facts that become part of the permanent record of the site. Later, back in the lab, analyses of these data often
yield estimates of the approximate age of each site, what the prehistoric site inhabitants did there, how long they used the site, and sometimes even where they may have come from and the rough age and sex composition of the group (Fig. 8-6).

Information from this site survey, as it is often called, enables the project directors to make informed decisions about excavating the sites. They’ll choose sites that are most likely to yield information necessary to solve the problem that motivated the research or, if it is a CRM project, to comply with relevant heritage management priorities, guidelines, and laws.

The popular stereotype of archaeology and archaeologists is that they spend most of their time digging square holes in the ground. Although this kind of activity will always be archaeology’s defining characteristic, the professional attitude toward excavation changed during the twentieth century from a this-is-what-we-do attitude to a deep appreciation of the fact that the archaeological record is a finite resource, much like oil and gas deposits. We can be confident, for example, that all the 2,000-year-old sites that will ever exist were laid down 2,000 years ago. There aren’t going to be any more of them, only fewer. And since excavation is obviously destructive, it’s not like archaeologists do a site any favor by digging it up! Having come to this realization in the second half of the twentieth century, archaeologists have since tried to take a leadership role in promoting the adoption of national policies that conserve the world’s remaining archaeological resources for the maximum public and scientific benefit. So yes, excavation will always be a distinctively archaeological activity. But such excavations should happen only in those situations where the data are needed to answer specific nontrivial questions about the human past or to collect basic archaeological information about sites that face imminent threat of destruction. Anything else simply vandalizes our collective heritage.

Figure 8-5
Dr. Michael L. Hargrave conducts an electrical resistance survey to locate archaeological features at a site in central Missouri. The electrical resistance is measured between two electrodes inserted in the earth. By systematically recording these measures across an archaeological site, researchers can plot the data to show soil disturbances such as ditches, walls, roads, and similar features that show no visible traces on the ground surface.

Figure 8-6
By analyzing this collection of cultural debris from the surface of a prehistoric site in southeastern Missouri, the archaeologist can estimate the site age and the kinds of activities its inhabitants performed there. Other information about the site—including approximate site area, site preservation conditions, present land use, soil type, ground cover, and visible cultural features—was recorded when this surface collection was made.
Piecing Together the Past

Archaeology produces useful information only because we can reasonably assume that the organization and structure of the archaeological record reflects the behavior of humans in the past. Were this assumption to be false, archaeology would cease to exist. It’s also undeniably true that it’s easier to use archaeological data to examine some aspects of the past than others. Archaeologists, for example, seem to delight in telling us about what ancient people ate. They’re typically far less prepared to tell us about such things as regional patterns of Neandertal ethnic identity in southwestern France or the social meaning of tattooed faces among the late prehistoric Native American villagers of the American Southeast.

It’s not that no one cares about these things. It’s just that it’s far easier to talk about the archaeology of food than about the archaeology of identity and body art. After all, the archaeological record really is “other people’s garbage”; it only becomes something more than garbage when we attempt to use it to inform ourselves about the past. Only then must we confront the possibility that what we wish to know may not be preserved in the archaeological record or be open to direct examination. If that’s the case, then the researcher must explore ways to examine the phenomenon of interest indirectly. And if that doesn’t work, the archaeologist smacks up against the state-of-the-art wall, something that exists in every field and beyond which the potentially knowable cannot yet be known until someone develops new technologies or theoretical approaches that make it possible.

ARTIFACTS, FEATURES, AND CONTEXTS

Four essential products—artifacts, features, ecofacts, and contexts—result from archaeological research. The relationships between these categories of remains are most often observed on archaeological sites, which are the locations of past human activity, such as the remains of a long-ago abandoned village or the place where an ancient hunter skinned and butchered a buffalo.

Figure 8-7

The discovery of these sherds of decorated Native American pottery on the surface of a Mississippi Gulf Coast prehistoric site enables the archaeologist to estimate how old the site is and to determine regional ties between the group who lived at this site and groups who lived elsewhere on the Gulf Coast.

features  Products of human activity that are usually integral to a site and therefore not portable. Examples include fire hearths and foundations.

ecofacts  Natural materials that give environmental information about a site. Examples include plant and animal remains discarded as food waste and also pollen grains preserved in the soil.
Artifacts are tangible objects; in fact, anything that was made or modified by people in the past qualifies as an artifact (Fig. 8-7). It might be a stone tool or a sherd (fragment) of broken pottery or even a tin can. Artifacts differ from archaeological features because they can be removed as a single entity from the archaeological record. You can’t do that with features, such as a medieval Hindu temple, a mud-lined hearth or fireplace, or a human burial, because none of them can be taken from the archaeological record in one piece (Fig. 8-8). Ecolfacts are natural materials that are used mostly to reconstruct the local environment of a site (Fig. 8-9). Ecolfacts can be found as both artifacts and features.

As noted, context describes the spatial and temporal associations existing in the archaeological record among artifacts and features (Fig. 8-10). What was the object’s precise location, recorded from several coordinates so as to provide its three-dimensional position within the site? Was it associated somehow with any other artifact or feature? For example, was this projectile point found deep within a trash pit, on the floor of a hunter’s shelter, or lodged between the ribs of a large animal? Can we be certain that this apparent association was really contemporaneous and not the result of natural processes of erosion or mixing (a key consideration of taphonomy; see p. 180)? Our point is that the context can be just as important as the artifact itself in understanding the past. With only artifacts, archaeology can give us a pretty limited understanding of the past, but with artifacts and their context, the limitations of what we can potentially know about the past probably rest more with archaeologists than with the archaeological record.

Figure 8-9
Thousands of land snails like the ones resting on this Lincoln penny were collected from a 4,000-year-old campsite in Illinois. These snails lived on the site location before, during, and after it was used by Native Americans; by analyzing them, archaeologists can reconstruct how the local site environment changed during that time.

Figure 8-10
The large, dark wedge of soil is a partially excavated late prehistoric house in southeast Missouri. Preserved parts of the house wall are dotted along the upper edge of the feature in the upper half of the photo. The remains of this house provide archaeological context for the artifacts, ecolfacts, and smaller features found within it.
CHAPTER 8

site survey The process of discovering the location of archaeological sites; sometimes called site reconnaissance.

ethnoarchaeology Approach used by archaeologists to gain insights into the past by studying contemporary people.

haft To equip a tool or implement with a handle or hilt.

ETHNOARCHAEOLOGY

In addition to site surveys and excavations, archaeologists sometimes seek to enhance their understanding and interpretations of the past by turning to ethnoarchaeology, which examines contemporary societies to gain insights into past human behavior (Fig. 8-11).

An ethnoarchaeologist personally conducts in-depth ethnographic research among a living group, such as the !Kung San in southern Africa (Yellen, 1980), the Australian aborigines (Gould, 1977; Meehan, 1982), the Nunamiat peoples of the Alaskan Arctic (Binford, 1978), or urban America. Such studies yield detailed information about hunting or gathering, toolmaking, discard of debris, residence data, and the like. By being “on the scene” as modern people literally create a site, the ethnoarchaeologist can better appreciate the comparable processes that formed the archaeological record (at the same time often becoming painfully aware of how much potential evidence simply decays and disappears between the time a site is created and the time an archaeologist may excavate it thousands or millions of years later).

So, how does ethnoarchaeological information get applied in archaeological research? It gives archaeologists testable ideas about the interpretation of archaeological patterns in much the same way that paleoanthropologists apply observation studies of modern living primates to their understanding of the behavior and biology of hominins known only from the fossil record. The researcher examines the modern information and asks the question, “If early hominins behaved like modern hunter-gatherer X or supermarket shopper Y or rodeo performer Z, what physical evidence and associations should I expect to find in the archaeological record only if this is true?” If the predicted evidence and associations are found, then the researcher reasons that the observed modern human behavior can’t be excluded as a possible interpretation of comparable patterning in the archaeological record.

EXPERIMENTAL ARCHAEOLOGY

Yet another way to gain a closer understanding of our ancestors is by learning how they made their tools (Fig. 8-12), containers, houses (Fig. 8-13), and other artifacts and features and how they used and discarded them. After all, it’s the artifactual traces of prehistoric tools of stone (and, to a lesser degree, of bone) that constitute our primary information about the earliest identified humanlike behavior. As we mentioned earlier, stone is by far the most common residue of prehistoric cultural behavior, and tons of stone tool debris litter archaeological sites worldwide. For example, if you were taking a casual walk along the bottom of Olduvai Gorge in Tanzania, you’d likely be interrupted every few seconds by tripping over prehistoric tools!

But what can these artifacts tell us about our ancestors? Quite a lot. Let’s say your excavation reveals a bunch of stone axe heads from the remains of an ancient campsite. If you were to make copies of these axe heads using appropriate technology, haft them on wooden shafts in ways that replicate the wear patterns found on the ancient axe heads, and use them for a few hours in a set of experiments (say, cutting down a tree with one axe, clearing brush with another, and so on), you’d end up with a much better understanding of how the ancient axes were made and used and, very likely, why they tended to break in patterned ways. You would even be able to compare the wear patterns of modern stone axes used for different tasks with observable wear on the archaeological specimens and identify the tasks for which the ancient tools were used.
Experimental archaeology

Research that attempts to replicate ancient technologies and construction procedures to test hypotheses about past activities.

**Dating Methods**

An essential consideration of archaeology and, more generally, paleoanthropology is to establish the age of artifacts, fossils, features, and sites. Only after placing discoveries firmly in time and space can researchers accurately interpret the relationships of archaeological materials and sites to each other and construct a valid and reliable picture of human evolution. Because of the importance of dating in every chapter that follows, in this section we provide a basic introduction to the most widely used dating methods and how they work. Table 8-2 summarizes the main characteristics of each method.

The question of the age of archaeological and other paleoanthropological materials can be answered in two ways. First, we can say that the hominin that became fossil X lived before or after the hominin that became fossil Y. This is an example of relative dating, which establishes the relative order of events but does not scale the amount of time that separates them. Many questions can be answered by knowing only relative ages. Second, we can say that a particular village site is X number of years old. This is an example of chronometric dating, which establishes the age of events (and obviously their relative order too) according to some fixed time scale—often, as in this example, in calendar years. Chronometric dating is sometimes called absolute dating because the result is a measured quantity of time, not a relative order.

Both relative and chronometric dating are used daily in archaeological research. Because, like most instruments, every dating method has its strengths and limitations, researchers often employ multiple methods to estimate the age of a given artifact or context. This helps to ensure that their interpretations are based on the most valid and reliable age estimates.
### Table 8-2  Summary of Dating Methods Described in This Chapter

<table>
<thead>
<tr>
<th>Method</th>
<th>Basis</th>
<th>Limitations</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Relative dating methods establish the relative order of events</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stratigraphy</td>
<td>Principle of superpositioning of strata</td>
<td>Most robust relative dating method</td>
<td>Geological stratigraphy and archaeological stratigraphy are created by different processes and must be interpreted separately</td>
</tr>
<tr>
<td>Biostratigraphy</td>
<td>Estimates of consistent modifications in evolving lineages of animals; presence/absence of species</td>
<td>Requires very well-documented sequences and somewhere must be correlated with chronometric results (e.g., with K/Ar)</td>
<td>Best estimates in East Africa using pigs, monkeys, antelope, and rodents; has been important dating method in South Africa</td>
</tr>
<tr>
<td>Cross-dating</td>
<td>Shared similarities of material remains found in an undated context with remains from a context of known age</td>
<td>Weak when used by itself; best applied in conjunction with other dating methods</td>
<td>Widely applied in archaeological research, the logic of cross-dating is similar to that of biostratigraphy</td>
</tr>
<tr>
<td>Seriation</td>
<td>Orders artifacts from different sites or contexts into series based on presence/absence or frequencies of shared attributes</td>
<td>There’s no way to know which end of a seriated sequence of artifacts is the oldest unless it is determined by stratigraphic or chronometric methods</td>
<td>Gradually being replaced in archaeological research by a quantitative method called correspondence analysis, which achieves the same end</td>
</tr>
<tr>
<td>Fluorine analysis</td>
<td>Estimates the relative age of bones from a given site based on fluorine content</td>
<td>Applicable only to bones found in the same location</td>
<td>The key to exposing the Piltdown hoax in the early 1950s</td>
</tr>
</tbody>
</table>

| **Chronometric methods give absolute measures of age, often scaled in calendar years** |                                                                       |                                                                            |                                                                          |
| Potassium-argon (K/Ar)          | Regular radioactive decay of potassium isotope                         | Contamination can occur; usually requires corroboration from other independent methods | Can be used only on sediments that have been superheated (usually volcanic deposits) |
| Argon-argon (40Ar/39Ar)         | Works similar to potassium-argon technique                             | Same as above                                                               | Same as above; often used to check the validity and reliability of potassium-argon results |
| Fission-track dating            | Regular fission of uranium atoms, leaving microscopic tracks          | Usually derived from volcanic deposits; estimates generally less accurate than for K/Ar | Very important corroboratory method in East Africa |
| Paleomagnetism                  | Regular shifts in earth’s geomagnetic pole; evidence preserved in magnetically charged sediments | Requires precise excavation techniques; both major and minor reversals occur and can easily confuse interpretation | Important corroboratory method in East and South Africa |
| Radiocarbon dating              | Measures the 14C/12C ratio in samples of organic materials             | Applications limited to roughly the past 50,000 years                       | Most widely used chronometric dating method |
| Thermoluminescence (TL)         | Measures the accumulated radiation dose since the last heating or sunlight exposure of an object | Yields the estimated age of the last heating event                          | Widely used for dating ceramics, hearths, and other artifacts and features that were subjected to extremes of heat |
| Electron spin resonance (ESR)   | Measurement (counting) of accumulated trapped electrons               | Age estimates can be biased by tooth enamel uptake of uranium; best applied in conjunction with other dating methods | Widely applied in paleoanthropology to date fossil tooth enamel |
| Uranium series dating           | Radioactive decay of short-lived uranium isotopes                      | Can yield high-precision age estimates; main limitation is the potential range of datable materials | Used to date limestone formations (e.g., stalagmites) and ancient ostrich eggshells |
| Dendrochronology               | Tree-ring dating                                                      | Direct archaeological applications limited to temperate regions for which a master chart exists for tree species that were used by humans in the past | Although very important for archaeological dating in some parts of the world (e.g., the American Southwest), its greatest general application is to calibrate radiocarbon age estimates, which greatly enhances their accuracy and precision |
RELATIVE DATING

The oldest relative dating method is \textit{stratigraphy}. A basic understanding of the nature of geological stratigraphy and the \textit{principle of superpositioning} has been critical to the development of the scientific understanding of human evolution for at least the past 150 years. When you stand and look at the rock layers visible in the side of the Grand Canyon, the Rift Valley in East Africa, or even many interstate highway road cuts, there’s nothing that cries out to you that the stuff on top must have been put there last and that, therefore, the stuff on the bottom is older than the stuff on the top. To make sense of it, you must, like James Hutton, Charles Lyell, and other nineteenth-century geologists, understand the processes by which sedimentary strata form and how they change. Once you grasp these concepts, then it’s obvious that every stratigraphic exposure is a time-ordered record that if systematically studied can inform you about the past (Fig. 8-14).

Conveniently, the layer upon layer of sedimentary rock and other earth strata that compose much of the earth’s near-surface geological record also contains most of the fossil evidence of our earliest ancestors and relatives. And even now, when so many chronometric dating methods exist, every researcher in the field knows that when he or she finds a fossil piece of an early hominin skull weathering out of an exposure in a geological \textit{stratum}, then it must be more recent than skull fragments found in context in stratigraphic layers below it and older than fossils found in layers superimposed on it. The principle of superpositioning is therefore both robust, because only one sequence of events is possible, and useful, because this sequence establishes the order, or relative dating, of events.

It’s appropriate to note here that geological stratigraphy and archaeological stratigraphy (in other words, the stratigraphy of an archaeological site) are not the same, nor are they created by precisely the same processes. As the archaeologist Edward Harris (1989) points out, geological stratigraphy is formed only by natural processes, whereas archaeological stratigraphy is formed by both cultural and natural processes. Geological strata are also typically sedimentary rocks that formed under water and that cover large areas, but archaeological strata are unconsolidated deposits that cover only small areas. The good news is that the principle of superpositioning applies both to geological

\textbf{stratigraphy}  Study of the sequential layering of deposits.

\textbf{principle of superpositioning}  In a stratigraphic sequence, the lower layers were deposited before the upper layers. Or, simply put, the stuff on top of a heap was put there last.

\textbf{stratum}  \textit{(pl., strata)} A single layer of soil or rock; sometimes called a level.
biostratigraphy  A relative dating technique based on regular changes seen in evolving groups of animals as well as the presence or absence of particular species.

index fossils  Fossil remains of known age, used to estimate the age of the geological stratum in which they are found. For example, extinct marine arthropods called trilobites can be used as an index fossil of Cambrian and Ordovician geological formations.

cross-dating  Relative dating method that estimates the age of artifacts and features based on their similarities with comparable materials from dated contexts.

seriation  Relative dating method that orders artifacts into a temporal series based on their similar attributes or the frequency of these attributes.

and archaeological stratigraphy; the bad news is that these two kinds of stratigraphy differ enough in other ways that the interpretation of many early hominin sites requires stratigraphic interpretations from both perspectives.

Closely connected to geological stratigraphy is the method called biostratigraphy, or faunal correlation, a dating technique employed in the Early Pleistocene deposits at Olduvai and other African sites. This technique is based on the regular evolutionary changes in well-known groups of mammals. Animals that have been widely used in biostratigraphic analysis in East and South Africa are fossil pigs, elephants, antelopes, rodents, and carnivores. From areas where evolutionary sequences have been dated by chronometric means (such as potassium-argon dating, discussed shortly), approximate ages can be extrapolated to other lesser-known areas by noting which genera and species are present and treating them as index fossils.

In a similar manner, archaeologists use cross-dating to estimate the age of artifacts and features based on their similarities with comparable materials from contexts that have been dated by other means. The reasoning is simple. Suppose that you’d excavated the remains of an ancient burned hut and found several rusted iron hoes of a distinctive design in one corner of the building. If you were to turn to the archaeological literature for that region and research the evidence for similar hoes, you might find that other excavated sites had yielded hoes of the same shape in contexts dated by chronometric techniques to between A.D. 1450 and 1600. By applying the logic of cross-dating, you could tentatively infer that the hoes—and perhaps more important, the hut in which the hoes were found—cannot be older than A.D. 1450. The weakness of such reasoning is its assumption that close material similarities are a reliable measure of contemporaneity of contexts; although it’s often true, this assumption is false enough of the time to warrant caution. Consequently, cross-dating is best applied as one of several independent methods of estimating the age of a given context.

Archaeologists also exploit the tendency for many items of material culture to change in patterned ways over time in another relative dating method called seriation, which simply orders artifacts into series based on their similar attributes or the frequency of these attributes. The familiar Stone–Bronze–Iron Age sequence long recognized by prehistorians is a good example of seriation: Sites containing metal tools are generally more recent than those where only stone was used, and since bronze technology is known to have developed before iron making, sites containing bronze but no iron occupy an intermediate chronological position. Likewise, the presence of clay vessels of a specific form in a given site may allow researchers to place that site in a sequence relative to others containing only pots known to be of earlier or later styles. Using this approach, archaeologists working in the southwestern United States determined the correct sequence of ancient Pueblo Indian sites based on the presence or absence of pottery and a comparison of stylistic traits. Later, radiocarbon dating—a chronometric technique—confirmed this sequence. Unless we have some independent means of actually assigning chronometric dates to some or all of the artifacts in the series, we know only that certain types (and, by extension, the sites where they occur) are relatively older or younger than others.
Another method of relative dating is fluorine analysis, which can be applied only to bones (Oakley, 1963). Bones in the earth are exposed to the seepage of groundwater that often contains fluorine. The longer a bone lies in the earth, the more fluorine it will incorporate during the fossilization process. This means that bones deposited at the same time in the same location should contain the same amount of fluorine. The use of this technique by Kenneth Oakley of the British Museum in the early 1950s exposed the famous Piltdown (England) hoax by demonstrating that a human skull was considerably older than the jaw (ostensibly also human) found with it (Weiner, 1955). A discrepancy in fluorine content led Oakley and others to more closely examine the bones, and they found that the jaw was not that of a hominin at all, but of a young adult orangutan!

Unfortunately, fluorine is useful only with bones found at the same location. Because the amount of fluorine in groundwater is based on local conditions, it varies from place to place. Also, some groundwater may not contain any fluorine. For these reasons, comparing bones from different localities by fluorine analysis is impossible.

CHRONOMETRIC DATING

It’s impossible to calculate the age in calendar years of a site’s geological stratum, and the objects in it, by using only relative dating techniques. To estimate absolute measures of age, scientists have developed a variety of chronometric techniques based on the phenomenon of radiometric decay. The theory is quite simple: Radioactive isotopes are unstable; over time, these isotopes decay and form an isotopic variation of another element. Since the rate of decay is known, the radioactive material can be used to measure past time in the geological and archaeological records. By measuring the amount of decay in a particular sample, scientists can calculate the number of years it took for the given radioactive isotope to decay to produce the measured level. The result is an age estimate that can be converted to calendar years. As with relative dating methods, chronometric methods have strengths and limitations. Some can be used to date the immense geological age of the earth; others may be limited to artifacts less than 1,000 years old. (For more on these techniques, see Lambert, 1997; Taylor and Aitken, 1997.)

The most important chronometric technique used to date early hominins involves potassium-40 ($^{40}\text{K}$), which has a half-life of 1.25 billion years and produces argon-40 ($^{40}\text{Ar}$). Known as the K/Ar or potassium-argon method, this procedure has been extensively used by paleoanthropologists in dating materials in the 1- to 5-million-year range, especially in East Africa. In addition, a variant of this technique, the $^{40}\text{Ar}/^{39}\text{Ar}$ or argon-argon method, has recently been used to date a number of hominin localities. The $^{40}\text{Ar}/^{39}\text{Ar}$ method allows analysis of smaller samples (even single crystals), reduces experimental error, and is more precise than standard K/Ar dating. Consequently, it can be used to date a wide chronological range—indeed, the entire hominin record, even up to modern times. Recent applications have provided excellent dates for several early hominin sites in East Africa (discussed in Chapter 9) as well as somewhat later sites in Java (discussed in Chapter 10). In fact, the technique was recently used to date the famous Mt. Vesuvius eruption of A.D. 79 (which destroyed the city of Pompeii). Remarkably, the midrange date obtained by the $^{40}\text{Ar}/^{39}\text{Ar}$ method was A.D. 73, just six years from the known date (Renne et al., 1997)! Organic material, such as bone, cannot be measured by these techniques, but the rock matrix in which the bone is found can be. K/Ar was used to provide a minimum date for the deposit containing the Zinjanthropus cranium by dating a volcanic layer above the fossil.

Rocks that provide the best samples for K/Ar and $^{40}\text{Ar}/^{39}\text{Ar}$ dating are those heated to extremely high temperatures, such as that generated by volcanic activity. When the rock is in a molten state, argon, a gas, is driven off. As the rock cools and solidifies, potassium-40 continues to break down to argon, but now the gas is physically trapped in the cooled rock. To obtain the date of the rock, it is reheated and the escaping gas measured.

**fluorine analysis** Relative dating method that measures and compares the amounts of fluorine that bones have absorbed from groundwater during burial.

**radiometric decay** A measure of the rate at which certain radioactive isotopes disintegrate.

**half-life** The time period in which one-half the amount of a radioactive isotope is chemically converted to a daughter product. For example, after 1.25 billion years, half the potassium-40 remains; after 2.5 billion years, one-fourth remains.

**potassium-argon (K/Ar) method** Dating technique based on accumulation of argon-40 gas as a by-product of the radiometric decay of potassium-40 in volcanic materials; used especially for dating early hominin sites in East Africa.

**argon-argon ($^{40}\text{Ar}/^{39}\text{Ar}$) method** Working on a similar basis as the potassium-argon method, this approach uses the ratio of argon-40 to argon-39 for dating igneous and metamorphic rocks; it offers precision and temporal range advantages for dating some early hominin sites.
When dating relatively recent samples (from the perspective of a half-life of 1.25 billion years for K/Ar, all paleoanthropological material is relatively recent), the amount of radiogenic argon (the argon produced by decay of a potassium isotope) is going to be exceedingly small. Experimental errors in measurement can therefore occur as well as the thorny problem of distinguishing the atmospheric argon normally clinging to the outside of the sample from the radiogenic argon. In addition, the initial sample may have been contaminated, or argon leakage may have occurred while it lay buried. Due to these potential sources of error, K/Ar dating must be cross-checked using other independent methods.

**Fission-track dating** is one of the most important techniques for cross-checking K/Ar determinations. The key to fission-track dating is that uranium-238 ($^{238}\text{U}$) decays regularly by spontaneous fission. By counting the fraction of uranium atoms that have fissioned (shown as microscopic tracks caused by explosive fission of $^{238}\text{U}$ nuclei), we can determine the age of a mineral or natural glass sample (Fleischer and Hart, 1972). One of the earliest applications of this technique was on volcanic pumice from Olduvai, giving a date of $2.30 \pm 0.28$ mya—in good accord with K/Ar dates.

Another important means of cross-checking dates is called **paleomagnetism**. This technique is based on the constantly shifting nature of the earth's magnetic pole. Of course, the earth's magnetic pole is now oriented in a northerly direction, but it hasn't always been. In fact, the orientation and intensity of the geomagnetic field have undergone numerous documented changes in the last few million years. From our present point of view, we call a northern orientation “normal” and a southern one “reversed.” Here are the major epochs (also called chrons) of recent geomagnetic time:

- 0.7 mya–present Normal
- 2.6–0.7 mya Reversed
- 3.4–2.6 mya Normal
- ?–3.4 mya Reversed

Paleomagnetic dating is accomplished by carefully taking samples of sediments that contain magnetically charged particles. Since these particles maintain the magnetic orientation they had when they were consolidated into rock (many thousands or millions of years ago), they function as a kind of fossil compass. Then the paleomagnetic sequence is compared against the K/Ar dates to check if they agree. Some complications may arise, for during an epoch, a relatively long period of time can occur when the geomagnetic orientation is the opposite of what is expected. For example, during the reversed epoch from 2.6 to 0.7 mya (the Matuyama epoch), there was an event lasting about 210,000 years when orientations were normal (Fig. 8-15). (Because this phenomenon was first conclusively demonstrated at Olduvai, it is appropriately called the Olduvai event.) Once these oscillations in the geomagnetic pole are worked out, though, the sequence of paleomagnetic orientations can provide a valuable cross-check for K/Ar and fission-track age determinations.

The standard chronometric method for dating later prehistory is **carbon-14 ($^{14}\text{C}$)** dating, also known as **radiocarbon dating**. This technique has been used to date organic material ranging from less than 1,000 years old up to around 50,000 years old. The radiocarbon dating method is based on the following natural processes: Cosmic radiation enters the earth’s atmosphere as nuclear particles, some of which react with nitrogen to produce small quantities of an unstable isotope of carbon, $^{14}\text{C}$. This radioactive $^{14}\text{C}$ diffuses through the atmosphere, mixing with ordinary carbon-12 ($^{12}\text{C}$). Combined with oxygen ($\text{O}_2$) in the form of carbon dioxide ($\text{CO}_2$), carbon is taken up by plants during photosynthesis. Herbivorous animals absorb it by feeding on plants, and carnivores absorb it by feeding on herbivores. So $^{14}\text{C}$ and $^{12}\text{C}$ are found in all living forms at a ratio that reflects the atmospheric proportion. Once an organism dies, it absorbs no more $^{14}\text{C}$, neither through photosynthesis nor through its diet. Without replacement, the $^{14}\text{C}$ atoms in the tissue continue decaying at a constant rate to nitrogen-14 ($^{14}\text{N}$) and a beta particle, while the
\[^{12}\text{C}\] remains unchanged. Thus, the \(^{14}\text{C}/^{12}\text{C}\) ratio in the tissues of a dead plant or animal decreases steadily through time at a rate that can be precisely measured.

This method is limited primarily to dating organic materials that were once alive and part of the carbon cycle, but the constraint can be a somewhat loose one. For example, South African archaeologist Nikolaas van der Merwe (1969) successfully devised a technique to use radiocarbon dating for archaeological samples of iron alloy, a material that was obviously never alive itself but that does contain carbon from living things due to its manufacturing process. This alone is sufficient for it to be dated by the radiocarbon method.

Carbon-14 has a radiometric half-life of 5,730 years, meaning it takes 5,730 years for half the remaining \(^{14}\text{C}\) to decay. Let’s say that charred wood, the remains of a campfire, is found at an archaeological site and analyzed for its \(^{14}\text{C}/^{12}\text{C}\) ratio. First, the sample is carefully collected to avoid contamination. It doesn’t have to be a large sample, because even tiny quantities of carbon—just a few milligrams—can be analyzed. In the laboratory, radiation detectors measure the residual \(^{14}\text{C}\) (Fig. 8-16). Suppose the findings show that only 25 percent of the original \(^{14}\text{C}\) remains, as indicated by the \(^{14}\text{C}/^{12}\text{C}\) ratio. Since we know that it takes 5,730 years for half the original number of \(^{14}\text{C}\) atoms to become \(^{14}\text{N}\) and another 5,730 years for half the remaining \(^{14}\text{C}\) to decay, the sample must be about 11,460 years old. Half of the yet-remaining \(^{14}\text{C}\) will disappear over the next 5,730 years (when the charcoal is 17,190 years old), leaving only 12.5 percent of the original amount. This process continues, and as you can estimate, there would be very little \(^{14}\text{C}\) left after 40,000 years, when
accurate measurement becomes difficult. Radiocarbon dates (and most other chronometric age determinations) are often reported as a mean age estimate and its associated standard error (1 standard deviation, by convention). So the age estimate of the campfire charcoal, as reported by the dating lab, might be expressed as $11,460 \pm 200$ radiocarbon years ago. Expressed in words, such an estimate states that the true age of the dated specimen will fall between 11,260 and 11,660 radiocarbon years ago about two times out of three, or roughly 68 percent of the time.

Some inorganic artifacts can be directly dated through the use of thermoluminescence (TL). Used especially for dating ceramics, but also applied to clay cooking hearths and even burned flint tools and hearthstones on later hominin sites (see p. 307), this method, too, relies on the principle of radiometric decay. Clays used in making pottery invariably contain trace amounts of radioactive elements, such as uranium or thorium. As the potter fires the ware (or a campfire burns on a hearth), the rapid heating releases displaced beta particles trapped within the clay. As the particles escape, they emit a dull glow known as thermoluminescence. After that, radioactive decay resumes within the fired clay or stone, again building up electrons at a steady rate. To determine the age of an archaeological sample, the researcher must heat the sample to 500°C and measure its thermoluminescence; from that the date can be calculated. TL is routinely used to authenticate fine ceramic vessels prized by collectors and museums, and the technique has exposed many fake Greek and Maya vases displayed in prominent collections.

Like TL, two other techniques used to date sites from the latter phases of hominin evolution (where neither K/Ar nor radiocarbon dating is possible) are uranium series dating and electron spin resonance (ESR) dating. Uranium series dating relies on radioactive decay of short-lived uranium isotopes, and ESR is similar to TL because it’s based on measuring trapped electrons. However, while TL is used on heated materials such as clay or stone tools, ESR is used on the dental enamel of animals. All three of these dating methods have been used to provide key dating controls for hominin sites discussed in Chapters 11 and 12.

An archaeologically important chronometric dating technique that does not involve radioactive elements is dendrochronology, or dating by tree rings. Its use is limited to contexts in temperate latitudes, where trees show pronounced seasonal growth rings and where ancient wood is commonly preserved. So far, the longest dendrochronological sequences have been developed in the arid American Southwest and the bogs of western Europe, especially Ireland and Germany.

Because tree rings represent seasonal growth layers, the amount of new wood added each year depends directly on rainfall and other factors. People have known for centuries, if not millennia, that the growth rings of an individual tree read like its biography. If we know when the tree was cut and then count from the outer rings inward toward the center, we can readily determine the year the tree began growing. The outstanding contribution of A. E. Douglass, an early twentieth-century astronomer, was to systematically exploit this idea. He reasoned that if we can tell how old a tree is by counting its seasonal growth rings, then we should be able to take a tree of known age and match its growth-ring pattern with the patterns compiled from older and older trees of the same species. The limit on how old this “master chart” of growth rings can extend into the past depends entirely on the extent to which old tree trunks are preserved, because they provide data from which the chart can be built.

By cutting or drawing core samples from living trees, recently dead trees, and successively older wood (including archaeological sources such as ancient house posts or beams), archaeologists obtain overlapping life histories of many trees. When compared, these life histories form an extensive record of tree-ring growth through many centuries. Remember,
the archaeologist is mostly interested in determining precisely when a tree stopped growing and became part of a cultural process such as construction or cooking. As a result, a tree used as a beam in a prehistoric structure in the American Southwest may be dated to the very year in which it was felled (Fig. 8-17), since the distinctive pattern of its growth should exactly match some segment of the tree-ring record compiled for the region. Archaeologists studying the ceiling beams in the traditional homes still occupied by the Acoma people in northern New Mexico were able to precisely date construction undertaken in the mid-seventeenth century (Robinson, 1990). Wood from the commonly used pinyon pines and the long-lived Douglas fir trees, sequoia redwoods, and bristlecone pines of the American West, as well as preserved oak logs from western European bogs, afford archaeologists continuous regional tree-ring records extending back thousands of years.

But there is yet another dimension to tree-ring dating. By radiocarbon dating wood taken from individual growth rings of known age, researchers have used dendrochronology to fine-tune \(^{14}\)C dating accuracy, factoring in past fluctuations in the atmospheric reservoir of \(^{14}\)C over the past 9,800 years (the period for which tree-ring dates are available). They then use this factor to recalibrate the raw dates obtained by standard \(^{14}\)C analyses, thereby enabling archaeologists to convert radiocarbon age estimates to calendar year ages. Recently, by comparing \(^{14}\)C dates obtained from coral reefs with dates on the same samples obtained using a uranium-thorium (\(^{234}\)U/\(^{230}\)Th) dating method, technicians have been able to adjust the radiocarbon calibration curve back to 23,700 years ago (Fiedel, 1999b).

In some areas, including Egypt and Central America, the recorded calendar systems of ancient civilizations have also been cross-referenced to our own, resulting in direct dating of some sites and inferential or cross-dating of others shown to be contemporaneous with them by the presence of distinctive artifacts. For example, firmly dated artifacts originating in the Nile valley and traded into the Aegean allow us to assign dates to archaeological contexts of Bronze Age Greece. Obviously, this approach is of little use outside those regions having some connection with literate societies.

Since the advent of radiocarbon and other chronometric dating methods in the latter half of the twentieth century, the age of many archaeological and paleoanthropological finds has been precisely and accurately estimated. Although no other dating technique is as widely used as radiocarbon dating, each is an ingenious method with its own special applications. Still, as with any instrument, researchers must consider the strengths and limitations of each chronometric method, both when applying it in the field and when interpreting the lab results.

### Paleoanthropology and Archaeology at Olduvai Gorge

We conclude this methodological introduction to paleoanthropology and archaeology with a case study from East Africa—Olduvai Gorge (Fig. 8-18), a locality that has yielded the finest quality and greatest abundance of anthropological information concerning the behavior of early hominins and an extraordinarily informative sequence of excavated Lower Paleolithic sites. The object of this case study is to illustrate how paleoanthropological methods, including most especially archaeological approaches, work together to create the modern understanding of early hominin life in this part of East Africa. It also sets the stage for Chapter 9, in which we explore in detail the early hominin fossil record and the oldest Lower Paleolithic archaeological evidence.

Beginning in the 1930s, the pioneering team of Louis and Mary Leakey (Fig. 8-19) worked at Olduvai. Together, they made Olduvai Gorge one of the most widely known place names in Africa. It was, you might say, one of the best mom-and-pop shops in twentieth-century paleoanthropology.
Located on the Serengeti Plain of northern Tanzania, Olduvai is a steep-sided valley resembling a miniature version of the Grand Canyon (Fig. 8-20). A massive ravine some 300 feet deep, Olduvai cuts for more than 25 miles across the grassy plateau of East Africa. The present semiarid climate of the Olduvai region is believed to be similar to what it has been for the last 2 million years. The surrounding countryside is a grassland savanna dotted with scrub bushes and acacia trees. Dry though it may be, this environment presently (as well as in the past) supports a vast number of mammals (such as zebra, wildebeest, and gazelle), representing an enormous supply of “meat on the hoof.”

Geographically, Olduvai is located on the eastern branch of the Great Rift Valley, which stretches for 4,000 miles down the east side of Africa (see Fig. 8-18). The geological processes associated with forming the Rift Valley make Olduvai (and many other East African regions) extremely important because they created an environment that favored the preservation of hominin remains and make it easier for paleoanthropologists and archaeologists to discover these remains. Here are the four most significant results of geological rifting:

1. Faulting, or earth movement, exposes geological strata that are normally hidden deep in the earth.
2. Active volcanic processes cause rapid sedimentation, which often yields excellent preservation of bone and artifacts that normally would be scattered by carnivore activity and erosion forces.
3. Strata formed by rapid sedimentation and, more important, the hominin fossils and archaeological sites preserved within them, can be dated by relative methods such as stratigraphy and cross-dating.
4. Volcanic activity provides a wealth of materials datable by chronometric methods.

Figure 8-18
Olduvai Gorge and the Rift Valley system in East Africa.

Figure 8-19
Mary Leakey (1913–1996), a major figure in twentieth-century paleoanthropology, devoted most of her life to fieldwork in Olduvai Gorge, where she made many important discoveries, including the *Zinjanthropus* skull (see Fig. 8-21) in 1959.
As a result, Olduvai offers researchers superb preservation of ancient hominins, good evidence of the environments in which these hominins lived, and archaeological sites containing the material remains of their existence in datable contexts, all of which are readily accessible. Such advantages cannot be ignored, and Olduvai continues to be the focus of considerable archaeological and other paleoanthropological research.

Over the decades of paleoanthropological fieldwork, partial remains of more than 40 fossilized hominins have been found at Olduvai. Many of these individuals are quite fragmentary, but a few are excellently preserved. Although the center of hominin discoveries has now shifted to other areas of East Africa, it was the initial discovery by Mary Leakey of the Zinjanthropus skull at Olduvai in July 1959 that focused the world’s attention on this remarkably rich area (see Fig. 8-21). “Zinj” is an excellent example of how financial support can result directly from hominin fossil discoveries. Prior to 1959, the Leakeys had worked sporadically at Olduvai on a financial shoestring, making marvelous paleontological and archaeological discoveries but never attracting the financial assistance they needed for large-scale excavations. However, following the discovery of Zinj, the National Geographic Society funded the Leakeys’ research, and within a year, more than twice as much dirt had been excavated than during the previous 30 years!

Olduvai’s greatest contribution to paleoanthropological research in the twentieth century was the establishment of an extremely well-documented and correlated sequence of archaeological, geological, paleontological, and hominin remains over the last 2 million years. At the very foundation of all paleoanthropological research is a well-established geological context. At Olduvai, the geological and paleogeographical situation is now known in minute detail. It’s been a great help that Olduvai is a geologist’s delight, containing sediments in some places 350 feet thick, accumulated from lava flows (basalts), tuffs (windblown or waterborne fine deposits from nearby volcanoes), sandstones, claystones, and limestone conglomerates, all neatly stratified (see Fig. 8-20). A hominin site can therefore be accurately dated relative to other sites in the Olduvai Gorge by cross-correlating known stratigraphic marker beds.

Because the vertical cut of the Olduvai Gorge provides a ready cross section of 2 million years of earth history, sites can be excavated by digging “straight in” rather than first having to remove tons of overlying dirt (Fig. 8-22). In fact, sites are usually discovered in Olduvai Gorge by merely walking the stratigraphic exposures and observing what kinds of bones, stones, and so forth, are eroding out, just as archaeologists often do when discovering sites in other parts of the world.

At the most general geological level, the stratigraphic sequence at Olduvai is broken down into four major beds (Beds I–IV), each containing hominin and other animal fossils and sites with artifacts and features created by early hominin cultural behavior. These contexts are reasonably well dated by both relative and chronometric methods. The fossilized remains of more than 150 animal species, including fishes, turtles, crocodiles, pigs, giraffes, horses, and many birds, rodents, and antelopes, have been found throughout these Olduvai beds and provide much of the basis for reconstructing the environmental conditions that existed when the early hominin sites were deposited.

The earliest identified hominin site (circa 1.85 mya) at Olduvai Gorge contains a Lower Paleolithic stone tool assemblage that archaeologists named Oldowan (Leakey,
For now, it is enough to know that Oldowan tools are simple and very crude to our eyes and that most were made by knocking small flakes off bigger rocks and by battering (Fig. 8-23). (We’ll look at Oldowan tools in more detail in Chapter 9.) Considerable research continues to focus on understanding the nature of these tools, with archaeologists eager to know just why they were made and what they were used for. Many insights about Oldowan tool function and use come from the results of experimental archaeology projects in which researchers try to replicate the wear, breakage, and discard patterns of artifacts found in Lower Paleolithic sites.

For example, in the mid-twentieth century, many archaeologists described Oldowan as primarily a “chopping tool industry” because they concluded that the large, broken cobbles found in these assemblages were used as heavy chopper-like implements (see Fig. 8-23). They also inferred that many of the equally common stone flakes were simply debris from making these so-called “core tools.” Over the decades, as archaeologists investigated more Oldowan sites and compared excavated artifacts with similar implements re-created by experimental archaeologists, these initial hypotheses came into question. Many of the choppers or core tools, while they were clearly artifacts, might not have actually been used as tools. In one such study, Richard Potts (1991, 1993), of the Smithsonian Institution, analyzed Olduvai Bed I artifacts and concluded that early hominins were deliberately producing flake tools, not heavy chopper-like core tools, and that the various stone nodule forms (discoids, polyhedrons, choppers, and so on) were simply “incidental stopping points in the process of removing flakes from cores” (Potts, 1993, p. 60).

To many students, the idea that one class of artifacts is not what we once assumed probably seems trivial, but it actually had important implications for how archaeologists view early hominins as cultural animals. If Oldowan tool use emphasized cutting (the flake tools), not chopping (the so-called core tools), then what were they cutting? What kinds of use wear are present on the flake tools, and what kinds of cutting scars are present on the animal bones found in Oldowan sites? And what are the lumps of rock once thought to be core tools? Just broken bits of raw material, or something else entirely? Researchers have paid a fair amount of attention to such questions over the past couple of decades, and their results continue to enhance our understanding of how early hominins, as creatures that were still learning to be tool-using animals, exploited the landscapes in which they lived.

The recognition that flake tools were a key part of the Oldowan tool industry forced paleoanthropologists and archaeologists to reassess their ideas about early human tool
use. A comparable impact may be felt from recent research on rocks that early humans may not have used at all! The Oldowan industry traditionally includes manuports—unmodified rocks of types that are not present in the geology of the immediate vicinity of the Oldowan sites where they are found. In other words, they're just rocks, and the only reasons for not treating them as such are that they are geologically out of place and that they are found in archaeological contexts believed to be the product of hominin behavior.

For decades, archaeologists have believed that the best explanation for the presence of manuports in Oldowan sites was that early hominins picked up the stones where they naturally occurred and carried them to the site where they were much later excavated. If that's true, such an otherwise irrelevant artifact depends for its significance entirely on the assumption that an early human moved it from point A to point B. So long as we believe that the evidence supports only this interpretation, these rocks are artifacts; once we cannot believe this evidence, they're just rocks.

Although they don’t seem important, manuports became key elements in some interpretations of the ecological niche of early hominins as tool-using animals on the arid savannas of East Africa. For example, among the several kinds of Oldowan sites excavated in Olduvai Gorge are those originally identified as “multipurpose localities,” or campsites, which were interpreted as general-purpose areas where hominins possibly ate, slept, and put the finishing touches on tools. Mary Leakey and the archaeologist Glynn Isaac (1976) were strong proponents of this interpretation, which carried with it the necessary implication that early hominins were home-based foragers. Lewis Binford’s (1983) comparisons of bone assemblages from early hominin contexts at Olduvai and similar assemblages drawn from his ethnoarchaeological research in Alaska on modern human and animal behavior led him to a different conclusion. He argued that much of the accumulated bone refuse on Oldowan sites can be explained as the result of nonhominin (that is, predator) activities and that early hominins were little more than passive scavengers of big game kills. This stance opened the door to a continuing debate about whether early hominins were primarily hunters or scavengers (e.g., Domínguez-Rodrigo, 2002; O’Connell et al., 2002; Domínguez-Rodrigo and Pickering, 2003).

One of the alternative interpretations put forth in the hunter versus scavenger debate came from Richard Potts (1988, 1991), who claimed that these sites served as stockpiles, or caches, for raw materials such as manuports in anticipation of future use. Potts’ argument was especially important, partly because other researchers picked up the idea and incorporated it into their own models of early hominin behavior and partly because the argument implied a particular set of behaviors as part of the way early hominins used landscapes and interacted with technology. De la Torre and Mora (2005) recently reanalyzed the Olduvai manuport collections and concluded that it’s unlikely that they are raw material caches in Potts’ sense because (1) they share few characteristics with objects that were modified by early hominins and (2) natural geomorphological processes are sufficient to account for their presence at Olduvai sites. In other words, many, and perhaps most, manuports are just rocks and have nothing to do with the behavior of early hominins.

Research will undoubtedly continue to focus on Oldowan chopping tools as well as manuports, but their stories make good examples of how we learn about the human past. As in every scientific endeavor, archaeologists and other paleoanthropologists will never cease to question everything they may currently think is accurate, knowing full well that tomorrow, or the next day, or 10 years from now, someone will conduct the test, excavate the site, or simply ask a different question that opens the door to a fresh understanding about how and why we made it from the African savannas to exploring other planets. And that's how science is supposed to work!
Summary

In this chapter, we’ve seen that to achieve any meaningful understanding of human origins, the biocultural nature of human evolution requires us to examine both biological and cultural information. The multidisciplinary approach of paleoanthropology, including especially archaeology, brings together varied scientific specializations to reconstruct the anatomy, behavior, and environments of early hominins. Such a task centers on the knowledge, skills, and abilities of the archaeologist, geologist, paleontologist, paleoecologist, and physical anthropologist.

In a sense, our view of the human past is something like what we see out of the small passenger window of a jet cruising high above the continent. On the ground far below us, we can see evidence of human activity—in the net of roadways, plowed fields, towns, and other large constructions. But from our high altitude, we can’t see the individuals who create these patterns on the landscape. The archaeologist’s understanding of an ancient cultural landscape is much the same. It’s usually difficult, if not impossible, to pick out the actions of individuals, but by systematically examining the archaeological record, even across the distance of hundreds of thousands (if not millions) of years, we can gain important insights into how they lived, what they achieved, and why the human past happened the way it did.

In paleoanthropology in general and archaeology in particular, time rather than space is the important dimension that separates us from those we study, and one of the main tasks of this chapter has been to describe the varied ways in which researchers estimate past time. We’ve also seen that archaeologists and other paleoanthropologists apply a battery of research methods to discover, excavate, and evaluate fossils, sites, features, and artifacts associated with the development and dispersion of hominins to all regions of the globe. Essentially, all of these techniques are attempts to close the distance between ourselves and our predecessors so that we might better understand their lives and our past.

The chapter closed with a quick look at Olduvai Gorge in East Africa, one of the best-known early hominin localities in the world. By reviewing the history of research at Olduvai, we’ve seen how scientists apply many of the methods described in the first part of the chapter, and we’ve noted the close collaboration of paleoanthropology and archaeology. And recalling some of the lessons learned in Chapter 1, we’ve seen how gaining scientific understanding of the past is a continuing process of learning, integrating, and reassessing the empirical basis of our knowledge.

Critical Thinking Questions

1. How are early hominin sites found, and what kinds of specialists are involved in excavating and analyzing such sites?
2. Why are cultural remains so important in interpreting human evolution? What do you think is the most important thing you can learn from cultural remains—say, from a site that is 2 million years old? What is the most important thing you can’t learn?
3. Compare relative dating and chronometric dating. Name one or two examples of each, and briefly explain the principles used in determining the dates.
4. What kinds of cultural information may not be represented by artifacts alone? How do archaeologists attempt to compensate for these shortcomings through approaches such as ethnoarchaeology and ethnographic analogy?