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2 THE RECORD OF THE PAST

LEARNING OBJECTIVES

After reading this chapter, you should be able to:

2.1 Explain how archaeological research is used to answer questions about past societies.

2.2 Define paleoanthropology and discuss what we can learn about the past from fossil evidence.

2.3 Discuss what the archaeological record can tell us about past societies.

2.4 Recall the basic techniques used to locate archaeological sites and fossil localities.

2.5 Summarize the basic techniques of archaeological excavation.

2.6 Compare and contrast how archaeologists and paleoanthropologists date their discoveries.

2.7 Discuss the challenges of interpreting the past and how these are overcome.

Why study the human past? During the early history of anthropology, the answer to this question was straightforward. The study of fossils and relics of the past sprang out of a curiosity about the world and the desire to collect and organize objects. This curiosity was, in part, a reflection of the increasing interest in the natural world that arose with the Western scientific revolution beginning in the fifteenth century (see Chapter 3). For early collectors, however, the object was often an end in itself. Items were placed on shelves to look at, with little or no interest expressed in where the fossils might have come from or what the stone tools or ancient pottery might tell about the people who produced them. Collectors of this kind are called *antiquaries*.

Early antiquarian collections often incorporated many different items in addition to fossils and archaeological materials. For example, the museum of Olaus Wormius, a seventeenth-century Danish scholar, included uniquely shaped stones, seashells, ethnographic objects, and curiosities from around the world, along with fossils and ancient stone tools. While these objects were sometimes described and illustrated with great care, they were not analyzed or interpreted to shed light on the evolution of life or on the lifeways of ancient humans. Ancient coins, metal artifacts, and jewelry were recognized for what they were, but stone tools and even ancient pottery were generally regarded as naturally occurring objects or the work of trolls, elves, and fairies (Stiebing 1994).

By the late eighteenth century, scholars started to move beyond the simple description of objects to an increasing appreciation of the significance of fossil remains and the material traces of ancient human societies. This appreciation fell within the context of a host of new observations in the natural sciences, including many about the geological record and the age of the Earth. In 1797, an English country gentleman named John Frere published an account of stone tools he had found in a gravel quarry in Suffolk. Although brief, the description is tantalizing in terms of the changing attitude toward traces of the past. Fossilized bones of extinct animals and stone tools—actually Paleolithic hand axes—were found at a depth of more than twelve feet in a layer of soil that appeared undisturbed by more recent materials. Frere correctly surmised that the tools were "from a very remote period indeed, even beyond that of the present world" (Daniel 1981, 39). This was a recognition of prehistoric archaeology.

The nineteenth century saw the first fossil finds of ancient human ancestors. They included the bones found in the Neander Valley of Germany in 1856, now recognized as an archaic human species, *Homo sapiens neanderthalensis*, or Neandertal man (see Chapter 5). Although this was a historic discovery, the significance of the fossils was not realized at the time. Interpretations were diverse. While some scholars correctly interpreted the finds as an early human ancestor, others variously dismissed the bones as those of a Cossack soldier, an elderly Dutchman, a powerfully built Celt, or a pathological idiot (Trinkaus and Shipman, 1993)! Information continued to accumulate, however, and by the end of the nineteenth century, the roots of modern archaeological and paleoanthropological study were well established.

In this chapter, we examine the material record of the past and some of the techniques used by modern anthropologists to locate, recover, and date their discoveries. On one hand, this includes the bones and preserved remains used by paleoanthropologists to trace human origins. On the other hand, it deals with the material traces of human behavior that archaeologists focus on to interpret past cultures. In reality, the subdisciplines are often intertwined. Paleoanthropologists use excavation and surveying techniques similar to those used by archaeologists—or they rely on archaeologists—to locate and recover their finds. As will be discussed in Chapter 24, archaeological methods have also played an important role in forensic anthropology.

This book provides an overview of the techniques used by paleoanthropologists and archaeologists in their research. It also deals with some of the major questions that have been addressed by anthropologists, including the evolution of the human species, the human settlement of the world, the origins of agriculture, and the rise of complex societies and the state. In reading these discussions, it is important to remember that interpretations are constantly being revised. New fossils are constantly being uncovered and new archaeological sites explored. Improved methods and analytical techniques also modify the amount and kind of information available to researchers. Each discovery adds to the amount of information available to interpret the past—and to evaluate and revise existing interpretations.

ANSWERING QUESTIONS

2.1 Explain how archaeological research is used to answer questions about past societies.

Few modern archaeologists or paleoanthropologists would deny the thrill of finding a well-preserved fossil, an intact arrow point, or the sealed tomb of a king, but the romance of discovery is not the primary driving force for these scientists. In contrast to popular movie images, modern researchers are likely to spend more time in a laboratory or in front of a computer than looking for fossils or exploring lost cities. Their most fundamental desire is to reach back in time to understand our past.

Although anthropologists make an effort to document the record of bygone ages as fully as possible, they clearly cannot locate every fossil, document every archaeological site, or even record every piece of information about each artifact recovered. Despite decades of research, only a minute portion of such important fossil localities as those in the Fayum Depression in Egypt and Olduvai Gorge in Tanzania have been studied (see Chapters 4 and 5). In examining an archaeological site or even a particular artifact, many different avenues of research might be pursued (see the box "Engendering Archaeology: The Role of Women in Aztec Mexico"). For example, when investigating pottery from a particular archaeological site, some archaeologists might concentrate on the technical attributes of the clay and the manufacturing process (Rice 2015). Others might focus on the decorative motifs on the pottery and how they relate to the myths and religious beliefs of the people who created them. Still other researchers might be most interested in where the pottery was found and what this conveys about ancient trade patterns.

Research is guided by the questions about the past that the anthropologists want to answer. To formulate these, the researchers review existing data that help place their research in a wider context. Anthropologists also begin by being well grounded in different theoretical perspectives that help frame their questions and evaluate their interpretations. With this background, anthropologists plan a research project. This is done in a systematic way, as outlined in the discussion of the scientific method in Chapter 1. To ensure that the data recovered are relevant to their questions, paleoanthropologists and archaeologists begin a project by preparing a **research design** in which the objectives of the project are set out and the strategies for recovering the relevant data are outlined. The research design must take into account the types of data that will be collected and how those data relate to existing anthropological knowledge. Within the research design, the anthropologist specifies what methods will be used for the investigation, what regions will be surveyed, how much of a site will be excavated, and how the materials recovered will be analyzed. Generally, the research design is then reviewed by other anthropologists, who provide feedback and recommend it for funding by various government agencies or private research foundations.

CRITICAL PERSPECTIVES

ENGENDERING ARCHAEOLOGY: THE ROLE OF WOMEN IN AZTEC MEXICO

Florentine Codex I, fol 347 right

An Aztec codex showing a woman blowing on maize before putting it in the cooking pot.

The interpretation of the material record poses a challenge to archaeologists. It provides excellent evidence on some subjects—ancient technology, diet, hunting techniques, and the plan of an ancient settlement—but some topics are more difficult to address. What were the marriage customs, the political system, or the religious beliefs of the ancient inhabitants of a site? These factors are by nature nonmaterial and are not directly preserved archaeologically. Even if documentary records exist, these may offer only limited insight on some topics.

In a fascinating study of gender among the Aztecs of ancient Mexico, archaeologist Elizabeth Brumfiel (1991, 2005) utilized both the archaeological and the documentary record to provide new insights into the past. The Aztec civilization was flourishing in central Mexico when the Spanish reached the Americas. It had emerged as the principal state in the

(*Continued*)

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region by the fifteenth century, eventually dominating an area stretching from the Valley of Mexico to modern-day Guatemala, some 500 miles to the southwest. The capital, Tenochtitlán, was an impressive religious center built on an island in Lake Texcoco. The city's population numbered tens of thousands when the Aztec leader, Montezuma, was killed during fighting with Spanish *conquistadores* led by Hernán Cortés (Cortez) in 1520. Within decades of the first Spanish contact, the traces of the Aztec empire had crumbled and been swept aside by European colonization. Records of the Aztec civilization survive in documentary accounts recorded by the Spanish. The most comprehensive is a monumental treatise on Aztec life, from the raising of children to religious beliefs, written by Fray Bernardino de Sahagún (Brumfiel 1991). It is the most exhaustive record of a Native American culture from the earliest years of European contact. For this reason, it has been a primary source of information about Aztec life and culture.

Brumfiel was particularly interested in reconstructing the roles of women in Aztec society. Sahagún's description of women focuses on weaving and food preparation. Regrettably, as Brumfiel points out, his work offers little insight into how these endeavors were tied to other economic, political, and religious activities. In addition, Sahagún does not comment on some of his own illustrations that show women involved in such undertakings as healing and marketing. Interpretations based solely on Sahagún's descriptions seemed to marginalize women's roles in production as nondynamic and of no importance in the study of culture change.

To obtain a more holistic view of women in Aztec society, Brumfiel turned to other sources. The Aztecs also possessed their own records. Although most of these were sought out and burned by the zealous Spanish priests, some Aztec codices survive. These sources indicate that textiles were essential as tribute, religious offerings, and exchange. Many illustrations also depict women in food production activities. In addition to various categories of food, the codices show the griddles, pots, and implements used in food preparation.

Independent information on these activities is provided by the archaeological record. For example, the relative importance of weaving can be assessed by the number and types of spindle whorls (perforated ceramic disks used to weight the spindle during spinning) that are found in large numbers on archaeological sites. Archaeological indications of dietary practices can be inferred from ceramic griddles, cooking pots, jars, and stone tools used in the gathering and preparation of food.

Brumfiel notes that the most interesting aspect of archaeological data on both weaving and food preparation is the variation. Given the static model of women's roles seen in the documentary records, a uniform pattern might be expected in the archaeological data. In fact, precisely the opposite is true. Evidence for weaving and cooking activities varies in different sites and over time. Brumfiel suggests that the performance of these activities was influenced by a number of variables, including environmental zones, proximity to urban markets, social status, and intensified agricultural production.

Food preparation, essential to the household, was also integral to the tenfold increase in the population of the Valley of Mexico during the four centuries preceding Spanish rule. As population expanded during the later Aztec period, archaeological evidence indicates that there was intensified food production in the immediate hinterland of Tenochtitlán. Conversely, the evidence for weaving decreases, indicating that women shifted from weaving to market-oriented food production. These observations are not borne out at sites farther away from the Aztec capital, though. In more distant sites, women intensified the production of tribute cloth with which the Aztec empire transacted business.

Brumfiel's research provides insights into the past that neither archaeological nor documentary information can supply on its own. She was fortunate to have independent sources of information that she could draw on to interpret and evaluate her conclusions. Her interpretation of Aztec life provides a much more dynamic view of women's roles. The observations are also consistent with the view of the household as a flexible social institution that varies with the presented opportunities and constraints. Brumfiel's work underscores the importance of considering both women's and men's roles as part of an interconnected, dynamic system.

Questions to Ponder

1. In the absence of any documentary or ethnographic information, how can archaeologists examine gender in past societies?
2. Can we automatically associate some artifacts with men or with women?
3. How would interpretations of gender vary in different cultural and archaeological settings? Discuss several examples.

PALEOANTHROPOLOGICAL STUDY

2.2 Define paleoanthropology and discuss what we can learn about the past from fossil evidence.

As discussed in Chapter 1, paleoanthropology is the field within biological anthropology that focuses on human evolution and the behavior of early human ancestors. The behavior, diet, and activities of these early humans were very different from those of modern humans. Determining their behavior, as well as the age of the finds and the environment in which early humans lived, is dependent on an array of specialized methods. Interpretation depends on the holistic, interdisciplinary approach that characterizes anthropology (these topics are examined in detail in Chapter 5).

As in all anthropological research, a paleoanthropological project begins with a research design outlining the objectives of the project and the methodology to be employed. This would include a description of the region and the time period to be examined, the data that will be recovered, and an explanation of how the proposed research would contribute to existing knowledge. For example, researchers might target geological deposits of a specific location and age for examination because of the potential to discover the origins of the common ancestors of humans and apes (see Chapter 4), the earliest branches on the human lineage, or the fossil record of the first modern humans (see Chapter 5). The initial survey work for a paleoanthropological project often relies on paleontologists and geologists, who provide an assessment of the age of the deposits within the study area and the likely conditions that contributed to their formation. Clues about the age may be determined through the identification of distinctive geological deposits and associated floral and faunal remains (see the discussion of dating methods and faunal correlation later in this chapter). Such information also helps in the reconstruction of the paleoecology of the region and, hence, the environment in which early human ancestors lived. **Paleoecology** (*paleo*, from the Greek, meaning "old," and *ecology*, meaning "study of environment") is the study of ancient environments.

Based on the information provided by paleontologists and geologists, more detailed survey work is undertaken to locate traces of early humans. Looking for such traces has been likened to looking for a needle in a haystack, except in this case the "looking" involves the scrutiny of geological deposits and the careful excavation of buried skeletal remains and associated material. This stage of the research may draw on the skills of the archaeologist, who is trained to examine the material remains of past societies (see later discussion of archaeological excavation).

Fossils and Fossil Localities

Much of paleoanthropological research focuses on the locating and study of fossil remains. **Fossils** are the preserved remains, impressions, or traces of living creatures from past ages. They form when an organism dies and is buried by soft mud, sand, or silt (see Figure 2.1). Animals also leave tracks or footprints that may be preserved. Over time, the sediments with these traces harden, preserving the remains of the creature or its tracks within. Occasionally, conditions may be such that portions of an organism are preserved—actual fragments of shells, teeth, or bones. But most fossils have been altered in some way, the decayed parts of bone or shell having been replaced by minerals or surrounding sediment. Even in cases in which fragments of bone or shell are present, they have often been broken or deformed and need to be carefully reconstructed. The challenge faced by paleoanthropologists is what criteria to use to distinguish species from a number of closely related taxa on the basis of these fragmentary remains. Despite the imperfection of the fossil record, a striking history of life on Earth has survived.

Paleoanthropologists refer to places where fossils are found as **fossil localities**. These are spots where predators dropped animals they had killed, places where creatures were naturally covered by sediments, or sites where early humans lived. Of particular importance in interpreting fossil localities is the **taphonomy** of the sites—the study of the variety of natural and behavioral processes that led to the formation of the deposits uncovered. The taphonomy of an individual fossil locality is complex and the unraveling of the history that contributed to its formation very challenging (Grupe and Harbeck 2015). The fossil locality may include traces of early humans' behavior, tool manufacture, and discarded food remains, as well as the remains of the early humans themselves. On the other hand, these traces may have been altered by natural processes, such as decay, wind and rain erosion, and destruction and movement by animals.

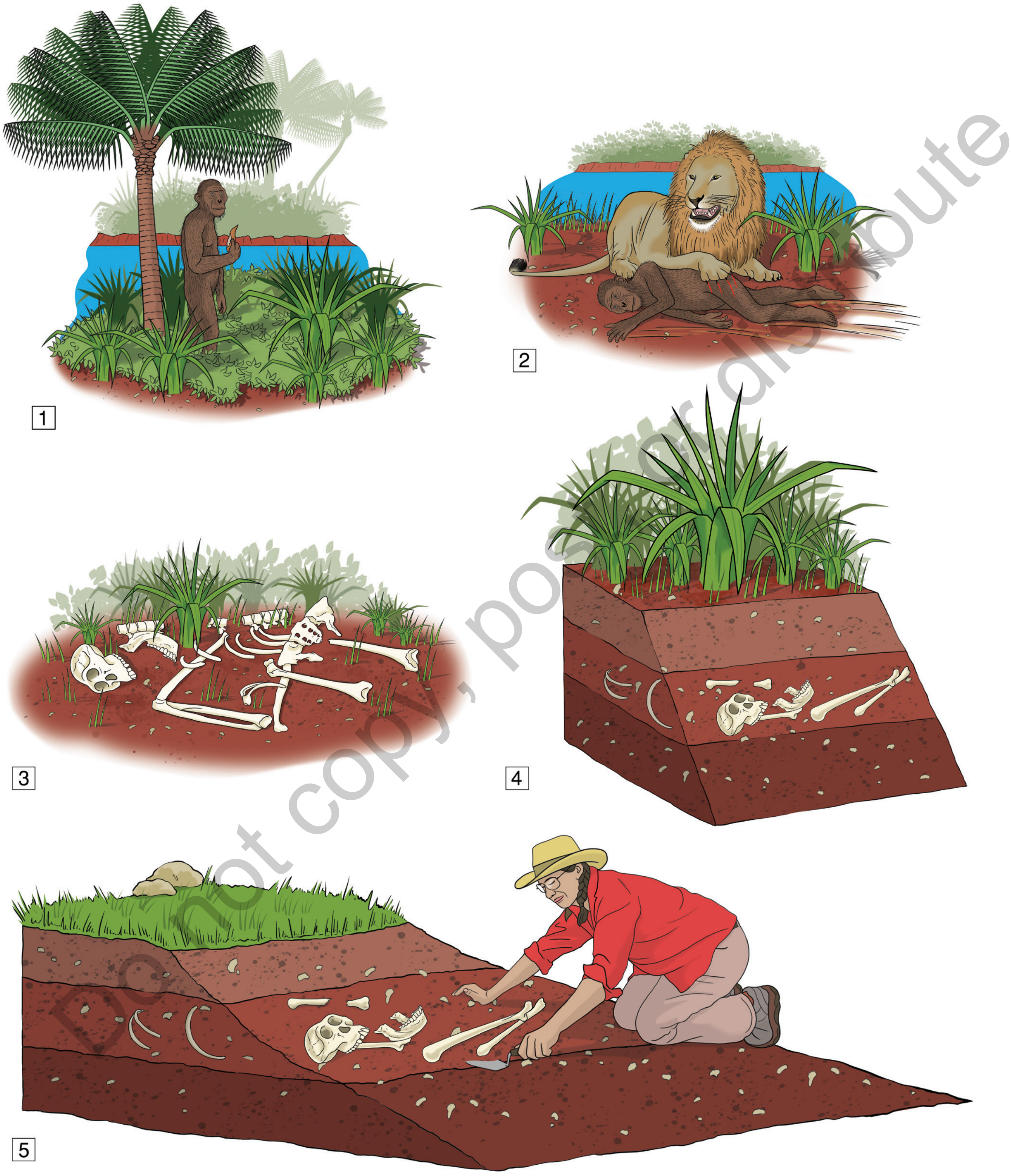
Only a small number of the once-living creatures are preserved in the fossil record. After death, few animals are left to lie peacefully, waiting to be covered by layers of sediment and preserved as fossils. Many are killed by predators that scatter the bones. Scavengers may carry away parts of carcasses, and insects, bacteria, and weather quickly destroy many of the remains that are left. As a result, individual fossil finds are often incomplete. Moreover, some areas might not have had the right conditions to fossilize and preserve remains, or the remains of early human ancestors that are present might be so fragmentary and mixed with deposits of other ages that they are of limited use.

Another consideration is the accessibility of fossil deposits. Fossils may lie buried under deep deposits that make them difficult to locate and impossible for researchers to study. In other instances, however, erosion by wind or water exposes underlying layers of rock that contain fossils, thus providing the paleoanthropologist the chance to discover them—even as they are weathering away.

Once a fossil locality is found, systematic excavations are undertaken to reveal buried deposits. In excavating, paleoanthropologists take great pains to record a fossil's context. **Context** refers to a fossil or artifact's exact position in relation to the surrounding sediments and any associated materials. Understanding a find's context is particularly important in paleoanthropological and archaeological research. Only if the precise location and associations are known can a fossil be accurately dated and any associated materials be fully interpreted.

After fossils have been removed from the ground, the detailed analysis of the finds begins. This starts with the careful cleaning of the fossils and associated materials. Fossils are often preserved in hardened, mineralized deposits, and cleaning may be tedious and time-consuming. Careful study of fine-grained sediments sometimes reveals the preservation of minute fossils of shellfish, algae, and pollen. Improved techniques, such as computer and electronic scanning equipment, have revealed

FIGURE 2.1 ■ **Only a small number of the creatures that have lived are preserved as fossils. After death, predators, scavengers, and natural processes destroy many remains, frequently leaving only fragmentary traces for researchers to uncover.**



that images of the delicate structure in bones or the interior of a skull may be preserved in a fossil. The materials recovered from the excavations are labeled and described, and the fossil remains of early humans reconstructed.

Drawing on all of the geological, paleontological, archaeological, and physical anthropological information, paleoanthropologists then attempt to place the discoveries in the context of other discoveries and interpretations. The anatomical characteristics and the ages of the fossils of the early humans are compared to other fossils to assess their evolutionary relationships. Other data will be brought to bear on the reconstruction of the ancient environment and models of the way they lived.

ARCHAEOLOGICAL RESEARCH

2.3 Discuss what the archaeological record can tell us about past societies.

As seen in Chapter 1, archaeology is the subdiscipline of anthropology that deals with the study of past human cultures through the material traces they left behind. Culture is a fundamental concept in the discipline of anthropology. In popular use, most people use the word *culture* to refer to "high culture": Shakespeare's works, Beethoven's symphonies, Michelangelo's sculptures, gourmet cooking, imported wines, and so on. Anthropologists, however, use the term in a much broader sense. A general contemporary definition of **culture** is that it is a shared way of life that includes the material products and nonmaterial products (values, beliefs, and norms) that are transmitted within a society or social group. Culture encompasses all aspects of human activity, from the fine arts to popular entertainment, from everyday behavior to the most deeply rooted religious beliefs. Culture contains the plans, rules, techniques, and designs for living.

In seeking to understand past cultures through their physical traces, archaeologists face an inherent difficulty. By its very nature, culture is *nonmaterial*—that is, it refers to intangible products of human society (such as values, beliefs, religion, and norms) that are not preserved archaeologically. Hence, archaeologists must rely on material culture—the physical remains of past societies. **Material culture** consists of the physical products of human society (from broken pots and weapons to monumental structures). The earliest traces of material culture are stone tools dating back more than 3 million years: simple choppers, scrapers, and flaked stones. Modern material culture consists of all the physical objects that a contemporary society produces or retains from the past, including our cities, streets, buildings, automobiles, toys, and medicines. Archaeologists investigate these material traces to examine the values, beliefs, and norms that represent the patterned ways of thinking and acting within past societies.

Archaeological interpretation has historically been strongly influenced by cultural anthropology theory (M. Johnson 2020; Praetzellis 2016; Trigger 1996). *Cultural anthropology*—the study of modern human populations—helps archaeologists understand how cultural systems work and how the archaeological record might reflect portions of these systems. On the other hand, archaeology offers cultural anthropology a time depth that cannot be obtained through observations of living populations; it provides a record of past human behavior. The archaeological record furnishes important insights into past technology, providing answers to such questions as "When did people learn to make pottery?" and "How was iron smelted?" However, material culture also offers clues to past ideals and belief systems. Consider, for example, what meanings and beliefs are conveyed by such objects as a Christian cross, a Jewish menorah, or a Hopi *kachina*. Other objects convey cultural beliefs in more subtle ways. Everyday items, such as the knife, fork, spoon, and plate used in Americans' meals, are not the only utensils suitable for the task; they are cultural choices. Indeed, food preferences themselves are culturally shaped choices.

The objectives of archaeological research vary tremendously in terms of the time periods, geographical areas, and research questions considered. Many researchers have examined the themes dealt with in this book: the behavior of early human ancestors, the initial settlement of the Americas, the origins of agriculture, and the emergence of complex political systems. These broad topics have been approached in a variety of ways, and revealed an array of information about the lifeways, art, and religion of prehistoric populations. Other archaeologists rely on early written texts such as Egyptian hieroglyphics or cuneiform writing, as well as the archaeological record, in their interpretations. In studies of the more recent past, archaeologists may be able to draw on observations of contemporary peoples, written records, or oral traditions to aid in their interpretation (see the box "Historical Archaeology"). Researchers have examined topics from the archaeological record of European colonization over the past 500 years to nineteenth-century American society. They have even shed light on modern society by sifting through garbage bags and contemporary landfills.

The Archaeological Record

Archaeological preservation varies (Lucas 2012; Schiffer 1987). Look at the objects that surround you. How long would these artifacts survive if left uncared for and exposed to the elements? As is the case with the fossil record, the archaeological past is a well-worn and fragmentary cloth rather than a complete tapestry. Stone artifacts endure very well, and thus it is not surprising that much of our knowledge of early human lifeways is based on stone tools.

CRITICAL PERSPECTIVES

HISTORICAL ARCHAEOLOGY

An ethnobotanist interviewing Aboriginal Australian elders.

Some archaeologists have the luxury of written records and oral histories to help them locate and interpret their finds. Researchers delving into ancient Egyptian sites, the ancient Near East, Greek and Roman sites, Chinese civilization, Mayan temples, Aztec cities, Islamic sites, biblical archaeology, and the settlements of medieval Europe can all refer to written sources ranging from religious texts to explorers' accounts and tax records.

Why dig for archaeological materials if written records or oral traditions can tell the story? Although such sources may provide a tremendous amount of information, they do not furnish a complete record (Deetz 1996; Orser 2017). Whereas the life story of a head of state, records of trade contacts, or the date of a temple's construction may be preserved, the lives of many people and the minutiae of everyday life were seldom written down. In addition, documentary sources are often biased by the writer's personal or cultural perspective. For example, much of the written history of Native Americans, sub-Saharan Africans, Australian Aborigines, and many other indigenous peoples was first recorded by European missionaries, traders, and administrators, who frequently provided only incomplete accounts viewed in terms of their own interests and beliefs.

Information from living informants and oral traditions may also provide important information about some populations, particularly societies with limited written records. In recognizing the significance of such nonwritten sources, however, it is also necessary to recognize their distinct limitations. The specific roles oral traditions played (and continue to play) varied in different cultural settings. Just as early European chroniclers viewed events with reference to their own cultural traditions, so oral histories are shaped by the worldviews, histories, and beliefs of the various cultures that employ them. Interpreting such material may be challenging for individuals outside the originating cultures. The study of the archaeological record may provide a great deal of information not found in other sources and provide an independent means of evaluating conclusions drawn on the basis of other sources of information (see the box "Engendering Archaeology: The Role of Women in Aztec Mexico"). For example, it has proven particularly useful in assessing change and continuity in indigenous populations during the past 500 years (DeCorse 2016; Lightfoot 2005; Orser 2017).

In the Americas, during the past several decades, an increasing amount of work has concentrated on the history of immigrants who arrived in the last 500 years from Europe, Asia, Africa, and other world areas. Archaeological studies have proven of great help in interpreting historical sites and past lifeways, as well as culture change, sociopolitical developments, and past economic systems. Among the most significant areas of study is the archaeology of slavery (L. Ferguson 1992; Singleton 1999). Although living in literate societies, slaves were prohibited from writing, were often illiterate, and thus left a very limited documentary record of their own. Archaeological data have been used to provide a much more complete picture of plantation life and slave society.

Questions to Ponder

1. What are some different sources of written and orally preserved accounts that you can think of? How are these different from one another in terms of the details they might provide?
2. Consider a particular activity or behavior important to you (for example, going to school, participating in a sport, or pursuing a hobby). How would evidence of the activity be presented in written accounts, oral histories, and the archaeological record?

Ceramics and glass may also survive very well, but iron and copper corrode, and organic materials, such as bone, cloth, paper, and wood, generally disappear quickly.

In some cases, environmental conditions that limit insect and microbial action and protect a site from exposure to the elements may allow for the striking preservation of archaeological

ANTHROPOLOGISTS AT WORK

GEORGE FLETCHER BASS: UNDERWATER ARCHAEOLOGIST

George Fletcher Bass is one of the pioneers of underwater archaeology—a field that he actually did not set out to study and, indeed, a field that was virtually unrecognized as a discipline when he entered it. Although he was always fascinated with the sea and diving, Bass began his career working on land sites, earning a master's degree in Near Eastern archaeology at Johns Hopkins University in 1955. He then attended the American School of Classical Studies at Athens and excavated at the sites of Lerna, Greece, and Gordion, Turkey. Following military service in Korea, Bass began his doctoral studies in classical archaeology at the University of Pennsylvania. It was there, in 1960, that he was asked by Professor Rodney S. Young if he would learn to scuba dive to direct the excavation of a Bronze Age shipwreck discovered off Cape Gelidonya, Turkey. Bass's excavations of this site marked the first time an ancient shipwreck was excavated in its entirety under the water.

During the 1960s, Bass went on to excavate two Byzantine shipwrecks off Yassi Ada, Turkey. At these sites, he developed a variety of specialized methods for underwater excavation, including new mapping techniques, a submersible decompression chamber, and a two-person submarine. In 1967, his team was the first to locate an ancient shipwreck using side-scan sonar. In addition to setting standards for underwater archaeological research, these excavations captured popular imagination and revealed shipwrecks as time capsules containing a spectacular array of artifacts, many unrecovered from terrestrial sites (Bass 1963, 1973; Throckmorton 1962).

After completing his doctorate in 1964, Bass joined the faculty at the University of Pennsylvania. He remained there until 1973, when he left to found the Institute of Nautical Archaeology (INA), which has been affiliated with Texas A&M University since 1976. Under his guidance, the INA has become one of the world's premier programs in underwater archaeology. The institute has conducted research throughout the world on shipwrecks and sites of a diversity of time periods. Bass has continued to focus on shipwrecks in Turkey, where he is an honorary citizen of the town of Bodrum. Some of his more recent projects include a fourteenth-century B.C. wreck with a cargo of copper, ivory, tin, glass, and ebony, and a medieval ship with a large cargo of Islamic glass (Bass et al. 2009). Bass has written or edited more than a dozen books and is the author of over 100 articles. Through his publications, he has introduced both archaeologists and the wider public to the potential and excitement of underwater archaeology.

Images & Stories/Alamy Stock Photo

George Fletcher Bass, father of underwater archaeology, on a survey trip with a submarine, Foça, Turkey.

Because of his unique contribution to underwater archaeology, Bass has been widely recognized and has received awards from the National Geographic Society, the Explorers Club, the Archaeological Institute of America, and the Society for Historical Archaeology. President George W. Bush presented him with the National Medal for Science in 2002.

materials. Some of the most amazing cases are those in which items have been rapidly frozen. An illustration of this kind of preservation is provided by the discovery in 1991 of the 5,300-year-old frozen remains of a Bronze Age man by hikers in Italy's Tyrol Mountains (Fowler 2000). With the body were a wooden backpack, a wooden bow, fourteen bone-tipped arrows, and fragments of clothing. In other instances, underwater sites, waterlogged environments, very dry climate, or rapid burial may create conditions for excellent preservation. Such unique instances provide archaeologists with a much more complete record than is usually found.

Places of past human activity that are preserved in the ground are called **archaeological sites**. Sites reflect the breadth of human endeavor. Some are settlements that may have been occupied for a considerable time—for example, a Native American village or an abandoned gold mining town in the American West. Other sites reflect specialized activities—ceremonial centers, burial grounds, or places where ancient hunters killed and butchered animals. To reconstruct the human past, archaeologists excavate ancient structures, temples, tombs, and burials. However, they frequently seek out far less prominent traces of past life. **Middens**, ancient piles of trash or domestic refuse, provide particularly important information on what ancient peoples ate, their technologies, and their beliefs.

Much of the archaeologist's time is devoted to the study of **artifacts**—any object made or modified by humans. They include everything from chipped stone tools and pottery, to plastic bottles and computers. Nonmovable artifacts, such as an ancient fire hearth, a pit dug in the ground, or a wall, are called **features**. In addition to artifacts and features, archaeologists examine items recovered from archaeological sites that were not produced by humans, but nevertheless provide important insights into the past. Animal bones, shells, and plant remains recovered from an archaeological

CRITICAL PERSPECTIVES

UNDERWATER ARCHAEOLOGY

Ian Dagnall/Alamy Stock Photo

The remains of the *Mary Rose* on display at the Mary Rose Museum, Portsmouth Historic Dockyard, Hampshire, England.

Sunken ships, submerged settlements, and flooded towns: This wide variety of sites of different time periods in different world areas shares the need for specialized techniques to locate, excavate, and study them (Bass 2005; Menotti 2004). Although efforts were occasionally made in the past to recover cargoes from sunken ships, it was only with the invention and increasing accessibility of underwater breathing equipment during the twentieth century that the systematic investigation of underwater sites became feasible. Often artifacts from underwater sites are better preserved and so present a wider range of materials than those from land. Even more important, underwater sites are often immune to the continued disturbances associated with human activity that are typical of most land sites. Shipwrecks can be compared to time capsules, containing a selection of artifacts that were in use in a certain context at a specific time. Archaeologists working on land seldom have such clearly sealed archaeological deposits.

A tantalizing example of an underwater archaeological project is the excavation and raising of the preserved remains of the *Mary Rose*, the pride of the young English Navy and the flower of King Henry VIII's fleet. The 700-ton warship, which was probably the first English warship designed to carry a battery of guns between its decks, foundered and sank in Portsmouth Harbor on a warm July afternoon in 1545. Henry VIII, camped with his army at Southsea Castle, is said to have witnessed the disaster and heard the cries of the crew. In the 1970s, the site of the *Mary Rose* was rediscovered and was systematically explored by volunteer divers from around the world. The ship produced a spectacular array of over 14,000 artifacts, ranging from massive cannons to musical instruments, famed English longbows, and navigational equipment. Finds from the *Mary Rose* and the preserved portions of the hull can be seen at the Mary Rose Ship Hall and Exhibition at Her Majesty's Naval Base, Portsmouth, England (Marsden 2003, 2009).

Most people associate underwater archaeology with sunken ships, and this, in fact, represents an important part of the subdiscipline. However, rising sea levels or natural disasters may also submerge cities and towns. Research on settlements now underwater is providing increasing insight into early human settlement (Bass 2005; Menotti 2004). As in the case of shipwrecks, the lack of oxygen and the sealed nature of the archaeological materials present special challenges in excavation, but also remarkable preservation. Such is the case of Port Royal, Jamaica, a flourishing trade center and infamous gathering place for pirates during the seventeenth century. In 1692, a violent earthquake and tidal wave submerged or buried portions of the city, preserving a record for future archaeologists. Excavations at the site spanning the last three decades have recovered a wealth of materials from seventeenth-century life (Hamilton and Woodward 1984).

Questions to Ponder

1. Archaeological excavation on land is a meticulous and careful process. Discuss how excavation and recording methods would have to be modified to conduct archaeological research underneath the water.
2. Given the unique location and preservation found at underwater sites, why might they be more appropriate or important than land sites for considering certain types of research questions?

Alex Segre/Alamy Stock Photo

A natural mummy from the Egyptian Predynastic period buried around 3500 B.C.

site furnish information on both the past climatic conditions and the diet of the early inhabitants. The soil of a site is also an important record of past activities and the natural processes that affected a site's formation. Fires, floods, and erosion all leave traces in the earth for the archaeologist to discover. All of these data may yield important information about the age, organization, and function of the site being examined. These nonartifactual organic and environmental remains are referred to as *ecofacts*.

As is the case with the recovery of fossils, archaeologists take special care to record the *contexts* in which archaeological materials are found, the artifacts' specific location in the ground, and associated materials. Without a context, an artifact provides limited information. By itself, a pot may be identified as something similar to other finds from a specific area and time, but it provides no new information. If, however, it and similar pots found are associated with particular types of graves, contain offerings of a particular kind, and are associated with female burials, a whole range of other inferences may be made about the past. By removing artifacts from sites, laypersons unwittingly cause irreparable damage to the archaeological record.

LOCATING SITES AND FOSSIL LOCALITIES

2.4 Recall the basic techniques used to locate archaeological sites and fossil localities.

In 1940, schoolboys retrieving their dog from a hole in a hillside near Montignac, France, found themselves in an underground cavern. The walls were covered with delicate black and red paintings of bison, horses, and deer. The boys had discovered Lascaux Cave, one of the finest known examples of Paleolithic cave art. Chance findings such as this sometimes play a role in the discovery of archaeological remains, as well as paleoanthropological research, but researchers generally have to undertake a systematic examination, or **survey**, of a particular area, region, or country to locate archaeological sites or fossil localities. They will usually begin by examining previous descriptions, maps, and reports of the area for references to archaeological sites. Informants who live and work in the area may also be of great help in directing archaeologists to discoveries.

Of course, some archaeological sites are more easily located than others; the great pyramids near Cairo, Egypt; Stonehenge in southern England; and the Parthenon of Athens have never been "lost." Though interpretations of their precise use may differ, their impressive remains are difficult to miss. Unfortunately, many sites, particularly some of the more ancient, are marked by only ephemeral traces and are difficult to locate. In many instances, sites are buried beneath many feet of sediment. Examination of the ground surface may reveal scatters of artifacts, discolorations in the soil, or exposed fossils, which provide clues to buried deposits. Sometimes nature inadvertently helps researchers, as erosion by wind or rain may expose sites. Archaeologists can also examine road cuts, building projects, and freshly plowed land for archaeological materials. Fossils are often deeply buried, resting beneath layers of sediment, making locating them especially difficult. For this reason, paleoanthropologists often cannot employ many of the techniques that archaeologists use to locate shallower archaeological deposits.

In the field, the researcher defines what areas will be targeted for survey. These areas are identified in the research design, which considers the research questions to be asked, as well as environmental and topographical considerations, and the practical constraints of time and money. Surveys can be divided into *systematic* and *unsystematic* approaches (Renfrew and Bahn 2016). The latter are less methodical as the researcher might take advantage of trails, riverbanks, and plowed fields within the survey area, recording any archaeological materials encountered. In a similar way, paleoanthropologists searching for fossils may examine places where buried sediments have been exposed by erosion. These unsystematic survey methods avoid the challenges of climbing through thick vegetation or rugged terrain. Unfortunately, they may also produce a biased sample of the remains present; ancient land uses might have little correspondence with modern trails or plowed fields.

To ensure more systematic results, researchers often employ more structured survey methods. For example, rather than following existing paths or roadways, an archaeologist may divide a region, valley, or archaeological site into a *grid*, which is then walked systematically. In other instances, transects may provide useful information, particularly where vegetation is very thick. In this case, a straight line, or *transect*, is laid out through the area to be surveyed. Fieldworkers then walk along this line, noting changes in topography, vegetation, and artifacts.

Subsurface Archaeological Testing and Geophysical Surveys

While hiking across the landscape remains the key means of locating sites, a variety of other techniques are often used in combination with surface surveys. Because many archaeological sites are buried in the ground, many surveys incorporate some kind of subsurface testing. This may involve digging auger holes or shovel test pits at regular intervals, the soil from which is examined for archaeological artifacts and features. This type of testing may provide important information on the location of an archaeological site, its extent, and the type of material represented.

Today, a variety of more high-tech, geophysical methods allow archaeologists to identify buried sites without lifting a spade. **Geophysical surveys** use a variety of ground-based sensing methods that map archaeological features buried in the soil. The most common of these methods employ magnetometers, electrical resistivity meters, or ground-penetrating radar. The *magnetometer* is a sensor that can detect differences in the soil's magnetic field caused by buried features and artifacts. A buried foundation, for example, will give a different reading from an ancient road, both being distinguishable from the surrounding, undisturbed soil.

Electrical resistivity provides similar information, though it is based on a different concept. A resistivity meter is used to measure the electrical current passing between electrodes that are placed in the ground. Variation in electrical current indicates differences in the soil's moisture content, which in turn reflects buried ditches, foundations, or walls that retain moisture to varying degrees.

Another method that has been widely utilized is ground-penetrating radar or GPR. The concept is similar to the methods used in tracking aircraft. However, in this case, the electromagnetic pulse is directed at the ground. A receiver then picks up the reflected signal, the depths of buried features, objects, and soil layers indicated by the time it takes the signal to bounce back.

By systematically moving these devices over the ground in regular transects, plans of buried structures and features can be created. Although at times yielding spectacular results, such techniques are not without their limitations. They work best in settings where the surrounding soils are uniform and can be readily distinguished from archaeological materials. Buried metal at a site may confuse the magnetic readings of structural features, and a leaking hose wreaks havoc with a resistivity meter. Undulating and shallowly buried geological features such as bedrock also muddle interpretation. As magnetometers, electrical resistivity meters, and GPR yield somewhat different results, they are often used in combination.

Remote Sensing

Remote sensing refers to methods of identifying sites and archaeological features without direct physical contact, through the use of aerial and drone photography and satellite imagery (Wiseman and El-Baz 2007). It is sometimes said that "one ought to be a bird to be a field archaeologist," and, indeed, the perspective provided by aerial photography, sometimes called "aerial archaeology," has been a boon to archaeologists. Experiments with aerial photography occurred prior to World War I, but it was during the war that its potential importance to archaeological surveys was recognized (Daniel 1981). Pilots noticed that some sites, invisible on the ground, were dramatically seen from the air. The rich organic soils found in archaeological sites, subtle depressions in the ground surface, or slight differences in vegetation resulting from buried features may be dramatically illustrated in aerial photographs. More recent technological innovations, such as the use of infrared, false color photography, help identify differences in vegetation and make abandoned settlements and patterns of past land use more apparent. Aerial photography has proven very important in locating sites, but it is also of particular use in mapping and interpretation (Brophy and Cowley 2005).

The development and increasing availability of drones and digital technology has taken remote sensing to a new level. Drones—unmanned aerial vehicles—can be fitted with cameras and used to capture some of the same data as aerial photography with far less cost. Apart from locating sites, drones can be used to provide 3-D digital documentation of complex sites that would be time-consuming to do using traditional surveying methods.

Of increasing use to archaeologists are photographs or images taken from extremely high altitudes by satellites or space shuttles (Comer and Harrower 2013; Lillesand, Kiefer, and Chipman 2015; Parcak 2009). The scale of these pictures sometimes limits their use, and their cost sometimes makes them beyond the reach of many researchers. The potential application of such sophisticated techniques, however, has been well demonstrated. National Aeronautics and Space Administration (NASA) scientists, working with archaeologists, have been able to identify ancient Mesopotamian and Mayan settlements and farmlands that had not been located with other techniques. *Space imaging radar*, which can detect features buried under six feet of sand, has proved increasingly helpful in identifying ancient sites. As this technology becomes both more refined and more affordable, it will provide an increasingly important resource for archaeologists (see the box "Anthropologists at Work: Scott Madry").

ANTHROPOLOGISTS AT WORK

SCOTT MADRY: GOOGLE EARTH AND ARMCHAIR ARCHAEOLOGY

Jacques Descloitres, MODIS Rapid Response Team, NASA/GSFC

This satellite photo of the Nile River in Egypt illustrates the stark contrast between the river's floodplain and the surrounding desert. The wide triangle of green at the top marks the well-watered Nile Delta. Archaeologists are increasingly able to use space-age technology to locate archaeological features.

The value of aerial photography and high-tech satellite imagery in archaeology is well demonstrated, but the cost of such resources has often placed them beyond the reach of most archaeologists. But this situation is changing. Once the purview of governments and space programs, high-altitude images are becoming both more common and of more general interest, and archaeologists are reaping the benefits.

A case in point is Google Earth, a popular desktop program that provides satellite imagery, allowing users to zoom in on specific locales and even track their own movements. The program is useful in getting directions and checking out vacation spots, as well as an aid in planning for a variety of nonprofit and public benefit organizations.

Archaeologists are increasingly able to use space-age technology to locate archaeological features. Anthroplogist Scott Madry became curious about the potential use of Google Earth in his long-term, collaborative research on the history and archaeology of Burgundy, France (Madry 2007; S. Murray, Jones, and Madry 2019). Madry is interested in the application of aerial photography, remote sensing, and geographic information systems technology to understanding the interaction between the different cultures and the physical environment over the past 2,000 years. While he found that the images available on Google Earth were of limited use in his research area, the data available for a neighboring region that shared a similar environment and cultural history proved spectacular. The images provided a dramatic view of archaeological sites. Although many of these sites had been previously identified, the results demonstrated the potential of Google Earth as an archaeological research tool.

Google Earth is not the perfect solution for every research situation. The coverage is dependent on the images available and is of variable quality. Consequently, it is of limited use for some areas. Even in cases where good images are available, thick vegetation and tree cover may limit the use of both satellite images and aerial photography. Finally, while the images provided by Google Earth may help in locating and mapping sites, archaeologists still need to excavate.

Another particularly exciting development in archaeology is the increasing availability of LIDAR, usually said to stand for "light detection and ranging." The method measures the reflected pulses of laser light to create very high-resolution maps of the ground surface. It has special applications for archaeologists working in regions covered with heavy vegetation, as the technology can penetrate the vegetation cover to reveal ruins, roads, structures, and other features that often cannot be identified by aerial photographs or satellite imagery. Although technology is still expensive, the price is going down, and smaller units that can be mounted on inexpensive drones are being developed.

There have also been important developments in the management and analysis of remote sensing data. An innovative analytic tool increasingly used in archaeology is GIS (geographic information systems). GIS refers to a wide range of technologies, programs, and methods that allow researchers to capture, manipulate, and present spatial information. Archaeologists can, for example, integrate archaeological survey information, aerial photographs, and satellite data to plot the locations of ancient settlements, transportation routes, and even the distribution of individual objects, allowing them to study the patterns and changes represented (Tripcevich and Wernke 2010).

NurPhoto/Getty

An aerial view of a 7,500-year-old Thracian site, Durankulak Lake, Bulgaria. The use of aerial photography, satellite imagery, and drones has facilitated archaeological survey and mapping.

ARCHAEOLOGICAL EXCAVATION

2.5 Summarize the basic techniques of archaeological excavation.

Archaeological surveys provide invaluable information about the past. The distribution of sites on the landscape offers knowledge about the use of natural resources, trade patterns, and political organization. Surveys also help define the extent of specific sites and allow for a preliminary assessment of their age and function. These data can be used to interpret regional developments and how individual sites form part of a larger picture. For example, changes in settlement patterns have been used to assess the development of sociopolitical complexity and state-level societies (see Chapter 9). However, depending on the project's research objectives, an archaeologist may want more detailed information about a particular site. Once an archaeological site has been located, it may be targeted for systematic archaeological excavation (see Figure 2.2).

Excavation is costly and time-consuming. It is also destructive. Once dug up, an archaeological site is gone forever; it can be "reassembled" only through the notes kept by the archaeologist. For this reason, archaeological excavation is undertaken with great care. Although picks and shovels, or even bulldozers, may occasionally come into play, the tools used most commonly are the trowel, whisk broom, and dustpan. Different techniques may be required for different kinds of sites. For example, more care might be taken in excavating the remains of a small hunting camp than a nineteenth-century house in an urban setting covered with tons of modern debris. On underwater sites, researchers must contend with recording finds using specialized techniques while wearing special breathing apparatus (see the boxes "Underwater Archaeology" and "George Fletcher Bass: Underwater Archaeologist"). Nevertheless, whatever the site, the archaeologist carefully records the context of each artifact uncovered, each feature exposed, and any changes in surrounding soil.

Work usually begins with clearing the site and preparing a detailed site plan. A grid is placed over the site. This is usually fixed to a *datum point*, some permanent feature or marker that can be used as a reference point and will allow the excavation's exact position to be relocated. As in the case of other facets of the research project, the research design determines the areas to be excavated. Excavations of *midden* deposits, or ancient trash piles, often provide insights into the range of artifacts at a site, but excavation of dwellings might provide more information into past social organization, political organization, and socioeconomic status.

A question often asked of archaeologists is how deep they have to dig to "find something." The answer is, "Well, that depends." The depth of an archaeological deposit is contingent on a wide range of variables, including the type of site, how long it was occupied, the types of soil represented, and the environmental history of the area. In some cases, artifacts thousands or even hundreds of thousands of years old may lie exposed on the surface. In other cases, flooding, burial, or cultural activities may cover sites with thick layers of soil. A clear illustration of this is seen in *tells* (settlement mounds) in the Near East, which sometimes consist of archaeological deposits covering more than 100 square acres hundreds of feet deep.

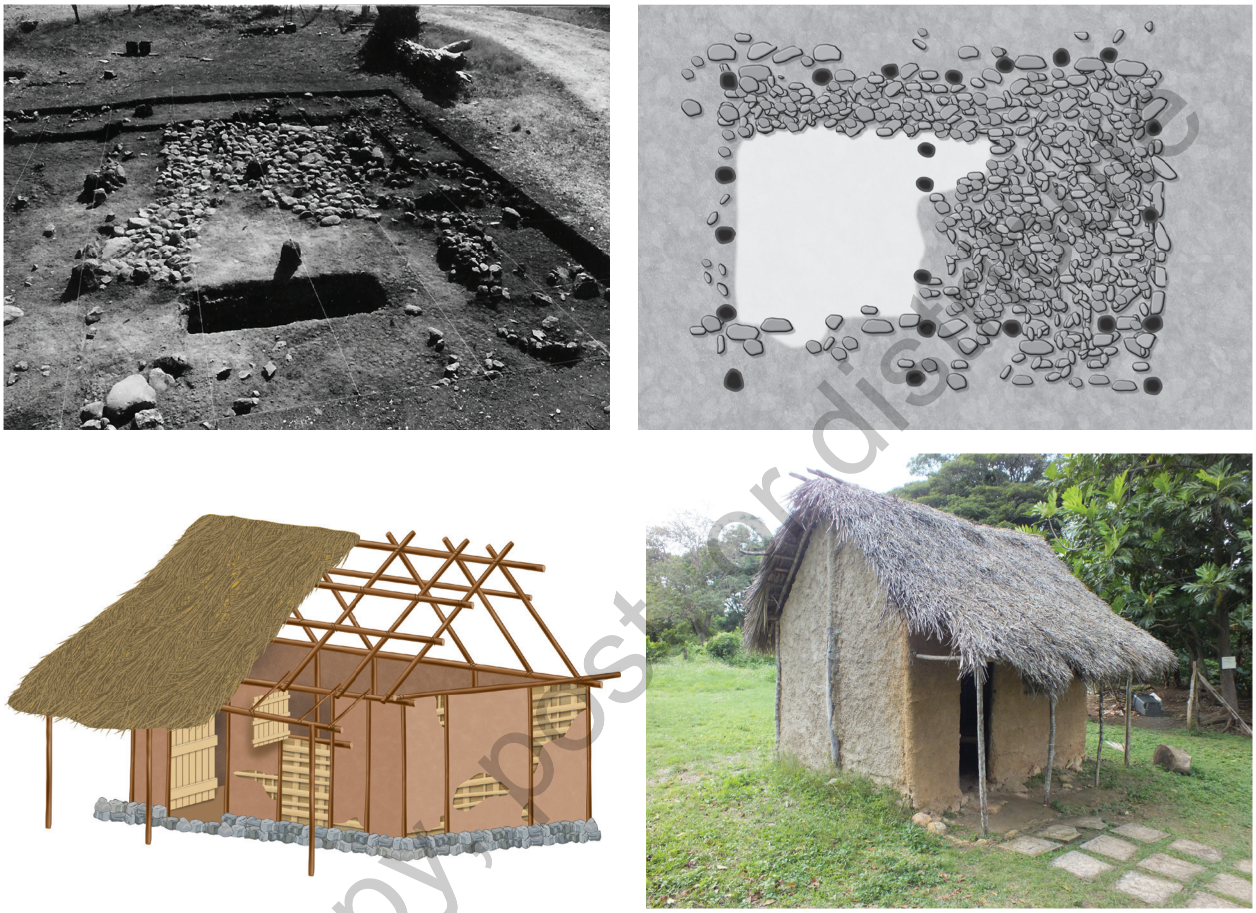
DATING METHODS

2.6 Compare and contrast how archaeologists and paleoanthropologists date their discoveries.

How old is it? This simple question is fundamental to the study of the past. Without the ability to temporally order fossils, archaeological sites, and artifacts, there is no way to assess evolutionary change, cultural developments, or technological innovations. Fortunately, modern paleoanthropologists and archaeologists have an array of dating techniques at their disposal. Some of these are basic to the interpretation of both the fossil record and archaeological sites. Other methods are more appropriate for objects of certain ages or for particular kinds of materials (for example, volcanic stone, as opposed to organic material). Hence, certain techniques are more typically associated with archaeological research than paleoanthropological research, and vice versa.

The following discussion outlines a few of the varied techniques available to illustrate the range of methods that paleoanthropologists and archaeologists use in establishing chronologies. In practice, accurate dating of individual archaeological and fossil finds depends on multiple methods; in any given project, researchers often use several different dating techniques in conjunction with one another to independently validate the age of the materials being examined.

FIGURE 2.2 ■ **Excavation, archaeological plan, drawing, and reconstruction of an eighteenth-century slave cabin at Seville Plantation, St. Ann Parish, Jamaica. The meticulous recording of excavated artifacts and features allows archaeologists to reconstruct the appearance of past settlements. In this case, eighteenth-century illustrations and written descriptions helped the artist add features, such as the roof, that were not preserved archaeologically.**



Photos courtesy of Douglas V. Armstrong, Syracuse University.

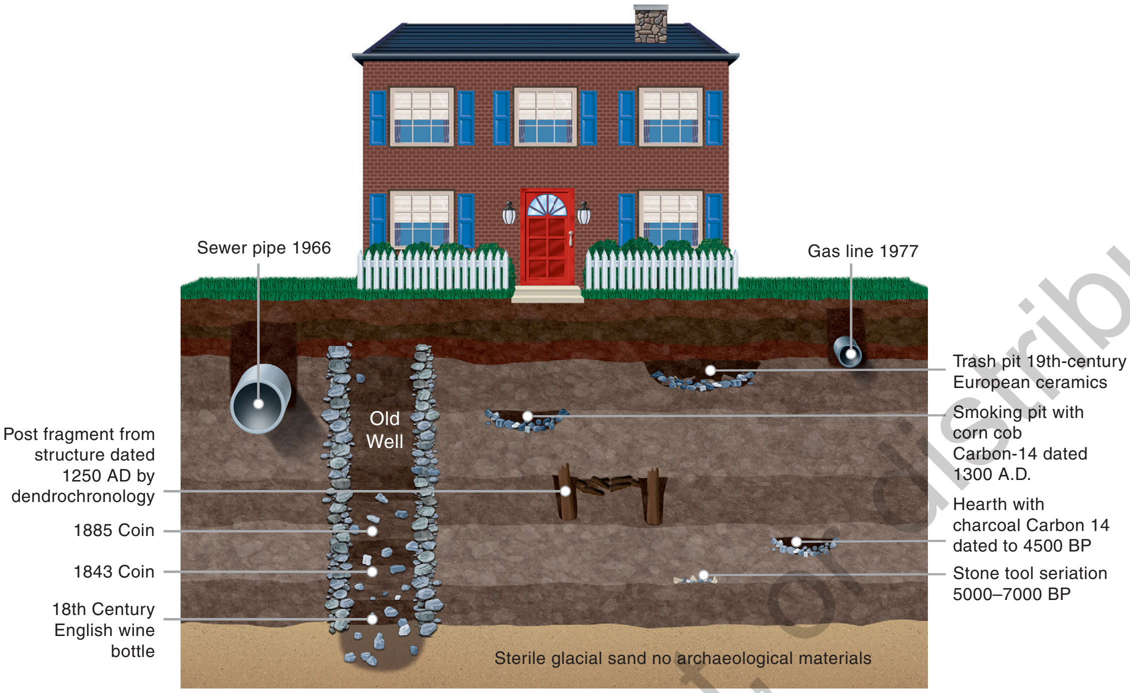
Dating methods can be divided into two broad categories that incorporate a variety of specific dating techniques: relative and numerical. Accurate dating of discoveries depends on both methods. The following discussion is not exhaustive, but rather intended to illustrate the different kinds of dating methods that have been employed.

Relative Dating

Relative dating refers to dating methods that determine whether one particular fossil, artifact, fossil locality, or site dates before or after another. Relative dating methods do not provide an actual date, just an age relative to something else. The most basic relative dating method is **stratigraphic dating**, a technique pioneered by the seventeenth-century Danish scientist Niels Stensen (1638–1687). Today, Stensen is better known by the Latinized version of his name, Nicolas Steno. Steno was the first person to suggest that the hard rock where fossils are found had once been soft sediments that had gradually solidified. Because sediments had been deposited in layers, or *strata*, Steno argued that each successive layer was younger than the layers underneath. Steno's *law of superposition* states that in any succession of rock layers, the lowest rocks have been there the longest, and the upper rocks have been in place for progressively shorter periods. This assumption forms the basis of stratigraphic dating.

Steno was concerned with the study of geological deposits, but stratigraphic dating is also of key importance in dating archaeological materials (see Figure 2.3). An archaeological site presents a complex layer cake of stratigraphic levels representing the accumulation of cultural material, such as trash and housing debris, as well as natural strata resulting from flooding, the

FIGURE 2.3 ■ The remnants of human occupation often accumulate to striking depths. This hypothetical profile illustrates the potentially complex nature of the archaeological record and how different dating techniques might be combined to date discoveries.



decomposition of organic material, and the like. Layers associated with human occupation often accumulate to striking depths.

Like all relative dating methods, stratigraphic dating does not allow researchers to assign an actual numerical age to a fossil or artifact. Rather, it indicates only whether one find is older or younger than another within the same stratigraphic sequence. This technique is essential to paleoanthropological and archaeological interpretation because it allows researchers to evaluate change through time. However, researchers must take notice of any disturbances that may have destroyed the order of geological or archaeological deposits. Disturbances in the Earth's crust, such as earthquakes and volcanoes, can shift or disrupt stratigraphic layers, while archaeological sites may be ravaged by erosion, burrowing animals, and human activity.

Faunal Succession

The systematic change in fossil species also provides a relative dating method. One of the first people to carefully record the location of fossils was William Smith (1769–1839), the "father" of English geology (Winchester 2002). An engineer at a time when England was being transformed by the construction of railway lines and canals, Smith noticed that as rock layers were exposed by the construction, distinct fossils occurred in the same relative order again and again. He soon found that he could arrange rock samples from different areas in the correct stratigraphic order solely on the basis of the fossils they contained. Smith had discovered the principle of **faunal succession** (literally, "animal" succession). A significant scientific milestone, Smith's observations were made sixty years before Darwin proposed his evolutionary theories to explain how and why life-forms changed through time. Since Smith's era, paleontologists have studied hundreds of thousands of fossil localities around the world. Fossils from these sites provide a means of correlating the relative ages of different fossil localities and afford a means of dating fossils that are not found in stratigraphic context. Placing fossils in a relative time frame in this way is known as **faunal correlation**.

Palynology

Remains of plant species, which have also evolved over time, can be used for relative dating as well. Palynology is the study of pollen grains, the minute male reproductive parts of plants. By examining preserved pollen grains, we can trace the adaptations vegetation underwent in a region from one period to another. In addition to helping scientists establish the relative ages of strata, studies of both plant and animal fossils offer crucial clues to the reconstruction of the environments where humans and human ancestors lived.

Relative Dating Methods of Bones

Scientists can determine the relative age of bones by measuring the elements of fluorine, uranium, and nitrogen in the fossil specimens. These tests, which can be used together, are sometimes referred to as the *FUN trio*. Fluorine and uranium occur naturally in groundwater and gradually collect in bones after they are buried. Once absorbed, the fluorine and uranium remain in the bones, steadily accumulating over time. By measuring the amounts of these absorbed elements, scientists can estimate the length of time the bones have been buried. Nitrogen works in the opposite way. The bones of living animals contain approximately 4 percent nitrogen, and when the bones start to decay, the concentration of nitrogen steadily decreases. By calculating the percentage of nitrogen remaining in a fossilized bone, scientists can calculate its approximate age.

The FUN trio techniques are relative dating methods because they are influenced by local environmental factors. The amounts of fluorine and uranium in groundwater differ from region to region, and variables such as temperature and chemicals present in the surrounding soil affect the rate at which nitrogen dissipates. Because of this variation, relative concentrations of fluorine, uranium, and nitrogen in two fossils from different areas of the world may be similar despite the fact that they differ significantly in age. The techniques are thus of greatest value in establishing the relative age of fossils from the same deposit. These methods have been supplanted by more modern, numerical dating methods, but they were historically important in establishing the relative ages of fossil finds (see the box "The Piltdown Fraud" in Chapter 5).

Obsidian Hydration

Obsidian hydration is a relative dating method that has proven very useful in dating artifacts made from obsidian. It is a particularly useful technique as it provides dates on actual artifacts, as opposed to associated materials. Obsidian, sometimes referred to as volcanic glass, is a naturally occurring stone that is common in some world areas. It flakes very regularly and so was used to produce beautiful stone tools such as knives, spear points, and scrapers. Obsidian hydration dating is based on the rate at which hydration layers accumulate on the surface of tools made from obsidian. When an obsidian artifact is made, the old weathered surface is flaked off, exposing the unweathered interior of the stone. This newly exposed surface contains little water. However, over time, the surface absorbs water, forming layers that can be measured using a high-powered microscope. As water is absorbed at a regular rate, the thickness of the hydration layers provides an indication of the relative ages of obsidian artifacts within an archaeological site.

Obsidian hydration is a relative dating method because the rate at which the hydration layers form is influenced by the local environmental conditions in which the obsidian artifacts are found. For example, the thickness of the hydrated surface layers on artifacts from a very dry region would be thinner than that on artifacts recovered from a waterlogged site, despite the fact that the sites might be of the same age. Obsidian hydration can, however, be used as a numerical dating method if the site conditions and chronologies are well understood. For example, if obsidian hydration rates from a specific site are tied to a well-established chronology based on radiocarbon dating, they will provide quite accurate numerical dates.

Seriation

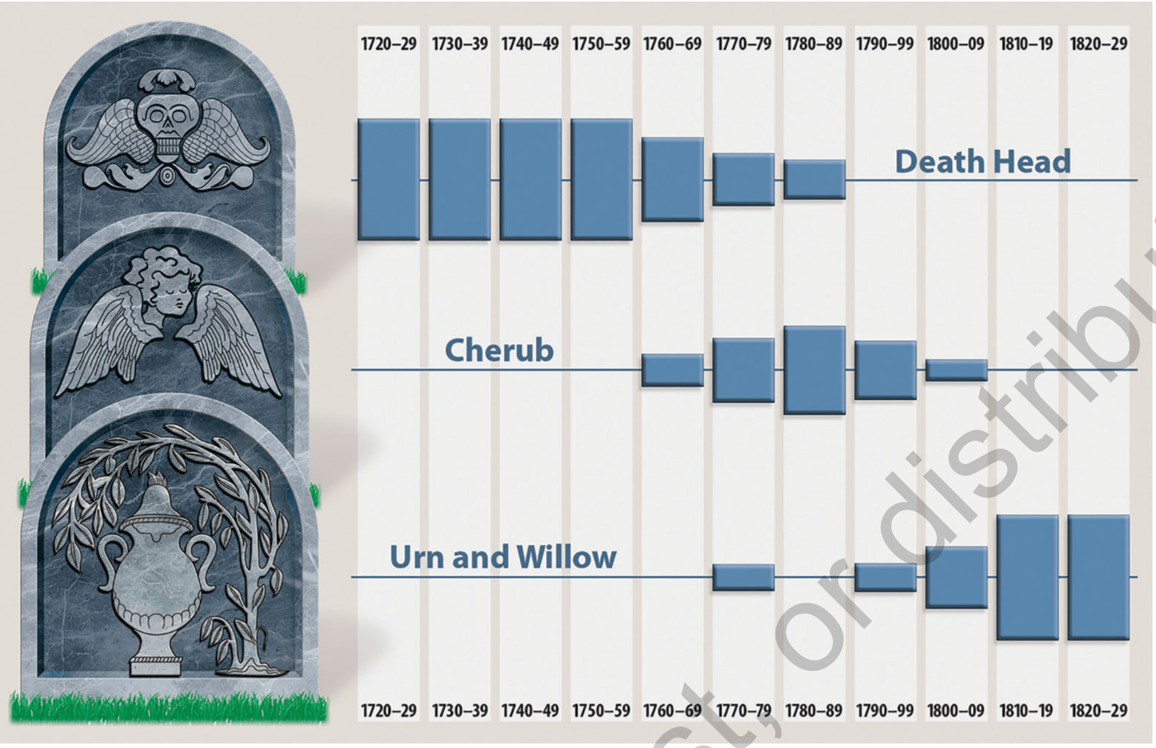
Unlike the methods discussed thus far that utilize geological, chemical, or paleontological principles, **seriation** is a relative dating method based on the study of archaeological materials. Simply stated, seriation is a dating technique based on the assumption that any particular artifact, attribute, or style will appear, gradually increase in popularity until it reaches a peak, and then progressively decrease. Systematic change in style can be seen in a wide range of cultural practices and material culture. For example, think of the changes that have occurred in technology, music, and fashion; various devices and styles have appeared, grown in popularity, and declined. Archaeologists measure changes in artifact types by comparing the relative percentages of certain attributes or styles in different stratigraphic levels in a site or across different sites. Using the principle of increasing and decreasing popularity of attributes, archaeologists are then able to place the artifacts in a relative chronological order. Seriation was particularly important for chronologically ordering ceramics and stone tools before the advent of many of the numerical dating techniques discussed later.

The principle of seriation can be illustrated by stylistic changes in many cultural practices. An interesting example of seriation is provided by archaeologist James Deetz's study of eighteenth- and nineteenth-century New England gravestones. Unlike artifacts such as prehistoric ceramics, gravestones can be closely dated, and so can be used to evaluate the principle of seriation. Deetz (1996) charted how designs on the dated gravestones systematically changed through time. In the course of a century, death's-head motifs were gradually replaced by cherub designs, which in turn were replaced by urn and willow decorations (see Figure 2.4). Deetz's study also illustrates how local variation in beliefs and trade patterns may influence the popularity of an attribute.

Numerical Dating Methods

In contrast to relative dating techniques, **numerical dating** methods (sometimes also referred to as "absolute" or "chronometric" methods) provide an actual age or date range. For

FIGURE 2.4 ■ The seriation of gravestones in a New England cemetery by archaeologist James Deetz illustrates the growth and gradual decline in popularity of a closely dated series of decorative motifs.



Source: Based on data from Deetz, J. & Dethlefsen, E. S. 1967. "Death's Head, Cherub, Urn, and Willow." *Natural History* 76(3): 29–37.

recent time periods, historical sources such as calendars and dating systems that were used by ancient peoples provide numerical dates. Mayan and Egyptian sites, for example, can often be dated by inscriptions carved into the monuments themselves (see the discussion of writing systems in Chapter 9). However, such written records only extend back a few thousand years, and these sources are not available for many regions. Researchers have consequently explored a variety of methods to establish the age of fossil finds and archaeological discoveries.

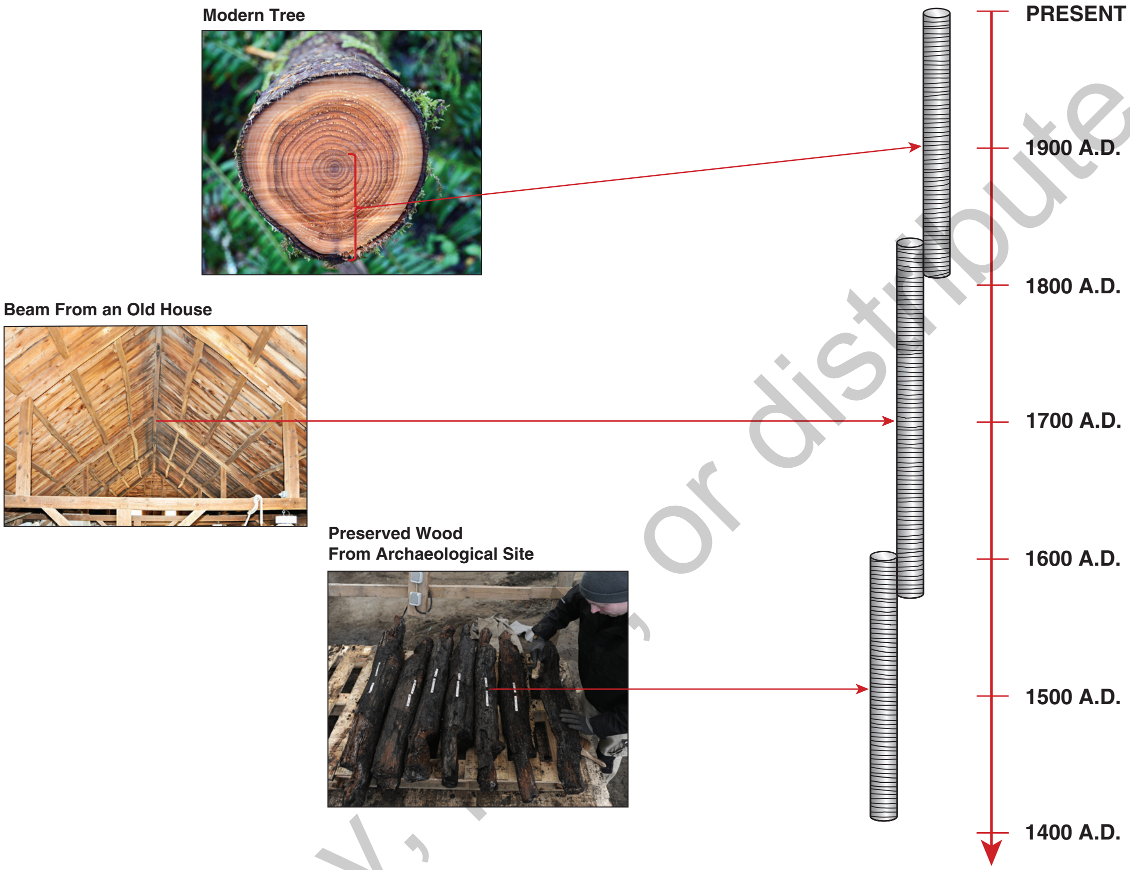
During the nineteenth century, scientists experimented with many methods designed to pinpoint the numerical age of the Earth itself. A number of these methods were based on observations of the physical world. Studies of erosion rates, for instance, indicated that it had taken millions of years to cut clefts in the earth like the Grand Canyon in the United States. Other strategies were based on the rates at which salt had accumulated in the oceans, the Earth had cooled, and geological sediments had formed (Prothero 1989). By observing current conditions and assuming a standard rate at which these processes had occurred, scientists calculated the amount of time represented. These early approaches were flawed, however, by a limited understanding of the complexity of natural processes involved and the range of local conditions. Therefore, these techniques at best provide only crude relative dating methods. In contrast to these early researchers, today's scientists have a wide variety of highly precise methods of dating paleontological and archaeological finds (Aitken 1990; Brothwell and Pollard 2001).

Dendrochronology

Dendrochronology, or tree-ring dating, was the first accurate, numerical dating method to be widely used by archaeologists. It is a unique dating method based on the annual growth rings found in some species of trees (see Figure 2.5). Because a ring corresponds to a single year, the age of a tree can be determined by counting the number of rings. This principle was recognized as early as the late eighteenth century by the Reverend Manasseh Cutler, who used it to infer that a Native American mound site in Ohio was at least 463 years old, based on the number of rings on a tree growing on top of the mound.

The modern dating method of dendrochronology is a great deal more sophisticated than simply counting tree rings. The method was pioneered in the early twentieth century by A. E. Douglass (1929), using well-preserved wood from the American Southwest. In addition to recording annual growth, tree rings preserve a record of environmental history: Thick rings represent years when the tree received ample rain; thin rings denote dry spells. In more temperate regions, the temperature and the amount of sunlight may also affect the thickness of the rings. Trees of the same species in a localized area generally

FIGURE 2.5 ■ **Dendrochronology is a numerical dating method based on the distinct patterns of growth rings found in trees that preserve a record of a region's environmental history. As illustrated here, samples of wood from progressively older contexts can be pieced together to provide a master dendrochronology. Fragments of wood recovered archaeologically can then be compared to this dendrochronology to determine when the tree lived.**



Source: Photos from ©iStock.com/erperlstrom, Courtesy of Eric Anderson, picture alliance/Getty.

show a similar pattern of thick and thin rings. This distinctive pattern can then be overlapped with patterns from successively older trees to build up a master dendrochronology sequence. In the American Southwest, a sequence using the bristlecone pine has now been extended to almost 9,000 years ago. Work on oak sequences in Ireland and Germany has been used to create a master dendrochronology sequence dating back over 10,000 years (Speer 2010).

The importance of this method is manifest. Dendrochronology has proven of great significance in areas such as the American Southwest, where the dry conditions often preserve wood. The growth rings in fragments of wood from archaeological sites can be compared to the master dendrochronology sequence, and the date the tree was cut down can be calculated. Even more important, dendrochronology provides an independent means of evaluating other dating methods, such as radiocarbon dating (discussed in the next section). Samples of wood dated by both techniques confirm the importance of radiocarbon as a dating method.

Radioactive Decay and Carbon-14 Dating

Several of the most important numerical dating techniques used today are based on *radioactive decay*, a process in which *radioisotopes*, unstable atoms of certain elements, break down or decay by throwing off subatomic particles and energy over time. These changes can produce either a different isotope of the same element or another element entirely. In terms of dating, the significance of radioactive decay is that it occurs at a set rate regardless of environmental conditions, such as temperature fluctuations, amount of groundwater, or the depth below the surface. The amount of decay that has taken place can be measured with a device called a *mass spectrometer*. Hence, by calculating how much decay has occurred in a specimen or an artifact, scientists can assign a numerical age to it.

Radiocarbon dating, also known as carbon-14 dating, is perhaps the best known and most common numerical dating technique based on radioactive decay. The technique of using radioactive decay as a dating tool was pioneered by Willard Libby, who received the 1960 Nobel Prize in Chemistry for his work on radiocarbon dating. The method is of particular importance to archaeologists because it can be used to date any organic matter that contains carbon, including fragments of ancient wooden tools, charcoal from ancient fires, and skeletal material.

Radiocarbon dating, as its name implies, is based on the decay of carbon 14 (14C), a radioactive (unstable) isotope of carbon that eventually decays into nitrogen. The concentration of carbon-14 in a living organism is comparable to that of the surrounding atmosphere and is absorbed by the organism as carbon dioxide (CO_2). When the organism dies, the intake of CO_2 ends. Thus, as the carbon 14 in the organism begins to decay, it is not replaced by additional radiocarbon from the atmosphere.

Like other radioisotopes, carbon 14 decays at a known rate that can be expressed in terms of its *half-life*, the interval of time required for half of the radioisotope to decay. The half-life of carbon 14 is 5,730 years. By measuring the quantity of carbon 14 in a specimen, scientists can determine the amount of time that has elapsed since the organism died. Dendrochronology and samples of wood from dated tombs have provided independent confirmation of the accuracy of carbon-14 dating. Dendrochronologies have also allowed scientists to account for variations in the amount of carbon 14 in the Earth's atmosphere and to correct or *calibrate* radiocarbon dates, rendering them more accurate.

The use of accelerator mass spectrometry (AMS), which makes it possible to determine the number of individual atoms of carbon 14 remaining in a sample, has allowed for more precise dating and also for the dating of much smaller samples. Dates of up to 80,000 years old have been obtained, but the technique is generally limited to dating materials less than about 60,000 years old (Plastino et al. 2001; Taylor and Southon 2007). The minuscule amounts of radiocarbon remaining in materials older than this make measurement difficult. Because of the time period represented, radiocarbon is of limited use to paleoanthropologists who may be dealing with fossil finds millions of years old. Radiocarbon dating is, however, of great importance to archaeologists who deal with materials of more recent age.

Potassium-Argon and Fission-Track Dating

Radioactive decay occurs in several isotopes often found in rocks of volcanic origin. Some of these isotopes decay at very slow rates over billions of years. Two radiometric techniques that have proven of particular help to paleoanthropologists and archaeologists studying early human ancestors are potassium-argon and fission-track dating. These methods do not date fossil material itself. Rather, they are used to date volcanic ash and lava flows that are associated with fossil finds. Fortunately, many areas that have produced fossil discoveries were volcanically active in the past and can be dated by using these techniques. These methods have been employed at such fossil localities as the Fayum Depression in Egypt (see Chapter 4), Olduvai Gorge in Tanzania, and Hadar, Ethiopia (see Chapter 5).

In *potassium-argon dating*, scientists measure the decay of a radioisotope of potassium, known as potassium 40 (40K), into an inert gas, argon (40Ar). During the intense heat of a volcanic eruption, any argon present in a mineral is released, leaving only the potassium. As the rock cools, the potassium 40 begins to decay into argon. Because the half-life of 40K is 1.3 billion years, the potassium-argon method can be used to date very ancient finds, and has thus been important in dating fossils of early human ancestors. Although this technique has been used to date volcanic rocks a few thousand years old, the amount of argon is so small that it is more commonly used on samples dating over 100,000 years (McDougall and Harrison 1999).

Fission-track dating is based on the decay of a radioactive isotope of uranium (238U) that releases energy at a regular rate. In certain minerals, microscopic scars, or tracks, from the spontaneous splitting of 238U are produced. By counting the number of tracks in a sample, scientists can estimate fairly accurately when the rocks were formed. Fission-track dating is used to determine the age of geological samples between 300,000 and 4.5 billion years old, and thus it can provide independent confirmation on the age of strata using potassium-argon and other dating methods. Although this is generally a technique of more use to paleoanthropologists, fission-track dating has also been used on ancient, manufactured glass. Dates have been obtained on glass and pottery glazes less than 2,000 years old, and so it presents a technique of potential help to archaeologists studying the more recent past (Aitken 1990).

Thermoluminescence Dating

The thermoluminescence dating method is also based on radioactive decay, but the technique operates differently than the methods discussed earlier. It is based on the number of electrons trapped in crystalline minerals. The electrons are primarily produced by the decay of three elements commonly present in varying amounts in geological deposits: uranium, thorium, and a radioactive isotope of potassium (40K). Hence, for accuracy, thermoluminescence dates should include an evaluation of the radioactivity in the surrounding soil so that the background radiation present in the deposit can be included in the calculations. As these elements decay, electrons are trapped in the crystals of the surrounding matrix. To be dated using the technique, artifacts must have been heated, as in the case of the firing of ceramics. Heating releases any electrons trapped in the clay; decay subsequently begins again, and electrons once again start to accumulate in the crystal matrix of the object. By calculating the rate at which electrons have accumulated and measuring the number of electrons trapped in a sample, the age of a piece of pottery, fired-clay statue, or clay-lined fire hearth can be determined.

The importance of thermoluminescence dating lies in the fact that it can be used to date artifacts themselves, as opposed to associated stratigraphic deposits, as with potassium argon dating. Thermoluminescence dating has been particularly useful in dating ceramics—one of the most common artifacts found on sites dating to the last 10,000 years. It has, however, also been used in cases where stone tools have been heated during their manufacture or time of use (some stone becomes easier to work with if heated). Similarly, it has been used in cases where the clay or stone of a hearth area has been heated; the key once again is that the sample has been heated at the time of use to set the amount of accumulated electrons to zero. Dates to tens or hundreds of thousands of years ago have been obtained on stone tools (Aitken, Stringer, and Mellars 1993). The method has also proven very useful in differentiating modern fakes from ancient ceramic objects.

INTERPRETING THE PAST

2.7 Discuss the challenges of interpreting the past and how these are overcome.

Views of the past are, unavoidably, tied to the present. As we discussed in Chapter 1, anthropologists validate their conclusions by making systematic observations and being explicit about their assumptions. Unfortunately, prevailing social and economic conditions, political pressures, and theoretical perspectives may affect interpretation. For example, during the early twentieth century, bits and pieces of physical anthropology, archaeology, and linguistic information were muddled together to support the myth of a superior German race (Pringle 2006). In this created version of the past, distorted archaeological interpretations were used to bolster chronologies that showed development starting in Germany and spreading outward to other parts of Europe.

Distorted interpretations of archaeological and historical information were also used to validate racist apartheid rule in South Africa. Prior to the end of apartheid, South African textbooks proffered the idea that black, Bantu-speaking farmers migrating from the north and white and Dutch-speaking settlers coming from the southwest arrived in the South African hinterland at the same time. This interpretation had clear relevance to the present: Both groups had equal claim to the land. However, archaeological evidence knocked out the foundations of this contrived history (M. Hall 1988). Archaeological evidence indicates that the ancestors of the black South Africans had moved into the region by 200 A.D., 1,500 years before the initial European settlement.

In these preceding cases, falicious versions of the past were constructed with dangerous effects on the present. More commonly, errors in interpretation are less intentional and more subtle. All researchers carry their own personal and cultural biases with them. Human societies are complex, and how this complexity is manifested archaeologically varies. These factors make the evaluation of interpretations challenging, and differences of opinion frequently occur.

Although there is no formula that can be used to evaluate all paleoanthropological and archaeological materials, there are useful guidelines. As seen in the preceding chapter, a key aspect of anthropological research is a systematic, scientific approach to data. Outmoded, incorrect interpretations can be revealed through new observations and the testing of hypotheses. The validity of a particular interpretation can be strengthened by the use of independent lines of evidence; if they lead to similar conclusions, the validity of the interpretation is strengthened. Academic books and articles submitted for publication are reviewed by other researchers, and authors are challenged to clarify points and strengthen observations. In many cases, the evaluation of a particular theory or hypothesis must await the accumulation of data. Many regions of the world and different aspects of the past are virtually unstudied. Therefore, any theories about these areas or developments must remain tentative and subject to reevaluation.

SUMMARY AND REVIEW OF LEARNING OBJECTIVES

2.1 Explain how archaeological research is used to answer questions about past societies.

As is the case with all anthropological research, the study of the past is guided by the questions that the researcher wants to answer. To formulate these, archaeologists and paleoanthropologists draw on varied theoretical perspectives to frame their questions and review existing data to place their research in wider context. To ensure that the data recovered are relevant to their questions, paleoanthropologists and archaeologists begin a project by preparing a research design in which the objectives of the project are set out and the strategies for recovering the relevant data are outlined. The research design must take into account the types of data that will be collected and how those data relate to existing anthropological knowledge. Within the research design, the anthropologist specifies what methods will be used for the investigation, what regions will be surveyed, how much of a site will be excavated, and how the materials recovered will be analyzed. Generally, the research design is then reviewed by other anthropologists, who provide feedback and recommend it for funding by various government agencies or private research foundations.

2.2 Define paleoanthropology and discuss what we can learn about the past from fossil evidence.

Paleoanthropologists often use fossils, the preserved traces of past life, to study human origins. Places where fossils are found are termed fossil localities. The fossil record is far from complete. Nevertheless, an impressive record of past life has survived. Careful study and improved technology reveal minute fossils of shellfish, algae, and pollen and images of the delicate structure in bones. On one hand, this information allows for the reconstruction of the environments in which early human ancestors lived. On the other hand, fossils of human ancestors are used to trace human origins and evolution.

2.3 Discuss what the archaeological record can tell us about past societies.

The archaeological record encompasses all the material traces of past cultures. Places of past human activity that are preserved in the ground are called archaeological sites. Sites contain artifacts (objects made or modified by humans), as well as other traces of past human activity and a record of the environmental conditions that affected the site. In studying archaeological materials, archaeologists are particularly interested in the context, or the specific location of finds and associated materials. Understanding the context is of key importance in determining the age, uses, and meanings of archaeological materials.

2.4 Recall the basic techniques used to locate archaeological sites and fossil localities.

Archaeological sites and fossil localities provide important information about the past. They may be located in many different ways. Traces of a site may survive on the ground, and local informants, maps, and previous archaeological reports may be of help. To discover sites, archaeologists may survey large areas, looking for any indications of archaeological remains. Technological aids such as aerial photographs and satellite imagery may help locate sites. Surface examinations may be supplemented by subsurface testing, as well as tools such as the magnetometer or resistivity meter, to help archaeologists identify artifacts and features beneath the ground. Fossils are often deeply buried, resting beneath layers of sediment, making locating them especially difficult. For this reason, paleoanthropologists often cannot employ many of the techniques that archaeologists use to locate shallower archaeological deposits. The depth of an excavation depends on a number of variables, including the type of site, the length of occupation, the soils present, and the area's environmental history.

2.5 Summarize the basic techniques of archaeological excavation.

Depending on a project's objectives, archaeological sites may be targeted for excavation, which can be thought of as "scientific digging." Excavation is always undertaken with great care, and the material recovered carefully recorded. Although picks and shovels may sometimes be used, hand trowels and dust brooms remain the most important tools. Before excavation, a site is divided into a grid, which allows for the context of each artifact to be carefully noted.

2.6 Compare and contrast how archaeologists and paleoanthropologists date their discoveries.

Dating of fossils and archaeological materials is of key importance in the interpretation of the past. Without the ability to place finds in their relative ages, there is no way of assessing evolutionary change, technological innovations, or cultural developments. Paleoanthropologists and archaeologists use many different dating techniques that can be classified as either relative or absolute dating methods. Methods such as stratigraphic dating, faunal succession, and obsidian hydration provide only relative ages for finds in the same deposits. In contrast, numerical dating techniques like radiocarbon dating, potassium-argon dating, and dendrochronology can be used to assign actual numerical ages to finds. In practice, researchers typically draw on multiple dating methods to establish the age of a specific find.

2.7 Discuss the challenges of interpreting the past and how these are overcome.

Interpretations of the past are inevitably influenced by the present. At times, interpretations of the past have been used to support political ends, as seen in Nazi Germany and the apartheid policies of South Africa. Researchers try to avoid biases by employing systematic, scientific methodology. Theories can be revealed as false through testing and be replaced by more convincing arguments. These, in turn, can be evaluated in light of new evidence and either negated or strengthened. Archaeological theories, often derived from cultural anthropology, help archaeologists conceptualize how cultures work and what aspects of a past culture might be preserved archaeologically. Ultimately, this reflection provides a more complete explanation of the dynamics of past cultures and culture change.

KEY TERMS

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artifacts, p. 27
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culture, p. 25
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