1.1 ARCHITECTURE AS A SECOND NATURE

Sacred Caves and Primitive Huts

Architecture, more than any other cultural expression, affects everyone. It originated in response to the act of dwelling: first as an adaptation to natural conditions such as mounds, caves, and tree trunks, and then as the reproduction of such shelter. From the outset, humans created architecture as a second nature.

Prehistoric home builders reproduced the shelter of the cave and the tree in their huts, using branches, twigs, mud, and stones. They piled stones and shaped mud-brick walls into cave-like environments to achieve a greater feeling of security. To dwell required a process of cooperation for procuring food, making the warmth of a fire, and protecting the inhabitants from both wild animals and other humans. Pre-agricultural peoples documented their reverence for the great beasts they hunted by decorating caverns and caves, which they transformed into shrines for practicing religious devotions.

When groups of hunter-gatherers built structures for their cults, they imitated the great caverns of the past. As agricultural practices took hold, small villages of permanent dwellings cropped up near water sources. In the early agricultural settlements people drew little distinction between religious and nonreligious structures. The act of dwelling addressed at once the questions of creating shelter and making a symbolic environment to fulfill religious imperatives.

Figure 1.1-1 Grand Canyon, Arizona, formed through erosion by the Colorado River over several million years.

The Act of Dwelling: Shelter and Symbol

Before the appearance of architects, the world already possessed architecture. Natural processes had shaped the land: ridges and rivers divided the plains, hills punctuated the horizon, and caves gouged the rocky cliffs. The Grand Canyon, sculpted by the Colorado River over millions of years of erosion, plunged through an elevated plateau of tawny stone more than 1.5 km (approximately 1 mile) in depth (Fig. 1.1-1). Its succession of temple-like piles of stratified rock presented a symbolic landscape that commanded reverence. Another gift of nature, the hundreds of grottoes that perforated the limestone cliffs of Matera in southern Italy, appealed to primeval settlers for millennia as excellent places for safe and comfortable homes (Fig. 1.1-2a,b). During the long prehistoric period when human beings learned how to dwell, from roughly 500,000 to 3000 BCE, the idea of architecture emerged through the awareness of two recurring themes: shelter and symbol.

Figure 1.1-2 Matera, southern Italy. (a) Grotto dwellings, lived in since the twelfth millennium BCE. (b) Section.

The art of building originated in many places and at different times. The so-called primitive hut, the mythical first dwelling, appeared all over the planet. Prehistoric structures and settlements offered fleeting interventions, at the outset conditioned by the nomadic way of life of hunter-gatherers. Early architects created similar building types—such as the rounded mud hut and the oblong, thatch-covered longhouse—on different continents at widely diverging moments, making it difficult to categorize them as part of a progressive sequence. The survival of architectural knowledge relied on the good fortune offered by geography and climate, as well as the tolerance of neighbors. Although dates can be attached to prehistoric artifacts through carbon-14 analysis, the interruptions in time and space of prehistoric works preclude an evolutionary or chronological understanding of them. Before the introduction of written language during the third millennium BCE, architecture must be allotted a certain timelessness.

Because the earliest designers constantly moved in search of a tolerable climate and food supply, their works remained tentative and unobtrusive. They made shelter in the pleats of the earth. Since the 1974 discovery at Hadar, Ethiopia, of so-called "Lucy" (*Australopithecus afarensis*), thought to be the first upright-walking human-like species, further discoveries in Kenya have pushed the date of the emergence of our predecessors back from more than 3 million years ago to 6 or 7 million. Hominids forged ahead of other species through their domestication of fire. In the Olduvai Gorge in Tanzania, archaeologists have identified tools and circles of shelter dating back almost 2 million years. The Neanderthals (500,000–30,000 BCE) created hearths for heating, cooking, and toolmaking. They pursued the primal architectural act of building a fire as the key element of dwelling, driving the wild beasts from the caves to make the home of the moment safe.

The earliest known hearths, found at the great cave of Escale near Marseilles in southern France and the cave

TIME LINE

▼ **2,500,000 BCE**

Evidence of "Lucy," a hominid living in Ethiopia

Olduvai Gorge, Tanzania, earliest toolmakers

▲ **ca. 1,500,000 BCE**

▼ **ca. 500,000 BCE**

Neanderthal hunter-gatherers make fires in south of France and northern China

Terra Amata, France, earliest known huts

▲ **ca. 400,000 BCE**

▼ **ca. 40,000 BCE**

Cro-Magnons replace Neanderthals; stone tools

Cave painters: Chauvet, Lascaux, Altamira

▲ **ca. 30,000–15,000 BCE**

▼ **25,000–14,000 BCE**

Last Glacial Maximum (Ice Age)

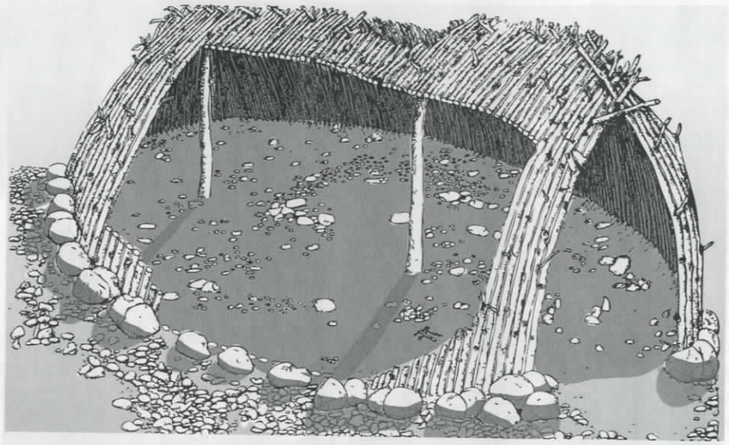

Figure 1.1-3 Terra Amata, France. Hypothetical reconstruction of the earliest known huts, ca. 380,000 BCE.

of "Peking Man" at Zhoukoudian, China, date from over 500,000 years ago. Deep within the Bruniquel cave in southwest France, archaeologists discovered two circular structures that Neanderthals built from pieces of stalagmites, scorched by bonfires, among the earliest evidence of the relationship between fire and architecture, datable to 176,000 BCE. The warmth of fire established an exclusive setting for a community of hunters to rest, cook their game, harden their tools, and create rituals. The human knowledge of combustion, while improving physical well-being, also set a course for the incremental consumption of natural resources, which periodically led to human-made ecological imbalances. But at a time when fewer than 10,000 human beings lived on the planet, the danger seemed inconsequential.

Aside from adapting to the shelter provided by nature, the Neanderthal hunter-gatherers built huts in the open as early as 400,000 BCE. The camp of Terra Amata, discovered near Nice in southern France in 1966, served many generations of hunters, who visited it briefly during the late spring. Archaeologists have identified traces of twenty oval huts, measuring as large as 6 × 15 m (18 × 47 ft), in a cove by the beach (Fig. 1.1-3). Bands of about fifteen persons built and occupied the huts for limited hunting forays, leaving them to collapse after their departure. The Neanderthal builders set rows of branches or saplings close together within a ring of stones. They pitched the boughs from one side to the other, creating a vault-like covering over large posts that ran down the center to help support the roof. They dug out the site with fire-hardened wooden spears, pruning and trimming the branches with hand axes made of pieces of flint or limestone. Each year the seasonal builders set new huts over the site of the old ones or else nearby.

Anthropologists often refer to the long period of prehistory as the "Stone Age," named after the prevailing technology of stone tools. They further divide it into Paleolithic, Mesolithic, and Neolithic subperiods, the last beginning around 10,000 BCE and involving the earliest settlements and the transition to metal tools. Around 40,000 BCE, the Neanderthals coexisted with but were eventually replaced by the Cro-Magnon peoples, a distinct strain of *Homo sapiens sapiens*. The newcomers, smaller in stature but with larger brains than the Neanderthals, improved on the earlier people's stone tools, making cutting knives sharp and easy to grasp. They also began to formulate religious behavior. Beyond their day-to-day survival, the Stone-Age hunters became aware of their social destiny as a chain of lives, and they carefully buried or burned their dead relatives, leaving markers behind. Death remained a disturbing mystery, but through the performance of ritual acts and the creation of permanent shrines, primal hunters hoped to influence the cosmos to prolong their collective existence.

The cults that grew up to appease human anxiety prepared the foundations for architecture as the setting for ritual actions. The cave acquired a new status of **sanctuary**. At its mouth the hunter might still make a dwelling, while reserving the dark inner recesses for rituals addressing life, death, and the afterlife. Around 70,000 BCE, in one of the thirty caves of Monte Circeo, a limestone promontory south of Rome, the cave dwellers placed a single Neanderthal skull in a trench along the farthest wall, with stones arranged around it in an oval ring.

Göbekli Tepe (Turkey), round structures

▲ **11,000–8,000 BCE**

▼ **ca. 7500 BCE**

Jericho (Israel), Çatalhöyük (Turkey), Ain Ghazal (Jordan), earliest cities

Khirokitia (Cyprus), evidence of a street

▲ **ca. 6500 BCE**

The attempt to impose formal order expressed a symbolic need that went beyond the demands of shelter to define one's place in the cosmos.

During the slow development of primal cosmological beliefs, Stone-Age nomads began to use painting and sculpture to decorate special hillside caves. Explorers have discovered painted caves dating from the end of the last glacial period (between 30,000 and 12,000 years ago) in places as far from one another as Western Australia, Namibia, Patagonia, Yucatán, and southern India, as well as the better-known examples in southern Europe. This suggests the surprising possibility of a prehistoric global culture. The cave decorators used similar motifs, ranging from the stenciled outlines of hands, achieved by blowing pigments from one's mouth, to abstract patterns of grids, spirals, circles, dots, and zigzags. In some cases they depicted profiles of the majestic animals of the hunt. The evocative images of moving animals, which would have been animated by the flitting light of campfires, carried obvious symbolic intentions meant to accompany rituals. While the painted caves did not require acts of construction, the ceremonial organization of their spaces constituted the earliest form of religious architecture.

Nomadic hunters, chasing herds across the planet, brought with them the extraordinary gift of art to commemorate their cults based on animal vitality. The caves at Lascaux (Fig. 1.1-4), in southwestern France, and Altamira, in northwestern Spain, both occupied around 15,000 BCE, remain among the most magnificently decorated of the 200 painted caves discovered during the past two centuries in southern Europe. The followers of these cults crept into the caves from an upper entry, symbolically returning to a womb-like opening in the earth. They covered the walls and ceilings with realistic, polychrome images of the beasts of the hunt, sometimes up to 7 m (22 ft) in width. The artist-hunters depicted themselves as insignificant stick figures in the background, powerless in the face of the mystery-filled forces of nature. Using a mixture of ground minerals and charcoal applied either with hollow bone styluses or by being chewed up and spat, the cave painters narrated their relation to the flux and flow of life, moving with the herds, courting them, slaying the beasts reverently, and devising magic rituals to ensure their continued abundance.

The Chauvet Cave (Fig. 1.1-5), discovered in 1994 near Pont d'Arc in the Ardèche region of southern France, appears to be the oldest in Europe, tentatively dated to around 30,000 BCE. As at Lascaux and Altamira, one entered the cave from above, moving into a three-part sequence of descending spaces articulated by ritual markings. The cult members decorated the foyer, previously occupied by bears, with small pictures of mammoths. The central grotto

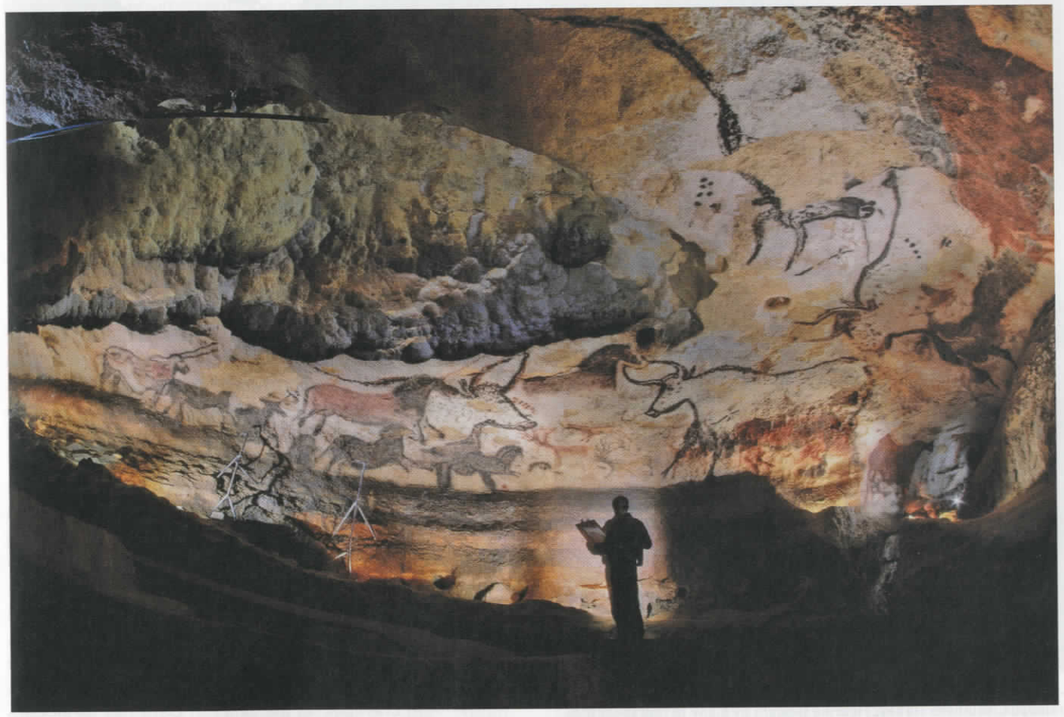

Figure 1.1-4 Dordogne, southwest France. Lascaux Caves, 17,000 BCE. The three chambers are covered with over 600 polychrome paintings and line drawings, executed by hunter-gatherers over many centuries during the last Ice Age.

RELIGION, PHILOSOPHY, FOLKLORE

The Great Goddess

The theory of the Great Goddess, a presumed archaic earth deity worshipped by the earliest cultures of Europe and Southwest Asia, was suggested by the discovery of numerous depictions of a corpulent female, such as this seated woman with royal felines found at Çatalhöyük. These commanding maternal figures appear to represent a matriarchal society and supply a necessary myth to counteract the prevalent patriarchal order found in most historical situations. Many archaeologists and anthropologists have put forward the notion of the Great Goddess as a means of interpreting the development of Neolithic cult sites constructed during the period of transition to agrarian society. While Çatalhöyük, Malta, and the later Minoan culture on the isle of Crete have been celebrated as peaceful, female-dominated societies, the evidence is in no way complete or conclusive. Phrenological studies indicate a surprising degree of equality in diet, work habits, and dwelling space between men and women in Neolithic communities, slightly contradicting the idea of matriarchy. The comforting figure of a primordial mother who ruled before the masculine militarization of society, when men armed themselves with metal weapons, nonetheless offers a story one would like to believe as an alternative to the tragic cycles of war and destruction that have littered the historical landscape.

Çatalhöyük, southern Turkey. Figurine thought by many to represent the Great Goddess, ca. 7000 BCE.

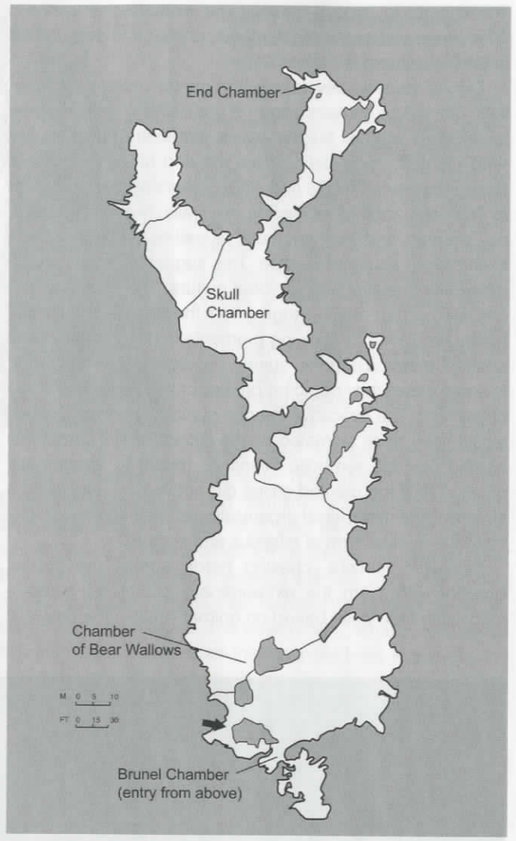

Figure 1.1-5 Ardèche region, southern France. Plan of Chauvet Cave, ca. 30,000 BCE, discovered in 1994. The central grotto extends as wide and as tall as a Gothic cathedral.

opens onto a space as large as a cathedral: 30 × 100 m (98 × 328 ft). The bears had dug out many of the nooks of the Chauvet Cave as hibernation spots, and the painters decorated them as if they were side chapels in a church. In one of the crannies the participants arranged an altar-like stone with the skull of a bear in its center as a sacrificial emblem. A collection of fifty-five bear skulls preserved the memory of the cave's previous occupants, presumably evicted after a struggle. Over 300 paintings and drawings of bears and spotted leopards, both fierce competitors for the hunt, cover the walls. The artists, working over the span of many millennia, depicted a collection of creatures including horses, woolly rhinoceroses, lions, bison, aurochs (wild oxen), panthers, mammoths, ibexes (wild mountain goats), and owls. Half of these species had become extinct by the time the decorators began working on Lascaux.

The "end chamber" of the Chauvet Cave has as its central icon a painting of a gigantic woman with bulging thighs, a prominent mound of Venus, and the horned head of a bison. The image resembles sculpted figures found in later agricultural settlements, often associated with a presumed cult of the Great Goddess of the Earth. Leopards and horned bulls often accompany the image of the goddess, who sometimes holds a horn, the instrument for channeling animal force. In the depth of this metaphorical "womb" in the earth, the mother goddess of Chauvet may have received her due veneration.

The painted caves of primal hunters celebrated a timeless faith in the animal spirit. The wild beast represented both literal food and the life force. Stone-Age artists took little initiative to change the natural configurations of the caves but skillfully adjusted to their irregular spaces. Somewhat like the work of late-twentieth-century graffiti artists, their decorations presented ongoing projects to be added to by others. Numerous hands worked on the walls over the course of many centuries, if not millennia. The successive generations of hunters each added their own imprint to the existing shrines. Both in the making and in the presumed blessings of these magical environments, caves such as Chauvet, Altamira, and Lascaux became enduring community projects, which merged the present with hopes for the future and respect for the past.

Figure 1.1-6 Neolithic Southwest Asia.

Living Together: Neolithic Settlements in Southwest Asia

Around 16,000 BCE the planet underwent a dramatic climate change, the last in the cycle of recurring ice ages that seriously threatened biological life with nine-month-long winters. A period of global warming followed, when a combination of water evaporation and greenhouse gases such as carbon dioxide formed a stratum in the atmosphere that retained solar energy. The milder weather and the gradual receding of the great ice sheets encouraged parts of the landscape to develop as forests and fertile plains. Between the twelfth and the fifth millennia BCE, the new stability of longer growing seasons permitted most of the nomadic hunter-gatherers in Europe, Southwest Asia, and East Asia to undertake farming and shepherding. They constructed dwellings near stable points of water supply where they found fertile soil.

With the cultivation of plant and animal resources and the introduction of improved tools, humans began to take more active control of the environment. Prehistoric agriculturalists created a second nature, reshaping the land by channeling water, terracing hillsides, and altering the fields through constant tilling. They fashioned shelters from the basic materials offered by the land—mud, wood, and stone—and covered them with woven grasses and animal hides. Over time they clustered their houses into villages both for sharing access to prime resources such as water and for defense against raiders. The villages created religious ceremonies to bond their communities, reenacting stories of their origins and ideas about their place in the cosmos.

The earliest Stone-Age settlers migrated to Southwest Asia (Fig. 1.1-6), where wild grains grew in abundance, allowing the accumulation of a food surplus. The oldest structures in the region were unearthed in 1994 at Göbekli Tepe, a mound in southeastern Turkey that contains a cluster of two dozen cult buildings. The oval structures (Fig. 1.1-7a), only four of which have been excavated, range in diameter from 10 to 30 m (32 to 98 ft). Contrary to previous theories of human development that assumed agriculturalists to be the first architects, these early "temples" belonged to a community of hunter-gatherers. The buildings, in use from around 11,000 BCE until 8000 BCE, served the religious ceremonies of a highly organized nomadic society. The architects of the round structures at Göbekli Tepe set a series of *T*-shaped megaliths in radial positions to serve as ribs in the thick oval walls made of stone and rubble. About twice human height, the prized stones weighed up to 20 tons and required the effort of hundreds of people to drag them from the quarries. The builders carved the megaliths in relief with animal figures, reminiscent of the iconography of the painted caves. A pair of taller *T*-shaped pillars dominated the center of each temple. Carved with arms, they apparently represented humans (Fig. 1.1-7b).

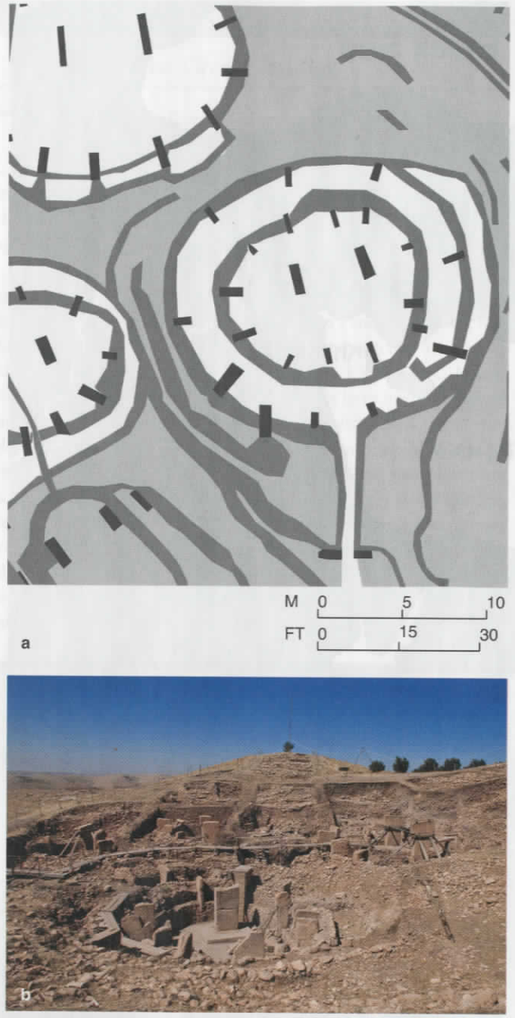

Figure 1.1-7 Göbekli Tepe, southeastern Turkey. (a) Reconstruction of oval temples built by a preagricultural society, ca. twelfth millennium BCE. (b) Archaeological site showing an oval space with decorated pillars; roof was probably corbelled.

The roundness of the oval structures at Göbekli Tepe evokes the morphology of the painted caves, demonstrating an effort to reproduce the natural prototype. The hunter-gatherers would have assembled at the temples for ceremonies, similar to the religious use of the great painted caves. Sometime in the early eighth millennium the entire site was purposefully buried under a thick layer of soil. One can speculate that as the inhabitants of this region made the transition to the agrarian way of life, moving from the collection of wild grains to the cultivation of higher-yield grains, the bizarre concealment of the oval temples signified the new agricultural regime's literal burial of old beliefs from the nomadic past.

The transition to agriculture inspired the earliest forms of urbanism in Southwest Asia. The region—comprising Palestine, Syria, southern Turkey, and Iraq—is often called the "Fertile Crescent" because of its abundance of spontaneous strains of wheat and barley. Jericho, settled around 7500 BCE, remains the best documented of thousands of settlements that sprouted up in the region during the Neolithic period, attracting the distinction as the oldest city in the world. With a population of fewer than 3,000 farmers, however, it would have appeared to today's eyes to be little more than an expanded village. The presence of imported obsidian, a hard, black volcanic glass indispensable for making sharp tools, demonstrates that these first towns in Palestine maintained distant trading relations, since the obsidian came from southern Turkey. The initial cluster of round houses at Jericho exploited the natural advantage of a reliable spring of freshwater that now gushes from a place called Elisha's Fountain. The life-giving value of such a resource in the arid region of the Dead Sea would have initially attracted the hunters, who likely followed their prey to the drinking hole and slowly converted to farming and a more settled life.

After several centuries of habitation, the occupants of Neolithic Jericho added an impressive fortification to protect their homes and silos. They built a wall 5 m (16.5 ft) high, with irregular, or cyclopean, masonry and set off by a deep ditch. Behind the wall they raised a conical tower, accessed by an interior stair made of single stone slabs (Fig. 1.1-8). They built small, round houses inside the walls, with mud walls set on stone foundations. Jericho's builders may have covered their houses with domes in imitation of the round tents of the nomadic hunters but more likely gave them flat roofs of reeds and clay. They periodically rebuilt houses on top of the originals. The floors of the houses lay below the ground level, requiring a wooden stairway to enter. Beneath the floors, each successive generation of deceased relatives lay buried, initiating a local tradition of stratification.

The site of ancient Jericho today presents a large mound near the oasis of the modern town, on the left bank of the Jordan River. Several layers of the city rose over the ruins of their predecessors. About 6500 BCE, the original town fell to outsiders. The newcomers built rectangular rather than round houses, with slightly rounded corners and open courtyards for cooking. Each house consisted of a few rooms, interconnected by wide, rounded doorways. The buildings set aside as shrines appear to have been similar to the houses, with identical rounded **doorjambs**.

Of the many towns and villages contemporary with Jericho, few have comparable archaeological traces. One of the better documented, Khirokitia, occupied a hillside on the southern coast of the island of Cyprus. Built around 6000 BCE, it shared a few architectural traits with ancient Jericho, including a ditch, a stone wall, and a series of small

round houses (Fig. 1.1-9a,b). During its two-century existence Khirokitia doubled in size to perhaps 600 inhabitants. The inhabitants rebuilt the city walls with a formal gateway accessed by stone steps that rose in three flights set at right angles to each other in a *U* shape to negotiate the higher level of the ground inside the walls. The expansion of the town produced a unique urban feature, a paved street, probably by default. The trace of the earlier wall that now lay between the two halves of the town became an ad hoc thoroughfare, running uphill from the riverbank on the south side of the bend. It crossed the settlement and descended to the opposite side. Stone ramps led from this elevated path as tributary lanes to the houses. Halfway up the steepest part of the ascent from the south, the street widened into a platform about 4.5 m (13.5 ft) wide. This rounded plaza, with its splendid panorama of the Maroniou River valley and the sea beyond, doubtless served as a place of social exchange and assembly.

The public spaces at Khirokitia had no precedents, nor did they inspire contemporary imitators. Ancient Jericho grew without streets, the houses packed one alongside the next like a beehive. Likewise the inhabitants of Çatalhöyük—the largest and most complex Neolithic settlement of Southwest Asia, located on the Konya Plain of southern Turkey—left neither streets nor gaps between their buildings. Occupied between 7400 and 6000 BCE, the town spread as a dense fabric of rectangular cells (Fig. 1.1-10), accommodating perhaps 10,000 inhabitants. Çatalhöyük arose as a transitional settlement caught between nomadic and agricultural ways of life, developing into a society with diversified crafts and businesses.

Beyond any agricultural advantage it might have commanded, Çatalhöyük's success came from its control of the market for obsidian, the Neolithic period's most valued commodity. The city also hosted some of the first smiths working with metal. Lead and copper were mined and then shaped into ornaments and small tools such as awls and drills. In exchange for their crafts, the townspeople acquired luxury items—including marble, flint, sulfur, pumice, calcite, and alabaster—which they used to enhance the shrines for their daily rituals and to embellish their personal appearance. While temples have been found at Çatalhöyük, most of the houses also contained shrine spaces and chapel-like decorations. The recurring images of religious subjects in the domestic settings give the impression that the inhabitants specialized in religion and that the entire city may have functioned as a pilgrimage site. Similar to the structures at Göbekli Tepe built a few millennia earlier, the houses and decorations of Çatalhöyük seem to have been inspired by the painted caves of the hunter-gatherers.

One entered the typical house through a hole in the flat roof, served by a wooden ladder (Fig. 1.1-11). The aperture doubled as a smokestack for the hearth and oven located directly beneath the entry. The interior atmosphere would have remained dark and cavernous. Occasionally, the houses included an open courtyard, which doubled as lavatory and rubbish dump. The house plans at Çatalhöyük were fairly uniform: each roughly 6 × 8 m (20 × 26 ft) with a single rectangular room, subdivided by a narrow, two-part storage space along one side and parallel, built-in platforms along two walls. One side served the men and the other the women of the household. They usually buried the dead (after their bones had been picked clean by buzzards) under the platforms.

The half-timber construction method used at Çatalhöyük remained a standard practice in this seismically challenged part of the world. A wooden frame of posts and beams divided the walls into a series of vertical slots filled with mud bricks and plastered over. The frame absorbed the **shear stresses** during a quake, while the mud was the most available material for thickening and patching up the walls. Rather than raise a defensive wall around the town, the inhabitants packed the houses tightly and protected themselves from the outside with continuous blank elevations penetrated by neither doors nor windows.

The social diversity of Çatalhöyük, a city that fostered merchants and artisans, encouraged the development of a complex religious life. Each house had its own shrine, and its walls were covered with religious imagery. The dead beneath the platforms remained like anchors holding the inhabitants to the place. The wall panels decorated with red plaster reliefs and paintings hearken back to the representations of wild animals found at Chauvet and Lascaux. The ritually active dwellers of Çatalhöyük incorporated the horns of wild oxen and the bones of other wild creatures into the benches and altars of their ceremonial platforms, infusing their dimly lit houses with the spiritual aura of the great caves. To dwell went beyond the need for shelter to become a sacred act.

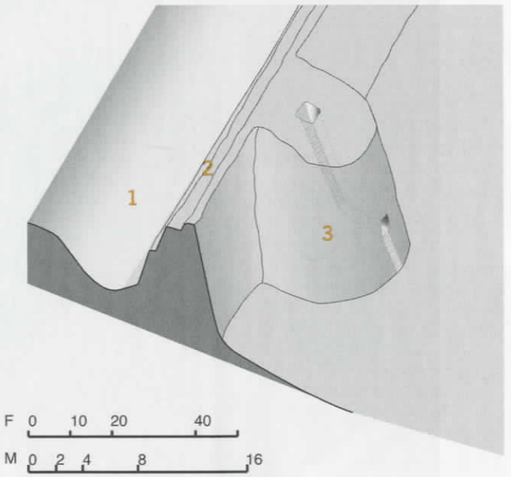

Figure 1.1-8 Jericho, ancient Palestine. (1) Ditch; (2) wall; (3) round tower with stair. Seventh millennium BCE.

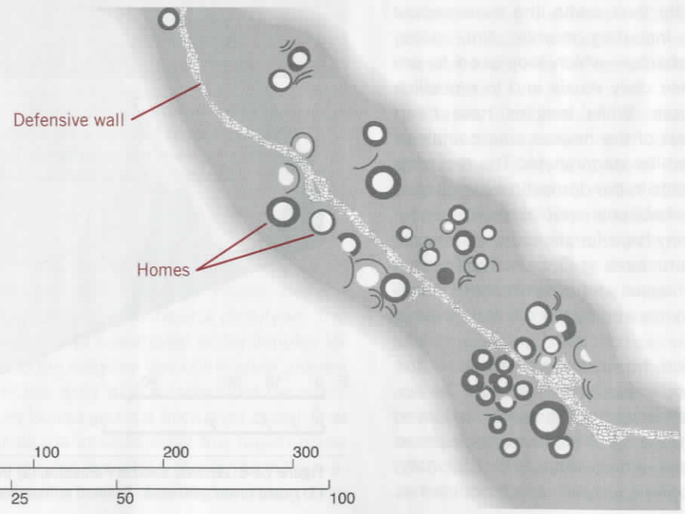

Figure 1.1-9 Khirokitia, Cyprus. (a) Street formed on top of old defensive wall, sixth millennium BCE. (b) Plan.

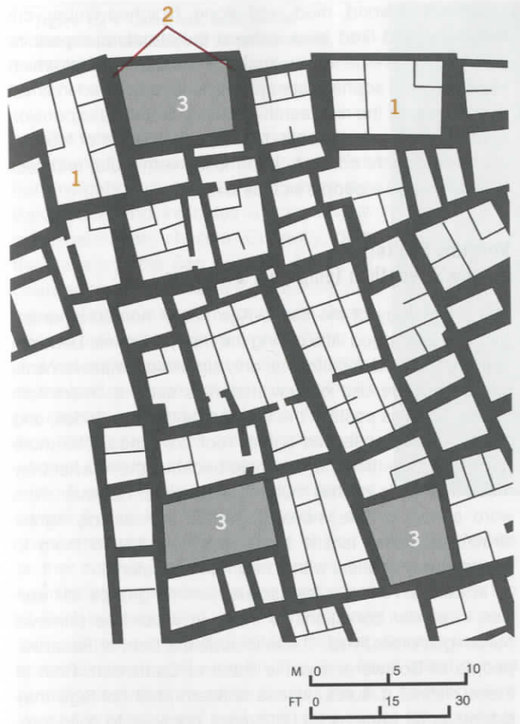

Figure 1.1-10 Çatalhöyük, southern Turkey. Plan of a district of the city, seventh millennium BCE, showing (1) individual cellular units with platforms and internal parapets, (2) party walls connecting individual units (there were no doors in these walls; inhabitants entered through the roofs), and (3) courtyards between units.

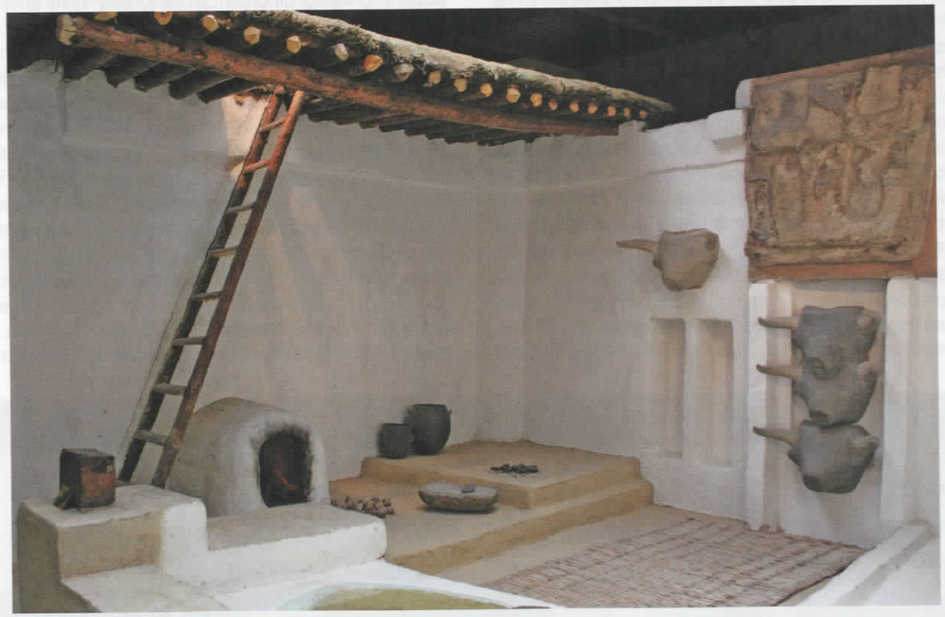

Figure 1.1-11 Çatalhöyük, southern Turkey. Reconstruction of a dwelling, seventh millennium BCE. Ankara, Museum of Anatolian Civilizations.

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1.2 VERNACULAR ARCHITECTURE
A Language of Mud, Logs, Hides, and Stones

Many animals—especially insects, birds, and fish—possess an uncanny instinct for building, rivaling that of humans. Animal architecture includes such structures as the common bee's hive, built as layers of hexagonal cells; the Australian compass termite's prodigious mud towers, more than head-height tall blades of mud oriented due north; the intricate canopies set between branches by weaverbirds; and the stone-lined pits of the jawfish. While humans doubtless share a similar genetic disposition to build, they differ from other animals in their capacity to go beyond instinct and learn how to build from others. Prehistoric designers at the outset imitated natural forms and, once they had established constructional processes, repeated and sometimes improved the solutions of previous generations. Builders borrowed tools and ideas from their neighbors.

While high-style architecture involves the patronage of elites and the skills of trained professionals and exhibits significant formal changes over time in response to religious and political pressures, the common buildings of vernacular architecture follow a plodding and constant evolution, like that of language. Vernacular architecture comprehends the traditions of building passed down from generation to generation. Unlike commissioned monuments, palaces, and religious structures, vernacular buildings respond to the local knowledge of materials, design, and construction. Thus, vernacular architects follow conservative building traditions but incorporate constant innovations meant to resolve the day-to-day problems of making shelter.

Vernacular builders invariably adapt to the constraints of regional materials and geological conditions. Both the nomad and the settled farmer, the two basic anthropological types of prehistoric humans, perfected their building methods through trial and error. Their creations ranged from the temporary shelter of tents and huts to more permanent structures in wood, mud, and stone. Notched timber, cut **masonry**, and fired brick entered the structural repertoire with the improvement of toolmaking. Glass and metal, which required more sophisticated processing, appeared in small quantities until the nineteenth century's industrial expansion made them more available. Like other elements of folk life, such as speech, cooking, and music, vernacular architecture reinforced a people's cultural identity.

Nomadic Shelter: Tensile Strength in Temporary Dwellings

The technology of the Stone-Age hut of nomadic hunter-gatherers changed little during the many millennia between Terra Amata and Jericho. The only significant improvements came from the use of new materials such as mammoth bones, used as posts in the Ukraine, and ropes, hides, and woven grasses used as tighter roof coverings. The more permanently settled that a people became, the heavier they made the walls of their huts. The nomads, however, who were always on the move, perfected increasingly lighter structures, using tensile strategies that allowed them to create sturdy shelters with a minimum of material.

In central Africa a few isolated ethnic groups still survive in similar conditions to those in which the primeval hunter-gatherers lived. These include the San, or Basarwa, people of Botswana and the Baka of Cameroon. Both of these distinct cultures, whose uninterrupted heritage may extend as far back as 20,000 years, continue to build temporary huts as they move through the wilderness. Although subject to vastly different climates, they both prefer half-dome structures made of intertwined branches, covered with woven grasses and leaves. The Baka live in *mongulu* huts (Fig. 1.2-1) built exclusively by the women, who weave slender branches into a thick arch stretching over a radius that comprehends the typical arm span of the famously short Baka. They insert parallel transverse poles into the gaps of the woven arch, bending them back as ribs to form the basket-like cup of a semidome. The Baka women then intertwine smaller branches laterally from rib to rib and attach the huge oval leaves of the mongongo tree to the exterior of the structure to create an impermeable covering. The same leaves, sometimes over 1 m (3.3 ft) in length, also serve as bedding. The Baka arrange their huts in a rough circle and live in them for up to three months before moving on. The late-twentieth-century introduction of rectangular versions of the hut derives from neighboring peoples with whom the Baka trade and indicates a transition to more permanent shelters. Currently, both the Baka and the San peoples are being coerced toward permanent settlement because of political and environmental objections to their hunter-gatherer way of life.

Figure 1.2-1 Cameroon. Baka hut, or *mongulu*, a semidome of woven branches, covered in mongongo leaves.

Most hunter-gatherer nomads lived lightly on the land, more interested in conserving its natural resources and the habitat of their prey than altering them. One can still observe the inherent economy of the nomadic way of life in the Tuareg people, who have crossed the Sahara Desert for millennia as traders and shepherds, carrying the elements of their temporary shelters on their camels. They raise their tents by throwing a canopy of sewn hides and woven goat hair over a central pole, at the top of which is a supporting ring. From this central turban-like point they pull ropes in a radial pattern, fastening them to wooden stakes laid out on a square plan. They then insert lateral, curved branches between the ropes to coax the skin covering into a dome-like canopy and pull more ropes across the outside to secure it against the wind. The strength of Tuareg structures relies upon the tensile forces of the coverings and the ropes. When the nomads move on, they fold up the hides and bind them into a package with the sticks and poles to be carried on a camel's back to the next campsite.

The indigenous nomadic peoples of North America achieved a similar elegance in their dwelling places, using a minimum of materials and causing little disturbance to the land. The *tipi* (Fig. 1.2-2), named after a Sioux word meaning "to dwell," required only a few minutes for its assembly. Sioux builders in the Dakota territories sank four straight poles into the ground at the points of a square, 2–3 m (6.5–10 ft) per side. The poles converged into an interlocking crux made firm by binding the neck joint with strips of bark. With this basic structure in place, a dozen other poles were set in a polygonal or circular pattern and leaned toward the apex. The tipi builders drew a conical covering of stitched buffalo hides over the frame, leaving an operable flap at the top to let the smoke out of the hearth and another flap to cover the entry at the base. Because of the prevailing western winds on the prairies, tipis frequently tilted to the west to brace against the elements. Like the Tuareg, the Native Americans of the Plains transported the basic ingredients of their dwellings with them as they moved across the continent.

Other nomadic peoples in North America, such as the Chippewa tribes, built domical **wigwams**, which served longer periods of settlement. Constructed of bent poles, the wigwam required more skill to prepare since the sapling branches had to be trained into shape. The arched ribs followed either a grid or a radial pattern, with a diameter of 3–4 m (10–13 ft). The structure looked like an overturned basket, with woven grasses, strips of bark, or sewn hides tucked into the ribs to keep out the elements. An **oculus**, a rounded hole at the top, served as a smokestack. The wigwam could be easily lifted intact and moved to another site. During seasonal migrations the occupants rolled up the coverings while leaving the skeletal frames in place for reuse when they returned to the site the following year.

The nomads of the steppes in Mongolia, Kyrgyzstan, Kazakhstan, and Turkmenistan build **yurts**, which are

TIME LINE

▼ **ca. 7500 BCE**

Ain Ghazal settlement (Jordan)

Dugout village in Banpo (China)

▲ **ca. 5000 BCE**

▼ **ca. 3000 BCE**

Skara Brae settlement, Orkney Islands (Scotland)

Adobe arch in Ctesiphon (Iraq)

▲ **ca. 500 CE**

▼ **ca. 1200 CE**

Hakka people's tulous *in Fujian Province (China)*

Mud-brick tower houses (Yemen)

▲ **ca. 1200 CE**

CONSTRUCTION, TECHNOLOGY, THEORY

Bone Huts of the Ukraine: Building as Body

The hut type first documented at Terra Amata underwent subtle changes over the years according to site conditions and availability of materials. Among Stone-Age huts, some of the most spectacular were built with the bones of the great mammoths at Mezhyrich near Kiev in the Ukraine. Dating from 20,000 to 15,000 BCE, the bone huts show a pragmatic variation on the basic type: the oval shelters were raised on the skeletal remains of the hunters' prey. A single hut with a roughly 5 m (16.5 ft) radius consumed up to 150 bones, including three dozen sets of mammoth tusks that served to frame the doorway and hold the roof. The hut builders of Mezhyrich imitated the symmetry found in the skeletons of their prey and in their own bodies. This bilateral order derived from an analogy to the biological body, one frequently made in vernacular architecture. Buildings represented bodies, and at Mezhyrich, they were literally composed of body parts.

Ukrainian bone hut, ca. 15,000 BCE.

larger, more sophisticated versions of the wigwam. A yurt requires such a large quantity of wooden poles that it might be considered a timber building. Yurt builders create a cylindrical base from a grid of diagonally set wooden poles raised to head height. They then place dozens of slender poles in a radial pattern on top of the perimeter wall and fasten them to a central oculus, which acts as a compression ring. They cover this umbrella-like frame, held up in the

Figure 1.2-2 Pine Ridge reservation, Dakota territories. Sioux tipi photographed by John Grabill in 1891, showing canvas flaps for chimney and entry.

CULTURE, SOCIETY, GENDER

The Primitive Menstrual Hut

The so-called primitive hut frequently appears as the basis of Western architectural theory. If one considers that almost all preliterate cultures practiced some sort of segregation of women, sending them to a menstrual hut during their periods, a social theory about gender can be attached to the primordial structures. Among the Dogon people in Mali (see Section 9.3), women are required to retreat to a menstrual hut, or *penulu*, during their monthly cycle. In a polygamous society this serves to keep track of who is fertile. The Dogon situate the *penulu* hut on the outskirts of the village, thus segregating the women. The antiquity of such a practice is preserved in the orthodox Jewish *mikveh*, the obligatory seven-day bathing requirement for women during menstruation, which goes back at least three millennia. While the ancient Greek physician Hippocrates considered menstruation to be a process of purification, the Roman historian Pliny the Elder, writing in the first century CE, expressed a more unsympathetic masculine bias, describing it as a form of impurity. Some argue that the segregation of women during menstruation became a source of empowerment for them in which they could celebrate their mystical connection with the lunar cycle, but the primitive menstrual hut generally enforced the subordination of women and remains an architectural legacy of the deep prejudices rooted in gender differentiation.

center by two slender columns, with substantial swathes of cloth, usually felt, and then lash ropes over it to bind the fabric to the roof.

Nomadic tents, quick to assemble and light, rely mostly on tensile strength. They achieve the goal of twentieth-century engineer Buckminster Fuller: to "make more with less" (see Section 20.2). Nomads travel with the ingredients of their dwellings the way others travel with clothing. Contrary to the significant alterations of the topography made by settled peoples, the flexibility of tents and huts allows the nomad to live lightly on the land, adjusting to its conditions without radically changing its ecology.

Building out of Earth

Unbaked mud provided the most common building material in the ancient world and remains very popular among traditional builders. Earth construction has both advantages and flaws. It is an incredibly flexible material, easily shaped and stiffened, but just as easily it loses its form when not protected from dampness or tremors. "Good boots and a nice hat," that is, stone footings and deep **eaves**, served as the traditional wisdom for protecting mud structures from moisture. To this one might add "a bit of makeup," such as bitumen-based or lime plaster, to help with impermeability. As to the vulnerability of mud structures to seismic tremors—they do not perform well unless reinforced with wood frames. The great tremor of 2003 in eastern Iran completely leveled the domes, towers, and houses of the ancient city of Bam, which was built exclusively of mud bricks. The magnificent **battered walls** of the fortress spread more than twice as thick as the upper wall at their base, anticipating the sliding forces of gravity, but unfortunately proved defenseless against lateral shear stresses.

One of the easiest ways to build with earth, and the safest protection from earthquakes, is to dig or cut into it. About 40 million Chinese people live in dugout houses in the northwestern Shaanxi Province just north of Xi'an, in an area as large as Spain known as the Loess Plateau. Winds and glaciers have packed the fine-grained silt and clay into solid, deep strata, so dense that trees do not easily grow on it. For three millennia builders have carved deep into the loess to make pit houses (Fig. 1.2-3) that yield an ideal thermal performance. They have cut some of the houses into the cliffs, which are accessed by ramps, while sinking others into the ground. They start the pit houses by carving out a courtyard 10 m (30 ft) deep and as many meters across. They then proceed to extract the rooms from the four faces of the court, as if they were cliffs. The entries into the loess dwellings are always through arches, and

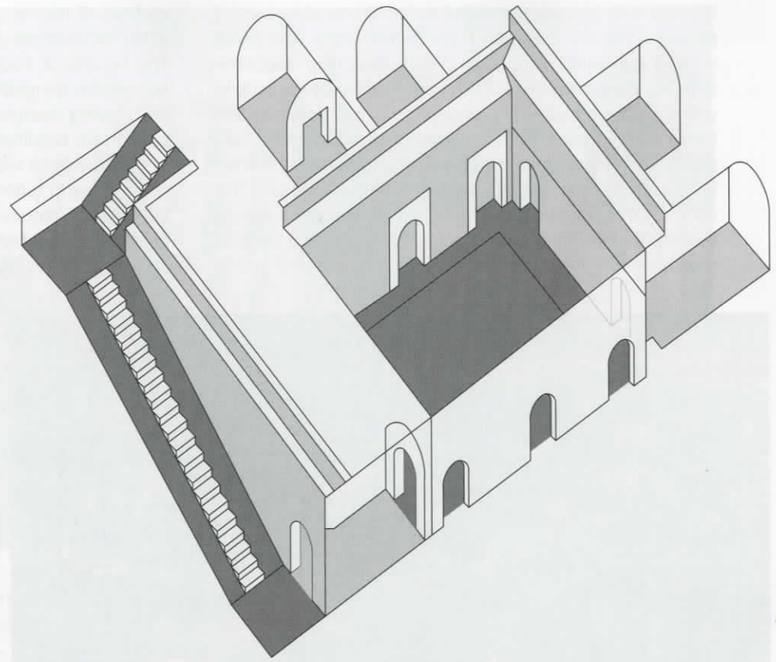


Figure 1.2-3 Loess Plateau, central China. Plan of cave house, or *yaodong*, dug into the dense soil. This typical earth dwelling has been used since the first millennium BCE.

the rooms are frequently carved with **vaults**, which have more compressive resistance than a flat beam or flat roofs. Rainfall in this region is scarce, making water retention the greatest problem. Pit-house courts do not have drains but attempt to collect the rainwater in cisterns.

Not far from the Loess Plateau, about 10 km (6 miles) east of Xi'an, lies one of the best-known prehistoric sites in China, the village of Banpo, with houses partially dug out of the earth. Dating from 5000 to 4000 BCE, the settlement supported about 500 inhabitants. Instead of building walls for their oval houses, the people of Banpo dug pits to a level of 1 m (3.3 ft) to serve as the walls. Pitched wooden beams were then set around each pit's perimeter to form conical roofs. Only the central building, which probably was used for assemblies, followed a different structural system. The builders of Banpo raised the rectangular hall 20 × 12.5 m (65.5 × 41 ft) off the ground on wooden posts. The fortifications of Banpo repeated the subtractive logic of the houses in the form of a deep ditch ringing the settlement.

While many Neolithic peoples dug pit houses out of the earth, geological conditions impeded others from doing so. Pit houses also have recurring problems with humidity. The next best method of building with earth involves mixing soil, water, straw, reeds, and leaves into balls that can be stacked. The piling up of mud balls is known as **cob technique** in English, and ***banco*** in West Africa, where until recently it was the most common form of construction. The

Batammaliba (roughly translated as "architects of the earth") people in the area between Togo, Burkina Faso, and Benin were documented during the 1970s designing and constructing *banco* dwellings. The villagers of Koufitoukou build walls as coils of mud balls, usually on circular plans. Each family's walled compound consists of several rounded huts that in form and decoration provide a metaphor of the human body, with the entry as mouth, the kitchen as stomach, the central hut as womb, and a great drain pipe as penis. *Banco* walls spread thicker at the base than at the top, and the process of molding their **elevations** resembles that of sculpting replicas of the body. The Batammaliba roof the huts with either flat mud-paved surfaces or conical bundles of straw. The houses of Koufitoukou need yearly replastering, and successive generations completely rebuild them as part of an ongoing tradition of dweller-architects, who in making biomorphic buildings narrate stories about themselves.

The two most widespread varieties of earth construction, rammed earth (often called by the French word ***pisé***) and adobe brick, require more skill and foresight. Rammed earth uses slightly moist earth poured into a rigid, wooden formwork and pounded into place, layer upon layer, with a heavy rammer.


a

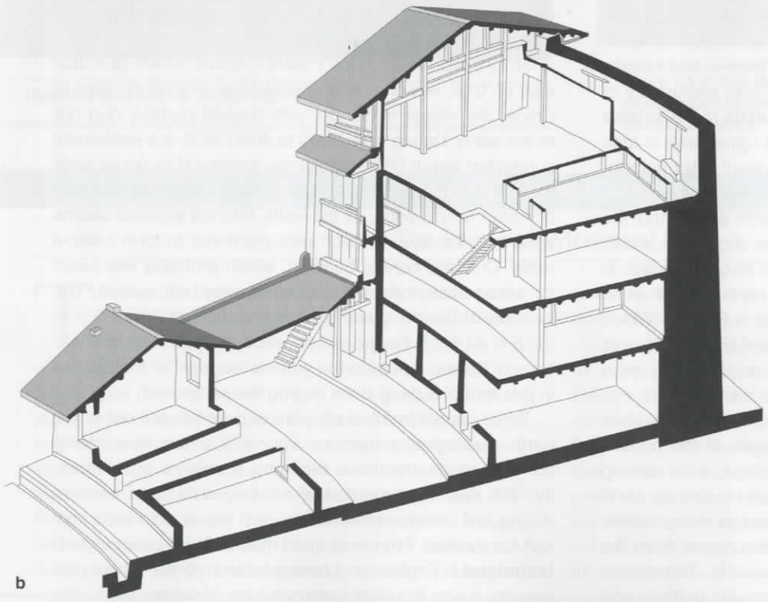

b

Figure 1.2-4 Chuxi, Fujian Province, China. (a) Hakka people's fortress houses, or *tulou*, made of rammed earth and dating as far back as the twelfth century. (b) Section.

The grand cylinders and cubes built as collective dwellings by the Hakka people in more than forty villages in Fujian Province, China, offer the largest and most beautiful examples. The village of Chuxi has five fortress-like compounds, known as *tulou* (Fig. 1.2-4a,b), built during the fifteenth century CE. As many as 200 rooms cling on wooden scaffolds to the solid mud perimeter walls. The occupants live in the concentric rows of structures built in the large open courts. The ingredients of *tulou* mud walls resemble a cake recipe, for in addition to clay-rich soil and straw, their builders included brown sugar, egg whites, and the juice of sticky rice to help bind the mixture. The outer wall, 3 m (10 ft) thick at its base and 1 m (3.3 ft) thick at the top, usually rose four stories high and was always set on a stone foundation to protect it from humidity. The absence of exterior windows on the first two levels indicates the defensive nature of the *tulou*. Their dwellers allowed only a single entry into these drum-shaped compounds, which could be carefully monitored.

Adobe, a Spanish word derived from the Arabic *al-tuba*, refers specifically to earthy substances shaped into unbaked bricks. Builders cast the earth mixture in rectangular bars, sometimes standardized through the use of wooden molds. After the bricks are sufficiently dried and hardened in the sun, they are laid in regular courses and bound together with mortar. The hand-molded mud bricks of Neolithic Jericho offer some of the first historical examples. The tradition of building with mud bricks continued in Southwest Asia, culminating in the immense stepped towers, or ziggurats, built during the third millennium BCE (see Section 2.1).

Figure 1.2-5 Sanaa, Yemen. Mud-brick high rises, sixteenth century CE.

The impressive mud-brick tower houses of Yemen (Fig. 1.2-5) derive from a centuries-old tradition. Their construction can be traced back to at least the twelfth century CE. In some cases the towers reach astounding heights of over 30 m (98 ft). The builders of Yemenite tower houses shape the frames of the windows and doors with mud thickened by white gypsum plaster, which can be carved into intricate geometric patterns like white lace after it sets.

In many semipermanent settlements in South America, Africa, and Asia, builders use wigwam-type frames to support a mud covering. The Fulani people, a minority group living in several different West African states, build their mud-walled huts on frames nearly identical to those of Chippewa wigwams. The sapling poles act as reinforcement for the thick mud walls, which are raised to head height. They then lay the domes over a skeleton made from lighter twined reeds that have been packed with mud and squared off, making them look like reinforced concrete beams. The Fulani's solidified wigwam huts suggest that the design of temporary nomadic structures served as the logical source for permanent architectural solutions such as the early round houses of Jericho and Khirokitia.

With skill and foresight builders can assemble mud bricks into sturdy vaulted coverings. Round houses built in Neolithic Southwest Asia probably had flat roofs made of reeds and plastered with mud, but in some cases they may have been covered with domes. Similar mud structures currently built in northern Syria often carry domes, whose mud bricks are placed in ascending spirals that gradually push in toward the center. During the 1960s the Egyptian architect Hassan Fathy (see Section 19.2) revived mud-brick vaults, known properly as "pitched" vaults, which can be built without expensive wooden scaffolds, or **falsework**, to hold them in place. The bricks are set in arching patterns on a 45° incline, which keeps them from slipping down. The great Arch of Ctesiphon, built by the Persian Sassanid regime in the early fifth century CE a few kilometers south of modern Baghdad, remains the most impressive adobe vault. Its shape is ovoid, similar to a modern **catenary arch**, like the inversion of a chain hung between two points. That the 25 m (75 ft) arch still stands speaks well of the spanning capacity and strength of mud bricks.

The Typical Structures of Spans

Baking mud bricks made buildings more durable. Fired bricks necessitated a greater quantity of materials, however, especially clay from quarries and firewood for the furnaces, which increased costs and required a more complex system of production. Standardized fired bricks were perfected by the third millennium BCE and used in both the Indus Valley and Mesopotamia. The orthogonal nature of bricks encouraged rectangular geometries that were more precise than the rounded forms created with mud. Building in the earth or out of earth has always been an organic process, and the forms became ready metaphors for bodies, but once designers started working with more specialized techniques such as fired bricks and drafted masonry, this meaning of architecture became less evident.

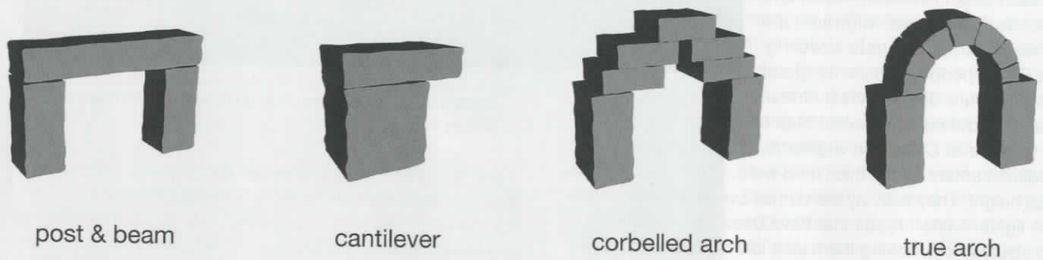
The Wooden Skeleton

The great forests of northern Europe initially provided a habitat and then the major building materials for the primeval settlers of the region, who usually lived in detached houses built of sticks and logs. Dozens of prehistoric sites show evidence of wooden **longhouses** (Fig. 1.2-6) built during the sixth and fifth millennia in a swathe of territory extending from the Black Sea to the British Isles. The longhouses of the village of Sittard in the Netherlands were structured on regularly spaced timber posts placed in parallel rows and braced at the top by roof beams. At Bylany, not far from modern Prague, there were over 100 houses, some up to 45 m (147 ft) in length, structured on five parallel rows of wooden posts. Boughs were woven around the exterior posts to create a basket-like wattle for the walls, which were then plastered with mud daub. The roofs of these **wattle-and-daub** structures were pitched to shed rain and snow and covered with either thatch or turf. The hearth was usually in the middle of the long central space, with a corresponding monitor cut in the roof overhead to admit light and vent the smoke. The designers divided the aisles into

CONSTRUCTION, TECHNOLOGY, THEORY

Tension and Compression

All architecture struggles with gravity, using the forces of **compression** and **tension**. The first pushes down with its weight to stabilize the mass of a building, while the latter pulls in opposite directions. All structures need to control the downward pull of the forces of gravity and the lateral stress of wind and shear forces. Compression responds to the weight of mass pushing down and out. The walls of vernacular buildings are thus often twice as thick at the base as at the top. Tension exerts horizontal stresses like the elastic pull of a taut rope, allowing one to reduce mass. In the conventional **post-and-beam** (or **post-and-lintel**) structural system, the walls and columns support a horizontal member that spans between walls or columns. The span favors the sort of tension found in fibrous materials like wooden beams. The tensile strength of spanning members can be assisted by a **cantilever**, an overhang beyond the supporting wall or column, which typically extends a third of the length of the member. Cantilevers can be used to stack stones or logs into corbelled arches or vaults, the components of which progressively step in toward the center as they rise until they reach a capstone that seals the system. The **true arch** developed from corbelled arches is among the strongest spanning methods. These arches are made of tapered masonry blocks, called **voussoirs**, which are arranged radially, each piece pushing against the next in total compression.



Structures of spans.

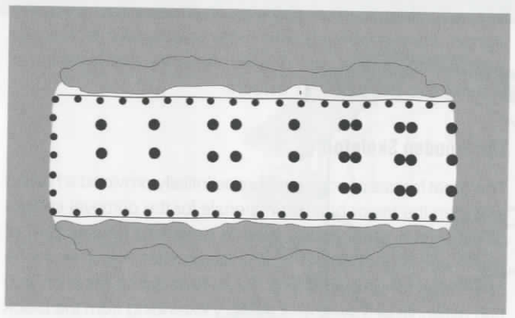


Figure 1.2-6 Cuiry-lès-Chaudardes, France. Plan of European longhouse, Neolithic period, ninth–fourth millennium BCE.

bays that served as stalls to shelter the livestock. Men and domesticated animals shared the dwelling. Like mud buildings, wooden buildings utilize organic materials, but the shape and stiffness of wood favors orthogonal geometry because of the natural right angles of intersecting timbers.

Variations of the Neolithic longhouse type have been found at European sites as widely spread as France, Norway, Romania, and Greece. Their configurations are not identical in terms of the positions of structural members. For instance, some have ridgepoles running down the center, while others have parallel posts along the sides. The timber used in their construction, which has not survived, was probably joined by tying the members together. The top of the posts may have been forked to receive the crossbeams. Builders could not make accurate notches for diagonal **braces** and **mortise-and-tenon** joints until the introduction of metal tools. Mortise-and-tenon members fit a tapered ridge into a gouged-out groove. The longhouse builders invariably made rectangular structures, which were at least 10 m (33 ft) long, with spaces reserved for farm animals either at one end or along the sides.

In heavily timbered areas the Neolithic craftspeople made their longhouses with split logs or planks and occasionally added masonry walls when there was a ready supply of stone. They used thatch roofs made of branches and grasses almost universally, leading to highly flammable and insect-ridden environments. The houses were usually grouped in clusters of five or six, with each one thought to serve an extended family of twenty to thirty members. A Neolithic longhouse discovered in Mold, Austria, extended 80 m (262 ft) and would have accommodated an even greater number of residents under the same roof. The type endured for millennia among the peasant communities of Europe and was still being built in the thirteenth century CE.

The longhouse, as a single container for a large extended family and its animals, appeared in many other cultures outside Europe, including Southeast Asia and North America,

Figure 1.2-7 Reconstruction of an Iroquois longhouse, typical of the fifteenth century CE. Royal Ontario Museum, Toronto.

with similar social implications. The grass-covered, open-sided version in Borneo at Sarawak stretches nearly 60 m (197 ft) in length, with three rows of parallel posts. The Iroquois tribes built a 110 m (360 ft) long structure around 1400 CE at Howlett Hill near Syracuse, New York (Fig. 1.2-7). They made the walls of the structure from a palisade of slender posts between which they wove a bark covering and ran two parallel rows of thicker columns down the center to help support the vaulted roof. The structure may have housed up to 200 people.

The other major vernacular type of wooden building rises on stilts. Neolithic villagers along the Swiss lakes at Egolzwil built their modest wooden houses on raised piles to protect them from sudden floods. Measuring 3.7 × 9 m (12 × 29 ft), the stilt houses had timber floors, and their frames were among the first to be connected with mortised joints. Stilt houses continue to be a popular type in alluvial areas of Southeast Asia.

The timber-frame house possesses some of the expediency and tensile virtue of the temporary huts built with poles. Like the skeleton in the bodies of vertebrates, the timber frame absorbs most of the stresses that bear upon the structure. Not all regions possess abundant supplies of wood, but where there were great forests, such as in Eastern Europe and Scandinavia, it became the prime building material, leading to the construction of log cabins and plank houses. The Navajo in the American Southwest made their houses, or *hogans*, of unstripped logs without notches. For the oval version of this type the men tilted the logs toward the center in a manner close to the style of the huts of Terra Amata. The women built their version of the hogan as a spiraling hexagon. They corbelled the logs toward the center to create a dome with an oculus that let out the smoke. Lumber was used almost like piles of stone.

Wooden frames, while subject to fire and rot, proved particularly resilient in seismic locations and thus became the preferred construction method in places like Japan, California, and Turkey. Often, a combination of wooden frame with stone or mud infill, seen in the ancient houses of Anatolia at Çatalhöyük, transferred the flexibility of one material to the other in half-timber construction.

The **cruck frame**, found mostly in England, appears as one of the most primitive and spectacular versions of the wooden skeleton. The principal structural members of this type came from large trees that, instead of being milled into flat posts, were left in their natural state, split down the middle, and then pitched one half against the other into an arch shape. The effect recalls the mammoth tusks of the Ukrainian bone huts, resulting in a series of monumental pointed arches formed out of its rib-like structure.

While no examples of prehistoric wood joinery have survived, the various representations of wood sculpted in stone, seen at Stonehenge in Neolithic England, Saqqâra in ancient Egypt (see Section 2.2), and the Parthenon in classical Greece (see Section 4.2), give some indication of its ingenuity. Greek artists depicted wooden dowel pegs on their temples, while the builders of Stonehenge simulated the interlocking mortise-and-tenon method of joining timbers in which a projecting tongue (tenon) of one member fits into a hole (mortise) of corresponding shape in another member. The disposition of standing tree trunks, first seen in the Neolithic longhouses, established the basis for the systems of **columns** used in Chinese, Persian, and Western classical systems of architectural order.

Of Stones and Compression

While the majority of Neolithic builders used some combination of mud, sticks, timber, animal hides, and woven grasses, they chose stone, which was almost always available, for

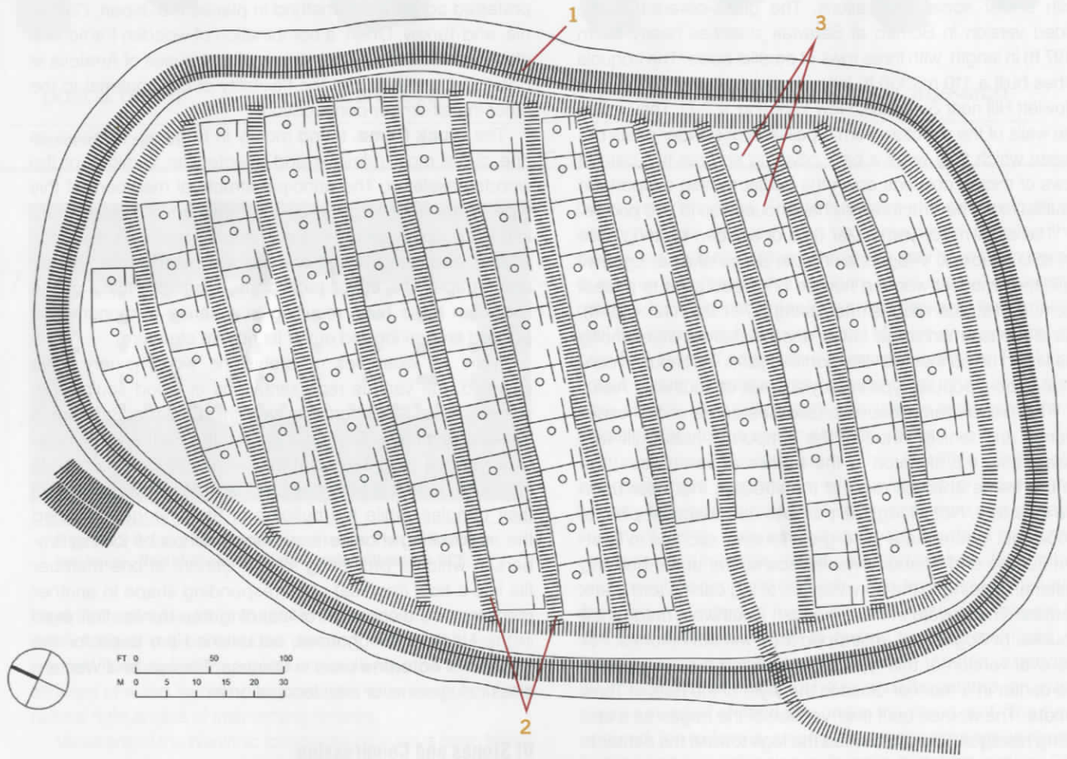
foundations, buttressing, and the hearth. Stone required the assistance of skilled masons to obtain and prepare, but it promised many advantages over the other materials, especially in its resistance to fire, the perennial destroyer. When Neolithic societies created religious structures, they usually chose stone as their medium for its permanence.

In some regions that have a ready supply of loose stone, such as the Orkney Island coast in northern Scotland, masonry construction became the easiest way to build. The small village of Skara Brae, built around 3000 BCE, consisted of eight small stone houses linked by stone-lined alleys that formed a compact organism (Fig. 1.2-8a). The problem with building in stone comes from the degree to which it must be dressed, or sculpted, in order to fit one stone with the next. At Skara Brae the local supply came from a granite shelf that left loose stones in brick-like shapes, making it relatively easy to construct solid dry walls without mortar (Fig. 1.2-8b). Each of the small houses had a single

CONSTRUCTION, TECHNOLOGY, THEORY

The Ancient Wooden Town of Biskupin

Despite the perishable nature of wood, several well-preserved ruins of ancient timber architecture in Eastern Europe reveal the millennial practice of wood joinery. The foundations of a Neolithic wooden village at Lake Biskupin, Poland, built during the eighth and seventh centuries BCE, lay protected under the viscous mud of its island site until discovered in 1933. The prehistoric lumbermen assembled Biskupin's ramparts as **blockwork** boxes, 3 m (10 ft) on each side, filled with mud and rubble. The oval wall enclosed 105 identical row houses arranged on twelve parallel streets paved with logs. Each of the log houses at Biskupin was built facing southeast, with an exterior porch and an internal hearth. Such urban regularity presages that of ancient Greek towns such as fifth-century-BCE Olynthus (see Section 4.2). The same construction technique of interlocking logs used in the Bronze Age endured well into the modern age throughout Eastern Europe (see Section 10.2).



Biskupin, Poland. Reconstruction of Neolithic log houses and town plan, ca. 500 BCE, showing (1) ramparts made of blockwork boxes, (2) log-paved streets, and (3) row houses.

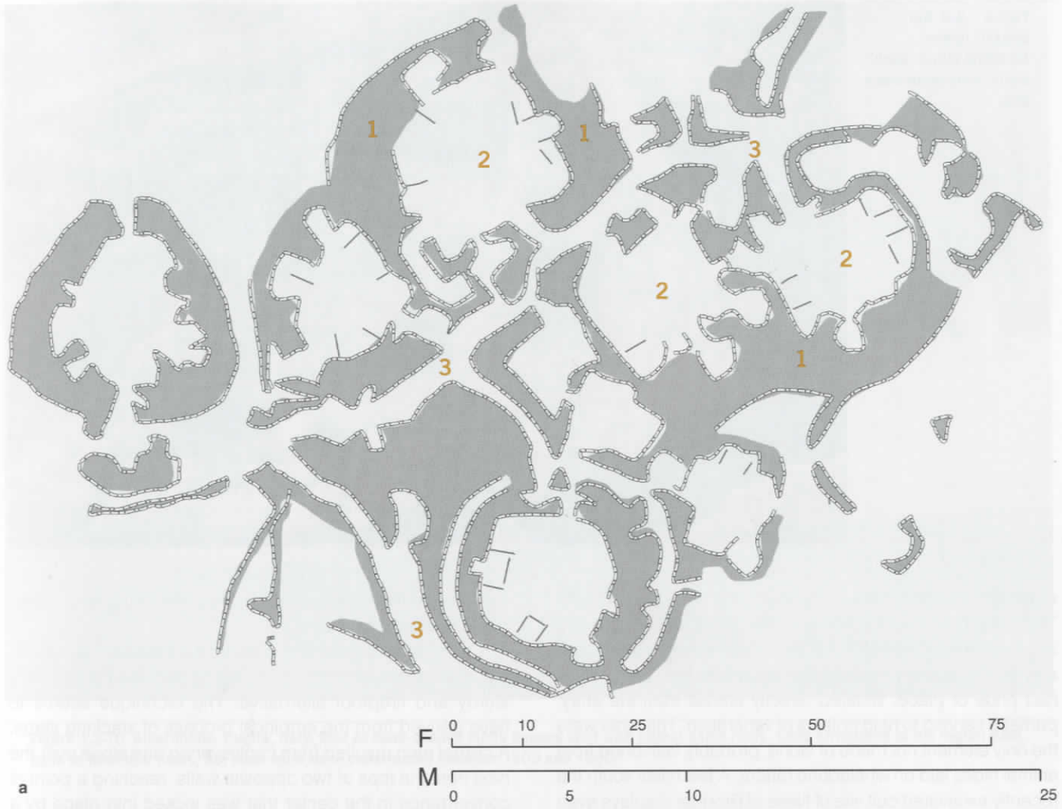


Figure 1.2-8 Orkney Islands, Scotland. Skara Brae, ca. 3000 BCE. (a) Plan, showing (1) thick walls built of dry-wall masonry, (2) individual lodgings featuring built-in furnishings made from stone slabs, and (3) narrow paths connecting the dwellings as a community. (b) Dry-wall masonry from brick-sized stones.

Figure 1.2-9 Ain Ghazal, Jordan. Neolithic stone "sack" walls, sixth millennium BCE.

room with rounded corners, typically 4 × 5 m (13 × 16.5 ft). The builders placed the hearth in the center of the room and used stone for all of their furniture, including beds, seats, and a system of shelves made of thin, broad panels. The shelves had pride of place, situated directly across from the entry, perhaps serving to hold objects of veneration. The roofs were the only element not made of stone, probably fashioned from animal hides laid on whalebone rafters. A few miles south the recently excavated cult site of Ness of Brodgar displays even more meticulous stone joinery of the same date, painted and decorated with reliefs and apparently topped with flagstone roofs. These temples were no doubt the progenitors of the great stone circle of Brodgar, built a few centuries later.

At Ain Ghazal, Jordan, a settlement built during the seventh millennium BCE and thus contemporary with Neolithic Jericho, the inhabitants constructed their houses of rectangular **sack walls** (Fig. 1.2-9). A sack wall is a sandwich of two outer layers of stone stuffed with mud and rubble infill. Such a system allowed builders to obtain a thick wall with much of the mass of mud construction while leaving a hard, impermeable exterior surface. Most of the structures at Ain Ghazal had squared-off corners, suggesting that cut stone often leads to orthogonal solutions.

The roof—usually built of organic materials (such as branches woven together), plastered with gypsum, and supported by wooden posts and beams—proved the weakest part of prehistoric houses. The caves of the nomads held solutions for a more solid way of spanning interior space. The easiest way to cover a room was to lay a solid slice of stone on top of two upright walls. The dolmen megalith tombs (see Section 1.3) built across Europe, Africa, and Asia during the third through the first millennia BCE offered ready examples, illustrating both the solidity and the limits of such a method, since slabs of stone rarely reach more than 3–4 m (10–13 ft) across. The megalith builders also had the extremely difficult task of transporting and lifting such spanning members into place.

One means of spanning involved the **corbel** (Fig. 1.2-10), introduced around 3000 BCE, which provided a relatively sturdy and fireproof alternative. The technique seems to have derived from the empirical process of stacking slabs. A corbel arch resulted from cantilevering one stone over the next from the tops of two opposite walls, reaching a point of convergence in the center that was locked into place by a **capstone**. A corbel vault could be formed by making a continuous series of corbel arches and a corbel dome by rotating a series of corbel arches around a central vertical axis. The various round stone houses with corbel roofs found around the Mediterranean, including the *trulli* of Puglia in southern Italy and the *borie* in southern France, hark back to the building techniques of Neolithic masons.

Neolithic masons shaped and dressed stones using stone axes and obsidian knives in a labor-intensive and imprecise process. They rendered the stones for the great megalithic works, such as the *T*-shaped monoliths at Göbekli Tepe, by adjusting to the forms offered by nature rather than completely controlling the form. They could sculpt limestone using tools made of harder stone, as some of the beautifully detailed temples on Malta indicate. In the Americas, where builders did not have metal tools until European contact during the sixteenth century CE, several cultures, such as the Mayans on the Yucatán Peninsula and the Inca of Peru, created impressive stone masonry joints with their limited stone tools.

In general, however, it was only with the introduction of metal tools that stonework became more precise and refined. As the masons perfected their craft, they used the clean lines of geometry to organize the laying of stones and draft perfectly rendered surfaces. The skill and theoretical knowledge needed to cut and design stone led to a class distinction among builders that elevated the chief masons

Figure 1.2-10 Alberobello, Puglia, Italy. Row of cone-shaped stone houses built with corbel dome roofs. Cone structures in the region date back to Neolithic times, but most *trulli* were constructed between 1500 and 1900.

with their "Masonic" secrets into the priestly caste. The high-style buildings commissioned for religious, princely, or community functions served an ulterior symbolic purpose that went beyond the expedient needs of shelter. In most parts of the world, such projects became the task of specialists working with stone masonry and the art of its assembly and decoration. Trained architects designed works intended to serve collective memory, which, unlike vernacular buildings, were built to endure beyond the span of a human life.

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1.3 MEGALITHS AND STONE CIRCLES

Building as Memory

The formal distinction between high-style architecture and vernacular building comes from the difference in intention. The program for monumental architecture arose when communities desired to commemorate their forebears and was continued later when powerful patrons sought ways to mark their status. Rock formations and stone construction, because of their greater endurance, became forms of materialization of human memory. All cultures, once they became relatively settled, longed to remember their dead, and throughout the prehistoric world they raised stones and covered mounds as conventional markers of the deceased. The ***dolmen***, a chamber made from two **monolithic** side stones capped by a monolithic roof stone and then covered with earth, became a conventional tomb for important persons, found in places as distant from each other as England and Korea.

Prehistoric tomb sites inspired religious ceremonies, leading to the construction of stone and mud-brick temples and shaped landscapes. The earliest builders preferred to make rounded works reminiscent of the atmosphere of primordial painted caves. As they became aware of the sun's behavior and the movements of the celestial bodies, they began to design open landscapes to register the cycles of the heavens. By setting stone markers aligned to astronomical phenomena, they attempted to link human destiny to a greater cosmos in the sky. The prehistoric cults used megaliths and stone circles as a theater of memory for uniting themselves to the experience of all who had come before and all who would follow.

Menhirs, Dolmens, and Cairns: To Honor the Dead

Architecture became an act of communication when groups of prehistoric dwellers joined together to pile up stones for a collective purpose. Adolf Loos, a twentieth-century architectural thinker from Vienna, put it this way: "You find a rise in the ground, two meters long and one meter wide, heaped up in a rough pyramid shape, then you turn serious, and something inside you says: someone lies buried here. That is architecture." The need to commemorate the dead instigated the earliest design of monuments. **Megaliths**, large stones dragged across the land and erected as markers, acted as icons for remembering the lives of those who came before. The earliest megaliths almost always served to mark burial sites. The designers selected the stones for their impressive scale and usually left them in their raw state. While this was due partly to the megalith builders' poor tools for sculpting the rocks, it also was a form of reverence for the irregularly shaped stones as expressions of the sacred forces of nature.

Megalith markers have been found on all continents and were particularly common in the years 4000 to 1000 BCE. Their dating remains problematic, as there are no written traces and few remains of these structures that can be tested with radiocarbon methods. One of the greatest collections of megaliths appeared in northwestern France, in Brittany, where the stones set in the ground were known as ***menhirs*** (meaning "raised stones"). The towering Menhir Brisé ("Broken Menhir") at Locmariaquer once stood 21 m (69 ft) high but now lies in four pieces on the ground. The technology for lifting this 350-ton mast served as the silent partner of design, a process that left few clues behind. One can only guess about the use of ropes, log levers, and earthen ramps to slip such a massive and bulky stone into its deep foundation hole. It surely required the group effort of hundreds of people, and as a landmark, once visible from great distances, the Menhir Brisé established the focus and identity for the regional community.

Not far away, in the farming town of Carnac (Fig. 1.3-1), lie four large fields of menhirs. The alignments of these funeral landscapes, dated between 4000 and 2500 BCE, suggest usage for mass ceremonies. One of the fields, Le Menec, possesses over 1,000 megaliths of local granite arranged in parallel lines that extend for 1.5 km (ca. 1 mile; Fig. 1.3-2). The dozen rows run east by northeast toward a rounded terminus. As they reach the circle, the megaliths grow in height from 1 to 4 m (3.3 to 13 ft) and shift their angle of alignment. Kerlescan, another field of megaliths at Carnac, has a few hundred menhirs arranged in a fanning series of lines. The stones get taller as the alignment widens, reaching a final height of 3 m (10 ft). They guide a procession toward a rectangular plaza 80 × 90 m (262 × 295 ft), shaped on three sides by megaliths and on the fourth by a burial mound. While the great stones initially served as burial markers, their function evolved into pieces of an astronomical observatory. The stone avenues at Carnac offered an intermediate architectural experience between openness and enclosure. The shadow-casting megaliths created a place for the community both to remember those who came before and to contemplate their connection to some greater collective destiny determined by the heavens.

During the same period between the fourth and third millennia BCE at Monte d'Accoddi near the northern coast of Sardinia a stepped pyramid accessed by a 40 meter long ramp lined with megaliths showed a similar interest in astronomical alignments. While the top platform was used as an altar for sacrifices, the structure's perfect northern orientation implies that it functioned as an observatory.

In contrast to the openness of the freestanding menhirs, Neolithic builders also created closed, cave-like spaces for their tombs. The basic tomb type, the dolmen, was a simple box-like chamber covered with earth. In its starkest form the dolmen comprised two lateral megalith slabs supporting a horizontal capstone. This **trilithon**, or three-stone assembly, embodies the most rudimentary principle of architecture, the post and lintel, that is, two columns holding up a horizontal bar of **trabeation**. The mourners would have placed the remains of the dead under the dolmen's bench-like space, a chamber just large enough for two standing figures. Although dolmens appear today mostly as freestanding stone structures, they were intended to be covered with earthen mounds.

Many dolmens, such as the Chianca Dolmen (Fig. 1.3-3) near Bisceglie in southern Italy, were approached by an articulated pathway lined with a continuous series of **orthostats**, or broad, flat stones. This privileged axis became the **passage tomb**, common in the larger **tumulus** gravesites of Neolithic times. The designers of these great mounds of stone and earth, known as **cairns** in the British Isles and northern France, created tunnels made of linked dolmens leading to an interior vaulted chamber. One of the oldest cairns, the great oblong pyramid of Barnenez (Fig. 1.3-4), dating to around 4500 BCE, stands on a promontory overlooking the Bay of Morlaix in the Finistère area of Brittany. Eleven passage tombs line up parallel to each other inside the mound and terminate in corbel vaults nearly 5 m (16 ft) high. The burial chambers at the end of the passages served as multiple tombs. Similar mounded cairns accessed by orthostat-lined passages that terminated in a domical space appeared throughout Europe from Los Millares in southern Spain to Newgrange in Ireland, indicating that invasions by groups such as the Beaker people and trade led to a pan-European cultural synthesis.

The mounded tombs at Newgrange, 50 km (30 miles) north of Dublin, were built around 3000–2500 BCE (Fig. 1.3-5a). Even though the builders' Celtic successors of the first millennium no longer knew the figures to whom the mounds were dedicated, they called the largest "Brú Oengusa," or house of the son of the Dagda, the king of the pre-Christian gods. This impressive pile, the grandest of over 150 cairns in Ireland, spreads over an 80 m (256 ft) diameter. It sits amid a diffused necropolis, within walking distance of two other similarly scaled cairns. Although more regular in shape than

Figure 1.3-1 Monumental sites in Neolithic Europe.

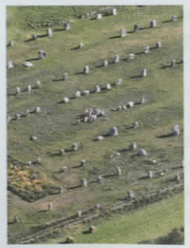
TIME LINE

▼ **ca. 4500 BCE**

Cairn at Barnenez (France)

Carnac (France) fields of upright megaliths

▲ **4000–2500 BCE**



▼ **ca. 3600–2500 BCE**

Hagar Qim, Malta, rounded stone temples

Stone circles and megaliths (northern France, Ireland, and England)

▲ **ca. 3500–1000 BCE**

▼ **3000–2500 BCE**

Cairns of Newgrange, near Dublin

Avebury stone circle and Silbury Hill (England)

▲ **3000–2500 BCE**

▼ **3000–1600 BCE**

Stonehenge circle made with trilithons

Figure 1.3-2 Carnac, Brittany, northwest France. Aerial view of Le Menec alignments, ca. 2500 BCE.

Figure 1.3-3 Bisceglie, southern Italy. Chianca Dolmen, ca. 4000 BCE.

Barnenez, the Newgrange mound was by no means a product of calculated geometry. The designers defined its perimeter with a continuous series of ninety-seven megaliths set on their sides as a girdle of orthostats, yielding a rough, heart-shaped circle. They inserted a smooth **revetment** of gleaming white quartz masonry at the entry and inscribed most of the curbstones with spirals, **chevrons**, grids, and other abstract patterns commonly found in the painted caves.

At Brú Oengusa the artisans lined the interior passage with a series of dolmen-like megaliths. The path gently rises to a cruciform-shaped central chamber with three niches, 6 m (19.5 ft) across and 6 m high. The corbels of the vaulted ceiling form a conical shape. It took great foresight to leave a special window above the **transom** of the entry (Fig. 1.3-5b), which allows rays of sunlight to penetrate the passage to the center for twenty minutes each day during the winter solstice, a sure sign that the celebrants intended the monument as more than a tomb. They also raised a ring of thirty-eight standing megaliths, twelve of which are still upright, around the mound at regular 10 m (33 ft) intervals. These added features at Newgrange demonstrate that Neolithic communities moved from the cult of the dead toward a concern for sacred time, turning their

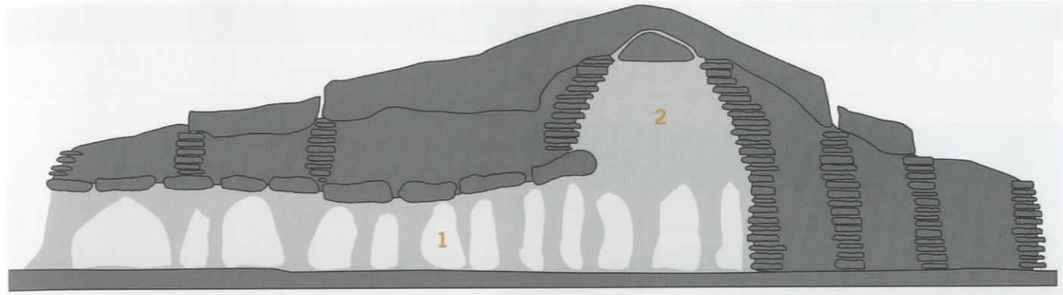


Figure 1.3-4 Barnenez, France. Section of a typical cairn tomb, ca. 4500 BCE, showing (1) main passage lined with raw megaliths, and (2) the central tomb space made with a corbel vault and closed with an immense capstone.

tomb structures into temples for observing the behavior of the celestial bodies.

Malta: The Roundness of Architecture

The prehistoric communities in the Maltese islands, located 90 km (56 miles) south of Sicily, produced an extraordinary collection of enclosed megalithic temples, built between 3600 and 2500 BCE. How these primordial places of worship came to be built in such a remote setting remains as mysterious as why their rounded forms had so little influence on the future of monumental architecture, which developed in almost all cases into a system of orthogonal geometry. The population on the two major islands of Malta and Gozo probably never exceeded 5,000. Their isolation from wild beasts and invaders, combined with a reasonable alimentary surplus from fishing and agriculture, allowed the Neolithic Maltese a certain advantage in the development of their cult sites.

All of the twenty-three temples on the Maltese islands correspond to a single design concept, seen in the complex of Hagar Qim (Fig. 1.3-6). Maltese designers began with a pair of rounded apses, which over time they multiplied, in a process similar to cell division. During a final phase they surrounded the curving cells by a layer of thick walls lined with megaliths. The outer walls of Hagar Qim rose independent of the interior, like a ring around the whole, leaving a sizable ***poché*** filled with rubble and smaller stones that in places stretched more than two body lengths across. They oriented the entry toward the rising sun and created an articulated threshold, capped on the exterior by a double row of horizontal spanning stones. This impressive concave facade, similar to facades at several other Maltese temples, provided stone benches at its base and opened to a paved plaza where people could gather. The designers seem to have conceived of the temple as a place of assembly for congregations in mourning, pilgrims seeking good fortune, supplicants with physical ailments hoping for relief, and prospective mothers longing for fertility. The votive offerings found at the site—ceramic statues of obese women, body parts, and horns—imply the undertaking of such quests.

On either side of the entry into Hagar Qim the architects made lobe-shaped rooms by propping up perimeter orthostat walls of linked megaliths. Their craftspeople tooled the stones with great precision, leaving smooth joints between the stones and the recessed doorjambs. They plastered the walls in deep red tones to make them appear as continuous surfaces. Hagar Qim expanded during the course of the third millennium into a total of eight apses, interspersed with tiny side rooms thought to have been oracle chambers. The radius of each apse never exceeded 8 m (26 ft), a dimension probably determined by the limited spanning technology for the roofs. Although the roofs of these Maltese temples have completely disappeared, leaving the interiors exposed like courtyards, there is evidence of corbels at the top of the walls. Like the vaulted chambers inside passage tombs, the Maltese temples would have been roofed over with slabs of stone arranged into corbel vaults and then covered with turf. The interior atmosphere, without windows and with the walls plastered in red oxides, would have exuded mysterious, cave-like darkness.

The curving apses of Maltese temples seem to have been inspired by the great underground cemetery, or Hypogeum, at Hal Saflieni, where over thirty scooped-out chambers on three separate levels served about 7,000 graves. The niches in this multilevel grotto, many of them similar in shape and scale to the lobed spaces of the outdoor temples, served as sites for rituals honoring the dead. Some of the ceilings of the Hypogeum were carved like the negative of a stepped pyramid, hinting at the presence of corbel vaults that once covered the outdoor temples. The Maltese craftspeople subdivided the Hypogeum with walls and special doors placed in front of the niches. At some early point the celebrants used the cave to pursue two functions—the burial of ancestors and the propitiation of their spirits so that the dead could influence the good fortune of the living. In the apses of the outdoor temples, celebrants would have repeated the ceremonies begun in the underground niches of the Hypogeum.

The tiny "oracle chambers" nestled in the thick *poché* between the interior and exterior orthostats at Hagar Qim suggest the complex ritual use of the temples and the development of a hierarchical priesthood. Accessed by secret doors, these chambers would have allowed the oracle to speak through tiny square slots cut through the panels. Altars for votive offerings in some of the apses received the


a

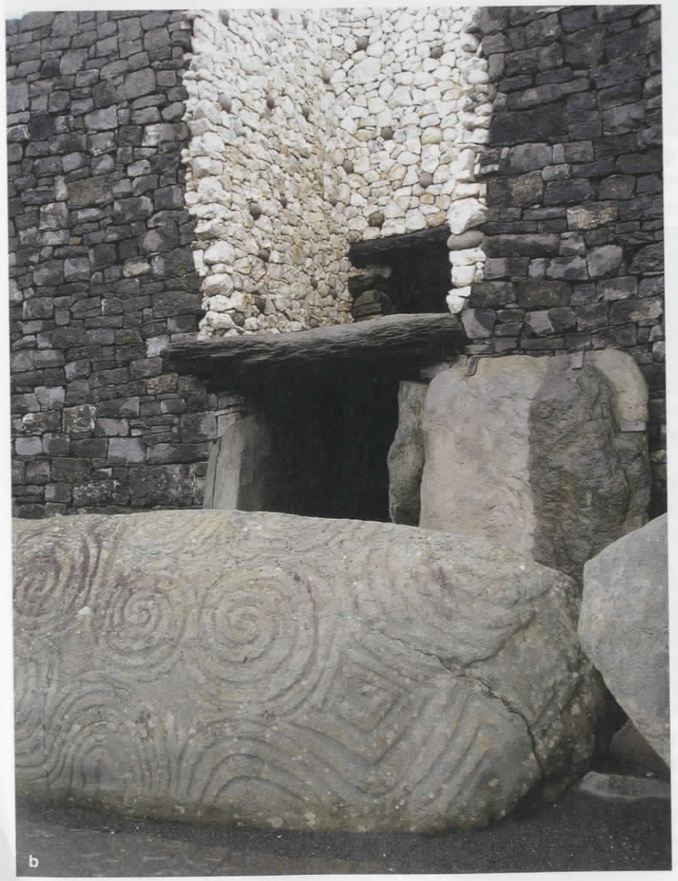

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Figure 1.3-5 Newgrange, Ireland. Mounded tombs, ca. 3000–2500 BCE. (a) Side view of the mound covering the passage tomb. (b) Entry.

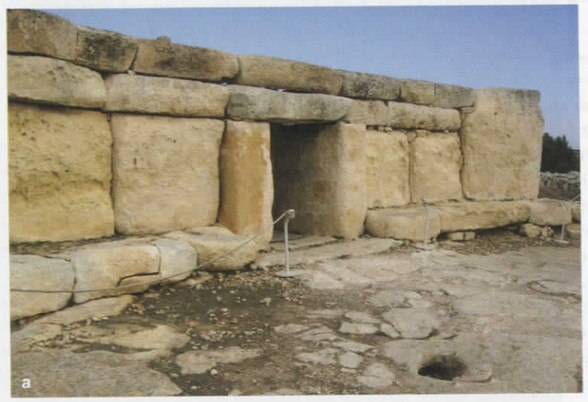
most detailed sculptural treatment, raised on single pillars and carved with special images such as a palm-tree motif or delicate foliated spirals. The numerous representations of obese women, in one case a statue twice human height, suggests a cult of a mother goddess; but without written texts, one can only guess at the meaning and ritual life of the place. Certainly, the inhabitants made sacrifices of animals and perhaps humans there. Libations would have been poured into holes in the paving as gestures begging for divine intervention.

Within the dark sanctuaries of Malta, a devout Neolithic culture enacted its sacred rites of pacifying the dead, curing the sick, and ensuring fertility. The ancient Maltese made their sacrifices and listened to oracles uttered by mysterious voices through tiny slots from within concealed chambers. The sick and the crippled came to sleep in the wonder-working embrace of the temples in the hope of regaining their health. These shrines comforted and healed the islanders until sometime around 2500 BCE, when invaders overran Malta and left the rounded temples to fall into ruin. The sensuous curves of Maltese architecture almost completely disappeared from the religious architecture of successive cultures in the region, perhaps

CLOSE-UP

Figure 1.3-6 Malta. Hagar Qim, ca. 3600–2500 BCE.

(a) Concave orthostat façade.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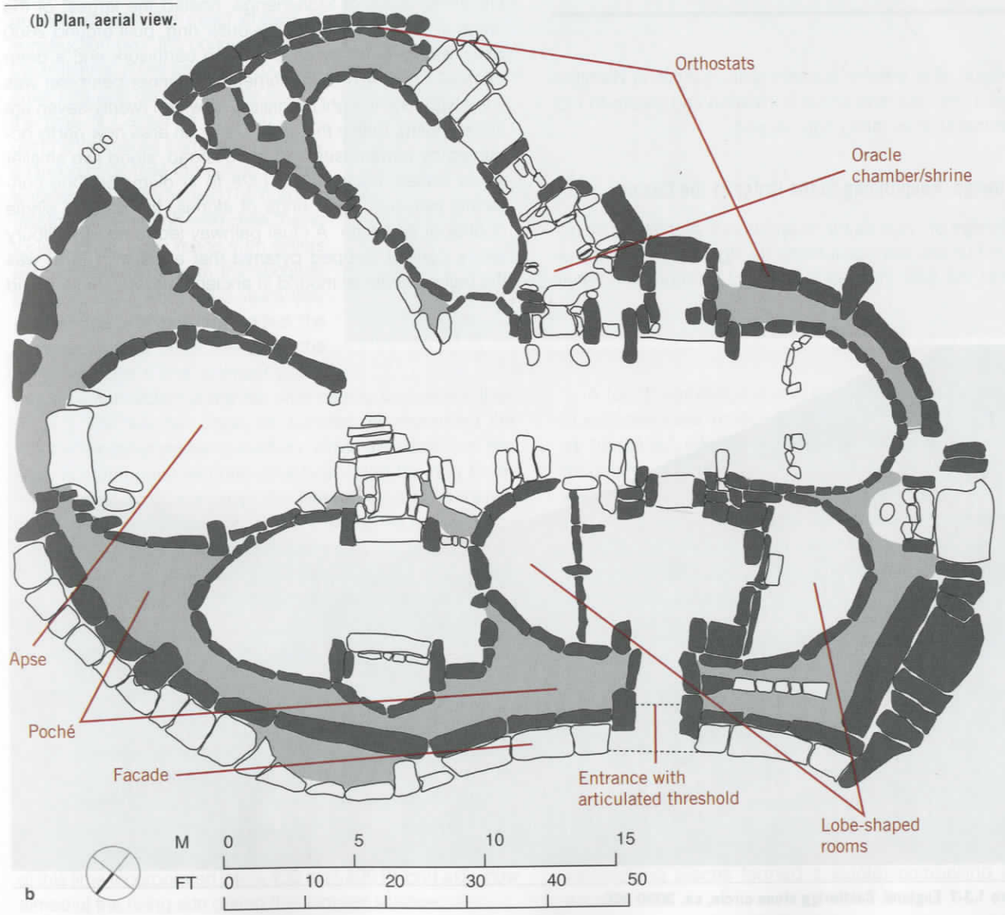
(b) Plan, aerial view.



b

RELIGION, PHILOSOPHY, FOLKLORE

Korean Dolmens

The greatest collection of dolmens is found on the Korean peninsula, where thus far over 30,000 have been studied. Often, the Korean tomb sites were built on slopes so as not to waste the arable land. The transport of the stones down the slopes was assisted by the force of gravity. In the village of Maesan there are 442 dolmens built between the seventh and third centuries BCE. Their shapes vary from straight-sided flanks carrying a flat slab to thicker blocks supported on four table-like legs. The largest capstone stretches 5.8 m (18 ft) in width, weighing 300 tons. The stability of the architecture results from the studied equilibrium between load and support. The heavier the ceiling is, the sturdier the walls must be. Although originally covered with soil and not intended to be seen, after several millennia the Neolithic dolmens in Korea and elsewhere have been left exposed as rather awkward freestanding archways. The accidental drama of these megalithic tombs as they stand denuded in the landscape evokes a sense of precarious stability, like a house of cards on the verge of collapse.

as a result of a greater concern with masculine divinities located in the heavens and a corresponding desire to plot out rational spaces using right angles.

Stonehenge: Responding to the Order of the Cosmos

Stonehenge prevails as the most famous prehistoric monument in Europe, but considering its significant transformation after the year 2000 BCE, it might be more accurately classified as a product of the Bronze Age. While neither the largest nor the oldest of the forty-six stone circles, or **henges**, in the British Isles, its final form reveals a superior refinement of craft, geometry, and astronomical knowledge. Just as Stonehenge has spawned the curiosity of millions of tourists today, it certainly attracted masses of pilgrims during its own time, people eager to participate in the rituals of a colossal timepiece.

An earlier stone ring, Castlerigg (Fig. 1.3-7) in Cumbria near the Scottish border, dates from 3200 BCE and provides a fine example of the precedents of Stonehenge. A bowl of hills surrounds the site on a treeless moor, and the circle looks from a distance like a group of people keeping silent vigil around a corpse about to be buried. Of the forty-two original megaliths, thirty-eight remain standing. The designers flattened the circle at the northern edge, perhaps to acknowledge the entry, and placed a rectangle of stones, known as "the cove," at the eastern end, probably for funerary rites. The megaliths ranged 1–2 m (3.3–7 ft) in height and were left in their raw shapes, each different from the other.

Avebury, an agricultural village in Wiltshire, 27 km (16 miles) north of Stonehenge, hosted the largest of the stone circles (Fig. 1.3-8). The outer ring, built around 2600 BCE, was defined by an enclosing earthwork and a deep ditch 427 m (1,401 ft) in diameter. The inner perimeter was lined with ninety-eight megaliths, of which twenty-seven are still standing. Within the great circle, an area now partly occupied by farmhouses and a crossroad, stood two smaller stone circles, each 100 m (328 ft) in diameter. One contained two concentric rings of stones, the other a single obelisk at its center. A ritual pathway led to nearby Silbury Hill, a conical stepped pyramid that at 39 m (128 ft) was the highest artificial mound in ancient Europe. These grand

Figure 1.3-7 England. Castlerigg stone circle, ca. 3000 BCE.

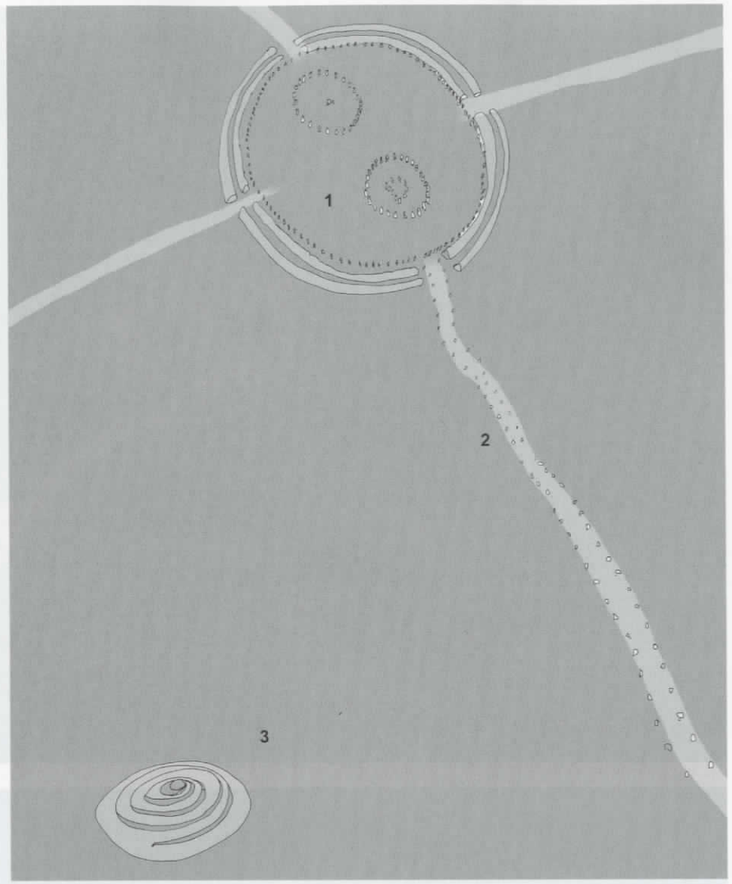


Figure 1.3-8 England. Reconstruction of Avebury, ca. 3000 BCE, showing (1) stone circles, (2) stone-lined ceremonial path, and (3) Silbury Hill.

constructions, which had their origins in the desire to honor the dead, achieved a scale and order that surpassed the needs of burials and addressed transcendent cosmic themes. The Avebury circle and Silbury Hill clearly correspond to observations of the movements of the heavens. Their construction required the labor of masses of participants, and thus they can be interpreted as expressions of political will.

Stonehenge (Fig. 1.3-9a,b), set majestically on Salisbury Plain in southern England, belongs to the same heritage as these earlier stone circles but underwent at least five major phases of construction over the course of nearly two millennia. A first generation built the outer ring and ditch, probably around the time of Castlerigg in 3000 BCE, using an immense compass, probably a stretch of ox-hide rope attached to a wooden peg at the center. The builders dug the ditch through solid chalk, using tools such as picks made from antlers and shovels made from the shoulder bones of oxen. About 500 years later another team of builders added the so-called Aubrey holes, just within the earthwork, and a ring of timber poles, probably connected at the top with beams to increase their stability. The wooden circle, or *woodhenge*, resembled the scale of the inner circles of Avebury, which also date from this time. A rectangular wooden structure inside the ring probably served as a mortuary. The Heelstone, a bent marker placed outside the ditch, oriented the site to the moon. It was the only megalith erected during these early stages.

Around 2200 BCE new builders removed the timber columns at Stonehenge from the Aubrey holes, which they reused to bury the ashes of their cremated dead. The new design replaced the inner mortuary with a nearly perfect circle of rare bluestone megaliths, placed in radiating pairs with a marked entrance aligned to the Heelstone's avenue. The transport of these 4-ton chunks from the Preseli Mountains in Wales, 200 km (125 miles) to the west, remains a mystery, as an overland route would have been virtually impossible and a sea route almost as unlikely. Some have gone so far as to theorize that the stones were deposited in the Wiltshire area by a millennial glacial drift. The Heelstone was at this time incorporated into a 400 m (1,200 ft) long axis, now aimed at the rising sun during the summer solstice.

A fourth campaign came two centuries later, when the bluestones were replaced by thirty sandstone piers, known as "sarsens," taken from the quarry at Avebury. The new megaliths, over 4 m (13 ft) in height, stood several times the size of the earlier stones and weighed up to 45 tons. Unlike any of the earlier megaliths, the sarsens had been intentionally "dressed," shaped and smoothed into relatively standard tapering uprights, all with the same height. The stones were prepared as if they had been made of lumber: knobs were carved on the top of each pier to be caught in a corresponding groove scooped out of the **lintels**, like a carpenter's mortise-and-tenon joint. The horizontal members involved the most sophisticated execution of masonry, shaped according to the curve of the circle. They connected each pier to the next as a continuous ring. How Stonehenge's builders lifted these enormous crossbeams into place can only be conjectured. Perhaps they were handled like logs with ropes and levers or else dragged up temporary earthen mounds and slid into place. The interlocking pieces formed a single, compelling work of architecture.

Figure 1.3-9 England. Stonehenge, ca. 3000–1500 BCE. (a) Aerial view. (b) The Sarsens.

Five pairs of slightly taller trilithons, erected before the ring was completed, were set within the sarsen circle in a *U*-shaped configuration. The axis of the Heelstone focused on its entry. In a fifth campaign, sometime around 1600 BCE, a millennium after the first megaliths had been delivered, the bluestones were reintroduced into the design. The new builders set a ring of these smaller stones inside the trilithons and a circle of them outside the sarsens, considerably complicating the composition. They placed an altar in the center, leaving no doubt that Stonehenge now served as a temple. During these later phases, the original settlers of the area had been conquered by the so-called Beaker people, which may explain the radical changes in ceremonial usage. The cosmic understanding of Stonehenge, however, endured beyond its change in owners, even as the new authority desired to express its power through the process of rebuilding the monument.

The meaning of Stonehenge resided in the ritual life that humanized this calendar of stone and earth set in the open countryside. Its strong religious purpose explained the prodigies of engineering and labor that went into its making. The builders did not choose the bluestones or the gray sarsens for their practicality. To transport the great megaliths from such long distances would have become a form of sacrifice. The special materials and the colossal size of the project gave the majestic stone circle singular authority in the celebration of celestial events. Public architecture at its best aspires to be a setting for collective rituals that endow each participant with the pride of belonging to a reality that extends beyond the present. The construction of sacred space allows one to imagine daily life in relation to the greater cosmos.

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