HEAVENLY CLOCKWORK

Time's natural cycles

> The first grand discovery was time, the landscape of experience.
>
> – Daniel Boorstin, *The Discoverers*

The city of Drogheda, just half an hour north of Dublin by Irish Rail's InterCity service, isn't at the top of most tourists' Ireland itineraries. Even *Lonely Planet*, which praises the surrounding counties for their historical and cultural wealth, describes this small coastal city as "charmless." As my taxi heads west, however, the view steadily improves, with Drogheda's industrial clutter giving way to the rolling hills and green valleys of County Meath. And just a few kilometers farther inland lies one of the most important prehistoric monuments in all of Europe – the "passage tomb" of Newgrange.

Most visitors to Newgrange approach from the south side of the Boyne, through the main visitor center, but for my early morning appointment I have to come from the north side of the famous river, past Newgrange Farm, where the sound of birds and cowbells fills the morning air. As the taxi rounds the last bend in the road, the monument itself – a shallow, circular, grass-covered mound some eighty meters across and a dozen meters high – comes into view. The outer walls are lined with blocks of white quartz that glitter in the sunlight. I'm met by Claire Tuffy of the Office of Public Works, which manages the site, and together we climb the gentle hill leading to the tomb's main entrance.

The structure, Tuffy explains, dates from around 3100 B.C. – making it five centuries older than the Great Pyramid at Giza in Egypt, and a full thousand years older than the "trilithons" at the center of Stonehenge. The Neolithic people who lived in Ireland at that time would have been farmers, tending grain crops and herding livestock. The Boyne – Tuffy nods toward the river, half-hidden by trees and low hills – was their

highway. They had likely been farming the land for a thousand years before construction at Newgrange began. “Their tools were stone and wood – no metal,” Tuffy points out. The quartz was transported from what is now County Wicklow, some eighty kilometers away. One can only imagine the Herculean effort required to move, shape, and lift the nearly two thousand stones used to construct the monument.

We pass the richly decorated sandstone blocks that mark the entrance, and approach the iron gate that now protects the interior. Tuffy unlocks it and we step inside, ducking our heads because of the low ceiling. Though circular on the outside, the interior of the tomb is long and narrow, cutting deep into the center of the mound. We make our way cautiously toward the rear of the chamber. Soon the entrance is little more than a tiny square of light in the distance behind us. Without the electric lights installed overhead every few meters, it would be pitch black. It is also eerily quiet. For the pair of bats that have built their nest here, it is no doubt the perfect home.

The tomb stretches twenty-five meters in length but rarely spans more than a meter across. At the far end are three small alcoves that branch off from the main passage, giving the tomb an elongated cruciform design. Though known to the modern Irish since the seventeenth century, the site wasn’t properly excavated until the 1960s, when archeologist Michael O’Kelly and his team discovered the cremated bones of at least five individuals, on basin-like stones in the alcoves at the rear of the tomb. Workers also uncovered intriguing Neolithic artwork. Several of the stones are decorated with geometrical patterns; the most complex is a trio of overlapping spirals at the very back of the tomb.

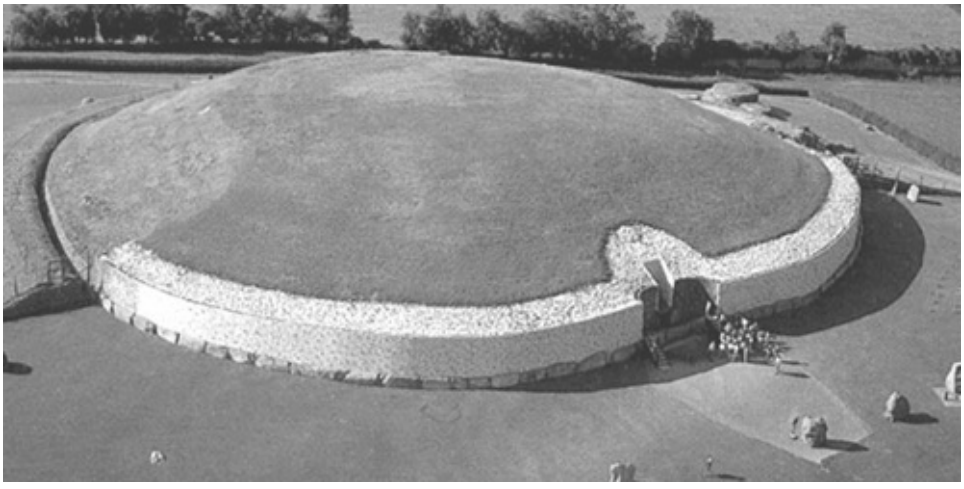
As we stand in the rear chamber, Tuffy shines her flashlight at the layers of cobbled stones that arch overhead. “That roof has not been restored, and it is still perfectly watertight after five thousand years of Irish weather,” she says. Why would Neolithic farmers have gone to that much trouble to protect the bones of the dead from a little water? Perhaps the spirits of the ancestors were thought to live on, she speculates. And while today is sunny, Tuffy reminds me with a smile that her country has been known to have the occasional spot of rain. “Maybe it’s every Irish person’s idea of heaven, to be dry for ever and

ever," she muses.

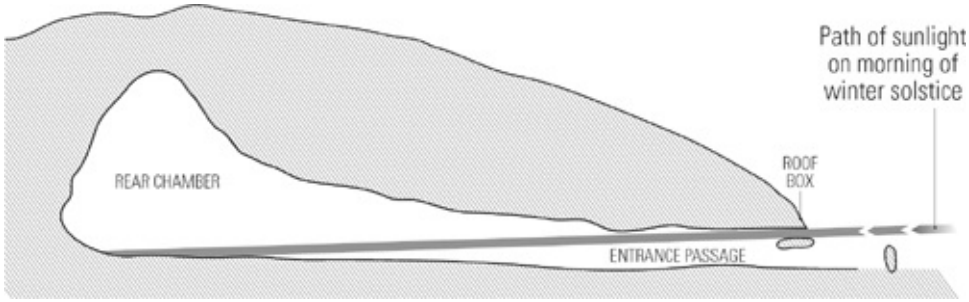
But the most intriguing feature of Newgrange is neither its walls, nor its roof, nor its artwork. It is not what one sees at any one place, but rather what one sees at a particular *time*. Every winter, on the morning of the shortest day of the year – the winter solstice – sunlight streams through a small opening above the main entrance, known as the "roof box," illuminating the back of the tomb. This seemingly innocuous event – a sliver of sunlight briefly creeping into a dusky burial chamber in the dead of winter – is what makes Newgrange unique. These weathered stones allow us to glimpse, however dimly, into the minds of those who first considered the matter of time.

The Sun in the Cave

Were the roof box and passage constructed along a slightly different angle, the solstice event would not happen. Could it be a coincidence, a chance alignment? Almost certainly not, says astronomer Tom Ray of the Dublin Institute for Advanced Studies, who investigated the geometry of Newgrange in the 1980s. "As an astronomer, as a mathematician, I'm looking at the statistics and saying, the chances of this being an accident are very, very small," Ray told me when I visited him in his Dublin office. The solar alignment "was their intention." Andrew Powell, writing in a prominent archeological journal a few years ago, reached the same conclusion: "There can be no doubt that this was an integral feature of the tomb's design."



The Neolithic “passage tomb” at Newgrange, in Ireland, dates from 3100 B.C. On the morning of the winter solstice, sunlight passes through an opening above the tomb’s entrance, illuminating the rear of the chamber. *(Above: University of Notre Dame)*



The modern name Newgrange comes from the Gaelic *Uaimh na Gréine*, “The Cave of the Sun.” In fact, even before those first excavations in the Sixties, there were local legends about sunlight entering the cave at a particular time of year. O’Kelly wondered if it might involve the winter solstice, as such alignments are well known in later Neolithic monuments. So he camped out in the cave overnight, waking up early on the morning of December 21, 1969, to see for himself (and, just to be sure, he repeated the experiment the following year). Ray, telling me the story, is mildly amused. “From the point of view of an astronomer, you don’t need to actually do that,” he says. “You could have just done a bit of surveying, and that would have told you the answer. So we have this sort of romantic image of Michael O’Kelly stuck in the back of the chamber, on the shortest day of the year, waiting for the sun to rise. And lo and behold, when it did, he realized that the light came into the main chamber of Newgrange.” As O’Kelly noted in his journal that morning:

> At exactly 8:54 hours GMT the top edge of the ball of the sun appeared above the local horizon and at 8:58 hours, the first pencil of direct sunlight shone through the roof-box and along the passage to reach the tomb chamber floor as far as the front edge of the basin stone in the end recess.

But our view today is not precisely the same as it would have been five thousand years ago. For one thing, Ray explains, the earth’s axis wobbles periodically over thousands of years. The phenomenon is related to the precession of the earth’s rotation axis: as the earth spins, the axis itself

gradually revolves with respect to the solar system, in a cycle that lasts about 26,000 years. The related wobble – astronomers call it “nutation” – causes a periodic change in the tilt of the axis. Today, the axis is tilted 23.5 degrees; at the time Newgrange was built, the tilt was slightly greater – about 24 degrees. The upshot of that small shift, Ray explains, is that the shortest day of the year was a little bit shorter back then, and the longest day was a little bit longer. That, in turn, affects the time of sunrise and sunset. Today, on the solstice – as O’Kelly noticed – several minutes pass between sunrise and the first penetration of sunlight into the rear of the tomb. Five thousand years ago, however, it would have been bang on. “You would have captured the sun just as it rose,” says Ray.

The solstice sunrise at Newgrange is still a remarkable event. Every year, thousands of people take part in a lottery for the privilege of a morning visit to the tomb in the week of December 21. Because the main passageway is angled upward, those first rays of sunlight don’t hit the back wall; instead, as O’Kelly observed, they hit the ground a few meters short of the rear of the tomb. It is that first strike of sunlight inside the tomb that those lucky visitors watch for. “Nobody takes their eye off the ground,” says Tuffy, who has probably witnessed the event more often than anyone else in recent years. “You lose your sense of how much time has passed. And despite the fact that everybody is watching the floor, people inevitably miss the first beam of light.” Soon the beam is about the length and width of a pencil, Tuffy says. “And then very quickly it gets longer and wider, and it moves down the floor.” By the time it reaches the middle of the chamber – just a few minutes later – it’s nearly twenty centimeters wide, and surprisingly intense. “It’s a lovely, warm color,” she says. “And then the whole room is so bright you can see right up as far as the capstone. You can see the faces of all the people gathered in the room.”

What does the solar alignment tell us about the Neolithic people who moved so many massive stones into place, in such a precise way, to build such a structure? We can imagine that the builders of Newgrange – as one could say of people in any farming community today – took an intense interest in the passing of the seasons and the motions of the heavenly bodies, particularly the sun and moon. In those days, before

the glare of streetlights and shopping malls, the skies would have been pristine. True, Irish weather is often rather gray – but on every clear, cloudless night, the sky would have presented a dynamic celestial display for all to see. The regularity of the heavens – the daily rising and setting of the sun, the monthly waxing and waning of the moon, the annual parade of the seasons – would have been impossible to ignore.

"Certainly they had an interest in astronomy," says Ray. He cautions, though, against projecting modern Western terms onto a culture so different from ours; we have to be careful about labeling those Neolithic farmers "astronomers" or calling Newgrange an "observatory" – although, as we'll see, scholars of all stripes can hardly refrain from using that particular term (one is tempted to call it "the 'o' word") when discussing elaborate Neolithic sites. Still, there is no question that those early farmers had a keen awareness of the heavens. "There clearly was an interest in the two main heavenly bodies," says Ray. "Whether there were sort of religious connotations as well, I don't know, and I don't think anybody else knows either."

The First Hominids

Our earliest ancestors had no clocks and calendars, but they had something that functioned in a similar way: nature itself. Early humans must have been captivated by time's endless cycles, as reflected in the rhythmic motions of the heavenly bodies, for many thousands of years. Today we look down at our watches (and the LCD clocks on our cell phones); our ancestors would have looked up at the sun, moon, and stars. And very likely a more basic awareness originated much earlier, from the time our ancestors first walked upright and chipped away at the first crude stone tools. But extrapolating from bones and tools to thoughts and beliefs is an enormous and endlessly frustrating challenge, and even the most plausible ideas are rarely proven beyond all doubt. Such efforts have been bolstered in recent years by remarkable advances in genetics, cognitive science, primate studies, and, of course, archeological discoveries. Even so, the farther back we look, the more scattered and ambiguous the clues become.

Anthropologists suspect that even the earliest hominids – the first

members of the human family – had some sort of temporal awareness, long before our own species, *Homo sapiens*, emerged as the dominant creature on our planet.* Those early hominids, living several million years ago, "probably had a rudimentary conception of time similar to our own," argues John Shea of the State University of New York at Stony Brook. They had "an understanding of the past, an understanding of the future – and the ability to perceive the future in terms of contingencies, in terms of 'if *this*, then *that* will happen.'" Shea didn't use the word "consciousness" – the word still carries a lot of baggage in many scientific disciplines – but it seems reasonable to assume that a creature that is conscious of itself and its environment would also have at least a rudimentary awareness of time. Early hominids had enough of an awareness of past and future to live in cooperative social groups and to hunt large animals across a harsh and varied landscape, Shea says. They could learn from the past and try to predict future events; they could mentally sort through different courses of action and imagine what kinds of results they would produce. (Psychologists call this "mental time travel," and we will look at it more closely in Chapter 5.)

Evidence that those early human ancestors could plan for the future can be found around the edges of ancient lake beds in Africa and the Middle East, where archeologists have found numerous large deposits of stone tools crafted by early humans, seemingly stockpiled in strategic locations around the landscape. Perhaps, Shea suggests, they planned such caches so that the tribe would always be within a short distance of material that could be turned into weapons if the need arose. Even the sophistication of the tools suggests some degree of planning: carefully chipped hand axes were almost certainly intended not for a single carving session but for repeated use. It seems that these hominids understood, in some way, past and future; they sensed that survival meant knowing not only what was over the next hill, but also what was to come the following day or the following season. As rudimentary as it may have been, they clearly had some conception of time.

One of the most intriguing – and controversial – early human behaviors is the ritual burial of the dead, a practice that emerges only in the most recent chapter of the hominid story. Such practices at least hint at our ancestors' conception of life and death, and, perhaps, of

"eternity." The first signs of systematic burial can be seen about 100,000 years ago with the Neanderthals, an offshoot of the human family tree that lived in Europe and western Asia. Modern *Homo sapiens*, however, had far more elaborate burials. Before we examine such practices in detail, it's worth looking at the complex relationship between these two branches of the human family.

A Meeting of Minds

The Neanderthals make their first appearance around 130,000 years ago, and thrived until about 25,000 years ago. They lived in the same geographical area as *Homo sapiens* at the same time – they certainly overlapped in southwestern Europe during the Upper Paleolithic period, beginning around 40,000 years ago – and shared many of the same traits. Yet there would be no confusing the two species. Neanderthals were stocky and muscular, with sloping foreheads and pronounced brow ridges. Even if given a shave and dressed in modern clothing, a Neanderthal would draw gasps on the streets of any twenty-first-century city. They actually had bigger brains than modern humans – though size, as we shall see, is not everything.

Some Neanderthal traits seem remarkably human: they crafted stone tools, learned to control fire, enjoyed a meat-heavy diet, and cared for their elderly and sick (as revealed by the bones of individuals who lived on for many years in spite of severe disability). "There could be no more compelling indication of a shared humanity," anthropologist Richard Klein has put it. (Recently there has been a debate as to whether the Neanderthals and *Homo sapiens* occasionally interbred; the emerging consensus, based on DNA studies as well as the fossil record, seems to be that such matings happened rarely, if ever.) What is clear, however, is that their lifestyles – and their mental capabilities – were worlds apart.

The Neanderthals left no evidence of art or jewelry; although they made stone-tipped spears and could flake axes from stone, they produced very few distinct types of tools and rarely worked with bone or ivory. And there is no evidence of innovation: they made pretty much the same kind of tools for 100,000 years. Klein concludes that the Neanderthals died out "not simply because they didn't behave in a fully modern way,

but because they couldn't." By contrast, early humans were prolific artists, painters, and sculptors.

The contrast between the two groups is just as sharp when we look at their burial practices. Neanderthal burials are typically just shallow pits that seem to lack any unambiguous "grave goods" or other evidence of accompanying ritual. Such burials could simply have been a hygienic way of disposing of a corpse. Only with the rise of modern humans do we see clear evidence of grave goods – tools, jewelry, and other items that would presumably be of use in the next life. Interestingly, even though *Homo sapiens* first appear on the scene in Africa around 200,000 years ago, such elaborate burial practices seem to originate only in fairly recent times, beginning perhaps 50,000 years ago – by which time our ancestors were burying their dead with great fanfare.

Life and Death – and Beyond

One of the most elaborate early human burials was found at a site called Sungir, in Russia, dating to 28,000 years ago. The bones of an elderly man rest there, alongside two adolescents, one male and one female. Each body is decorated with thousands of ivory beads (presumably attached to clothing, long since decomposed). The man wears an ivory bracelet showing traces of black paint. The boy wears a belt; under his shoulder is an ivory sculpture of a mammoth. By his right side is a huge lance, carved from a mammoth tusk. The girl wears a beaded cap; by her side are many small ivory knives or daggers.

It is hard to escape the conclusion that these citizens of the Upper Paleolithic expected *something* in the next world. As the archeologist Steven Mithen notes, they were the first beings whose world view suggests a belief in supernatural beings and, possibly, an afterlife. Their elaborate burial rituals can be seen as "the first appearance of religious ideologies," he says. Of course, *religion* is a difficult word to define, but for Mithen (and probably most scholars) it includes the religious person's assumption that death is not final. They must have believed that some nonphysical component of a person can survive after death – and that such a being could still hold beliefs and desires just like a living person. In other words, our Paleolithic ancestors had a mental picture of time

that was complex enough to allow for the possibility of life after death; they could imagine time extending from this world to another, unseen world.

Within about ten thousand years of the arrival of modern *Homo sapiens* in Europe, the last of the Neanderthals disappeared. The newcomers had some kind of advantage in the struggle for survival. Many anthropologists believe that the capacity for language is what gave them – us – the edge. While other hominids, including the Neanderthals, may have grunted and gestured, modern humans developed a complex, symbolic language. With speech came the power of abstraction – a way of looking beyond the here and now. *Homo sapiens* were thinking, strategizing hunters with a sophisticated sense of time and place.

With that consciousness of time, however, came an awareness that the span of one's own life was finite. As the historian J.T. Fraser puts it, our knowledge of time "made for a double-edged weapon that cuts both ways." Our ability to plan for the future allowed our species to flourish, but, he adds, "these advantages were paid for by a profound sense of restlessness, rooted in the certainty of passing and death."

Bone of Contention

Just how carefully did early humans track the passage of time? A few calendar-like artifacts from the Paleolithic era have been put forward, but by far the most compelling is a carved bone tablet – part of an eagle's wing – discovered in a cave in the Dordogne Valley in southwestern France. The fragment – one of the most intriguing of all prehistoric artifacts – is about ten centimeters long and dates back some thirty thousand years. On its surface are a series of notches, set down in rows of fourteen or fifteen, in a winding, snakelike pattern. The American archeologist Alexander Marshack, who studied the carving in the 1960s, suggested that the notches were tally marks – that the Paleolithic hunter who made the markings was counting something. But counting what? The number of notches on each row, Marshack realized, was roughly the number of days from new moon to full moon and vice

versa (the average length of a complete lunar cycle is about 29.5 days). The tablet, he speculated, may have been a primitive lunar calendar.

Anthony Aveni, of Colgate University in upstate New York, who has written extensively on timekeeping in prehistoric societies and non-Western cultures, is intrigued – and seems nearly convinced – by Marshack's claim, referring to the bone tablet as "a beguiling and captivating little artifact." Aveni acknowledges that the markings are open to other interpretations: they could have been made by a hunter keeping track of kills, or a woman tracking her menstrual cycle – or it may simply have been a knife-sharpening tool. Anthropologists also wonder if Paleolithic humans had quite enough mental agility to set up and maintain a calendar over a period of several months. Still, Aveni suspects that Marshack's interpretation is the right one: "I believe that what we have here is one of the earliest records of the passage of time, most notably the phases of the moon," he says.

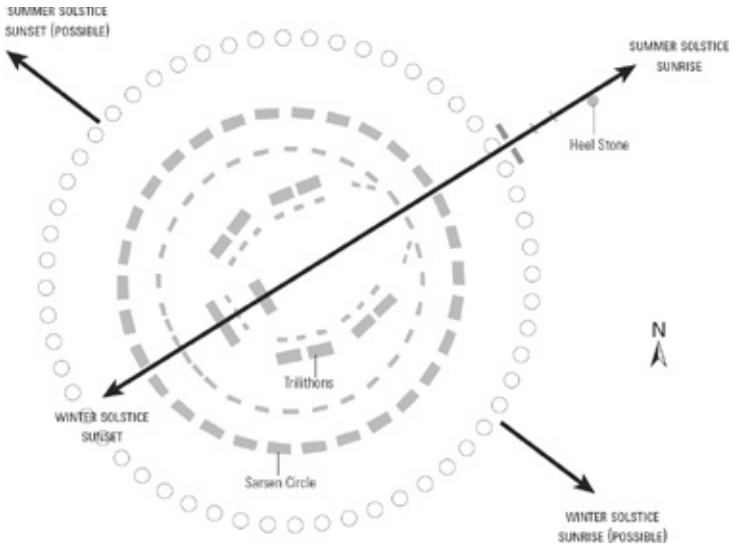
While the Dordogne bone (allegedly) covers only two and a half calendar months, Aveni notes that the tally marks could in principle have been easily extended; a longer series of marks could have led early humans to understand that the period from human conception to birth was nine moons, or that certain plants and animals would become scarce at certain intervals; perhaps they could even see that the seasons would complete a full cycle every twelve or thirteen moons. Still, Aveni urges caution: "Fitting an artifact to our impression of who made it is one of the most speculative areas in the discipline of archeology."

By the late Neolithic period – around the fourth and third millennia B.C. – that interest in time's passage would be embodied in some of the most spectacular and intriguing structures on the face of the planet.* Across Europe, from the western Mediterranean to the British Isles and along the northern Atlantic coast, great stone monuments – "megaliths" – begin to appear, including dozens of stone circles, especially in Britain and Ireland. We have already had a brief look at Newgrange, one of the earliest sites believed to have calendrical significance. Stonehenge, of course, is even more famous, while nearby Avebury is larger and more complex, and Callanish, on the island of Lewis in northwestern Scotland,

rivals Stonehenge in size and sophistication. These monuments have often been interpreted as observatories used to help track the motion of the sun, moon, and stars. Such interpretations invite controversy – the "'o' word" always does – but the most basic claims, such as the alignment of Stonehenge's main axis with the midsummer sunrise, are beyond dispute. (Older structures, such as the "long barrows" that pepper the countryside of southwestern England, also typically display a solar orientation – though a much less precise one. Most are oriented in an east-west direction, with the entrance pointing to the eastern quadrant of the horizon. But the actual orientation angles of these structures cover quite a wide range; some scholars have suggested a lunar rather than a solar orientation.)

The Mystery on Salisbury Plain

Stonehenge itself can be traced back nearly five thousand years, to the erection of a vast circular embankment and ditch, about 100 meters across. Just inside the embankment is a ring of fifty-six chalk-filled holes that archeologists believe once held upright wooden posts. Construction continued in spurts over the next few centuries, reaching a climax between 2400 and 2100 B.C. with the erection of a great circle of forty-tonne standing stones – also called "sarsen" stones, after the dense glacial rock used for the purpose. The sarsens are capped with ten-tonne horizontal "lintels" – an effort representing millions of work-hours. Just inside the sarsen circle is a smaller concentric ring of upright "bluestones," some of which, archeologists have determined, were dragged from the Preseli Mountains in Wales, more than 200 kilometers away.



At Stonehenge, in southwestern England, one celestial orientation is unambiguous: the main axis of the central "horseshoe" grouping of trilithons is aligned with the summer solstice sunrise (or, equivalently, the winter solstice sunset). Other alignments have been suggested, but remain controversial.

The innermost ring at Stonehenge, consisting of five enormous trilithons (each made up of two uprights and a lintel), is laid out like a horseshoe, with its axis of symmetry lying along a southwest-northeast line. That axis also passes by an outlying stone known as the "heel stone." One can speculate that a priest or chieftain observing from the center of the monument could have used the heel stone as a kind of gun sight to observe the rising sun on the morning of the summer solstice, the day on which the sun reaches its northernmost position on the eastern horizon. (Equivalently, the observer could have been standing at the heel stone, looking southwest, watching the sun set on the evening of the winter solstice. Or, quite possibly, both.) At the very least, the monument appears to have been used as a kind of reference frame to monitor the movement of the sun and, perhaps, the moon and stars. There is no doubt that Stonehenge and the other megaliths owe *some* of their design and motivation to sky events – the question is how much, and what other motivations may have been equally important.*

In the 1960s and '70s, a few authors went to great lengths to expound on the astronomical use of Stonehenge and other Neolithic monuments –

claims which were highly controversial. A few eager writers claimed that Stonehenge was a sophisticated observatory, that it served as an analog calculator that allowed – perhaps by making use of the fifty-six posts in those postholes – for the prediction of eclipses. That episode of unbridled celestial enthusiasm, as archeologist and archeo-astronomer Clive Ruggles has put it, "forms one of the most notorious examples known to archaeologists of an age recreating the past in its own image." (In the era of the Apollo moon landings, perhaps we longed to think of our ancestors as having had similar cosmic aspirations.) There is, Ruggles says, "no reason whatsoever to suppose that at any stage the site functioned as an astronomical observatory – at least in any sense that would be meaningful to a modern astronomer."

Heavenly Designs?

The problem is one of design versus chance: certain stones may be aligned with certain astronomical phenomena, but that doesn't necessarily mean that they were built with such alignments in mind. With enough stones and enough celestial "targets" – the rising or setting position of a particular bright star, for example – alignments become inevitable. "Statistically, the odds are in favour of a good celestial sight-line occurring fortuitously in almost any circle," writes archeologist Aubrey Burl. Taking a site known as Grey Croft in Cumberland, England, as an example – a circular monument consisting of 12 stones – he finds there are so many possible lines and so many possible targets "that to discover nothing would be improbable." At a 12-stone circular site, he calculates, there are 132 possible alignments.

One also has to look at each site in the context of the larger landscape – both natural and artificial – examining all of the monuments in a particular region. Consider, for example, the Drombeg stone circle in County Cork, Ireland. The main axis of the circle – as at Stonehenge – aligns with the sun's solstice position. Yet there are some fifty stone circles in southwest Ireland, and none of the others seems to share such an alignment. If the builders were thinking astronomically, why was the solstice alignment the exception rather than the rule?

At Stonehenge, the solar alignment is clear enough – but the role of other celestial bodies is much less certain, and expert opinion is divided. Burl believes that extreme risings and settings of the moon, as well as of the sun, must have been recorded.* Aveni agrees that the site's main axis could have been used to monitor the most northerly moonrises during the winter months, and, in fact, he doesn't rule out its use as an eclipse indicator. When the moon rose within the stone gateway to the northeast of the circle (today, only the heel stone remains), those early skywatchers may have known that there was a possibility of an eclipse during the next full moon. "But even if no eclipse took place," Aveni writes, "that special midwinter full moon, rising opposite the setting sun, would provide ample light for a night-long ceremony to honor the attending gods." The builders of Stonehenge may well have been tracking celestial bodies, Aveni says. But, he adds, "I am convinced that if Stonehenge has anything to do with lunisolar astronomy, the association between its Neolithic builders and the sky is more closely allied with theater than with exact science." No wonder that, in the Middle Ages, Stonehenge was known as *Chorea Giganteum* – the Giant's Dance.

The Temple of Time

There can be no doubt that people once gathered at these monuments – but gathered to do what? To observe the heavens? To mark the seasons? To worship the sun and moon? To deify ancestors, or honor the dead? Very likely all of these, and more. Stonehenge was, among other things, a cemetery: recent archeological work has found that the cremated remains of more than two hundred individuals were buried within the site. Yet religious observance is not easily disentangled from cosmology – especially when celestial bodies themselves were almost certainly objects of devotion, with the sun and the moon at the top of an elaborate cosmic hierarchy. The monument was likely home to a pantheon of gods and of spirits of animals and people. And we must remember that sites such as Stonehenge served as a meeting place for more than a thousand years; no doubt its function evolved over the centuries. We can think of Stonehenge, Aveni says, "as a place of social gathering, of religious

assembly, as a cultic center, as a place of fortified habitations, a celestial temple, and observatory. All of these definitions crosscut one another, some perhaps being stressed more at one time than another."

Whatever the symbolic meaning of monuments like Stonehenge may have been, there is no doubt that those symbols involved time as much as space. Their construction suggests an interest in temporal matters far beyond what would be needed to merely track the seasons. The many burials found at Stonehenge can be seen as "a reference to the past and perhaps to mythic beginnings," according to Clive Ruggles and colleague Joshua Pollard. These were places where time may have been seen as standing still – a feeling reinforced by the continuity of celestial rhythms and public ritual. "Stonehenge always embodied notions of time – both of time past and continuity – in a world of punctuated social change," the scholars write. As Alasdair Whittle observes, the monument served as a "timeless frame of reference," a mystical arena that "made the future possible by suspending the past." It was a place where people felt united with their ancestors, the gods, the earth, and the heavens; a place where participants felt they could transcend time.

On the European mainland, equally intriguing sites are being unearthed. Archeologists have recently begun to excavate a Bronze Age settlement near the town of Goseck in eastern Germany. The site includes a cir cular mound and ditch, about seventy-five meters in diameter. Its origins are uncertain, but it was likely first used during the late Neolithic period, around 5000 B.C., making it significantly older than Stonehenge. Archeologists believe it was a site of cult worship but also had astronomical significance, with the "gates" to the complex aligned with the summer and winter solstices. The most arresting find: a depiction of the heavens, embossed in gold, on a bronze disk about thirty centimeters in diameter. This "map" dates from much later – about 1600 B.C. – and shows the sun, crescent moon, and thirty-two stars (possibly including the Pleiades star cluster). Archeologist Harald Meller describes it as "without a doubt the earliest genuine depiction of the cosmos." It suggests that the site where it was found "almost certainly functioned … as an astronomical observatory, like Stonehenge in Britain."

Fascination with celestial rhythms can be seen far beyond northwestern Europe. The ancient Egyptians and Babylonians – we'll look more closely at their achievements in the next chapter – developed a sophisticated astronomy employing mathematical and geometrical methods. In Central America, the great Mayan pyramids were aligned with the sun's position at the equinoxes, and their builders developed a spectacularly complex calendar system (more on that, too, in the next chapter). Farther to the south, the Inca were building solar observatories by A.D. 1500. In the Ohio and Mississippi valleys of North America, great earthen mounds – likely fortifications as well as ritual sites – also appear to have had astronomical significance. The Hopi, living in the southwestern American desert, used their local environment as a calendar, tracking the sun's changing position along the horizon over the course of the year. In Africa, a circle of nineteen basalt pillars in northwest Kenya may have had astronomical functions and is still used by modern inhabitants to mark important dates in their calendar. Neolithic burials in northern China, dating from 5000 to 3000 B.C., are aligned with the cardinal directions of the compass. And the list goes on.

Archeologists continue to uncover ancient stones and structures that illuminate our preoccupation with celestial cycles. In 2007, a team working in Peru's coastal desert announced the discovery of what may be the oldest astronomical site in the Americas – a series of thirteen stone structures known as the Towers of Chankillo. Dating from 1300 B.C., the towers run in a north-south line along a low ridge, with the entire complex extending three hundred meters in length. Archeologists believe the towers were used as horizon markers for observing the sun. To the east and the west of the line, they uncovered the ruins of a number of ceremonial buildings; these sites, they believe, served as observation posts. As seen from two suspected observation points, the north-south spread of the towers along the horizon matches the range of the sun's rising and setting positions over the course of the year. At the solstices, the sun would rise or set above the northernmost (or southernmost) tower; at other times of the year, the towers would have provided a way of tracking the sun's position to within an accuracy of a couple of days.

The Neolithic Mind

Nearly every claim made about prehistoric people and their conception of the cosmos is fraught with controversy. But it is clear that by the later Neolithic period – a time when anatomically modern humans had spread across the globe, hunting, farming, and tending crops – our ancestors were captivated by the night sky and its rhythmic cycles. The clockwork of the heavens had stirred something deep within us.

We will, of course, never know exactly what motivated those Stone Age builders. No doubt every archeologist has fantasized about using a time machine to drop by the site of Stonehenge during its construction. (One would feel an urge to approach the workers with a long list of questions – though it would presumably be less disruptive to watch the proceedings from behind some distant shrubs, with a pair of binoculars and a notepad.) Yet we must settle for what the stones themselves – at Stonehenge and across the Neolithic world – can tell us.

Back at Newgrange, Claire Tuffy has often entertained those kinds of thoughts; she can't help wondering what was going through the minds of the monument's builders as they labored over the massive stones and carved those mysterious figures. Our best guesses, she says, will almost certainly remain just that. She also recognizes that we can't help reading into the stones any number of motivations and desires that may or may not have been shared by the monument's builders. In the twenty years that she's been working at the site, Tuffy has heard visitors describe their experiences in terms that often reflect, more than anything, our ever-changing pop-cultural visions of the universe. In the 1970s, in the wake of Erich von Däniken's *Chariots of the Gods*, visitors would sometimes tell her that the mound looks like a spaceship. (The idea that aliens from another world built Newgrange used to annoy her – "They were going to give the credit to some guys from outer space," she laments.) In the 1980s, as the environmental movement gained ground, the earth itself became a revered entity; people started dowsing for "earth energies" and spoke of living in harmony with "Mother Earth." These days, Tuffy says, many visitors are thinking in terms of spirituality

and a yearning for a universal religion. “In a world where we’re abandoning established religion, people are branching off on their own, and they’re going back to these places to find answers.”

We take a last look at the spiral patterns on the rocks in the back of the tomb. Archeologists suggest that the markings symbolize the sun – a plausible enough idea, and one that seems to mesh with the site’s winter-solstice solar orientation. But what, Tuffy asks, did such symbolism really mean to the builders of Newgrange? “We don’t bring the same meaning with us as they would have,” she says. “What did the sun mean to the people five thousand years ago? That’s the big gap that will never be bridged.”

Exiting the cave, we both squint in the morning sunlight.

“Even if we got the old time machine and zipped back to 3100 B.C.,” Tuffy speculates, “I’m not quite sure that we’d be able to communicate adequately to understand them, to see the world like they see it.”

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* The taxonomy of early humans and related species is changing. In this book I use the term *hominid* to mean all members of the human family, including *Homo sapiens* and their extinct bipedal cousins – roughly speaking, all the primates that have ever walked upright, beginning approximately 4 million years ago. Some anthropologists now use the term *hominid* more broadly so as to include the great apes – this is, in fact, the new technical definition – and would use the term *hominan* to refer specifically to human and human-like species. For simplicity, I use the term *hominid* in its more traditional sense, which is also how it continues to be used in the popular press. (An anthropologist friend admits that the new definition causes her “no end of grief.”)

* Cultural eras such as “Paleolithic” and “Neolithic” are not absolute; they start and end at different times in different geographical regions. The dates mentioned above refer to the late Neolithic in Europe.

* On a side note, it is interesting that the site is claimed by modern-day Druids – a Celtic religious sect – as their own, considering that Stonehenge was built long before the Celtic invasion of the British Isles. Druids may have used Stonehenge, but they certainly did not build it.

* The moon’s northernmost rising and setting positions are slightly farther north than those of the sun, while its southernmost rising and setting positions are farther south by the same

amount.