

Stonehenge and Ancient Astronomy

Stonehenge is one of the most impressive and best known **prehistoric stone monuments** in the world. Ever since antiquarians' accounts began to bring the site to wider attention in the 17th century, there has been endless speculation about its likely purpose and meaning, and a recurring theme has been its possible connections with astronomy and the skies. Was it a **Neolithic calendar**? A **solar temple**? A **lunar observatory**? A **calculating device** for predicting eclipses? Or perhaps a combination of more than one of these? In recent years Stonehenge has become the very icon of **ancient astronomy**, featuring in nearly every discussion on the subject. And yet there are those who persist in believing that it actually had little or no connection with astronomy at all.

A more informed picture has been obtained in recent years by combining evidence from archaeology and astronomy within the new interdiscipline of **archaeoastronomy** – the study of beliefs and practices concerning the sky in the past and the uses to which people's knowledge of the skies were put. This leaflet attempts to summarize the evidence that the Stonehenge monument was constructed by communities with a clear interest in the sky above them.

Photograph: Stonehenge in the snow. (SKYSCAN/ENGLISH HERITAGE)



*Advancing
Astronomy and
Geophysics*

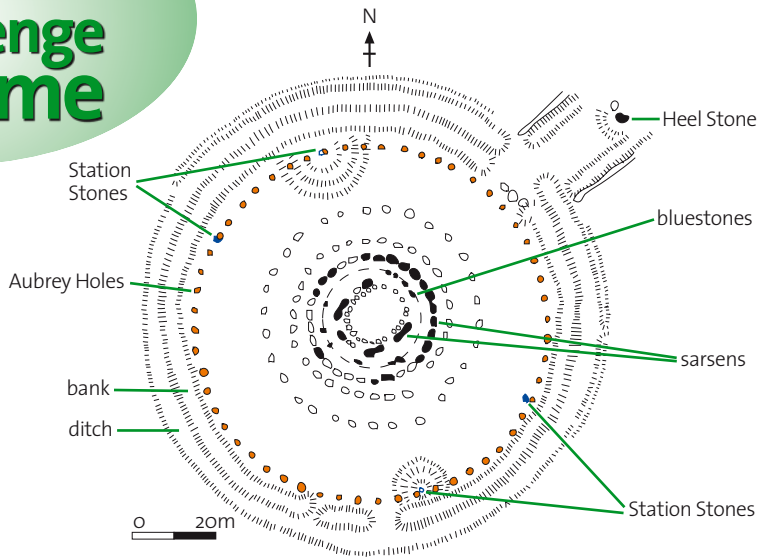
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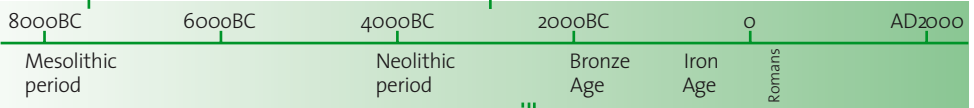


Stonehenge in Time



The earliest known structures so far discovered in the vicinity of Stonehenge were great **timber posts** erected as far back as the **Mesolithic** period, in roughly **7500 BC**, when Britain was largely forested and inhabited by **hunter-gatherers**. Possibly “totem poles”, the positions of three of them are marked by large painted white circles in the car park.

The earliest known developments at Stonehenge itself were the construction of a **circular earthen ditch and bank** in the Middle Neolithic period, close to **2950 BC**. It had an entrance to the northeast and another to the south. An inner ring of 56 pits, known as the **Aubrey Holes**, were probably dug at around the same time. Archaeologists still debate whether any or all of these pits held permanent timber posts from the outset.



A rectangular arrangement of four stones, known as the **Station Stones**, were built at some stage inside the existing circular ditch. The **Heelstone** and a **companion** were erected outside the northeast entrance. Where exactly these stones fit into the chronological sequence is still unclear archaeologically.

Around **2550 BC**, but possibly earlier, as many as 60 “**bluestones**” around 2 m long and weighing several tonnes apiece were brought by water and land all the way from the **Preseli mountains** in South Wales – some 250 km. At first they were arranged into a partial circle with an “altar” stone facing the southwest.

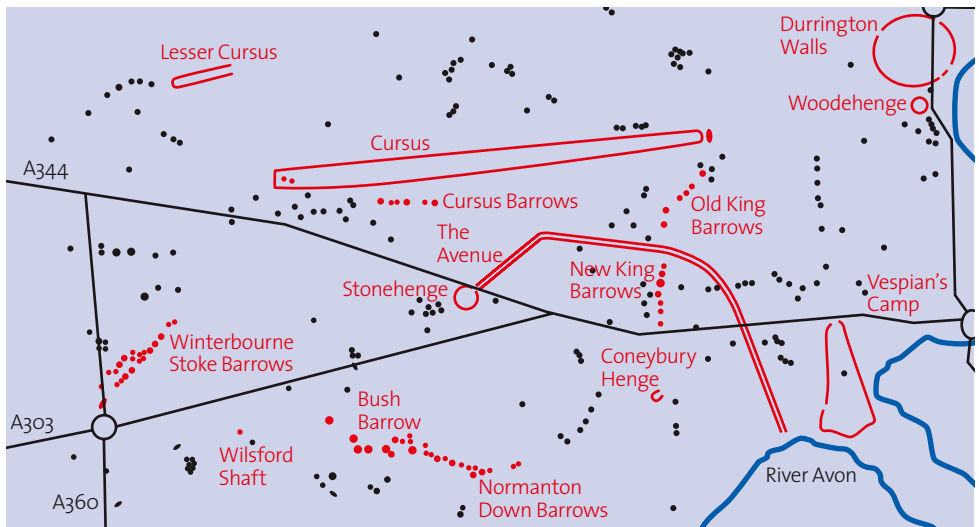
The huge sandstone blocks known as **sarsens**, up to 7 m tall, were hauled 30 km southwards to the site, most probably in about **2450 BC**. Five trilithon archways, in an arc facing the northeast, were surrounded by a lintelled circle.

Stonehenge in its Landscape

Stonehenge did not exist in isolation, but within a landscape filled with people. This **cultural landscape** developed over time, so that the “prehistoric monuments” we see today were built over a timespan of more than 2000 years, from the fourth millennium BC through to the second millennium.

At some time after the construction of the sarsen monument at Stonehenge, a 3 km long ceremonial way known as the **Stonehenge avenue** was built to connect the site with the River Avon.

Several other henges – round earthen enclosures – were built at around the same time that the stones were brought to Stonehenge. These include **Woodhenge**, inside which several concentric ovals were built of timber posts, and **Durrington Walls**, a huge henge more than 300 m across.



The **open grasslands** that characterize the chalk downlands of the Salisbury Plain today developed gradually as a result of increases in animal herding and crop cultivation from the fifth millennium BC onwards. **Long barrows**, communal burial mounds of the Early Neolithic period (fourth millennium BC), occupied this landscape for many centuries before the first known constructions began at Stonehenge itself. Also belonging to this era is the so-called **cursus**, an enigmatic 3 km long and 100 m wide strip delineated by two earthen banks, running roughly east to west. It is only barely visible today.

“Ancient” monuments built by earlier generations already formed part of the landscape, even in prehistoric times. Many centuries after construction activities had ceased at Stonehenge, powerful **Bronze Age chieftains** ensured that they were laid to rest in magnificent tombs (**round barrows**) with sight of the great monument. By then, Stonehenge may have lain at the heart of a ritual landscape that people only entered at propitious times.

Ancient Skies

Ancient peoples had the benefit of dark skies and experienced the full spectacle of the starry heavens. **The Moon** gave light at night and would have been particularly useful in the two weeks centred on full Moon. The regular monthly cycle of lunar phases provided a convenient measure of time, upon which many ancient calendars were based. **The Sun** was an indicator of the changing seasons, being low in the sky in winter and high in summer, as well as giving the daily alternation of day and night.

Some ancient peoples also recognized that the Sun's rising and setting points vary over an **annual cycle**. In the northern hemisphere, it rises/sets furthest north at the **summer solstice** and furthest south at **winter solstice**. The Sun reaches its maximum midday altitude at summer solstice and minimum midday altitude at winter solstice, making the solstices significant turning points of the year. The angle between the Earth's rotation axis and the ecliptic plane of the solar system (known as the **obliquity of the ecliptic**) varies slowly. Consequently, in **Neolithic times** the summer solstice Sun rose and set about 1° further north and the winter solstice Sun rose and set about 1° further south than it does now. This effect must be kept in mind when **horizon alignments** are being considered.

The Moon on the horizon

The Moon's rising/setting points move to and fro along the horizon in a manner similar to the annual movement of the solar rising/setting points, but over a period of just 27 days. However, in the case of the Moon, the extreme monthly rising/setting points themselves gradually move over an **18.6-year cycle** caused by a gradual cyclic variation of the Moon's orbit. The period of maximum excursion between rising/setting points is known as the **lunar major standstill** and the period of minimum excursion of rising/setting points is called the **lunar minor standstill**. Minor standstill occurs about 9.3 years after major standstill and is followed by another major standstill 9.3 years later. In practice, however, the change in the extreme rising/setting positions close to a standstill is so slow that the standstill effectively lasts for up to 18 months. The most recent lunar major standstill occurred in **2005/2006**.

Over the 5000 years separating us from the builders of Stonehenge, there have also been subtle changes in the orientation of the Earth with respect to the background stars – the effects of the slow **precession** of the rotation axis of the Earth. These variations can cause difficulties in assessing the importance of particular stars for Neolithic peoples, since precession, acting over time, shifts their rising/setting positions quite considerably and may even mean that certain stars, once visible from a given location, no longer appear in the sky at all, while others may only be visible now. One such example is the **Southern Cross**; surprisingly, this would have been visible from the Stonehenge area low in the southern sky up to a few centuries before the digging of the ditch and bank.

Ancient Peoples

Cycles in the skies were readily correlated with earthly cycles such as the **seasonal cycle**. The **winter solstice** stood out as a time of renewal and regeneration. At the Neolithic passage tomb of **Newgrange** in Ireland, the light of the Sun shortly after dawn around the winter solstice shines directly in to the interior through a roof-box above the entrance, lighting up a long passage and inner chamber that are usually in darkness. An important connection clearly existed in people's minds between the **Sun, death, ancestors**, and (very likely) the **annual process of renewal**. Most archaeologists believe that we should view astronomical connections at great temples such as Stonehenge in a similar light.

People in later prehistory had our mental capacity – they were intellectually capable of building “observatories” to record the motions of the heavenly bodies in great detail – but what they were actually motivated to do may have been very different. **Anthropology** – informed by case studies from various human cultures including **historical** and **modern indigenous** ones – tells us much about human conceptions of the skies and the systems of thought within which they develop. Outside the framework of thought prevailing in the modern Western world, people's perceptions of the cosmos typically integrate features of the natural environment, the living world, the sky, people, and even imagined worlds, that we would see as inherently separate, into holistic **world-views**. In the past, objects and events in the skies were understood in the context of broader **cosmologies**.

Most monuments, even astronomically aligned ones, were *not* what we would choose to call **observatories**. Instead, they encapsulated what was already known. Temples, tombs, and even dwelling houses frequently “modelled” the perceived cosmos in various ways as a way of keeping cycles of human activity in tune with the cosmos. They were **microcosms**.



Mayan astronomy

Mayan priests and astronomers studied the cycles of the heavens in huge detail, but the motivation was primarily **astrological**. Here, as in numerous other human societies, the skies were not studied for their own sake; nor were they just used to help regulate **seasonal activities** or for other practical purposes such as **navigation**. Sky knowledge was also used for **social and political ends**.

The Characol at Chichen Itza – a supposed Mayan observatory.

(CLIVE RUGGLES, WWW.CLIVERUGGLES.NET)

Assessing the Evidence

Every aligned structure must point somewhere. Just because a monument points in an astronomically significant direction such as the rising or setting position of the Sun at a solstice, does not mean this was intended by the builders. For example, the axis of the stone circle at **Drombeg**, Ireland, is aligned upon midwinter sunset, but it is one of a group of more than 50 similar monuments in and around County Cork. No other monument in the group is



Drombeg stone circle, County Cork, Ireland.

(CLIVE RUGGLES, WWW.CLIVERUGGLES.NET)

solstitially aligned, so we would be inclined to put Drombeg's alignment down to chance.

For this reason it is important, wherever possible, to study **groups of similar monuments** looking for **repeated trends**.

The **archaeological context** is crucial too. Because we are dealing with people rather than laws of the universe, we cannot always expect consistent behaviour. And many monuments are unique, including the great sarsen monument at Stonehenge itself. Archaeology can provide a range

of other evidence concerning traditions and beliefs in particular places and times.

It is clearly essential to take into account the firmly established **archaeological facts**. For example, astronomical associations that have been noted between the "car park postholes" and the main monument are almost certainly entirely fortuitous, since the holes (which held great timber posts in Mesolithic times) predate the other known constructions at Stonehenge by several millennia.

Planetary alignments

Extremes of the **Sun's and Moon's motions** along the horizon are easy to identify as potential targets for monumental alignments. **Planets** are not so simple, because their motions are considerably more complex.

While many ancient monuments may have had associations with the **stars**, there are many bright stars and their rising and setting positions change over the centuries owing to **precession**. Furthermore, the **atmospheric extinction** of their light as they near the horizon adds a further complication. This makes it extremely difficult in most cases for us to identify particular stellar alignments as deliberate rather than fortuitous.

Stonehenge may well have had connections to the planets, stars and possibly to the Milky Way, but these are effectively lost to us. On the other hand, solar and lunar associations are more obvious.



Planetary alignment at Stonehenge.

(DEREK MCNALLY)

Stonehenge and the Sun

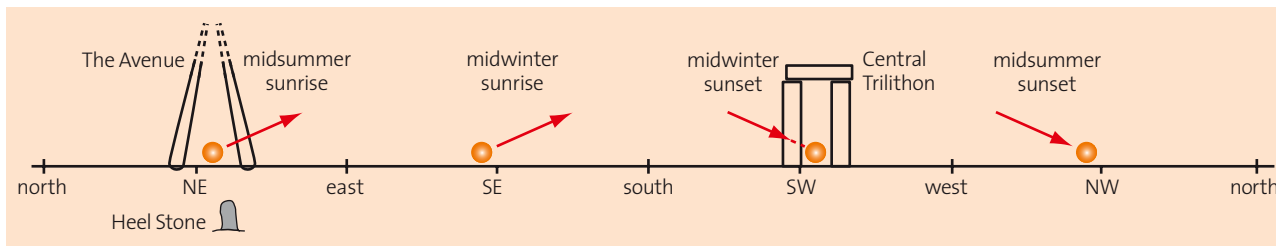
An interest in the rising position of the Sun on the Wessex chalklands did not commence with the arrival of the stones at Stonehenge. Around a millennium earlier, **Early Neolithic** people had constructed many dozens of **long barrows**, each of which had a particular orientation, between northeast and south. This pattern of orientation cannot be explained except in relation to the sky, and the most plausible explanation is that these barrows either faced **sunrise** (on some day) or the **Sun climbing** in the sky.

The “**midsummer sunrise**” alignment at Stonehenge is one of the most famous manifestations of ancient astronomy in the world. It was recognized in the 18th century by the antiquarian **William Stukeley**, and continues to attract thousands of people to the monument at dawn on the longest day of the year to witness the event at first hand. Contrary to popular belief, the “midsummer Sun” does not rise directly above the **Heelstone**, but along the axis of the sarsen monument to its left. The Heelstone is now known to have been one of a pair, one on each side of the axis, and there were further upright pillars between these two outliers and the sarsen circle. This arrangement would have given the impression of the stones forming a **corridor** along which solstitial sunlight would have shone into the centre of the monument. Solstitial alignments exist in other nearby henges and are probably not accidental.

But did Stonehenge actually face



Midwinter sunset at Stonehenge. (CLIVE RUGGLES, WWW.CLIVERUGGLES.NET)



A panoramic view of the horizon at Stonehenge showing the main solar alignments.

the other way – that is, towards “**midwinter sunset**”? A range of evidence supports this view. The bluestone setting, which preceded the sarsens, had its focus (a larger “**altar stone**”) in this direction. The ceremonial approach to Stonehenge along the **avenue** was from the northeast, suggesting that the focus of interest was straight ahead, i.e. to the southwest. Also, an analysis of **pig bones** at nearby **Durrington Walls** shows that slaughtering and feasting took place as part of winter – rather than summer – festivities.

Did the **equinoxes** mean anything to prehistoric people? Probably not. While the limits of the Sun’s rising and setting arcs were physically tangible, there are no grounds for inherently assuming that people attributed any special significance to their midpoints, either in space or time, let alone to a modern astronomer’s definition of the equinox.

Was Stonehenge a **calendar**? Probably not. The solstitial axis may be spatially accurate but it is not precise in time, because the shift in the Sun’s rising (or setting) position close to the solstices is small and not easy to measure. Although modern people seek to visit on the actual solstice (21 June) it is unlikely that prehistoric people knew this exact date: even the Romans had trouble determining the precise date of the solstices, which – indirectly – is why **Christmas** is celebrated on 25 December and not on the 21st, the actual winter solstice date.

Stonehenge and the Moon

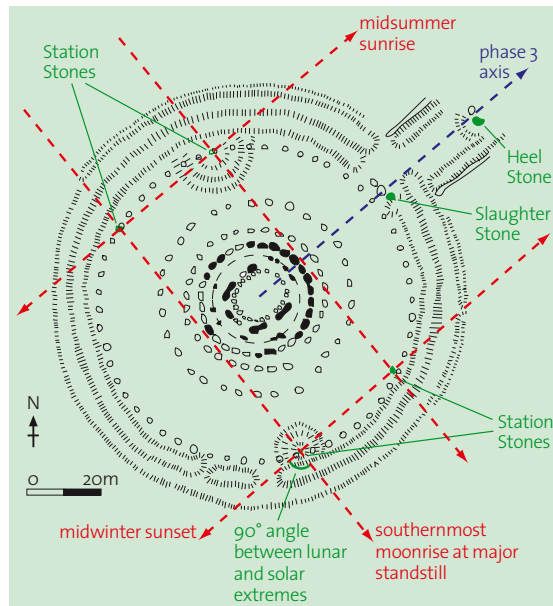
Whereas we can be sure that Stonehenge related directly to the Sun, its possible associations with the Moon remain much debated. Claims made in the 1960s that the monument incorporated large numbers of intentional alignments upon significant solar and lunar rising and setting positions are undermined by the archaeological evidence and are also statistically unsupported.

Nonetheless, some tantalizing strands of evidence remain. Chief among these is the orientation of the **Station Stone rectangle**. While its shorter axis simply follows the main solstitial orientation of the sarsen monument, its longer axis is oriented southeastwards close to the most southerly possible rising position of the Moon (**most southerly moonrise**). It has been argued that the **latitude** of Stonehenge was carefully chosen so that these two directions were nearly perpendicular, but the perfect location would have been further south, in the English Channel.

In any case, the precise location of Stonehenge was actually fixed by the pre-existing earth and timber monument upon whose remains the stones were constructed. The sightlines along the sides of the Station Stone rectangle were not (quite) blocked out by the sarsen monument. This suggests that they were of enduring significance.

The **lunar phase cycle** (“**synodic month**”) averaging 29.5 days is, for many indigenous peoples, the best-known cycle in the sky. The position of moonrise (moonset) moves up and down the eastern (western) horizon during a slightly shorter period – the “**tropical month**” of 27.3 days. Its phase is related to the season: the most southerly Moon is full around the summer solstice and new around the winter solstice. For the most northerly Moon the opposite is true.

Before the stones arrived, there was no evident solstitial orientation at Stonehenge. Yet after the **earthen enclosure** built several centuries earlier had fallen into disuse, and the timber posts standing in the Aubrey Holes had rotted away, a few people came here to make offerings of animals, tools and even human cremations. These were placed in the ditch, in the (now empty) Aubrey Holes, and were not placed randomly. There are concentrations in the directions of most northerly and most southerly moonrise, suggesting that



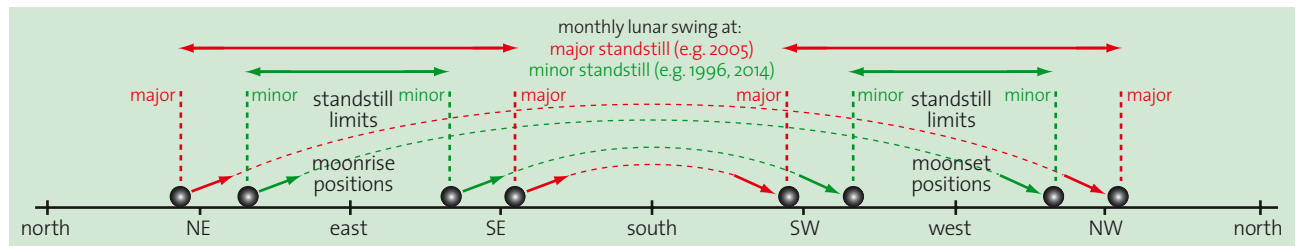
The Station Stone rectangle shows the orientation with respect to movements of the Sun and the Moon.



Stonehenge, with a crescent Moon and Venus in the evening twilight. (FRED ESPENAK/SCIENCE PHOTO LIBRARY)

the motions of the Moon were a concern even at this early stage. (See the discussion on **major and minor lunar standstills** in the panel “Ancient Skies”.)

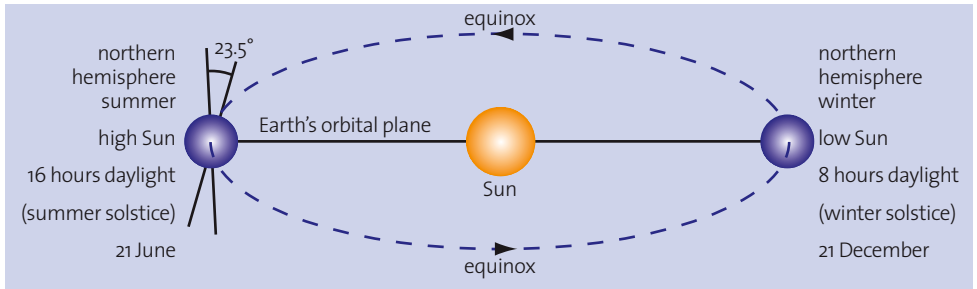
Fred Hoyle famously endorsed the idea that the **56 Aubrey Holes** could have been used to **predict eclipses** by moving marker posts around according to certain rules. This idea does not stand up to scrutiny. For one thing, this could only predict **eclipse danger periods** – very different from predicting actual eclipses, for which the device would have been unreliable. For another, there exist several other Neolithic sites containing **pit circles** and they have widely ranging numbers of holes. Finally, the Aubrey Holes most likely held a **circle of timber posts**, predating the later constructions in stone, that mimicked older woodworking techniques.



A panoramic view of the horizon at Stonehenge showing the main lunar alignments.

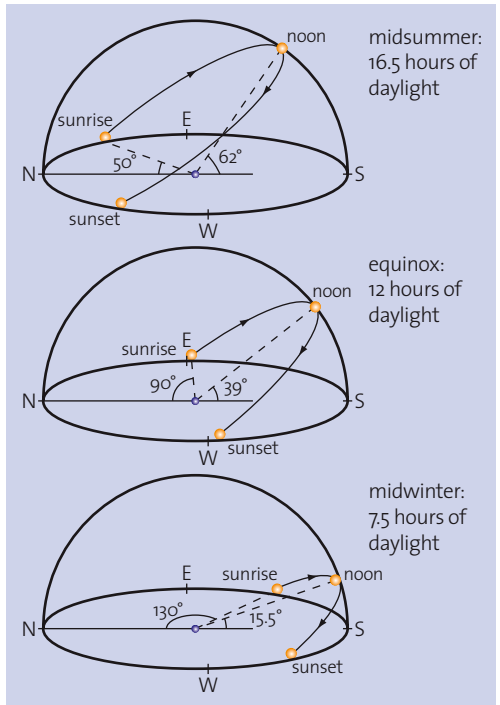
Astronomy and the Seasons

The annual **cycle of the seasons** results from the orbital movement of the Earth around the Sun and the 23.5° tilt of the Earth's **rotation axis**. In the northern hemisphere summer the Sun is high in the sky, rising in the NE and setting in the NW, while in winter it is low, rising in the SE and setting in the SW. The opposite NE and SW directions are marked at Stonehenge by the axis of the sarsen monument and the orientation of the Avenue, and also by the shorter sides of the Station Stone rectangle.

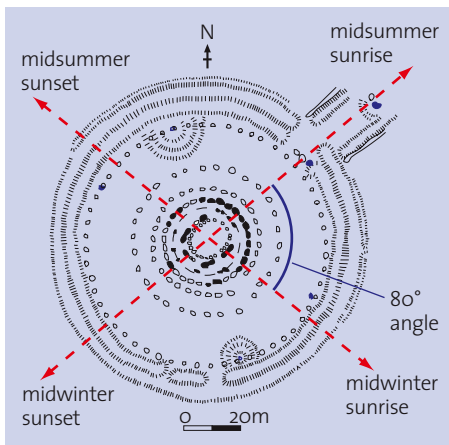


The orbit of the Earth around the Sun.

The apparent path of the Sun across the sky in winter and summer.



Plan of the Stonehenge monument showing the Sun-related alignments.



Beyond Stonehenge

Other broadly contemporary monuments in western Europe

All over western Europe from Scotland to the Mediterranean are local groups of **megalithic tombs and temples** built between the fourth and first millennia BC, numbering several thousand in all. **Orientation** was an important consideration almost everywhere, but – just like other features of design and construction – practices vary from place to place and time to time. Local orientation practices typically produce sets of orientations restricted to a limited arc covering at most one-third of the horizon. This can only be explained by reference to the **diurnal (daily) motions of the skies**, which define the **meridian** (north–south axis) universally.

A group of distinctive **seven-stone “antas”** (dolmens) are found in Portugal and western Spain. Without exception, every one of 177 measured orientations falls within the arc of sunrise, providing overwhelming evidence that they deliberately faced the rising Sun, perhaps on the day that construction began.



Mellizo anta, in the Extremadura region of western Spain. (CLIVE RUGGLES, WWW.CLIVERUGGLES.NET)

Thornborough

At **Thornborough** in Yorkshire are three henges in a line that appear to have been an important Neolithic **pilgrimage centre**. People came here from as far away as across the Pennines, perhaps converging for autumn ceremonials. Various structural alignments upon the stars of **Orion's Belt**, following the shift in its rising position over several centuries, suggest that the first annual appearance (**heliacal rise**) of it provided the trigger for people to set out on their pilgrimage.

Recumbent stone circles

Found only in the Grampian region of **Scotland**, this type of stone circle is characterized by having one large (“recumbent”) stone on its side with two flanking uprights. All of the more than 60 surviving is oriented with the recumbent stone between ESE and WSW. Studies of the group show that these circles related strongly to the Moon, probably the **midsummer full Moon** (the full Moon closest to the summer solstice), passing and setting over the recumbent stone.

Callanish: A “Scottish Stonehenge”

The stones of **Calanais (Callanish)** in the Isle of Lewis, form one of the most impressive settings of standing stones in Britain apart from Stonehenge itself. At around the time of **major standstill**, every 18.6 years, the Moon, upon reaching its most southerly path each month, grazes along the southern horizon before setting into the centre of the monument as viewed inwards along an avenue extending out to the NNE. An account by the Greek historian **Diodorus of Sicily**, writing in the first century BC, mentions a “northern island” (believed to be Britain) where there was a “spherical temple” dedicated to Apollo (the Sun or Moon), who returned every 19 years and “skimmed the earth at a very low height”. While often taken as referring to Stonehenge, others have pointed out that the description of this event applies even more readily to Callanish.