Stonehenge Aotearoa

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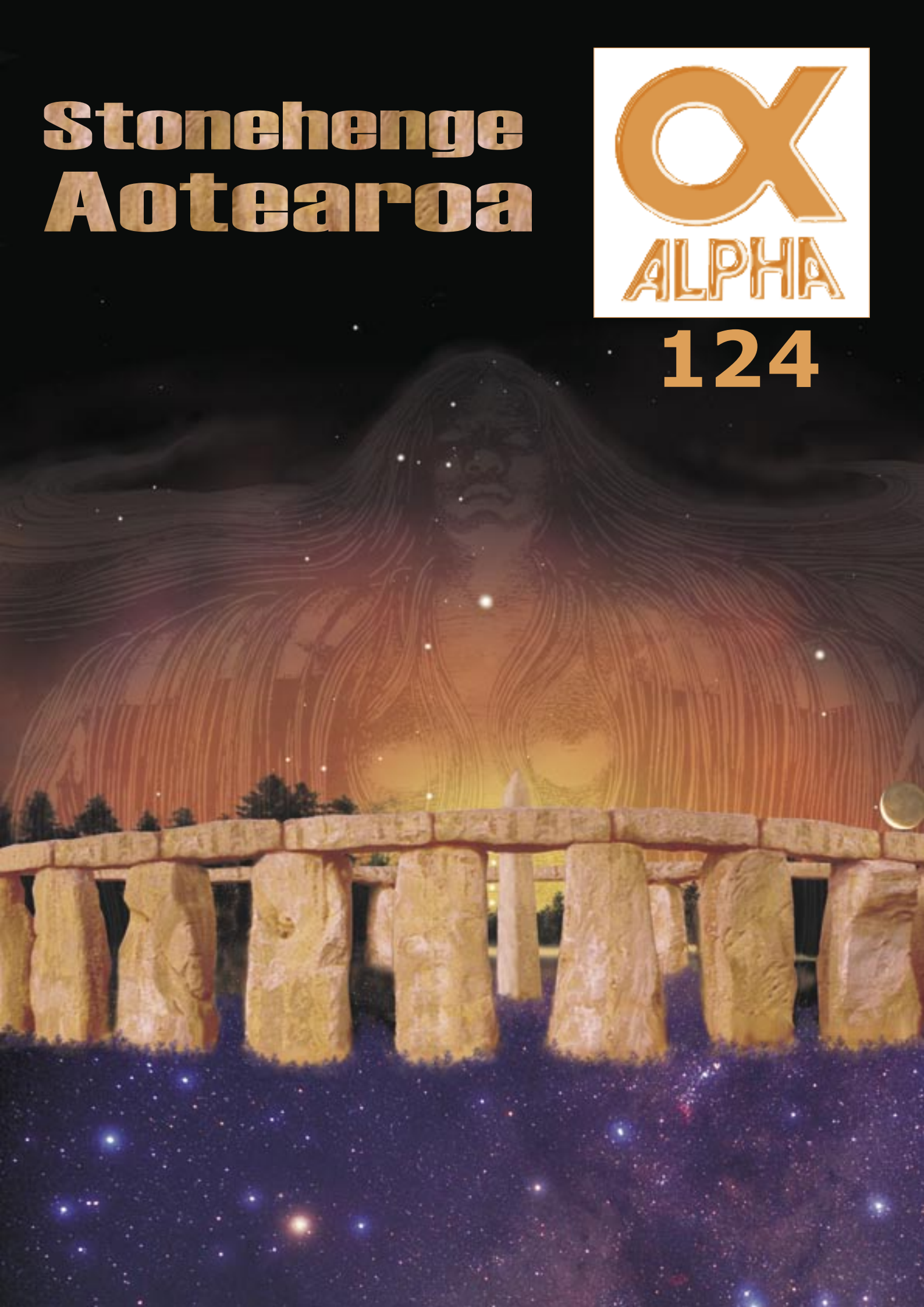


Stonehenge England
Photography by Sacha Hall.

Introduction

The ancient and mysterious circle of massive stones known as Stonehenge is one of England's most prominent icons. For thousands of years, people from all over the world have visited Stonehenge, gazing in awe at its majestic size, and wondering about its mysterious origins. Now, a full-scale working adaptation of Stonehenge has been built right here in Aotearoa, allowing all New Zealanders to experience some of the wonder of Stonehenge for themselves. Situated near Carterton, in the Wairarapa, Stonehenge Aotearoa is designed specifically for its location in the Southern Hemisphere, to allow us to explore and experience how the people of ancient times used the sky to obtain detailed information on the seasons, on time, and for navigation.

The original Stonehenge

Most people have heard about Stonehenge in England. Yet many do not realise just how incredibly long it took to build, and for what exact purpose the structure was used. The structure was built in several phases, the first of which is thought to have began about 5300 years ago. At the end of the first phase the structure consisted of a circular wall, with ditches containing a series of pits (known as the Aubrey holes) running along them. At this time other societies were also constructing massive stone structures. Some of these consisted of circular ditches with one or more inner circles built of stone or wood. Others were palisades or stone tombs. It is thought that the stone circles, including Stonehenge, may have been designed to predict the cycles of the Sun and Moon.

About 500 years later at Stonehenge, in the second phase, an inner circle of bluestones was erected inside the original circular ditch. The bluestones came from the Preseli Mountains in southern Wales, 400 km away. Just how the people at the time managed to transport the stones such an enormous distance has understandably been a topic of intense debate.

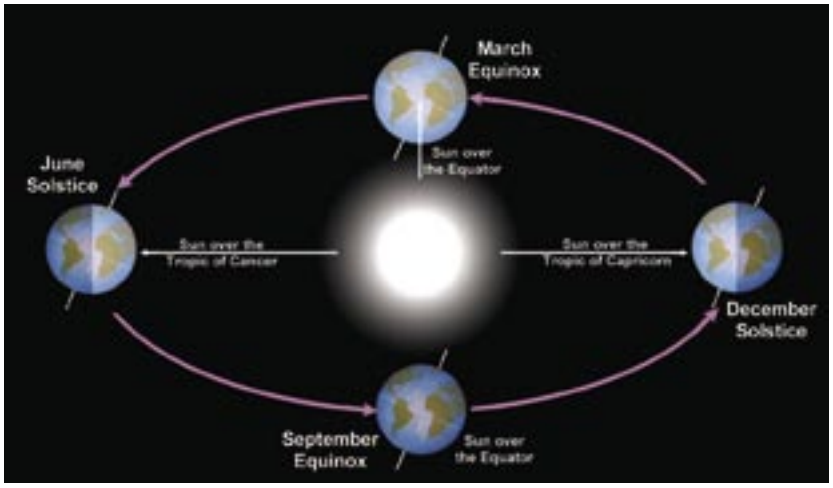
The third and final building phase saw the construction of the most outstanding feature, a circle of huge upright stones, capped with lintels – stones which span the gaps between the tops of the upright stones – forming archways. This is known as the Sarsen circle. The original Sarsen circle at Stonehenge is now in ruins. However, it is easy to imagine what it might once have looked like. Originally, the circle was made of 30 sandstone blocks, each about a metre apart, and four metres high. Now, only 17 of the blocks still stand. The Sarsen circle and lintels were added about 3800 years ago, in the Bronze Age. The stones were thought to have been brought from the Marlborough Downs, about 30 km away. To build Stonehenge was such a huge task that many workers would have been needed, and is likely that the workforce that built Stonehenge would have come from many different locations – perhaps even from the whole of southwestern England.

The original Stonehenge
Artwork by Richard Hall. This is the structure when it was fully complete.

Just what the enormous stone circle at Stonehenge was used for has long remained a mystery, but a major theory is that it may have acted as one of the first computers. Long before Stonehenge was built, people were aware of the regular cycles of the Sun, Moon and stars and their relationship to the cycle of the seasons. Although no one knows for certain, it is thought that the position of the stones may have allowed the cycles of the Sun, Moon and seasons to be accurately predicted. In this way, Stonehenge may have acted as a calendar around which people ordered their lives. At Stonehenge itself, there are some tantalising clues that this may have been so. For example, the main axis of the henge aligns to the direction of rising of the midsummer sun, and in another direction, to the setting position of the midwinter sun. In addition, the Aubrey holes could have been used to predict the complicated cycle of the Moon, including eclipses.

Ancient cultures and the night sky

As the existence of structures like Stonehenge suggest, a knowledge of the Sun, Moon and stars, and their daily and seasonal changes, was essential to the survival of early communities. As a result, astronomy – the study of the stars, planets, and the universe emerged early on in human history, and can now be considered one of the oldest of the sciences. Below are some examples of how the cycles of objects in the sky were important in ancient times.



The Seasons
Due to its 23.5 degree tilt, as the Earth orbits the Sun different hemispheres point to the Sun at different times in its orbit. This causes our seasons.
Artwork by Richard Hall.

Rising stars

If you watch the stars for a while you will soon become aware that the sky overhead appears to be moving. Stars that were close to the western horizon will have disappeared while new stars will have appeared in the east. We talk of the Sun, Moon and stars rising and setting but the stars are motionless; it is we who are moving. As the Earth turns on its axis from west to east, celestial objects appear to move in the opposite direction from east to west. In addition, because of the Earth's orbital motion around the Sun, each evening a given star will rise or set four minutes earlier than the evening before. If you look at the sky at the same time each night, you will notice that the stars are all a little further west than they were at the same time the night before. Eventually, the position where a given star is first seen after sunset will have moved right across the sky. It will be seen briefly above the western horizon before setting itself. After that, it will be lost in the western evening twilight and not be seen because it is too close to the Sun. After about a month, it will reappear in the eastern morning twilight.

In ancient times, it was believed that when the rising stars reappeared, they had been reborn from the fires of the Sun. This was seen as a cosmic cycle of birth, death and resurrection. The time when the star or constellation first appeared in the morning twilight, rising just before the Sun (its heliacal rising), was very significant. Seasonal events were believed to be initiated by the heliacal rising of a particular star or constellation. For example, to Maori, the heliacal rising of the star Whanui (known to astronomers as Vega), towards the end of February, was a sign that the kumara crop had matured and that summer would soon be drawing to a close. To many Maori, the heliacal rising of the star cluster Matariki (also known as the Pleiades) heralded the beginning of the New Year.

Setting stars
Each night, a particular star will set 4 minutes earlier.
Artwork by Richard Hall.

Constellations

In ancient cultures, stars whose heliacal rising occurred in association with seasonal changes were grouped together to form patterns that we call constellations. The names given to them often reflected something to do with that particular season. It could be the appearance of certain animals or birds, such as the swan (marked by the constellation known as Cygnus), the lion (marked by the constellation known as Leo), or the bear (marked by the constellation known as Ursa Major). Or it could be a change in the weather such as the coming of the rains (marked by the constellation known as Aquarius). In Maori culture, certain constellations had greater significance than others, depending on what events they marked.

Today, by international agreement, the sky is divided into 88 constellations. The borders and names of these constellations remain the same no matter where or when they are seen.

The rising of Matariki
The stars along the Eastern horizon in the dawn of early June, the time of the Maori New Year. The same stars can be seen rising in the evening in summer. The Maori names of the stars are in brackets.

This, however, was not necessarily true for some ancient cultures. Although the pattern of the stars does not change, their orientation does, depending on the time of the year, and, to some ancient people, the boundaries of the constellations were thought to be flexible. The same stars could be used to make different pictures. For instance, it seems that here in Aotearoa, the stars that make up the constellation that we call Orion, could at times be seen as tekoteko on the celestial meeting house, a bird's snare, a chief's adze, or the figure of the great bird snarer, Tautoru.

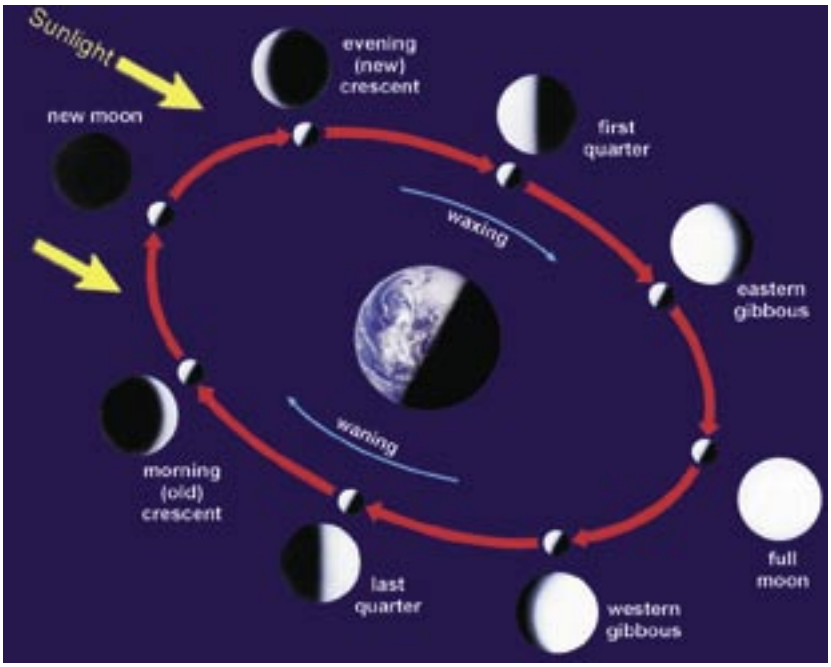
Sunrise
The changing rise position of the Sun through the seasons. Artwork by Kay Leather and Richard Hall.

The cycle of the Sun

As mentioned earlier, although the time of the rising and setting of each star and constellation varies throughout the year, their position of rising and setting remains the same. The rising and setting positions of the Sun, however, vary throughout the year. From our viewing point on Earth, in the Southern Hemisphere, the rising position of the Sun appears to move steadily southward from midwinter to midsummer, and then steadily northward from midsummer to midwinter.

In the yearly cycle of the Sun, there are two events known as equinoxes, that mark the beginning of spring and autumn, and two events known as solstices, that mark midwinter and midsummer. The winter solstice occurs in midwinter, and is the stage when the Sun reaches its northernmost position in the sky. The summer solstice occurs in midsummer, and is the stage when the Sun reaches its southernmost position in the sky. The spring and autumn equinoxes are also events which occur twice a year, and are the stages when the Sun reaches halfway between its northern and southernmost positions and rises due east, and sets due west.

Some of the most important stars are those that mark the solstices and equinoxes which were, and still are, important events. For example, Easter is associated with the northern spring equinox and Christmas with the northern winter solstice.



Phases of the Moon
As the Moon orbits the Earth we see different amounts of its illuminated side, which we call phases. The large images of the Moon show the phase seen from Earth for respective positions of the Moon in its orbit. Artwork by Richard Hall.

The cycle of the Moon

The Moon goes through a regular cycle of 29.5 days from one New Moon to the next. The cycle of the Moon can be used to mark the months of the year, and is where the word "month" or "moonth" comes from. Each week represents a quarter of the Moon's cycle, which involves the following stages. First is the New Moon, which occurs when the Moon is between the Earth and the Sun, and cannot be seen. Next is First Quarter, when the Moon has completed a quarter of its cycle (seven days), and is half illuminated. This is followed by the Full Moon, which occurs when the Moon is fully illuminated and has completed half of its cycle. It is now opposite the Sun. Finally comes Last Quarter, when the Moon has completed three quarters of its cycle, 21 days from the new Moon, and is half illuminated again.

At the beginning of each cycle the Moon is first seen as a thin crescent in the western evening twilight. Each night the Moon appears further eastwards, until, by the end of the cycle, it is finally lost in the eastern dawn twilight. After three days, the moon reappears in the western evening twilight, and the cycle begins again. Ancient cultures believed that when the Moon reappeared, it had been resurrected by the life-giving powers of the Sun, hence the term "New Moon". Today we still talk of a New Moon, even though we now know that it is the same Moon.

The Moon's regular cycle is easy to observe, so it is not surprising that people used it as the first clock. Two nomadic groups could arrange to meet at a certain place in say,

four months, or "moonths" from now. All they needed to do was count the full Moons. If the travel time to the meeting place took two weeks, they would embark upon their journey at the time of the new Moon before the fourth full Moon.

The first calendars were based upon the cycle of the Moon (our present calendar uses the position of the Sun). Maori used a lunar calendar, the Maramataka, and lunar calendars are still used today by Jewish and Islamic cultures.

An introduction to Stonehenge Aotearoa

Stonehenge Aotearoa under costruction. Photography by Chris Picking.

Stonehenge Aotearoa has been built as a full-scale working adaptation of the original Stonehenge, designed to highlight aspects of both ancient and modern astronomy. First, it is a tribute to the early astronomers, illustrating how they used the night sky. In particular, Stonehenge Aotearoa is designed to highlight aspects of the sky that were important to ancient societies, in particular, to Maori and Pacific Islanders.

Although modern astronomers have the benefit of sophisticated equipment such as telescopes and computers, structures such as Stonehenge can still be used today to help people understand the cycles of the Sun, Moon and stars. Stonehenge Aotearoa identifies the:

1. rise and set positions of stars and constellations important in Maori tradition and navigation;
2. rise and set positions of stars and constellations important to New Zealanders trying to find their way around the night sky;
3. rise and set positions of the Sun and Moon throughout the year;
4. annual path of the Sun through the Zodiac;
5. date and the times of solstices and equinoxes;
6. cardinal points of the compass (true north, east, south, and west) and the south celestial pole.

Stonehenge Aotearoa is designed to work in a similar way to how the original Stonehenge was thought to have operated, but it is not an exact replica of it. This is because it is designed for its exact location in the Wairarapa, and is designed to be a working structure. It is, however, similar in size to the original Stonehenge.

Like Stonehenge in England, Stonehenge Aotearoa is made up of a circle of huge stones. There are 24 of these in total, and each one is three metres high. The stones of the circle are capped with lintels – stones that span the tops of the upright stones, forming archways between each pillar. The henge circle is 30 metres in diameter, which is almost exactly the same size as the Sarsen Circle of the original Stonehenge.

How Stonehenge Aotearoa works

When an observer stands in the centre of Stonehenge Aotearoa, the stones, and the archways in between, mark the rising and setting positions of certain prominent stars and constellations. They also mark the rising and setting positions of the Sun and the Moon at different times of the year.

Stars and constellations important in Maori tradition that are marked by Stonehenge Aotearoa

1. The star Vega, known to Maori as Whanui. In Maori legend, this star is the great chief who sails from the north to warn the people to lift the kumara before the frost.
2. The Pleaides star cluster, known to Maori as Matariki. The heliacal rising of this cluster, which occurs close to the midwinter solstice, heralds the beginning of the New Year for many iwi.
3. The star Altair, known to Maori as Pou-tu-te-Rangi. In Maori tradition, the heliacal rising of this star indicates the time to inspect the kumara crop ready for harvest.
4. The Belt, part of the constellation of Orion, known to Maori as Tautoru. Its rise and set position marks due east and west.
5. The star Rigel, known to Maori as Puanga. The heliacal rising of this star is used by some iwi to mark the beginning of the New Year.
6. The star Procyon, known to Maori as Puanga-hori (false Puanga).

7. The star Spica, used in the Pacific Islands as a navigation star. Although it is not known for sure, it may have been used in the same way by Maori.
8. The star Sirius, known to Maori as Takurua, the frost star. Its twinkling revealed the state of the atmosphere near the horizon. Its heliacal rising marked the winter solstice.
9. The star Antares, known to Maori as Rehua. Its heliacal rising marked the summer solstice.
The stones and archways of Stonehenge Aotearoa also form a Polynesian star compass, marking the locations of some of the stars and constellations used by Polynesian sailors on their voyages to and from Aotearoa. Using the stars, Polynesian sailors could be very precise in their navigation, without the use of modern compasses and other equipment.

Polynesian navigational stars and constellations marked by Stonehenge Aotearoa

1. The star Capella, called Matariki in some islands. It is the most northerly of a series of stars along the Milky Way used for navigation by travellers from the islands to Aoteraroa.
2. The Kupe stone, which indicates the set position of the constellation of Scorpius, in Hawaii called the fishhook of Maui. The fishhook of Maui was used with Te Punga (the Southern Cross), to navigate to Aotearoa.
3. The Te Punga stone, which marks the position of the Southern Cross at the beginning of the Maori New Year. Te Punga was used to locate due south.
4. The star Pollux, known to Maori as Whakaahu. Whakaahu's rise position marks the direction of the ancestral homeland to the northeast.
5. The star Shaula, known to Maori as Potiki. Potiki is the zenith star for Aotearoa, and was used by navigators to reach Aotearoa. (Zenith means directly overhead when you reach the right latitude.)

Just south of the central viewing point at Stonehenge Aotearoa stands a five-metre-high obelisk. The line of sight through a hole in the obelisk's identifies the South Celestial Pole in the sky. The South Celestial Pole is a point around which the entire sky appears to revolve.

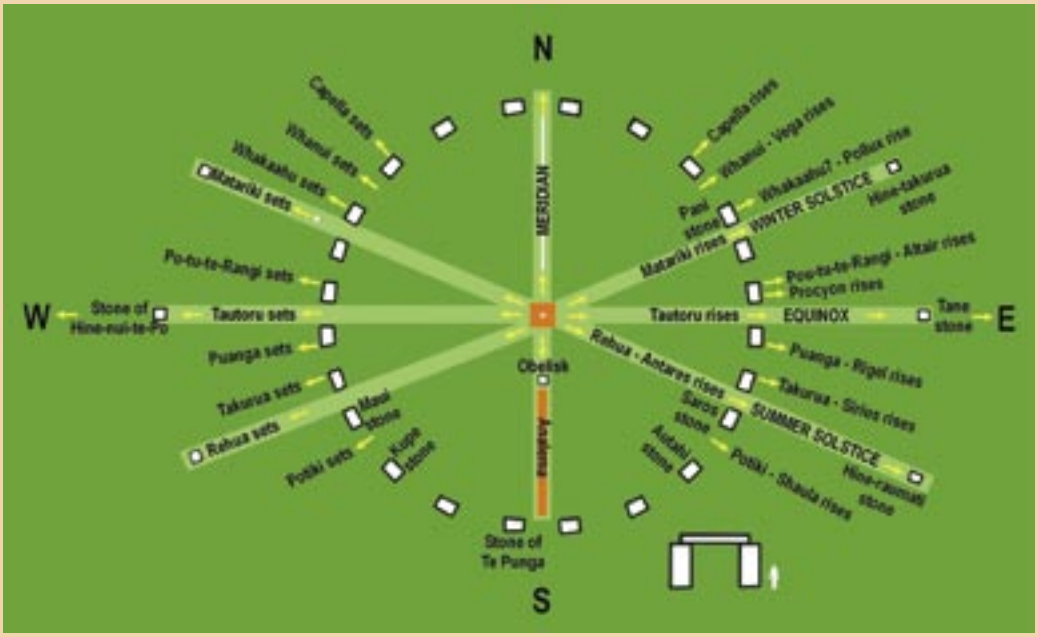
The obelisk also casts a shadow onto a 10 metre long shape on the ground called an analema. The analema is the path traced by the tip of the obelisk' shadow at noon (when the Sun is the highest point in the sky at that site) over the course of the year. The shape of the analema is graduated to provide a calendar accurate to two or three days. It is also used to identify which constellation the Sun is in at any time of the year.

Beyond the henge circle at Stonehenge Aotearoa are six "heel" stones that mark where the Sun rises and sets at the solstices and equinoxes. These heel stones are named after figures from Maori legends.

The positions of the Sun marked by Stonehenge Aotearoa

The six heel stones are as follows:

- The stones of Hine Raumati (the Summer Maid), and Hine Takurua (the Winter Maid) mark the position of the rising Sun at the summer and winter solstices. In Maori tradition, Hine Raumati and Hine Takurua are the two wives of te Ra (the Sun).



- The stones of Rongomai-tahanui and Rongomai-taharangi mark the position of the setting Sun at the solstices. In the Matorohanga manuscripts (East Coast tradition), these are the great guardians of the sky.
- The stones of Tane and Hine-nui-te-Po mark the rising and setting positions of the Sun at the spring and autumn equinoxes.

Stonehenge Aotearoa also marks the rising and setting positions of the Moon throughout the year. Like the Sun, the rising and setting positions of the Moon move north and south along the horizon. These positions were also marked on the original Stonehenge.

The people involved in Stonehenge Aotearoa

Stonehenge Aotearoa is located at Ahiaruhe, Carterton, in the Wairarapa, and is part of the Phoenix Astronomical Society's observatory complex. To build Stonehenge Aotearoa, many Phoenix Astronomical Society members generously donated their time, skills and enthusiasm to the project. This was aided by a government grant administered by the Royal Society of New Zealand.

How Stonehenge Aotearoa was built

Designing and building Stonehenge Aotearoa has been a very large project – although not quite on the scale of the original Stonehenge! Before building could actually begin, months of surveying, calculations and groundwork had to be done, to determine features such as the exact position of the henge on the earth; the horizon line (a feature which determined the height of the pillars and the heel stones); the position at which all the important stars, Sun and Moon would rise and set, and therefore the correct position of the pillars and avenues; the height and position of the obelisk; the exact position and length of the analema; and the exact position of services and fences.

The positions of the upright stones were calculated so that they would not obscure the key rise and set positions of celestial objects. Using a theodolite, the shape of the visible horizon was obtained by measuring angles of elevation (vertical angles) around the horizon, and plotting them by computer. The shape of Stonehenge Aotearoa was superimposed on the same plot to provide the positions of the upright stones, to make sure they did not obstruct the rising and setting positions. The tracks of the key star, Sun and Moon rising and setting were calculated and plotted on the same plot as the horizon and Stonehenge shapes. The positions of the upright stones were then adjusted to ensure acceptable clearances of the lines of sight to the key rising and setting positions.

Finally, with the calculations and surveying complete, the building itself could begin.

The building process for Stonehenge Aotearoa

1. The Stonehenge Aotearoa site was fenced off. Many volunteers helped build the 60 m2 boundary fence, including Robbie, the farmer next door, who very helpfully lent his post-driving machinery to the task. Roading was also put in place.
2. The site was levelled, ready for the foundations to be dug.
3. Heavy rain meant the site temporarily turned into a large duck pond. Work had to be put on hold to allow the site to dry out. A system of drainage pipes has now been laid beneath the ground to stop water pooling in the henge area.
4. While waiting for the site to dry out again, the stones for the circle were constructed offsite, ready to be

From left: Graham Palmer, Chris Carhill, Alan Green, Geoff Dobson, Richard Hall, Kay Leather

The key people involved in Stonehenge Aotearoa

Richard Hall

Richard is the project manager, and an astronomer. He worked on all aspects of the henge and is the main media spokesperson.

Kay Leather

Kay is the construction team manager. With Richard Hall she researches and teaches Maori and Polynesian astronomy. She also assists with media as required, and assisted with surveying.

Bob Adam

Bob is the team's surveyor. Before and during the building process, Bob spent many months surveying the site, so that the stones would be put in just the right place to align with the necessary points in the sky.

Geoff Dobson

Geoff is the project's researcher. One of his main tasks was to research information on the original Stonehenge.

Lesley Hall

Lesley in her capacity as the treasurer of the Phoenix Astronomical Society took care of the project's accounts, arranged working bees, and acted as gofer as required.

Chris Martin, Katrina Leather, Chris Cahill, Alan Green, Graham Palmer and Richard Beavis were the key volunteers and team leaders. One or more of them was involved in every working bee for about a year.

moved into place later on. The "stones" are not actually made of stone at all. Instead, they consist of a wood frame, covered with cement board, then wire mesh and concrete. The final stone "look" was created with the use of stone plaster. In a very modern twist compared with the original Stonehenge, the stones are also wired for sound, with microphones.

5. Once the site had dried, the foundations for the stone circle were dug, and the circle was surveyed again, just to make absolutely sure that the pillars could be precisely placed.
6. Concrete with steel reinforcing was poured to form the foundations of the circle. It was necessary for this to be strong, to support the 24 pillars and lintels that form the main structure of Stonehenge Aotearoa. Eight truckloads of concrete were used in this process.
7. The positions where the stones were to be placed were marked out on the concrete.
8. The stones and obelisk were finally put in place. The wood frames of the stones were anchored into the concrete ring.
9. A 10-metre-long concrete plinth was precisely laid for the analema. The analema and its constellation figures were initially drawn up on a computer. The final product was created out of 19000 coloured tiles cemented to the concrete plinth.
10. Once the henge was complete to a suitable stage, readylawn was laid. The lawn runs between the pillars under the lintels so that the pillars will seem to rise from the ground.
11. Water features, important to Maori cosmology, were constructed around the henge.

Overall, Stonehenge Aotearoa creatively combines the following ancient technologies:

- **stone circles found throughout Europe, dating to about 3000 BC;**
- **the Polynesian star compass, which was developed in southeast Asia, also about 3000 BC;**
- **the obelisk, which was developed by the Mesopotamians about 6000 BC;**
- **modern mathematics and astronomy.**

Stonehenge Aotearoa brings these ancient technologies to New Zealand in a form that is similar to their original form and scale. Visitors to the henge become both scientists and time-travellers, discovering for themselves the knowledge of their ancestors.

Direct enquiries and orders to:
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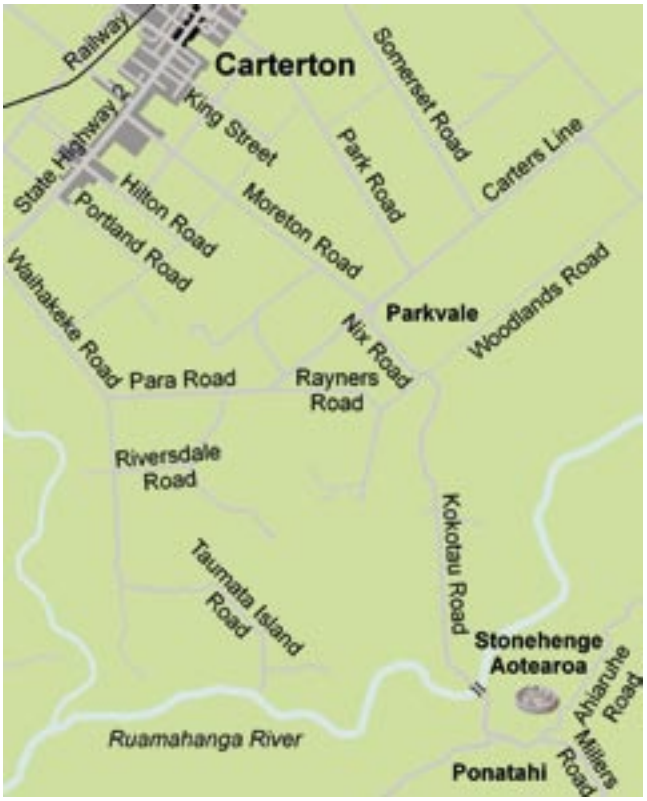

Location of Stonehenge Aotearoa. Access by appointment only. Ph 027 2466 766. P.O. Box 2217, Wellington

Front cover
Hine-nui-te-Po, holding the New Moon in her hand.
Below is Stonehenge Aotearoa against a southern starfield.
Artwork by Richard Hall. Photography by Chris Picking.

References

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