

How many days are there between full moons - think you know? Is there an ancient key to the calendar hidden in stone circles? What is the magical secret of the Sun-Moon-Earth system?

If you have ever wondered about eclipses, tides or the seasons, this amazing little book by acknowledged time-lord Robin Heath will quickly introduce you to the astonishing beauty of the primary cycles around this planet. Advanced wizarding at its best!

"Timeless" - Resurgence Magazine



£4.99
All recycled
Made in Britain

WOODEN BOOKS

ISBN 1 904263 46 1
9-781904-263463

SUN, MOON & EARTH

WB

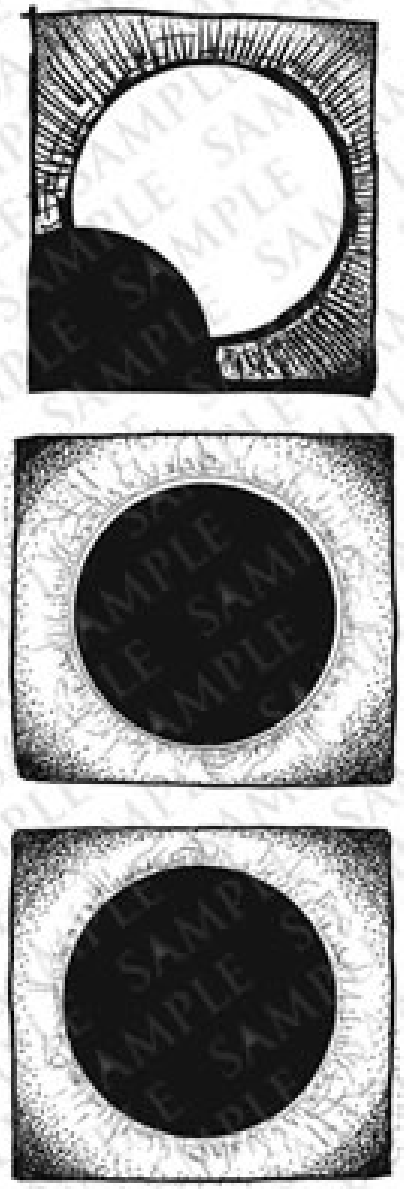
the here and now whole happening cosmic guidebook

SUN, MOON & EARTH



Robin Heath

an invitation to the alchemical wedding



The three types of Solar Eclipse: Partial, Annular and Total

First published 1999 AD
This revised edition © Wooden Books Ltd 2006 AD

Published by Wooden Books Ltd.
8A Market Place, Glastonbury, Somerset

British Library Cataloguing in Publication Data
Heath, R.
Sun, Moon & Earth

A CIP catalogue record for this revolutionary
little book is available from the British Library

ISBN 1 904263 46 1

Recycled paper throughout.
All rights reserved. For permission to
reproduce any part of this book
please contact the publishers.

Printed and bound in Great Britain by
The Cromwell Press, Trowbridge, Wiltshire.
100% recycled papers supplied by Paperback.

WOODEN BOOKS

SUN, MOON & EARTH



written and illustrated by

Robin Heath

Some pages in this book assume you are living in the northern hemisphere. Special thanks go to my brother, Richard, for being a vital part of the early research. Many thanks to John Martineau.

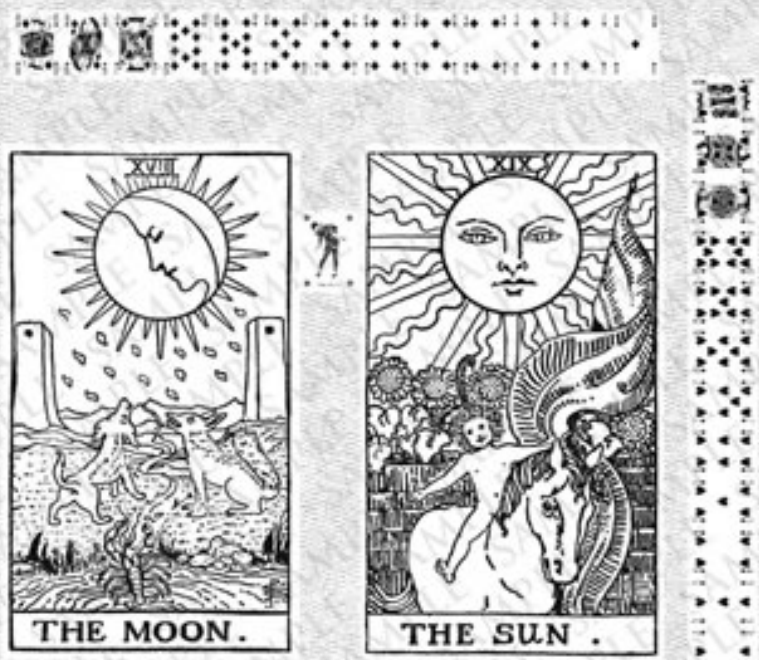
The title page shows the Venus of Laussal, circa 18,000 BC. A clear message survives the aeons, confirming ancient human knowledge of the link between the Moon and the human reproductive cycle; thirteen notches on a crescent horn link astronomy with human culture.



The Moon and Sun follow a circular 12:13 rhythm just like the minute and hour hands of a clock.

CONTENTS

Introduction	1
Searching for Patterns	2
Some Early Solutions	4
The Sun	6
Solstices and Equinoxes	8
Sun Watching	10
The Moon	12
The Moon's Two Rhythms	14
The Tock of the Moon	16
The Lunar Day	18
The Earth	20
Sun, Moon and Landscape	22
The Moon's Nodes	24
The Breath of the Moon	26
Eclipses	28
Lunar Eclipses	30
Solar Eclipses and the Saros	32
Saros Patterns	34
The Dance of the Moon	36
The 19 year Metonic Cycle	38
Thirty-three	40
The Precessional Cycle	42
Designing a Calendar	44
Stonehenge	46
The Silver Fraction	48
The Lunation Triangle	50
Sun, Moon and Earth	52
A Stone-Age Computer	54
Pebbles on the Shores of Time	56
Tables	58



Eighteen and Nineteen - the Tarot cards numbers of the Moon and Sun, framed by a playing card set; 4 suites of 13 cards, representing the 52 weeks in the year. Adding up the 'pips' on each suite (the sum of 1 to 13) yields 91, the number of days per season. All four seasons then total 364 days, the joker completing the year at 365. An ancient aide memoire for the calendar.

Introduction

In an uncoordinated attempt to better understand and control the material universe, our present culture has strayed so far from simplicity and beauty that we are often startled or afraid when it reveals itself.

The modern system of ideas we call *Science* has dispensed with the poetic and broadly fails to see the subtle connecting strands of meaning woven into the web of life. In addition, science is today shackled to commerce, also blind to such things, and thus we have 'the blind leading the blind'. As if that wasn't enough, today's high priests of Science also inform us which interpretations of the cosmos are valid, and which are not. Some questions are just not to be asked any more, let alone answered.

This little book reveals a poetic cosmology which lies within the cycles of the Sun and Moon, as seen from Earth. It is found to be supremely rational, so simple and elegant that no priestly intermediary is needed to interpret, censor or intervene.

All the mathematics given here may be verified by those of little faith with a simple calculator and the mind of an inquisitive teenager.

SAMPLE

Searching For Patterns

finding order in the cosmos

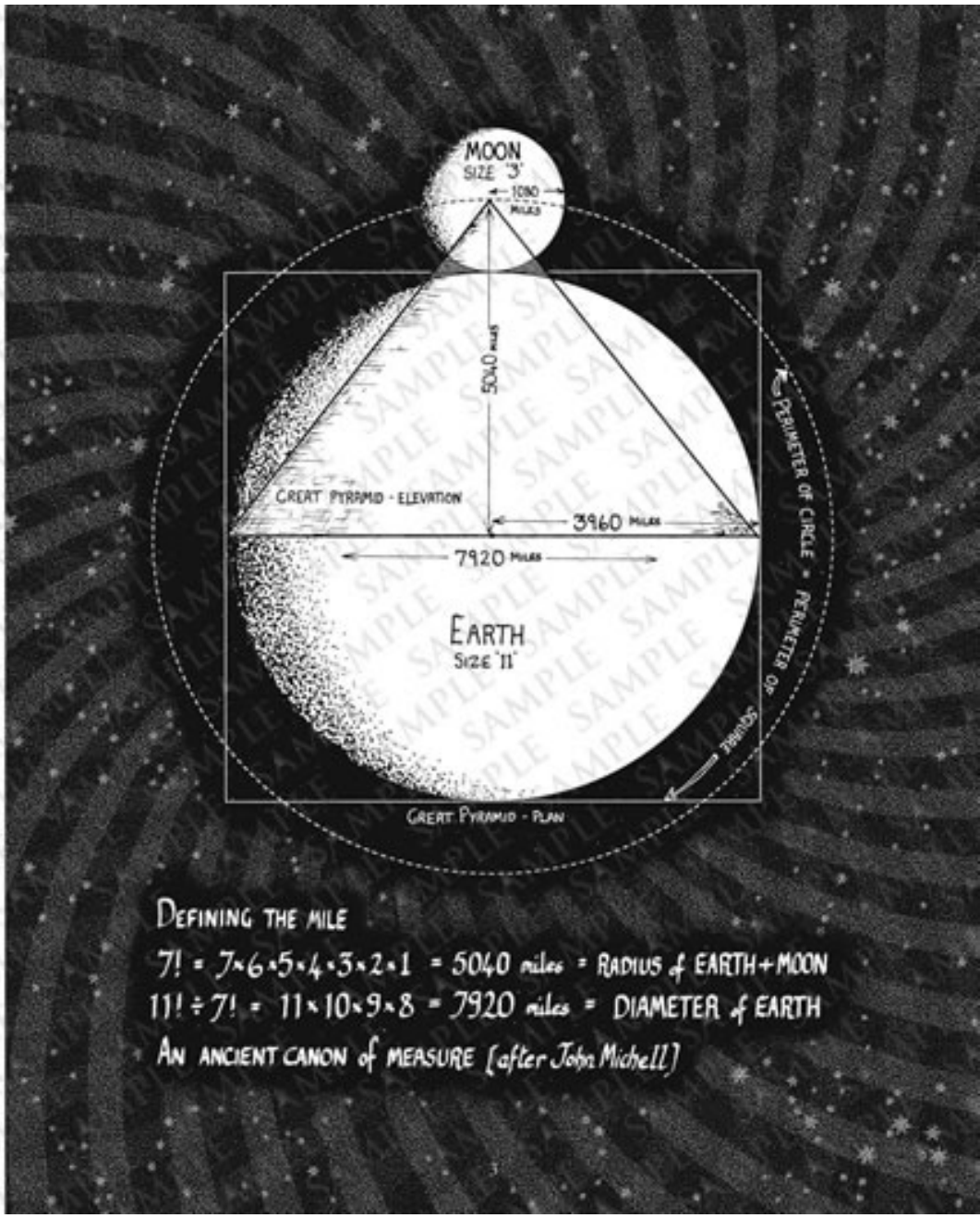
The first systematic observations of the Sun and Moon are shrouded in the mists of prehistory. Scored bones from 40,000 BC (*below*) display lunar number cycles whilst the famed *Venus of Laussal* (*title page*) links the Moon with the number thirteen.

Repeated cycles such as full moons, eclipses and planetary conjunctions revealed a cosmology to ancient astronomers which was both numerical *and* geometrical, and which imbued creation with order and meaning - 'God is a geometer'. The delphic adage '*as above, so below*' suggests cosmic patterns are reflected in earthly life, becoming a source of revelatory information.

The Great Pyramid (2480 BC) epitomizes this approach. Built to the points of the compass, with passages aligned to stars, its base and height fit the 'squared circle' of Earth and Moon.

This archaic approach to cosmology is today discarded as worthless, and has been replaced by modern astronomy, yet most people now know almost nothing about the Sun, Moon and Earth system, despite our total dependence on its rhythms. This book will gently put that right, and re-invoke something of the spirit of the old sciences.





Some Early Solutions
from megaliths to the Maya

Skywatching is an ancient art. Stone circles date from 3000 BC, aligned megaliths even earlier. The Egyptians were using accurate surveying and a precise metrology for both sky and Earth. The Great Pyramid enshrined its date of construction through astronomical alignments to fixed stars. The Sumerians recorded astral cycles from 2200 BC and later defined the 24 hour day and 360 degree circle. Chaldean and Chinese astronomers knew of the Saros eclipse cycle (*page 32*). Various solar calendars were in use, and lunar calendars of 354 days.

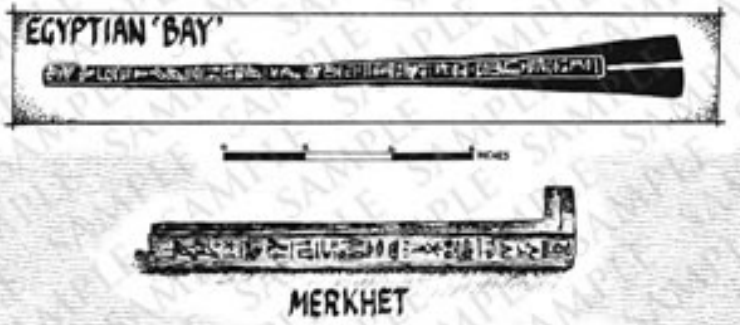
From 600 BC, the Greeks inherited this ancient wisdom. Eratosthenes measured the size of the Earth and Eudoxus devised a solution for the complex motion of the Moon. In the 4th century BC, the 19 year cycle of Sun and Moon was described by Meton. The Romans gave us our modern calendar in 45 BC.

When the Empire collapsed around 500 AD the Arab world kept the torch of learning burning as Europe sank into the Dark Ages. Following the Crusades this material returned, seeding the Renaissance in Europe. Copernicus showed that the Earth orbited the Sun, whilst Galileo's telescope revealed moons orbiting other planets. Kepler published his three laws of planetary motion in the early seventeenth century, whence Newton used data about the Moon to quantify his universal laws of motion and gravity in 1687, thereby spawning our modern world. A century later Harrison's chronometer greatly improved time-keeping and navigation.



El Castillo, Chichen Itza

4 flights of 91 steps totalling 364
plus the high altar - 365.



~ Early Surveying Instruments from Egypt ~

These instruments belonged to an "Hour Priest"
of the twenty-sixth Dynasty, circa 1000 BC.

The Sun
the day and the year

Each day, the Sun appears to rise from an easterly direction, traces a clockwise arc across the heavens and then sets towards the west, disappearing for the dark time we call night. This cycle repeats perpetually; it is the diurnal rhythm, called, more simply, the *day*, 24 hours of our clock time. What we see is caused by the daily rotation of a spherical Earth on its own axis.

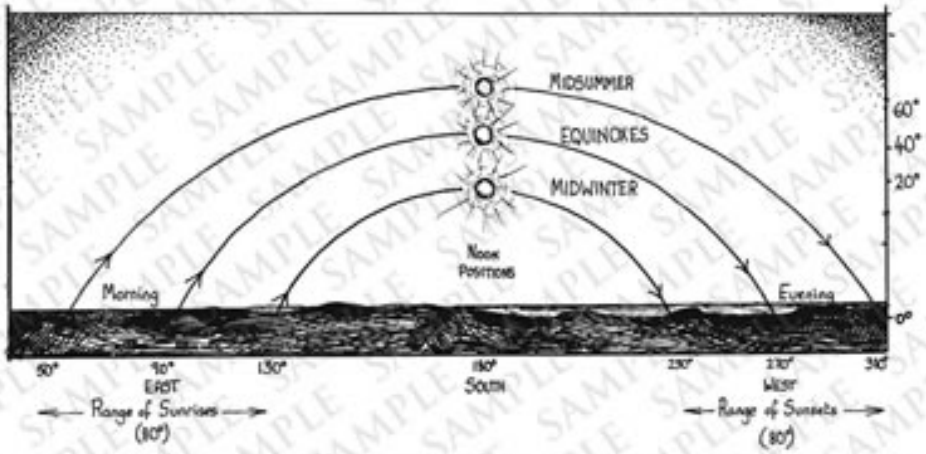
To complicate matters the Sun each day appears to move about a degree anticlockwise (eastwards) with respect to the fixed stars, along a path known as the *ecliptic*. This may be observed as the stars rising by just under four minutes earlier each evening and is caused by the Earth orbiting the Sun. Thus the solar day, to which we set our clocks, exceeds the *sidereal* (star) day by 3 minutes and 56 seconds.

The axial tilt of the Earth (*page 8*) causes the Sun to rise and set each day at different positions on the horizon. Only at the summer and winter *solstices* is this daily change in the Sun's rise and set positions reduced to zero, at their extreme *standstill* positions. Subsequent sunrises and sunsets gradually reverse back along the horizon, the observed range being dependent on the latitude of the observer (*opposite below*). This is the four-fold rhythm of the *year*.

The Earth's orbital period is 365.242199 days. Our solar calendar of 365 days keeps pace by adding a leap-year day every four years (except once every four centuries), and by occasionally inserting the odd leap second or two.



the earth takes one year to orbit around the sun
a slightly elliptical orbit means the earth is very slightly closer to the sun
in our wintertime (on the right in the diagram above) than in the summer



the path of the sun at different times of the year at the latitude of london

Solstices & Equinoxes

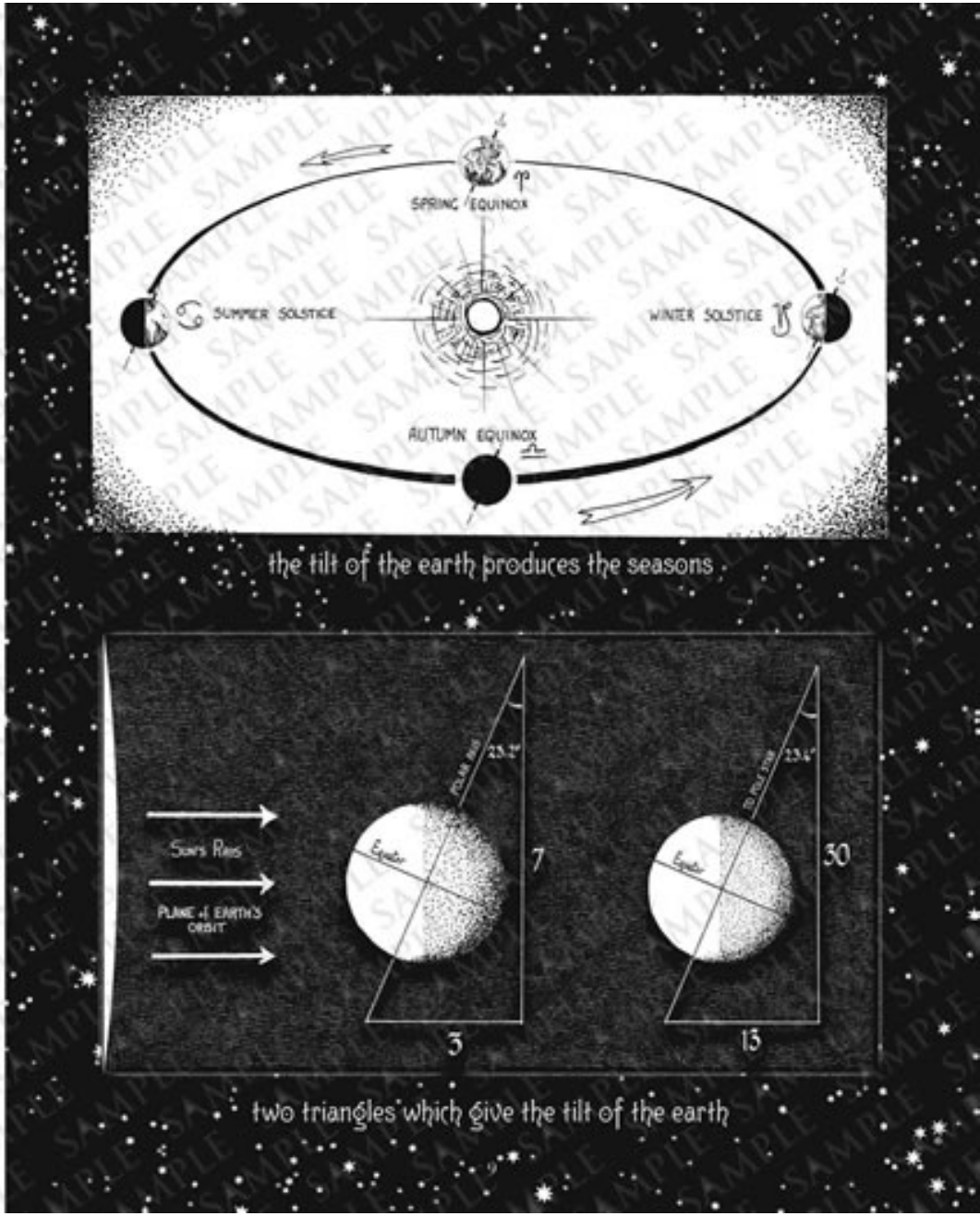
the four natural divisions of the year

In between the two solstices, the longest and shortest days in the year (normally 21st June and 22nd December), lie the two equinoctial periods in the spring and the autumn. The *equinoxes* (21st March and 23rd September) deliver equal lengths of day and night everywhere on the planet, with the Sun rising exactly due east and setting exactly due west, on a level horizon.

These equinoctial dates are accompanied by the maximum rate of change in the length of the day. In temperate latitudes, this creates the impression that the year is divided into two distinct halves, a light, warm, summer half, and a dark, cold, winter half. During the summer half the Sun rises and sets north of an east-west line; in the winter half always south of it.

The solstices and equinoxes naturally divide the year into four quarters, defining the four seasons. Each season is about 91 days in length (*see page 5 and opposite page 1*), caused by the tilt of the Earth on its own axis (currently $23\frac{1}{2}^{o}$ with respect to its orbital plane). This angle may be constructed using a right triangle, base 13 and height 30, or more approximately 3 and 7.

The 'cross-quarter' days, halfway between equinoxes and solstices, are still celebrated as the Celtic festivals of *Samhain* (November), *Imbolc* (February), *Beltane* (Mayday) and *Lughnasadh* (August). The Earth orbits the Sun at the incredible speed of 66,666 miles per hour and at a distance of 108 solar diameters.



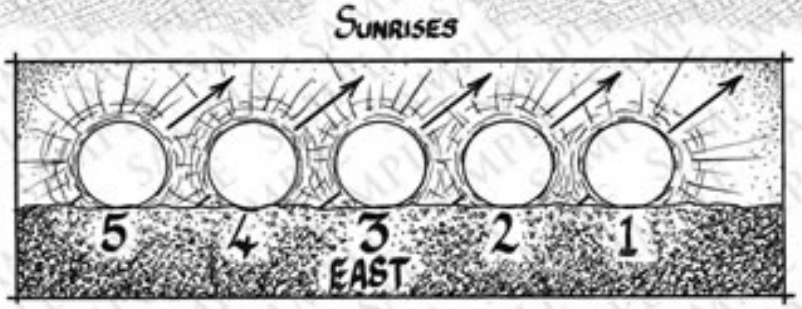
Sun Watching

packets of days and repeat cycles

Folk who haven't ever thought the matter through will often tell you there are 365 'and a quarter' days in the year but if you stop to think about it you will soon realise that *one cannot ever experience a quarter day in isolation*. Days come in packets of one, and 365 of these make up the year, except that every fourth year an extra day slips in to make it 366.

At high latitudes, consecutive sunrises around the equinoxes are spaced more than the Sun's diameter apart (*five sunrises shown opposite top*). Each year, the vernal equinox sunrise appears from a slightly different position on the horizon (about one quarter of a degree - *lower opposite*). During three years of observation, the Sun appears to rise to the left of the original alignment until, in the fourth *leap* year, it rises once more very close to the original position, the tally for that year becoming 366 days. This accounts for the 'quarter day' and is the basis for the extra *intercalary* day, February 29th.

The length of the year can be observed to much higher accuracy by noting key years when the Sun rises *precisely* behind a foresight, stone marker or notch in a distant mountain peak on a given day, indicating a perfect repeat solar cycle. The best of these occurs after 33 years, or 12,053 days or sunrises, and defines the solar year as $365\frac{8}{33}$ days in length, accurate to 99.9999% compared with the modern calendar at 99.998%. This has made 33 an important solar number for skywatchers since prehistoric times.



around the time of the equinoxes in late March and September the position of the rising sun on the horizon changes by more than a solar diameter every day



the exact position of an equinox sunrise on the horizon slightly drifts each year, roughly resetting every fourth year, but most precisely after 33 years

The Moon

the goddess of the night

Although apparently lifeless, the Moon greatly affects life on the Earth. The fluctuating monthly rhythm of reflected light, the twice daily ebb and flow of the tides and many natural cycles are all essentially locked to the lunar phases as, uniquely, is the reproductive cycle of humankind. The Moon is associated with women and the number 13, perhaps because she moves 13 degrees a day and orbits the Earth 13 times in one year. People see a man in the moon or sometimes a hare, owl, swan or lady.

At an average distance of 240,000 miles, the Moon is our nearest neighbour. Her radius is 1080 miles compared with that of the Earth at 3960 miles, a ratio of 3:11. However, the Moon is not spherical, and the Earth's gravity pulls the larger hemisphere always towards us. The Moon thus has its 'dark side', which we never see, but which paradoxically becomes fully lit each new moon.

The Moon's orbital plane is tilted to that of the Earth (*below*) and the Moon crosses the Sun's path (the ecliptic) twice monthly. A full or new Moon occuring at this time places the Sun, Moon and Earth in alignment, enabling eclipses to occur.





The Moon's Two Rhythms

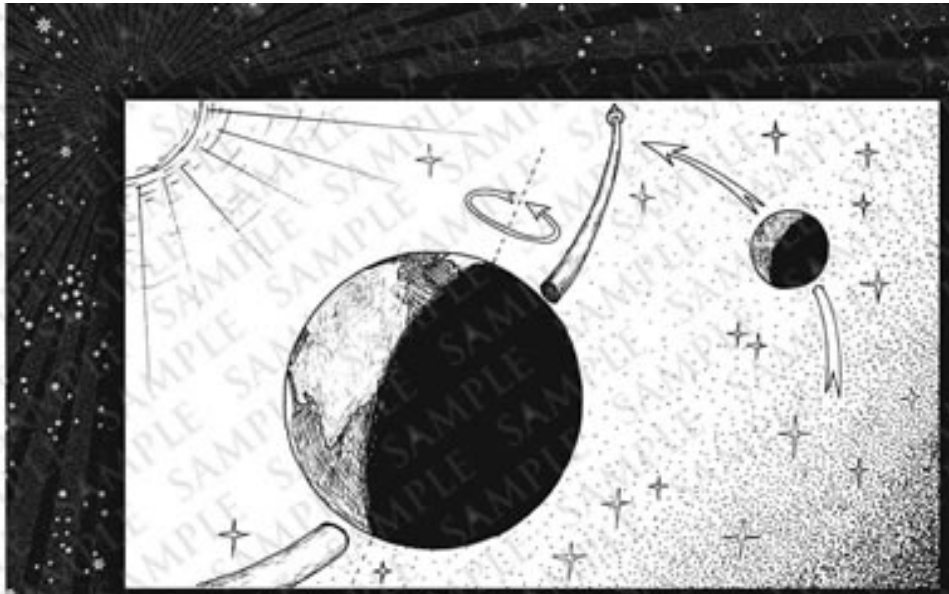
sidereal and synodic months

Observe the Moon and you will soon discover one of her rhythms - she moves past the fixed stars quite rapidly, taking about an hour to move her own diameter. In one day, she covers thirteen degrees, thereby taking slightly less than 28 days to return to the same stars. This is the *sidereal* month of 27.322 days.

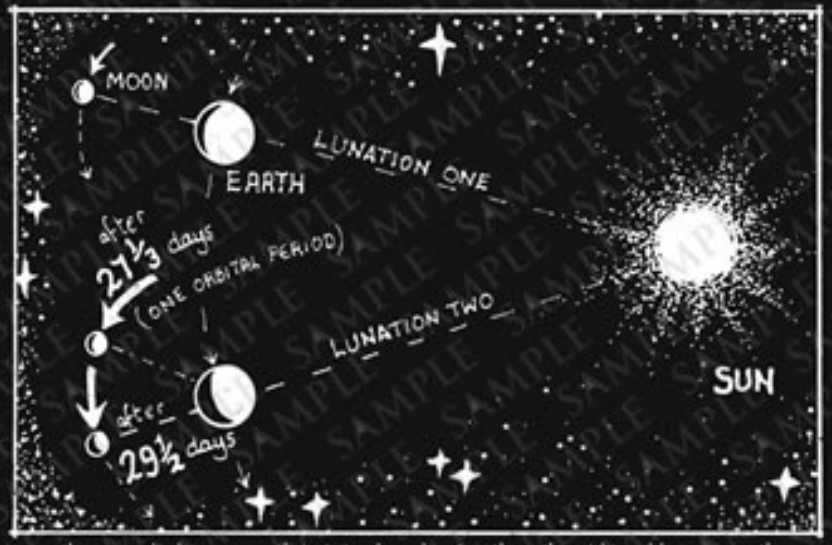
Three principal rotations are now defined: the *day* (Sun-Earth), the *sidereal month* (Moon-Earth-stars) and the *year* (Sun-Earth-stars). All three are shown opposite. But there is a fourth rotation, the lunar phases or *lunation cycle*, the time between full moons, which is truly Sun, Moon and Earth. Because the lunar phases are visible all over the Earth the lunation cycle is the prime lunar rhythm. It is also called the *synodic month* or, more simply, the *lunar month*. The lunation cycle takes 29.53059 days to complete.

These two rhythms resemble a clock face. The 2.21 day 'catch-up' difference becomes one 'period' - five minutes in the clock. Imagine the centre of the clock is the Earth. If the minute hand is made to represent the position of the Moon and the hour hand that of the Sun, then one rotation of the Moon takes twelve periods (sidereal month) whereas the hands meet after every thirteen periods (the lunation or new Moon). This 12:13 rhythm is a fundamental Earth rhythm (*see picture opposite contents page*).

In fact there are 13.368 sidereal months and 12.368 synodic months in the year. The fractional part is very close to seven nineteenths.



the three Key heavenly rotations: .Day, Month and Year



the synodic lunar month is two days longer than the sidereal lunar month

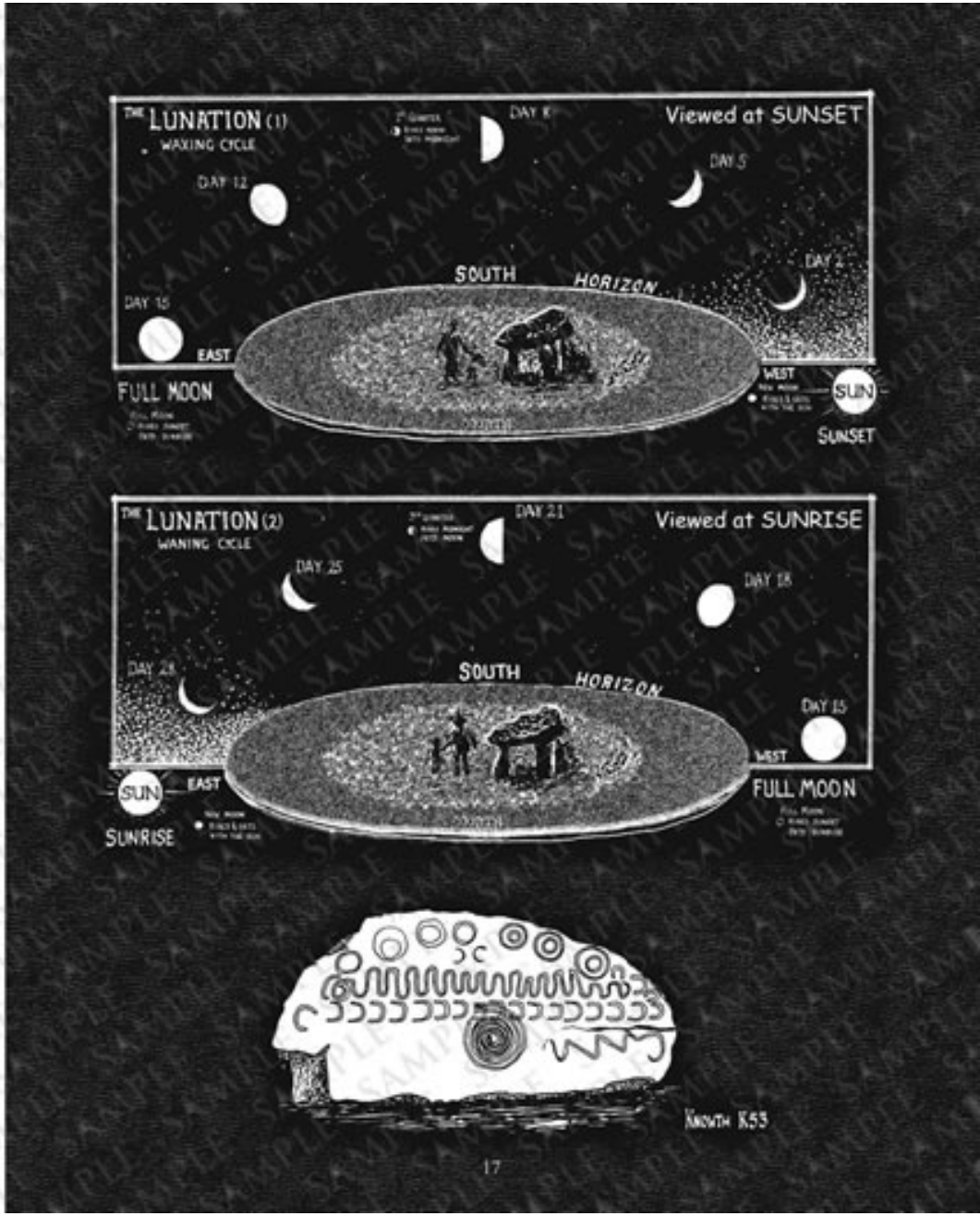
The Tock of the Moon

the lunation cycle or lunar month

The Moon begins her monthly phases acting as consort to the Sun, appearing as a sliver of silver to his left. This is the *new moon*, shaped like a reversed 'C'. Each successive day finds her belonging more and more to the night sky as the *waxing* phases increase the crescent to a *quarter*, *gibbous*, and then *full moon*, taking about thirteen days to complete.

Only at full moon does the Moon 'escape' the Sun, becoming entirely nocturnal and reflecting the maximum silvery light down onto the night landscape. The *waning* cycle then progressively delivers the Moon back into the daytime skies as she leads the Sun, setting later and later in the day until, again after about thirteen days, she approaches the Sun once more, glimpsed as a tiny 'C' shaped crescent to his right. The Moon then disappears for about three days, lost in the light of the Sun at the new moon. This whole cycle is called the *lunation cycle*, lunar or *synodic* month; the time between full (or new) moons, an average 29.53059 days.

An inscribed 5000 year old kerb stone at Knowth, in the Boyne valley, Ireland, appears to mark the lunation cycle. The impressive spiral correctly covers the three days of new moon, and 15 days later the full moon is marked ')(' within a 29 based motif. The 'serpent' enclosed by this lunation motif has 30 turns, $29\frac{1}{2}$ being the average between the two. The sarsen circle at Stonehenge was built with with 30 huge upright stones, one of which is half the width of the others, again suggesting $29\frac{1}{2}$ and hence a lunation cycle.



The Lunar Day

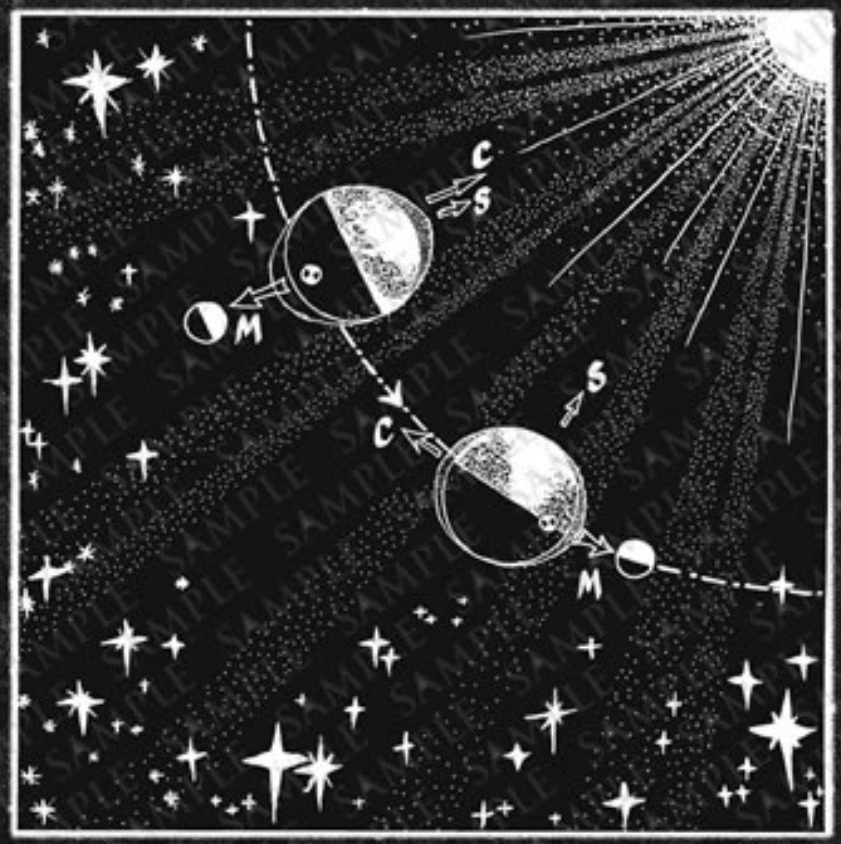
tides of lunar time

Anyone who lives by the sea witnesses the inexorable silent power of the Moon, whose invisible claws draw the tides up and down the beach twice a day. Tides are not just limited to the oceans - the Earth's atmosphere above our heads and even its crust beneath our feet rise and fall to this lunar rhythm. The highest *spring* tides occur two or three days following a new or full moon. The low-range *neap* tides occur two days after a waxing or waning quarter moon.

The *lunar day* is the time between consecutive moonrises, the Moon rising an average of 52 minutes later each day. There are exactly two tides each lunar day, each taking an average 12 hours and 26 minutes. Tides are thus synchronised to the lunar day and therefore to the Moon's position in the sky. High tides will always occur at the same two positions of the Moon in the sky at any given location, these being opposite each other (one position is always beneath the horizon). Knowing where the Moon is in the sky, you can also know the state of the tide locally.

There are $28\frac{1}{2}$ lunar days and therefore 57 tides (3 x 19) in each lunation cycle. In isolation tanks, human bodily rhythms eventually transfer from the the solar to the lunar day.

The Earth and Moon form a huge dumb-bell in space, with their centre of rotation located about 1000 miles beneath the Earth's surface (*shown as a chequered circle opposite*).



The Moon's gravitational pull (*M*) lifts the oceans on the side of the Earth facing the Moon. On the opposite side, centrifugal force causes a similar effect (*C*), because the centre of mass (and so of rotation) of the Earth-Moon system does not lie at the centre of the Earth. The Sun also pulls at the oceans (*S*), and according to the phase of the Moon adds or subtracts to and from the height of the tide. "Spring" tides occur near full and new Moons (*upper*), the lesser "neap" tides at the quarter-moons (*lower*). The monthly ratio between the heights of spring and neap tides is 8:3.

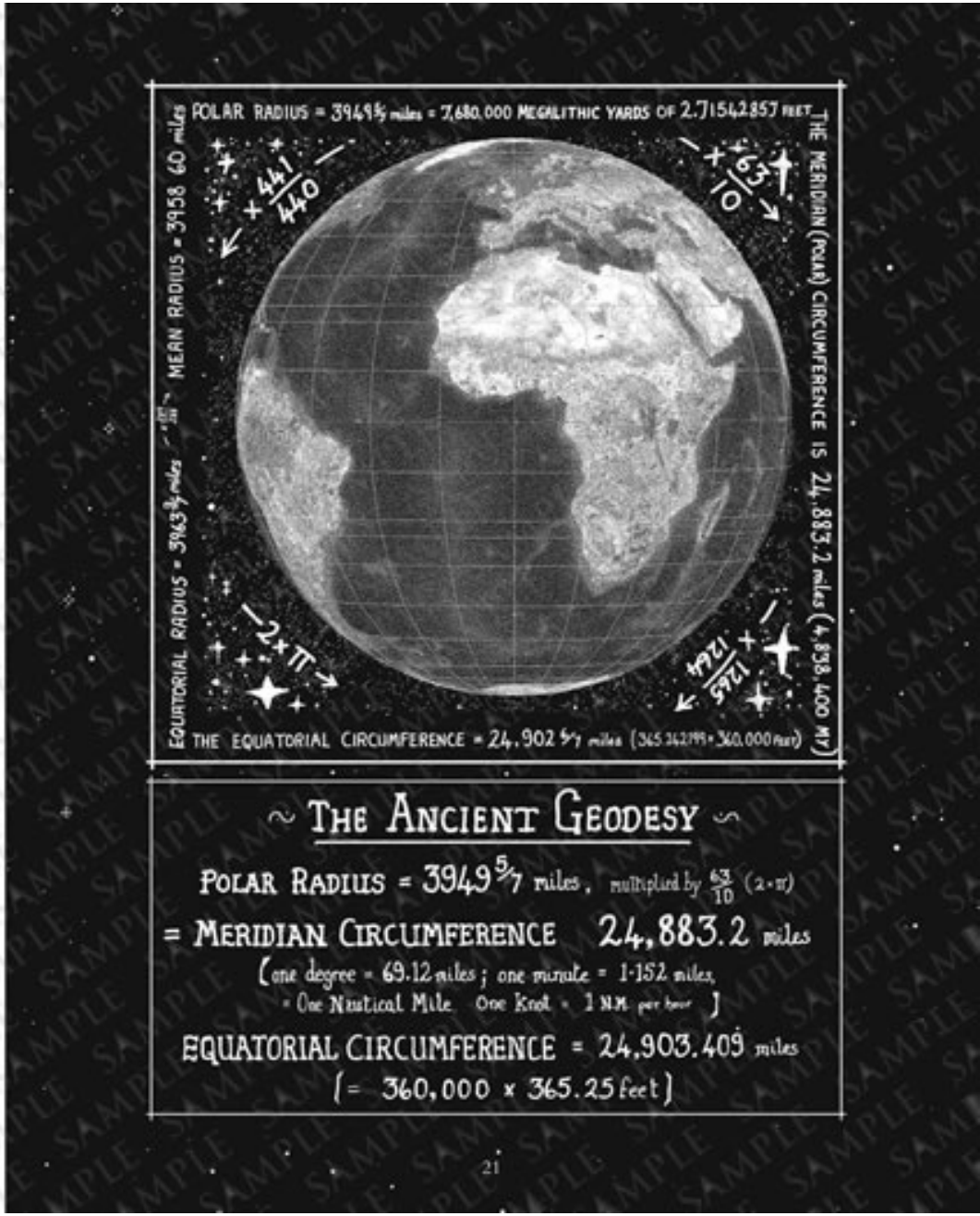
THE EARTH

geometry, metrology and ancient geodesy

The Earth is a giant flywheel in space, a stable rotating platform from which to observe the heavens. Ancient geocentric (earth-centred) observations for calendars, navigation and surveying appear to have been greatly aided by the use of traditional units of length which harmonised with the principal fixed dimensions of the Earth (*see opposite*). We have already seen how the diameter of the Earth may be accurately expressed as 8×9×10×11 miles (*see page 3*). The Earth's equatorial circumference of 24,902.86 miles turns out to be 360,000×365.242 'English' feet, enabling space, angle and time to be calibrated in either feet, degrees or days.

Because the Earth spins she is slightly fatter at the equator than at the poles, the precise shape being an ellipsoid known as the *Geoid*. The polar radius of the Earth ($3949\frac{5}{7}$ miles) multiplied by $\frac{63}{10}$ (an approx. for 2π), neatly accounts for the Earth's equatorial bulge, giving a value of 24,883.2 miles for the *meridian circumference* (through the poles). The ellipsoidal shape causes surface degrees of latitude to measure longer at the poles than they do at the equator. One degree of latitude *averages* at 69.12 miles, a length quoted by Ptolemy (as 300,000 Roman remens) and which, astonishingly, remains the UK Admiralty figure today for navigational purposes.

The global system of ancient measures related to each other through simple fractions, making calculations easier in a world without electronic calculators. Their elegant system is now lost, almost totally obscured by the adoption of the metric system.



Sun, Moon & Landscape

the moon as mirror of the sun

Each month the Moon more or less mirrors the entire annual range of rising and setting positions performed by the Sun in a year.

The full moon is brightest and highest at midwinter, when she occupies the sign of Cancer, copying the midsummer Sun, and rising and setting at the most northerly positions on the horizon. The midsummer full moon, in the sign of Capricorn, correspondingly behaves like the midwinter Sun, remaining low in the dusky sky and rising and setting at the most southerly positions of the month.

At extreme latitudes (above 60°), such as Finland, Sweden or northern Canada a midwinter full moon may become *circumpolar* and circles the sky visible for several days while the Sun never rises at all. Conversely, at midsummer, when the Sun never sets, the full moon is similarly not to be seen at all, sometimes for three months. Thus the full moon mirrors the Sun at the opposite point in the calendar, and like a true mirror she fully reflects the Sun's light.

This reciprocation mysteriously extends into the numbers themselves, for 1 ÷ Sun = Moon and 1 ÷ Moon = Sun! In more detail 1 ÷ 365.242 (the solar year) = 0.0027379, which in days is 3 minutes and 56 seconds, the difference between sidereal and solar days, whilst 1 ÷ 27.322 (the lunar sidereal month) = 0.0366, which in days is 52 minutes, the difference between lunar and solar days.

It is fun to ask an astronomer why.



sunsets through the year - looking west



full moonsets through the year - looking west

The Moon's Nodes

the path of the moon crosses that of the sun

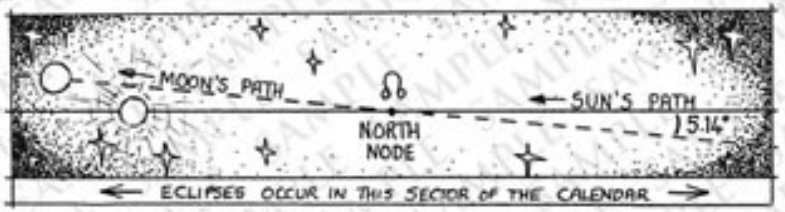
The orbit of the Moon is tilted with respect to that of the Earth by an angle of 5.14° (*see page 12*). The effect is that the Moon travels *above* the ecliptic (the apparent path of the Sun around the zodiac) for about half the sidereal month, and travels *beneath* it for the other half.

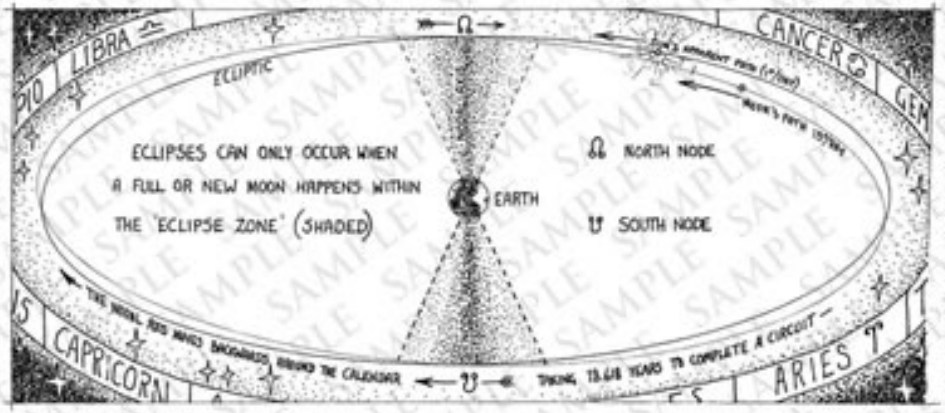
The two places where the Moon crosses the ecliptic each month are called the lunar nodes and they always lie opposite each other. The smaller illustrations show these crossing points as observed from the Earth - but in truth, they are invisible! Eclipses only happen when a full or new moon occurs within $12\frac{1}{2}$° or $18\frac{1}{2}$° respectively of the nodes, total eclipses when the alignment is almost exact. These are the *eclipse limits* for lunar and solar eclipses.

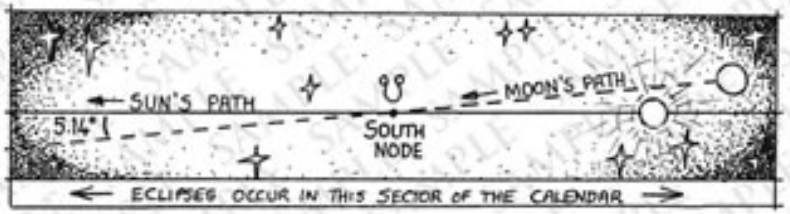
The axis of the nodes moves backwards around the calendar, taking 18.618 years (6800 days) to complete a circuit. It thus moves 19.618 days per year. To the ancients the nodes were thought of as the head and tail of a huge celestial dragon which swallowed the Moon or Sun during an eclipse. The nodal period is still known as the Draconic year.

The Sun meets a node every 173.3 days (an eclipse season); it meets a particular node after two of these periods have elapsed, this both defining and completing the *eclipse year* of 346.62 days.

Is it not the strangest thing that 346.62 = 18.618×18.618?







The Breath of the Moon

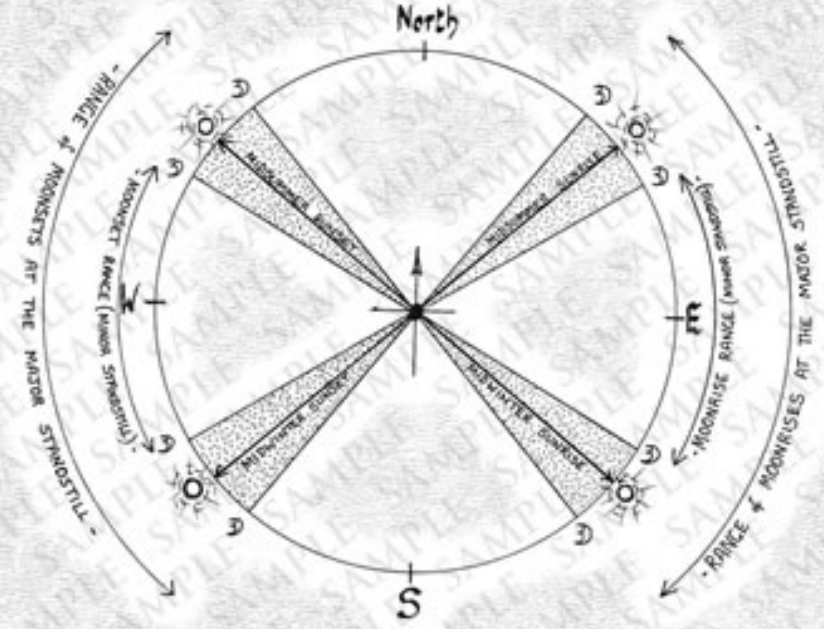
major and minor standstills

The monthly extreme northerly and southerly risings and settings of the Moon gently 'breathe' in and out either side of the Sun's extreme solsticial positions, taking one nodal period to complete the 'breath'. This greatly alters the possible maximum rise and set positions of the Moon each month with respect to the solsticial positions of the Sun. There are thus eight limiting 'lunstice' positions, four for rises and four for sets (*opposite top*).

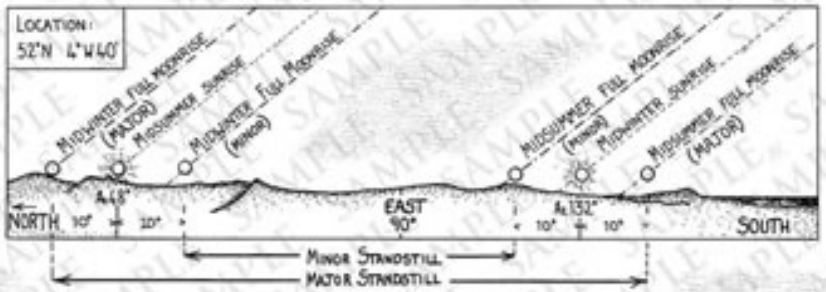
The distance of these extreme positions of the lunstice from the solstice position is dependent on the latitude of a location. In southern Britain they occur more than eight degrees either side of the solstice positions (*opposite below*). These extreme stations of the Sun and Moon drew the attention of neolithic astronomers who made alignments of stones in their honour.

At the *major standstill*, the Moon describes her wildest monthly swings of rising and setting, gyrating to her highest and lowest ever paths across the sky, all within one sidereal month. 9.3 years later, at the *minor standstill*, the Moon calms down and the range always lies inside the extreme solsticial positions.

In contrast to the Sun, Moon and planets, the backdrop of stars rises and sets, each star in its alloted position for scores of years, irrespective of the season or time of day. Over longer periods of time even these move slowly: the cosmos is always in motion, yet always in place.



every month the moon copies the sun's annual rising and setting dance, breathing inside and outside the extreme solar positions over *18.618* years



ECLIPSES

cosmic attention seeking

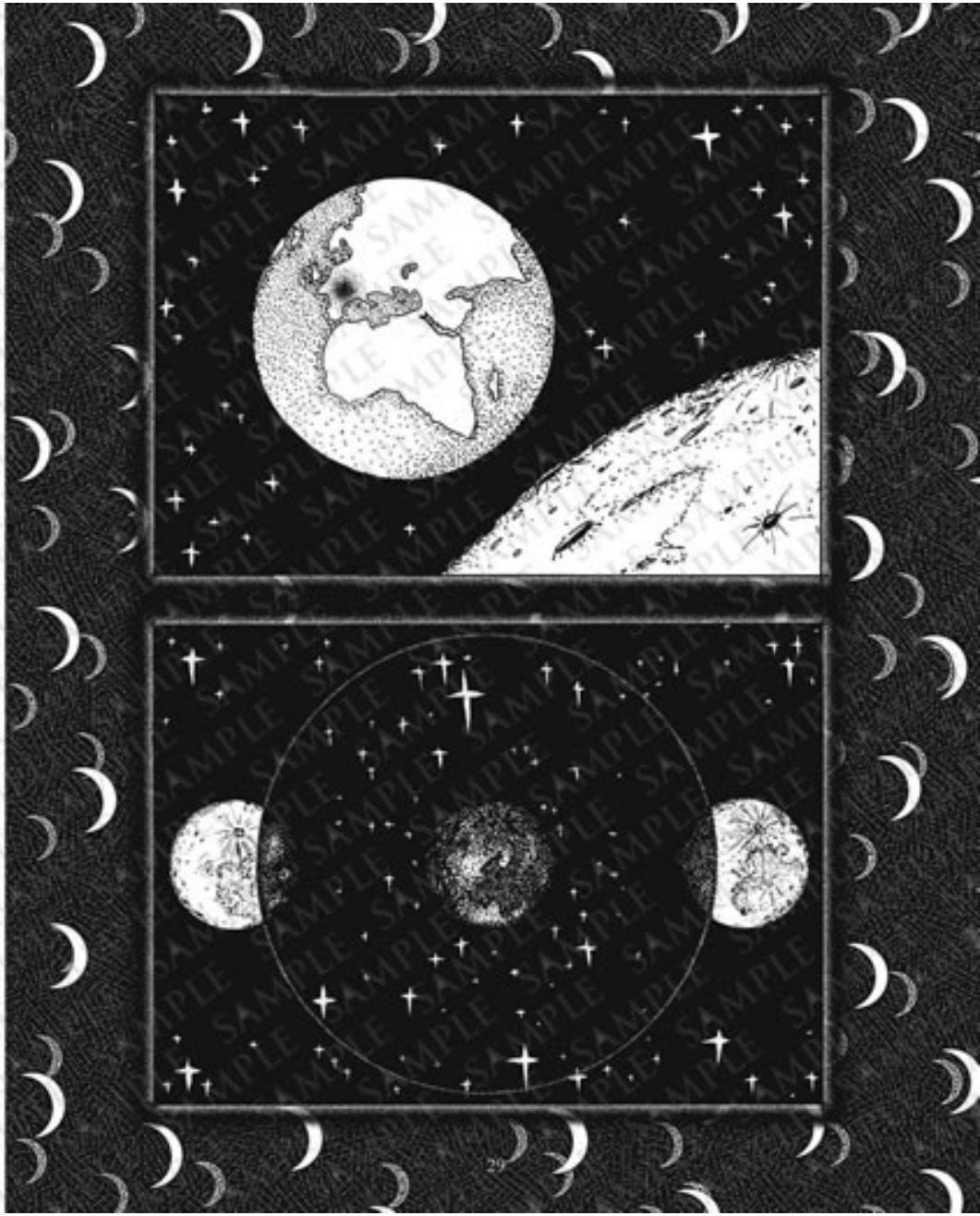
By what almighty coincidence do the discs of Sun and Moon appear the same size to we earthlings? The Sun is 400 times larger than the Moon, yet 400 times further away. The distance of the Moon from the Earth is just over thirty Earth diameters. Total solar eclipses could never occur if the Moon's orbital distance was changed by just one Earth diameter.

Total solar eclipses instill an elemental awe in us, with a sudden brief reversal from light into darkness, after which 'dawn' returns *from the west*, at over 2000 miles per hour! Lunar eclipses are gentler, longer and simulate a whole lunation cycle in just a few hours.

Solar eclipses occur when the new moon passes directly between Sun and Earth. They can only be seen during daytime, the area of totality tracing a narrow smudge of blackness across the Earth. Totality never lasts longer than seven minutes at any one location (*opposite top*). During lunar eclipses the full moon passes from right to left through the Earth's shadow, its reflected light extinguished for several hours (*opposite below*). Lunar eclipses are visible to all on the night side of the Earth.

As the angle between Sun and node increases, total eclipses decrease and become partial (*page 25*). Beyond 18.5° no eclipse can occur. There can be up to seven eclipses in any one year, and solar eclipses are the more common, by the ratio √2:1.

If you stand under a tree during a solar eclipse the dappled light at your feet transforms into a myriad of crescent suns (*border opposite*).



Lunar Eclipses

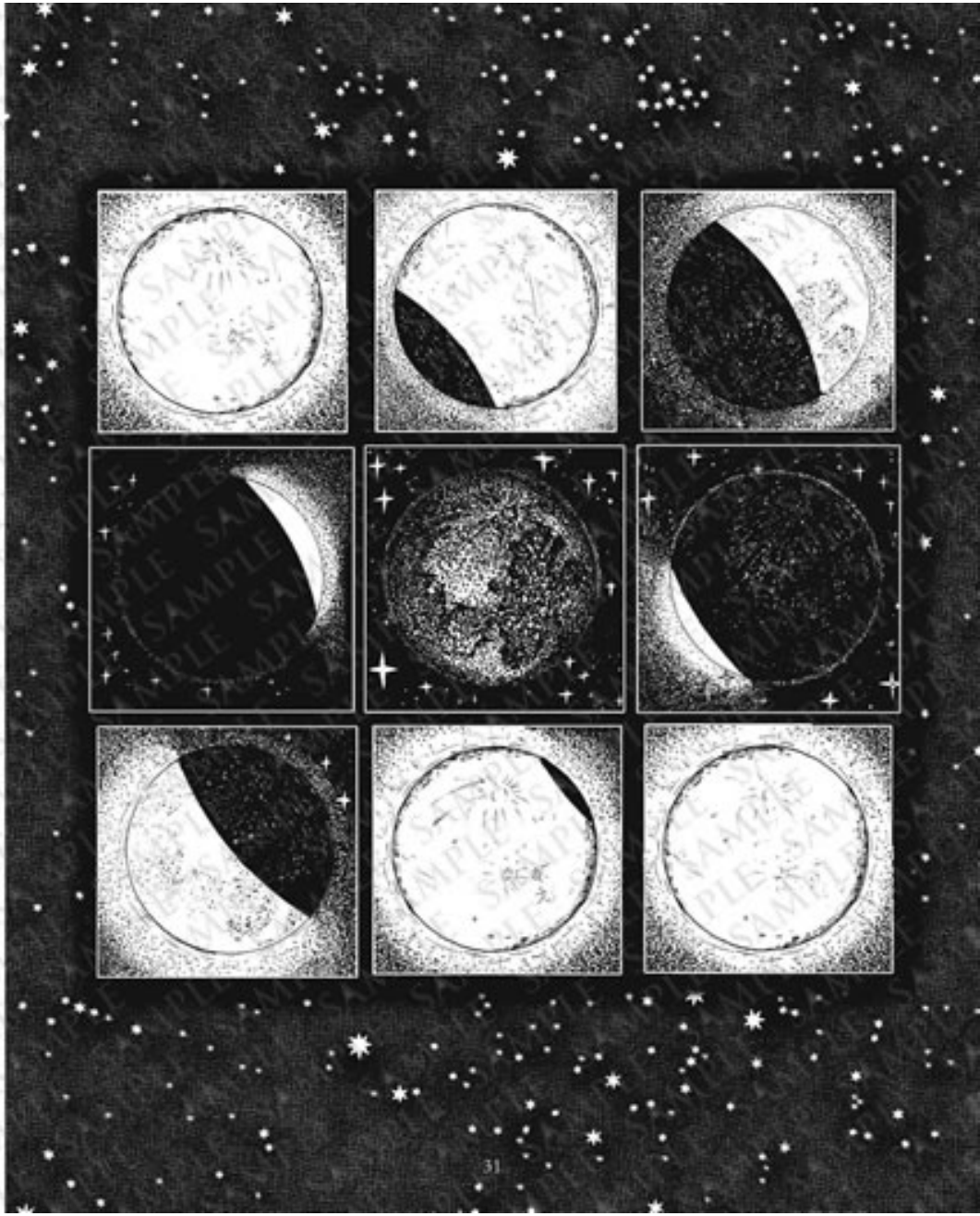
studies in light and darkness

A lunar eclipse is a striking phenomenon. The reflected light of the full moon greatly diminishes the light from the stars, and during the eclipse a curious and beautiful effect unfolds. As the full Moon enters the Earth's shadow cone (*previous page lower*), her face darkens and the night sky radically alters its appearance, becoming brilliantly peppered with many more stars than were previously visible. This effect is also shown opposite, where a satisfying diagonal symmetry may also be seen.

During the period of totality, the Moon often takes on a remarkably beautiful coppery colour within the starry firmament. Also stirring is the curve of the Earth's shadow as it draws across the lunar orb. It confirms that our planet is spherical in shape and about three times larger than the Moon.

Before 2500 BC, Megalithic astronomers in northwestern Europe appear to have observed a tiny variation in the 5.14° tilt of the Moon's orbit ($\frac{1}{6}$° with period 173.3 days) in order to predict eclipses. Their observatories still exist, throughout western Britain. Were our Stone Age ancestors predicting eclipses?





Solar Eclipses & The Saros

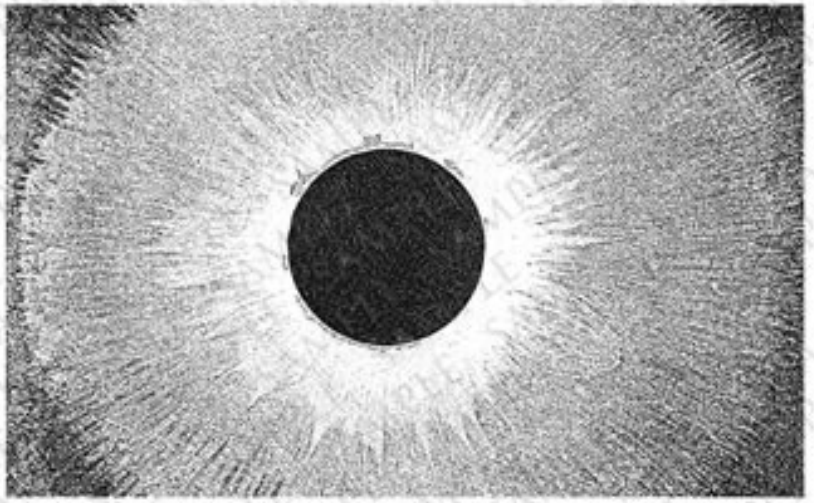
the 18 year cycle of eclipses

There are three types of solar eclipse: *partial*, *annular* and *total* (*see frontispiece illustration*). These are produced by variations in orbital distances and lunar nodal offset at *syzygy*, the barely pronounceable term for a full or new moon (Sun, Moon and Earth in line).

All eclipses belong to families, consecutive individuals of which display similar characteristics. The most famous of these is the *Saros cycle*, of 18 years and 11.32 days, which is 223 lunations, 19 eclipse years or 6585.322 days. The cycle was known to the Chaldeans and used to predict eclipses before 2000 BC. A Saros cycle evolves and decays, producing 1300 years of solar and 800 years of lunar eclipses. At any given time about 42 solar and 27 lunar eclipse families are evolving, each delivering about 70 and 45 individuals respectively over its lifetime. The fractional 0.322 day means that successive members will occur 8 hours later, every third eclipse in the family taking place at the same time of day. Another eclipse family takes 358 lunations and runs for 15,000 years.

The Saros is 19 eclipse years, which may be accurately expressed as 19x18.618x18.618 days (to 99.99%). Now an eclipse year is 11.74 lunations and here Sun ÷ Moon = 19 ÷ 11.74 = 1.6186, the *Divine Proportion*. Harmoniously, 19 lunations is also *phi* eclipse years!





During totality small bursts of light, 'Bailey's Beads', can appear through valleys on the Moon. The Sun's corona and some solar flares may also be visible.

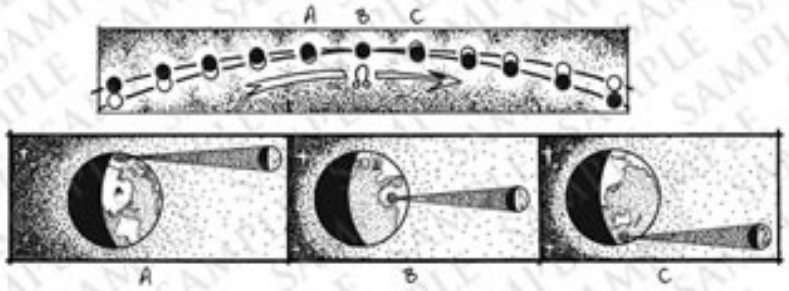


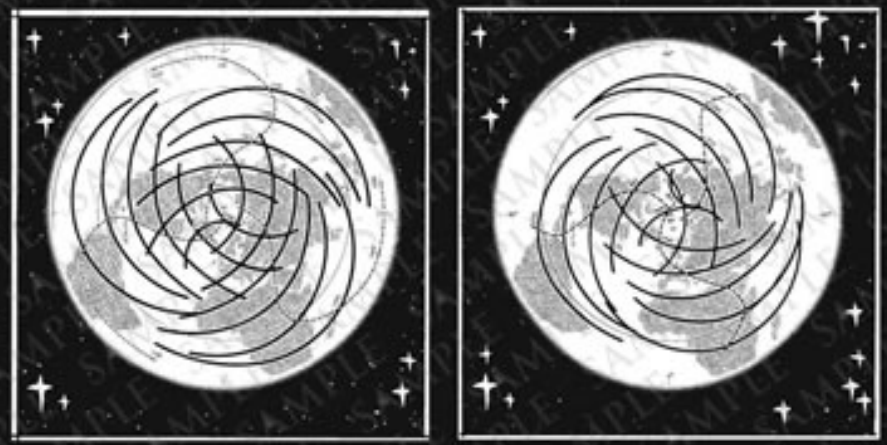
The sequence of a total solar eclipse. Knowing when and where an eclipse will occur represents the consummate skill of an astronomer.

Saros Patterns
a trilateral evolution

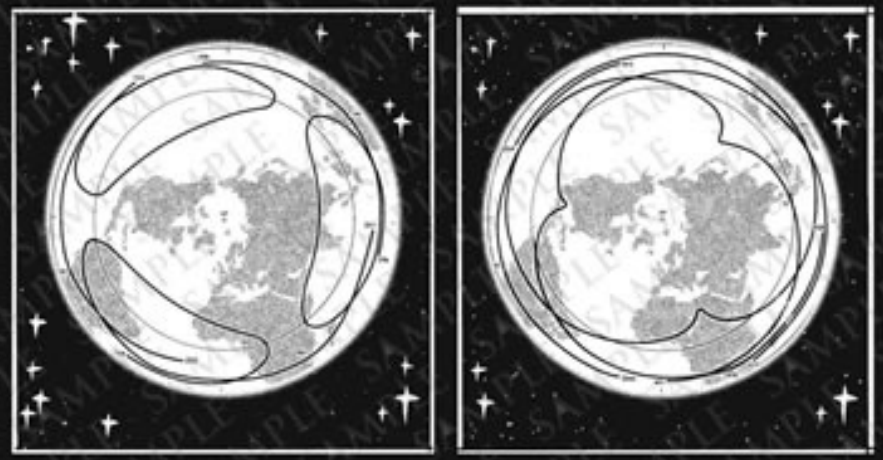
All Saros eclipse families first make an appearance at one of the poles, gradually evolving into equatorial regions before eventually dying out at the other pole (*below*). The time difference between the Saros and 19 eclipse years (0.46 days) causes each new member to be displaced about half a degree further west with respect to the nodes. Thus the family takes about 36 Saros cycles (650 years) to reach the node (B) and thereafter departs from it in the same time, slowly dissipating (*below top - every 7th Saros shown*).

The patterns made by these metamorphosing families of eclipses (solar or lunar) form threefold motifs on the Earth, due to the fact that each consecutive Saros period (223 lunations) is 6585.321 days in length, the fractional component being about one third of a day (or Earth rotation) out of alignment. The midpoints of the paths of totality for every third member may be joined up to reveal this threefold pattern. The resulting gizmos are called *exelegismos* curves (*opposite, dotted top for solar and solid lower for lunar eclipses*).





Eclipses repeat after 18 years, a third of the way west round the globe, and displaced slightly north or south - two Saros families of Solar eclipses are shown above. Below we see the midpoint curves of two Saros families of lunar eclipses.



The Dance of the Moon

Ariadne's eight-fold web in the sky

The orbital distances of the Earth and Moon undergo periodic changes. This affects the duration and type of eclipses (*see pages 28 to 34*). When the Earth is nearest the Sun, strangely now in chilly January, it is said to be at *perihelion*; when furthest from the Sun it is said to be at *aphelion*. Similarly, *perigee* occurs when the Moon is nearest the Earth, whilst *apogee* finds the Moon furthest from us. The line connecting these two points in the moon's slightly elliptical orbit is called the line of *apsides*. This line or axis, the coming and going of the Moon, itself rotates, completing a cycle every 8.85 years, dividing the zodiac into eight (*opposite A=apogee, P-perigee*). A full moon at perigee appears 30% larger than at apogee.

The line of apsides moves anticlockwise around the zodiac by 40° 40' per year, whilst the nodal axis moves clockwise by 19° 20' per year (*see page 24*). Their combined separation is thus 60° per year, a remarkable coincidence causing the nodes and apsides to rendezvous once more after 6 years (360°). Three of these meetings takes 18 years (6+6+6) years, coinciding almost exactly with the Saros cycle of 18.03 years. This is why eclipses within consecutive Saros cycles appear of the same type and duration.

In nautical almanacs and ephemerides, the position of the Moon is today predicted years in advance using a formula which contains over 1500 separate factors.



Every time the Moon is closest to the Earth, at her perigees (marked P above) she is an eighth of the way round the heavens from where she was last time. The Moon's furthest positions from the Earth, her apogees (labelled A above), likewise divide the heavens into eight.

The 19 Year Metonic Cycle

the marriage of Sun and Moon

After 19 years, and within two hours of exactitude, the Sun and Moon return to the same places in the sky on the same date. This astonishly accurate repeat cycle is named after Meton, a 4th century BC Greek astronomer. It does not involve the Moon's nodes and therefore does not produce eclipses. Another similar and important cycle takes 8 years, or 99 lunations and is synchronised with the 5 synods of Venus, the famous Venus pentagram; Avebury's outer ring once comprised 99 stones.

The 1st century BC historian Diodorus suggested that the Celts knew of the 19 year cycle. We need not be surprised at his account, for the Celts inherited the culture of the stone circle builders, and many fine circles, particularly in southwestern Britain, contain 19 stones (*Boscawen-un in Cornwall shown opposite*). The bluestone horseshoe at Stonehenge comprised 19 slender polished megaliths, brought from the Preseli mountains of West Wales, 135 miles as the crow flies. Some weighed over four tons!

There are 12.368 lunations (full moons) in one solar year. The lunar year of 354.367 days (12 lunations) falls short of the solar year by just under 11 days, which after 19 years accrues to 7 lunations, totalling 12 x 19 plus 7, or 235 lunations. From these numbers, the *annual* number of lunations may be found: 235 ÷ 19 equals $12\frac{7}{19}$, or 12.368, the fraction better revealing the underpinning astronomy.

19 solar years is 6939.60 days; 235 lunations is 6939.69 days. The Metonic cycle may be written as 19 x 18.618 x 19.618 days.

☽⊙ CALENDAR REPEAT CYCLES ⊙☽			
YEARS	LUNATIONS	ERROR	EXAMPLE
3	37	3 days	
5	62	2 days	Coligny Calendar
8	99	1½ days	Avebury
19	235	2 hours	Stonehenge
⊙ = 365.242 days		☽ = 29.53059 days	



BOSCAWEN-UN

Thirty-Three

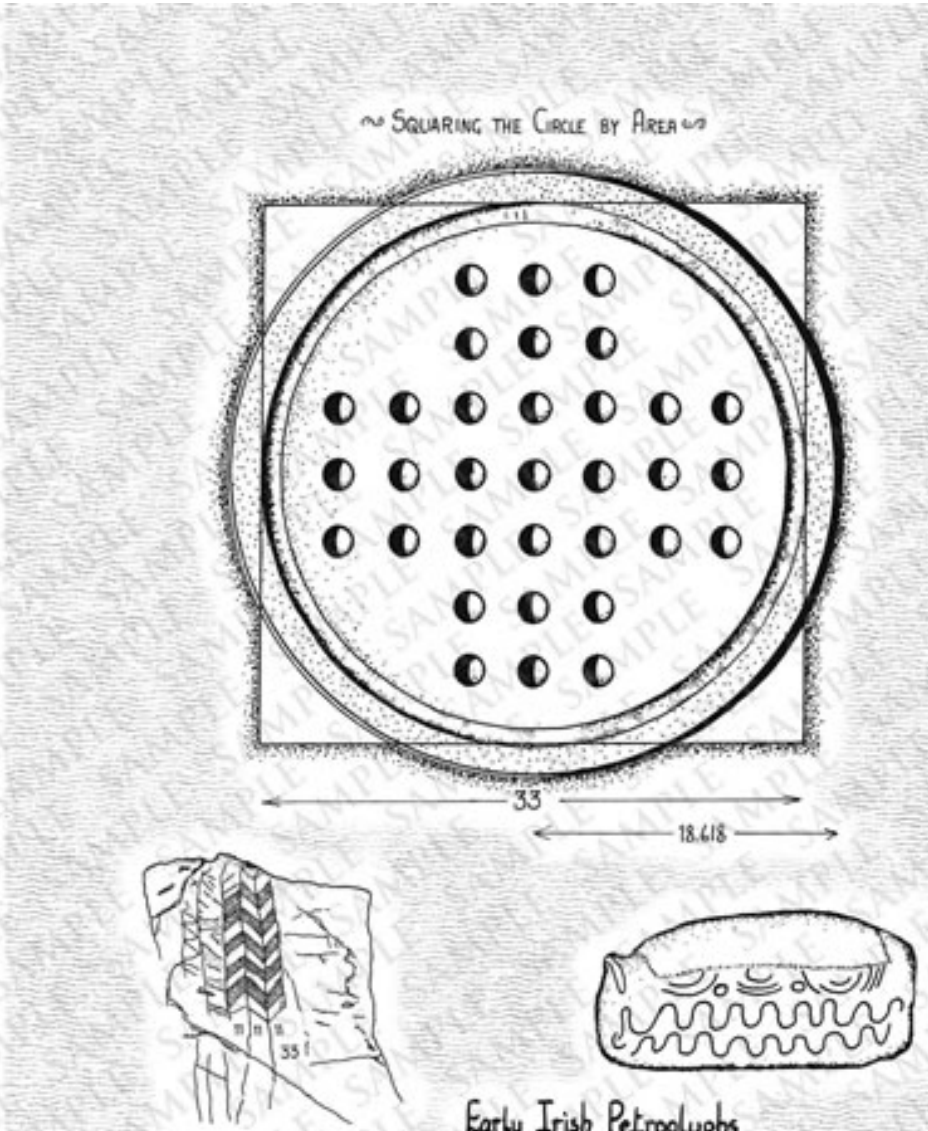
the number of the solar hero

Thirty-three is a significant calendar number (*see page 10*) which threads its secret through human culture. At a neolithic equinoctial site in Scotland, a cache of 33 tightly packed quartz pebbles was discovered by archaeologists, one for each year of the solar cycle. A renowned Irish megalithic site contains a stone with 33 enhanced chevrons, and another has a snake motif with 33 folds (*opposite below*). Ancient stories about the heroic *Tuatha de Danaan* frequently use the number 33. The first battle of *Mag Tuired* was fought by a saviour-hero *Lug* and 32 other leaders. In the second battle thirty-three leaders of the *Fomore* perish, thirty-two plus their highest king.

The Christian 'highest king', Jesus, was crucified and resurrected aged 33, rising again from behind a large stone. Islamic and Jewish calendar traditions recognise that it takes 33 solar years to complete 34 lunar years (of 12 lunations). A lunar calendar therefore cycles around the seasons, *Ramadan* falling eleven days earlier each year, returning to the same date again after 33 years. The Masonic Order recognises 33 degrees of proficiency, whilst the lonely game of Solitaire (*opposite, within the circle)* consists of 32 balls and 33 holes.

These cultural artefacts share a common numerical factor, apparently derived from prehistoric observations of the 33 year solar repeat cycle. Pairing this with the nodal cycle of the Moon we may now 'square the circle' as shown opposite. Circle and Square have the same area, a marriage of Heaven and Earth.

Incidentally, the spine of the human body consists of 33 vertebrae, in heros and non-heros alike.



The Precessional Cycle

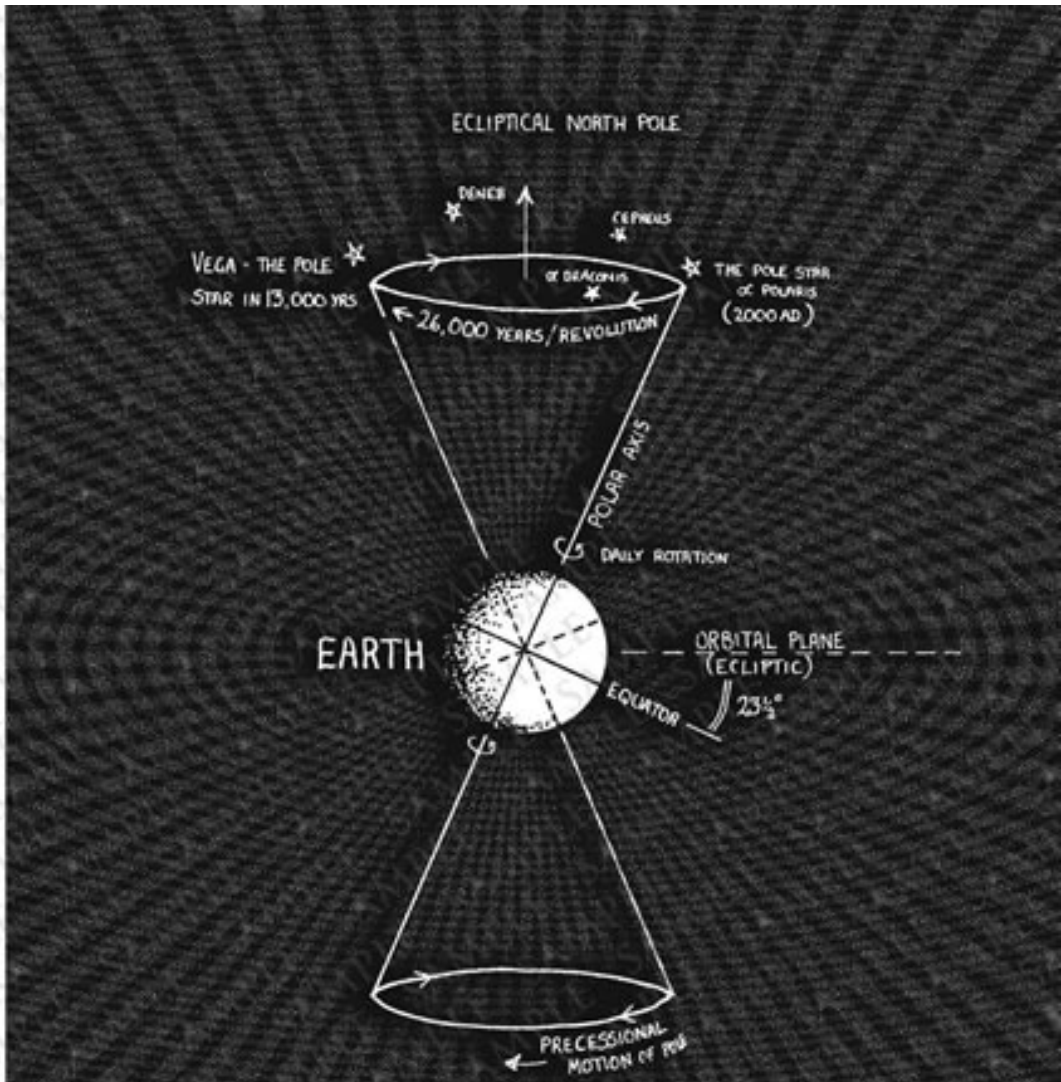
throwing a 26,000 year wobbly

The Earth's axis will not point to the present pole star for ever. Like a spinning top that has tilted over a little and begun to wobble or *precess*, the axis describes a complete circular rotation over about 25,920 years, tracing out the northern and southern circle of pole stars over this period. This is the *precessional cycle*, also known as a *Great Year* (*opposite*).

Equinoxes occur when the axial tilt of the Earth is at right angles to the Sun rather than facing towards or away from it (*see page 9*). This tilt is itself rotating backwards very slowly, and the stars behind the Sun, on a given day of the year, change very slowly over time. The *Age of Pisces* commenced in 1 AD. The *Age of Aquarius*, the next *Great Month*, will commence about 2160 AD when, at spring Equinox, the stars behind the Sun are those of the constellation of Aquarius. Magically, the diameter of the Moon is 2160 miles, evoking the 2160 year length of the Great *Moonth* in the Western tradition. Space becomes time!

The ancient Maya had a slightly different value for precession, reckoning it at five of their 13 Baktun 5,200-year Long Counts, or 26,000 years. The modern observed value is 25,770 years.

In a human lifetime, precession is experienced as a single degree change in the position of the Sun against the fixed stars on a given date in the year. The precessional effect is caused by orbital asymmetries of the Sun and Moon. The Earth's axial tilt itself varies between 21.5° and 24.8°, taking 41,000 years to cycle.



the circle of notherly pole stars caused by precession

Designing a Calendar

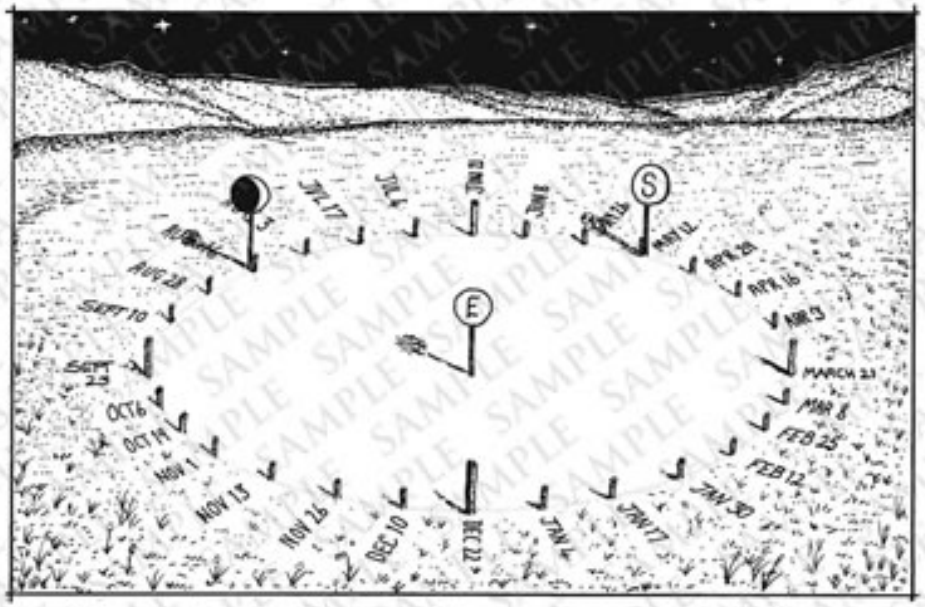
13 months of 28 days

Accurate timekeeping begins with a calendar, which ideally should relate both to the solar year and the Moon's phases, divide easily into weeks, months and seasons and show us the current phase and position of the Moon, the tides and when to expect eclipses.

A calendar designer soon discovers a solution based on the Moon passing the same star in the sky every 27.3 days while the Sun takes 365. Dividing one by the other suggests a calendar of 13 months each of 28 days within a 364-day year, a useful representation of astronomical truth. 364 is divisible by 2, 4, 7 and 13, so we end up with a 52-week year with 13 months, or four 13 week seasons, each of 91 days. All whole numbers and every year a leap year!

Practically, our designer could arrange 28 markers around the perimeter of a circle and arrange for a 'moon-pole' to be moved anticlockwise once a day, about 13°. A 'sun-pole' would then be moved in the same direction, only thirteen times more slowly, one hole every 13 days. This is the most simple way of providing a practical *soli-lunar* calendar, only requiring occasional resetting of the 'Moon' (place the moon-pole opposite the sun-pole when full). If the stars were then represented on the circumference of the circle, the date, season, state of the tides (*see page 18*), lunar position and lunar phase could be read off at a glance.

The ancient Maya were keen astronomers and calendar-keepers and also keen on the numbers 13 and 364. They came up with some extraordinary gearings between the Sun and Moon (*lower opposite*).



A basic calendar with 28 holes, each hole representing one day for the Moon, or 13 days for the Sun. Yields a 364 day year and needs occasional retuning.

The Moon in the Mayan Calendar

Ritual Year, or Tzolkin = 260 days = 13 x 20 days
Civil Year, or Tun = 360 days = 18 x 20 days
Vague Year, or Haab = 365 days, so that
One Calendar Round = 52 Haab = 73 Tzolkin

From the Dresden Codex and inscribed stones at Palenque we know:

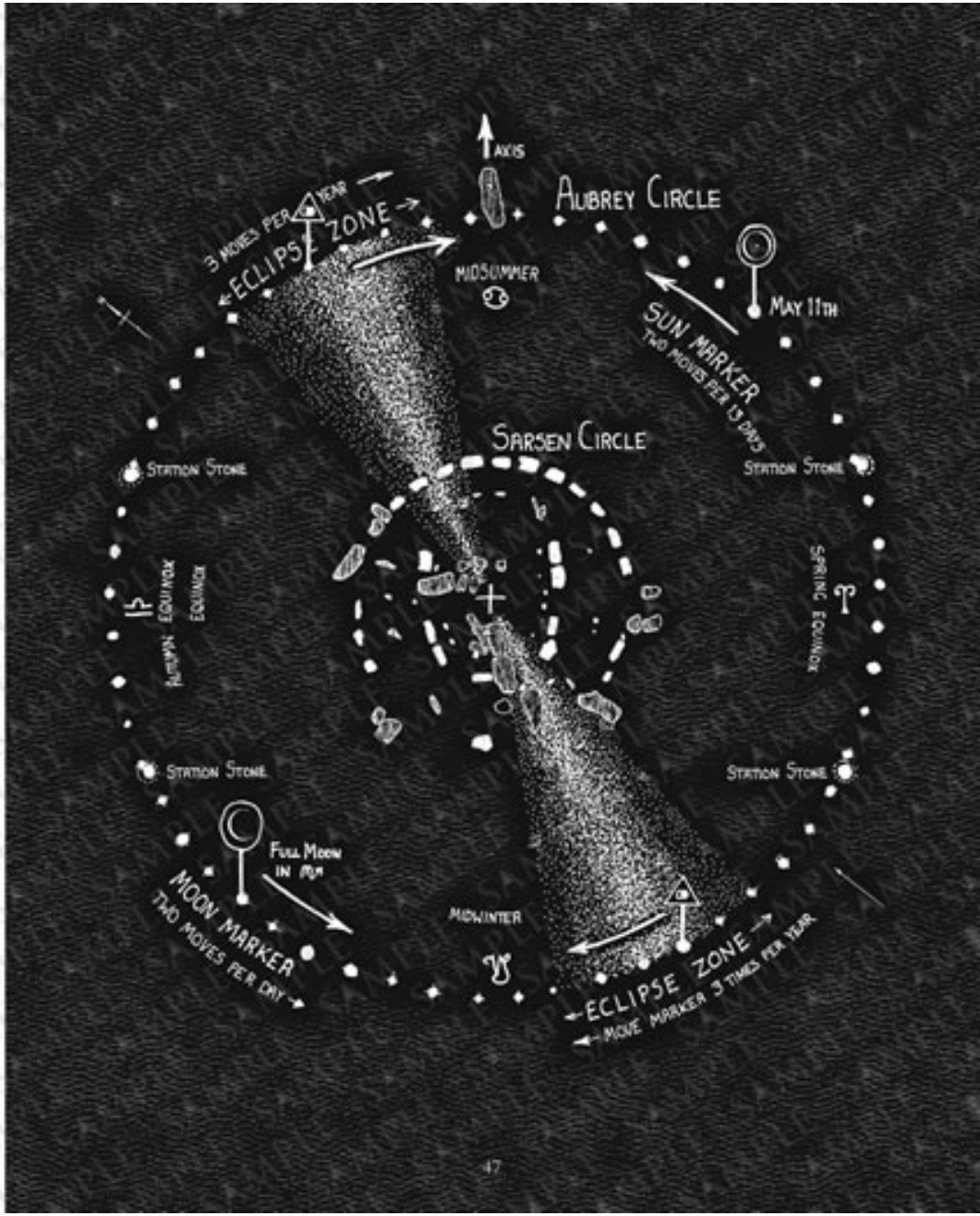
149 lunations = 220 x 20 days (99.99% accurate)
405 lunations = 46 x 260 days, or 81 lunations = 2392 days (99.99%)
256 lunations = 21 x 360 days, or 32 lunations = 945 days (99.99%)

STONEHENGE
the oldest known calendar

The basic 28-hole model shown on the previous page may be improved to include eclipse prediction. By doubling the number of post-holes to 56 we exploit the useful coincidence of there being almost exactly 3 cycles of the lunar nodes in twice 28 years. The lunar nodes are here shown as two diametrically opposed triangular markers, initally placed near to the date-positions where eclipses have been recently observed.

The Sun-pole now moves 2 holes anticlockwise every thirteen days, and the Moon-pole 2 holes anticlockwise every day. The node marker is moved 3 holes *clockwise* every year. When the Sun pole lies within three holes of a 'node-pole', an eclipse of some sort will take place at each full or new moon, although it may not be visible at the location. If at each new moon the moon-pole is made to 'skip' past the Sun-pole (omitting this hole), this calendar will run for at least a year before the Moon-pole needs resetting (easiest to do at full Moon).

Remarkably, this design is to be found hidden within the plan of Stonehenge, which can indicate the date (season), Moon position and phase, and predict full and new moons and eclipses. The Aubrey circle (3000 BC) comprises 56 holes, accurately arranged round the perimeter of a 283 foot diameter circle, predating the erection of the famous massive inner Sarsen circle. Perhaps posts were once placed in these holes; now they are filled with concrete, but this oldest known calendar would still work today.



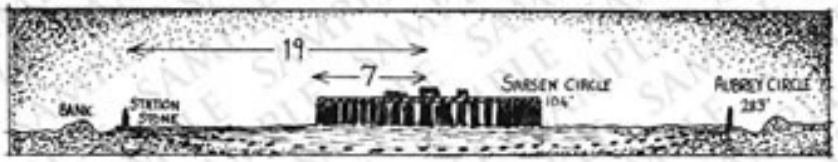
The Silver Fraction

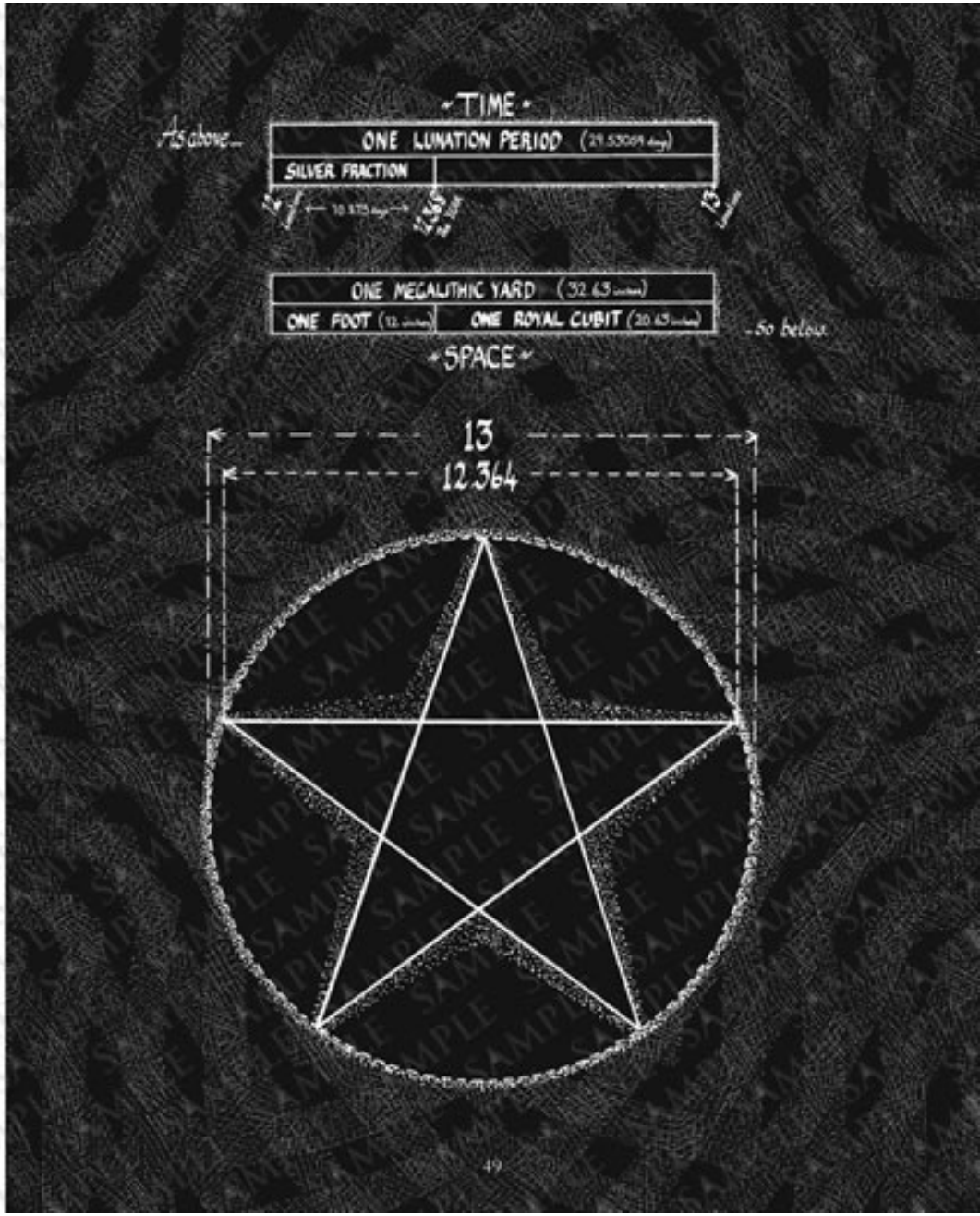
'twixt 12 and 13 full moons

The secret of the calendar is the 11 day mismatch between the lunar year (12 lunations) and that of the solar year (12.368 lunations). Enoch called this the 'over-plus of the Moon', but more poetically we may call it the *silver fraction*. Remarkably, three common units of length used by the ancient world, the *Megalithic yard*, the *Royal cubit* and the *foot*, relate through the astronomy of the lunation and the silver fraction (*opposite above*).

The *silver fraction* is actually 10.875 days in length, which is 0.368 lunations; almost exactly *seven-nineteenths* as a fraction. Intriguingly, the diameters of the two main circles of Stonehenge, the Aubrey circle (283 feet) and the Sarsen circle (104 feet) are in the ratio 7:19 to each other (*below*).

Simple geometry can also reveal the annual lunation figure. A pentagram drawn inside a circle of diameter 13 units has star-arms of length 12.364 (*opposite below*)! All five star-arms add to 61.82, the number of full moons in 5 years and also 100/*phi* (*to 99.9% - see page 32*). The famous Celtic *Coligny* calendar (100 BC) is based on a 5 year, 62 lunation cycle (*see page 39*). *Phi* in the sky!





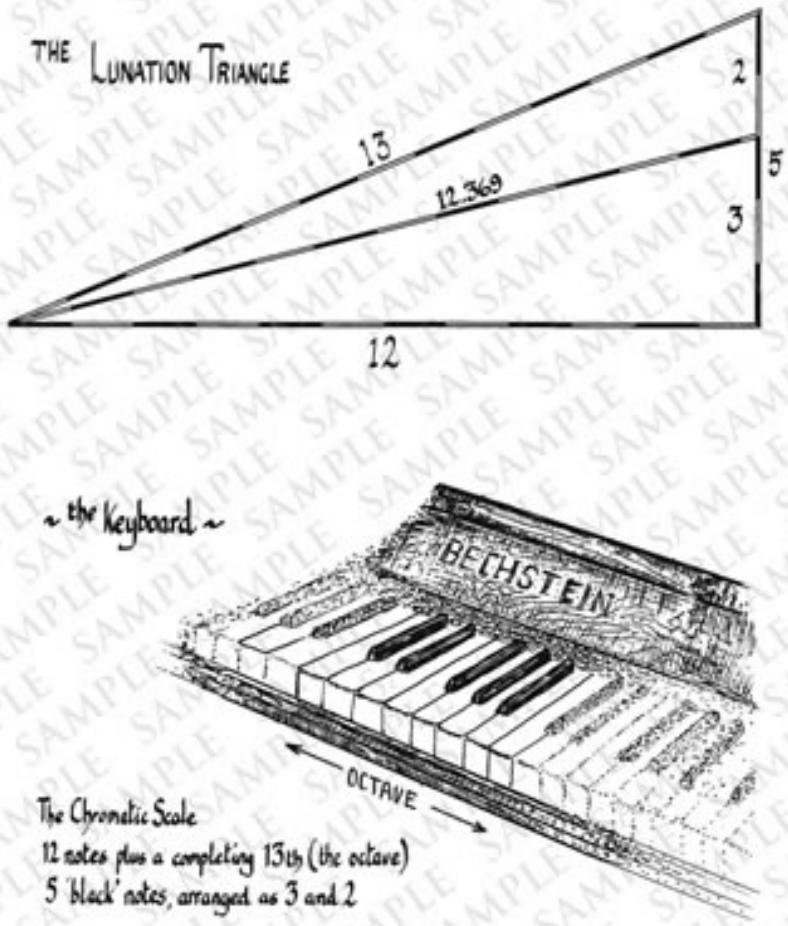
The Lunation Triangle

Solomon meets Pythagoras

A 5:12 rectangle has a diagonal length of 13. The four station stones at Stonehenge define one (*see page 47*), as do the proportions of Solomon's Temple at Jerusalem. Twelve plus a thirteenth, as the redeeming Saviour, occurs in many heroic stories, Jesus, King Arthur and the Mayan wind god Kukulcan being examples. To the Pythagoreans the number 5 signified completeness or marriage, formed as the first male number, 3, becomes wedded to the first female number, 2.

The true number of months in the year falls between 12 and 13 and in order to define a true soli-lunar calendar this figure, 12.368, must be determined. The *lunation triangle* is simply a 5:12:13 right triangle, the second *Pythagorean triangle*, with the '5' side divided as 3:2. A new hypotenuse to this point measures 12.369. The Moon, 13, thereby becomes married to the Sun, 12, where the female, 2, joins to the male, 3. The *Sacred Marriage* of Sun and Moon, made in Heaven, is witnessed on Earth accompanied by the most harmonious interval, the fifth (3:2). Other musical allegories abound (*opposite below*) and Solomon's throne was wisely placed at the 3:2 point in the 5:12 Temple walls at Jeruslaem.

St John's Gospel ends as Jesus reappears for the third time since his resurrection. He instructs his fishless disciples '*cast your nets on the right side*', whence they catch 153 fishes. Why 153? Perhaps because 153 is 12^2+3^2, the square on our hypotenuse and thus the square of the annual lunation rate, 12.368. Fishy indeed!



the second Pythagorean triangle, the 5 · 12 · 13, embodies the structure of the musical keyboard and produces the number of full moons in a year.

Sun, Moon & Earth

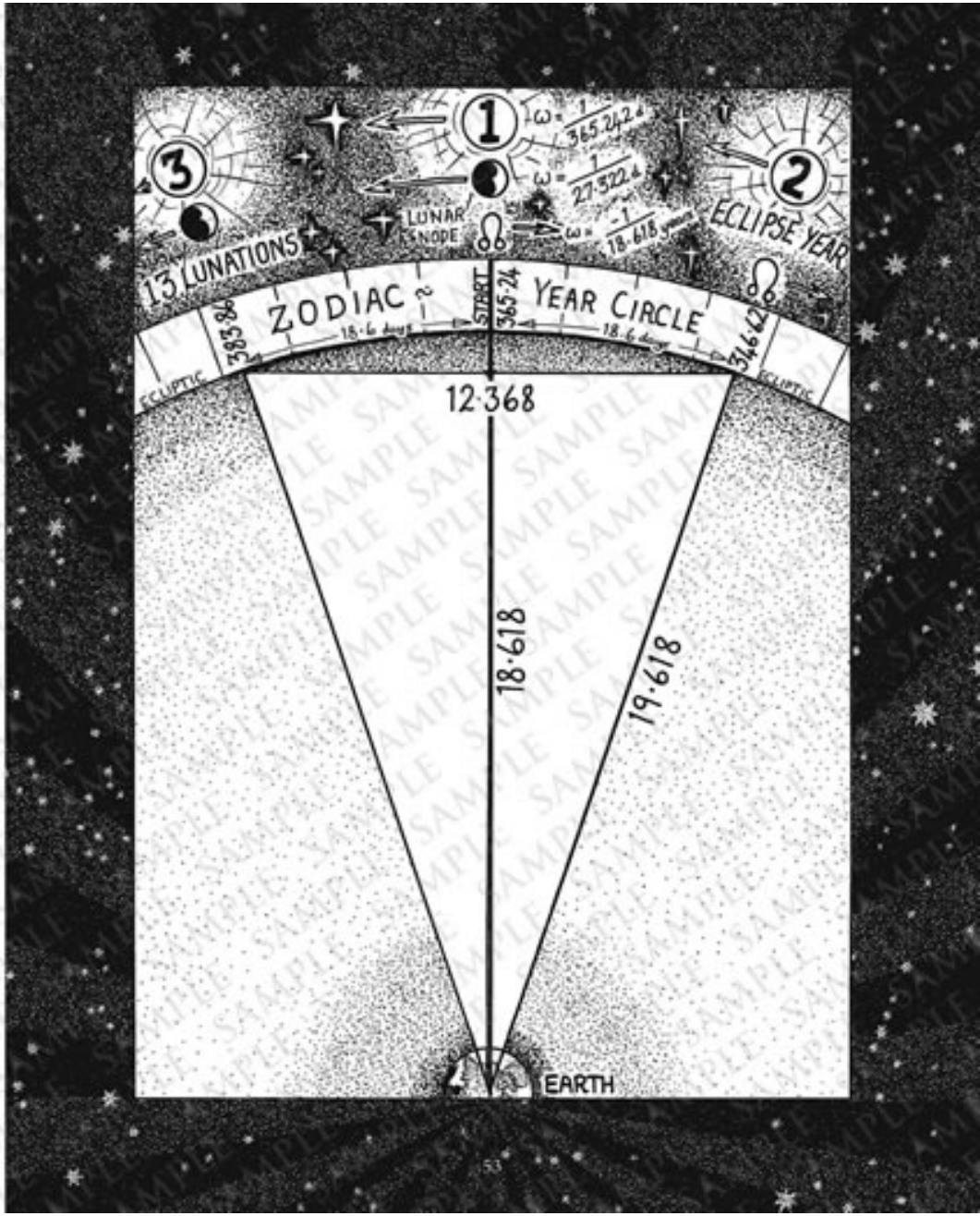
the revealed structure of the system

The diagram opposite frames a curious symmetry. Both the eclipse year (346.62 days) and thirteen full moons (383.89 days) are almost exactly equally spaced, at 18.6 days, either side of the solar year of 365.242 days. Because the eclipse year is the square of the lunar node period expressed in days (18.618^2), we can now state that the solar year is (18.618 x 18.618) + 18.618, or 18.618 times 19.618. The number 18 added to 1/*phi*, *phi* or phi^2 now delivers the following extraordinary formulae (to 99.99%):

18.618 x 18.618 = 346.62 days (the Eclipse Year)
18.618 x 19.618 = 365.242 days (the Solar Year)
18.618 x 20.618 = 383.89 days (13 Lunations)

The astronomy reveals the actual geometry and numerical structure of the Sun, Moon, Earth system (*opposite*). Imagine a solar eclipse at (1). The Sun then moves to meet up with the same node after an eclipse year (2), 346.62 days later. Passing the original eclipse point (1) at the end of one year, the Sun and Moon then meet for the thirteenth lunation at (3) (but without an eclipse).

An isosceles triangle, drawn to fit the angles generated by the astronomy, also then defines the solar eclipse limits, and has the remarkable property of replicating the numbers shown above as ratios. In addition, the shorter side has a length 12.368, the annual lunation rate. One marvels at this revelation of cosmic order!



A Stone-Age Computer

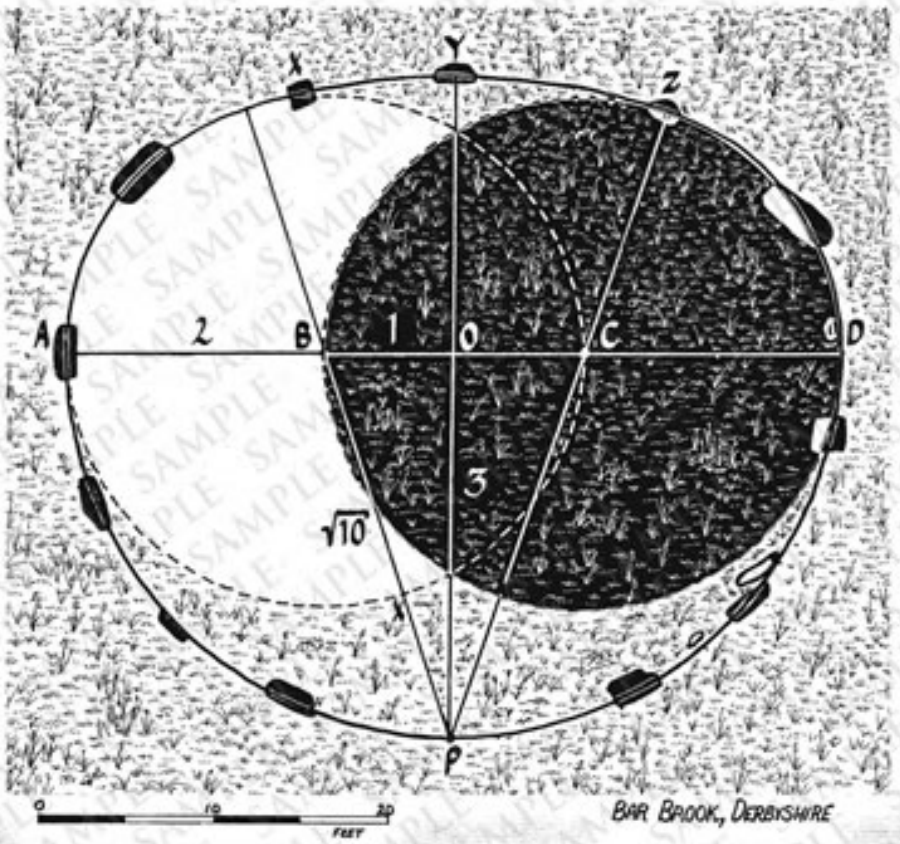
neolithic cosmology revealed

In remote places in Britain survive many examples of curiously flattened stone 'circles', constructed some 4500 years ago and named 'type-A' and 'type-B' by Professor Thom, the discoverer of the Megalithic yard (2.72 feet, 32.64 inches, 0.83 m).

Both type-A and type-B rings invoke a Christian symbol, the *vesica piscis*, the almond shape between two overlapping circles, here applied 2500 years before Jesus. Stones are commonly placed intelligently to the geometry (*opposite*). Astonishingly, this design invokes the *same* triangle we have just witnessed underpinning the structure of the Sun, Moon, Earth system!

The right triangle has side ratios $1:3:\sqrt{10}$. A hemp rope taken from the centre O to point P, and thence to B and A, has a length $3+\sqrt{10}+2$, which is 8.16227, exactly one quarter of the Megalithic yard, in inches. If length PB is considered to represent a lunation period, then the intersection of the vesica circle cuts it at 0.368 of its length (at X). If PB is now considered to represent the solar year, then PO represents the eclipse year, this ratio being either $\sqrt{10}:3$ or $19.618:18.618$. The ratios foot : Royal cubit : Megalithic yard may also be 'read' from this exquisite device.

This most beautiful analogue of the Sun, Moon and Earth system stores their key constants *and* the ancient metrology all within itself, as ratios. An awesome glimpse of an ancient wisdom is now finally revealed.



BAR BROOK, DERBYSHIRE

Foot : Royal Cubit : Megalithic Yard = 1 : 1.72 : 2.72 $\quad \frac{\sqrt{10}}{\sqrt{10}-2} = 2.72 \quad \frac{\sqrt{10}}{\sqrt{10}-5} = 1.72 \quad 2+3=\sqrt{10}=3.1623$

The Royal Cubit is 1.72ft, 20.64" The Megalithic Yard is 2.72ft, 32.64" (4×8.1623")

the exact same triangle as defined the marriage calendar of the Sun and the Moon on the previous page is mysteriously present at the heart of all of England's ancient flattened stone circles

Pebbles on the Shores of Time

multidimensional solutions to local cosmology

18:618 days
(one "wide-day")

18.618 years
Moon's nodal period



Eclipse Year = 18.618² days



12 Lunations = 18.618 × 19



Solar Year = 18.618 × 19.618 days



13 Lunations = 18.618 × 20.618 days

× The Saros Box ×



18.618 × 18.618 × 19 days

× The Dragon's Box ×



18.618 × 18.618 × 19.618 days

× The Metonic Box ×



18.618 × 19.618 × 19 days

× The Precessional Box ×



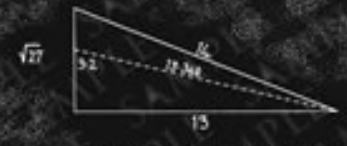
4 nested 18.618 cubes
= 4 × 18.618³ years



The Roman: An Egyptian unit of 1.215 ft



× Calendar Triangle ×



× The 'Sidereal Month' Triangle ×



× The 'Eclipse Year' Triangle ×



× The 'Saros-Metonic' Triangle ×



The 1, ϕ, √10 triangle



Instructions for use

1. Open Saros drawer.
2. Remove a lunation match
3. Strike against the eclipse year

and then...

4. Set fire to all previous ideas you had about the moon.

19 × 11.74 = 223

19 × 11.74 = ϕ

19 × 29.53
= ϕ eclipse years

Volume
= 29.53 × 11.74 × 19
= 6585.97 days
= Saros

TIMES

Solar Year: 365.242199 days
Lunar Year: 354.367 days
Lunation period: 29.53059 days
Eclipse Year: 346.62 days
Lunation rate: 12.36826623/year
Saros eclipse cycle: 18.03 years or 223 lunations or 6585.322 days
Lunar node cycle (Draconic year): 18.618 years or 6800.0 days
Metonic cycle: 19 years or 235 lunations or 6939.602 days
Sidereal lunar month: 27.322 days
Sun-spot cycle: 11 years
Sidereal day: 23 hours 56 minutes and four seconds
Solar tropical day (clock time): 24 hours
Lunar day (average): 24 hours, 52 minutes and 4.31 seconds
Precessional cycle: approx 25,770 years
Tidal spacing (average): 12 hours, 26 minutes and 2.15 seconds

LENGTHS

One foot: one degree of arc along the equator = 365,242
Megalithic yard: 2.72 feet (+/- 0.003 feet).
Earth's equatorial radius: 3963.4 miles
Polar radius: 3950.0 miles
Lunar radius: 1,080 miles
Lunar distance: 222,000 - 253,000 miles
mean: 240,000 miles
Sun's radius: 432,000 miles
Sun's distance (mean): 93,009,000 miles

ANGLES & RATIOS

Lunar orbit inclination to Earth-Sun plane: 5° 8' 30" (+/- 9' period 173.3 days)
Solar angular diameter (mean): 0° 32'
Lunar angular diameter (mean): 0° 31' 30"
Earth's axial tilt: 23° 27'
Earth to Moon density ratio: 1.6 : 1
Earth to Moon mass ratio: 81:1
Eccentricity of lunar orbit: 1/18

SOME DEFINITIONS

Lunation Period: Time between consecutive new Moons (or full Moons).
Ecliptic: The Sun's apparent path through the zodiacal belt of stars, seen from Earth.
Solar Tropical Year: Time between consecutive spring equinoxes.
Precessional (Great) year: Time for the zodiac to rotate (backwards) around the calendar.
Syzygy: Sun, Moon & Earth in a line.
Solar/Lunar Day: Time between consecutive south transits of the Sun/Moon.
Lunar Year: 12 lunations.
Sidereal Lunar Period: Time for the Moon to return to the same longitude (or Star).
Lunar Nodes: Two opposite points where the Moon's path crosses the ecliptic.
Eclipse Year: Time between consecutive conjunctions of the Sun and north Node.

IRRATIONALS

e = 2.718282 ...
ps(π) = 3.141593 ...
$\sqrt{2}$ = 1.414214 ...
$\sqrt{3}$ = 1.732051 ...
phi(ϕ) = 1.618034 ...
$\sqrt{5}$ = 2.236068 ...