



Lunar Calendars

Week 4 – Sacred Skies

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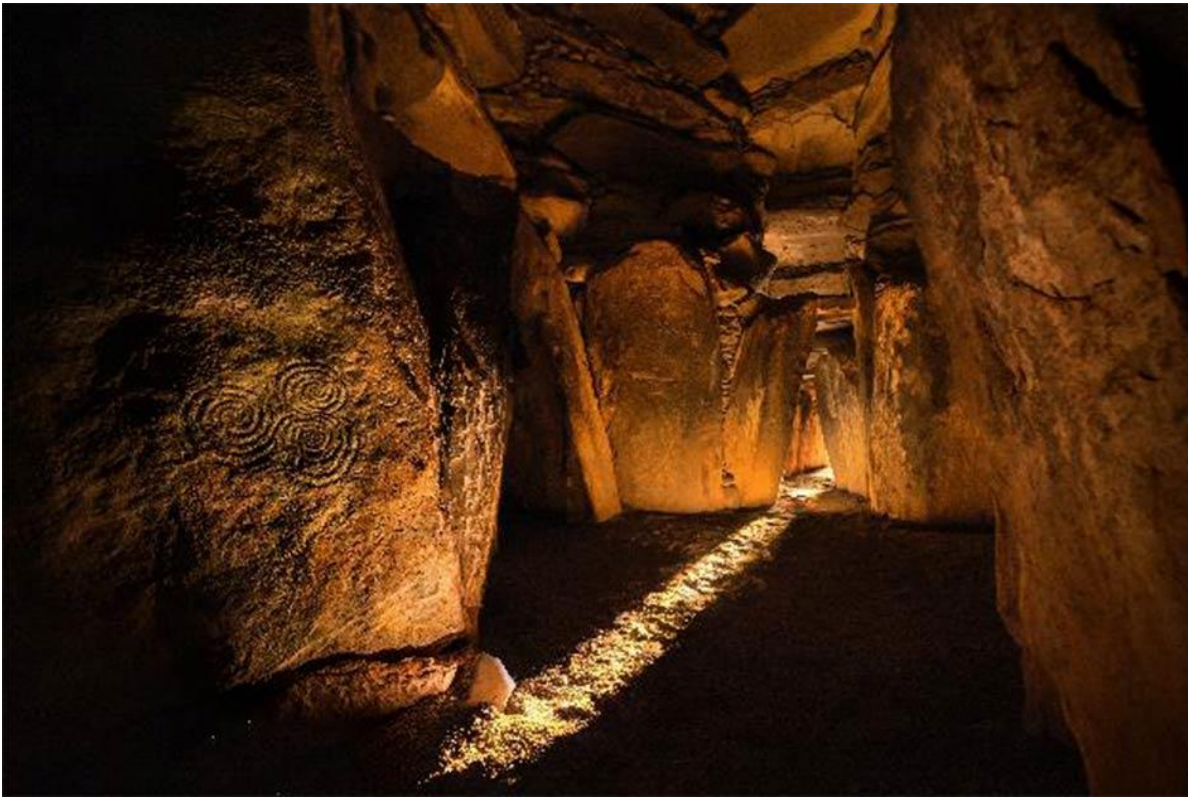
There are three celestial movements that produce calendars.

The **Lunar Calendar based on the New or Full Moon** is recognised as the earliest known form of calendar. The Celtic spiral petroglyphs are thought to be statements about the working with lunar phases.

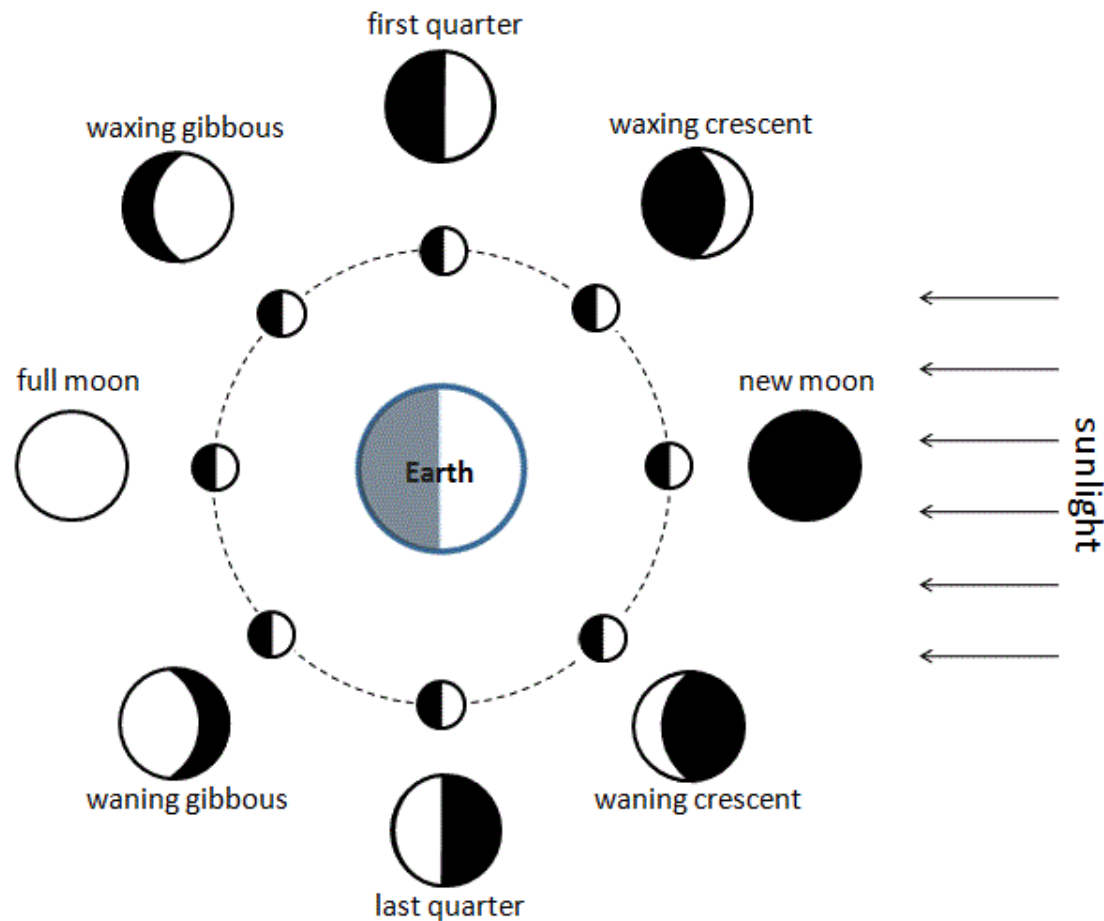
The **Solar Calendar** provides the agricultural year – the seasons. This is also celebrated at Newgrange with sunbeam at the winter solstice.

A **Stellar Calendar** – aligns with the solar calendar

Newgrange



The Phases of the Moon



The Moon takes 27.3 days to orbit the Sun but the lunar phase cycle – because the sun moves in that 27 days – takes an average of 29.53 days.

This phase cycle does vary in length by a few hours, due to the moon's orbit path being elliptical.

The Moon is **WAXING** when it is moving from New to Full and **WANING** when moving from Full to New.

FULL MOON 2020

JANUARY 10
FEBRUARY 9
MARCH 9
APRIL 8
MAY 7
JUNE 5
JULY 5
AUGUST 3
SEPTEMBER 2
OCTOBER 1
OCTOBER 31
NOVEMBER 30
DECEMBER 30



FULL MOON 2021

JANUARY 28
FEBRUARY 27
MARCH 28
APRIL 27
MAY 26
JUNE 24
JULY 24
AUGUST 22
SEPTEMBER 21
OCTOBER 20
NOVEMBER 19
DECEMBER 19



FULL MOON 2022

JANUARY 18
FEBRUARY 16
MARCH 18
APRIL 16
MAY 16
JUNE 14
JULY 13
AUGUST 12
SEPTEMBER 10
OCTOBER 9
NOVEMBER 8
DECEMBER 8

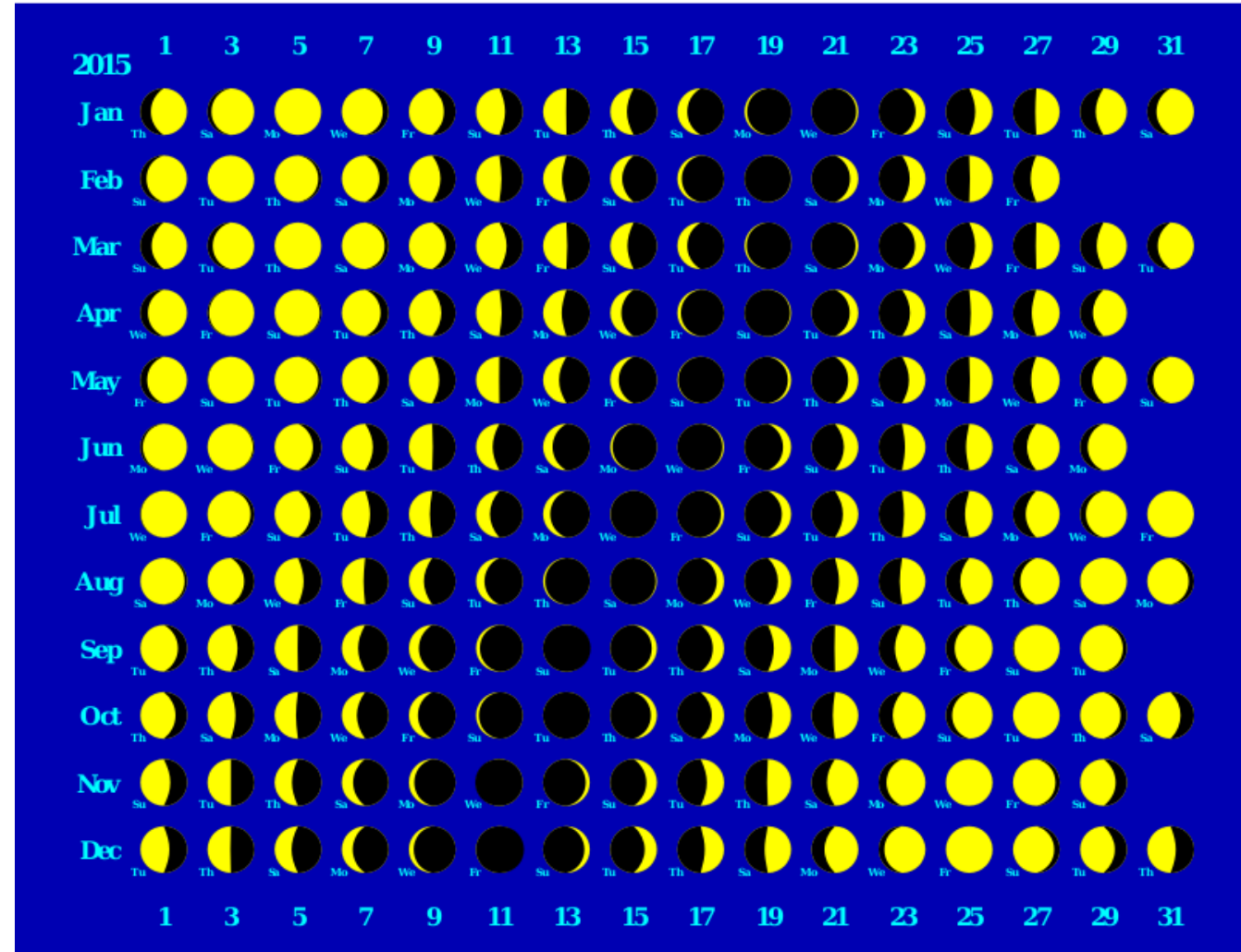


The Lunar phases do not align to the solar calendar .

The Lunar Calendar and the seasons

The lunar year, twelve new moons, is on average 11 days short of the solar year of $365 \frac{1}{4}$ days. This means that every second to third year a thirteenth month needed to be included in the calendar otherwise the seasons would drift through the year.

However, this method over five years, produces an excess of 7-8 days.



Some Anglo Saxon lunar month names

The problem

January: Wolf **Moon**. The Full **Moon** in January is the Wolf **Moon** named after howling wolves, which may stem from the Anglo-Saxon **lunar calendar**. ...

- February: Snow **Moon**. ...
 - March: Worm **Moon**. ...
 - April: Pink **Moon**. ...
 - May: Flower **Moon**. ...
 - June: Strawberry **Moon**. ...
 - July: Buck **Moon**. ...
 - August: Sturgeon **Moon**.
-

Due to the mis alignment of the Lunar which is 11 days in every Solar year then within three years the Wolf Moon would shifts backwards into December, three years later it would be in November, and so on.



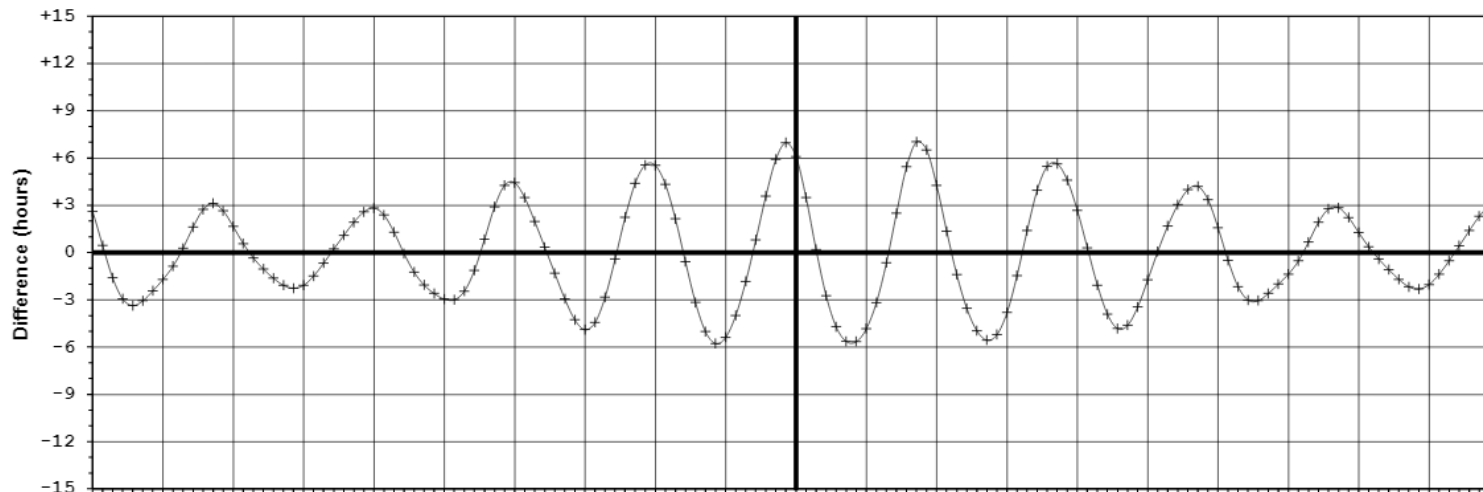
The other problem – an ‘inconsistence’ lunar phase cycle.

SOLEX Lunar Cycle Duration minus Mean Synodic Month (atomic time)
by Lunation Number relative to Zero = January 6, 2000 AD at 14:20:44 TT

Short-term periodic variability repeats at intervals of about 412 days (almost 14 lunar months), due to lunar orbital perigee advance.

The maximum positive peaks occur when Earth is near perihelion (moving fastest) and Moon is near apogee (moving slowest).

The maximum negative peaks occur when Earth is near aphelion (moving slowest) and Moon is near perigee (moving fastest).



Graph from: <http://individual.utoronto.ca/kalendis/lunar/#trend>

The length of a lunar phase cycle

The longest waxing or waning cycle is 15 days 14 hours 30 minutes, the shortest is 13 days 22 hours and 30 minutes.

Hence the length of a lunar phase can vary by around 13.5 hours from one cycle to the next.

Description	Assumed Lunar Cycle Length (exact days)	Decimal Month (days) overscored groups repeat	Time in excess of 29 days
Orthodox Easter <i>computus</i>	$(365+\frac{1}{4}) \times \frac{19}{235} = 29+\frac{499}{940}$	≈ 29.530851	12:44:25+ $\frac{25}{47}$ s
Hebrew calendar molad	$29+\frac{12}{24}+\frac{44}{1440}+\frac{1}{25920} = 29+\frac{13753}{25920}$	29.530594135802469...	12:44:03+ $\frac{1}{3}$ s
Yerm Lunar calendar	$\frac{25101}{850} = 29+\frac{451}{850}$	29.530588235294117647...	12:44:02+ $\frac{14}{17}$ s
Hindu <i>Surya</i> calendar (modern)	$29+\frac{7087771}{13358334}$	≈ 29.530587946	$\approx 12:44:02.8$
Mean Synodic Month (2000 AD, mean solar days)	$29+\frac{82517}{155520}$	≈ 29.53058770576	12:44:02+ $\frac{7}{9}$ s
Tibetan <i>Phugpa</i> calendar	$29+\frac{3001}{5656}$	29.530586987270155...	12:44:02+ $\frac{506}{707}$ s
Gregorian Easter <i>computus</i>	$\frac{2081882250}{70499183} = 29+\frac{37405943}{70499183}$	≈ 29.53058690056	$\approx 12:44:02.7$
Cycle of 49 yerms	$\frac{25101}{801} = 29+\frac{425}{801}$	29.530588235294117647...	12:44:02+ $\frac{62}{89}$ s
Cassidy-Dee Easter <i>computus</i>	$\frac{48091470}{1628531} = 29+\frac{864071}{1628531}$	≈ 29.530583083773	$\approx 12:44:02.4$
25 Saros cycle	$29+\frac{2958}{5575}$	$\approx 29.5305829596412556$	12:44:02+ $\frac{82}{223}$ s
Hindu <i>Arya</i> calendar (old)	$\frac{1577917500}{53433336} = 29+\frac{2362563}{4452778}$	≈ 29.53058180758	$\approx 12:44:02.3$
Fixed Islamic calendar	$\frac{(30 \times 6 \times 59 + 11)}{(30 \times 12)} = 29+\frac{191}{360}$	29.5305...	12:44:00

Different methods of trying to find a mathematical method for the calculation for a FIXED lunar calendar – that is fixed to the solar year.

Table from: <http://individual.utoronto.ca/kalendis/lunar/#trend>

This problem of alignment of the lunar and solar cycles also dominated Christian arguments around Easter.

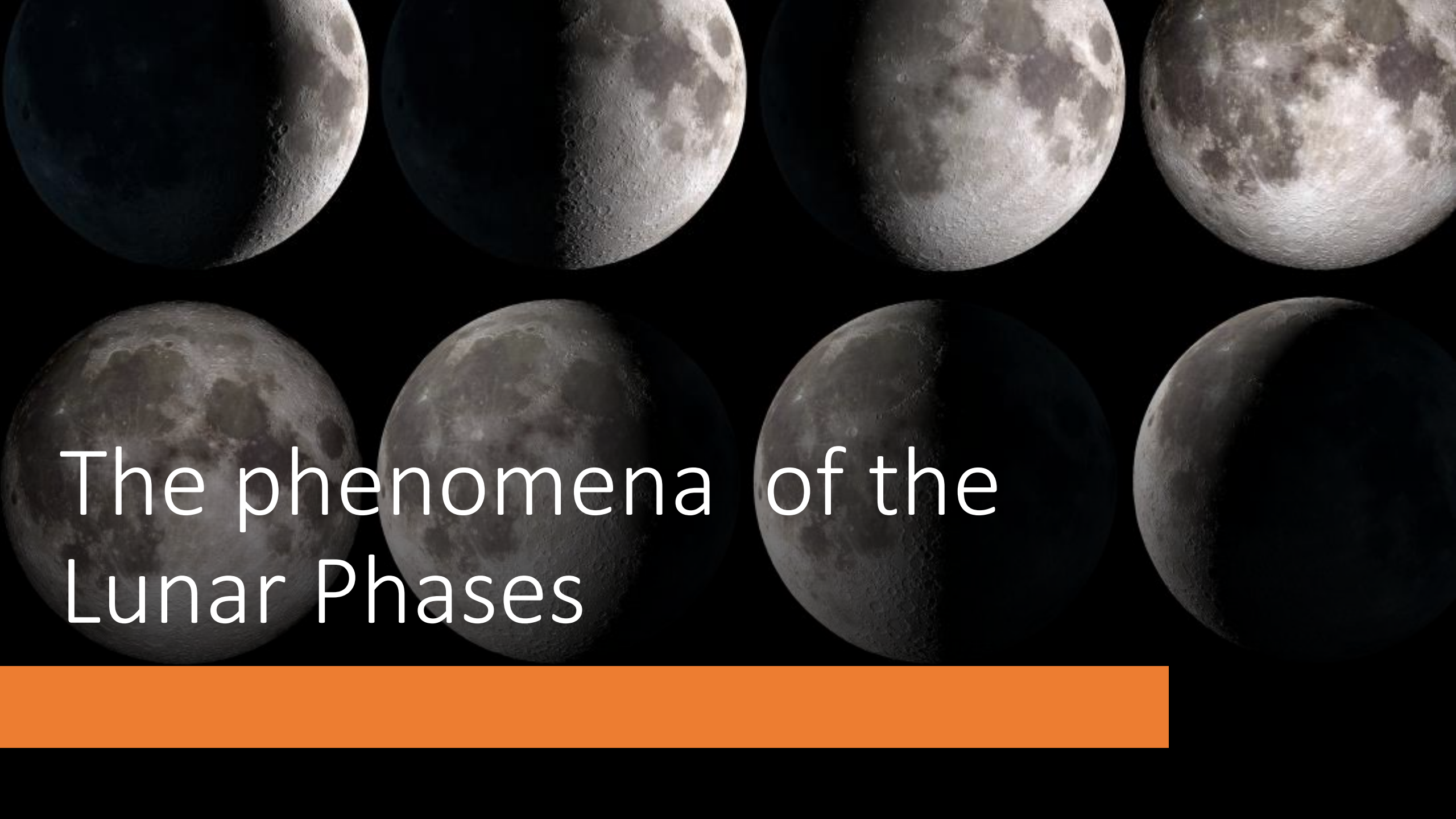
The Paschal Full Moon

The date of Easter used to be decided by the formula that Easter was to be celebrated on the **Sunday following the first full moon after the vernal (spring) equinox**. This statement was true prior to 325 A.D and is still, for the West, generally true.

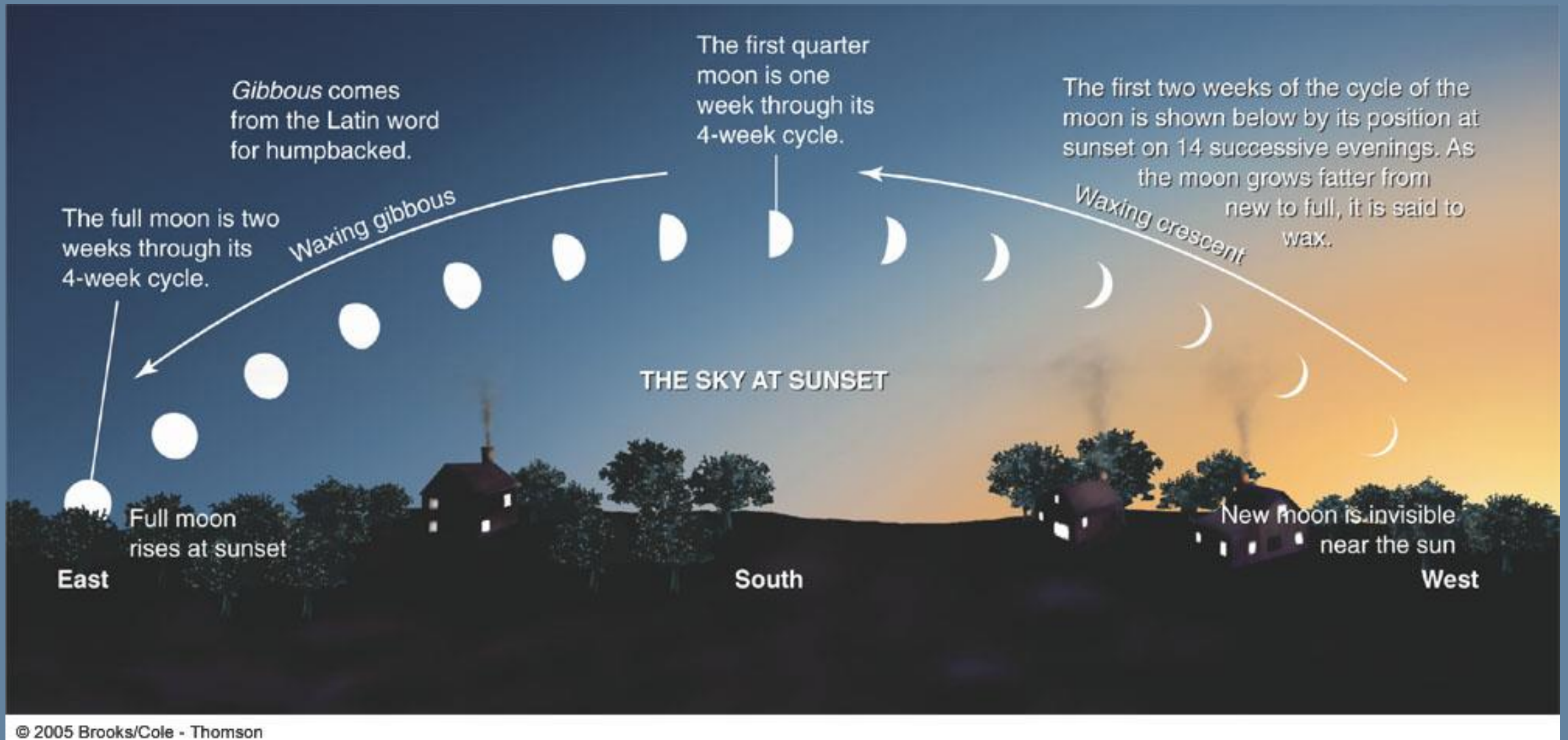
The Council of Nicea 325 CE for the Western Church standardised it further to have it based on tables rather than a lunar event – that is it had to fall on a Sunday regardless of the phase of the moon. By 1583 A.D. the table for determining the **Ecclesiastical Full Moon** dates was permanently established and has been used ever since to determine the date of Easter for the Western Church.

Thus, according to the Ecclesiastical tables, the **Paschal Full Moon is the first Ecclesiastical Full Moon date after March 20 (which happened to be the vernal equinox date in 325 A.D.). So, in Western Christianity, Easter is always celebrated on the Sunday immediately following the Paschal Full Moon.**

The Eastern Orthodox Church adhered to the tradition that Easter must always fall after the Jewish Passover, since the resurrection of Christ happened after the celebration of Passover. Thus it is linked to the Jewish lunar calendar.



The phenomena of the Lunar Phases

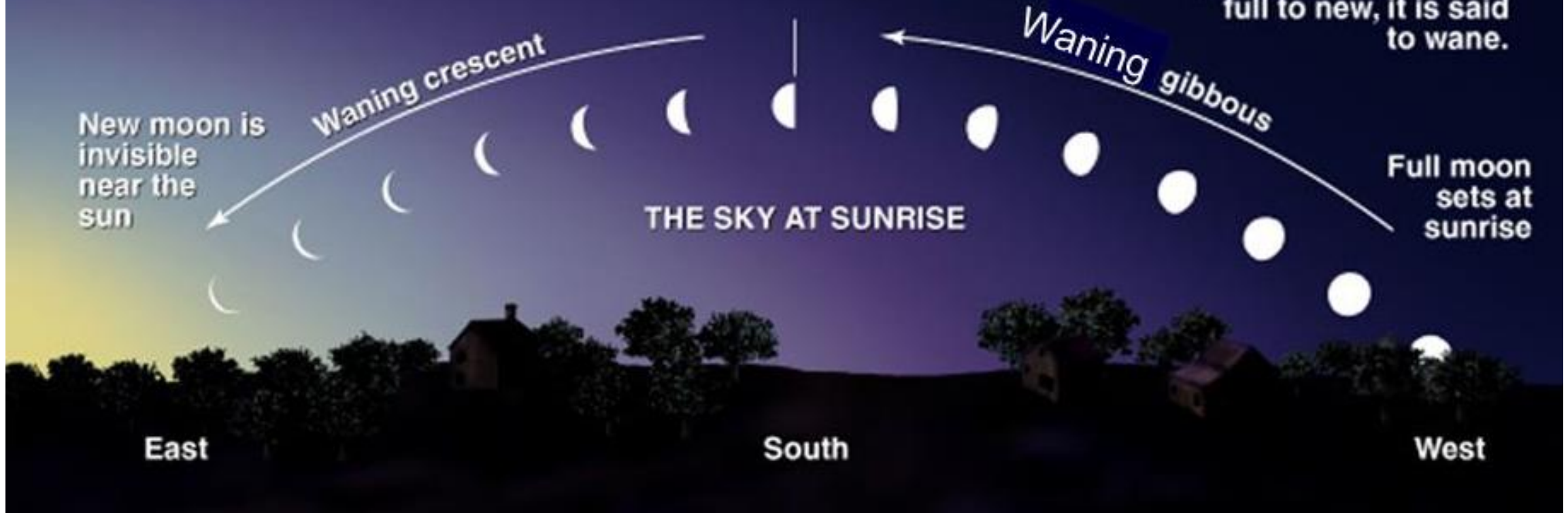


Waxing Moon – the moon moves from WEST to EAST

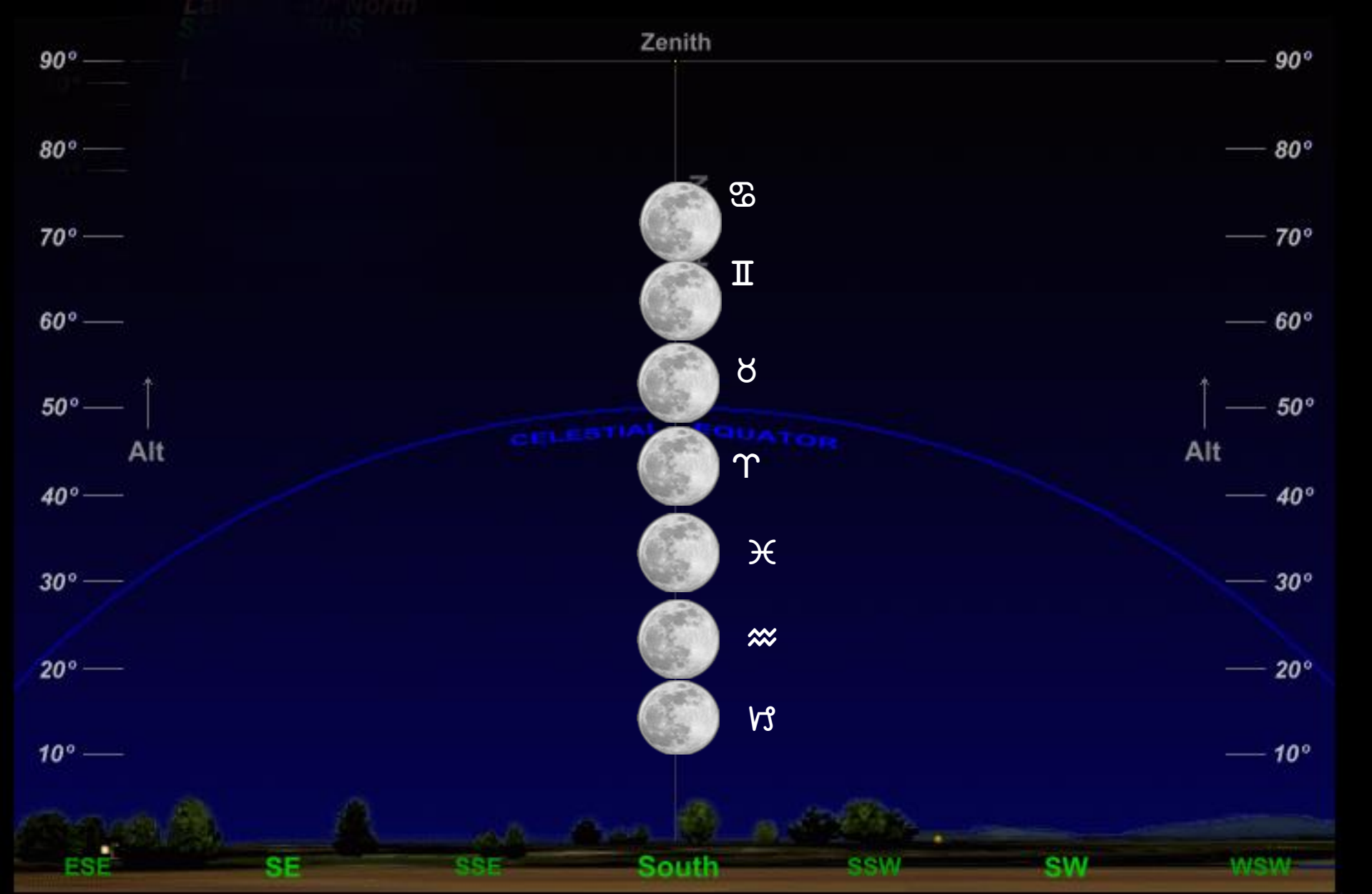
Morning Sky

The third quarter moon is 3 weeks through its 4-week cycle.

The last two weeks of the cycle of the moon is shown below by its position at sunrise on 14 successive mornings. As the moon shrinks from full to new, it is said to wane.



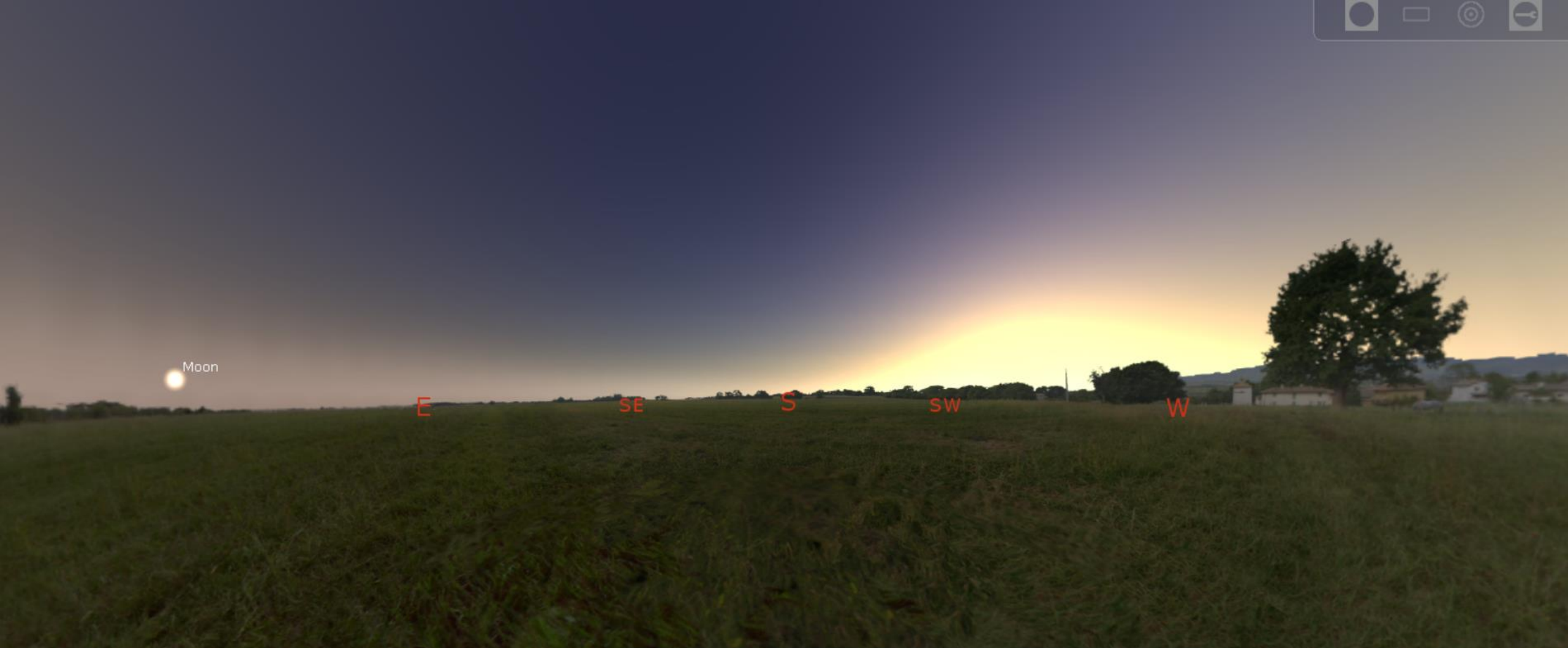
Waning Moon – the moon moves from WEST to EAST



Winter Solstice:
When Sun was dark
and low the Full Moon
is high.

Summer Solstice:
When the sun was high
in the sky the full
moon is low.

The Moon appears to follow a different path in the sky to the Sun during the course of a month.
Watching the Full Moons (ignoring the possible celestial latitude of the Moon) - Bath, UK



Moon

E

SE

S

SW

W

Jan 2021



Feb 2021



March, 2021



April, 2021



May 2021



June 2021



July 2021



August 2021



Sep 2021



Oct 2021



Nov 2021



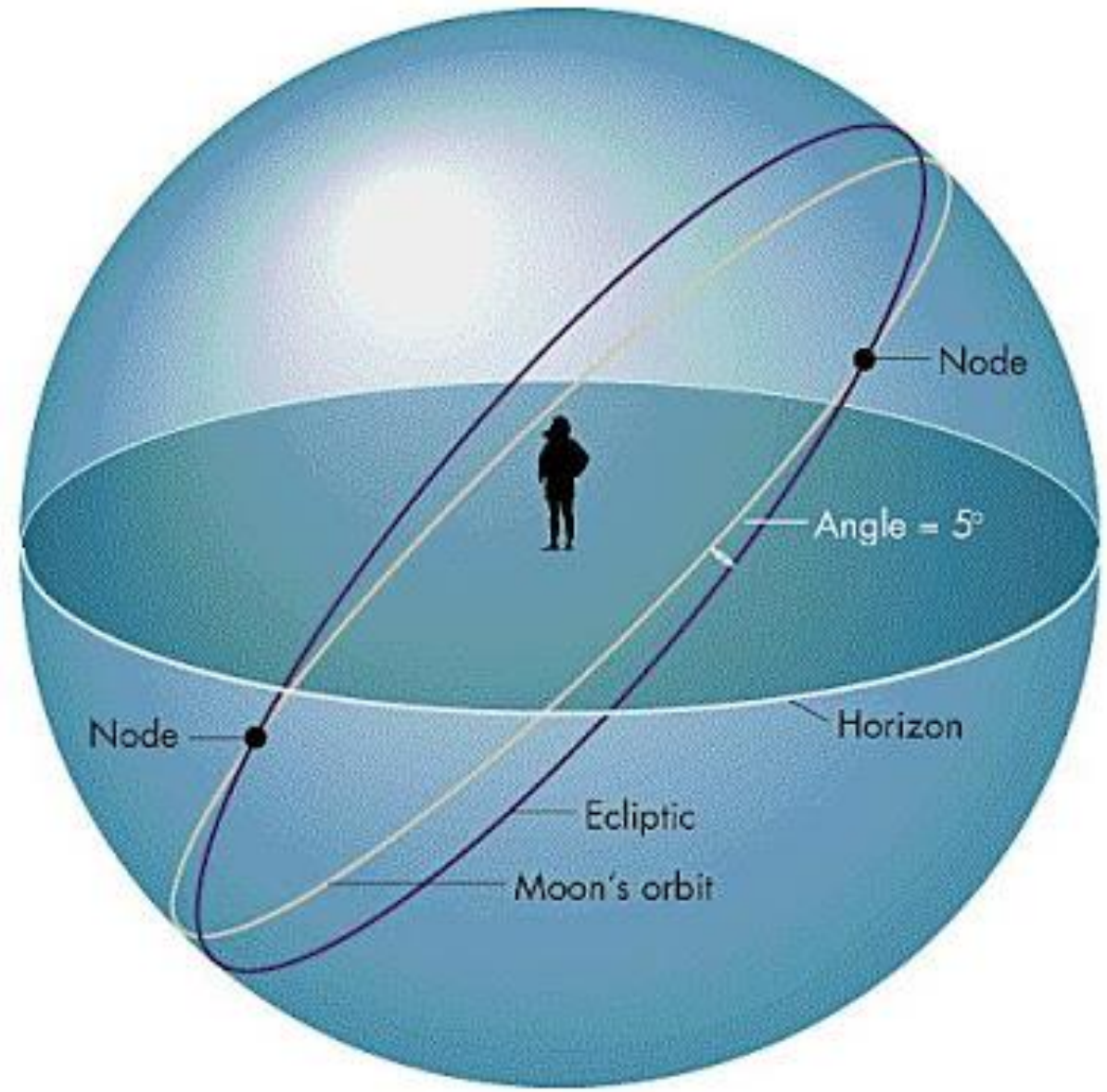
Dec 2021

But the Full Moon for each month will not rise in the same place each year – it will vary depending on the day of the month that the Moon is full plus the Moon's celestial latitude.

The Celestial Latitude of the Moon

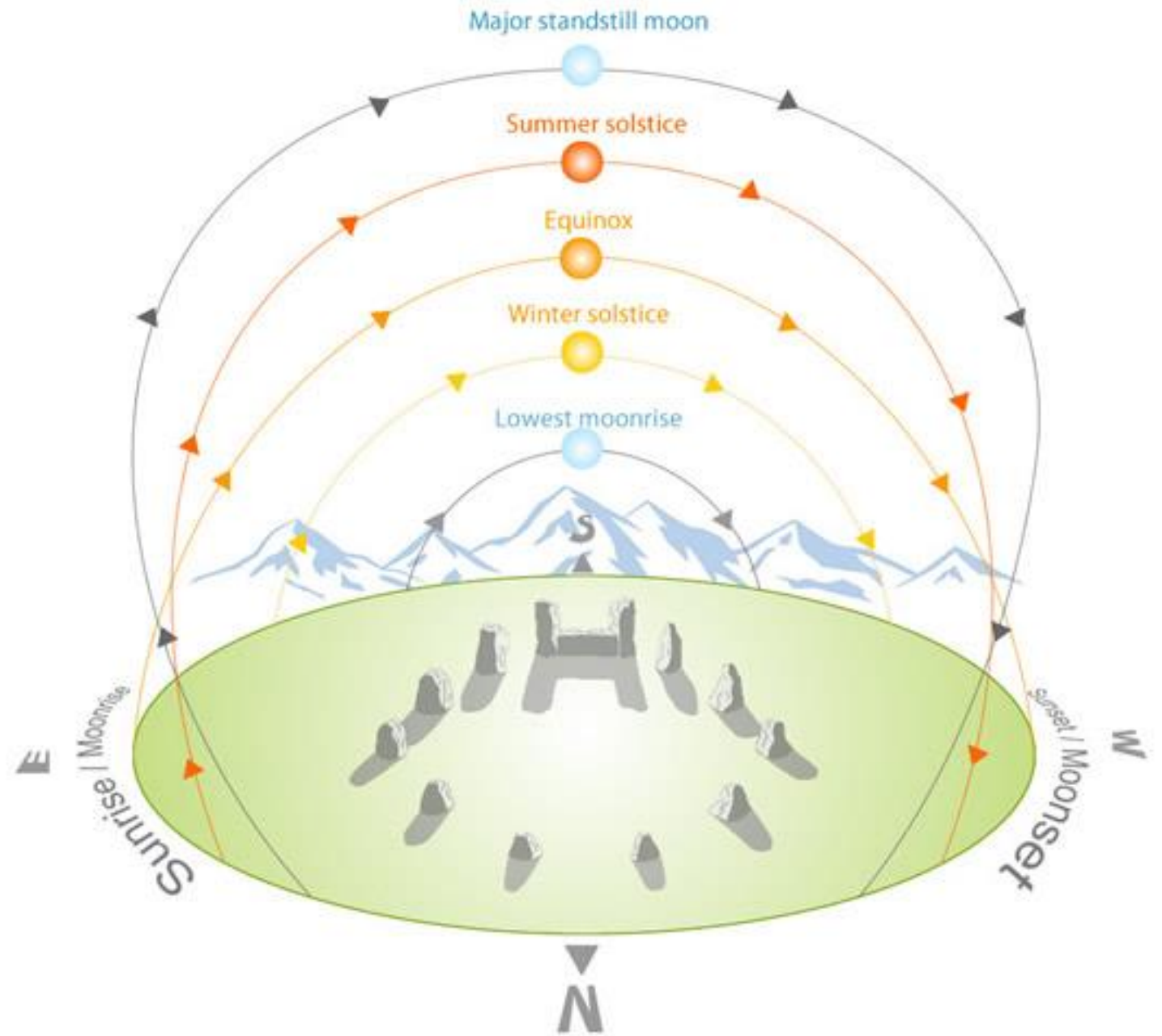
The Moon's orbital path moves above and below the ecliptic – the path of the sun, it crosses the ecliptic every 14 days at what is known as the Nodes.

This influences where the moon rises on the horizon and produces over a 19 year cycle what is known as major and minor lunar standstills.



The Moon's Standstills – Major and Minor

Breaking the boundaries of the Sun.



All of these variables:

- the mis-match of timing between the solar year and the lunar phases.
- the ecliptical orbit of the Moon around the earth which means this mis-match varies.
- the shifting celestial latitude that changes the Moon rise position on the horizon.

Combine to make the religious calendar complex and mysterious.

Lunar Cycles overlap
with Solar years

The Metonic Cycle

235 synodic months which is 19 years – the same phase on the same solar date. Only 0.086 days short.

The Lunar Calendar



Different ways of beginning a lunar month. The dominant method which Islam adopts is the first day of the month being counted from the first appearance of the crescent moon in the west at sunset.

Sunset and the first visible crescent of the new moon.

Note for the northern hemisphere the horns of the crescent moon point south -you are looking west in this picture – and they are not forming the letter ‘C’.

This is the beginning of the Islamic lunar month.

The Ancient Egyptian Lunar Month



Sunrise, last visibility of the balsamic moon – the next day at sunrise you will **not see the moon**. That is the first day of the Egyptian lunar month.

Note, for the northern hemisphere, the horns of the balsamic moon are a 'C'.

You are looking east in this picture, thus the horns of the moon are still pointing south.

A known Lunar Calendar – the Celtic approach

The Coligny Calendar considered to be a Celtic (Druidic calendar) from the third century BCE. Reveals the astronomical challenge of correctly aligning the solar year with the lunar calendar. This was essential as the correct full moon needed to fall in the correct season of the year.

Garrett Olmsted, *The Gaulish calendar : a reconstruction from the bronze fragments from Coligny with an analysis of its function as a highly accurate lunar/solar predictor as well as an explanation of its terminology and development*, (Bonn: Habelt, 1992), pp. 73-75.

Adolfo Zavaroni, *On the structure and terminology of the Gaulish calendar*, (Oxford: Archaeopress, 2007), p. 18., 89.



The Coligny Calendar is a Celtic calendar found in bronze fragments at Coligny, France in 1897.

The Coligny calendar is one of the earliest examples of the struggle to deal with the astronomical puzzle of aligning the lunar and solar cycles.



The process.....

- Adding a **leap month every third year** was not sufficient as the length of the lunar cycle cannot be evenly fitted into the length of a solar year.
- Using a **five solar year period is the best fit**, but this still gave a calendar that would be **seven to eight days** too long against the solar year. Hence leap days had to be removed!
- Added to this problem the moon does not move at a consistent rate and thus a five year block of lunar /solar years can be established by observation **but it cannot be tabulated.**
- The ONLY way to link the two calendars was by **direct observation of the sky.**
- This can be done in two ways. Link a particular part of the **lunar phase to a solar event or to a lunar event or to a solar/lunar/stellar event.**

Other ways of representing a Lunar Calendars



Lunar Cycles and Calendars can be hard to recognise



Tutankhamun – crowned by the Sun and the Moon.

The scarab beetle holds a sacred barque that carries a
left the **Wedjat Eye** topped with the lunar disk.

Three figures are shown on gold relief. In the centre Tutankhamun wearing a crown (with a moon above him) and flanked by two divinities making protective gestures – on the left is the ibis-headed moon god Thoth and on the right is the falcon-headed god Re-Horakhty.





The Lunar Phases at Esna – Temple of Khnum - Ptolemaic Egypt. New to Full moon.

Thoth offering the full moon – the complete eye – to the setting sun

Calendars – Lunar and Solar

Lunisolar calendars – where the lunar calendar is readjusted through adding intercalary months to the solar year with or without the removal of leap days.

Hebrew

Buddhist

Hindu

Burmese

Bengali

Tibetan

Traditional – Chinese

Japanese

Vietnamese

Mongolian

Korean

Hellenic

Coligny

Babylonian

The **Islamic calendar is lunar**, it is not a lunisolar calendar because its date is not related to the sun.

The **Egyptians used a lunar +stellar** calendar so sunrise on the horizon was not linked to a particular calendar date.

PRIMARY SOURCES - Required Reading

The calendars themselves as well as astrolabes provide your primary sources for this week. Additionally the classical texts of Hesiod, Ptolemy and Ovid are also primary sources.

Visit the Online Exhibition 'The Astrolabe East and West' <http://www.mhs.ox.ac.uk/astrolabe/exhibition/>

This exhibition from the Museum of the History of Science is quite extensive and uses particular instruments to reveal the issues of cosmos, destiny and faith all entangled with the astrolabe.

Hesiod's *Works and Days* <http://www.sacred-texts.com/cla/hesiod/works.htm>

Ovid's *Fasti* - <http://www.poetryintranslation.com/PITBR/Latin/Fastihome.htm>

Fox, M. (2004). 'Stars in the 'Fasti': Ideler (1825) and Ovid's Astronomy Revisited'. *The American Journal of Philology*, 125, 91-133.

Hesiod's *Shield of Hercules* http://ancienthistory.about.com/library/bl/bl_text_hesiod_shield.htm

The Greek world – the flow of war, life and death, the agricultural cycles – this can be compared with the Shield of Achilles from Homer's *Illiad*.

SECONDARY SOURCES - Required Reading

eBook - Stern, Sacha. *Calendars in Antiquity : Empires, States, and Societies*. Oxford ; New York: Oxford University Press, 2012.

Read - Chapter 6 - Dissidence and Subversion: Gallic, Jewish, and Other Lunar Calendars in the Roman Empire.

Finding this chapter : Log in to your library account and either go through the TSD library to the eBook section OR select from the list of available resources OXFORD SCHOLARSHIP ON LINE . Once at that site in the search engine type the author's name – Sacha Stern. Two of her works will appear, select *Calendars in Antiquity*.

Module Textbook: HARRIS, Alexandra, *Weatherland; Writers and Artists under English Skies* (London Thames & Hudson, 2015). chapter 2, 51-81, 'All things have their season.'

JSTOR Papers

Lehoux, Daryn Rosario. "Parapegmata, Astrology, Weather, and Calendars in the Ancient World ", University of Toronto, 2000.

Jones, Alexander. "On the Reconstructed Macedonian and Egyptian Lunar Calendars." *Zeitschrift fur Papyrologie und Epigraphik* 119, no. (1997): 157-166.

Melville, Charles. "The Chinese-Uighur Animal Calendar in Persian Historiography of the Mongol Period." *Iran* 32, British Institute of Persian Studies (1994): 83-98.

References

CLAGETT, Marshall, *Ancient Egyptian Science, a Source Book: Volume li, Calendars, Clocks and Astronomy* (Philadelphia: American Philosophical Society, 1995).

Giddens, Anthony, *Modernity and self-identity. Self and society in the late modern age* (Cambridge Polity Press, 1991), p.85.

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Stern, S. (2012). *Calendars in antiquity : empires, states, and societies*, Oxford ; New York, Oxford University Press. p1

Zavaroni, Adolfo *On the structure and terminology of the Gaulish calendar*, (Oxford: Archaeopress, 2007), p. 18., 89.