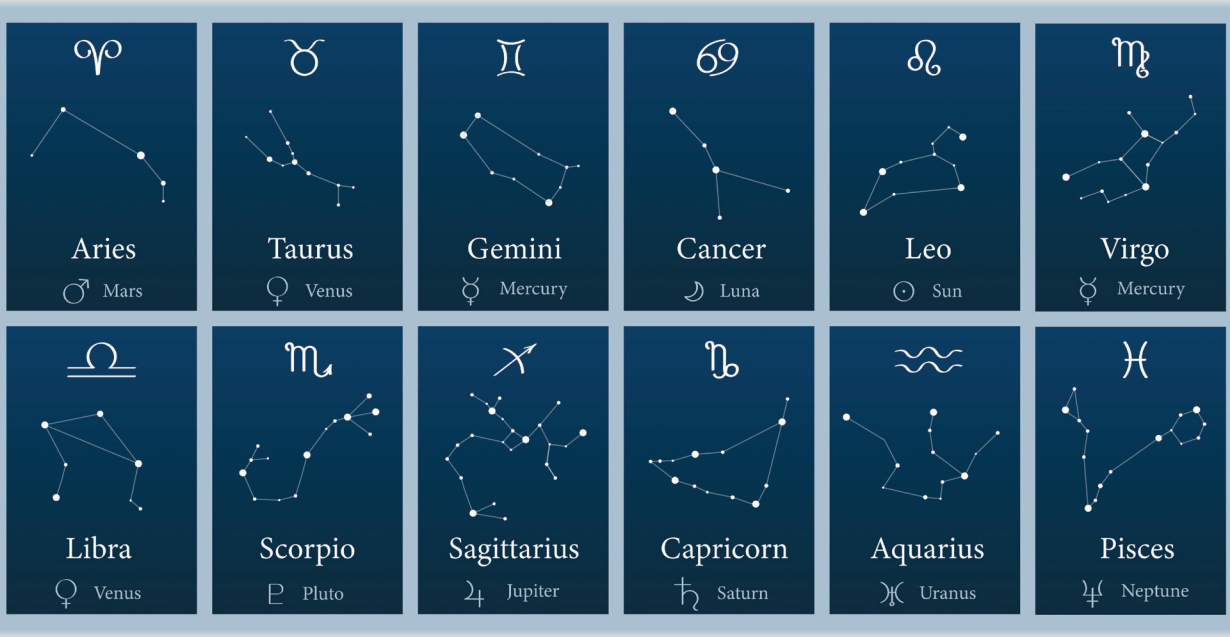

Evolution of Calendars

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Evolution of Calendars in Ancient Times

Archaeologists from Britain announced in 2013 that they had uncovered the world's earliest calendar. The discovery was made at Warren Field in Scotland, where twelve pits were found to be aligned with the southeast horizon. These pits were used by hunter-gatherers to track the height and stage of the moon, which allowed them to keep time in relation to the sun and the changing seasons. The pits pointed towards a hill that was associated with the sunrise on the midwinter solstice.

Warren Field in Scotland is approximately twice as old as Stonehenge, which was discovered in 1978. While Stonehenge is a more well-known sight, it is believed to have been used for performing rituals at specific times of the year rather than as a means of keeping track of time. Nonetheless, it is still capable of revealing times of the equinoxes and solstices. Recent findings suggest that Stonehenge may have also been believed to possess curative and healing properties.

Interpreting these sights can be challenging because they were constructed during a time when there were no written records. Archaeologists have analysed the alignment and shape of the stones, as well as the contents of nearby burial sites, to determine the practices that were carried out there and to uncover any additional secrets that may be concealed within these sights.

The Warren Field site in Scotland could have been used by hunters to determine when to start looking for specific types of migrating animals. In addition to providing information about when to plant or harvest crops, the pits may have also been used to guide hunters.

History of the Babylonian Calendar

The first cities were established between the Tigris and Euphrates rivers, which originate in the Taurus mountains of south-eastern Turkey. These rivers' headwaters diverge and flow south through Syria and Iraq, with several tributaries added from Iran before finally flowing into the Persian Gulf.

Ur, founded approximately 3,800 BCE, was once a coastal city. Due to changes in the landscape, it is now more than 200 kilometres away from the sea. The Ur III empire, at one point, would have extended up through much of modern Iraq, including several smaller cities.

Clay tablets with cuneiform writing reveal that before Ur incorporated them, those cities would have had their own calendars with their own names for the months of

the year. For instance, Nippur had months named "du6-ku33," or "Shiny Mound," and "kin-Dianna," or "Work of Inanna."

The city of Umma had months that translated as "Harvest," "Barley is at the quay," and "First fruit (offerings)." Each of the cities had a month called "Extra," which enabled them to reset the calendar, just as a leap year does.

The conquests of King Shulgin, who ruled in the 21st century BCE, united those calendars into the Umma calendar – which became the foundation of the Babylonian calendar. The Umma calendar had twelve months and a thirteenth month every four years.

The calendar starts in the spring, around March or April in the Gregorian calendar, with Araḫ Nisḫu, the "Month of the Sanctuary." This is followed by the "Month of the Bull," which corresponds to the zodiac sign of Taurus. The seventh month is the "Month of the Beginning," which begins the second half of the year, followed by the "Month of Laying Foundations."

Babylonian weeks would not have been unfamiliar. Every seventh day was a rest day on which officials were prohibited from engaging in certain activities. For the Babylonian calendar, these same activities couldn't be done on the 28th day of each month either. On each rest day, Babylonians made offerings to a different god. The most peculiar aspect of a Babylonian month would have been the length of the last week. Each week lasted seven days, but during the lunar cycle, the month, which lasted 29 or 30 days, made it so that the last week of each month lasted eight or nine days.

The History of the Egyptian Calendar

The Babylonian Empire existed from approximately 1896 BCE to 539 BCE and experienced its zenith during the reign of King Hammurabi, who ruled from 1792 BCE to 1750 BCE. During the same period when the Babylonians anticipated the extended weekend at the end of the month, the Egyptian empire was expanding towards the west.

There is a debate among scholars regarding the early Egyptian calendars that were based on the rising of Sirius or the presence of a 360-day year. Nevertheless, it is evident that as early as 3000 BCE, the Egyptians were interested in the annual cycle, particularly the yearly flooding of the Nile. The monsoon brings heavy rains to the Ethiopian highlands south of Egypt between May and August, according to the Gregorian calendar, and the waters flow into the Nile, causing it to flood.

The size of the harvest was determined by the flooding. The floodwater was directed into fields through a system of dams and dikes to saturate the soil. The water that

accumulated in the fields had to be enough to sustain the crops throughout the dry season. A low flood meant a poor harvest.

The floods also dictated the year's pattern, and the Egyptians divided their calendar into three seasons. The Flood Season took place from approximately June to September when the Nile flooded, and the waters engulfed the fields. "Emergence" took place between October and January. Finally, the Low Water or harvest season occurred from February to May. During the early dynasties of Egyptian history, the months within those seasons were numbered as "First Month of the Flood," "Second Month of The Flood," and so on. However, by the Middle Kingdom, the months had acquired names that have largely persisted through the New Kingdom and Greek calendars to the present-day Coptic calendar.

The Calendar According to the Nile

The year in ancient Egypt was divided into three periods based on the rise and fall of the Nile, which occurred regularly but were not entirely predictable, much like migratory birds were crucial to the hunter-gatherers of the Scottish Isles. While the movement of the sun, moon, and stars followed recognizable patterns, the arrival of the monsoon and the flight of storks depended on unpredictable weather systems that varied from year to year.

Although the seasonal calendar enabled Egyptian farmers to anticipate the appropriate time to open their dams and plant their seeds, it was less helpful in predicting or marking other events that took place throughout the year. During the Old Kingdom period, when the pyramids were constructed, Egypt introduced a civil calendar based on the reappearance of Sirius, a star that returned to the sky about the same time as the Nile flooded.

The civil year was made up of twelve months, each consisting of 30 days, with an additional month of five days, resulting in a year of 365 days. However, the absence of a leap year caused the movement of the stars to gradually fall out of sync with the names of the month. As Sirius moved backwards through the calendar, the Egyptians devised a Sothic Cycle. Every 1,461 Egyptian civil years, Sirius would return to its original position in the calendar.

The Roman Calendar

After centuries of experimenting with various calendrical systems and ways of marking time, by the time of the Roman Empire's establishment, we had made significant progress. We had tried stone circles, stone markings, lunar calendars, and combinations of solar and lunar calendars. Despite all these efforts, we still struggled

to get it right. The primary issue was that the Earth's revolution around the sun could not be counted in whole days. When a civilization couldn't count an entire day, calendars worldwide would regularly fall out of sync with the seasons, stars, and the moon's movement.

The earliest Roman calendars were not much better than most other calendars, but they had impressive tile work. They began as lunar calendars, tracking the moon's development over 29.5 days and losing only ten or eleven days each year. Early Rome also had a nundinal cycle, which they derived from the Etruscans. It was an eight-day week that ended with a market or festival, and farmers would head to the city to buy and sell goods. On this day, children had no classes, and slave-owners warned their property not to enjoy themselves too much.

A year in early Rome consisted of 38 nundinal cycles, divided into ten months of 30 or 31 days. While it is unclear how the Romans dealt with the remaining days, some scholars believe that the Romans disregarded them, while others suggest that the early Romans practised intercalation. They inserted extra days into the calendar to fill the gap and ensure that the calendar didn't fall out of sync with the seasons.

The Ides, The Kalends and the none (Revised Roman Calendar)

The Romans revised their calendrical system after the end of their kingdom and the growth of the Roman Republic. They were influenced by Greek calendars that divided the year into twelve lunar months, alternating between 29 and 30 days. The Romans assigned 31 days to the third, fifth, seventh, and tenth months, while every other month had 29 days, except February, which had 28 days and 29 in each leap year. The Romans also carefully divided each month, calling the first of the month "kalends", the day before the middle of the month "ides", and the eight days before the ides "nones" (or nine days counting inclusively). These moments likely reflect the calendar's lunar origins and mark the sighting of the crescent moon, quarter moon, and full moon.

We can now begin to comprehend some information about the foundation of the calendar that we use today. Notably, we see the use of an intercalary month in February to keep the months aligned with the seasons. However, the Roman calendar had one interesting difference. After the establishment of the Roman Republic, control over intercalation was passed to the high priests. They could adjust the number of days in February to lengthen or shorten the term of office of the consuls they supported. It was as if a political party could determine the length of a year and make the year longer when they were in office. Therefore, the priests could gerrymander the calendar.

The History of the Julian Calendar

Julius Caesar proposed a change to the Roman calendar in 48 BCE. This was due to the high priests manipulating the length of the year to favour their political allies, which caused the calendar to become out of sync with the actual year. This issue was exacerbated by events such as the Punic War against Carthage and the Civil Wars.

Between 63 BCE and 46 BCE, only five intercalary months were added instead of eight, and none were added between 51 BCE and 46 BCE. This period is often referred to as the "years of confusion" by historians. Caesar, who had previously spent time in Egypt and knew the correct date, wanted to establish a more conventional way of maintaining the calendar. After returning from the African campaign in 46 BCE, Caesar added two intercalary months between November and December, making that year 67 days longer.

The calendar in 46 BCE was 445 days long, as the year had already been extended from 355 to 378 days. The reform involved adding ten days to each year, including two days to January, August (formerly known as Sextilis), and December and one day to April, June, September, and November. February remained 28 days long. The new calendar eliminated the previous intercalary month and replaced it with a new leap day placed before the kalends of March. Although Romans continued to mark kalends, ides, and nones, this reform established the modern world's calendar pattern.

How Months Were Named

The calendar, which was introduced throughout the empire and neighbouring states and client kingdoms, had 365 days and one leap day, which was initially added every three years but eventually every four years. The months' names mostly remained unchanged, with January honouring Janus, the god of new beginnings. Janus was known for having one head but two faces, one looking forward to the future and one looking back at the previous year. Each month was taken seriously and involved deep reflections, thoughts, concerns, and deliberations to come to a consensus of opinions. February likely originated from the Februa festival, while March was dedicated to the god Mars. The origins of April, May, and June are unclear, but they may have been derived from the Etruscan god Apru and the gods Maia and Juno, respectively. Another theory suggests that April comes from the Latin word "aperire," meaning to open, while May and June were old terms for "senior" and "junior." The remaining months were named after their order in the calendar, with Quintilis being the fifth month, Sextilis being the sixth, September being the seventh, October being the eighth, November being the ninth, and December being the tenth. The Julian reform pushed the months down the calendar, making December the twelfth month

but without changing its name. Quintilis, the birth month of Julius Caesar, became known as Iulius (or July in English), while Sextilis became Augustus or August. Other emperors, such as Caligula, Nero, and Domitian, attempted to rename months as well, but their attempts were unsuccessful. For instance, Caligula tried to call September "Germanicus" to honour his father, Nero wanted April to be called "Neroneus," and Domitian wanted October to become "Domitianus."

History of the Georgian Calendar

The Julian Calendar functioned reasonably well; however, it was not entirely accurate.

The calendar operated under the assumption that a year consisted of precisely 365.25 days. Nevertheless, the Earth takes 365.2422 days to revolve around the sun, and the difference of eleven minutes each year was sufficient to shift the calendar out of alignment with the equinoxes by approximately three days every 400 years.

Saint Bede, an English Benedictine monk, had already noted that the calendar had moved by three days by the eighth century. Five hundred years later, Roger Bacon approximated that it was misaligned by approximately a week, and by 1300, Dante had mentioned the necessity for complete calendar reform.

The calendar's drift proved problematic for the church, as the date of the spring equinox determined the celebration of Easter, which the church had established to fall on March 21. By the sixteenth century, the equinox had moved back approximately ten days.

In 1545, work began on changing the calendar. The Council of Trent authorized Pope Paul III to adjust the dates so that the spring equinox matched the equinox during the First Council of Nicaea in 325. The Nicaean Council had also requested a new method of keeping time to prevent Easter from drifting through the calendar again.

How Aloysius Lilius Fixed the Calendar

Work during the sixteenth century was time-consuming despite the calendar's drawbacks. The reform commission requested mathematicians' contributions in 1577, and Aloysius Lilius, an Italian doctor and astronomer, submitted the winning proposal. According to his suggestion, the leap year should be cancelled for the next forty years to allow the equinox to catch back up with the calendar. He then proposed a new formula to stabilize the calendar, stating that a day would only be added during a leap year if the year were divisible by 100 and 400. Thus, 1600 was a leap year, but 1700, 1800, and 1900 were not. The calendar was brought back into

alignment regularly with these additions and subtractions, as a leap day was added on only 97 days out of every 400 rather than every 100 days.

On Friday, October 15, 1582, during the papacy of Gregory XIII, the new calendar was adopted. The previous day was Thursday, October 4th, according to the Julian calendar. Spain was the first to accept the new calendar, followed by Portugal, France, Poland, Italy, the Catholic Low Countries, and Luxembourg. The Kingdom of Bohemia adopted the calendar two years later, while Prussia accepted it in 1610. Protestant countries were more hesitant to adopt the calendar, fearing that it would bring them closer to Rome. As a result, Britain only chose to adopt the Gregorian calendar in 1752, while Greece waited until 1923 and Turkey until 1926.

The Gregorian calendar rectified the Julian calendar's mistake of one day every 128 years, replacing it with an error of one day every 3,030 years. Sir John Herschel, a nineteenth-century English mathematician, suggested that the calendar's accuracy could be improved by not making the year 4000 and its multiples a leap year. However, his suggestion was ignored.

The Local Calendar Still in Use

Throughout the course of history, we have witnessed the evolution of calendars from basic stone formations used to anticipate the return of animals during solstice to intricate systems of star tracking and month counting. The evolution of calendars has largely been influenced by the struggles of various cultures and empires to create a standard way of counting days and months in a year. The biggest challenge was accounting for the extra quarter day that the Earth uses to make a full rotation around the sun. Failure to do so would cause the calendar to slip through the year. Over time, calendars have also been given unique names for the months.

The introduction of the Gregorian calendar marked the pinnacle of calendar development. Lilius's correction, which was introduced during the papacy of Gregory XIII, ensured that the year was always accurate and required little to no correction. The calendar's adoption across Christendom and beyond has led to the world sharing a single method of timekeeping.

The Continued Use of Julian Calendar

The marking of time isn't limited to the use of the calendar. There are various calendars still in use globally, not just the Gregorian calendar. Although people can locate the same date on the same calendar worldwide, other calendars are still used in different regions. In Greece's autonomous province of Mount Athos, the Julian calendar is still in use and holds authority. This province consists of twenty Orthodox

monasteries, and women are prohibited from entering the island. Orthodox churches, and sometimes countries, still rely on the Julian calendar. These countries even declined to adopt a lunar calendar that would match the Gregorian calendar until the year 2800. The calendar was proposed at a synod (congress, committee) in Constantinople in 1923. Except for the Estonian and Finnish Orthodox Churches, Orthodox churches still celebrate their Christian festivals according to the Julian calendar, not the Gregorian calendar. Traditional calendars are also still in use in other regions and religions.

The Hebrew Calendar

Israel has two calendars—the Gregorian calendar and the Hebrew calendar. The Gregorian calendar is used for secular activities such as scheduling school breaks, arranging business meetings, and celebrating birthdays. However, the Hebrew calendar determines the dates of religious festivals, which occur almost every month. Additionally, the Jewish calendar is used to decide which portion of the Torah will be read each Shabbat and to determine the dates of memorials for deceased relatives.

The Hebrew calendar is strongly influenced by the Babylonian calendar, which came about because of Jewish exile in Babylon that ended in the sixth century BCE. Before the exile, the Hebrew calendar consisted of ten months, each with thirty days. Only four months were mentioned in the Bible: Aviv (spring), Ziv, Ethanim, and Bul. These names are believed to be Canaanite. After the Babylonian exile, the names of the months were changed to match the Babylonian calendar more closely.

One key difference between the Gregorian and Hebrew calendars is the way the days are measured. In the Hebrew calendar, a day starts at sunset, meaning that Shabbat starts on Friday evening and ends the following day when the sun sets. Another important difference is how the months are measured. The Gregorian calendar is solar and based on the sun's relative position to the stars. In contrast, the Hebrew calendar is a lunisolar calendar, meaning that the months are based on lunar months (taking into consideration the phases of the moon), and the years are based on solar years. The Hebrew calendar consists of twelve lunar months, with each month lasting either 29 or 30 days.

The Buddhist Calendar

The Buddhist calendar follows the lunisolar system and is primarily used in Cambodia, Laos, Myanmar, and Thailand. It has many variations and versions in countries around the world. This calendar is mainly used for Theravada Buddhist

festivals, and there is no official Buddhist calendar status anymore. It keeps track of the movements of both the Moon and the Sun, and it mostly follows the Hindu calendar. Due to the "sidereal year" and the 19-year cycle used to determine the distribution of leap years based on the length of a tropical year, this calendar is somewhat inaccurate when reflecting the length of a solar year and the onset of the seasons.

The Metonic Calendar

The Hebrew calendar has a lunar year that is twelve months long, while a solar year is eleven days longer. This difference causes the holidays to fall out of sync with the seasons and requires the addition of leap months to correct it. Unlike the Gregorian calendar, which adds a leap month every four years, the Hebrew calendar adds seven leap months every nineteen years, following the Metonic cycle. Meton of Athens, inspired by the Babylonians, first discovered that nineteen years is almost equal to 6,940 days. In addition to the Metonic cycle, the calendar also adjusts to ensure that Yom Kippur, the Day of Atonement, never falls immediately before or after Shabbat. The month of Kislev can lose a day, while the month of Cheshvan can add a day. Despite its complexity, the Hebrew calendar is mainly used to mark Jewish holidays, with the dates appearing at the top of newspapers.

The Islamic Calendar

The Jewish Calendar tries to stay synchronized with the solar calendar while also adjusting the duration of its months. To ensure that a holiday fixed by month does not coincide with a holiday fixed by week, the calendar needs to make these adjustments. On the other hand, the Islamic calendar takes a simpler approach and does not make any corrections. It consists of twelve lunar months that add up to 354 or 355 days in total, which accounts for the difference with the 365.25 days of the solar year. As a result, the Islamic calendar experiences a shift of around ten days each year, and its cycle repeats only every 33 lunar years. Due to this variation, Ramadan, the month of fasting, can occur in either summer or winter, depending on the position of the calendar. For this reason, most Islamic countries use the Gregorian calendar for civil events and only rely on the Islamic calendar for religious holidays. However, Iran and Afghanistan are exceptions to this rule and use the solar Hijri calendar for both civil and religious events.

The Hijri Year

The Islamic calendar is based on the Hijri year, which was established when Muhammad and his followers migrated from Mecca to Medina to form the first Muslim community. This event occurred in 622 AD and marked the beginning of the annual count. The year 2019 in the Gregorian calendar corresponds to the year 1440 in the Islamic calendar. The Hebrew calendar, on the other hand, designates this year as 5779.

The Islamic calendar consists of twelve months, with each month starting at the start of a new lunar cycle. Each month has its own significance. Four months - Rajab, Dhu al-Qa'dah, Dhu al-Hijjah, and Muharram - are considered sacred. Ramadan is a month of fasting. Shawwal means "raised" and is said to be when camels are in calf (with calf), meaning they are pregnant. Sha'ban means "scattered" and marks the time when Arab tribes scatter to find water. Dhu al-Hijjah is the time when the hajj, the pilgrimage to Mecca, is performed.

Two Countries, Two Months

The calendar faces and creates a challenge in that most Muslim countries determine the start of a new month by observing the rise of the new moon. Each country has its own way of observation. However, due to the sun setting later as you move towards the west, it may be easier or harder to observe the moon in one place than another. As a result, two Muslim countries may find themselves in different months at the same time.

Efforts have been made to overcome this problem. Malaysia, for instance, is among several countries that begin the month not when they see the new moon but at sunset on the first day of that moonset after the sunset. Some representative bodies have expressed their intention to use calculations instead of observations to determine the months, but not all associations have agreed, and not all those who have declared an intention have followed through with it.

Considering the complexity of this matter, it's not only the Islamic calendar that is misaligned with the solar year and the Gregorian calendar, but it's also sometimes out of sync with other users of the Islamic calendar.

The Chinese Calendar

The Chinese calendar is not simply a means of measuring time but rather a way of assigning personality traits based on an individual's date of birth. The Chinese

calendar is based on the zodiac and is particularly noteworthy for the grand celebration that occurs at the beginning of each year, usually in February. This calendar is too significant to overlook as it commands the attention of over a billion people who take a New Year holiday every year. Although the Western astrological calendar associates twelve signs with the constellations present in the sky at the time of an individual's birth, the Chinese calendar rotates twelve animals through the years. One ancient tale provides an explanation for the order in which these animals appear.

According to the story, the Jade Emperor announced that the first animal to cross a river would be listed first in the calendar, and so on, until all twelve animals had been accounted for. The cat and the rat requested the ox's assistance in getting across the river. However, the rat pushed the cat into the water when they reached the bank, and the rat came first. The tiger arrived after the ox, followed by the rabbit, which hopped from rock to rock and then onto a log that floated to the shore.

The dragon came in fifth place since it had stopped to bring rain to a village before blowing the rabbit's log to the shore. The horse followed, with the snake clinging to its hoof. The snake took sixth place, while the horse was seventh. The rooster discovered a raft, which it shared with the monkey and the goat. The goat was eighth, the monkey ninth, and the rooster tenth.

What Happened to the Cat?

Unfortunately, the rat had pushed it into the river, and it drowned. This is a lovely story (except for the cat's part), and the Chinese calendar continues to play a vital role in modern Chinese culture. This calendar's greatest significance is that it marks the country's most significant holiday, and people know which animal corresponds to their birth year. What many people may not realize, however, is that each sign coincides with a month and season of the year, like the Western astrological signs.

For example, the tiger corresponds to Aquarius and Pisces and runs from early February to early March. The dragon indicates Aries and Taurus and runs from early April to early May. Even the days of the week are associated with zodiac animals: Monday with the goat, Tuesday with the dragon and pig, Wednesday with the horse and rooster, and so on. It is primarily the Chinese calendar that tells you when to light fireworks and what sort of decorations to use in February.

Mesoamerican Calendar

Mesoamerica has also developed its own indigenous calendrical systems alongside Europe and Asia. Some of these calendars are still being used today, particularly in

certain highland regions of Guatemala and Mexico. However, the most common calendar in Mesoamerican cultures is a ritual calendar that lasts for 260 days, which is not related to any astronomical movements or farming cycles.

The origin of this calendar is unclear, though it may be linked to the settlement of Izapa in Mexico, which experiences 260 days between the sun's two zeniths each year. Alternatively, it may be attributed to the Maya's fascination with the numbers thirteen and twenty. Another theory is that it's related to the length of human pregnancy, but this is still uncertain.

The Mayans named their calendar "tzolk'in," which consisted of twenty days associated with thirteen numbers. There were no months or weeks, but each day had a name and a number, aligned with a natural phenomenon such as death or crocodile. Glyphs on stone carvings represented each day.

Similarly, the Aztecs called their calendar "tonalpohualli," meaning "count of days" in Nahuatl. It also combined a 20-day cycle called "veinenas" with a 13-day period called "trecenas." Each day was associated with a glyph of an Aztec deity such as Quetzalcoatl or Mayahuel. The tonalpohualli consisted of only 260 days, but the Aztecs had another calendar called "xiuhpōhualli," which was closer to the solar calendar. It had 18 months, each lasting 20 days, with an extra five-day period. The year amounted to 365 days, and the xiuhpōhualli aligned with the tonalpohualli every 52 years.

The Modern Calendar

Throughout history, calendars have always been important in civilizations worldwide, as they help us understand time and our place in the universe. Although there have been many calendars in use for thousands of years, the Gregorian calendar has become the most widely used and accepted calendar worldwide, allowing people from anywhere to synchronize their times with anyone else on the planet. While about 40 differing calendars are still in use, they are mostly used to mark religious events rather than secular occasions.

The presentation format of calendars has undergone significant changes over time. Early man created the first calendars using stone to mark the solstice and track the migration of animals, but these calendars were challenging to modify or adapt to changing circumstances. As a result, they were not easily movable, and people had to visit places like Stonehenge or Warren Field to determine the time of year. Fortunately, today's calendars are much more convenient. While some designers have come up with creative ways to mark dates, days, and months, most calendars are either paper or digital.

The Astronomical Basis of the Calendar

All calendars rely on astronomical cycles, but these cycles are not consistent in duration and cannot be accurately predicted over very long periods of time. This means that calendars are not entirely reliable, and even direct observations made to maintain accuracy can be subject to error. To address this, calendars are usually based on rules that aim to provide a close approximation of astronomical cycles over a given period.

Day

It is observed from the surface of the Earth that the Sun appears on the eastern horizon and disappears below the western horizon.

The occurrence of day and night is due to the Earth's rotation on its axis in a direction from west to east when viewed from above the North Pole. The duration of a day depends on the point of reference used to measure a complete rotation.

Day's Length According to the Sun

As seen from the Earth's surface, the sky appears to form a dome-like hemisphere where all celestial objects (including the Sun, Moon, planets, and stars) move across.

Throughout the day, an observer would witness the Sun's ascent during the morning and descent during the afternoon, reaching its highest point at local noon. At this point, in the northern hemisphere, the Sun's shadows are at their shortest and point precisely towards true north.

Recording the length of day based on the Sun's movements is known as an apparent solar day. However, timing two successive occasions where the shadows are shortest would rarely result in exactly 24 hours due to a difference in length between the shortest and longest apparent solar day, which can be as much as 16 minutes.

Apparent solar time is a measure of the Earth's rotation relative to the Sun. However, in the modern world, it would be challenging to adapt our lives around a constantly changing day length. Instead, our clocks and watches keep a mean time based on the length of an average apparent solar day over the year, known as the mean solar day, which lasts 24 hours.

The length of the apparent solar day changes from day to day due to a couple of factors. Firstly, the Earth's orbit around the Sun is an ellipse rather than a perfect circle, which means that the distance between the Earth and the Sun varies throughout the year. For example, in January, the Earth is closest to the Sun, whereas

in July, it is furthest away. Secondly, the Earth rotates around an axis that is tilted, causing the height of the Sun in the sky to change over the year. In summer, the Sun is higher in the sky at local noon, while in winter, it is lower. These two factors work together to alter the apparent speed of the Sun as it moves across the sky at different times of the year, ultimately affecting the length of the day.

The Day Length According to the Star

We observe that stars behave similarly to the Sun during the day on a clear night. They ascend from the eastern horizon and move across the sky until they set somewhere in the west. Every star will eventually reach its highest point in the sky as it crosses the local meridian. Astronomers use a transit instrument to record the exact moment that a star transits the local meridian. This instrument is a telescope that is stationary and can only point at a narrow strip of sky that aligns with the local meridian. The telescope can be adjusted in altitude and aimed at any star that becomes briefly visible in the narrow field of view.

The time between two successive transits of a star is the duration of a day measured by the stars. It is the length of time it takes for the Earth to rotate and bring the star back to the same position in the sky it occupied on the previous night. This is known as the sidereal day, which lasts just over 23 hours and 56 minutes. Since the sidereal day is shorter than 24 hours, the stars rise four minutes earlier every night according to our watches. This is why we observe different constellations in the night sky at different times of the year.

Months

The Earth's natural satellite, the Moon, completes one orbit around our planet in a month. As it moves in its orbit, it changes its position relative to the Sun, which affects the portion of its face that is visible to an observer on the Earth's surface. This phenomenon results in the different phases of the Moon.

When the Moon is closest to the Sun in the sky, none of its illuminated sides is visible to us, making it a new Moon. We can only see it if there's a solar eclipse, which is a rare event when part or all of the Moon's disc moves in front of the Sun.

As the Moon moves farther away from the Sun, a small sliver of its illuminated face becomes visible, creating a waxing crescent Moon. This phase is usually seen in the western horizon just after sunset, and it sets relatively quickly.

As the Moon continues in its orbit, it moves even further away from the Sun, illuminating a larger fraction of its Earth-facing side, which sets later. By the seventh

day, the Moon is in the first quarter, so-called because it has completed one-quarter of its orbit, though it appears like a half Moon. When the Moon completes half of its orbit, it's opposite the Sun in the sky, and its entire illuminated side is visible to us. This is called a full Moon, and it rises at sunset and sets at sunrise, so it's visible throughout the night.

The waning Moon looks like it's shrinking because it's getting closer to the Sun. A bolden quarter Moon rises around midnight and stays high in the sky until the next morning. Contrary to popular belief, the Moon is not just visible at night.

The synodic month, which is the time between one new Moon and the next, is approximately 29.5 days and is based on the Moon's phases.

Years

The regular cycle of four seasons—spring, summer, autumn, and winter—is experienced by people living at mid- and high latitudes. In contrast, at low latitudes, in the tropics, the temperature remains relatively constant, and there are distinct wet and dry seasons. The progression of the seasons was integral to ancient people in finding or growing food and would have spurred them on to determine the lengths of the year and the seasons. One of the ways this problem was tackled was by observing the position of the Sun and how its position shifts in the sky throughout the seasons. There is considerable archaeological evidence that this was undertaken independently by numerous cultures worldwide in prehistoric times.

The Seasons

Exploring the cause of the seasons requires understanding the Earth's rotation axis, which is tilted at an angle of 23.5° from the vertical, known as obliquity. As the Earth orbits around the Sun throughout the year, the Sun's rays hit first one pole and then the other, resulting in the seasons, as depicted in the animation below.

June 21 marks the **summer solstice**, during which the North Pole of the Earth tilts most towards the Sun. This causes the Sun to be directly overhead at latitude 23.5° North (the Tropic of Cancer) at local noon. This day is often called midsummer's day, despite being considered by astronomers as the start of summer, as it is the longest day of the year. The northern hemisphere experiences warmer temperatures in summer than in winter because the Sun's rays are more concentrated when they strike the Earth and because the Sun is above the horizon for a longer period. Conversely, during this time, those in the southern hemisphere experience midwinter because the South Pole is tilted furthest away from the Sun.

By about September 22, the Earth orbits anti-clockwise and reaches the **autumn equinox**, signifying the start of autumn. Currently, neither pole is tilted towards the Sun, and the Sun is directly overhead at the equator (latitude 0°) at local noon. All places on Earth experience equal amounts of daylight and night, hence the term equinox, which means 'equal nights.' Only during the autumn and spring equinoxes does the Sun rise due east and set due west.

On December 21, the Earth experiences the **winter solstice**, during which the North Pole is tilted furthest away from the Sun, and it is now overhead at local noon at latitude 23.5° south (the Tropic of Capricorn). This marks the shortest day of the year, with the Sun rising to its lowest altitude above the horizon for northern hemisphere observers. Astronomers consider this as the beginning of winter, but it is often referred to as midwinter's day. Since the Sun's rays are more spread out and the Sun is above the horizon for only a shorter duration in winter, it is colder. During this time, people in the southern hemisphere experience summer when it is winter in the northern hemisphere.

Spring begins on the vernal equinox, which occurs around March 21. As with the autumn equinox, daylight and night are of equal length everywhere, and the Sun is directly overhead at the equator at local noon. The number of daylight hours changes throughout the year, with the UK experiencing more daylight hours in summer than in winter. However, the number of hours of daylight and darkness we experience each day varies depending on **latitude**. At the equator, days and nights are equally long throughout the year. Conversely, for those living at the North Pole, the Sun is above the horizon for half the year during the northern hemisphere summer but never rises during the northern hemisphere winter. This is the opposite at the South Pole, where day and night last around six months each. For latitudes between the equator and the poles, the difference between daylight hours and darkness at midsummer and midwinter increases as latitude increases.

Sun's Journey Through the Sky

The path of the Sun through the sky varies throughout the year due to the Earth's tilt, and this path is known as the ecliptic. The celestial equator, the equivalent of Earth's equator, is where the ecliptic intersects, and it is where the equinoxes are located on the celestial sphere.

During the spring equinox, the Sun moves northward along the ecliptic, crossing the celestial equator as summer approaches for northern observers. In contrast, during the winter equinox, the Sun moves southward across the celestial equator,

resulting in a lower position in the sky for northern observers and a higher position for southern observers who are anticipating their summer.

Calendars have historically been developed based on the duration of **one cycle of the seasons**. The tropical year, which is defined as the time between two successive vernal equinoxes, is commonly used in modern astronomy. The term "tropical" comes from the Greek word "tropos," meaning "to turn," referring to the Sun's movement from south to north and back again during the year of the seasons. Although the calculation methods may differ, all methods agree that the current length of the year of the seasons is 365.242 civil days, rounded to three decimal places.

The sidereal year, which is the time taken for the Earth to complete one orbit with respect to the fixed stars, was equal to 365.2564 mean solar days in 2000. Over the course of a year, an observer can see every constellation of stars visible from their latitude due to the sidereal year.

The figure below illustrates how the sidereal year works. In the northern hemisphere summer, the North Pole is lit by the Sun, and an observer on Earth can see only stars in direction 3, such as the zodiacal constellation Scorpius because the stars in direction 1 are on the day side and hence not visible.

Six months later, during the northern hemisphere winter, stars in direction 1 (e.g. the zodiacal constellation Taurus) become visible in the night sky, while stars in direction 3 are only up during daylight hours. The stars in direction 2 (e.g., Leo) are visible in Spring, while those in direction 4 (e.g., Pisces) are visible in autumn.

Alternatively, we can think of the sidereal day—the day length measured according to how the Earth rotates in relation to the stars—which is shorter than 24 hours, meaning the stars rise four minutes earlier each night according to our watches.

Over 30 days, the stars rise 120 minutes or 2 hours earlier, and over 12 × 30 days, the stars rise 24 hours earlier. Several ancient civilizations, including the Egyptians, Babylonians, and Greeks, have used sidereal (star) calendars based on the constellations' slow progress across the sky over the year.

The Calendars Today

1. The Gregorian Calendar

The Gregorian calendar is a widely used calendar in the Christian world, as well as in several other parts of the world, for commercial and administrative purposes. It is based on a solar system.

The years in the Gregorian calendar are counted from the birth of Christ, which has been established as 1 AD (Anno Domini) by the scholar Dionysius Exiguous in the 6th century. However, the English historian Bede introduced a system of counting years backwards from 1 AD, where the preceding year was 1 BC (Before Christ) instead of zero. This makes it difficult to compare dates across the divide. Astronomers introduced the year zero in the 18th century to address this issue. As per this system, 1 AD is +1, 1 BC is 0, 2 BC is –1, and so on. Even in non-Christian countries where the Gregorian calendar is used, AD is often replaced with CE (Common Era) and BC with BCE (Before the Common Era). Interestingly, Jesus of Nazareth was probably born around 4 BCE.

The Gregorian calendar comprises two types of years: common years of 365 civil days and leap years of 366 days. Every year that is divisible by 4 is a leap year, except if it is divisible by 100. Century years are leap years only if they are divisible by 400.

Therefore, the Gregorian calendar is based on a cycle of 400 years, which is equivalent to 146097 days. Since 146097 is divisible by 7, which is the number of days in a week, the Gregorian calendar repeats every 400 years. By dividing 146097 by 400, an average of 365.2425 days per calendar year is obtained. This is almost the same as the length of the mean tropical year of 365.24219 civil days.

The Julian calendar is the source of the order of the months and the number of days in each month, while the Babylonians originally determined the days of the week.

Months of the Gregorian Calendar

Months	Days	Months	Days
January	31	July	31
February	28*	August	31
March	31	September	30
April	30	October	31
May	31	November	30
June	30	December	31

To Be Noted:

In a common year, February has 29 days in a leap year.

Notes:

- The resurrection of Christ is celebrated on Easter day, which is considered the most significant day in the Christian religious calendar. The date for Easter is determined by a moveable feast that generally falls on the Sunday after the first full Moon on or after the vernal equinox. This synchronization is necessary to align the calendar year with the tropical year, as measured by the interval between vernal equinoxes.
- However, dating Easter is more complicated than this description suggests. Firstly, the church assumes that the vernal equinox occurs on March 21, which is not always true. Secondly, the church uses tables based on the Metonic cycle to determine the time of the full Moon, and this ecclesiastical full Moon may not correspond to an astronomical full Moon. Furthermore, the Metonic cycle is not a perfect match between synodic months and Gregorian calendar years, as 235 synodic months is 6939.688 days rather than 6939.6075 days (19 Gregorian calendar years). Therefore, 19 calendar years slip 0.08 days concerning lunar phases. Ecclesiastical tables include adjustments to prevent this error from accumulating in the long term.
- All moveable feasts in the Christian calendar (except Advent and Epiphany) are determined concerning Easter.
- Christmas commemorates the birth of Christ, and the date, December 25, was borrowed by the early Christian church from the Roman festival 'Natali Invictus Solis' (Birth of the New Sun) in the Julian calendar. The festival celebrated the winter solstice but was four days late due to the incorrect timing of the vernal equinox in the Julian calendar.

2. Hebrew Calendar

The Hebrew calendar serves as both the religious calendar of the Jewish people and the official calendar of Israel. It was developed from the Babylonian calendar and was finalized by Hillel II, the president of Sanhedrin, in the year 359 CE. In the past, the beginning of each month was determined by the sighting of the first crescent moon in the western sky at sunset.

However, in modern times, the start of the month is calculated through extrapolation from the new moon that initiated the calendar, which took place at 5h 11m 20s after sunset on Julian day 6 October 3761 BCE, by adding the required number of synodic months, which are reckoned at 29.530583 days (i.e., 29d 12h 44m 2.4s). To correct the approximately 11.25-day drift against the tropical year, an intercalary month of 30 days (Adar II) is added in accordance with the Metonic cycle so that intercalations are made if the year number divided by 19 gives the remainder 0, 3,

6, 8, 11, 14 or 17. The current 19-year cycle, which began in the Jewish year 5758 AM (Anno Mundi; year of the world), started on 2 October 1997 in the Gregorian calendar.

It is important to note that the Jewish day begins at sunset, and traditionally, days of the week are numbered and not named, except for the seventh day, Sabbath, which starts at sunset on Friday and ends at sunset on Saturday. Calculating the length of the year in the Jewish calendar is a complicated process. The first day of the solar year is on 1 Tishri (Rosh Hashanah). However, the time interval between two successive 1 Tishri can take any one of six values.

Year Length In The Jewish Calendar

Year Length/Days			
Year Type	**Deficient Year**	**Regular Year**	**Complete Year**
Non-Leap Year	353	354	355
Leap Year	383	384	385

Each year has months that alternate between 29 and 30 days. If a year is deficient, one day is removed from the third month, Kislev.

On the other hand, if a year is complete, one day is added to the second month, Heshvan.

The length of a year is determined by four rules:

1. If the new moon occurs after noon, then the new year is delayed by one day.
2. If the new year begins on a Sunday, Wednesday, or Friday, then the new year is delayed by one day to avoid conflicts with Yom Kippur (10 Tishri) falling on a Friday or Saturday and Hoshanah Rabba (21 Tishri) falling on Saturday (the Jewish Sabbath).
3. If there is a span of 356 days between two consecutive 1 Tishri, which is an illegal year length, then the start of the first year is delayed by two days.
4. If there is a span of 382 days between two consecutive 1 Tishri, which is an illegal year length, and the first year starts on a Tuesday, then the start of the second year is delayed by one day.

There is a secondary new year in the Jewish calendar, which begins on 1 Nissan and follows the lunar calendar. Whenever there is a leap year, Adar II, an intercalary month, is added just before Nissan.

The Structure of the Jewish Calendar

Month	Deficient Year	Regular Year	Complete Year	Festivals	Gregorian Equivalent
Tishri	30	30	30	Rosh Hashanah (1), Yom Kippur (10)1, Sukkot (15–21) Hoshanah Rabba (21), Shemini Atzeret (22–23), Simchat Torah (23)2	September/ October
Heshvan	29	29	30		0ctober/ November
Kislev	29	30	30	Hanukkah (25 Kislev-2 Tevet)3	November/ December
Tevet	29	29	29		December/ January
Shevat	30	30	30		January / February
Adar/Adar I	29/30	29/30	29/30	Purim (14/15)4	February/ March
Adar II	30	30	30		March/April
Nissan	30	30	30	Pesach (15–21 in Israel, 15–22 elsewhere)5	March/April
Iyar	29	29	29		April/March
Sivan	30	30	30	Shavuot (6)6	May/June
Tammuz	29	29	29		June/July
Av	30	30	30		July/August
Elul	29	29	29		August/ September
Total (non-leap)	353	354	355		365
Total (leap)	383	384	385		366

To Be Noted:

Adar II is a month that occurs only in leap years, which are those with 13 months. In leap years, Adar I last for 30 days. In years without a leap year, Adar I is referred to as Adar and lasts for 29 days.

Note:

- Havdallah, the ceremony that signifies the end of the Sabbath, is not conducted at sunset on the Sabbath day to ensure that no work is done during this time. Instead, it is performed when three medium-magnitude stars become visible.
- According to Judaic mythology, the creation of the world took place on the Julian day of 6th October, 3761 BCE.
- The Jewish calendar commemorates several important events in Jewish history.
  - The most significant day in the Jewish calendar is Yom Kippur, also known as the Day of Atonement.
  - Simchat Torah is a celebration that marks the end of the annual cycle of readings from the Torah.
  - The rededication of the Temple after the Maccabean victory over the Greeks is commemorated during Hanukkah.
  - Purim is a celebration that marks the salvation from the genocide that was instigated under Persian rule. In leap years, Purim is celebrated in Adar II.
  - Passover, also known as Pesach, celebrates the Exodus from Egypt and the beginning of the harvest season.
  - Shavuot is a celebration that commemorates receiving the Torah.

3. The Islamic Calendar

The Islamic calendar is a lunar calendar with 12 synodic months, each lasting 29.5 days, making a year of 354 days, which is 11.25 days shorter than the tropical year. The start of each month is determined by the first sighting of the crescent Moon (Hilal) with the naked eye. As this sighting depends on various factors, printed calendars are based on estimated dates. However, calculations that consider the astronomical factors affecting the visibility of the crescent Moon ensure the accuracy of these calendars.

To achieve a year of 354 days, odd months have 30 days, and even ones have 29 days, giving each month an average length of 29.5 days. The synodic month is slightly longer than 29.5 days, so an extra day is added to the 12th month in leap years. Leap years are those in which dividing the year number by 30 gives a remainder of 2, 5, 7, 10, 13, 16, 18, 21, 24, 26, or 29. This results in a calendar with an average month length of 29.53056 days, which is very close to the synodic month. The Islamic year is numbered starting from 622 CE, with Islamic Year 1 corresponding to that year. The Islamic New Year 1425 began on February 22, 2004, in the Gregorian calendar.

Not all Islamic countries use the first sighting of the crescent Moon to signal the start of the month. In Saudi Arabia and Egypt, the beginning of the month is fixed based on the relative timing of sunset and moonset on the 29th day of each month. If the Moon sets before the Sun, the next day is the 30th of the month. If the Sun sets before the Moon (by at least 10 minutes in Egypt), the next day is the first of the next month.

Months of the Islamic Calender

Month	Days	Month	Days
Muharram	30	Rajab	30
Safar	29	Sha'ban	29
Rabi Al-Awwal	30	Ramadan	30
Rabi Al-Thani	29	Shawwal	29
Jumada Al-Ula	30	Zul Qida	30
Jumada Al-Thani	29	Zul Hijja	29

To Be Noted:

- Zul Hijja has 30 days in a leap year.

a. The year of Mohammed's migration from Mecca to Medina is known as Islamic Year 1 or 1 AH (Anno Higerae).

b. Muslims are expected to abstain from eating, drinking, smoking, and engaging in sexual relations between sunrise and sunset during Ramadan, with some exceptions, such as those who are seriously ill or travelling.

c. The feast that marks the end of the Ramadan fast, known as Eid al-Fitr, is celebrated on the first day of Shawwal.

4. Chinese Calendar

The traditional Chinese calendar is used for religious purposes and agriculture, while the Gregorian calendar is used for administrative and commercial purposes in the People's Republic of China. The Chinese calendar's astronomical calculations are based on Latitude 120 degrees East. Like the Hebrew calendar, ordinary years of the traditional Chinese calendar have 12 months and 353, 354, or 355 days, while leap years have 13 months and 383, 384, or 385 days. Days are measured from midnight to midnight, and the first day of the month corresponds to the date of the new Moon, not the first visible crescent used in the Islamic and Hebrew calendars. The Chinese

calendar is divided into 24 solar terms, which span 15 degrees of solar longitude each and are named after seasons or weather. Each pair of solar terms consists of a Sectional and a Principal solar term, covering 30 degrees of solar longitude. The divisions of the ecliptic into 12 increments of 30 degrees are made by principal terms.

The months of the Chinese calendar are numbered based on the principal term that falls within them, and the calendar is adjusted to ensure that the 11th month always contains the principal term for the winter solstice. If a month has two principal terms, the month numbering may need to be adjusted to ensure that the winter solstice falls in the 11th month. Leap years consist of 13 months, and the number of new Moons between the 11th month in one year and the 11th month in the following year is calculated to determine if a year is a leap year. If there are 13 new Moons from the start of the 11th month in the first year to the start of the 11th month in the second year, a leap month must be inserted. In leap years, at least one month does not contain a principal term, and the first such month is the leap month.

Principal Terms in Chinese Calendar

Principal Term	Sun's Longitude
1	330
2	0 (Vernal Equinox)
3	30
4	60
5	90 (Summer Solstice)
6	120
7	150
8	180 (Autumn Equinox)
9	210
10	240
11	270 (Winter Solstice)
12	300

The Chinese calendar has a problem in that it was developed with the assumption that the Sun's motion along the ecliptic is uniform. Although the calendar's rules to keep it in sync with the seasons are effective most of the time, discrepancies can arise. The Chinese calendar does not count years in an infinite sequence like most other calendars.

Instead, years are named and repeated every 60 years, corresponding to five repeats of the Chinese zodiac cycle of 12 animals, which are rat, ox, tiger, hare, dragon, snake, horse, sheep, monkey, rooster, dog, and pig.

The system for naming years has been utilized for around 2000 years, but it is traditionally extrapolated back to 2637 BCE when the calendar was supposed to have been invented. The current 60-year cycle began on 2 February 1984. However, there is also a counting system now in use, which has year 1 as the first year of the Yellow Emperor in 2698 BCE. In this system, 2005 is 2698 + 2005 = Chinese year 4703. The year of the Rooster began on 9 February 2005.