

*National University
Of Singapore*

DEPARTMENT OF MATHEMATICS

EQUINOXES AND SOLSTICES

GEM 1506K

**HEAVENLY MATHEMATICS – HIGHLIGHTS
OF CULTURAL ASTROMY**

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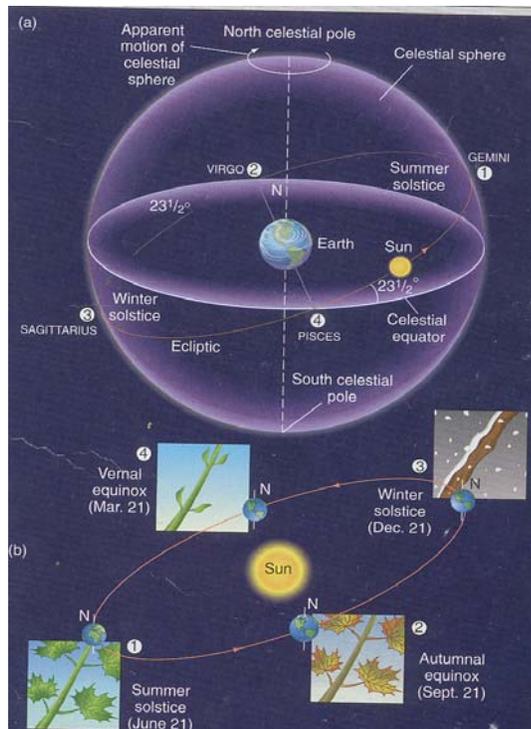
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Equinoxes and Solstices

Brief Introduction

Before we begin discussing our project topic, here are some facts that one should know which can aid in the understanding of this project topic better. The Earth rotates on its axis every day, giving us day and night. The axis is an imaginary line through the center of the Earth between the North Pole and the South Pole. When our part of the world is facing the Sun, it is daylight and when we are facing away, it is night. The Earth also revolves around the Sun in a counterclockwise direction as seen from above the North Pole. The orbit of the Earth is an ellipse. The North Pole points towards the Sun for part of the year and it points away for another part of the year. That makes a big difference in how sunlight hits the Earth's surface. When light rays hit a surface straight on, they are more intense and warm the surface more. When rays hit at an angle, the warmth is spread out over a larger area. In the same way, when your part of the world is pointed more toward the sun, you are getting more sunlight and it is summer.



In reference to the figure on the previous page, the celestial equator is the outward projection of the Earth's equator onto the celestial sphere, the imaginary bowl of the sky containing all the stars centered on the Earth. The ecliptic, or the path the Sun follows, is inclined to the celestial equator at an angle of 23.5° . There are two points on the ecliptic which are farthest away from the celestial equator. These two points are called solstices, namely the summer solstice (the farthest point above the celestial equator) and the winter solstice (the farthest point below the celestial equator). In addition, the ecliptic intersects the Earth's equator at two points. These two points are called equinoxes, namely the vernal equinox (point where the Sun crosses the equator from the southern half of the celestial sphere to northern half) and the autumnal equinox (where the Sun crosses the equator from the northern half to southern half).

To aid in visualizing the equinoxes and solstices, we have made a model which explains these points to a certain degree. For simplicity sake, we describe these 4 points with respect to the northern hemisphere.

The vernal (or spring) equinox is where the axis on the Earth points perpendicular to the Sun. The Sun's rays hit directly on the equator. This day is usually on March 20 or 21. As the word "equinox" means "equal night", the daytime and nighttime are of equal length anywhere on the Earth, each lasting 12 hours. In western astronomy, the vernal equinox marks the beginning of spring.

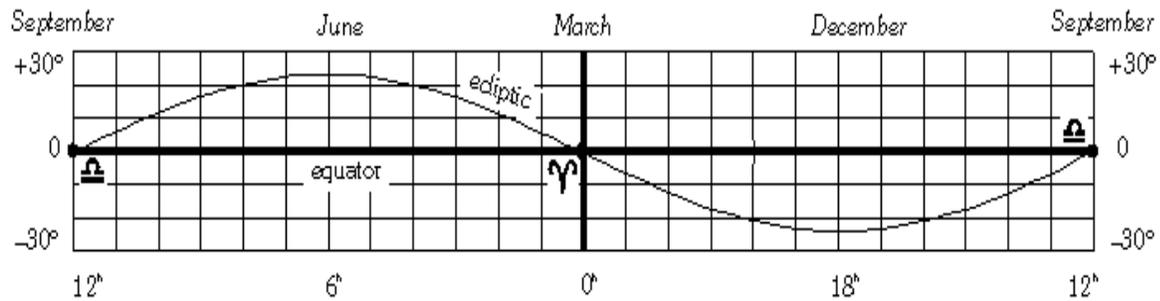
Next is known as the summer solstice, which falls on June 21 or 22. The axis of the Earth points straight at the Sun. On this day, the daytime is the longest in the northern hemisphere and this day marks the beginning of summer.

Moving on around the Sun, we come to another point where the Earth's axis points perpendicular to the Sun – the autumnal equinox. The Sun's rays hit directly on the equator and the daytime and nighttime are of equal length anywhere on the Earth. This day is usually around September 22 or 23 and it marks the beginning of autumn.

Finally, we travel around to where the Earth's North Pole is pointed the most away from the Sun – the winter solstice. This day falls on December 21 or 22 and the daytime is the shortest. This day is marks the beginning of winter.

We can define the positions of the equinoxes and solstices by using the equatorial coordinate system. This system is used to specify star positions on the celestial sphere. Declination and right ascension (RA) are used as methods of measurement. Declination

measures the vertical position of the object in degrees with respect to the celestial equator. Right ascension measures the horizontal position of the object in time units and the vernal equinox is taken as the reference point. Thus we can measure the position of the Sun at the equinoxes and solstices. In reference to the figure below, vernal equinox: RA= 0 hrs; declination= 0°. Summer solstice: RA= 6 hrs; declination= +23.5°. Autumnal equinox: RA= 12 hrs; declination= 0°. Winter solstice: RA= 18 hrs; declination= - 23.5°.



Days of Equinoxes and Solstices

The equinoxes and solstices do not always occur on the same days each year. This is due to the Earth taking approximately 365.25 days to revolve around the Sun. Since the days of the tropical year is not a whole number, the time of the equinoxes are generally about 6 hours (0.25 day) later each year. However, to prevent a drift of dates over a long period of time, we add a day to our calendar, thus we have a leap year every 4 years. Take the time of equinoxes for example. As you can see from the chart below, the time of both equinoxes varies within 2 days. The days occur about 6 hours later each year for 3 years before taking a jump backwards on the leap years.

Vernal (Spring) Equinox	Autumnal Equinox
All times are UTC (GMT)	
1994 March 20 at 20.28	September 23 at 06.19
1995 March 21 at 02.14	September 23 at 12:13

1996 March 20 at 08.03	September 22 at 18:00	(leap year)
1997 March 20 at 13.55	September 22 at 23:56	
1998 March 20 at 19.55	September 23 at 05.37	
1999 March 21 at 01.46	September 23 at 11.31	
2000 March 20 at 07.35	September 22 at 17.27	(leap year)
2000: March 20 th 07:35	2000: Sept 22 nd 17:27	
2001: March 20 th 13:31	2001: Sept 22 nd 23:04	
2002: March 20 th 19:16	2002: Sept 23 rd 04:55	
2003: March 21 st 01:00	2003: Sept 23 rd 10:47	
2004: March 20 th 06:49	2004: Sept 22 nd 16:30	*

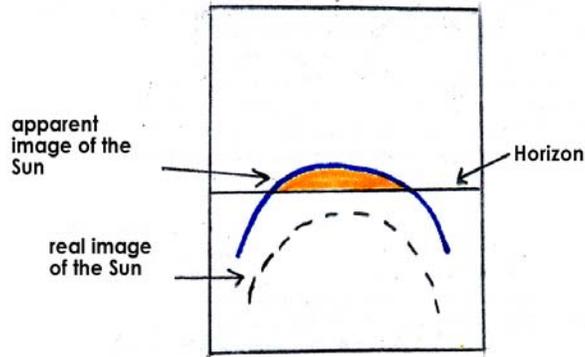
Length of Daytime and Nighttime on the Day of Equinoxes

One similarity both the March and September equinoxes share is that on these particular days, the daytime and nighttime are of equal length, that is, people encounter 12 hours of day and 12 hours of night, as mentioned above. This explanation is just to simplify things. In reality, the daytime and nighttime are not of equal length at the equinoxes. The dates on which they are of equal length occur a few days before and after the equinoxes and these dates differ for various latitudes.

On the day of either equinox, the geometric centre of the Sun's disk crosses the equator and this point is above the horizon for 12 hours. However, we cannot regard the Sun as just a geometric point. Sunrise is defined as the instant when the leading edge of the Sun's disk is visible on the horizon, whereas sunset is the instant when the trailing edge of the disk disappears below the horizon. Due to atmospheric refraction, the Sun's disk appears higher in the sky than it would if the Earth had no atmosphere. Atmospheric refraction is the bending of light due to a density gradient in our atmosphere. The density gradient will depend on the temperature, pressure and humidity profile of the atmosphere. As your altitude increases, the atmosphere becomes less dense and so the effect of atmospheric refraction becomes less. Therefore, this effect is most noticeable during sunrise and sunset when light travels through much atmosphere.

Thus, at sunrise (on the day of either equinox), the leading edge of the apparent image of the Sun is seen even though the actual image of the Sun is still below the horizon. Similarly, at sunset, the trailing edge of the apparent image the Sun is seen even though the actual Sun has already set below the horizon. We can conclude that the apparent image of the Sun rises earlier and sets later than the actual image of the Sun. Since the Sun is refracted by about one Sun

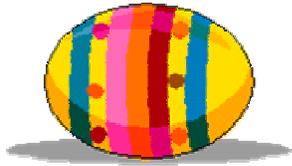
diameter, this makes an impact on the actual time of sunrise or sunset. Hence daytime is slightly more than 12 hours, which makes the daytime and nighttime of unequal length. See the figure on the next page for reference.



In light of the above explanation, in order to get equal length of daytime and nighttime, the geometric centre of the Sun's disk must be above the horizon for slightly less than 12 hours, so that we can see 12 hours of daylight. In the northern hemisphere, daytime is shorter than nighttime from the September equinox to the March equinox. Thus, equal daytime and nighttime occurs a few days before the March equinox and a few days after the September equinox. On the other hand, in the southern hemisphere, daytime is longer than nighttime from the September equinox to the March equinox. Thus, equal daytime and nighttime occurs a few days after the March equinox and before the September equinox. At a couple of degrees of the equator, the length of daytime and nighttime is regarded as equal throughout the year as the daytime is only several minutes longer than the nighttime.

Festivals

- **Festival related to the Vernal Equinox – Easter**



In Christian countries, Easter is celebrated as the religious holiday commemorating the resurrection of the son of God, Jesus Christ. However, the celebrations of Easter have many customs and legends that are pagan in origin and have little to do with Christianity.

Date of Easter

The churches of the West observe Easter on the first Sunday following the full moon that occurs on or following the vernal equinox. Thus, Easter became a "movable" festival which can occur as early as March 22 or as late as April 25. The date of Easter depends on when the full moon occurs. If the full moon occurs on the day of the vernal equinox, take for example March 21 and that this day is a Saturday, then according to the definition stated above, Easter falls on March 22. However, if the full moon occurs before March 21, then Easter would fall on days only after the next full moon in April.

Prior to A.D. 325, Easter could be celebrated on different days of the week, including Friday, Saturday, and Sunday. In that year, the Council of Nicaea was convened by emperor Constantine. It issued the Easter Rule which states that Easter shall be celebrated on the first Sunday that occurs after the first full moon on or after the vernal equinox. However, a caveat must be introduced here. The "full moon" in the rule is the ecclesiastical full moon, which is defined as the fourteenth day of a tabular lunation, where day 1 corresponds to the ecclesiastical New Moon. It does not always occur on the same date as the astronomical full moon. The ecclesiastical "vernal equinox" is always on March 21. Therefore, Easter must be celebrated on a Sunday between the dates of March 22 and April 25.

Here are some dates of Easter from Year 2001 onwards:

Easter 2001

Good Friday is 13 April

(Western) Easter Sunday is 15 April

Easter 2004

Good Friday is 9 April

Easter Sunday is 11 April

Easter 2002

Good Friday is 29 March

Easter Sunday is 31 March

Easter 2005

Good Friday is 25 March

Easter Sunday is 27 March

Easter 2003

Good Friday is 18 April

Easter Sunday is 20 April

Origins of Easter

Scholars, accepting the derivation proposed by the 8th-century English scholar St. Bede, believe the name Easter is thought to come from the Scandinavian "Ostra" and the Teutonic "Ostern" or "Eastre". Both these Goddesses of mythology signify spring and fertility whose festival was celebrated on the day of the vernal equinox.

This festival, which was to celebrate the arrival of spring, took place around the vernal equinox when nature is in resurrection after the darkness of winter. It is believed that the goddess Eastre saved a bird whose wings were frozen from the harsh winter by turning it into a hare. It turned out that this magical hare could actually lay eggs. Thus, this brought about the Easter bunny symbol. Prior to the Christian era, rabbits were also a symbol of fertility, aptly so for their reproductive abilities.



From the earliest times, the egg was a symbol of creation and new life along with being the major symbol of fertility in most cultures. In the past, eggs were often wrapped in gold leaf or, if you were a peasant, colored brightly by boiling them with the leaves or petals of certain flowers. Today, the modern version of real Easter eggs are those made of plastic or chocolate candy.

As Christianity spread across Europe and Britain, these older symbols became incorporated into the new faith's holiday of Easter. The Easter bunny, Easter egg and the centuries-old custom of exchanging eggs, which predates the Christian holiday of Easter, are some of the symbols. Even the name "Easter" itself seems to have been derived from the Goddess -- Eastre.

Hence, we see that festivals on or around the vernal equinox which were meant to celebrate the arrival of spring, perform old rites to honour the planting of new seeds, and bring the hope of the new life arising in the world being replaced by the Christian holiday, Easter, which commemorates Christ.

- **Festival related to the Summer Solstice -- St. John's Eve**

St. John's Eve, which was sometimes called Bonfire Night in Ireland, is celebrated on 23 June. It is around the day of the summer solstice where one experiences the longest daytime in the northern hemisphere. It is associated with the Midsummer celebrations as many countries regard the day of the summer solstice as the mid-point of the summer season.

Origins of St. John's Eve

The pagan population often refers to the holiday by the generic name of Midsummer's Eve. Just as the pagan mid-winter celebration of Yule was adopted by Christians as Christmas (December 25), the pagan mid-summer celebration was also adopted by them, mainly the Catholics, as The Feast of the Nativity of Saint John the Baptizer (24 June), aka St. John's Day.

In the past, as most European peasants were not accomplished at reading an ephemeris or did not live close enough to Salisbury Plain to trot over to Stonehenge and sight down the exact date of the summer solstice, they celebrated this event on a fixed calendar date, June 24th. The Celts reckoned their days from sundown to sundown, so the festival actually begins on the previous sundown, which is June 23. Thus, St. John's Eve was incorporated into the Christian calendar as the feast day of St. John the Baptist instead of St. John's Day. Occurring 180 degrees apart on the wheel of the year which the pagan population uses, the mid-winter celebration commemorates the birth of Jesus, while the mid-summer celebration commemorates the birth of John, the prophet who was born six months before Jesus in order to announce His arrival.

Celebrations of St. John's Eve

St. John's Eve, celebrated in many parts of the world, have many various customs. In England, it was the ancient custom on St. John's Eve to light large bonfires after sundown, which

served the double purpose of providing light to the revelers and warding off evil spirits. This was known as 'setting the watch'. People often jumped through the fires for good luck. In addition to these fires, the streets were lined with lanterns and people carried cressets (pivoted lanterns atop poles) as they wandered from one bonfire to another.

Up to the mid-20th century in Ireland, Irish Catholics also lit large communal bonfires at sunset on this day, or small family fires outside their houses. The communal bonfires were traditionally piled very high with wood, sticks, dry brambles *et cetera*. Each household would contribute fuel for the fire. At dusk, the whole town would gather around the pile, and an elderly man in the community would light the bonfire while saying the following prayer: "In honor of God and of St. John, to the fruitfulness and profit of our planting and our work, in the name of the Father and of the Son and of the Holy Spirit, Amen." The elders then led everyone in praying the Rosary to receive God's blessing on their crops and a bountiful harvest. Everyone would walk clockwise around the bonfire while praying the Rosary.

After the prayers, the celebration would begin. There would be dancing, singing shouting, blowing horns, storytelling and instrumental solos. The bonfire was tended until long after midnight. As it burned down, some men would begin jumping over the low fire and boys might grab burning sticks and throw them into the air to watch the sparks fly.

It was believed that by walking through the fields holding torches lighted from the fire, this would bring God's blessing on the fields and protect the crops from harm. After the fire burned out, households would carry the ashes home to sprinkle on the four corners of the fields to bless their crops.

Small family fires were more subdued and prayerful, with prayers for God's blessing and protection on flocks, fields and members of the household. Although the large communal bonfires seem to have ceased by the mid-twentieth century, these small fires may still occur in remote parts of Ireland.

- **Festival related to the Autumnal Equinox -- Mabon**

. This Mabon festival is the Wiccan Thanksgiving Feast. Wicca is a type of neo-paganism, that is, it is a modern pagan religion. Mabon refers to the autumnal equinox where

there is an equal length of day and night. Daytime become shorter and the weather gets colder in the northern hemisphere from the day of the autumnal equinox onwards. This festival takes place around September 22.

This festival is also known to the Wiccans as The Second Harvest Festival because according to their ancient cycle of the year, Mabon was actually the second harvest and people did the final gathering of the crops and began to prepare for the long winter that lay ahead. Mabon is therefore a time of thanksgiving to Mother Nature for the bounties of the harvest and the good fortune of the past year. People take this moment to pay their respects to the impending dark and give thanks to the waning sunlight too.

Celebrations of the Mabon Festival

Things such as wine, gourds, pinecones, acorns, grains, pomegranates and dried seeds are some of the symbols of this festival. Activities carried out during this festival include making wine, gathering dried herbs, plants, seeds and seed pods, walking in the woods, scattering offerings in harvested fields and offering libations to trees. Some of the gods and goddesses include Modron, Morgan and The Green Man. The Wiccans also take this time to remember and honour the dead by adorning burial sites with leaves, acorns, and pinecones.

At this festival, people would wear all of their finery and celebrate in a lavish setting as they prepare for the winding down of the year.

- **Festival related to the Winter Solstice -- DONG ZHI**

Dong Zhi literally means the "arrival (至) of winter (冬)". It is the second most important festival of the Chinese calendar, the Chinese New Year being the most important. Dong Zhi is considered the thanksgiving festival of the Chinese calendar. The entire family gets together on this day to celebrate the past good year.

Origins Of Dong Zhi

Coinciding with the day of winter solstice where the longest night is experienced in the northern hemisphere, Dong Zhi is celebrated around December 22.

Dong Zhi has its origins in the farmer's celebrations of the year-end harvest. The ancient Chinese farmers divided the year into 24 "joints" of two weeks, and as a result, each Dong Zhi occurs six weeks before the Chinese New Year.

Dong Zhi was in fact the antecedent of Chinese New Year as some of the earlier emperors celebrated the New Year at Dong Zhi. This lasted till Emperor Han Wu Di (194 – 187 B.C.) fixed the Chinese New Year at the beginning of each year. Even today, some Chinese “traditionalists” insist that everyone becomes 1 year older after Dong Zhi.

The celebration of Dong Zhi is also deeply rooted in the Chinese belief of yin and yang, which represent balance and harmony in life. To the Chinese, the day of winter solstice marks the mid-point of winter where the length of daytime will begin to get longer and the weather to get less cold after this day. Therefore, though it is believed by the Chinese that the yin qualities of darkness and cold are at their most powerful during Dong Zhi, it is also a turning point, heralding the dawning of the light and warmth of yang. Hence, Dong Zhi is considered a time of optimism.

Celebrations of Dong Zhi

Dong Zhi is a time for family reunions. An indispensable item on the menu is tang yuan (汤圆) which is a sweet soup of glutinous rice flour balls. The Chinese word tang (meaning 'soup') sounds like tuan which means reunion, while yuan means round, signifying "yuan man" (complete). The entire phrase tang therefore symbolizes "tuan yuan" (family reunion / 团圆) Eating tang yuan on Dong Zhi signifies family unity, harmony and prosperity.



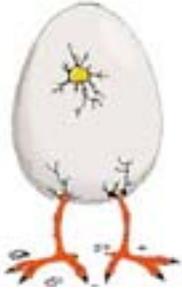
item

yuan

Glutinous rice balls are made from flour rolled into small balls. Many families prefer to have some pink tang yuan to mix with their white ones.

In ancient China, many poor people were not able to protect themselves from the bitter cold winter. Families would thus gather to eat bowls of warm tang yuan. This tradition was then passed down till today.

The Myth of the Vernal “Egg”-uinox



Origin of Myth

A certain ritual is practised every year on the day of the vernal equinox all across the United States and around the whole world. On this day (20th or 21st of March), people of all ages will try to balance a chicken egg on its end. The practice is based on the urban legend which states that you can balance a raw egg perfectly on its end only on the day of the vernal equinox. Some people even claim that it must be done on the exact time of the equinox. Sounds ridiculous? Well, a nonscientific survey conducted by Philip C. Plait, an astronomer working at the physical and astronomy department at the Sonoma State University in the United States, shows that about half of the population in America itself (approximately 130 million!) has either heard of this practice or tried it themselves!

Every year on or around the day of the vernal equinox, ordinary citizens and school children will try to balance eggs. Newscasters talk on air about balancing eggs. Sometimes, the newscasters will even go to the classrooms and broadcast the students' attempts.

This urban legend can be traced back to a Chinese origin. Martin Gardner in the *Skeptical Inquirer* (May/June 1996 issue) reported an article penned by Annalee Jacoby in the *Life* magazine (March 19, 1945). Ms Jacoby was on an assignment in China in 1945 and witnessed a Chinese ritual on Li Chun (the first day of spring in China) where many people were balancing eggs in the city of Chungking. Ms. Jacoby reported this event to *Life*. The United Press picked this story up and sent it out to other areas. Thus, this was how the legend was born.

On March 20 in 1983, Donna Henes mobilized a hundred people in New York City to publicly balance eggs at the exact moment of the vernal equinox. This event appeared in the *New Yorker* magazine on April 4, 1983. She handed out eggs to the onlookers and made them promise not to balance the egg before the designated time. At around 11:39 pm, she balanced an egg and announced, “Spring is here.” Ms. Henes continued holding such balancing rituals. One was in 1984 where more than five thousand people gathered at the World Trade Centre to take part in the egg balancing.

Arguments Against The Legend

The most common reason people, who believe the legend to be true, give to support their stand is that there exists some special gravitational balance on the day of the vernal equinox. Some people say that the Sun's gravity lines up with the Earth's gravity on this day, thus bringing about the special balance. However, if you were to draw a line between the centre of the Earth and the Sun, you will realize that at any time there will be a place on the Earth which is on the line. If there is any validity in this claim, then the egg can be balanced any day of the year. Some also feel that on the day of the vernal equinox, the Sun exerts a greater gravitational attraction on the Earth due to the position of the Sun and the Earth.

Regarding gravitational effects, there are a few things we should consider. 1) The Earth's orbit is elliptical, not circular. Thus, there is a slightly stronger force between the Earth and the Sun in January where we are closest to the Sun. In July where we are further away from the sun, the force is slightly less. 2) Tidal forces on the Earth which are caused mostly by the Moon and the Sun do exist. 3) The Earth is slightly flattened at the poles, not spherical in shape. Thus some places on the Earth are nearer to our planet's centre of gravity than other places. These points are listed to remind us that we have to consider many factors if we want to prove that there is a special gravitational balance at the equinox time. Also, if gravity is involved in balancing eggs, should not other objects balance as well? Is gravity selective such that only eggs are affected on this particular day?

Another argument against the legend is that since it is said that one can balance an egg on its end on the vernal equinox, should not this apply to the autumnal equinox too, since at both this days, the earth's axis points 90 degrees away from the Sun? This should indicate that there's something fishy about this legend.

The next argument concerns the article written by Ms Jacoby on the Chinese ritual on Li Chun in China. She reported that the egg balancing ritual was performed on the first day of spring. However, she failed to point out that the first day of spring in China (Li Chun) was actually a month and a half before the first day of spring as recognized by the Americans. This can be explained as such: In America, equinoxes and solstices mark the beginning of seasons, thus the first day of spring is the day of vernal equinox to the people there. However, in most countries, this is not the case. Equinoxes and solstices are actually midpoints of the seasons.

Since a season is 3 months long, people regard the first day of spring as 6 weeks before the day of vernal equinox. Therefore, this error in the time factor displays yet another flaw in this legend.

Experiments

Since the legend states that the egg can be balanced on its end only on the day of the vernal equinox, this would mean that it will not stand on its end at any other time. Thus, to prove whether this legend is just a myth or not, we can actually rely on experimental verification, that is to try balancing an egg on its end some other time. Phil Plait did such an experiment on October 25, 1998, five months before the day of the vernal equinox. (see picture below) He was able to stand 3 eggs on their ends and his wife then helped him stand up five more.



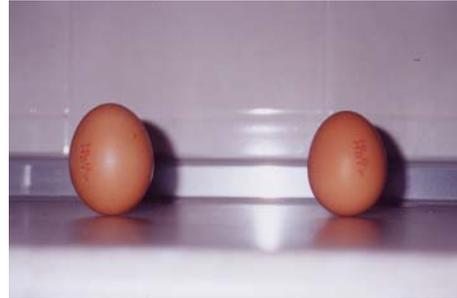
In addition, whenever Mr. Plait gives public lectures about misconceptions on astronomy, he would usually begin by balancing an egg. Hence, this further reinforces the argument that balancing eggs on ends has nothing to do with the time of the year. Instead, what is needed is a steady hand, a rather strong desire to balance an egg, a flat table surface and loads of patience, care and stamina!

A teacher, Lisa Vincent, and her students from Mancelona Middle School in Michigan also tested the egg myth on October 16, 1999. They not only managed to balance the eggs, but they could balance them on their narrow ends! In addition, the eggs remained standing for over a month.

Inspired by the students, we decided to let actions speak louder than words and tried to balance eggs on their ends. Only Raizah succeeded. (see picture below) She managed to balance 2 eggs on their ends after much



effort on August 25 and the eggs continued to stand overnight until her younger brother made them fall. She tried again about 1 month later, this time on September 23 (the day of the autumnal equinox). Unfortunately, she could not balance this time though. However, we had achieved our aim, which is proving that eggs can be balanced on any other day.



Conclusion

The bottom line is: if an egg balances on its end, it would do it at any time, and not just on the day of the vernal equinox. Thus, this legend is just a myth, an “egg”-uinox myth.

Structures

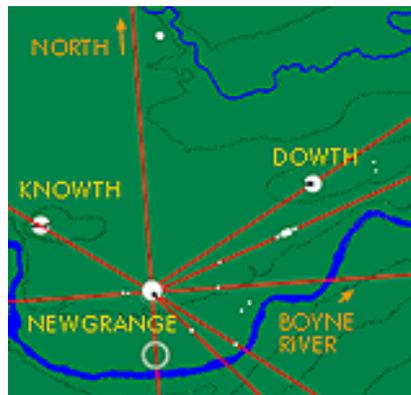
Megalithic Passage Tombs of Ireland

Megalithic literally means big (mega) stone (lithos) from the Greek. Stones are used to build a tomb structure that can weigh up to 80 tons.

In County Meath, the east coast of Ireland are found five fascinating megalithic passage tombs, that were most probably built for astronomical purposes due to the special observations that were made only during solstices or equinoxes. The Megalithic Passage Tombs of Newgrange, Knowth, Dowth, Fourknocks, Loughcrew and Tara were built about 5000 years ago, making them older than the Stonehenge and the great pyramids in Egypt.

- **Newgrange Megalithic Passage Tomb**

Location



Newgrange Megalithic Tomb, together with Knowth and Dowth, are found on a piece of land surrounded by the River Boyne. The river flows from west to east and has a loop to the south. The tombs are located inside this loop. This arrangement is probably due to the builders' belief that the river can protect the cemetery.

Description



Large stones surrounding the mound.

Aerial view of Newgrange

The Newgrange Megalithic Passage Tomb consists of a mound, which is about 85m in diameter and 13.5m high. The mound contains a passage leading to a burial chamber. The mound is surrounded by 97 large stones, which form a ring of about 104m in diameter. Many of these large stones have beautiful designs carved on them such as spirals, zigzags and other symbols. The most prominent of these stones is the stone in front of the entrance of the passage. This stone is carved with the most outstanding designs such as triple spirals, double spirals and concentric semi-circles.

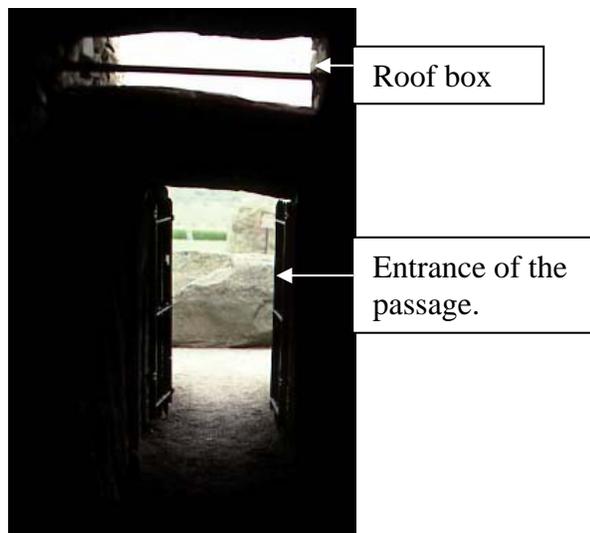
The passage, which is 19m long, is located on the southeast of the mound. It is lined on each side by 43 standing stones, 21 on the right and 22 on the left side. The average height of the stones is 1.5m. The passage leads into the burial chamber, which is divided into three parts, such that the plan of the passage and the chamber looks like a cross.



The tri spiral design found on the stone.



Entrance stone found in front of the entrance of the passage.



The chamber measures 6.5m by 6.2m and has three recesses which are small chambers set off at right angles from the passageway. Topped by a corbelled roof 6m above the floor, the recesses contain three huge stone basins, which were probably used for burial purposes.

Relation to the Solstice

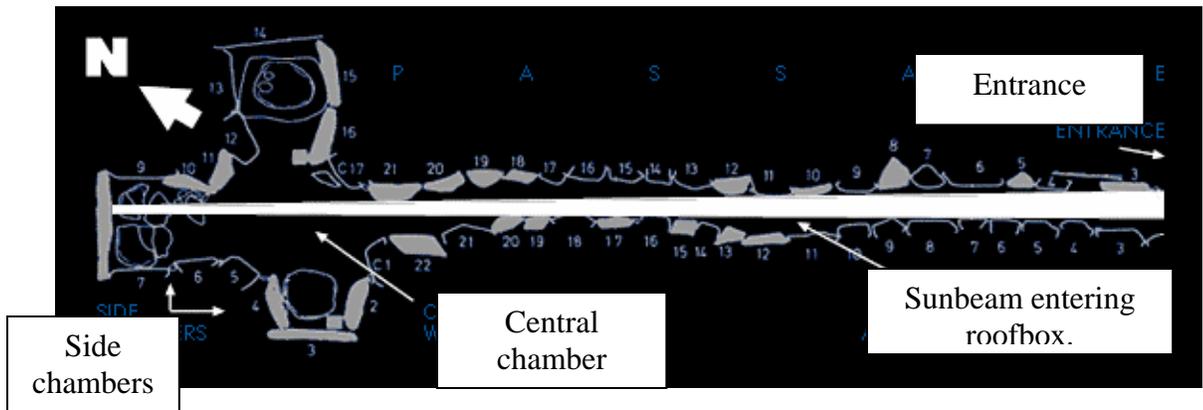
Above the entrance of the passage is a small opening called the roof box. The roof box is aligned such that at dawn from around 19th to the 23rd December, a beam of sunlight shines through the roof box and illuminates the passage and the chamber. This lasts for about 15 minutes and after that the passage and the chamber return to complete darkness. The illumination is the brightest on 21st December, the winter solstice. Illumination occurs only during the sunrise in this period of time and no other time. The fascinating part is that the sunbeam enters at an angle and is still able to shine all the way to the chamber.

Between 1967-70 Professor Michael J O'Kelly, who was in charge of excavations at Newgrange, made careful observations about this phenomenon. In 1969 Professor Michael J O'Kelly made some observations about this phenomenon. He observed that at 9.58a.m. (British Summer Time) a beam of sunlight shone through the roof box and penetrates the passage and creeps slowly to the back of the chamber. At 10.04a.m., the light beam began to narrow. At 10.15a.m., the light was totally cut off and the chamber and the passage returned to complete darkness.



Sunbeam entering the passage at an angle.

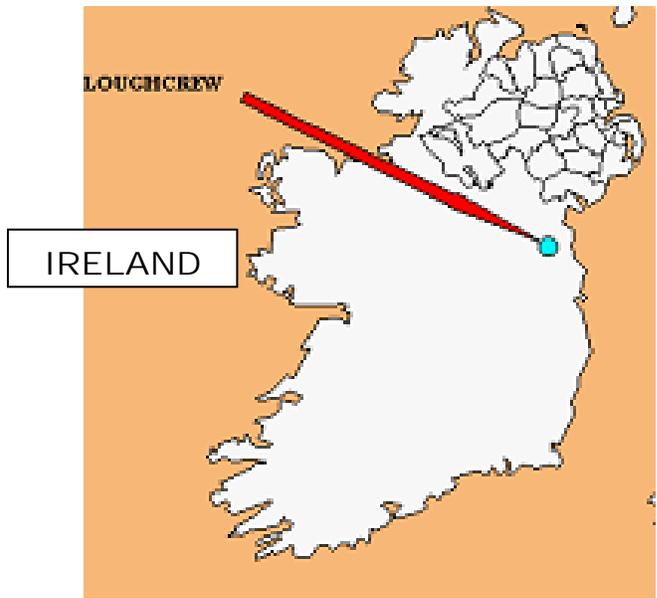




Plan of the passage and chamber.

- **Loughcrew Megalithic Cairns**

Location



The Loughcrew mounds are located 55 miles North West of Dublin, Ireland, 40 kilometres from Newgrange. They are found around the hills near the town of Oldcastle, County Meath. The main cairn called Cairn T is found on the "Sliabh na Cailligh", or the "Mountain of the Witch".

Description

The Loughcrew consists of 30 passage tombs. The main cairn, Cairn T is of similar design to Newgrange. The cairn contains a passage and a chamber which also has walls carved with interesting symbols. One of the most decorated stones is the stone found at the back of the chamber, called the backstone. The backstone is covered with symbols.

How it is linked to equinoxes

One of the tombs labelled "Cairn T" by archaeologists faces the east. During sunrise of the vernal and autumnal equinoxes, the sun lights the passage and the chamber and shines on the symbols on the stone at the back of the chamber. The upright stones in the passage cause the shape of the sunlight on the backstone to be rectangular in shape. As the sun rises, the sunlight, shaped like a rectangular spotlight, moves across the stone. The symbols on the stone are illuminated one at a time.



Rectangular shape of sunbeam illuminates the symbols.

- **Why these monuments were built**

When the phenomena that occur during solstice and equinox in these monuments were discovered, many people, including archaeologists, were sceptical about the fact that this was what the builders wanted when the monuments were designed and built 5,000 years ago. There were some hypothesis that the entry of sunlight into the chambers and passages was due to mere chance or worse, due to unintentional alteration of the entrance stones during excavations and reconstruction. For example, Newgrange was at first excavated and reconstructed only as a tomb, not as a delicate astronomical instrument. Hence, no extra precautions were taken to prevent any alterations that may affect the astronomical observations. Hence there is a possibility that the phenomena are not due to the excellent planning and designing skills of the builders but due to the mistakes of the excavators.

However, there is some evidence that shows that the orientation of the passage tombs such that the illumination of the chamber and passage occur only during solstices or equinoxes was deliberate. If the roof box of the Newgrange passage tomb is lower, or the passage is a few meters longer, the sunlight will not enter the chamber. If the roof box is higher, the sunlight will still enter the chamber but will be projected straight onto the back wall. Hence the fascinating and dramatic effect of sunlight entering at an angle will not be observed.

This leads to the question to whether the carvings on the rocks are merely meaningless decorations or they really have astronomical meanings. For example, are the symbols on the backstone in Loughcrew records of the period of time when each part of the stone is illuminated? Or are they just meaningless pictures carved randomly to decorate the stone? To obtain the answer for this problem, the symbols have to be compared in detailed with the calendrical systems of other ancient civilizations.

The functions of these monuments can be deduced from their layouts and designs. The mounds in Newgrange create an interior piece of land which resembles an amphitheatre. Thus that area could be used as a gathering site for ritual ceremonies. About 100m east of the central passage is found a pair of parallel banks resembling a path. The parallel banks are called cursurs. As one walks along the cursurs, he will be able to see a fantastic view of the horizon and the

central mound and the smaller mounds. The cursurs probably functioned as a ritual possession route through the landscape.

Although there are no certain answers to the reasons why the monuments were built, the uses of the features in the monuments and whether the close relations to the solstices and equinoxes were deliberate or by chance, these monuments are definitely worth visiting!

----- *The end* -----

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