

The Mathematics of the Public Holidays of Singapore

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Adam Schall (汤若望 [湯若望], Tāng Ruòwàng,
1592-1666)



Public Holidays in Singapore

- ▶ There are 11 public holidays in Singapore. Three of them are secular.
 1. New Year's Day
 2. Labor Day
 3. National Day

Cultural, Racial or Religious Holidays

- ▶ The remaining eight cultural, racial or religious holidays consist of two Chinese, two Muslim, two Indian and two Christian.

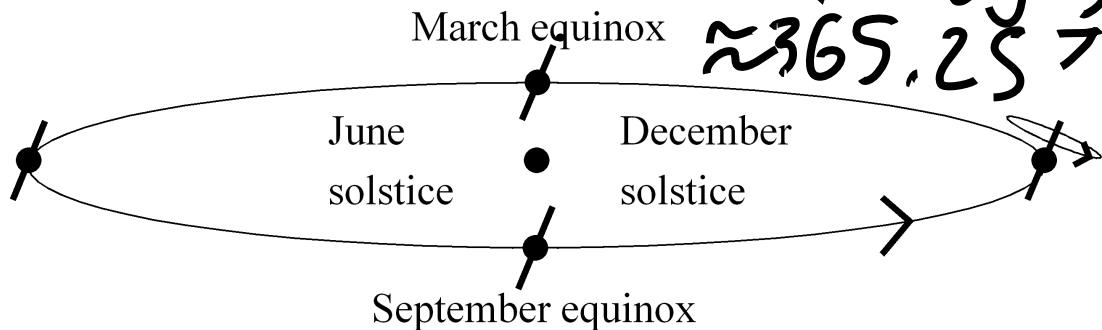
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- ▶
 1. Chinese New Year and 2nd day of CNY
 2. Good Friday (Easter Sunday is a day off anyway!)
 3. Vesak Day (Buddha's birthday)
 4. Deepavali
 5. Christmas Day
 6. Eid ul-Fitr (Hari Raya Puasa), the end of Ramadan
 7. Eid ul-Adha (Hari Raya Haji)

- ▶ Christmas Day falls on a fixed date, but all the others move.
- ▶ The Muslim holidays move throughout the year, while the others move within a one month interval.

A Quick Course in Astronomy

- ▶ The Earth revolves counterclockwise around the Sun in an elliptical orbit. The Earth rotates counterclockwise around an axis that is tilted 23.5 degrees.



- ▶ In the northern hemisphere, the day will be longest at the June solstice and shortest at the December solstice. At the two equinoxes day and night will be equally long. The equinoxes and solstices are called the seasonal markers.

The Year and the Month

- ▶ The tropical year (or solar year) is the time from one March equinox to the next. The mean value is 365.2422 days.
- ▶ The synodic month is the time from one new Moon to the next. It ranges from 29.27 days to 29.84 days with a mean of 29.53 days. *lunar year*
- ▶ $12 \times 29.5 = 354$, so a lunar year consisting of 12 lunar months is about 11 days short of a solar year

$$365 - 12 \times 29.5 = 11.$$

- ▶

solar lunar

$$365/11 \approx 33.$$

The Metonic Cycle

- ▶ 19 solar years is almost exactly $235 = 19 \times 12 + 7$, lunar months.

$$\begin{aligned}235 \times 29.53 &= 6939.6884, \\19 \times 365.2422 &= 6939.6018.\end{aligned}$$

The difference is about two hours.

- ▶ This is called the Metonic cycle (432 BCE). It was known in China by about 600 BCE and was called the zhāng (章) cycle.
- ▶ The Metonic cycle is used in the Jewish calendar, in the computation of Easter, and was used in the Chinese calendar before 104 BCE.

Classification of Calendars

solar Gregorian calendar. Basic unit is day. Approximates the tropical year by adding leap days. Ignores the Moon. The year is 365 or 366 days.

lunar Islamic calendar. Basic unit is lunar month. Ignores the Sun. The year is 12 months or 354 (sometimes 353 or 355) days.

lunisolar Chinese and Jewish calendars. Basic unit is lunar month. Approximates the tropical year by adding leap months. The year is 12 or 13 months. A 12-month year is 354 (sometimes 353 or 355) days. A 13-month year is 384 (sometimes 383 or 385) days.

- ▶ The Chinese calendar is NOT a lunar calendar!

Alternative Classification of Calendars

- ▶ Arithmetical: Gregorian and Jewish calendars. Based on arithmetical formulas. Prediction and conversion between different arithmetical calendars is simple.
- ▶ Astronomical: Islamic, Indian and Chinese calendars. Based on astronomical data. Prediction and conversion is hard.

The Roman Calendar

- ▶ The Roman year started on March 1. That's still reflected in the names September, October, November and December.
- ▶ February 29 would then be the last day of the year.

The Gregorian Calendar

- ▶ A normal year consists of 365 days, but leap years have 366 days. Year n is a leap year if n is divisible by 4, but not by 100 or if n is divisible by 400. 1900 is not a leap year, but 2000 is.
- ▶ The average length of the Gregorian year is 365.2425. The difference between this and the tropical year will cause an error of about one day in 2,500 years.

The Julian Calendar

- ▶ The Julian Calendar was implemented by Julius Caesar.
- ▶ In the Julian calendar, every fourth year is a leap year.
- ▶ Pope Gregory XIII introduced the Gregorian calendar in 1582.
- ▶ 4 October 1582 was followed by 15 October 1582.
- ▶ In the UK, 2 Sep 1752 was followed by 14 Sep 1752.
- ▶ Russia changed after the revolution in 1917. They had to skip 13 days.

Computation of Easter

- ▶ The rule of thumb is that Easter Sunday is the first Sunday after the first full Moon on or after the day of the March equinox.
- ▶ The actual rule is that Easter Sunday falls on the first Sunday after the first ecclesiastical full Moon on or after March 21. The ecclesiastical full Moon is an approximation to the real full Moon used by the Church and the first one after March 21 is called the Paschal Moon. Each year it will move either 10 or 11 days earlier, or 18 or 19 days later.
- ▶ It will fall between March 22 and April 25. In order to derive the latest date, you need to know that the Paschal full Moon is always 29 days after the previous ecclesiastical full Moon.

The Actual Computation of Easter

If you study the rules for the ecclesiastical Moon, you can show that Easter Sunday in year y falls on day d in month m where d and m are computed as follows (all remainders from division are dropped).

$$\begin{aligned}c &= y/100 \\n &= y - 19 * \lfloor y/19 \rfloor \\k &= \lfloor (c - 17)/25 \rfloor \\i &= c - c/4 - \lfloor (c - k)/3 \rfloor + 19 * n + 15 \\i &= i - 30 * \lfloor i/30 \rfloor \\i &= i - \lfloor i/28 \rfloor * (1 - \lfloor i/28 \rfloor * \lfloor 29/(i + 1) \rfloor \\&\quad * \lfloor (21 - n)/11 \rfloor) \\j &= y + \lfloor y/4 \rfloor + i + 2 - c + \lfloor c/4 \rfloor \\j &= j - 7 * \lfloor j/7 \rfloor \\l &= i - j \\m &= 3 + \lfloor (l + 40)/44 \rfloor \\d &= l + 28 - 31 * \lfloor m/4 \rfloor\end{aligned}$$

Christian Solar Holidays

- ▶ Annunciation Day (Lady Day), March 25, nine months before Christmas, used to mark the start of the year until 1752 in the UK
- ▶ Walpurgis Night, April 30 or May Day, May 1
- ▶ Midsummer Day, June 24, birth of John the Baptist
- ▶ Lammas (loaf-mass day), August 1, the festival of the first wheat harvest of the year
- ▶ Michaelmas, September 29, named after the Archangel Michael
- ▶ All Saints' Day (All Hallows), November 1 or Halloween on the night of October 31
- ▶ Christmas, December 25
- ▶ Candlemas, February 2, presentation of Jesus at the Temple forty days after Christmas, Groundhog Day
- ▶ These form the four quarter days (solstices and equinoxes) and the four cross-quarter days (halfway between)

Christian Lunar Holidays

- ▶ Lent, forty days of fast before Easter, but also including Sundays, so it starts on Ash Wednesday in the seventh week before Easter
- ▶ Ascension Thursday, the fortieth day after Easter Sunday, counted inclusively
- ▶ Pentecost, the fiftieth day after Easter Sunday, counted inclusively

Buddha's Birthday (Vesak Day)

- ▶ Traditionally, Buddhists have observed Buddha's Birthday (Vesak Day) on the 8th or 15th day of the fourth month.
- ▶ Since the 1950s the Singapore Buddhist Federation celebrates it on the first full Moon in May.

Indian Calendars

- ▶ There are three main types of calendars in India.
- ▶ Solar calendars (following the sidereal, not the tropical year).
- ▶ Lunisolar calendars that *end* with the new Moon (amanta), mostly used in southern India.
- ▶ Lunisolar calendars that *end* with the full Moon (purnimanta), mostly used in northern India.
- ▶ Notice that in Indian lunisolar calendars, the day of the new (full) Moon is the *last* day of the month, not the first as in the Chinese calendar.
- ▶ Since they follow the sidereal years, solar based Indian new years drift in the Gregorian calendars. New years around April 14 were intended to mark the vernal equinox.
- ▶ Indian days start with sunrise.

Deepavali

- ▶ Diwali, known as Deepavali in southern India, is a national public holiday in India, Sri Lanka, Nepal, Mauritius, Fiji, Malaysia and Singapore.
- ▶ The holiday in Sri Lanka, Malaysia and Singapore usually falls one day earlier than the holiday in India and Mauritius. In Nepal both days are public holidays.
- ▶ In India there are both national and state public holidays.
- ▶ Naraka Chaturdasi (the day before the new Moon) is celebrated as a state holiday in Tamil Nadu, Kerala and Puducherry.
- ▶ The next day Lakshmi Puja (the day of the new Moon or Amavasya) is celebrated as a national public holiday.
- ▶ The next day Govardhan Puja is celebrated as a state holiday and New Year Day in Gujarat and Karnataka.
- ▶ The next day Bhai Duj (Bhai Dooj) is celebrated as a state holiday in Uttar Pradesh and Uttarakhand.
- ▶ It can be shown that Deepavali will fall between Oct 15 and Nov 15.

Tithi

- ▶ In order to understand the Indian lunisolar calendar, we must understand tithi. Tithi is a lunar day, or the time it takes for the longitudinal angle between the moon and the sun to increase by 12° .
- ▶ There are 30 tithis in each lunar month, and they vary from approximately 19 to approximately 26 hours.
- ▶ The day gets its name from the name of the tithi at the time of sunrise.
- ▶ Since a tithi can be more than 24 hours, there will sometimes be a tithi that contains two sunrises. In that case we will get a repeated day.
- ▶ Since a tithi can be less than 24 hours, there will sometimes be a tithi that contains no sunrise. In that case we will skip a day.

Deepavali Details

- ▶ The second to last tithi before the new Moon is called Chaturdasi and the tithi ending at the new Moon is called Amavasya.
- ▶ Notice that the new Moon will occur during the Amavasya day, unless the Amavasya day is skipped.
- ▶ In southern India Deepavali is celebrated on Chaturdasi day (29) in the month of Asvina. (If there is an added Chaturdasi day it falls on the second Chaturdasi day, and if the Chaturdasi day is skipped it falls on the Amavasya day.)
- ▶ In northern India it is celebrated on Amavasya.
- ▶ However, in northern India, some of the Deepavali ceremonies are supposed to be done during a time period called Pradosha. It is the first 2/15 of the night, or about the first 1.5 hours after sunset.

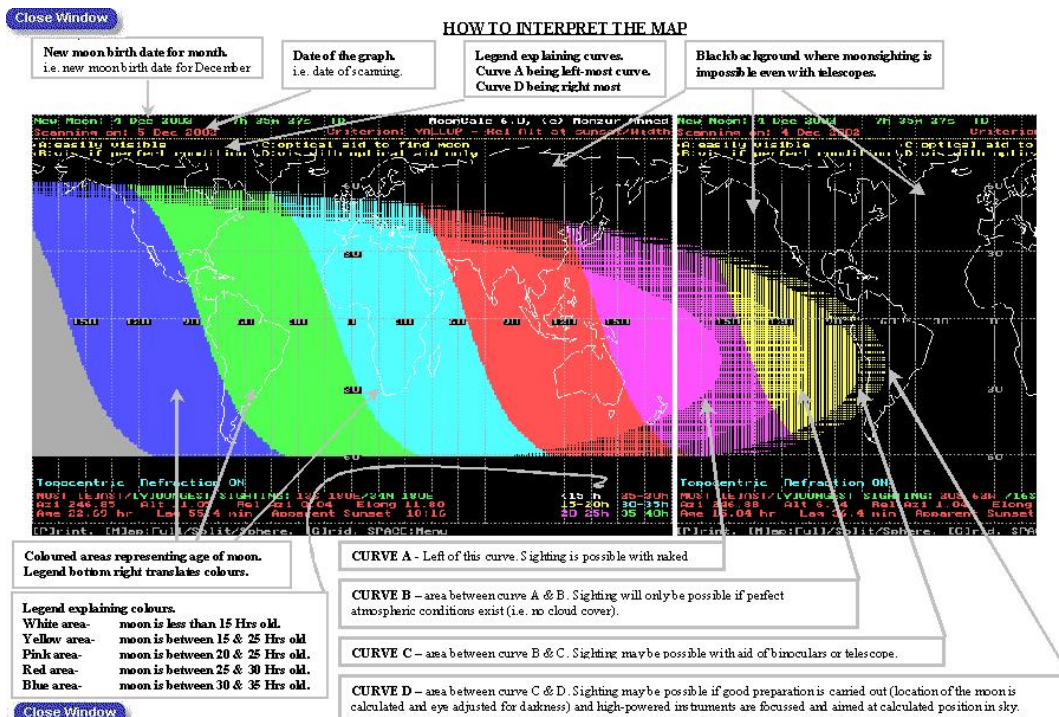
The Islamic Calendar

- ▶ No leap months. Muslim holidays move about 11 days earlier each year.
- ▶ New months are determined by the first sighting of the waxing crescent.
- ▶ We know perfectly well where the Moon and the Sun are at any given time, but how light must the Moon be and how dark must the sky be before we can see the crescent?
- ▶ And what if the weather is bad?
- ▶ Strictly speaking, the Muslim day starts at sunset the previous day, but when converting dates, we usually ignore the first part of the Muslim day.
- ▶ A waxing Moon is normally not visible until it is more than 24 hours old. Most of the time, the crescent will be seen on the evening of the second day of the Chinese month.
- ▶ The first day of the Muslim month is therefore usually the third day of the Chinese month.

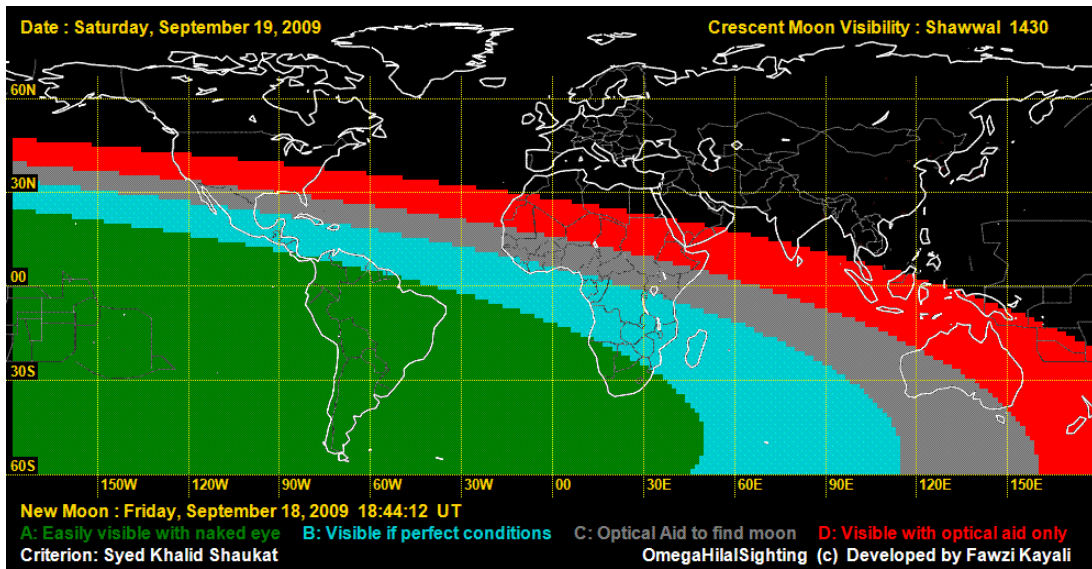
The Islamic Holidays

- ▶ Eid ul-Fitr (Hari Raya Puasa), the end of Ramadan, is the first day of the 10th month. Eid ul-Adha (Hari Raya Haji) is the 10th day of the 12th month.
- ▶ In 2000 the end of Ramadan fell on Jan 8 and on Dec 27. Since $365/11 \approx 33$, we see that such double Eids will occur every 32 or 33 years.

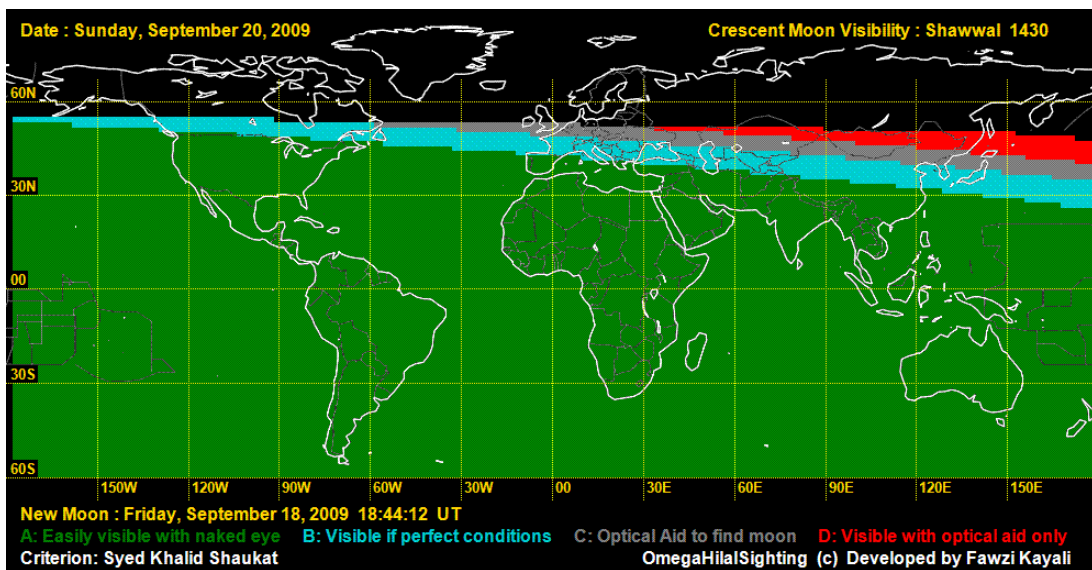
Lunar Visibility Chart



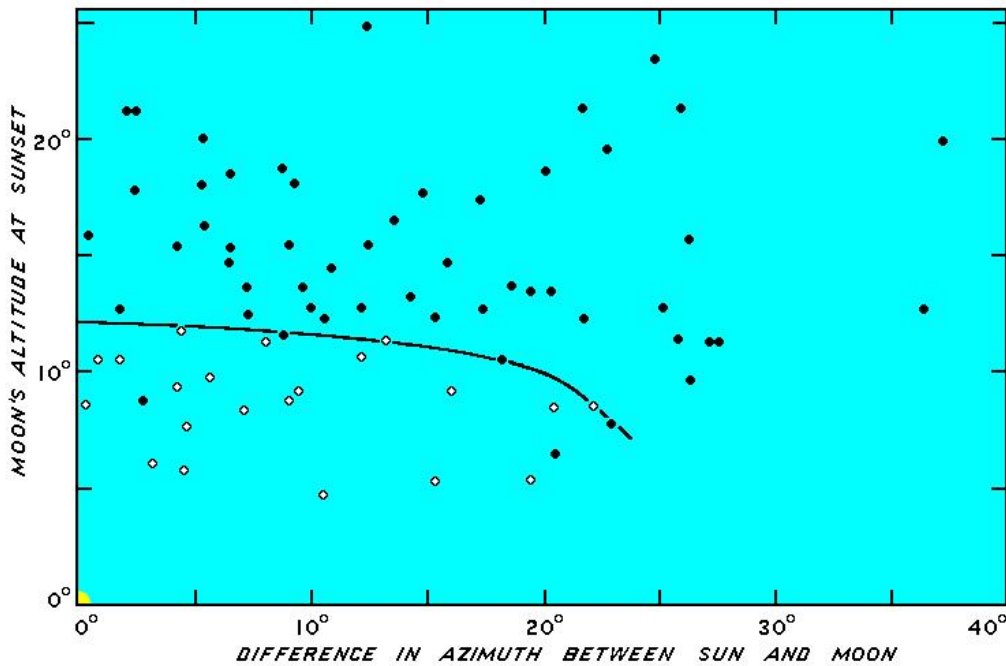
End of Ramadan 2009



End of Ramadan 2009 2



Lunar Visibility Theory



Muslim Calendar in Singapore

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日  一 		正月 是日肖鼠相冲 农 历 初 二 6 1 Dzulkaedah	正月 是日肖牛相冲 农 历 初 三 7 2 Dzulkaedah	正月 是日肖羊相冲 农 历 初 九 13 8 Dzulkaedah	正月 是日肖猴相冲 农 历 初 十 14 9 Dzulkaedah	正月 是日肖虎相冲 农 历 初 十六 20 15 Dzulkaedah	正月 是日肖兔相冲 农 历 初 十七 21 16 Dzulkaedah	正月 是日肖龙相冲 农 历 初 廿 27 22 Dzulkaedah	正月 是日肖蛇相冲 农 历 初 廿 28 23 Dzulkaedah

Muslim Calendar in Singapore 2

正 月 初 二 6	吉隆坡赛马 农历新年 是日肖鼠相冲		宜：万事如意 忌：恭喜发财
K LUMPUR RACE DAY CHINESE NEW YEAR 1 Dzulkaedah 23			
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CHINESE NEW YEAR 2 Dzulkaedah 24			

Muslim Calendar in Singapore 3

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	正 月 初 三 7	是日肖牛相冲 CHINESE NEW YEAR 1 Dzulkaedah 24	正 月 初 十 14	是日肖猴相冲 西方情人节 Valentine's Day 8 Dzulkaedah 31	正 月 初 七 21	是日肖兔相冲 CHINESE NEW YEAR 15 Dzulkaedah 22

Muslim Calendar in Singapore 4



MUIS

- ▶ Before 1974, the Muslim calendar in Singapore was based on sightings from Sultan Shoal, the southernmost part of Singapore. MUIS (Majlis Ugama Islam Singapura), the Islamic Religious Council of Singapore, then decided that the new month starts if the Moon is above the horizon at sunset on the eve of the 29th day.
- ▶ In the 80s they decided to require that the altitude of the Moon should be more than 5 degrees at sunset.
- ▶ In the 90s they switched to 2 degrees. This was part of an attempt to coordinate the major holidays with Malaysia, Brunei and Indonesia, called the MABIMS criteria.

MABIMS Criteria

- ▶ The altitude of the Moon at sunset is more than 2 degrees.
- ▶ The distance between the Sun and the Moon at sunset is more than 3 degrees.
- ▶ The age of the Moon at sunset is more than 8 hours.
- ▶ In practice, however, MUIS only looks at the first of the criteria.
- ▶ The minimum possible values of the three variables in the MABIMS criteria are approximately:
 - ▶ Altitude $> 6^\circ$
 - ▶ Distance $> 7^\circ$
 - ▶ Age > 16 h

The Islamic Calendar in Various Countries

- ▶ The Islamic is in principle observational, but what is the practical reality?
- ▶ Some Muslim communities base their calendar on actual Moon sightings. This is done in India, Pakistan, Bangladesh and the US.
- ▶ In Saudi Arabia and most of the Gulf countries they have simplified the calendar. They start the lunar month if the Moon sets after the Sun on the 29th day of the previous month, as seen from Mecca.
- ▶ Egypt requires the Moon to set at least 5 minutes after sunset.

The Chinese Calendar

- ▶ The goal is to approximate the solar year by adding leap months. Since 12 lunar months are 11 days too short we will need to add a leap month a little bit more than every third year.
- ▶ In ancient times, this was done by observing nature.
- ▶ Since $235 = 19 \times 12 + 7$, we can use the Metonic cycle and get a decent lunisolar calendar by having 7 leap years in every 19-year cycle.

Chinese New Year

- ▶ It can be shown that Chinese New Year will always fall between Jan 21 and Feb 21. *1 Feb 32 Jan*
- ▶ Most of the time Chinese New Year will fall 11 (or 10 or 12) days earlier than the previous year, but if that would take us outside of the Chinese New Year range of Jan 21 to Feb 21, we must add a leap month, so Chinese New Year jumps 19 (or 18 or 20) days later. *23 Jan 21 Jan*

2004	2005	2006	2007	2008	2009	
Jan 22	Feb 9	Jan 29	Feb 18	Feb 7	Jan 26	
18	11	20	11	12	19	
2010	2011	2012	2013	2014	2015	
Feb 14	Feb 3	Jan 23	Feb 10	Jan 31	Feb 19	
11	11	18	10	19		

Chinese New Year and the End of Ramadan

- ▶ The Muslim holidays will always fall about 11 days earlier.
- ▶ Sometimes the End of Ramadan will coincide with Chinese New Year. They will then stay together for two or three years. After that, Ramadan will continue on its 33 year cycle through the calendar, while CNY will jump later because of a leap month.
- ▶ They will then meet up again in 30 or 31 years. This happened from 1964 to 1966, from 1996 to 1998, and will happen again from 2029 to 2031.

Deepa-Raya

Countdown to Deepa-Raya

BY SHAIK KADIR
For The Straits Times

IT'S A multiculturally festive time in Singapore at the moment as Hindus and Muslims prepare for their respective festivals — Deepavali and Hari Raya Puasa. These two colourful festivals occur very close to each other this year.

Deepavali (Festival of Light) is on Nov 1 and Hari Raya Puasa or Eid ul-Fitri (Festival of Charity) on Nov 3.

Some may ask: Didn't Hari Raya Puasa and Chinese New Year fall back-to-back some years ago?

Yes, Singaporeans celebrated "Gongxi-Raya" in 1996, 1997 and 1998. In those years, Chinese New Year fell on Feb 19, Feb 8 and Jan 28, and Hari Raya Puasa the following day.

After the three consecutive years of back-to-back celebration, Chinese New Year and Hari Raya Puasa "parted company".

Why is it that Hari Raya Puasa has the privilege of "visiting" the festivals of other communities — Chinese New Year in those years, and now Deepavali?

The answer lies in the Muslim calendar.

The Chinese, Muslims and Hindus follow a lunar calendar in which the months are each fewer than 30 days. The solar month in the Gregorian calendar has 30 or 31 days except for February which has 28 days, and 29 days every four years.

In the Chinese lunar calendar, there is a "leap" month of three to four weeks every few years, inserted to ensure that the Chinese New Year falls in late January or February — an auspicious time of the year heralding the beginning of spring.

Similarly, a "leap" in the Hindu calendar keeps Deepavali in October or November.

In the Muslim calendar, or more appropriately the Hijrah calendar, there are no "leap" months. The Muslim year comprises 354 days — 11 days shorter than the Gregorian year.

Thus, in 1999, when Chinese New Year and Hari Raya Puasa parted company, the Chinese New Year was given a leap or "pulled back" to Feb 16 to "catch up" with the solar calendar while Hari Raya Puasa advanced to Jan 19.

Hari Raya Puasa carried on its advancement of 11 days a year till it "visited" Deepavali this year. Hari Raya Puasa will carry on advancing — in October, September, August and so on, "visiting" any lunar-based non-Muslim festivals along the way.

At the practical level, the absence of a leap in the Muslim calendar means that Muslim events need not be celebrated year in and year out in the same season.

For example, when Hari Raya Puasa is in December (winter) of a particular year in England, the festival will be in autumn eight years later (11x8 = 88 days or roughly three months). In another eight years it will be in summer, and so on.

Thus Muslims will be able to celebrate the festival, including experiencing the Ramadan fast, not always in winter, but in all seasons of the year.

The Muslim calendar dates from the event called Hijrah, the migration of Prophet Muhammad from Mecca to Medina, a significant episode in Islamic history.

The Hijrah was selected as the start of the Muslim calendar because the event denoted the success, triumph and progress of Islam from Medina. The Hijrah took place on July 2 in the year 622 of the Gregorian calendar.

The Muslim year this year is 1426H (1426 Hijrah). In other words, the Hijrah took place 1426 lunar years ago or 1383 years ago on the Gregorian calendar.

Although Islam was born in Saudi Arabia, the Muslim calendar does not require that Islamic events be based exclusively on the cultural aspects of Saudi Arabia. The Muslim calendar is applicable universally, to Muslims of any race or country, according to their local context.

The Muslim calendar allows "new moon" festivals like Hari Raya Puasa to "visit" not only Chinese New Year and Deepavali, but also other celebrations like Christmas, as they "move" through all 12 months of the solar calendar.

In the year 2000, for instance, Hari Raya Puasa fell on Dec 27, just two days after Christmas.

Such "visits", when they take place, should indeed give Muslims and non-Muslims the opportunity to celebrate their respective festivals and share their festive happiness together, strengthening friendship and promoting cultural integration.

The writer is a lecturer at ITE College Central (MacPherson Campus). His latest book, *Inside Islam: 101 Questions And Answers*, was published in January this year.

Why 3 ethnic festivals won't coincide exactly

I WAS very happy when I saw the article, "Countdown to Deepa-Raya" (ST, Oct 31). The two coinciding holidays is not only a great way to promote understanding of different cultures and religions, but also a great way to promote understanding of the mathematics and science behind the different calendars.

However, I was somewhat disappointed by the article. It contained several incorrect or imprecise statements. The most glaring statement is this: "In the Chinese lunar calendar, there is a 'leap' month of three to four weeks every few years."

The lunar months in the Chinese, Muslim and some Indian calendars follow the lunar cycle, which has an

average length of 29.53 days. Both the regular and the leap months in these calendars will therefore always have 29 or 30 days and not "fewer than 30 days" as stated in the article.

Leap months of three weeks, as claimed in the article, would fundamentally upset the calendars, and could result in Chinese New Year being celebrated at the time of the full moon!

One interesting point that was not discussed in the article is how often Hari Raya Puasa will coincide with the various other holidays. As the Muslim holidays move about 11 days earlier each year (not always exactly 11 as claimed in the article), it will take about 33 years for them to move through the Gregorian year.

However, as the Chinese and Indian holidays also move, Hari Raya Puasa will be close to, for instance, Deepavali, for two or three years, and then meet up again in 30 to 31 years.

Another important point that was not explained is why Hari Raya Puasa will never coincide exactly with Deepavali or Chinese New Year.

Chinese New Year falls on the day of the new moon, while Hari Raya Puasa falls on the day after the first visibility of the lunar crescent. On the day of the new moon, the moon is not visible, which is why the Muslim month usually starts one or two days after the Chinese.

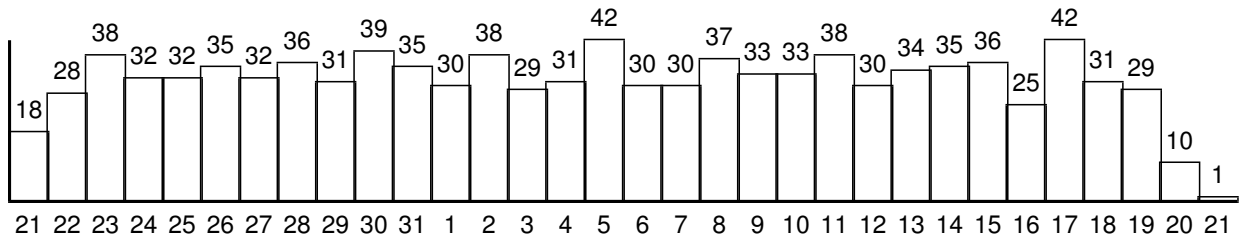
For more information about the four calendars in Singapore, readers can look at my webpage www.chinese-calendar.org or www.math.nus.edu.sg/aslaksen/calendar/.

Helmer Aslaksen (Dr)

The 19-year Cycle

- ▶ Because of the Metonic cycle, there is almost a 19-year cycle in the Chinese calendar.
- ▶ I was born on April 16, 1960. This was the 21st day in the 3rd month in the Chinese calendar. Normally my birthday will fall on different days in the Chinese calendar, but my 19th birthday fell on the 20th day in the third month. The same goes for my 38th and 57th birthday. So we see that the 19-year cycle is close but not exact.
- ▶ There are two reasons for this. First of all, the Metonic cycle is off by about two hours.
- ▶ But more importantly, we are now comparing the Chinese calendar not with the tropical year, but with the Gregorian calendar, which is just an approximation to the tropical year. In particular, since 19 is not a multiple of 4, different cycles will contain different numbers of leap years.

Dates of Chinese New Year Between 1645 and 2644



The 24 Jiéqì

A fundamental concept in the Chinese calendar is the 24 solar terms or jiéqì (节气). They are a generalization of the solstices and equinoxes. The even ones are called major solar terms or zhōngqì (中气).

List of the 24 Jíqì

J1	Lìchūn	立春	Beginning of spring	February 4
Z1	Yǔshuǐ	雨水	Rain water	February 19
J2	Jīngzhé	惊蛰 (驚蟄)	Waking of insects	March 6
Z2	Chūnfēn	春分	March equinox	March 21
J3	Qīngmíng	清明	Pure brightness	April 5
Z3	Gǔyǔ (or Gǔyù)	谷雨 (穀雨)	Grain rain	April 20
J4	Lìxià	立夏	Beginning of summer	May 6
Z4	Xiǎomǎn	小满 (小滿)	Grain full	May 21
J5	Mángzhòng (or Mángzhǒng)	芒种 (芒種)	Grain in ear	June 6
Z5	Xiàzhì	夏至	June solstice	June 22
J6	Xiǎoshǔ	小暑	Slight heat	July 7
Z6	Dàshǔ	大暑	Great heat	July 23
J7	Lìqiū	立秋	Beginning of autumn	August 8
Z7	Chǔshǔ	处暑 (處暑)	Limit of heat	August 23
J8	Báilù	白露	White dew	September 8
Z8	Qiūfēn	秋分	September equinox	September 23
J9	Hánlù	寒露	Cold dew	October 8
Z9	Shuāngjiàng	霜降	Descent of frost	October 24
J10	Lìdōng	立冬	Beginning of winter	November 8
Z10	Xiǎoxuě	小雪	Slight snow	November 22
J11	Dàxuě	大雪	Great snow	December 7
Z11	Dōngzhì	冬至	December solstice	December 22
J12	Xiǎohán	小寒	Slight cold	January 6
Z12	Dàhán	大寒	Great cold	January 20

When is Qing Ming?



SEARCHING FOR LOVED ONES: With four days until the Qing Ming festival, families are thronging columbaria to pay respects to those who have died. At the Nam Ann Siang Theon Temple columbarium in Paya Lebar Crescent, these people were looking for the niches holding the urns of their relatives' ashes. Qing Ming falls on the fourth day of the fourth month of the Chinese lunar calendar and is a time when the Chinese visit columbaria or cemeteries to remember the dead.

HOW HWEY YOUNG

A Chinese Calendar

公元 1982 年——壬戌年							公元 1982 年——壬戌年						
公历日期	1 月	2 月	3 月	4 月	5 月	6 月	公历日期	7 月	8 月	9 月	10 月	11 月	12 月
	农日期	农日期	农日期	农日期	农日期	农日期		农日期	农日期	农日期	农日期	农日期	农日期
1	初七	初八	初九	初十	十一	十二	1	十一	十二	十三	十四	十五	十六
2	初八	初九	初十	十一	十二	十三	2	十二	十三	十四	十五	十六	十七
3	初九	初十	十一	十二	十三	十四	3	十三	十四	十五	十六	十七	十八
4	初十	十一	十二	十三	十四	十五	4	十四	十五	十六	十七	十八	十九
5	十一	十二	十三	十四	十五	十六	5	十五	十六	十七	十八	十九	二十
6	十二	十三	十四	十五	十六	十七	6	十六	十七	十八	十九	二十	廿一
7	十三	十四	十五	十六	十七	十八	7	十七	十八	十九	二十	廿一	廿二
8	十四	十五	十六	十七	十八	十九	8	十八	十九	二十	廿一	廿二	廿三
9	十五	十六	十七	十八	十九	二十	9	十九	二十	廿一	廿二	廿三	廿四
10	十六	十七	十八	十九	二十	廿一	10	二十	廿一	廿二	廿三	廿四	廿五
11	十七	十八	十九	二十	廿一	廿二	11	廿一	廿二	廿三	廿四	廿五	廿六
12	十八	十九	二十	廿一	廿二	廿三	12	廿二	廿三	廿四	廿五	廿六	廿七
13	十九	二十	廿一	廿二	廿三	廿四	13	廿三	廿四	廿五	廿六	廿七	廿八
14	二十	廿一	廿二	廿三	廿四	廿五	14	廿四	廿五	廿六	廿七	廿八	廿九
15	廿一	廿二	廿三	廿四	廿五	廿六	15	廿五	廿六	廿七	廿八	廿九	三十
16	廿二	廿三	廿四	廿五	廿六	廿七	16	廿六	廿七	廿八	廿九	三十	初一
17	廿三	廿四	廿五	廿六	廿七	廿八	17	廿七	廿八	廿九	三十	初一	初二
18	廿四	廿五	廿六	廿七	廿八	廿九	18	廿八	廿九	三十	初一	初二	初三
19	廿五	廿六	廿七	廿八	廿九	三十	19	廿九	三十	初一	初二	初三	初四
20	廿六	廿七	廿八	廿九	三十	初一	20	三十	初一	初二	初三	初四	初五
21	廿七	廿八	廿九	三十	初一	初二	21	初一	初二	初三	初四	初五	初六
22	廿八	廿九	三十	初一	初二	初三	22	初二	初三	初四	初五	初六	初七
23	廿九	三十	初一	初二	初三	初四	23	初三	初四	初五	初六	初七	初八
24	三十	初一	初二	初三	初四	初五	24	初四	初五	初六	初七	初八	初九
25	初一	初二	初三	初四	初五	初六	25	初五	初六	初七	初八	初九	初十
26	初二	初三	初四	初五	初六	初七	26	初六	初七	初八	初九	初十	十一
27	初三	初四	初五	初六	初七	初八	27	初七	初八	初九	初十	十一	十二
28	初四	初五	初六	初七	初八	初九	28	初八	初九	初十	十一	十二	十三
29	初五	初六	初七	初八	初九	初十	29	初九	初十	十一	十二	十三	十四
30	初六	初七	初八	初九	初十	十一	30	初十	十一	十二	十三	十四	十五
31	初七	初八	初九	初十	十一	十二	31	十一	十二	十三	十四	十五	十六
节	小寒: 6日	立春: 4日	惊蛰: 6日	清明: 5日	立夏: 6日	芒种: 6日	节	小暑: 7日	立秋: 8日	白露: 8日	寒露: 8日	立冬: 8日	大雪: 7日
气	大寒: 20日	雨水: 19日	春分: 21日	谷雨: 20日	小满: 21日	夏至: 22日	气	大暑: 23日	处暑: 23日	秋分: 23日	霜降: 24日	小雪: 22日	冬至: 22日

Chinese Seasons

- ▶ A useful rule of thumb is that Chinese New Year is the new Moon closest to the beginning of spring (立春, lìchūn). This rule is correct most of the time, but it failed in 1985 and will fail again in 2015.
- ▶ Since the beginning of spring falls around Feb 4, this helps explain why Chinese New Year will always fall between Jan 21 and Feb 21. It also helps explain why Chinese New Year is called the spring festival.
- ▶ In Western astronomy, spring begins at spring equinox. In Chinese astronomy, spring begins midway between winter solstice and spring equinox.

The Chinese Meridian

- ▶ Calculations are based on the meridian 120° East.
- ▶ Before 1929 the computations were based on the meridian in Beijing (116°25'), but in 1928 China adopted a standard time zone based on 120° East. This change corresponds to about 14 minutes.

1978 in Hong Kong

- ▶ Before 1978, many calendars in Hong Kong and Taiwan were still based on the old imperial calendar from 1908, the year in which the last Qīng emperor ascended the throne.
- ▶ The new Moon that marked the start of the 8th month in 1978 occurred at 16h 07m UTC on September 2. Using standard Chinese time, the new Moon occurred after midnight at 0h 07m UTC + 8 on September 3. However, using local Beijing time, as they did in Hong Kong, this was 14 minutes earlier, just before midnight at 23h 53m on September 2.
- ▶ So in Hong Kong the month started on September 2, while in China it started on September 3.
- ▶ The Mid-Autumn Festival is celebrated on the 15th day of the 8th month, so the Mid-Autumn Festival was celebrated on different days, causing a lot of confusion.
- ▶ After 1978, both Hong Kong and Taiwan have followed the same calendar as China, so at least when it comes to calendars, everybody agrees on a “one-China” policy.

The Vietnamese Calendar

- ▶ Traditionally, the Vietnamese used the Chinese calendar based on the longitude of Beijing ($116^{\circ}25'$ East), even though the longitude of Hanoi is $105^{\circ}55'$ East.
- ▶ However, on August 8, 1967, the North Vietnamese government approved a new lunar calendar specifically compiled for the UTC + 7 time zone.
- ▶ The following year, the Chinese New Year new Moon occurred at 16h 29m UTC on January 29. In North Vietnam, the new Moon therefore occurred at 23h 29m UTC + 7 on Jan 29. So Chinese New Year, known as Tet in Vietnam, was celebrated on January 29 in the North.
- ▶ However, in South Vietnam, the new Moon occurred 46 minutes (11.5°) later at 0h 15m on January 30, so Tet was celebrated on January 30.

The Tet Offensive of 1968

- ▶ The North Vietnamese Army and the Vietcong guerillas were preparing for what would be known as the Tet Offensive. The instructions were to attack in the early morning of the second day of Tet.
- ▶ The units in Da Nang and other Central Vietnamese cities had closer links to North Vietnam and were aware of the calendar change, so they attacked on the morning of January 30, the day after the new Tet.
- ▶ However, in Saigon and other cities to the South, everybody was using the traditional calendar, and the attack started on the morning of January 31, the day after the traditional Tet.

The Length of a Chinese Month

- ▶ The day on which a new Moon occurs is the first day of the new month.
- ▶ The length of the months are determined astronomically. The lunar month can vary between about 29.25 and 29.75 with a mean of 29.53.
- ▶ Suppose a month is 29.5 days.

New Moon	Next new Moon	Length
May 1 13h	May 31 1h	30 days
May 1 1h	May 30 13h	29 days

- ▶ There can be four long months or three short months in a row.

The Mid-Autumn Festival

- ▶ If the 1st month marks the beginning of spring, autumn should start with the 7th month.
- ▶ This explains why the Mid-Autumn Festival is celebrated on the 15th day of the 8th month.

The Chinese Solar Calendar

- ▶ It is important to understand that the Chinese calendar is a combination of two calendars, the usual lunisolar calendar and a solar calendar that follows the 24 jiéqì.
- ▶ The solar calendar is traditionally called the farmer's calendar (农历). Unfortunately the term farmer's calendar has come to include the lunisolar calendar.
- ▶ The Chinese solar calendar follows the tropical year closely, so it is perfect for farming purposes, but the lunisolar calendar is not at all suitable for farmers.

Qīngmíng (清明)

- ▶ There are two Chinese holidays that are determined by the solar calendar, namely Qīngmíng (清明) around Apr 5 and winter solstice Dōngzhì (冬至) around Dec 22.
- ▶ Notice that lunar dates can fall within a range of about one month in the solar calendar and conversely. Chinese New Year can fall between Jan 21 and Feb 21.
- ▶ Qīngmíng can fall between the 13th day of the 2nd month and the 17th day of the 3rd month.

The Chinese Year

- ▶ There are several years in the Chinese calendar. The most important are the suì (岁) and the nián (年).
- ▶ A suì is the solstice year from one winter solstice to the next. This is similar to the tropical year.
- ▶ In modern Chinese, the word suì is only used when talking about a person's age. Traditionally, Chinese people count their age from the December solstice, but some instead count from Chinese New Year, the seventh day of the new year (人日) or from lìchūn. Using the word suì when talking about a person's age is probably related to this custom.
- ▶ A nián is the Chinese year from one Chinese New Year to the next, which has variable length.
- ▶ Just like we can think of the Gregorian year as an approximation to the tropical year, we can think of the nián as an approximation to the suì.
- ▶ The Chinese astrological year runs from the beginning of spring (立春, lìchūn) around Feb 4, not from Chinese New Year.

The Sexagenary Cycle

The sexagenary cycle is important in the Chinese calendar.

Heavenly Stems	天干	tiāngān	Element
1	甲	jiǎ	Wood
2	乙	yǐ	Wood
3	丙	bǐng	Fire
4	丁	dīng	Fire
5	戊	wù	Earth
6	己	jǐ	Earth
7	庚	gēng	Metal
8	辛	xīn	Metal
9	壬	rén	Water
10	癸	guǐ	Water

The Sexagenary Cycle 2

Earthly Branches	地支	dìzhī	Animal
1	子	zǐ	Rat
2	丑	chǒu	Ox
3	寅	yín	Tiger
4	卯	mǎo	Rabbit
5	辰	chén	Dragon
6	巳	sì	Snake
7	午	wǔ	Horse
8	未	wèi	Goat
9	申	shēn	Monkey
10	酉	yǒu	Chicken
11	戌	xū	Dog
12	亥	hài	Pig

The Sexagenary Cycle 3

- ▶ The branches are often associated with the sequence of 12 animals: rat, ox, tiger, rabbit, dragon, snake, horse, sheep, monkey, rooster, dog, and pig. It is not clear when the branches were associated with the 12 animals, but it seems to have taken place around the time of the Táng Dynasty.

The Golden Dragon

- ▶ Let us denote both the stems and the branches by their numbers. We denote 1 by (1, 1) or (甲, 子), 2 by (2, 2) or (乙, 丑) and so on up to (10, 10) or (癸, 酉).
- ▶ Now we have run out of stems, so we denote 11 by (1, 11) or (甲, 戌) and 12 by (2, 12) or (乙, 亥). Now we have run out of branches, too, so 13 becomes (3, 1) or (丙, 子).
- ▶ We continue in this way through 6 cycles of stems and 5 cycles of branches up to 60, which is (10, 12) or (癸, 亥).
- ▶ The next number is then (1, 1) or (甲, 子), which starts a new sexagenary cycle.
- ▶ Notice that each branch, or animal, occurs five times in each 60-year cycle. An animal corresponding to an odd number, will meet the stems that correspond to the odd numbers.
- ▶ Year 2000 is the 17th year in the current cycle (see below), so it corresponds to (7, 5) ($17 = 10 + 7 = 12 + 5$) or (庚, 辰). So we see that it is a metal dragon year, or a golden dragon.

The Eight Characters

- ▶ The sexagenary cycle is used for keeping track of years, months, days and (double) hours in Chinese astrology. Your date and time of birth is determined by the “Eight Characters” (八字) formed by the pair of cyclical characters for the year, month, day and hour.
- ▶ The 60-day cycle has been used for keeping track of days since ancient times. During the Hàn (汉) dynasty, the 60-year cycle was also introduced.

What is Year 2000 in the Chinese Calendar?

- ▶ The Chinese do not have a continuous year count. They started counting from one again with each new emperor.
- ▶ some scholars tried to reconstruct ancient Chinese chronology by adding up years of reigns, much the same way some westerners in the past tried to reconstruct Biblical chronology.
- ▶ Some claim that the calendar was invented by the Yellow Emperor, Huángdì (黃帝), in 2637 BCE during the 61st year of his reign.
- ▶ Some people prefer to start the count with the first year of his reign in 2697 BCE.
- ▶ Since these years are 60 years apart, it follows that 1984 was the first year of either the 78th or 79th 60-year cycle. Using this as a starting point, Chinese New Year in 2000 marks the beginning of the Chinese year 4637 or 4697.
- ▶ Some people write 2636 BCE, but they really mean -2636, using the astronomical year count, where 1 BCE is year 0, 2 BCE is -1, etc.

Sun Yat-sen

- ▶ To add to the confusion, some authors use an epoch of 2698 BCE. I believe this because they want to use a year 0 as the starting point, rather than counting 2697 BCE as year 1, or that they assume that the Yellow Emperor started his year with the Winter solstice of 2698 BCE.
- ▶ In particular, this system was used by Sun Yat-sen (孫逸仙, Sūn Yìxiān or 孫中山, Sūn Zhōngshān, 1866–1925). He and other political activists wanted to use a republican and “modern” year numbering system.
- ▶ This system actually won some acceptance in the overseas Chinese community, and is for example used occasionally in San Francisco’s Chinatown. (At least around the time of Chinese New Year!)

The continuous year count is not an integral part of Chinese culture

- ▶ The continuous year count is not an integral part of the Chinese calendar, but rather an afterthought. While there isolated incidents of Chinese scholars who have used it, it only gained popularity with the Jesuit missionaries.
- ▶ Most of the people who use it are Westerners who refuse to believe that it is possible to have a “civilized” society without a continuous year count.
- ▶ While Chinese chronology is fairly reliable going back to 841 BCE, and oracle bones with date inscription go back to the 13th century BCE, modern scholars consider the Yellow Emperor to be a mythological figure.

Kāngxī (康熙)

- ▶ Beginning in the Hàn dynasty, emperors would adopt era name or reign names (年号 [年號], niánhào), which together with the 60-year cycle would fix the year.
- ▶ In the past, the emperors often changed their era names during their reign, but by the time of the Míng and Qīng dynasties, the emperors used the same era name for their whole reign.
- ▶ This system worked well most of the time, but the Kāngxī Emperor (康熙) ruled more than 60 years. He ruled from February 7, 1661 to December 20, 1722. Since Chinese New Year fell on January 30 in 1661, the first year of his reign started on February 18, 1662, and the last year of his reign ended on February 4, 1723.
- ▶ Since both 1662 and 1722 are rényín years, the term Kāngxī rényín (康熙壬寅) is ambiguous.

Qiánlóng (乾隆)

- ▶ This is the only such problem in Chinese history. The Qiánlóng Emperor (乾隆) ruled from October 18, 1735, to February 8, 1796. The first year of his rule started on February 12, 1736, but he chose to retire on February 8, 1796, as a filial act in order not to reign longer than his grandfather, the illustrious Kāngxī Emperor.
- ▶ Despite his retirement, however, he retained ultimate power until his death in 1799.

Why Was the Calendar Important?

- ▶ With a lunar or lunisolar calendar, errors are much more obvious than with a solar calendar.
- ▶ A solar calendar can be off by a couple of weeks without anybody noticing. The reason why the Catholic church had to reform the Julian calendar was because the rules for computing Easter had frozen the March equinox to be March 21. That meant that Easter was drifting noticeably towards summer. Otherwise, few would have cared about the drift of the March equinox.
- ▶ With a lunar calendar, an error of even a couple of days is a serious problem. Every peasant could each month see that the new Moon was visible near the end of the previous month or that the old Moon was visible in the next month.

Foreign Talent

- ▶ Because of the importance the Chinese rulers placed on calendars, they were surprisingly open to incorporate foreign ideas into the making of calendars. The last three main calendar reforms have all been associated with foreign impulses.

The Main Calendar Reforms

- ▶ Before 621 BCE, the start of the month was based on visibility of the crescent Moon. During the Zhōu (周) dynasty, the Metonic cycle was used for determining leap months and the leap months were always placed at the end of the year.
- ▶ After the Tàichū (太初) calendar reform in 104 BCE, the no zhōngqì (无中气) rule was used for determining leap months, and the month containing the December solstice was fixed to be the 11th month.
- ▶ The Táng (唐) dynasty calendar reform in 619 switched to following the true Moon. This was inspired by Indian Buddhist astronomers.
- ▶ The Yuán (元) dynasty reform in 1280 was inspired by Muslim astronomers. It was the most accurate calendar in the world at that time.
- ▶ The last calendar reform came in 1645 during the Qīng dynasty (清) and was implemented by Jesuit missionaries. It used the true Sun.

The Jesuits

- ▶ In 1644, the German Adam Schall (汤若望 [湯若望], Tāng Ruòwàng, 1592-1666) went to the new Qīng rulers and presented his calculations for an upcoming solar eclipse.
- ▶ He challenged the Chinese and the Muslim astronomers in the Imperial Astronomical Bureau (欽天監, Qīntiānjiān), and the Jesuits' calculations were best.
- ▶ Schall was appointed director of the Bureau. The next year, he formulated the current rules for the Chinese calendar.

The Trial of the Jesuits

- ▶ A Chinese official, Yáng Guāngxiān (杨光先), had as his slogan that it was “better to have a wrong calendar than to have foreigners in China”. Yang managed to have the Jesuits arrested in 1664.
- ▶ A solar eclipse was coming up and while in prison, the Jesuits predicted it would occur at 3 p.m., Yang predicted 2:15 p.m., and the Muslim Wú Míngxuǎn (吴明炫) predicted 2:30 p.m.
- ▶ On the day of the eclipse, the Jesuits were brought into the palace in chains, and everybody watched as the eclipse occurred at 3p.m. sharp!
- ▶ Unfortunately, the regents were not impressed and the Jesuits were sentenced to death.
- ▶ However, the next day a strong earthquake struck Beijing. This was taken as a sign from Heaven that the sentence was unjust, and the sentence of the Jesuits was first converted to flogging and eventually to just house arrest.

The Kang Xi Emperor

- ▶ In 1668, the Kāngxī (康熙) emperor took over from the regents. The emperor ordered the Belgian Ferdinand Verbiest (南怀仁 [南懷仁], Nán Huáirén, 1623-1688), Yáng and Wú to compute the length of the shadow of a pole on a certain day and the position of the Sun at noon on a certain day.
- ▶ They were to leave their instruments pointing towards the predicted spot in the emperor's garden two weeks in advance. Verbiest easily won and was appointed director of the Bureau, while Yáng and Wú were arrested.
- ▶ Verbiest became personal tutor to the Kāngxī emperor, and even learned Manchu. Jesuits remained as directors of the Bureau until 1746 and it was run by other Westerners until 1826.