The Mathematics of the Chinese Calendar

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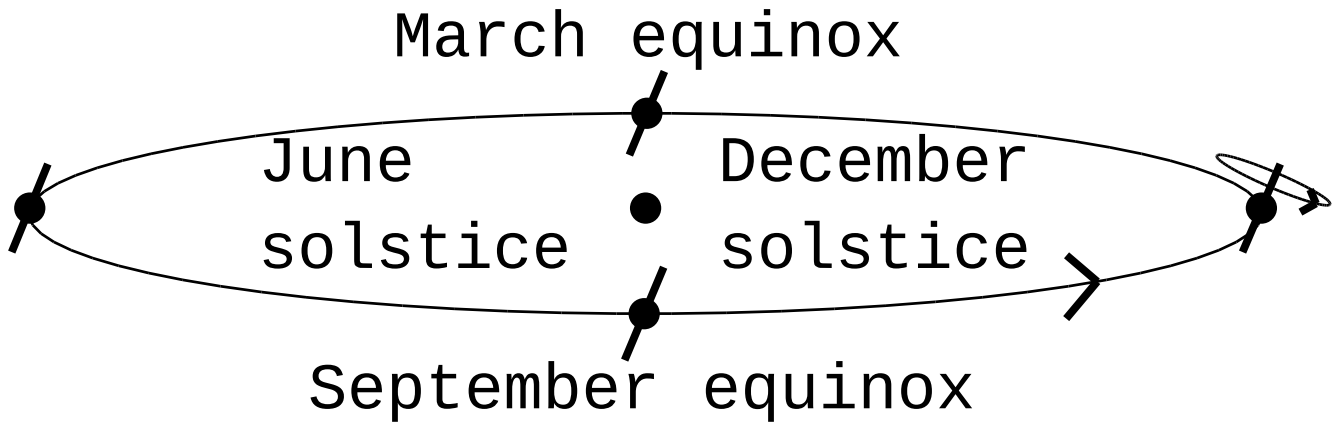
Adam Schall (汤若望 [湯若望], Tāng Ruòwàng, 1592-1666)

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.



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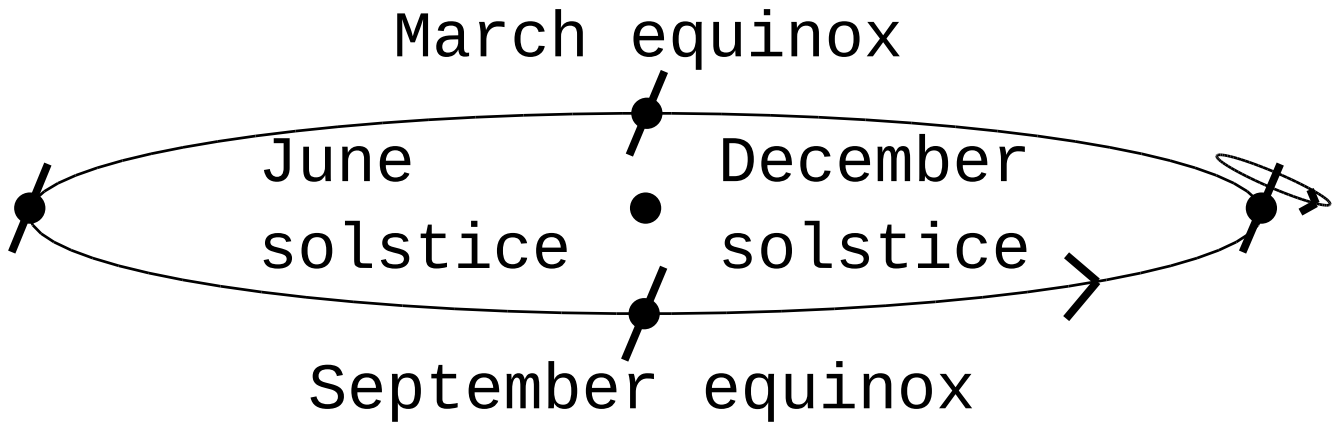

- In the northern hemisphere, the day will be longest at the June solstice and shortest at the December solstice. At the two equinoxes day and night will be equally long. The equinoxes and solstices are called the seasonal markers.

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$$365/11 \approx 33.$$

The Metonic Cycle

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- The Metonic cycle is used in the Jewish calendar, in the computation of Easter, and was used in the Chinese calendar before 104 BCE.

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- The Chinese calendar is NOT a lunar calendar!

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- Astronomical: Islamic, Indian and Chinese calendars. Based on astronomical data. Prediction and conversion is hard.

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- 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.

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1998	1999	2000	2001	2002	2003
Jan 28	Feb 16	Feb 5	Jan 24	Feb 12	Feb 1
	19	11	12	19	11

	2004	2005	2006	2007	2008	2009
	Jan 22	Feb 9	Jan 29	Feb 18	Feb 7	Jan 26
10		18	11	20	11	12

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- 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.

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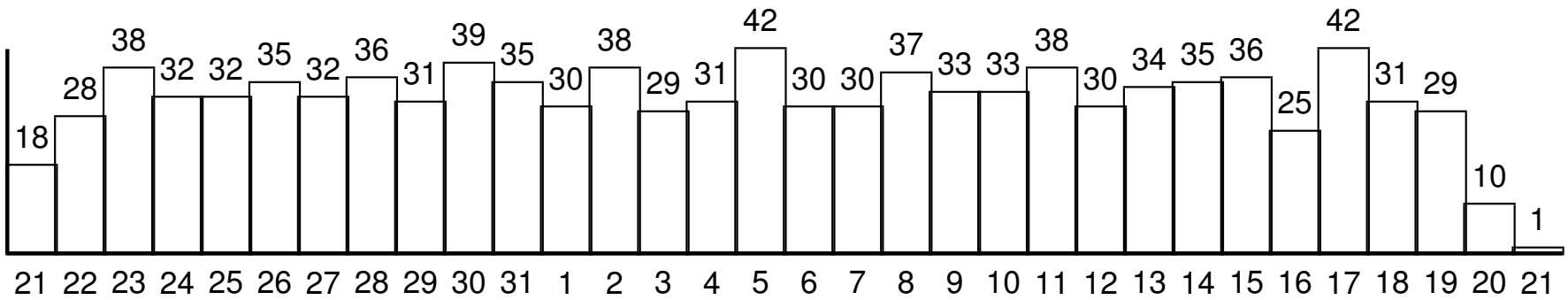
- There are two reasons for this. First of all, the Metonic cycle is off by about two hours.
- But more importantly, we are now comparing the Chinese calendar not with the tropical year, but with the Gregorian calendar, which is just an approximation to the tropical year. In particular, since 19 is not a multiple of 4, different cycles will contain different numbers of leap years.

Dates of Chinese New Year Between 1645 and 2644



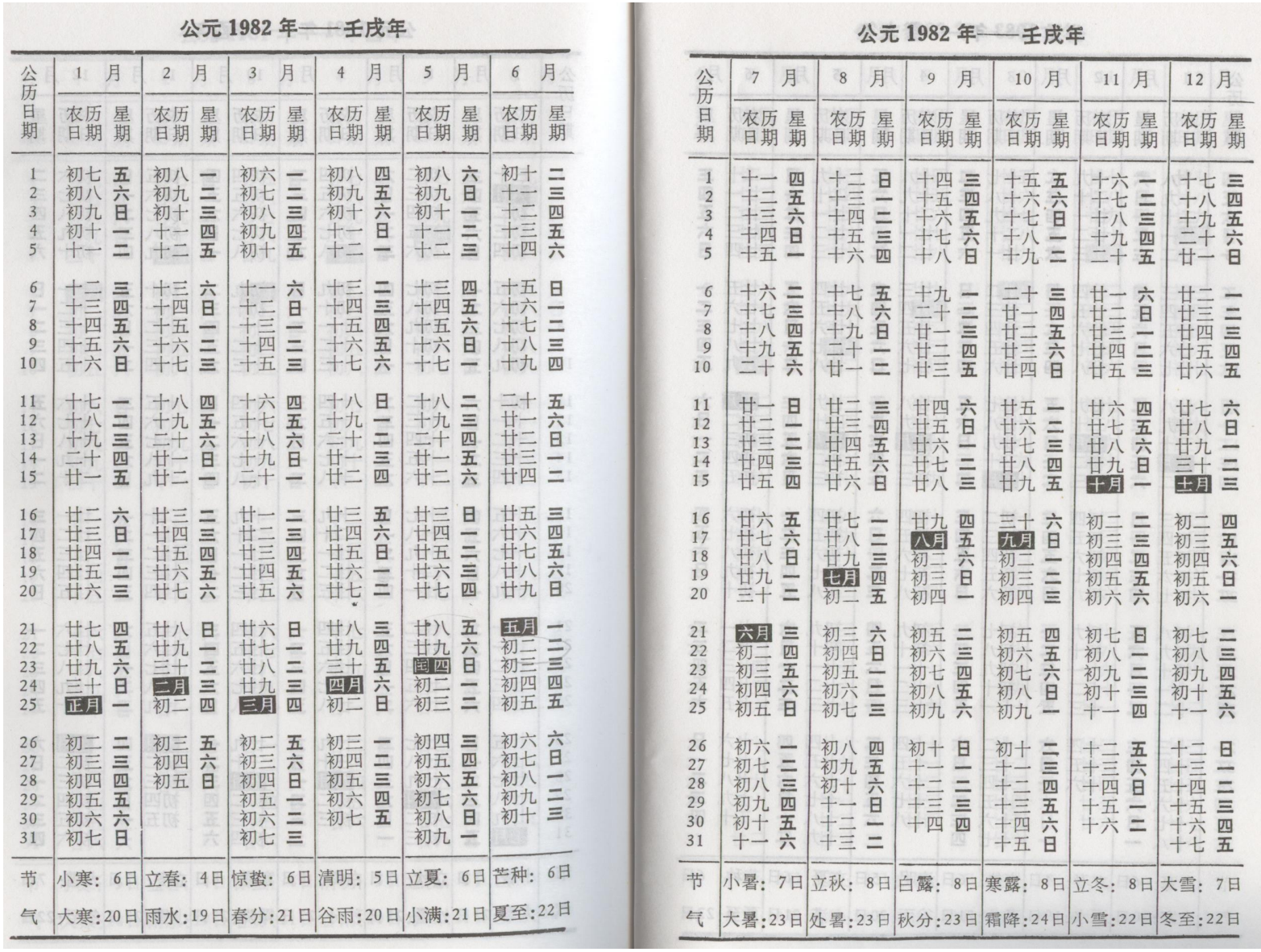
The 24 Jiéqì

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 Jiéqì

J1	Lìchūn	立春	Beginning of spring	February 4
Z1	Yǔshuǐ	雨水	Rain water	February 19
J2	Jīngzhé	惊蛰	Waking of insects	March 6
Z2	Chūnfēn	春分	Spring equinox	March 21
J3	Qīngmíng	清明	Pure brightness	April 5
Z3	Gǔyǔ	谷雨	Grain rain	April 20
J4	Lìxià	立夏	Beginning of summer	May 6
Z4	Xiǎomǎn	小满	Grain full	May 21
J5	Mángzhòng	芒种	Grain in ear	June 6
Z5	Xiàzhì	夏至	Summer 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	Limit of heat	August 23
J8	Báilù	白露	White dew	September 8
Z8	Qiūfēn	秋分	Autumnal 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	Winter solstice	December 22
J12	Xiǎohán	小寒	Slight cold	January 6
Z12	Dàhán	大寒	Great cold	January 20

A Chinese Calendar



公元 1982 年——壬戌年

公历日期	1 月			2 月			3 月			4 月			5 月			6 月		
	农日	历期	星期	农日	历期	星期	农日	历期	星期	农日	历期	星期	农日	历期	星期	农日	历期	星期
1	初	七	五	初	八	一	初	六	一	初	八	四	初	八	六	初	十一	二
2	初	八	六	初	九	二	初	七	二	初	九	五	初	九	日	十	十二	三
3	初	九	日	初	十	三	初	八	三	初	十	六	初	十	一	十	十三	四
4	初	十	一	初	十一	四	初	九	四	初	十一	日	初	十一	二	十	十四	五
5	十	一	二	十	十二	五	初	十	五	十	十二	一	初	十二	三	十	十五	六
6	十	二	三	十	十三	六	十	十一	六	十	十三	二	十	十三	四	十	十六	日
7	十	三	四	十	十四	日	十	十二	日	十	十四	三	十	十四	五	十	十七	一
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9	十	五	六	十	十六	二	十	十四	二	十	十六	五	十	十六	日	十	十九	三
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14	二	十	四	十	十一	日	十	十九	日	十	十一	三	十	十一	五	二	廿四	一
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16	廿	二	六	十	十三	二	十	廿一	二	十	十三	五	十	十三	日	二	廿六	三
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22	廿	八	五	十	九	一	十	廿七	一	十	九	四	十	九	六	初	初二	二
23	廿	九	六	十	十	二	十	廿八	二	十	十	五	十	十	日	初	初三	三
24	廿	十	日	二月	初一	三	三月	初一	三	四月	初一	六	闰四	初一	一	初	初四	四
25	正月	初一	一	初	初二	四	初	初二	四	初	初二	日	初	初二	二	初	初五	五
26	初	二	二	初	初三	五	初	初三	五	初	初三	一	初	初三	三	初	初六	六
27	初	三	三	初	初四	六	初	初四	六	初	初四	二	初	初四	四	初	初七	日
28	初	四	四	初	初五	日	初	初五	日	初	初五	三	初	初五	五	初	初八	一
29	初	五	五				初	初六	一	初	初六	四	初	初六	六	初	初九	二
30	初	六	六				初	初七	二	初	初七	五	初	初七	日	初	初十	三
31	初	七	日										初	初八	一			
节气	小寒：6日			立春：4日			惊蛰：6日			清明：5日			立夏：6日			芒种：6日		
	大寒：20日			雨水：19日			春分：21日			谷雨：20日			小满：21日			夏至：22日		

公元 1982 年——壬戌年

公历日期	7 月			8 月			9 月			10 月			11 月			12 月		
	农日	历期	星期	农日	历期	星期	农日	历期	星期	农日	历期	星期	农日	历期	星期	农日	历期	星期
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Chinese Seasons

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- In Western astronomy, spring begins at spring equinox. In Chinese astronomy, spring begins midway between winter solstice and spring equinox.

The Chinese Meridian

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- 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.

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- The Mid-Autumn Festival is celebrated on the 15th day of the 8th month. Because of this, 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

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- However, on August 8, 1967, the North Vietnam government approved a lunar calendar specifically compiled for the UT+7 time zone.
- The following year, the Chinese New Year new Moon occurred on Jan 29 16h 29m. That meant that in the new North Vietnamese calendar, Chinese New Year, known as Tet in Vietnam, would be celebrated on January 29, while in South Vietnam it would be celebrated on January 30.

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- 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.

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

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- This explains why the Mid-Autumn Festival is celebrated on the 15th day of the 8th month.

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- 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)

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- Qīngmíng can fall between the 13th day of the 2nd month and the 17th day of the 3rd month.

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- 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.

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- Since the 1950's the Singapore Buddhist Federation celebrates it on the first full Moon in May.

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- It follows that Deepavali can fall between Oct 15 and Nov 15.

The Sexagenary Cycle

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 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).

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- 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.

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- 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.

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- 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.

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- 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.

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- 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!)

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- 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.

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- 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.

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- 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.

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- Despite his retirement, however, he retained ultimate power until his death in 1799.

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- 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

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- 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

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- Schall was appointed director of the Bureau. The next year, he formulated the current rules for the Chinese calendar.

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- 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

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- 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.