A Chance Encounter with Time
Chinese Calendar Reform—1280 AD

By Jennifer Lynn Bartlett, PhD
Kenny W. Riggleman

Canst thou number the months that they fulfill?
or knowest thou the time when they bring forth?
Job 39: 2 (KJV)

We have heard that, of the tasks of rulers, none is more weighty than the ephemeris.
Guo, 1280, in Ch'i "The Account of Conduct of Kuo Shou-ching"[1]

When we are not eagerly awaiting the passage of the Moon in front of the Sun, we tend to let the cycles of these celestial bodies slip from our minds and allow our lives to be regulated by the ticking of mechanical clocks. Yet the major divisions of our calendar have their origins in the motions of two prominent members of the Solar System. Our ancestors watched their movements to predict the seed time, the harvest time, and the flooding of the Nile and other rivers: sunset to sunset is one day; new moon to new moon is one month; winter solstice to winter solstice is one year. However, the cycles of days, months, and years do not fit neatly into one another. The Gregorian calendar we use today developed out of a series of compromises among multiple patterns in the natural world and our human desires for order and predictability. Three centuries earlier and thousands of miles to the east, Guo Shoujing (1231–1316 AD) established a comparable set of accommodations.

Authoress with Guo Shoujing (on right).

As someone who is so frequently running behind or out of time in my daily life, I find the history of time-keeping fascinating. To bring the Roman civil calendar back in line with the seasons, Julius Caesar (100–44 BC) subjected his empire to the "Year of Confusion," which lasted 445 days. As recommended by Sosigenes, an Alexandrian astronomer, he based his 12-month calendar on a 365.25-day year with the quarter day being accommodated by a leap year every four years. However, the year he used still

[1] Sivin, N. 2009, *Granting the Seasons* (New York: Springer) 580

allowed the seasons and calendar to drift slowly apart. Thus, in October 1582 AD, residents of Catholic countries lost 10 days when Pope Gregory XIII required them to adopt his calendar based on a year of 365.2425 days as proposed by Aloysius Lilius (1510–1576), an Italian physician. England and its colonies, including us, did not accept this calendar until 1752 at a cost of 11 days, but with the benefit of a uniform calendar across the colonies and Continental Europe. [2]

Julius Caesar and Pope Gregory are not the only political leaders to concern themselves with calendar reform. While enjoying our hour at the Ancient Observatory in Beijing, perhaps you noted the venerable gentlemen depicted in the courtyard. Among them, I encountered Guo Shoujing, who, at the behest of his emperor undertook a major reform of the Chinese calendar. In particular, Guo estimated the length of the tropical year of 1280 AD to be 365.2425 days, about three hundred years ahead of the Papal Commission.

As part of the New Year's observances intended to maintain accord between heaven and earth, the emperor of China annually presented his people with a formal calendar that predicted important lunisolar events and other propitious times. Consequently, Khubilai Khan (1215–1294 AD) celebrated the reunification of China under his Yuan Dynasty by ordering a new and more accurate system of generating the annual ephemeris, the Season-granting System (Shoushi). In 1277, Guo, a former Supervisor in the Directorate of Waterways, was among the officials Khubilai reassigned to the Astrological Commission.[3]

Guo, an expert hydraulic engineer, was also an accomplished amateur maker of astronomical instruments. To carry out the decreed astronomical reforms, he developed a shadow aligner and an observing table for use at the 31-ft (9.5-meter) Dengfeng Star Observation Platform (Fig. 1), a monumental gnomon. A detail of the platform is shown in Figure 2. He also organized empire-wide observations using smaller gnomons (Fig. 3). To determine celestial positions, he simplified the armillary sphere (Fig. 4). Figure 5 shows a more traditional armillary sphere, similar to those in use at the time. He also designed a Square Table to gauge angles along the horizon, or azimuths (Fig. 6). His Up-facing Instrument measured the position of the Sun and the progress of solar eclipses (Fig. 7).

After more than a decade, Guo finally submitted voluminous documentation of the resulting Season-granting system along with an equally detailed evaluation of it. This system predicted solstices, lunar months, and eclipses with an accuracy superior to its predecessors and reduced the associated computational errors to the order of minutes. Furthermore, the careful, state-sponsored development of the system and its ritual use contributed to the legitimization of the Yuan Dynasty.[4]

---

[2] Duncan, D. 1998, *Calendar* (New York: Avon Books), 6, 22, 29–34, 197, 201–203, 208, 225

[3] Sivin, N. 2009, *Granting the Seasons* (New York: Springer) 19, 24, 25, 158, 159

[4] Sivin, N. 2009, *Granting the Seasons* (New York: Springer) 28, 146–149, 158, 160, 553–555, 557, 558, 570–572

The Season-granting System developed by Guo and the Astrological Commission remained in official use with only minor changes until 1644. Korea and Japan also adapted and used the system to generate their official calendars.[5] During the establishment of the Qing Dynasty, the Manchurians replaced it with one based on the work of Jesuit missionaries.[6]

Now, the People's Republic of China employs the same Gregorian system we use for civil purposes. However, our calendar still runs fast by about 26 seconds each year so we may have to forego a leap day in the next 3,300 years.

[5] Sivin, N. 2009, *Granting the Seasons* (New York: Springer) 554
[6] Brucker, J. 1912, "Johann Adam Schall von Bell" in *The Catholic Encyclopedia* (New York: Robert Appleton Co.)

Figure 1. Model of Dengfeng Star Observation Platform designed by Guo. The actual platform is 31 feet tall with a path for measurements extending 105 feet in front. This monumental instrument with Guo's innovative shadow aligner allowed more precise measurements than were possible with the smaller gnomons.

Figure 2. Detail of platform of the Dengfeng Star Observation Platform.

Figure 3. Gnomon with base following design of Guo, who used several similar instruments along with the monumental gnomon known as the Dengfeng Star Observation Platform to measure the length of the tropical year.

Figure 4. Model of Simplified Instrument, an armilla designed by Guo c.1280 AD to measure positions of celestial bodies.

Figure 5. Example of a more complex armillary sphere built in 1744 AD with interlaced dials for measuring time and celestial positions.

Figure 6. Reproduction of Square Table designed by Guo to gauge angles along the horizon, or azimuths.

Figure 7. Model of Up-facing Instrument designed by Guo to measure the position of the Sun and progress of solar eclipses.