# 曆法

嘉靖乙酉江西

問自古帝王之治天下莫不以治曆明時爲首務羲和欽天之法其詳不可得而聞矣漢作三統曆始立積年日法爲推步之準後世因之歷唐及宋作者無慮數十家然行之未久輒復更易其故何歟堯典以閏月定四時而後世又有所謂歲差之說不知昉於何人豈置閏之外復有所謂差歟我
朝大統曆法悉用勝國之制不用積年日法以歲實加氣應求冬至以中積加閏應求經朔行之二百餘年無有改者諸家之曆皆有元顧不能久授時曆不立元乃能久而無弊何歟夫天運無形而難知所可見者日月之交而已詩書春秋所載日食俱在朔漢魏以後日食或在晦何歟近年以來步交食者率多先後不同而不能一一密合或謂授時曆法久而不能無差建議欲增損之者不知果真有所見歟古今論曆者或曰有一定之法或曰無一定之法不過隨時考驗以合於天而已若果有一定之法則皆可以常數求而考測推步之術爲不足憑是皆載諸史冊班班可攷諸

several structural features of the Triple Concordance system of constants.

LUNATION 月 $29\frac{43}{81}$ days [1]).
YEAR 歲 $365\frac{385}{1539}$ days.

The precision of this constant is specious. The fraction comes from a trivial modification of the previously current value, $365\frac{1}{4} = 365\frac{385}{1540}$.

CONCORDANCE CYCLE 統 1539 years = 19,035 lunations = 562,120 days.

Since this cycle contains an integral number of days, months, and years ($1539 = 81 \times 19$), it defines simultaneous recurrence of solar and lunar events at the same time of day—e.g. coincidence of new moon and winter solstice at midnight.

EPOCH CYCLE 元 1, 686, 360 days = 4617 years = 3 Concordance Cycles.

Since this cycle contains a number of days exactly divisible by 60, it defines the recurrence of solar and lunar events (spaced by the "official" constants) on a given day in the 60-day cycle—e.g. coincidence of winter solstice and new moon at midnight on sexagenary day #1. The Triple Concordance system was named after the three Concordance Cycles which make up the Epoch Cycle.

into a universal system which became the pattern for his successors, is the only one which accounts for all the evidence. This interpretation can be traced back at least as far as Hsu Kan's 徐幹 (170-217) *Chung lun* 中論 (*Han Wei ts'ung-shu* 漢魏叢書, Han-fen-lou 涵芬樓 reprint of 1925), *B*: 12a.

The Epochal Erection period was named for the Martial Emperor's performance of the Altar-erection Sacrifice 封 in 110.

1) In order to make the structure of the system as clear as possible I discuss only a few of the most relevant constants, and cite them in highly condensed forms. The lunation, for example ($29\frac{43}{81} = \frac{2392}{81}$ days) is actually expressed as two separate integral constants, the Day Rule 日法 (81) and the Lunation Rule 月法 (2392).

The constants discussed are mean figures, of course. Any particular calendar month was either twenty-nine or thirty days long, and the interval between two true conjunctions (i.e. the length of a true lunation) could vary by as much as a day.

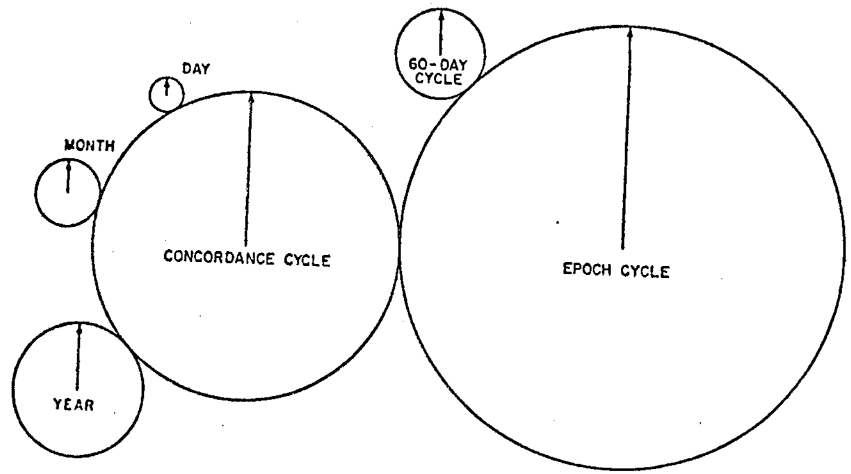



Figure 1. System of calendrical constants in the Triple Concordance treatise In a scale model, circumference would be proportional to length of cycle. The rotating arrows all point upward at the same time only once every 4617 years.

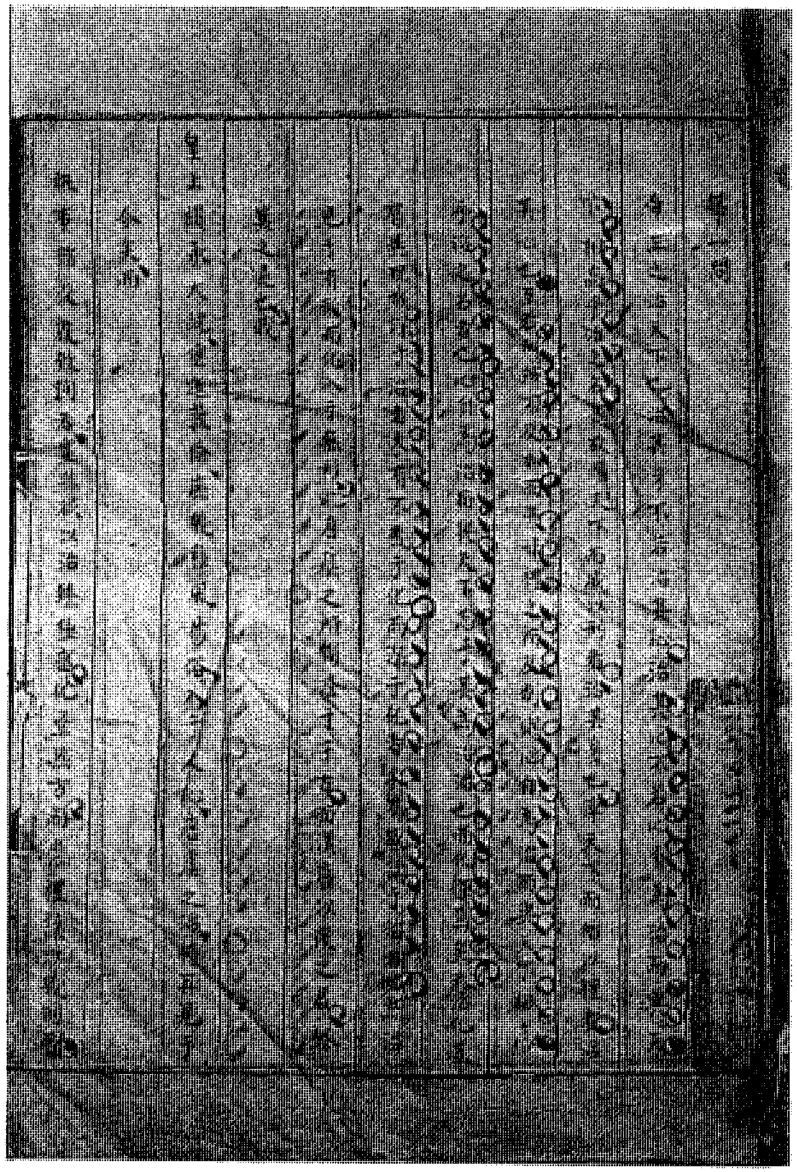
motion of the integral system is needed to return all cycles simultaneously to their original orientations. In such a system, if we know the original orientation and the number of revolutions any one circle has passed through at any given moment, we can predict the orientation of any other circle. In other words, by counting the time elapsed from epoch we can compute the date of any event with respect to the winter solstice (what day of the tropical year the event falls on), conjunction (what day of the month it falls on), sexagenary day cycle, and hour.

*Eclipse complex.* The small set of constants which performs the ordinary calendrical functions is not the only one driven by the Epoch Cycle. Another set allows prediction of eclipses, incorporating for this special purpose an ancient intercalation cycle simpler than the calendrical complex's Concordance Cycle.

PHASE COINCIDENCE CYCLE 朔望之會 135 lunations = 23 lunar eclipses [1]).

The properties of this eclipse cycle will be examined further on.

1) Note that the element "coincidence 會" serves what might be called



1667 Vermillion Ink Examination Paper. *Source:* Ming-Ch'ing Archives, Academia Sinica, Taiwan. Thanks are due Chang Wejen, the director, for permission to use these materials, and the Institute of History and Philology.

# A Cultural History of Civil Examinations in Late Imperial China

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SMC PUBLISHING INC.
Taipei

to deal with astronomical, medical, mathematical, and other technical questions was an essential tool of the new classical studies emerging in the late Ming and early Ch'ing. It just was not tested in the Ch'ing civil service before 1860.[25] Below I give a sequence of questions and answers from Ming civil examinations to explain what happened in practice in policy questions on natural studies.

### *Calendrical Studies*

For the 1525 Chiang-hsi provincial examination, one of the policy questions prepared by the examiners dealt with "calendrical methods" (*li-fa* 曆法). In the first part of their question, the examiners asked the candidates for the *chü-jen* degree to elaborate on the methods employed by the ancients to order the calendar, which they noted "had been the immediate priority of all ancient kings and emperors in bringing order to the empire."[26] Next the examiners noted that the astronomical systems established by the Han, T'ang, and Sung dynasties all followed the precedent of the Triple Concordance system (*San-t'ung li* 三統曆) of 104 B.C. in basing computation on a Day Divisor (*jih-fa* 日法) and Accumulated Years (*chi-nien* 積年) counted from a set epoch. They asked: (1) Why did the calendar frequently have to be revised? (2) Why did the current system introduce an Annual Difference (*sui-ch'a* 歲差) constant in addition to the old method of periodically inserting extra lunar months? And (3) why was the current system, which employed no epoch, accurate enough to have been used for two centuries without revision?

To answer these questions one needed a sound knowledge of both mathematical astronomy and its history, which was available to candidates in the Dynastic Histories, particularly those of the Chin and Yuan dynasties, and statecraft-oriented encyclopedias. The point was: when the Triple Concordance system adopted a Day Divisor of 81, which amounted to setting the length of a lunar month as 29 43/81 days, and counted Accumulated Days from an epoch 143,727 years in the past, it was inevitable that the small discrepancy in the constant of 29.53086 minus the modern value of 29.53059 days, which equaled an error of only one

25. See Yuan-ling Chao, "Medicine and Society in Late Imperial China: A Study of Physicians in Suzhou" (Ph.D. diss., UCLA, History, 1995); and Chu Ping-yi, "Technical Knowledge, Cultural Practices and Social Boundaries." Cf. my *From Philosophy to Philology*, pp. 61–64, 79–85, 180–84.

26. *Huang-Ming ts'e-heng*, 1.19a. A similar policy question and answer on the calendar appeared on the 1594 Kuei-chou provincial examination. See *Huang-Ming ts'e-heng*, 4.32a. My thanks to Nathan Sivin for his guidance on the technical aspects of this question and answer.



day per 310 years, would accumulate over such a great span of time to become appreciable.[27]

Succeeding computational systems simply adjusted the Day Divisor and Accumulated Days without realizing that they unavoidably led to errors. Finally, the Yuan Season-Granting system (*Shou-shih li* 授時曆), which the Ming's Great Concordance system (*Ta-t'ung li* 大統曆) closely followed, rejected this approach entirely. The Triple Concordance system and its successors had been improved upon in the *Shou-shih* calendar developed in 1280 during the Yuan dynasty by Kuo Shou-ching 郭守敬 (1231–1316) to give more precise measurements of the length of a solar year. The Yuan system adopted precise decimal constants and counted from the solstice of December 1279 rather than an ancient epoch. Without the earlier sources of error, revision of the system became unnecessary.

The Annual Difference was a constant used to compensate for the slight difference between the tropical or "solar" year (the time it takes the sun moving along the ecliptic to pass the same point twice, for instance, the interval between two winter solstices) and the sidereal year (the time it takes for the sun to line up twice with the same star, related to the celestial equator). Functionally (but only functionally), the Annual Difference corresponds to the precession of the equinoxes in Western astronomy. It first appeared in the Yuan system because the latter used what roughly amounts to spherical trigonometry, and thus had to deal in new ways with the discrepancy between motion along the equator and that along the ecliptic of the celestial sphere.

Candidates were then reminded that the celestial orbits were invisible and could be known only through phenomena such as conjunctions of the sun and moon, and asked a fourth part of the policy question: Why do solar eclipses recorded in the *Documents Classic*, the *Poetry Classic*, and *Spring and Autumn Annals* occur only on the first day of the month (by definition, the day of conjunction), while those set down from the Han dynasty on sometimes fall on the last day of the month? Records of eclipses not on the first day, despite the impression the examiners gave, did not postdate the Han, and many such records in Han sources refer to pre-Han eclipses. The reason is, first, that times associated with records in the Classics were not precise and, second, that until the Han neither observation nor calculation could yield precise timings of either conjunctions (the true new moon) or eclipses.

The fifth part of the policy question had to do with various proposals to alter the Yuan-Ming system because, like its predecessors, it was bound

27. *Huang-Ming ts'e-heng*, 1.19b–23a. See the detailed explanation in Sivin, "Cosmos and Computation," pp. 1–73, esp. pp. 12, 19. The candidate gave the period from the epoch as 144,511 years, probably due to a difference in endpoint rather than an error.

eventually to show accreted errors. "Of those who have discoursed on the calendar from antiquity to today, some say that there can be a determinate method [that is, a theory]. Some deny it on grounds that all one can do is periodically adduce observations to keep the computational system in accord with the phenomena. But if there actually can be a determinate method, it will always be possible to make predictions on the basis of constants, and techniques of observation to track the orbits are not [comparably] dependable. These arguments are all recorded in historical documents and are open to scrutiny."[28] The question, unlike the preceding four, had no correct answer. But it raised a perennial issue of Chinese astronomy, the tension between prediction based on continual observation, interpolation, and extrapolation, on the one hand, and, on the other, forecasts derived from rigorous mathematical techniques that did not require continual infusions of new data.[29]

One of the answers (by an unknown candidate but one of the highest finishers) focused immediately on the chief theoretical question. His response was impeccable from the literary point of view, formally stereotyped, and astronomically well informed. It is unclear, however, how many other such essays were as knowledgeable. The candidate began with a neat antithesis: Because there has been no change in the sky as we have known it from antiquity on, "I don't believe the declaration that there is no definite method" (曰無一定之法，吾不信也). Because of the undeniable irregularities in the orbital motions of the sun, moon, and planets, "I don't believe the declaration that there is a definite method" (曰有一定之法，吾不信也). He quoted verbatim the early Classics enumerated in the question, with glosses for each difficult word, to summarize what was known about the astronomy of antiquity, and he gave precise Han dynasty values for the Day Divisor and Accumulated Years. He also quoted historical critiques, including a maxim of the astronomer-geographer and classicist Tu Yü 杜預 (222–84): "Creating an astronomical system is a matter of conforming celestial phenomena [lit., 'the sky'] to find what [techniques] accord with them, not forcing accord (*wei-ho* 為合) so that predictions will be validated [by phenomena]." This exhibition of learning lead him naturally to his answer. "The orbits in the sky are not uniform, but astronomy [between Han and Sung] was restricted to set methods, because they were not aware of 'conforming to the sky to find what accords with it' (*shun-t'ien i ch'iu-ho* 順天以求合)."[30]

28. *Huang-Ming ts'e-heng,* 1.19a.

29. See the discussion of a particular crisis in Sivin, "Cosmos and Computation," p. 63, which speaks of "a commitment to continued observation, which Chinese calendrical astronomy was dedicated to transcend."

30. For his source see *Yuan-shih,* 52.1130–31, where Yü the Great and his successors are identified as precursors of the Yuan technique.



The answer to the second question is extraordinary in its recall of techniques and its ability to relate them. The response noted that the discrepancy was too small to be noted in antiquity. Although the Season-Granting system was the first to master it, a succession of astronomers from Yü Hsi 虞喜 (ca. A.D. early fourth century) on worked out simple empirical corrections that minimized precessional error. The candidate listed them and accurately summarized the techniques used by each. It took considerable understanding to see that these adjustments anticipated the Annual Difference; the candidate had obviously digested the account in the *Yuan History* of the Season-Granting system's predecessors.[31] He finally gave a succinct account of the Yuan innovation, closing with a literary conceit of his own: "In antiquity there was no intercalation of months until the time of [Emperor] Yao. Once [this practice] was established, the calendrical intervals of the seasons were regularized. In antiquity there was no Annual Difference until the time of Yü Hsi and his colleagues. Once it was established, the anomalous motions of the Seven Governors [the sun, moon, and five planets] became clear. Both [techniques] have become so interdependently useful that neither can be dispensed with."[32]

The combined responses to the third and fourth questions were similar. The author did not delve into principles but rather summarized successive improvements in determining the time of conjunction and eclipse. These improvements had combined with the substitution of true (actual and varying) solar and lunar motions for mean (average) motions to yield precision that could avoid error for more than 150 years. The candidate did not entirely depend on the account in the *Yuan History,* citing changes in the Ming period.[33]

In the final question the candidate made short work of current debates: "In my ignorant opinion, if you have the right people [to manage astronomical computation, discussion of cumulative errors] is permissible; if not, I fear that superficial discussion is best not permitted." Here he explicitly cited Li Ch'ien's 李謙 report included in the *Yuan History,* which made it clear that the Season-Granting system had been meticulously tested against records covering more than two millennia of phenomena and extending even beyond the borders of China. The author concluded, not altogether correctly, that remarks about the limits of its precision must be badly informed. Periodic divergences in the Annual Difference did not compromise the basic reliability of the computational system, so long as errors when no longer negligible were corrected by observation. He even

31. *Huang-Ming ts'e-heng,* 1.21a–21b.

32. Ibid., 1.21a–21b.

33. Ibid., 1.21b–22a.

noted that the refined instruments used in the Yuan calendar reform were fully documented, and could be reconstructed for this purpose (he was unaware that they had in fact been reconstructed in 1421 and were extant).[34] Writing a generation before the arrival of the Jesuits, the candidate recommended reviving the instruments bequeathed to the astronomical bureau since Kuo Shou-ching's reforms of 1280.[35]

This remarkable call for calendar reform and rebuilding instruments some fifty years before the arrival of the Jesuits was just as quickly framed in orthodox Ch'eng-Chu *Tao-hsueh* rhetoric, however. The answer closed with a flourish, a quotation from Chu Hsi that, however irrelevant to mathematical astronomy, moved the focus back to the imperial throne: "The kingly ruler uses his virtue to govern, and uses worthy [subordinates] to get rid of treacherous ones. If he is able to make yang predominant so as to ensure its victory over yin, then the [yin] moon will avoid the [yang] sun, so there can be no eclipses." The candidate conventionally declared that "as a rustic scholar of the lowest sort who has never received transmission from a [qualified] teacher, I merely set out what has been recorded in the Classics and Histories, without daring to assert that it is true."[36]

The candidate's ability to recall technical data from ancient sources and quote them accurately from memory would be impressive in a historian of Chinese astronomy today. In addition, the candidate's appeal to Yuan instrumentation as a corrective measure in the sixteenth century suggests that the policy question had been formulated as a way for the dynasty to get some response about what to do with the Ming Grand Concordance (*Ta-t'ung* 大統) Calendar that was now increasingly out of whack. Accordingly, the candidate argued that the dynasty should rely on expert instrumentation to reform the calendar. Rather than technical manuals, however, the candidate cited dynastic histories as his sources of information, which indicates that what the examiners also expected was knowledge of the role of the calendar in political life and awareness of the difficulties in keeping the official calendar accurate and up-to-date.

And it is clear that the examiners did not grade this essay so high

34. See the illustration of one of them in Sivin, "Science and Medicine in Chinese History," in Paul S. Ropp, ed., *Heritage of China: Contemporary Perspectives on Chinese Civilization* (Berkeley: University of California Press, 1990), pp. 164–96, esp., p. 175; and for a detailed account, P'an Nai 潘鼐, "Nan-ching te liang-t'ai ku-tai ts'e-t'ien i-ch'i—Ming chih hun-i ho chien-i" 南京的兩台古代測天儀器—明制渾儀和簡儀 (Nanking's two ancient instruments for astronomical observation, the armillary sphere and the simplified instrument of the Ming), *Wen-wu* 文物 7 (1975): 84–89.

35. *Huang-Ming ts'e-heng*, 1.23a.

36. Ibid., 1.22b–23a.



solely because of the details in its answers. They were not only astronomically informed but high-minded, unimpeachably orthodox (thus the citation from Chu Hsi), compounded of conventional sentiments culled from broad reading, and estimable for their rhetorical structure and balance. They represented, in other words, astronomical counterparts of what made a good essay on morality or governance. The fact that there were astronomical counterparts adds to the evidence that has been accumulating for decades to prove that the humanistic bias of imperial orthodoxy, as it affected the educations of civil service careerists, did not effectively discourage knowledge of science, medicine, technology, statistics, finance, and so on. To the contrary, passing this 1525 civil examination demanded thorough study and general recall of highly technical material.

### *Celestial Counterparts*

Next we turn to a representative policy question on "celestial luminaries as counterparts to matters in the human world" (*t'ien-hsiang* 天象) that appeared on the 1561 Che-chiang provincial examination.[37] Initially, the examiners queried candidates about the order given by the sage-king Yao to his ministers Hsi 羲 and Ho 和 to delineate the motion of the sun, moon, planets, and stars and thereby clearly establish the seasons. In later times, the examiners continued, men relied on the celestial counterparts (*hsiang-wei* 象緯) to predict the future. Subsequently, the official post of Grand Historian was established to observe patterns in the heavens (*t'ien-wen* 天文) and record the seasons. The examiners asked why the astrological and political functions of the Grand Historian had been separated.[38]

Again, we do not know the name of the high-ranking candidate whose policy answer was chosen, but what is interesting about the 1561 essay that survives is the equation between astrological "regularities" (*shu* 數) and heavenly principles (*li* 理) that the candidate made in his opening statement: "Regularities capture the wonder of revolving changes [in the heavens]. They are equivalent to principles. That which fathoms the wonder of the changes is the mind. The record of the changes themselves is not [enough]. Principles avail themselves of regularities. The mind is completed in principles."[39]

37. Typically such policy questions were titled "celestial portents" (*t'ien-wen* 天文) when they appeared. See, for example, policy questions from the 1573 Hu-kuang and the 1603 Fu-chien provincial examinations in *Huang-Ming ts'e-heng*, 4.49a, and 21.7a. See also Edward Schafer, *Pacing the Void: T'ang Approaches to the Stars* (Berkeley: University of California Press, 1977), pp. 63ff.

38. *Huang-Ming ts'e-heng*, 2.54a.

39. Ibid., 2.54a–54b.