A LUNAR-SOLAR YEAR CALENDAR STICK FROM NORTH AMERICA

Alexander Marshack

The microscopic and sequential analysis of an early nineteenth-century American Indian calendar stick documents the notation of a precise, non-arithmetic, observational lunar year of twelve months with the evidence for added, subsidiary months suggesting the use of a thirteenth intercalary month every three years to bring the calendar into phase with the solar tropical year. The calendar stick is the most complex astronomical-calendric, problem-solving device known from the Americas outside of the high Mesoamerican and Andean Civilizations, but it is not derived from these late traditions. The analysis suggests the presence of an underlying observational conceptual base that may have come into the Americas from Asia.

Modern archaeoastronomy, since its sudden beginnings in the well-publicized controversies over Stonehenge and the megalithic alignments in neolithic Europe (Hawkins 1965; Thom 1967, 1971), has focused primarily on the measurable and quantifiable aspects of prehistoric and protohistoric astronomical structural alignments both in the Old World and the New (Aveni 1975, 1977; Aveni and Urton 1982; Urton 1981; Williamson 1981). Accompanying these increasingly sophisticated studies of the structural alignments to astronomical rising and setting points on the horizon or to a point in the sky have been a range of subsidiary attempts to interpret astronomical images and symbols in Old and New World rock art and general iconography, with still broader attempts to unravel the complexity of the astronomical references in rituals, ceremonies, and lore and myth among the world's cultures. The field has expanded so rapidly that the established journals in anthropology, archaeology, and the history of science have not been able to handle the burgeoning research; and two professional journals in archaeoastronomy have begun to appear regularly, one in the United States (*Archaeoastronomy*) and the other in England (*Archaeoastronomy,* annual issue of the *Journal for the History of Astronomy*).

The recent surge in archaeoastronomy and ethnoastronomy has roots that go back almost a century to Frazer's pioneering efforts in *The Golden Bough* (1890) to use ancient literary sources to reconstruct some of the uses that periodic time played in the structuring of social and ritual process and myth in the maintenance of cultural continuity. Studies in cultural time frames and astronomical reference carried out in the century that followed have contributed some theoretical depth to our understanding of the central role that a knowledge of time and periodicity play in culture and adaptation. My own research has attempted to document the beginnings of such cultural developments going back to the cultures of the European Upper Paleolithic (Marshack 1970, 1972a, 1972b, 1974, 1975, 1979, 1984b) and to indicate their relevance to developments that followed with the end of the Ice Age, ca. 10,000 B.C. The contemporary subdisciplines of ecological archaeology and anthropology have indirectly contributed to these studies of the relevance of conceptual time in cultural process by investigating the adaptive interface between the practical, material subsistence activities of a culture and the natural, seasonal periodicities of flora and fauna. However, in their documentation of seasonal adaptive strategies in various cultures, these disciplines have so far avoided consideration of the *historical* development of the conceptual models of time and periodicity

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that exist in different cultures, which in large part define the level of adaptive capacity and cultural complexity extant in those cultures. Despite the vast accumulation of relevant data there has been no consistent theoretical effort to investigate the role that a changing and accumulating knowledge of time and periodicity has played in the diverse development of cultures.

The First International Conference on Ethnoastronomy, in which archaeoastronomy, anthropology, and the history of science joined in an interdisciplinary effort to explore the extraordinary variety and range of astronomical knowledge and the uses of periodic time by the world's cultures, was held in Washington, D.C. in 1983. The conference touched on the astronomical knowledge, use, and rituals of cultures in every part of the world and every period, from cultures at the hunting-gathering stage such as the Australian aboriginal or the hunter-gatherers of the European Upper Paleolithic to the high civilizations. The present paper, prepared for that conference, presents the internal analysis of the most complex astronomical-calendric artifact to come from any of the traditional North American Indian cultures. The artifact represents a far more complex *system* of astronomical and calendric reference than is apparent in the much publicized American Indian "medicine wheels" or solar solstitial alignments (Sofaer et al. 1979). The astronomical and calendric knowledge it documents may derive from the underlying cultural contents and lore brought into the Americas by early migrants from Asia.

NORTH AMERICAN INDIAN ASTRONOMY

In the nineteenth century ethnologists noted the presence among diverse North American Indian groups of what seemed to be a generalized lunar "calendar" consisting of named moons or months. The names, which differed with each tribe, described the seasonal phenomena or human activities occurring in a particular season and within a particular moon: "moon of the yellow leaf," "planting moon," "moon of the ripe corn" or the "rutting moon of bison or deer," "moon of the first rains," etc. Precisely this mode of naming lunar months for regional seasonal phenomena and human activities is documented among the non-agricultural reindeer hunting and herding peoples of the Siberian arctic and subarctic (Delaby 1968; Orlova 1966). There are also among these Siberian peoples, as among the American Indians, specialized "keepers of the calendar" who were in charge of maintaining the schedule of practical and ritual activities. Named lunar months describing the natural phenomena or activities in each existed also among the North American Eskimos before contact with the Christianized calendar (Boas 1884–1885, 1907; Rasmussen 1930). This mode of naming the lunar months for a *sequence* of culturally observed natural phenomena or human economic and ritual activity is not present among the peripheral and geographically isolated hunter-gatherers such as the San bushman of South Africa or the aboriginals of Australia. It is probably reasonable to assume that underlying elements of this observational naming and sequencing lore, as an adaptive, conceptual structuring mode, entered the Americas with diverse groups of Asian migrants as an aspect of traditional Asian hunter-gatherer practical knowledge and shamanistic practice.

There was at first a tendency to denigrate the non-arithmetic, non-scientific, and seemingly amorphous nature of these indigenous North American Indian "calendars." Dodge (1882) stated that "the 'moon' (or month) commences when the first faint streak of its crescent can be discovered in the west and lasts until the next one appears, but the *days* of the moon are *neither numbered nor named*" [emphasis added]. The ethnocentric comparison was, of course, not only to the quantified year of 365+ days, but also to the quantified month of 30–31 days and our contemporary structure of seven named and numbered days of the week. The impression left by such early descriptions was that of a lack of conceptual knowledge of the structure of the month and the structure and length of the year. The descriptive ethnological literature reported Indian "years" of 10, 11, 12 and even 13 and 14 months. At the same time, however, there began to appear a more complex picture. Ethnologists who lived with particular tribes and learned the language reported a surprising sequential complexity in the ritual and practical calendar of farming peoples such as the Zuni (Cushing 1941) and Hopi (Stephen 1936) in which both non-arithmetical lunar and solar observation played a part.

It has been one of the major contributions of the new archaeoastronomy that it has begun to document the presence of stone structures and alignments for precise solar solstitial observation not only among North American Indian farming groups but also among non-agricultural hunting-gathering peoples such as the Chumash Indians of the California coast (Hudson and Underhay 1978). Recent ethnoastronomical investigation has reported the presence of complex observational and non-arithmetic lunar-solar calendrics, maintained by specialized "skywatchers" and "calendar keepers" in the Siberian mode, for the Pueblo Indians of New Mexico (Ellis 1975), apparently representing a tradition going back to their Anasazi ancestors, ca. 1000 A.D., and not entirely derived from Mesoamerican influence.

How the sophisticated observational and arithmeticized astronomy and calendars of the "high" agricultural civilizations of Mesoamerica and the Andes might have been derived from such essentially non-arithmetic, observational practices has never been investigated or theoretically addressed, primarily because conceptual observational and record-keeping systems do not ordinarily become archaeological. The available evidence is always of systems that have achieved an end-product complexity and an evolved artifactual status. It has, however, been generally assumed—without presence of the early evidence—that centuries of cumulative record-keeping must have been involved in order to establish the synchronicity of and the arithmetic regularity in the long-range periodicities of lunar, solar, stellar, and planetary cycles. The nature of the non-arithmetical observational records that might be accumulated to lead to an arithmeticized astronomy and calendrics has not, except for my own studies, been investigated in the field of archaeoastronomy.

Fortunately, hints of American Indian calendric notation or record-keeping accompanying astronomical observation have appeared in the ethnographic literature. Cushing (1941) in the nineteenth century lived among the Zuni of New Mexico, learned their unique language, was initiated into the tribal priesthood, and described the specialized activity of the tribal calendar keepers and "skywatchers":

> Each morning . . . at dawn, the Sun Priest, followed by the Master Priest of the Bow . . . slowly approached a square tower and seated himself just inside . . . before a pillar sculptured with the face of the sun, the sacred hand, the morning star, and the new moon [the first crescent. A.M.] . . . . With prayer and sacred song (he awaited) the rising sun . . ." The priest waited for the "shadows of the solar monolith . . . (and) Thunder Mountain and the pillars of the gardens of the Zuni (to) lie along the same path . . . then the priest blesses, thanks, and exhorts his father, while the warrior guardian responds as he cuts the last notch in his pinewood calendar, and both hasten back to call from the housetop the glad tidings of the return of spring [1941:116–117].

Cushing reports, therefore, not only observation of sunrise along a structural alignment aimed at a point on the horizon, but accompanying notation on a calendar stick. The structural alignments in stone would remain long in the archaeological record and, like the "medicine wheels" and the Anasazi solar dagger at Fajada Butte, New Mexico (Sofaer et al. 1979), would be available for study and measurement, while the far more complex daily record and notation (the sequential accumulation of astronomical observations including problem-solving contents and strategies) would not and could not become part of the archaeological record. In addition, a priestly utilitarian device such as a calendar stick would not ordinarily find its way into ethnographic collections or be mentioned by average informants. It was a specialized and elitist tool. Yet it is probably from some form of combined observation and record-keeping of the type reported by Cushing that the calendric astronomical periodicities recognized by the high civilizations of Mesoamerica and the Andes would have been derived. The problem of a possible record-keeping that does not exist in the archaeological record holds also for the astronomical stone alignments of Megalithic Europe, since any notations or records kept on wood, like the Clogg almanacs of England (Brady 1812) and the Rune calendars of Scandinavia (Svärdsröm 1966)—used into historical times—would not become archaeological.

A handful of wooden calendar sticks from diverse North American Indian language groups have, fortunately, survived: from the Pima and Papago of the Uto-Aztecan language family and the Osage and Winnebago of the Siouan language family. The Zuni calendar stick mentioned by Cushing,

Figure 1. Chief Tshi-zun-hau-kau of the Winnebago Indians, Wisconsin, in a portrait painted in the 1820s. He carries an axe as a Warrior Chief and a calendar stick as a keeper of the tribal calendar (Mckenney 1838). The calendar stick documents a precise observational lunar year and includes sets of intercalary months to bring it into phase with the solar year.

from a still different language group, has not, to my knowledge, survived. None of the extant calendar sticks has previously been analyzed to determine the information and astronomical concepts they represent. My analysis indicates that such calendar sticks may be the most complex astronomical and problem-solving conceptual artifacts and devices available to North American Indian ethnology.

THE WINNEBAGO CALENDAR

In 1828 the Department of War in Washington, D.C. had a series of portraits painted of Indian chiefs with whom it had "treaty" relations. In one of these paintings (Figure 1), the Winnebago chief, Tshi-zun-hau-kau, is portrayed with three symbols of his status and authority, an ax in his left hand as a warrior,[1] a wooden calendar stick in his right hand as a non-curing ceremonial priest, and a pendant apparently indicating "treaty" ties with Washington. Tshi-zun-hau-kau, when the painting was made, was a member of a deputation that accompanied Nawkaw, the principal chief of the Winnebago, to Washington (McKenney 1838).

The calendar stick was retained in a Winnebago family into the twentieth century when it passed into the hands of a local collector and then to the Cranbrook Institute of Science in Michigan, situated across the lake from the Winnebago habitation area on the Western shore of Lake Michigan. The calendar was briefly, but inadequately, described in the Cranbrook Institute Bulletin (Merrill 1945), but has not otherwise been mentioned in the rapidly expanding archaeoastronomical literature of the New World. Analysis of the calendar was prepared for the first Conference on Ethnoastronomy (1983), as part of a cognitive comparative analysis of nineteenth century calendar sticks from the reindeer hunting and herding peoples of subarctic Siberia (1983b).

The calendar stick (Figure 2), made of hickory and 132 cm long, is highly polished and worn along its edges and is discolored with hand oils, indicating a rather long use and handling. It is about 13 mm × 13 mm and has four faces. It contains two years of lunar notation, each year divided into 6 "moons" or months. These months vary in length. Since the synodic, astronomical lunar month is 29½ days long, and a half day cannot be observed, and since weather may obscure observation, an *observational* and notated lunar month may vary in length from 28 to 32 days. There are two days of invisibility after the last crescent. These are the "zero" days that fall between the last crescent observed in the eastern sky at dawn and the first crescent observed in the western evening sky. This breakdown and variability is clearly indicated on the calendar stick.

The Winnebago lunar month as notated by Tshi-zun-hau-kau is broken down into three parts (Figure 3), usually of 10 plus 10 and a third part, which is of *variable* length, depending on the number of days to observation of the last crescent. This breakdown of the lunar month into three parts, covering the *periods* of waxing, full, and waning, is known from North American ethnology, although the discrete phases of the moon were recognized, named, and used. As we shall see, this tripartite division of the month was not arithmetical, but conceptual. The last crescent on the calendar stick is always made as an arc at an angle whose bow faces upward ( ). This last crescent is always followed by two days of invisibility, indicated by two long vertical strokes, which are appended to the smaller day marks (.!!.). These two strokes are followed by the first crescent of the new month, which is visible in the western sky at sunset as a fragile arc whose bow is aimed at the setting sun. This first crescent is depicted as a *horizontal* arc, facing downward ( ). Observationally, this crescent follows the sun downward as evening deepens.

Figure 4 is a detail on line A, indicating the marking of the last crescent of one month, the two days of invisibility, and the first crescent of the new month. The reading goes from right to left: ←!! .

Figure 5 is a detail from the six-month period immediately following, on Line B, in which the reading of crescents is in the opposite direction, from left to right: !!→. The lunar year of the two six-month periods on rows A–B proceeds, therefore, in a continuous, boustrophedon or serpentine manner. When the end of the first six months was reached, the stick was turned 90° and the reading was continued immediately below with the beginning of the next or seventh month (Figure 6a, Lines A–B).

The number of days in the year in rows A–B, from the day of first crescent of the first month to the day of first invisibility following the last crescent of the twelfth month, is 355, an almost precise notation of the astronomically correct 354 days in the synodic lunar year. All the crescents and days of invisibility fall in their astronomically correct positions. The actual number of days notated, however, is larger than 355, since the first month (Line A) contains 5 to 6 days *before* the first crescent of the first month. The full sum of notated days is 360–361. We therefore have a precisely

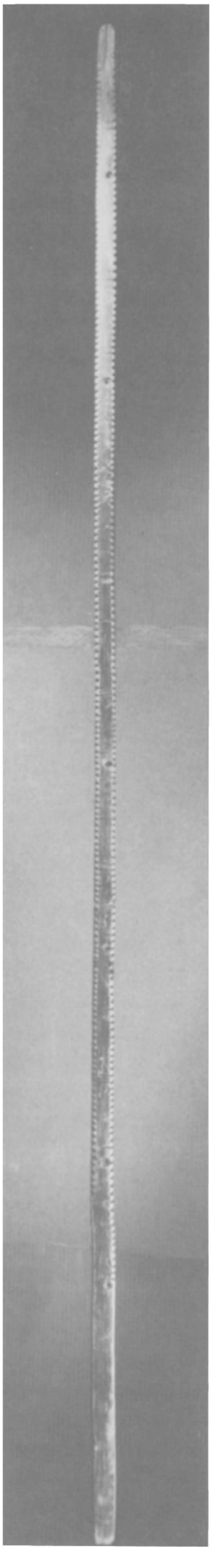

Figure 2. One face of the hickory calendar stick of Tshi-zun-hau-kau. It has four faces with six months of lunar notation incised on each edge. Added intercalary months are at the bottom.

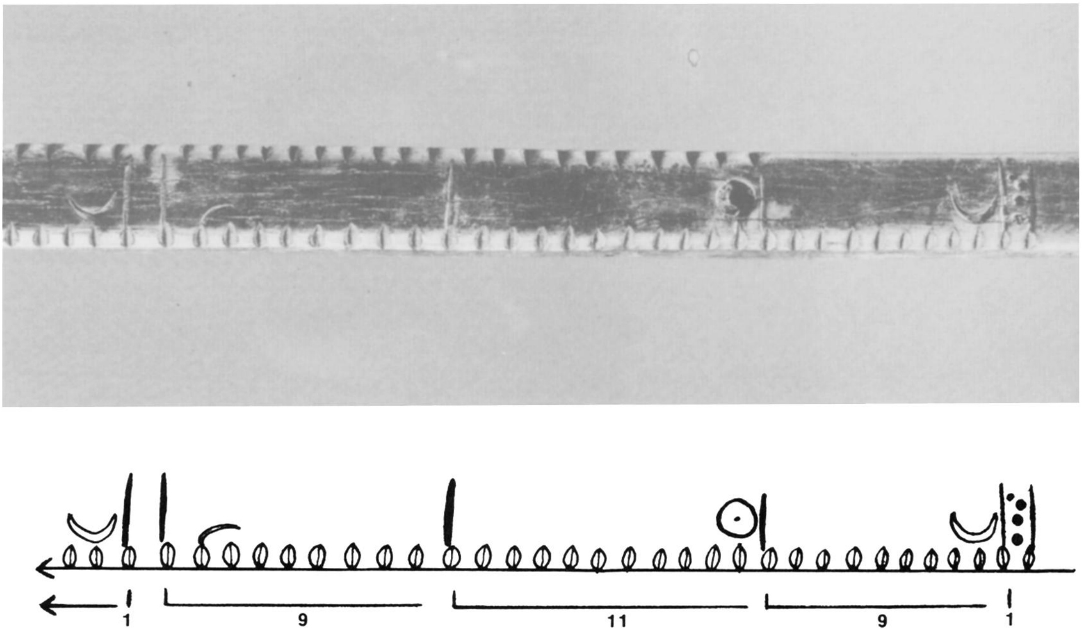

Figure 3a, b. The opening month of the second year of the Winnebago calendar stick (Line C), indicating a beginning of two days of invisibility, with dots accumulated within the two days, followed by a horizontal first crescent, a division of the month into three periods of waxing, full and waning, a terminal last crescent made at an angle and the beginning of the next month. From first crescent to last crescent is 28 days.

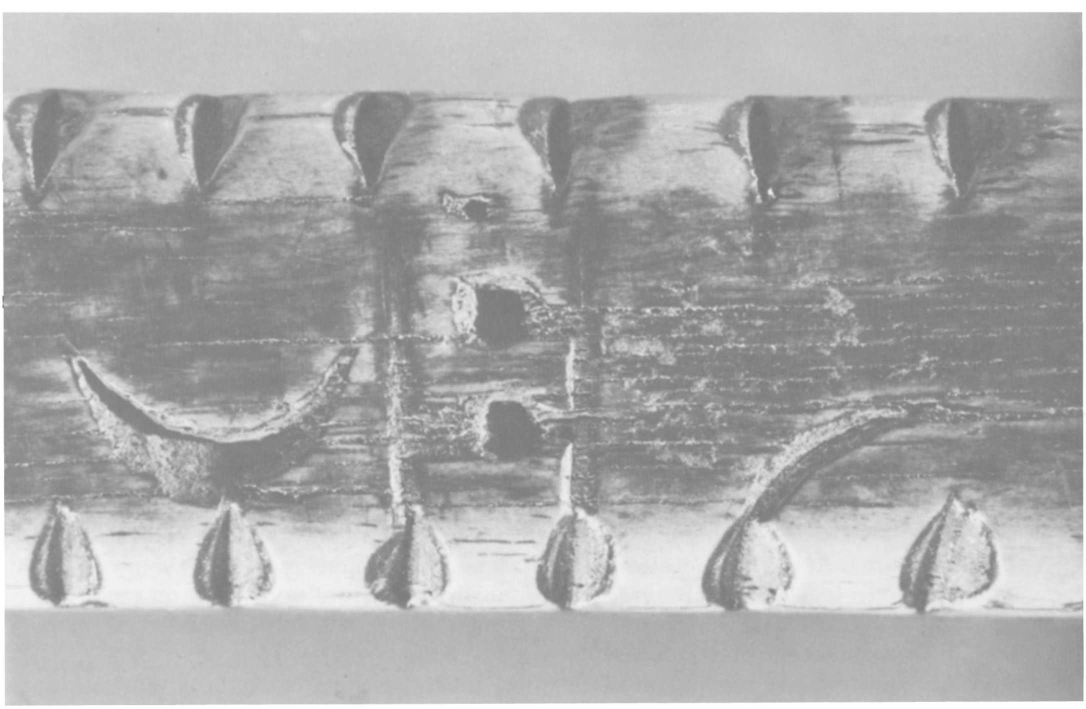

Figure 4. Detail of the mid-point in the six month period (Line A) showing the angled last crescent at right ending one month, the two days of invisibility marked internally by dots made by different points and pressures and presumably at different times, with the horizontal first crescent at left. The signs of the crescents and days of invisibility are above their observationally correct small day marks.

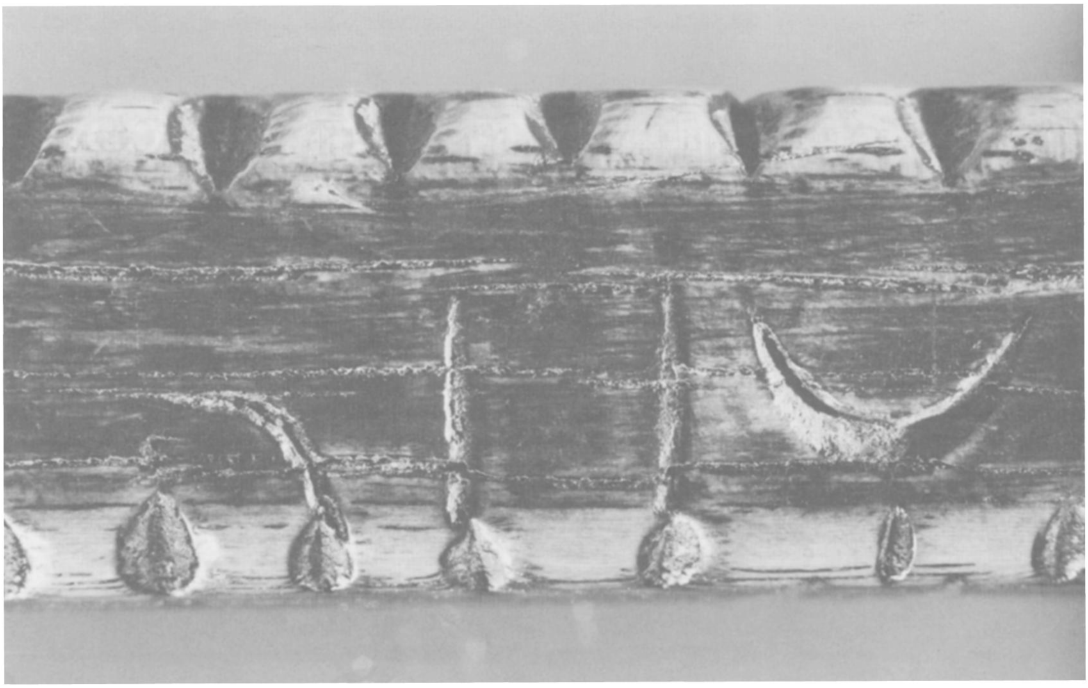

Figure 5. Detail of the ending of one month (Line B), indicating a reversed order of reading. The angled last crescent, at left, followed by two days of invisibility and the horizontal first crescent at right. Reading is from left to right.

notated observational lunar year that apparently contains a *waiting* period at one end. We look at the reasons below.

Placing the notation against an astronomically correct lunar model (Figure 6) indicates the presence of a number of marking, cueing, and discriminating strategies by the engraver. The days of invisibility, as zero days of no observation, act as terminating and beginning points for the true observational month, encompassed by the crescents. Double marks also begin the first half year, terminate the half year, begin the second half year, and terminate the twelve months. At the beginning of the first month (Line A) and the beginning of the seventh month (Line B), these double marks are apparently not "counted," or observed. Between months six and seven of Lines A–B they are, in fact, redundant. These "zero" days therefore serve visually to make a reading of the months, and their beginnings and endings, easier. Cueing and "reading" strategies occur at other points in the notation. Midway in each month there is a circle. While the days of the crescents and invisibility fall precisely on the astronomically correct day, with a variation at most of one day, the circles have a seemingly random placement in relation to the correct day of the full moon, often falling three or four days on either side of full. These circles, therefore, mark not the day but the *period* of the full moon within the tripartite division of the month into waxing, full, and waning. In working with the stick I realized that in order to locate a particular month one first counted to the proper "full moon" circle and then located oneself in relation to the double lines of invisibility on each side. It was almost impossible to locate oneself quickly by a use of the subsections of the month or by a use only of the finely engraved crescents and lines of invisibility.

There are other cueing and marking strategies that make a reading of the accumulating lunar sequence and periods easier. At the end of each subset in the tripartite division of the month there is a long stroke terminating that set, making the accumulation of subsets easier to discriminate. The original museum description of the stick suggested that the sets provided evidence of a counting by decades or tens. However a breakdown of the year indicates that while a counting capacity by tens

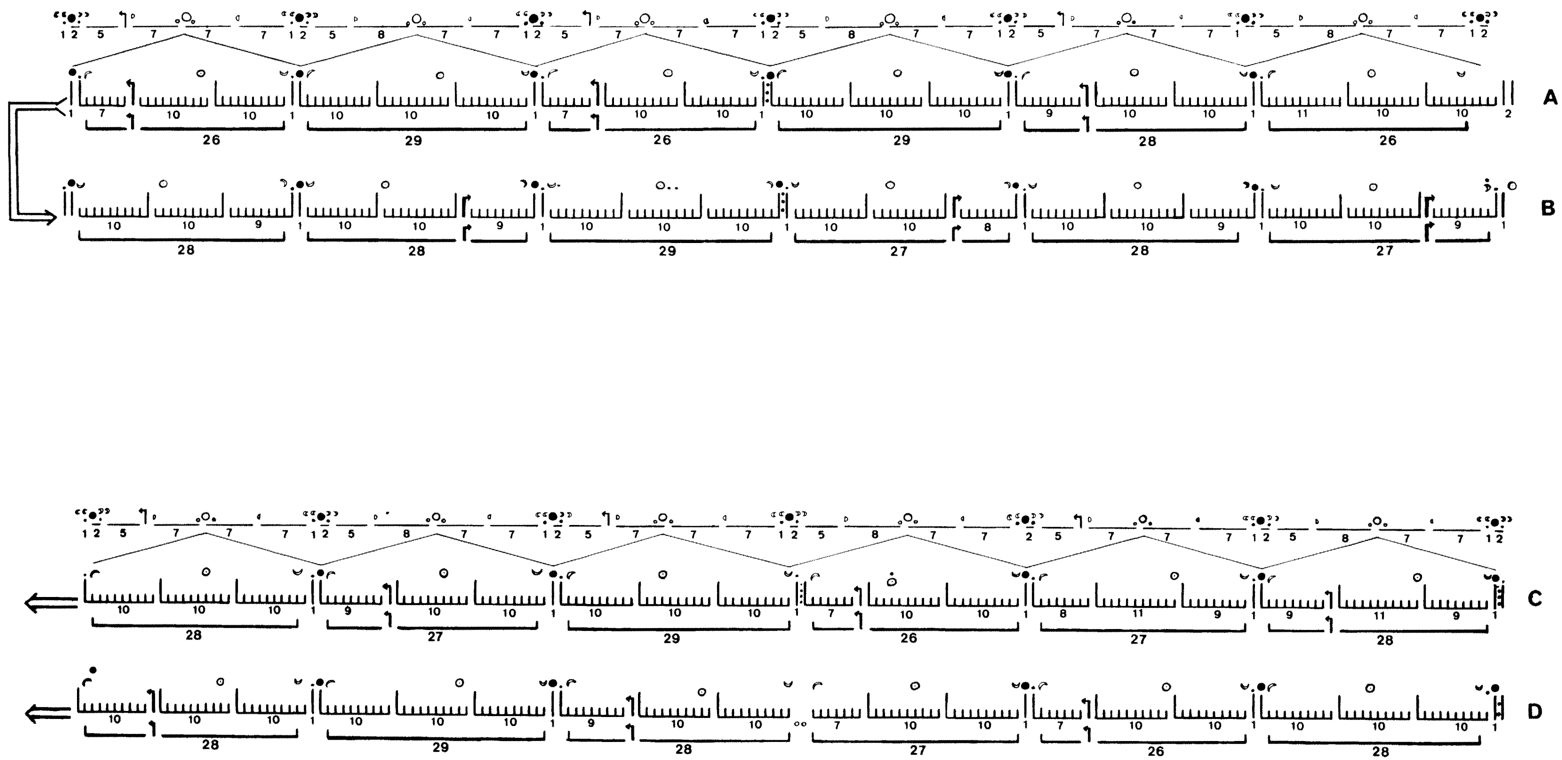

Figure 6a, b. The two observational lunar years of the Winnebago calendar stick against an astronomically correct lunar model, indicating the differences in the two years. All the crescents and days of invisibility fall at their correct observational points, except for the last crescent of the last year (Line D). To indicate the astronomically correct placement, indicative dots have been added *above* the vertical lines marking the days of invisibility. All other dots within the year were made by Tshi-zun-hau-kau.

was probably present, the months and subsets were not accumulated as continuous sequences of 10s or as arithmetical sums. The breakdown of the first year (Lines A–B), gives us a reading of: 10+10+11+1 (32); 10+10+9+1 (30); 10+10+10+1 (31); 10+10+7+1 (28); 10+10+10+1 (31); 10+10+7+1 (28); 10+10+9+1 (30); 10+10+9+1 (30); 10+10+10+1 (31); 10+10+8+1 (29); 10+10+9+1 (30); 10+10+9+1 (30). The sum of marked days is 360. As suggested earlier, if we delete the five days before the first crescent of the first month we get 355 days. If we delete the second day of invisibility at the end of the twelfth month we get 354 days, precisely one lunar year. It must be stressed that these *analytic* sums were not arithmetic counts for the engraver.

The internal analysis provides other evidence that we are dealing with an essentially observational, non-arithmetic, lunar month. The number of notated days in the first year from the first crescent to the last crescent of each month, gives us a variable sequence of: 26-28-29-26-29-26-28-28-29-27-28-27 (Figure 6a:A–B). This is the way that an observational, but not an arithmetic, sequence of lunar months would be marked.

This observational calendar stick was the structural frame upon which a number of other astronomical and phenomenological or cultural observations were made. The evidence is present at different analytic levels and points.

At the end of the third month or the beginning of the fourth, within the two "zero" days of invisibility and in the middle of the first six month period (Line A), there are three incised dots (Figure 4). Unlike the day marks, which are incised along the edges and show a basic similarity, these dots possess a variability that suggests that they may have been added or accumulated one at a time, during the period of the calendar's use (see also Figure 7). Six months later, after 178 days, between the end of the ninth and the beginning of the tenth month, and once again in the middle of a six-month period (Line B), there is a similar marking within the period of invisibility. The original description of the calendar stick (Merrill 1945) suggests the possibility of an astronomical conjunction at these points, or a sighting of Venus.[2] However, the sum of 178 represents half a lunar year and does not seem related to other periodicities. This mode of marking *between* the months suggests that either before or after the last crescent of the third and ninth months, there may have been an awaited or an observed solstitial or equinoctial observation. Among the American Indians solar observations were often made within particular named months, and a limited number of days was then counted to the next lunar phase for the proper ritual (McCluskey 1977).

It is therefore possible that the lunar year (Line A) began with the first crescent that occurred a number of days after a solar observation. If we tentatively assume that a year began, as it does among many Siberian reindeer hunting and herding groups and among some American Indian groups, in the autumn or the beginning of "winter," say with the equinoctial lunar month of the "harvest moon," the time also of the yellow leaf and the rut, then these two mid-point periods with their dot marking might indicate the place of an awaited coming or just observed winter and summer solstitial observation. With such an assumption, the beginning of the year (Line A) some five or six days before the observed first crescent might indicate the number of days from an equinoctial observation to the first crescent and the beginning of the lunar year. The engraving of the calendar stick may thus have begun with this oversized "month."

The evidence for solar observation in the Winnebago calendar comes at a number of other points. The count of the notated days from the beginning of the year (Line A) to the dot marking in the days of invisibility between the third and fourth month is 93 days, suggesting that a winter solstitial observation may have occurred in the *third* lunar month, some five or six days before the first crescent of the fourth month. This would place the summer solstitial observation on the next row (Line B), six months later and within the ninth month.

Following the first crescent of the ninth month (Figure 8), there is a dot, perhaps representing a ritual observance at that point. Next to the "full moon" circle in mid-ninth month there are two engraved dots (Figure 8), perhaps representing the period of summer solstitial ritual obervation in that period. Ellis (1975) reports that among the Pima of Arizona, a Uto-Aztecan language group, "only one symbol was consistently employed by all the Pima calendar keepers and always for the same event: a dot which specifically referred to their major ceremony . . . one may wonder whether this dot could have been an abbreviation for the sun symbol" (1975:61). The last crescent of the

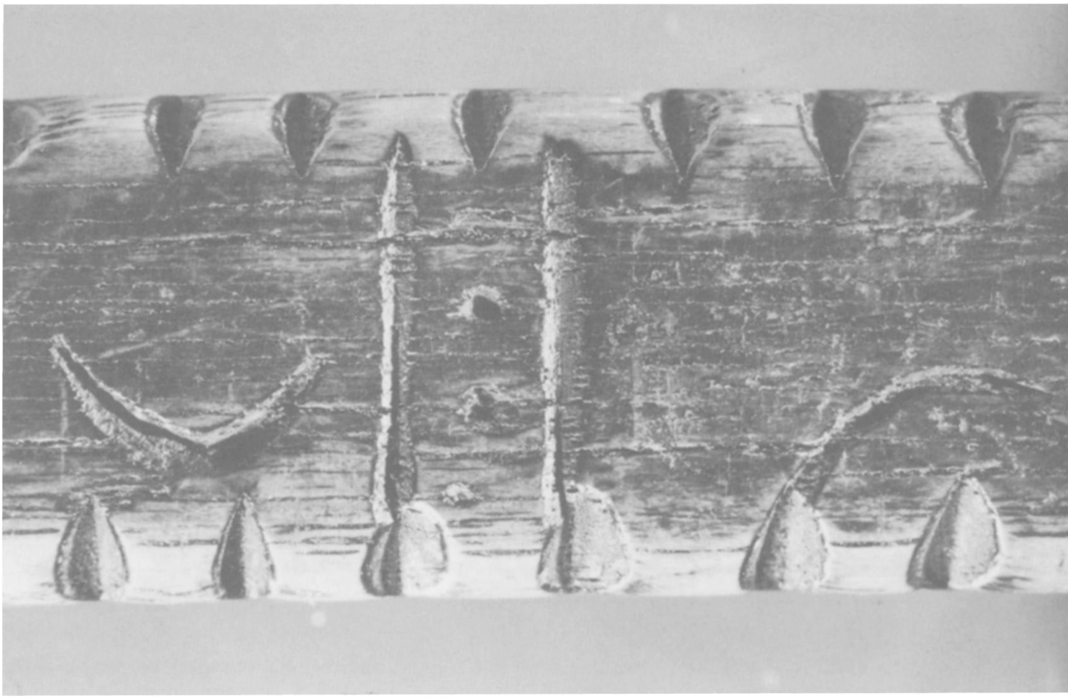

Figure 7. Detail from Line C. The last crescent is at right, followed by two days of invisibility containing four dots between the two lines, made by different points and pressures, suggesting an accumulation over a period of time. Compare these interior dots with those in Figure 4.

twelfth month (Line B) has a dot above it, suggesting an observation or ritual at the end of that lunar year. McCluskey (1977) reports on the counting of days from a solar observation to the next lunar phase or period, a first crescent or full moon, for the relevant ritual activity. The suggestion for the presence of a lunar-solar observational notation derives, therefore, from an internal analysis of the notated year and from ethnographic data. Ellis (1975:82), for instance, reports that among Pueblo Indians "the watchers for the winter solstice are the War Priest and the head War Captain who, each evening, note the place of sunset and keep track of the appearance of the moon," recalling both the Priest of the Bow reported by Cushing who kept a notation for the Zuni solstitial ritual and the symbolic war axe in the hand of the Winnebago Chief, Tshi-zun-hau-kau.

THE ENGRAVED SECOND LUNAR YEAR

The second lunar year on the Winnebago calendar stick (Lines C–D) is made in the same mode and with a similar use of cueing marks and signs. There is a similar use of the last crescent, days of invisibility, and first crescent (Figure 6b). However, to differentiate this year visually from the other, the creator of the calendar for this year marked it not in a boustrephedon or serpentine manner, but in the only alternative mode possible, from right to left for both lines. This is evident in the order of reading of the images, last crescent, invisibility, and first crescent, reading right to left, a direction that does not reverse on Line D.

Holding the calendar stick in hand, one quickly learns to separate the two years by this visual difference. There are other differences between the two years. Each six-month period of Lines C and D begins with two days of invisibility (Figure 9) that are marked internally with dots, suggesting that a solar, perhaps equinoctial observation occurred in the lunar month preceding the first crescent that opens each of these six-month periods. Additionally, in the middle of the first six-month period

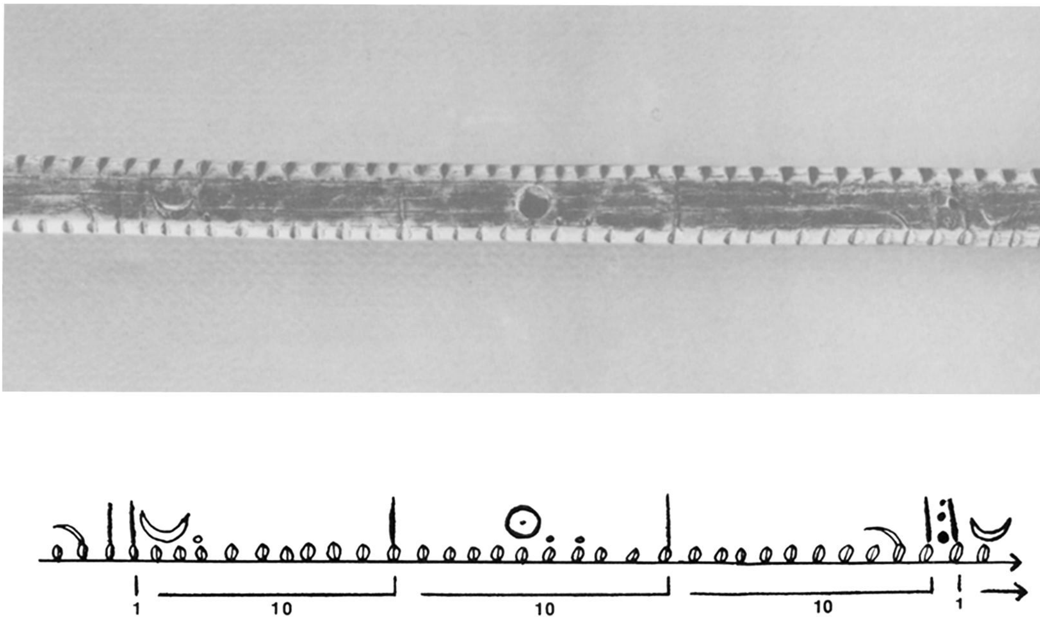

Figure 8a, b. The ninth month (Line B), reading from left to right, indicating a dot after the first crescent and two dots after the "full moon" sign in mid-month. The days of invisibility between the ninth and tenth months, at right, have three dots made by different points, apparently accumulated during the calendar stick's use.

between months three and four (Line C), within the days of invisibility, we once again have an accumulation of dots, suggesting, as before, a solar observation in the preceding third month. The "full moon" circle of this third month has a dot incised above it (Figure 10), suggesting that it may have been a day of relevant ritual for the solar observation in that month.

The months in this year have the same tripartite division of approximately 10 plus 10 with a variable third period whose length is dependent on the number of days to an observation of the last crescent in the eastern dawn sky. The reading for this year is: 9+11+9+1 (30); 9+11+8+1 (29); 10+10+7+1 (28); 10+10+10+1 (31); 10+10+9+1 (30); 10+10+10+1 (31); 10+10+10+1 (31); 10+10+7+1 (28); 10+10+7 (27); 10+10+9+1 (30); 10+10+10+1 (31); 10+10+10 (30). The sum of marked days is 356 if one begins this year with the first crescent of the first month (Line C) and if one does not count the two "zero" days of invisibility that begin each six-month period. That this is the proper procedure is suggested by the fact that the first crescent of the seventh month, the first month on Line D, is marked over the *second* day, with the result that two days of invisibility have already been included at that point.

The count of days from first crescent to last crescent of each month is: 28-27-26-29-27-28-28-26-27-28-29-28, again indicating an observational, non-arithmetic month. The one true mismatch in the year comes in the final days of the twelfth month (Line D), where the last crescent appears three days after its supposedly correct observational point. If that crescent fell properly, we would have a lunar year, not of 356 days, but of 353–354 days. It is possible, therefore, that there was difficulty in obtaining an observation of the crescent due to cloud cover. Except for this terminal mismatch and the missing vertical days of invisibility between months 9 and 10 (Line D), the notation provides a perfect match for an observational, non-arithmetic lunar year.

The Winnebago calendar therefore has two visually differentiated lunar years. This poses an inherent astronomical and utilitarian problem. Since the synodic lunar year is approximately 11 days short of the solar year of 365¼ days, a sequence of two lunar years will accumulate some 22–

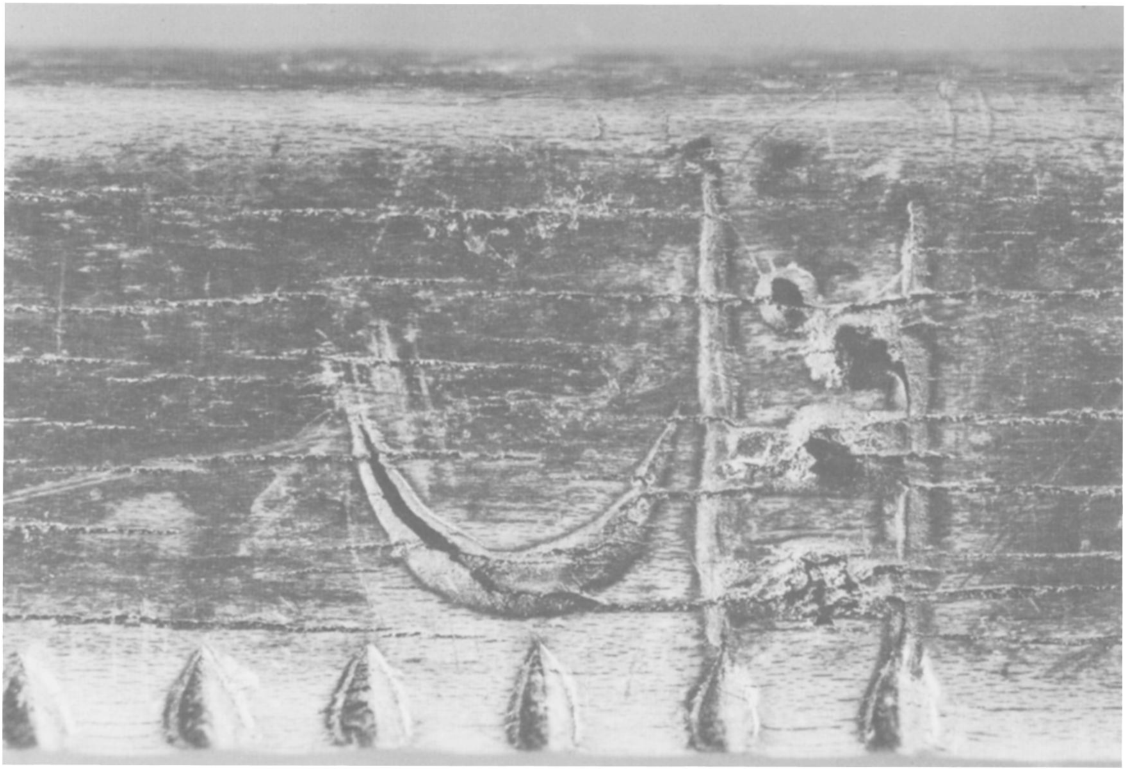

Figure 9. Detail of the opening of the first month of the second year (Line C), indicating two days of invisibility marked by four dots that are made by different tools and pressures, suggesting an accumulation during the period of the calendar's use.

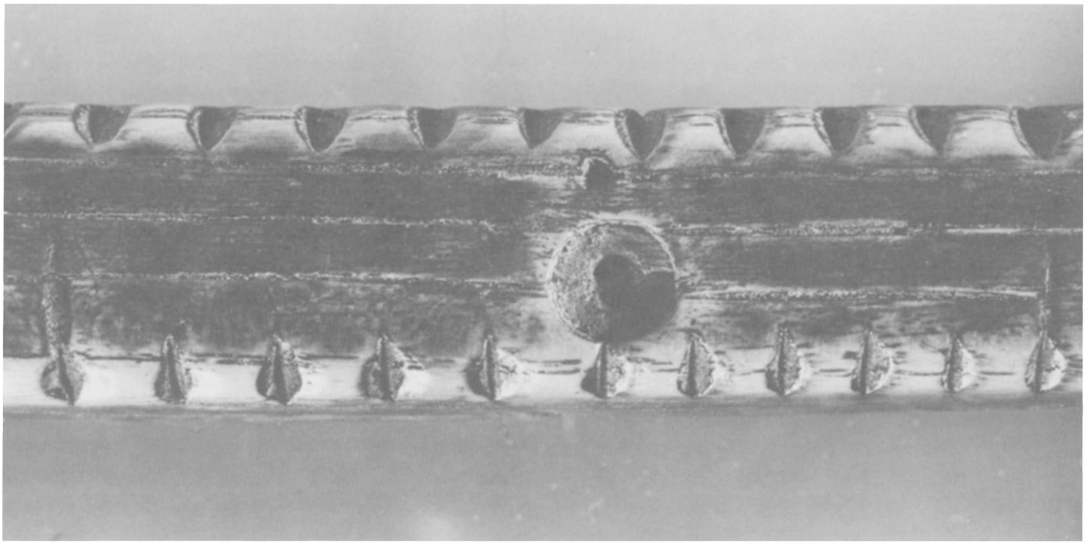

Figure 10. Detail of the dot above the "full moon" sign of the third month of the second year (Line C), suggesting a solar ritual observation at that point.

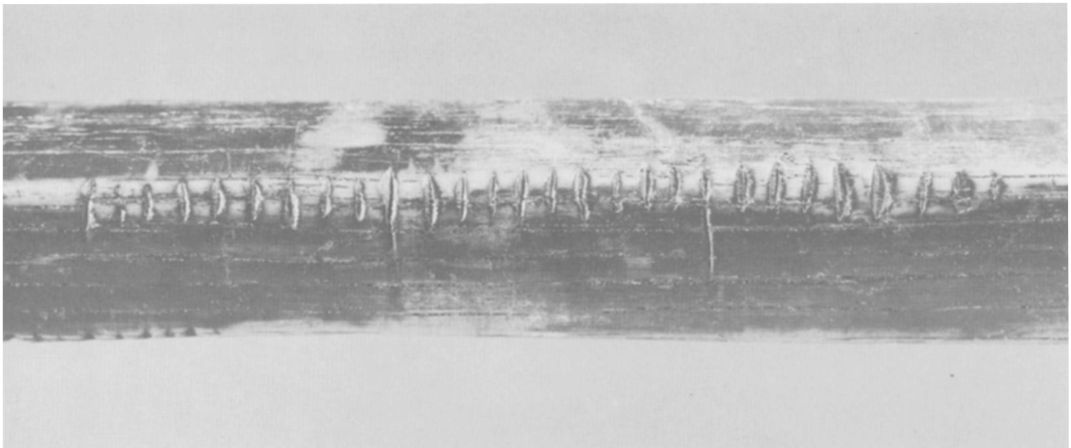

Figure 11. Detail of one of the subsidiary sets added at the bottom of the calendar stick, outside of the primary notation. It contains 28 marks, probably reading from left to right and is broken into three subsets of 10+10+8, as in the primary notation, indicating that this is an additional lunar month, an "intercalary" month intended to bring the primary notation into phase with the solar year.

23 days of divergence from the solstitial and equinoctial observational points. The calendar stick therefore has built into it a mismatch with the observational solar year, the functional year by which the seasonal cycles of flora and fauna and the practical cycles of hunting, gathering, and farming operate. It was with some satisfaction, therefore, that I found at the bottom of the Winnebago calendar stick, separated from the primary notation, sets of *subsidiary* marking that clearly were intended to function outside of the precise notation of the twelve-month lunar year.

At the bottom of the stick, along the edges, are three sets of small marks. One of these is structured as a lunar month, being divided into 10+10+8 (28) by long verticals, as in the main notation (Figure 11), indicating a lunar month from first crescent to last crescent. Two other edges at the bottom of the stick have unstructured sets of 23 and 27 marks (Figures 12, 13). In addition to these sets of small day marks there are two sets each of three larger symbolic marks (ııı) (Figures 13, 14).

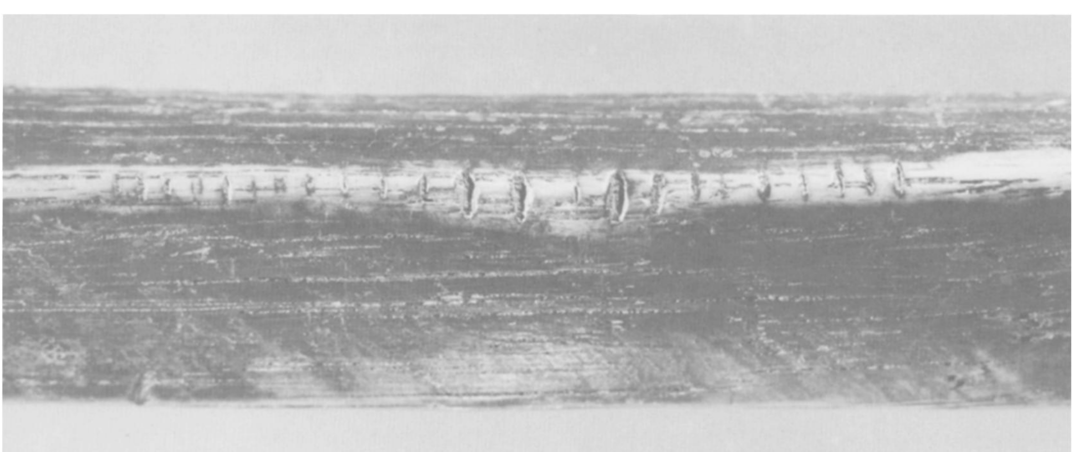

Figure 12. Detail of another set of subsidiary marks at the bottom of the calendar stick, containing 23 marks, made over a period of time by different points and pressures, suggesting a period of accumulation and waiting.

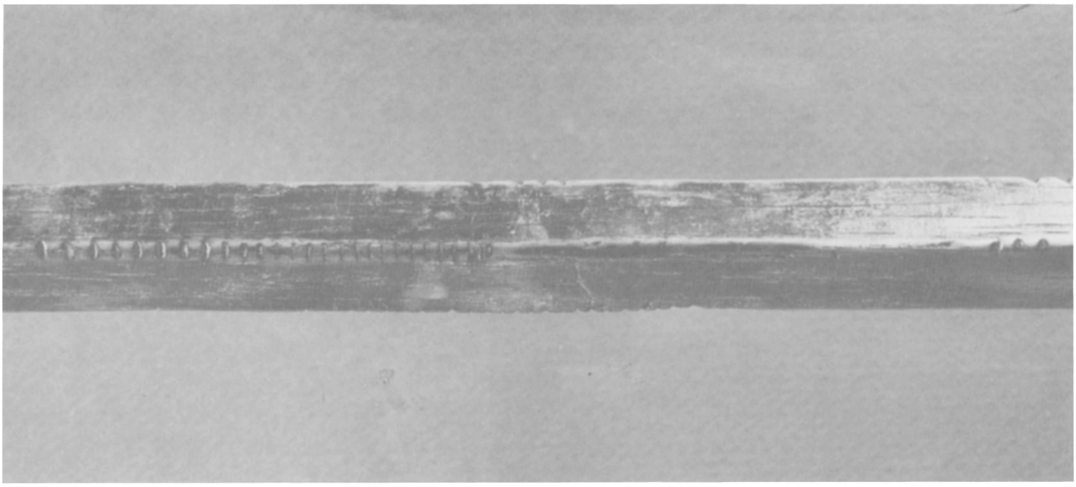

Figure 13. Detail of the third set of subsidiary marks at the bottom of the stick, containing 27 marks, with an additional set of three larger, separated marks at far right, apparently representing a count not of days, but of years.

Since the two lunar years are rigidly self-contained, I assume that these subsidiary sets (Figure 15) might be the necessary intercalary lunar months that would keep a twelve-month lunar year in phase with the functional solar year. The addition of one lunar month every three years would maintain a non-arithmetic lunar calendar in phase with the solar year. A model of how this would work, using all the notated sets on the calendar stick (Figure 16) suggested a possible answer to the long beginning of the first year (Line A) with its five or six days before the first crescent. A short intercalary month of some 23 days would fit at this point.

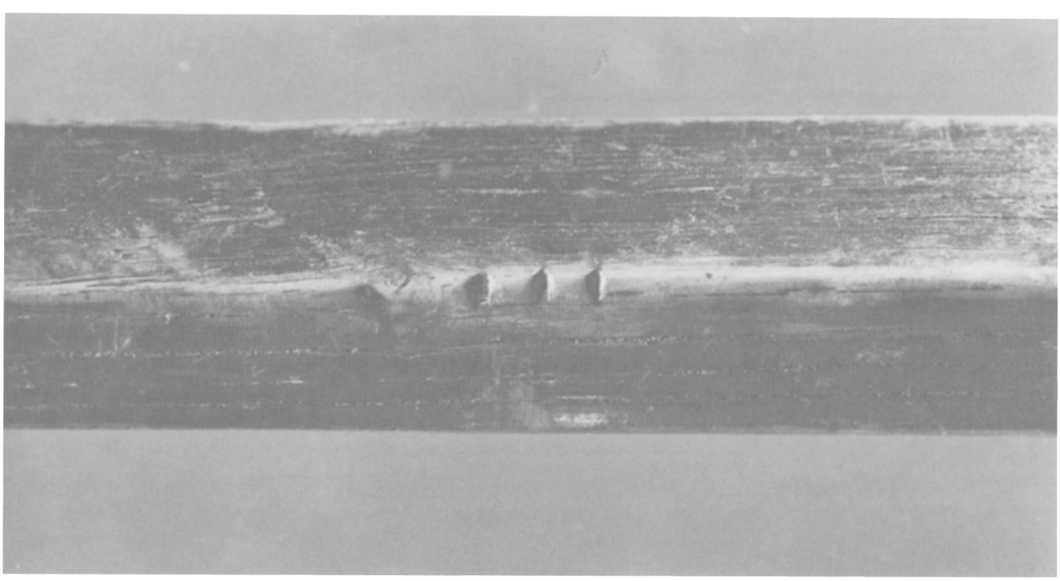

Figure 14. Detail of the second set of three subsidiary marks at the bottom of the calendar stick and outside of the primary notation, again apparently representing a count of years and not of days.

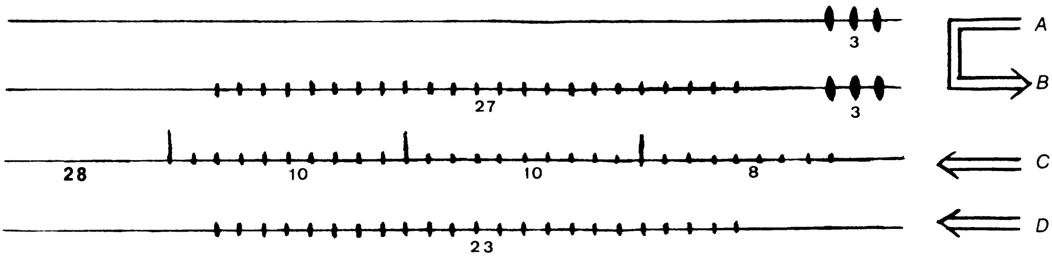

Figure 15. Schematic rendition of all the subsidiary marks at the bottom of the Winnebago calendar stick, indicating the three variable "month" periods and the two sets of three marks suggesting year counts.

The model uses the two years in alternate sequence so that every third year one intercalary month is added. In effect, what has been created observationally, notationally, and *non-arithmetically* is an intercalary frame that is comparable to the arithmeticized Metonic cycle developed by the classic Greeks, in which seven intercalary lunar months were added every 19 years. A decade ago, at the first international conference on Pre-Columbian archaeoastronomy held in 1973, I had presented an internal analysis of an Olmec or Pre-Classic pendant mosaic, which documented the presence of an arithmeticized lunar year of 12 months with an incipient thirteenth intercalary month indicated in the structural frame (Marshack 1975a). At that time the concept of lunar-solar intercalation at

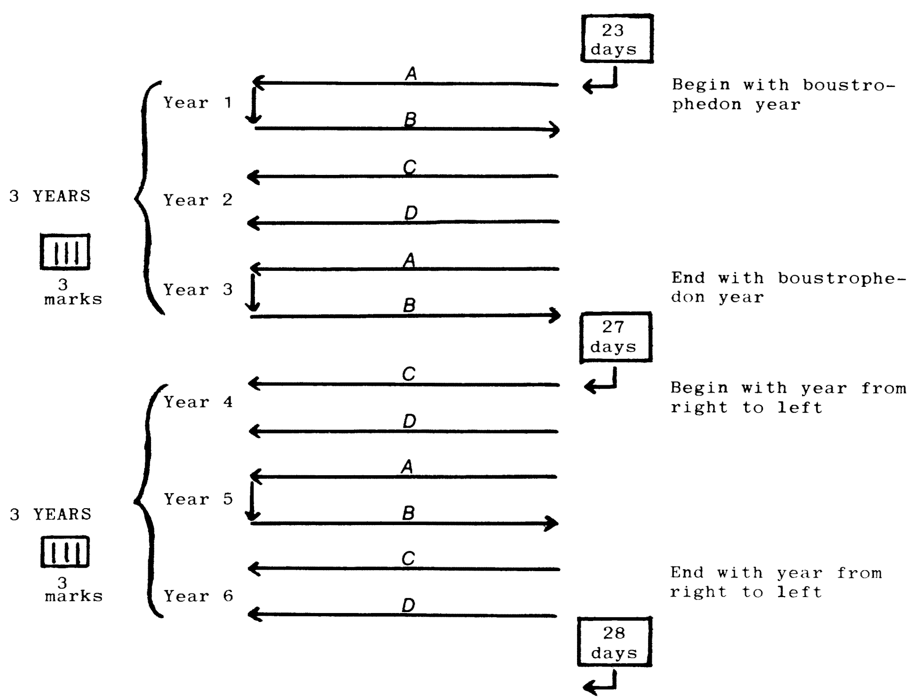

Figure 16. A schematic rendition of all the months, years and sets on the Winnebago calendar stick indicating how these would function to maintain the precisely observed and notated lunar year in phase with the solar year by the addition of one month every three lunar years, in effect creating an ad hoc, non-arithmetic "Metonic" cycle.

so early a date, ca. 1000 B.C., and particularly in the Americas, was considered impossible. Therefore, as an addendum to the published paper, I provided a history of intercalation with an explanation of its generic basis in any system of lunar and solar observation.

Subsequently, S. C. McCluskey (1977) published, in the *Journal of the History of Astronomy,* a statistical computerized Fourier analysis of the lunar-solar ceremonial and practical agricultural calendar cycle of the Hopi Indians of New Mexico, based on a study of the published nineteenth-century records containing the dates for Hopi ritual and practical activity. McCluskey documented the presence of two synchronous and parallel cycles of observation and of ritual and practical activity, one lunar and the other solar. The analysis provided the first evidence of systematic lunar-solar calendric adjustment among the Hopi. The earlier ethnographic literature had indicated that the "skywatchers" and calendar keepers were aware of the problem and had struggled with it (Ellis 1975). McCluskey found that the Hopi were essentially adding one lunar month every three years to bring the lunar and solar cycles in phase. He was clearly not aware of my early paper (1975a) or of the Winnebago calendar to which I had called attention earlier (1972a:140) in the hope that American archaeoastronomers would subject it to analysis.

McCluskey describes the Hopi calendar in terms comparable to those derived from my internal analysis of the Winnebago calendar. Hopi astronomy, he notes, "despite its complexity . . . has an entirely different orientation than the scientific astronomy of the Greeks and Babylonians . . . . It is directed almost entirely towards practical ends, either as it serves to mark time for planting and harvesting . . . or indirectly as it regulates religious festivals . . . ." This observational calendar, he states, involves no astronomical theory either of the calendar or the year. "Related to (the) absence of theory is the absence of continuous quantification, with the counting of the passage of a specific number of days or nights (seldom exceeding 16) substituting for the measurement of duration in time," that is, for arithmetical counts of the days between longer astronomical periods and cycles [1977:190–191].

The non-arithmetic, observational, lunar-solar intercalary calendar of the Winnebago chief, Tshi-zun-hau-kau, made in the 1820s by someone speaking a Siouan language, is of the same non-arithmetic type documented by McCluskey among the Uto-Aztecan-speaking Hopi for the late nineteenth century. The Winnebago calendar, however, exists as notation, within a carefully structured, problem-solving, functional frame.

RELEVANCE OF THE WINNEBAGO CALENDAR

The artifactual presence of an astronomical, observational, notational, intercalary lunar-solar device of the complexity and sophistication of the Winnebago calendar poses problems at a number of levels and for different disciplines. What is its relevance a) for American archaeology and ethnology, b) for our understanding of the history or prehistory of science and astronomy, c) for our understanding of individual "invention" or capacity at different stages in historical development or social complexity and d) for our understanding of problem-solving modes and information-processing systems among cultures with a different historical development and preparation? I touch on these briefly.

Archaeology is a discipline that has inherent limitations due to the constraints of its artifactual and materialistic data base. It cannot theorize about cultural processes and contents or about the historical development, persistence, or demise of cultures except in terms of that hard remnant evidence that is recovered from the soil. The human products excavated, however, are merely end-products of cultural behaviors involving complex cognitive, decision making, problem solving, and symboling efforts. They therefore are, to begin with, ideational and information processing. The remnant end-products found archaeologically do not always, and perhaps never, reflect the complexity of the cultural processes and problem-solving efforts from which they are derived. It may not be incorrect to say that most of such relevant human cultural activity does not become artifactual and, when it does, does not become archaeological. There is no way, for instance, that the astronomical activity of the Zuni sky-watcher reported by Cushing (1941), the social complexity of the lunar-solar calendar of the Hopi uncovered by McCluskey (1977), or the inferential astronomical knowledge indicated in the Winnebago calendar stick could ever become archaeological. At most, the architectural and structural alignments and a few symbols of the Zuni, made of stone, might be left to indicate a concern with astronomical bodies and one solar point on the horizon. This is the level at which contemporary archaeoastronomy, with its concern for the measurement and validation of remnant astronomical structures of any type, operates.

It is the level at which the American alignments (Aveni et al. 1975, 1978; Urton 1981) and the North American "medicine wheels" (Eddy 1974) have been studied, that the solstitial sunlight dagger at Fajada Butte, New Mexico, was reported (Sofaer et al. 1979) and that the megalithic alignments in Europe have been discussed and debated. But these structures, like the Winnebago calendar stick, are the end-products of long historical cultural evolution and development; they are the subsidiary end-products of far more complex cultural processes and of astronomically oriented and time-factored conceptual systems. Traditional archaeology and contemporary archaeoastronomy have not, to date, known how to deal with such developmental, preparatory or non-artifactual levels of cultural problem-solving and ideational, conceptual modelling of time and process. Where there is artifactual evidence of seasonal subsistence activity and decision making, archaeology can approach the problem in terms of the *practical* activities involved. It can approach the problem indirectly and seek comparative data in anthropological studies of the subsistence strategies and optimal foraging and decision-making processes of living hunter-gatherers or simple farmers and herders. There is a problem, however, in such comparison. The conceptual and cultural models of time, space, and process upon which these adaptive decisions and strategies are based and made by cultures at different levels of historical development, even among "simple" cultures, have not yet begun to be investigated to any depth.

Archaeological studies of the Winnebago Indian economy and ecology on the western shore of Lake Michigan (Peske 1971) and of the woodland cultures of the Great Lakes (Emerson 1979) provide us with a wealth of significant detail about the subsistence practices, the seasonal ecology, and the available resources of that region. But without conceptual, cultural data of the type contained in the Winnebago calendar stick, we are left with a body of materialistic data that seems somehow to suggest that the materialist conditions provide us with a set of problems, opportunities, and adaptive strategies, without the intervention of culture and without the presence of complex and ancient, historically developed models and concepts of time, space, and process. Placing the archaeological data on the seasonal ecology and practices of the Great Lakes woodland cultures against the Winnebago calendar creates an entirely different picture of the decision-making processes and the level and pattern of the subsistence strategies that may have been involved.

American Indian ethnography and contemporary archaeoastronomy have begun to make it clear that solstitial observation and diverse levels of a non-arithmetic lunar calendrics were common among diverse Indian language groups with different economies and ecologies. Monitoring of the lunar year, while always present, varied in its regional complexity. Solstitial observations also varied regionally. They were performed by observation of sunrise or sunset along points on the eastern or western horizon, sometimes by setting up aligning structures; they were conducted by a use of shafts of sunlight passing through openings in standing stone structures or by observing the length and position of a shadow cast by the sun in different seasons. These are modes that have been used by many peoples who have learned to mark the seasons by a use of the sun. The American usage, however, seems to indicate the presence of a widespread and traditional cognized, referential lore.

Among the hunting and herding peoples of subarctic and arctic Siberia, lunar and solar observation were similarly assigned to skilled specialists and keepers of the calendar and were similarly geared to periodic economic and seasonal ritual behavior. If it can be assumed that aspects of this tradition, carried non-artifactually in language and myth and as part of a generalized hunting-gathering adaptive lore and perhaps as part of the shamanistic tradition, came into the Americas with diverse groups of Asian migrants, it can probably also be assumed that these traditions formed part of the cultural preparation that helped to make the slow, seasonal, migratory movements of the dispersing hunter-gatherers possible. These traditions would have aided in the conceptual adaptation to a range of climatic zones and ecologies. They would have provided the incipient and preparatory base for the calendric and astronomical developments that began to take place with the indigenous beginnings of agriculture in Mesoamerica and the Andean region. Archaeology has evidence from early sites in America primarily of a movement of tools, yet it was surely not simply tool kits and tool styles that came into the Americas, but peoples carrying aspects of historically developed, traditional culture.

One would expect aid in this problem from the ethnographic study of so-called "archaic" or "primitive" cultures. While comparative ethnography and anthropology in the last century have documented the enormous range and variety in human behavior, culture, and social patterns, ethnology, like archaeology, has not known how to handle this evidence historically. The modern ethnography of the hunter-gatherer way of life, for instance, has been largely analytic and descriptive. While interested in the practical subsistence activities of the world's remnant hunting-gathering peoples and in the materialistic basis of these cultures and its biological and social contents, ethnologists have not until recently (Leacock and Lee 1982) been interested in the comparative *historical* development of these cultures or of hunting-gathering adaptations. They have shown no interest in the historical development of adaptive conceptual systems among these hunter-gatherers, of what might be described, in the terms of a comparative cognitive anthropology, as changes in the cultural level of competence and capacity. Instead, there has been a tendency to create essentially *ahistorical* models of subsistence adaptation and of the hunting-gathering way of life.

These models have been based in large part on present-day ethnographic studies of remnant peripheral and geographically isolated hunter-gatherers such as the San Bushmen of South Africa or the aboriginals of Australia. For the purposes of this report I note that while all these hunting-gathering peoples were aware of the seasonal periodicities of flora and fauna, the phases of the moon, the changing position and angle of the sun, and the seasonal appearance of constellations, their ideational and utilitarian concepts of these phenomena, and of process and functional time and space generally, were largely parochial. By contrast, the shamanistic traditions in much of Siberia, even among hunter-gatherers, involved complex, historically developed, abstracted notions of time and space, the four directions, a cosmological center, a cosmological structuring of space, a lore of the comparative periodicities of sun, moon, and certain stars, all of which were combined and integrated with a knowledge of the differential seasonal reappearance and behavior of various plant and animal species. The abstracted, structural, and conceptual complexity of this "cosmology" was of a different order from that found among the San or the Australian aboriginals. It is theoretically possible to derive native American astronomical and calendrical knowledge and lore developmentally from these Asian concepts of time, space, and process. It is not possible to derive them from the conceptual contents of the historically and geographically isolated hunter-gatherer cultures that have so often served as the contemporary models of a supposedly typical, ahistorical, and archaic hunting-gathering way of life. One can theoretically derive the Winnebago calendar from prehistoric Eurasian traditions, one could not from San or Australian aboriginal traditions. I am not discussing the diffusion or dispersal of the artifact, but of the conceptual tradition from which such notation would derive.

The calendar stick therefore poses problems at a number of historical or diachronic levels. It is in no way comparable structurally or conceptually to the advanced and arithmeticized astronomical and ritual calendars of Mesoamerica, extant and developing some 2,000 years earlier. If we therefore assume that the Winnebago calendar stick is ultimately derived from basic and widespread American Indian lunar-solar traditions of observational, non-arithmetic, utilitarian and ritual "calendrics," with an ancient Eurasian history, we can perhaps assume that this stick was "invented" or devised by Tshi-zun-hau-kau at a particular point in the history of the Winnebago.

In my original draft of this manuscript I had written that the Winnebago had, early in the nineteenth century, apparently "reached a point in their historical development at which the complex of synchronous and sequential intragroup and intergroup activities (including hunting, gathering, agriculture, ritual, preparations for winter, trade, visits and exchange, and even war and the preparations for war) were being conducted against a seasonal and astronomical referential frame that was more or less common among the different language groups and tribes of the region." The assumption was based on some two decades of research in the contents, history, and development of early observational and non-arithmetic astronomical and calendar systems in different periods and parts of the world. There was clear evidence that such calendar frames and systems were always referable to developments in synchronous interactional cultural and social complexity. I assumed that "as calendar keeper and 'Warrior Chief,' Tshi-zun-hau-kau was probably involved in the ritual, practical, and military decisions and plans that were always seasonal and were by then required to be increasingly precise. The calendar stick would therefore have served as a referential 'linear-programming' or scheduling and planning device that could be used to order and structure the spectrum of Winnebago social life."

Robert L. Hall called my attention to the possible "association of the prehistoric Winnebago with Mississippian centers such as Aztalan in southern Wisconsin. This association need not be correct, but [there is also] the suggested association of the Winnebago with the Lake Winnebago Focus of the Oneota Culture, a regional climax culture in eastern Wisconsin . . . . It is more usual to see the Winnebago after the 1640s as a defeated, decimated population with a life style altered in the direction of atomization of social organization and away from complexity" (Lurie 1960).

This suggestion that the Winnebago calendar stick might have reference to a widespread and dispersed tradition assignable to the Oneota and still earlier Mississippian cultures took on immediate significance, for I had just completed analysis of two calendar sticks of the Osage, another Siouan language group, and two additional calendar sticks of the Winnebago made in mid-nineteenth century when the group had been ousted from Wisconsin and was now barely holding on in Nebraska to the west. All four calendar sticks were made in the same tradition as that analyzed in this report but each was an individual variant. (The detailed analyses will be published subsequently.) Each of the four sticks accumulates basic sets and sequences of "ten," which, however, vary around the norm; and each has complex internal cueing and marking strategies that were of aid to the engraver and keeper of the calendar.

That we are, therefore, dealing with an indigenous, regionally evolved tradition that was developmentally different from the calendric traditions that evolved in Mesoamerica and the Andes, but that like these others was probably ultimately derived from widespread observational month-naming and year-structuring modes known in Asia, can now be suggested. It was probably as a result of a slowly increasing complexity in the synchronous and sequential scheduling of intragroup and intergroup practical and ritual activities, as suggested earlier, that formal Mesoamerican and Andean calendrics began to develop, slowly over time becoming arithmeticized and increasingly ritualized and mythologized. These developments probably began with observational record-keeping of the type made by Tshi-zun-hau-kau, though the record-keeping modes and materials would probably have differed from the Eastern Woodland mode here described. The analytic approach I am taking is cognitive and developmental. The new field of archaeoastronomy has, primarily because of the influence of the astronomers who have gravitated to the field, dealt primarily with the measurement of artifactual remains, not with the cognitive problem-solving modes involved in the diverse traditions or with the diachronic developments that take place in such cognitive, problem-solving systems. I mentioned earlier the widespread Asian tradition of naming the lunar months for natural seasonal phenomena and for the sequence of ritual, cultural, and economic activities. I must now, additionally, indicate the widespread Asian division of the month into three parts, involving the periods of waxing, full, and waning and the division of the year into two halves.

In my early book (1972a:116–117) I presented the analyses of two calendar sticks engraved on soft and perishable wood, collected ethnographically from the primitive, coconut-harvesting cultures of the Nicobar Islands in the Andaman Sea off Malaysia. The notated Nicobar year was divided into two equal halves, either of six and six or of five and five. Each month was divided into three parts usually of ten units, though occasionally of seven, nine, or eleven. Each subset within a month was visually differentiated from the next by being engraved at a different angle, a problem-solving mode that I had documented for the far earlier notations of the European Upper Paleolithic. This visual differentiation of the lunar parts is achieved on the Winnebago stick by a single bold stroke at the end of each set of ten. Each month or group of three subsets on the Nicobar calendar is visually differentiated by a deep bold cut between the months, a solution that is functionally comparable as a reading device to the double lines at the end of the Winnebago month and the circle within the full-moon period. At the end of the Nicobar year, outside of the main notation at the bottom of the stick, or added internally in the last month, there are subsidiary sets of marks, apparently added to bring the year to its proper ending or new beginning.

The division of the month into three parts and of the year into two halves is well documented in Asian and Pacific calendric lore, always with regional variation. At the opposite end of Asia, the Tungus of Siberia divide their year into two halves of six months, each considered as a separate "year," with the double year often beginning in September/October. The Dolgon, of northern Tungus extraction, absorbed both Turkic and Christian influences in the historic period but never gave up use of the old functional reindeer hunting and herding lunar naming and month sequencing calendar and wove it into later Turkic and Christian calendar traditions (Orlova 1966, Delaby 1968, Marshack 1983b). One of the most primitive of Siberian calendars, that of the Ostiak-Hante, has the month divided in three 10-day periods. The even more primitive Kamchadal of the Kamchatka peninsula, before adopting the Christian calendar, had a ten-month year with the months named for natural processes, the year divided into two halves and the months divided into three 10-day periods.[3] The variety and range of pre-Turkic, pre-Christian indigenous calendar modes found in Siberia roughly tallies the range of calendric variation documented for the American Indian West and Southwest (Spier 1955). The fundamental Asian mode of naming the lunar months for natural phenomena and human activity is documented also for the Winnebago (Griffin 1960), but as utilized with a late terminology derived from agriculture.

"This emphasis on agriculture is reflected in the Wisconsin Winnebago names for the fifth to eighth months, which are translated as 'drying of the earth month, digging month, cultivating month and tasseling month.'" In the seventh month of the Bear clan there was a deer hunt carried out away from the village. Griffin notes (1960:817) "the data in regard to the Winnebago strongly indicate that, while there was considerable dependence upon agriculture, there was also wild rice gathering and seasonal hunting and fishing activities."

With these data we can approach the calendar stick of Tshi-zun-hau-kau as a cultural end-product of traditions derived from the Eastern Woodland hunter-gatherers, with possible accretions from the agricultural Mississippian cultures, but with ultimate derivation from widespread Asian modes and traditions of structuring the month and year. We can also understand the stick as an individual "invention" at the end of a long and complex cultural preparation. At another level, we can now take the stick and fill in the strictly schematic and abstracted frame with the known round of named and marked Winnebago months, our knowledge of Winnebago periodic activities including ritual and ceremony as documented by Paul Radin, and those aspects of periodic natural phenomena of relevance to the Winnebago at the time the calendar was made and used.

The archaeology and ethnology of the Winnebago and other tribes of the Eastern Woodland Great Lakes region (Emerson 1979; Peske 1971) suggest some of the material, economic, and ecological processes that may have contributed to the usefulness of the calendar. The calendar frame can thus be filled out and be illustrated with a series of images, symbols, and signs of a type that were probably conceptually internalized in the culture and the mind of the engraver. It is precisely this suggested mode of marking a calendar frame that is found in the nineteenth-century Dolgan and Yakut calendars of Siberia (Marshack 1983b) and in the earlier wooden Clogg Almanacks of England and Rune calendars of Scandinavia. We are encountering, once again, what I term cognitive, symbolic abstraction, synthesis, and problem-solving in an evolved, historically prepared cultural context.

That the calendar was being maintained, as Hall suggests, long after the "climax" of the Oneota culture and during the demise of the Winnebago culture, as indicated also by calendars in the same tradition still being made by the Winnebago in mid-nineteenth century in Nebraska, should not surprise us. The historical record is rich in instances where calendar frames and their ritual, ceremonial, and mythic contents are maintained long after the climax and demise of the original cultures that framed them, from the *tzolkin* still maintained by certain Mayan groups to the Old World examples of the Chinese, Muslim, and Hebrew lunar calendars.

Diachronic or historical questions concerning such conceptual cultural frames are difficult to handle archaeologically, even within the new field of archaeoastronomy. Because of the material and data base limitations inherent to these disciplines they have access only to certain classes and types of artifactual end-products representing these developmental processes. The artifactual evidence, except in such rare instances as the exceedingly rich incised bone, antler, and ivory tradition of the European Upper Paleolithic, is quite rare. Nevertheless, the available archaeological and ethnographic materials do provide us with insights into certain current archaeological problems of a broader nature.

It is perhaps significant that merely as a structural frame, without the overlay of indigenous cultural reference that must have accompanied it, the Winnebago calendar as engraved by Tshi-zun-hau-kau could probably have been used by any of the cultures that have or had a lunar or a lunar-solar calendar: the predynastic Egyptian, the early Mesopotamian, the early prehistoric Mesoamerican, the early Greek, the Hindu, Chinese, Muslim, or Hebrew. The reason, of course, lies in the inherent constraints and patterns of the phenomena being observed and recorded. But it lies equally in inherent constraints and logic of a different type, those necessarily involved in attempting to notate a linear, cumulative sequence of sets on an essentially two-dimensional surface. The cognitive, cueing, differentiating, and sequencing strategies found on the Winnebago calendar are, for instance, similar to those found on the prehistoric, non-arithmetic lunar notations that I have documented for the Upper Paleolithic hunter-gatherers of Europe (Marshack 1970, 1972a, 1972b, 1972c, 1983a). In the Upper Paleolithic of Europe the presence of such notation also suggests a certain level of evolved intragroup, interactional, ecological complexity. It is perhaps interesting that one major difference in the calendars from such different periods and cultures is that the early European notations, and even some from the historic period in Asia, tended to divide the lunar month into four parts, based on observation of the phase points (crescent moon, half moons, full moon) rather than as in the Winnebago calendar and many others from Asia, utilizing a three-part month divided into periods of waxing, full, and waning.

These comparative data and many considerations may have some significance for our understanding of the early history or prehistory of "science." The studies of the history of science and astronomy are disciplines that developed originally as investigations of the already formalized, arithmeticized astronomies and calendrics of the high, agricultural civilizations. These studies were often colored by the historical Western concern with the intellectual and cultural developments and achievements that first appeared in the Fertile Crescent of the Middle East, Egypt, and later in Greece. This ethnocentrism is clearly expressed in a recent evaluation of the megalithic alignments in neolithic Europe. Because there is no artifactual, archaeological evidence of a tradition of writing, record-keeping, or even of "quantification" to accompany the alignments, which are clearly lunar and solar, it has been suggested that there could be no "science," as we understand the term, among the farming cultures that built the European alignments.

Ellegård (1981), basing his ideas of arithmetical astronomical development on the history of the Fertile Crescent, states categorically that accurate astronomical record-keeping cannot exist before the development of urban civilization and the invention of writing and a higher arithmetic consisting of addition, subtraction, multiplication, and division. The Winnebago chief, Tshi-zun-hau-kau, made an accurate, functional, non-arithmetic[4] observational lunar-solar intercalary notation, though he was illiterate or preliterate, "non-scientific" or "pre-scientific" in our Western use of the term, and non-urban. I have already indicated that a comparable level of non-arithmetic, observational lunar-solar calendrics and notation was present in Europe at the end of the Würm some seven to ten thousand years before construction of the megalithic alignments (Marshack 1983a, 1984b).

The observational accuracy and precision that accumulate in such observation and notation, apart from the mythic uses and explanations that would accompany such early calendars, may have provided the incipient and preparatory basis for the later development of arithmeticized astronomies and calendrics. A proper history of those "pre-scientific" modes of observation, abstraction, and symbolization that were preparatory to the development of astronomy, record-keeping and even arithmetic requires that we reevaluate the nature of the cultural, conceptual contents, and problem-solving modes and capacities that developed in certain areas before the beginnings of farming and the rise of the later, high civilizations. That such cognitive and cultural analyses and comparative studies are possible has, I think, been indicated in the analytic studies of artifactual materials I have presented from different periods and areas. (It is possible that agriculture itself, as a formal and structured cultural, time-factored conceptual mode, apart from its usual mythical overlay, was incipiently prepared for and therefore made possible as indigenous invention many times because of the accumulated and generalized functional knowledge and lore of nature's periodicities that had accrued and had been disseminated within the Eurasian heartland, and the geographic areas touching on this core area, during the Upper Paleolithic and mesolithic.) It also seems likely that aspects of this Eurasian preparation came into the Americas—locked into language and myth as part of the hunter's generalized knowledge about animal and plant behavior and seasonality, and as part of an already abstracted knowledge of patterns in the sky.

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ENDNOTES

[1] R. L. Hall has noted that the axe in Tshi-zun-hau-kau's hand was apparently made by the Canadian-born Joseph Jourdain, who was the first blacksmith to reach the Green Bay area of Wisconsin in 1798. Jourdain's axes and tomahawk pipes were popular trade items and his distinguishing mark on these was the inlaid copper crescent that is visible on the axe of Tshi-zun-hau-kau. The Neville Public Museum has two Jourdain axes with

inlaid copper crescents and there is at least one in the Milwaukee Public Museum. Jourdain's axes and tomahawk pipes were often purchased by Indian chiefs and were apparently used symbolically during negotiations with American and British authorities.

[2] A. Aveni (personal communication 1983) suggested from the analysis that the calendar stick has a "luni-solar *count*" [emphasis added] and that "the 178 day period as a lunar count . . . might connect with eclipses. This is, of course, the same day count employed by the Maya in the Dresden eclipse tables." Aveni also suggested that "if the stick was a predictive device in any way then I think the difference between it and the Maya codices is simply a matter of degree of complexity and precision. I tend to see them as the same thing. You say it was a referential or planning device. Weren't they therefore predicting full moons with it and isn't that conceptually the same thing as predicting eclipses or heliacal risings of Venus?" It is apparently difficult for first-time readers of analyses such as those presented in this report to separate the arithmetic counting of grouped sets used in the analysis from the *non-arithmetic* accumulation of observed and grouped sets. The same difficulty was expressed by Ellegärd (1981) in his comment on the Upper Paleolithic notations when he assumed that I had called them arithmetical. The sum of 178 is derived from the analysis, it was almost certainly not a number or sum of significance to the engraver. The calendar was predictive of human activity within a few days of observation of the sun or moon, within a still broader frame of seasonal prediction. Predicting the coming of the full moon, or even of a solstitial or equinoctial horizon point on the basis of continual observation is not the same as predicting it in advance arithmetically as a culturally recognized discrete count of days. Evidence for a use of such sums does not appear in the calendar. That the calendar was a planning device for cultural and economic activities and a predictive device for the periods and sequences of such activities does not mean that it was an arithmetic-astronomical predictive device for determining eclipses or the appearance of Venus. It would be difficult to use a two-year frame of this type for either eclipse or Venus prediction without a corollary use of true large sum counting being added to the system. Given the proper developmental cultural conditions and a long enough period of such record-keeping and a comparison of such accumulated records, such notation could lead to arithmeticized Venus counts and eventually to eclipse predictions. That the possibility is inherent in the mode is part of the significance of such calendric record-keeping. Contemporary archaeoastronomy as a discipline, while able to measure certain types of end-products, is still unfamiliar with the general theory of notational systems, their development, their constraints, their uses, and the potential that is present in different systems of notation and record-keeping utilizing different materials and modes. Many modes of observation and record-keeping were used in the Americas. Very few had the potential for developing into eclipse and Venus cycle predictors. I think that one of the difficulties is that astronomers and archaeoastronomers have not been concerned with the general problem of the theory of such systems and the range of cognitive, problem-solving modes involved in human symbolling, or the nature of the developmental histories of different systems and modes.

[3] Lydia T. Black (1973) has written of the small, morphologically separate paleoasiatic group, the Nivkh (Gilyak), that has theorized ties to southwest Asia and possibly Oceania as well as to the American Northwest, that "the Nivkh have well defined concepts of time, measurement and spatial distance. They recognize major constellations, planets and stars and have specific names for them. The year is basically divided into two seasons, and into lunar months . . . . Shrenk thought that the Nivkh year was roughly divided into twelve months, but Krunovich reports thirteen. The months are named for seasonal activities and fish or animals associated with the economic life of the group at any given time. The thirteenth month reported by Krunovich is called "moon month." While the year is roughly divided into winter [approximately October through April] and summer [approximately May through September], fall and spring seasons have names as well . . . . The daily passage of time is described in terms of reference to the position of the sun. The sun is born (rises) and it dies (sets). Different time spans of the day, such as morning, noon, evening, have specific designations" (1973:51).

[4] I use the term "non-arithmetic" to indicate that, although a capacity to count may have been present in the cultures making such notations and observations, there was not a count of the number of days in a lunar month or a count of the number of days in the lunar or solar year, at least not as clearly defined arithmetical sums. That a month consisted of three counted periods of approximately ten days or of four counted periods of approximately seven to eight days, or that a year consisted of approximately ten to thirteen months, does not yet give one an arithmetically defined month or year. However, as I have repeatedly noted, the possibility of transition to that order of arithmetical abstraction, given a long period of record-keeping and a developing social need or usefulness, is already inherent in many of the earlier stages and systems. Agriculture, like hunting-gathering, does not require an arithmetical calendar month or year. Evolved, increasingly complex politicized social systems such as those that developed in the higher agricultural civilizations of the Old and New World, may, however, find them increasingly useful for ordering their many specialized synchronous activities. As religions become politicized they too may find such cohering arithmetical precision useful. These latter are diachronic problems concerned with cultural process, development, accretion, and change, involving corollary changes in symbol system complexity and informational precision.