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THE VENUS TABLE OF THE DRESDEN CODEX AND THE MOVEMENTS OF THE PLANET VENUS

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ABSTRACT

The movements of the planet Venus in the 10th century A.D. are compared with the record of the Maya scribes in the Dresden codex. The manner in which the Venus table may have been used by the Maya is examined in detail. Orbital patterns of Venus are related to Maya glyphic representations of Venus. The correlation issue is discussed in brief and a new correlation constant of 660208 is proposed.

RÉSUMÉ

Les mouvements de la planète Vénus au cours du dixième siècle après J.-C. sont comparés avec les archives des scribes mayas contenues dans les manuscrits dits Codex de Dresde. La façon dont les mayas utilisaient les tables de Vénus est examinée en détails. L'orbite de Vénus, telle que vue de la Terre, est reliée à sa représentation par des glyphes. La question de la corrélation est également abordée et on suggère une nouvelle valeur pour la constante de corrélation de 660208.

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Introduction. The Maya inhabited what is now eastern Mexico, Guatemala, Belize, and western Honduras and El Salvador (figure 1). Their culture is recognizable in the archaeological record from about 1500 B.C. Scattered occurrences of hieroglyphic texts appear on Olmec and Zapotec monuments as early as 600 B.C. The Olmec and Zapotec were predecessors, but not ancestors, of the Maya. It was not until 200 A.D. (in the most accepted archaeological chronology) that city-states, divine rulers, and hieroglyphic writing had emerged fully among the Maya. From 200 A.D. to 900 A.D. the Maya flourished in what archaeologists call the Classic Maya culture. The Classic Maya civilization declined after 900

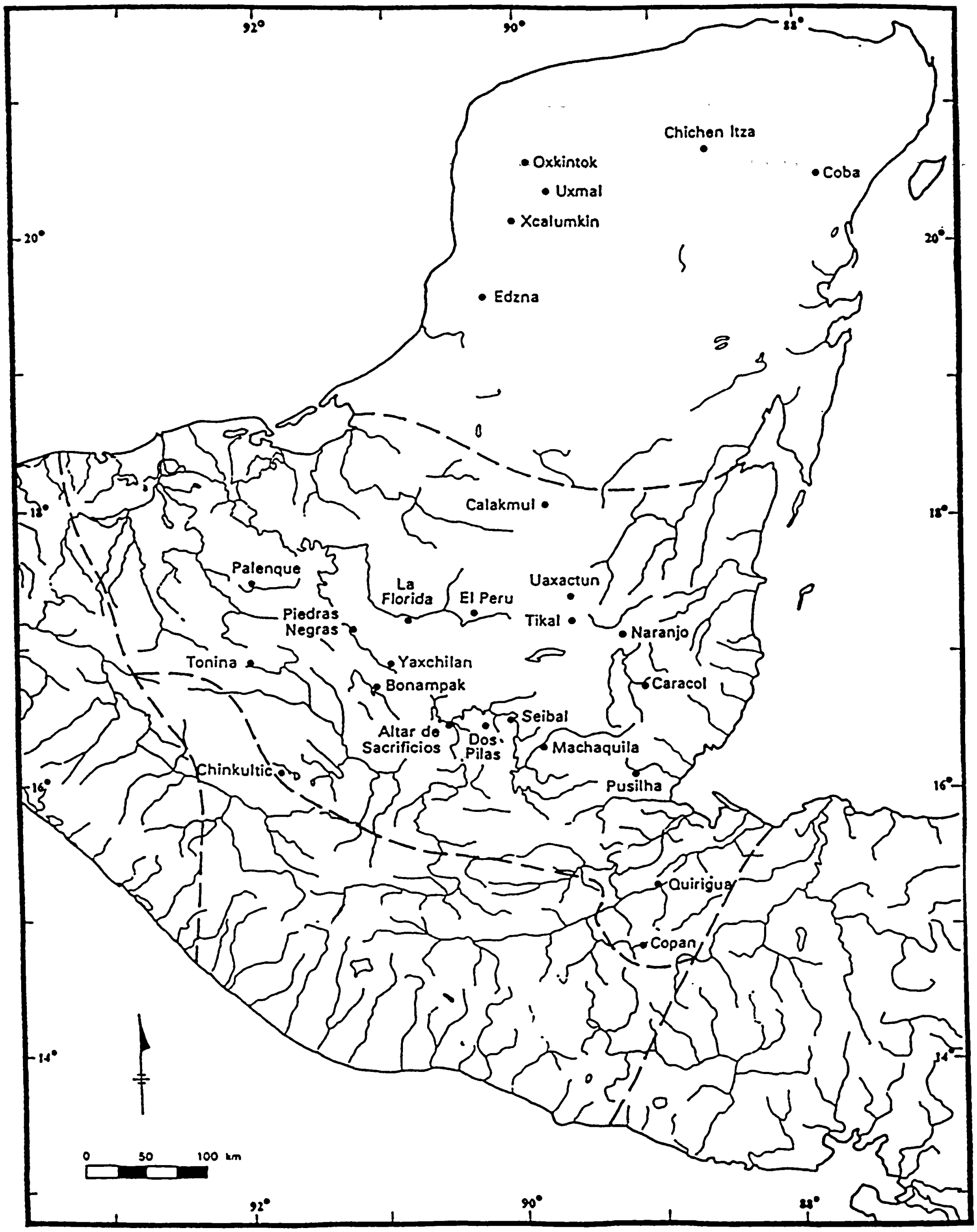


FIG. 1—Map of the Maya area. (Drawn by Peter Mathews.)

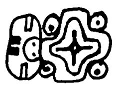
A.D., and by 950 A.D. the great ceremonial centres of the Southern Lowlands had been abandoned (Thompson 1974). The Maya culture continued in the Northern Lowlands of the Yucatan Peninsula. Over the next 600 years the Maya's arts and influence declined. They retained their written language and continued to use bark paper books. This period of decline (called the post-Classic) continued until the Spanish conquest in 1540 A.D.

The Maya had the most highly developed writing system in Pre-Columbian America. They inscribed their glyphs on stone monuments and temples, painted them on pottery, incised them on bone, and wrote in bark paper books. Many Maya texts survived until the Spanish conquest, but only four are known at the present to have survived the effects of Spanish religious persecution and other destructive forces. In the words of a Spanish spiritual leader of that time: "They [the Maya Books] contained nothing in which there were not to be seen superstition and lies of the devil, we burned them all ..." (Bishop Landa, First Bishop of the Yucatán, (in Tozzer, 1941:77)).

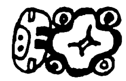
In 1880 Ernst Forstemann (the Royal Librarian at Dresden) started to study one of the surviving Maya books known as the Dresden codex. From it he deciphered the Maya calendar and some glyphs, most notably the Venus glyph (Table I). Most Maya glyphs have been deciphered through their context. Numbers and dates have been recognized by their context since the turn of the century. Maya texts are written in uniform sized blocks called glyphs. Glyphs can contain more than one sign. One sign, called the main sign, is usually larger than the rest of the signs in the glyph. Other signs in the glyph are called affixes. Words can be composed of more than one glyph and some glyphs are short prepositional phrases. Since 1900 two very different approaches have been used in attempts to decipher Maya glyphs. One approach treats all glyphs as logographs, each glyph representing a word or concept. The other approach views the Maya glyphs as combinations of consonant-vowel syllables, with several separate syllables combined into words. It seems now that some glyphs are logographs and some are combinations of phonetic syllables. "Maya writing seems to be a combination of ideographs ... and syllables ..." (Jones: 1984:5). In both the Classic and Postclassic Maya script the majority of the glyphs are logographic with heavy use of phonetic syllables (P. Mathews, personal communication, 1991).

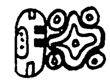
The Maya Calendar and Number System. Unlike our base ten number system which uses ten symbols (0–9), the Maya number is a base 20 (vigesimal) system utilizing only three symbols. These symbols have fixed values: the dot represents one, the bar represents five and the stylized shell represents zero. The Maya used place notation similar to ours (units, tens, hundreds, thousands) but their values were based on values of twenty as follows: numbers from 1–20 in the first position; numbers from 21–359 in the second position; numbers from 360–7199 in the third position; numbers from 7200–143999 in the fourth position; and numbers from 144000–287999 in the fifth position. For larger numbers additional positions can be added as needed. The Maya wrote these numbers vertically with the first position on the bottom. Examples of Maya numbers can be seen in figure 2. Archaeologists write these numbers in our script using

TABLE I A SIMPLIFIED VENUS TABLE WITH CYCLE GLYPHS


CYCLE 1


CYCLE 2


CYCLE 3


CYCLE 4


CYCLE 5

	Kib	Kimi	Kib	K'an	Ahaw	Ok	Ahaw	Lamat	K'an	Ix	K'an	Eb	Lamat	Etz'nab	Lamat	Kib	Eb	Ik'	Eb	Ahaw	
1	3	2	5	13	2	1	4	12	1	13	3	11	13	12	2	10	12	11	1	9	
2	11	10	13	8	10	9	12	7	9	8	11	6	8	7	10	5	7	6	9	4	
3	6	5	8	3	5	4	7	2	4	3	6	1	3	2	5	13	2	1	4	12	
4	1	13	3	11	13	12	2	10	12	11	1	9	11	10	13	8	10	9	12	7	
5	9	8	11	6	8	7	10	5	7	6	9	4	6	5	8	3	5	4	7	2	
6	4	3	6	1	3	2	5	13	2	1	4	12	1	13	3	11	13	12	2	10	
7	12	11	1	9	11	10	13	8	10	9	12	7	9	8	11	6	8	7	10	5	
8	7	6	9	4	6	5	8	3	5	4	7	2	4	3	6	1	3	2	5	13	
9	2	1	4	12	1	13	3	11	13	12	2	10	12	11	1	9	11	10	13	8	
10	10	9	12	7	9	8	11	6	8	7	10	5	7	6	9	4	6	5	8	3	
11	5	4	7	2	4	3	6	1	3	2	5	13	2	1	4	12	1	13	3	11	
12	13	12	2	10	12	11	$\boxed{1}$	9	11	10	13	8	10	9	12	7	9	8	11	6	
13	8	7	10	5	7	6	9	4	6	5	8	3	5	4	7	2	4	3	6	$\boxed{1}$	Lub 23/11/934
14	4	14	19	7	3	8	18	6	17	7	12	0	11	1	6	14	10	0	5	13	Haab
	Yaxk'in	Sak	Sek	Xul	Kumk'u	Sotz'	Pax	K'ayab	Yax	Muwan	Ch'en	Yax	Sip	Mol	Wo	Wo	K'ank'in	wayeb	Mak	Mak	Date
16	North	West	South	East	North	West	South	East	North	West	South	East	North	West	South	East	North	West	South	East	Direction
17	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	God
18	Venus	Venus	Venus	Venus	Venus	Venus	Venus	Venus	Venus	Venus	Venus	Venus	Venus	Venus	Venus	Venus	Venus	Venus	Venus	Venus	
19	236	326	576	584	820	910	1160	1168	1404	1494	1744	1752	1988	2078	2328	2336	2572	2662	2912	2920	Total
	8	18	4	12	3	13	18	6	2	7	17	5	16	6	11	19	15	0	10	18	Haab
20	Sek	Muwan	Yax	Yax	Sotz'	Mol	Uo	Sip	Muwan	Pohp	Mak	K'ank'in	Yaxk'in	Keh	Xul	Xul	Kumk'u	Sek	K'ayab	K'ayab	Date
21	T	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	God
22	Cheun	Cheun	Cheun	Cheun	Cheun	Cheun	Cheun	Cheun	Cheun	Cheun	Cheun	Cheun	Cheun	Cheun	Cheun	Cheun	Cheun	Cheun	Cheun	Cheun	
23	Venus	Venus	Venus	Venus	Venus	Venus	Venus	Venus	Venus	Venus	Venus	Venus	Venus	Venus	Venus	Venus	Venus	Venus	Venus	Venus	
24	East	North	West	South	East	North	West	South	East	North	West	South	East	North	West	South	East	North	West	South	Direction
	19	4	14	2	13	3	8	16	7	17	2	10	6	16	1	9	0	10	15	3	Haab
25	K'ayab	Sotz'	Pax	K'ayab	Yax	Muwan	Ch'en	Ch'en	Sip	Yaxk'in	Wo	Wo	K'ank'in	Kumk'u	Mak	Mak	Yaxk'in	Sak	Sek	Xul	Date
26	236	90	250	8	236	90	250	8	236	90	250	8	236	90	250	8	236	90	250	8	Interval
	Page 46				Page 47				Page 48				Page 49				Page 50				

After Thompson (1971)

periods to separate each position in the sequence. In this notation system the number 2200 would be written 6.2.0 (figure 2a, lower left).

The base twenty number system was also part of the Classic Maya calendar. Many monuments contain these numbers, referred to as Initial Series (IS) dates or Long Count (LC). The number of days since the beginning of the current World Age are given, expressed in base twenty notation.

The Maya also used a 260 day calendar called the Tzolk'in. Numbers from 1–20 combined with a sequence of 20 day names, give 260 unique values. Additionally, the Maya have a 365 day calendar very similar to ours called the Haab. The Haab consists of 18 months of 20 days each and five unlucky days at the end of the year. The Haab and the Tzolk'in combine to form a sequence of day and month dates which repeat every 52 years. This 52 year period is called a Calendar Round and contains 18980 unique Calendar Round days. The Maya still use the 52 year calendar today.

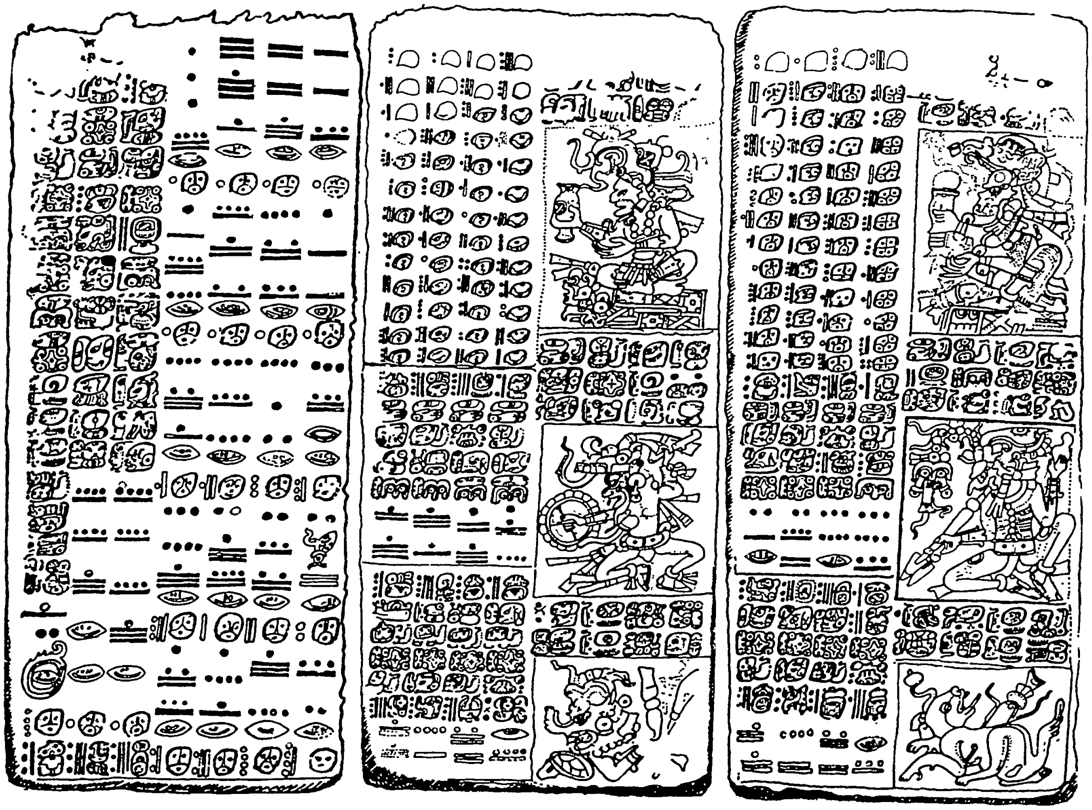
Each Maya language group has its own unique pronunciations for the day names of the Tzolk'in and the month names of the Haab. "Recently it has been generally agreed to standardize Maya orthographies. The impetus for this change is from contemporary Maya groups who are writing their own languages. Many Maya epigraphers have decided to conform to the new orthography, partly for the sake of consistency but mainly out of a sense of solidarity." (P. Mathews: personal communication, 1991).

The Tzolk'in names are: Imix, Ik', Ak'bal, K'an, Chikchan, Kimi, Manik', Lamat, Muluk, Ok, Chuwen, Eb, Ben, Ix, Men, Kib, Kaban, Etz'nab, Kawak, and Ahaw. The names of the Haab months are: Pohp, Wo, Sip, Sotz', Sek, Xul, Yaxk'in, Muwan, Pax, K'ayab, and Kumk'o. The unlucky days at the end of the Haab are called wayeb and are numbered 1–5.

A complete Classic Maya Long Count date consists of the count of days since Maya zero and the calendar round date. For example, a long count date is given on page 20 of the Dresden codex. This date is 9.9.9.16.0 1 Ahaw 18 K'ayab, and is a day 1364360 days after 0.0.0.0.0 4 Ahaw 8 Kumk'u (Maya zero).

While the previous explanation of the Maya calendar and number system gives the basic mechanics of this complex calendar, it is incomplete. There are many other components of the Maya calendar. Explanations of these calendric components and the details of calendric calculations can be found in J. Eric Thompson (1971) and D.H. Kelley (1976). These publications are excellent sources of mythological and cosmological information and of the working of the Maya calendar.

The Venus Table. The Maya codices have many undeciphered sections containing auguries, instruction for rituals, and tables of numbers. The meaning and use of the tables of numbers in the Maya codices has perplexed students of Maya



Introductory Ring	Glyphs / LCD Dates	Table of Multiples of 584 (2920)	Tzolkin Dates a	Elderly God d	Tzolkin Dates a	Death God d
			Totals b	Black Bacab God L (Venus #1) e	Totals b	Lahun Caan (Venus #2) e
			Intervals c	God K f	Intervals c	Jaguar God f
Page 25			Page 46		Page 47	

FIG. 2a—Schematic of Dresden, pages 25, 46 and 47.

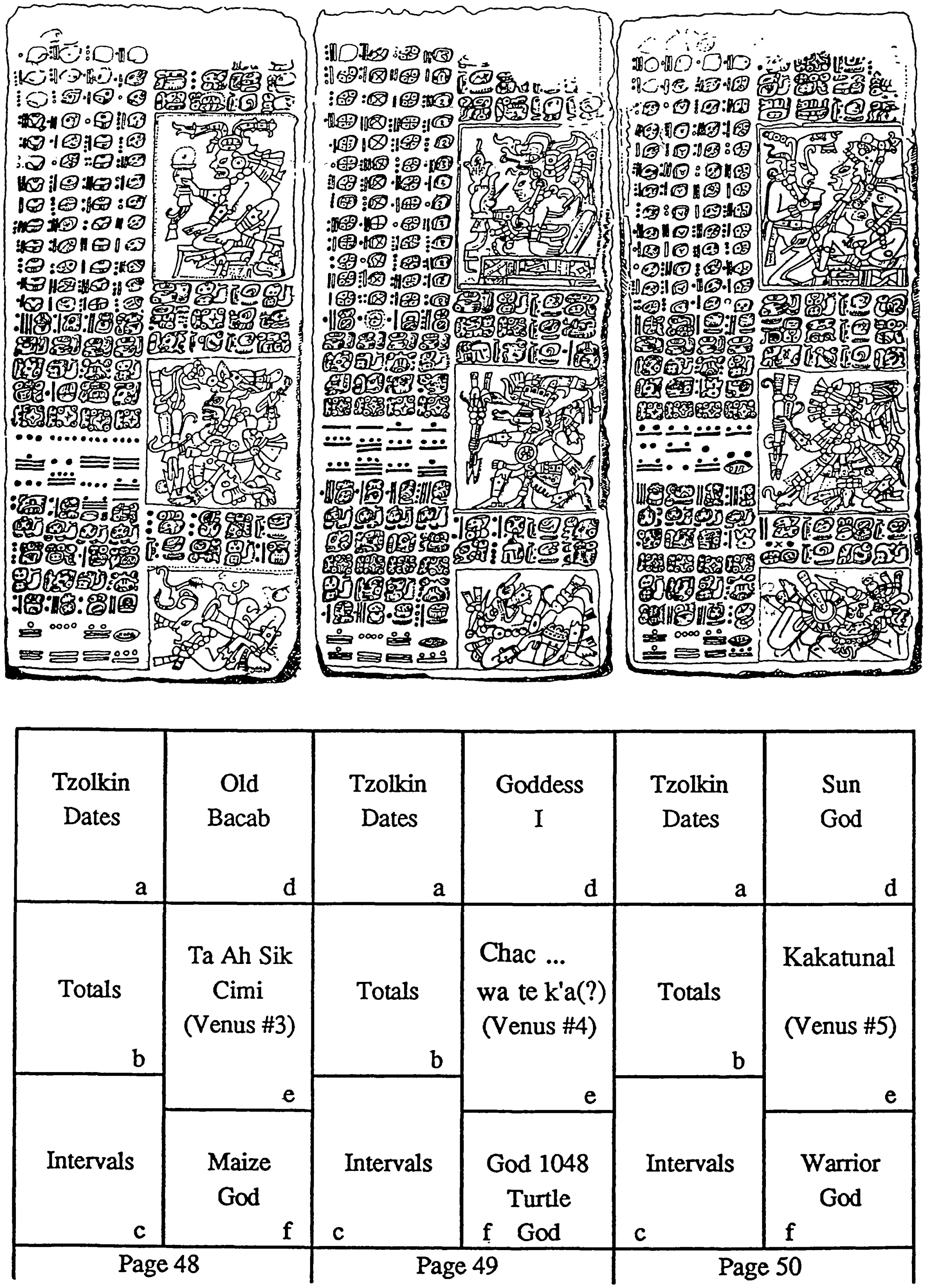


FIG. 2b—Schematic of Dresden, pages 48, 49 and 50.

writing for more than 100 years. While many tables have remained complete mysteries, others have been partially deciphered. Since Forstemann first identified the meaning of the Venus table (Dresden 24 & 46–50), it has been thought that some of these tables might have been used to predict or record astronomical events. Of these the Venus table is the best understood and still only one of three tables with clear astronomical connections. The others are the Venus table of the Grolier Codex and the Eclipse Warning table, located next to the Venus table, in the Dresden Codex.

The Structure Of The Venus Table. The Venus table is organized into a matrix of 260 Tzolk'in dates (Table I). There are 13 rows with 20 dates in each row. The lub, or starting point, of the Venus table is a day 1 Ahaw. With the passing of the table from lub to lub 2920 days elapse. Both in terms of magnitude and position relative to the horizon, Venus appears similar on the days of the lub. The 20 dates in each of the 13 rows of the Venus table are arranged in groups of four dates to a page over the five pages of the table. Each page contains 13 rows of four Tzolk'in dates, separated by intervals of 236, 90, 250, and 8 days. The following are the first four entries on page 50 of the Venus table:

236 days to 12 Eb   90 days to 11 Ik'   250 days to 1 Eb   8 days to 9 Ahaw

The period between the last date on one page and the first date on the next page is 236 days. The dates record the first day of each of the four periods in the synodic period of Venus. The Maya were recording the sequence: morning star, superior conjunction, evening star, and inferior conjunction. This sequence is repeated five times between each lub of the table.

The five repetitions are not just for convenience or to make the lubay, the completion of 13 lub, (1 Ahaw) "come out right." Figure 3 illustrates the five visual patterns traced by Venus through the heavens. These five patterns are repeated in the same order *ad infinitum* with minor morphological variations in shape and periodicity. Each page, then, is a record of the 13 occurrences of a pair of cycles.

Many researchers have proposed explanations of how the Venus table may have been used (Makemson: 1943; Thompson: 1972 and 1974; Coe: 1975; Kelley: 1977; Closs: 1977; Lounsbury: 1978 and 1983; Justeson: 1989). Yet there are still some structures within the Venus table that remain undefined. Identification of some of these structures and how they relate to the movements of the planet Venus are the subject of the following discussion.

Venus And The Moon. The Venus table chronicles the passage of Venus through his (Venus is portrayed as being male by the Maya) 584 day synodic revolution.

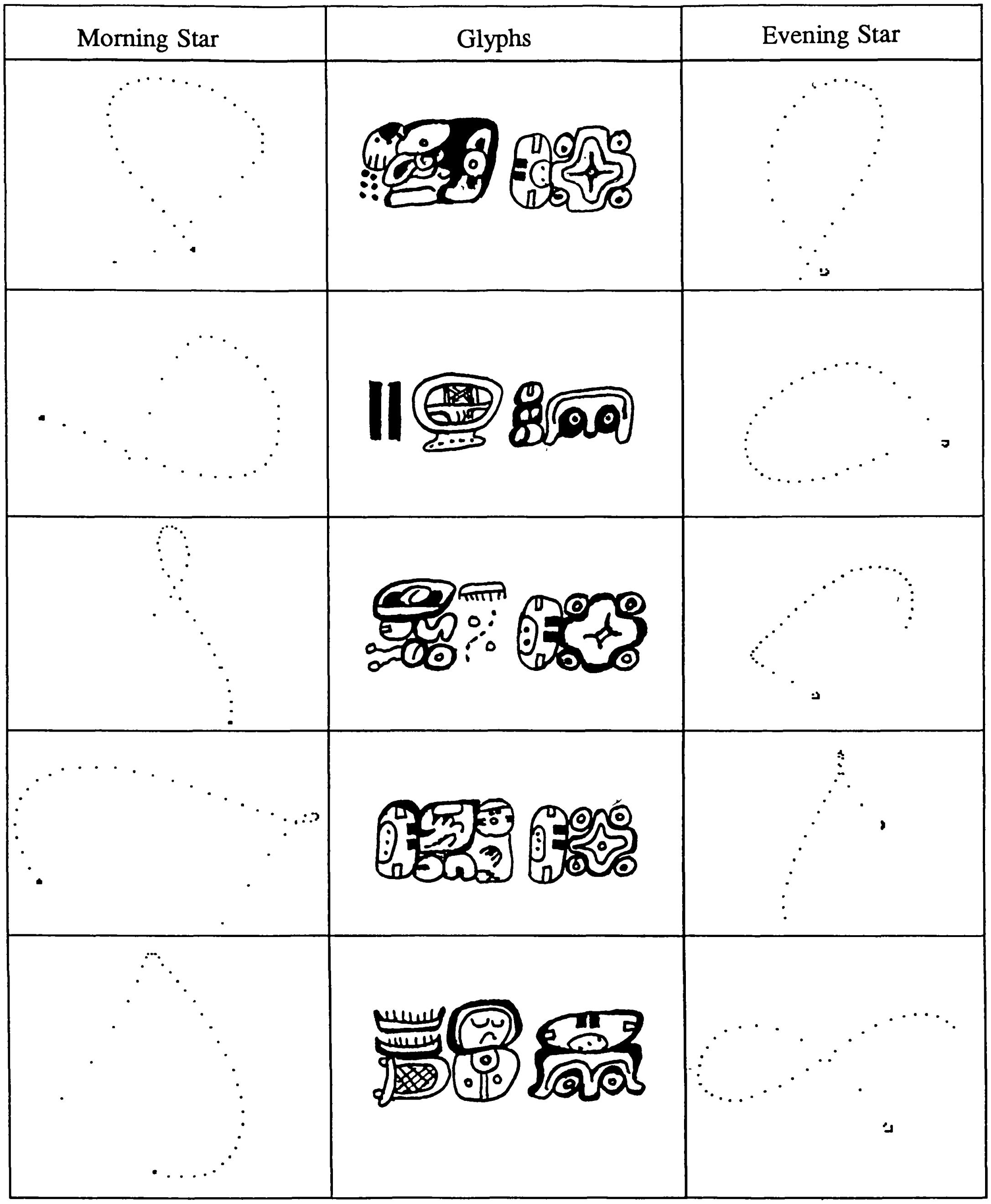


FIG. 3—The five astronomical cycles of Venus and their glyphs.

The Maya knew Venus by many names: Noh Ek (great star); Chac Ek (great star); Sasta'ek (bright star); Xux Ek (wasp star) and Lahun Chan (ten sky) among others. The Maya estimate of 584 days for Venus' synodical period is the nearest whole day approximation of the modern value of 583.92 days. There are no fractions in the Maya number system. The astronomical stations of Venus' synodical period are different from the values used by the Maya scribe in the Venus table of the Dresden codex (figure 2). In the following discussion I shall put the Maya values from the Dresden codex first, and the modern astronomical values (Gibbs, 1977) for these stations following in parentheses. Venus first appears in the East as the morning star. After 236 days (263) it disappears into the solar glare for the 90 days (50) of the superior conjunction. At the end of the superior conjunction Venus reappears for 250 days (263) as the evening star. Following the last day of Venus as evening star it passes once more into the Sun's glare for 8 days (8). This disappearance marks the beginning of the inferior conjunction. The whole 584 day cycle then repeats itself when Venus rises again as morning star. The first day of Venus as the morning star is the lub (starting point) of the Venus table.

The astronomical values for Venus' periods for morning and evening star are symmetrical, and very close to the 260 day length of the Tzolk'in (the Maya ritual calendar). Why the authors of the Venus table should not have used the symmetrical values is not known. It seems that the value of 263 days in particular would appeal to the Maya as it closely approximates the length of the Tzolk'in and would have simplified the calculation of heliacal risings. Apparently other considerations outweighed the close coincidence of the astronomical periods of visibility to even Tzolk'in intervals. J. Eric Thompson (1971) points out that the numerical values of the Tzolk'in dates on each page decrease by one as you move right across any row of 20 dates (Table 1). Lounsbury (1978) suggests that geography (local topography) may account for this phenomenon. Lounsbury (1983) points out, and A.F. Aveni agrees, that these intervals are tied to age of the Moon. The age of the Moon on the first and last days of Venus' morning star (236 day) cycle are the same. The Moon age on the last day of Venus' evening star (250 day) is 14 days later than (the opposite phase of the moon) on the first day as evening star.

Another possibility is that the gods on lines 17 and 21 (Table 1) of the Venus table are tied to particular days and this connection, perhaps tied to mythological events, supersedes other concerns. In support of this I would point out than if one counts forward 48488 days from the base of the Venus table, a day **9** Eb is reached which is a formal position in the Venus table (Table I, in boldface). This day is 16 days before the Lub of the Eclipse Warning table (Dresden 51–58). Also in boldface in Table I, on lines 17 and 21, is "**L**" the glyph of the Moon goddess (sometimes called goddess I). In figure 2 the relationship between the **9** Eb date, the Moon goddess glyph, and the Picture of the Moon goddess on Dresden page 49 is clear.

There are three rows of Haab dates in the Venus table. The middle row, beginning with 18 K'ayab, is associated with the 9.9.9.16.0 date on Dresden page 24. The top row begins with 13 Mak and may be separated from the

18 K'ayab line of the table by 11960 days (the length of the Eclipse Warning table on Dresden 51–58). The bottom row begins with 3 Xul which may be separated from the 18 K'ayab table by 9360 days (another eclipse interval from the Eclipse Warning table). Additionally, on page 24 of the Dresden codex, the last two glyphs in the first column of glyphs appear in the Eclipse Warning table (associated with the first and last of ten pictures in that table), and nowhere else in the Dresden codex. All other glyphs on page 24 can be found elsewhere in the pages of the Venus table.

Whatever the reason, the Maya intervals are very different from modern intervals, have a strong connection with the Moon's age, and are somehow related to the Eclipse Warning table.

Cycles within Cycles and the Lubay. The Maya related the length of Venus' synodic period to their Haab (also known as the vague year) of 365 days and to their Tzolk'in of 260 days. Relationships between the Haab, Tzolk'in and other cycles of time were considered significant by the Maya. Every 2920 days, exactly five synodic revolutions of Venus (eight Haab), the Venus table returns to its lub. In Table I every lub (2920 days) is equivalent to 20 Tzolk'in dates or one row of four dates from each of the five pages. Thirteen rows are equivalent to exactly 37960 days, or 65 synodic periods of Venus, or 104 Haab, or 146 Tzolk'in. After thirteen lubs the table returns to its lubay, or "great resting place", where all the cycles begin again. The whole cycle then repeats itself. The universe must have seemed in harmony with their world on that day 1 Ahaw when the lubay was reached and the thirteen cycles of Venus began again.

Dresden 24: Correcting The Venus Table For Errors. The Venus table is accurate to 5 days every 104 years if left uncorrected. It has been suggested that the table of numbers on Dresden 24 gives a mechanism for correcting even this minor error (Thompson: 1974 and Closs in Aveni 1977). The top of Dresden 24 has been eroded, and numbers appearing in Table II in boldface have been reconstructed.

The Maya definition of the length of Venus synodical period was too long by 0.08 days. The error in this whole-day approximation compounds to 5.2 days from lubay to lubay (104 years). The lubay is the start (and completion) of 13 repetitions of the five cycles of Venus. Any correction formula acceptable to the Maya had to be a multiple of the 260 day Tzolk'in and maintain one Ahaw as the lubay. Dresden 24 is an introductory page to the Venus table proper and it contains instructions for use and mathematical information. The mathematical information consists mainly of multiples of 584 (Table II), Tzolk'in dates and long count dates. Table II gives the multiplication table in Maya numbers and base ten. The base ten values are then divided by the synodic period of Venus

TABLE II THE TABLE OF NUMBER DRESDEN PAGE 24

Bak	Kat	Tun	Uinal	Kin	No. Of Days	Tzolkin	1820	Venus	52	65	91	Tzolkin	Haab	1820	Ven	52	65	91	Tzol	Haab
1	**1**	1	14	0	151840	1 Ahaw	83.4286	260	2920	2336	1668.57	584	416	780	0	0	0	52	0	0
	15	**16**	6	0	113880	1 Ahaw	62.5714	195	2190	1752	1251.43	438	312	1040	0	0	0	39	0	0
	10	**10**	16	0	75920	1 Ahaw	41.7143	130	1460	1168	834.286	292	208	1300	0	0	0	26	0	0
	5	**5**	8	0	37960	1 Ahaw	20.8571	65	730	584	417.143	146	104	1560	0	0	0	13	0	0
1	5	14	4	0	185120	1 Ahaw	101.714	316.986	3560	2848	2034.29	712	507.178	1300	576	0	0	26	0	65
	9	11	7	0	68900	1 Ahaw	37.8571	117.979	1325	1060	757.143	265	188.767	1560	572	0	0	13	0	280
	4	12	8	0	33280	1 Ahaw	18.2857	56.9863	640	512	365.714	128	91.1781	520	576	0	0	65	0	65
	1	5	5	0	9100	1 Ahaw	5	15.5822	175	140	100	35	24.9315	0	340	0	0	0	0	340
	4	17	6	0	35040	6 Ahaw	19.2527	60	673.846	539.077	385.055	134.769	96	460	0	44	5	5	200	0
	4	9	4	0	32120	11 Ahaw	17.6484	55	617.692	494.154	352.967	123.538	88	1180	0	36	10	88	140	0
	4	1	2	0	29200	3 Ahaw	16.0440	50	561.538	449.231	320.879	112.308	80	80	0	28	15	80	80	0
	3	13	0	0	26280	8 Ahaw	14.4396	45	505.385	404.308	288.791	101.077	72	800	0	20	20	72	20	0
	3	4	16	0	23360	13 Ahaw	12.8352	40	449.231	359.385	256.703	89.8462	64	1520	0	12	25	64	220	0
	2	16	14	0	20440	5 Ahaw	11.2308	35	393.077	314.462	224.615	78.6154	56	420	0	4	30	56	160	0
	2	8	12	0	17520	10 Ahaw	9.62637	30	336.923	269.538	192.527	67.3846	48	1140	0	48	35	48	100	0
	2	0	10	0	14600	2 Ahaw	8.02198	25	280.769	224.615	160.440	56.1538	40	40	0	40	40	40	40	0
	1	12	**8**	0	11680	7 Ahaw	6.41758	20	224.615	179.692	128.352	44.9231	32	760	0	32	45	32	240	0
	1	4	6	0	8760	12 Ahaw	4.81319	15	168.462	134.769	96.2637	33.6923	24	1480	0	24	50	24	180	0
		16	4	0	5840	4 Ahaw	3.20879	10	112.308	89.8462	64.1758	22.4615	16	380	0	16	55	16	120	0
		8	2	0	2920	9 Ahaw	1.60440	5	56.1538	44.9231	32.0879	11.2308	8	1100	0	8	60	8	60	0

(584) and other ritual numbers important to the Maya. The remainders for each of these calculations is given. Remainders are the days reached in each cycle.

For example, the entry 8.2.0 1 Ahaw is reduced to 2920. This is exactly five times 584; in the "Venus" column the number 5 appears, and in the "Ven" (remainders) column a 0 appears indicating that there is no remainder.

Using the patterning of these values the multiplication table can be seen to contain three separate numerical groupings. The first four numbers are even multiples of 584, 2920, 52, 65, 260 and 365. The next four numbers are evenly divisible by 52, 65, 260 and 365. The fourth number in the second group (9100) is also evenly divisible by 91 and 1820. The next twelve numbers are all evenly divisible by 584, 2920 and 365. Each of the numbers in this last set are the number of days from the lubay to the completion of successive 2920 day cycles.

Many researchers (Thompson: 1973; Lounsbury: 1983; Closs: 1977) believe the first two groups of numbers are used to correct the Venus table.

J. Eric Thompson uses the following method: Sixty-one Venus periods after the lubay of the table a day five Kan is reached. Five Kan is four days after one Ahaw. The accumulated error after 61 synodical periods of Venus is 4.88 days (61×0.08). Subtracting four days from five Kan restores the lubay (one Ahaw) and eliminates most of the accumulated error. The remainder of 0.88 days goes uncorrected until, after four cycles of 61 Venusian years, this error reaches nearly four days ($4 \times 0.88 = 3.52$). The error goes uncorrected for 57 more synodical periods, until a day nine Muluc is reached. Nine Muluc is eight days after one Ahaw. Subtracting eight days from nine Muluc recaptures the lubay of the table (one Ahaw), and reduces the accumulated error to 0.08 days. Equation 1 summarizes this process (J.E.S. Thompson: 1973):

$$4(584 \times 61 - 4) + 584 \times 57 - 8 = 175760 \qquad (1)$$

After 301 synodical revolutions of Venus the total correction is 24 days. These corrections serve the dual purpose of regaining the all-important Tzolk'in day 1 Ahaw as the table lubay and correcting for the difference between the actual and estimated synodic period of Venus. The use of corrections makes the table accurate to within 0.08 days in 481 years (Thompson: 1973). Other schemes for correcting the Venus table have been suggested (Lounsbury: 1983; Closs: 1977).

Another class of error is "scribal error". These are errors made by the Maya scribe in calculating or writing. The number most often corrected as being a "scribal error" is the eighth entry 1.5.5.0 (9100). This number has two interesting properties. First, it is the only number in the table which is evenly divisible by 1820. This fact is relevant in terms of other tables in the Dresden codex. Maya books are used on both sides and the obverse of the Venus table is a series of 91 and 65 multiplication tables (Dresden 71–74). 1820 figures prominently in this table as a multiple of both 91 and 65. It is also represented on Dresden page 74 on a scroll attached to a pot. The pot is used by Ixchel (Chac Chel) to catch the celestial fire issuing from an eclipse glyph, which is hanging from a celestial band with Venus represented on it. The number 1820 also appears on Dresden 52 in the Eclipse Warning table. In the same table on Dresden 52 there is another often "corrected" number, 13780. This number is 1820 less than one pass through the Eclipse Warning table.

The second property of 9100 is its remainder in the "Ven" column of Table II. The remainder of 9100 divided by 584 equals 340 (90 + 250). In terms of the stations of the Venus table, this is exactly one superior conjunction and one evening star cycle. That means if you calculated 9100 days from the last day of Venus as morning star you would reach the last day of Venus as evening star. This remainder represents two of the four positions of the Venus cycle as represented in the Venus table. It would seem that these tables are interconnected.

Synchronizing the Maya and Christian Calendars. The starting point for any investigation of the astronomical properties of the Maya writings must be the synchronization of the Maya long count and the Christian calendar. While this issue has preoccupied many of the great Mayanists of the last 150 years, no solution which satisfies all interested scholars has yet been proposed.

Wilson (1924) first suggested that the correlation of the Christian and Maya calendars be accomplished by adding some number to the Maya long count of days to give a Julian day number (commonly used by astronomers). This calculation he called the Ahaw formula, and the number to be added he called the correlation constant.

Between J. Eric Thompson's 1935 and D.H. Kelley's 1983 examination no comprehensive summary and analysis of the correlation material was done. Most archaeologists would like to put the correlation issue to bed and get on with the business of doing archaeology. This desire, while universally shared, should not lead us to accept prematurely any proposed correlation constant until it has fully answered all reasonable questions concerning its viability. The acceptance of a calendar correlation by rationalizing its shortcomings does not do justice to the Maya nor to the community of professional archaeologists. Most correlations pick up structural realities in the astronomy of the Maya period. The correct correlation coefficient will make evident to what extent astronomical events influenced various aspects of Maya cultural and religious life (accessions, burials, and marriages). It will also give us insights into the relationships between the Maya calendar, mythology and long term astronomical cycles (birth of the gods, the relationship between planets and day names, and calendar reform). The "right" correlation may also make evident the way in which the Maya used their tables (in various folding books) to interlock their cosmology, religious practices, astronomy and the routine and ritual of their everyday lives.

The degree to which all of the above were influenced by the "real-time" astronomy of the Maya era *is* the business of archaeology. That is, the understanding of the way in which the Maya thought and felt about their world, their gods, and themselves can be better understood with the right correlation constant. Opening this window into the minds and souls of the Maya is, in my opinion, one of the most pressing questions facing Mayanists today.

The detailed discussion of the synchronization of the Maya and Christian calendars is beyond the scope of this paper. It is necessary, however, to present a brief overview of the Thompson correlation (584285) and why I shall use the 660208 correlation in my computer simulations of Maya astronomy for the Venus table.

Since the 1960s the mainstream of Maya archaeology has largely followed the teachings of Sir J. Eric Thompson. Many issues were put to rest in spite of minority opinions that questioned some of these solutions. Maya script was, according to Thompson, primarily logographic with little, if any, phonetic components. Research into the phonetic nature of the Maya script was curtailed and more fruitful lines of research were pursued (discovering the logographic values of glyphs from their context). Slowly it became evident that the Maya script did have some phonetic components. It now seems that as much as 80 percent of the script could be phonetic syllables (L. Schele, personal communication, 1991).

The calendar correlation issue was likewise resolved. The 584283/5 correlations were uncritically accepted by most Mayanists. However, a small number of interested researchers (see Table III for a partial list) could not ignore what seems to be a large discrepancy between the astronomy the glyphs seemed to predict and the astronomy of the Thompson correlation. Dirt archaeologists and geophysical dating experts also express concerns over the way in which the Thompson correlation fits these classes of evidence (Chase: 1985, Lincoln: 1985, Wolfman: 1991). The consensus is that Thompson is too early.

Thompson (1974) pointed out that there are as many Ahaw constants as there are people examining the problem. This is perhaps reflecting a dissatisfaction with the way in which Thompson's correlation addresses the expectations of epigraphers and archaeoastronomers. Many correlations fit one set of data particularly well, while fitting others poorly or not at all. A good example is the Dittrich (1936) correlation (Table III). This correlation equates a very important heliacal rise of Venus as morning star (20-11-934 A.D.) with the Lub of the Venus table. This correlation fits the Venus data well but not the dirt archaeology, historical documents, geophysical dating and other astronomy.

It is worth noting that no correlation can fit all of the evidence and expectations. Consequently, the reliability of the data used to support a correlation should be examined in detail.

The 584285 correlation constant was first proposed by Thompson in his landmark 1937 article, "*Maya Chronology: The Correlation Question*". The strongest

TABLE III TWENTY-SEVEN CORRELATION CONSTANTS

Name	Date	Correlation
Willson	1924	438906
Bunge	1940	449817 (?)
Smiley a	1960	482699
Owen	1975	487410
Makemson	1946	489138
Spinden	1924	489384
Teeple	1926	492622
Dinsmoor	-	497879
Smiley b	1960	500210
Kelley a	1967	553279
Vollemaere	1972	577264
Goodman	1905	584280
Martinez	1926	584281
Thompson a	1935	584285
Cook de Leonard	1973	585789
Mukerji	1936	588466
Pogo	1937	588626
Schove	1977	615824
Kreichgauer	1927	626927
[Wells a	In This Paper	660208]
Kelley b	1978	663310
Hochleitner	1974	674265
Schultz	1955	677723
Escalona Ramos	1940	679108
Vaillant	-	679183
Dittrich	1936	698164
Weitzel	1945	774078

After Kelley 1983

evidence supporting this correlation comes from the 16th Century (and later) historical documents.

Of Diego de Landa's Relación de las Cosas de Yucatán, J. Eric Thompson (1937:58) says, "Landa's statements on the Maya calendar having been proved correct in almost every detail, one must consider any statement of his on the end of a katun as highly reliable. He tells us 'The Indians say that the Spaniards had just arrived at Merida in the year of our Lord 1541, which was exactly the first year of the era of 11 Ahau . . .' ". Thompson seems to be implying that the first year of the katun 11 Ahaw overlapped the year 1541 A.D. Yet on the same page he contradicts this statement by adding "Despite a certain ambiguity in Landa's statement, one can draw the conclusion from it with some certainty that the [previous] katun ended between the fall of 1539 and 1540" (*ibid.*). These confused and contradictory statements lead to the conclusion that this line of evidence is of limited reliability. Thompson goes on to describe various other historical documents as follows: "... the undoubted fact that many errors have crept in and additions been made to the various Chilam Balams by numerous copyists." Thompson (*ibid.*:57); "Page 66 of the Chronicle of the Oxkutzcab ... can not be classed as original material." Thompson (*ibid.*:59); "The Chronicle of Nakuk Pech ... the original is missing, and only copies exist". Thompson (*ibid.*:60).

It would seem that Thompson (1937) is cautioning the reader as to the reliability of these sources. On page 61 Thompson (*ibid.*) modifies the data in the Nakuk Pech to agree with Landa, which he modified from 11 Ahaw overlapped 1541 A.D. to 11 Ahaw began in 1539 or 1540 A.D. These data are unreliable and might best be used to confirm a correlation derived from different sources.

The evidence from ^{14}C, archaeomagnetic and other geophysical dating techniques have been used (Kelley 1983) to set limits within which a correlation must fall. D. Wolfman (1991) has pointed out that the mean of ^{14}C dates during the first millennium A.D. may vary from previously accepted interpretations by about 100 years. He suggests that dates which have seemed to support the Thompson correlation could easily support a correlation up to about 100 years later. Further, he sets a limit of ± 100 or so years on this ideal correlation. Thompson's correlation is at the lower end of this range; my correlation (660208) is at the upper end (Wolfman: 1984 and 1990).

Thompson (1937:68) points out that, "... an error in carving the glyphs on making the computation may have occurred. One can scarcely employ [this] the third [possibility] to bolster up some preconceived theory". I would offer this advice to proponents of the Thompson correlation who use "correcting the scribal errors" as a panacea to cure its many shortcomings. Another problem throughout the literature concerning the archaeoastronomy of the Thompson correlation is the use of very large resolutions for matching the astronomy to the Maya dates, and the inclusion of astronomical events not mentioned or implied by the Maya writings (Bricker and Bricker, 1986; Aveni 1990:207; Dutting, 1985; and Lounsbury, 1989). Thompson's (1937:89) view that "... astronomical phenomena are worthless as proofs of correlations unless accompanied by glyphs indicating the nature of the phenomenon", is very good advice. In contrast to this statement, Thompson (*ibid.*:64) previously proposed that the reason for his correlation's poor fit to the Venus table might be attributed to: "... the known desire of the Maya to record completion, it would, perhaps, seem more probable that the astronomers would have been more interested in the heliacal setting of the planet than its heliacal rising". This statement is at odds with the fundamental structure of the Venus table.

To analyse the Venus table we must assume the Maya constructed this table in such a way as to allow them to predict (and back calculate) the positions of Venus using the 9.9.9.16.0 1 Ahaw 18 K'ayab base date, and the four stations for Venus documented in the Venus table. Clearly, the Maya were interested in specific positions of Venus at specific times. The Thompson correlation fits the Venus table very poorly. He would put the lub of the Venus table 20 days before the heliacal rise of the planet (Aveni:1990, 207). This twenty day error would seem to be at odds with the accuracy implied by Thompson's previously described correction scheme.

The concept of completion might be applied to the Venus table on a larger scale. The 660208 correlation constant would fit the data in just such a fashion. Lounsbury (1990), in support of Thompson's original correlation, points to a day 1 Ahaw 18 K'ayab in the year 934 A.D. This is the only point, in 2000 years, that a day 1 Ahaw 18 K'ayab, counted back from the modern Maya calendar, coincides with a heliacal rise of Venus as morning star. The structure of the Venus table suggests that this occurred at 9.9.9.16.0 1 Ahaw 18 K'ayab and was approximately repeated 104 years later at the end of the table. In the Thompson correlation the heliacal rise of 934 A.D. is 312 years after 9.9.9.16.0 1 Ahaw 18 K'ayab. During this period the accumulated error would be 15.6 days.

Interestingly, the 660208 correlation places the 934 A.D. heliacal rise of Venus at the end of the table, that is, on a day 1 Ahaw 18 K'ayab, 104 Maya years after the documented lubay. I believe the Venus table was used by the Maya to calculate the positions of Venus both forward and backward in time. They positioned the 934 date at the end of the table to make observational errors symmetrical from the Lubay. In this way the table can be used for ±416 years without correlation, accumulating 20.8 days of error. The table can serve for calculations in both directions with equal proficiency. Note that page 24 has multiples of 584. The largest value in this multiplication table is 416 Maya years or four repetitions of the table. All standard correction schemes, described earlier, can still be applied (Thompson: 1973 and 1974; Closs in Aveni: 1977 and Lounsbury: 1983).

In the 660208 correlation the end of the Venus table at 1 Ahaw 18 K'ayab is within a few days of Venus' first day of visibility as morning star. On this day the Moon's age is 14 days, Mercury is visible at a magnitude of −0.05, 10° above the horizon in the morning sky. On the same day Mars and Venus rise in conjunction (having magnitudes of 1.8 and −4.6 respectively). All three planets are in the constellation of Libra. Venus and Mars rise 30 minutes before the Sun.

It would seem that the Thompson correlation was built upon a rather shaky foundation, held in place by the lack of a working alternative correlation.

The 660208 correlation fits the Venus data much more closely. At 9.9.9.16.0

1 Ahaw 18 K'ayab (19-12-830 A.D.), Venus is two days before heliacal rise as morning star, two after the winter solstice and on the day of the New Moon. On 9.14.2.6.0 1 Ahaw 18 Wo (the second lub from Dresden 24; 30-01-922 A.D.) Venus is two days before its heliacal rise as morning star and it is the day of a New Moon. This day is 33280 after 9.9.9.16.0 1 Ahaw 18 K'ayab, a value found on Dresden 24 (Table II), and is a formal position in the Venus table (boxed in Table I). The remaining base dates in the Venus table are calendar round dates and not explicitly tied to long count dates. The calendar round dates are 1 Ahaw 13 Mak (Table I, Page 50, Line 14) and 1 Ahaw 3 Xul (Page 50, Line 25). These calendar round dates have been calculated to be 9.11.3.2.0 1 Ahaw 13 Mak, and 9.8.3.16.0 1 Ahaw 3 Xul (Spinden: 1924 and Kelley: 1983). Makemson (1945), Thompson (1974) and others have placed these calendar round dates in different long count positions. These dates are used as alternative, corrected bases for the Venus table.

At 9.11.3.2.0 1 Ahaw 13 Mak (17-09-863 A.D.) Venus is the last day of Venus as morning star, 2 days before the autumnal equinox, and on the day of the New Moon. This date falls 11960 days, an eclipse interval used by the Maya, after the 1 Ahaw 18 K'ayab lub of the table.

For 9.8.3.16.0 1 Ahaw 3 Xul (05-05-805 A.D.) Venus is 15 days past inferior conjunction with the Sun, 11 days into its morning star cycle, and the Moon age is two. On this day Venus is in conjunction with Jupiter (1°53′). This date is 9360 days before the 18 K'ayab base of the table. 9360 days is also an eclipse interval used by the Maya.

The 660208 correlation also fits the Eclipse Warning table of the Dresden codex very well. The Eclipse Warning table has 3 lubs, at 15 day intervals. The first of these is (A) 9.16.4.10.8 12 Lamat 1 Muwan. This is the day (20-09-963 A.D.) of a New Moon, 2 days after the autumnal equinox. The next two lubs are a Full Moon (15 days later) at (B) 9.16.4.11.3 1 Ak'bal 16 Muwan and a New Moon (15 days later) at (C) 9.16.4.10.18 3 Etz'nab 11 Pax. Various schemes have been proposed as to how these dates might be used with the Eclipse Warning table to predict solar eclipses (Bricker and Bricker, 1986; Aveni, 1990; Lounsbury, 1978; Smiley, 1975). The first entry of the table proper [7 Chikchan (13 Sec)] is 177 days after date (A). In the 660208 correlation this is the day of a near total solar eclipse visible in the Maya area. All visible solar eclipses (there are 6 total and 9 partial) from 20-09-964 A.D. (date A) to 13-12-996 A.D. (11960 days later) can be predicted using the Eclipse Warning table (7 exactly, 6+1 day and 2+2 days). It is necessary to shift to date (C) for entry 49 (Picture 7) and entry 65 (Picture 9). Visible lunar eclipses fall on these two entries (using the date (C) base), perhaps signaling this shift.

The Thompson correlation works less well, predicting 4 near total and 4 partial eclipses (Bricker and Bricker, 1983). The explanation of the method necessary to make the Eclipse Warning table fit the Thompson correlation is far too lengthy to be discussed here (see Bricker and Bricker, 1983, for the best explanation).

One final point about the 660208 correlation. On Dresden 59 there is a 78 times table, an interval often associated with Mars. The Lubs of this table 9.12.10.16.9 13 Muluc 2 Sip (11-02-891) and 9.18.1.7.9 13 Muluc 17 Wo give positions for Mars in retrograde motion for both dates. In both cases Mars is exactly half the distance (in days) from its two stationary points. For the first date Jupiter and Saturn are in retrograde motion as well. This table follows the Eclipse Warning table in the Dresden codex. The exact method for using the table is still unclear, but some of the glyphs in the introductory text can be found in the Venus and Eclipse Warning table.

There are many other examples from the inscriptions which support the 660208 correlation, but even this brief overview demonstrates its superiority over the fatally flawed 584285 correlation.

Some Structures of the Venus Table and How They Compare with the Movements of the Planet Venus. While the resolution of what date is the true astronomical starting point for the Venus table will doubtless add much to our understanding of this table, an absolute resolution of the correlation problem is not a prerequisite for comparing the structure of the Venus table with the movements of Venus. In terms of the discussion that follows, any heliacal rising of Venus as morning star (including a modern one) could serve as a starting point for constructing a model of the movements of Venus.

The process of comparing the movements of Venus to the tables of numbers in the Dresden codex wants only a starting point in the Venusian synodical cycle. I have used 16/11/934 A.D. as a starting point for figure 3. This is the inferior conjunction just before the heliacal rising of Venus as morning star on 20/11/934 A.D. Figure 3 shows a computer recreation of the movements of Venus as both morning and evening star. The viewing point for this reconstruction is the Maya city of Copan, Honduras. This horizon view is analogous to what would be seen out a window if the horizon were completely flat. That is, if you went to your window at dawn each morning and plotted the position of Venus on the window pane, and if at the end of 263 days you "connected the dots", you would see a unique pattern. These patterns change subtly over time. After hundreds of years the morning star pattern looks very much like morning star pattern three (figure 3). These changes in shape are morphological and occur over very long periods. While changes in the shape of the patterns of Venus could have gone unnoticed by the Maya, the differences between the five patterns in figure 3 could not. Some patterns (2 and 5 figure 3) could be easily blocked by intervening topography, delaying the heliacal rising or setting of Venus for weeks. There is some glyphic evidence that the Maya were aware of these cyclic patterns and I shall return to this topic.

The most obvious structure in the Venus table is the vertical separation of the individual pages into halves. The pages are further divided into blocks of glyphs and pictures called t'ols. T'ols are labelled with lower case letters, beginning with the top left t'ol and ending with the bottom right. All the information in figure 2 is from the left half of pages 46 to 50 (t'ols a–c) in the Dresden codex. The right half of these pages is less often discussed.

Thompson (1972) gives the best treatment of the text of the right half of Dresden 46 to 50. While the main focus of this examination of the Venus table will be on the left half (astronomical data) of Dresden 46 to 50, a few points about the right half (divinations) seems appropriate. The right half of the page is divided into 3 T'ols. The top t'ol (d) contains sixteen glyphs and a picture. In figure 2 (Dresden page 50d) the Sun God orders the Maize God to subservience. Dresden page 48 shows the Maize God as the victim of Venus' third cycle. Many of the glyphs are destroyed, but Venus obviously had some effect on agriculture in Maya mythology. This is supported further by the many references in the auguries of the Venus table to the maize seed, maize of different colours, and maize harvests (Thompson: 1971).

The middle t'ol (e) of each page contains 12 glyphs and a picture. In figure 2 t'ol e shows the current manifestation of Venus for each of the five synodical periods – Black Bacab, Lahun Chan, Ta Ah Sik Cimi, Chac ... wa te k'a(?), and Kakatunal, respectively. In figure 3 the god and cycle glyph for each of the five cycles are compared. The glyphs in the Venus table identify the current manifestation of Venus and the effects of his light.

The bottom t'ol (f) contains 8 glyphs and a picture of the current celestial victim of Venus. These glyphs deal with Venus' effects on agriculture, intended terrestrial, and celestial, victims.

What is the relationship between the three pictures and text blocks on the right half of Dresden 46 to 50 and Venus? Thompson (1971) makes several good points concerning the symbolism used to describe Venus. We know from Aztec mythology that the rays of Venus' light were considered: "fateful in the extreme: according to the day on which the planet rose, different categories of humanity and nature suffered affliction. It is certain that similar ideas existed among the Maya at the time the present edition of Dresden was written." (Thompson, 1971: 217). The symbolism in the following text is very reminiscent of the pictures on the right hand side of Dresden pages 46 to 50: "if it [the day which coincides with the heliacal rising] falls on 1 Ocelotl, he spears the old... If on 1 Xochitl, he spears children. If on 1 Acatl he spears the great lords... If on Qulauitl, he spears the rain and it will not rain." (Codex Chimalpopoca (1945, par.51, Quoted in Thompson, 1971).

The similarities between descriptions and the symbolism of the pictures in the Venus table are unmistakable. Venus is considered powerful and dangerous and therefore must be watched carefully and guarded against through ritual.

The glyph block in t'ol e is read:

1	2	7	8
3	4	9	10
5	6	11	12

My interpretation of these positions is as follows: The glyphs in positions 1 and 2 are the same in each t'ol and are introductory. They read "was observed" and "east". The glyph in position 3 is the name of Venus for this synodical period. The glyph in position 4 is Venus' manifestation, as both the evening and morning star, for the current synodical period. Figure 3 shows glyphs 3 and 4, and their associated cycles. The glyphs in positions 5 and 6 are the god to which a ritual of protection may be made. Glyphs 7 through 12 are gods for whom this synodical period is particularly unlucky.

As to the left half of Dresden pages 46 to 50, it is my contention that each page contains intervals which represent the two orbital patterns, one morning and one evening (figure 3). These two patterns (or cycles) and the two conjunctions separating the cycles comprise the synodic period of Venus. Further, I believe each pair of cycles has a patron god, character (good or evil), and a manifestation of Venus in one of his five guises. The five pages of the Venus table record five sets of thirteen distinct periods. Could this be ek chab (Venus) ascending (or descending) the thirteen layers of heaven, with each layer having five manifestations of Venus?

Epigraphic evidence supporting the existence of five pairs of cycles is summarized in figure 3. The glyphs show a different glyph for Venus with each change of pattern. These glyphs can be seen in their original context in figure 2. The idea that there are five cycles of Venus was put forward by A.F. Aveni (1986). His view is that while there are few published works on the subject, the relationship of the five cycles of Venus and the five page structure of the Venus table are well known to him and others studying archaeoastronomy (Aveni: personal communication, 1990). The relationship between the glyphs in positions 3 and 4 of t'ol e has not been previously suggested.

Conclusions. The structure of the Venus table demonstrates that the Maya had some understanding, not only of the four stations of Venus' synodic period, but also of the characteristics of the patterns Venus traced through the heavens. The structure of the Venus table is such that it is organized to allow the prediction of Venus' behaviour, not only from synodic station to synodic station, but also through the longer eight year repetition of the five cycles.

In each of the five cycles Venus traces two orbital patterns – one as morning star, one as evening star. Each pattern is separated by a period of conjunction when Venus is lost in the solar glare. While similarities exist, each pair of orbital patterns has a distinct shape (figure 3). The five cycles repeat, in the same order, perpetually. In the Venus table each cycle has its own Venus glyph, patron god, and character. The Venus table is a detailed record (and prediction) of the behaviour of Venus for 13 periods of eight Haab.

The right half of the Venus table contains auguries, instructions for rites of protection, and warnings about who is in danger from the influences of Venus. These three sections are organized with one set of instructions for each pair of orbital patterns traced by Venus through the sky. Each of the five manifestations has its own glyph (t'ol e). That is, there are a new set of pictures and glyph blocks every 584 days. After five repetitions the same cycles, auguries, and instructions repeat. This sequence takes us from lub to lub. After 13 repetitions of all five cycles, the table reaches its lubay (completion).

The numbers 5, 13, 20 and 260, which comprise the matrix of dates in Table I, are very significant in Maya cosmology. The symbolism of the Venus table, with its 13 rows, 20 columns, and 260 Tzolk'in dates over five pages must have added to Venus's significance in Maya mythology. The fact that the calendar round (of 52 years) and the synodic period of Venus coincide after exactly 13 repetitions of the five cycles of Venus, must have seemed beyond coincidence to the Maya. The 13 layers of heaven play a central role in Maya cosmology.

Dresden 24 gives instruction, dates, and multiples of 584 with which the stations of Venus' synodic period can be calculated. That Venus and the Moon were strongly related in Maya thought is evidenced by both the structure of the Venus table (the length of the intervals between stations and between the line of Haab dates), and glyphs on Dresden 24 referring to the Eclipse Warning table.

The Maya universe rested on a crocodile in a cosmic sea. Each quarter of the earth was associated with a colour. There are four periods in the synodic period of Venus, each related to a direction by line 16 (see Table I). Through the heavens moved Venus, passing through its five cycles before moving to the next layer of the cosmos. On the day of the great lubay the Tzolk'in, Haab, and the cycles of Venus come to rest (at the completion of the 104 years of the table) on a day 1 Ahaw. On this day Hun Ahaw completes his cycle and begins his next, in an endless loop through time and space.

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