Figure 1. A portion of the north-wall mural is illuminated within Structure 10K-2. Research on the structure is supported by the National Geographic Society. Photo by Tyrone Turner © 2012 National Geographic. For more Structure 10K-2 photos and illustrations see www.mesoweb.com/reports/ngs/xultun.

Unearthing the Heavens: Classic Maya Murals and Astronomical Tables at Xultun, Guatemala

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Archaeologists led by William Saturno of Boston University recently announced the discovery of early ninth-century murals and associated astronomical tables in a residential structure at Xultun, Guatemala (Figures 1 and 2). The announcement was made at a press conference arranged by *National Geographic*, which funded the research, and coincided with the publication of preliminary results in *Science* (Saturno et al. 2012), to be followed by additional coverage in *National Geographic*'s June issue. A model of interdisciplinary collaboration, the *Science* authors include Saturno (who directed the research), epigrapher David Stuart, astronomer Anthony Aveni, and archaeologist Franco Rossi.

Noteworthy news coverage has included detailed reports by John Wilford in *The New York Times*, Erik Vance in the *National Geographic Daily News*, Carolyn Johnson in the *Boston Globe*, and Brian Vastag in the *Washington Post*. These reporters were all either present at the press conference or took the time to interview the *Science* authors or other Mayanists, with Erik Vance in the enviable position of reporting directly from Xultun. Unfortunately, as so often when news stories are boiled down to a few hundred words, must compete for headlines on the open market, and are able to pilfer previous reports for out-of-context quotes, some outlets have mistakenly reported the find as

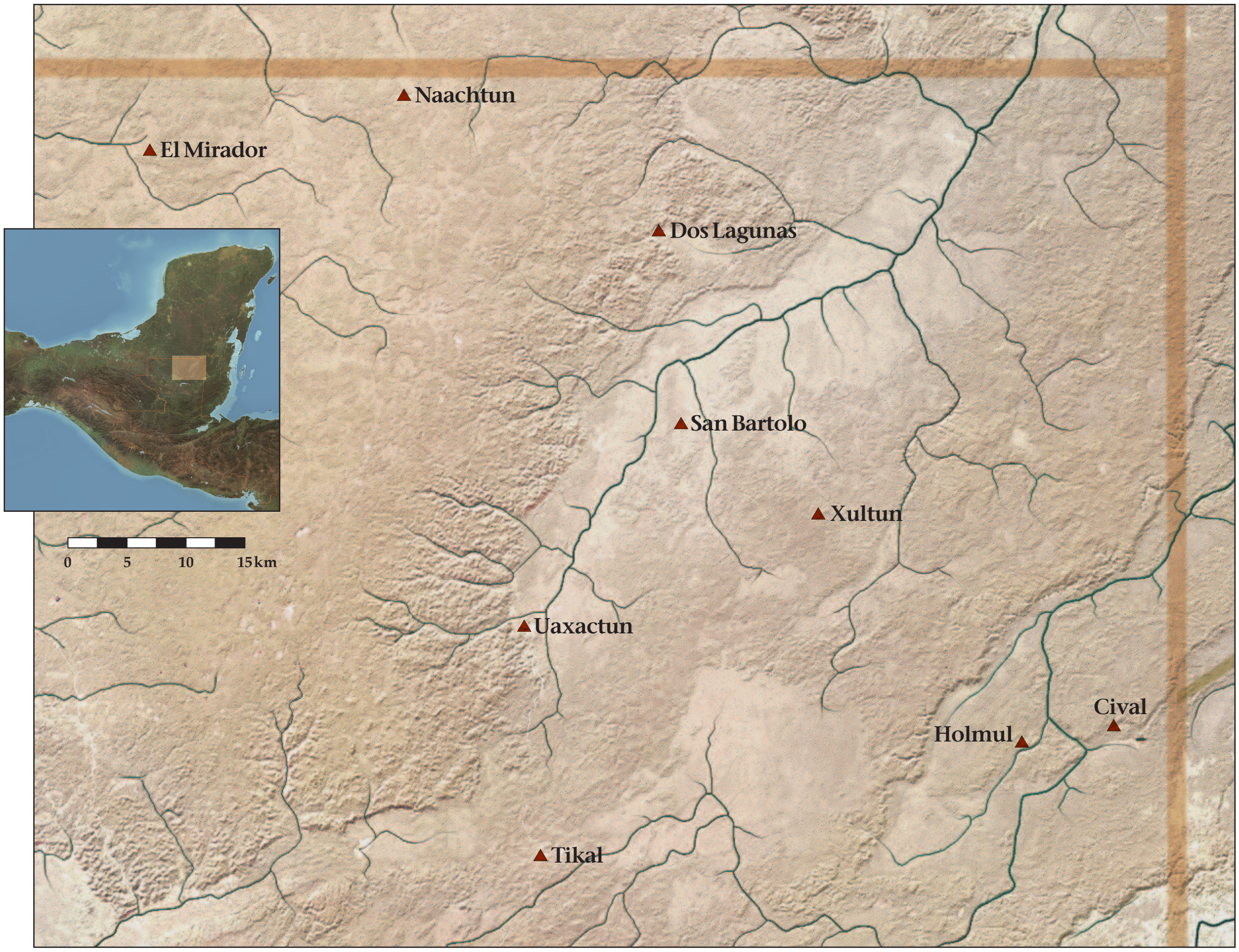

Figure 2. Xultun and neighboring sites (map courtesy of Precolumbia Mesoweb Press).

"the earliest Maya calendar" or have strained to make it appear relevant to 2012, which any story on the Maya apparently must address for at least the next eight months. Such treatment would be unfortunate for any find, but it is doubly so for the Xultun discoveries, which provide exciting new glimpses into the astronomical knowledge and calendrical practice of the Classic Maya.

The ruins of Xultun, Guatemala, were first reported in 1915 (Morley 1938:383-385). The name (pronounced shool-TOON) is school-boy Mayan for "end stone," given to the site by Sylvanus Morley on the basis of Xultun Stela 10 recording what was then the latest Long Count known (Figure 3). Morley had similarly named nearby Uaxactun "eight stone" for the early eighth-cycle dates on its monuments, and Naachtun "far stone" for its remoteness from Tikal. The curious origin and outdated spelling of these names are a part of their history, so we view attempts to update them (e.g., "Waxaktuun" for the site of Uaxactun) as both unnecessary and potentially confusing to the unwary: as such names approach modern spelling it becomes even easier to conclude, mistakenly, that they are authentic ancient names rather than convenient modern labels. It should also be pointed out that "Xultún" is a legitimate spelling only in a Spanish medium, as it marks the characteristic final-syllable stress of Mayan words as opposed to the default penultimate stress of Spanish ones. English-language news reports identifying the site as "Xultún" betray an unnuanced use of foreign place names and spelling conventions.

Although known for almost a hundred years, and despite several scientific expeditions to map the site and record its monuments in 1920–1923 (see Morley 1938:383-385) and again by the Corpus of Maya Hieroglyphic Inscriptions Project in 1974–1975 (Von Euw 1978; Von Euw and Graham 1984), Saturno et al. (2012:714) point out that "illicit excavations have left the largest mark on the site." Intensive looting during the mid- to late-1970s saw many of Xultun's structures trenched and tunneled in the search for ceramics and artifacts that now fill numerous private and public collections; this period even saw the theft of Stela 10, which as of this writing remains unrecovered. The wholesale removal of objects from Xultun's caches and burials, coupled with the relative lack of archaeological work at the site before the beginning of Saturno's project in 2008, means that much of what we know about Xultun historically, including its dynastic line and ancient toponym (Baaxwitz,[1] "Quartz Hill"), comes from looted pieces (see Garrison and Stuart 2004; Houston 1986; Prager et al. 2010; Saturno and Urquizú 2009).

In some ways, even the present find owes something to that massive period of looting in the 1970s. During the press conference, Saturno related some of his experiences during the past decade of archaeological work at the nearby site of San Bartolo, only eight kilometers from Xultun, noting that he had "long wanted to work at the truly massive site of Xultun, which was just over the horizon, sprawling over 16 square kilometers, with many significant temples and structures, the tallest topping some 35 meters high." Saturno finally got his chance in 2008, when systematic mapping of the site began in earnest. Two seasons later, Maxwell Chamberlain, an undergraduate student on a break from mapping in Sector 10K of the site, stuck his head into a looter's tunnel in Structure 2 and saw faint traces of exposed murals on the southern edge of the west interior wall. The murals were close to the surface and badly damaged, yet other walls were still buried and might be in better shape. Saturno felt it was his responsibility to investigate: "Maya paintings in and of themselves are exceedingly rare. Not because they didn't paint them often—all signs are that they did—but rare because they rarely preserve."

As Saturno and his colleagues note in their *Science* article:

> The structure, designated 10K-2, is located within a residential compound and was modified by the Maya over several construction phases. The most recent of these phases saw the room filled with rubble and earth, and the final phase built over it, effectively preserving its interior painting. The looters' excavation broke through this final veneer and exposed the southernmost portion of the room's west wall. They later abandoned their excavation, and the exposed painting began to weather. (Saturno et al. 2012:714)

Figure 3. Xultun Stela 10, current whereabouts unknown. The standing figure holds a diminutive jaguar as in many of the stelae of Xultun. The sides of the monument record the Long Count date 10.3.0.0.0 1 Ajaw 3 Yaxk'in (AD 889). After Morley (1937-1938:Plate 80).

Excavating the partially-damaged and sensitive murals took Saturno and his colleagues the better part of two field seasons, eventually "revealing that three of the structure's interior walls (west, north, and east), as well as its vaulted ceiling, were once covered by mural paintings" (Saturno

[1] We do not italicize this proper noun, or a Mayan name like Yax Pasaj Chan Yopaat, any more than we would the French names Paris or Sarkozy.

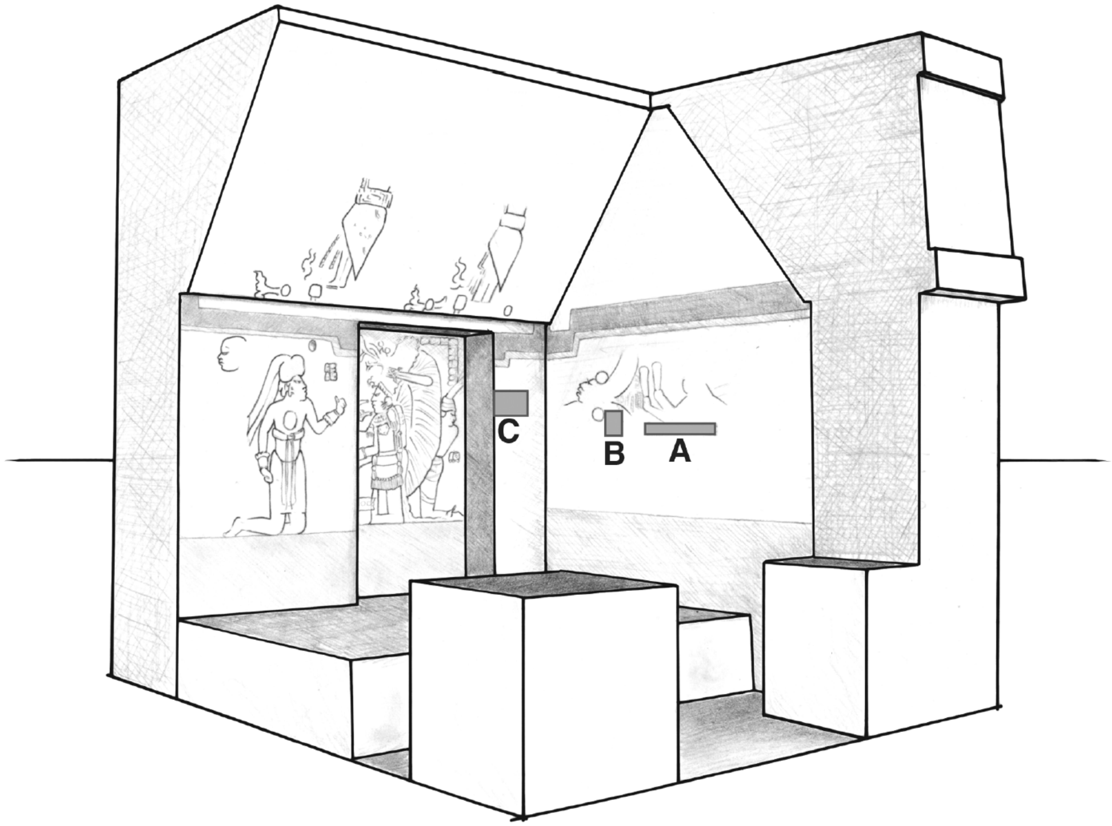

Figure 4. Reconstruction drawing of Structure 10K-2 showing the location of the murals (*A* indicates the lunar table, *B* the ring number, and *C* the numerical array). Drawing by Heather Hurst.

et al. 2012:714) (Figure 4). As Saturno (personal communication 2012) notes with grim humor, "the south wall was almost entirely doorway and what wasn't ended up being destroyed by the looters in what strikes me as a Wile E. Coyote-like entrance, bursting through the wall an inch to one side of the doorway." Overall, the "state of preservation of the murals varies considerably, owing to the damaging effects of water, roots, and insects. The east wall, located closest to the exterior surface of the covering mound, has eroded the most" (Saturno et al. 2012:714).

Saturno's team has thoroughly documented the surviving murals by means of broad-spectrum photography and flatbed scans taken directly from the mural surface (Figures 6, 7, 15), many of them included as Supplementary Materials with the *Science* article and in the news release. Artist Heather Hurst, a project member, prepared several stunning reconstruction drawings on the basis of these images (Figure 5).

During the press conference, Saturno and Stuart described the north-wall scene as centered on the portrait of a seated individual set inside a niche (Figure 5b). His captions are badly eroded, and his name effaced, but enough survives to identify him as a ruler of Xultun. Other associated texts provide dates clustering around AD 814 (Saturno et al. 2012:717), suggesting that the ruler might eventually be linked to those known from looted vessels (see Garrison and Stuart 2004).

The ruler is attended by a kneeling figure who appears to be either peeking out from behind his throne or, perhaps, helping him with his elaborate costume of quetzal feathers, like the priestly attendants in the costuming scenes in the somewhat earlier Bonampak murals (Zender 2004:230-233). Facing the king just outside the niche, another kneeling figure holds out a delicate stylus (Figure 5a). Saturno suggests that this may represent the mural's painter applying finishing touches to the king's portrait, though it's also worth considering that he may be yet another attendant applying body paint to the king in preparation for ritual celebration. Stuart notes that his caption identifies him as an **i-tz'i-ni-ta-ji**, *itz'intaaj* "younger (brother) obsidian," while the foremost of the three seated figures from the west wall is labeled **sa-ku-nu-ta-ji**, *sakuntaaj* "elder (brother) obsidian" (Figure 5c). The titles are rare and remain poorly understood, though Stuart notes that they appear in a few other contexts. One such is an

a

b

c

Figure 5. The figural murals of Structure 10K-2: (a) north-wall figure glyphically captioned as an *itz'intaaj*; (b) seated ruler from north-wall niche (not to scale respectively); (c) west-wall figures, the rightmost glyphically captioned *sakuntaaj*. Paintings by Heather Hurst.

Figure 6. Composite scan of approximately 80 cm of the east wall, spanning from a group of glyphs of different sizes, colors, and degrees of preservation on the left to the final column of the lunar table (Text A) on the right (for the lunar table see Figures 7 and 11). Composite image by William Saturno.

alabaster vase from La Florida, Honduras, where a "younger (brother) obsidian" is connected to Copan's sixteenth king, Yax Pasaj Chan Yopaat (see Riese 1986:Fig. 1). Another is Palenque's House C (West Court, Glyphic Panel 4) where a possessed context relates an "elder (brother) obsidian" (here **u-su-ku-na-ta-ji**) to his overlord at Santa Elena.

If these murals were the sum of the new discoveries at Xultun they would still be noteworthy, given their contribution of new contexts for two poorly-understood Classic titles, and in a residential setting no less. Yet there are other and equally remarkable things about the Xultun mural room, as Saturno and his colleagues have noted:

> The paintings on the east wall include a large number of small, delicately painted hieroglyphs, rendered in a variety of sizes and in black or red line near the two (possibly three) seated figures that once dominated the imagery. Thin coats of plaster were reapplied over existing texts to provide a clean slate for others. Still other texts are incised into the plaster surface. Given their arrangement around and on the figural painting and earlier texts, as well as the variety of sizes and method of execution of the preserved glyphs, there is little doubt that [the] texts were not integral to the original design of the chamber's mural decoration, but were created during the room's continual use. (Saturno et al. 2012:714-715)

During the press conference, Saturno and Stuart likened the room to a scribal workshop, with new texts periodically replacing earlier ones on the walls above the bench, almost all of them confined to an area where natural light would have been plentiful as it streamed in through the doorway of the small, six-foot-square room. Some fifteen painted or incised texts have been documented, ranging in length from 5 to 30 glyphs.

Figure 4 shows the locations of the three texts detailed in the *Science* article. Figure 6 represents a composite scan taking in some 80 centimeters of the east wall, spanning from one of the groups of differentially-sized and -colored glyphs (at left) through the entirety of the poorly-preserved Text A (at right). Figure 7, by contrast, is a close-up of the best-preserved portions of Text A, including a drawing by David Stuart (Figure 7c), made on the basis of processed images of the mural.

Text A: Lunar Table

Although Text A is poorly preserved overall, Saturno et al. (2012:715) note that it comprises columns of numbers in bar-and-dot notation, each topped by a hieroglyph depicting a deity profile conflated with a lunar sign. Similar "lunar deities" are found in other inscriptions recording Maya dates (as will be discussed in detail below), and this suggested that the Xultun numbers had lunar significance and counted elapsed days using the periods of the Long Count calendar.[2] Thus, for the rightmost column:

13 =	13 'tuns' =	13 x 360 =	4,680 days
5 =	5 'uinals' =	5 x 20 =	100 days
4 =	4 'kins' =	4 x 1 =	4 days
			4,784 days

And for the column to its left:

12 =	12 'tuns' =	12 x 360 =	4,320 days
14 =	14 'uinals' =	14 x 20 =	280 days
6 =	6 'kins' =	6 x 1 =	6 days
			4,606 days

The interval between these columns is 178 days (4,784 minus 4,606).

[2] Whereas it has long been thought that such columns of numbers might be used to express non-calendrical quantities in a straightforward vigesimal (base-20) manner, David Stuart (2012) has shown that all such columns, wherever found to date, pertain only to the periods of the Long Count.

Figure 7. Rightmost columns of Text A, the lunar table: (a) unprocessed composite scan made with Epson Perfection 4870 Photo flatbed scanner held in direct contact with painted surface; (b) image processed by increasing contrast, reducing color variation, and multiplying variation in black, then converting from 24-bit color to 8-bit black and white while controlling the effect of the reduced color categories; (c) drawing made on the basis of image *b*; (d) "stack" of the three images *a-c* as Photoshop layers of different opacities, effectively accentuating the texts while revealing the original color and patina of the plaster background. Composite images by William Saturno; drawing by David Stuart.

The bottom number for the third column from the right is eroded, but enough remains to be certain that it must have represented either a seven, an eight, or a nine, leading to a total of 4,427, 4,428, or 4,429 days. This also agrees with an interval of 177–179 days.

Although the rest of the numbers are differentially preserved, nothing that survives (including the accumulated total of 4,784) contradicts the basic observation that the numbers are a long list of accruing additions of 177, 178, or 179 days. Projecting this backwards to its logical conclusion, David Stuart has reconstructed the whole of this table as it might have appeared when it was new (Figure 11). In order to understand the rationale for Stuart's reconstruction (particularly his use of 177- and 178-day intervals exclusively, and the sequence of lunar faces above them) not to mention its significance for our understanding of the Classic Maya lunar calendar, it will repay our attention to briefly revisit what was known about these important topics before the discovery of the Xultun table.

In their *Science* article, the authors note:

> Visible atop at least five of the columns are individual "Moon" glyphs combined with facial profiles. Enough detail is visible on two of these glyphs to see that they are deities. Elsewhere, similar hieroglyphs are used to record Moon ages in Maya date records—as part of the so-called Lunar Series identified by Teeple. (Saturno et al. 2012:715)

Let's consider a standard Long Count and embedded Lunar Series as an illustration. (Those readers already familiar with the Long Count as a whole may wish to skip to the beginning of the next paragraph.) The south side of Palenque's Temple XIX bench opens with a text recounting the coronation of one of Palenque's patron gods in the year 3309 BC (Stuart 2005). Figure 8 reproduces the first 24 glyph blocks of this inscription, providing the date of the event in both the Initial Series and Supplementary Series (Morley 1920). The first glyph (A1) is the Initial Series Introductory Glyph, whose central variable element, the personified head of the **AHK'AB** "darkness" sign, indicates a date falling in the solar calendar period Mol. The five primary constituents of the Long Count follow, giving the date 12.10.1.13.2 (B1-B3). This is immediately followed by the position in the 260-day ritual calendar, 9 Ik' (A4). The next two glyphs initiate the Supplementary Series, providing an indication of the date's position in a perpetual 9-day cycle (B4-A5). Continuing the Supplementary Series, the next five glyph blocks provide the Lunar Series (B5-B7), to which we return in the next paragraph. Glyph blocks A8-D3 conclude the Supplementary Series by indicating the position of the date within the still poorly-understood 819-day count, indicating that an interval of 1.16.17, or 697 days (A8-C1), have elapsed since the last important station in that cycle, 1 Chikchan 17 Ch'en (D1-C2), when an aspect of K'awiil (C3) is said to have "stood" (D2) in the east (D3). Finally, at C4, comes a return to the Initial Series, with the position of the date in the 365-day solar calendar, 5 Mol (D4).

The Lunar Series (B5-B7)[3] can be transcribed and transliterated as follows (where JGU stands for Jaguar God of the Underworld):

B5:	2-20-**ji**-**HUL**-**ya**	*cha' winik ij huliiy*
A6:	**u**-2-JGU-**UH**?	*u cha'* JGU *uh*(?)
B6:	**BAHLAM-K'UH-AHIN-ni**	*bahlam k'uh ahin*
A7:	**u**-[**ch'o-ko**]**K'ABA'**	*u ch'ok k'aba'*
B7:	20-**ki**-9	*winikbaluun*

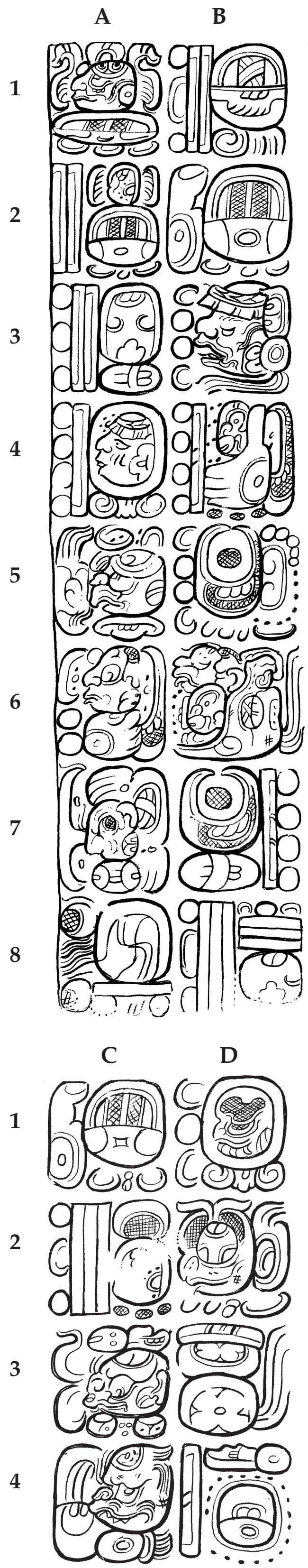

Figure 8. Temple 19 Bench, A1-D4. Drawing by David Stuart.

[3] Note that not all Lunar Series provide all five constituents, though this is always the order of the individual elements. See Thompson (1950:Figs. 36-37) for variations in the kind and number of elements in the Lunar Series.

Undeciphered signs and insufficient variation preclude a full transliteration and literal reading of this (or any) Lunar Series, though following recent work by Juan Ignacio Cases (personal communication 2007) their syntactic integrity is no longer in doubt. Taking into account the verb *hul* "to arrive, appear" and the possessed predicate noun *uk'aba'* "is its name," we can propose the following rough translation:

> "It is (now) 22 days since the second JGU-Moon appeared. The child-name of this twenty-nine(-day-long moon) is Bahlam K'uh Ahin."

For now, note the resemblance of the Jaguar God of the Underworld head at A6 of the Palenque inscription to the head at the top of column A of the reconstructed Xultun lunar table in Figure 11. Here and elsewhere, the Jaguar God of the Underworld, always combined or conflated with a lunar glyph, is a known patron of the Lunar Series.

The basis for these interpretations has a long history. Although Morley (1920) gave us the nomenclature for the study of the Lunar Series glyphs, designating them Glyphs D/E, C, X, B, and A, it was John Teeple (1930) who first demonstrated their lunar associations. To begin with, he noticed that the final glyph of the series always recorded an interval of either 29 or 30 days, suspiciously similar to the length of the moon's mean synodic period of 29.53059 days.[4] He also noticed that the first numbers in the series always record an interval between 0 and 29 days, suggesting that they record the number of days elapsed since New Moon. From these considerations, coupled with the observation that the coefficient of the second glyph in the series (designated Glyph C) never exceedes six, came the suggestion that the Maya may have counted moons in what Teeple called "semesters" of six lunations, each 177 or 178 days in length (depending on whether they contained three or four of the 30-day intervals necessary to bring calculations into alignment with lunar observations over the long run). Teeple went on to confirm his lunar-semester hypothesis by examining the intervals between Long Counts in the inscriptions of Palenque.

As such, the basic role of Glyph C to record the moon number in a recurring cycle of six months, similar to those in the eclipse table of the Dresden Codex (which we will look at in a moment), has been more or less understood since at least 1930. But the precise role of the lunar patrons depicted in Glyph C remained enigmatic until much more recently. No less an authority than J. Eric S. Thompson (1950:247) saw in them a bipartite division between "young" and "old" gods, while David Kelley (1976:93) discerned as many as a dozen different deities. In fairness, these scholars had to contend with a substantially smaller number of Lunar Series inscriptions, about half of those available for study today, many of which were badly eroded.[5] For these reasons, it wasn't until John Linden's (1986, 1996) work that the role of three distinct lunar patrons in defining a calendar of eighteen (3 x 6) lunar synodic months first became apparent (see also Schele et al. 1992).

But even though Linden's work represented a large step forward, his identifications of the patrons as "Skull," "Human," and "Mythical" nonetheless leave something to be desired. Today we can identify these patrons as the Death God (God A), the Tonsured Maize God (Juun Ixiim), and the Jaguar God of the Underworld (a label of convenience, not a decipherment, since his glyphic name remains unclear). Images of at least two of these lunar patrons can be seen on an unprovenanced vase (Figure 9). The vessel illustrates a scene from the well-known tale of the deposing of God L by the Hero Twins and the Tonsured Maize God, assisted in this and other scenes by the Moon Goddess and her rabbit companion (see Stuart 1993; Miller and Martin 2004:58-62; Stone and Zender 2011:199).[6] Importantly, note the visual separation of the Moon Goddess from the male lunar patrons facing her. Although central to lunar iconography (see Figure 10) the Moon Goddess plays no role in the Lunar Series (contra Schele et al. 1992:4-5). The young lunar patron visible at the top of the rightmost column in Figure 7c, and repeated atop every third column in Figure 11, is best identified as the Tonsured Maize God (Juun Ixiim) in his lunar aspect. In several key Glyph C contexts this lunar patron sports Juun Ixiim's characteristic dentition, forehead jewel, or maize curl (e.g., Tikal Marcador, A7; Copan HS, date 24; Quirigua St F, East, E7).

As for the basis of the repeating sequence of lunar patrons in David Stuart's table, this stems from observations of intervals in Classic Maya

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[4] The lunar synodic period is the time it takes the moon to complete all of its phases.

[5] Some two hundred Lunar Series are known today (see Schele et al. 1992).

[6] Discussions of this ancient myth usually focus on God L's well-known role as the Merchant God of the Underworld. Nonetheless, God L also appears as Venus in its baleful Morning Star aspect on page 46b of the Dresden Codex (see Figure 14b). For this reason, it's worth considering that God L's comeuppance at the hands of the Moon may represent some seasonal contest between Venus and the Moon as bright nocturnal objects.

Figure 9. The Moon Goddess, rabbit, and lunar patrons humiliate God L. Photograph K5166 © Justin Kerr.

Figure 10. Moon Goddess and rabbit from the skyband bench of Copan Structure 8N-66C (photo: Marc Zender).

Lunar Series inscriptions going back to Sylvanus Morley (1920:560). Intriguingly, even occasional errors in the Classic Lunar Series prove revealing. For instance, there are a number of examples of identical Long Counts actually showing different Glyph C positions. This variation most commonly falls into one of two observable patterns:

(1) The same lunar patron, but with a discrepancy of one in the coefficient (e.g., Yaxchilan Stela 11, front and back, both sides recording the Long Count position 9.16.1.0.0, but with Glyph C positions of fourth Maize God moon and fifth Maize God moon, respectively)

(2) A different lunar patron with different coefficients (e.g., 9.16.10.0.0 recorded as sixth Maize God moon on Quirigua Stela F, but as first JGU moon on Yaxchilan Stela 1, Sacul Stela 1, and Copan Stela N)

Multiple examples of these errors are known (see Linden 1996). Now that we have the Xultun lunar table, we can see that these are probably the same basic error: a calculation off by one lunation (i.e., one 29- or 30-day period). When such an error fell within the same lunar semester, the outcome was a difference of one number in the coefficient. When the error straddled two lunar semesters, the outcome was two sequential patrons, the first identified as the last moon of its semester (e.g., sixth Maize God moon in the case of Quirigua Stela F) and the second as the first moon of the next semester (e.g., first JGU moon on Copan Stela N and elsewhere). Even the errors, then, agree with the notion of a calendar of 18 lunar synodic months, divided up into three lunar patrons, each governing six moons (a 177-day period), before retiring in favor of the next patron.

All that remains now is for us to discuss the reasoning behind the 177- and 178-day intervals of the reconstructed Xultun lunar table (Figure 11). It has long been known that pages 51–58 of the Dresden Codex contain a lengthy lunar table, sometimes called the Dresden Codex eclipse table (Figure 12). The Dresden Codex calculates moons in intervals of six lunations (177 days), with an occasional correction of five lunations (148 days) over a period spanning 11,958 days, or 405 total lunations (see Aveni 2001:173-184 for a thorough discussion). This works out to an average of 29.52593 days per lunation. Mayanists have long marveled at the accuracy of this table, which places the average length of a lunation within seven minutes of the modern figure of ~29.53059 (Aveni 2001:183). More fascinating still, however, is that the recently-discovered Xultun table actually comes even closer to the modern value. It will be remembered that the Xultun table covers a total of 4,784 days and represents 162 lunations (Saturno et al. 2012:715), which works out to a mean length of 29.53086 days per lunation, or *within four minutes* of the modern figure.[7]

Nonetheless, the way the Dresden lunar table worked is strikingly similar to the table discovered by Saturno and his colleagues at Xultun. Starting on Dresden page 53a and running along the top half of the next five pages before returning to 51b and running along the bottom half of the next seven pages can be observed the entirety of the count of 11,958 days in three running tallies. Reading from the bottom of the page to the top, these are:

(1) a series of 8.17 (177-day, or six-moon) intervals, interspersed occasionally with a 7.8 (148-day, or five-moon) interval, usually right before an image representing an eclipse;

(2) the positions in the 260-day ritual calendar reached with each addition, including a ±1-day error (for instance, in the first column of page 53a we observe the sequence 6 K'an, 7 Chikchan, 8 Kimi, all separated by one day, the result of adding either 177, 178, or 179 days to the 12 Lamat starting position seen on pages 51a to 52a); and

(3) the cumulative totals, eventually reaching 1.13.3.18 (11,958 days) at the bottom of page 58b. (Note, for instance, that any two sequential numbers in this upper section will usually be separated by the number at the bottom of the previous column. Thus, in the first column of page 54b we have the upper number 1.2.2.12, or 7,972 days, which is precisely 177 days later than the number in the preceding column on page 53b: 1.1.11.15, or 7,795 days. Occasionally, however, the interval proves to be 178 days, despite that 177 is always written in the lower intervals column.)

Although many more details are present in the Dresden Codex tables, including poorly understood passages of glyphic descriptions associated with the eclipses, their basic structure is very similar to the cumulative 177- and 178-day totals

[7] All things being equal, one might have imagined that the substantially later and roughly two-and-a-half times longer Dresden Codex table would have even more closely approximated the average lunation. Yet it seems the Dresden table sacrificed overall accuracy in the length of a single lunar synodic period for a closer running approximation of the moon, making for a more capable predictor of lunar (and perhaps even solar) eclipses.

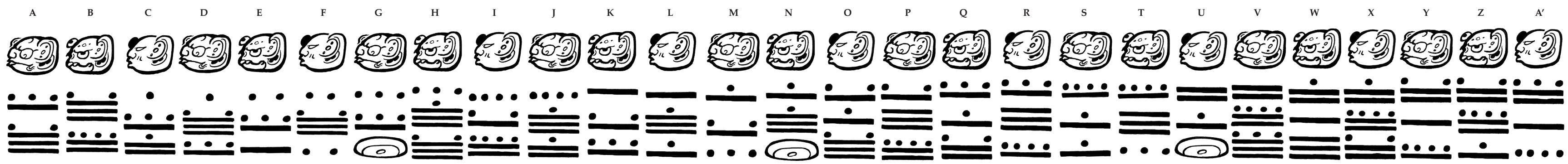

Figure 11. The reconstructed Xultun lunar table. Drawing by David Stuart.

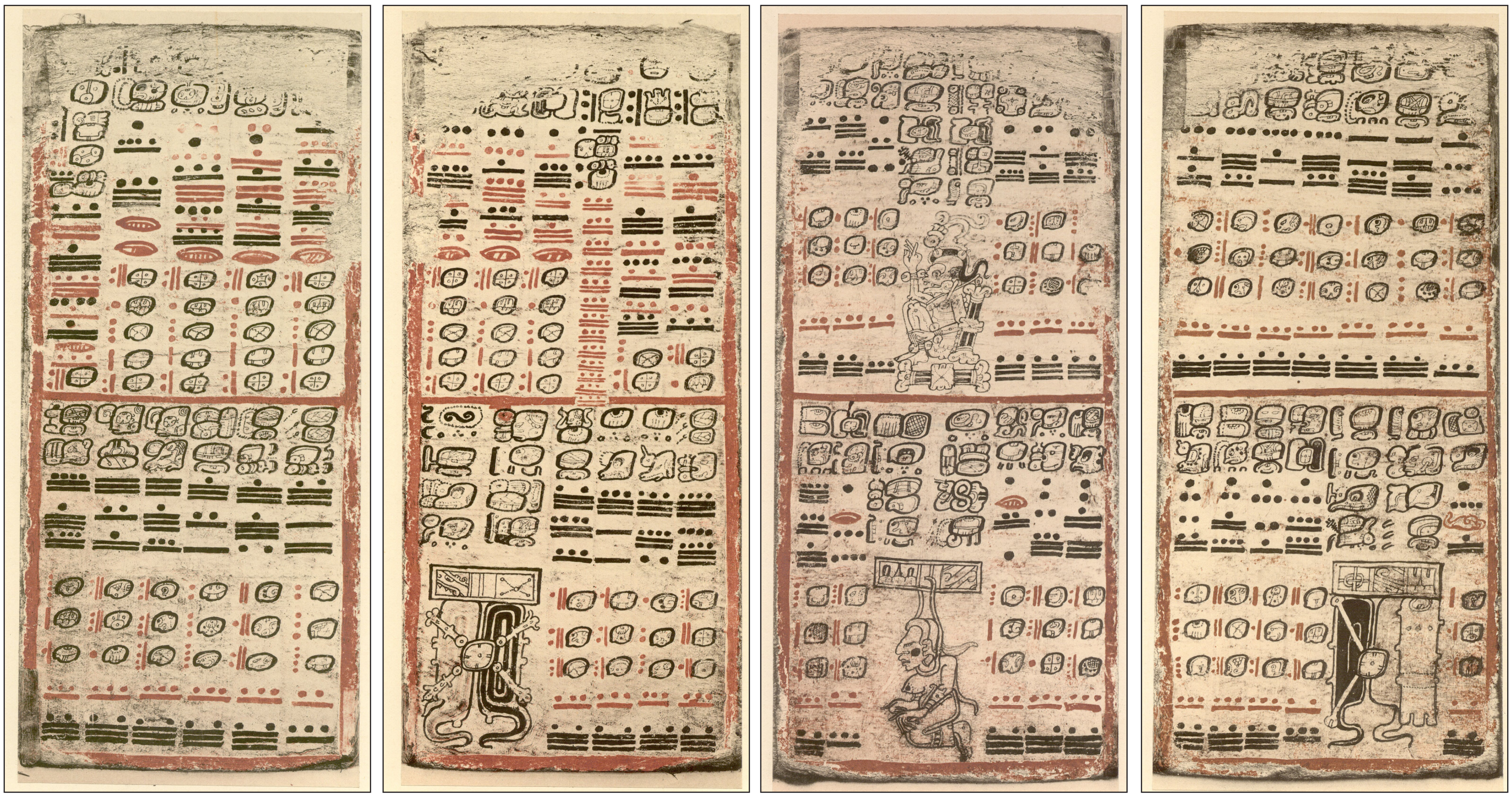

Figure 12. The first four pages (51–54) of the Dresden Codex eclipse table. Images courtesy of FAMSI (see www.famsi.org/mayawriting/codices/dresden.html).

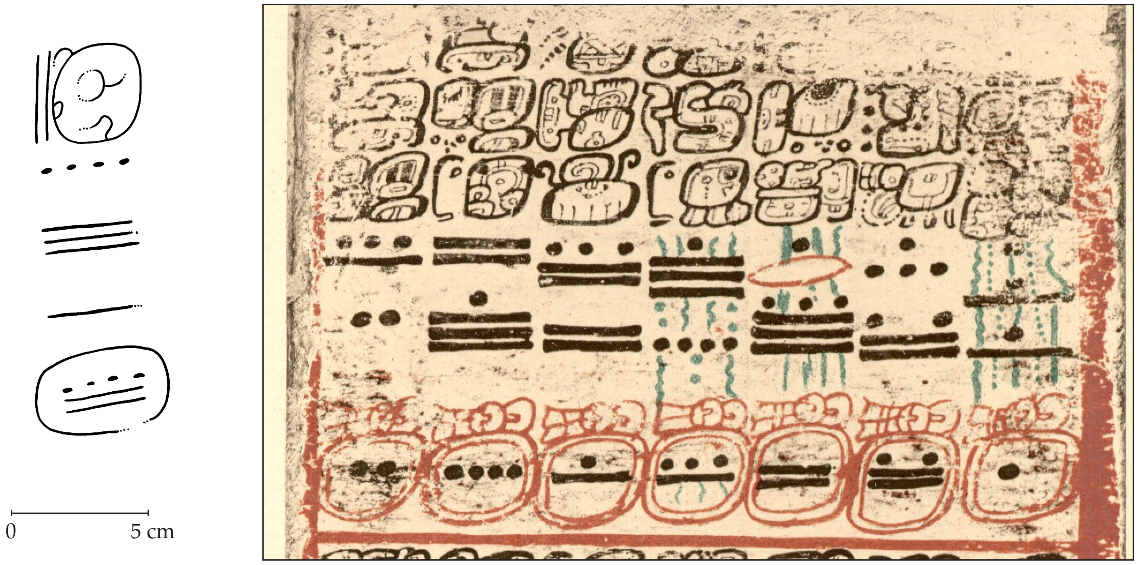

Figure 13. Ring numbers in Maya inscriptions: (left) ring number from Xultun (drawing by David Stuart); (right) ring numbers from the Dresden Codex, page 72a (image courtesy of FAMSI).

recorded in the Xultun table.

Ever since Teeple's (1930) work, discussion of the lunar cycle has revolved around clever formulas derived from the observed Lunar Series records at archaeological sites such as Copan and Palenque. A particularly fascinating and refreshing aspect of the Xultun discovery is the revelation that the Maya of the early ninth century AD were already using calculating tables not unlike those of the centuries-later codices. That the Xultun table more closely followed the 177- and 178-day intervals, and was specifically associated with the Glyph C lunar patrons, suggests that its primary usage was as a calculator of lunar semesters (Saturno et al. 2012:715). The Dresden table, by contrast, does not even mention Glyph C and seems instead to have been used primarily for the determination of eclipses (hence the occasional interpolation of a 148-day interval of five moons) and their commensuration with the 260-day ritual calendar. As Aveni (2001:184) notes, this close association of astronomical and ritual intervals was in many ways the driving force behind Maya observations of the heavens. For the Dresden Codex, then, but perhaps somewhat less so the new Xultun find, Thompson's (1972a:77) dictum seems to be amply validated, that "so far as ends are concerned Maya astronomy is astrology."

Text B: Ring Number

In their supplementary materials to the *Science* article, the authors illustrate and describe a small incised text that can once again be linked to calculations otherwise known only from the much later Dresden Codex (Figure 13). They note:

> A small carefully incised text was also made on the east wall, directly upon one of the large painted figures of the mural. This begins with the day record 10 Kimi, followed by a column of four numbers: 4, 15, 5 and 14, with the last encircled within a cartouche. The format of this final number is identical to so-called "Ring Numbers" in the Dresden Codex, which were used to express time intervals projected backward from the known base date of the Long Count calendar, 13.0.0.0.0 4 Ahaw 8 Kumk'u. Subtracting 4.15.5.14 from the 13.0.0.0.0 base date, we arrive at 12.15.4.12.6 10 Kimi 4 Kumk'u, or September 25, 3207 BCE. The 10 Kimi heading the column confirms the calculation, which provides the only solidly readable Long Count date among the writings on the mural's east wall. Falling four thousand years before the date of the Xultun mural, it clearly cannot be a historical or contemporaneous record.

By way of illustration, let's compare the Xultun ring number to a well-known example at the outset of the Dresden Codex Venus table (Figure 14a, bottom left). Like the Xultun number, we meet several numbers arranged in a vertical column, in this case 6.2.0 (140 days), with the last number encircled in a cartouche. Counting back from 13.0.0.0.0 4 Ajaw 8 Kumk'u (note the Calendar Round notation for this date directly below the ring number) we reach 12.19.13.16.0 1 Ajaw 18 K'ank'in. To the right we find the notation 9.9.16.0.0. As a Long Count position, this would equate to 4 Ajaw 8 Kumk'u,

Figure 14. A portion of the Dresden Codex Venus table: (a) page 24; (b) page 46. The four repeating glyphs five rows up from the bottom left in *b* (and associated with the Venus intervals discussed in the text) are each read **CHAK-EK'**, "Big Star," the Mayan name for Venus. Images courtesy of FAMSI.

but as a distance number, added to 12.19.13.16.0, it reaches 9.9.9.16.0 1 Ajaw 18 K'ayab, the Long Count position noted two columns to the right of the ring number and the Calendar Round position noted immediately to the right of 4 Ajaw 8 Kumk'u.

Saturno and his colleagues (2012:715) cautiously observe that the relationship between the Xultun ring number and the other Xultun texts is unclear at present, but it's enticing to speculate that, like the Dresden Codex ring number, it may have provided a base date for additional calculations, perhaps for Venus or other astronomical bodies.

Text C: Numerical Array

The third of the three calendrical texts detailed in the authors' *Science* article is a fascinating array of numbers and associated 260-day ritual calendar

Figure 15. Numerical array (intervals) from the north wall of Structure 10K-2. The signs and coefficients in the top row are 1 Kawak (or Kaban), 9 K'an, 13 Chikchan, and ? Manik'. Composite image by William Saturno; drawing by David Stuart.

No.	Interval	Decimal	Tzolk'in (260 days)	Haab (365 days)	CR (18,980 days)	Venus (584 days)	Mars? (780 days)
A	8.6.1.9.0	1,195,730	4599	3276	63	—	1533
B	2.7.9.0.0	341,640	1314	936	18	117	438
C	17.0.1.3.0	2,448,420	9417	6708	129	—	3139
D	12.5.3.3.0	1,765,140	6789	4836	93	—	2263

Figure 16. Simplified version of Table 1 from Saturno et al. 2012.

positions (Figure 15). The authors note that the individual columns of this array, unlike the lunar calendar, seem independent of one another, inasmuch as the intervals do not link the different ritual calendar stations, and they transcribe and total them as in Figure 16 above (slightly simplified from the original).

As the authors note, several of these numbers show clear signs of having been contrived to represent even multiples of important astronomical and ritual intervals. All of them contain even multiples of the 260-day ritual calendar, the 365-day vague year, and the 18,980-day Calendar Round (CR). This would have been a convenient calendrical aid, allowing a scribe to return to iterations of each of the column-heading ritual calendar positions while still retaining the same position within the 365-day calendar. At least one of the Xultun columns (B) apparently also commensurates with the Venus cycle, inasmuch as it is evenly divisible by the same 584-day interval employed along the bottom of the Dresden Codex Venus pages to approximate the 583.92-day average synodic period of Venus. Note that the red numbers at the bottom of page 46 of the Dresden Codex (Figure 14b) read 11.16 (236), 4.10 (90), 12.10 (250) and 0.8 (8), totaling 1.11.4, or 584 days. These intervals are repeated on succeeding pages, and cumulatively totaled higher up on the page, eventually reaching 8.2.0 (2,920 days) in the middle of page fifty. Thus 2,920 days is five Venus cycles and exactly eight 365-day vague years.

Nonetheless the authors caution that "the Xultun intervals and the aforementioned submultiples can be generated solely as a consequence of their relationship to the Calendar Round" (Saturno et al. 2012:716-717). For instance, the intriguing Venus multiple of Column B might follow naturally from its numerical relationship with the 365-day vague year, or the consideration that the full 37,960-day length of the Venus table is "also a double Calendar Round" (Saturno et al. 2012:716). Similarly, although all four of these numbers are evenly divisible by 780, a close approximation of the 779.94-day cycle of the planet Mars, this is also a number automatically generated by multiplying the 260-day ritual calendar by three.

All apart from the precise role of the numerical array, the Xultun tables have already provided remarkable information on the specifics of Classic Maya astronomy and calendrical practice, and have confirmed long-standing assumptions that the astronomical tables of the Dresden Codex must have had Classic Period antecedents.

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