

# **Contributions to the Encyclopaedia of the History of Science, Technology, and Medicine in Non-Western Cultures**

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## **The Use and Practice of Geography in Mesoamerica.**

Unlike the ancient Greeks, for whom all knowledge could be categorized according to a tripartite classification, the phenomenon itself, its place in time (history), and its place in space (geography), the civilizations of pre-Columbian Mesoamerica viewed all knowledge as religion, some aspects of which found their reflection both in time and space. The most original intellectual creation to emanate from Mesoamerica was the 260-day sacred almanac, known variously as the tzolkin among the Maya and as the tonalpohualli among the Aztecs. Pre-dating the 365-day secular calendar, which these people also developed, it ran concurrently with the latter to produce a never-ending series of 52-year cycles ( $365 \times 52 = 260 \times 73 = 18,980$  days), giving rise to the Mesoamerican belief that history repeated itself every 52 years.

Though the origin of the 260-day calendar has long been debated, the most convincing explanation for its astronomic underpinnings was first given by Zelia Nuttall in 1928, who argued that it represented the interval between zenithal sun positions at Copán, the major Maya astronomical center located in the mountains of western Honduras. At the latitude of Copán ( $14.8^\circ$  N.), the sun passes overhead at noon on August 13 on its apparent southward journey to the Tropic of Capricorn and again on April 30 on its apparent northward journey to the Tropic of Cancer. In 1945, R. Merrill called attention to the "coincidence" of the August 13 date with the start of the so-called Maya Long Count, which in the Goodman-Martínez-Thompson correlation between the Maya and Christian calendars fixes the beginning of the present cycle of the world as August 13, 3114 B.C. (The Long Count represented a meshing of the 260-day sacred almanac and the 365-day secular calendar in such a way that each day was as uniquely and precisely identified as they are in the Julian Day system employed by modern astronomers.) In 1948 a Guatemalan scholar, R. Girard, contended that the calendar's birth-place lay along the same parallel of latitude but in the mountains of his country instead. While concurring in the astronomical importance of the  $14.8^\circ$  parallel of latitude, the present writer was forced to reject both Copán and the highlands of Guatemala as the

calendar's cradle, for reasons both of history and of geography. No pre-Columbian site situated along that parallel in the highlands of Central America predates the fifth century A.D., whereas the sacred calendar is known to have been in use for several centuries before the birth of Christ. Furthermore, many of the day-names used in the sacred almanac commemorate lowland tropical animals. The only place where the requisite astronomy, history, and geography come together is at Izapa, on the Pacific coastal plain of Mexico, where a large ceremonial center of Formative age (1500 B.C. - 300 A.D.) is found amidst a tropical rainforest ecological niche.

Field work at Izapa in 1974 not only revealed that the entire ceremonial center is oriented to Tacaná, a commanding volcano of 13,428 feet elevation on the northern horizon but also that the highest volcano in Central America, Tajumulco (13,845') marks the azimuth of the rising sun on the summer solstice (June 22) as seen from Izapa. This use of prominent topographic features to serve as calendrical markers was subsequently traced to the oldest so-called "Olmec" ceremonial centers of San Lorenzo (1200 B.C., oriented to Zempoaltepec (11,138') at the winter solstice sunset), La Venta (1000 B.C., oriented to Cerro Santa Martha (4,600') at the summer solstice sunset), and Tres Zapotes (800 B.C., oriented to Cerro San Martín (4,600') at the summer solstice sunrise), but also to the earliest ceremonial centers of the Mexican plateau, including Cholula, Cuicuilco, Tlatilco, and Tlapacoya. Significantly, only two of the earliest Maya sites, Uaxactun and Tikal, have mountains within view, but both of them are likewise oriented to the winter solstice sunrise over the highest peak within sight -- the first to Baldy Beacon (3,346') and the second to Victoria Peak (3,680'). In each instance, the local site-factor which pinpointed the ceremonial center's location was the availability of water, both for domestic uses and, in the early "Olmec" centers, for transport, but only when the situational factor of the proper solstitial orientation coincided with it.

Interestingly, where prominent mountains are not visible on the horizon, the early Mesoamericans substituted architectural alignments for solstitial orientations. The greatest of pre-Columbian cities, Teotihuacán, about 30 miles northeast of present-day Mexico City, combines an intriguing blend of both principles: it is located precisely in line with the winter solstice sunrise over the highest mountain in Mexico -- Orizaba, 18,700' -- but the peak itself is obscured by a low ridge of hills on the southeastern horizon. It would appear that a "relay station" was built there to allow the priests of Teotihuacán to calibrate their calendar with the southernmost position of the sun, whereas the entire city itself was meticulously gridded to the sunset position on August 13 -- the day the present cycle of the world was believed to have begun.

The commemoration of the August 13 sunset is also found in the layout of other ceremonial centers on the Mexican plateau of later, Toltec vintage, but its most widespread use in city-planning was amongst the Maya. The location of the earliest Maya ceremonial center at Edzná (dating to 150 B.C.) was primarily dictated by the presence of the largest aguada, or temporary lake, in all of the Yucatán, but its internal layout clearly reflects their religious preoccupation with the August 13 sunset. Similarly, numerous structures throughout the Maya regions of Yucatán and Petén reflect the August 13 alignment, among them the Codz Pop at Kabah, the Pyramid of the Magician at Uxmal, and El Caracol at Chichén Itzá, to name but a few. The crowning blend of celestial mechanics, time, and space is to be found in the Maya capital of Tikal, where five sky-scraper pyramids, all over 200 feet in height and all constructed in the eighth century, mark the alignments of the August 13 sunset (Temple I to Temple IV), the equinoxes (sunrise Temple III to Temple I; sunset Temple I to Temple III), and the winter solstice sunrise (Temple IV to Temple III) in a sophisticated "astronomical matrix". Further, an alignment from Temple V to Temple I not only marks a perfect right-angle to the August 13 alignment but one from Temple V to Temple II likewise pin-points the westernmost point in the rotation of Polaris, which at that time was the closest thing to a pole-star which existed, even though it was a full 8° away from its present position. (Clearly, the repeated use in Mesoamerican ceremonial centers of the August 13 sunset orientation not only forcefully argues for the sacred almanac's astronomical origin but it also makes any alternative explanation, such as the length of the human gestation period or the simple permutation of the numbers 13 and 20, untenable.)

In the fifth century, the Mesoamericans appear to have carried out two remarkable geographic expeditions. Although they both had ultimate religious goals in mind, these endeavors probably reflected the closest approach the pre-Columbian civilizations ever made to what we regard as scientific inquiry. The priests of Teotihuacán dispatched an expedition into the northern desert to determine where the "sun stopped" in its annual migration, and in consequence of this, the astronomical center of Chalchihuites was founded on the Tropic of Cancer. Lacking a better means of recording key alignments, they dug trenches through the earth and plastered them with adobe to mark the summer solstice sunrise. (In the tenth century the Toltecs added a trench to mark the beginning of their New Year, February 12.) Perhaps under Teotihuacán's sponsorship, the Maya carried out a similar expedition at about the same time to locate the place where the 260-day sacred almanac could be calibrated. The result of this venture was the founding of Copán, in the western mountains of Honduras, whose oldest recorded Long Count date is 435 A.D. Thanks to its key geographic location, Copán was ultimately to become the

Mayas' principal center for astronomic studies -- the late and distant heir of Izapa where the first intellectual stirrings had begun nearly two millenia earlier.

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### **The Long Count.**

One of the most original creations of pre-Columbian Mesoamerica was the so-called "Long Count", a system of recording events in time with unique precision; no parallel system existed in any other society until the Julian Day count was begun in Western Europe in 1582. Because it was most widely used by the Maya, its development was first credited to them, but subsequent research has shown that the earliest inscriptions which employed the Long Count not only lay well outside of the Maya core-area geographically but also pre-dated the rise of the Maya historically.

The Mesoamerican Long Count was a meshing of the two time-reckoning systems which had been already been in use in the region for about a millenium: a sacred almanac of 260 days and a secular calendar of 365 days. In both counts a vigesimal system was used to group the days into 'bundles', for a total of thirteen in the sacred almanac and a total of eighteen in the secular calendar; the five remaining days in the latter count were considered "unlucky" or "worthless". The basic unit of the count was the day, or kin, in Maya. Twenty days constituted one uinal, and eighteen uinals made up one tun, for a total of 360 days. (The tun was the only deviation the Maya allowed from a strictly vigesimal system, and was only employed in their count of days.) Twenty tuns comprised a katun (7200 days) and twenty katuns constituted a baktun (144,000 days).

The fundamental premise of the Long Count was that it recorded the number of days that had elapsed from a date in the distant past which marked the beginning of the present cycle of the world. Because the Maya recorded their Long Count dates by enumerating, in order, the number of baktuns, katuns, tuns, uinals, and kins which had elapsed from that date, together with the number and name of the day in both the sacred almanac and secular calendar which it represented, any given day was identified by a minimum of nine elements. Thus, in the present convention for transcribing Long Count days, the first day of the Long Count was designated as 13.0.0.0.0. 4 Ahau 8 Cumku.

Although many attempts were made to reconcile the Long Count with the Christian calendar, one of the first credible explanations was that offered by the American newspaper editor, John Goodman in 1905. According to his calculations, the Maya had fixed the beginning of the present cycle of world as August 11, 3114 B.C. -- a date which accords with Julian Day number 584,283; hence, his correlation has been identified by that value. However, because Goodman was not an academic, little attention was paid to his findings until 1926 when a Mexican astronomer named Juan Martínez Hernández re-calculated the beginning date of the Long Count as August 12, 3114 B.C., yielding an equivalent Julian Day number of 584,284. The following year, when the British archaeologist J. Eric Sydney Thompson made his own attempt to reconcile the two calendars, he determined that the correct date should be August 13, 3114 B.C., for an equivalent Julian Day number of 584,285. Because all three of these correlations produced results within two days of each other and have subsequently been shown to accord most closely with known astronomical events, the so-called Goodman-Martínez-Thompson is now the accepted means of equating the Long Count with our own calendar. (It should be noted, however, that in 1935 Thompson revised his calculations and adopted Goodman's original formula of 584,283 instead; unfortunately, this 'correction' served to confuse the correlation issue for an entire generation because it

rendered all astronomical equivalencies impossible. Subsequently, Malmström (1978, 1992), among others, has conclusively demonstrated that the 584,285 correlation is the only one which has astronomical validity).

As early as 1930, the American mathematician John Teeple concluded that the Long Count had been devised on a date which the Maya recorded as 7.6.0.0.0. 11 Ahau 8 Cumku. Teeple had been struck by the fact that seventy-three cycles of the 260-day sacred almanac equated with fifty-two cycles of the 365-day secular calendar and that the day-numbers and names of each count then came back into phase with each other. He believed that the Maya had also employed seventy-three cycles of larger intervals, such as katuns, in order to define longer spans of time, and that to fix the beginning of the present era of the world at an appropriately early date, they had projected their count backwards for a total of 146 katuns, or 7 baktuns and 6 katun. This meant that the Long Count had been originated on September 18, 236 B.C., a date which Thompson rejected as being too early because it assigned its creation to a people other than the Maya, who he championed.

In a paper published in 1978, Malmström, using a different premise -- namely that the originator of the Long Count was bound by the recognition of the astronomical importance of August 13th as its initiating impulse -- reached the same starting date for its origin as Teeple had done. Also in his paper he argued that, by using internal evidence contained in the Long Count, it is possible to establish both the beginning dates of the secular 365-day calendar and the sacred 260-day almanac as well. The former, he states, was set in motion at the summer solstice around the year 1320 B.C., whereas the latter was initiated with the zenithal passage of the sun over Izapa in southernmost Mexico on August 13 about the year 1358 B.C. (Each of these dates may vary by as much as four years, due to the fact that the indigenous Mesoamerican calendars did not correct for leap years.) All of the earliest, or Baktun 7, Long Count inscriptions have been discovered along an axis which extends from the Soconusco region of southern Mexico and adjacent Guatemala, through central Chiapas into the Gulf coastal plain of Veracruz -- an area which constituted the original homeland of the Zoque-speaking "Olmec" people.

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### **Knowledge of Magnetism in Pre-Columbian Mesoamerica.**

That the pre-Columbian peoples of Mesoamerica were familiar with the property of magnetism has been suggested by several researchers, among them the geographer Robert Fuson and the anthropologist Michael Coe. Indeed, a flattened oblong piece of hematite discovered during Coe's excavation of the Olmec site of San Lorenzo in southern Veracruz state in 1966 has been thoroughly examined by John Carlson, who suggests that it probably was fashioned for use as a compass. In 1975, a basaltic sculpture at the site of Izapa, on the Pacific coastal plain of Mexico near the Guatemalan border, was found to possess a strong magnetic field. Variousy described as being the representation of either a frog (Norman, 1976) or a turtle's head (Malmström, 1976), it has a north-seeking pole in its snout and a south-seeking pole at the back of its head. The discovery led the latter researcher to speculate that the stone's carver may have associated the property of magnetism with the homing instinct of the turtle. Because it was the only magnetic object found at the site, critics of the notion that it was a human artifact argued that it may have been struck by lightning and that its magnetic field had induced in that manner.

However, in 1979, several additional magnetic sculptures were discovered in the Pacific coastal plain of Guatemala, including seven which now repose in the central plaza of the town of La Democracia, and two more which were identified at the nearby sugar plantation of El Baúl. Those at La Democracia are extremely crude depictions of human beings, and, because of their rotundity, have been termed the "Fat Boys" by archaeologists. When an entire body is depicted, the two magnetic poles are usually found on either side of the navel; when only a head is portrayed, the two magnetic poles are almost invariably centered on the right temple. The sculptures at El Baúl include a rampant jaguar, with magnetic poles in each upraised paw, and a tablet showing two men seated on a bench with their arms folded over their chests. This single block of stone has four magnetic poles, one north-seeking pole between each of the men's folded arms and one south-seeking pole below each man in the space beneath the bench. In 1983 a small humanoid sculpture in the plaza of Tuxtla Chica, Mexico, just back of Izapa, was found

to be magnetic in the right side of its head. Clearly, the patterns of polarity discerned suggest a conscious intent on the part of the sculptors to fashion their carvings around a known center of magnetic attraction, for in none of the stones has any inset of foreign material been made. That such recurring patterns could have been the result of random lightning strikes must also be ruled out. Because the "Fat Boys" are considered to date from 1500-2000 B.C., it is possible that these sculptures represent the oldest known magnetic artifacts in the world. But to what use, other than art and magic, this knowledge was put, we have no answer as yet.

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