CURRENT ANTHROPOLOGY Vol. 14, No. 4, October 1973

Archaeoastronomy and Ethnoastronomy So Far[1]

by Elizabeth Chesley Baity

A NEW SUBDISCIPLINE, a direct interaction between astronomy, engineering, and archaeology, has recently arisen out of interest in the apparent use of astronomical techniques in the construction of megalithic and other monumental structures of ancient times. Hawkins (1963) has proposed the name "astro-archaeology" for this subdiscipline. "Megalithic astronomy" is the term used by Thom (1967, 1971), who has presented meticulous evidence of megalithic

ELIZABETH CHESLEY BAITY comes to anthropology (protohistory) from a career in independent research and writing. She was educated at the Texas University for Women, Denton, and at the University of North Carolina (M.A., anthropology, 1962; Ph.D., anthropology, 1968). She has been a special student in anthropology and prehistory at the universities of Geneva and Tehran and at the School of Oriental and African Studies of the University of London and has done anthropological research in Spain, Turkey, Greece, Iran, India, and Bulgaria. When living in Geneva (where Dr. H. G. Baity was a Director in the World Health Organization), she covered the first Asiatic Conference and later political conferences as a special correspondent for the Greensboro (N.C.) *Daily News*, subsequently reporting on the work of various specialized agencies of the United Nations visited in the Middle East, South Asia, and Africa. As the director of writing workshops for nationals in the subcontinent and Africa (sponsored by the Committee for World Literacy and Christian Literature, now Intermedia), she produced six readers for use in tribal areas of West Pakistan (1954), five for use in tribal areas of the South Sudan (1955), and twenty-one for translation into Swahili and the vernacular languages of East Africa (during the workshop in Kinampanda, Tanzania, in 1956). She has surveyed population literature in East and South Asia and Oceania (1969).

Among her publications are two prize-winning books for young people, *Americans Before Columbus* (New York: Viking Press, 1951) and *America Before Man* (revised edition, New York: Viking Press, 1964). In preparation are a younger-readers' book on the protohistory of the Black Sea area and reports on fire, bull, and astra rituals and iconography of the Middle East, Western Europe, and Asia. As a consultant to the Morehead Planetarium, Mrs. Baity assisted with a show on British megalithic astronomy (March–April 1972). She teaches in the African Studies Program of the University of North Carolina (Division of Political Science) and continues to be interested in population literature work.

Coming from a family with strong astronomical interests extending through three generations (son William is with an astrophysics team), Mrs. Baity first grappled with the precession of the equinoxes while studying with her brothers, Hervey and Ted Chesley, at the latter's telescope and solar-system model on a Texas hilltop. Star-studying and museum research in South America, Asia, and Africa deepened the interest, leading to a dissertation study in which Ibero-Saharan astra iconography supplied clues to the solution of the distribution of protohistoric fire rituals and their survivals studied ethnographically in Spain, India, and Oceania.

The present paper, submitted in final form 14 II 72, was sent for comment to 50 scholars, of whom the following responded: Anthony F. Aveni, Rainer Berger, David A. Breternitz, Geoffrey A. Clark, James W. Dow, P.-R. Giot, Leo S. Klejn, H. H. E. Loofs, Rolf Müller, Richard Pittioni, Emilie Pleslová-Stiková, Zenon S. Pohorecky, Jonathan E. Reyman, S. B. Roy, Charles H. Smiley, Dean R. Snow, James L. Swauger, and P. M. Vermeersch. Their comments are printed below and are followed by a reply from the author.

[1] In view of the growing interest in archaeoastronomy and ethnoastronomy and the absence of indexed bibliographical data on the two, it seemed that a synthesizing review of the literature would be worth attempting: it was not initially evident that the subject would demand global coverage and a time depth of some 30,000 years. The task is beyond the competence of one reviewer; for aid, I thank the following scholars, absolving them from responsibility for errors or misunderstandings: H. Alimen, R. J. C. Atkinson, Anthony Arkell, H.-G. Bandi, José Miguel de Barandiarán, R. Berger, Verla Birrell, L. Cabot Briggs, Donald Brockington, Pedro Bosch Gimpera, Peter Boev, Aubrey Burl, Cottie Burland, Anthony Christie, George Cowgill, J. Desmond Clark, Krishna Deva, James Dow, Vladimir Dmitriev, Wolfram Eberhard, Robert Ehrich, Clifford Evans, Brian Fagan, Thomas Stuart Ferguson, P. R. Giot, Rojer Grosjean, Wayland B. Hand, Hubert Harber, David Hart, Horst Hartung, Gerald S. Hawkins, Vance Haynes, Robert Heizer, Hugh Hencken, Josef Henninger, G. Evelyn Hutchinson, David Kelley, Ivan King, Paul Kirchhoff, Leo S. Klejn, Richard Knapp, K. K. Leuba, Paul Lévy, Henri Lhote, Alan Lomax, Euan MacKie, Alexander Marshack, Robert L. Merritt, Hugh Moran, Rolf Müller, C. A. Newham, Raúl Noriega, Nancy Kelley Owen, Asko Parpola, Stuart Piggott, Leon Pomerance, Colin Renfrew, Jonathan E. Reyman, Leonid Rezepkin, A. E. Roy, D. Robertson, the late Keith Seeley, Charles H. Smiley, Marc Sauter, D. J. Schove, Ramón P. C. Schulz, J. B. Segal, Archer Taylor, Alexander Thom, B. L. van der Waerden, and Gene Weltfish. I was not able to locate every study cited, but for the sake of future researchers have listed the titles in the appropriate context.

I thank my fellow workers at Soria, Sr. and Sra. Teógenes Ortego y Frías and Jose Antonio P. Rioja; elsewhere in Spain, I was helped by ethnographers Julio Caro Baroja, Luis Cortes, and José Tudelo, linguist Antonio Tovar, and archaeologists Antonio Arribas, Luis Pericot García, and A. Panyello. At Greek fire rituals I enjoyed the company of ethnographers Georges and Anastassios Megas, M. Romaios, and Georges Spyridakis, and in Bulgaria, that of Peter Boev. I thank Rossitza Anghelova for her book on the Bulgarian fire dance. In Turkey on various occasions I received hospitality at their excavations and institutions from Hamit Koşay, Tahsin Özguç, and Raci Temizer, and in Iran was taught by Mohamet Moghadam and helped by David Stronach, O. R. Gurney, and Maurizio Tosi. Among the specialists on Indian archaeology to whom I am indebted for interviews in London and India are Sir Mortimer Wheeler, F. R. Allchin, Swami Ranganathananda, S. Chaudhuri, and L. P. Vidyarthi and his anthropology staff at Ranchi University, through whose efforts I attended a Sorai fire walk. Reference librarians giving invaluable assistance include Louise McG. Hall and her assistants at the Library of the University of North Carolina at Chapel Hill, Margaret Currier of the Peabody Museum at Harvard, and A. H. Weisencraft of the University of London.

man's skills in astronomy, engineering, and mathematics. MacKie (1968, 1971*a,b*), who is testing Thom's astronomical theories by traditional archaeological methods, prefers "archaeoastronomy." As a broader term, this appears more widely useful than the others and will be adopted here. "Ethnoastronomy" is the accepted name for a closely allied research field which merges astronomy, textual scholarship, ethnology, and the interpretation of ancient iconography for the purpose of reconstructing lifeways, astronomical techniques, and rituals. By whatever name, the new interdisciplinary studies are potentially of great significance for the insights they afford into the mental attainments of certain prehistoric, protohistoric, and early historic societies in Eurasia, Africa, and the Americas. Archaeoastronomy is a form of information recovery with time- and space-specific aspects which, when further refined and systematized, may provide not only a new theoretical framework for explicating certain problems of prehistory, but also a method of producing, ordering, analyzing, and expressing data with regard to the socioeconomic systems of particular cultures. These time- and space-specific aspects may also aid in tracing the influence of early groups whose most important seasonal rituals appear to have been set by astronomical events and recorded in rock art, on painted ceramics, and through other media. Archaeoastronomy, in the narrow sense, focuses on the analysis of the orientations and measurements of megalithic and other monumental ancient structures, many of which, as we will see, could have served for the prediction of solar and lunar eclipses and unquestionably *did* serve for the determination of solstices and equinoxes, enabling the setting of dates for agricultural activities and for the ritual cycle of the year. Astronomical knowledge has afforded a prime facility for timekeeping and the determination of the beginning of seasons, a function which had a cultural-economic significance to Paleolithic hunter-gatherers and which since the Neolithic has been extremely important for the successful cultivation of crops (Essen 1969, Goudsmit et al. 1966, Hawkes 1962, Toulme and Goodfield 1966).

This article will (1) review the debate between astronomers and archaeologists that initiated archaeoastronomy as an interdisciplinary field of study, the debate concerning the possible use of Stonehenge as an astronomical observatory, and cite some of the evidence, both recent and earlier, for astronomical functions with regard to megalithic and other early structures and town plans elsewhere in the Old and New Worlds; (2) briefly review developments in time-factored art and other aspects of ethnoastronomy; (3) note the implications of these studies for prehistorians and protohistorians; and (4) suggest areas where further study is indicated. A major function of this synthesizing review is to bring together references to articles, scattered in a variety of international professional journals, that indicate possibilities for a new interdisciplinary study for which as yet virtually no indexing system exists. Only the broad conclusions of the studies bearing on ancient astronomy can be noted: these are in many cases supported by essential mathematical, engineering, astronomical, and linguistic data which cannot be summarized here.

ARCHAEOASTRONOMICAL STUDIES

Stonehenge as an Observatory

The archaeological knowledge with regard to Stonehenge in Wiltshire and other megalithic structures in the British Isles and France had by 1960 become sufficiently detailed to encourage specialists from other disciplines to attempt to assess the function these structures might have served for their builders (Atkinson 1960, Daniel 1963). The azimuths of sun and moon, unlike those of constellations, are little affected by the precession of the equinoxes.[2] Thus

[2] Precession, a conical motion of the earth's axis around the pole of the ecliptic approximately every 25,800 years, is caused by the gravitational pull of the sun and moon on the earth's equatorial bulge. It causes a westward displacement of the vernal equinox along the ecliptic. Thus Paleolithic Eurasian observers of some 26,000 B.P., regarding a fixed directional point around which the circumpolar star groups nightly circled, would have been viewing Polaris; their descendants of half this time ago would have had a far more spectacular pole star, Vega (assuming that there has been no such shifting of landmasses as Hapgood [1970] hypothesizes). Precession and other astronomical concepts used in the following discussion, briefly defined in the glossary below, are explained and related to early astronomical systems in *Introduction to Astronomy* (Payne-Gaposchkin and Haramundanis 1970). Wallenquist's (1970) astronomical dictionary is also helpful.

Astronomers measure azimuth westward from the south point of the *meridian*, the north-south great circle passing through the zenith (the east-west great circle passing through this point being the *prime vertical*). (Engineering and navigation convention, in contrast, measures from true, not magnetic, north east along the horizon; cf. Thom [1967:14–33].) Four kinds of celestial coordinates are used in celestial surveying: (1) the horizon system, (2) the ecliptic system, (3) the equatorial system, and (4) the galactic system, which does not concern us.

The horizon system serves to indicate for a celestial object its *altitude*, measured in degrees up toward the zenith from the horizon (with negative altitudes referring to points below the horizon), and its azimuth. On the horizon system, the altitude of the celestial north pole, now marked by our Polaris, is equal to the latitude of the observer, but the position of other heavenly bodies varies with the place and time of observation (there being no star to mark the other pole).

The ecliptic system is defined by the plane of the earth's orbit, which fixes the *ecliptic*, the apparent yearly path of the sun through the constellations. The ecliptic intersects the plane of the celestial equator at two points, the *equinoxes:* called the *nodes*, these points are the locus of eclipses. The sun crosses the *vernal equinox* en route from the *winter solstice*, the point of its southernmost rising, to the summer solstice, the point of its northernmost rising; at the *autumnal equinox*, it crosses the same point (i.e., due east) returning south. The ecliptic and the celestial equator do not coincide because of the earth's tilt with reference to its orbit; the angle, called the *obliquity of the ecliptic*, varies over time (see n. 13). The *zodiac* is a cultural construct, coming to us from early astronomers of Western Asia: it is a band of constellations centered on the ecliptic and including the apparent path of the sun, moon, and planets. Certain constellations north or south of the zodiac but rising at the same time as zodiacal ones and sometimes more easily detected were called *paranatellonta* by the ancient Greeks and were used, like the zodiacal constellations, for determining dates.

The equatorial system measures the *declination* of a celestial body as its angular distance from the equator towards the nearest pole, measured in degrees north (positive) or south (negative).

There is a trigonometrical relation between the four angles—azimuth, declination, latitude, and altitude; knowing any three, one can find the other.

For timekeeping by the stars and constellations, early astronomers referred to the *heliacal rising*, the first visible rising of a star or constellation at dawn after a period of invisibility owing to its proximity to the sun, or to the *heliacal setting*, its first visible setting after sunset. The *sidereal year* ("sidereal" pertaining to stars) sun and moon alignments marked out by megalith-builders still function to mark with fair precision the winter and summer solstices and the vernal and autumnal equinoxes, after taking into account changes in the obliquity of the ecliptic, presently diminishing by approximately 46.84 seconds of arc per century, according to Newcomb's formula (R. L. Merritt, personal communication, 26 XI 71). Stonehenge has been assumed from archaeological evidence to have been built in three main stages from approximately 2000 B.C. to 1500 B.C.: new dating techniques (Renfrew 1970*a,b,c*) indicate that its initial henge may be over half a millennium older, but that does not invalidate the tentative formulations with regard to the solar-lunar alignments, except as particular postulated azimuths are affected by the fact that the obliquity of the ecliptic was slightly greater during the period of construction and use of the monument.

Folklore has traditionally assigned an astronomical function to Stonehenge. Diodorus, in his *History of the Ancient World,* written about 50 B.C., described the spherical[3] temple of Apollo in Britain and its Hyperborean supervisors, the star-gazing Boreadae: though the connection is unproven, either with the area or the monument, there is a tendency to equate this description with Stonehenge. British folklore has immemorially associated the structure with celebrations attending the two hinges on which the solar year turns, the winter and summer solstices. In Scotland, similarly, tradition associates the many stone circles with solar and lunar observations. Astronomer Lockyer (1901, 1902, 1905, 1906*a,b,* 1965; Lockyer and Penrose 1901) was not the first observer to suggest that Stonehenge and other megalithic circles had a significant astronomical function.[4] Also working

without benefit of electronic computation to test the relationship between proposed sighting lines and significant astra events, Somerville (1912) had noted astronomical indications for a circle at Callanish in the Outer Hebrides.

Although, as the following discussion will indicate, much remarkable work on megalithic astronomy had been done by Thom (1954, 1964*b*) and Newham (1963, 1964), and Newham's hypothesis of lunar and solar alignments at Stonehenge had been published (cf. Emmott 1963), little of it was known even to archaeologists, much less to the general public, before the debate which followed the publication by Hawkins (1963; 1964; 1965*a,b*; 1966; 1968) of the computerized correlation of Stonehenge alignments with the rising and setting of the sun and moon at their extreme positions during the period of the construction and reconstruction of the monument (fig. 1). Hawkins proposed that the Aubrey Circle may have been used to mark off, count, or compute the swing of the azimuth of the moon, functioning as an

is defined by the heliacal rising of a given star. The *tropical year* (from the Greek word for turning) is measured from solstice to solstice. The *anomalistic year* is measured from perihelion (the point nearest the sun) to perihelion. The three years differ in length, and this is what enabled Hipparchos, in 123 B.C., to discover the precession of the equinoxes. The *synodic month* or *lunation* is the interval from new moon to new moon.

[3] C. A. Newham (personal communication, 1 VII 71) and G. E. Hutchinson (personal communication, 4 IV 72) call my attention to the fact that the Greek word "spherical" has astronomical connotations.

[4] In the excitement generated by the Stonehenge controversy, it is often overlooked that many earlier studies anticipated the recent discoveries and hypotheses. Scholarly literature in French, English, German, Spanish, and other languages foreshadowed and supports the new subdiscipline. While this ignoring by contemporary archaeoastronomers of earlier data has been methodologically sound in that the new work has been approached independently, many early studies contain data well worth reviewing. It is to be hoped that comprehensive synthesizing studies and bibliographies will soon be undertaken. The *Subject Catalogue* of the Peabody Museum Library, Harvard University, indexes impressive scholarship with regard to megalithic structures and astra, stone, and calendar cults. The encyclopaedias of religion discuss such cults at length: these and other well-indexed topics, including judicial and client astrology, will not be reviewed here. Lewis (1888, 1897) recognized the purposeful nature of megalithic constructions and the importance of outlying stones and studied megalithic measurements. Peet (1894) connected megaliths with mythology and showed interest in American and European stone circles (1901). Baudouin (1912), a pioneer archaeoastronomer, studied the solar orientation of rock engravings and megalithic structures, offered (1913) a technique for determining the orientation of dolmens, discussed (1917*a*) prehistoric stellar knowledge, and recognized (1917*b*) the cultural significance of the Pleiades group (cf. Hamilton 1902, 1904). Devoir (1911) found that the megalithic structures of Brittany fit Lockyer's hypothesis of orientations directed at the risings at solstices, equinoxes, and intermediate points, for the determination of an agricultural calendar, and that the same hypothesis explained orientations in other areas (see also Devoir 1915–16, 1916, 1917). Jacquot (1915) noted the persistence of Breton solar cults. Lenoir (1956) surveyed what he called megalithic thinking. Boule (1930) considered the use of astronomical data in determining the age of megalithic structures. Baschmakoff (1930) summed up descriptions of the Carnac alignments, attributed them to a pre-Aryan population, noted the correspondence of cromlechs with alignments indicating solstice, equinox, and midquarter points on the horizon, and interpreted a megalithic engraving as a calendar dividing the year into eight astronomically determined parts and marking the times for fêtes at specific locations for each major division. (An ethnologist and not an engineer, Baschmakoff attributed the noncircular shapes and adjacent parallel lines as designating clans and a number of carvings as totemic signs; since the carving illustrated shows bull, ram, and serpent, I suggest that the corpus be restudied for possible presence of a zodiac of the Western Asian type [see below].) Foreshadowing present discussions, Baschmakoff also postulated that an élite laid out the alignments, which were then constructed by another class of workers. Cunnington (1935) studied Stonehenge; Keiller (1934) surveyed megaliths in Scotland. Roy, McGrail, and Carmichael (1963) have examined the Tormore circle, and others listed below have discussed other circles. O'Connell and Henry (1915) edited Irish astronomy.

Though establishing that the contemporary association of Stonehenge with Druids is less a folk memory than the invention of antiquary William Stukeley, Piggott (1968:122–24) reviews classical data indicating for barbarian European priests a degree of astronomical and calendrical skill which, in view of Thom's increasing findings, suggests to me that certain of the useful techniques of megalithic time-setting survived. Caesar (*De bello Gallico,* book 6), borrowing from Posidonius (ca. 135–ca. 50 B.C.), attributed to the Celtic priests "much knowledge of the stars and their motions, of the size of the world and of the earth" (cf. Burn 1969:2–6); Hippolytus spoke of their ability to foretell certain events by calculations and Pliny of their measuring time by the moon. The Getae were said to have been taught by the semilegendary Dicineus "the courses of the 12 signs and of the planets passing through them, and the whole of astronomy" as well as "the names of the 356 stars" (quoted by Piggott from the 6th-century A.D. writer Jordanes or his source Cassiodorus). The presence of a 12-house zodiac among barbarians known to the Romans is of course suspect, as Greek colonies along the coasts of Spain, the Black Sea, and elsewhere were already old by the time of Dicineus (1st century B.C.), but Iberian sources and the 5th-century B.C. periplus quoted by Avienus mention astral, solar, and lunar cults on Iberian islands and capes (cf. Arribas 1962), and other Spanish scholars cite many indications that these cults were pre-Greek. Further, there is much folkloric and archaeological evidence that "Celtiberian" solstice rituals are more strongly pre-Celtic than Celtic (Baity 1968).

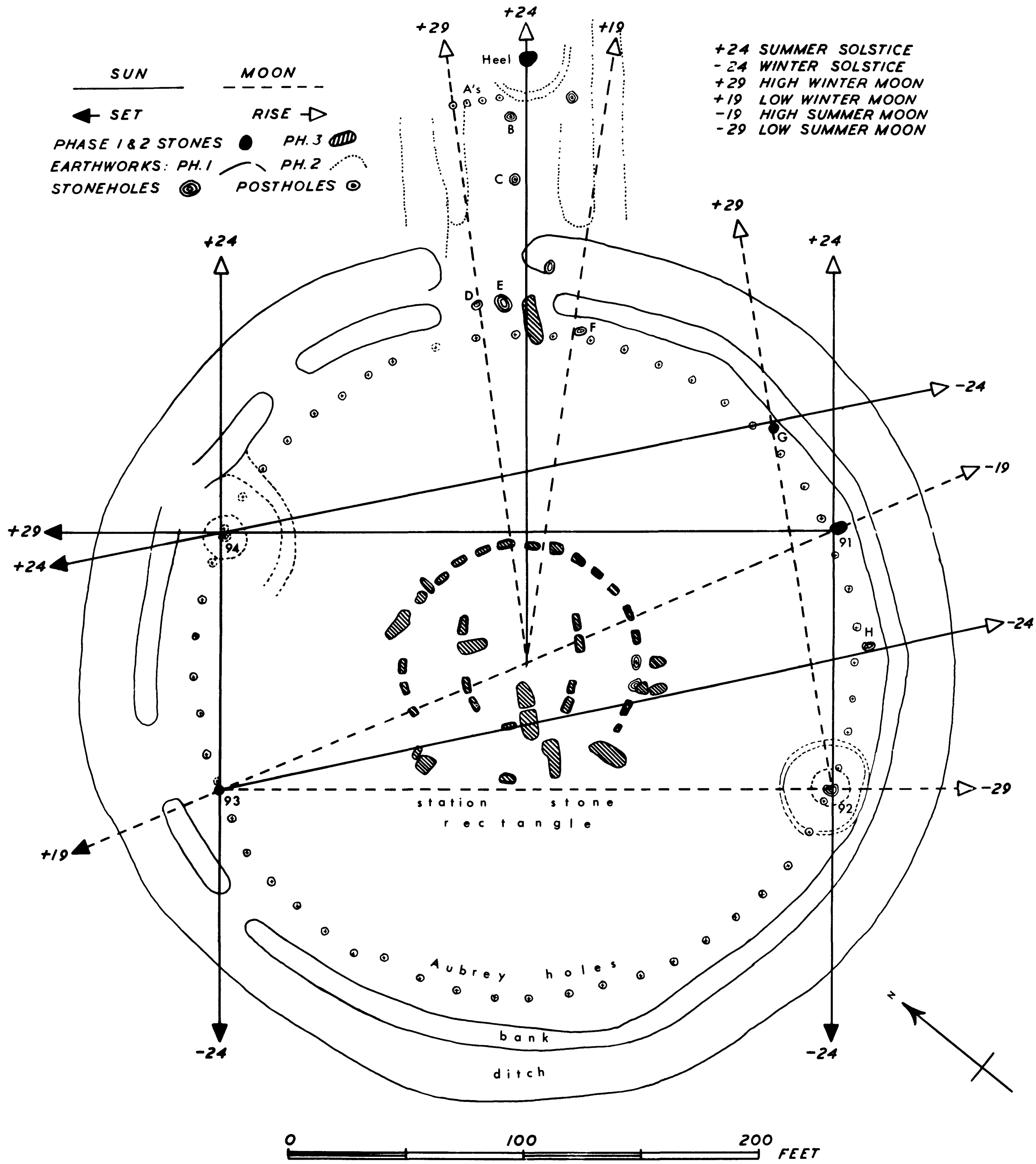

FIG. 1. Sketch plan of Stonehenge, showing alignments suggested by Hawkins for Stonehenge I. The Sarsen Circle and Horsehoe of Stonehenge III are also shown, but not the bluestones. The "Station Stone rectangle" is assigned archaeologically to Stonehenge II, not I. The numbers at the arrows are declinations. (Drawing by Euan W. MacKie.)

eclipse-predictor operated by moving stones from one hole to another around the circle.

In a witty, if less than enthusiastic, initial rejoinder, "Moonshine over Stonehenge," Atkinson (1966*a*; cf. also 1966*b,c*) criticized Hawkins' claims on the grounds of inappropriate site plans, inaccurate archaeological data, indiscriminate selection of stones as markers, and overconfidence in the computer, "the secular equivalent of divine revelation." Atkinson was, however, interested in the idea that the Aubrey Circle *could* have been used as an eclipse-predictor "provided that Hawkins' fifty-six-year cycle is acceptable to other astronomers" (which it subsequently proved not to be) and saw a suggestion of possible value in the hypothesis that whenever an observer at the center of the circle saw the full moon nearest the winter solstice rise over the Heel Stone, it might alert him to the fact that an eclipse of the sun or moon would follow (though not all eclipses predictable from Stonehenge could be observed there). Atkinson also commented with interest upon Hawkins' argument that the latitude of Stonehenge appears to have been deliberately chosen so that the extreme northerly and southerly risings and settings of the sun and moon at the solstices were approximately at right angles one to another, permitting a nearly rectangular layout of the four Station Stones, a circumstance which makes this area exceptional. Newham (1966), whose hypothesis that Stonehenge was both a solar and lunar observatory had been published earlier in the year, commented that we must be grateful to Hawkins for quickening the interest of prehistorians in the early development of observational science and methods; he argued, however, that Hawkins' 56-year cycle seemed untenable.

Hoyle (1966*a*), like Atkinson, found Hawkins' measured and calculated azimuth values outside the suggested margin of error, but suggested an even more sophisticated purposeful placing of the sighting lines a degree or so inside the azimuthal extremes at which the moon and sun appear to stand still.[5] Hoyle further proposed that the Aubrey Circle may have represented an ecliptic, with Stonehenge serving as a simple protractor for measuring the angles involved with reference to solstice risings and settings and for predicting eclipses. An editorial in *Nature* (July 3, 1966) described the Hoyle hypothesis as "breathtaking not merely by its ingenuity, that of Professor Hoyle as well as of the supposed builders of Stonehenge, but by its practicality," adding (prophetically, it proved) that "the cleverness is the most difficult part of his theory to accept."

To clarify the astronomical argument, Hoyle (1966*b*) explained his model in trigonometry. Rephrasing the question "How did *they* do it?" as "How would *we* do it (granted Neolithic technical possibilities)?" he concluded that "an excellent procedure would be to build a structure of the pattern of Stonehenge, particularly Stonehenge I." To Atkinson's question (by correspondence) why a pegboard would not have served equally well, Hoyle answered that with large stones as markers a large circle was necessary for accuracy of angle measurements and was moreover a definitive system which it is impossible to disturb by accident. He suggested that the Aubrey Circle could have been the reference studied for small pegboards.

Regarding the determination of the solstices, so important in Neolithic renewal rituals set by an astronomically determined New Year, Hoyle (1966*b*:263 and fig. 1) reminded nonastronomers that the seasons are determined by the tilt in the earth's axis of rotation and have no relationship to the diurnal rotation of the earth—a fact also ignored by the builders of Stonehenge, whose concern with the extremes of declination of the solstices of the sun and of the moon is indicated by the placement of the stones. Hoyle further suggested that the Stonehengers had resolved the two unfortunate coincidences that the sun and the moon have the same apparent diameter and appear to replace each other, and that 12 lunar months roughly approximate a solar year, although the difference is great enough to throw a lunar-based calendar fairly quickly out of synchronization with the solstices and hence the seasons. The Metonic cycle (named after Greek astronomer Meton, whose description of it is the earliest known) affords an elementary adjustment through a cycle of 235 synodic months of 29.53 days each, or 6,939.7 days, which is practically identical with 19 tropical years of 365.2422 days each, or 6,939.6 days.[6] Hoyle (1966*b*) suggested that Stonehengers knew that by dividing the 19 years into two sets, 12 years of 12 lunar months each and 7 of 13, an adjustment could be made.

Sadler (1966) viewed as astronomically acceptable the hypothesis that Stonehenge was designed to mark the extreme and mean azimuths of the rising and setting of the sun and moon, but suggested that better methods of predicting eclipses were available. Newham (1966) offered an alternative astronomical function for Stonehenge, suggesting that some 40 postholes in six ranks seeming to radiate from the center of the Aubrey Circle may have been temporary markers set to align on the point where the winter full moon appeared over the horizon every year: observations over a large number of years would be sufficient to ascertain the 19-year phase and possibly the 56-year eclipse cycle. He saw a strong lunar influence at Stonehenge and had little doubt that in its earlier stages it was an astronomical observatory.

Colton and Martin (1967) showed that a sustained 56-year cycle does not exist. The 18-year $11\frac{1}{3}$-day Saros eclipse cycle, which is almost equal to 223 lunations, is believed to have been known to the Chaldeans and was certainly known to the Chinese (and perhaps to the Babylonians, though consensus does not exist on this). The Saros cycle was more easily detected by early observers than other eclipse cycles because each eclipse occurs close to the calendar date of the previous one.[7] Colton and Martin argued

[5] This apparent pause that occurs when the sun or the moon reaches extreme swing and turns makes the exact time of the solstices hard to determine: as MacKie has expressed it, the notorious phenomenon of the midsummer sun rising behind the Heel Stone when viewed through the great trilithon at Stonehenge is impressive only when one knows the date of midsummer anyway.

[6] By coincidence, the Metonic cycle of 19 tropical years corresponds to the 18.61 tropical years required to complete the retrograde nodal cycle of the moon (the time interval required for the moon to return to the extreme azimuths at the winter and summer solstices: the nodes are the points at which the moon's orbit crosses the plane of the earth's orbit, i.e., the ecliptic). Newham (1970:17) points out a possible connection between this and the 56 holes of the Aubrey Circle: $3 \times 18.61 = 55.83$.

[7] The relationship is: 19 eclipse years (6,585.78 days) equals nearly 223 synodic months (6,585.32 days). The difference of a fraction of a day causes each eclipse to fall west of the last by almost a third of the way around the earth. Piggott (1968) notes that the Coligny calendar, a great bronze plate engraved with a calendar of 62 consecutive lunar months with two intercalary months inserted alternately at two-and-a-half- and three-year intervals, suggests the use of the Saros eclipse cycle and the adjustment of lunar to solar dates (cf. Charrière 1960).

that while the Saros cycle produces more total eclipses than some other cycles and is thus useful, other eclipse cycles, including a "more logical" 47-year sequence (others are 23, 42, and 61 eclipse years), must be considered. They noted that it has been known since the 3d millennium that for a lunar eclipse to occur the sun and the full moon must be diametrically opposed in the sky and the moon must rise a short time before the sun sets, which suggests that the Aubrey Circle and the many stone circles elsewhere could have served as protractors enabling observers in their centers to judge whether the sun and moon were exactly opposite each other. They pointed out that the method is a poor one for predicting solar eclipses.

In a summarizing panel of comments on the Hoyle hypothesis (Hawkins et al. 1967), Hawkins noted the extremely far-reaching assumptions concerning intelligence and purpose. Atkinson found that new site data did not affect the Hoyle hypothesis substantially "as an explanation of how *we* could use Stonehenge to predict eclipses" and accepted the possibility that the positions of the Heel Stone and the Station Stones and the latitude of Stonehenge were astronomically determined. He criticized the use of some of the holes suggested as markers, as did Newham, who favored the alignment with winter solstices but rejected others. Thom agreed that the astronomers' evidence that Stonehenge was a solar and lunar observatory equated with his hypotheses (resulting from 30 years of surveying megalithic sites) with regard to the precision of megalithic engineering and astronomy, but did not accept the Aubrey Stones as the eclipse-predictor Hawkins had seen. Newham summed up arguments against the Aubrey Circle as an eclipse-predictor, though affirming the Stonehengers' interest in eclipses.

Defending the hithertofore accepted archaeological view, Hawkes (1967) challenged Stonehenge as Apollo's circular temple, dismissed the Aubrey Circle as an eclipse-predictor (on the grounds that the holes were refilled soon after they were dug and show no evidence of ever having held stones), fitted Stonehenge harmoniously into British, European, and Mediterranean history, and—unwarned by King Canute's unsatisfactory experience—dismissed the *"nouveau vague"* flowing over Stonehenge by reaffirming the monument as a sanctuary, its structure as architectural rather than mechanical, and its orientation as symbolic rather than astronomical. The new wave, not so easily dismissed, flowed back in Newham's (1970) counter-reappraisal, a succinct, original, and plausible summary of Stonehenge man's probable astronomical experiments and in capsule form the young archaeoastronomer's guide to site surveys. Feeling that astronomers had overstated Stonehenger astronomical skills less than archaeologists had understated them, Newham turned his attention to three recently discovered "disturbances" situated in the adjoining carpark. In view of Thom's many discoveries of "distant markers" (usually mountain gaps or other skyline features, which are remarkably lacking on the Stonehenge skyline), Newham calculated that had tree trunks some 30 ft. high been placed in the "disturbances" they would have served as precise, nonreversible distant markers with regard to important setting phenomena of sun and moon when observed from the four Stations and the Heel Stone position. Site excavation data (then unknown to Newham) indicates that the holes once held tree trunks some 2 ft. 6 in. in diameter supported by wedges.[8] Newham analysed the possible significance of the Aubrey holes in relation to astronomical phenomena, not only in number but also in their alignments and spacing, suggesting that the 56 holes could have been dug to hold posts serving their brief time in an experimental "trial-and-error" process and then abandoned when found inadequate for the hoped-for purposes.

Robinson (1970), agreeing with Atkinson that although the axis and Avenue were oriented to the summer-solstice sunrise the Heel Stone did not in fact mark the midsummer precisely, has advanced the hypothesis that instead it marked the full moon when it rose at the winter solstice point, thus serving a most important function as a winter eclipse-warning moonrise marker. The hypothesis gives a functional explanation of why the Heel Stone is set slightly south of the center of the Avenue: rising slightly to the left, the midsummer sun hung just above the horizon when passing directly above the Heel Stone. In suggesting that other alignment "errors" could be reduced by associating stones and archways with the moon rather than with the sun, Robinson agrees with Newham's initial hypothesis. Newham (1968:9, 1970:15) has since given much independent data with regard to the strong possibility of lunar functions of the structure.

Whatever the final decision as to the motives and skills of megalith-builders, the Stonehenge controversy and its aftermath have shown the necessity for interdisciplinary work in archaeology, for adequate summaries in national journals of ongoing research elsewhere, and for wider recognition of the contributions made to archaeoastronomy by professionals in other disciplines. To illustrate both points, no British commentator known to me refers to Charrière's (1961) earlier analysis of Stonehenge, which anticipated the argument that consideration should be given to its interesting site in a narrow zone where the maximum azimuths of sun and moon could be indicated by the right-angle construction of the Station Stones. Charrière also observed the repetition of the number 19 in connection with the bluestones, relating it both to the fact that the nodes of the lunar orbit rotate relative to the place of the ecliptic in approximately 19 years (actually a retrograde nodal cycle of 18.61 tropical years) and to Diodorus' account of Apollo's visit every 19 years to his spherical temple, where he sang and played his zither the night through from

[8]The use of tall tree trunks for distant markers is supported by the finding of early British boats indicating quite surprising timber sizes and woodworking skills (Wright and Churchill 1965). I have elsewhere (Baity 1971*a*) noted the extreme significance of posthole data which might indicate the former presence of posts serving as distant markers.

the spring equinox to the rising of the Pleiades.[9] Himself an architect, Charrière noted the architectural parallels between the orientations of the French megalithic monuments, including tombs, and those of Etruscan, early Roman, and Christian sacred edifices.[10] Moreover, Charrière (1963, 1964, 1966, Charrière and Roos 1964) attaches as much importance to lunar orientations as do Thom and Newham, attributing so-called errors in orientation to a purposeful and highly sophisticated skill which in his view reconciled lunar and solar calendars and set "intermediate" (neither solstice nor equinox) dates for festivals, as Thom has established in his studies of the megalithic calendar. Charrière (1963) notes the singular resemblance in form between the design of Stonehenge and that of the far later calendric circle and horseshoe monument at Sarmizegetusa in Romania, more fully described by Daicoviciu (1960).[11]

Time has already indicated that the most revolutionary and valuable aspect of the Stonehenge debate has been its introduction to archaeologists of the radical, innovative, and extremely precise work of engineer Alexander Thom. It is impossible to review Thom's 30-year self-dedicated task: his summarizing books (1967, 1971) are required reading for anyone concerned with archaeoastronomy. Thom's (1967) study supports with statistics and numerous clear illustrations his argument that British noncircular stone rings were not carelessly designed circles, but deliberate, purposeful, and experimental demonstrations of mathematical concepts, including the use of Pythagorean triangles, in the service of advanced observational astronomy or perhaps as a parallel intellectual study. His (1971) further examination of Scottish sites indicates that "lunar observatories" had a far more searching function than that of calendar correction and date-setting for New Year's and other rituals, which activities may, he suggests, have become mere routine fund-raising projects supporting a scientific study of the moon's motions.

Thom (1971:147) demonstrates the possibility that through the use of temporary markers placed during observations of the rising and setting orbs sliding past small, clean-cut distant marks (mountain contours or precisely aligned megaliths), megalithic astronomers were able to indicate mean differences with their stone markers (hence the "errors" reported by modern students who fail to take into account the sophistication of the megalithic observatories). From many thousands of precise measurements, Thom deduces a standard measurement unit, the megalithic yard (MY) of 2.720 ± .003 ft. (Thom 1968:43), subdivided by a smaller unit, 1/40 MY, appearing in connection with cup-and-ring rock carvings and forming part of a larger unit of $2\frac{1}{2}$ MY (i.e., 6.80 ft.).[12] Though he has not worked at Stone-

[9]The Diodorus text is supposed to have been derived from an account by Hecataeus probably written around 500 B.C., at which time the tradition may already have been ancient. R. S. Newell (cf. Newham 1964:15–16) obtained from astronomer F. Addey the information that around 1500 B.C. the Pleiades would have been almost in conjunction with the sun, rising unseen shortly after sunrise. As neither the computers nor the astronomers are programmed for cultural lag, no account is taken of the fact that the tradition may have originated at an earlier date, perhaps when the Pleiades were linked to the Bull. Hartner (1965:4–5) considers that the heliacal rising symbols were established around the time of the first Elamite and Mesopotamian settlements (ca. 4000 B.C.), when Taurus, Leo, and Scorpio (roughly 90° apart) preceded the sunrise at the spring equinox, summer solstice, and autumnal equinox respectively by ca. 10–25° and thus were the last visible zodiacal risings. The probable time of the construction of the circular ditch at Stonehenge I was around 3000 B.C. (Renfrew 1970), at which time the heliacal rising of Taurus marked the spring equinox in the Mesopotamian zodiac. There is no evidence (known to me) that the British megalithic astronomers used such a zodiac, but the Diodorus text is thought-provoking.

[10]Though it is peripheral to this study, I note the significance of Borst's (1966–69) suggestion that a megalithic structure gave its plan to Canterbury Cathedral, a hypothesis with which Barmore (1969) and MacKie (personal communication, 29 II 72) do not agree. In Iberia and elsewhere churches mark many a pre-Christian shrine; in Mesoamerica, many a pyramid.

[11]I am indebted to Daicoviciu (personal communication, 29 X 71) for the following information: "Besides the great circular sanctuary, at Sarmizegetusa there is a small circular sanctuary, and another, with limestone pillars, was found at Feţele Albe, in the neighbourhood of Sarmizegetusa, and a third one with wood pillars at Pecica (ancient Ziridava); this latter one has been published by I. H. Crişan in *Acta Musei Napocensis* (Cluj) 3:91–101. We do not know the origin of this type of sanctuary, though it seems to be a marvellous resurrection of the megalithic monuments. Its circular shape might be a result of its connection with the seemingly circular motion of the Sun, or with the discoidal aspect of the Sun and of the Moon. I believe that the importance of this kind of sanctuary lies in the fact that it proves the existence of a serious preoccupation of the Dacians with astronomy, and of an original calendar based on their own observations."

[12]Thom's megalithic yard has aroused much interest among students of ancient metrology. Hammerton (1971), studying Thom's (1967: table 5.1) table of values of the site unit at 145 sites, suggests that Thom's "megalithic fathom" has a range value which does not suggest a standard issued from a center: he advances the theory that the site unit was based on the height of the engineer-priest in charge (or of a local dignitary). In view of Müller's evidence of similar "egg-shaped" structures, orientations, and measurements in Germany as well as in Britain (and France), the "chief's height" hypothesis may afford more problems than it solves. Fletcher (1969), in a typescript which Robert L. Merritt has sent me along with other papers from his collection on megalithic astronomy, links the megalithic yard with ancient measures identified by Petrie and others, concluding that it and the megalithic fathom (5.44 ft.) were not mere upstart British-French standards but were part of a major metric system common to the ancient Mediterranean and Middle Eastern civilizations and related to an empirical prescientific geometry. Newham (personal communication, 1 VII 71) does not, however, find that the MY consistently applies at Stonehenge, though in some instances it coincides with his "moon-swing" long measure (LM) of 47.6 ft. ($17\frac{1}{2}$ MY), and this discrepancy leads him to question whether the builders of Stonehenge were the same as those responsible for other megalithic structures. Newham's work, like Thom's, offers the possibility of archaeological proof, as he predicts that certain alignments must be found in as yet unexcavated areas of the site. He cites a large depression in a field to the southeast (in the position of a stone shown in an early etching) which centers exactly 13 LM from the Sarsen center, aligning with moonrise seen from Aubrey Hole 28 (where a stone was supposed to have been) and also with other significant sun and moonrise positions. Newham's question with regard to the identity of the Stonehenge builders is of interest in connection with the fact that the diagonals of the four Station Stones, which cross at the center of the Sarsen Circle of Stonehenge II to form a rectangle about 105 by 260 ft., did not do so in the time of Stonehenge I, but centered about 3 ft. southwest of the common center.

Stecchini's (cf. Tompkins 1971) study indicating the precision of 3d-millennium Egyptian measurements affords much data for comparative studies. Eberhard's (personal communication, 21 IV 72) reference to Chinese links between astronomical and musical concepts is significant (cf. n. 23), as are his references to studies of early Chinese metrology: "On Chinese measurements we have a number of studies in Chinese. They have found some early measures and by using these they have been giving interpretations to texts. Some references (but by no means the most important ones—those I do not have at hand): *Monumenta Serica* 6:357; *Bulletin of Chinese Studies (Ch'eng-tu)* 1:93; *T'oung Pao* 35:246; *Oriental Art* 2:1, 46; *Tôyô Gakuhô* 35:1–30."

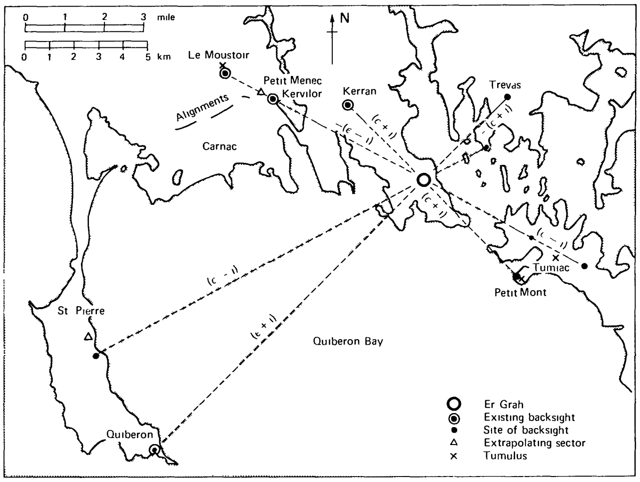

FIG. 2. Er Grah (*Le Grand Menhir Brisé*) as a universal foresight for the rising and setting moon at the eight critical positions. (Reprinted from Thom and Thom 1971:150, by permission of the *Journal for the History of Astronomy*.)

henge, Thom (1968:28) has surveyed Woodhenge, which he sees as a possible example of mathematical experiment.

Among the lacunae in the Stonehenge debate, as suggested above, is the failure to consider the astronomical alignments of the French megalithic structures suggested by a number of French archaeologists (Niel 1961, 1970; Savary 1966). The inevitable question whether the highly impressive megalithic sites of Brittany, remarkably concentrated in the Carnac area (Giot 1960), show the same astronomical and metrical patterns as British megaliths has led Thom (1970*a*; Thom and Thom 1971, 1972) and colleagues to make site surveys and orientation studies of several thousand Breton megaliths or menhirs. At Carnac, a huge lunar observatory spread over a wide territory surrounding Quiberon Bay was centered on the greatest menhir in Europe, Er Grah *(Le Grand Menhir Brisé)*, which, as Thom and his colleagues show, could have served as a universal foresight used by stations located in several different directions (see fig. 2). Measuring at least 67 ft. and weighing over 340 tons, this menhir appears to have been brought from the west coast of the Quiberon Peninsula on a prepared track with rollers, a task doubtless requiring decades of work following those necessary to locate a suitable site.

Several commentators on Thom's astronomical hypotheses have objected to the process of starting with the known menhir position, on the grounds that some apparent celestial target can always be indicated (an objection which begs the point that the targets may have had some functional role to play in ceremonialism). In the first study of the Carnac alignments (Thom and Thom 1971), Thom predicted that Er Grah could have served as a universal foresight and estimated on which lines focusing on Er Grah observing stations must have been located. His team searched for and found five of the eight predicted stations (cf. fig. 2). Thom further hypothesized that the rows of stones at Petit Ménec and at St. Pierre must have been used as extrapolating sectors, as he had suggested for similar rows at Caithness (Thom 1970*a*). A further objective in the first Brittany survey was to ascertain the geometrical layout of the various sites and to determine the problem which the Carnac alignments had been laid out to solve. As most of the stones had been reerected, with possible inaccuracies, the first task was to determine by surveys and statistical analyses the original designs and the unit of measurement employed. The second survey, in March of 1972, further tested and confirmed these hypotheses (Thom and Thom 1972). The surveys establish that reerection of stones has been sufficiently accurate to permit statistical analyses indicating the geometrical designs laid out by the builders. The analyses indicated that the Le Ménec west and east cromlechs are Type 1 and 2 megalithic egg-shaped rings, based on 3,4,5 triangles of the type previously studied in Scotland (Thom and Thom 1971). The standard megalithic unit of measurement used was $2\frac{1}{2}$ megalithic yards (called by Thom a megalithic rod). The Brittany studies indicate a remarkable uniformity of the measuring unit, which Thom estimates must have been a rod measuring 6.802 ± 0.002 ft. The remarkable closeness of this to the British unit indicates an accuracy today attained only by trained surveyors using good modern equipment. The high degree of organization and administration responsible for the impressive Breton alignments and the presence in Brittany and Scotland of identical units suggests a common culture. Which area was the center of this culture? The extensive remains in Brittany are suggestive, but Thom and Thom indicate that so far none of the Breton sites examined affords a geometry comparable to that of Avebury. Thom suggests that the continual use of observatories like those in Argyllshire and Caithness may have presented problems the solution of which was found at Carnac. The Brittany alignments have also been surveyed by Hülle (1942, 1967) and by Rennes-Beaulieu (H. Alimen, personal communication, 4 XII 70), neither of whose reports are available to me. The Crucuno rectangle (near Erdeven-en-Morbihan), cited by Charrière (1964:166) as a structure in which the diagonals indicated the rising and setting points of the sun at the first and last gleam at summer and winter solstices, has been surveyed and studied by Thom, Thom, Merritt, and Merritt (see pp. 450–54 of this issue).

Thom (1970*a,b*; Thom and Thom 1971, 1972) has determined by statistically analyzed surveys that British/Breton Neolithic astronomers were capable of determining complex lunar movements by means of stakes put into the ground at successive observations near the major (maximum) and minor (minimum) standstills, thus obtaining an eclipse-warning system.[13]

[13] Not only does the moon complete its solstice swings monthly rather than yearly as the sun does, but the angle of arc is not precisely the same from month to month for reasons which include both the obliquity of the ecliptic and the fact that the inclination of the moon's orbit *(i)* is subject to a small oscillation: as Thom (1970*b*:93) describes it, "The lunar orbit is inclined at $i = 5° 08' 43''$ to the ecliptic. The line of the nodes rotates relative to the equinox in 18.613 years. So in this period, the inclination

In a rare flight of fancy, Thom and Thom (1971:158) visualize the work involved:

We must now try to think of how a position was found for Er Grah which would have satisfied the requirements. Increasingly careful observations of the Moon had probably been made for hundreds of years. These would have revealed unexplained anomalies due to variations in parallax and refraction, and so it may have been considered necessary to observe at the major and minor standstills at both rising and setting. At each standstill there were 10 or 12 lunations when the monthly declination maximum and minimum could be used. At each maximum or minimum, parties would be out at all possible places trying to see the Moon rise or set behind high trial poles. At night these poles would have needed torches at the tops because any other marks would not be visible until actually silhouetted on the Moon's disc. Meantime some earlier existing observatory must have been in use so that erectors could be kept informed about the kind of maximum which was being observed; they would need to know the state of the perturbation. . . . Then there would ensue the nine years of waiting till the next standstill when the other four sites were being sought.

The process of establishing the maximum points was further complicated by the fact that the rising and setting times only occasionally coincide with the moon's monthly declination maximum. Thom (1970*b*:96) shows how megalithic astronomers solved this by setting stakes on several successive nights near the solstice, from them calculating the maximum position by extrapolation; he interprets the grids and fans of carefully placed small stones found alike in Britain and Brittany as devices (computers) to aid in this extrapolation.

Thom's system, though discussed in a simple and lucid prose and illustrated with explicit drawings, demands a high degree of mathematical, engineering, and astronomical knowledge: as yet few archaeologists have responded to the challenge. MacKie (1969:11) analyzes this resistance, noting unarguably that "scholars are only human beings and may be motivated by things other than purely rational, objective thought. . . . none of us are astronomers; none of us possess the detailed knowledge of the motions of the celestial sphere without which one simply cannot know where to look for evidence of prehistoric astronomy." He explains why the usual type of archaeological evidence is irrelevant and observes that the astronomical function of the standing stones can only be deduced by testing the designs against various hypotheses of geographical design and astronomical function. He questions, however, the use of statistical analyses based on a large number of orientations abstracted from different sites, concluding (MacKie 1969:11):

Though some of the details are open to discussion I find the geometrical and astronomical theories basically quite convincing, mainly because of the way in which they are developed. . . . Here is a vast amount of information, painstakingly collected over many years—plans of sites and carefully measured potential alignments in them. When one has enough of such information it begins to fall into patterns of its own accord when analyzed in various ways. The patterns are real and we must accept them. If we do not like the conclusions drawn from the patterns then we must think of better ones, but it is impossible to ignore the new data in any future assessment of Neolithic Britain.

Heggie (1972) commends Thom's hypotheses and, above all, the meticulous detail that characterizes his reduction of the data, source material that will be useful to other workers. Discussing the monthly maximum declination of the moon, Heggie points out that although it changes from month to month over a period of 19 years, the limits are almost the same for some centuries, so that it would have been worthwhile to record the corresponding positions on the horizon. Asking "Is there any indication that records of some of these points still exist in the megalithic sites?", he answers that, to his mind, Thom has shown this quite conclusively. Many alignments appear to him to fit the hypothesis that they were erected to indicate the points at which very bright stars rose and set. Heggie suggests a minor improvement on Thom's theoretical derivation of "G" in the analysis of the fan-shaped alignments which appear to have been used for extrapolation and concludes (p. 48):

Thom's evidence that megalithic man observed the moon is so strong that it may be accepted without hesitation. That he also used extrapolation seems to be indicated by the evidence of the stone fans of Caithness and elsewhere. The data on which Thom bases his assertion that the builders of the monuments established accurate sightlines for several interesting declinations, implying a knowledge of its motion that was not to be improved upon for over three thousand years, may have been interpreted incorrectly. . . . Much interesting material for feeding research in this subject may be found in Professor Thom's writings. The fact that few others have repeated his work should be understood as a symptom, not of doubts as to its value, but of the enormous effort that must be expended if Thom's standards are to be maintained.

of the orbit to the equator goes through a complete cycle between ($\epsilon = i$) and ($\epsilon - i$) where ϵ is the obliquity of the ecliptic." Megalithic astronomers appear to Thom to have been able by means of stakes and stones (empirical mathematics) to determine the moon's nodal cycle and its maxima, thus enabling eclipse prediction, as eclipses can occur only at the two points called nodes (knots) where the moon's orbit crosses that of the sun along the plane of the ecliptic. The inclination is at a maximum when the sun is passing a node. For about a year, the declination maxima do not range over more than 20′, a period Thom calls a major standstill; a minor standstill will occur 9.3 years later. As Thom points out, for the past several years the rising and setting points of the moon have ranged over very wide arcs, far to the north and then, two weeks later, far to the south; the maxima of both cycles coincided in 1969, producing a high peak which will not be equalled for many millennia: it will gradually decrease for nine years until it obtains a minimum value, after which it will again increase. In megalithic times, when the obliquity of the ecliptic was half a degree greater than today, this action was more pronounced, with a spectacular result: to an observer in the north of the Hebrides the moon was for a few days circumpolar, never setting at all (Thom 1970*a*:901). This striking phenomenon, as seen from megalithic observatories near the Arctic Circle, such as Callanish (cf. Thom 1967:122–28, fig. 11.1; Hawkins 1965*b*), might well have given rise to the tradition repeated by Diodorus that in the time of Apollo's visits to his spherical temple the moon came closer to the earth (i.e., swung nearer the horizon in a circumpolar sweep).

Hutchinson (1972*a*), in a summary review of Thom's geometrical arguments, applies a type-A flattened circle to the plan of Castle Rigg and a type-B flattened circle to a plan of Long Meg and her Daughters, demonstrating that a reverse fit is not possible. He suggests that the term "stone ring" be used in place of "stone circle," in view of the many noncircular rings with geometric aspects. He further suggests that slight irregularities attributed to frost heaving or to variations in the tension of measuring lines might instead be due to work by two groups, the ritual laying out of the sacred enclosure having perhaps been done by people of superior intellectual capacities using geometrical procedures as part of a philosophical-religious orientation similar to that of the Pythagoreans, the subsequent construction having been left to less skilled hands. In his review of Thom's astronomical arguments, Hutchinson (1972*b*) suggests that the distribution of solar calendrical declinations, with maxima at the solstices but with the next mode one megalithic month or sixteenth of a year (in Thom's suggested megalithic calendar) from the winter solstice, may represent a precaution in case of bad weather at the solstice. In this study of Thom's astronomy, it is stressed that the search for possible central observing points is a next step; Hutchinson finds that Thom's general conclusions appear to stand, though lunar computations may involve arbitrary identifications. The sight lines to Capella imply dates later than the majority of C^{14}-dated structures, if the bristlecone pine calibration (see below) is accepted. Hutchinson is impressed with the earliness of elaborate geometrical constructions: he suggests that these may represent the fusion of an older chamber-tomb megalithic architecture with a geometry worked out on a smaller scale using perishable material. MacKie (personal communication, 29 II 71) finds Hutchinson's suggestion that the geometric designs may have been worked out by a separate group (and then translated into architecture by workers who did not fully understand the geometry) of interest in connection with his study of brochs, stone tower forts with nonutilitarian geometrical plans incorporated in them, which show what appear to be sudden departures from the precise geometrical plans indicated.

To some commentators, Thom's data suggest other conclusions. Hogg (1968) accepts the astronomy and the measurements, but suggests another unit in place of Thom's megalithic yard. Crampton (1967) and others have argued that Stonehenge was in fact never a sacred structure totally open to the sky, but instead was a roofed and walled kingly center. Burl's (1971*a*) survey of the corpus of British stone circles (which has a most useful comprehensive bibliography) [14] has led him to assign a directional rather than an astronomical function to circles and outliers (see also Burl 1971*b*:49). He also cites new evidence for domestic occupation of certain of the henge sites. This does not, however, necessarily disqualify them for astronomical use: astronomer-priests elsewhere have lived in or near their observatories. The reference of Diodorus to the royal and priestly Boreadae in charge of Apollo's spherical temple, "of whom the succession has never been broken," suggests a perhaps very ancient tradition of custodianship. Burl's (1969*a,b*) further finding that only 17 of the 83 henges studied have stone circles within them again does not—at the present stage—disqualify them; stone circles in stony treeless areas and wood post circles in agricultural areas could equally have demarked the sacred area and served for sighting lines. In a well-documented study of diminutive and late stone circles called "four-posters," Burl (1971*b*) suggests that the people who built them, apparently for burial purposes, had left their homeland in search of *lebensraum* when the earlier society that could undertake vast building works began to split into small family groups interring their dead in family vaults or simple flat cemeteries.

Kendall (1971) discusses Thom's major hypotheses and suggests a number of checks, not all at present possible because of changes in the objective astronomical facts since megalithic times. With regard to his emphasis on the number of sight lines afforded by the notches in hill country, it must be remembered that, even aside from settlement patterns and vagaries of topography, the megalithic élite enjoyed an extremely long period of time for experimental stake-setting and undoubtedly tested various sites before erecting the stone markers. The basic question is whether or not the "astronomical observatories" existed: the exactitude of Thom's methods of declination refinement, as shown not only in the corpus of his work but in the accuracy of prediction his methods afford, puts a weighty burden of disproof on those who wish to deny this.

Cowan (1970) extends Thom's argument with regard to the sophisticated design of megalithic circles: he favors, however, the use of stakes and a rope, rather than two standard-length rods as Thom proposes (1967:32), and his theory assumes that two anchor stakes and two other pivot stakes were used in the construction of each ring and that they were aligned at right angles; he concludes that the megalithic geometers knew rudimentary trigonometry and simple topology, had a standard length, and had developed a unique method of geometric construction.

The determination of the presence or absence of postholes in astronomically significant locations, and of man-made observation platforms, is required to establish astronomical-mathematical function, and this, as Thom stresses, is one of archaeoastronomy's first tasks. To carry out such a test, MacKie (1971*b,c*) has worked at Kintraw, where Thom (1967:154; 1971:36–38) has surveyed a site which he designates as a highly accurate solstitial observatory which also could have given megalithic observers an accurate lunar eclipse-warning station (Thom 1971:65; see also Thom's [1971:26, 107] imaginary dialogue in which a megalithic astronomer teaches an apprentice how

[14] I am indebted to Burl (personal communication, 27 VIII 71) for the following references dealing with stone circles in Britain and Ireland: Browne (1921), Bushell (1911), Coles (1909), Fahy (1959, 1961, 1962), Hyslop (1912), Lewis (1878–1914), Morrow (1915), Somerville (1909*a*, *b*, 1912, 1922, 1923, 1925, 1929, 1930), Watson (1900), and Worth (1953).

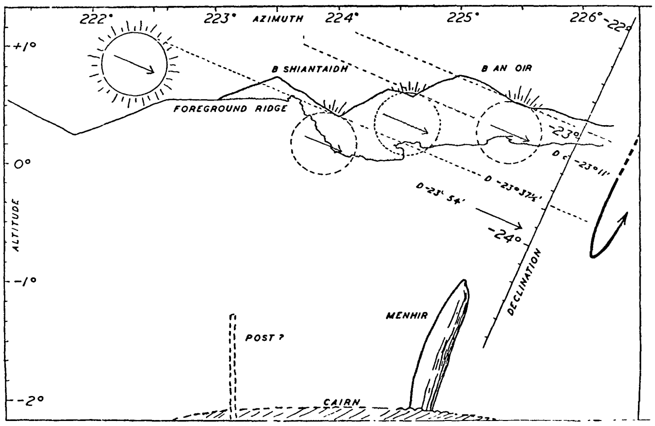

FIG. 3. View from the proposed stone platform at Kintraw, Argyllshire, looking southwest towards the col between Beinn Shiantaidh and Beinn a Chaolais (the distant marker indicated by Thom). The theodolite was set up in the notch formed by two boulders on the platform; the declination of the mountain notch is that determined by Thom. The cairn and standing stone (menhir) at the Kintraw site below are 1,135 m. distant, and the foreground ridge that hides the col from the site is about a mile away. The left-hand solar position marks the winter solstice as it should have been some 38 centuries ago, the central dotted disc marks the present solstice (at declination −23° 27′), and the right-hand one a second plausible alignment of unknown significance which the menhir could equally be indicating. The post shown marks the position of a wooden post indicated for the center of the cairn in the 1960 excavation. (Drawing by Euan W. MacKie.)

to employ the site to determine the date of a coming lunar standstill and thus of coming eclipses). Thom estimates that at the site of the Kintraw cairn and menhir, a small portion of the upper limb of the setting sun at the winter solstice, after it had set behind Beinn Shiantaidh, would flash momentarily in the col. By moving rapidly across the line of sight, an observer (or a row of stationary observers) could mark with a stake the precise stop from which this could be viewed: the stakes set for several successive nights would have moved first to the right (just before the solstice), then to the left (after the solstice), the extreme right-hand point marking the solstice. The site, however, afforded a problem to megalithic astronomers which has provided the test needed by contemporary archaeologists. It is situated on a small plateau on a very steep hillside, and from its surface the mountain target is hidden by a nearby foreground ridge. To enable the col to be seen, Thom theorized, it had been necessary to establish an observation platform on a steep hillside to the north of the plateau and across a deep and almost impassable gorge, so that the exact location of a flat-topped cairn which would bring the col into sight could be determined (fig. 3). A search at the site of the hypothesized platform revealed a stone platform at the edge of which two boulders afforded a notch suitable for viewing the col. The archaeological problem of establishing whether this platform was man-made or had been formed by natural processes—by accumulation of fallen scree behind fortuitiously placed boulders or by natural solifluction in glacial times—has been complicated by the absence of charcoal usable for radiocarbon dating, datable artifacts, or pollen (the latter suggests postglacial times but is badly preserved). The scree hypothesis can be dismissed: the slope of scree would have been far steeper. MacKie (1971*c*) brought a soil scientist to determine by measuring the angle and dip of the long axes of 100 adjacent stones whether these were nonrandom (as in a solifluxed layer) or random (as in a man-made layer). The test and other evidence strongly suggest that the layer is man-made: further testing should be conclusive. If so, the astronomical interpretation of the site will have been independently vindicated and Thom's theory of sophisticated prehistoric astronomical work supported by implication.

Before leaving the British-Breton megalithic astronomy controversy to consider the astronomical significance of other archaeological sites, we must review another revolution in prehistory, that occasioned by Renfrew's (1968; 1970*a,b,c*) application to megalithic Britain and to Neolithic Europe of the bristlecone pine tree-ring correction of radiocarbon dates. Briefly, the 5,000-year dendrochronology obtained from the study of the rings of this California tree has been compared by Suess (1967) and others (cf. Stuiver and Suess 1965) to radiocarbon determinations made upon its wood, leading to the discovery that radiocarbon dates before 2000 B.C. may be up to some 700 years too young (Delibrias, Guillier, and Labeyrie 1970; *Nature* 228:1019–20). To shift Western European cultures formerly dated to the 3d millennium back some 700 years would alter radically the relative chronological positions of the Near East and Europe, making untenable the accepted archaeological theory that European skills were derived from the Near East. Egyptian chronology, based on historical records astronomically dated by the heliacal risings of Sirius (the Egyptian year-bringer Sothis), remains unchanged: in fact, the revised radiocarbon dates are in better agreement than older ones with Egyptian astra-determined historical chronology (MacKie 1970: figs. 1 and 2). Minoan and Mycenaean chronologies, obtained by cross-dating with Egyptian artifacts, also remained unchanged.

In Western Europe, however, in the absence of historical records recent dating has been based on radiocarbon determinations. Now at one stroke the megalithic structures of Malta, of Los Millares and other early Iberian sites, and Western European megalithic structures may have to be dated around or before 3000 B.C., draping some of these monuments in a venerable antiquity outranking that of the Egyptian pyramids, not to mention the voyages of the Myceanaean traders whose building skills have been suggested as a model for those evident at Stonehenge. The British structures so far dated by archaeoastronomy (primarily by Thom) appear to cluster around 2100–1600 B.C.,[15] which is not greatly earlier than

[15] Newham (personal communication, 1 VII 71) states that reliable dating appears possible where very accurate survey data is available:

the C^{14}-determined and archeologically accepted estimates for Stonehenge II and III. Renfrew (1971) estimates that Stonehenge I, the henge ditch, may, however, have been in construction around 2930–2550 B.C. and Aubrey Hole 32 around 2500–1900 B.C. The new bristlecone pine dating is in better agreement with recent archaeological studies which have proposed British origins for the designs of many of the megalithic structures and also falls into line with some previously unaccepted dates. MacKie (1969:6) notes that a possible date of 2900–2600 B.C. in real (i.e., calibrated C^{14}) years for the Phase I henge at Stonehenge is exceeded by the dates of other henges; the vast ring ditch enclosing several circular settings of posts at Durrington Walls yields radiocarbon dates equivalent to about 3400–3100 B.C., while Arminghall appears to have been constructed between 3000 and 2800 B.C.; thus the three henge monuments are a millennium or so older than the period of the stone circles deduced on astronomical grounds, and appear to be contemporaneous with the Old Kingdom and the great pryamids. As MacKie notes, the henges will provide a crucial test for the reliability of the astronomical theory of the purposeful construction of the Neolithic rings: if they indicate this older dating, the theory will be vindicated; if not, some other explanation must be found for the uniformity of Thom's evidence with regard to the megalithic structures (cf. Atkinson 1967, 1969).

In summary, weighing together the many well-documented analyses made by the several participants in the Stonehenge debate and their most generous responses to my own questions, I am inclined to set aside such exasperated personal comments from them as "the astronomers and the archaeologists are not speaking the same language" and "a brilliant and explosive theory has gone rocketing ahead without anything like critical control." By 1972 a rapid growth of mutual understanding and of critical control is quite evident, and there is increasingly well-informed opinion that Stonehenge (and many other ancient monuments) not only *could* have been used for sophisticated observations and predictions of astra events ("astra" being a shorthand expression for all the celestial bodies), including eclipses and moon perturbations, but probably *were* so used. That they were used precisely as theorized by Hawkins and Hoyle is not accepted, and an understandable and mutually educational scholarly exchange continues, in which archaeologists and others in various areas are now engaging. The outcome of this standard scientific procedure promises to be the addition of astronomy to the archaeologists' conceptual tools, even more scrupulous attention to accurate reconstructions and to the construction of precise site maps, adequately documenting the presence of outlying stones, postholes, and distant markers, and the acknowledgement of the necessity for cooperation between archaeologists, astronomers, engineers, and others.

Evidence of Astronomical Functions for Other Early Structures

The possible earlier dating of the megalithic structures, considered in connection with the hypotheses with regard to their astronomical-mathematical function, focuses interest on megalithic structures in other areas than Britain and Brittany. Müller's (1970) admirably concise presentation of Thom's hypotheses extends the range of similar structures to Central Europe, indicating for this area an early interest in astra orientation and calendar sites. If archaeologists in Central Europe and beyond confirm this further extension of Thom's megalithic measurements and orientations and agree with his astronomical hypotheses (while perhaps disagreeing with him in some details), then clearly archaeoastronomy will have proved its value.

Mennevée (1960) suggests that the rarity of megaliths in Italy may be due to the comparative rarity of suitable rocks: he reproduces iconography (rock art and stelae) and compares the distributions of megaliths, bell beakers, and metal deposits exploited in prehistoric times. Rojer Grosjean (personal communication, 14 XI 70) reports that no archaeoastronomical hypotheses have been tested in Corsica but notes that Corsica's anthropomorphic stelae face east, as if facing the rising sun at the equinox. Less archaic monuments in Sardinia and the Balearic Islands were, he suspects, *"temples de feu,"* either for incineration of the dead, for burning of offerings, or as the site of ritual repasts. (Evidence from Iberia to India indicates to me that fire rituals, symbolically related to solar events and accompanied by bull rituals and bull sacrifice, were a part of a New Year's sacred drama cycle [Baity 1962, 1968].)

Barandiarán (personal communication, 7 XI 71) notes that the almost 400 dolmens in the Basque country for the most part face east, though some are oriented to the south and a few to the northeast; this suggests patterned behavior concentrating on the rising sun at the equinoxes and solstices. Basque tombs have similar orientation, as do the more recent Basque *illarri* (death stones), the designs of which have long suggested to me solar-stellar symbols. Barandiarán fully documents this symbolism and shows that swasticas also appear: moreover, the stones appear to him to match the myths (Barandiarán 1960, 1970). At present there are few C^{14} dates for Iberia; I am thus unable to compare the date of Iberian megaliths with the high Breton dates in the time range 3500–3000 B.C. that are now substantiated (Delibrias, Guillier, and Labeyrie 1970; cf. *Nature* 228:1019–20), making it appear possible that collective burial in megalithic chamber-tombs was known to the first immigrant farmers who reached Britain around 3500 B.C. (or, in calibrated C^{14} dating or real years, around 4200 B.C.): it also appears possible that the tradition

---

e.g., at Stonehenge, the 91 station to No. 1 carpark hole gives a sun declination corresponding to 1700 B.C. ± 200 years. Dating by the sun is only possible when it is at the solstice: once this is known at a particular site where intermediate alignments also exist, it is possible to calculate the day of the year to which they will apply.

Merritt (1968) shows that megalithic astronomy establishes dates which invalidate the hypothesis of Velikovsky that Venus entered the sun's planetary family as a comet well after the first historical records were made.

of astronomical alignments for burials came as part of the funerary complex.

Burl (personal communication, 8 VIII 71) indicates that stone circles are reported in connection with megaliths in Galicia and elsewhere (calling attention to Leisner and Leisner 1956, among others), but no reports known to me indicate whether Thom's hypotheses have been tested in this rich area, the significance of which to archaeoastronomy is indicated not only by its megaliths and metals but also by its African and Anatolian prehistoric connections. Should Iberian megaliths demonstrate orientations and measurements similar to those of Britain and Brittany, the attempt to construct a megalithic calendric ritual cycle might profit from the remarkable richness of Iberian folkloric survivals and scholarship: most extensive bibliographies are available in the works of Caro Baroja (1958) and Barandiarán (1960, 1970). The "solstice madness" that sweeps through Iberia at midsummer, expressing itself in a rich variety of bull and fire rituals closely paralleling hundreds of scenes in protohistoric cattlekeepers' rock art (and also resembling Berber summer-solstice rituals reported by Laoust [1921]), strongly suggests to this participant observer that the association of such activities with a solstice ritual event (perhaps in earlier times a New Year) is at least as old as Iberia's cattlekeeping traditions and may even preserve elements of predomestication fire rituals (though I am not suggesting derivation from the *Homo erectus* fire-drive indicated at an elephant kill-site in Soria Province).

The significance for archaeoastronomy of the Black Sea megaliths is evident: the many similarities of Basque-Caucasus folklore, dance, and music, and above all the extensive linguistic correspondences, suggest the possibility that similar orientations may also be found. Markovin (1969), Lunin (1924, 1936), Leshchenko (1931), Lavrov (1960), Shchepinsky (1963), and Chechenov (1970) have conducted large-scale surveys and excavations of megalithic structures in the Caucasus and nearby: I have not been able to examine their reports, but suggest that orientations and measurements already made or obtainable may make possible a systematic comparison.[16] It will be interesting to see whether a synthesis of this Basque-Caucasus archaeological and folkloric data shows correspondences with the French megalithic folklore collected by Saintyves (1934) and students with reference to some 2,000 stones and structures. (French folkloric classics appear to me to be especially significant sources with regard to megalithic traditions and survivals: Wayland Hand [personal communication, 18 I 72] notes that Sébillot [1968], like Saintyves, based much of his folkloric data on the physical world.)

Regrettably, I have uncovered almost no reports on archaeoastronomy elsewhere in Eurasia or in Africa. Allchin (1956) has suggested that stone alignments in southern Hyderabad may have had astronomical significance; the alignments he reports seem to indicate this. Evidence, both textual and astronomical, to be published by Hawkins (personal communication, 6 XI 71) indicates that the Egyptian pyramids were oriented with reference to stellar targets (see also Pogo 1930, Giedion 1962). The stone circles of the Gambia and the Senegal are reported to be recent (Beale 1968). Perhaps commentators will be able to contribute further information on these areas.

Pre-Hispanic architecture and art in the Americas have fascinated a generation of archaeologists and other students, many of whom have suggested astronomical functions for the structures (cf. Marquina 1951, 1960; Morley 1956; Noriega 1954, 1956, 1958; Saville 1909, 1929; Spinden 1940).[17] As the textual and iconographic evidence indicates the presence of astronomical-mathematical skills of a high order, it is predictable that these skills will be reflected in the orientations and measurements of sacred structures and cult sites. As yet Mesoamerican archaeoastronomy has found no worker with the determination and engineering qualifications of Thom to make and statistically analyze the needed series of precision studies, and until such studies are systematically made on a statistical basis American archaeoastronomy cannot be expected to yield the information which, the evidence suggests, may be encoded in the structures. Morley (1956:fig. 33) indicates the possible use of astronomical alignments in Group E, Uaxactun (Guatemala): here an astronomer-priest using Pyramid E-VII as an observation platform could, Morley estimates, have observed the flash of the rising sun at the equinoxes and solstices, using the wall and platform angles of three temples on an opposite pyramid as precise distant markers (fig. 4; cf. Morley 1956:figs. 4, 32).

Hartung (1969), studying site-maps of Tikal, Copán, Uxmal, and Chichén Itzá, finds subtle overall planning suggested despite the apparent irregularity: at Copán a network of coordinates and parallel lines appears to connect ballcourts, while altars M and N correspond with cardinal points (cf. Guillemin 1969). Ballcourts, long recognized as connected with a solar cult, are a central feature of overall planning at various sites (cf. De Borhegyi 1969). Hartung surmises, as have others, that the doors of the Caracol at Chichén Itzá and other round structures which may have been observatories functioned as observa-

[16] I am indebted to Leo S. Klejn (personal communication, 9 X 71), aided by megalith students Vladimir Dmitriev and Leonid Rezepkin, for these and other most useful references.

[17] Not an Americanist and largely absent from the Americas for over two decades, I am relatively unfamiliar with the growing body of current unpublished work in this area and have elsewhere (Baity 1969, 1971*a*) noted the need for a synthesizing review of American archaeoastronomy and ethnoastronomy. I hope that commentators will supplement the following discussion. For sources and criticisms with regard to American archaeoastronomy, I am deeply appreciative of the help of D. H. Kelley, Jonathan Reyman, and Charles H. Smiley. In connection with the various Maya studies, Kelley observes (personal communication, 8 V 71) that when one has a large number of figures with which to work and little control as to their meaning, impressive results may be cited that may not stand up; to me it seems important that skills from the fields of archaeology, protohistory, astronomy, and engineering may now be brought to bear on problems of common interest.

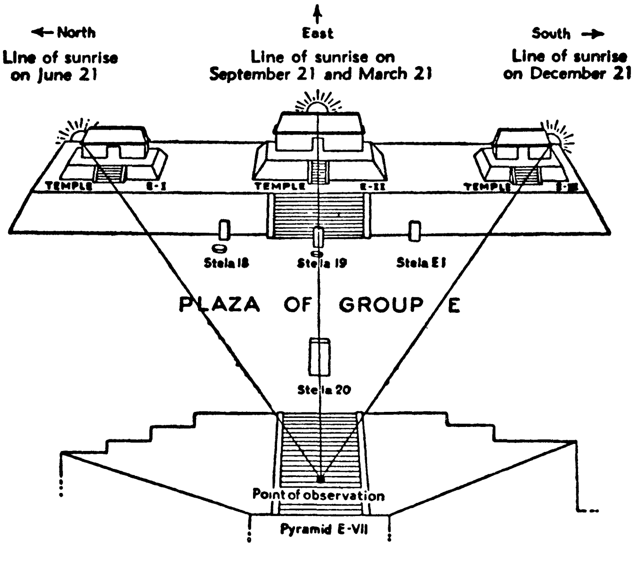

FIG. 4. Diagram of the astronomical observatory at Group E, Uaxactun, Petén, Guatemala, for determining the dates of the solstices and equinoxes. Morley (1956) describes this Old Empire observatory, found in an area where a number of stelae date back to around A.D. 328, as one of over a dozen similar observatories at Old Empire sites. (Reprinted from Morley 1956:300, fig. 33, by permission of the publishers, Stanford University Press. Copyright © 1946, 1947, 1956 by the Board of Trustees of the Leland Stanford Junior University.)

tion posts (cf. Ricketson 1928, Ricketson and Ricketson 1937, Pollock 1939, Ruppert 1935). He warns against the possibility of errors in calculations based on site-plans rather than site examinations. Dow (personal communication, 5 x 68) warns in turn against the possibility of errors where reconstructions have been wrongly oriented, a factor which invalidated some of his conclusions with regard to the stellar targets at Teotihuacán (Dow 1967). The pyramids of the Sun and of the Moon at this ancient Mexican cultural and sacred center are spectacular reminders of the pre-Aztec culture that dominated a wide area of Mesoamerica and influenced far-distant cultures (Millon, Drewitt, and Bennyhoff 1965). Much evidence indicates that astronomical observations functioned as a part of a complex ceremonialism using astra indicators and accompanied by astra mythology and deities. Teotihuacán is clearly the flowering of much older cultures, and for earlier stages of astronomical development researchers must turn to La Venta and other centers of the Olmec culture and also to the Chavín culture of the Peruvian highlands, in each of which a vigorous culture is in evidence in the 1st millennium B.C., and in each of which a jaguar-god symbolism is present. Possible Asian influences in the ancient American cultures have been theorized on the basis of stylistic resemblances (Birrell 1970, Ekholm 1953, Kirchhoff 1964, Moran and Kelley 1969). Mertz (1969*a,b*) suggests that early Greeks voyaged to the area, and Taylor (1957) assesses the navigational astronomy which would have made this possible. As yet consensus is lacking on transoceanic contact, and archaeoastronomy may well contribute useful insights. At La Venta, as in megalithic cultures, a priestly élite prevailed upon its followers to cut and transport 50-ton stones which Olmec artists carved into huge heads, though similar-sized stones were used architecturally on the western coast of South America. Throughout Mesoamerica for at least two millennia, impressive pyramids were built and an endless flow of carved stone time-marking art works produced. The preoccupation of Maya-Mexican astronomer-mathematician-priests with time and the stars, and the extent of their accomplishments, are further assessed below.

South American astronomical achievements also give evidence of having been rooted in some ancient culture (Reichlen 1963, Zerries 1952, Wittkower 1938). Reiche (1968, 1969) documents with extensive aerial photography the Nasca giant ground figures. Straight lines running for miles with incredible precision across the Peruvian plains and up mountainsides could have indicated such events as solstice sunrises and sunsets or perhaps encoded measures of history and calendar science. Reiche sees a unit of measurement of 1.10 m., perhaps subdivided by the decimal system. Hawkins (1969, 1970) does not see an astronomical function in the Nasca iconography. Belli (1952) indicates the importance of the sun cult in the Nasca civilization. The Nasca figures do not suggest to me a correlation with a known zodiac, nor do they resemble North American ground figures and effigy mounds, and yet in both cases the enigma remains of why designs not visible at ground level were worth the outlay of energy involved in making them. Present in North America but apparently absent here is the serpent-and-egg (or lizard-and-egg) motif that is associated with eclipses in various Asian cultures (cf. Elwin 1951, 1955).

Posnansky (1942) and others have suggested strong astronomical associations of Tihuanaco megalithic monuments with agricultural ceremonialism: the elevation of this ancient center to 12,500 ft. (an altitude which does not now permit corn to ripen) does not lessen its possible importance with regard to the sources of Inca calendric lore and architectural practice. Zuidema (1968) has pointed to the importance of the Inca cosmological model in its application to temple- and city-building.

Ferdon (1955) and others have noted architectural parallels between Mexico and the Southwest. R. F. Heizer reports (undated CA referee comment, 1970) that on the time level of 1000 B.C. Poverty Point (Louisiana) is, like La Venta (Tabasco), oriented in the line of 8° west of North and asks: Is this coincidence, or did the same system of stellar orientation exist in these areas separated by some 1,500 miles? And, if the latter, does this imply a link between the builders of the two sites? A systematic large-scale comparison of American site orientations should reveal the presence or absence of significant consistencies.

Pre-Columbian towers in the Southwest have been noted by Schulman (1950). Reyman (1971*a*) associates frequent citations of astronomical phenomena among the historic and modern pueblos, in particular Anasazi, with astronomical alignments of the prehistoric sites and structures. He emphasizes the importance of the scattered references to astronomical alignments and rituals in Fewkes' (1891–1922) works, especially his reference to determining the length of the autumnal equinox by a shadow (Fewkes 1916*a*), and of the data obtained by Parsons (1936; 1939*a,b*) and Stephen (1936) with regard to Puebloan astronomical practices. Reyman (1971*a,b*) ties the Anasazi astronomy to the agricultural "tool-kit" ceremonialism from the Mesoamerican area and stresses the cultural importance of astronomical observation for site planning, for the planning and execution of a successful agricultural cycle, and for ordering the procession of events within a given ceremonial. Stellar referents may have been mandatory in the ceremonial activities and thus in construction. He has made a distinctive-feature analysis of various features, ceremonial and architectural, that are parallel in Mexico and the Southwest: his analysis includes artifacts that occur with the features and the context of the features within the structure and the structure within the site, on the hypothesis that consistent astronomical features reflect similar ceremonial contexts (personal communication, 8 IV 71). Similar (unpublished) work has been done by John Molloy in the Hohokam area, and with ballcourts by Schroeder (1966) and Wasley and Johnson (1965).

The Anasazi data analyzed by Reyman is generally significant as a late and well-documented example in which astronomical ceremonialism is caught red-handed entering an already populated area with improved maize. The data also emphasize the importance of postholes in areas which no longer have surviving cultures. Wittry (1964–70) has excavated at Cahokia four henge-type structures, part of a vast ceremonial complex, radiocarbon-dated to around A.D. 1000, where spaced wooden posts appear to have been arranged in circles of from 240 to 480 ft. in diameter: Wedel (1967) describes henge structures which may have served a similar function in central Kansas. European megalithic astronomy throws new light on these American circles marked now in many sites only by postholes. The more elaborate "American Woodhenge" described by Wittry (1970*a*:15; 1970*b*) was 410 ft. in diameter, laid out by means of a peg-and-rope compass. The cardinal points were marked by four posts, and the total of 48 posts were evenly spaced around the circle. At around A.D. 1000, Wittry shows, an observer standing at a post located 5 ft. to the east of the true center of the circle excavated and looking at the fourth post to the left would have been looking at the angle required, slightly greater than 30°, toward the summer-solstice sunrise. In 1964, when first described, these Cahokia circles were the only known indications north of Mexico of structures which could have served as sun circles defining the tropical year. The circle examined by Wedel (Tobias site) consists of elongated house circles arranged around a patio within the ditched zone; the houses appear to have served as sighting lines of the solstitial sunrise points. Wedel cites Dorsey (1907:8), who described the Wichita and the Pawnee religious systems as star cults: the Skidi Morningstar sacrifice of a captive girl is one of the several evidences of sacrifices at the winter solstice, the "feast of fire," evidently for the purpose of strengthening the weak winter sun for its journey north. Like Reyman, Wedel stresses the significance of the solstice rituals described by Parsons (1939*a,b*; 1936) and Fewkes (1897:259; 1898:678) for Zuñi, Taos, and Picuris, in which posts and other markers are known to have served as solstice indicators. Hardman (1971) reports two roughly carved menhirs which mark solstice alignments in shell mounds at Crystal Lake, Florida: the determinants, though primitive, appear to have offered an accurate base for prediction. In a preliminary survey of the literature on other Southeastern temple mounds, he sees indications which suggest the value of testing for astronomical function and suggests trans-Gulf contact with Yucatan in early centuries B.C.

EVIDENCE FROM ETHNOASTRONOMY: ICONOGRAPHY, TEXTS, RITUALS

The line between archaeoastronomy and ethnoastronomy cannot be sharply drawn, as much evidence overlaps; notably, the evidence of astra iconography,[18] often made accessible by archaeological methods and informative to archaeoastronomy, is in many instances clarified by iconographic and other traditions of living peoples. My division of the two topics is necessarily arbitrary and sometimes hinges upon the assumption of a certain duty to a hypothetical reader who may be unfamiliar with astronomical facts and constructs, with whom a ground of understanding should be established before I attempt to briefly review iconoclastic studies. Marshack's work, like that of Thom, requires such a mental restructuring: each stands alone, each represents years of grueling fieldwork with a scrupulous regard for the difference between objective data and subjective assumption; and just as Thom requires us to modify traditional views with regard to Neolithic man's cognitive capacities, Marshack requires us to think about how these abilities developed in Paleolithic man in response to observed seasonal (including astronomical) realities.

The question of the backward thrust in time of

[18] Elsewhere (Baity 1917*b*) I have used "astra (astro-) iconography" to designate sets, subsets, and classes of motifs observable in ceramic and rock art: (1) obvious astra forms, lunar, stellar, and solar, including what I take to be annular eclipses and total eclipses with coronas; (2) the representation of recurring astra events serving to date rituals, such as heliacal and other risings and settings, and of symbols denoting these; (3) the representation of subjective concepts such as constellations, which represent gods in their animal forms; and (4) the record of rites duly performed. The term is inadequate, as Marshack notes (personal communication, 28 x 71), in that it excludes the greater part of the Paleolithic-Mesolithic astronomical notations, which are nonstatic, cumulative records of phenomena observed and recorded over periods extending into months and years. He sees a relatively late stabilized official iconography and mythology, following an earlier use of open seasonal images, abstract signs related to diverse seasonal observations, reportorial depictions of seasonal ritual including images of sky bodies, and, finally, a lunar notation. His terms appear to me to be preferable for the greater number of astronomical symbols, rituals, and myths, but I suggest that for sets specifically depicting astra bodies and events, and the ritual directly related to them, the term astra iconography may have a specific use.

man's astronomical interest was first raised in Marshack's (1964) study of lunar notations on Upper Paleolithic remains; these include cave markings which suggest notations which could represent the synodic month (the $29\frac{1}{2}$ days from new moon to new moon), one of the recurring astra events most helpful in man's early attempts at timekeeping. We have seen from Thom's work that the solstices and equinoxes of sun and moon are easily observable recurring events. The vernal and autumnal equinoxes could have become early associated with man's quest for food in Ice Age Eurasia, where the migration of great animal herds and the appearance and disappearance of plant foods were vitally important to the advanced *Homo sapiens* groups who created Paleolithic iconography featuring bulls, stags, other animals, and plants in what appear to have been symbolic contexts. Cliffside cave-mouths would have been excellent vantage points from which to observe such distant markers as mountain slopes and horizon gaps, which often must have bounded the annual swing of the sunrise from north to south and back again and the more complex moon swings, as well as the recurring rising at certain seasons of brilliant stars such as Sirius and Capella and the unpredictable appearance of eclipses, comets, and novae.

That Paleolithic men thoughtfully observed these astra events and recorded some of them, notably the moon's movements, in calendric notations in both mobiliary and cave art is indicated by Marshack's (1969; 1970*a,b,c*; 1971; 1972*a,b*) painstaking documentation. His analysis of European Upper Paleolithic and Mesolithic engraved artifacts verifies the presence of highly complex interlocking symbolic systems. He traces a 25,000-year development of these interrelated, "time-factored" traditions into the Neolithic. His work indicates that these early cultures symbolized seasonal and periodic phenomena to a greater extent than do present-day or historic hunting-gathering cultures. With regard to lunar or calendric symbolism and notation, Marshack (1972*a*) states that these were probably not yet truly astronomical in that they were not yet truly arithmetic; the notations and images had a seasonal reference related to economic and ritual periodicities comparable to the seasonal "moons" of later American Indian usage.

Marshack's continuing studies of interrelated time-factored traditions traced through the Mesolithic will in all probability document the sources of well-attested Neolithic astra-determined rituals. Pending the publication of his findings, there is little known to me to prove the probable Mesolithic interest in astra events except the orientation of burials and vague indications of early solstice fire rituals. Later interest in solar movements and solstice dates is unambiguously indicated by the intensified fire rituals, including both the widespread fire walk and the *toro de fuego* or fire bull ritual. These are associated with solstice occasions in Soria Province, Spain, the French and Spanish Basque provinces, and the Indian subcontinent. The fire walk is connected with a winter-solstice New Year in China and Mesoamerica, occurs at a spring equinox in Iran, and is endemic in India (Baity 1962, 1968). One may, in view of evidence suggesting a pre-Neolithic origin for these and other intensified fire rituals, ask if their prototypes may have been associated with astra occasions even in the Paleolithic, and this may be suggested by Klíma's (1962:199–204) documentation for Dolní Věstonice. Here, in a permanent mammoth-hunters' settlement datable to around 29,000–25,000 B.P., numerous broken bits of ceramic animal figurines were found in a large bake-oven in a hut suggestive of a cult center and also in a common central hearth containing an ash layer some 100 cm. in depth, in which was found the Venus of Wisternitz (Věstonice), protectress of the common economic-social life and perhaps a prototype of the hearth goddess. This evidence suggests animal sacrifices symbolically made at a seasonal ritual event, a hypothesis to be further considered by Soviet and Czechoslovakian scientists, who may indicate whether solar orientations are indicated in structures, settlement patterns, and burials of Pavlovian and other Paleolithic permanent settlements.

The widespread occurrence of Mesolithic interest in solar movements is indicated by Saxe's (1971) study of the orientation of skulls in a Mesolithic population at Wadi Halfa (Sudan), which utilized only 42% of the 360° range. Saxe (1971:fig. 2) indicates concentration in the southeast quadrant and a well-defined clustering between 65° (sunrise at summer solstice) and 115° (sunrise at winter solstice), which he interprets as an indication of patterned behavior. Other data on the orientation of burials suggests a similar patterning: with reference to Thule burials, Merbs (1968) sees congruency of burial axes with solar positions, and examining Pennsylvania burials Gruber (1971) suspects orientation towards the position of the sun on the horizon at dawn.

Various studies indicate that Afro-Eurasian ceramic and wall iconography from the 4th millennium downward records astra-set rituals. Several well-documented and somewhat different traditions appear evident. In view of the prolonged association in later Asian and Ibero-Saharan iconography of astra symbols and the horns of stags or bulls (with rams appearing in the Sahara and Iberia), it is tempting to surmise that the large horned animals—stags and bulls—were already associated not only with deities but with constellations by the 8th millennium, a hypothesis suggested by the appearance of bull and stag icons in cult contexts at Chatal Hüyük (Mellaart 1967) and supported by textual evidence reviewed below.

Classical Tripolye iconography charmingly employs motifs which to me appear to incorporate astra symbols into the Neolithic spiral associated with early agricultural diffusion (Hawkes and Woolley 1963:255–56, 332), though the designs suggest a cosmological orientation rather than specific rituals (as in Iran, Elam, Sumer, the Indus, and the Ibero-Saharan continuum). However, a design of concentric half-ovals enclosing a stellar motif has a certain resemblance to a motif which Hartner identifies as a symbol for a heliacal rising (compare Gimbutas 1956: fig. 37, no. 4 with Hartner 1965: figs. 23, 24). Tell Halaf painted pottery designs published by Von Oppenheim (1933) show star-surrounded bulls and other obvious cult emblems.

By the 3d millennium some sophisticated cosmological belief which was expressed in ritual and recorded in iconography appears to have existed around the Black Sea and the Persian Gulf. I have noted the resemblances between stag and bull icons of Anatolia, notably of Alaca Hüyük, and Galician rock-art stags and bulls (Baity 1968:103–13, figs. 7*a*, 8***B***). The Egyptian iconography is for the most part different. Earlier Saharan rock-art scenes, however, appear to contain elements of both traditions: this area is interesting because of the early appearance of the solar ram, a figure absent from the early Mesopotamian zodiac but present in the Indus zodiac Heras (1953) postulates, and appearing as a borrowed element (perhaps from Egypt) in the Greek zodiac. As Sumerian-Babylonian astronomical texts and iconography offer the possibility of "text-aided" interpretations, let us briefly review studies in this area which afford a basis for comparisons with iconography in "text-free" areas.

In the earliest known writings, we find an intense concern with astronomy and a rather apprehensive concentration, in Mesopotamia at least, on astra-based predictions. Textual evidence proves that the Egyptians told time by means of the "decans," 10° sections of the ecliptic and nearby regions originally based on constellations rising heliacally 10 days apart after having been invisible due to conjunction with the sun. In a precomputer attempt to calculate the effects of precession (by drilling several pairs of "polar" holes in a celestial globe), Pogo (1930) offered identifications for constellations appearing in the earliest known of several astronomical tomb ceilings, that of Hatshepsut's architect Senmut, of the 18th dynasty, ca. 1500 B.C., and indicates the importance of circumpolar constellations in temple orientation. He cites a text describing the "cord-stretching" ritual for astronomical alignment. An English translation (Giedion 1962) identifies the target constellation as Ursa Major, but Pogo identifies the Bull, Meskheti, as terminating with the then polar star (Thuban). The ritual text reads: "I have grasped the peg. . . . I observe the forward striding movement of the constellations. My eye is fixed on the Great Bear. . . . I . . . determine the corners of your temple" (cf. Pogo 1930: pl. 16; Giedion 1962: figs. 77, 78). The paraphernalia for this ritual of temple orientation are represented in iconography; actual examples dating from the time of Hatshepsut may be seen in the Cairo museum. Pogo compares Senmut's ceiling with two 12th-century-B.C. examples, noting changes that precession would have caused in the decans system and its associated deities. The use of an ancient astronomical system built on exact observations is evident, as is the importance of the Pleiades: as Pogo notes, around 3000 B.C., when the vernal equinox was in the Taurus constellation of the Mesopotamian zodiac, the celestial equator by definition ran through our Taurus constellation and thus very near Procyon. A check with the Morehead Planetarium at Chapel Hill for the approximate latitude of Thebes (Karnak Luxor) shows that Pogo's method is sufficiently accurate for observational astronomy. (Cf. Smiley's similar description of the Maya calendar Zero Day below.) Senmut's bull constellation, with its ovoid body terminating in what appears to be an orientation line, resembles an iconographic part-bull in an Ibero-Saharan rock scene which I had taken to be a zodiac representation (Baity 1968: fig. 14*c*) and thus not early Egyptian in origin.

Senmut's astronomical ceiling, with its proof that a quite representational bull head had preceded the "leg of beef" constellation of later days, offers the possibility of another interpretation. By 1500 B.C., as the planetarium test shows, Thuban was too far from the pole to be significant, though our Taurus still was close to the celestial equator, with the Pleiades at +8° N and Aldebaran at +3° N, and Aries the Ram moving to take its place. Neugebauer (1942*b*:402) makes the point that the complexity of Egyptian and Babylonian calendars "represents the peaceful coexistence of different methods of defining time moments and time intervals in different ways on different occasions." Schematic devices expressing future dates in round numbers, useful for long-term economic agreements, were always subject to adjustment by inspection of lunar phases. Meanwhile, as the strongly agricultural character of these civilizations emphasized the seasons of the solar year, the heliacal rising of stars was practical for determining solstices and equinoxes and thus for regulating agricultural rituals and labors (cf. also Neugebauer 1945:794). Constellation figures, such as that of the bull in Senmut's astronomical ceiling and on coffin lids, highly mythological in content, were not always understood by later copyists, when precession had changed the objective astra facts. In Mesopotamian texts the shift to systematic prediction (cf. Neugebauer 1945:795) of lunar phenomena and the use of the cycle of 19 years can be seen by the 4th century B.C. Giedion's (1962) analysis of flat-topped pyramids and other types of sacrificial altars and his extensive data on Ram (Ra) cults and other horn and antler symbolism associated with fertility renewal cults afford a basis for comparative studies on the fundamental difference in Egyptian and Mesopotamian astra cults, the one cheerfully focusing on the sun as deity and on constellations as soul guides and the other gloomily studying night skies for predictions.

Although the decans appear in drawings on the inner side of coffin lids around 2100 B.C., Sarton (1927–48), Taton (1963), and others (not including Lockyer 1965) have thought that astronomy did not develop the scientific stature in Egypt that it attained in Mesopotamia. To their credit, however, the Egyptians of around 4228 B.C. had tried, by adopting sidereal time keyed to the heliacal rising of Sirius (Sothis), to resolve the problem presented by the fact that there is no lunar year which corresponds to the solar year marked by the solstices. They dealt with the incommensurability of the solar and sidereal years (the latter being about $\frac{1}{4}$ day longer than the former) by maintaining both a civil (with leap year) and a sacred calendar (cf. Parker 1950). It is interesting that when forced to choose between the stars and social custom, the Egyptians recognized social primacy: exhausted, perhaps, with the attempt to reconcile calendars which coincided only every 1,460 years (i.e., 365 × 4; cf. Edwards 1970), they may well have lost faith in the stars, and who can blame them? However, selection biases of Arab scholars in favor of medicine and magic may have operated against astronomical papyri, whereas astronomical scholars have worked with archaeologists from the first deciphering of cuneiform and of Maya hieroglyphics (Fleckenstein-Gallo 1967). Later Egyptian astronomy is closely tied to Greek and Roman astronomy and astrology, based on the Mesopotamian zodiac, which introduced constellation figures new to the Egyptians (cf. Claggett 1955; Zinner 1931, 1933).

The achievements of early Middle Eastern astronomers have been intensively studied.[19] Neugebauer's (1937–72; Neugebauer, De Falco, and Krause 1966; Neugebauer and Parker 1964, 1969; Neugebauer and Sachs 1968–69) highly specialized studies relate early astronomy to mathematics and ancient geography. There is little doubt that by the 2d millennium B.C. a reasonably respectable astronomy existed in the Middle East, which the West assimilated, along with inheritances from its own megalithic cultures. The textual evidence indicates that this sophisticated astronomical knowledge existed in Mesopotamia well before Sargon of Agade boasted (ca. 2350 B.C.) of having rescued his trading colony at Parsuhanda, 1,000 miles away in Asia Minor. (Sargon's reference to long-distance trading is validated by the finding of uniform Akkadian architecture in distant trading areas [Mallowan 1965:5].) Mesopotamian astronomy continued to develop: Van der Waerden (1949, 1963) discusses Venus tablets dating to the Hammurapi Dynasty and lists of 36 stars connected with the 12 months of the year. He also notes the significance of the heliacal rising of individual stars and constellations as indicators for seasonal festivities in Babylonia, Egypt, and Greece. As the stars of the Elam, Akkad, and Amurru lists are identical with those of later lists, he suggests a very ancient origin in Old Babylonian times or earlier. Hammurapi's scribes appear to have reworked the calendric and stellar traditions into "a fine symmetrical system." A series of Venus observations made under Ammizaduga, which Van der Waerden (personal communication, 8 IX 70) dates to around 1582–1561 B.C., are well in accord with modern calculations "if one assumes that no serious disturbance of the orbit of Venus occurred after 1582 B.C."

It may be helpful to more fully discuss two of the subjective constructs the wide distribution of which is strongly suggestive of East-West and Old World-New World contacts. The zodiac, a band encompassing the paths of the planets, sun, and moon (with the ecliptic in its center), is a construct common to Western Asia, China, Mesoamerica, and probably the Indus area; thus it is of increasing interest to prehistorians for the light it may throw on the diffusion of astra cults. The zodiac is a highly subjective construct involving star-groups given the symbolic forms of living beings (aside from Libra). With the exception of Scorpio, the constellation patterns do not resemble the beings they represent, and therefore the presence of roughly similar zodiacs in widely separated areas suggests borrowing from some early center, though it is not yet identified. Further, because of the precession of the equinoxes, the zodiac is helpfully time-specific.

The Sumerian zodiac, from which our own was derived via later Mesopotamian and Greek astrologists, is of early and unknown origin, having like Athena appeared full-grown. Van der Waerden (1952) discusses its division by later Mesopotamian astronomers into 12 sections (called houses) of 30° each, designated by zodiacal signs. This regularity is not characteristic of earlier zodiacs, and the division into 12 is only one of many possible divisions: Heras (1953:241) reconstructs an Indus zodiac with only 8 houses and suggests that the earliest zodiacs may have been limited to the constellations serving by their heliacal rising to indicate solstices and equinoxes. Lunar houses (or mansions), as will be further discussed below, contain 27 or 28 asterisms (constellations). The precession of the equinoxes causes each zodiacal constellation in the 12-house system to move backward one house approximately every 2,100 years (fig. 5). Thus around 2000 B.C. precession displaced the heliacal rising of Taurus and the heliacal setting of Scorpio away from the vernal equinox, which they had precisely marked for renewal rituals for well over 1,000 years (though due to cultural lag the displaced bull did not disappear from ritual or symbolism). This unexpected astral machination undoubtedly confounded early priestly astronomers accustomed to dating New Year's rituals by the heliacal risings and settings of these constellations, and it caused far later Ionian Greek astronomers to note "errors" in the sky-charts and descriptions of their predecessors which led to their discovery of the phenomenon. Precession is, therefore, a prime cause for rejoicing among ethnoastronomers for the comparative data it affords.

With regard to the origin of the zodiac, Maunder (1908) argues unanswerably that the space of the southern sky left blank in early sky-charts was necessarily centered on the celestial South Pole, as constellations adjacent to it could not be seen in a northern latitude. Since precession shifts the pole among the stars a known amount, the ascertainment of a former place for the invisible South Pole circumpolar constellations roughly indicates the time and place of origin for a sky-chart. By this system Maunder estimates that the constellations described by Aratus in 270 B.C. indicate that he was using a far older sky-chart or description, one made around the 28th century B.C. at or near 40° north latitude. Ovenden (1966:12),

[19] Cf. Aaboe (1967), Audin (1945–55), Berger (1970), Conteneau (1940), De Saussure (1919–24), Dicks (1970), Hirmonech (1913), Hopman (1934), Langdon (1935), Pinches et al. (1955), Pogo (1931), Sachs (1955), Thierens (1935), and Thorndike (1938). An excellent short summary of historical astronomy is to be found in the *Dictionnaire archéologique des techniques* (see 1963 articles by Auboyer, Baudez, Bloch, Largement, Mugler, Reichlen, Schrimpf, and Vercoutter). More extensive summaries abound, including those by Dozy (Pellat translation, 1961), Schlegel (1875), Wensinck (1921), Sarton (1927–48), Claggett (1955), Beer (1967), Pannekoek (1961), Taton (1963), and Siverama Menon (1932).

restudying the positions of the constellations described, locates the time of origin at 2600 ± 800 years B.C. and the place near lat. 36° N ± $1\frac{1}{9}$°. He notes the tendency of place names to survive change of culture and language, if in corrupt form, and chooses Stampalia (local name Astropalia) as his site.[20] This accords with Richer's (1967) hypothesis that a network of astrologically assigned sites centered near Crete, which I can only see as occurring in Minoan times, before the widespread tectonic action, including the exposion of Santorini (Marinatos 1939, Galanopoulos and Bacon 1969) which destroyed Knossos

sense, an explanation which offers a key to garbled astra mythology.

Leon Pomerance (personal communication, 2 III 72) indicates the type of mnemonic device which may have made possible the remembering of the astronomical lore in his hypothesis with regard to the astrological meaning of the Phaistos Disc, accepted as a "workable" hypothesis when presented at the third Cretological Congress, Rhethymnon, Crete, September 1971. The Disc, found in 1908 in a Middle

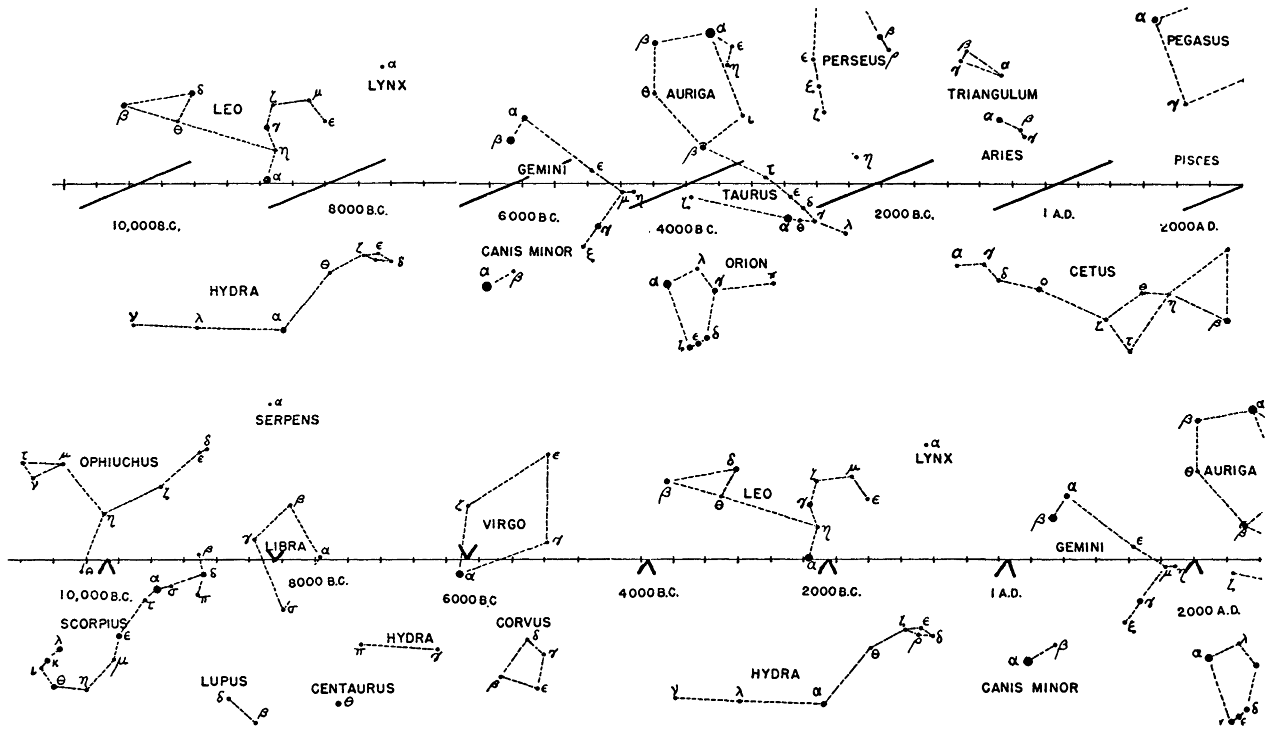

FIG. 5. Positions of the vernal equinox (above) and the summer solstice (below) between 10,000 B.C. and A.D. 2000. Horizontal line represents the plane of the ecliptic; short slanting lines represent the positions of the plane of the celestial equator, each intersecting the plane of the ecliptic in a position of the vernal equinox; arrows indicate the positions of the summer solstice. (Drawing by Charles H. Smiley.)

and the Minoan culture. Aside from this area, however, China, Iran, and Spain are also strategically located with regard to observations appropriate to our zodiac that could have been made in 2800 B.C., and Iran fulfills better than does Crete certain other requirements, among them the well-documented presence in Elam of 4th- and 3d-millennium astria iconography including what appear to be prototypes of the figures of the Western Asian zodiac (cf. Hartner 1965). Ovenden attributes the preservation of astral data from the 28th century B.C. to early sailors who repeated nautical star-lore to their children while the inexorable march of precession turned it into non-

[20] C. H. Smiley (personal communication, 15 VIII 71) would make the time 2800 B.C. ± 600 and the latitude 34° N ± 3°, adding "I wouldn't rule out Babylon." He estimates that a statement made by Aratus would have been true about 1788 B.C. (indicating that the Greek astronomer had access to far older data long since lost).

Minoan context which included a Linear A tablet, appears to Pomerance to be a religious calendar of agricultural festivities, showing the progression through the year of constellations which he identifies as the Pleiades, the Eagle, and the Serpent's Tail, familiar Near Eastern constellations associated with astrology by the classical Greeks. Pomerance regards the icons as symbolic ideograms without phonetic value, which would place them in the class with the icons used in Sorai wall art and with some of the icons in the Ibero-Saharan iconographic scenes. He identifies some as Sumerian-Babylonian in origin, others as Egyptian. The Disc appears to him to indicate by means of the heliacal rising and setting of the Pleiades the time for harvesting and planting, a hypothesis consistent with surviving Pleiades folklore. The instructions, as he interprets them, parallel those in Hesiod, further evidence that Hesiod made use of astronomical traditions remounting to Minoan times, which Baschmakoff (1948) has found to be true with regard to nautical directions in the Black Sea periploi fragments. Circumpolar stars may also be indicated on the Disc.

To repeat, it is not the fact of the use of certain star groups as constellations that implies dissemination of a system, but the subjective constructs involved; Egyptian constellations were for the most part different from those of the Sumerian zodiac, as are those reported for the Tuareg by Lhote (1952), while Mesoamerican and Indian zodiacs share certain constellations but not others.[21]

Next to the solar zodiac, which was so helpful in date-setting, the best-documented ancient subjective astronomical construct with a wide distribution is that of the corresponding "lunar mansions" (Allen 1963:7–101). The comparative studies of Moran and Kelley (1969) show correspondences between Chinese and Mesoamerican lunar houses. Kelley (1960, 1971) further demonstrates similarities in Mesoamerican, Indian, and Chinese lunar house asterisms and cites the work of Boll (1904), Bork (1914, 1924, 1929), Chavannes (1906), Graebner (1921), Röck (1919, 1922), Stucken (1913), and Weinstock (1950), as well as Burmese and Tibetan models. Chatley (1940*a*) indicates that Egyptian astronomers also grouped the equinoctial-ecliptic stars under 28 sets. Chatley (1940*b*), who dates the decans system of Egypt back to the 10th Dynasty, notes the agreement of Coptic and Arabic names. This lunar mansion construct, documented for China and India well into the 1st millennium B.C., is evident in Korean and early Arabic texts. Needham (1969), Weinstock (1950), and Moran (1969) have seen a Western origin, but Kelley (1969:150) notes the absence of such a list in Assyrian, Babylonian, and Sumerian early sources. To me the early appearance in Sumeria of a fully developed zodiac suggests origin elsewhere in an undetermined location. Hartner's (1965) hypothesis of the Iranian use of the heliacal rising of a horned-animal constellation (ibex or stag) as a solstice-predictor around the 4th and 3d millennia B.C., as indicated by art representation on painted ceramics and other artifacts, agrees with the findings of other astronomical scholars that the heliacal rising and setting of zodiacal constellations timed ritual cycles of the New Year.

The antiquity and depth of early Indian astronomical knowledge has been stressed by many scholars (Bhattacharyya and Mitra 1925; Clark 1930; Schmidt 1944; Sengupta 1929, 1931). That its origin lay with proto-Indians, the Indus people described in early Vedic texts and epics as great astronomers and "masters of the deep," has appeared probable, Heras (1953) having determined that the Indus language was proto-Dravidian and argued that an Indus eight-house zodiac closely paralleled the major Sumerian signs. The recent decoding of the Indus script by Parpola (1970) and colleagues parallels the Heras reading of certain signs, including those for star and Pleiades ("six-star"). Parpola (personal communication, 23 III 71), while not supporting Heras as to the zodiac, sees an astral orientation in the Indus religion, with the sun, moon, and planets (identified by color) as the major deities, characters in a mythic drama of the victory of the god of light and good over the demon of darkness and evil (the planet Rahu, causer of eclipses). The Indus gods, like those of Iran and Anatolia, had animal counterparts. Parpola suggests that the traditional Hindu luni-solar calendar operating with 27–28 asterisms was created by the Harappa people, essentially independently of Mesopotamia, and early borrowed into China. He notes that Soviet scholars agree with this interpretation. They recognize, however, the trade relations between the Indus area and Sumer. Coming probably from the Iranian plateau, the Dravidians who settled along the Indus became sea-traders who founded colonies along the Persian Gulf (Bibby 1966, 1969). When disaster overtook the Indus ports almost a millennium later, survivors took refuge in South India, or remained in their distant trading posts, to be absorbed in time into the local populations. Tamil calendric cults, stressing bull rituals and solstice occasions, to me suggest possible survivals of ancient cults: Neugebauer (1952) describes a prediction device involving pebbles as mnemonic devices, which recalls Hoyle's suggestion that Stonehenge may have been a definitive system by which pegboards and other systems were calibrated. Tosi (1971:24), summing up scholarly opinion which has been substantiated by Bibby's (1969) analysis of Indus colonies along the Arab coast of the Gulf from Kuwait to the island of Bahrein, the most important center, notes that artifacts found link the island with the Oman culture, "which is clearly Iranian in origin"—specifically, a sherd with a representation of a zebu-humped bull, which Bibby compares to those occurring on Kulli ware of southeast Baluchistan and which Tosi further compares to the Bampur Culture.

The scope and interest of early Chinese astronomy

[21] In view of the extreme cultural significance of the evidence with regard to widespread zodiacal iconography, Moran's hypothesis (Moran and Kelley 1969) of a zodiacal origin for our alphabet deserves close study. Moran (personal communication, 4 IV 72) indicates that while Kelley sees the autumnal equinox as setting the major early Chinese festival, he himself sees evidence (Chinese and Old Testament) that the harvest festival became secondary to a winter-solstice New Year somewhere around the 14th to 12th centuries B.C. and notes that Confucius called himself merely the editor of sacred books remounting to perhaps the 12th century. Moran finds close relationships between the Hebrew, Greek, and Latin alphabets and the corresponding zodiacal constellations and sees the signs for *Niu*, "the Ox," and *Tsade*, "to shoot an arrow," as bringing the systems into juxtaposition. Moran's comparison of ancient Chinese sky-charts and legends, specifically that of the Oxherd, leader of the Seven Stars of the Dipper, who became separated from the Weaver Woman by the River of Heaven (the Milky Way), suggests ancient recognition of the changes caused by precession. Moran (personal communication, 25 IV 72) adds, "In the maps of the astrological works, the upper left-hand corner is the Northwest corner. That is where the River of Heaven comes into view in two streams which shortly unite. It is at that point that the astrological table of the original man and woman is found. It was at that point that the herdsman kept his cattle, and to him his former wife the Weaver Woman crossed over once a year to spend the night. Confucius makes numerous references to the Northwest Corner, which would be on the heavenly map shortly before the winter solstice." In this connection, I think of Moghadam's (1938) hypothesis that the Iranian New Year, now set by the spring equinox, was once set by the summer solstice. South Indian myths and astra-set festivals also indicate the displacement of the New Year's celebration. In each of these cases, the emphasis upon bull sacrifice or bull rituals strongly suggests that the heliacal rising of a bull constellation may have set the date.

is indicated by many studies, including those of De Saussure (1919–67), Eberhard (1933, 1940, 1957, 1971), Hartner (1944–49), Hartner and Ettinhausen (1964), Lessa (1968), Needham (1969), Porter (1950), and Schlegel (1875). According to legend, an ancient Chinese astronomical system was renovated by the (probably mythical) Emperor Yao, who according to earlier (and not fully accepted) interpretations of the Shu King could have had a 2d-millennium date: the legend relates that Yao beheaded two court astronomers delinquent with regard to customary eclipse rituals. It has been suggested that the eclipse referred to was that visible in North China in 2161 B.C., but Eberhard (personal communication, 15 III 72) notes that according to recent studies the Shu King was not composed before 1000 B.C., with the data on Yao perhaps as late as 400 B.C.: moreover, the episode of the two astronomers may be a solar myth, as is suggested by the resemblance of their names to that of a solar deity, Hsi-ho. The belief that early Chinese astronomers discovered the obliquity of the ecliptic is not confirmed by the early astronomical texts, datable to around 220 B.C. Eberhard cites Bezold's comparison of Babylonian and Chinese oracles based on astronomical factors and suggesting possible similarities, implying contact.

On the grounds that the Babylonian-Greek astronomical system was ecliptic, annual, and angular whereas the Chinese was equatorial, with reckoning by night, De Saussure (1967:12–13) assumed an independent Chinese origin, and saw the pole star (not then Polaris) as the center of Chinese astronomy and metaphysics. Needham (1969) and Lessa (1968:48) stress the distinctive nature of Chinese constellation constructs, but Moran and Kelley (1969), whose studies of lunar mansions I have mentioned as suggesting contact with Mesoamerica, also note resemblances of Chinese-Western circumpolar constellations (our Great and Little Bears or Dippers and Draco); they note the absence of these asterisms in Assyrian, Babylonian, and Sumerian sources. Needham and other scholars do not agree with the hypothesis of Chavannes (1906) that the Chinese derived constructs from Turkish or Hunnish peoples in the 1st millennium. Both Eberhard and Kelley do, however, comment with interest on the work of Röck (n.d., 1919, 1922), who attempted to make a comparison of various zodiacs, and Eberhard suspects that several Chinese cycles of unknown character may have been based upon foreign words. This lack of consensus among scholars with regard to the legendary antiquity of Chinese astronomy, considered conjointly with the data in other studies listed here, further suggests a Neolithic origin and probable linking to the earliest agricultural ritual cycles. Hartner (1965:7, n. 28) describes the Babylonian constellation *ban* (cf. Van der Waerden 1949:16) as identical with the Chinese *hu-shih*, "the bow and arrow" (cf. Schlegel 1875:434), and discusses other early Chinese symbolism (Hartner 1944–49). In the absence of datable texts, the iconographic studies serve to supplement the archaeological evidence of early contact (Hawkes and Woolley 1963:255), perhaps that of the Neolithic expansion and of later cultural diffusions (Lindsay 1951).

Minakata (1919) also studies the Chinese use of zodiacal symbols. Nakamura (1930) analyzes constellation symbolism of the Korean era, and Nakayama (1969) indicates the Chinese base of Japanese astronomy. Ho Peng Yoke (1962) criticises catalogues of ancient and medieval observations of comets and novae in Chinese sources as not coming from the best sources, which he cites. Beer et al. (1961) describe the accomplishment of medieval Chinese astronomers and engineers in laying out an arc of observation no less than 3,800 km. in length and fixing a civil unit prefiguring the metric system of a millennium later, estimating that this project would hardly have been possible without tables of trigonometrical functions, as values were calculated from the summer-solstice shadow series. This compares interestingly with data cited by Moghadam (seminar, University of Tehran, 1964–65) which suggest early collaboration between Iranian and Chinese observatories and the possible establishment of something resembling a prime meridian. Knobel (1917) studies the star catalogue of Ulugh-Beg (1392–1449), whose observatory in Samarkand may still be seen. Petri's (1967) work on Tibetan astronomy indicates that early astronomical knowledge was diffused along some east-west continuum.

Kelley (1971) documents the use of cosmological designs not only in the laying out of ancient cities in Assyria, Iran, China, and Greece, but also in kinship groups, games, and the alphabet. Shorto (1963) sees similar pattern regularities, involving the number 32, in Burmese and other Asian city designs (cf. Buchanan 1801), accompanied by a mythology involving serpent-princesses dowered with the land (a feature notable in French mythology and one which Herodotus [Book IV] tied to the Hercules cult in Scythia).[22] He observes in city design the use of the square (4 made 5 by the central pillar) and the circle and mentions an astronomical calendar. As noted above, zodiacal patterns on a vast scale are seen by Richer (1969) to connect the sacred prophetic centers of ancient Crete, Greece, and Ionia in a system perhaps predating the Mycenean culture.

The field of Arabian astronomy is significant for its possible evidences both of the astronomy of the earlier Arabian cultures which disappeared with the increasing aridity and of the astronomy which later Arabs carried far and wide as a navigational aid (surely as significant on the desert as on the sea). Carmody's (1956) critical bibliography of Arabic sources in Latin translation gives an idea of the immense scope of Arabic astronomical literature: Kennedy, Engle, and Wamsted (1965) translate Al-Bīrūnī on Hindu calendars, and Lesley (1957) finds in his work an indication of a survival of Babylonian data. Carmody (1961)

[22] It has interested me, as it did Herodotus (Book IV), that the Homeric Greek hero Herakles (whose sun-god attributes have been extensively studied) arrived in the Pontic steppes *from* the Golden Hesperides in the West, presumably the Iberian peninsula. Soviet scholars have also found the Hercules cult of interest (Artamonov 1961, Grakov 1950, Peredolskaya 1958).

has similarly translated and discussed the work of Thabit b. Qurra. Campos (1953) and Mesnard (1949) are among those who contribute valuable studies of Arabic star and constellation names, indicating the familiarity of Arabic peoples with the zodiacal constellations. Monod's (1963) study of early Arab sailing discusses other early navigators who were familiar with the stars and constellations of the southern hemisphere; this study is especially valuable for the sources cited, which indicate the surprising extent of early sailing. An authority has hopefully observed that Arabic documents should be organized and in translation in another century, which should cheer the impatient.

The survival in the Middle East of star and planet cults, as well as of cults of sun and moon deities, offers perspective to archaeoastronomy studies (Cumont 1927). Henninger (1954) has given a most valuable and extensive documentation to his study of the survival of Venus and other cults in Arabia. Ancient planet cults survive still elsewhere along the Persian Gulf: Lady Drower's (1962) remarkable study of the Mandaean cults is a model both as ethnography and as an exercise in meticulous scholarship relating the present to the past (see also Drower 1936). In all of these areas of ancient astronomy, the iconography is of great importance for the information it may provide, as the sets of motifs appear in other areas where no records exist (cf. Boll 1904; Bork 1914, 1924, 1929; Pogo 1931).

With the function of the Mesopotamian zodiacal animals in mind (as well as the rather sudden appearance in Sumer of the zodiac), let us examine rock art and ceramic iconography distributed in a continuum from Iberia to India and appearing on both sides of the Mediterranean. Anati (1964) reproduces a series of rock-art stag ritual scenes from Camonica Valley, an early North Italian ore-producing area in which rituals were recorded in iconography from roughly the 4th millennium to the time of the Roman conquest. He notes (pp. 162–67) motifs symbolizing the rising sun, stag's horns resembling a half-sun, and stags or bulls with solar orbs between or above their horns, and suggests (p. 28) that icons of this type represent a fusion of sexual and solar energy. He concludes (p. 156): "At the center of the Camunian religion—whatever transformations it underwent over the centuries—lay sun worship and stag worship. The two constitute the theme of more than three-quarters of the religious scenes in the Valley." To me, comparing the Camunian art with that of North Africa and Iberia (and with the function of the zodiac in mind), the possibility of a primitive zodiac is also present, in the form of a solar disc divided into seven spokes. The animal entering the solar standard occurs frequently in North African and in Iberian rock art. The theme is suggested in a somewhat different form in the metal "stag" statuettes at Alaca Hüyük (Baity 1968: pl. XXXII, from original at the Hittite Museum in Ankara). MacWhite (1951: fig. 8) shows Galician "stags" (with cows) which I have interpreted as cult bulls wearing stag-horn masks. The stag with solar orb above his horns occurs in Chalcolithic Andalusian iconography, and an animal with a radiant head and legs together in the position of the stag of an Anatolian standard occurs in Africa (Baity 1968: fig. 7*A*). I need not summarize here the evidence of stag rituals which may imply stag worship and sacrifices: reindeer-hunters of the Mesolithic, in their summer camps at the edge of the retreating ice cap, threw stags weighed down with stones into a lake and mounted the skulls of reindeer bucks on poles at Stellmoor and Meiendorf, as Alfred Rust discovered. The stag dance at Abbot's Bromley in England is one of many folkloric survivals indicating ancient stag cults in this area.

It is premature to attempt a synthesis of the iconographic and folkloric evidence, but I have suggested that a stag constellation may have been used as a season indicator for a New Year's ritual cycle before Taurus assumed this function late in the 4th millennium or early in the 3d millennium. Alternatively, the stag constellation could have been a *paranatellon:* Boll (1904) cites early sources which identify a stag as a *paranatellon* to Pisces. Finally, the stag could have been an instance of cultural lag, the carrying-over of an earlier symbolic figure. In the absence of reliable dating for rock art, an exact sequence can hardly be formulated at present, but to me the stag appears to have been an older symbol; as mentioned above, certain evidence could be interpreted as indicating that a horned-animal constellation, more often an ibex in the earliest iconography of Mesopotamia and Elam, may have indicated by its heliacal rising the winter solstice (cf. Hartner 1965:9). This question of zodiacal function is to be resolved only by astronomical scholars, but the stag iconography in rock, ceramic, and early metal art suggests the astronomical symbolism of the horn-with-orb symplegma.

Grosjean (1969) publishes Corsican rock-art motifs, among them stylized men and cattle that to me suggest the recording of rituals: his figures 1 and 12 may, I suggest, be stylized representations of the mountain peaks which defined the sunrise points of winter and summer solstices. Grosjean notes the obvious resemblance to Iberian and French rock-art motifs. Southern Andalusia is a well-documented picture-gallery in which hundreds of such scenes are depicted (cf. Breuil and Burkitt 1929). In many of these scenes bull sacrifices occur with astra motifs in unmistakable evidence of astra-set rituals, the details of which resemble those of ongoing Iberian solstice rituals at midsummer. Ortego y Frías (1951–65) has published rock-art scenes featuring bull rituals with solar symbols in contexts which, considered in connection with Bronze Age artifacts found in Soria Province, suggest to him (as to me) that the present midsummer fire walk of San Pedro Manrique and the recently discontinued fire bull ritual of Medinaceli had their roots in the ritual cycles of protohistoric ore prospectors and cattlekeepers in this ancient transhumance area. The reappearance of Iberian themes in Ethiopian rock art has been discussed by Breuil (1934) and Graziosi (1964).

Saharan rock-art scenes by the hundreds have been recorded by Lhote (1952, 1966, 1970), Lajoux (1963), Mori (1964), and Huard (1959–68; Beck and Huard

1969). Each of these has published many works not listed here, supported by extensive bibliographies; as these works are readily found in libraries, I need not emphasize the importance to ethnoastronomy of the Ibero-Saharan continuum other than to note that astronomical symbolism is clearly recognized. Huard (1959, 1961) notes the frequency of association of the solar disc with cattle and Lhote (1970) with rams. Huard (1966) sees evidence that a spiral design is linked to the bull rituals: he documents bull-transport and shows bull robes (1968). Simoneau (1968) shows circles which appear to be directional and which to me seem to have elements in common with the "Union Jack" design of crossed lines, a probable solstice and equinox schematic motif. (The "Union Jack" [cf. Baity 1968: pl. XXIX; Ortego y Frías 1965: pl. III, fig. I) has been studied in depth by Audin [1945, 1956] and found by Charrière [1964:166, fig. 2] in the Crucuno rectangle and also in Etruscan and early Roman architectural design; Charrière suggests that in carrying the design to the Roman forum, the Romans may not have observed that the solstice azimuths indicated the latitude of Etruria rather than that of Rome. The design reappears in a stylistic version in pre-Christian painted ceramics of the Celtiberian town of Numantia [Soria] published by Wattenberg [1963:2–1261], where it occurs with identifiable astra motifs; in this ware, a double fish suggestive of Pisces, which during this period was approaching its period of announcing the spring equinox by its heliacal rising, is shown above an icon strongly resembling Hartner's [1965: fig. 23] proposed symbol for a heliacal rising.) Hampaté Bâ and Dieterlen (1966) report rock-art motifs indicating magic and religion.

Lhote (1952) has queried Tuareg of the Hoggar with reference to "geometrical" designs published by Monod (1938). Although other Tuareg did not recognize the designs, an ironworker responded at once that they represented stars (including the sun). The star groups he cited included those known to us as Orion, the Great Bear, the Pleiades, and the Hare, but neither names nor descriptions match those of the Middle Eastern constellations for which Campos (1953) gives the Arabic names. This suggests that a system unlike that of the Middle East existed in the Sahara, perhaps connected with ironworkers, who are known to folklorists to preserve vestiges of an ancient cult. The icons do, however, have obvious parallels in the rock art of other areas of the Ibero-Saharan continuum. The dating of Ibero-Saharan rock art is an unsolved problem (Pericot and Ripoll 1964:191–214). The earlier stages of the Saharan cattlekeepers' rock art may date back well over 5,000 years (Lhote, personal communication, 11 XI 65), and the cattlekeepers' culture may date to the 5th millennium. Butzer (1966:78–79), reviewing the palaeoclimatic sequences in the Sahara, notes the difficulty in dating, but suggests as a working hypothesis that the period ca. 5500–2350 B.C. was comparatively moist, with savanna woodlands probably present on the best-watered highlands and good pastures probably available seasonally on the remaining uplands and in most of the wadi systems (which supports the rock-art evidence of herding). To my thinking, much of the rock art suggests astra-oriented rituals, with stag, bull, and ram motifs indicating the presence of a cult resembling that of Iberia and also of Western Asia, as well as that of Egypt. Which way the current flowed, or whether similar cults developed from a far older tradition, is not clear. East African rock art is sporadic; that seen by me resembles Bushman art, but Chaplin (1958) identifies among cattle scenes found near Lake Victoria a pictograph to which he plausibly gives a calendric interpretation. South African rock art has recognized Asian-type motifs (Slack 1962).

The origin of the Saharan astra and cattle iconographic complex may be more clear when Anati has published further studies of the themes represented in materials collected by the Philby-Rycksmans-Lippens expedition in 1951–52 to Saudi Arabia: Anati (1968) points out that these data represent an irreplaceable means of investigation, hardly an overstatement. Asian connections, the earliest of which may have existed when both Arabia and the Sahara were ment. Asian connections, the earliest of which may have existed when both Arabia and the Sahara were sufficiently green to support herds, are indicated by the fact that humped cattle were introduced into prehistoric Africa on several occasions; as the hump breeds out rapidly, fresh reappearances of the stock may be documented by the iconography (J. Desmond Clark, personal communication, 28 V 68). The turban-wearing men accompanied by elaborately dressed and coiffed women riding cattle and taking part in ritual activities involving both branch and astra symbols are of an unmistakably Western Asian ethnic type, many displaying "the nose" famous in Iran and Armenia. Though disagreement has existed with regard to the dating of the North Africa art, Anati has given provisional 3d-millennium dates to some of the Central Arabian drawings, on the basis of comparisons with Egyptian artifacts. It will be of interest to see whether he finds motifs corresponding to the Saharan series of horned animals carrying discs or of animals entering circles or ovoid forms, which may imply the early use of a zodiac in this area; a comparison with the contellations referred to by Lhote's (1952) Tuareg blacksmith would also be of interest.

The importance of Africa for ethnoastronomy is indicated not only by the Ibero-Saharan rock art but also by Bronze Age artifacts indicating a West African trading zone in communication with Atlantic cultures (Souville 1965). Egyptian records testify to early trade with the East Coast, while periploi and early Arabic historians describe later trade. The presence of far earlier proto-Indian traders has been surmised on linguistic evidence, and to me Dravidian elements appear present in cattle cults. For these reasons a synthesizing review of the ethnoastronomy studies is needed. Afro-Arabic chronologies of the Ahaggar region are studied by Dubief (1942). Wassef (1971:42) states that the 12th month in the ancient Coptic calendar, Mésoré, took its name from the fact that in ancient Egypt it was consecrated to the festival of the heliacal rising of Sirius (Sothis), considered the time of birth of the sun god Re (Mesu-Ré). The Coptic Mésoré is distinguished for its "saint's days," the list including a number of names which I have found to be associated with the fire rituals: one peculiarity of these saints is that their legends tend to reach a vanishing point around the 4th century A.D., and another is that in attributes and names they are remarkably similar to deities and cult heroes and heroines associated with fire-ritual legends. (Their names also tend to occur as place names in megalithic areas of France, Spain, and Italy.) The importance of Sirius in the Sudan as an indication of changing seasons is indicated by Griaule and Dieterlen (1950); South Sudanese cosmologies are discussed by Zahan (1951, 1958) and tribal calendars by Sabater (1953). Lagercrantz (1952) studies beliefs about the Milky Way, also noted by Monod (1963), along with much other significant data. The survey by Laoust (1921) of Berber fire and solstice rituals is especially valuable for its analysis of ancient rituals, some of which resemble those shown in the rock art, and for the preservation of cultic chants; the resemblance of the solstice rituals to the intensified fire and cattle rituals of megalithic areas in Western Europe again suggests the pre-Indo-European origin of the solstice fiestas and raises the question of ancient survivals, some of which may remount to the megalithic cultures. The megalithic culture practices surviving in Madagascar again are of interest. Bloch (1968, 1971) emphasizes the role of astrology in the burial practices of the Merina of Madagascar, a society of Southeast Asian origin practicing megalithic burial associated with bull sacrifices. The purpose of reburial in joint tombs is shown to be the need to incorporate the dead into the unchanging kinship order of the ancestors, a practice related to the fear of anyone not among the *havana* (kinsmen). The significance attached to cardinal points (towards which all structures are aligned) and to the northeast (summer solstice?) is noted. The ritual bull play which takes place before the bull sacrifices belongs to an ancient pattern illustrated in Ibero-Saharan rock art (Baity 1968).

The archaeology of Central Asia from the 6th to the 3d millennium B.C., summarized by Masson in a book reviewed by Van Loon (1971), has produced goat horn cores showing traces of torsion, suggesting the possibility of something similar to the horn cult practices accompanying zodiacal symbolism in Saharan rock art. This finding perhaps indicates an ancient heritage shared by cultures practicing irrigation agriculture in the 5th millennium B.C. Masson notes that the Central Asian 6th-millennium communities technologically resembled the early village cultures in Southeast Asia (notably Phase I at Sialk, dated to around 5500–4600 B.C.). The Anau IB period (renamed Namazga I) shows stylized ibex, an icon that appears in painted pottery as early as Namazga IV, in company with a full range of motifs suggesting astra rituals visible since Namazga III (e.g., compare Hartner 1965 with Tretiakov and Mongait 1961: fig. 25, nos. 3*c*–6). As Soviet archaeologists including Formozov (1955, 1966, 1969) have studied solar, lunar, and stellar symbols on petroglyphs, data exist for comparative studies in depth of specific sites and classes of motifs from an early date to the historic cultures. Iconographic clues and surviving rituals suggesting the presence of early astronomical cults around the Black Sea indicate that the earliest known astronomical sources should be carefully examined and compared: Kulikovsky (1967) surveys valuable sources in the U.S.S.R. and Tumanyan (1967) cites early sources in Armenia.

Rock-art representations from the area of the "glass mounds" Allchin (1963) has excavated in the Deccan show bulls wearing torch structures between their horns; Allchin cites similar representations on the painted burial urns from Harappa, Cemetery H, and notes fire bull rituals surviving in South India and connected with the winter solstice.

In Bali, as in Madagascar, the association of buffalo bull and cow attends burial practices: here again, much is of interest in connection with ethnoastronomy and megalithic survivals. Goris (n.d.) traces temple practices not to India but to megalithic sanctuaries, and stresses the importance of the sun god Surya and the survival of stepped pyramids, menhirs, and zodiacal symbolism. Friederich (1959:45) may throw light on the association of fire rituals with a name like Sori (or Sauri), as in Bali these are names both for Vishnu and for the planet Saturn. Here a type of fire dance survives both in the Hinduized villages and in the hill villages where pre-Hindu culture elements predominate. Despite some differences, to me the Oceanic fire (or oven) dances clearly show in ritual and legend their connection with the Eurasian fire walk or dance (Baity 1962).

Indonesian culture patterns have been analyzed in detail by Dutch students other than Goris. In well-documented studies. Maass (1920–33) surveys Balinese and Malay astronomy and astrology. It is of interest in connection with the study of the zodiac that the Balinese *rasi*, used for astrological purposes, uses the classical figures known in India except that a water-pitcher occurs in place of Aquarius and a shrimp (*udang-makara*) in place of the ram, which to me suggests the survival of an early zodiac (cf. Friederich 1959:156). Here, too, the crab-lobster-shrimp symbolism receives a possible interpretation—that in shedding its outgrown shell and growing a new one, this creature became the symbol of death and resurrection. In view of the association made by Heras (1953) between the crab and the city of Mohenjo-daro, it is tempting to surmise that proto-Indians may have recognized such a symbolism.

Ethnoastronomy in Oceania is of particular interest for several reasons: astronomical lore and techniques may have diffused from Southeast Asia and Indonesia with both the pre-Tangoreans and the later voyagers, and despite the lack of extreme seasonal changes and the absence of most of the food crops and animals associated with Neolithic astronomical rituals there appears to have been a persistence of the Neolithic pattern of determining planting seasons and the New Year by the heliacal rising of the Pleiades and other constellations (the cosmic setting also appeared); at least one of the intensified fire rituals—the fire walk—which were part of the New Year's ritual cycle in Asia (and in Mesoamerica) survived despite the scarcity of wood, its legends changed but still recognizable. Navigational astronomy was vitally important during both the colonization period and the later exploration and trading phases. Finally, discovery was so recent that the possibility of recovering aboriginal lore and skills is not totally lost. Though no systematic study of the entire region is known to me, data exist for a valuable synthesizing study, as various of the island groups have been the subject of specific ethnoastronomy studies (cf. Best 1955; Bryan 1933; Collocott 1923; Erdland 1910; Goodenough 1951, 1953; Grimble 1931; Makemson 1938–39, 1941; Nilsson 1920; Phillips 1966; Stimson 1928).

An extensive series of studies in American ethnoastronomy benefits from aboriginal and early postconquest texts and iconography and from the survival in many areas of oral traditions, astra cults, and calendric rituals (Spinden 1940, Taylor 1946, Zerries 1952, Stirling 1945). Fray Diego Durán's (Horcasitas and Heyden translation, 1971) remarkable account of the gods, rites, and ancient calendar provides data to compare with surviving rituals. The *Popul Vuh* (Goetz and Morley translation, 1950) is a poetic statement of precontact beliefs that show surprising similarities to Biblical cosmology. The close correlation of pre-Columbian dance and ritual with astra-set dates is shown by Kurath and Martí (1960), as is the resemblance to Asian rituals, considered coincidental by the authors. The Maya codices have a heavy astronomical content. Archaeoastronomers and ethnoastronomers can all too well understand the wail of horror that went up from Maya astronomer-priests when in July of 1562 some 27 codices and about 5,000 stelae were destroyed at the direction of Bishop Diego de Landa. If, as De Landa feared, the Devil had inspired these writings, he had thoughtfully employed his time as Morning Star and has subsequently shown a commendable scholarly productivity: over 3,000 articles which touch on Mexican astronomy have been written during this century (Noriega, personal communication, 31 XII 70). (See, e.g., Bowditch 1901; Bunge 1970; Burland 1950, 1954, 1964, 1970; Caso 1947, 1950, 1958; Henseling 1938; Kelley 1954–71; Spinden 1940; Weitzel 1948, 1950.) The many writings of Noriega (1954, 1956, 1958) are significant: in particular, his studies of eclipses of the sun as registered in the astronomical monuments of Mexico, his work on calendars, and his suggested interpretation of various astronomical glyphs should repay study. In a long series of publications since 1933, Schulz (1933–68; Cook de Leonard and Schulz 1947) has examined various aspects of Maya chronology, including the solar year, the recording of eclipses of the sun and moon, the various correlations between the Maya and the Christian calendars, and other problems in the understanding of Maya astronomy. Schulz (1964) sums up the precise work of Maya students of the moon's movements, of solar and lunar eclipses, and of the creation of the Long Count.

The classic Maya are known to have elaborated into an astonishingly exact science certain calendric principles shared with other Mesoamerican people (Morley 1956; Smiley 1960*a,b,* 1971; Thompson 1971), but where and when were these principles originally formulated? The Maya solar year of 365-plus days is based on objective astronomical fact, but its organization into 18 months of 20 days each, with a period of 5 extra days, is a cultural construct which does not fit the synodic lunar month (Beyer 1936*a,b*). The Maya sacred calendar of 260 days was similar to that of the Mexican culture and until recently was not commonly considered to have been based on astronomical phenomena. Smiley (1964) and students have suggested, however, that the sacred calendar was based on such sophisticated astronomical calculations that the connection has escaped observation: studying a pair of cycles in the Dresden Codex, they note that these cycles may represent a Maya astronomer's attempt to tie the synodic periods of Mercury, Venus, and Mars—taken as 117, 585, and 780 days respectively—with the sacred calendar of 260 days ($9 \times 260 = 2{,}340 = 20 \times 117 = 4 \times 585 = 3 \times 780$). The Maya calendar round, a 52-year cycle, does *not* match the 56 holes of the Aubrey Circle or the astronomically unaccepted 56-year eclipse cycle, but Maya astronomers had developed their own method of predicting solar eclipses (cf. Harber 1969). They may have used more easily observed regularities such as the phases of Venus, as described in the Dresden Codex for a period of almost 104 years. Smiley (1971) gives names with built-in mnemonic devices to Maya eclipse cycles: "Thix" ($36 \times 260 = 9{,}360$ days) and "Fox" ($46 \times 260 = 11{,}960$ days). At the archaeoastronomy seminar in Norman, Oklahoma, in 1971, discussion revealed that Smiley's (1960) correlation differs from Kelley's in that Kelley sees a spring equinox as the Zero Day. Smiley and Robinson (1969) set Zero Day at July 23, 3392 B.C., and suggest that the constellations indicate that this date was chosen because Procyon was precisely on the celestial equator, rising and setting in two exactly opposite directions, with Antares and the Pleiades near. Makemson's correlation, however, sets Zero Day at March 10, 3374 B.C. (Nancy Owen, personal communication, 12 IV 72). From an examination of 57 dates of astronomical significance, Smiley uses his correlation of Maya and Christian calendars to locate the Dresden Codex as covering the interval 103 B.C. to A.D. 812, the Paris Codex A.D. 551–638, and the Madrid Codex A.D. 662–714, with one date A.D. 1250. Smiley's (1968*a*) studies of stationary conjunctions and near-conjunctions and (1968*b*) of "serpent dates" invite cross-cultural comparisons. Smiley (1965*b*) has also studied orientations by sextant and sun. In addition (Smiley, personal communication, 8 V 71), he and students have measured true azimuth at some 16 important Mesoamerican sites, uncovering significant indications of a slowly changing reference direction, almost certainly astronomical, in a study which also indicates Maya units of length. His 1971 paper suggests that "errors" attributed to Maya astronomers may be attributed to the failure of modern students to study the skies and the known stellar events for the time under consideration. Anderson (1971) shows that the Maya numerical system, which, like the Babylonian, combines properties of place-value and non-place-value, resembles the calendric notation system. Andrée (n.d.) indicates the importance of the Pleiades with reference to Mesoamerican agriculture and New Year's festivities. Proskouriakoff (1952) suggests the survival into the Colonial period of a Maya counting system.

American iconography, whether calendric or otherwise, appears to have been strongly tied to astronomical themes (cf. Hagar 1906–31, Kelley 1960–71, Moran and Kelley 1969). Johnson (1971) has identified small cruciform objects found associated with burials as stellar symbols inlaid in a special type of atlatl, the *xonicuilli*, associated with the wind god Quetzalcoatl, a legendary culture-bearer: Sahagún and others identify the *xonicuilli* as symbolizing stars or a constellation. Reko (1936:16), on the basis of a passage of the Chumayel text, indicates that precious stones were metaphorical representations of the astra and that the images of the deities themselves symbolized the stars, presumably including the planets. (This interpretation compares interestingly with the information given by the Finnish team that the planets were deities in the Indus religion.) Ferguson (1962) describes five calendar seals he has found at Chiapa de Corzo (Chiapas, Mexico) with radiocarbon dates ranging from approximately 1050 B.C. to A.D. 400: he submitted an impression of one of the seals to Albright and quotes him as noting a resemblance to Egyptian hieroglyphics. Von Winning (1959) discusses the astronomical symbolism on a carved human femur rattle, the function of which was to provide musical accompaniment in Aztec funeral ceremonies for warriors; his analysis emphasizes the use of an eye as a solar symbol (i.e., light) and cites iconography connected with blood sacrifices to the sun.

In a computerized study of signal importance for archaeoastronomy, Owen (1972) rechecks Makemson's (1946) correlation of the Mayan-Gregorian calendars, finding significant astronomical events indicating that the Dresden Codex describes the astronomical events upon which the ritual events described by De Landa were based. The emphasis on solstice and equinox events is confirmed, but Owen's data, like Smiley's, indicate far more complex observations. Her detailed astronomical descriptions of the Dresden Codex dates (according to Makemson) should stimulate further ethnoastronomical research into interrelationships between ritual, calendric, and astronomical events, not only in Mesoamerica but in adjacent areas. Her work also affords data for determining the meaning of glyphs adjacent to those already known (cf. Cline 1970; Evreinov, Kosarev, and Ustinov 1961; Hochleitner 1970*a,b*). She indicates the significant observations with regard to the Pleiades; citing De Gallatay (1959) as stating that a culmination of stars in the Pleiades at midnight was an occasion for a service of great solemnity among Peruvians, she gives data making it possible to check this event with ethnographic descriptions of Mesoamerican rituals.

Zuidema (1966) discusses the importance of the Inca calendar for social organization, ceremonial life, and agricultural practice. He deduces that the Incas knew the function of the zodiac and used solstice determinations in the construction of the solar calendar, but connected many rituals with lunar phases. Rauh (1971), tentatively reconstructing the Peruvian calendar system, sees Venus as the only planet at present known by a native word, which he infers to indicate that the Venus cult had a significant place in the Peruvian cosmology. He suggests a two-year calendar period as important on the basis of frequent references and as allowing an even division by lunar months. The data on calendars is well indexed and in general will not be reviewed here, but it may be noted that Graebner (1921) and many later scholars have seen resemblances between the New World aboriginal calendars and those of the Old World.

Mesoamerican referents have been found for astra-determined rituals in aboriginal North America, and diffusion from Mexico into the Southwest is recognized (Schroeder 1965, 1966). Wissler and Spinden's (1916) and Weltfish's (1965) studies of the Pawnee Morning Star girl-sacrifice point out parallels with data in codices indicating an Aztec origin. Kurath and Martí (1964:212) describe a bow-and-arrow fertility dance also common to the two cultures. The Pawnee ethnography by Weltfish is a model in that it is sufficiently detailed to permit comparison with both Mesoamerican and Eurasian rituals, which show strikingly similar features. Buckstaff (1927) indicates Pawnee interest in single stars and constellations. Tooker's (1970) study of the Iroquois winter-solstice festival indicates this ritual's former dating by the appearance of the Pleiades in the zenith at dusk of the new moon, which the researcher finds comparable to an Aztec ritual, the new-fire kindling at a winter-solstice ritual also timed by the Pleiades in the zenith (Prescott 1843:125–27; Andrée n.d.). The Iroquois Green Corn ceremonial was apparently a summer-solstice event; that the collection of such data is "salvage ethnology" is only too obvious from its present dating from a drugstore calendar. Witthoft (1946) studies the winter-solstice ritual of the Cayuga.

A significant topic for American ethnoastronomical research is the dating of the New Year's rituals. Nuttall (1888, 1906), among others, has compared Mesoamerican New Year's rituals and astronomical methods. We have seen that North American archaeoastronomy shows unmistakable emphasis on solstice-determining structures. As calendric rituals have been investigated by almost every observer of Indians since Morgan, an extensive literature affords scope for comparative ethnoastronomy studies (cf. Parsons 1939*a,b*). Benchley (1970) studies Mississippian calendrics, a topic of special interest in view of Mesoamerican correspondences. She suggests a method for studying the early astronomical calendars used in mound-building areas. As yet such studies are rare, and those under way are for the most part unpublished; aside from these, insufficient attention has been paid to the measurement of the structures which would have been essential to the determination of solstices and equinoxes and thus necessary in the setting up of calendric rituals and the determination of the dates for agricultural events. Father Durán has indicated that these were of extreme importance in aboriginal agriculture.

INTERPRETATION AND IMPLICATIONS

The overall implication of studies reviewed here is that astronomical knowledge formed an important aspect of culture processes from the Paleolithic onward. Marshack's microanalyses suggest that European Paleolithic men kept daily records of lunar phases, relating the astronomical to the seasonal phenomena and fitting observations into a complex symbolic system, subtle and varied, which was expressed in cave paintings and in mobiliary art. Cave paintings also suggest the presence of dance-drama rituals with musical accompaniment. As recognition of lunar phases would inevitably have drawn attention to the shift of moonrise and moonset along the horizon, and as animal migrations and plant growth were associated with seasonal changes initiated by solstices and equinoxes (the shift of sunrise along the horizon being equally obvious, though taking much longer), the recording of lunar phases implies the possibility that the solstices were associated with ritual observances far earlier than we may have thought. Whatever is true of Paleolithic burials, Mesolithic burials appear to have been associated with solar positions.

When the pictures of the animal (or deity) forms were first projected on the starry heavens (i.e., the first constellations marked out) is problematical. If the bull and stag cult scenes from Chatal Hüyük involve astronomical symbolism, as is suggested by the association of such scenes with unmistakable solar-stellar symbolism in later iconography, then the deities in their theriomorphic forms may have had heavenly counterparts as early as the 8th millennium, and there is little question of it by the time of the star-surrounded bulls of Tell Halaf painted pottery. By the 4th and 3d millennia, the association of a specific bull and stag cult with solar-stellar symbolism is present in art in Western Asia, in North Italy, along both sides of the Mediterranean, and in Iberia, in contexts which imply not only the recognition of a link between the solar events and the New Year but also the possession of a solar zodiac, perhaps in a primitive stage in the earliest representations, but present as the zodiac we know by the 3d millennium in Sumer.

The impact of Thom's work with regard to the technical attainments of the British and Continental Neolithic astronomer-engineers, combined with Renfrew's suggested dating revision, has been to make it clear that in this early period Britain was in truth that "nest of calculating geniuses" originally called into question by Hawkes (1967). Atkinson's (1968*b*, 1969, 1970) excavations at Silbury Hill show it to have been a flat-topped stepped pyramid during construction in Neolithic times: the flat top, again, suggests the possibility of an observation station or perhaps of a site for bonfires to signal calendar events. While in general it has been considered that these skills were "made in Britain," the high dates for the Breton tombs suggest that the elements of observational astronomy and of structural orientations may have come to Britain with the megalithic undertakers. It is of course highly significant that Thom finds not only the same egg-shaped designs in Brittany, but also the same megalithic yard; he feels that the unit must have been transported in rods issued by a controlling center (Thom, personal communication, 5 XI 71). For Britain, Thom and MacKie (1969:8) postulate a time-span of some 2,000 peaceful years, coinciding perhaps with a drier climatic phase affording clearer skies (and, incidentally better maritime travel conditions), between the arrival of the Neolithic farmers and that of the Beaker people. Such a span of time would allow for an immense range of trial-and-error stake-setting observations on the part of an astronomical élite in search of techniques affording dependable eclipse warnings. Scottish observatories, according to Thom (1971), were capable of furnishing just the precise information needed for exact prediction. To a later élite less dependent on oracular prestige than on bronze weapons, such skills may have appeared irrelevant if not positively suspect, and, as both Hoyle and MacKie suggest, Stonehenge III may well have been more impressive for dramatic decor than for astronomical exactitude. (Palynological evidence cited by Frenzel [1966:99] suggests that the early megalithic observers might, as Thom suggests, have had better observational conditions than the later ones; the findings indicate a cold spell ca. 3400–3000 B.C., with a deterioration of climate [wetter and colder growing seasons] after ca. 1500 B.C. [dates uncorrected by the bristlecone pine calibration].)

Archaeoastronomical studies indicate that well before the final phases of Stonehenge reconstruction the cognitive abilities of British and Breton engineer-astronomers enabled them to measure with increasing precision complex lunar movements, including minor perturbations: the suggestion that these were used to refine eclipse prediction methods implies impressive ritual observance, further suggested by French megalithic folklore. Significantly, it is Atkinson (1968*a*:78) who most seriously considers the far-reaching implications of megalithic astronomy and of the backdating which will be necessary if the bristlecone pine chronology is established:

> If we accept the evidence here presented by Professor Thom (in such detail that the reader can check all stages of the argument), and if we concur in even a part of his conclusions (which are drawn with the most scrupulous regard for the legitimate limits of inference), we must alter radically our current view of the intellectual calibre of man in Britain in the late third and second millennium B.C. Indeed, we must consider the revision of a whole chapter in the accepted history of science, in which primacy in the development of geometry, mensuration, observational astronomy and the calendar has been ascribed hitherto to the literate civilizations of the Ancient East.

And again (Atkinson 1971:117): "Those who cannot follow Thom's argument here will, if they are honest, surrender on grounds of ignorance; if they are not, they will retreat to a position of equivocal nescience."

Scholars are notoriously combative in defense of their own views and no more inclined to surrender or retreat than is the population at large; it cannot be said, however, that they are unable to read the writing on the wall, and the implications of what the moving finger is inscribing in a fair sample of the world's areas are becoming increasingly clear: namely, that the possibility of astronomical alignments must be considered in connection with seasonal cults, burials, and structures.

Archaeoastronomy implies an unexpectedly high level of Neolithic astronomy—the discovery of objective astra phenomena, the orientation of sacred structures with reference to complex astronomical targets, and the analysis of the moon's precise movements—and this knowledge is confirmed by early astronomical texts and by astra iconography on painted ceramics, walls, and rock surfaces. The presence of similar motifs in areas where writing, if it existed, was on perishable materials implies the possible inheritance of techniques and information from prehistoric cultures. The early presence of lunar notations, considered in connection with the iconography indicating the recognition not only of equinoxes and solstices but also of their relationships with the rising and setting of various star groups, indicates that a complex educational system of an intellectual élite must have been established earlier than previous conceptions of the Neolithic have held. It is harder to recognize the geographical extent of these common techniques and subjective constructs: the presence of similar units of measurement and similar orientations and constructions implies the possible existence of similar cosmologies and ritual cycles. The subjective constructions, including zodiacs and lunar houses with sequences of similar sacred animal and deity figures, certainly as old as Elam and Sumer, but apparently known also in China and in the Indus culture (from which area the concepts appear to have spread at a later date to Mesoamerica), imply somewhat more than trade operating from one area to the next by barter methods. These correspondences are both too singular and too massive to be explained away as coincidence, psychology, or parallel development, although, in this preliminary synthesizing study, there is no space to document them fully. The suggested correspondences between the megalithic yard, the Egyptian *remen,* the Spanish *vara,* and other units of measurement again cannot be dismissed without further investigation (Thom 1967; cf. MacKie 1968:283; see also Fletcher 1968*a,b,c,* 1969; Ivimry 1969).

The singularly appropriate sites of Stonehenge, Callanish, Er Grah, and many other suggested megalithic observatories imply a degree of sophisticated geographical knowledge, and it has been noted that the mathematical and engineering skills of megalithic designers could in time have led to a realization of the spherical shape of the earth (whether or not they did). The nautical astronomy reported for early sailors of the Black Sea, the Indian Ocean, and the Mediterranean and the size indicated for megalithic-age ships are again suggestive, as is the archeologically attested evidence of Bronze Age traders on the Atlantic Coast of Africa and in the Pontic steppes. The hints of ancient prime meridians in Africa and in Iran suggest forgotten coordinate systems the knowledge of which disappeared with the élite which established them. Evidence from Ptolemy (Peters and Knobel 1915) to Baschmakoff (1937, 1948) suggests that mariners could have profited from a wider geographical knowledge than we have assumed. The evidence of early calendars and folkloric survivals has yet to be synthesized, but the studies listed here suggest close correspondences over wide areas. Studies of the zodiac imply that a precise place of origin and a relatively precise dating may soon be determined: the suggestive coordinates of latitude and longitude leave a wider choice than Ovenden's Mediterranean island; to me Minoan iconography does not suggest the preoccupation with the astra that is visible in several other areas.

In general, the evidence appears to indicate that astronomical lore, astra and deity symbolism, and seasonal rituals set by astra events and considered essential to successful agriculture and stockbreeding were part of the Neolithic mixed-farming tool-kit traveling along with seeds and stocks, with an origin perhaps as early as the 9th millennium. To me, the extremely widespread distribution of remarkably similar summer-solstice rites, including not only bonfires and other fire ceremonies but a ritual mating and human sacrifice (vestiges of which are implied both in European and Berber summer-solstice customs), implies a far earlier origin. It is premature to attempt to attach the observation of solstices and equinoxes and of specific constellations and stars to the early Neolithic expansion, yet certain widespread similarities with regard to the circumpolar constellations and to the use of the Pleiades as season indicators imply this possibility. However, the highly specific rituals attached to a spring equinox and a zodiac, especially appropriate to agricultural activities, may be associated with the zodiacal constellations which had a heliacal rising in the early Bronze Age. Thus subsequent research may indicate the interplay of two patterns for the New Year, one tied to the solstices and another to the spring equinox. Though the hypothesis cannot be documented at present, the great emphasis on the summer-solstice rituals in areas where the megalithic cultures were evident does imply a possible connection, and this tradition may well be older than the food-producing revolution.

The much more limited and spotty distribution of highly specific, even singular, rituals such as that of the fire bull (evident in rock art and ceramics from India to Iberia, with evidence suggesting an Ethiopian center) and the possible linking of this ritual with the heliacal rising of Taurus to mark the spring equinox imply a far later origin within a specific culture, probably one with overseas colonies interested in procuring some specific product (perhaps tin).[23]

[23] The suggestion that economic motivations implemented the distribution of zodiacal symbolism and fire rituals associated with New Year's renewal festivities is supported by Dayton's (1971) study of the occurrence of tin ores and of natural bronzes in the ancient world and his note that the techniques of controlled kiln firing served equally in the production of certain ceramics.

I have proposed that both Indus and Iberian traders may have been involved in a trans-African trade which skirted the Arabian peninsula; and Lamberg-Karlovsky (1967:149) locates tin in Trucial Oman, well within the Indus colonial sphere (Bibby 1966, 1969). The bull rituals are strongly evident in early Dravidian literature but are equally evident in Iberian customs, the humped bull appearing in rock art along the continuum. Whether this implies Indus colonies in Africa and perhaps in Iberia or Iberian traders extending their activities to East Africa and perhaps beyond (or more likely both) is not at present clear, but it is hard to imagine that a *toro de fuego* ritual would have had two centers of origin. This ritual is also unquestionably practiced at the summer solstice, as it is even now among the Basques in a symbolic form; whether this is by association with earlier summer-solstice fire rituals or not is unclear, though further studies in depth of specific iconograms and astra rituals may clarify this.

Lamberg-Karlovsky (1970:80), in his analysis of the corpus of Tepe Yahya material indicating a 3d-millennium literate culture in an area identified with Magan, discovers no direct Indus or Mesopotamian material but does note identical design motifs on steatite bowls which may have been gifts serving to oil the wheels of trade, on the "kula ring" principle. The Tepe Yahya finds support the concept that each cultural area along the Indus-Mesopotamian trading continuum had its own local middlemen who met at common ports of call on neutral territory, as suggested by Polanyi (1963:30–45). The Danish team's discovery of large Indus trading communities at Bahrein and in Saudi Arabia indicates one area, however, where Indus settlers and Mesopotamian traders met (Bibby 1966, 1969).

Thus the evidence of specific astronomical or astra-set rituals suggests that such activities accompanied early Bronze Age ore prospectors and traders to ports of call and to trading colonies which have not yet been discovered, perhaps because they are located on offshore islands subject to flood damage and in regions where desert conditions (and political conditions as well) have made their recovery difficult or impossible. Further, Özguç (1963) has shown that such colonists left few traces except baked clay tablets, as they depended on the local market both for furnishings and for wives: records left on perishable materials would have left no trace. Inferential evidence suggests that Indus, Iranian, Old Assyrian, and Phoenician traders used astronomy for navigation, with a far wider trading sphere than has been realized, and perhaps unplanned landings on even more distant shores. Indus early sailing has been little studied, but the evidence implies that Indus (or intermediary) sailors could have carried astronomical knowledge and rituals widely. The Finnish team's decoding of Indus documents indicates early Indus-Chinese contacts which must have been well prior to the destruction of the Indus home port towns. While Moran and Kelley suggest later contacts in tracing similarities between Indian, Chinese, and Mesoamerican lunar mansions, and East African similarities to Indian arts and crafts have been attributed to Indonesian settlers, the recent discoveries in Arabia should indicate caution in the denial of earlier contacts. The Phoenicians, who may have inherited far older astronomical and navigational skills, are known to have closely guarded their trade routes and their "factories" (as they called the colonial settlements); their rounding of the Cape of Africa is historically attested. Evidence increasingly suggests that many pre-Columbian voyagers arrived on American shores, some of them accidentally, others by intent (Ashe 1971, De Santillana and Von Dechend 1969, Ekholm et al. 1970, Gordon 1971, Meggers, Evans, and Estrada 1965, Morison 1971, Riley et al. 1971).

There is no reason to assume that long-term colonists such as those of the Old Assyrian *karums* documented by Özguç would have given up their astra-set New Year's rituals even though they married local girls coming from cultures with different rituals, and in view of this undeniably close cultural contact the possible survival of rituals with a foreign origin even after the disappearance of the colonies may be implied by the evidence of folkloric survivals. Though little material evidence may remain to prove this, various other types of evidence do imply such a possibility. Long before the Danish team found Indus colonies in the Persian Gulf, the sea trade between the Indus and Mesopotamia was postulated on textual and iconographic evidence (Kramer 1963, 1963:64; Leemans 1965). Archaeological findings indicated Harappan outposts and sophisticated Indus port facilities (Dales 1965, Rao 1965). An Indus-Mesopotamia overland trading continuum operating by means of long-established colonies was suggested on the grounds of stylistic elements in painted cult ceramics by Starr (1941) and on the evidence of the influence of Indus art in the West by Mode (1944), as well as by Sir Aurel Stein's widely scattered ceramic findings in Iran, three decades before the Harvard team's (Lamberg-Karlovsky 1970) discovery of the trading center in southeastern Iran. In general, southern Iran, a mound-dotted area, appears on the basis of traditional and early Arabic evidence to be a likely area to investigate in search of a protohistoric astronomical center (Moghadam seminar, University of Tehran, 1964–65). Such a possibility might be implied by the finding of astra iconography similar to that of other sites along the area of the continuum suggested by Starr.

His study indicates Bohemia and probably Iberia as centers in which the use of natural bronze (stannite) preceded its commercial production. I suggest that the distribution of early tin workings in Western Europe and perhaps even in Africa may parallel that of some of the bull and fire rituals attached to astra occasions. Bronze torques appear to have figured in the trade. Iberia flowed, Strabo tells us, with electrum, a natural alloy of gold and silver. The collapse of ancient trading with the destruction of Troy II and the disappearance of the Minoan culture did not put a stop to ore production and use in areas not affected by tectonic disasters followed by social upheaval. Although the economic interests may have backed the travels of traders and astrologers, we have seen evidence that the astronomical élite were no less interested in the cosmic spectacles they observed than are contemporary astronomers, who do not have strong economic motives for their studies.

INDICATIONS FOR FURTHER STUDIES

The interdisciplinary study of archaeoastronomy, supplemented with the insights which a broader ethnoastronomy can provide, affords the possibility of a new dimension for archaeology—upward—while ethnoastronomy, looking within ideological structures, must apply the ancient cultic concept, "As above, so below." Although the archaeoastronomical evidence will not be present at all sites to the same degree, it is important that we not be blinded to what *is* there by the models we have held: Martin (1971:4) has aptly demonstrated such a possibility with the example that prior to the time of Copernicus, Western astronomers, thinking in terms of the Ptolemaic model, regarded the heavens as immutable, whereas the Chinese, uninhibited by such a dogma, were recording the appearance of novae, comets, and sunspots. New working hypotheses based on the evidence indicating the importance of astronomy and astrology in early cultures, particularly in those areas where the religion was predominantly astral, will make it possible for us to examine sites, documents, and rituals in a new and meaningful perspective. As this synthesizing review indicates, many possible working formulations are being and must increasingly be developed. Prehistoric and protohistoric communities in which astronomical subsystems were significantly present may be identified by research testing such formulations as the following: (1) that nondomestic structures in general and those suitable for astronomical observations or used for cult purposes in particular will be oriented (door, window, and gate openings, structure profiles, outliers and postholes, arrangements of buildings, city plans, and wider constructs) with regard to the major observable astra events of the site and probable era (the rising and setting of the astra, including zodiacal constellations, at the solstices, equinoxes, and possibly at intermediate positions reconciling lunar and solar calendars); (2) that stylistic categories will include astra iconography in wall, rock, and mobiliary arts symbolizing these major astra events (including annular and total eclipses, mountain ranges with brackets or other indications of distant markers used for marking solstice extremes, representations of constellations and of deities and animals associated with them in lunar and solar zodiacs) and depicting ritual dramas symbolizing them (fire bull and other solstice rituals and astra-oriented games and bull sports); (3) that survivals of such rituals or of traditions concerning them (myths, legends, astrological cults, linguistic survivals) may be detected; and (4) that evidences of the diffusion or trading activities of agricultural, stockbreeding, and ore-processing groups practicing the astronomical rituals may be traced through the analysis of both archaeoastronomical and ethnoastronomical findings.

The development of a new scientific subdiscipline normally demands the subsequent working out of an appropriate methodology and of suitable textbooks. Archaeoastronomy, though in its infancy, is a remarkably precocious infant, due largely to Thom's work, its appraisal by British archaeologists (notably Atkinson and MacKie), and Müller's review of similar megalithic structures on the European continent. Thom's establishment of criteria and methods for archaeoastronomical fieldwork and the archaeological tests of his hypotheses are of major importance. Astronomical evidence can only be discovered by those with a precise idea of what they are looking for, which assumes a detailed knowledge of astra events for the area and era under study as well as the formulation and testing of hypotheses involving geometrical designs and astronomical function.

The essential textbooks for archaeoastronomical fieldwork are thus already in existence: the step from megalithic astronomy to a statistically adequate and methodologically sound analysis of the orientations and functions of stones, pyramids, and other sacred structures in various areas is not a difficult one. Students elsewhere can benefit from Thom's precise site-analysis methodology, from his and Newham's emphasis on the significance of postholes for temporary stake and pole sightings, and from his emphasis on the study of site plans with respect to distant markers (notably mountain slopes and gaps, but also, Mesoamerican evidence suggests, pyramids). The use of a computer is not necessary with respect to sun and moon alignments: Newham (personal communication, 1 VII 71) estimates that it took him less than four hours in 1962 to establish sun and moon alignments at Stonehenge. Where alignments with target stars must be determined, however, the use of a small computer can be timesaving (cf. Gingerich 1967; Hawkins 1966, 1968; Reyman and Sanders 1972). What is essential is accurate site data, a list of basic alignments for the area and probable era of the site, standard graphs such as Thom has worked out for elevation, refraction, etc., and a meticulous eye for postholes and depressions which may indicate the former presence of posts or outliers. Wittry (1970*a*:17) sums the variables up as (1) the latitude of the observer, (2) the inclination of the ecliptic, (3) refraction, and (4) the relationship of the point of observation to the horizon.

Anderson and Fletcher (1968) offer a shortcut to the analysis of significant sites between latitudes 60° N and 60° S, plotted for solstices and equinoxes, undoubtedly important for calendars and ritual dates, though Thom's statistically analyzed orientations indicate midquarter dates and Charrière indicates the importance of intermediary orientations. Utmost attention is due Thom's plea that reconstructions should not be undertaken without a professional surveying and the consideration of astra referents and that distant markers should be noted and photographed. Above all, the possibility of astronomical correspondences over much wider areas than individual sites must be explored, following a more intensive statistical analysis of temple, pyramid, and sacred-city orientations in all areas. Statistical methods need attention, and again here Thom's work provides models.

New studies in methodology are in process. The Smithsonian's computer program, followed by Hawkins, which uses a 100-year interval and interpolates the values in between, differs from that being developed by Frank C. Sanders, Jr. and Jonathan Reyman (personal communication, 21 x 71) chiefly in that the latter works in smaller increments of time and is more easily adapted to small machines. In a forthcoming publication, Reyman and Sanders (1972) will give a step-by-step discussion of the collecting and organizing of the archaeoastronomical data. The essential data from astronomers is increasingly available. Interdisciplinary involvement probably will always be essential, but archaeologists are in need of specialized short-term courses in archaeoastronomy taught by an interdisciplinary staff using demonstrations such as are possible at a planetarium (cf. Weber 1961). The importance of site photography at solstice and equinox (and perhaps intermediate points) is demonstrated by the spectacular photographs of the sun rising behind the Heel Stone at midsummer at Stonehenge (Hawkins and White 1965). Reyman's (1971*a*) photograph of the midsummer rising sun halved by the corner of a pueblo structure is hardly less striking; his photographs also demonstrate that sticks placed in certain holes in the walls define the length of summer-solstice shadows (an ancient method).

It is obvious that a first step in archaeoastronomy is the further testing of Thom's methods and hypotheses in other megalithic areas, notably the Iberian peninsula, Scandinavia, and the Black Sea region. I have noted that Basque and Caucasian folkloric and linguistic survivals show a strong resemblance, but to my knowledge archaeological findings have not been compared in the two areas: an immense amount of Soviet archaeological documentation awaits synthesis with regard to orientations and to astra iconography. Folklore in all megalithic areas, certainly including the Caucasus region, should be tested for traditions resembling those of Western Asian astronomical cults. Near Eastern astronomy has the practical virtue of being so much better known to us than prehistoric European and American astronomy that it should serve usefully as a probing tool.

Though archaeoastronomy, studying the material evidence of astronomical knowledge and cults, can move ahead on the basis of methods, criteria, data, and hypotheses already apparent in megalithic astronomy, ethnoastronomy has as yet no well formulated criteria and no comparable solid data to afford hypotheses for testing. Clearly ethnoastronomers must also know the objective astronomical facts of the area and era, must understand subjective constructs that have been built on such astra events, must structure and test hypotheses soundly based on systematically observed evidence which, when enough of it has been assembled, also falls into patterns; but where the reconstruction of ritual cycles and religious systems, rather than physical structures, is the task, the chance of wrong reconstructions is of course far greater and proof harder to obtain. Here again, however, the problem of how and where to begin has an obvious answer.

With regard to European ethnoastronomy, megalithic astronomy also affords a structuring principle. Piggott's (1956) study of the suitability of megalithic monuments for impressive rituals is supported by the evidence of archaeoastronomy: Stonehenge and Carnac would have afforded a particularly dramatic setting for such rituals, but tombs and less spectacular structures would also have served. Students may begin, on the basis of local archaeological findings, with studies in depth aimed at the reconstruction, in broad outline, of the ritual calendar of the megalith-builders. The structuring principle to which I refer is that of Thom's suggested megalithic calendar. Though archaeologists have not altogether accepted it and archaeological proof is of course requisite, Thom's calendar appears to me to offer ethnoastronomers a working hypothesis. In the development of this hypothesis they will have to call upon the skills of folklorists (dance, drama, music),[24] linguists, and rock and ceramic art specialists; for Britain, James (1961:272–319) and Alford (1952) will be of great assistance.

Thom (1966*c*) postulates, on the basis of a statistically significant number of alignments, a 16-month calendar determined by the solstices, equinoxes, and midquarter points. His evidence is based on a study of the bearings marked out at megalithic sites. On the hypothesis that each azimuth suggested by orientations probably specified the rising or setting point of some celestial object at some particular time, he converted azimuths into declinations (angular distances north and south of the celestial equator): finding that some 60 of the declinations thus obtained grouped themselves about seven declinations, he restudied these seven on the supposition that each represented the solar declination at two separate days of the year, or 16 days during the year. He then compared these with the days in the year 1800 B.C. when the sun had these declinations.[25] The matched pairings of these 16 days fit a regular pattern of solstices, equinoxes, and midquarter days, spaced at

[24] Though the connection between folk music and astronomy may not be immediately apparent, its potential value to ethnoastronomy is indicated by the astronomical meanings of dervish dances (recognized by Turkish scholars), the cosmological meanings of some of the classical Indian chants, and the appearance of similar musical instruments (including the bagpipe) in Eurasian areas where the astra-set fire and bull fiestas survive. Struck by the similarities noted in the field, I referred these to Alan Lomax (personal communication, 25 XI 68), who confirmed the resemblance of the Andalusian modal profile to that of Asia: he notes that the closest similarity is to Central Asia, especially to the Turkmen profile. The percentage of similarity to other cultures is high in areas where either iconography or ritual survivals indicate intensified fire rituals: Turkmen 85%, Sicily and Turkey 76%, Amhara, Ruanda, and Kerala 72% each. He classifies the basic song style of Andalusia as part of a very ancient Old High Culture style area that includes the Mediterranean, Middle and Near East, and India, and notes that certain of the song types, such as the threshing cries, are virtually identical in Egypt, Sicily, Sardinia, Corsica, Majorca, Spain, and Morocco (a finding of interest in connection with megalithic cultures). Although he describes these as remounting to a very ancient agricultural civilization, I note the similarities of distribution to that of cattlekeepers' iconography and ritual patterns, a suggestion supported by early Tamil textual records of bull sports (cf. Crooke 1917, Lomax 1968).

[25] It can hardly be attributed to coincidence that the dates obtained are those of the traditional European calendar rituals: Christmas, Candlemas, the spring equinox, May Day, Midsummer, Lammas, the autumnal equinox, Martinmas, and so back to the winter solstice. That the early Church, doubtless on the principle

regular intervals of 23 days (with one 24-day period). It is evident that such a calendar has gone far beyond the unsatisfactory lunar calendar which so plagued the priests of certain cultures. It is also evident that when the astronomical élite disappeared which had kept the calendar geared to the sidereal year, rituals would continue to match the objective astra events only where practical methods survived of determining the solstice points.

Following the calibration of Western European ritual cycles with the ritual calendar which megalithic astronomy predictably will soon make available as a working hypothesis, it may be possible to relate the indicated dates to folklore and surviving rituals and to confused astronomical myths and legends (Olcott 1936; Graves 1948, 1957; Erixon 1939). Alford's studies of British and Iberian folk dances suggest a strong correlation between Morris dances and solstice festivals, sword dances and ancient mining sites, and the presence of an ancient mountain goddess, often a "black Virgin" (cf. Alford and Gallup 1935; Alford 1937, 1962). These dance and drama cycles parallel the fire, bull, and solstice fiestas to a considerable extent, and the hypothesis appears worth further testing that they date back to a pre-Celtic population. Alford observed strong resemblances between the dance forms of Iberia and Central Europe well before the recognition of the early date of the Central European Bronze Age, which Dayton (1971:61) places prior to the appearance of tin bronzes in Eastern Asia (aside from the Royal Tombs of Ur). Dayton documents the presence here, as in Cornwall and Spain, of stannite and mixed ores of tin and copper and disproves the alleged presence of tin in the Caucasus.

A major topic for study is that of the possible existence of a sophisticated early geographical knowledge; that this is as early as Hapgood (1966) suggests is questioned, but the specific and unique location of several significant megalithic monuments, including Stonehenge, may imply something more than trial-and-error placement: Charrière (1964:161) suggests that Brittany may have been a region of high religious values because here the moon's rising and setting at its extreme positions corresponded to the directional points of the "rose of the winds." Monod (1963:421) suggests independent development for this construct among Chinese and Arab mariners: comparisons of Asian and Mesoamerican designs which suggest derivatives from such a construct have not (to my knowledge) been made (cf., however, Mertz 1969*a*). Monod's study documents the wide range of early Indian, Arab, and Chinese traders, notes the early use of the Magellan Clouds as a navigational aid, and cites the use of the Pleiades as season indicators among various aboriginal peoples of Africa and Oceania.

A study in depth of the Taurus and Pleiades iconography and mythology, with a comparison of the symbols designating the group in Asian, European, and the American culture, would be useful in view of suggestions that Mesoamerican structures were oriented to the Pleiades. Early Greco-Asian sky-charts indicate that the Pleiades were once conceived as flaming on (or between?) the horns of the Bull, but Mesoamericans associated these stars with different symbols. Hamilton (1902, 1904) identified the Pleiades with the concept of "the isle of the Blest": this constellation, according to both Heras and Parpola, was known to Indus mariners, and as its heliacal rising announced the spring equinox with precision for a millennium around 3500–2500 B.C. (roughly serving for an even longer period) a comparative study of iconography and traditions connected with it appears useful.

Hopkins' (1965) interpretation of scenes on Phoenician bowls from the Bernardini tomb in Praeneste (7th century B.C.) as the recording of a total eclipse of the sun raises the question of Phoenician interest in celestial phenomena, a topic insufficiently studied here and elsewhere: Spoer (1938) also similarly analyzes an astrological bowl, indicating a continuing tradition. In view of the importance of Indian Ocean sailing to early maritime trading cultures and of the widespread early Bronze Age trade, studies of early nautical astronomy might be structured with regard to areas significant to Indus traders for products of high value, low bulk, and special interest to the early riverine high cultures: i.e., tin, precious metals, jewels, pearls, spices, and incense. To me coincidence cannot explain the presence in areas where such treasure items are found of names evidently already old when Ptolemy mapped them and to my thinking significantly resembling those of the "Asuras" of Vedic fame as "masters of the sea" and great astronomers (cf. Shafer 1954). I note also the association of these names with oil-bearing areas, which is perhaps understandable in view of the use of natural asphalt in the torches attached to the horns of fire bulls and also for caulking sewn boats of the type identified with Indus and other early mariners. Though I have stressed the significance of Taurus and the Pleiades, equal interest is attached to other constellations known from Elamite and Sumerian iconography and associated with the solstices (cf. Hartner 1965:12–15). In short, a structuring principle for further ethnoastronomy studies is that of comparing subjective constructs such as the constellation symbols described by astronomers of early cultures with the natural time-marking astra events of the tropical year. It cannot be too much emphasized that the objective astra facts were roughly the same for the astronomers of cultures existing at approximately the same time and latitude, and that similar observatories and observing methods might well have been used by astronomers at a comparable stage of development: the subjective constructs built upon this data, would, however, be culturally determined, and the presence of similar astra iconography, zodiacal symbolism, and mythology deserves careful examination.

Further research is indicated in several areas which are scarcely touched in this review. A comparative study of astra names could usefully recheck earlier examinations of correspondences between Meso-

popularly expressed as "what you can't whip you had better join," took over the pagan ceremonies which country people saw no reason to give up is too well-documented to need reviewing here, and saintly robes scarcely disguise many a deposed astral deity.

american and Western Asian names for stars, constellations, and lunar houses. A Dravidian scholar might throw light on the correspondences between the place and ethnic names found in association with the intensified fire, bull, and astra rituals from Iberia to India (Baity 1966*a*), which appear to match names listed by Shafer (1954) as those of the "Asuras" identified in the Great Rebellion against the Aryans which he believes to have been described in the Mahābhārata. In view of the spectacular nature of eclipses and their indicated importance in early cultures, a study in depth of eclipse prediction, folklore, and iconography, considered in connection with the known data on the prehistoric occurrence of eclipses, would be of interest (Schwartz 1925, Van den Bergh 1954). A comparative study of New Year's dates and rituals might either indicate the presence of common constructs over wide areas or prove their independent origin (cf. Bonnerjea 1935; Noriega 1954; Guthe 1932; Nuttall 1888). In the ancient cultures the New Year was a time of anxious stock-taking, and the vast literature on judicial and client astrology might contribute insights (cf. Neugebauer and Van Hoesen 1959). Father Durán's references to Mesoamerican astrology merit restudying. Nautical astronomy (cf. Ferrand 1928, Gerrard 1928) is of interest: Arabic terms and methods should be compared with Old Persian terms, which in Iran they are said to strongly resemble. Early map-making would make a valuable study: both the town lists and star lists of Ptolemy would serve as source materials here, as would the periploi, including the eight Black Sea fragments.

New uses for the astronomical subdisciplines are evident. Dating problems were restudied in a symposium in London, December, 1967, which also reviewed eclipse chronology (cf. papers by Berger, Edwards, Sachs, and Schove). Beer (1967) has ingeniously dated works of art by astronomical and astrological content. Translations, abstracts, and syntheses are urgently needed of valuable materials not easily available, and above all, of Arabic, South Asian, and Chinese early sources. Much of the work needed in ethnoastronomy is especially urgent in view of rapidly changing cultures: in particular, Laoust's (1921) extremely valuable study of Berber midsummer "fires of joy," important both for the rituals described and for the terms and names used (which are common to fire-ritual events from Iberia to the Indian subcontinent), indicates a field where earlier customs are vanishing rapidly.

Seminars on archaeoastronomy are increasingly scheduled: such sessions might consider measures such as the formation of an interdisciplinary committee which might devise more effective means of utilizing the various skills necessary in the subdiscipline, create a clearinghouse for bibliographical facilities and the exchange of papers, and plan projects testing the theories and methods. I have elsewhere (Baity 1971*b*) indicated the value of an international astra motif index, which requires a central clearinghouse for microfilms. Pohorecky (1969) has initiated the study of rock-art motifs in Canada, and Jones (1969) describes a proposed method of transcribing rock art, but as yet no facilities exist for comparing the findings in one area with those elsewhere.[26] Computer techniques along lines proposed by Gardin (1967) for iconography in general should facilitate the creation of a systematic classification.

Astrophysics indicates that the concept of the universe as orderly and peaceful is startlingly incorrect; if the interest of ancient men in the heavens and their preoccupation with astra-determined predictions seems excessive, we need not deduce thereby that they were less intelligent than ourselves—oral tradition may have given them cause for alarm (Ninkovich and Heezen 1965). Since the International Geophysical Year, evidence has documented widespread tectonic disturbances, extensive vulcanism with resulting tidal waves and atmospheric disturbances, and major climate changes within the time-span of man's iconographic traditions (Lamb, Lewis, and Woodroffe 1966). Even if precession alone has operated, many changes in sky-patterns have occurred during the some 26,000 years that separated the Paleolithic period, when Taurus rose heliacally at the spring equinox, from the Bronze Age recurrence of this astra event which so profoundly influenced religion and iconography. To my thinking, astronomers could be of use to archaeologists in the preparation of charts showing the constellations which could have been associated by the astronomers of early cultures with significant astra events such as the solstices and the equinoxes. The chart of figure 5 is of significance with regard to early ritual cycles in Western Asia and Europe: the importance of Taurus and the Pleiades as indicators of the spring equinox (a New Year in many cultures) is clear, as is the absence at the summer solstice of such well-defined and conspicuous star-grouping. In this connection it must of course be remembered that ancient astronomers related their New Year's rituals to the solstices where these were more significant for agricultural rituals (Lockyer [1965] related Egyptian New Year rituals to the summer-solstice rising of the Nile). As the *paranatellonta* were also used as season indicators, our chart cannot be interpreted as indicating that megalithic astronomers had no good constellation target for midsummer sunrise. A midwinter chart would also be of interest in megalithic areas, in view

[26] Elwin's (1951, 1955) studies of Middle Indian tribal art bear out Marshack's (1972*a*, *b*) argument that the Paleolithic-Mesolithic time-factored iconography was significant with regard to input, recall, recognition, and feedback, and that insight and reference to its function and mythic meaning may be obtained from the study of man's cognitive behavior in living situations. The Sorai wall art, the creation of which involves prayer, fasting, and libations, is addressed to the deities, serving to note rites duly performed, vows carried out, petitions made, and responses to dream instructions. Elwin elicits the meaning of various of the icons: for instance, a solar icon, far from indicating "sun worship," is a reference to the fact that the all-seeing sun deity can bear witness to the truth of the assertion symbolically made. The lizard swallowing an orb is used as an eclipse symbol; plowing depicts seasonal activities, jars on shoulders a full harvest (petitioned hopefully); houses may be designed as deity houses, with the hope that the gods, whom the Sorai regard as the major source of their troubles, will settle there ("like flies") and leave them alone. I deduce similar purposes for the thousands of ritual scenes involving stellar-solar forms which occur along the Ibero-Saharan–Iranian–Indus continuum, where fire, bull, and solstice rituals survive.

of the emphasis which falls on the winter solstice in related folklore. Finally, it must not be forgotten that heliacal settings and other astra events too complex to describe here were also used by ancient astronomers. We are in need of an "archaeoastronomer's handbook" designating the astra events which could have been significant in early astronomical cultures. Such a handbook would indicate the shifts necessary with regard to the reversal of seasons in the southern hemisphere, which must have further confused early voyagers whose planting seasons had been tied to the rising of Taurus, the Pleiades, or other 3d-millennium spring-equinox indicators.

The speculative nature of much of the foregoing discussion needs stressing, but the studies reviewed provide hypotheses that might be tested: Did the Western European ritual cycle hinge on midsummer and midwinter rituals, as folkloric survivals and Thom's measurements suggest? Is a similar ritual pattern implied by the similar iconography in early Atlantic cultures from Ireland to Scandinavia (cf. MacWhite 1951, 1956), and did Iberian rituals travel with Bronze Age traders to Northwest Africa? Was the megalithic astra ritual pattern, yet to be determined, prior to or based on a zodiac such as the well-developed zodiac which appears in Sumer? Or should we look farther east, to Iran or the Indus, for the zodiac's origin? Are these constructs older than Hinduism in the Indonesian archipelago? Do the constructs relate to the Bronze Age need for tin? To the possibility of high-value commodities in certain areas? Are they apparent in Oceania? Does Pacific navigational astronomy resemble that of the Old Persian, Chinese, or Arabic systems? If astronomy traveled as part of the Neolithic mixed-economy tool-kit and also accompanied far later Bronze Age trading expeditions, could the constructs survive in tropical areas, where winter never comes, and in the southern hemisphere, where seasons are reversed? If so, what modifications might we expect? To what extent do the differing plants, animals, deities, and agricultural systems change the constructs? How do religious systems incorporate the astronomical events? Some such questions as these must be devised as new findings and older studies are fitted into a meaningful pattern (Downs 1961; Graves 1948, 1957; Goodenough 1951, 1953; James 1961; Jobes and Jobes 1964; Kelley 1954, 1957; Lehmann-Nitsche 1922–27; Nilsson 1920; Stirling 1945; Taylor 1946).

CONCLUSION

The aim of this review has been not merely to present a list of studies in archaeoastronomy and ethnoastronomy, but to demonstrate if possible the role these studies may increasingly play in explicating certain problems in prehistory and protohistory. The methodology advocated has been that of comparing for different cultures the objective astronomical data, as presented by the heavens that wheeled impartially over ancient men, with the subjective and culturally conditioned mental and pictorial constructs ancient men built upon those data. We have seen that astronomers can now compute the objective astra facts for any culture studied. Unfortunately, no "secular equivalent of divine revelation" can compute the matching subjective constructs where no texts exist, but in areas of ancient literacy, notably the Middle East and Mesoamerica, these are even now roughly known. Because of the vagaries of discovery and preservation (including losses from the record due to book-burning in Mesoamerica and Alexandria), our knowledge of these cultural constructs is uneven, but the literature reviewed indicates that we may hope soon to know more about Indus, Iranian, Arabic, and other early systems. Megalithic cultures remain mute and increasingly challenging, but even here further work in archaeoastronomy and ethnoastronomy, allied with folkloric, linguistic, and other comparative studies, may show correlations with known systems.

The literature in both subdisciplines demonstrates—to my mind quite conclusively—that Eurasian megaliths and American sacred structures encode a remarkable astronomical knowledge which, moreover, was common over wide areas. Notably, the exact correspondences in orientations and metrology which Thom and colleagues have found between British and French megalithic structures leave little doubt of the presence of some central system, operating at least in Britain and France and perhaps in the Iberian peninsula, Scandinavia, and Russia. Tradition suggests a central observatory in southeastern Iran, with possible connections as far as China and the Azores, giving an arc of observation of thousands of miles; it is perhaps not at all coincidental that a 3d-millennium B.C. literate center trading with both the East and the West (if only through traders meeting in ports of call) has been found in this area. Astronomers and archaeologists are similarly discovering the outlines of wide correspondences in the Americas and in Oceania as well as in Eurasia and Africa. The unresolved questions which remain with regard to the time and place of origination of the ancient subjective constructs are susceptible to calculation on lines similar to those demonstrated by Ovenden. The parallels are too striking to be explainable by chance or psychology: a common conceptual scheme based on a common origin appears to be the only explanation which does not wrench the long arm of coincidence.

Thus, as to the "why" of the diffusion of subjective astronomical constructs based on a long process of recording objective astronomical data (neither of which could always have fitted the observations which could have been made in the new environments), we can reasonably think in terms of man's acquisitiveness and his liking for adventure and intellectual achievement, united in a systematic explorative and commercial drive operating since at least the 3d millennium B.C., when the development of sailing ships began to open up the world to the adventurous. The most likely mechanism appears to be that of trade-colonists, mariners, and caravan masters using navigational astronomy and cherishing celestial deities and astra-determined renewal rituals, accompanied now and then by astrologers with their divining boards. Add to this an occasional storm-driven and current-directed unplanned landing on shores where alien stars looked down but enough familiar ones remained to permit a carry-over of familiar constructs, and both the parallels and the divergences in the ancient astronomical systems appear ultimately explicable.

References Cited

AABOE, A. 1967. On period-relations in Babylonian astronomy. *Vistas in Astronomy* 9:157.

ALFORD, V. 1937. *Pyrenaean festivals.* London: Chatto and Windus.

———. 1952. *Introduction to English folklore.* London: Bell.

———. 1962. *Sword dance and drama.* London: Merlin Press.

ALFORD, VIOLET, and RODNEY GALLOP. 1935. *The traditional dance.* London: Methuen.

ALLCHIN, F. R. 1956. The stone alignments of southern Hyderabad. *Man* 56(150): 133–59.

———. 1963. *Neolithic cattle-keepers of South India—A study of the Deccan ashmounds.* London: Cambridge University Press.

ALLEN, RICHARD HINCKLEY. 1963. *Star-names and their meanings.* New York: Stechert.

ANATI, E. 1964. *Camonica Valley.* London: Jonathan Cape.

———. 1968. *Rock-art in Central Arabia: Vol. 1, Pt. 1, The "oval-headed" people of Arabia.* Louvain: Institut Orientaliste, Université de Louvain.

ANDERSON, FRENCH W. 1971. Arithmetic in Maya numerals. *American Antiquity* 36:54–63.

ANDERSON, SUSAN E., and EMERY S. FLETCHER. 1968. The inverse Stonehenge problem. CURRENT ANTHROPOLOGY 9:316–18.

ANDRÉE, R. n.d. *The Pleiades in mythology and in their relation to the New Year and agriculture (text and translation).* Miscellaneous Mexican and Central American Pamphlets 3(3).

ARRIBAS, ANTONIO. 1962. *The Iberians.* Translated by Celia Topp. London: Thames and Hudson.

ARTAMONOV, M. I. 1961. "The anthropomorphic deities in the religion of the Scythians," in *Arkheologicheskii Sbornik Ermitazha,* vol. 2, pp. 57–87. Leningrad.

ASHE, GEOFFREY. Editor. 1971. *The quest for America.* New York: Praeger.

ATKINSON, R. J. C. 1960. *Stonehenge.* London: Pelican Books.

———. 1966*a*. Moonshine over Stonehenge. *Antiquity* 60:212–16.

———. 1966*b*. Stonehenge in darkness. *New York Review of Books,* June 23, p. 14.

———. 1966*c*. Review of: Stonehenge decoded, by Gerald S. Hawkins (*Nature* 200:306–8). *Nature* 210:1302.

———. 1967. Further radiocarbon dates for Stonehenge. *Antiquity* 41:63.

———. 1968*a*. Review of: *Megalithic sites in Britain,* by Alexander Thom (Oxford: Clarendon Press, 1957). *Antiquity* 42:77–78.

———. 1968*b*. Silbury Hill. *Antiquity* 42:299.

———. 1969. The date of Silbury Hill. *Antiquity* 43:266.

———. 1970. Silbury Hill, 1969–70. *Antiquity* 44:313–14.

———. 1971. Moon measures: a review of *Megalithic lunar observatories,* by Alexander Thom (Oxford: Clarendon Press, 1971). *New Statesman,* January 22, pp. 117–18.

AUBOYER, J. 1963. "Inde," in *Dictionnaire archéologique des techniques.* Edited by Madeleine Burke et al., p. 93. Paris: Editions de l'Accueil.

AUDIN, AMABLE. 1945. *Les fêtes solaires: Essai sur la religion primitive.* Paris: Presses Universitaires de France.

———. 1955. Le monde carré et sa figuration. *Revue Archéologique de l'Est et du Centre-Est* 6:67–69.

———. 1956. Dianus bifrons ou les deux stations solaires. *Revue de Géographie de Lyon* 31:191–99.

BAITY, ELIZABETH CHESLEY. 1962. The firewalkers of San Pedro Manrique. Unpublished Master's thesis, University of North Carolina, Chapel Hill, N.C.

———. 1966*a*. El nombre de Soria y los cultos al sol y a los astros. *Celtiberia* 27:221:53.

———. 1966*b*. "The Sorian fire-rituals and Eurasian protohistory." *Actas del XXXVI Congreso Internacional de Americanistas,* vol. 2, pp. 483–88.

———. 1966*c*. Los cultos del fuego de Soria (España) y Serria (Grecia). *Celtiberia* 31:97–108.

———. 1968. The fire, bull and solstice fiestas of Soria Province, Spain and Afro-Asian parallels, a documentary study in prehistory. Unpublished Ph.D. dissertation, University of North Carolina, Chapel Hill, N.C.

———. 1969. "Some implications of astro-archaeology for Americanists." *Akten des XXXVIII Internationalen Amerikanisten-kongresses, Stuttgart-München,* vol. 1, pp. 85–94.

———. 1971*a*. Astro-archaeology and ethno-astronomy: Problems and possibilities. Paper read at the 36th annual meeting of the Society for American Archaeology, Norman, Okla., May 8.

———. 1971*b*. The need for an international astro-iconographical index. Paper read at the 36th annual meeting of the Society for American Archaeology, Norman, Okla., May 8.

BALOAN, LOUIS. 1936. Le dolmen de la plaine, commune de Saint André de Vezines (Aveyron). *Cahiers d'Histoire et d'Archéologie* 11:301–10.

BARANDIARÁN, JOSÉ M. 1960. *Mitología vasca.* Madrid: Ediciones Minotauro.

———. 1970. *Die baskische Mythologie.* Stuttgart.

BARMORE, FRANK E. 1969. Canterbury Cathedral: An alternate explanation of its plan. *Science* 166:772–74.

BASCHMAKOFF, ALEXANDRE. 1930. Les alignements de Carnac (Morbihan). *L'Anthropologie* 40:40–75.

———. 1937. *Cinquante siècles d'évolution ethnique autour de la mer noire.* Paris: Geuthner.

———. 1948. *La synthèse des périples pontiques.* Paris: Geuthner.

BAUDEZ, CLAUDE. 1963. "Amérique précolumbienne," in *Dictionnaire archéologique des techniques.* Edited by Madeleine Burke et al., pp. 89–96. Paris: Editions de l'Accueil.

BAUDOUIN, MARCEL. 1912. Procédés et techniques pour l'étude de l'orientation des gravures sur rochers et de l'axe d'érection des mégalithes par rapport a l'astre solaire. *Société Préhistorique Française, Bulletin* 9:711–6.

———. 1913. Technique de la détermination de l'orientation des dolmens. *L'Homme Préhistorique,* ser. 2, 1:369–77.

———. 1917*a*. La préhistoire des étoiles à l'Académie française. *Société Préhistorique Française, Bulletin* 14:290.

———. 1917*b*. La préhistoire des étoiles: Les pléiades au néolithique. *Société d'Anthropologie de Paris, Bulletins et Mémoires,* ser. 6, 7:25–103.

———. 1922. Preuves matérielles que les cupules représentent bien des astres. *Société Préhistorique Française, Bulletin* 19:270–72.

———. 1926. *La préhistoire par les étoiles.* Paris: N. Maloine.

BEALE, P. O. 1968. The stone circles of the Gambia and the Senegal. *Tarikh* 2(2):1–11.

BECK, PIERRE, and PAUL HUARD. 1969. *Tibesti, carrefour de la préhistoire saharienne.* Paris: Arthaud.

BEER, A. 1967. Astronomical dating of works of art. *Vistas in Astronomy* 9:177–223.

BEER, A., HO PING-YÜ, LU GWEI-DJEN, J. NEEDHAM, E. G. PULLEYBLANK, and G. I. THOMPSON. 1961. An 8th-century meridian line: I-Hsing's chain of gnomons and the pre-history of the metric system. *Vistas in Astronomy* 4:3–28.

BELLI, PRÓSPERO L. 1952. El culto del sol en la civilización Nazca. *Yikal Maya Than* 13:27–29, 40.

BENCHLEY, ELIZABETH. 1970. "Mississippian calendars: Some suggestions." *Proceedings of the Annual Meetings of the American Anthropological Association, San Diego, Calif.*

BERGER, R. 1970. Ancient Egyptian radiocarbon chronology. *Philosophical Transactions of the Royal Society of London,* ser. A, 269(1193).

BEST, ELSDON. 1955. *The astronomical knowledge of the Maori, genuine and empirical.* Wellington, New Zealand: University Museum.

BEYER, HERMANN. 1936*a*. The lunar glyphs of the supplementary series at Quirigua. *El México Antiguo* 3(11–12):1–11.

———. 1936*b*. Eine weitere Mayahieroglyphe für "Tag." *El México Antiguo* 3 (11–12).

BHATTACHARYYA, R. K., and S. C. MITRA. 1925. On the worship of the sun-deity in Bihar, western and eastern Bengal. *Anthropological Society of Bombay, Journal* 13:313–20.

BIBBY, G. 1966. Arabiens Arkaeologi. *Kuml,* pp. 86 ff.

———. 1969. *Looking for Dilmun.* New York: Knopf.

BINFORD, LEWIS R. 1970. *The Hatchery West Site.* Society for American Archaeology, Memoir 24.

BIRRELL, VERLA. 1970. New and Old World contacts. Paper delivered at the 35th annual meeting of the Society for American Archaeology, Mexico City.

BLOCH, M. 1963. "Rome," in *Dictionnaire archéologique des techniques.* Edited by Madeleine Burke et al., pp. 88–89. Paris: Editions de l'Accueil.

———. 1968. "Astrology and writing," in *Literacy in traditional societies.* Edited by J. Goody. London: Cambridge University Press.

———. 1971. *Placing the dead: Tombs, ancestral villages, and kinship organization in Madagascar.* London and New York: Seminar Press.

BOLL, FRANZ JOHANNES. 1904. *Sphaera: Neue griechische Texte und Untersuchungen zur Geschichte der Sternbilder.* Leipzig: Teubner.

BONNERJEA, BIRON. 1935. Eclipses among

ancient and primitive peoples. *Scientific Monthly* 40:63–69.
BORK, FERDINAND. 1914. Tierkreisforschungen. *Anthropos* 9:66–80.
———. 1924. Zur Entstehungsgeschichte des Futharo. *Mannus* 16:127–37.
———. 1929. Planetenreihen. *Zeitschrift für Ethnologie* 59:153–86.
BORST, LYLE B. 1966–69. Megalithic plan underlying Canterbury Cathedral. *Science* 163:567–70; 166:774.
BOULE, MARCELLIN. 1930. Peut-on calculer, à l'aide de l'astronomie, la date approximative de certains monuments mégalithiques? *L'Anthropologie* 40:202–3.
BOWDITCH, CHARLES P. 1901. *A method which may have been used by the Mayas in calculating time.* Cambridge: University Press.
BREUIL, ABBÉ HENRI. 1934. Peintures rupestres préhistoriques de Harrar. *L'Anthropologie* 44:470–84.
BREUIL, ABBÉ HENRI, and MILES BURKITT. 1929. *Rock paintings of southern Andalusia.* Oxford: Clarendon Press.
BROOKS, C. E. P. 1927. The climate of prehistoric Britain. *Antiquity* 1:412.
BROWN, ROBERT, JR. 1899–1900. *Primitive constellations.* London: Williams and Norgate.
BROWNE, G. F. 1921. *On some antiquities in the neighbourhood of Dunecht House, Aberdeenshire.* Cambridge.
BRUEL, GEORGES. 1932. Noms donnés par les populations de l'Oubangi et du Chari à des planètes, à des étoiles et à des constellations. *Société des Recherches Congolaises, Bulletin* 17:109–14.
BRYAN, E. H. 1933. "Astronomy and the calendar," in *Ancient Hawaiian civilization*, pp. 247–52. Honolulu: Kamehameha Schools.
BUCHANAN, FRANCIS. 1801. On religion and literature of the Burmas. *Asiatick Researches* 6:163–308.
BUCKSTAFF, R. N. 1927. Stars and constellations of a Pawnee sky map. *American Anthropologist* 29:279–86.
BUNGE, O. D. E. 1940. Contribution à l'astronomie maya. *Société des Americanistes, Journal* 32:69–92.
BURL, H. A. W. 1969*a*. Henges: Internal features and regional groups. *Archeological Journal* 126:1–28.
———. 1969*b*. Henges and stone circles. Paper presented at a conference on stone circles and henge monuments, Glasgow, November 29.
———. 1971*a*. The stone circles of Great Britain and Ireland. Unpublished Ph.D. dissertation, University of Leicester, Leicester, England.
———. 1971*b*. Two "Scottish" stone circles in Northumberland. *Archaeologia Aeliana* 49:37–51.
———. 1972. The recumbent stone circles of Scotland. *Proceedings of the Society of Antiquaries of Scotland, Edinburgh.* In press.
BURLAND, C. A. 1950. *The four directions of time.* Santa Fe: Museum of Navajo Ceremonial Art.
———. 1954. Some notes on ancient Mexican stellar beliefs. *New World Antiquity* 2:1–4.
———. 1964. *The bases of religion in Aztec Mexico.* London Guild of Pastoral Psychology, Lecture no. 127.
———. 1970*a*. "Morning star at mid-day—a Mexican solar eclipse." *Akten des XXXVIII Internationalen Amerikanistenkongresses, Stuttgart-München*, vol. 2, pp. 151–53.
———. 1970*b*. "The consummation of Quetzalcoatl: Transits of Venus in Mexican inscriptions." *Akten des XXXVIII Internationalen Amerikanistenkongresses, Stuttgart-München*, vol. 2, pp. 155–57.
BURN, A. R. 1969. Holy men on islands in pre-Christian Britain. *Glasgow Archeological Journal* 1:2–6.
BUSHELL, W. D. 1911. Amongst the Prescelly circles. *Archaeologia Cambrensis* 11:287–333.
BUTZER, KARL W. 1966. "Climatic changes in the arid zones of Africa during early to mid-Holocene times." *World climate from 8000 to 0 B.C.: Proceedings of the 1966 International Symposium, Royal Meteorological Society*, pp. 72–83.
CALLENDER, H. 1859. Notice of the stone circle at Callernish in the island of Lewis. *Proceedings of the Society of Antiquaries of Scotland, Edinburgh* 2:380–84.
CAMPOS, JOAQUÍN. 1953. *De toponimia Arabigo-estelar.* Berkeley: University of California Press.
CARMODY, F. J. 1956. *Arabic astronomical and astrological sciences in Latin translations, a critical bibliography.* Berkeley: University of California Press.
———. 1961. *Astronomical works of Thabit b. Qurra.* Berkeley: University of California Press.
CARO BAROJA, J. 1958. *Los Vascos.* Madrid: Ediciones Minotauro.
CASO, ALFONSO. 1947. *Calendario y escritura de las antiguas culturas de Monte Albán.* México.
———. 1950. De la necesidad de la crítica histórica para interpretar los eclipses de sol en los manuscriptos mexicanos. *Revista Mexicana de Estudios Anthropológicos* 11:15–22.
———. 1958. *The Aztecs: People of the Sun.* Translation by Lowell Dunham. Norman: University of Oklahoma Press.
CHAPLIN, J. H. 1958. Rock-drawings from the Lake Victoria region. *Antiquity* 32:146–47, pl. XVIII–XIX.
CHARRIÈRE, G. 1960. Carnac, les alignements du Ménec, orientation. *Société Préhistorique Française, Bulletin* 57:661.
———. 1961. Stonehenge: Rythmes architecturaux et orientation. *Société Préhistorique Française, Bulletin* 58:276–79.
———. 1963. Le comput et le monument calendaire des Daces à Sarmizegetusa. *Société Préhistorique Française, Bulletin* 60:408–10, 562–66.
———. 1964. Typologie des orientations mégalithiques et protohistoriques. *Société Préhistorique Française, Bulletin* 61:160–68.
———. 1966. Les signes algébriques dans le calendrier de Coligny. *Revue Archéologique de l'Est et du Centre-Est* 17:95–103.
CHARRIÈRE, G., and A. ROOS. 1964. Stonehenge, temple votif et monument calendaire. *Société Préhistorique Française, Bulletin* 61:169–84.
CHATLEY, HERBERT. 1940*a*. The lunar mansions in Egypt. *Isis* 31:394–97.
———. 1940*b*. Egyptian astronomy. *Journal of Egyptian Archaeology* 26:120–26.
CHAVANNES, EDOUARD. 1906. *Le cycle Turc des douze animaux.* Leyden.
CHECHENOV, I. M. 1970. A shrine of the Early Bronze Age in the city of Nalchik. *Sovetskaya Arkheologiya* 2:109–24.
CLAGGETT, MARSHALL. 1955. *Greek science in antiquity.* New York: Abelard-Schuman.
CLARK, WALTER EUGENE, Translator. 1930. *The Āryabhaṭīya of Āryabhaṭa, an ancient Indian work on mathematics and astronomy.* Chicago: University of Chicago Press.
CLINE, HOWARD. 1970. *Christian-native synchronologies in Codex Telleriano-Remensis, Sahagún's manuscripts, and Crónica Mexicayotl.* Washington: Hispanic Foundation.
COLES, F. 1909. On some stone circles in Perthshire-Aberfeldy district. *Proceedings of the Society of Antiquaries of Scotland, Edinburgh* 44:117–68.
COLLOCOTT, E. E. V. 1923. Tongan astronomy and calendar. *Bernice Pauahi Bishop Museum of Polynesian Ethnology and Natural History, Occasional Papers* 8:155–73.
COLTON, R., and R. L. MARTIN. 1967. Eclipse cycles and eclipses at Stonehenge. *Nature* 213:476–78.
CONTENEAU, GEORGES. 1940. *La divination chez les Assyriens et les Babyloniens.* Paris: Payot.
COOK DE LEONARD, CARMEN, and R. P. C. SCHULZ. 1947. El códice maya de Dresde frente a la astronomía y a la mitología. *El México Antiguo* 6:342–82.
COWAN, THADDEUS M. 1970. Megalithic rings: Their design and construction. *Science* 168:321–25.
CRAMPTON, PATRICK. 1967. *Stonehenge of the Kings.* New York: John Day.
CROOKE, WILLIAM E. 1917. Bull-baiting, bull-racing, bull-fighting. *Folklore* 28: 141–63.
CUMONT, FRANZ. 1927. Le culte de Venus chez les Arabes au 1[er] siècle. *Syria* 8:368.
CUNNINGTON, ROBERT H. 1935. *Stonehenge and its date.* London: Methuen.
DAICOVICIU, H. 1960. "Le monument-calendrier des Daces de Sarmizegetusa," in *Nouvelles études d'histoire*, pp. 55–72. Bucarest: Editions de l'Académie de la République Populaire Roumaine.
DALES, G. 1965. "A suggested chronology for Afghanistan, Baluchistan, and the Indus Valley," in *Chronologies in Old World archaeology.* Edited by R. W. Ehrich. Chicago: University of Chicago Press.
DANIEL, GLYN. 1963. *The megalith builders of Western Europe.* London: Penguin.
DAYTON, J. E. 1971. The problem of tin in the ancient world. *World Archaeology* 3(1):49–71.
DE BORHEGYI, STEPHAN F. 1969. "The pre-Columbian ballgame—a pan-Mesoamerican tradition." *Akten des XXXVIII Internationalen Amerikanistenkongresses, Stuttgart-München*, vol. 1, pp. 499–515.
DE GALLATAY, VINCENT. 1959. *Atlas of the sky.* Translated by H. S. Jones. London: Macmillan.
DELIBRIAS, G., M. T. GUILLIER, and J. L. LABEYRIE. 1970. Gif natural radiocarbon measurements V. *Radiocarbon* 12:4210.
DE SANTILLANA, GIORGIO, and HERTHA VON DECHEND. 1969. *Hamlet's Mill.* Boston: Gambit.
DE SAUSSURE, LÉOPOLD. 1919. Le zodiaque lunaire asiatique. *Extraits des Archives des Sciences Physiques et Naturelles* 1.
———. 1919–20. Le système astronomique des chinois. *Extraits des Archives des Sciences Physiques et Naturelles* 1:186–216, 561–88; 2:214–31, 325–50.
———. 1923*a*. Origine Babylonienne de l'astronomie chinoise. *Extraits des Archives des Sciences Physiques et Naturelles* 5.
———. 1923*b*. L'origine de la rose des vents et l'invention de la boussole. *Extraits des Archives des Sciences Physiques et Naturelles* 5.
———. 1924. La série septénaire, cosmologique et planétaire. *Extraits des Archives des Sciences Physiques et Naturelles* 6.
———. 1967. *Les origines de l'astronomie chinoise.* (Reprint.) Taipei: Ch'eng-wen.
DEVOIR, ALFRED. 1911. Orientations mégalithiques de la presqu'île de Crozon. *Société Archéologique du Finistère, Bulletin* 38:338.
———. 1915–16. Contribution à l'étude de l'ère monumentale préhistorique: L'architecture mégalithique Bretonne et les observations solaires. *Société Préhistorique Française, Bulletin* 12:369–76, 403–16, 458–62; 13:70–80, 115–28.
———. 1916. A propos des critiques et des ouvrages astronomiques de M. le Dr. M.

Baudouin. *Société Préhistorique Française, Bulletin* 13:343–45.

———. 1917. *Notes sur l'archéologie de l'ère préhistorique: La solution du problème de l'astronomie solaire (1902); les hypothèses stellaires (1906); les critiques les contre-theories de M. le Docteur Marcel Baudouin (1912–6).* Morlaix: A. Chevalier.

DICKS, D. R. 1970. *Early Greek astronomy to Aristotle.* London: Thames and Hudson.

DORSEY, G. A. 1907. "The Skidi rite of human sacrifice." *Proceedings of the 15th International Congress of Americanists* 2:65–70.

DOW, JAMES W. 1967. Astronomical orientations at Teotihuacán, a case study in astro-archaeology. *American Antiquity* 32:326–34.

DOWNS, RICHARD E. 1961. On the analysis of ritual. *Southwestern Journal of Anthropology* 17:75–80.

DOZY, R. 1961. *Le calendrier de Cordoue de l'année 961.* New edition with French translation annotated by Ch. Pellat. Leiden. (First published in 1873).

DROWER, LADY E. 1936. The Mandaean new year festival. *Man* 36:185–88.

———. 1962. *The Mandaeans of Iraq and Iran.* Leiden: E. J. Brill.

DUBIEF, JEAN. 1942. Note sur les chronologies des Kel Ahaggar et des Taitoq. *Algiers, Université, Institut de Recherches Sahariennes, Travaux* 1:87–132.

DURÁN, FRAY DIEGO. 1971. *Book of the gods and rites and the ancient calendar.* Translated, edited, and annotated by Fernando Horcasitas and Doris Heyden. Norman: University of Oklahoma Press.

EBERHARD, WOLFRAM. 1933. Beiträge zur kosmologischen Spekulation Chinas in der Han-Zeit. *Baessler-Archiv* 16:1–100.

———. 1940. 2d edition, revised. *A history of China.* Berkeley: University of California Press.

———. 1957. "The political functions of astronomy and astronomers in Han China," in *Chinese thought and institutions.* Edited by John K. Fairbank. Chicago: University of Chicago Press.

———. 1971. *Sternkunde und Weltbild im alten China.* Taipei: Chinese Materials and Research Aids.

EDWARDS, I. E. S. 1970. Absolute dating from Egyptian records and comparison with carbon-14 dating. *Philosophical Transactions of the Royal Society of London,* ser. A., 269(1193):11–18.

EKHOLM, GORDON. 1953. A possible focus of Asiatic influence in the Late Classic cultures of Mesoamerica. *American Anthropologist* 55(3, pt. 2):72–97.

EKHOLM, GORDON, et al. 1970. *Ancient Mexico and Central America.* New York: American Museum of Natural History.

ELWIN, VERRIER. 1951. *The tribal art of Middle India.* London: Oxford University Press, Geoffrey Cumberlege.

———. 1955. *The religion of an Indian tribe.* London: Oxford University Press, Geoffrey Cumberlege.

EMMOTT, DOUGLAS. 1963. The mystery of Hole G. *Yorkshire Post,* March 16.

ERDLAND, AUGUST. 1910. Die Sternkunde bei den Seefahrern der Marshallinseln. *Anthropos* 5:16–26.

ERIXON, SIGURD E. 1939. "Actual tasks in investigations on the agricultural year in Nordic ethnology." *International Congress of Anthropological and Ethnological Sciences, Proceedings,* pp. 307–8.

ESSEN, L. 1969. The measurement of time. *Vistas in Astronomy* 11:45–67.

EVREINOV, E. V., YU. G. KOSAREV, and V. A. USTINOV. 1961. *An analysis of Maya manuscripts with the aid of electronic computer.* Vol. 2.

FAHY, E. M. 1959. Recumbent stone circles at Drombeg, County Cork, Ireland. *Journal of the Cork Historical and Archaeological Society* 64:1–27.

———. 1961. A stone circle at Bohonagh, County Cork. *Journal of the Cork Historical and Archaeological Society* 66:93–104.

———. 1962. A stone circle at Reanascreena, County Cork. *Journal of the Cork Historical and Archaeological Society* 67:59–69.

FERDON, EDWIN. 1955. *A trial survey of Mexican-Southwestern architectural parallels.* School of American Research Monograph 21.

FERGUSON, THOMAS STUART. 1962. *One fold and one shepherd.* Salt Lake City: Olympus.

FERRAND, GABRIEL. 1928. Introduction a l'astronomie nautique arabe. *Aran* 16(95):89.

FEWKES, JESSE. 1891. "A few summer ceremonials at Zuni pueblo," in *A journal of American ethnology and archaeology.* Edited by J. Fewkes, vol. 1, pp. 1–62.

———. 1898. The winter solstice ceremony at Walpi. *American Anthropologist* 11:65–87, 101–15.

———. 1913. *Ancient stone monuments in history and geography.* Washington: Smithsonian Institution.

———. 1916*a*. *Excavation and repair of the Sun Temple, Mesa Verde National Park.* Washington: U.S. Department of the Interior.

———. 1916*b*. A sun temple in the Mesa Verde National Park. *Art and Archaeology* 3(6):341–46.

———. 1917*a*. Far View House—a pure type of Pueblo ruin. *Art and Archaeology* 6(6):133–41.

——— 1917*b*. A prehistoric Mesa Verde pueblo and its people. *Smithsonian Institution, Annual Report, 1916,* pp. 461–88.

———. 1917*c*. Archaeological investigations in New Mexico, Colorado, and Utah. *Smithsonian Miscellaneous Collections* 68(1):1–38.

———. 1920. Sun worship of the Hopi Indians. *Smithsonian Institution, Annual Report, 1918,* pp. 493–526.

———. 1922. Fire worship of the Hopi Indians. *Smithsonian Institution, Annual Report, 1920,* pp. 589–611.

FLECKENSTEIN-GALLO, JOACHIM-OTTO. 1967. Papyrology and sources in astronomical history. *Vistas in Astronomy* 9:151–56.

FLETCHER, E. N. R. 1968*a*. Ancient metrology. *Survey Review* 19:270–77.

———. 1968*b*. Prehistoric arrangements of stone cairns in Australia. MS.

———. 1968*c*. Copmanhurst I: An arrangement of prehistoric cairns on Mount King William, near Copmanhurst N.S.W. MS.

———. 1969. The megalithic units in ancient linear metrology. MS.

FORMOZOV, A. A. 1955. A picture on the slabs of the cromlech from the barrow near the village Verbovka. *Kratkie Soobshcheniya Instituta Arkheologii AN USSR* (Kiev) 5:71–74.

———. 1966. *The monuments of prehistoric arts in the territory of the U.S.S.R.* Moscow: Nauka.

———. 1969. *An outline of prehistoric art: The petroglyphs and stone sculptures.* Moscow: Nauka.

FRENZEL, B. 1966. Climatic change in the Atlantic sub-boreal transition in the Northern Hemisphere: Botanical evidence." *World climate from 8000 to 0 B.C.: Proceedings of the 1966 International Symposium, Royal Meteorological Society,* pp. 99–123.

FRIEDERICH, R. 1959. *The civilization and culture of Bali.* Revised and translated by A. H. May. Calcutta: Susil Gupta. (First published in 1849–50.)

GALANOPOULOS, A. G., and EDWARD BACON. 1969. *Atlantis.* Indianapolis: Bobbs-Merrill.

GARDIN, J. C. 1967. Methods for the descriptive analysis of archeological material. *American Antiquity* 32:13–30.

GIEDION, SIGFRIED. 1962. *The eternal present.* New York: Pantheon Press for the Bollingen Foundation.

GIMBUTAS, MARYA. 1956. *The prehistory of Eastern Europe.* London: Cambridge University Press.

GINGERICH, OWEN. 1967. Applications of high-speed computers to the history of astronomy. *Vistas in Astronomy* 9:229–36.

GIOT, P. R. 1960. *Brittany.* London: Thames and Hudson.

GOODENOUGH, WARD H. 1951. Native astronomy in Micronesia: A rudimentary science. *Scientific Monthly* 73:105–10.

———. 1953. *Native astronomy in the Central Carolines.* University of Pennsylvania Museum Monograph 46.

GORDON, CYRUS H. 1971. *Before Columbus: Links between the Old World and ancient America.* New York: Crown.

GORIS, R. n.d. *Atlas Rebudajaan: Cults and customs.* Djakarta: Government of the Republic of Indonesia.

GOUDSMIT, S. A., R. CLAIBORNE, and the Editors of *Life.* 1966. *Time.* New York: Time.

GRAEBNER, ROBERT F. 1921. Alt- und neuweltliche Kalender. *Zeitschrift für Ethnologie* 52:6–37.

GRAKOV, B. N. 1950. The Scythian Hercules. *Kratkie Soobshcheniya Instituta Istorii Material'noy Kul'tury* 34:7–18.

GRAVES, ROBERT. 1948. *The white goddess.* New York: Creative Age.

———. 1957. *The Greek myths.* New York: Braziller.

GRAZIOSI, PAOLO. 1964. New discoveries of rock paintings in Ethiopia. *Antiquity* 38: 91–98, 187–90.

GRIAULE, MARCEL, and G. DIETERLEN. 1950. Un système soudanais de Sirius. *Société des Africanistes, Journal* 20:273–94.

GRIMBLE, ARTHUR. 1931. Gilbertese astronomy and astronomical observances. *Journal of the Polynesian Society* 40:197–224.

GROSJEAN, ROJER. 1969. A propos de l'article d'Antonio Beltrán, de Sarragosse, sur les peintures rupestres à la Grotto-Scritta. *Société Préhistorique Française, Bulletin* 66:132–33.

GRUBER, J. W. 1971. Patterning in death in a late prehistoric village in Pennsylvania. *American Antiquity* 36:64–74.

GUILLEMIN, JORGE F. 1969. "Some aspects of function and symbolism at the ceremonial centers of Tikal and Copan." *Akten des XXXVIII Internationalen Amerikanistenkongresses, Stuttgart-München,* vol. 1, pp. 173–74.

GUTHE, C. E. 1932. Notes on the eclipse table in the Dresden Codex (Maya hieroglyphic manuscript). *Science,* n.s., 76:572.

HAGAR, STANSBURY. 1906. "Cherokee star lore," in *Boas Anniversary Volume,* pp. 133–41. New York: Stechert.

———. 1911. The four seasons of the Mexican ritual of infancy. *American Anthropologist* 13:229–34.

———. 1912*a*. The bearing of astronomy on the subject. *American Anthropologist* 14:43–48.

———. 1912*b*. The Mexican maize season in the Codex Fejervary-Mayer. *American Anthropologist* 14:525–29.

———. 1913. Izamal and its celestial plan. *American Anthropologist* 15:16–32.

———. 1914. The Maya zodiac at Acanceh. *American Anthropologist* 16:88–95.

———. 1917. The Maya day sign Manik. *American Anthropologist* 19:518–32.
———. 1931. The November meteors in Maya and Mexican tradition. *Popular Astronomy* 39(7):
HAMILTON, JAMES C. 1902. The Pleiades in legends, Greek drama and orientation. *Proceedings of the Royal Canadian Institute* 2:121–22.
———. 1904. The Pleiades as the Hesperides, Isle of the Blest, or place of future bliss. *Proceedings of the Royal Canadian Institute*, n.s., 2:125.
HAMMERTON, MAX. 1971. The megalithic fathom: A suggestion. *Antiquity* 45:302.
HAMPATÉ BÂ, A., and G. DIETERLEN. 1966. Les fresques d'époque bovidienne du Tassili N'Ajjer et les traditions des Peul: Hypothèses d'interprétation. *Journal de la Société des Africanistes* 36(1):141–57.
HAPGOOD, C. H. 1966. *Maps of the ancient sea kings.* Philadelphia: Chilton Books.
———. 1970. *The path of the pole.* Philadelphia: Chilton Books.
HARBER, HUBERT E. 1969. Five Maya eclipses in thirteen years. *Sky and Telescope* 37: 72–74.
HARDMAN, CLARK, JR. 1971. The primitive solar observatory at Crystal Lake and its implications. *Florida Anthropologist* 24(4): 135–74.
HARTNER, W. 1944–49. Studien zur Symbolik der frühchinesischen Bronzen. *Paideuma* 3:279.
———. 1965. The earliest history of constellations in the Near East and the motif of the Lion-Bull combat. *Journal of Near Eastern Studies* 24:1–16.
HARTNER, W., and R. ETTINHAUSEN. 1964. The conquering lion, the life cycle of a symbol. *Oriens* 17.
HARTUNG, HORST. 1969. "Consideraciones urbanísticas sobre los trazos de los centros ceremoniales de Tikal, Copán, Uxmal y Chichén-Itzá." *Akten des XXXVIII Internationalen Amerikanistenkongresses, Stuttgart-München*, vol. 1, pp. 121–25.
HAWKES, JACQUETTA. 1962 *Man and the sun.* New York: Random House.
———. 1967. God in the machine. *Antiquity* 41:174–80.
HAWKES, JACQUETTA, and SIR LEONARD WOOLLEY. 1963. *Prehistory and the beginnings of civilization.* London: Unwin.
HAWKINS, GERALD S. 1963. Stonehenge decoded. *Nature* 200:306–8.
———. 1964. Stonehenge: A Neolithic computer. *Nature* 202:1258–61.
———. 1965*a*. Sun, moon, men and stones. *American Scientist* 53:391–408.
———. 1965*b*. Callanish, a Scottish Stonehenge. *Science* 147:127–30.
———. 1966. *Astro-archaeology. Research in space science. Special Report 226.* Cambridge, Mass., October 28.
———. 1968. Astro-archaeology. *Vistas in Astronomy* 10:45–88.
———. 1969. *Ancient lines in the Peruvian desert.* National Geographic Society.
———. 1970. Un secreto del antiguo Peru. *Peruvian National Geographic Magazine.* In press.
HAWKINS, GERALD S., R. J. C. ATKINSON, ALEXANDER THOM, C. A. NEWHAM, D. H. SADLER, and R. A. NEWALL. 1967. Hoyle on Stonehenge: Some comments. *Antiquity* 41(162):91–98.
HAWKINS, GERALD S., and JOHN B. WHITE. 1965. *Stonehenge decoded.* New York: Doubleday.
HEGGIE, D. C. 1972. Megalithic lunar observatories: An astronomer's view. *Antiquity* 46:43–48.
HENNINGER, JOSEF. 1954. Über Sternkunde und Sternkult in Nord- und Zentralarabien. *Zeitschrift für Ethnologie* 79:82–117.
HENSELING, ROBERT. 1938. The scope and antiquity of Mayan astronomy. *Research and Progress* 4:121–28.
HERAS, H. 1953. *Studies in Proto-Indo-Mediterranean culture.* Bombay: Indian Historical Research Institute, St. Xavier's College.
HIRMONECH, H. P. 1913. Les hypothèses astronomiques en préhistoire. *Bulletin et Mémoires de la Société d'Anthropologie de Paris*, ser. 6, 4:675–82.
HOCHLEITNER, FRANZ JOSEPH. 1970*a*. *Semantic deciphering of 70 Mayan hieroglyphs of astronomical meaning.* Juiz de Fora: University of Juiz de Fora Press.
———. 1970*b*. *An attempt at a chronological-astronomical interpretation of the numbers and day signs of pages 3–24 of the Dresden Codex.* Translated by Munro Edmonson. New Orleans: Tulane University.
HOGG, A. H. A. 1968. Review of: *Megalithic sites in Britain*, by Alexander Thom (Oxford: Clarendon Press, 1967). *Archaeologia Cambrensis* 117:267–68.
HO PENG YOKE. 1962. Ancient and mediaeval observations of comets and novae in Chinese sources. *Vistas in Astronomy* 5:127–225.
HOPKINS, CLARK. 1965. Astrological interpretations of some Phoenician bowls. *Journal of Near Eastern Studies* 24(1,2):28–36.
HOPMANN, J. 1934. Methodisches zur vorgeschichtlichen Sternkunde. *Mannus* 26:261–89; 27:373–97.
HOYLE, FRED. 1966*a*. Stonehenge—an eclipse predictor. *Nature* 211:454–56.
———. 1966*b*. Speculations on Stonehenge. *Antiquity* 40:262–76.
HUARD, P. 1959. Les cornes déformées sur les gravures rupestres du Sahara sud-oriental. *Travaux de l'Institut de Recherches Sahariennes* 18:109–31.
———. 1961. Les figurations d'animaux à disques frontaux et attributs rituels au Sahara oriental. *Bulletin de l'Institut Français d'Afrique Noire* 23:476–513.
———. 1966. Contribution a l'étude des spirales au Sahara central et nigerotchadien. *Société Préhistorique Française, Bulletin* 63:432–64.
———. 1968. Nouvelles figurations sahariennes et nilo-soudanaises des boeufs porteurs, montés et attelés. *Société Préhistorique Française, Bulletin* 65:114–20.
HUARD, P., and J. P. MASSIP. 1963. Gravures rupestres du Tibesti meridional et du Boukou. *Société Préhistorique Française, Bulletin* 60:468.
HÜLLE, WERNER. 1942. *Die Steine von Carnac.* Leipzig: J. A. Barth.
———. 1967. *Steinmale der Bretagne.* Ludwigsburg: Die Karawane.
HUTCHINSON, G. EVELYN. 1972*a*. Long Meg reconsidered. *American Scientist* 60:24–31.
———. 1972*b*. Long Meg reconsidered, part 2. *American Scientist* 60:210–19.
HYSLOP, J. 1912. *Langholm as it was.* Langholm.
IVIMRY, JOHN. 1969. Megalithic mathematics. *The Listener* 82:859.
JACQUOT, LUCIEN. 1915. Persistence du culte des astres jusqu'à nos jours: Boutons à figurations astrales. *Société Préhistorique Française, Bulletin* 12:197–98.
JAMES, E. O. 1961. *Seasonal feasts and festivals.* New York: Barnes and Noble.
JOBES, GERTRUDE, and JAMES JOBES. 1964. *Outer space: Myths, names, meanings, calendars.* New York: Scarecrow Press.
JOHNSON, ANN A. 1971. Finger-loops and cruciform objects. *American Antiquity* 36:188–94.
JONES, TIM E. H. 1969. "Problems in recording rock paintings in the Pre-Cambrian Shield." *Akten des XXXVIII Internationalen Amerikanistenkongresses, Stuttgart-München*, vol. 1, pp. 109–16.
KEILLER, A. 1934. *Megalithic monuments of north-east Scotland.* (Reprint for Morven Institute of Archaeological Research.) London: Vecher.
KELLEY, DAVID H. 1954. On ancient Mexican stellar beliefs. *New World Antiquity* 10:3–6.
———. 1957. Our Elder Brother Coyote. Unpublished Ph.D. dissertation, Harvard University, Cambridge, Mass.
———. 1960. Calendar animals and deities. *Southwestern Journal of Anthropology* 16:317–37.
———. 1965. The birth of the gods at Palenque. *Estudios de Cultura Maya* 5:93–134.
———. 1971. Cosmology, social organization, and settlement patterns. Paper read at the 36th annual meeting of the Society for American Archaeology, Norman, Okla., May 8.
KENDALL, DAVID. 1971. Review of: *Megalithic lunar observatories*, by Alexander Thom (Oxford: Clarendon Press, 1971). *Antiquity* 45:310–13.
KENNEDY, E. S., SUSAN ENGLE, and JEANNE WAMSTAD. 1965. The Hindu calendar as described in Al-Birūnī's Masudic Canon. *Journal of Near Eastern Studies* 24:274–84.
KIRCHHOFF, PAUL. 1964. "The diffusion of a great religious system from India to Mexico." *XXXV Congreso Internacional de Americanistas, Actas y Memorias, Mexico, D.F.*, pp. 73–100.
KLÍMA, BOHUSLAV. 1962. "The first ground-plan of an Upper Paleolithic loess settlement in Middle Europe and its meaning," in *Courses toward urban life.* Edited by Robert J. Braidwood and Gordon R. Willey. New York: Wenner-Gren Foundation for Anthropological Research.
KNOBEL, EDWARD BALL. 1917. *Ulugh-Beg's catalogue of stars.* Washington: Carnegie Institution of Washington.
KRAMER, SAMUEL NOAH. 1963. Dilmun: Quest for Paradise. *Antiquity* 37.
———. 1963–64. The Indus civilization and Dilmun, the Sumerian Paradise Land. *Expedition* 6:44–52.
KULIKOVSKY, PIOTR G. 1967. Sources for the history of astronomy in the scientific archives of the U.S.S.R. *Vistas in Astronomy* 9:245–52.
KURATH, GERTRUDE PROKOSCH, and SAMUEL MARTÍ. 1960. *Dances of Anahuac.* Viking Fund Publications in Anthropology 38.
LAGERCRANTZ, STURE. 1952. The Milky Way in Africa. *Ethnos* 17:64–72.
LAGUESSE, JANINE. 1945. A propos des connaisances astronomiques des anciens tahitiens. *Société des Études Océaniennes, Bulletin* 7:141–52.
LAHOVARY, N. 1963. *Dravidian origins and the West.* Bombay: Orient Longmans.
LAJOUX, J. D. 1963. *The rock paintings of Tassili.* Cleveland and New York: World Book; London: Thames and Hudson.
LAMB, H. H., R. P. LEWIS, and A. WOODROFFE. 1966. "Atmospheric circulation and the main climatic variables between 8000 and 0 B.C.: Meteorological evidence." *World climate from 8000 to 0 B.C.: Proceedings of the 1966 International Symposium, Royal Meteorological Society*, pp. 174–217.
LAMBERG-KARLOVSKY, C. C. 1967. Archeology and metallurgical technology in prehistoric Afghanistan, India, and Pakistan. *American Anthropologist* 69:145–62.
———. 1970. *Excavations at Tepe Yahya, Iran.* American School of Prehistoric Research, Peabody Museum, Harvard University, Progress Report 1, Bulletin 27.
———. 1971. The Proto-Elamite settlement at Tepe Yahya. *Iran* 9. In press.
LANGDON, S. 1935. *Babylonian menologies and*

the Semitic calendars: The Schweich lectures of the British Academy. London: Published for the British Academy.

LAOUST, E. 1921. Noms et cérémonies des feux de joie chez les Berberes du Haut et de l'Anti-Atlas. *Hesperes* 1:3–66.

LARGEMENT, R. 1963. "Asie occidentale," in *Dictionnaire archéologique des techniques.* Edited by Madeleine Burke et al., pp. 93–97. Paris: Editions de l'Accueil.

LAVROV, L. I. 1960. The dolmens of the northwestern Caucasus. *Trudy Abkhazkogo Instituta Yazyka, Literatury i Istorii* 31:101–78.

LEEMANS, W. F. 1965. *Foreign trade in the old Babylonian period.* Leiden: Studia et Documenta 6.

LEHMANN-NITSCHE, ROBERT. 1922. Las constelaciones del Orión y de las Híadas y su pretendida identidad de interpretación en las esferas eurasiática y sudamericana. (Mitología sudamericana 4.) *La Plata Museo, Revista* 26:17–68.

———. 1923. La astronomía de los Matacos. *La Plata Museo, Revista* 27:253–66.

———. 1924–25*a*. La astronomía de los Chiriguanos. *La Plata Museo, Revista* 28:80–102.

———. 1924–25*b*. La constelación de la Osa mayor y su concepto como huracán o dios de la tormenta en la esfera del mar Caribe. *La Plata Museo, Revista* 28:103–45.

———. 1924–27. La astronomía de los Mocoví. *La Plata Museo, Revista* 28:66–79; 30:145–59.

———. 1925. Aus ethnologischen Sternbilderstudien. *Philologus* 81:202–7.

LEISNER, GEORG, and VERA LEISNER. 1956. *Die Megalithgräber der iberischen Halbinsel.* Berlin: Gruyter.

LENOIR, RAYMOND. 1956. La mentalidad megalítica. *Revista Mexicana de Sociología* 18:507–23.

LESHCHENKO, A. F. 1931. Materials on the decoration of the dolmens in the northwestern Caucasus. (In Ukrainian.) *Antropologiya* (Kiev) 4:237–63.

LESLEY, MARK. 1957. Birūnī on rising time and daylight lengths. *Centaurus* 5:121–41.

LESSA, W. A. 1968. *Chinese body divination.* Los Angeles: United World.

LEWIS, A. 1878. Rude stone monuments in Wales. *Journal of the Royal Anthropological Institute* 7:118–23.

———. 1878. The Devil's arrows, Yorkshire. *Journal of the Royal Anthropological Institute* 8:180–83.

———. 1882*a*. Two stone circles in Shropshire. *Journal of the Royal Anthropological Institute* 11:3–7.

———. 1882*b*. On the relation of stone circles to outlying stones. *Journal of the Royal Anthropological Institute* 27:194–208.

———. 1882*c*. Archaic structures in Somerset and Dorset. *Journal of the Royal Anthropological Institute* 11:117–21.

———. 1883. On the relationship of stone circles to outlying stones or tumuli. *Journal of the Royal Anthropological Institute* 12:517.

———. 1886. Three stone circles in Cumberland. *Journal of the Royal Anthropological Institute* 15:471–81.

———. 1888*a*. Stone circles. *Archaeological Journal* 44.

———. 1888*b*. Stone circles near Aberdeen. *Journal of the Royal Archaeological Institute* 17:44–57.

———. 1890. On the Wiltshire circles. *Journal of the Royal Archaeological Institute* 20:282.

———. 1892*a*. The stone circles of Britain. *Archaeological Journal* 69:136.

———. 1892*b*. Cornish circles. *Journal of the Royal Institute of Cornwall* 13:107–13.

———. 1896. Prehistoric remains in Cornwall. *Journal of the Royal Anthropological Institute* 25:2–16.

———. 1897. Ancient measures in prehistoric monuments. *Journal of the Royal Archaeological Institute* 27:194–203.

———. 1899. Cornish and Scottish circles. *Journal of the Royal Institute of Cornwall* 14:378–83.

———. 1903*a*. Notes on orientation. *Man* 3:48.

———. 1903*b*. Stone circles in Derbyshire. *Man* 3:133–36.

———. 1905. Prehistoric remains in Cornwall. Pt. 2. *Journal of the Royal Anthropological Institute* 35:427–34.

———. 1909. Some stone circles in Ireland. *Journal of the Royal Anthropological Institute* 34:517–29.

———. 1910. Lockyer: British stone monuments astronomically considered. *Man* 10: art. 34.

———. 1914. Standing stones and stone circles in Yorkshire. *Man* 14–15: art. 83.

LHOTE, HENRI. 1952. Interprétations indigènes de quelques gravures et peintures rupestres géométriques du Sahara occidental. *Notes Africaines* no. 53, janvier, pp. 5–6.

———. 1966. Les peintures pariétales d'époque bovidienne du Tassile: Eléments sur la magie et la religion. *Journal de la Société des Africanistes* 36:7–27.

———. 1970. *Les gravures rupestres du Sud-Oranais.* Mémoires du Centre de Recherches Anthropologiques, Prehistoriques et Ethnographiques, Institut des Sciences Humaines, Alger, 16.

LINDSAY, J. H. 1951. The Makara in early Chinese Buddhist sculpture. *Journal of Royal Asiatic Society* 1951:134–38.

LOCKYER, J. N. 1901. An attempt to ascertain the date of the original construction of Stonehenge from its orientation. *Nature* 65:55–57.

———. 1902. The farmers' years. *Nature* 65:248–49.

———. 1905. Notes on Stonehenge. *Nature* 71:297–300, 345–48, 367–68, 391–93, 535–38; 73:153–55.

———. 1906*a*. Some questions for archeologists. *Nature* 73:280–82.

———. 1906*b*. Notes on some Cornish circles. *Nature* 73:366–68, 561–63.

———. 1965. *Dawn of astronomy.* (Reprint.) Cambridge: M.I.T. Press.

LOCKYER, J. N., and F. C. PENROSE. 1901. An attempt to ascertain the date of the original construction of Stonehenge from its orientation. *Proceedings of the Royal Society, London* 69:137–47.

LOMAX, ALAN. 1968. *Folk song style and culture.* Washington: American Association for the Advancement of Science.

LUNIN, B. V. 1924. The dolmens of the Black Sea region. *Materialy po arkheologiya Yugo-Vostoka Rossii* 1:1–28.

———. 1936. The archaeological explorations on the Black Sea shore of the Causasus in 1923–24. *Byulleten' Severo-Kavkazskogo byuro Kraevedeniya* 3–4.

MAASS, ALFRED. 1920–21. Sterne und Sternbilder im Malaiischen Archipel. *Zeitschrift für Ethnologie* 52:38–63.

———. 1924–26. Sternkunde und Sterndeuterei im Malaiischen Archipel. *Tijdschrift Bataviaasch Genootschap* 64:1–172, 347–461.

———. 1926. Astrologische Kalender der Balinezen. *Feestbundel Koninklijk Bataviaasch Genootschap* 2:26.

———. 1933. Die Sterne im Gauben der Indonesier. *Zeitschrift für Ethnologie* 65:264–303.

MACKIE, EUAN W. 1968. Stone circles: For savages or savants? *Current Archaeology* 11:279–83.

———. 1969. *An archaeological view of Neolithic astronomy.* Glasgow: Hunterian Museum. (Reprint of paper presented at a conference on stone circles and henge monuments, Glasgow, November 29.)

———. 1971*a*. Archaeoastronomy: A review of *Megalithic lunar observatories,* by Alexander Thom (Oxford: Clarendon Press, 1971). *The Listener,* January 28.

———. 1971*b*. Prehistoric astronomy and Kintraw. *University of Glasgow Gazette* 66:8–9.

———. 1971*c*. Comment on the current state of the evidence for the human or natural origin of the stone platform at Kintraw. MS.

MACWHITE, EOIN. 1951. *Estudios sobre las relaciones atlánticas de la peninsula hispánica en la edad del bronce.* Seminario de Historia Primitiva del Hombre, Madrid, Disertaciones matritenses, 2.

———. 1956. On the interpretation of archaeological evidence in historical and sociological terms. *American Anthropologist* 58:3–25.

MAKEMSON, MAUDE W. 1938–39. Hawaiian astronomical concepts. *American Anthropologist* 40:370–83; 41:589–96.

———. 1941. *The morning star rises: An account of Polynesian astronomy.* New Haven: Yale University Press.

———. 1946. *The Maya correlation problem.* Vassar College Observatory, publ. no. 5.

MALLOWAN, M. E. L. 1965. The mechanics of ancient trade in Western Asia: Reflections on the location of Magan and Meluhha. *Iran* 3:1–7.

MARINATOS, SPYRIDON. 1939. The volcanic destruction of Minoan Crete. *Antiquity* 13:425–43.

MARKOVIN, V. I. 1969. "The study of the Caucasian dolmens," in *Arkheologicheskie otkrytiya 1968 r.* Moscow.

MARQUINA, I. 1951. *Arquitectura prehispánica.* México, D.F.: Instituto Nacional de Antropología e Historia.

———. 1960. *El templo mayor de México.* México, D.F.: Instituto Nacional de Antropología e Historia.

MARSHACK, A. 1964. Lunar notation on Upper Paleolithic remains. *Science* 146:743–45.

———. 1969. Polesini: A reexamination of the engraved Upper Paleolithic mobiliary materials of Italy by a new methodology. *Rivista de Scienze Prehistoriche* 24:219–81.

———. 1970*a*. "New techniques in the analysis and interpretation of Mesolithic notation and symbolic art." *Actes du Symposium International d'Art Préhistorique, Valcamonica, 1969.* Capo di Ponte: Centro di Studi Preistorici.

———. 1970*b*. Le bâton de commandement de Montgaudier (Charente): Réexamen au microscope et interprétation nouvelle. *L'Anthropologie* 74:321–52.

———. 1970*c*. The baton of Montgaudier. *Natural History* 74(3):56–63.

———. 1971. Bone markings indicate Ice Age notational system. *New York Times,* January 20.

———. 1972*a*. Cognitive aspects of Upper Paleolithic engraving. CURRENT ANTHROPOLOGY 13:445–61.

———. 1972*b*. *The roots of civilization: A study in prehistoric cognition.* New York: McGraw-Hill.

MARTIN, PAUL. 1971. The revolution in archaeology. *American Antiquity* 36:1–9.

MAUNDER, E. W. 1908. *The astronomy of the Bible.* London: T. S. Clark.

MEGGERS, BETTY, CLIFFORD EVANS, and EMILIO ESTRADA. 1965. *Early formative period of coastal Ecuador: The Valdivia and*

Machalilla phases. Smithsonian Contributions to Anthropology 1.
MELLAART, JAMES. 1967. *Çatal Hüyük, a Neolithic town in Anatolia*. New York: McGraw-Hill.
MENNEVÉE, R. 1960. Introduction à l'étude des monuments mégalithiques en Italie. *Société Préhistorique Française, Bulletin* 57:141–48.
MERBS, C. 1968. Burial patterns in the Canadian Arctic. Paper presented at the annual meeting of the Society for American Archaeology.
MERRITT, R. L. 1968. Velikovsky's cosmic catastrophe hypothesis refuted by megalithic sites in Britain and by ancient calendars. MS.
MERTZ, HENRIETTE. 1969*a*. "The Echenique plaque." *Akten des XXXVIII Internationalen Amerikanistenkongresses, Stuttgart-München*, vol. 1, pp. 479–84.
———. 1969*b*. "Carved statue at Tiwanaku." *Akten des XXXVIII Internationalen Amerikanistenkongresses, Stuttgart-München*, vol. 1, pp. 485–90.
MESNARD, H. 1949. Les noms arabes d'étoiles. *Ciel et Terre* 65:1–19, 70–79.
MILLON, RENE, BRUCE DREWITT, and JAMES A. BENNYHOFF. 1965. The Pyramid of the Sun at Teotihuacán: 1965 excavations. *Transactions, American Philosophical Society*, n.s., 55(6):1–93.
MINAKATA, K. 1919. Notes on Chinese associations with animals of the cardinal points and zodiacal divisions. *Journal of the Anthropological Society of Tokyo* 34:251–60.
MODE, H. 1944. *Indische Frühkulturen und ihre Beziehungen zum Westen*. Basel: Schwabe.
MOGHADAM, M. 1938. The Indo-European origins of the Iranian New Year festivals. Unpublished Ph.D. dissertation, Department of Oriental Languages and Literature, Princeton University, Princeton, N.J.
MONOD, T. 1938. *Contributions à l'étude du Sahara occidental: Gravures, peintures et inscriptions rupestres*. Paris: Larose.
———. 1963. Le ciel austral et l'orientation. *Bulletin de l'Institut Français d'Afrique Noire* 25:415–26.
MORAN, HUGH, and DAVID KELLEY. 1969. *The alphabet and the ancient calendar signs*. Palo Alto: Bell's College Bookstore.
MORI, F. 1964. "Some aspects of the rock art of the Acacus (Fezzan Sahara) and data regarding it," in *Prehistoric art of the western Mediterranean and the Sahara*. Edited by L. Pericot-García and E. Ripoll Perelló, pp. 225–51. Viking Fund Publications in Anthropology 39.
MORISON, SAMUEL ELIOT. 1971. *The European discovery of America. Vol. 1. The northern voyages A.D. 500 to 1600*. London: Oxford University Press.
MORLEY, S. G. 1956. 3d edition, revised by G. W. Brainerd. *The ancient Maya*. Stanford: Stanford University Press.
MORROW, J. 1915. Carles, Keswick, Cumberland. *Transactions of the Cumberland and Westmoreland Archaeological Society* 15:99–111.
MUGLER, CHARLES. 1963. "Grèce," *Dictionnaire archéologique des techniques*. Edited by Madeleine Burke et al., pp. 99–100. Paris: Editions de l'Accueil.
MULLER, ROLF. 1936. Kritische Bemerkungen zur vorgeschichtlichen Sternkunde. *Mannus* 28:95–98.
———. 1970. *Der Himmel über dem Menschen der Steinzeit*. New York: Springer.
NAKAMURA, K. 1930. On the ancient tomb at the time of the Korean era by the study of mural constellations (in Japanese). *Archaeological Manuscripts* 4:374–401. (Reprint in Peabody Museum Library, Harvard University, Cambridge, Mass.)
NAKAYAMA, SHIGERU. 1969. *A history of Japanese astronomy: Chinese background and Western impact*. Cambridge: Harvard University Press.
Nature. 1970. Breton origin for tombs. 228:1019–20.
NEEDHAM, JOSEPH. 1959. *Science and civilisation in China. Vol. 3, sec. 20: Astronomy*. London: Cambridge University Press.
NEUGEBAUER, O. 1937. *Tafeln zur astronomischen Chronologie*. Leipzig.
———. 1942*a*. Egyptian planetary texts. *American Philosophical Society, Transactions* 32:209–50.
———. 1942*b*. The origin of the Egyptian calendar. *Journal of Near Eastern Studies* 1:396–403.
———. 1942*c*. On some astronomical papyri and related problems of ancient geography. *American Philosophical Society, Transactions* 32:251–63.
———. 1945. The history of ancient astronomy: Problems and methods. *Journal of Near Eastern Studies* 4:1–38.
———. 1952. Tamil astronomy. *Osiris* 10:252–76.
———. 1954. "Ancient mathematics and astronomy," in *A history of technology*. Edited by Charles Singer, vol. 1, pp. 785–803. Oxford: Oxford University Press.
———. 1957. 2d edition. *The exact sciences in antiquity*. Providence: Brown University Press.
———. 1962. Astronomical papyri and ostraca: Bibliographical notes. *Proceedings of the American Philosophical Society* 106:383–91.
———. 1963. The survival of Babylonian methods in the exact sciences of antiquity and the Middle Ages. *Proceedings of the American Philosophical Society* 107:528–35.
———. 1964. Notes on Ethiopic astronomy. *Orientalia* 33:49–71.
———. 1965. The Egyptian "decans." *Vistas in Astronomy* 6:47–50.
———. 1967. Problems and methods in Babylonian mathematical astronomy. *Astronomical Journal* 72:964–72.
———. 1971*a*. An Arabic version of Ptolemy's *Parapegma* from the "Phaseis." *Journal of the American Oriental Society* 91:506.
———. 1971*b*. On a fragment from a planetary table. *Zeitschrift für Papyrologie und Epigraphik* 7:267–74.
———. 1972. On some aspects of early Greek astronomy. *Proceedings of the American Philosophical Society* 116. In press.
NEUGEBAUER, O., V. DE FALCO, and M. KRAUSE. 1966. *Hypsikles, Die Aufgangszeiten der Gestirne*. Abhandlungen der Akademie der Wissenschaften in Göttingen, Philologisch-Historisch Klasse, 3(62).
NEUGEBAUER, O., and R. A. PARKER. 1964. *Egyptian astronomical texts. II*. Providence: Brown University Press.
———. 1969. *Egyptian astronomical texts. III*. Providence: Brown University Press.
NEUGEBAUER, O., and A. SACHS. 1968–69. Atypical astronomical cuneiform texts. *Journal of Cuneiform Studies* 21:183–218; 22:92–113.
NEUGEBAUER, O., and H. B. VAN HOESEN. 1959. *Greek horoscopes*. Philadelphia: American Philosophical Society.
NEWHAM, C. A. 1964. *The enigma of Stonehenge and its astronomical and geometrical significance*. Privately printed.
———. 1966. Stonehenge: A Neolithic "observatory." *Nature* 211:456–58.
———. 1968. A re-appraisal of the Stonehenge astro-archaeological controversy. MS.
———. 1970. *Supplement to The enigma of Stonehenge and its astronomical and geometrical significance*. Leeds: John Blackburn.
NIEL, FERNAND. 1961. 2d edition. *Dolmens et menhirs*. Paris: Presses Universitaires de France.
———. 1970. *La civilisation des mégalithes*. Paris: Plon.
NILSSON, MARTIN M. P. 1920. *Primitive time-reckoning*. Lund: C. W. K. Gleerup.
NINKOVICH, DRAGOSLAV, and BRUCE C. HEEZEN. 1965. Santorini tephra. *Colston Papers* 7:413–59.
NORIEGA, RAÚL. 1954. *La piedra del sol y 16 monumentos astronómicos del México antiguo, simbolos y claves*. México: Editorial Superación.
———. 1956. Registry of eclipses of the sun found on two monuments of ancient Mexico. Preliminary information to the 5th International Congress of Anthropological and Ethnological Sciences, Philadelphia.
———. 1958. Desciframientos de inscripciones ciclográficas del México antiguo. México: Conferencia en la Asociación Mexicana de Periodistas.
NUTTALL, Z. 1888. New Year of tropical American indigenes: The New Year festival of the ancient inhabitants of tropical America and its revival. *Pan-American Union, Bulletin* 62:67–73.
———. 1906. "The astronomical methods of ancient Mexicans," in *Boas Anniversary Volume*, pp. 290–99. New York: Stechert.
O'CONNELL, F. W., and R. M. HENRY. Editors. 1915. *An Irish corpus astronomiae*. London: David Nutt.
OLCOTT, WILLIAM TYLER. 1936. *Star lore of all ages*. New York: Putnam.
ORTEGO Y FRÍAS, TEÓGENES. 1951. Las estaciones de arte rupestre en el monte Valonsadera de Soria. *Celtiberia* 2:275–305.
———. 1953. "Nuevos grupos de pinturas rupestres en el término de Soria." *III Congreso Arqueológico Nacional, Zaragoza*.
———. 1957. "Bronce atlántico en territorio soriano." *IV Congreso Arqueológico Nacional, Zaragoza*, pp. 113–22.
———. 1960. Excavaciones arqueológicas de la Provencia de Soria. *Caesaraugusta* 15–16:107–32.
———. 1956–61. *Noticiario arqueológico hispánico*. Madrid: Ministerio de Educación Nacional.
———. 1962. "Un nuevo abrigo con pinturas rupestres en el término de Pedrajas de Soria: La cueva de 'El Prado de Santa Maria.'" *VII Congreso Arqueológico Nacional*.
———. 1963. Las pinturas rupestres de El Portalón, en el término de Villacadima (Guadalajara). *Ampurias* 25.
———. 1965. *Val de Caballos, nueva estación de arte rupestre esquemático en el término de Soria*. Barcelona: Deputación Provencial.
OVENDEN, MICHAEL W. 1966. The origin of the constellations. *Philosophical Journal* 3(1):1–18.
OWEN, NANCY KELLEY. 1972. *Astronomical events on the dates of the Dresden Codex*. Encinitas: San Dieguito Pressmen Association.
ÖZGÜÇ, TAHSIN. 1963. An Assyrian trading outpost. *Scientific American* 208:96–102.
PANNEKOEK, A. 1961. *A history of astronomy*. New York: Barnes and Noble.
PARKER, RICHARD A. 1950. *The calendars of ancient Egypt*. Chicago: University of Chicago Press.
PARPOLA, ASKO. 1970. *The Indus script decipherment: The situation at the end of 1969*. Copenhagen: Scandinavian Institute of Asian Affairs. (Reprinted from *Journal of Tamil Studies* 2:89–109.)
PARSONS, ELSIE CLEWS. 1936. *Taos Pueblo*. Menasha, Wisc.: General Series in Anthropology.

———. 1939*a*. *Pueblo Indian religion*. Chicago: University of Chicago Press.
———. 1939*b*. Picuris, New Mexico. *American Anthropologist* 41:206–22.
PAYNE-GAPOSCHKIN, CECILIA, and KATHERINE HARAMUNDANIS. 1970. *Introduction to astronomy*. Englewood Cliffs: Prentice-Hall.
PEET, S. D. 1894. Solstitial orientation. *American Antiquarian* 16:250–52.
———. 1901. Stone circles in Europe and America. *American Antiquarian* 23:371–76.
PEREDOLSKAYA, A. A. 1958. On the question of the chthonic Hercules cult in the Bosphorus. *Trudy gos. Ermitazha* 2:55–61.
PERICOT GARCÍA, LUIS, and E. RIPOLL PERELLÓ. Editors. 1964. *Prehistoric art of the western Mediterranean and the Sahara*. Viking Fund Publications in Anthropology 39.
PETERS, C. H. F., and E. B. KNOBEL. 1915. Editors. Revised edition. *Catalogue of stars, by Claudius Ptolemaeus*. New York: Kraus.
PETRI, WINFRED. 1967. Tibetan astronomy. *Vistas in Astronomy* 9:159–64.
PHILLIPS, PHILIP. 1966. "The role of trans-Pacific contacts in the development of New World pre-Columbian civilizations," in *Handbook of Middle American Indians*, vol. 4, pp. 296–315.
PIGGOTT, STUART. 1956. Architecture and ritual in megalithic monuments. *Journal of the Royal Institute of British Architecture* 63:175.
———. 1968. *The Druids*. New York: Praeger.
PINCHES, THEOPHILUS G., et al. Editors. 1955. *Late Babylonian astronomical and related texts*. Providence: Brown University Press.
POGO, ALEXANDER. 1930. The astronomical ceiling-decoration in the Tomb of Senmut. *Isis* 14:301–25.
———. 1931. Zum Problem der Identifikation der nördlichen Sternbilder der alten Aegypter. *Isis* 16:102–14.
———. 1932. Calendars on coffin lids from Asyut (Second half of the third millennium). *Isis* 17:6–24.
POHORECKY, ZENON S. 1969. "Rupestral art in the Pre-Cambrian Shield of Canada." *Akten des XXXVIII Internationalen Amerikanistenkongresses, Stuttgart-München*, vol. 1, pp. 103–8.
POLANYI, K. 1963. Ports of trade in early societies. *Journal of Economic History* 23:30–45.
POLLOCK, H. E. D. 1939. *Round structures of aboriginal Middle America*. Carnegie Institution of Washington publ. 471.
Popol Vuh: The Sacred Book of the Ancient Quiche Maya. 1950. English version by Delia Goetz and Sylvanus G. Morley from the translation of Adrian Recinos. Norman: University of Oklahoma Press.
PORTER, LUCIUS C. 1950. Climate, calendar and philosophy in ancient China, suggested relationships. *Yenching Journal of Social Studies* 5:143–56.
POSNANSKY, ARTHUR. 1942. Los conocimientos astronómicos de los constructores de Tihuanacu y su aplicación en el templo del sol para la determinación exacta de las fechas agrícolas. *Sociedad Geográfica de La Paz, Bulletín* 64:40–49.
PRESCOTT, WILLIAM H. 1843. *History of the conquest of Mexico*. Vol. 1. New York.
PROSKOURIAKOFF, TATIANA. 1952. The survival of the Maya *tun* count in colonial times. *Notes on Middle American Archaeology and Ethnology* 4:211–19.
RAO, S. R. 1965. Shipping and maritime trade of the Indus people. *Expedition* 7(3):30–37.
RAUH, JAMES H. 1971. Tentative reconstruction of the Peruvian calendar system. Paper read at the 36th annual meeting of the Society for American Archaeology, Norman, Okla., May 8.
REICHE, MARIA. 1968. *Mystery on the desert*. Stuttgart: Reiche.
———. 1969. "Giant ground-drawings on the Peruvian desert." *Akten des XXXVIII Internationalen Amerikanistenkongresses, Stuttgart-München*, vol. 1, pp. 379–84.
REICHLEN, R. 1963. "Amerique du Sud," in *Dictionnaire archéologique des techniques*. Edited by Madeleine Burke et al., pp. 90–91. Paris: Editions de l'Accueil.
REKO, B. P. 1935–39. Star-names of the Chilam Balam of Chumayel. *El México Antiguo* 3(9–10):1–52; 3(11–12):12–84; 4(1–2):21–67; 4(3–4):95–129; 4(5–6):63–78; 4(7–8):255–85.
RENFREW, COLIN. 1968. Wessex without Mycenae. *Annual of the British School of Archaeology at Athens* 63:277–85.
———. 1970*a*. New configurations in Old World archaeology. *World Archaeology* 2:199–211.
———. 1970*b*. The tree-ring calibration of radiocarbon: An archaeological evaluation. *Proceedings of the Prehistoric Society* 36:280–311.
———. 1970*c*. Revolution in prehistory. *The Listener* 84:897–901.
REYMAN, JONATHAN E. 1971*a*. Astroarchaeology in the Anasazi area. Paper read at the 36th annual meeting of the Society for American Archaeology, Norman, Okla., May 8.
———. 1971*b*. Mexican influence on Southwestern ceremonialism. Unpublished Ph.D. dissertation, Southern Illinois University, Carbondale, Ill. (Ann Arbor: University Microfilms.)
REYMAN, JONATHAN E., and FRANK C. SANDERS, JR. 1972. Archaeoastronomy: How to do it. MS.
RICHER, JEAN. 1967. *Géographie sacrée du monde Grec, croyances astrales des anciens Grecs*. Paris: Librairie Hachette.
RICKETSON, OLIVER G., JR. 1928. Astronomical observatories in the Maya area. *Geographical Review* 18:215–25.
RICKETSON, OLIVER G., JR., and EDITH B. RICKETSON. 1937. *Uaxactun, Guatemala: Group E—1926–1931*. Appendices by Monroe Amsden, A. Ledyard Smith, H. E. D. Pollock. Carnegie Institution of Washington, publ. 477.
RILEY, CARROLL L., J. CHARLES KELLEY, CAMPBELL W. PENNINGTON, and ROBERT L. RANDS. 1971. *Man across the sea: Problems of pre-Columbian contacts*. Austin and London: University of Texas Press.
ROBINSON, J. H. 1970. Sunrise and moonrise at Stonehenge. *Nature* 225:1236–37.
RÖCK, FRITZ. n.d. Die Götter der 7 Planeten im alten Mexiko und die Frage eines alten Zusammenhanges Toltekischer Bildung mit einem altweltlichen Kultursystem. *Anthropos*.
———. 1919. Der Palaeozodiakus. *Memnon* 6:147–76.
———. 1922. Kalender, Sternglaube und Weltbilder der Tolteken als Zeugen verschollener Kulturbeziehungen zur Alten Welt. *Anthropologische Gesellschaft Wien* 52:43–136.
ROY, A. E., N. MCGRAIL, and R. CARMICHAEL. 1963. A new survey of the Tormore circle. *Transactions of the Glasgow Archaeological Society* 15(pt.2):59–67.
RUPPERT, KARL. 1935. *The Caracol at Chichén Itzá, Yucatan, Mexico*. Carnegie Institution of Washington, publ. 454.
SABATER, J. 1953. "El curso del año entre los fang-ntumu y sus conocimientos astronómicos." *Conférence Internationale des Africanistes de l'Ouest, Cinquième, Abidjan, Transactions*, pp. 144–45.
SACHS, A. J. 1955. *Late Babylonian astronomical and related texts*. Copied by T. G. Pinches and J. N. Strassmaier. Providence: Brown University Press.
———. 1970. Absolute dating from Mesopotamian records. *Philosophical Transactions of the Royal Society of London*, ser. A, 269(1193).
SADLER, D. H. 1966. Prediction of eclipses. *Nature* 211:1120.
SAINTYVES, P. 1934. *Corpus du folklore préhistorique dans la France et dans les colonies françaises*. Vol. 2. Paris.
SARTON, G. 1927–48. *Introduction to the history of science*. Baltimore: Williams and Wilkins.
SAVARY, J. P. 1966. Étude théorique et statistique sur l'orientation des monuments funéraires à structure d'accès rectiligne. *Société Préhistorique Française, Bulletin* 63:365–94.
SAVILLE, M. H. 1909. "The cruciform structures of Mitla and vicinity," in *Putnam Anniversary Volume*, pp. 151–90. New York: Stechert.
———. 1929. Astronomical observations in ancient Mexico. *Indian Notes* 6:79–81.
SAXE, ARTHUR A. 1971. "Social dimensions of mortuary practices in a Mesolithic population from Wadi Halfa, Sudan," in *Approaches to the social dimensions of mortuary practices*. Edited by James A. Brown, pp. 39–57. Memoirs of the Society for American Archaeology 25 (American Antiquity 36[3, pt. 2]).
SCHLEGEL, G. 1875. *Uranographie chinoise*. Leiden, The Hague.
SCHMIDT, OLAF H. 1944. The computation of the length of daylight in Hindu astronomy. *Isis* 35:205–11.
SCHOVE, D. J. 1970. Astro-archaeology Symposium. *Journal of the British Astronomical Association* 80:382.
SCHRIMPF, R. "Far East," in *Dictionnaire archéologique des techniques*. Edited by Madeleine Burke et al., pp. 91–92. Paris: Editions de l'Accueil.
SCHROEDER, A. 1965. Unregulated diffusion from Mexico into the Southwest prior to A.D. 700. *American Antiquity* 30:297–309.
———. 1966. Pattern diffusion from Mexico into the Southwest after 600. *American Antiquity* 31:683–704.
SCHULMAN, ALBERT. 1950. Pre-Columbian towers in the Southwest. *American Antiquity* 15:288–97.
SCHULZ, RAMÓN P. C. 1933. Zur Korrelation des Mayakalendars mit der europäischen Zeitrechnung. *Zeitschrift für Ethnologie* 65:396–99.
———. 1936. Beiträge zur Chronologie und Astronomie des alten Zentralamerika. *Anthropos* 31:758–88.
———. 1941. "Apuntes sobre algunas fechas del Templo de la Cruz de Palenque y sobre astronomía y cronología de los antiguos Mayas." *27. Congreso Internacional de Americanistas, México 1939*, pp. 352–55.
———. 1944. Los sistemas cronológicos de los libros del Chilam Balam (con traduciones de Alfredo Barrera Vásquez). *El México Antiguo* 6:239–60.
———. 1962. "El año solar de los antiguos Mayas y algunos otros cómputos astronómicos de los mismos." *35. Congreso Internacional de Americanistas, México*, pp. 45–46.
———. 1964. Algunos problemas de la astronomía maya. *Estudios de Cultura Maya* 4:261–66.
———. 1967. Acerca de las fechas en el Templo del Sol y en el Templo de la Cruz Enramada de Palenque. *Boletín del Centro de Investigaciones Antropológicas de*

México 14:16–19.
———. 1968. Über den Nullpunkt des "Maya Long Counts" und die astronomischen Inschriften in Palenque. *Zeitschrift für Ethnologie* 93:157–61.
SCHUSTER, MEINHARD. 1960. Zur Diskussion des Megalithproblems. *Paideuma* 7:133–41.
SCHWARZ, H. F. 1925. Eclipses as interpreted by the American aborigines. *Natural History* 25:162–65.
SEBILLOT, PAUL. 1968. *Le folklore de la Bretagne*. Paris: G. P. Maison Neuve et Larose.
SENGUPTA, P. C. 1929. Āryabhaṭa, the father of Indian epicyclic astronomy. *Calcutta University, Department of Letters, Journal* 18(3):1–58.
———. 1931. Greek and Hindu methods of spherical astronomy. *Calcutta University, Department of Letters, Journal* 21(4):1–25.
SHAFER, ROBERT. 1954. *Ethnograph of ancient India*. Wiesbaden: Otto Harrassowitz.
SHCHEPINSKY, A. A. 1963. The monuments of art of the Early Metal epoch in the Crimea. *Sovetskaya Arkheologiya* 2:38–47.
SHORTO, H. L. 1963. The 32 *myos* in the medieval Mon kingdom. *Bulletin of the School of Oriental and African Studies, University of London* 26:572–91.
SIMONEAU, A. 1968. Recherches sur les gravures rupestres du Haut-Atlas marocain. *Société Préhistorique Française, Bulletin* 65:642–53.
SIVERAMA MENON, CHERUBALA PATHAYPURA. 1932. *Early astronomy and cosmology*. London: Allen and Unwin.
SKELTON, R. A. 1963. *Theatrum orbis terrarum Claudius Ptolemaeus*. Amsterdam: N. Israel.
SLACK, LENA. 1962. *Rock engravings from Driekops Eiland*. New York: Archer House.
SMILEY, CHARLES H. 1960*a*. A new correlation of the Mayan and Christian calendars. *Nature* 188:215–16.
———. 1960*b*. The antiquity and precision of the Mayan calendar. *Journal, Royal Astronomical Society of Canada* 54:222–26.
———. 1961. Bases astronómicas para una nueva correlación entre los calendarios maya y cristiano. *Estudios de Cultura Maya* 1:237–42.
———. 1962. *The Mayan calendar*. Publication of the Astronomical Society of the Pacific, Leaflet 392.
———. 1963. Radio-carbon dates and the Mayan correlation problem. *Nature* 199:473–74.
———. 1964. Interpretación de dos ciclos en el códice de Dresden. *Estudios de Cultura Maya* 4:257–60.
———. 1965*a*. Solar eclipse intervals in the Dresden Codex. *Journal, Royal Astronomical Society of Canada* 59:127–31.
———. 1965*b*. Orientation by sextant and sun. *Publication of the Astronomical Society of the Pacific* 77:241–45.
———. 1967. A possible periodicity of hurricanes. *Cycles* 18:283–85.
———. 1968*a*. Stationary conjunctions and near-conjunctions of Jupiter and Saturn. *Journal, Royal Astronomical Society of Canada* 62:181–84.
———. 1968*b*. Serpent dates in the Dresden Codex. *Estudios de Cultura Maya* 8:1.
———. 1971. Astronomical errors made by Mayan experts. Paper read at the 36th annual meeting of the Society for American Archaeology, Norman, Okla., May 8.
SMILEY, CHARLES H., and EUGENIA ROBINSON. 1969. *The sky on zero day of the Mayan calandar*. Providence: Ladd Observatory, Brown University.
SOMERVILLE, B. T. 1909*a*. Drombeg, Cork. *Journal of the Cork Historical and Archaeological Society* 15:105–8.
———. 1909*b*. Ancient stone monuments near Lough Swilly, County Donegal. *Journal of the Royal Society of Antiquities of Ireland* 39:192–202, 215–33, 343–49.
———. 1912. Astronomical indications in the megalithic monument at Callanish. *Journal of the British Astronomical Association* 23:83.
———. 1922. Megaliths and astronomy. *Man* 22:art. 77.
———. Instances of orientation in prehistoric monuments of the British Isles. *Archaeology* 73:193–224.
———. 1925. The stones of Stonehenge. *Man* 25:art. 45.
———. 1927. Orientation. *Antiquity* 1:31–41.
———. 1929. Culdaff stone circle, Ireland. *Journal of the Royal Society of Antiquities of Ireland* 59:152–54.
———. 1930. Five stone circles of West Cork. *Journal of the Cork Historical and Archaeological Society* 35:70–85.
SOUVILLE, GEORGES. 1965. "Influences de la péninsule Ibérique sur les civilisations postnéolithiques du Maroc," in *Prehistoric art of the western Mediterranean and the Sahara*. Edited by L. Pericot García and E. Ripoll Perelló. Viking Fund Publications in Anthropology 39.
SPINDEN, HERBERT. 1940. *Sun worship*. Washington: U.S. Government Printing Office.
SPOER, H. HENRY. 1938. Arabid magic bowls II: An astrological bowl (with illustrations). *Journal of the American Oriental Society* 58:366.
STAHL, WILLIAM HARRIS. 1953. *Ptolemy's geography: A select bibliography*. New York: New York Public Library.
STARR, RICHARD. 1941. *Indus Valley painted pottery*. Princeton: Princeton University Press.
STEPHEN, ALEXANDER. 1936. *Hopi journal*. Edited by Elsie Clews Parsons. New York: Columbia University Press.
STEPHEN, P. 1915. Vorgeschichtliche Sternkunde und Zeiteinteilung. *Mannus* 7:213–48.
STEVENSON, MATILDA COXE. 1904. The Zuni Indians: Their mythology, esoteric fraternities, and ceremonies. *47th Annual Report of the Bureau of American Ethnology*.
STIMSON, J. FRANK. 1928. Tahitian names for the nights of the moon. *Journal of the Polynesian Society* 37:325–37.
STIRLING, MATTHEW W. 1945. Concepts of the sun among American Indians. *Smithsonian Institution, Annual Report,* pp. 387–400.
STUCKEN, EDUARD. 1913. *Der Ursprung des Alphabets und die Mondstationen*. Leipzig: J. C. Hinrichs'.
STUIVER, M., and H. E. SUESS. 1965. On the relationship between radiocarbon dates and true sample ages. *Radiocarbon* 8:534.
SUESS, H. E. 1967. "Bristlecone pine calibration of the radiocarbon time scale from 4100 B.C. to 1500 B.C.," in *Radiocarbon dating and methods of low-level counting*. Vienna: International Atomic Energy Agency.
TATON, RENÉ. 1963. *Ancient and medieval science*. Translated by A. J. Pomerans. New York: Basic Books.
TAYLOR, DOUGLAS. 1946. Notes on the star lore of the Caribbees. *American Anthropologist* 48:215–22.
TAYLOR, E. G. R. 1957. *The haven-finding art: A history of navigation from Odysseus to Captain Cook*. New York: Abelard-Schuman.
THIBAUT, G. 1854. On the hypotheses of the Babylonian origin of the so-called lunar zodiac. *Asiatic Society of Bengal* 63:144–63.
THIERENS, A. E. 1935. *Astrology in Mesopotamian culture*. Leiden: E. J. Brill.
THOM, A. 1954. The solar observatories of megalithic man. *Journal of the British Astronomical Association* 64:397.
———. 1955. A statistical examination of the megalithic sites in Britain. *Journal of the Royal Statistical Society* 118(pt. 3):275–95.
———. 1961. The egg-shaped standing stone rings of Britain. *Archives of the Institute for Historical Sciences* 14:291(2).
———. 1962. The megalithic unit of length. *Journal of the Royal Statistical Society* 125:243–51.
———. 1964*a*. Megalithic geometry in standing stones. *New Scientist*, March 12.
———. 1964*b*. Observatories in ancient Britain. *New Scientist*, July 2.
———. 1964*c*. The larger units of length of megalithic man. *Journal of the Royal Statistical Society* 127:527–33.
———. 1966*a*. Megalithic astronomy: Indications in standing stones. *Vistas in Astronomy* 7:1–57.
———. 1966*b*. Megaliths and mathematics. *Antiquity* 40:121–28.
———. 1967. *Megalithic sites in Britain*. Oxford: Clarendon Press.
———. 1968. The metrology and geometry of cup and ring marks. *Systematics* 6:173–85.
———. 1969*a*. The lunar observatories of megalithic man. *Vistas in Astronomy* 11:1–29.
———. 1969*b*. Geometry of cup-and-ring marks. *Transactions of the Ancient Monuments Society* 10:77–89.
———. 1970*a*. The megaliths of Carnac. *The Listener* 84:900–901.
———. 1970*b*. Observing the moon in megalithic times. *Journal of the British Astronomical Association* 80:93–99.
———. 1971. *Megalithic lunar observatories*. Oxford: Clarendon Press.
THOM, A., and A. S. THOM. 1971. The astronomical significance of the large Carnac menhirs. *Journal for the History of Astronomy* 2(3):147–60.
———. 1972. The Carnac alignments. *Journal for the History of Astronomy* 3(1):11–26.
THORNDIKE, LYNN. 1938. Astronomy according to the Jews. *Isis* 29:69–71.
TOMPKINS, PETER. 1971. *Secrets of the Great Pyramid*. With an appendix by Livio Catullo Stecchini. New York: Harper and Row.
THOMPSON, J. F. S. 1971. *A commentary on the Dresden Codex, a Maya hieroglyphic book*. Philadelphia: American Philosophical Society.
Times Literary Supplement. 1970. The moon and megaliths. No. 3,614:633–35.
TOOKER, ELISABETH. 1970. *The Iroquois ceremonial of midwinter*. Syracuse: Syracuse University Press.
TOSI, MAURIZIO. 1971. Review of: *Looking for Dilmun*, by Geoffrey Bibby (New York: Knopf, 1969).
TOULMÉ, STEPHEN, and JUNE GOODFIELD. 1966. *The discovery of time*. London: Hutchinson.
TRETIAKOV, P. N., and A. L. MONGAIT. 1961. *Contribution to the ancient history of the U.S.S.R., with special reference to Transcaucasia*. Translated by Vladimir M. Maurin. Edited by Henry Field and Paul Tolstoy. Cambridge: Peabody Museum.
TUMANYAN, BENIK E. 1967. On the history of Armenian astronomy. *Vistas in Astronomy* 9:253–59.
VAN DEN BERGH, G. 1954. *Eclipses, −1600 to −1207*. Holland: Tjeenk, Willink and Zoon.
VAN DER WAERDEN, B. L. 1949. Babylonian astronomy II. The thirty-six stars. *Journal*

of *Near Eastern Studies* 8:6–26.
———. 1952. History of the zodiac. *Archiv für Orientforschung* 116:216–30.
———. 1963. "Basic ideas and methods in Babylonian and Greek astronomy," in *Scientific change.* Edited by A. C. Crombie. London: Heinemann.
VAN LOON, MAURITS. 1971. Review of: *Sredeniaia asiia i drevnii vostoki* (Central Asia and the ancient Orient), by Badim Mikhailovich Masson (Moscow and Leningrad: Instituta Arkheologii, Akademiia Nauk SSSR, 1964). *Journal of the Near Eastern Studies* 30:229–32.
VERCOUTTER, J. 1963. "Egypte," in *Dictionnaire archéologique des techniques.* Edited by Madeleine Burke et al., pp. 97–99. Paris: Editions de l'Accueil.
VON OPPENHEIM, BARON MAX. 1933. *Tell Halaf.* New York: G. P. Putnam's Sons.
VON WINNING, HASSO. 1959. A decorated bone rattle from Culhuacán, Mexico. *American Antiquity* 25:86–93.
WALLENQUIST, AKE. 1970. *Dictionary of astronomical terms.* Cambridge: Sky.
WASLEY, WILLIAM, and ALFRED JOHNSON. 1965. *Salvage archaeology in the Painted Rocks reservoir, Western Arizona.* Anthropological Papers of the University of Arizona 9.
WASSEF, C. W. 1971. Le calendrier copte de l'antiquité à nos jours. *Journal of Near Eastern Studies* 30:1–48.
WATSON, G. 1900. *The Long Meg druidical circle near Penrith, Cumberland, a suggested theory of its geometrical construction, and adaptation to sun worship.* Privately printed.
WATTENBERG, FEDERICO. 1963. *Las cerámicas indígenas de Numancia.* Madrid: Instituto Español de Préhistoria.
WEBER, RICHARD. 1961. Investigación del cielo maya por medio de un planetario. *Estudios de Cultura Maya* 1:243–59.
WEDEL, WALDO. 1967. The Council Circles of Central Kansas: Were they solstice registers? *American Antiquity* 32:54–63.
WEINSTOCK, S. 1950. Lunar mansions and early calendars. *Journal of Hellenic Studies* 69:48–69.
WEITZEL, R. B. 1948. An astronomical test of Caso's correlation. *American Antiquity* 13:323.
———. 1950. Mexican manuscripts and solar eclipses. *Revista Méxicana de Estudios Anthropológicos* 11:5–13.
WELTFISH, GENE. 1965. *Lost universe.* New York: Basic Books.
WENSINCK, A. J. 1921. Tree and bird as cosmological symbols in Western Asia. *Proceedings Koninklijke Akademie van Wetenschappen te Amsterdam* 22(1):1–56.
WISSLER, C., and H. J. SPINDEN. 1916. The Pawnee human sacrifice to the Morningstar. *American Museum Journal* 16:49–56.
WITTHOFT, JOHN. 1946. Cayuga midwinter festival. *New Folklore Quarterly* 2:24–39.
WITTKOWER, R. 1938. Eagle and serpent: A study in the migration of symbols. *Journal of the Warburg Institute* 2:289.
WITTRY, WARREN L. 1964. An American Woodhenge. *Cranbrook Institute of Science News Letter* 33(9):102–7.
———. 1970*a*. "The American Woodhenge," in *Exploration into Cahokia archaeology.* Edited by Melvin Fowler, pp. 47–48. Illinois Archaeological Survey Bulletin 7.
———. 1970*b*. An American Woodhenge. *Explorer* 12(4):14–17.
WORTH, R. H. 1953. *The stone rows of Dartmoor.* Dartmoor.
WRIGHT, E. V., and E. M. CHURCHILL. 1965. The boats from North Ferriby, Yorkshire, England. *Proceedings of the Prehistoric Society* 31.
ZAHAN, DOMINIQUE. 1951. Études sur la cosmologie des Dogon et des Bambara du Soudan Français: La notion d'écliptique chez les Dogon et les Bambara. *Africa* 21:13–20.
———. 1958. La notion d'écliptique chez les Bambara et les Dogon du Soudan Français. *Notes Africaines* 80:108–11.
ZERRIES, OTTO. 1952. Sternbilder als Ausdruck jägerischer Geistenhaltung in Südamerika. *Paideuma* 5:220–35.
ZINNER, ERNST. 1931. Die Sternbilder der alten Aegypter. *Isis* 16:92–101.
———. 1933. Die astronomischen Kenntnisse des Stern-Odde. *Mannus* 25:301–6.
ZUIDEMA, R. T. 1966. "El calendario inca." *XXXVI Congreso Internacíonal de Americanistas, Actas y Memorias*, vol. 2, pp. 24–30. Seville.
———. 1968. The Inca cosmological model applied to temple and city building. Paper read at the 38th International Congress of Americanists, Stuttgart-München.

Comments

by ANTHONY F. AVENI
Hamilton, N.Y., U.S.A. 15 III 73

As an astronomer with an interest in building orientations in Mesoamerica, I am hardly qualified to comment on all aspects of Baity's broad review article. It would appear that her energy, enthusiasm, and organizational ability have produced the largest bibliography of its kind in an interdisciplinary field which, as she suggests, has developed rapidly.

Baity's definition and use of astronomical terms are often unclear. Her use of the term "astra" (as in "astra phenomena") is confusing. A more established term like "celestial" would include sun, moon, and planets as well as stars. Baity's continued reference to the fire bull ritual in discussing the zodiac leaves unequal time for the other members of that celestial realm. Accordingly, the disucssion frequently is slanted in favor of her own research. Some of her statements are emphatic and undocumented and could invite more than a few dissenters (e.g., "The Maya codices have a heavy astronomical content"). Her strong beliefs about transoceanic migration give the impression that archaeoastronomy should set out to prove what we already know. Finally, Baity ought to discriminate more thoroughly between alignments measured with the transit (e.g., Thom's work) and those determined on the basis of the examination of site maps. Unfortunately, a plethora of falsehood permeates the literature because so many investigators have used erroneous site maps.

I strongly endorse Baity's suggestion for a bibliographic clearinghouse to further an exchange of papers, though I find her concept of the well-rounded, broadly educated archaeoastronomer a bit unreal. Rather, I see real progress in this new interdiscipline resulting from cooperation among professionals, each schooled in his own discipline. Since most of the existing professional societies are not broad enough to reach all who are interested, perhaps an organization such as the American Association for the Advancement of Science could serve as a preliminary meeting ground. The fact that Baity has made some misinterpretations by going far outside her field in producing the review only underlines the need for scholarly cooperation.

Obviously, Baity has spent countless hours in many libraries producing the review, and in spite of its aforementioned shortcomings her colleagues owe her a debt of gratitude for assembling the references, many of which have been long forgoten, and, ideally, for summoning together a new community of individuals.

by RAINER BERGER
Los Angeles, Calif., U.S.A. 1 III 73

The article by Baity is a very extensive review of a subject which has needed to be treated for some time. In fact, there exists a considerable body of information in the area of ethnoastronomy today that in itself could be used for another major article. In several continents of the world today, rituals are still practiced or astronomical events noted which are of significance to the everyday life of the natives involved.

In the interest of the best possible time placement, radiocarbon dates may be calibrated by a chart in Olsson (1970) based on various tree-ring measurements made in the La Jolla radiocarbon laboratory of the University of California under the direction of H. E. Suess. The tree-ring calibration obtained there by radiocarbon dating has been corroborated by a number of separate studies, one of which is based on the radiocarbon dating of historically well-dated specimens from the Middle Ages and ancient Egypt (Berger 1970).

There is obviously no question that prehistoric and protohistoric astronomical observatories were centers for ritual activity, yet we do not understand what the sequence of the evolution of these facilities was and whether or not they grew out of a very important practical need that later acquired ritual overtones and dominance.

Because of the size and antiquity of the larger megalithic facilities, they may serve as a check for plate tectonic studies. Careful studies of their orientation today and stellar alignments of the past might be correlated to yield such information.

Last but not least, it would be good to know why the megalithic observatories fell into disfavor and what replaced their astronomical function in later centuries.

by DAVID A. BRETERNITZ
Boulder, Colo., U.S.A. 20 III 73

To those of us unfamiliar with the obviously extensive literature on archaeoastronomy, Baity's compilation and documentation almost boggle the mind.

As an instructor for an undergraduate survey course in Old World archaeology, I find the detailed analysis of the Stonehenge debate very informative. Beyond this, the amount of data available and the possibilities for astronomically meaningful investigations are most thought-provoking.

In dealing with the interdisciplinary, but somewhat esoteric, subject matter, I can only contribute a couple of bibliographic items to the already long list of astronomically motivated actions of past peoples: There is a reference to the possible astronomical alignment of Sun Temple, in Mesa Verde National Park, Colorado, by Robinson (1961). Awareness of astronomical phenomena by the prehistoric Anasazi of the Southwest is noted by Miller (1955), who interprets certain rock-art panels as evidence of the observation of the supernova of the Crab Nebula, in A.D. 1054, an event also recorded by Chinese astronomers.

by GEOFFREY A. CLARK
Tempe, Ariz., U.S.A. 19 III 73

Baity is to be commended for attempting to review so vast a subject; however, I am left with the impression that she has bitten off more than she can chew. As a nonspecialist, I can offer only a few general comments; I will confine myself to the archaeological aspects of the paper.

First, I was struck by the uncritical inclusion of references and commentary only peripherally allied to archaeoastronomy (e.g., data from the American Southwest). Restriction of problem scope would have been in order; a preliminary consideration of important source material might have been preferable to the necessarily uneven "scatter-gun" approach adopted.

Second, many specific controversies outlined by Baity (e.g., Stonehenge) could have been resolved by a more rigorous application of scientific method. Evidently the field suffers more than most from a plethora of competing and alternative hypotheses. Once alternative hypotheses are statistically validated (i.e., once it is demonstrated that there is a low probability that the null hypothesis is true), they can successively be eliminated by the derivation of consequences. If the consequences hold for some validated hypotheses and not for others, given that the hypotheses are otherwise comparable on the criteria of parsimony and simplicity, then the spectrum of acceptable hypotheses is correspondingly reduced. This approach characterizes some of Thom's best work.

Third, while I acknowledge the pioneering role of Alexander Thom in paleometrological research, I continue to assert that mathematically derived prehistoric units of measurement can be carried to pragmatically absurd levels of precision (e.g., Thom's MY = 2.720 ± .003 ft.). It does not follow that "megalithic man" in fact employed such units. I suggest instead that he employed units, as we do, which only approximate some ideal standard (see my comment on Thom et al. in this issue). With regard to the promising new field of quantum mathematics, it should be borne in mind that quanta will almost always be derived; moreover, they tend to "fit" the data set from which the original measurements were taken. But it is the mathematical process which imparts the precision which Thom asserts characterizes ancient units of measurement (specifically, his megalithic yard). This precision is not demonstrably a feature of the units actually employed in antiquity.

Fourth, the demonstration of the existence of prehistoric "observatories" does not lie, as Baity asserts, in the exactitude of Thom's measurements (which evidently have been vigorously contested). The case seems to rest on a mass of fairly convincing circumstantial evidence which can, at any point, be contradicted in detail.

Fifth, the attempt to extend astronomical implications to a wide variety of megalithic monuments throughout western Europe (and beyond) seems extremely ill-advised in a survey article of this sort. Baity's often highly speculative comments are based mainly upon superficial impressions taken out of context. Such structures are certainly polygenetic and multifunctional. It is highly unlikely, on the face of it, that all megalithic constructions necessarily had astronomical functions. Nevertheless, I agree that the possibility should be investigated.

Sixth, the New World data with which I am familiar imply none of the astronomical regularities suggested by Baity. Except for Mesoamerica, and perhaps Peru, only the most tenuous links are discernible between architecture and astronomical phenomena; numerous alternative and more plausible interpretations are possible. The New World sections of the article are replete with arguments based upon "facts in isolation" which don't substantiate any systemic regularities (metrological, astronomical, or otherwise). These assertions depend upon trait associations. Association is among the weakest forms of relationship, in that it is dependent upon qualitative "presence/absence" data rather than upon more powerful quantitative measures of covariation. I had to remind myself constantly here that there is a big difference between the "possible" and the "probable." Many explanations are possible in the review presented, but no evaluation of probability (other than contestable assertions based upon appeals to "expert" opinion) is provided.

Seventh, the appeal to an outmoded and largely bankrupt diffusionist paradigm throughout much of the paper does much to discredit Baity's scrupulous research of the subject. To write of centers and widely shared cognitive "interpretations" of astronomical systems is extremely premature.

Finally, the assertion that patterns will emerge from data "when enough of it is assembled" is misleading. What constitutes patterning is determined ultimately by the paradigm under which the investigator is operating: change the paradigm, and you change the nature of the data and its consequent patterning. I mention this because of the preceding point. The archaeoastronomy paradigm seems obsolete, yet its methodology is sophisticated. Until the theoretical/interpretative framework is overhauled, the potential latent in the battery of techniques for doing archaeoastronomy cannot be fully realized.

by JAMES W. DOW
Rochester, Mich., U.S.A. 20 III 73

Ethnoastronomy, with its techniques of discovering ancient belief through the analysis of symbols, still seems to be much less secure from the dark, unmentionable beasts of ethnohistory—such as the theories of Atlantis (Donnelly 1882), Mu (Churchward 1926), pyramidology (Smyth 1880), and gods from outer space (Von Däniken 1971, 1972)—than archaeoastronomy, with its techniques of discovering protoscientific knowledge through the analysis of orientations and computing machines. Although scholars laugh in the face of these beasts, they may still be capable of discrediting legitimate ethnoastronomy if it does not verify its findings carefully. Ethnoastronomy is on the safest ground when it is based on textual records. It is least secure when it is based on the imaginative interpretation of religious symbols. How can we be sure that an admittedly religious symbol had an astronomical referent at any particular time in history for a majority of persons in a culture? Symbols can persist in spite of changing meaning, and concerns with astral events can persist in spite of changing beliefs. So what particular astronomical belief or bit of knowledge can one reliably deduce from the presence of a few symbols?

Now that archaeoastronomy is beginning to develop, it would be helpful to have statistical analyses of the random occurrences of astronomical orientations in different natural and man-made situations so that researchers can determine if particular orientations have a low or high probability of having been deliberately set.

I should also like to note that a bad pre-Revolutionary reconstruction of the Pyramid of the Sun at Teotihuacán led everyone to believe that its *adosada* was originally built to face the setting sun on the day the sun passed through the zenith. Only very recently have excavations shown that the original *adosada* had the same orientation as the Pyramid itself. This discovery did not invalidate my main conclusions that the entire city of Teotihuacán was oriented to the setting of the Pleiades and the rising of Sirius (Dow 1967). The widespread concern with the Pleiades and other Tauran stars in semitropical zones in the northern hemisphere could be due to the fact that their heliacal risings coincide with the spring arrival of the tropical rain.

by P.-R. GIOT

Rennes, France. 20 II 73

About Brittany I only want to improve the bibliography by reference to the earlier hints of Du Cleuziou (1882: 117–22; 1887: 486), Gaillard (1888, 1897), Grossin (1898), Kerviler (1904*a*, *b*), Devoir (1908, 1909), Martin (1911), and the later elaborations of Merlet (1929, 1935); the influence of megalithic orientations on modern field structures has been advocated by Meynier (1943 *a*, *b*; 1944 *a*, *b*; 1945; 1958: 70–71).

by DAVID H. KELLEY

Calgary, Canada. 19 III 73

This study will be a very useful compendium for a long time to come. The one major problem I see is that Baity's enthusiasm allows her to accept the potential value of studies which are often contradictory in detail and may be contradictory in principle and that this will not necessarily be obvious to a reader not familiar with the material. Thus, Baity sees a Neolithic base for many astronomical ideas which I regard as coming together or originating during the Hellenistic period. With respect to the statements which have been made about Mayan astronomy, Baity mentions work of Smiley on eclipses, astronomical descriptions by Owen, and studies by Schulz of the moon's movements and of eclipses. The fact that these scholars see different significance in particular dates which they put at different points in real time is implicit in mentioning different correlations of the Mayan calendar with our own. Every astronomer who has worked on the material has come up with a different answer and a different interpretation, and in no case do they agree with colonial and modern calendrical evidence. I have recently found inscriptional evidence suggesting interest in Jupiter-Saturn conjunctions, but a check of about 40 correlations showed that none of them put Jupiter-Saturn conjunctions at the indicated dates. Smiley, Hochleitner, Escalona Ramos (1940), and I have all developed correlations which identify the same dates as equinoxes and solstices, but Smiley's winter solstice is my spring equinox, Hochleitner's summer solstice, and Escalona's fall equinox. Without control from the written texts, scholars are playing a simple game of numbers. When one sees how many brilliant scholars must be wrong on the interpretation of Mayan astronomical materials simply because their solutions are incompatible, one becomes skeptical of alleged solutions of this sort. This is the most generic criticism which can be made of many of the studies cited by Baity. In most cases, we do not know what the builders of monuments thought they were doing, and structurally correct "interpretations" may sometimes derive from geometic or mathematical necessities. This seems to me also the central problem of Thom's work. He has demonstrated impressive regularities in the construction of megalithic monuments which can be correlated with specified astronomical phenomena. If the regularities can only be explained by those particular phenomena, then his conclusions must be accepted. Having seen how many ways astronomers can explain any set of figures given to them, I wonder if some ingenious fellow may not yet come up with an alternative explanation, although not one which would dismiss the regularities as meaningless.

by LEO S. KLEJN

Leningrad, U.S.S.R. 9 III 73

As a review and summary of many scattered studies, Baity's paper is very useful, but the field of the proposed subdiscipline does not seem to be reasonably defined. Baity identifies the subject matter of archaeoastronomy as "the apparent use of astronomical techniques in the construction of megalithic and other monumental structures of ancient times." Why merely the "megalithic" and the "monumental"? If we imagine an ancient observatory in every dolmen (even if in addition to its tomb function), then not even modern astronomers could hope for so well developed a set of observation points. But if we concentrate our attention only on the most complex structures, probably indeed especially designed for astronomical observations and predictions, then the rich information on the use of astronomical knowledge in ancient times which may be obtained from the orientation of ordinary tombs will be lost (and in this respect I see no distinction between the dolmen and the catacomb or shaft grave). Further, since we usually include studies of petroglyphs in archaeology and not ethnography, why must we deal with ancient solar and lunar symbols in the frame of ethnoastronomy and not archaeoastronomy?

The supposed ties of Caucasian megaliths with Iberian ones are supported neither archaeologically nor by evidence from linguistics and folklore. The connections of Caucasian dolmens with the modern Caucasian cultures are very problematic, although possible. The connections of modern Caucasian languages with that of the Basques have never been demonstrated. The Caucasian dolmens are typologically much closer to the North European than to the Iberian ones.

In general, Baity's impressive summary emphasizes once more the tendency to reevaluate the intellectual power of early man and the antiquity of human characteristics. The first step in this direction was taken by Boucher de Perthes and the evolutionists when they discovered the immense antiquity of man, the second step by Breuil and his contemporaries when they recognized Palaeolithic cave art, Palaeolithic cultural diversity, and the relatively great effectiveness of Palaeolithic hunting. The third step is being taken now. It consists of the establishment of an age of the Anatolian or European Neolithic and an antiquity of man twice as great as earlier supposed and the discovery of unexpectedly great intellectual abilities in Upper Palaeolithic man. It seems that the intellectual abilities of early man and the antiquity of human characteristics grow along with the growth of our own modern civilization. Perhaps this means that our own abilities to see and understand humanity are growing. Anf if we are becoming better at seeing humanity in such remote beings, so we may also be growing to understand each other better in our own modern world, where we are divided inter alia into generations, races, peoples, states, and holders of beliefs. It is in this perspective that the emergence of archaeoastronomy may be seen.

by H. H. E. Loofs
Canberra, Australia. 20 iii 73

Not being an astronomer, but claiming to know something about this nebulous matter of what constitutes the "Megalithic," my main criticism of Baity's article is that, although the author clearly did a tremendous amount of research on the astronomical side, her homework on megalithic cultures and ideas in general leaves something to be desired. Proof of this may be found in the omission from an otherwise truly impressive bibliography of the many works dealing with this latter problem, ranging from Fergusson's *Rude Stone Monuments in All Countries* (1872) to the latest contributions by Heine-Geldern (1959, 1963), Varagnac (1959, 1961), Schmitz (1961), Closs (1966), and Jettmar (1971), to name but a few. Only Schuster's (1960) admittedly significant, but hardly all-encompassing, nine-page article is included.

The reason I stress this point is that from this article it would appear that there is an inherent link between megaliths and astronomy, and this has in no way been proved. On the contrary, scholars dealing with the tricky problem of the purpose of megaliths seem to be practically unanimous in concluding that it is mainly to enhance the prestige of living or dead persons, to serve as a link between the living and the dead, to commemorate wealth, to enable people to partake of the wisdom of their ancestors, to promote fertility, and the like, and make no mention of astronomy. (Incidentally, I wonder whether expressions like "astra facts," "astra events," "megalithic astra ritual pattern," etc., are necessarily a useful contribution to archaeological terminology.) It must be concluded that any astronomical purposes are marginal, a mere by-product of megalithic culture. Indeed, one might legitimately ask whether such unique constructions as Stonehenge, some of the other stone circles in England, or *alignements* in Brittany, although indeed made of big stones, really deserve to be labelled "megalithic" at all, since they are not typical of megalithic cultures elsewhere. That these "stone circles and their non-circular variants" are a highly localized phenomenon which thus cannot be taken as a paradigma of megalithic cultures in general was recently acknowledged by no less an authority than Atkinson (1968).

As is unavoidable in such a wide-ranging survey, the author is obviously more familiar with some areas than with others. This becomes painfully clear when considering anything outside the well-trodden cultural path leading from Western Europe to Mesopotamia, the Indus Valley, China, and Mesoamerica. For example, Southeast Asia, although full of megalithic cultures, living, dying, or dead (Loofs 1967, 1970), gets little mention, and what there is does not always seem to be based on adequate documentation. A question such as "are these constructs older than Hinduism in the Indonesian Archipelago?" is not really to the point, as Buddhist influence may have been just as old as, if not older than, that of Hinduism in the area. By plotting known megalithic cultures and instances of "archaeoastronomy" on a map, particularly in the case of Southeast Asia, the author would have easily discovered that the little overlapping that there is of the two does not warrant the assumption that they must inherently be connected.

Insufficient attention is also sometimes given to chronological considerations, in particular as far as alleged transmissions of archaeoastronomical concepts are concerned. It is difficult to understand, for instance, how such a transmission from the 2d millennium B.C. Indus Valley to the 1st millennium A.D. Mesoamerica can be postulated without somehow analyzing it further in time and space (through Southeast Asia?). Chinese, Tibetan, and Burmese "models" are treated as if they were contemporaneous; there may well be 1,000 years' difference between them. The same attitude is also shown in the use of such nonsensical (especially in the context of a worldwide survey!) terms as "megalithic man," "Megalithic Age," etc. Are we back to Perry's *Children of the Sun* (1923)?

I nevertheless consider this article to be a very worthwhile attempt to come to grips with an archaeologically intriguing, complex, and somehow elusive subject, in which an admirable amount of scholarly research has been invested to some effect. By collating and reviewing work done in this field so far, the author has fulfilled the aim she set for herself and deserves high praise; it is not really she who is to blame if the picture she presents is still somewhat blurred.

by Rolf Müller
Nussdorf/Inn, Germany. 9 iii 73

The megalithic monument in the ruins of Tihuanaco (the Sun Temple Kalasasaya) was measured in 1932 by Posnansky and myself. The most significant result was that the equinox of the people of Tihuanaco was not the astronomical equinox, but a point that divided the year into two equal parts (with a declination of the sun of +0.5°, exactly the same value Thom found for megalithic man in Britain; see Müller 1972).

Sîngeorzan (1970) has discussed the orientation of 320 skeletons from the Neolithic Boian Culture (ca. 4000–3500 B.C.) excavated near Bucharest, Rumania, 300 of which were oriented to the rising sun. In this epoch, man had a clear and distinct concept of the yearly motion of the sun. The bodies were buried with the face toward the rising sun. More than half (164) faced directly east, the position of the sun at the equinoxes.

by Richard Pittioni
Vienna, Austria. 5 iii 73

I can restrict my comments to the statement that the author has very clearly and lucidly presented the results of research done up to the present time. It becomes clear in particular that, as early as the Neolithic, knowledge of natural processes must have been substantially more extensive than has generally been assumed. It is much to the author's credit to have made this even more evident by drawing on pertinent material from the fields of ethnology and folklore.

As a supplementary remark in the field of ethnoastronomy, I might mention the often ascertainable time-indicative names of mountains (e.g., *Mittagskogel* 'noon-peak'), which originated in the relation of these mountains to specific positions of the sun (cf. Willvonseder 1928).

by EMILIE PLESLOVA-ŠTIKOVA
Prague, Czechoslovakia. 23 II 73

This new subdiscipline is very useful for understanding the past of humanity. Though the present results are still partly hypothetical, there is much evidence to be considered which has not yet been subjected to astronomical study. This is the case, as Baity notes, in Central Europe. Here some steps in this field were taken some time ago by Müller (1936*a*, *b*), whose recent book I have had no chance to read. Therefore, and being a layman in the field of archaeoastronomy, I can only suggest two promising Neolithic and Aeneolithic structures in Czechoslovakia, not yet fully excavated, which ought to be carefully examined in this light. The first is a settlement of the oldest phase of the Moravian painted-ware culture (Těšetice-Kyjovice, Znojmo district, Moravia), where there is a circular, monumentally enclosed area 50–55 m in diameter, probably of some cult character, with two known entrances orientated to the north-south (Podborský 1972). The second is a settlement of the older phase of the Funnel Beaker culture (Makotřasy, Kladno district, Bohemia) with a rectangularly enclosed area (two corners known) 300 m by at least 280 m, with diagonals to the southwest-northeast (?), southeast-northwest(?) (Linington 1969, Pleslová-Štiková 1972). In this connection I would mention Neolithic Kothingeichendorf in Bavaria (Maier 1962), with a structure similar (in shape, diameter, entrances) to that of Těšetice-Kyjovice, and the complicated enclosed structure at Altheim (Altheim group) in Bavaria (Maier 1962). Good results on archaeoastronomy have been published for the much younger (Celtic period) sanctuary of Libenice in Bohemia (Holub 1962).

by ZENON S. POHORECKY
Saskatoon, Canada. 26 III 73

I would agree with Baity that men have always attached great importance to events observed in the sky. I would go even further than she to say that the sun and the moon were seen not only as the calendrical cues noted by calculating astronomers, but also as the aesthetic, spiritual, and even navigational phenomena which have fascinated star-gazers for millennia.

The sun and the moon, especially, have been viewed as sources of many powers embodied in almost everything on earth, because men have always been more interested in meaning than in measurement; this seems a proper priority, although Baity tends to neglect it. Objects we see as inanimate are seen by many peoples as having souls related to all other souls in this world.

For instance, there are many aboriginal paintings on more or less smooth, vertical rock faces along innumerable lakes and streams in the forested Precambrian Shield of Canada in which sunlight plays a vital role in casting a magic spell. On bright, calm days, the sun's dazzling beams are reflected by slightly rippling waters in repetitive, shimmering patterns on the rock walls. Glittering lights appear to be released like dancing spirits from the stone, and it is easy to understand what is meant by some old people who still say that even rocks can harbour spirits with the power to harm or heal. The spectacle of the paintings in their natural settings may be further enhanced by some vague awareness of their mystic meanings. There is no doubt that many of the painted symbols represent dream-like or visionary experiences of the painter. Yet the paintings, which lack any representations of sun or moon or stars, defy exact comparison with any other religious art in the world, representing such fantastic creatures as horned serpents and thunderbirds (prominent deities in Indian tales and origin myths).

The floor plan of the so-called sun dance ceremony in central Saskatchewan is naturally oriented according to the cardinal directions. All ritual activities and movements, including dancing, must be done in a clockwise direction, that is, following the path of the sun. However, there is no calendrical significance here.

One of the most spectacular rock-carvings in southern Saskatchewan occurs at St. Victor, on the edge of a high cliff that was used as a buffalo jump. Buffalo and bear tracks are imprinted on the limestone rim, but can be seen only at sunrise and at sunset; the sun bleaches them out during the rest of the day. The religious significance of these vanishing petroglyphs is linked to sympathetic magic used to hunt animals, of course, but the mystery is enriched by the symbols' becoming invisible in broad daylight and at night.

The Plains Cree in Saskatchewan once had a gigantic 100-ton rock, called Mistaseni, which looked like a huge reclining bufalo at sunset and at sunrise. During the day it looked like a common haystack. Its daily transformations into a buffalo made it a shrine. The sun had somehow revealed the spirit. Still, dam engineers had it blasted in 1966, since its inevitable flooding threatened to transform it into a ripple rock endangering canoe traffic.

Baity's thesis envisages ancient architects plotting the movements of the sun and the moon on their flat drawing-boards, not only at Wiltshire's Stonehenge, but also wherever a pyramid was built or a pot painted with respect to an observed circling of heavenly bodies. It focuses on how man has used the constant rate of motion evident in the sun and the moon to measure time, so that clocks and calendars emerge as man-made constructs reflecting celestial cycles. My view is that people have generally relied far more on earthier cues like birds migrating or rivers freezing than on the position of the sun to guess when another season was beginning. I am tempted to quip that the invention of the clock never revolutionized rabbit hunting. Baity's theory may not apply so much to ordinary people, who are most concerned with just surviving. Hungry people find little time to gaze at the sky in order to reckon time. I would accept her thesis as true for the better-fed part of mankind, who may have nothing better to do with time than measure it.

by JONATHAN E. REYMAN
Normal, Ill., U.S.A. 9 III 73

Baity's article is an important contribution and adds another dimension to the anthropological study of both prehistoric and ethnographic populations. In addition, it represents a fair and thorough synthesis of much of the existing literature and current arguments; her bibliography will remain a basic reference source in archaeoastronomy for years to come. Her use of the term "archaeoastronomy" instead of "astro-archaeology" is also welcome from the standpoint of etymology: we are studying ancient astronomical practices, not doing celestial archaeology.

It is difficult not to take issue with some of the arguments of others which Baity cites. In certain cases I feel that she should have included critical comments (e.g., Cowan's [1970] statements regarding the "rudimentary" trigonometry of the megalithic geometers); perhaps these can be included if this article is expanded into a book. There are a number of points on which I would like to comment. Much of what I have to say can best be considered as an addendum to rather than a criticism of her paper.

Baity states that "the high degree of organization and administration responsible for the impressive Breton alignments and the presence in Brittany and Scotland of identical units [of measure] suggests a common culture." There is no doubt that contacts and/or cooperative efforts existed between peoples in the two areas, but that these geographically and temporally separated groups possessed a *common culture* does not seem likely. They occupied very different ecological niches and presumably used astronomical observations for different purposes, e.g., navigation in south Argyllshire (Thom 1971:10–11) and agriculture in Brittany. The sites may incorporate the same unit of measure, but some structures are lunar in orientation (Temple Wood), some are primarily solstitial (Kintraw), and others include both types of orientations (Stonehenge, the Crucuno rectangle). What evidence exists, aside from the astronomical data, to indicate a common culture? Can we reasonably infer this from the settlement patterns? resource exploitation and trade? artifact assemblages and their distributions in time and space?

Baity accurately describes the purpose for which many and perhaps most of the current archaeostronomical studies are being conducted, i.e., data collection. If there is one criticism to be made of these recent projects, it is that they are data- and not problem-oriented. An enormous amount of information has been gathered concerning the astronomical alignments of numerous buildings and how these alignments could have been used from a technical (observer's) standpoint; however, there is a dearth of hypotheses dealing with *why* there was this intense interest in the sky and what these astronomical data may mean in terms of cultural-ecological adaptations. Baity is not to be faulted for this, and, indeed, she does state that new hypotheses are needed, listing several possibilities. However, she does not provide a definite method for hypothesis formulation and testing within archaeoastronomical studies. This shortcoming, in part, may reflect her acceptance of MacKie's (1969:11) position that because we are not astronomers we do not know how or where to look for evidence of prehistoric astronomical practices. This position disregards the vital role which ethnographic materials play in the formation, testing, and evaluation of hypotheses, whether they are related to archaeoastronomical studies or to some other archaeological problem.

On several occasions Baity uses secondary sources and/or takes quotes out of context. For example, it was Ricketson (1928; see also Ricketson and Ricketson 1937) and not Morley who first described the astronomical alignments at Group E, Uaxactun. As for the Wadi Halfa burials, Saxe does regard the skull orientations as indicative of patterned behavior but adds "we find it dfficult to decide the basis of this patterning at this point" (1971:49). With regard to my work at Anasazi sites, the astronomical alignments are not quite as well-documented as Baity suggests, although the loose ends should be tied up in the near future. More important, however, is that the astronomical ceremonialism is not "caught red-handed," but enters, in conjunction with improved varieties of maize and other crops, as an integral part of the *planned and systematic exploitation of the Southwest by Mexican pochteca,* particularly in the Anasazi and Hohokam regions. These astronomical practices became the basis for adaptation of the various cultigens to the ecologically marginal agricultural conditions which existed throughout much of the Southwestern Plateau. The use of astronomical observations in connection with the agricultural cycle is frequently discussed in the ethnographic and archaeological literature relating to the Southwestern Pueblos (e.g., Bunzel 1932, Benedict 1935, Stephen 1936, Parsons 1939, Lange 1959, Dutton 1963, Kelley 1966, Ellis and Hammack 1968, and Lange and Riley 1970:69–70). One further technical point is that my photographs of the corner of a pueblo splitting the rising sun and the shadow time-keeping sequence were all taken at the autumnal equinox, not the summer solstice.

Baity's mention of the controversy concerning the beginning of the Maya year is interesting, especially since she draws on important but unpublished discussions. It seems to me that Kelley has the stronger argument (vernal equinox = Zero Day, rather than June 23, 3392 B.C.) both on archaeological grounds and because the sun's position is (relatively) constant through time, whereas the positions of Procyon, the Pleiades, and Antares change with comparative rapidity.

Baity's use of the term "reconstruction" with regard to lifeways and even buildings is conceptually unacceptable. Taylor (1948:35) and Goldstein (1962:177), among others, have noted that while the facts per se may be verifiable, what actually happened in the past is not. Therefore, when we discuss the past, that which we describe is *our construction* and *not* a *re*construction; one cannot reconstruct what is not actually known in the first place. This does not mean that all contexts or historical schemes are equally useful and valid; some do seem to be better explanations of the data. However, all such schemes are "artificial" constructs and are not verifiable on the basis of the unknowable. Perhaps nothing illustrates this point better than the several recent "reconstructions" of the Adosada at Teotihuacán.

Finally, I would like to make three technical points: (1) With regard to ancient Egyptian astronomical practices,I note the curious omission of classic references such as Breasted (1905). (2) The long-held assumption that the Egyptian pyramids were constructed in accordance with a celestial referent has been challenged and an alternative hypothesis proposed which states that their present alignment may be due to continental drift (Pawley and Abrahamsen 1973). (3) Baity's contention that Upper Paleolithic iconography was created by "advanced *Homo sapiens*" is untenable on genetic grounds; rather, we are only beginning to understand the degree of intellectual development and sophistication possessed by prehistoric peoples and nontechnologically advanced societies. So-called primitive thought is no less developed than ours, but it is expressed in a very different symbolic system, one based on manifest or concrete properties instead of abstract entities (Lévi-Strauss 1966).

The breadth and depth of Baity's study are impressive: she has written the definitive synthesis of archaeoastronomy and ethnoastronomy to date. Baity has provided both the data for problem-oriented research and the impetus to conduct such studies. She is to be commended.

by S. B. Roy

New Delhi, India. 3 IV 73

In her well-documented article, Baity has given a comprehensive account of recent work (1950–72) on archaeoastronomy and ethnoastronomy. As this article is likely to be a basic source because of its comprehensive coverage, she might also have given a brief digest of the earlier work on these subjects. The great Indologist Sir William Jones (1790) suggested that the precession of the equinoxes could be used to define the chronology of Indo-European prehistory reflected in the Vedic works. Wilson (1861) did the pioneering work of identifying the *nakshatras*—the 27 bright stars used to define the positions of the moon in the celestial circle in which the moon moves during the month. Jacobi (1893) showed that the traditions of year-beginnings contained in the Rig-Veda go back to ca. 4400 B.C. Independently, Tilak (1894) reached the same conclusion. Bühler (1893) supported these pioneering attempts.

The source book for these scholars was the Vedic texts. Of them, the Rig-Veda is of unique value for ethnologists. It is a collection of hymns (sacerdotal, mystical, and astronomical), a complete index of which was made ca. 1300 B.C. by the scholiasts Shaunaka and Katyayana. Since then, it has been preserved intact by a complex scheme of variant recitations that permits not even half a syllable to be changed. It is, therefore, an indispensable source of perfectly maintained traditions (traditions already of hoary antiquity in 1300 B.C.!) for the student of Indo-European prehistory. For example, in Vedic astronomy, a bright star was used to mark the equinox: λ Orionis (long. 84°), called Mrga-s'iras, literally "stag's head." The full moon at the "stag's head" marked the autumnal equinox in ca. 4100 B.C. What is of crucial importance in applying astronomical methods to the chronology of periods prior to 6000 B.C., however, is to keep in mind the quarter-phase shift every 6,500 years. For instance, the full moon at this star marked the summer solstice in 10,600 B.C., the spring equinox in 17,100 B.C., the winter solstice in 23,600 B.C., and the autumnal equinox in 30,100 B.C. Similarly, if the observation is of the new moon (or the heliacal rising of a bright star, which is the same thing), there is a half-phase shift. For instance, the heliacal rising of the star β Arietis, which represented the god-hero Ashva-Yujau, marked the spring equinox in 500 B.C., the winter solstice in 7,000 B.C., the autumnal equinox in 13,500 B.C., the summer solstice in 20,000 B.C., and the spring equinox in 26,500 B.C.

Imagination should not be allowed to boggle while considering these vast distances in time, but the worker should carefully analyze the phenomenon observed, the event to which it is related, the geographical locale, and, above all, *the culture to which it is related* before drawing any chronological inference.

Primitive man of the Pleistocene used the moon, not the sun, as a time-measurer. Marshack (1964–72) has shown that the Aurignacian peoples knew that the moon completes two full cycles in 59 days (in sets of 30+29 or, more probably, 15, 15, 14, 15). The ancient (pre-Vedic) Indo-Europeans also used a season of two months and called it *rtu*. The English word "moon" is related to the measurement of time through menstruation, both being derived, according to the *Oxford English Dictionary*, from the root *me* 'to measure' (cf. the Vedic root *mā*). Even in the early Pleistocene, the female must have noticed the correspondence between the full moon and her own monthly period of menstruation. The ramifications of the Vedic root *ṛt* will be clear from the following: *rtu* 'season,' 'menstruation'; *ṛtam* 'grand cosmic law,' 'truth,' 'right'; *rtvij* 'priest' (who knows the seasons and performs the rituals accordingly). (Cf. the English *right, rhythm, ritual.*)

It is also apparent that the first astronomer-cum-calendar-maker was female: perhaps it was she who was deified as a mother goddess, for not only was she the procreatrix par excellence, but also she controlled the future because she knew the mystery of time. According to the Rig-Veda, she was Aditi, the mother of 12 luminous beings called *ādityas* (stars marking months). Aditi declared Punarvasu (Pollux) to be the autumn star; she is, therefore, its presiding deity.

Baity has laid too much emphasis on the solar calendar; the importance of moon astronomy has not been sufficiently stressed. The first observations of Pleistocene man must have been crude and therefore simple. He (or, rather, she, as I have suggested) observed only the points at which the moon was full when a season was beginning. The primary rituals were the *purnamāsa*, or full-month, rituals. Autumn was the first season, and the autumnal equinox was marked by the "autumn star." "A hundred autumns" meant 100 years. The calendar was, therefore, simple enough for Pleistocene man to follow.

The Indo-Europeans also used a simple calendar based on the stepwise motion of the full moon in the *nakshatra* circle. Rigvedic lore prescribes elaborate full-moon and new-moon rituals to be observed at particular *nakshatras*. The observation of the bright star at which the full moon (or the new moon) occurs was a hallmark of Vedic (and pre-Vedic) calendar-making. For instance, when Punarvasu was declared to be the autumn star, the autumn rituals were observed when (and only when) the moon was full at Punarvasu.

Being star-bound, the system is admirably suited to chronological computations. It is hardly necessary to point out that when the moon is full at, say, Rohinī (Aldebaran; long. 69°), the sun will be at long. 249° (i.e., 69° + 180°); the "opposite" star (at long. 249°) was called Jyeshtha Rohinī, "elder Rohinī," showing that the Vedic astronomers had a clear notion of the celestial circle even ca. 3100 B.C. (when the autumnal equinox took place at the Rohinī full moon).

Incidentally, the linking of the full moon with the star at which it occurs automatically calls for the inclusion of an extra full moon in the third year (observational intercalation!). Thus, 37 full moons were needed to complete a cycle of about three years called *yuga*, and a year was made up of 370 "moon-days" (called *tithis*). An extra month was needed after 30 years for finer correction. Viswamitra I, a brilliant astronomer-poet of the Rig-Veda, observed that a similar result was achieved by a secondary intercalation after the ninth year. The method was so accurate that he determined that a period of nine years contained 3,339 moon-days (see the Rig-Veda hymn 3.9.9). This means that a Viswamitra year was made up of 371 *tithis*, equivalent to a period of 365.20 days. Viswamitra lived ca. 2600 B.C., and therefore his determination was an achievement of the very first magnitude by any standard.

All this was achieved by naked-eye observation of the moon with no clock other than the clock of the seasons and the menses. Therefore, the importance of moon astronomy should not be minimised, particularly for the periods prior to 2000 B.C. (Roy 1972).

To sum up:

1. Baity has made a good case for intensive study of astronomy by the ethnologist and the archaeologist. There is a grand cosmic clock in the heavens whose invisible hands turn once every 26,000 years. Those who can read it can read the past with unerring accuracy, for the sun and the moon will bear witness to what they say.

2. The astronomical legends of the Rig-Veda, containing the prehistoric traditions of the Indo-Europeans, would be a fruitful source of exploration for ethnoastronomers.

3. More attention should be given to the simple, crude moon observations of the pre-Vedic Indo-Europeans than to the more accurate (and, therefore, more sophisticated) observations needed for a solar calendar.

4. It would be necessary to go beyond the first quarter-phase of the precession cycle of 26,000 years in studying astronomically the astro-religious symbolism of the Magdalenian (14,000–8,000 B.C.), the Solutrean (18,000–14,000 B.C.), the upper Perigordian (23,000–18,000 B.C.), and the Aurignacian (28,000–23,000 B.C.).

5. A comprehensive but simple text on moon astronomy is a desideratum for the archaeologist. The ethnologist must learn to look at the stars and know how to locate the east, for one

cannot hope to understand and interpret the spirit of Aurignacian man unless one can mentally go back to his epoch and rejoice when the sun turns north.

by CHARLES H. SMILEY
Providence, R. I., U.S.A. 18 III 73

Baity's report makes a valuable contribution in fields crossing two or more disciplines. Many of the persons working in these fields are experts in only one or two disciplines and cannot necessarily be trusted in other areas. Nor can these experts hope to keep informed in all areas. Baity has served well in summarizing and evaluating burgeoning publications in fields as far apart as astronomy, archaeology, linguistics, and engineering. Her splendid list of more than 600 references will allow scholars to fill in gaps in their backgrounds and avoid duplicating work already completed by others.

by DEAN R. SNOW
Albany, N.Y., U.S.A. 17 III 73

What I hoped for, but did not find, in Baity's article was a clear statement of methodology. As a science, archaeology suffers because its subject matter is made up of fragmentary traces of often unique and unrepeatable human activity. Hypotheses proliferate, but adequate proofs do not, much less an accepted measure of adequacy. In this regard, I think that archaeoastronomy is particularly vulnerable. That some specified site had a specific set of astronomical functions prehistorically must be shown to be probable through the use of explicit techniques and methods, and that is no easy task. A consensus of archaeologists is not enough.

In its conclusion, the article advocates a methodology of comparing objective astronomical data to prehistoric constructs, but this is strategy, not methodology. Baity comes closer to the latter when discussing Thom's prediction and subsequent discovery of eight stations around Er Grah and his similar prediction and discovery of a stone platform at Kintraw. The essential difference between investigators like Thom and the likes of Erich Von Däniken is not truthfulness as opposed to falsehood, but scientific rigor as opposed to the lack of it. Indeed, without the concerted development of rigorous methods in the near future, this new subdiscipline may be lost in a maelstrom of haphazard speculations. To judge from the popular press, it looks as though we might already be moving into another round of Egyptian pyramid numbers magic.

There are at least a few errors of fact in this overwhelming compilation, but I hope that its reviewers will avoid caviling over relatively trivial points. The real importance of Baity's contribution will probably be that it marks an end to the specimen-collecting stage in the development of the subdiscipline. We can now hope for some discussion of proper classification. It makes little sense to discuss Stonehenge, South African rock art, Sumerian astrology, the orientations of burials, Medieval symbolism, Mayan calendrics, and the Plains Indian Sun Dance as if they were comparable phenomena. We can look forward to the development of classification, explicit theory and method, and syntheses of several different kinds. Unless this new subdiscipline advances quickly and carefully, there is a good chance that volumes of nonsense will accumulate in our libraries, burying and discrediting valid findings.

by JAMES L. SWAUGER
Pittsburgh, Pa., U.S.A. 16 III 73

Interested in the general subject of this article because of my work with dolmens and other megalithic structures in Palestine and with petroglyphs in the northeastern United States, I asked permission to comment in order that I would become familiar with current theory and studies. Confronted by Baity's Niagara of information and citation, I became aware of my ignorance and was abashed. It will take me some months of hard reading of cited sources to begin to comprehend enough of the information in Baity's article to make meaningful appraisals of data and deductions, but I'm most grateful for such a comprehensive guide.

There are, however, attitudes implied in archaeo- and ethnoastronomy of whose validity I will have to be convinced. For instance, there is assumption of necessity for sophisticated astronomical and mathematical knowledge in the arrangement of sighting structures such as menhirs. From my own experience I know that sighting along a menhir's top line to another such structure to fix a point on a horizon presents the viewer with enough of an arc of observation, depending on the angle of his vision, to permit another to say the observer is fixing almost any point on a considerable stretch of the horizon. Trained as a surveyor, I know how difficult it is and how much knowledge is required to fix two points in order to establish a line of sight, but the lines of sight used by the ancients in many cited instances were not point to point but gross structure to gross structure, and I see no reason why they could not have been established empirically by use of good sense and reasonable care after repeated observation.

The same sort of thought applies to the assumed high level of ancient astronomical knowledge necessary for travel over the deserts and the seas. Until the relatively late domestication of camels, caravans did not travel sand deserts of any size, but rather stony deserts, with their distinctive landmarks. Again, from personal experience, I know that one traversing such deserts sets a general course by the stars by night and by which cheek the sun falls on by day, but the course is general and designed to establish a heading to bring one to a sighting of a distinctive "landfall," just as on the sea one steers largely by landfalls to whose proximity one is brought by use of a sextant but could have been brought by grosser astronomical observation. That the ancients had to have more precise astronomical knowledge than a modern desert traveler or sailor, I doubt. Again, I think empirical knowledge largely sufficient.

by P. M. VERMEERSCH
Leuven, Belgium. 21 III 73

The attempt of the author to gather the scattered data of this new discipline can only be acclaimed. This review article opens new perspectives to those scholars who are not directly involved in this research. Such research can undoubtedly throw new light on the spiritual world of prehistoric societies. It seems to me that traditional archaeology pays too little attention to such problems, probably because of hesitation as to the interpretation of observational data. Moreover, it happens that the fancy of some scholars proves the sceptics to be right. Nevertheless, one should not be blind to certain facts requiring interpretation.

Still, I don't feel secure about the idea that the wide distribution of some astronomical constructs is the result of diffusion by trade-colonists, mariners, and caravan masters. It seems to me that some customs and inventions may arise independently in different regions. As an example I should point out the appearance of microlithic techniques at the end of the Upper Palaeolithic not only in Europe but also in the Near East and Africa. There are no sound indications that the worldwide appearance of these new technological habits was supported by trade-colonists. We must recognise that in the present state of research there is not yet a valid explanation of this phenomenon. To me it seems acceptable that some innovations, perhaps some "subjective astronomical constructs" may appear independently over a large area. Why is another question.

Reply

by Elizabeth Chesley Baity

Chapel Hill, N.C., U.S.A. 13 iv 73

The comments and references offered by the commentators add greatly to the potential usefulness of this pioneering essay. Loofs' bibliographical data on megalithic studies and Giot's specialized list will be helpful to all who have fallen behind on their megalithic homework through difficulties in locating pertinent studies. The absence of references to astronomical orientations noted by Loofs does not to me prove a lack of astronomical interests on the part of megalithic draftsmen, but instead suggests the probability that, faced with the necessity of measuring time in order to allay anxieties or to schedule essential renewal rituals in a world lacking clocks, television, and printed calendars, they were more acute observers of the heavenly clockwork than megalithic sholars have been. How many of these scholars can determine the times of solar and lunar solstices and equinoxes and predict eclipses? There remains little doubt that megalithic astronomers of Britain and Brittany could do so, by methods so remarkably similar that, despite Reyman's reservations, at least a common astronomical subculture must be attributed to them. Recent work strengthens this case, as Thom (personal communication, 17 iii 73) has been kind enough to confirm:

> There is such similarity between megalithic remains in Britain and Brittany that there is little doubt that they belong to the same culture. . . . We find an identical value for the megalithic yard in Orkney and Brittany. We find megalithic eggs in Brittany laid out with the same terms of reference as those in Britain. At Kerlescan we find the remains of a huge cromlech, set out in circular arcs, centered on the corners of a right-angled triangle reminiscent of the ring at Avebury but with smaller stones and no ditch. We also find extrapolating sectors for the huge lunar observatory in Morbihan, reminiscent of those in Caithness. Need one look further?

MacKie (personal communication, 28 iii 73), while pointing out that the techniques outlined by Thom were the only ones that could have been practiced effectively to get accurate results with Neolithic technology, shares Thom's view as to a cultural relationship between Brittany and Britain. He cites early Neolithic chambered tombs scattered along Europe's western seaboard and the late Bronze Age square-sectioned socketed axes made in France but also appearing in England. Keeping in mind the priority of Breton tombs and the possibility that an élite was familiar with both areas whatever the economic and cultural differences in the peasantry, we may also consider recent evidence from Ireland. In a talk reported in the *Cleveland Press* (March 29, 1973), Ruaidhri de Valera said, "We are developing a detailed picture of the people who came from northwest France to the northwest coast of Ireland about the year 3000 B.C."; he reports the unearthing of prehistoric tombs, larger burial grounds, and houses in Counties Mayo and Sligo.

Klejn emphasizes the importance of the orientation of ordinary tombs (as I did above), which accords with the evidence from Müller and Pleslová-Štiková. To me, if not to Reyman, the range of burial orientations cited by Saxe and others does imply a very early ability to determine the positions of the rising sun at solstices and equinoxes. With regard to the Basque-Caucasian parallelisms, Klejn and I may be familiar with different bodies of scholarship that should be collated. The linguistic parallelisms of Fita, Schuchardt, Trombetti, Dumézil, Bouda, and Lafon are summed up by Tovar (1954:25–27), as is the hypothesis of Menghin that in the 3d millennium proto-Caucasian speakers may have come to the West. The enormous body of Western scholarship with regard to linguistic and folkloric parallels suggests the usefulness of a similar comparison with regard to the orientation of the megaliths; in the West there is considerable evidence that Basques may have had megalithic peoples among their ancestors. Evidence for common ritual practices in these two areas comes from rock-carvings in Soviet Armenia studied by Tumanian and Petrosian (1970), Martirossian and Israelian (1971), and Petrosian (1971) and reviewed by Petri (for whose notes I am originally endebted to R. L. Merritt, and who has himself sent me his summary of the latter book and a further reference to Okladnikov [1972]). Petri's summary confirms my original impression that the "sparkling goat" and "goat with stellar symbols" discussed by Martirossian and Israelian indicate rituals similar to those of the Iberian and Indian cattle-keepers which I have suggested (Baity 1968) may have also been practiced in the Black Sea region. The Soviet authors place this art in the 5th–3d millennia and trace the motifs in painted pottery, as I do, and we agree that the horned animals with astra symbols possibly represented both deities and constellations. Without seeing the full text, it is impossible to determine if the Soviet researchers also find evidence of cult rituals in which animals wearing horn-torches may have impersonated a celestial event, such as heliacal rise-set or other phenomena at solstice or equinox which marked the New Year. To the hypothesis of these workers that the "sparkling goat" represented a lightning deity, I offer the suggestion that a horn-torch ritual may also have been involved, the deity construct originating perhaps in Ice Age observations of electrical displays on animal horns during storms (the "St. Elmo's fire" effect) and among some Bronze Age cultures represented by Taurus wearing the torch of the Pleiades. If my hypothesis is plausible, the winter-solstice New Year best fits Thom's megalithic calendar.

Many archaeoastronomical studies have been made since 1968, and Atkinson (cited by Loofs) would not today refer to stone rings as "an almost exclusively British phenomenon." Despite the zeal of Charlemagne and later Christians, who systematically destroyed the rings as the prime sites of satanic revels, many somehow escaped destruction (perhaps because they were still in use; cf. Borst 1969). Pleslová-Štiková gives valuable documentation as to circular structures in Central Europe, certainly not sufficiently studied. Gordon (1960:pl. XXXII) publishes a prehistoric Indian stone circle. Until measurements are made, we cannot assert an astronomical function for all of these rings, some of which may be imitative. A flat horizon anywhere could have suggested a circular model for the observing of rise-set phenomena (though the remarkably flat horizon of Yucatan does not appear to have done so), but in the light of Thom's findings I would find this a reductionist explanation. Several referees have suggested that there may be alternative explanations: I have noted above that Burl's work should also be studied. According to

Burl (1973), there are over 900 stone circles known from Cornwall to the Orkneys and from Yorkshire across to Kerry: he provides a provisional chronology (in C^{14}, not real, years) for their geometrical designs, basing his study on an examination of 166 megalithic rings (40 circles, 32 flattened circles, 84 ellipses, and 10 egg-shaped rings). In view of De Valera's evidence with regard to the French immigrants in Ireland, it is of interest that the earliest known date for a stone circle is from New Grange, County Meath. The latest, from Sandy Road, is as late as 1200 B.C.. We have seen that Müller applies Thom's theorems to Central European rings and that Wittry assigns a probable solstice function to mound-building posthole circles (about which more will be known when ongoing work with the Sanders and Reyman computer program is completed). Joseph Mountjoy (personal communication, 7 III 73) reports a site in northern Mexico where aerial photography indicates the presence of a number of circles; with a colleague, he will test for astronomical significance a group of eight circles surrounding a central one. Müller (1972; cf. fig. 18) notes that among the large stone installations in the Tihuanaco region there are stone rings that in startling fashion resemble those with astronomical orientations occurring by the hundreds in Neolithic Europe. He sees a cult significance for the circles, as I do, both on the basis of archaeoastronomy and on that of European folkloric survivals. Measuring with a theodolite various of the Peruvian sacred structures and complexes, Müller suggests that winter-solstice orientations were highly significant, early records also indicating that nobles came from all regions to Cuzco to take part in the ceremonials of the winter-solstice sunrise (occurring in Peru in June). The chronology of the appearance of megalithic traits seems to me to have been fairly confused before I compounded the confusion by adding astronomy. Sankalia (1962:100–105) cites a number of megalith types including the cairn circle (with two or more subtypes) and the usual run of dolmens, porthole cists, and menhirs, frequently connected with secondary burials and associated with stone rings. He relates these to the earliest Tamil culture, as I do the cattle and solstice rituals. He cites Christoph von Fürer-Haimendorf's theory that the megalith-builders were a people of Mediterranean stock practicing irrigation and metallurgy who entered South India by sea around 500 B.C., the evidence including the dolmenoid cist with porthole which in Western Europe is dated before 2000 B.C. (uncorrected). Whether this indicates a rather long sea voyage with intermediate stops or the persistence of megalithic traits, I do not know.

Clark's comments about the uncritical inclusion of references and the advisability of limiting the problem scope seem beside the point in a first bibliographical synthesis of a new subdiscipline not yet indexed (aside from the astronomy covered by the Peabody Museum Catalogue and the Human Relations Area Files). Though the data-collection stage is not yet terminated (as Snow hopes), that of hypothesis formulation has begun, with the Southwest as one of the richest areas for the task because of abundant ethnographic data, well-preserved archaeological and iconographic evidence, and the presence of living aboriginals who still remember traditional astronomical practices and beliefs. Reyman has estimated that in six months of hard reading one could cover the source materials well enough for hypothesis formulation. For example, Stephen's (1936) *Hopi Journal* and Parsons' (1939) *Pueblo Indian Religion* would, he estimates, furnish evidence for at least a half-dozen hypotheses, all equally plausible, regarding the astronomical alignment of kivas and other structures to solar and stellar referents (cf. his references above and also DiPeso 1968, Ellis 1970, Fewkes 1900, Goldfrank 1962, Judd 1964, Kelley 1960, Reed 1956). Reyman (1973*a*) cites Bandelier (as quoted by Lange and Riley 1970:69–70) with regard to the astronomical function that might be attributed to towers: "The year begins about the winter solstice. The sun tower is used as follows. In winter, they look through a notch in the western wall, over a pillar to the east. When the sun rises over a certain point, there in a line with the pillar, then it is midwinter or the beginning of the year. In summer they look from a pillar in the summer gardens to the sun tower." In papers that are model studies in method (which Snow wishes to see), Reyman (1970, 1971*a*, *b*, 1972) uses this Southwestern ethnology for the formulation and testing of hypotheses: he observes that every pueblo was and is significantly involved with astronomical observations organized on an institutional basis, linked with architecture and ritual (including an accurate horizon calendar based on fixed observation points) and demonstrating attention to the sun (the major deity), the moon, Venus, the Pleiades, Orion, and Polaris, among other heavenly bodies. As he points out above, he sees astronomy as developing coincident with the sedentary village as the means of adapting high-yield cultigens to the uncertain growing season of the Southwestern plateau.

Clark's questioning of Thom's megalithic yard is legitimate; I am told, however, by a correspondent who attended the London symposium on ancient astronomy in December, 1972 that Hogg there withdrew his alternative explanation in an aside to Thom. If Thom's case rests on "circumstantial evidence which can, at any point, be contradicted in detail," studies doing so have escaped my attention, and it is clear that Clark should have cited some. (Another former critic, Burl [1973], has fitted Thom's typology to British rings to establish chronology, as I have indicated above.) Because of restrictions of space, I necessarily limited the data supporting some of my own arguments; in case this should unfairly prejudice some readers against archaeoastronomy itself, I feel that I should identify my own hypotheses and briefly sketch the type of evidence on which they are based.

I have suggested above that documentary and folkloric evidence in megalithic areas appears to support Thom's megalithic calendar, and that astronomical skills and rituals (perhaps tied to critical agricultural tasks) traveled with the Neolithic, megalithic, and Bronze Age expansions. When further documented with ethnohistorical and archaeological data and tested in indicated areas, these hypotheses will be proven or disproven, but to dismiss them without testing as "speculative" or "diffusionist" misses the point that hypothesis formulation in a new subdiscipline must start somewhere. I suggested that Thom's megalithic calendar is archaeologically and ethnologically testable, and I further suggest that such archaeoastronomical research may in some cases indicate by conflicting legends and dates that precession has invalidated the ancient astronomical "announcer" data. A specific and testable finding is also evident in Müller's statement that the Tihuanaco people did not use the astronomical equinox, as unsophisticated astronomers would have done, to divide the year into halves, but apparently used a sun declination of $+0.5°$, the value Thom finds for megalithic man. If, upon testing by precision methods, this is found to be true in a statistically significant number of cases, these data will tell us something for which an explanation must be found—especially if they occur in the context of a complex of other parallelisms. Is it "speculation" based on "superficial impressions taken out of context" to insist that such astronomical functions for megalithic and other ancient structures will be proven or disproven not by argument but by ethnohistoric research followed by precision mapping and measuring, combined with the use of aids such as Aveni's tables (see below) and Sanders and Reyman's computer program?

While I may differ from some of the commentators with regard to the extent of such speculation admissible in the pioneer data-collection and hypothesis-formulation stages of a new subdiscipline, it seems evident that the greater number of them do not quarrel with my major hypothesis—that prehistoric and early historic men encoded a remarkable degree of astronomical knowledge in architecture, art, and ritual and carried this knowledge with them when they traveled. It is clear that we will never recover all elements of belief, but I have theorized that we may recover with assurance many data with regard to astronomical knowledge, building orientations that indicate which stars and constellations were of significance, and the dates and general nature of calendric rituals, not only those in text-aided areas such as the Americas but also those in megalithic Western Europe. Specific hypotheses for which the evidence unfortunately is not yet published include the following: (1) that the Indus commercial sphere extended into and well across Africa; (2) that West Africa must be investigated as a type of staging area between the East and the New World; (3) that European folkloric evidence and surviving witchcraft practices, if closely studied, will afford much evidence as to the function and use of stone rings and of Thom's megalithic calendar; and (4) that archaeoastronomy may be yet another discipline to afford evidence for pre-Columbian interhemispheric contacts.

Mitra (1927:308–11), discussing Indian megaliths, has characterized the southern seaboard of India as an area in which dolmen-like structures with cup marks are found near Asura sites occupied over a wide range of time from the Neolithic onward and associated with long-headed peoples practicing Mediterranean rites including cremation. Fergusson (1872:498)—whose citation by Loofs remedies an omission—compares Eastern with Western dolmens, asserting that the holed dolmen and the simulated cist are part of a system affording innumerable points of contact and that "it seems very difficult to refuse to believe that both styles were the product of one kindred race of men . . . more or less directly in communication with one another."

Roy's comments and references further support the high importance of pre-Vedic astronomical knowledge, which, in my hypothesis, drew heavily upon proto-Indian sources (cf. Shafer 1954). Necessary archaeoastronomical tasks for this area are the precision measurement of Indus structures to determine possible astronomical alignments and the further study of Indus cosmogony, in which planets were deities (cf. Parpola above). I have noted a strong iconographic tradition of bull sacrifice (or play) associated with astronomical icons, evident in the Harappa city sherds and suggestive of a fire-bull cult in those of Cemetery H. The "stag's head" to which Roy refers is of interest in view of the frequent appearance of a stag in 4th-millennium Western Asian iconography (Iranian in particular) and in ritual scenes of the Camonica Valley, Iberia, and Noth Africa; but which rise-set phenomena this star or constellation was associated with, and whether it announced a solstice or equinox New Year, remain to be determined. The quarter-phase shift to which Roy alludes takes us in time (i.e., in *four* quarter shifts) through the complete precession cycle; though astronomers are capable of computing the position of significant asterisms throughout this 26,000-year period, some readers may have observed that the accuracy of such long-range computation is questioned by a counterhypothesis that questions the stability of the earth's crust throughout this period.

By May, 1973, the reviewer of archaeoastronomy studies can hardly overlook Velikovsky's (1950, 1955, 1963) view, mentioned in passing above, that near-collisions of Venus with Mars ca. 2400 B.C., 1500 B.C., and 800 B.C. caused worldwide catastrophes involving volcanic action and changes in sea levels (see Talbott 1972). MacKie (1973) sees the argument as having two parts—that catastrophes afflicted the earth in past ages and that planets have come into near-contact in historic times. Attempting to test the first, he charts radiocarbon dates having to do with volcanic action and changes in fossil shorelines and finds them to cluster, as the catastrophism hypothesis would predict. Juergens (1972) argues that while celestial mechanics in 1950 could not accommodate such a disordering of planets, recent space probes have indicated that the interplanetary medium is not a vacuum but a plasma (an ionized gas) and that planets have shielding mechanisms, space-charge sheaths, which would unleash electrical fields and forces on approach, with disastrous effects. Such events, he suggests, are described in the historical documentation upon which Velikovsky has built his hypotheses. Cyr (1970) discusses the Vail hypothesis of ice crystals which may have given special effects to Stonehenge and other monuments of the megalithic period.

Like Berger, I wonder *why* megalithic observatories fell into disuse; were the astronomers who manned them the victims of conquest or of natural disaster? Who, if not the Egyptian astronomers, would have been held responsible for not having predicted or prevented that appalling catastrophe so graphically described by an eyewitness in the Papyrus Ipuwer (Van Seters 1964) that destroyed Egypt's Middle Kingdom? In an article that gives valuable documentation from this source, astronomer Bell (1970, 1971) advances the alternative hypothesis that the disaster was caused by a failure of the Nile floods; her argument is cogent, but as yet she has not completed her plan to account for other Bronze Age disasters in areas with different climatic conditions. The drought hypothesis does not to me account for all of the conditions described by Ipuwer or for the Mycenean Dark Age, the Indus and Minoan catastrophes, and the Western Asian tectonic disasters.

Vermeersch has suggested that similar subjective constructs might have arisen independently. While this could hardly apply to highly complex constructs with a known history—such as the lunar mansion construct, which may be identified in oracle-bone inscriptions of about the 14th century B.C. and is also known from early Indian documentary evidence—I would agree that the Big Dipper could have been seen in unrelated cultures as a swastica, dipper, or spoon. That the same asterism would also have been seen as a bear is less plausible unless one hypothesizes a common heritage from ancient times. Certainly other asterisms should be studied, among them the Pleiades, the dragon and his American cousin the feathered serpent, the Asian-American turtle and scorpion, the Southeast Asian *macara* and crocodile, the Asian feline and the American jaguar, which Hatch (1971) takes to be an analogue to Ursa Minor. (I note in passing a possible connection of the water-loving felines and bears with rain symbolism.) A comparative study of the north circumpolar constellations would be especially interesting in view of their near-invisibility in Peru, where the north pole star is below the horizon and the seasons are reversed. The independent appearance of similar subjective constructs over a large area could, however, imply a major cosmic event of an exceptional and threatening nature which in the course of 24 hours would be seen over the entire globe. The appearance of comets and novae is recorded early in China; Needham (1959:424 and fig. 182) publishes an engraved oracle-bone dating from about 1300 B.C. which records "a great new star" in company with Antares. Not only the Chinese and the Japanese, but also (as Breternitz points out) the Southwestern Indians recorded the nova which became the Crab Nebula.

As Berger states, another article the length of this one could have been written on ethnoastronomy; the vast field of astronomical myth (cf. Lévi-Strauss 1969), for example, has hardly been touched. De Santillana and Von Dechend (1969) interpret ancient myths as a codified statement personifying the precession of the equinoxes and presenting it as the overthrow of a world order. (Most authorities have placed a knowledge of precession at a later date than the probable origin of these myths.) No less interesting is their thesis that the geography of the myths is not that of earth but that of the star-filled sky, the fateful events they depict not the acts of men but of gods who are also the astra. They see this cosmology as expressed in a structure of number, something perceived as a whole and expressed in myth and iconography. They interpret an ancient iconogram—that of the horned animal carrying between his horns (in Western Asia) or on his flank (in iconography I have observed in the American Southwest) the square of "the inhabited earth"—as representing not our earth but that ideal plane located by archaic astronomers along the ecliptic, the two solstices and the two equinoxes. They place Time Zero around 5000 B.C., when the bounding constellations of this "inhabited earth" were Gemini and Sagittarius, with Pisces and Virgo at the other two corners, and the Milky Way ran along the celestial meridian.

In further reply to Clark, whether or not trait association is a weak reed depends, it seems to me, upon the weight and nature of the evidence under consideration. Heyerdahl (1971*a,b*) has demonstrated that a sufficient number of reeds bound together can cross oceans, whether or not early Egyptian prototypes of *Ra* did so. If the "diffusionist paradigm" is bankrupt, I suspect that like many another bankrupt concern it has opened up a flourishing business elsewhere under an assumed name: "interhemispheric contact," a subject upon which much interdisciplinary scholarship of high quality is edited by Riley et al. (1971) and Ashe (1971). Somewhat less critically, Gordon (1971) brings together evidence from various fields to support his hypotheses regarding the specific peoples involved.

Kelley's statement that I see a Neolithic base for astronomical ideas which he regards as coming together only during the Hellenistic period prompts me to observe that I am discussing beginnings whereas he is studying a finished product (the lunar mansion construct of Chinese, Indians, and Mesoamericans). Western Asian iconography suggests to me that these subjective systems constructed on observations of the ecliptic had their origins in a limited way when archaic astronomers first observed, in connection with fixing the rise-set positions of the sun at its solstices, that certain star groups served as "announcers" of this by their heliacal rise-set times, that is, by their first appearance after occultation due to conjunction. It is of course speculation on my part (based on iconography and on recorded or surviving rituals) that in Iran (and again in Iberia) a stag constellation (whether zodiacal or a *paranatellon*) may have served thus in the 5th–4th millennia, and at the moment it is equally speculation that such an event might have occurred at a solstice occasion in certain cultures, whereas during the 4th–2d millennia Taurus appears to have announced a spring equinox New Year to others. (Note, however, that Old World astronomers may have observed meridian passages as well as rise-set phenomena.) These hypotheses are yet unproven: in general, a concern with summer and winter solstices appears more reasonable for the colder north and a spring date with the needs of Neolithic agriculturalists, but we also must think in terms of hunters changing hunting grounds seasonally.

Kelley has objected to the inclusion of studies which are "contradictory in detail and principle," but, again, is not one function of a synthesizing review the indication of differing points of view? Kelley, Dow, and others have stressed the necessity of control from the written sources. Not all areas, however, provide texts, and not all scripts have been adequately translated, while iconography often affords quite explicit evidence with regard to rituals.

Swauger and others have questioned the necessity for sophisticated astronomical and mathematical knowledge in the arrangement of sighting structures. The gnomon, which was virtually universal among the ancient cultures, could have been independently invented as a result of observations of shadow-casting natural objects. All peoples with fixed dwellings must have observed that the midwinter and midsummer sunrises reached certain distant markers on the horizon and then changed directions. We have seen that the Greeks used sky-charts suited to the skies of a millennium earlier; the proportion of sophisticated astronomers in any culture may have been small and their science closely guarded, and their overthrow could have wiped out astronomical knowledge and training systems.

The inadequate coverage of Southeast Asia is, as Loofs suspects, due to my unfamiliarity with textual materials. In fact, however, it was curiosity aroused in this region that directed me into protohistory. Angkor, the Burmese stupas, and other great architectural works overwhelm the imagination, but Bali nourishes it gently; it is touching to be shown the very seat (a megalithic one) occupied by the Sun God when he visits, fortunately only in spirit. Though a difficult area, somewhat lacking in stone and characterized by a climate and vegetation that destroys wooden structures and disrupts stone ones, Southeast Asia is particularly important to this study. Perhaps someone qualified to do so will discover and list archaeoastronomy studies. When measurements with a transit can be made, Southeast Asian sacred structures should be compared with remarkably similar ones in the Americas and elsewhere. Needham well documents the region as a route of passage for early Chinese and Indian travelers, including the Buddhist ones I should have noted above. A massive influence is archaeologically indicated by Chinese and Indian types of architecture and art, including astronomical proto-chess and other forms of prognostication or imitative magic. Le May (1954) has noted pyramid orientations to the cardinal points and published a terraced square pyramid and a round tower which would have been at home in Chichén Itzá. Though in the absence of systematic measurements or orientations it is futile to speak of function or resemblances, I do call attention again to Kelley's citations of parallels in the Asian and Mesoamerican lunar mansions, Heine-Geldern's and Ekholm's comparative studies of art, Kirchhoff's study of similar religious traits, and various studies of archaeological parallels (Meggers 1971; Meggers, Evans, and Estrada 1965; Beirne 1971; Heyerdahl 1971*a, b;* Sorenson 1971).

Loofs' suggestion that known megalithic cultures and evidence of archaeoastronomy be plotted on a map is a good one. When the requisite archaeoastronomy studies make this possible, I for one will be surprised if there is not considerable overlapping.

I agree with Aveni that a clearer distinction should have been made between studies of site orientations based merely on map inspection and those based on measurements with a transit. Though Aveni may not consider himself that improbable hybrid the well-rounded archaeoastronomer, I suggest that MacKie, Reyman, Kelley, and others here listed whose profession is archaeology are becoming sufficiently aware of astronomical facts to indicate that the archaeoastronomer is not far in the future. Aveni, as director of a seminar and field research program, should, however, agree that archaeology students must be taught how to identify potentially significant sites, to map by astronomical north, and to scan the foreground for markers or postholes and the horizon for distant markers. Though archaeoastronomy will remain interdisciplinary, the early studies of Reyman, Molloy, Hatch, and others indicate that doctoral candidates can make outstanding contributions to theory and method.

Nor do I feel that Aveni really questions the heavy astronomical content of Maya texts. In addition to the references listed above, the following sources are important to archaeoastronomers: Förstemann (1904), Guthe (1932), Kelley (1970, 1972), Nuttall (1901), Sahagún (1953), Seler (1904), Smiley (1970), Spinden (1916, 1928), Teeple (1931), Thompson (1972), and Weitzel (1949). An 11-page fragment which may be part of a fourth surviving codex has been described by Michael Coe (New York *Times*, April 21, 1971) as covering 25 Venus cycles (almost 104 solar years) and as furnishing additional pictorial information on the Venus calendar and its influence on Maya religion and astrology. This codex shows that the Maya considered all four phases of the Venus cycle to be malevolent and threatening: "The gods ruling each phase of Venus are depicted as killing and capturing people and burning towns." The new fragment, with Coe's interpretation, will soon be published by the Grolier Club (47 E. 60th St., New York, N.Y.).

We must agree with Pohorecky that meaning was important, but when cultures had developed to the point where agricultural rituals required precise dating, measurement and food-getting must have coincided. Pittioni shares my feeling that as early as the Neolithic there was extensive knowledge about astronomy; the evidence of pre-Neolithic burials indicates some reasonably precise method of determining the sun's rising position at the equinoxes and solstices.

I did not mean to imply that Morley was the *first* to describe the Group-E-type alignment, and am glad Reyman noted this, as in fact I took Ricketson's (1928) article along when inspecting an alignment of this type (but reversed, perhaps for the observation of sunset phenomena) at the Temple of the Dolls at Dzibilchaltun in January; this complex, meticulously measured by Aveni, will be discussed by him in a subsequent publication (cf. Andrews 1959*a*, *b*).

I am chagrined at the proofreading slip which deprived Paleolithic artists of the final *sapiens* due them, observed by Reyman but I hope not by my students. I dislike neologisms as much as the next person, but "astra," as a collective term, is useful to those to whom "celestial" evokes romantic overtones, while Thom's "megalithic man," though doubtless as mythical as the all-round archaeoastronomer, is too valuable a portmanteau term to abandon. Other errors which are less defensible (including doubtless still others generously not noted) are explainable in the phrase Samuel Johnson used in reply to an irate reader's question as to why he had made a certain error in his encyclopaedia, "Ignorance, Madam, ignorance!" Happily, ignorance is vincible.

Since final submission of this paper, I have learned of much significant research. In a paper of great heuristic value for archaeoastronomy, Hatch (1971) assigns an astronomical function to the site plan of La Venta, where around 1000 B.C. the Olmecs constructed a hugh fluted-cone pyramid as part of an impressive ceremonial complex oriented along a line 8° west of true north. In her hypothesis, the builders of La Venta had inherited a tradition appropriate to 2000 B.C., when to observers in the northern hemisphere the summer solstice would have been marked by a stellar configuration including not only Ursa Major, but also Cygnus, the Pleiades, Leo, and Scorpio; i.e., the *center* of the bowl of the Big Dipper (her CP Ursae Majoris) made a lower transit of the meridian going each way less than 15 minutes before midnight, crossing the triangulum of Cygnus making the transit going west, while at the same time the Pleiades rose in the east and Scorpio set in the west. (In her hypothesis, these four equidistant constellations, following each other by approximately 90° in right ascension, marked for the Olmecs the summer solstice, the autumnal equinox, the winter solstice, and the vernal equinox respectively with their midnight transits.) Thus, she holds, the La Venta site at 18° north latitude was oriented ca. 1000 B.C. to CP Ursae Majoris, which set on the horizon 8° west of north. She attributes to the Olmecs a practical astronomy and glyphic records of such phenomena as meridian transits in connection with solstices. Her hypothesis is of further interest in that the Olmec concern with circumpolar constellations, like Olmec art, is suggestive of Chinese influence. Fuson (1969), working with the orientations of Mesoamerican sacred structures and city sites, observes what appear to be culturally important solar and stellar rise-set alignments; he has also assembled evidence supporting M. D. Coe's suggestion that a magnetite object found in southern Veracruz may have been part of an early Olmec magnetic compass. A group from Colgate University headed by Aveni has been conducting field investigations in Central Mexico and Yucatan to determine whether particular site alignments obtained with a transit are correlated with astronomical rise-set phenomena (Aveni 1970). The field program utilizes a set of tables (Aveni 1972) giving rise-set dates of bright stars for a combination of epochs, latitudes, and horizon elevations. Preliminary results with regard to Building J at Monte Albán (cf. Caso 1932) have been analyzed (Aveni and Linsley 1972) in a paper which suggests the possible importance of the heliacal rising of Capella as an "announcer" of a solar zenith passage. Students of Aveni are making studies in depth of astronomical glyphs. Computerized results of the field surveys should be available within the year.

On the basis of archaeoastronomical, iconographic, and textual studies, Zuidema (personal communication, 1 V 73) independently confirms Müller's (1972) views with regard to the astronomical basis of the Inca architecture and cosmology. He has identified certain markers (pillars) which may have been used as sighting devices for the determination of the winter-solstice sunrise and plans to investigate this possibility further this summer. His research indicates 328 sacred sites in Cuzco; when these are added to others in the Temple of the Sun, the total is 365. The days of this solar year were, in his hypothesis, arranged in nine-day weeks and $27\frac{1}{2}$-day months, indicating lunar as well as solar calendric observations. From the Temple of the Sun, he suggests, 41 lines radiated like the spokes of a wheel in groups of three linked to a pillar indicating the new month. His nine-day week is of interest in connection with Kelley's (1972) study of the Nine Lords of the Night, in which he examines Maya glyphs, Mexican sources, and a Zapotec calendar list and concludes that the Lords represented nine days named for gods, the planet list indicating that they began their rule at midnight. Kelley turns to Indian sources for an explanation of the number nine, finding evidence that the gods involved in their day-name order were Sun, Moon, Mars, Mercury, Jupiter, Venus, and Saturn (precisely the same as in the Latinized names of our weekdays), the two remaining deities being the moon's ascending node (Rahu, head of the eclipse dragon) and its descending node (Ketu, tail). His study of the characteristics of the Mesoamerican Nine Lords and the Indian day-list deities also indicates parallels in attributes; he sees the time indicated by the order of the Indian lists as somewhat postdating the 2d century B.C., a period also suggested by his study of the lunar mansions. (I point out again that specific evidence of this nature need not lead us to assume that a *first* contact is indicated; if Proto-Indian travelers were in Africa, as the evidence seems to me [see Jones 1964, 1971], the further step to the Americas is not inconceivable.) That the Indus people were great astronomers as well as magicians we know from Vedic sources; though Roy assigns these astronomical traditions, already evident in Vedic materials in 1300 B.C., to Indo-Europeans, the similarity of Kelley's data to the astronomical materials described by Parpola from the decoding of Indus seals leads me to believe that the invaders took over what they could of the Indus science. Zuidema's comments on Peruvian astronomy further indicate the importance of archaeoastronomical studies in this area where a variety of evidence indicates many Old World-New World parallels.

Increasing interest in archaeoastronomy is evidenced by recent seminars. At a Mesoamerican symposium at Cambridge University, August 29–31, 1972, Marshack (1972) discussed Gossen's (1972) find of a surviving aboriginal Mesoamerican solar calendar of evident antiquity, Digby (1972*a*; see also 1972*b*) described a hypothetical astronomical instrument suggested by representations in the codices, and Baity (1972) reported on recent research. "The Place of Astronomy in the Ancient World" was the title of a meeting held by the Royal Society, in conjunction with the British Academy, December 7–8, 1972; the discussion stressed Thom's findings in regard to megalithic astronomy and further confirmed the significant role of astronomy in the early cults of Mesopotamia, Egypt, and China. Newton (1972) analyzed the need of ancient astronomers to develop methods of dealing with rise-set and other apparent phenomena in terms of a coordinate system based on the observer's horizon. Aaboe (1972) broadly classified prescientific astronomy, compared late with earlier Babylonian astronomy (attributing the uniqueness of Babylonian mathematical astronomy to its base in a particular type of mathematics), and traced its influence in Hellenistic, Indian, and Islamic astronomy. Sachs (1972) gave evidence of systematic astronomical observation early in the 2d millennium B.C., during which period Venus was closely scrutinized. Parker (1972) summed up Egyptian calendrics. Hawkins (1972) offered new evidence on Stonehenge and on the Amon Ra temple, which he found to be oriented to sunrise at the winter solstice. Needham (1972) described early Chinese astronomy as polar and equatorial rather than planetary and ecliptic and as bureaucratic rather than scholarly, also emphasizing the significance of astronomy in the development of the other sciences and the arts. Thom (1972) summarized the megalithic designers' use of an integral right-angled triangle, their observations of the moon's perturbations, and the structure of the megalithic calendar (cf. Thom and Thom 1972). In connection with the study of the moon's perturbations, Thom described the extrapolation sectors in Caithness, the Orkneys, and Brittany and suggested that the alignments at Le Ménec may provide an adjustment for the moon's varying speed in its orbit. Atkinson (1972) reaffirmed his support of Thom's high opinion of Neolithic engineering and stressed the impact of corrected radiocarbon chronology on the dating of Western European cultures, with its implication that mining, megalithic construction, and perhaps the wheel may have developed independently in the West. Climatic factors which had bearing on the early cultures were reviewed by Lamb (1972). MacKie (1972) discussed his two archaeological tests of Thom's astronomical implications. Kendall (1972) analyzed the difficulties in dealing with Thom's megalithic quantum of 5.44 ft. (1.66 m.) on the basis of current studies. Lewis (1972*a*) contributed data on astronomical navigation and weather lore in Polynesia and Micronesia and suggested that widespread parallels indicate the possible diffusion of astronomical concepts throughout the Neolithic world (cf. Lewis 1972*b*:45–82 on steering by the stars). The Maya astronomical system was discussed by Thompson (1972), who called attention to objective astronomical knowledge of such precision that the corrected error in Venus revolutions is one day in 6,000 years.

A symposium arranged and chaired by me was jointly sponsored by the departments of anthropology, geography, and physics of the University of North Carolina at Chapel Hill on March 7, 1973, and additional papers were read at a joint meeting of the Southern Anthropological Society and the American Ethnological Society at Wrightsville Beach on March 8. Aveni (1973*a,b*) discussed the determination of astronomical orientations by measurement with a transit and the use of his tables (cited above). Fuson (1973*a*) discussed a new research tool, "magneto-archaeology," the study of the deliberate alignment of structures to magnetic north, and (1973*b*) showed that a large number of Maya sites have longitudinal alignments to present magnetic north and that dramatic shifts in orientation occurred at approximately the same time (as indicated by dated stelae) in widely separated sites. Magnetic north is of course a strictly local and shifting phenomenon, though the low latitude of the Maya sites cuts down the variation somewhat. (Readers interested in magnetoarchaeology should see Needham's [1962:229–334] discussion of magnetism, divination, and chess; it is also of interest that Maya noblemen, the Lords of Totonicapán, stated that their ancestors brought to Mesoamerica a "sacred director" and were led by four principal leaders, whose names B. P. Reko identifies as the four constellations representing the four quarters of the heavens [cf. Ferguson 1962:17–38].) Reyman (1973*a,b*), discussing ethnographic accounts of Puebloan astronomical practices, listed sources for the formulation of archaeoastronomical hypotheses. Smiley's (1973*b*) communication was of particular interest for introducing yet another celestial variable which has been a concern of archaic astronomers—the differing positions of the Milky Way throughout time, from approximately the 5th millennium to the Classic Maya period. Comparing the orientations of a Maya platform described to him by Ruiz with those of the longest of the Nasca desert straight lines, Smiley (1973*a*) suggested that the Peruvians may have had priority in constructing a match to the position of the Milky Way (cf. Cowan's hypothesis below with reference to template matches). Smiley suggested that when this research tool is refined, it can perhaps be used to date these and other constructions and lines. I (Baity 1973*a,b*) surveyed some of the evidence from other scientific disciplines which indicates the possibility that mariners could have brought a knowledge of Old World astronomical instruments and constructs to the New World.

A seminar on archaeostronomy in pre-Columbian America (part of the program of the American Association for the Advancement of Science) to be co-chaired by Aveni and Hartung in Mexico City in mid-June aims to explore the astronomical knowledge and skills of the ancient peoples of the New World and their effect upon other aspects of life. To judge from the abstracts at hand, this meeting should bring new evidence to bear on problems of the origin and correct correlation of the Mesoamerican calendar and the role of astronomical orientations and calendric rituals in Mesoamerican sacred architecture; a secondary focus will be on the astronomical record in the rock art of the southwestern United States. Coe's (1973) keynoting paper will compare the information provided by the codices, the carved monuments, and native intellectuals and Spanish scholars writing shortly after the Conquest with that derived from modern ethnography to determine which heavenly bodies and asterisms were of interest to ancient Mesoamericans—an analysis designed to provide information applicable to the problems of site and building orientations. Though the seminar focuses on Mesoamerica, Hawkins (1973) will summarize his recent research in Europe and Egypt as well as in Peru and Central America, and Jon Olson (personal communication, 28 XI 72) will also discuss Old World materials. Olson suggests that the Stanton Drew stone circles, three large Neolithic stone circles 60 km. northwest of Stonehenge, could have been used to mark the seasonal risings of the sun and full moon in a similar but more complex manner than at Stonehenge. His study of megalithic rings as counting devices shows a preference for groupings of 12 and 13, 18 and 19, 29 and 30 stones, leading him to suggest that the circles may have indicated the numbers of months, years, and days in lunar and solar cycles. Marshack (1973) will analyze an arithmetic-calendric Olmec mosaic dated to around 1200 B.C. Hatch (1973) finds that pictures accompanying the 260-day count in the Madrid Codex (pp. 12–18) correlate with constellations as they would have been observed after sunset as the year progressed, in the general time period of the estimated date of the Codex, and suggests that the pages deal with a "serpent calendar."

Hochleitner (1973) will analyze six Long Count dates found in the Dresden Codex in support of his correlation of Maya and Christian calendars: he finds evidence here of a match with two solar eclipses and a lunar eclipse. Utilizing the rattlesnake (Pleiades) and the turtle (Gemini-Scorpio) constellations, he reconstructs a hypothetical Maya zodiac which places the beginning of the year at the spring equinox. His equation puts the date of the last Mayan calendar reform (according to De Landa) in A.D. 1081. Owen (1973) will use Makemson's correlation in the interpretation of the astronomical meaning of the "ten pictured" intervals in the Dresden Codex eclipse table.

Other iconographic evidence of interest in connection with the beginnings of Maya astronomy will be cited by Marsh (1973), among them a possible pre-Mayan numbering system, eclipse hieroglyphics, and other icons which he compares with Asian iconographic symbols, suggesting a relationship. Schove (1973) suggests that a comparison of Aztec astronomical and meteorological dates with Chinese and European astronomical records might be used to determine when the Mixtec and Maya peoples would have observed datable astronomical events such as comets, eclipses, conspicuous meteor showers, or unusual meteorological conditions such as severe droughts. With a "spectrum of time" thus established, he suggests, a comparison might be made of proposed solutions of the Maya correlation problem. Harber (1973), on the same assumption that the Maya recorded comets, novae, and other temporary astronomical events, tests the theory by his hypothesis that the "cross-legged" glyph (Glyph X, form 40) was used to signify the arrival of a comet or nova. On the basis of this hypothesis he compares Chinese and European records of comets and novae with Mayan dates associated with this glyph, finding confirmation for certain calendar correlation constants. A concordance table is also to be presented by Noriega (1973), who will analyze Maya and Nahua calendric systems and astronomical computing and describe mathematical-astronomical symbols used by the Aztecs.

Several papers indicate that astronomical events were routinely used to date essential agricultural tasks. Shaw (1973), studying the 260-day calendar, concludes that it marks critical time elements in maize cultivation, and offers further evidence that the heliacal risings of specific constellations and stars may have governed the timing of agricultural operations. Cook de Leonard (1973*a*) studies the survival of feasts related to the agricultural cycle, together with the celebration of events on or about the solstices and equinoxes, to explain coincidences in the dates of Christian and aboriginal festivities. She also (1973*b*) studies the four panels on the walls of the Tajín ballcourt (dated ca. A.D. 1000), using known astronomical signs to aid in the interpretation of others in order to add a timetable to their contents.

The orientations of Mesoamerican structures and ceremonial centers will be discussed by Aveni, Drucker, Fuson, Hartung, and Hurtado. Aveni (1973*c*) will report on fieldwork with a transit in several areas; he has found nearly identical orientations for the Pyramid of the Sun at Teotihuacán and the pyramids of Tenayuca (cf. Marquina 1932) and Tepozteco, all of which align approximately 17° north of west, confirming an early match with the Pleiades-set position noted by Marquina and Ruiz (1932). Aveni suggests that further measurements must be made to establish whether a "17° family of orientation" exists. (This should be compared with Müller's [1972] indications of architectural alignments in Peru that appear to match setting phenomena and with MacGowan's [1945] remarkable one-page paper anticipating Aveni's findings.) Aveni's measurement of Caracol windows suggests two alignments with Venus-set positions when at extreme declinations, an argument supported by Kelley's discovery of Venus representations on Caracol Stela 3 (A. F. Aveni, personal communication, I 73). This and other findings discussed above indicated the use of alignments in calendar setting, the use of "announcer" stars to predict solar zenith passage, and the use of Group-E-type structures to indicate solstices and equinoxes.

Drucker (1973), arguing that the main axis of Teotihuacán was originally oriented 15°25′ east of true north (the same orientation having been followed in a major rebuilding of the city around A.D. 600, by which time precession would have rendered this orientation obsolete), concludes that a solar rather than a stellar orientation is indicated and finds this further suggested by indications of winter-solstice observation from the pyramids of the Sun and of the Moon. Fuson (1973*c*) adds further evidence with regard to factors affecting the orientations of the ceremonial structures, concluding that astronomical and geomagnetic factors were the principal determinants of the Mesoamerican alignments. Hartung (1973) adds further evidence of the importance of astronomical knowledge in Mesoamerican sacred architecture and suggests rigorous criteria for distinguishing the class of lines relating to visual functional composition from that having to do with astronomical and other orientation directions. Hurtado (1973) analyzes an archaeological plaza with regard to both its cultural ambit and its astronomical function.

Chamberlain (1973) will examine astronomical legends and symbols which appear in pictographs, petroglyphs, kiva art, dry paintings, and more recent art. Williamson et al. (1973) will review evidence that the Indians who occupied Chaco Canyon, New Mexico, from A.D. 700 to 1200 had a sophisticated understanding of astronomy and used their structures as crude astronomical instruments, astronomically aligning their great kivas. They note perpendicular directional markings cut into a rock which appear to align with winter-solstice sunrise, a hypothesis which agrees with that of Smiley (1973*a*) with regard to the Nasca lines. Citing previous work by Miller (1955) and Brandt et al. (1972), Williamson (1973) hypothesizes that the Crab Nebula supernova explosion—which, according to the *Sung-shih,* was reported by the Chinese astronomer Yang Wei-Tak on July 4, 1054—is represented by both a pictograph and a petroglyph in Fern Cave and that these also record a rare conjunction visible essentially only from western North America, the crescent moon a few degrees north of the supernova. His argument, like that of Miller, is based partly on the rare appearance of crescents in the North American rock art collated and discussed by Heizer and Baumhoff (1962), Schwartz (1963), and Grant (1967). Ellis (1973), in a study of Southwestern calendric observation and symbols, suggests, however, that this symplegma may be a sun-moon-morning-star combination pertaining to solstice observations. She offers evidence that stars were important as symbols of certain supernatural beings (as we have seen they were in Indus and Mexican cosmology) and that the astra were observed as time-markers. The system, she suggests, may have been introduced from Mexico by traders. Britt (1973) will summarize the literature on the 14 "star ceiling" archaeological sites of early Navajo origin in the Cañon de Chelly and report on his work with Navajo interpreters to correlate pictographs with Navajo star mythology.

Cowan (personal communication, 28 II 73) will advance a hypothesis with regard to the function of effigy mounds which, I suggest, should be tested with the Nasca figures and even with Asian city plans. Many ancient sites, he notes, involve single-point alignments, where a fixed terrestrial point coincides with a single stellar object on the horizon; the effigy mounds, however, may be actual models or reproductions of constellations (bears, serpents, birds) or, in short, a template match. (Could a translation into architecture of this principle—i.e., the Chinese polar-cum-four-quarters model in astronomy and governmental structure—be present in the Southeast Asian stepped cones of pyramids which are surmounted by a central stupa surrounded by four others?)

Reyman (1973*c*) notes that many archaeoastronomical studies have not produced convincing results because the investigators have neither adequately defined their problem nor considered the incompleteness of the archaeological record; he offers a program for the formulation and testing of archaeoastronomical hypotheses.

A significant function of the Mexico City seminar will be to draw together the threads which indicate the strongly astronomical nature of Mesoamerican culture and to indicate some directives for continuing archaeoastronomy and ethnoastronomy in the Americas, the topic of my summarizing report (Baity 1973*c*).

References Cited

AABOE, A. 1972. Scientific astronomy in antiquity. Paper read at symposium "The Place of Astronomy in the Ancient World," Royal Society and British Academy, London, December 7–8.

ANDREWS, E. WYLLYS. 1959*a*. Excavations at Dzibilchaltun, northwestern Yucatan, Mexico. MS.

———. 1959*b*. Dzibilchaltun: Lost city of the Maya. *National Geographic* 115:90–130.

ASHE, GEOFFREY. Editor. 1971. *The quest for America.* New York: Praeger.

ATKINSON, R. J. C. 1968. Review of: *Megalithic sites in Britain,* by Alexander Thom (Oxford: Clarendon, 1967). *Antiquity* 42:77–78. [HHEL]

———. 1972. Neolithic science and technology. Paper read at symposium "The Place of Astronomy in the Ancient World," Royal Society and British Academy, London, December 7–8.

AVENI, A. F. 1970. Astroarchaeology and its application to Mesoamerican studies. MS.

———. 1972. Astronomical tables intended for use in astroarchaeological studies. *American Antiquity* 37:531–40.

———. 1973*a*. The determination of astronomical orientations with application to Mesoamerican archaeological sites. Paper read at the archaeoastronomy seminar at the University of North Carolina at Chapel Hill, March 7.

———. 1973*b*. Astronomy and city planning in ancient Mexico. Paper read at the joint meeting of the Southern Anthropological Society and the American Ethnological Society, Wrightsville Beach, N.C., March 8.

———. 1973*c*. Possible astronomical orientation of structures in Central Mexico, Oaxaca, and Yucatan. Paper prepared for symposium "Archaeoastronomy in Pre-Columbian America," American Association for the Advancement of Science, Mexico City, June 20–22.

AVENI, ANTHONY F., and ROBERT LINSLEY. 1972. Mound J, Monte Albán: Possible astronomical orientation. *American Antiquity* 37:528–31.

BAITY, ELIZABETH CHESLEY. 1968. The fire, bull, and solstice fiestas of Soria Province, Spain, and Afro-Asian parallels, a documentary study in prehistory. Unpublished Ph.D. dissertation, University of North Carolina, Chapel Hill, N.C.

———. 1972. Some critical research questions for Mesoamerican archaeoastronomy. Paper read at the Mesoamerican symposium at Cambridge University, August 29–31.

———. 1973*a*. The Old World ecumene and New World archaeoastronomy. Paper read at the archaeoastronomy seminar at the University of North Carolina at Chapel Hill, March 7.

———. 1973*b*. Archaeoastronomy and ethnoastronomy: The relevance of Old World systems to the New World. Paper read at the joint meeting of the Southern Anthropological Society and the American Ethnological Society, Wrightsville Beach, N.C., March 8.

———. 1973*c*. Mesoamerican archaeoastronomy so far. Paper prepared for the symposium "Archaeoastronomy in Pre-Columbian America," American Association for the Advancement of Science, Mexico City, June 20–22.

BELL, BARBARA. 1970. The oldest records of the Nile floods. *Geographical Journal* 136:569–73.

———. 1971. The Dark Ages in ancient history. I. The first Dark Age in Egypt. *American Journal of Archaeology* 75:1–26.

BENEDICT, R. 1935. *Zuni mythology.* Columbia University Contributions to Anthropology 21. [JER]

BERGER, R. 1970. Ancient Egyptian radiocarbon chronology. *Philosophical Transactions of the Royal Society of London,* ser. A, 269(1193). [RB]

BORST, LYLE B. 1969. English henge cathedrals. *Nature* 224:335–42.

BRANDT, J. C., S. P. MARAN, MURIEL M. KENNEDY, and R. S. HARRINGTON. 1972. A northern California pictograph that may be another record of the Crab Nebula supernova explosion. Paper read at the 138th meeting of the American Astronomical Society, Lansing, Mich.

BREASTED, J. H. 1905. *A history of Egypt.* New York: Scribner. [JER]

BRITT, CLAUDE, JR. 1973. Early Navajo astronomical pictographs in Canyon de Chelly, northeastern Arizona, U.S.A. Paper prepared for symposium "Archaeoastronomy in Pre-Columbian

America," American Association for the Advancement of Science, Mexico City, June 20–22.

BÜHLER, G. 1893. On the date of the Rig Veda. *Indian Antiquary* 23:238–49. [SBR]

BUNZEL, R. 1932. Introduction to Zuni ceremonialism. *Bureau of American Ethnology, Annual Report* 47:467–544. [JER]

BURL, AUBREY. 1973. Dating the British stone circles. *American Scientist* 61:167–74.

CASO, A. 1932. Monte Albán: Richest archaeological find in America. *National Geographic* 62:487–512.

CHAMBERLAIN, VON DEL. 1973. American Indian interest in the sky indicated in legend, rock art, ceremonial and modern art. Paper prepared for symposium "Archaeoastronomy in Pre-Columbian America," American Association for the Advancement of Science, Mexico City, June 20–22.

CHURCHWARD, JAMES. 1926. *The lost continent of Mu.* New York: W. E. Rudge. [JWD]

CLOSS, ALOIS. 1966. Fragen und Gesichtspunkte zum Megalithikum an kanarischen Steindenkmälern. *Paideuma* 12:102–16. [HHEL]

COE, MICHAEL D. 1973. Mesoamerican ethnoastronomy. Paper prepared for symposium "Archaeoastronomy in Pre-Columbian America," American Association for the Advancement of Science, Mexico City, June 20–22.

COOK DE LEONARD, CARMEN. 1973. An astronomical interpretation of the four ball-court panels at Tajín, Mexico. Paper prepared for symposium "Archeoastronomy in Pre-Columbian America," American Association for the Advancement of Science, Mexico City, June 20–22.

COWAN, T. M. 1970. Megalithic rings: Their design and construction. *Science* 168:321–25. [JER]

CYR, DONALD L. 1970. *Hidden halos of Stonehenge.* Santa Barbara: Annular Publications.

DE SANTILLANA, GIORGIO, and HERTHA VON DECHEND. 1969. *Hamlet's Mill.* Boston: Gambit.

DEVOIR, ALFRED. 1908. *Les monuments de la préhistoire et l'astronomie primitive dans l'Europe occidentale.* Morlaix. [PRG]

———. 1909. Urzeitliche Astronomie in Westeuropa. *Mannus* 1:71–82. [PRG]

DIGBY, ADRIAN. 1972*a*. Crossed trapezes: A pre-Columbian astronomical instrument. Paper read at the Mesoamerican symposium at Cambridge University, August 29–31.

———. 1972*b*. Evidences in Mexican glyphs and sculpture for a hitherto unrecognized astronomical instrument. Paper read at the 39th International Congress of Americanists, Rome, September 7.

DI PESO, CHARLES C. 1968. Casas Grandes and the Gran Chichimeca. *El Palacio* 75:45–61.

DONNELLY, IGNATIUS. 1882. *Atlantis: The antediluvian world.* New York: Harper. [JWD]

DOW, JAMES W. 1967. Astronomical orientations at Teotihuacán: A case study in astro-archaeology. *American Antiquity* 32:326–34. [JWD]

DRUCKER, R. DAVID. 1973. The shortest day of the year at Teotihuacán. Paper prepared for symposium "Archaeoastronomy in Pre-Columbian America," American Association for the Advancement of Science, Mexico City, June 20–22.

DU CLEUZIOU, HENRI. 1882. *L'art national.* Paris: Le Vasseur. [PRG]

———. 1887. *La création de l'homme et les premiers âges de l'humanité.* Paris: Flammarion. [PRG]

DUTTON, B. P. 1963. *Sun father's way: The kiva murals of Kuaua.* Albuquerque: University of New Mexico Press. [JER]

ELLIS, FLORENCE HAWLEY. 1970. Calendar priests in Jemez Pueblo: Another item borrowed from Mexico. Paper read at the 35th annual meeting of the Society for American Archaeology, Mexico City.

———. 1973. The Pueblo Sun-Moon-Star calendar in the southwestern United States. Paper prepared for symposium "Archaeoastronomy in Pre-Columbian America," American Association for the Advancement of Science, Mexico City, June 20–22.

ELLIS, F. H., and L. HAMMACK. 1968. The inner sanctum of Feather Cave, a Mogollon sun shrine linking Mexico and the Southwest. *American Antiquity* 33:25–44. [JER]

ESCALONA RAMOS, ALBERTO. 1940. *Cronología y astronomía Maya-Mexica.* Mexico, D.F. [DK]

FERGUSON, T. S. 1962. *One fold and one shepherd.* Salt Lake City: Olympus.

FERGUSSON, J. 1872. *Rude stone monuments in all countries.* London: John Murray. [HHEL]

FEWKES, JESSE W. 1900. The new-fire ceremony at Walpi. *American Anthropologist,* n.s., 2:80–138.

FÖRSTEMANN, E. 1904. *The Pleiades among the Mayas.* Bureau of American Ethnology Bulletin 28.

FUSON, ROBERT F. 1969. The orientation of Mayan ceremonial centers. *Annals of the Association of American Geographers* 59:494–511.

———. 1973*a*. Magnetoarchaeology: A new method of archaeological research. Paper read at the archaeoastronomy seminar at the University of North Carolina at Chapel Hill, March 7.

———. 1973*b*. Building alignments in pre-Columbian Mesoamerica: Fixed or moving reference points? Paper read at the joint meeting of the Southern Anthropological Society and the American Ethnological Society, Wrightsville Beach, N.C., March 8.

———. 1973*c*. Factors affecting the arrangement of Mesoamerican ceremonial centers with particular reference to astroarchaeology and magnetoarchaeology. Paper prepared for symposium "Archaeoastronomy in Pre-Columbian America," American Association for the Advancement of Science, Mexico City, June 20–22.

GAILLARD, FELIX. 1888. Les alignements de menhirs dans le Morbihan et leur définition. *Bulletins de la Société d'Anthropologie de Paris* 11:434–37. [PRG]

———. 1897. *L'astronomie préhistorique.* Paris: Les Sciences Populaires. [PRG]

GOLDFRANK, ESTHER. Editor. 1962. *Isleta paintings.* Bureau of American Ethnology Bulletin 181.

GOLDSTEIN, L. J. 1962. Evidence and events in history. *Philosophy of Science* 29:175–94. [JER]

GORDON, CYRUS H. 1971. *Before Columbus: Links between the Old World and ancient America.* New York: Crown.

GORDON, D. H. 1960. 2d edition. *The prehistoric background of Indian culture.* Bombay: N. M. Tripathi (Private).

GOSSEN, GARY H. 1972. A Chamula solar calendar board from Chiapas, Mexico. Paper discussed at the Mesoamerican symposium at Cambridge University, August 29–31.

GRANT, CAMPBELL. 1967. *Rock art of the American Indians.* New York: Crowell.

GROSSIN, P. 1898. Note sur l'orientation des mégalithes. *Annales de la Société d'Emulation de l'Ain* 31. [PRG]

GUTHE, K. 1932. The Maya lunar count. *Science* 75:271–77.

HARBER, HUBERT E. 1973. Did the Mayans record comet and nova events? Paper prepared for symposium "Archaeoastronomy in Pre-Columbian America," American Association for the Advancement of Science, Mexico City, June 20–22.

HARTUNG, HORST. 1973. Método de trabajo para definir posibles reflejos de observaciones astronómicas en la arquitectura pre-Colombina de Mesoamerica. Paper prepared for symposium "Archaeoastronomy in Pre-Columbian America," American Association for the Advancement of Science, Mexico City, June 20–22.

HATCH, MARION P. 1971. An hypothesis on Olmec astronomy with special reference to the La Venta sites. MS.

———. 1973. A possible new calendar in the Madrid Codex. Paper prepared for symposium "Archaeoastronomy in Pre-Columbian America," American Association for the Advancement of Science, Mexico City, June 20–22.

HAWKINS, GERALD S. 1972. Astronomical alignments in Britain, Egypt, and Peru. Paper read at symposium "The Place of Astronomy in the Ancient World," Royal Society and British Academy, London, December 7–8.

———. 1973. Astro-archaeology: The unwritten evidence. Paper prepared for symposium "Archaeoastronomy in Pre-Columbian America," American Association of the Advancement of Science, Mexico City, June 20–22.

HEINE-GELDERN, ROBERT. 1959. "Das Megalithproblem." *Beiträge Österreichs zur Erforschung der Vergangenheit und Kulturgeschichte der Menschheit, Symposium 1958,* pp. 162–82. Horn. [HHEL]

———. 1963. "Monuments to killers," in *A Pedro Bosch-Gimpera en el septuagésimo aniversario de su nacimiento,* pp. 181–88. Mexico. [HHEL]

HEIZER, ROBERT F., and MARTIN A. BAUMHOFF. 1962. *Prehistoric rock art of Nevada and eastern California.* Berkeley: University of California Press.

HEYERDAHL, THOR. 1971*a*. "Isolationist or diffusionist?" in *The quest for America.* Edited by G. Ashe, pp. 115–54. New York: Praeger.

———. 1971*b*. "The bearded gods speak," in *The quest for America.* Edited by G. Ashe, pp. 199–238. New York: Praeger.

HOCHLEITNER, FRANZ J. 1973. An astronomical test for Ahau equations. Paper prepared for symposium "Archaeoastronomy in Pre-Columbian America," American Association for the Advancement of Science, Mexico City, June 20–22.

HOLUB, STANISLAV. 1962. "Keltská svatyně u Libenic z astronomického hlediska", in *Libenice, keltská svatyně ve středních Čechách,* by A. Rybová and B. Soudský. Edited by J. Filip, pp. 281–87. Praha: Nakladatelství Československé akademie věd. [EPS]

HURTADO SERRANO, ALFONSO. 1973. Palenque, Chiapas, Mexico: Analisis y programa de una plaza arqueológica recreando su ámbito cultural en función del espacio-tiempo astronómico. Paper prepared for symposium "Archaeoastronomy in Pre-Columbian America," American Association for the Advancement of Science, Mexico City, June 20–22.

JACOBI, H. 1893. On the date of the Rig Veda. *Indian Antiquary* 23:154–59.

[SBR]
JETTMAR, KARL. 1971. "Einige Überlegungen zum Megalithproblem," in *Mélanges de préhistoire, d'archéocivilisation et d'ethnologie offerts à André Varagnac*, pp. 477–85. Paris: Sevpen. [HHEL]
JONES, A. M. 1964. *Africa and Indonesia.* Leyden: E. J. Brill.
______. 1971. "Africa and Indonesia: An ancient colonial era?" in *Essays on music and history in Africa.* Edited by Klaus P. Wachsmann. Evanston: Northwestern University Press.
JONES, SIR WILLIAM. 1790. A supplement to the essay on Indian chronology. *Asiatick Researches* 2:389. [SBR]
JUDD, NEIL M. 1964. *The architecture of Pueblo Bonito.* Smithsonian Institution Miscellaneous Collections 147(1).
JUERGENS, RALPH. 1972. "Reconciling celestial mechanics and Velikovskian catastrophism," in *Immanuel Velikovsky reconsidered II.* Edited by Stephen L. Talbott, pp. 6–12. Portland: Student Academic Freedom Forum.
KELLEY, DAVID. 1970. Indo-Greek cosmology and science in ancient Mesoamerica. Paper read at a conference on the Mayan calendar and writing systems, American Museum of Natural History, New York, July 22–24.
______. 1972. *The Nine Lords of the Night.* Contributions of the University of California Archaeological Research Facility 16.
KELLEY, J. CHARLES. 1960. "North Mexico and the correlation of Mesoamerican and Southwestern cultural sequences," in *Man and culture.* Edited by Anthony F. C. Wallace, pp. 566–73. Philadelphia: University of Pennsylvania Press.
______. 1966. "Mesoamerica and the southwestern United States," in *Handbook of Middle American Indians,* vol. 4. Edited by G. F. Ekholm and G. R. Willey, pp. 95–110. Austin: University of Texas Press. [JER]
KENDALL, D. G. 1972. Hunting quanta. Paper read at symposium "The Place of Astronomy in the Ancient World," Royal Society and British Academy, London, December 7–8.
KERVILER, RENÉ. 1904*a*. Les mesures de longueur et les nombres 7 et 3 chez les constructeurs de monuments mégalithiques en Armorique. *Comptes-Rendus de l'Académie des Inscriptions* (reprint). [PRG]
______. 1904*b*. Les mesures de longueur, les nombres 3 et 7 et les connaissances en arithmétique, géométrie et astronomie chez les constructeurs de monuments mégalithiques en Armorique. *Bulletin archéologique de l'Association Bretonne* 23:288–306. [PRG]
LAMB, J. C. 1972. Climate, vegetation, and forest limits in early civilized times. Paper read at symposium "The Place of Astronomy in the Ancient World," Royal Society and British Academy, London, December 7–8.
LANGE, C. H. 1959. *Cochiti: A New Mexico pueblo past and present..* Austin: University of Texas Press. [JER]
LANGE, C. H., and C. L. RILEY. 1970. *The Southwestern journals of Adolph F. Bandelier: 1883–1884.* Albuquerque: University of New Mexico Press. [JER]
LE MAY, REGINALD. 1954. *The culture of South-East Asia.* London: George Allen and Unwin.
LÉVI-STRAUSS, C. 1966. *The savage mind.* Chicago: University of Chicago Press. [JER]
______. 1969. *The raw and the cooked.* New York: Harper and Row.
LEWIS, DAVID. 1972*a*. Voyaging stars: Aspects of Polynesian and Micronesian astronomy. Paper read at symposium "The Place of Astronomy in the Ancient World," Royal Society and British Academy, London, December 7–8.
______. 1972*b*. *We, the navigators: The ancient art of landfinding in the Pacific.* Honolulu: University of Hawaii Press.
LOOFS, H. H. E. 1967. *Elements of the megalithic complex in Southeast Asia: An annotated bibliography.* Canberra: Australian National University Press. [HHEL]
______. 1970. "The use of stone by the Ifugao (Luzon, Philippines)." *Proceedings, VIIIth International Congress of Anthropological and Ethnological Sciences, 1968, Tokyo and Kyoto,* vol. 3, pp. 435–47. Tokyo: Science Council of Japan. [HHEL]
LININGTON, ROBERT E. 1969. The prospecting campaign undertaken in Czechoslovakia in 1968. *Prospezioni archeologiche* 4:131–38. [EPS]
MACKIE, E. W. 1969. *An archaeological view of Neolithic astronomy.* Glasgow: Hunterian Museum. [JER]
______. 1972. Archaeological tests on supposed astronomical sites in Scotland. Paper read at symposium "The Place of Astronomy in the Ancient World," Royal Society and British Academy, London, December 7–8.
______. 1973. "A quantitative test for catastrophic theories," in *Immanuel Velikovsky reconsidered III.* Edited by Stephen L. Talbott, p. 6–9. Portland: Student Academic Freedom Forum.
MAIER, RUDOLF A. 1962. Fragen zu neolithischen Erdwerken Südbayerns. *Jahresbericht der Bayerischen Bodendenkmalpflege* 2:5–21. [EPS]
MARQUINA, I. 1932. *Tenayuca.* Mexico: Museo Nacional de Arqueología, Historia, y Etnología.
MARQUINA, I., and L. RUIZ. 1932. "La orientación de las pyrámides." *XXV Congreso International de Americanistas, La Plata,* vol. 2, pp. 101–6.
MARSH, R. 1973. A possible pre-Mayan numbering system, eclipse hieroglyphs, and astronomical structures. Paper prepared for symposium "Archaeoastronomy in Pre-Columbian America," American Association for the Advancement of Science, Mexico City, June 20–22.
MARSHACK, ALEXANDER. 1972. The Chamula calendar board: An internal and comparative analysis. Paper read at the Mesoamerican symposium at Cambridge University, August 29–31.
______. 1973. Cognitive analysis of an arithmetic-calendric Olmec mosaic c. 1200 B.C. Paper prepared for symposium "Archaeoastronomy in Pre-Columbian America," American Association for the Advancement of Science, Mexico City, June 20–22.
MARTIN, ARTHUR. 1911. L'unité de mesure chez les Néolithiques. *Bulletin de la Société Archaéologique du Finistère* 38:116–18. [PRG]
MARTIROSSIAN, H. A., and H. R. ISRAELIAN. 1971. *The archaeological monuments and specimens of Armenia. Vol. 6. The rock-carved pictures of the Gueghamian Mountains* (in Armenian, with introduction in Russian and English). Yerevan.
MEGGERS, BETTY. 1971. "Contacts from Asia," in *The quest for America.* Edited by G. Ashe, pp. 239–59. New York: Praeger.
MEGGERS, BETTY, CLIFFORD EVANS, and EMILIO ESTRADA. 1965. *Early Formative period of coastal Ecuador: The Valdivia and Machalilla phases.* Smithsonian Contributions to Anthropology 1.
MERLET, RENE. 1929. Peut-on calculer, à l'aide de l'astronomie, la date approximative de certains monuments mégalithiques? *Mémoires de la Société d'Histoire et d'Archéologie de Bretagne* 10:13–26. [PRG]
______. 1935. Valeur métrique du pied employé en Gaule, comme mesure de longueur, avant l'ère chrétienne. *Mémoires de la Société d'Histoire et d'Archéologie de Bretagne* 16:133–45. [PRG]
MEYNIER, ANDRE. 1943*a*. Champs et chemins de Bretagne. *Conférences Universitaires de Bretagne 1942–43,* pp. 159–78. [PRG]
______. 1943*b*. Une enquête sur le bocage breton. *Annales de Bretagne* 50:102–3. [PRG]
______. 1944*a*. Sur de curieux alignements de chemins et de monuments en Bretagne. *Annales de Bretagne* 51:125–29. [PRG]
______. 1944*b*. Notre enquête sur les champs Bretons. *Annales de Bretagne* 51:136–39. [PRG]
______. 1945. Les enseignements géographiques de la photographie aérienne Pléhérel. *Annales de Bretagne* 52:73–81. [PRG]
______. 1958. *Les paysages agraires.* Paris: A. Colin. [PRG]
MILLER, WILLIAM C. 1955. Two possible astronomical pictographs found in Northern Arizona. *Plateau* 27:4:6–13. [DB]
MITRA, PAÑCHĀNANA. 1927. 2d edition. *Prehistoric India: Its place in the world's cultures.* Calcutta: University of Calcutta Press.
MÜLLER, ROLF. 1936*a*. Kritische Bemerkungen zur vorgeschichtlichen Sternkunde. *Mannus* 28:95–93. [EPS]
______. 1936*b*. *Himmelskundliche Ortung auf nordisch-germanischen Boden.* Leipzig: Käbitzsch. [EPS]
______. 1972. *Sonne, Mond und Sterne über dem Reich der Inka.* Berlin, Heidelberg, New York: Springer.
NEEDHAM, JOSEPH. 1959. *Science and civilisation in China. Vol. 3, sec. 20. Astronomy.* London: Cambridge University Press.
______. 1962. *Science and civilisation in China. Vol. 4, pt. 1. Physics.* London: Cambridge University Press.
NEWTON, R. R. 1972. Two uses of ancient astronomy. Paper read at symposium "The Place of Astronomy in the Ancient World," Royal Society and British Academy, London, December 7–8.
NORIEGA, RAUL. 1973. Symbology of the chronological-astronomical expression of the Aztecs. Paper prepared for symposium "Archaeoastronomy in Pre-Columbian America," American Association for the Advancement of Science, Mexico City, June 20–22.
NUTTALL, Z. 1901. *The fundamental principles of Old and New World civilizations.* Peabody Museum, Harvard University, Archaeological and Ethnological Papers 2.
OKLADNIKOV, A. P. 1972. *Der Hirsch mit dem goldenen Geweih: Vorgeschichtliche Felsbilder Sibiriens.* Wiesbaden: E. A. Brockhaus.
OLSSON, I. U. Editor. 1970. *Radiocarbon variations and absolute chronology.* Stockholm: Almqvist and Wiksell. [RB]
OWEN, NAN. 1973. An attempt to interpret the astronomical meaning of the "10 pictured" intervals in the Dresden Codex eclipse table using Makemson's correlation number. Paper prepared for symposium "Archaeoastronomy in Pre-Columbian America," American Association for the Advancement of Science, Mexico City, June 20–22.
PARKER, R. A. 1972. Ancient Egyptian astronomy. Paper read at symposium "The Place of Astronomy in the Ancient

World," Royal Society and British Academy, London, December 7–8.
PARSON, E. C. 1939. *Pueblo Indian religion.* Chicago: University of Chicago Press.
PAWLEY, G. S., and N. ABRAHAMSEN. 1973. Do the pyramids show continental drift? *Science* 179:892–93. [JER]
PERRY, W. J. 1923. *The children of the sun.* London: Methuen. [HHEL]
PETROSIAN, S. 1971. Astronomical pictures in Armenia's mountains (in Armenian). *Voice of the Fatherland* no. 23, pp. 4–5.
PLENEL, ALAIN. 1943. Un réseau géométrique de sites anciens. *Annales de Bretagne* 50:89. [PRG]
PLESLOVÁ-ŠTIKOVÁ, EMILIE. 1972. Funkce příkopů na sídlišti kultury nálevkovitých pohárů v Makotřasích (okr. Kladno). *Archeologické rozhledy* 24:269–76. [EPS]
PODBORSKÝ, VLADIMÍR. 1972. Opevněná část neolitické osady v Těšeticích-Kyjovicích. *Archeologické rozhledy* 24:155–62. [EPS]
REED, ERIK. 1956. "Types of village plan layouts in the Southwest," in *Prehistoric settlement patterns in the New World.* Edited by Gordon R. Willey, pp. 11–17. Viking Fund Publications in Anthropology 23.
REYMAN, JONATHAN E. 1970. Southwestern Pueblo conservatism: A new look at an old "myth." Paper read at the 35th annual meeting of the Society for American Archaeology, Mexico City.
———. 1971*a*. Astro-archaeology in the Anasazi area. Paper read at the 36th annual meeting of the Society for American Archaeology, Norman, Okla.
———. 1971*b*. Mexican influence on Southwestern ceremonialism. Unpublished Ph.D. dissertation, Southern Illinois University, Carbondale, Ill.
———. 1972. American Indian interest in the sky as indicted by the orientation of structures in Mexico and the southwestern United States. Paper read at the fall conference of the Great Lakes Planetarium Association, Youngstown, Ohio.
———. 1973*a*. Ethnographic accounts of Puebloan astronomical practices. Paper read at the archaeoastronomy seminar at the University of North Carolina at Chapel Hill, March 7.
———. 1973*b*. Sources for the formulation of archaeoastronomical hypotheses. Paper read at the joint meeting of the Southern Anthropological Society and the American Ethnological Society, Wrightsville Beach, N.C., March 8.
———. 1973*c*. The nature and nurture of archaeoastronomical hypotheses. Paper prepared for symposium "Archaeoastronomy in Pre-Columbian America," American Association for the Advancement of Science, Mexico City, June 20–22. City, June 20–22.
RICKETSON, O. G., JR. 1928. Astronomical observatories in the Maya area. *Geographical Review* 18:215–25. [JER]
RICKETSON, O. G., JR., and E. B. RICKETSON. 1937. *Uaxactun, Guatemala: Group E (1926–1931).* Carnegie Institution of Washington, publ. 477. [JER]
RILEY, CARROLL L., J. CHARLES KELLEY, CAMPBELL W. PENNINGTON, and ROBERT L. RANDS. 1971. *Man across the sea: Problems of pre-Columbian contacts.* Austin and London: University of Texas Press.
ROBINSON, L. J. 1961. *Astronomy in anthropology.* Astronomical Society of the Pacific Leaflets 380. [DB]
ROY, S. B. 1972. Chronological infrastructure of Indian protohistory. Paper presented at a seminar held at Kurkshetra University, November. [SBR]
SACHS, A. Babylonian observational astronomy. Paper read at symposium "The Place of Astronomy in the Ancient World," Royal Society and British Academy, London, December 7–8.
SAHAGÚN, B. DE. 1950. *General history of the things of New Spain: Florentine Codex.* Translated by A. J. O. Anderson and C. E. Dibble. School of American Research Monograph 14.
SANKALIA, H. D. 1962. *Indian archaeology today.* Bombay, London, New York: Asia Publishing House.
SAXE, A. A. 1971. "Social dimensions of mortuary practices in a Mesolithic population from Wadi Halfa, Sudan," in *Approaches to the social dimensions of mortuary practices.* Edited by J. A. Brown, pp. 39–57. Society for American Archaeology, Memoir 25. [JER]
SCHOVE, DEREK J. 1973. The spectrum of time in Mesoamerica A.D. 400–1500. Paper prepared for symposium "Archaeoastronomy in Pre-Columbian America," American Association for the Advancement of Science, Mexico City, June 20–22.
SCHMITZ, CARL AUGUST. 1961. Gibt es eine "Megalith-Kultur" in Ozeanien? *Zeitschrift für Ethnologie* 86:234–49. [HHEL]
SCHWARTZ, B. K. 1963. *Clamath Basin petroglyphs.* Madison: Society for American Archaeology, University of Wisconsin Press.
SELER, EDUARD. 1904. *Venus period in the picture writing of the Borgian Codex group.* Bureau of American Ethnology Bulletin 28.
SHAFER, R. 1954. *Ethnography of Ancient India.* Wiesbaden: Harrassowitz.
SHAW, HAROLD R. 1973. Astronomical implications of the Maya agricultural calendar. Paper prepared for symposium "Archaeoastronomy in Pre-Columbian America," American Association for the Advancement of Science, Mexico City, June 20–22.
SÎNGEORZAN, I. C. 1970. Zur Vorgeschichte der Astronomie. *Andromeda* 2, ser. 2 (1–2). [RM]
SMILEY, CHARLES H. 1970. Mayan glyphs associated with the sun, moon, and planets. Paper read at the New World Writing Systems Conference, Dumbarton Oaks, July 22–24.
———. 1973*a*. The astronomical significance of the Nasca desert ground figures. Paper read at the archaeoastronomy seminar at the University of North Carolina at Chapel Hill, March 7.
———. 1973*b*. Milky Way orientations in the distant past. Paper read at the joint meeting of the Southern Anthropological Society and the American Ethnological Society, Wrightsville Beach, N.C., March 8.
SMYTH, CHARLES PIAZZI. 1880. *Our inheritance in the Great Pyramid.* London: W. Isbister. [JWD]
SPINDEN, HERBERT. 1916. The question of the zodiac in America. *Natural Science* 18:53–80.
———. 1928. Ancient Mayan astronomy. *Scientific American,* January, pp. 8–12.
STEPHEN, A. M. 1936. *Hopi journal.* Edited by E. C. Parsons. Columbia University Contributions to Anthropology 23.
TALBOTT, STEPHEN L. Editor. 1972. *Immanuel Velikovsky reconsidered.* (Special issues of *Pensée.*) Portland: Student Academic Freedom Forum.
TAYLOR, W. W. 1948. *A study of archeology.* American Anthropological Association Memoir 69. [JER]
TEEPLE, J. 1931. Maya astronomy. *Carnegie Institution of Washington Contributions to American Archaeology* 1:29–115.
THOM, A. 1971. *Megalithic lunar observatories.* Oxford: Clarendon. [JER]
———. 1972. Astronomical significance of prehistoric monuments in Western Europe. Paper read at symposium "The Place of Astronomy in the Ancient World," Royal Society and British Academy, London, December 7–8.
THOM, A., and A. S. THOM. 1972. The uses of the alignments at Le Ménec, Carnac. *Journal of the History of Astronomy* 3:151–64.
THOMPSON, J. E. S. 1972. Maya astronomy. Paper read at symposium "The Place of Astronomy in the Ancient World," Royal Society and British Academy, London, December 7–8.
TILAK, B. G. 1894. *Orion.* Poona. [SBR]
TOVAR, ANTONIO. 1954. 2d edition. *La lengua vasca.* San Sebastian: Biblioteca Vasconzada de los Amigos del País.
TUMANIAN, B. E., and S. B. PETROSIAN. 1970. Astronomical pictures on rocks (in Armenian, with summary in Russian). *Learned Papers of the Yerevan State University,* no. 1, pp. 16–23.
VAN SETERS, JOHN. 1964. A date for the Admonitions. *Journal of Egyptian Archaeology* 50:13–23.
VARAGNAC, ANDRÉ. 1959. "Le navire, porteur de religion: Le Chalcolithique," in *L'homme avant l'écriture.* Edited by André Varagnac, pp. 390–407. Paris: Armand Colin. [HHEL]
———. 1961. Le premier symposium international sur l'étude des mégalithes. *Antiquités nationales et internationales* 2:20–23. [HHEL]
VELIKOVSKY, I. 1950. *Worlds in collision.* New York: Doubleday.
———. 1955. *Earth in upheaval.* New York: Doubleday.
———. 1963. Some additional examples of correct prognosis. *American Behavioral Scientist* 7.
VON DANIKEN, ERICH. 1971. *Chariots of the gods.* Translated by Michael Heron. New York: Bantam Books. [JWD]
———. 1972. *Gods from outer space.* Translated by Michael Heron. New York: Bantam Books. [JWD]
WEITZEL, R. B. 1949. The dark phase of the moon and ancient Maya methods of solar eclipse prediction. *American Antiquity* 3:230–33.
WILLIAMSON, R. A. 1973. Possible rock art records of the Crab Nebula supernova in the western United States. Paper prepared for symposium "Archaeoastronomy in Pre-Columbian America," American Association for the Advancement of Science, Mexico City, June 20–22.
WILLIAMSON, R. A., A. F. WILLIAMSON, H. J. FISHER, and C. COCHRAN. 1973. The astronomical record in Chaco Canyon, N.M., U.S.A. Paper prepared for symposium "Archaeoastronomy in Pre-Columbian America," American Association for the Advancement of Science, Mexico City, June 20–22.
WILLVONSEDER, KURT. 1928. Zeitbestimmende Bergnamen. *Jahresbericht der akad. Sektion Wien des Deutschen und Österreichischen Alpenvereins,* pp. 3–16. [RP]
WILSON, H. H. 1861. *Collected works.* London. [SBR]