PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A
MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

Voyaging Stars: Aspects of Polynesian and Micronesian Astronomy

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Voyaging stars: aspects of Polynesian and Micronesian astronomy

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[Plate 21]

In Polynesia and Micronesia, where concepts are virtually identical, astronomy and navigation form one inseparable science. Sky 'domes', stellar zones, the seasons, yam growth and the Pleiades, as well as time spans of settlement, are mentioned in the paper, and attention is drawn to apparent maritime technological parallels elsewhere.

An explanation is advanced to account for survivals into the ethnographic present, *vide* the author's 1700 miles as navigators' apprentice, observations from a Sun-oriented trilithon and a stone instructional device, hitherto unrecorded, that is still in use. Solar observational platforms, navigational sighting stones and astro-navigation are touched upon. Pan-Pacific beliefs in stellar control of weather, astronomical lore inappropriate to its present location and the excellence of astro-navigation lead to speculation on possible one-time widespread diffusion through the neolithic world of related astronomical concepts.

'There is no specific word for "astronomer" in the Gilbertese tongue', Grimble wrote. 'If you would find an expert on stars, you must ask for a *tiaborau* or navigator' (Grimble 1931, p. 197). The study of astronomy was treated by the Tongans as a branch of navigation, according to Collocott (1922, p. 157). Similarly, in eighteenth-century Tahiti, Forster (1778, p. 501) remarked upon the subservience to navigation of the sciences of astronomy and geography. Such a relationship is hardly surprising considering that the Polynesian and Micronesian habitat, if we exclude New Zealand, is of the order of two parts of land for every thousand of water.

A few words about possible origins, time spans and technologies, of necessity grossly over-simplified, are desirable if we are to relate the astronomy of Oceania in any way at all to that of the ancient world in general. The ancestors of the Micronesians and Polynesians moved into the island world from Asia, the former coming to occupy the northwestern sector and the latter the west-central and central Pacific. Figure 1 shows these two areas and also Melanesia, which has unfortunately had to be excluded from this paper for lack of space. Archaeologists now tend to identify the makers of Lapita pottery as the most important Polynesian precursors (Groube 1971; Green 1972). Their coastal settlements appear mostly in the second millennium B.C. scattered over a huge area of Melanesia from New Britain to Fiji, in the Polynesian Santa Cruz Reef Island, and in Tonga, on the western margin of Polynesia. The rapidity of the dispersal of the Lapita pottery makers suggests that they were possessed of an advanced marine technology. This latter supposition gains indirect support from Haddon and Hornell's conclusion to their monumental work *Canoes of Oceania*, that the 'vessels used by the proto-Polynesians had frames and were plank-built, rather than ordinary dugout hulls with strakes' (1938, p. 40), in other words, were highly sophisticated craft. The size of double canoes in early historic times is attested by Cook, who saw some in Tahiti that were longer than the *Endeavour* (Haddon & Hornell 1938, p. 43). The inserted frames themselves and their attachments to planking are similar to those found in pre-Viking Scandinavian craft, leading Hornell (1935) to raise the possibility of the Pacific designs being distant offshoots of, or influenced by, some general neolithic or post-neolithic boat building tradition.

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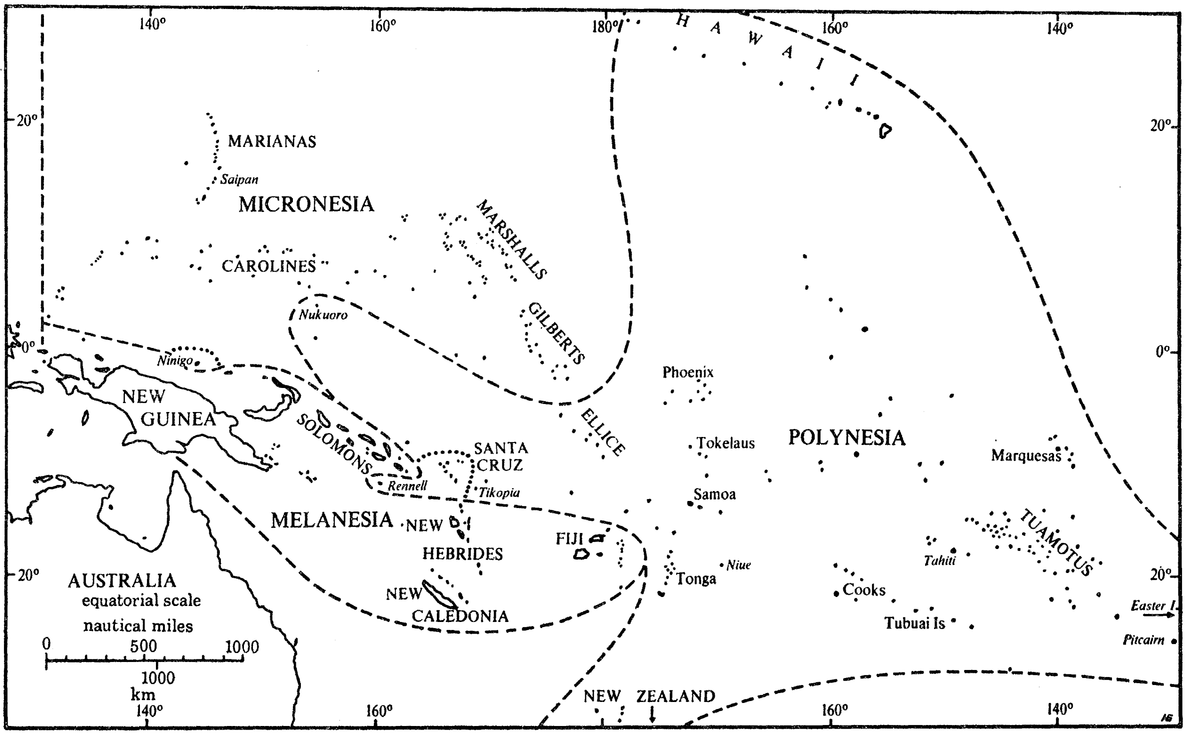

Figure 1. Map of Pacific regions showing Polynesia, Micronesia and Melanesia.

The entity we know as 'Polynesian' seems to have evolved in Tonga during the six or so centuries following settlement (Groube 1971), though it was from Samoa early in the Christian era that the dramatic move into the vast spaces of the central Pacific took place, the last eastern Polynesian outpost, New Zealand, being colonized from tropical eastern Polynesia by about A.D. 800 (Pawley 1966; Green 1966).

The economy of the neolithic Polynesians and Micronesians was in general based on yam, *taro*, sweet potato and breadfruit cultivation, harvesting the ubiquitous coconut, reef gathering and fishing. (This generalization ignores many anomalies, the role of pandanus in the Gilberts and Marshalls, for instance, or the remarkable absence of shell middens from Samoa.) Voyaging in Oceania seems to have been motivated more by quest for adventure, plunder and prestige, among other causes, than by trade cycles, which were more typical of Melanesia.

Astronomical concepts

Astronomy, including nautical astronomy, is practically the same in Polynesia as in Micronesia, every significant concept being, in some degree, duplicated. The considerable differences that exist between individual archipelagos do not, as one might have anticipated, polarize across the linguistic-cultural 'frontiers' between the Polynesian Ellice and the Micronesian Gilberts. On such evidence as is available to us today, it does not appear justifiable to speak of separate Polynesian and Micronesian *systems*, but only of an Oceanic one with local variations (Lewis 1972, pp. 11, 160–162). A dissenting view, that the systems were distinct, is advanced by Akerblom (1968, p. 12), on the basis of a documentary study.

The usual cosmological concept is of sky domes, single or multiple and often solid, centred

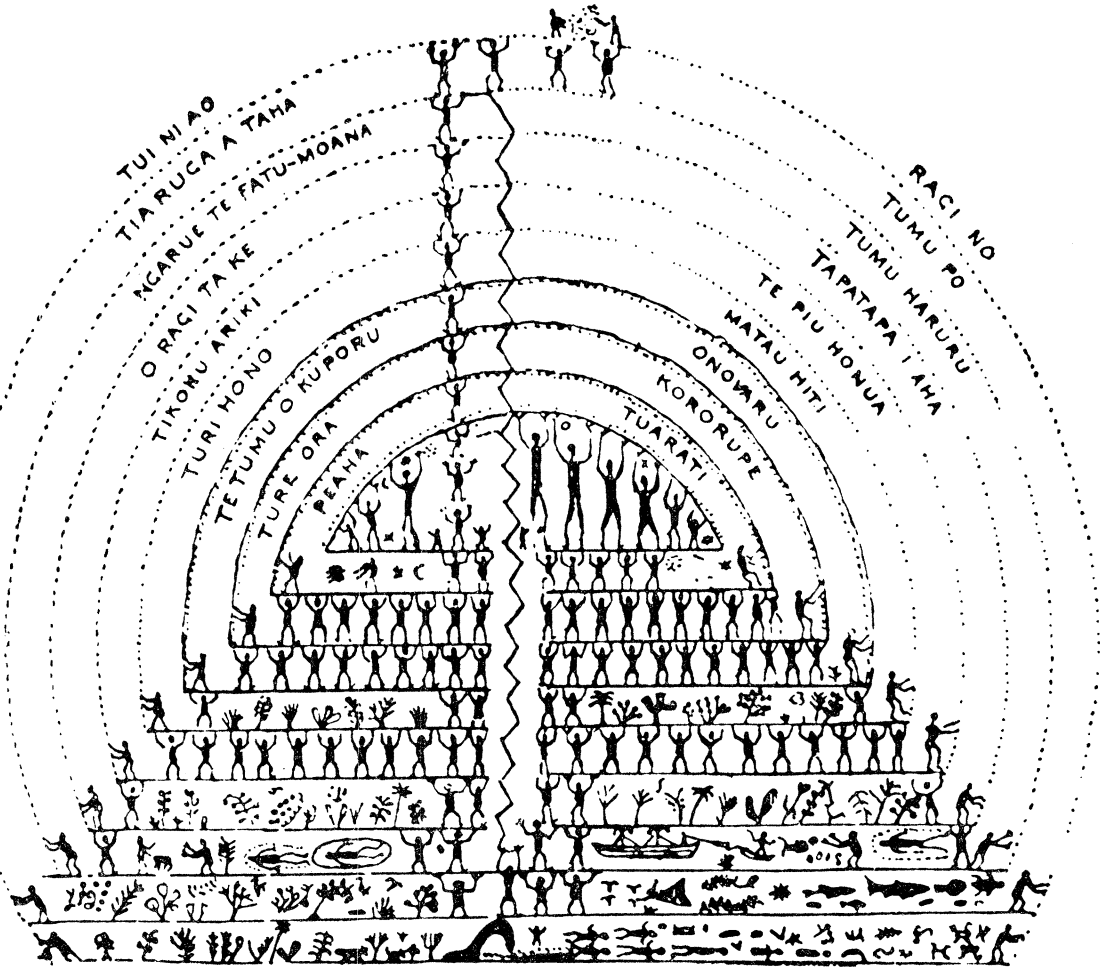

FIGURE 2. A Polynesian (Tuamotuan) heaven.

upon the home island or group, other groups having their own celestial cupolas, openings around the horizon allowing communication between them. Figure 2 shows a Polynesian heaven from the Tuamotu (Henry 1928); and figure 3 a Micronesian sky dome from the Gilberts (Akerblom 1968, p. 136). The similarities are obvious.

Navigator-priest-astronomers were familiar with the solstices and sometimes the equinoxes, the celestial equator, the zenith (which had special navigational significance), the distinction between stars and planets, and the precise azimuths of all navigationally useful stars, together with the approximate dates of their appearance in the night sky. The Maori of New Zealand were not atypical in having names for close on two hundred stars (Akerblom 1968, p. 22; Best 1922; Grimble 1931; Goodenough 1953; Makemson 1941). The magico-religious aspects of astronomy cannot be discussed adequately here, but religious beliefs and Polynesian star and sun myths are well documented (Williamson 1933; Fornander 1878, 1880). The rarity of Micronesian star myths, compared with their Polynesian profusion, remarked upon by Goodenough (1953, p. 4), is not readily explicable.

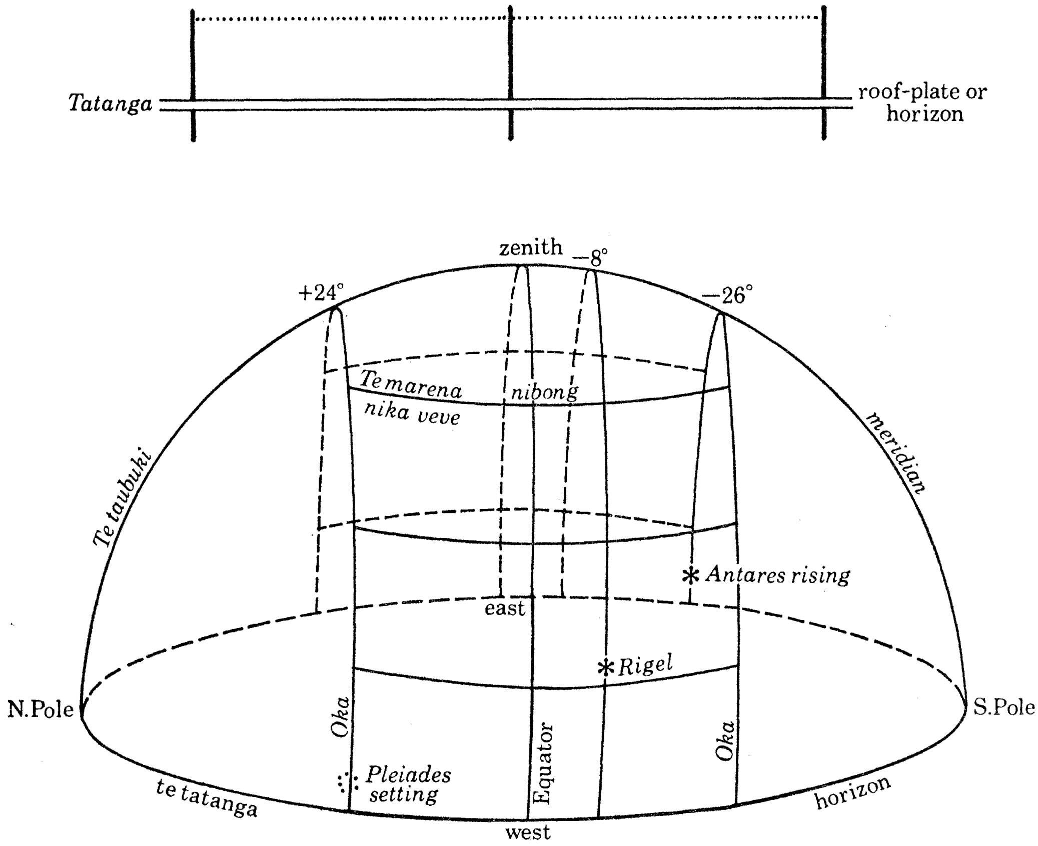

Figure 3. A Gilbertese sky dome.

Who were the astronomers?

They were specialists. As J. R. Forster noted in Tahiti (1778, p. 528), 'geography, navigation and astronomy are known only to few'. Most of these were of high rank, like Tupaia, a dispossessed high chief and priest-navigator from Raiatea near Tahiti, who was Cook's most knowledgeable geographical informant (Beaglehole 1955, p. 117n.). Tupaia's known world in terms of islands radiating from Tahiti, embraced every major group in Polynesia and Fiji, except Hawaii, New Zealand, and the isolated Easter Island (Hale 1846, p. 122). Yet we know virtually nothing about his actual astro-navigational concepts.

The secrets of Tongan astronomy were held by a hierarchy of navigator families of varying, but always chiefly rank. So jealously guarded were their more esoteric concepts that it was not until 1969, well after the overwhelming bulk of their lore had been lost, that leaders of the Tuita navigator clan consented to divulge to me, an outsider, the half-forgotten residuum of what a nineteenth-century blind Tuita once claimed, according to Ve'ehala (personal communication 1969),† to be secrets that only he and the devil knew. We will discuss some of these secrets under *fanakenga* sky zones and under zenith stars.

Similar examples of secrecy are legion. Thus in the Marshalls, Winkler (1901, p. 505) tells us it was 'strongly and religiously forbidden to divulge anything concerning this art [navigation] to the people'. Such sanctions, coupled with the tendency, inherent in oral disciplines,

† See appendix to the references on contemporary indigenous authorities.

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for even the most learned individuals to be variously informed, must in large part be to blame for the paucity of our knowledge of Pacific astronomy.

Sun observations from stone structures

Accounts come from all parts of Oceania. The observation places seem usually to have been temple platforms. Fornander (1878, p. 127) mentions one in Hawaii that was located between two cliffs at the point where the rising sun at the summer and winter solstices just tipped the northern and southern cliffs respectively. Several similar platforms were seen by Laval (1938, pp. 213–214) in Mangareva. Where suitable natural marks were lacking, sighting stones were erected. According to Heyerdahl (1961, pp. 189, 222), one Easter Island temple platform appeared to have been used for noting the equinoxes as well as the solstices, an unusual refinement for Polynesia (Akerblom 1968, pp. 17, 22).

The Gilbertese, on Butaritari at any rate, distinguished much finer gradations in the Sun's annual progression. It entered a named station, determined by the altitude of the Pleiades, every tenth day. Antares was used to fix the autumnal equinox. Observations were made from platforms on top of tapering structures that varied in height from 0.6 to 3.7 m. The dawn observation ritual, *te kauti*, was believed to give strength in love and war (Grimble 1931, pp. 205–211).

The evidence for Tongan sun observation is circumstantial. A solitary coral rock trilithon called *Ha'amonga a Maui*, a structure unique in Oceania, stands near the north-east coast of Tongatapu (see figure 4, plate 21). Tradition holds it to have been erected by Tu'itatui, the eleventh *tu'i tonga* or sacred ruler, who reigned around A.D. 1200 (Gifford 1929, p. 52). While no memory of its purpose survives, the present king, who is an amateur astronomer, discovered its long axis to be on the precise alinement of the summer solstice sunrise and thinks it probable that a trough on the horizontal coping stone was similarly related to the winter solstice.

If a personal digression may be permitted, it was to help confirm this latter possibility that I was invited to Tonga in 1969. King Tupou being indisposed on the morning of 21 June, I ascended the massive monument in the pre-dawn darkness (by way of a prosaic ladder) as his deputy. The sequence of events was predictable enough and, of course, there was no continuity with, nor attempt to re-create prehistoric observance. So I was unprepared for the evocative impact of the moment when the sun burst up over the sea horizon, bathing the lintel stone in blinding light, and the low chanting of the people massed below in the darkness swelled to a thunderous crescendo. However, the depression on the horizontal stone was too worn to permit of a definite conclusion.

Stones for navigation

Certain Micronesian and Polynesian stone structures undoubtedly subserved the purposes of nautical astronomy and one still does. Three sets are sighting stones or groups of stones and the other is a training device. It should be mentioned in passing that there is no evidence of any significant navigational artefact ever having been used at sea in Oceania. The oft-cited Hawaiian 'magic calabash' is no more than a chief's travelling trunk (Bryan 1936; Buck 1938).

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The Hanga'i' Uvea

This solitary basalt stone set on edge, whose name means 'facing Uvea', is situated on the Tongan island of Niuafo'ou. Compass bearings taken along its 1.5 m length by the yachtsman-anthropologist Rogers (personal communication 1969) indicated a course that would take a voyager to a point 16 km upwind of Uvea, some 210 km distant. Landfalls in the Pacific were and are invariably made a little to windward and upcurrent of the objective.

The other two sets of sighting stones are both in the Gilberts. The first comprises the Butaritari stones, a group on the northern rim of the big Butaritari atoll (E. V. Ward, personal communication 1969) so situated that it can only indicate courses to the Marshalls, 264 km further north. Voluminous Butaritari traditions collected by Grimble (MS. n.d.) of contact with the Marshalls, the unique 18 m voyaging canoes seen on Butaritari by Wilkes (1845, vol. 5, pp. 74, 94), and a valid extant star path course to the Marshalls given me by a classically trained *tia borau* (Lewis 1972, p. 160), reinforce this assumption.

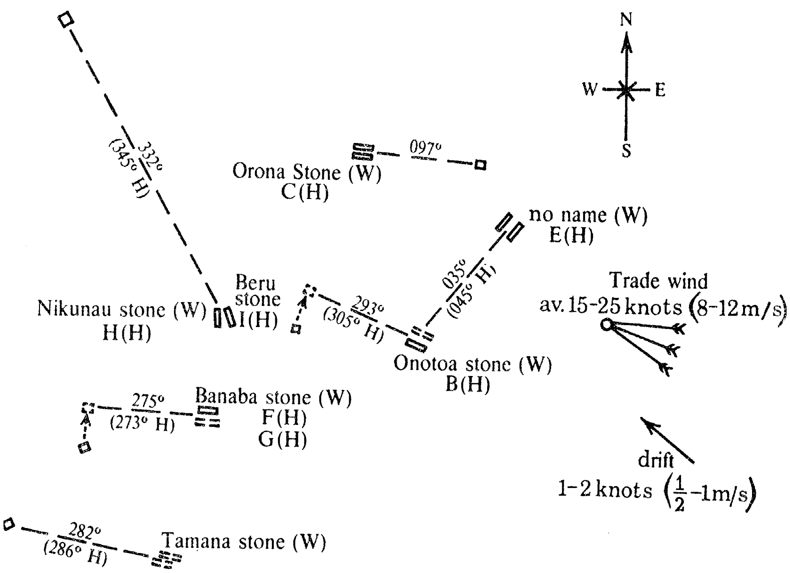

FIGURE 5. Arorae 'stones for voyaging'.

The second is called *Te Atibu ni Borau*, the 'stones for voyaging', on Arorae, the southernmost island of the Gilberts, described by E. V. Ward in 1946 (MS. 1946) and by Hilder a decade later (1959, 1963, 1972). Ward saw thirteen of these coral slabs in place and the former positions of four more could be determined (figure 5). Most were in groups of three that were named for the islands towards which their sight lines pointed (or perhaps indicated the transits of the azimuths of stars on the islands' bearings). All the targets were in the Gilberts except for Banaba or Ocean Island and Hull Island or Orana. The former was indeed once in contact with the Gilberts (H. E. Maude & H. C. Maude 1932), but the latter is one of the Phoenix group, uninhabited and unknown to the pre-contact Gilbertese. In fact H. E. Maude, the former administrator, was a member of the party that first decided to name Hull Island 'Orana' – in 1938 (personal communication 1969). The perils of uncritical reliance upon unsupported local tradition are obvious. All the other names, including Banaba, can be accepted and all indicate close approximations to the bearings of the islands concerned. The incompatibility of the

FIGURE 4. *Ha'amonga a Maui*, Tonga. A summer solstice-oriented trilithon.

FIGURE 6. Rewi instructing his daughter on 'stone canoe'.

(*Facing p.* 138)

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numerous extant traditions as to the stones' origin (agreeing only on their navigational purpose) suggests their considerable antiquity and lends weight to Hilder's supposition (1972, p. 88), that the site represents an ancient school of navigation.

The stone canoe

The so called 'stone canoe' of Beru in the Gilberts has not been, as far as I know, previously recorded (Lewis 1972, pp. 184–187). It stands behind the house of the *tia borau* Rewi, where it was built by his father on the model of one made by his own father, Tebotua, the present navigator's grandfather. Rewi knows of only three other examples, though this is but negative evidence. The device is instructional and is currently being used by Rewi to train his own children (figure 6, plate 21 and figure 7). The longer axis is east–west and the shorter north–south. Seated upon it as on the thwarts of a canoe, the boy and girl learn beneath the night sky the directional stars of the islands.

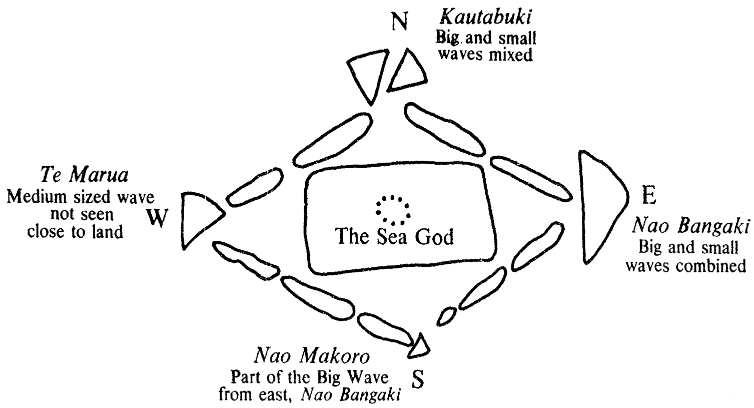

FIGURE 7. 'Stone canoe' diagram.

The structure is at other times conceived of as an island, when the triangular stones set at the corners represent by their sizes and angles the swell distortions detectable at sea beyond an atoll's sight range. The largest corner stone, for instance, corresponds to *nao bangaki*, the great swell from the east. Hidden from view in the photograph by the seat stone is a lump of brain coral personifying the sea god who, in Rewi's words, 'is most important of all. He helps us sail over the sea because he rules the sea'. Here, in contrast to the Arorae voyaging stones traditions, we have useful ethnographic data, in whose absence the 'stone canoe's' purpose would have been, to say the least, obscure. It might equally have been a sacrificial altar as a navigational artefact.

THE SEASONS

In Tonga the same word, *ta,u* stands for 'year' and for 'yam season', while a large part of the nomenclature of the 12 or 13 lunar months is based on this plant's seasonal changes (Collocott 1922, pp. 164, 166). A year varying between 12 and 13 months is also used in Samoa and in Tahiti, again related to the yam seasons and, in Tahiti, to the ripening of breadfruit and to fishing as well (Williamson 1933, vol. 1, pp. 126, 154–155, 167, 172).

The Gilbertese calendar, more accurately described, in Grimble's opinion, as a 'nautical almanac', is divided into the 'time for voyaging', *Aumaiki*, and the inclement *Aumeang* season. The former is associated with Antares in the ascendant and the latter with the Pleiades, the star's or the constellation's height, expressed in terms of meeting house (*maneaba*) purlins and roof beams, determining the division of the corresponding season into eight 'months' (*bong*). The names of most *bong* refer to the circumstances of navigation, for instance *Baro* is a contraction of *buta te ro*, 'cast off the cable' (Grimble 1931, p. 202).

Weather and currents are to this day firmly held to be under the sway of Antares and the Pleiades. The four learned *tani borau* Iotiebata, Teeta, Abera and Rewi, the most accomplished astronomer-navigators in the Gilberts today, all went to great lengths to reconcile this lore, in which they implicitly believed, with actual observed phenomena. Thus an aberrant current encountered when at sea in Iotiebata's sailing canoe was explained by Iotiebata as being the result of 'a struggle for mastery' between the controlling stars, 'which left the current free to move in any direction' (Lewis 1972, pp. 113–114). There is reasonable agreement between pilot book date (Ward 1967) and the seasonal current and weather patterns described by the *tani borau* – though the causes ascribed to the phenomena are somewhat different.

The Pleiades

This constellation is important in other calendars where we saw under Sun observations from stone structures that it determined the stages of the Sun's progression besides the Gilbertese. It plays a similar role in Mangaia (Gill 1876, p. 317), possibly in Tonga (Collocott 1922, p. 166), in Pukapuka, where it indicates the month when turtles land to lay eggs (E. Beaglehole & P. Beaglehole 1938, p. 351), and in Tahiti, whence comes the following account from an 1806 mission diary (*Transactions L.M.S.* 1806):

For some months there had been 'much disputing' as to whether the Pleiades (*mata-ree*) would set in daylight before or after the 'death of the Moon'. When the constellation was seen to be still above the horizon after the Moon had changed those who had been proved right 'shouted and triumphed over the other party'.

The amount of popular feeling aroused by the disagreement is noteworthy. The incident is also a reminder that naked eye observations, when calendars too are approximate, can give only approximate results. The point is also made for the Gilberts by Grimble (1931, p. 201).

Division of the sky into zones

Here we have a widely held concept that often has navigational connotations, particularly in the role asigned to zenith stars. As mentioned earlier the Gilbertese divide the sky, *uma ni borau*, 'the roof of voyaging', into latitudinal zones by analogy with the rafters and purlins of their meeting houses. The celestial equator is fixed by the declination of Rigel, so is 8° south of our own (Grimble 1931, p. 197–200), a point whose possible significance will be discussed later. The Carolinian heavens are similarly divided into latitudinal bands or *jaan* (paths) (Goodenough 1953, p. 4).

Hawaiian cosmogony, as expounded by Kamakau (1891), lumps together as navigation and land-ruling stars all those between the northern and southern limits of the Sun – the two highways of the navigation stars. Beyond are the strange or outside stars, among which, however, the Southern Cross and Polaris receive mention. (This concept does not appear to bear any European imprint. Some other of Kamakau's statements may have been influenced by his high school education and his general Christian upbringing.) The other main authority, Kepelino

(1932, p. 19), gives a more elaborate classification into fixed, moving, ruling and protecting stars that guide towards land. The passage about the latter having been severally interpreted by Beckwith (Kepelino 1932), Makemson (1941, p. 13) and Akerblom (1968, p. 39–40), Professor Elbert, at the request of Dr Finney (personal communication 1969), kindly re-translated it from the original Hawaiian. Protecting stars are 'suspended (*kau*) severally over various lands, such as Hoku-lea in the Hawaiian islands, and the Southern Cross over the lands of Tahiti, etc'. *Hoku-lea* appears to be Arcturus which, in A.D. 1000 culminated just north of the Hawaiian chain (V. Radhakrishnan, personal communication 1970). The Southern Cross, on the other hand, is very far indeed from being in Tahiti's zenith, though it indicates the island's approximate bearing. However, the word 'Tahiti' instead of 'Kahiki' is used in the Hawaiian text of the second phrase, an indication of European 'borrowing'.

The Tongans likewise divide the heavens into latitudinal zones, the northern, middle and southern *fanakenga* (Collocott 1922, p. 158). These divisions are reflected in the sea below, the northernmost zone being the warmest and vice versa.

'My father said any true sailor knew when he had crossed any of these *fanakenga* because of the temperature', the 88 year-old Sione Fe'iloakitao Kaho, the oldest surviving Tuita, told me. Indeed the clan owes its prominence to the celebrated feat of Kaho's great grandfather, the blind Tuita, who succeeded in re-orientating a lost royal flotilla by putting his hand in the water and announcing that Fiji was just below the horizon and indicating its direction. (He had also asked his son Po'oi to tell him the positions of certain stars.)

Kaho asserted, probably with truth, that his great grandfather's action was not to test the sea temperatures alone. He was also making contact with 'the devil' – the old sea god *Tangaloa*.

Stars in navigation

The succession of stars that rise or set on the same azimuth makes up the star path or *kavienga* (Tonga), *kavenga* (Tikopia). By this one steers. The Carolinian 'star compass', discussed below, is but a specialized variant of the horizon star path, whose advantage is to reduce the number of stars that need to be memorized. The same degree of precision obtains with either, as nearly 2700 km steered by master navigators using one or other system demonstrated (Lewis 1972). The accuracy was such as to justify the Tongan aphorism, 'the compass may go wrong, the stars never'. Daytime steering is by the Sun and the angle of selected ocean swells.

A pertinent question is whether worthwhile data can be collected in the ethnographic present after one or two centuries of acculturation. Traditional nautical astronomy is still the favoured system in the Central Carolines and, to varying degrees, in the Santa Cruz Outer Reef Islands, Tikopia, Ninigo, the Gilberts and Tonga. Even in the Carolines there are lacunae and much more has been forgotten elsewhere. But while the old methods continue in use at sea, unlooked for reefs and unexpectedly empty ocean exert sanctions against distortions; the navigator's data and his conclusions therefrom are subject to confirmation by landfall. The validity of extant Carolinian nautical astronomy was demonstrated in 1969 by Hipour's return Saipan voyages, when he twice made accurate landfalls after crossing 720 km of open sea devoid of intervening land, navigating solely by eye in accordance with 'star compass' sailing directions, orally transmitted for some three generations since last used (Lewis 1971).

Survivals seem to have been of two kinds – relatively straightforward practices like horizon star steering, and elaborate concepts that resist modification because of their incompatibility with their Western equivalents. Examples of the latter include such stellar orientation systems as reference islands visualized as 'moving' beneath the star points (*etak*) (Alkire 1970, pp. 51–55; Gladwin 1970, pp. 181–195), the navigational application of zenith stars (Lewis 1972, pp. 223–243), and the Carolinian 'star compass'.

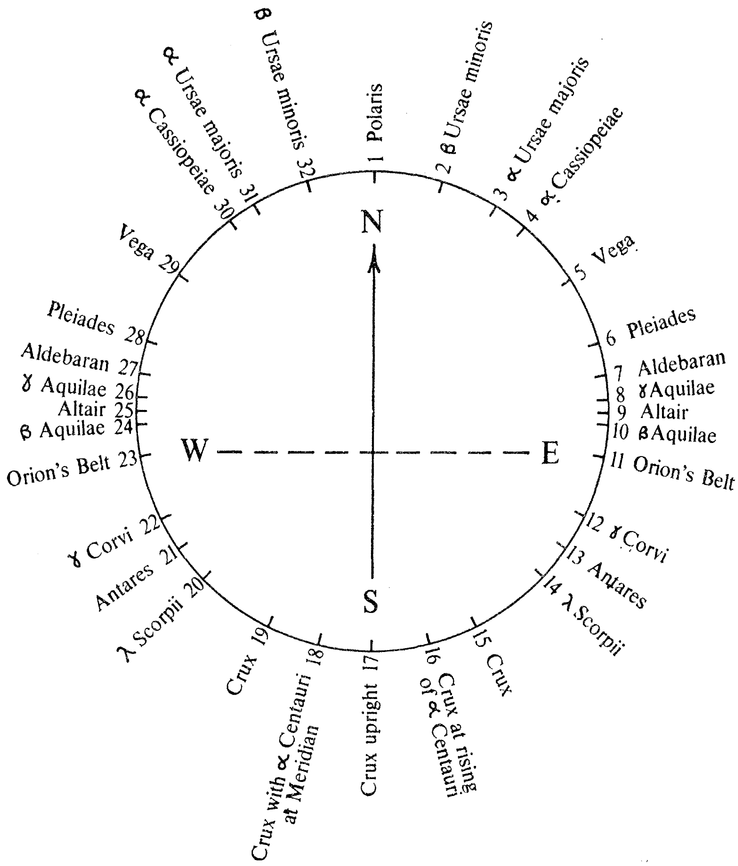

FIGURE 8. Carolinian star compass (modified from Goodenough 1953).

This last mental construct owes nothing to Europeans, its directional references being the 32 to 36 points on the horizon where given stars rise or set, regardless of whether they be currently visible or not (Goodenough 1953; Gladwin 1970, p. 148). It can be readily seen from the diagram (figure 8) that the star points are not equidistant, but crowded together in the east–west plane and spread out in the north and south. Herein lies the incompatibility: no practical correction factor could be devised to convert sidereal points into true ones. The 'star compass', therefore, may be expected to remain intact until its final replacement by the magnetic instrument.

Zenith stars

Horizon, star path, or compass stars stand in sharp contrast to overhead stars, that culminate in or near the observer's zenith. By the former one steers, by the latter one cannot; their function is to indicate what we term latitude.

My informant Ve'ehala explained in 1969 that the Tongan word *fanakenga* or sky zone has an additional meaning in the private usages of the Tuita navigator clan. A *fanakenga* star in this sense is 'the star that points down to an island'. When it is right overhead it indicates that 'you are nearing the island'. Experienced Tikopian navigators likewise insisted that the appropriate 'on top star' being overhead showed that they were near the island, and went on to stress the distinction between 'on top' and steering stars (Rafe, personal communication 1968; Tupuai & Samoa, personal communication 1969).

Of course, neither zenith star observations nor any other non-instrumental techniques can give the slightest clue as to longitude and so, at first sight, the Tikopian and Tongan formulations of being 'near land' when only latitude is known, seem strange. They are quite logical, however, in the light of a universal Polynesian and Micronesian navigational principle of always making a 'windward landfall', that is, of imparting a deliberate bias to the course in order to arrive a little upwind of the objective. The practice of true latitude sailing has never been reported from Oceania.

There is a documented instance of zenith stars having once been used for navigation in the Carolines (Sanchez 1866, p. 236), a more circumstantial one from the Gilberts (Sabatier 1939, pp. 94–95), and less direct evidence from Hawaii (Kepelino 1932) and Tahiti (Henry 1907, p. 121–124), as well as the contemporary Tongan and Tikopian sources we have already mentioned. Neyret suggests a zenith star interpretation of the Fijians' association of a particular star with the corresponding island (1967, p. 24).

The Tahitian concept is of star pillars supporting the sky dome. That it had navigational significance is mere inference from the circumstance that most 'pillars' were also zenith stars of geographically significant islands (Lewis 1972, pp. 239–241). Regardless of the correctness of this interpretation, the fact that one of these important props of the cosmos was Polaris, which is invisible until 1600 km north of Tahiti, points towards long consciously navigated voyages having once been made half way at least towards Hawaii.

How accurately can latitude be estimated by naked eye observation of zenith stars? A controlled trial during a 3200 km non-instrumental voyage from Tahiti to New Zealand gave results, in average weather, generally accurate to within 30′. The latitude error of the New Zealand landfall was 26′. The double-hulled yacht used in this experiment provided a stable platform, from which to make observations, equivalent to a double or outrigger voyaging canoe (Lewis 1967, pp. 281–285).

Altitude of the Pole Star

Estimation of latitude from the altitude of Polaris is only possible north of the equator, in Hawaii, the Gilberts, Marshalls and Carolines. The record is silent apart from the Carolines, where the question remains open. When Hipour was approaching Saipan, and the Pole Star had doubled its height from 7° 30′ at Puluwat in the Carolines to 15°, he insisted that the phenomenon was devoid of navigational significance. The following year the same navigator told Edwin Doran (personal communication 1970) that he *had* drawn conclusions from the observation. I fear that the explanation may lie in Hipour having noticed me surreptitiously checking the star's height by loosely extending my hand at arm's length. However, the equally celebrated Satawal navigator Repunglug, who also made a return voyage to Saipan – by sailing canoe in 1970 – expressed the Pole Star's altitude in a local unit, *ee-yass*, one and a half at Satawal, two at Saipan (McCoy, personal communication 1970). The correct ratio, whatever the unit of measurement, should have been 1:2. Here the matter rests.

The significance of certain concepts and of their distribution

Weather prediction by the stars

Atmospheric signs apart, star-weather correlations are necessarily seasonal. Predictions of day-to-day changes can have no more validity than 'stars foretell' columns. What is so significant is the near-universal distribution throughout Oceania of erroneous beliefs to the contrary.

Captains Cook (Cook & King 1784, p. 144) and Andia (Corney 1913–19, vol. 2, p. 284) refer to star-weather divination in Tahiti, where one sign was the 'bending' of the Milky Way by the wind. The three stars Canopus, Sirius and Procea (together called *Maan*) were pointed out to me as controllers of wind direction and weather on the 'para-Micronesian' atoll of Ninigo. My informant, Itilon, had confidently relied upon them during numerous inter-island sailing canoe voyages of up to 96 km in length. Gilbertese beliefs about sidereal control of currents and weather were mentioned earlier. Gladwin (1970, p. 212) found stellar weather forecasting to be an essential ingredient in trained Carolinian navigators' repertoires. He makes the intriguing observation that the forecasts of the two navigational schools, *warieng* and *fanur*, more often contradict each other than are congruent, the fine weather stars of one school being frequently the ones that foretell bad weather in the other. It strains one's credulity to imagine that the same kind of erroneous deduction about stars influencing weather could have been made quite independently in corners of Oceania so remote from each other as are Tahiti, Ninigo and the Carolines.

Concepts possibly derived elsewhere

There is a Maori legend of the Sun travelling southward to join *Hine-takurua*, the Winter Maid and, after the June solstice, returning northward to *Hine-raumati*, the Summer maid (Best 1922, p. 14). The myth seems logical enough to us here in the Northern Hemisphere, but for New Zealand, in the 30s and 40s of south latitude, it reverses summer and winter. Makemson (1941, p. 85–6) suggests that the story represents memories of a sojourn in the Northern Hemisphere. An alternative explanation would be borrowing from Hawaiians or Micronesians.

A concept that the Maori may well have carried southward from tropical Polynesia is their identification of Rigel (*Puanga*) with the zenith (Makemson 1941, p. 30). This star's A.D. 500 declination, as worked out by Dr Radhakrishnan, was 11° 06′ and New Zealand does not anywhere extend north of 34° S. But neither do Tahiti, about 17° S, nor Samoa, 13° 30′, though closer, really fit the bill.

Nevertheless, we cannot entirely dismiss the possibility of Rigel-zenith identifications reflecting one-time real observations because, as we have seen, Rigel is the apex of the sky dome in the equatorial Gilberts (Grimble 1931, p. 198). Did the Gilbertese, then, originate further south? A major Samoan immigration actually took place around A.D. 1400 (Maude 1963, p. 7). But Rigel's declination in A.D. 1000 was 9° 52′ S, so even then it did not culminate over Samoa, whose northernmost point reaches only up to 13° 30′ S. It was a zenith star for Samoa, however, in 500 B.C., which was about the time the archipelago was settled.

As so often in the field of Pacific astronomy, we are left with contradictory evidence, pointing to no definite conclusion.

A concept seemingly locally arrived at

This is the Tahitian and Samoan belief that the sun descends into the sea each evening and traverses a submarine passage during the night to arise in the east next morning (Williamson

1933, p. 113). The Tahitians alleged that people on Borabora, farther west, had heard the hissing as the sun plunged into the ocean at sunset (Ellis 1839, vol. 3, p. 170). Such an idea could hardly have entered the minds of anyone except islanders conscious of their sea horizons.

Discussion

The pan-oceanic distribution of essentially similar astronomical, astro-navigational and sidereo-meteorological concepts is remarkable, considering the probably diverse origins, both temporal and geographical, of the elements that went into the formation of Micronesian and Polynesian populations and cultures, and the relatively modest scope of voyaging at European contact. Something like 800 km without intervening land was about the limit of recorded deliberate journeys, though marine technology and nautical astronomy were perfectly adequate, when the target was an archipelago for 3200 km (Lewis 1972, pp. 21, 101–102). There is, of course, ample evidence of the importance of accidental drifts in settlement and inter-group encounters (Sharp 1963; Golson 1972; Riesenberg 1965), but recent computer studies have shown (within the limits of the model) that pure drifts could not have been responsible for the crossing of a number of the long seaways that we know must have been traversed. The sailing of consistent cross-wind courses would have been required (Levison, Ward & Webb 1972).

We are left with the alternatives of an unlikely degree of pre-Pacific cultural homogeneity among Polynesian and Micronesian precursors, or of astro-navigationally orientated voyages – whether planned or forced is immaterial – having been longer and more frequent in earlier times. That the latter is the correct explanation is suggested by evidence from various areas of voyaging which suffered a pre-European decline. The reasons are quite obscure, though increased agricultural efficiency could well be among them.

There is time for but one example. Tupaia told Cook that his father had known of islands farther south than he did (Beaglehole 1955, p. 157). More significantly, Tupaia's own enormous geographical horizons far exceeded the range of eighteenth-century Tahitian voyaging. His information could not have been derived, in any large measure, from drifters, since the overwhelming majority of trade wind drifts have been from east to west, that is, from Tahiti towards Tonga and Samoa (Golson 1972). But the Tongans, who were the leading seafarers in contact times, and stood to gain most from involuntary arrivals, had but vague ideas about Eastern Polynesia, whereas Tupaia could name and point towards any number of Tongan, Samoan and Fijian islands. Myths of islands having drifted apart would appear to symbolize the severence of once-close relations. One such story relates how Rarotonga became separated (by 800 km) from Raiatea on account of sacrilege (Williams 1846, pp. 47–48, 88). Another is the tale of a (400 km) 'land bridge' once having existed between Niue and Tonga and having long since sunk (Loeb 1926, p. 12).

But the bold range of Pacific voyaging, even in contact times, and the excellence of the indigenous navigational systems leaves us to speculate with Doran, Kehoe and Jett (in Riley 1971), on a more general question: whether the oceans of the world could not once have been pathways to a far greater extent than we generally allow. Of course, the fallacy of assuming that our fragmentary data about the astronomy and astro-navigation of eighteenth to twentieth century Oceania can open some kind of ethnographic window into the neolithic past of continental cultures, earlier by millennia and up to half the Earth's circumference away, is too obvious to labour. But observations from the Pacific may be indirectly relevant.

They demonstrate, for instance, the surprising efficacy of non-instrumental navigational techniques for finding even small targets, thus removing one major objection to trans-oceanic pre-instrumental voyaging in general. Secondly, they draw attention to the possibility that certain astronomically oriented megalithic sites elsewhere may have had navigational as well as other correlates. Should confirmation of such association be forthcoming, neolithic Oceania may be shown not to have been alone in conceiving as one single entity the 'pre-sciences' of navigation, geography and astronomy.

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Appendix: Contemporary indigenous authorities

It would be anomalous not to recognize the precepts and demonstrations of these trained masters of astronomy and astro-navigation as primary sources, and important ones at that. They are acknowledged in the text as 'personal communications' and are listed in this appendix to the references, together with something of their qualifications and status, in lieu of references to published work.

Abera of Nikunau, Gilbert Islands, is a trained navigator (*tia borau*). He makes frequent sailing canoe voyages among the southern and central Gilberts.

Hipour of Puluwat, Carolines, is a highly trained initiated navigator (*ppalu*). He has been voyaging for years in his canoe over an east–west range of something like 1300 km.

Iotiebata of Maiana, Gilberts, is a *tia borau* who makes frequent canoe passages between Tarawa and Maiana. Once 5 weeks storm-drifted, he kept his bearings by stars, Sun and ocean swells and, eventually, recognized land clouds.

Itilon of Ninigo, Manus Group, is a canoe captain and star navigator, who has visited islands up to 100 km away in his 16 m vessel.

Kaho, Hon Sione Fe'iloakitau of Tonga is the 88 year-old great grandson of the famous blind Tuita navigator, Kaho Mo Vailahi. He is the uncle of the present Tuita title holder.

Rafe of Tikopia learned navigation by surreptitiously listening to the elders, who were withholding instruction because of losses of youths at sea. He captained canoes to Vanikoro (180 km) and to New Hebrides (175 km).

Rewi of Beru, Gilberts, is the *tia borau* who was instructed by his father with the aid of the 'stone canoe'.

Samoa of Tikopia was trained by the elders. He has made the canoe voyage to Vanikoro.

Teeta of Kuria, Gilbert Islands, is a *tia borau* trained in the full classical *maneaba* tradition. He made secret wartime voyages without chart or compass throughout most of the archipelago.

Tupui of Tikopia was trained by the elders. He has navigated the Tikopia–Anuta return canoe voyage (114 km each way).

Ve'ehala, Hon., Governor of Ha'apai, Tonga, formerly of the Tradition Department, is the most knowledgeable member of the Tuita navigator clan. His chief informants were an old woman, Makelesi Lakoti, who had been taught the chants by the grandfather of the present Tuita, and his own grandfather Ve'eto, who was over 90 when he died in 1959.

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FIGURE 4. *Ha'amonga a Maui*, Tonga. A summer solstice-oriented trilithon.

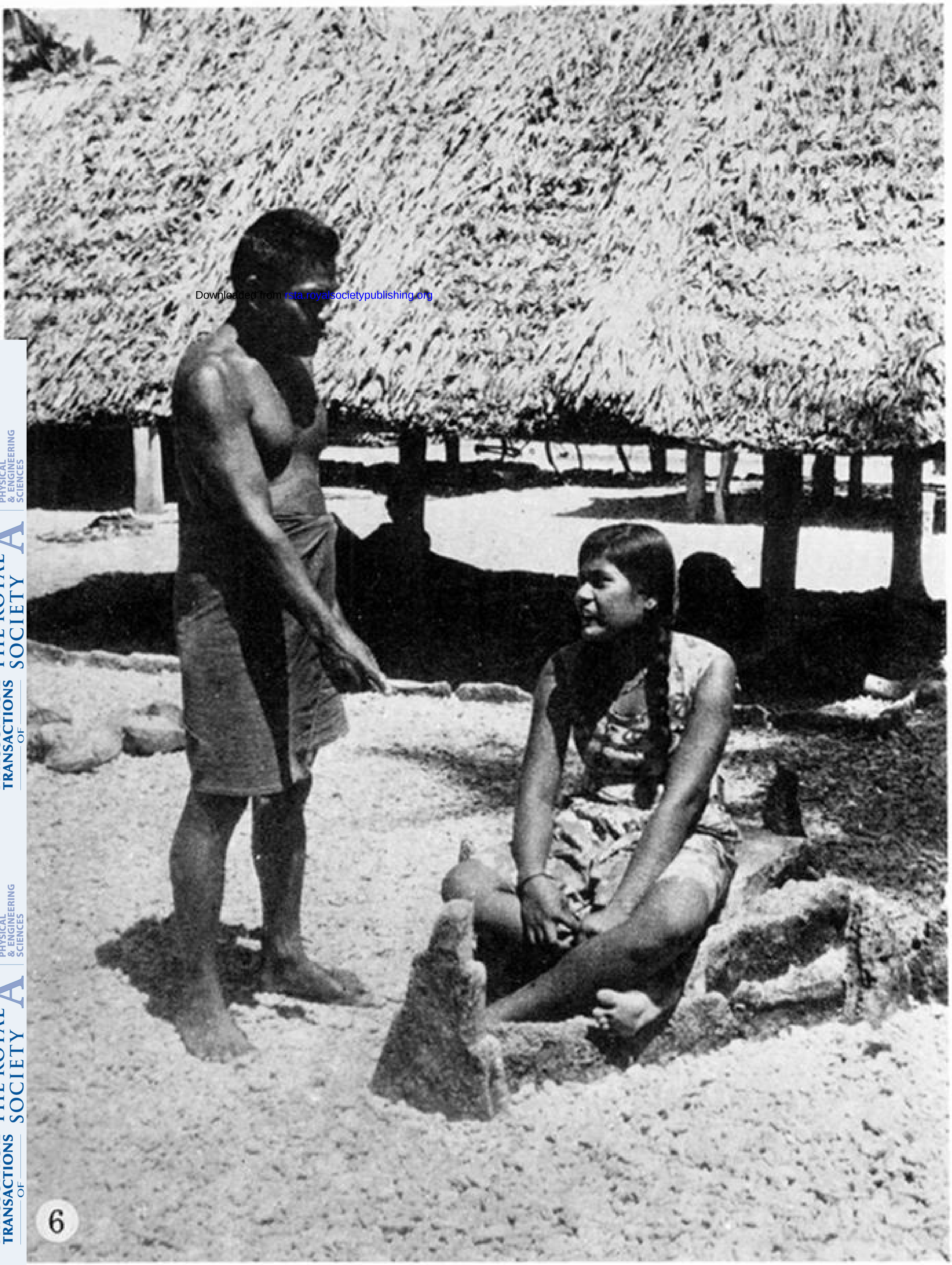

FIGURE 6. Rewi instructing his daughter on 'stone canoe'.

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