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Absolute dating from Egyptian records and comparison with carbon-14 dating

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The purpose of this Symposium being to discuss 'The impact of the natural sciences on archaeology', I feel I am laying myself open to the criticism that the subject of my paper is putting the proper order into reverse, for I cannot pretend that ^{14}C has yet made any actual impact on our reconstruction of Egyptian chronology. If therefore, in the present context, my line of approach seems a little devious perhaps I may seek refuge in a claim made by the late Professor Maynard Keynes at a meeting which I attended at Cambridge many years ago. After listening to a distinguished French economist contending that the methods of procedure of his English colleagues were more logical than those of his French confrères, Keynes retorted: 'We in England like to think that we arrive at a logical conclusion by a process which often seems illogical'. My excuse for speaking about what, in effect, is the assistance which Egypt can give to ^{14}C investigation is that this is something which Professor Libby has recognized as important from the very beginning of his work in that field and he himself has done his best to mobilize it. The reasons are twofold: (*a*) no other ancient civilization has left so large and varied a quantity of physically suitable material, and (*b*) it is generally possible to find Egyptian specimens, the age of which can be determined by other means than by ^{14}C measurement. It is with these other means of dating that I shall now deal.

The ancient Egyptians, from very early times, employed three calendars, two mainly for religious purposes and the third for administrative and economic purposes, and for numbering the years of a king's reign. The religious calendars were lunar in character and offer little help in determining absolute dating. It is the third—the so-called civil calendar—which is of importance for chronological purposes.

In the civil calendar the year consisted of 12 months, each of 30 days, to which were added 5 days (the so-called epagomenal days) to complete a 365-day year. The 12 months were divided into 3 seasons bearing names which are generally rendered Inundation, Winter and Summer, each season consisting of four months. The year began in the season of Inundation, and in the ideal year the first day of the first month of the season of Inundation coincided with the first day on which the dog-star Sirius could be seen on the eastern horizon just before the rising of the sun (i.e. roughly about 19 or 20 July in the Julian calendar). Since the dynastic Egyptians never introduced a leap year into their civil calendar, New Year's Day advanced by one whole day in relation to the natural year in every period of four years. As a result of this displacement New Year's Day and the day on which Sirius rose heliacally actually coincided for no more than four years in every period of approximately 1460 years (i.e. 365×4), the so-called Sothic cycle.

Although the figure 1460 is close enough to the truth for most purposes, it is worth mentioning that the Sothic year differs very slightly from both the Julian year of 365.25 days and the year of the so-called fixed stars, the latter being 365.25636 days. According to a very recent study by Ingham (1969) the length of the mean Sothic year, in the three Sothic cycles which cover the history of ancient Egypt, varied from 365.25025 to 365.25104 days. The lengths of the cycles, given a constant *arcus visionis*, he has calculated were 1458, 1456 and 1453 years respectively.

By a fortunate chance the Roman writer Censorinus tells us that New Year's Day in the Egyptian civil calendar and the day on which Sirius rose heliacally coincided in A.D. 139 and by simple arithmetical calculation it follows that this coincidence occurred previously in approximately 1322, 2782 and 4242 B.C., or more precisely 1314, 2770 and 4228 B.C. These are the first years of the three Sothic cycles which concern us.

Dates in Egyptian records were generally set out according to a fixed formula: year X, month 1–4 of season Y, day Z in the reign of king N. If, in addition to this formula, a document tells us that Sirius rose heliacally on that day it is only necessary to count the number of days which had elapsed since the first day of the year given in the formula and multiply the total by four to obtain the number of years since the beginning of the particular Sothic cycle. From other evidence it is easy to identify to which Sothic cycle the date refers. As an example let us glance at one of these so-called Sothic dates which occurs on the back of the Ebers Medical Papyrus (table 1).

Table 1

'Year 9 in the reign of King Amenophis I. Sirius rose heliacally on month 3 of Summer, day 9'
Advance in civil calendar since Sirius rose heliacally on month 1 of Inundation, day 1:

inundation	1st month	29 days	
	2nd month	30 days	
	3rd month	30 days	
	4th month	30 days	119 days
winter	1st month	30 days	
	2nd month	30 days	
	3rd month	30 days	
	4th month	30 days	120 days
summer	1st month	30 days	
	2nd month	30 days	
	3rd month	9 days	69 days
			total 308 days

308 × 4 = 1232 years

Year 9 of Amenophis I = 2782 B.C. − 1232 = 1550 B.C.

Correction: Sirius rose heliacally on month 1 of Inundation, day 1 in 2771 B.C.
Year 9 of Amenophis I would thus be: 2771 − 1232 = 1539 B.C.

Including the record of Censorinus we have seven Egyptian documents which give Sothic dates (Parker 1952) but only three are of real assistance. I have just mentioned the document referring to Amenophis 1, the second is dated to Tuthmosis III, but does not give the year in his reign, and the third is dated to year 7, month 4 of winter, day 16 of a king who, from other evidence, can be none other than Sesostris III of the Twelth Dynasty. Translated into years B.C., this last date would correspond with 1872 B.C. (Parker 1950, p. 63). It is the earliest date in Egyptian history for which we have at present any record of a heliacal rising of Sirius on a day in the civil calendar. From that date backwards we are dependent on documentary evidence which cannot be verified by records of astronomical events.

Another check on dating afforded by the celestial bodies, which can be used for a few kings from Sesostris III onwards, is an occasional record that the new moon was observed in such and such a year of a named king on a given date in the civil calendar. If the observation was correct the event can be pinned down to a single year in a lunar cycle of 25 years. As an example, an inscription of Tuthmosis III records that a lunar month began on day 20 of the 1st month of summer in the 23rd year of his reign. A glance at Parker's table of lunar risings will show that the year in question must have been the 10th in the particular lunar cycle (table 2). The dates of the lunar cycles, in terms of years B.C., have of course been calculated and the only problem is to pick the right cycle. We know from another record of Tuthmosis III that Sothis rose heliacally on day 28 of the 3rd month of summer in an unstated year of his reign of 54 years and this date would correspond with the year 1463 B.C., which narrows down very considerably the lunar cycles which must be taken into account. From other evidence the only possible lunar cycles are those in which the 10th year of the cycle would fall in 1493, 1468 or 1443 B.C. Since the date in question refers to the 23rd year of his reign year 1 would be 1515, 1490 or 1465 B.C. The first and the last dates do not fit in with other evidence available and so, on the basis of this moon-date alone, 1490 B.C. should be correct (Parker 1957).

TABLE 2. THE 25-YEAR LUNAR CALENDARS

From Parker 1950, p. 25

	inundation				winter				summer				
months	... I	II	III	IIII	I	II	III	IIII	I	II	III	IIII	epagomenal
year 1	1	1	1–30	30	29	29	29	28	27	27	27	26	—
2	20	20	19	19	18	18	18	17	16	16	16	15	—
3	9	9	8	8	7	7	7	6	5	5	5	4	4
4	28	28	27	27	26	26	26	25	24	24	24	23	—
5	18	18	17	17	16	16	16	15	14	14	14	13	—
6	7	7	6	6	5	5	5	4	3	3	3	2	2
7	26	26	25	25	24	24	24	23	22	22	22	21	—
8	15	15	14	14	13	13	13	12	11	11	11	10	—
9	4	4	3	3	2	2	2	1	1–30	30	30	29	—
10	24	24	23	23	22	22	22	21	20	20	20	19	—
11	13	13	12	12	11	11	11	10	9	9	9	8	—
12	2	2	1	1	1–30	30	30	29	28	28	28	27	—
13	21	21	20	20	19	19	19	18	17	17	17	16	—
14	10	10	9	9	8	8	8	7	6	6	6	5	5
15	30	30	29	29	28	28	28	27	26	26	26	25	—
16	19	19	18	18	17	17	17	16	15	15	15	14	—
17	8	8	7	7	6	6	6	5	4	4	4	3	3
18	27	27	26	26	25	25	25	24	23	23	23	22	—
19	16	16	15	15	14	14	14	13	12	12	12	11	—
20	6	6	5	5	4	4	4	3	2	2	2	1	1
21	25	25	24	24	23	23	23	22	21	21	21	20	—
22	14	14	13	13	12	12	12	11	10	10	10	9	—
23	3	3	2	2	1	1	1–30	30	29	29	29	28	—
24	22	22	21	21	20	20	20	19	18	18	18	17	—
25	12	12	11	11	10	10	10	9	8	8	8	7	—

In this connexion it is necessary to point out that, as Parker has demonstrated, the lunar month in ancient Egypt began on the morning after the last crescent of the waning moon had become invisible in the eastern sky just before sunrise (Parker 1950, p. 9). In calculating lunar dates there is always a risk that, through faulty observation caused by poor visibility, a lunar month was begun a day too early or a day too late. If it was a day too early it would mean that the date in the lunar cycle would generally be 11 years earlier than the true date, while a day too late would normally result in an error of 14 years before the actual date (Parker 1957).

While Sothic and lunar dates provide the fixed points to which any scheme for Egyptian chronology must be anchored, they are few and unevenly spaced apart, and the earliest of these dates, as I have already said, takes us back only to 1872 B.C., more than a 1000 years after the beginning of Egyptian history. Apart from ^{14}C what are the other sources of evidence? Omitting those of minor importance they are the following (Hornung 1964):

(1) Lists of kings in order of succession, but without indication of the length of their reigns.

(2) Monuments dated to particular years in the reigns of kings which help to provide the information missing from the king-lists.

(3) Dated inscriptions of royal officials and sacred animals.

(4) Genealogical inscriptions.

(5) References to eclipses.

(6) Synchronisms with other Near Eastern and Greek chronologies.

(7) Royal annals which name the kings in order of succession and record the lengths of their reigns.

The most useful of these sources are certainly the annals, the earliest of which is the Palermo Stone. Dating from the Fifth Dynasty (*ca.* 2400 B.C.), it is just a fragment of what was once a large slab inscribed on both faces with rows of compartments arranged horizontally under the names of kings, each compartment representing one year in the reign of the king named above it and recording an important event which had occurred in that year as well as the height of the Nile in the Inundation (Schaefer 1902). Other fragments in Cairo and London may belong to the same annals but they are mostly poorly preserved and no two pieces join together. Estimates of the number of year-compartments on the stone when complete for the first two dynasties vary widely, the lowest being 295 by Helck (1956). Parker, with whom most historians seem now to be in general agreement, has estimated that the number should be about 445 (see Hayes 1970).

Fortunately the Palermo Stone and its associated fragments are not our only annalistic source of evidence for the chronology of the Third Millennium B.C. Another document of immense value is the Turin Royal Canon, a papyrus which dates from about 1300 B.C. (Gardiner 1959). This document is also fragmentary. When complete it gave a list of kings and the lengths of their individual reigns. At certain intervals it also gave the total number of years for a whole group of kings. By a lucky chance the fragment giving the total for the period from the beginning of the First Dynasty to the end of the Eighth Dynasty has been preserved, the total being 955 years and probably 10 days. Since there is no evidence that there were any overlapping dynasties at this period, Egyptologists have generally accepted this figure at its face value.

Far less trustworthy than the Palermo Stone and the Turin Royal Canon are the figures given in the extant excerpts from Manetho's History of Egypt (see Waddell 1940) (written in the Third Century B.C. and preserved only in the corrupt texts of later copyists) but its information cannot be disregarded.

It will, I think, be clear from what I have said that our knowledge of the chronology of ancient Egypt is something of a patchwork built up of evidence from many different sources, some of unprovable reliability. Even the accepted Sothic dates may be 25 years too early if the point of observation was Thebes and not the region of Memphis-Heliopolis, as has generally been supposed. Nevertheless, the fact that the evidence from the different sources fits together so well inspires confidence in its trustworthiness. With only one or two exceptions, which can be explained, the Turin Royal Canon never gives a higher figure for a reign than the dated inscriptions, which not only suggests that the Egyptians kept fairly accurate records but also that the document itself was a careful copy. As far back as the beginning of the Eighteenth Dynasty, (*ca.* 1570 B.C.), we have enough evidence to feel confident that the uncertainties are never greater than the standard deviation in a ^{14}C determination. For the Twelfth Dynasty we have the Sothic date for Sesostris III which, combined with dated records, enables us to fix the beginning of the dynasty at 1991 B.C., and the end at 1786 ± 10 years. Contemporary records show that the Eleventh Dynasty lasted for $120 + x$ years and if we accept the figure of 143 years given in the Turin Canon, we can fix the beginning of the dynasty at 2134 B.C. The Tenth Dynasty was contemporaneous with the Eleventh Dynasty. The Ninth Dynasty lasted for no longer than about 30 years. For the period from the Eighth to the First Dynasties our main evidence is admittedly the total of 955 years given in the Turin Royal Canon, but such information as we possess from the Palermo Stone and other sources agrees with this figure. Given that the Eleventh Dynasty began in 2134 B.C. and allowing 30 years for the Ninth Dynasty, we arrive at a date of 3119 B.C. for the beginning of the First Dynasty, and it is difficult to believe that this date is likely to be more than 100 years wide of the mark.

How do ^{14}C measurements compare with the so-called 'historical dates' which are based mainly on Egyptian astronomical and textual evidence? Table 3 shows results obtained by the Research Laboratory of the British Museum from well-dated Egyptian material. It will be clear that wide divergencies occur between the dates calculated by the two methods. If, however, the Stuiver–Suess correction (1966) is applied and consideration is limited to the 29 samples which antedate 1500 B.C. it will be seen that 71 % of the results show divergencies of 50 years or less and 89 % of the results are in agreement to within 100 years or less:

agreement within the error assigned to the carbon-14 measurement	12
divergencies of 50 years or less	8
divergencies of 51 to 100 years	5
divergencies of 101 to 126 years	2
divergencies exceeding 126 years	2
total	29

When Stuiver & Suess (1966) published their article on the correction they pointed out that it offered no more than 'a crude approximation' for estimating the true age from the radiocarbon age. Eventually, it may be hoped, a more precise method will be devised, but in the meantime it would seem preferable to use this approximation when quoting radiocarbon dates, at least for archaeological purposes, rather than to continue to publish dates which are generally acknowledged to be too low.

I wish to express my gratitude to Professor R. A. Parker for his generous assistance to me when I was preparing this paper.

TABLE 3

British Museum code no.	material and provenance	tomb etc.	dynasty	'historical date' (approx.) B.C.†	radiocarbon date (half life = 5730 years) B.C.	radiocarbon date with Stuiver–Suess correction‡ (half life = 5570 years) B.C.	U.C.L.A. code no.§
228	reed Saqqara	Mastaba 3357	I (Hor Aha)	3075	2480 ± 65	2970 ± 65	1200
319	wood Saqqara	Mastaba 3504	I (Wadji)	3025	2460 ± 105‖	2942 ± 105	—
320	wood Saqqara	Mastaba 3504	I (Wadji)	3025	2390 ± 115‖	2844 ± 115	—
321	wood Saqqara	Mastaba 3504	I (Wadji)	3025	2684 ± 119‖	3254 ± 116	—
322	wood Saqqara	Mastaba 3504	I (Wadji)	3025	2518 ± 104‖	3027 ± 101	—
229	reed Saqqara	Mastaba 3503	I (Meritneith)	3000	2710 ± 65	3278 ± 65	1201
230	reed Saqqara	Mastaba 3035	I (Den)	2950	2560 ± 65	3082 ± 65	1202
323	wood Saqqara	Mastaba 3035	I (Den)	2950	2540 ± 100‖	3058 ± 97	—
231	reed Saqqara	Mastaba 3505	I (Qaa)	2900	2450 ± 65	2928 ± 65	1203
232	reed Saqqara	Mastaba 3046	II¶	2800	2410 ± 65	2872 ± 65	1204
233	reed Saqqara	Mastaba 3030	III (early)¶	2650	2170 ± 65	2550 ± 65	1205
507	reed Saqqara	Mastaba 3518	III (Zoser)	2650	2215 ± 60	2616 ± 60	—
508	flax rope Saqqara	Mastaba 3518	III (Zoser)	2650	2276 ± 60	2698 ± 60	—
234	wood Saqqara	Mastaba 3510	III¶	2686–2613	1950 ± 65	2256 ± 65	1206
235	reed Saqqara	Mastaba 3073–5	III (end)-IV	2600	2240 ± 65	2648 ± 65	1207
324	wood Dahshur	Pyramid of Sneferu	IV (early)	2600	2114 ± 106‖	2479 ± 103	—
325	wood Dahshur	Pyramid of Sneferu	IV (early)	2600	2029 ± 118‖	2364 ± 115	—
332	halfa grass rope Giza	Funerary boat	IV (Cheops)	2570	2150 ± 105	2536 ± 105	1389
401	wood Abu Sir	Tomb of Ptahshepses	V	2450	2056 ± 66	2399 ± 66	—
346	reed Saqqara	Mastaba of Haishetef	V (late)	2400	2030 ± 80	2504 ± 80	1403
331	wood Saqqara	Pyramid of Teti	VI	2335	1940 ± 115	2228 ± 115	1388
330	reed Saqqara	Mastaba of Mereruka	VI (Teti)	2335	1930 ± 115	2228 ± 115	1387
317	wood Deir el-Bahri	Temple of Nebhepetre Mentuhotep	XI	2010	1650 ± 90‖	1845 ± 90	—
335	wood Thebes	Chapel of Sankhkare Mentuhotep	XI (late)	2000	1830 ± 75	2088 ± 75	—
341	linen Thebes	Tomb of the Overseer of the Soldiers, Intef	XI–XII	2000	1660 ± 70	1850 ± 75	1398

TABLE 3 (*cont.*)

British Museum code no.	material and provenance	tomb etc.	dynasty	'historical date' (approx.) B.C.†	radiocarbon date (half life = 5730 years) B.C.	radiocarbon date with Stuiver–Suess correction‡ (half life = 5570 years) B.C.	U.C.L.A. code no.§
342	charcoal Thebes	Tomb of the Overseer of the Soldiers, Intef	XI–XII	2000	1820 ± 70	2074 ± 70	1399
343	wood Thebes	Tomb of the Overseer of the Soldiers, Intef	XI–XII	2000	1880 ± 85	2158 ± 85	1400
347	wooden bow Gebelein	—	XI–XII ††	2000	1800 ± 80	2060 ± 80	1413
238	reed El-Lahun	Pyramid of Sesostris II	XII	1880	1740 ± 65	1962 ± 65	1212
333	reed Thebes	Ramesseum	XIX (Ramesses II)	1250	1070 ± 100	—	1390
336	reed Thebes	Tomb of Tjanefer	XIX–XX	1170	1020 ± 100	—	1393
337	wood Thebes	Tomb of Tjanefer	XIX–XX	1170	1220 ± 75	—	1394
338	wood Thebes	Tomb of Roma	XIX–XX	1170	1170 ± 85	—	1395
334	reed Thebes	Tomb of Mentuemhat	XXV–XXVI	650	570 ± 70	—	1391
344	wood Thebes	Intrusive burial of Saite date in tomb of the Overseer of the Soldiers, Intef	XXVI	600	730 ± 70	—	1401
345	wood Thebes	Intrusive burial of Saite date in tomb of the Overseer of the Soldiers, Intef	XXVI	600	700 ± 100	—	—
381	reed Buto	Temple	XXVI	600	700 ± 105	—	—
509	cloth Saqqara	Tomb	XXVII (Darius)	522–485	361 ± 60	—	—
340	reed Karnak	Wall of Nectanebo I	XXX (Nectanebo I)	380–363	430 ± 80	—	1397

† The dates quoted are those published in the *Cambridge Ancient History*, vol. I (3rd ed. 1970).
‡ See *Radiocarbon*, **8**, 534 ff.
§ U.C.L.A. results are published under their code numbers by Professor Rainer Berger on pp. 25–29 below.
|| Result not corrected for $\delta^{13}C$.
¶ Dated by architectural style of mastaba.
†† Dated by archaeological evidence.

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References (Edwards)

Gardiner, A. H. 1959 *The Royal Canon of Turin*. Oxford University Press.

Hayes, W. C. 1970 Chronology—Egypt, to the end of the Twentieth Dynasty. *The Cambridge Ancient History*, 3rd ed. vol. 1, p. 175. Cambridge University Press.

Helck, W. 1956 *Untersuchungen zu Manetho und den ägyptischen Königslisten* (Berlin), **82**, n. 1.

Hornung, E. 1964 *Untersuchungen zur Chronologie und Geschichte des neuen Reiches*, p. 9. Wiesbaden.

Ingham, M. F. 1969 The length of the Sothic cycle. *J. Egypt. Archaeol.* **55**, 36–40.

Parker, R. A. 1950 *The calendars of Ancient Egypt*. Chicago.

Parker, R. A. 1952 Sothic dates and calendar 'adjustment'. *Rev. d'egyptologie* **9**, 101–108.

Parker, R. A. 1957 The lunar dates of Thutmose III and Ramesses II. *J. Near Eastern Studies* **16**, 39–43.

Schaefer, H. 1902 *Ein Bruchstück altägyptischer Annalen*. Berlin.

Stuiver, M. & Suess, H. E. 1966 On the relationship between radiocarbon dates and true sample ages. *Radiocarbon* **8**, 534–540.

Waddell, W. G. 1940 *Manetho*. London: The Loeb Classical Library.

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