Chapter 5
The Temple Measurements and the Sacred Cubit

Overview of Ancient Measurements

In 2 Chronicles 3:2, Solomon instructed that the Temple be built in cubits "after the first measure". This implies an ancient standard and the cubit was one of the most widely used measurements in the ancient world. It was considered to be a natural measurement. Deuteronomy 3:11 describes the bedstead of Og, the King of Bashan: "nine cubits was the length thereof, and four cubits the breadth of it, after the cubit of a man". To measure the bed with a cubit was to measure it with the length of the forearm from the elbow joint to the end of the middle finger. The body as a measurement was a simple and ever handy measuring stick. This simple measurement is inscribed in Egyptian hieroglyphs. The hieroglyph for a cubit is the image of the forearm,[370] and the cubit can be divided into smaller parts; there are also measurements of the body, of palms and of digits.

Methods of standardising these measurements can be seen in the archaeological record. In the Piraeus Archaeological Museum in Greece a fourth century BC stone engraved with standard measurements has been preserved and it gives the measurement for: an orgyiae, which is the arms fully outstretched; a cubit (43.7 cm); an open palm (24.2 cm) and the foot (32.2 cm) (see Fig. 5.1). There is another Greek measuring standard in the Ashmolean Museum, Oxford. It is a fifth century BC carved relief and the remaining fragment shows the outstretched arms of a man to measure the orgyiae, and the imprint of the foot.[372] The orgyiae is seven times the foot in this relief,[373] which is larger than the idealised human span of six feet that was later made famous by Vitruvius. Also, the Rhind Mathematical Papyrus,[374] c1550 BC, held at the British Museum records the length of the Egyptian Royal cubit as 20.6–20.7 in. or 52.4–52.7 cm. The rod of Haremhab, c1333–1306 BC, records the Egyptian Royal cubit to be 20.4 in. or 51.8 cm.[375] While an Egyptian measuring stick c1069–715 BC held at the Metropolitan Museum, New York measures a unit of 27.5 in. or 69.8 cm.[376] There appears to be no consistency in the standards of these ancient measurements and from the various archaeological sources that have survived it would appear that the "standards" were very localised or at least they were not standardised with any precision. However, Newton did not have the benefit of this evidence. He had Biblical and ancient literary sources, and the only other source

T. Morrison, *Isaac Newton's Temple of Solomon and his Reconstruction of Sacred Architecture*, DOI 10.1007/978-3-0348-0046-4_5, © Springer Basel AG 2011

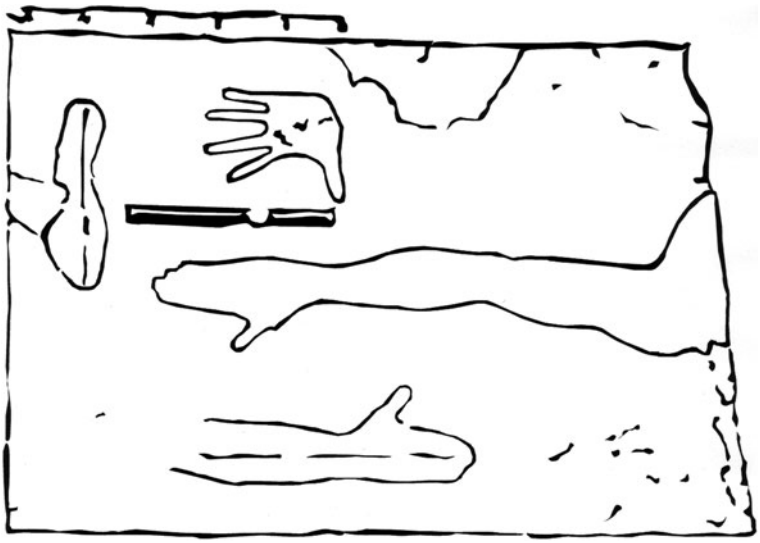

Fig. 5.1 Greek fourth century BC stone engraved with standard measurements[371] (Drawn by the author at Piraeus Archaeological Museum in Greece)

were the measurements of the Great Pyramid by John Greaves (1602–1652), Professor of Geometry at Gresham College.

There is no Hebrew standard of measurements that has been recovered and all the attempts at finding the length of the Hebrew vulgar and sacred cubit have been through equivalent Roman, Greek, Arabian, Egyptian, Memphis and Babylonian measurements. The Biblical and ancient sources are as inconsistent as the archaeological evidence. Herodotus writing on Babylon claimed that "the royal cubit is three inches longer than the ordinary cubit".[377] Presumably the royal cubit is the Babylonian cubit since Herodotus is in Babylon, although it is impossible to be sure of that as he does not establish what the ordinary cubit is. Sabbath day's journey for the Jews was to be not longer than two thousand cubits.[378] According to Acts 1:12, a Sabbath day's journey was the distance from Jerusalem to the Mount of Olives following the ascension of Christ. But the distance between Jerusalem to the Mount of Olives is described by Josephus as being five Roman furlongs in *Jewish Antiquities*[379] and six Roman furlongs in *the Jewish Wars.*[380] In 1 Kings 7 and 2 Chronicles 4, the Bronze Sea of the Temple of Solomon is described and the measurements are in cubits and its capacity is in baths. In 1 Kings. the sea was 10 cubits in diameter, 5 cubits in height and it was 30 in circumference,[381] and it held 2,000 baths.[382] In 2 Chronicles, the sea was 10 cubits in diameter, 5 cubits in height and it was 30 cubits in circumference,[383] and it held 3,000 baths.[384] These and many other inconsistencies in the ancient texts make any direct method of converting the measurement from one to the other impossible.

John Greaves and Egyptian Measurements

John Greaves (1602–1652), Savilian Professor of Astronomy at the University of Oxford, was a mathematician-Orientalist with a command "of ancient and modern astronomical and geographical literature of Latin, Greek, Hebrew, Arabic and Persian authors".[385] He conducted a survey of the Pyramids of Giza which resulted in the publication of *Pyramidographia* in 1646.[386] Greaves described the physical attributes of the Great Pyramid and was the first to execute an architectural section of the Pyramid. He also attempted to establish its chronology and the history of its construction. Using Biblical prophecies and the epochal dates of the Olympiads, on the authority of Diodorus and Herodotus, Greaves concluded that the Great Pyramid was built at some time between Moses and the destruction of the Temple.[387] Like Newton he shortened Egyptian history.

In a time when Hermetic philosophy was at its zenith, Greaves' aim in studying the Pyramids was not to search for Egyptian esoteric wisdom – it appears that he was uninterested in Egyptian mysticism – but to search for the origins of modern measurement. To achieve many of the measurements of the interior of the Pyramid he had to crawl through dark tunnels and then meticulously take the measurements. Before the Greaves' study the measurement of this dark and mysterious interior had been only made by approximation.[388] Greaves bought mathematic precision and a passion into the study of metrology.

In 1647, he published *A discourse of the Romane foot and denarius, from whence the measures and weights used by the ancients may be deduced*.[389] He claimed "that the foot was the most received, and usual measure among the Romans, as the cubit among the Jews, is not controverted by any".[390] He used a wide range of ancient and modern sources in his study including Polybius, Suetonius, Pertius Vicentiniss, Philandrier, Vitruvius, Donatus, Villalpando and many others. Greaves also examined archaeological evidence in Rome such as the marks on columns and pavement stones at the Pantheon, Via Appia and the Roman brass feet, but he found them disappointing.[391] He constructed a table of all of the variations of the Roman foot and a comparative table in English feet, and concluded that the Roman foot was 0.967 of an English foot[392] or 11.6 in. Greaves does not attempt to calculate the Hebrew cubit; his measurements in English feet were used to calculate the Royal cubits, Memphis cubits and the Egyptian cubits.

Newton's Interpretation of the Hebrew Cubit

In Ezekiel's vision of the Temple, two types of cubits were described which Newton distinguished as the sacred cubit and the vulgar cubit. The description of the cubits in Ezekiel is very confusing as he claimed, "The cubit is a cubit and a palm breath",[393] leaving the distinction between the two cubits ambiguous. One of the essential elements of Babson 0434 is measurements. Everything is carefully measured, those measurements are thoroughly scrutinised and the structure of the building is

considered from these measurements and classical architectural proportions. Newton noted the ambiguity in Ezekiel's description of the cubit[394] and notes, "Jerome was reading a corrupted version which he took to serve as an example by the use of the reed being six cubits and a palm and the Latin ones followed him ordinarily".[395] In fact, the text claimed that a reed was six cubits in length and each of these cubits were one cubit plus a palm in length. In other words, the sacred cubit was one palm greater than the vulgar cubit. Newton claimed that a vulgar cubit was five palms and a sacred cubit was six palms.[396] But Newton does not extend the discussion of what would seem to be a salient point in Babson MS 0434. However, he made an extensive study of the cubit which was posthumously printed as "A Dissertation upon the Sacred Cubit of the Jews and the Cubits of the Several Nations".[397] Here Newton examined the measurements taken by Greaves, which he took to determine the Royal cubits, Memphis cubits and the Egyptian cubits.[398] From Greaves' calculations of the ancient cubits, Newton proceeded to calculate the measurement of the Jewish sacred cubit, which was essential for understanding the Temple structure.

Newton's "Dissertation" begins: "To the description of the Temple belongs the knowledge of the sacred cubit; to the understanding of which, the knowledge of the cubits of the different nations will be conducive".[399] Newton used Greaves' measurements of the Great Pyramid and systematically compared them with measurements given by ancient sources such as Herodotus, Vitruvius, Strabo, Josephus, Hesychius of Alexandria, Lucius Iunius Moderatus Columella, Philandrier, Gnaeus Julius Agricola, Publius Clodius Thrasea Paetus, *the Talmud* and more contemporary writers such as Willebrord Snellius, Samuel Purchas and Juan Bautista Villalpando. Greaves quoted from Arabic sources, such as Ibn Abd Alhokm (321–405), who Newton also cited.[400] However, the sources may extend beyond those that Newton directly references. José Faur claimed that Newton alluded to a commentary of R Obadiah of Bertinoro (second half of the fifteenth century) in the "Dissertation"[401] and that he translated "the Aramaic version of Ruth 1:6 in conjunction with the distance a Jew is permitted to travel by foot on the Sabbath".[402]

First, Newton examined the Roman and Greek cubit and foot, measuring them in palms and digits, together with the Greek orgyiae, because these measurements were defined by the ancient authors. To estimate their value, Newton approached the problem of the variations in the measurements of the ancient authors by assessing each one of their limits and then comparing them to each other. Throughout the "Dissertation", various ancient measurements are surveyed and calculated.

Newton reasoned that the builders of the Great Pyramid would have used a uniform unit of measurement in their design – a cubit of Memphis. In his calculations he claimed that one Greek orgyiae is equal to four Memphis cubits. However, Ibn Abd Alhokm had claimed that the side of the Great Pyramid was one hundred Royal cubits. Newton argued that "it is probable, that the Egyptians learned, from the orgyiae of the Greeks, their measure of four cubits of Memphis, and gave it the name of the Royal Cubit".[403] From this point, Newton examines the ancient measurements with Greaves' measurements (see Table 5.1).

Newton pointed to the difference between these measurements of the table as being a mere seventh of any inch, "an error of no importance if we consider the much

Table 5.1 Measurement of the Great Pyramid as given by Greaves and the ancient source

Feature measured	Greaves' measurements (in English feet)	Ancient measurements	Newton's ancient measurement (in English feet)
Length of the base of the Great Pyramid	693	100 Royal cubits = 400 Memphis Cubits	400 × 1.732 = 692.8
The square passageway entrance width and height	3.463	2 Memphis cubits	2 × 1.732 = 3.464
The length of the chamber	34.38	20 Egyptian cubits	20 × 1.719 = 34.38
The width of the chamber	17.19	10 Egyptian cubits	10 × 1.719 = 17.19
The marble gallery to the chamber	6.87	4 Egyptian cubits	4 × 1.719 = 6.876
In the middle of the gallery was a marble way its width	3.433	2 Egyptian cubits	2 × 1.719 = 3.428
The height and length of the benches of the polished marble	1.717	1 Egyptian cubit	1.719

greater irregularities observed by Mr Greaves in the best buildings of the Romans".[404] The other measurements given by Greaves can all be converted into even amounts of Royal, Memphis or simple Egyptian cubits: the main gallery was 138 English feet, or 20 Royal cubits; two other galleries were found to be 110 English feet or 16 Royal cubits; another chamber 17 English feet or 10 Memphis cubits and so on. Newton also demonstrated that measurements of the King's monument such as the height and length of the benches of the polished marble were 1.717 English feet; since a cubit is 6 palms, a palm was equal to 0.286 English feet and a digit was equal to 0.0715 of an English foot. Further measurements by Greaves, taken in English feet, proved to be equal to measurements in palms and digits based on the conversion previously mentioned and quoted by Newton. From this Newton concluded, "And it is my opinion that the Pyramid was built throughout after the measure of this (Memphis) cubit".[405]

To support the argument that the ancient buildings were built to a standard unit of measurement, Newton considered the measurement of Babylonians bricks. They were all uniform in size, according to the measurements of Samuel Purchas, their length was one foot, the width was eight inches and the thickness was six inches. So that two bricks in length, three bricks in width and four bricks in thinness formed a square cubit. Therefore, Newton concluded that the Babylonian cubit was two English feet,[406] but this is much larger that the human elbow from which the word "cubit" derived, and Newton failed to note this. Yet he still claimed that the Babylonians built in cubits. Therefore, this consistent measurement for bricks was the Babylonian cubit. He claimed that all measurements which exceeded human proportions, such as the Roman calamus, clima, scruplum, actus and many others, were

deduced from the multiples of human proportions. The ancient nation rounded off their large numbers into even numbers of cubits – the cubit of man.[407]

Greaves found the modern Egyptian cubit was 1.824 English feet, exceeding that of the ancient Egyptian cubit or Memphis cubit. "The measurements of feet and cubits now exceed the proportion of the human members".[408] According to Greaves' measurements of the Egyptian monuments, the human stature was the same as it was in ancient times. The measurements have increased because of human and instrument error.

> Feet and cubits were used first (as a measurement) in every nation according to the proportion of the members of a man, from which they were taken. For the foot of a man is to the cubit or lower part of the arm of the same man as about 5 to 9.[409]

Newton confirmed this ratio of 5:9 between the foot and cubit with other ancient measurements. He considered that the Jewish measurements were determined in the same manner.

Newton claimed that Villalpando had calculated the Jewish vulgar cubit to be two and a half Roman feet,[410] but since this does not fit the "cubit of man" Newton rejected it outright. He claimed that the Jewish vulgar cubit cannot exceed the cubit of a tall man.

> The stature of the human body, according to the Talmud, contains about three cubits from the feet to the head; and if the feet be raised, and the arms lifted up, it will add one cubit more and contain four cubits. Now the ordinary stature of men, when they are bare-foot, is greater than five Roman feet, and less that six Roman feet, and may be best fixed at five feet and an half.[411]

According to the Book of Erubin in the Talmud, the area of "his place" is "three cubits for his body and one cubit to enable him to take up an object at his feet and put it down at his head".[412] Newton also moved away from the classical "Vitruvian" man. In Vitruvius the height of man is set at six Roman feet; Vitruvius claimed that the number six was perfect and this perfection was further expressed in the cubit which equalled six palms or 24 digits.[413] Newton's measurements of the stature of a man, five to six Roman feet, equalled three vulgar cubits, which was to be no less that 20 Roman unciæ and no more than 24 unciæ. With the extra cubit, the height of a man with raised arms became the sacred cubit, which he calculated to be no less that 24 Roman unciæ and no more that 28.8 unciæ.

Newton gave two examples from ancient literature, where he further defined the limits of the sacred cubit. In the first, Josephus wrote that the columns of the great court of the Jewish Temple could be embraced by three men with their arms joined. Newton claimed that the orgyia or the fathom of a man, which is the length of the outstretched arms of a man, was supposed to be the same as the height of a man but in fact is a palm wider.[414] Vitruvius stated, "For if we measure the distance from the soles of the feet to the top of the head, and then apply that measure to the outstretched arms, the breadth will be found to be the same as the height".[415] Newton further abandons this traditional image of Vitruvian man, which is confined by the circle and the square, by adding an extra palm to the length of a man's outstretched arms giving a slightly more elliptical and rectangular image to the geometry of man (see Fig. 5.2).

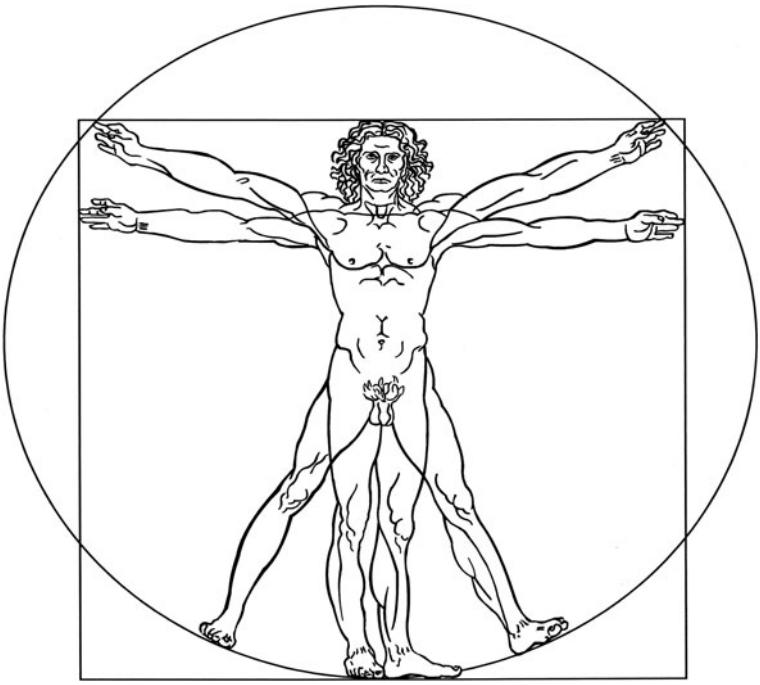

Fig. 5.2 The Newtonian man[419] (Drawn by author from Newton's description in Isaac Newton, 1737)

The circumference of the columns, according to the Talmud and Josephus is eight cubits, for Newton this is equal to three times the height of a man plus three palms i.e. greater than 15.75 Roman feet and less than 18.75 Roman feet. This further defined the sacred cubit to be greater than two Roman feet and less than two and a third Roman feet.

In Newton's second example of the use of the cubit from the ancient literature, the Sabbath day's journey, in the opinion of what Newton called the "unanimous" content of the Talmud and all the Jews, was 2,000 cubits. According to Josephus, this measurement is not so consistent, and he claimed that the Sabbath day's journey is five stades (3,000 Roman feet) and in another place six stades (3,600 Rome feet).[416] Newton, who was very familiar with the work of Josephus, used the reference from the Talmud instead and claimed that instead of "cubits" the Jews sometime substituted "paces". Walking on the Sabbath is not hurried but is of a moderated speed:

> Now man of a middling stature, in walking in this manner, go every step more than two Roman feet, and less that two and a third. And within these limits was the sacred cubit circumscribed. And within these limits was the sacred cubit circumscribed.[417]

From the height of a step from Vitruvius,[418] Newton claimed that the middling proportion referred to by the Jews was about 13.5 unciæ, and from this he calculated that a pace or sacred cubit was less than 27 unciæ and more that 24 unciæ. From the

examples of the height of a man, the circumference of the columns and the Sabbath day's walk, Newton defined the limits of the sacred cubit and rejected "the erroneous opinions of other writers".

Newton argued that the vulgar cubit of the Jews was derived from the Memphis cubit when the Jews were held captive in Egypt. The vulgar cubit was used for building and daily measurements. Therefore, there was a need for a cubit for profane use and this was provided by the Babylonian cubit of two Roman feet. The proportion of the Babylonian cubit to the Memphis cubit was 6:5.0157 rounded off to 6:5. In Babson 0434, Newton confirmed that the sacred cubit was six palms[420] and the vulgar cubits was five palms.[421] In the "Dissertation", Newton continued to define his limits using Greaves measurements and a proposition by Mersennus, which defined the cubit to be 23.25 French feet. He concluded that the sacred cubit was 25.6 unciæ.

The "Dissertation" ends with a comparison of Josephus' and the Talmud's measurements, which is similar to the one in Babson 0434.[422] In Babson 0434, Newton does not state which vulgar cubit Josephus used but in the "Dissertation" he clearly states that it is the Roman cubit and that the ratio between the Roman cubit and the sacred cubit when rounded off was 2:3.

In attempting to establish the length of the Hebrew cubit Newton was endeavouring to prove the impossible. The paper is ingenious but it has problems and is fundamentally flawed. The published translation is poor and has many misprints. For example there is a misprinted number on page 411, which is corrected on page 412.[423] On page 429, the sacred cubit in the time of Moses was 25.6 in. of English feet while three pages later the sacred cubit is 25.6 unciæ of Roman feet.[424] The translation at times is confused. "And" is often printed instead of "or" as for example: "four Palms, and sixteen Digits".[425] This clearly should be "or" not "and" since four palms are equal to 16 Digits. The sacred cubit consisted of "only a single palm"[426] and this should have said "an additional palm".

What the Memphis cubit is quite unclear throughout the paper. Newton clearly stated in the beginning of the paper that a Memphis cubit was 1.732[427] English feet and worked his calculations according to this measurement. Later he claimed that the Memphis cubit was 1.719 English feet[428] and this figure was previously referred to as an Egyptian cubit, as being distinct from the Memphis cubit, and even later he claimed that "the different measurements of the cubit of Memphis, taken from the pyramid were 1.717, 1.719, and 1.732 of the English foot".[429] From Newton's defined limits of the sacred cubit and from the three Memphis measurements, he derives the sacred cubit to be 25.6 unciæ. The proportion of the sacred cubit and the vulgar cubit is 6:5 and this proportion confirmed the vulgar cubit to be 1.719 English feet. "Thus therefore, by means of these limits, those measurements agree with the sacred cubit, and consequently the measurements of the cubit of Memphis agree with the vulgar Cubit".[430]

From Greaves' measurements of the Great Pyramid, he worked out the length of the Memphis cubit. Greaves took the Memphis cubit, which he estimated to be 1.717 English feet, to consist of six palms. He took his measurements in English feet but he proved that all the other measurements of the pyramid could be measured in even

amounts of palms and digits according to this estimate i.e. there would be no fractions of a digit. From this Memphis cubit, Newton derived the vulgar Jewish cubit as stated above. However, Newton claimed that the vulgar Jewish cubit consisted of five palms.[431] If this was the case, then many of Greaves' measurements would no longer equate neatly into palms and digits.

The length of a palm is very confusing in the "Dissertation". Using the measurements of the ancient writers he claimed that the Roman and Greek cubits were one and a half Roman feet and like the sacred cubit they consisted of six palms. But Newton gave the length of the Roman cubit to be 1.4504 English feet. From Greaves' measurements, Newton took the palm to be 0.286 English feet and after some calculation the sacred cubit to be 2.068 English feet. However, none of these measurements equate to each other. He clearly stated that the proportion of the sacred cubit to the vulgar Jewish cubit is 6:5 and equals six and five palms, respectively. From his final estimation of the sacred cubit, which is 2.068 English feet, this infers that the palm is equal to 0.3438 English feet but Newton retains his previous palm measurement, which he used to calculate the Memphis cubits and vulgar Jewish cubit, and to support his measurement for the sacred cubit. He retained the Talmud's description of the sacred cubit to be equal to six palms[432] and the vulgar cubit as being five palms,[433] and also Ezekiel's "The cubit is a cubit and a hand breath".[434] He also attempted to retain other ancient measurements from literary sources and Greaves' measurement of the pyramids, but the palm measurement, which is crucial to Newton's argument, is never satisfactorily resolved.

Conclusion

"Dissertation" was published 10 years after Newton's death in 1738. Although the "Dissertation" is presented as a finished work it should not be considered at all complete since it was translated directly from a working manuscript. It was originally an Appendix in "De magnitudine cubiti sacri" which is a draft on Solomon's Temple that became Babson MS 0434. In Babson MS 0434, he only repeated the section on Josephus' measurements and he does not attempt to specify the length of the cubit except to say that the sacred cubit equals six palms and the vulgar five palms. Newton does not return to the study as there are no other surviving drafts and he only used a small section of it in Babson MS 0434.[435] However, it is important to consider this paper in context with his other work on the Temple. His application of the principles of limits to these ancient measurements is ingenious and, despite its flaws, "Dissertation" is a significant manuscript. It gives an insight into Newton's vast understanding of ancient sources and measurements, his working methods and his interest in gaining a complete understanding of the Temple.