Leofranc Holford-Strevens

THE HISTORY OF TIME

A Very Short Introduction

OXFORD

The History of Time: A Very Short Introduction

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Preface

The title of this book may suggest a survey of problems in philosophy or physics: whether time can have a beginning or an end; whether the laws of space–time cease altogether to apply in black holes; whether it would ever be possible to reverse the flow and change the past – a favourite fantasy with people who imagine that they alone would have the privilege of doing so, and forget that in the new improved past their parents might never have met.

These are indeed good questions, but no more my concern than the definition of time. About AD 268 the great Neoplatonist philosopher Plotinus observed that while we constantly talk about age and time as if we had a clear idea of what they were, when we investigate the question we find ourselves puzzled. The point was pithily restated some 130 years later by St Augustine: 'So what is time? If no one asks me, I know; if I seek to explain it, I do not.'

No pretence to greater wisdom is made in this book; whether time is a fourth dimension of the universe or a reified abstraction, whether it is continuous or atomistic, whether it can exist independently of motion to be measured, whether any meaning attaches to 'before' in the phrase 'before Creation' or 'before the Big Bang', are for others to determine. The same St Augustine, faced with the question what God was doing before he created the world, quoted, though he did not endorse, the jocular answer, 'Preparing hells for folk who invented clever

conundrums like that'; I shall not take the chance that a true word was spoken in jest.

Nor shall I consider whether time proceeds in a straight line or in cycles. Although it is not true that linear time was a Judaeo-Christian speciality, set against the cyclical time symbolized in late Graeco-Roman paganism as a serpent devouring its tail, some philosophers did speak of time in cyclical terms. That poses conceptual problems that I shall not discuss; rather I shall confine myself to time in its ordinary-language or man-in-the-street sense, and shall concentrate on the methods by which its passage is and has been measured.

The English word 'time' may refer to a more or less closely defined period, from 'a short time', meaning not very long, to 'the time of the Pharaohs', some three thousand years; it may also refer to the 'indefinite continuous duration', as the *Oxford English Dictionary* expresses it, in which all events have taken place, are taking place, and will take place. This notion, the focus of Plotinus' and St Augustine's perplexity, presupposes a developed capacity for abstract thought; not only are various primitive peoples reported by anthropologists not to have such a concept of time, but in the epics ascribed to 'Homer' and dating from the 8th to 7th centuries BC that the Greeks regarded as the foundation of their culture, *chrónos* denotes only a lapse of time, not what we are tempted to think of as time itself. Nevertheless it already has that sense in the great Athenian lawgiver Solon of the early 6th century BC, who personifies it as a judge: 'in the court of Time'. Since then, this concept of indefinite continuous duration has been so familiar a concept to Western civilization that we find its absence unimaginable in any advanced culture; yet the case has recently been argued that neither the Hebrew Bible nor rabbinical literature displays it. However, in any but the simplest society, even if people are unaware of time as a thing in itself, they need to measure it. This book is about the methods by which the passage of time has been measured.

Homer has terms for years, months, and days; his references to disputes and lawsuits remind us of one important context for time-

measurement, namely that even in his relatively simple society some cases must have turned, not on whether something had happened, but on whether it had happened before something else. If the two events had been witnessed by the same persons, there might be no problem; if not, both might be related to some third event, preferably one known to both parties and the judge, such as the local magnate's wedding. If there were no such event, difficulties would ensue unless the facts of the case could be plotted against a socially accepted measure of time.

The recording and coordination of human activities make it necessary to devise systems for relating events to a sequence of regular and predictable natural recurrences; since these systems were of artificial contrivance, and evolved in partial or complete independence one from another, they are different in many details. The range of variation, however, is limited by facts of nature, in particular the earth's rotation on its axis, the moon's revolution round the earth, and the earth's revolution round the sun; it is these that underlie the most widespread units for measuring time, the day, month, and year respectively.

The more complex life becomes, the more sophistication is demanded of the intellect not merely to distinguish one year, month, day, or subdivision of the day from another (the science of *time-measurement*), but to relate the years and so forth thus distinguished to each other (the science of *chronology*). This latter includes comparing the systems established for this purpose by different cultures to determine whether two apparently similar designations refer to two different things, or the same thing is lurking under two different names.

In much time-measurement fidelity to nature is in conflict with convenience; sometimes the former is sacrificed, as has repeatedly happened in Western methods of telling the time of day, sometimes the latter, as when Pope Gregory XIII made the Roman calendar more accurate but also more complex. By contrast, the designation of the year is free of natural considerations, being entirely a matter of convention; nevertheless, it is all too easily reified. In the early months of 1961 a manufacturer of electrical goods is said to have advertised its products

in the name of a housewife called 'Mrs 1961', who because she was Mrs 1961 had to have the latest vacuum cleaner and the latest refrigerator. Her reward for thus increasing the company's sales was to disappear without trace in 1962.

Mrs 1961 was a victim of the delusion that years measured in our particular calendar and numbered in our particular era possess a reality beyond the conventions that created them. Yet in other calendars the year 1961 of the Christian era was not even a self-contained whole: in one Indian era it combined portions of 1882 and 1883, in another of 2017 and 2018, in Ethiopia of 1953 and 1954, in the Jewish calendar of 5721 and 5722, in the Muslim calendar of 1380 and 1381.

Such reification extends to larger units. 'The Sixties', meaning the 1960s, marks an entire decade as a time of political rebellion and cultural innovation; the 1890s (during which Oscar Wilde was convicted) are called 'the Naughty Nineties' because the elite chafed at the pretence of conforming to middle-class respectability. Centuries too are branded: 'in the 15th century religious devotion became increasingly personal and emotional', '18th-century English literature was dictated by the head and not the heart' – as if on the first day of 1401 or 1701 (not necessarily 1 January, as we shall see in Chapter 7), old ways of thought and feeling were abandoned like Mrs 1961's old vacuum cleaner.

When the emperor Trajan admonished Pliny, perhaps late in AD 110, that receipt of anonymous accusations was not compatible with 'our times', he meant quite specifically 'my reign', the principles by which he chose to rule. By contrast, modern journalists and politicians tell us that certain practices of government (though not that one) have no place in the 21st century, as if the date were a fact of nature and a legislator, so solidly is it reified. One purpose of this book is to combat such reification by illustrating the contingent and arbitrary nature of the measures to which it is applied.

Although the subject of this book is not politics or religion, I shall as occasion serves consider the political and religious implications in the

choice of calendar, and the acceptance or rejection of reforms (e.g. the Gregorian calendar in Christendom, the 'Shahänshahi' era in Iran): even when the Government of India, in 1957, introduced a new secular calendar, it did not dare touch the multiplicity of religious calendars beyond substituting the synodic for the sidereal year. I shall also devote one chapter to a religious festival, the Christian Easter, not because of its religious significance but because of its calendrical complexity.

Nevertheless, my concern is with calendars as such rather than with their use or meaning; likewise, though much may be written about time as a social construct – and constructor – or about its perception by young and old, by men and women, or by office workers, factory hands, and peasants, there are others more qualified to write it.

Technical terms, when unavoidable, will be explained in a glossary; however, I note here that I have occasionally employed the single words 'feria', 'quantième', 'lune', and 'millésime' in place of the lengthier phrases 'day of the week', 'day of the month', 'day of the lunar month', and 'number of the year'. Numbers have been written in the scientific fashion, without commas: one thousand is 1000, ten thousand 10 000, one ten-thousandth 0.0001, one hundred-thousandth 0.000 01.

The traditional terms AD and BC have been retained, in preference to CE and BCE, for two reasons: adopting the latter causes the maximally distinguished BC 1 and 1 AD to become the minimally distinguished 1 BCE and 1 CE; and although, as a date for the birth of Jesus Christ the epoch is almost certainly wrong, it remains a commemoration of that event, and no other event of the same year can be proposed as an alternative of world significance. Attractive, especially in a globalized age, as a purely secular era may appear, the Christian era cannot be made secular by denying its origin.

List of illustrations

The publisher and the author apologize for any errors or omissions in the above list. If contacted they will be pleased to rectify these at the earliest opportunity.

Chapter 1
The day

Natural, artificial, civil day

The most fundamental unit of time-measurement is in most societies the period of the earth's rotation on its axis, which is normally known as the day. Unfortunately this word and its equivalents in other languages are ambiguous: other meanings apart, they may denote either the light period (daytime) as opposed to the night, or the combination of daytime and night. In some cultures, this combination is termed the night, as it used to be by Celtic and Germanic peoples, who measured the length of journeys or campaigns by the periods of inaction during darkness; this practice – to which we still revert when booking a hotel – survives in the English word 'fortnight', meaning 14 nights (formerly too in 'sennight', meaning a week). Nevertheless, the prevailing word is 'day'.

The two senses, 'daylight' and 'period of rotation', are distinguished by the Latin author Censorinus, writing in AD 238, as *dies naturalis* and *dies civilis* respectively; by the 7th century, however, educated opinion had decided that the true day was the combined entity. As a result, it was the latter that was called *dies naturalis*, the daytime being renamed *dies artificialis*; accordingly Chaucer speaks of the sun's 'artificial day' in the introduction to the *Man of Law's Tale*. It is in this fashion that the terms 'natural' and 'artificial' day will be used in this book.

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In principle the natural day, being a segment of a continuum, may begin at any time. Some languages have an everyday word for a 24-hour period irrespective of starting point (e.g. Dutch *etmaal*, Russian *sutki*, Swedish *dygn*); this is particularly useful in measuring the duration of sea voyages, which unlike land journeys are not interrupted by nightfall. English has no corresponding term except the rare and scientific *nychthemeron*, a Greek word, literally meaning 'night-day', used by St Paul when he tells the Corinthians 'a night and a day have I been in the deep' (2 Cor. 11: 25). The New English Bible, anxious to avoid the implication that his ordeal began at sunset, renders 'for twenty-four hours'.

This unanchored natural day must be distinguished from the *civil day* in the strict sense, which is the natural day as reckoned from a particular point determined by law or custom. In the modern West, following Roman practice, and also in China, that point is midnight, but the Jewish and Muslim day is counted from sunset, as it was by the ancient Greeks and Babylonians; so (despite the midnight services that introduce Easter and Christmas) is the Christian liturgical day. The Egyptians (though not the Greeks of Egypt) reckoned from sunrise; in the same spirit most people in our own society, after midnight, call the next artificial day 'tomorrow' not 'today'. (In many languages, including English, the word for 'tomorrow' is related to that for 'morning', or is even the same, like Spanish *mañana*.) The peoples of ancient Umbria, however, began the day at noon, which struck the Romans as absurd. Noon was also the traditional beginning of the astronomical and nautical day, allowing all observations relating to a single night to fall on the same date; modern astronomers and sailors, however, have adopted the civil day.

Natural and social divisions

The apparent progress of the sun through the heavens can be measured, in the less cloudy climates, by observing the position or length of its shadow. It is recorded in the Bible that when, in the late

8th century BC, King Hezekiah of Judah fell ill, the prophet Isaiah induced a miraculous retreat of the sun's shadow by ten steps on an instrument evidently set up by the king's father, 'the steps of Ahaz'. Although the Authorized or King James Version speaks of 'degrees' on a 'dial' – meaning a sundial, not a clockface – the Hebrew word remains the same, *maʿălôt*; more recent interpreters have supposed the steps to be a staircase or terrace, installed for use or beauty without regard to timekeeping. This would suit better with later midrashim, or elaborations of biblical stories, in which a scratch is made in the wall and a prophecy given that when the sun's shadow reaches the mark, such-and-such an event will take place.

These are not times of day as we understand them, any more than cock-crow or the natural and social events used as markers in Homer – 'when the early-born, rosy-fingered Dawn appeared', 'when the sun made his way towards ox-loosing', 'when a man rises for his supper after judging many disputes' – and long afterwards in the expositions of Jewish law known as the Mishnah; even midday and midnight are rather bands than points of time, halfway between sunrise and sunset or vice versa.

The hour

By contrast, the ancient Egyptians had for many centuries divided both the artificial day and the night into 12 'hours' each; in the former case, there was an earlier division into 10 hours of daytime plus 2 hours of half-light. The daytime hours were measured with shadow-clocks and sundials, those of the night identified by the succcessive risings of constellations. Every 10 days, a new constellation was recognized as rising with the sun (on each of the 9 succeeding days it rose 4 minutes earlier), yielding a set of 36 constellations known in Greek as *dekanoí*; this word, Anglicized as 'decan', was also used for an officer with 10 men under him, giving rise to our 'dean' and 'doyen'. For each 10-day period the decan that rose nearest to dawn, and the beginning of each hour, was noted in

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'diagonal calendars', so called because each decan was one line higher from one column to the next (see Figure 1).

Such hours, technically called *unequal* or *seasonal* because they vary in length according to the time of year, were adopted by the Hellenistic Greeks and Romans (though the latter often divided the night into four *vigiliae*, or watches), and survived in normal use until the later Middle Ages. That is why Jesus, in St John's Gospel, asks 'Are there not twelve hours in the day?', meaning the artificial day. It is also why a midday rest is known as a *siesta*, Old Spanish for 'sixth', that is the sixth hour of the day (see box).

Ancient numbering of hours

- **When it is said that on the day of the Crucifixion 'from the sixth hour there was darkness over all the land unto the ninth hour', this means from midday till mid-afternoon. Similarly, a Greek epigram states that there are 6 hours for working; the next 4 are for living, because the Greek letters zeta, eta, theta, iota, which were the normal notation for the numbers 7, 8, 9, and 10, spell the word *zêthi*, 'live!'**

- **The ecclesiastical offices of terce and nones owe their names to Latin *tertia* and *nona*, the 3rd and 9th hour respectively. However, a tendency to sing offices earlier than prescribed caused *noon*, the older form of 'nones', to mean 'midday'; the new sense is well established by the 14th century.**

Although astronomers divided the natural day (reckoned from midday) into 24 equal, or equinoctial, hours, called by the latter name because at the equinoxes the nights and days are equal, other folk

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1. **Detail of Egyptian diagonal calendar**

preferred the seasonal variety, which so long as work and travel were confined to daylight indicated both the time consumed and the time remaining. There were tables for converting the equal hours naturally measured by the clepsydra, or water-clock, into the unequal hours read off the sundial; not even the mechanical clock, which spread in Europe from the 14th century, gave immediate supremacy to equal hours, for the more complex clocks sometimes indicate unequal hours alongside the date and the position of sun and moon.

Once equal hours became the norm, however, it was more convenient to count them from midnight or midday than from sunrise or sunset; for that reason, people began to count the two sets of 12 hours before and after midday. Especially in English-speaking countries, this remains the norm outside bureaucratic and military usage, which favours the unambiguous count from 0 to 24. In Italy, however, there was a single sequence of 24 hours from sunset, the clock being adjusted from time to time as sunset moved later or earlier in the year; even now, when hours are counted from midnight, Italians freely use the 24-hour reckoning in everyday conversation. English-speakers do not arrange to meet for lunch 'at 13 hours' instead of 'one o'clock', meaning 1 p.m., but '*alle tredici*' is not in the least pretentious in Italian.

A variant on these 'Italian hours' characteristic of Majorca was a 24-hour sequence counted from dawn; these are known as 'Babylonian hours', from a false opinion in ancient authors that the Babylonian day began at sunrise. In fact, it began at sunset; night and artificial day were each divided into three 'watches', each in turn divided into four 'parts' or seasonal hours (see Figure 2); but the natural day was divided either (as we shall see) into 60ths, or into 12 *kaspu*, one for each sign of the zodiac, occasionally called *hôrai* in Greek, but commonly now known from a Eurocentric point of view as 'double hours'.

Double hours were adopted by the Chinese in 102 BC, displacing a previous division into 10 parts. The decree establishing the French

2. Babylonian ivory with calculation of length of hours

revolutionary calendar also envisaged a decimal division of the day into 10 hours, each of 100 minutes, themselves each of 100 seconds, to take effect on 1 vendémiaire year III (22 September 1794). Although the scheme would prove impractical, 10-hour clockfaces were made (see Figure 3).

Smaller divisions

The arithmetic of ancient Babylon was based on the number 60; accordingly, astronomers (despite the existence of double hours) divided the natural day into 60 parts, these parts in turn into 60ths, and so on. The length of the synodic month, for instance, was estimated at 29 days + 31/60 + 50/3600 + 8/216 000 + 20/12 960 000, which modern scholars write as 29;31,50,8,20 days.

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