THE CALENDAR

by

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EXPLANATION.

THE CALENDAR

A calendar is a method of combining days into periods adapted to the purposes of civil life and religious observances, or to the requirements of scientific precision, such as weeks, months and years. Three of the periods used in calendars, namely days, months and years, are based on those astronomical periods which have the greatest importance for the conditions of human life. Other measures of time, such as the week and the subdivisions of the day, are artificial.

The complexity of calendars is due mainly to the incommensurability of the astronomical periods on which they are based. The supply of light by the two great luminaries is governed by the periods known to astronomers as the solar day and the synodic month, while the return of the seasons depends on the tropical year. The length of the synodic month at the present time is 29·5305879 days, while that of the tropical year is 365·24219 days, each period being subject to an uncertainty of about one unit in the last figure given. Both periods are slowly decreasing, the synodic month or lunation by about three and a half units in the last figure every century, and the year by about one unit in the last figure every century. From the lengths of these two periods we find that the number of lunations in a tropical year is 12·3682668, decreasing by about two units in the last figure every century. The changes in the lengths of these periods are of little importance in the study of calendars.

Egyptian Calendar.—The Egyptian year from an extremely remote date consisted of 12 months of 30 days each, followed by 5 days called in Greek ἐπαγόμεναι or "added", making 365 days altogether. The 30-day period is obviously based on the lunation, so that the calendar must at some date have been governed by the Moon, while its primitive connection with the solar year is proved by its division into three seasons—Flood time, Seed time, Harvest time—each containing four months, which in hieroglyphics are always designated by their place in the season to which they were supposed to belong. But before the earliest times known to us, all attempt to equate the calendar month to the phases of the Moon or the calendar seasons to the natural seasons had been abandoned, and the beginning of the Egyptian year and of the calendar seasons gradually retrograded, returning to its place in the tropical year in 1505 tropical or 1506 Egyptian years. The Egyptians, however, used to check the relation of the calendar to the natural year, not by the solstices and equinoxes, but by the heliacal rising of Sirius, which, according to Herr Schoch's determination,* returned in the latitude of Memphis at a mean interval of 365·2507 days. The Egyptians, taking the length of the natural year as 365·25 days, formed a cycle of 1461 calendar years which they equated to 1460 natural years, and which was known by the name of the Sothic or dog-star cycle. In the absence of an accurate historical chronology and of a continuous record of years a cycle of this length had a purely theoretical importance.

The Egyptian calendar was, up to the time of Julius Cæsar's reform of the Roman calendar in 46 B.C., the only civil calendar in which the length of each month and of each year was fixed by rule, instead of being determined by the discretion of officials or by direct observation. If the number of years between two astronomical observations, dated by the Egyptian calendar, was known, the exact number of days could be determined by a simple calculation. No such comparison could be made between dates referred to any other civil calendar unless the computer had access to a record showing the number of days which had actually been assigned to each month and the number of months which had actually been assigned to each year. It is

* *Die Länge der Sothisperioden beträgt* 1456 *Jahre,* Selbstverlag, Berlin–Steglitz, 1928.

true that the Egyptians did not use a continuous era, but were content to number the years of each reign separately, so that there was a difficulty in identifying a particular year, but the astronomers of the Ptolemaic age rectified this by the introduction of eras. The simplicity and regularity of the Egyptian calendar commended it to astronomers, who found it excellently adapted to the construction of tables, which could be readily applied and which could be used even for a remote past or for a distant future without any fear that the system by which time was reckoned in the tables might not coincide with the system in actual use. In the second century B.C. we find Chaldæan observations, sometimes nearly six centuries old, reduced to the Egyptian calendar in the works of Hipparchus, who observed not in Egypt but at Rhodes, and cited from him by the Egyptian Ptolemy in the second century of our era, and we also find in the second century B.C. an Athenian observation of 432 B.C. reduced to the Egyptian calendar on an inscription found at Miletus, which appears to represent the work of the astronomer Epigenes.

Each Egyptian month had its proper festival. These festivals were finally fixed about 1200 B.C., and in Aramaic and Greek texts from the fifth century B.C. onwards the Egyptian months bear names based on the monthly festivals.

An attempt by Ptolemy Euergetes in 238 B.C. to introduce a sixth ἐπαγομένη once in four years failed, but a renewed attempt under Augustus (26–23 B.C.) was more successful. An additional day was inserted at the close of the Egyptian year 23–22 B.C. on August 29 of what we call the Julian calendar, and at the close of every fourth year afterwards, so that the reformed or Alexandrine year began on August 30 of the Julian calendar in the year preceding a Julian leap year and on August 29 in all other years. The effect of this reform was to keep each Egyptian month fixed to the place in the natural year which it happened to occupy under the old calendar in the years 26–22 B.C. But the old calendar was not easily suppressed, and we find the two used side by side till A.D. 238 at least. The old calendar was probably the more popular, and was preferred by astronomers and astrologers. Ptolemy always used it, except in his treatise on annual phenomena, for which the new calendar was obviously more convenient. Theon in the fourth century A.D., though mentioning the old calendar, habitually used the new.

The old Egyptian calendar survives in a slightly modified form in the Armenian calendar, the three first months of the old Egyptian year corresponding exactly with the three last months of the Armenian year. These are followed in the Armenian calendar by the five additional days, so that for the remainder of the year the Armenian months begin five days later than those of the old Egyptian calendar. The Alexandrine calendar is still in use in Abyssinia and in the Coptic church.

Babylonian Calendar.—The main principles of the Babylonian calendar became fixed in the latter half of the third millennium before Christ. The year began in the spring with the month *Nisannu*. It contained ordinarily twelve months, the beginnings of which were fixed by observation of the lunar crescent. In this calendar, as in all lunar calendars except the Mohammedan, one of the months was repeated when necessary, in order to keep each month fixed to a definite season in the year. At Babylon the month so repeated was most commonly the last month *Addaru*, but not infrequently the sixth month *Ululu*, and very occasionally some other month. The intercalary month was inserted at very irregular intervals, the known intervals between one intercalation and the next varying from six months to six years. It would appear that from the accession of Nabonassar in 747 B.C. a record was kept of the observations in each month and of the number of days that were assigned to each month. This made it possible to define the exact interval between observations and provided the means for a precise determination of astronomical periods, especially those which affected the times and magnitudes of lunar eclipses. The oldest precise determination of which we have any knowledge was the eclipse period or *saros* in which 223 lunations were taken as equal to 6585⅓ days. The correct astronomical length of 223 lunations was 6585·323 days, so that the error would amount to one day in about 1800 years. This period must have been known early in the sixth century B.C. The saros is independent of the length of the tropical year, but Geminus and Ptolemy state that the motion of the Sun in longitude in the saros period was taken as equal to 18 revolutions plus $10\frac{2}{3}°$. The correct time for the Sun's longitude to increase by this amount was 6585·19 days, so that the assumed length of the natural year involved an error of about 0·14 day in 18 years.

From 529 to 504 B.C. an octaeteris or 8-year cycle was in use at Babylon. In this the length of each month was still determined by observation of the crescent, but the intercalary months occupied fixed places in the cycle and each cycle of 8 years was made to contain 99 months. The effect of this was to make the mean length of eight years amount to 2923·53 days as compared with a correct duration of 2921·94 days and the received value of 2922 days. It is not surprising that this cycle was soon laid aside and arbitrary intercalation resumed. If we may accept Schnabel's dates* for Naburianos and Cidenas there was a steady improvement in the determination of astronomical constants in the next age. Naburianos about 500 B.C. found for the synodic month a length of 29·530614 days as compared with the correct value of 29·530596 days, and for the year 365·2609 days as compared with the correct value of 365·2425 days for the tropical year. But since the length of the year was derived from the inequalities which it produced in the length of the month, it would be more correct to compare it with the anomalistic year which had a duration of 365·2598 days. Cidenas about 383 B.C. determined the length of the synodic month as 29·530594 days. He also determined the length of the tropical year as 365·236 days. In 383 B.C. a 19-year cycle of intercalations was introduced at Babylon, which continued in use as long as a Babylonian calendar can be traced. This provided for 7 intercalary months occupying fixed places in each cycle of 19 years, so that 19 years were equated to 235 lunations. The beginning of each month continued to be determined by observation of the lunar crescent. An astronomical 19-year cycle had, as will be seen, been published by Meton at Athens in 432 B.C. The effect of the Babylonian 19-year cycle is to make the mean year consist of 12·36842 lunations, and to make the mean calendar year consist of 365·2468 days, an excess of 0^{d}·0043 over the correct value.† Cidenas' value for the mean synodic month is retained in the modern Jewish calendar, as is the system of seven intercalations in 19 years, so that the Jewish calendar continues to imply a length of 365·2468 days for the year.

Greek Calendars.—All Greek calendars were lunar until the Roman period. Each community had a separate calendar. Bischoff has succeeded in putting together more or less complete lists of months in about a hundred Greek calendars.‡ There was great variety in the season when the year began in different calendars. But each month was kept roughly to one season of the year by the insertion of a thirteenth or intercalary month when required. In some calendars this was done by repeating the sixth month, in some by repeating the twelfth month; but in a few the intercalary month occupied other positions, and at Athens there are four instances preserved on inscriptions where an intercalation was made at an exceptional place in the year, and it is probable that the same happened elsewhere from time to time. Not only the intercalation of months, but also the regulation of the length of each month, appears to have been always in the hands of the public authorities, and if, as time advanced, they paid increasing respect to astronomical calendars, there is no evidence that any astronomical calendar ever acquired legal validity. The beginning of the Attic civil year is known to have fluctuated by 50 days as compared with the natural year during the Peloponnesian war.§ We have less definite information as to the extent to which the beginning of the civil month was permitted to depart from the New Moon, but Aristophanes in *The Clouds*, acted in 423 B.C., makes the Moon complain that the days are not being kept correctly according to the Moon.

* *Zeitschrift für Assyriologie.* N.F., Band II (XXXVI) (1926), pp. 11, 16.

† For the Babylonian astronomical constants see Schnabel, *ubi supra*, and Fotheringham, *The Observatory*, LI (1928 October), pp. 301–315.

‡ Pauly-Wissowa, Real-Encyclopädie, X (1919) 1567–1602.

§ See Meritt, *The Athenian Calendar* (Harvard University Press, 1928).

During the fifth century B.C. the Athenians had a senatorial or financial year, which was independent of the ordinary civil year and of the Moon. The council of 500 was divided into ten boards or prytanies, each of which functioned for the tenth part of the senatorial year. Meritt has shown that this year was a solar year of approximately 365¼ days, beginning about July 9 of the Julian calendar, though the actual length could be varied at the discretion of the competent authorities. Inscriptions dealing with public accounts regularly date by the days of the different prytanies, though the year consisting of lunar months regulated the admission of magistrates, the celebration of festivals, and the proceedings of courts and assemblies. The financial year was, however, accommodated to the lunar calendar in or about 403 B.C.

The Macedonian calendar, which was of the Greek type, became current in western Asia as a result of Alexander's conquests, and even competed with the native calendar in Egypt. But in the Roman period the Greek calendars of Asia became purely solar calendars.

From the sixth century B.C. onwards the Greek astronomers, beginning with Cleostratus of Tenedos, framed a number of cycles, in which each month and year were given exact lengths dependent on their places in the cycle, and the attempt was made, so far as could be done without making the cycle too cumbrous, to maintain both for the mean month and for the mean year their correct astronomical values. It was an easy matter to compute the interval from one date to another in a calendar regulated by cycle, which was independent of the discretion of city governments. The original intention may have been merely to facilitate the determination of the age of the Moon and the season of the year, but the Metonic and Callippic cycles at least came to be used for dating astronomical observations.

The cycle invented by Cleostratus was an *octaeteris* or 8-year cycle and it probably dates from the time when an 8-year cycle was in use at Babylon. It made 8 years equal to 99 lunations and to 2922 days. As 99 lunations contain 2923·53 days, this form of the octaeteris would, if persisted in, have led rapidly to a large error in the tabular date of New Moon. Geminus records successive improvements in this calendar without mentioning their dates. The first was to add 3 days every 16 years, thus making 16 years equal to 198 lunations and to 5847 days. As 16 years should be 5843·88 days and 198 lunations should be 5847·06 days, the increased accuracy in the month was purchased at the expense of a large error in the year. Finally, we are told that a month of 30 days was omitted once every 160 years, so that 160 years were made equal to 1979 lunations and to 58440 days. As the correct length of 160 years was 58438·8 days and of 1979 lunations 58441·0 days, the error in each was only about one day in 160 years.

It was probably long before the octaeteris had reached its final form that the Athenian astronomer Meton published his 19-year cycle, which began on June 27, 432 B.C., this being according to Meton the day of the summer solstice and the 13th day of the lunar month Scirophorion. The months in this calendar had the same names as the Attic months, and the intercalation was made as in the Attic calendar by repeating the sixth month, Poseideon. But the length of each year and month was made dependent on its place in the cycle, which also governed intercalation. In this cycle 19 years were made equal to 235 months and to 6940 days. The correct length of 235 months was 6939·69 days, and of 19 tropical years 6939·61 days, but Meton may have been aware of Naburianos' value for the year, which made 19 years equal to 6939·95 days.

An attempt to improve on this calendar was made by Callippus, who gave to the year its generally received value of 365·25 days, and combined four 19-year periods to form a period of 76 years, which he made one day shorter than four Metonic periods, so that it consisted of 27759 days, which he equated to 940 lunations. This made 19 years equal to 235 lunations and to 6939·75 days, a great improvement on Meton in respect both of the synodic month and of the tropical year. Callippus' first cycle was made to begin in 330 B.C., when the summer solstice and New Moon coincided. It appears to have been used by astronomers as a means of dating for two centuries.

The last of the Greek astronomical cycles was that devised by Hipparchus, who proposed to omit one day from every fourth Callippic cycle, thus making a cycle of 304 years equal to 3760 lunations and to 111035 days. This would give a length of 29·530585 days to the lunar month and of 365·24671 days to the year. The former approximates very closely to Cidenas' value, which Hipparchus had adopted; the latter is almost identical with the value assumed by the 19-year cycle in use at Babylon in Hipparchus' time and is still nearer to the value 365·24667, which he himself deduced from observations. Neither Hipparchus himself nor anyone else appears to have made use of this cycle.

The lunar calendar was not suitable for determining the proper season for agricultural operations. In order to know the exact time of the year the Greek farmer used to observe the annual risings and settings of certain of the fixed stars, and to note the solstices and the comings of birds. Hesiod gives some information in his *Works and Days* on this subject. In the fifth century B.C. parapegmata showing the annual dates of the principal risings and settings and the weather that might be expected to follow them began to be constructed, and the published calendars of Meton and Euctemon included these. Fragments of Milesian parapegmata of the second century B.C. are preserved. They are arranged according to the solar year, with a hole against each day and instructions, sadly mutilated, for showing the lunar month and day by means of movable pegs.

Roman Calendar.—The Roman calendar, which is now used throughout the whole world, had its origin in the local calendar of the city of Rome. It is generally stated by our ancient authorities that the year of Romulus consisted of 304 days divided into 10 months beginning with March, and that Numa introduced a lunar year and added January and February. It may be regarded as certain that the Roman months were originally lunar, and throughout the republican period the normal length of the year remained 355 days, exceeding 12 lunations by 0·63 days. This small excess could have been compensated by making the intercalary month consist sometimes of 27 and sometimes of 28 days. Such a month was in fact inserted, when it was considered necessary, after February 23. But in historical times at least the five last days of February were not repeated after the close of the intercalary month. As the days at Rome were generally enumerated in reference to the next following Kalends (1st of month), Nones (5th or 7th of month), or Ides (13th or 15th of month), it is a purely academic question whether the five days preceding the Kalends of March were part of February or part of the intercalary month. Both views can be supported from classical texts. At all events the failure to repeat these five days necessitated a departure of the calendar from the Moon. We do not know when this took place, but, if the eclipse of Ennius is correctly dated in the 350th year of the city, then we have an eclipse of the Sun on June 5 of the Roman calendar as far back as 400 B.C., and we may infer that the calendar had by that date worked free from the Moon. In historical times the months of March, May, Quintilis (July) and October contained 31 days each, the months April, June, Sextilis (August), September, November, December and January 29 days each, while February contained 28 days. In March, May, Quintilis and October the Nones were on the 7th day and the Ides on the 15th; in the other months the Nones were on the 5th day and the Ides on the 13th. The intercalary month was generally inserted in alternate years, but the actual regulation of intercalation was in the hands of the pontifices.

Under the pontificate of Julius Cæsar, who became Pontifex Maximus in 63 B.C., intercalation was neglected with such frequency that the Kalends of January, which had fallen on or about December 13 of the subsequent Julian calendar at the close of 64 B.C., fell on October 13 of that calendar at the close of 47 B.C. In order to restore the months to their normal position in the natural year, Cæsar not only gave the year corresponding to 46 B.C. the usual intercalation of 23 days after February 23, but inserted two additional intercalary months, amounting together to 67 days, between November and December, so that the Kalends of 45 B.C. fell on what is still called January 1 of the Julian Calendar. From that time each month has had its present duration, the sixth day before the Kalends of March being repeated when necessary. The intercalary day came to be called *ante diem bis sextum Kalendas Martias*, or more briefly *bissextum*, whence our word bissextile for leap year.

The revised calendar, in framing which Cæsar had the assistance of the astronomer Sosigenes of Alexandria, adopted for the mean year the value current in Egypt, 365·25 days, three years out of four being given 365 days, and the fourth 366 days. As the calendar year was purely solar, the annual astronomical phenomena were expected to return annually on the same dates, and an almanac showing these dates was published with the new calendar. This rendered unnecessary the observation of these phenomena by farmers, who were now able to orientate themselves in the natural year by means of the new calendar.

Cæsar's edict requiring the intercalary day to be inserted every fourth year was misunderstood by the pontifices, who reckoned the four years inclusively and intercalated at intervals of three years. In consequence the year 8 B.C. began three days too late. Augustus rectified this error by omitting all intercalations till A.D. 8, from which date the Julian calendar was observed strictly till the reform of Pope Gregory XIII in A.D. 1582. As the first year of the new calendar (45 B.C.) was a bissextile or leap year, it follows that years of the Christian era divisible by four are leap years. The name Quintilis was changed to July (Julius) in 44 B.C. in honour of Julius Cæsar and the name Sextilis was changed to August (Augustus) in 8 B.C. in honour of Augustus Cæsar. Later attempts to change the names of months were unsuccessful.

The position of the Roman intercalary month agrees with the ancient tradition that March was originally regarded as the first month of the year. The years were commonly designated by the names of the consuls, so that the designation changed on the day when the new consuls along with the other curule magistrates entered office. After considerable fluctuation the date of entering office was fixed as March 15 about 222 B.C., but was transferred to January 1 in 153 B.C., and was never afterwards changed. In this way January became the first month of the official year. In the eastern provinces under the empire the years were often reckoned from the accession of the reigning emperor, his second year being made to begin on the first new year's day after his accession. The day which served as new year's day for this purpose varied from district to district. The January new year was in fact confined to western Europe.

Indictions.—The Cycle of the Indiction, a non-astronomical cycle of 15 years, is first mentioned in receipts for taxes collected in Egypt in A.D. 303 in respect of profits or produce of the fifth indiction (A.D. 301–302). It probably takes its origin in a provincial census for taxation following Diocletian's reconquest of Egypt in 297, a new census being taken every fifteen years. Each year in this cycle was regarded as a separate indiction. The earliest indictions appear to be reckoned from the Alexandrine new year, which fell generally on August 29, but, so long as it was strictly a financial year, the date from which the indiction was reckoned was frequently shifted according to the exigencies of public policy. The use of this cycle spread afterwards to other countries, where it was adopted as a means of designating years without special reference to public finance. There are various forms of the cycle, differing as to the day of their commencement. The Greek or Constantinopolitan indiction changed on September 1. The Roman indiction, which changes on December 25 or January 1, does not appear to be older than the 11th century.

The rule for finding the indiction corresponding to any year of the Christian era is: add 3 to the year and divide the sum by 15: the remainder (or 15 if exactly divisible) is the Roman indiction or the Greek indiction up to the day of change; if the indiction beginning in any year is required, 4 instead of 3 must be added.

Jewish Calendar.—The ancient Jewish calendar was of the normal lunar type with twelve months, each of which began with the first visibility of the crescent Moon. Intercalation was performed when necessary by repeating the twelfth month, which in post-exilic times was known as Adar. The responsibility for intercalation rested with the public authorities, and in the early centuries of the Christian era was vested in the Sanhedrin, regard being had to the progress of crops and stock with a view to the proper celebration of the Passover, which fell in the first month. The months are most commonly designated in the Old Testament and Apocrypha by their numerical order, which is always counted from the spring month of Abib or Nisan. Originally the months had the same names as are found on Phœnician inscriptions, but in post-exilic times these were replaced by the Babylonian names. There are, however, references in the Hebrew Scriptures to the end of the year which would imply an autumn new year. This would be the agricultural year beginning with the autumn ploughing and ending with the vintage. In the book of Nehemiah regnal years are reckoned from the autumn month of Tishri, though everywhere else in the Old Testament they are reckoned from Abib or Nisan. Both beginnings of the year seem to be found in the Apocrypha, although as has been seen the months are always numbered from Nisan. In the last centuries before the Christian era the autumn new year was well established in Syria, and the reckoning of the year from Tishri is probably due to Syrian influence.

The papyri belonging to the Jewish colony at Elephantine in Southern Egypt in the fifth century B.C. show that at that place the beginning of the month was reckoned from the first evening when mean sunset or 6 p.m. followed mean new moon, so that we have a calendar determined by astronomical calculation, not by astronomical observation. There is, however, no reason to suppose that the Elephantine custom extended to Palestine. At Elephantine as in Palestine intercalation appears to have been irregular. The regnal years are reckoned from Nisan although the papyri are contemporary with Nehemiah who reckons such years from Tishri.

This empirical calendar has been superseded by one based on fixed rules, in which nothing is left to observation or discretion. The date when the modern calendar was designed is unknown, but it is commonly assigned to the fourth century of our era. This calendar is based on a rigorous determination of the mean new moon of Tishri, in which Cidenas' value for the mean lunation is used. Intercalation is governed by a 19-year cycle, and so the mean duration of the calendar year is the same as that which was adopted at Babylon in 383 B.C. The actual beginning of the calendar Tishri is obtained from the mean new moon by complicated rules which are designed to prevent certain solemn days from falling on inconvenient days of the week. The effect of these rules is that a common year may contain 353, 354 or 355 days, and an embolismic or leap year 383, 384 or 385 days. Ten of the months have fixed durations, the other two varying according to the requisite length of the year. The intercalary month always contains 30 days. It is placed next before the month Adar whose name and place it usurps. Adar itself becomes the second Adar or Veadar, and retains its normal length of 29 days.

The Jews now employ an era of the creation, whose epoch is taken as October 7, 3761 B.C.

The Week.—At Babylon the king appears to have avoided the performance of acts of state on the 7th and 14th days of each month, and particularly on the 19th day, which may have been regarded as the seven times seventh day of the previous month. The Mosaic law enjoined a general abstinence from work on each seventh day, which was called the Sabbath. It has been suggested that the Hebrew periods of seven days may have been reckoned originally from the beginning of each month, but this is only surmise. When we come upon clear evidence, the period of seven days was reckoned independently of the month and in fact of all astronomical periods. From the Jewish church it has passed into the Christian, in which special veneration is paid to the first day of the week, or Lord's Day (κυριακή, Dominica, dimanche).

Quite independently of the Jews there arose not long before the Christian era a group of astrological periods of seven hours, seven days, seven months and seven years. According to Cassius Dio the astrological period of seven days was of Egyptian origin, and as it was based on the Egyptian practice of dividing the day and night separately into twelve hours, there is every reason to believe that his statement is correct. The seven planets including the Sun and Moon were arranged in the order of their supposed distance from the Earth, according to the theory which was current in Hellenistic Egypt:—Saturn, Jupiter, Mars, Sun, Venus, Mercury, Moon. Each of these in turn was supposed to control one hour, and the planet which controlled the first hour of the day, month or year was regarded as the regent of that day, month or year. A day of 24 hours, therefore, included three periods of seven hours and three hours of a fourth period, and the regent of each day would be removed by three places in the order of the planets from the regent of the preceding day. There was thus obtained the following series of regents of the days:—Saturn, Sun, Moon, Mars, Mercury, Jupiter, Venus. These planetary days acquired a rapid and world wide popularity, while the planetary hours, months and years interested none but astrologers. The first reference to a planetary day is in a poem by Tibullus written between 30 and 26 B.C. Although the planetary week began originally with the day of Saturn, the day of the Sun soon came to be more commonly regarded as the first of the week, partly, no doubt, because it coincided with the first day of the Jewish week. But the planetary hours continued to be enumerated from the hour of Saturn. Although there has been universal agreement in the attribution of individual days to individual planets, there has been no such agreement in the attribution of nights and hours. In the Teutonic languages the names Tiu, Woden, Thor and Freya of the Teutonic divinities with whom Mars, Mercury, Jupiter and Venus were respectively identified have taken the place of their Roman counterparts. But, while the planetary names for the days of the week have established themselves throughout western Europe, they are not in use among oriental Christians.

Ecclesiastical Calendar.—The Christian church has continued the Jewish festival of Passover, which as a Christian festival has received in our language the name of Easter. In Greek and Latin the identity was maintained by the use of the same name Pascha. According to Christian teaching the sacrifice of the Passover, which had been celebrated on Nisan 14, was fulfilled in the sacrifice of Christ. According to the Mosaic law the sacrifice of the Passover on Nisan 14 had been followed by a feast of seven days lasting till Nisan 21. The Christian churches in Asia Minor largely retained the Mosaic rule and celebrated Easter on the Jewish Nisan 14 without regard to the day of the week. With a few unimportant exceptions the rest of Christendom celebrated Easter on a Sunday, selected so as to fall within the passover week. It is found that when the customs hardened, the Church of Rome observed the Sunday which was believed to fall not earlier than the 16th nor later than the 22nd day of the Moon, that of Alexandria the Sunday which was believed to fall not earlier than the 15th nor later than the 21st day of the Moon, while the British churches observed the Sunday which was believed to fall not earlier than the 14th nor later than the 20th day of the Moon. There was heated controversy between the churches of Rome and of Asia Minor on this subject in the second century. In the third century Christian churches, refusing to accept the authority of the Jewish councils to decide which month was to be regarded as Nisan or on which day it was to begin, began to construct tables of their own for computing the 14th day of the Easter month and the date of Easter. Two cycles, dating from the latter part of the third century, obtained a wide currency, the Roman cycle of 84 years and the Alexandrine of 19 years.

The Alexandrine cycle was simplicity itself. March 21 of the Julian calendar was regarded as the date of the vernal equinox, and all Alexandrine, and therefore all Julian years, were treated as of equal duration. The cycle was made to begin in the year which placed a new moon on the Alexandrine new year's day, August 29–30, and which, in consequence, gave April 5 as the date of the 14th day of the Easter moon. This 14th day was placed 11 days earlier in each year than in the preceding year when this could be done consistently with its not falling before March 21. Where this was impossible, it was placed 19 days later than in the preceding year. Finally, in passing from the 19th to the 1st year of the cycle, an interval of 12 days instead of 11 was allowed, so as to bring the 14th day in the 1st year of the next cycle back to April 5. Easter day was the first Sunday after the 14th day of the Easter moon. This calendar assumed the same mean length of the year and the lunar month as the Callippic cycle and was therefore subject to the same errors. Its authors can hardly have expected it to remain uncorrected for many cycles. As a cycle it was subject to the inconvenience that it took 532 years for the whole series of Easter dates to recur.

The Roman cycle of 84 years was made to begin in a year in which a new moon fell on the Roman new year's day, January 1, and also on the Sabbath (Saturday). It made 84 tropical years equal to 1039 lunations and to 30681 days. The correct length of 84 tropical years was 30680·36 days, and of 1039 lunations 30682·29 days, so that the equinox fell 0·64 days earlier as compared with the assumed date every 84 years, and the new moons 1·29 days later as compared with the assumed dates in the same interval. The error in the length of the year was the same as in the Alexandrine cycle, but the error in the length of the lunation was nearly five times as great as in the Alexandrine cycle and was in the opposite direction. A further difference arose from the facts that the Roman rule treated the 16th, while the Alexandrine treated the 15th day of the moon as the earliest date for Easter, that the Roman rule accepted a 14th day of the month even if it fell before the equinox, so long as the resultant Easter fell after the equinox, and that the Roman rule regarded April 21 as the latest date for Easter, while the Alexandrine rule permitted it to fall as late as April 25. During the fourth and the first half of the fifth centuries differences between the two calendars were often, but not always, settled as they arose by agreement between the Roman pope and the patriarch of Alexandria, but long before the end of the fourth century the concessions had come to be all on the Roman side.

In 325 the General Council of Nice dealt with the date of Easter. Its decision is expressed in its epistle to the Church of Alexandria :—" We also send you the good news concerning the unanimous consent of all in reference to the celebration of the most solemn feast of Easter, for this difference also has been made up by the assistance of your prayers, so that all the brethren in the East, who formerly celebrated this festival at the same time as the Jews, will in future conform to the Romans and to us and to all who have from of old kept Easter with us."

A cycle of 532 years based on the 19-year cycle was composed by Victorius in A.D. 457 at the request of the Pope. It agreed with the Alexandrine cycle in the mean lengths of the year and month, but there were minor differences, which from time to time gave different dates for Easter. The papal Curia did not hold itself bound to any of the three cycles, and local usage varied. Easter was last celebrated at Rome according to the 84-year cycle against both the Alexandrine and the Victorian cycles in A.D. 501.

The Alexandrine cycle found a capable exponent at Rome in the person of Dionysius Exiguus, about A.D. 530. He constructed an Easter table extending from A.D. 532 to A.D. 626, in which he introduced for the first time the years of the Christian era, which was adopted from him by Bede and from Bede by western Christendom generally. The only part of the furniture of a late mediæval Easter table which was not used by Dionysius was the solar cycle, which would appear to have been first used by Maximus Confessor in Africa in A.D. 641.

The British and Irish churches continued to use the 84-year cycle in a form which permitted Easter to fall as early as the 14th day of the moon and which used

March 25 as the earliest possible date of Easter. But at the Synod of Whitby in A.D. 664 King Oswy of Northumbria under the influence of Wilfrid decided to adopt the Dionysiac system. The decision was accepted by the other English communities, and Bede, the Northumbrian church father, was brought up to the use of the Dionysiac system. His *De temporum ratione*, written in 725, included not merely an exposition, but an Easter table for the 532 years from A.D. 532 to 1063, and rapidly became the standard treatise on the subject. Before the end of the eighth century the 84-year cycle had been abandoned by the last of the British churches, and even in France the Victorian cycle had given way to the Alexandrine.

Gregorian Calendar.—As the centuries advanced, the gradual shifting of the calendar dates of the seasons did not escape attention. In fact in 11,000 years or so January would have ceased to be a winter month. Dante* refers to this as follows :—

> Ma prima che gennaio tutto si sverni,
> per la centesma ch'è laggiù negletta ;
>
> " But, ere that January be all unwintered by that hundredth part neglected upon earth."

The hundredth part is here the difference between the mean calendar year of 365·25 days and a supposed tropical year of 365·24 days.

The defect of the calendar in the sixteenth century showed itself mainly in its effect on the date of Easter, since the tables in use placed both the vernal equinox and the Easter full moon, or more exactly the 14th day of the Easter moon, later than their true dates. Accordingly in 1582 Pope Gregory XIII published a bull instituting a revised calendar. He considered it desirable to restore the vernal equinox to the position assigned to it in the Easter tables, namely March 21, and accordingly ordained that the day after 1582 October 4 should be called October 15. In future the intercalary day, which in the Julian calendar was inserted once every four years, was to be dropped in those centurial years that were not divisible by 400. Thus 1600 and 2000 were to be leap years, but not 1700, 1800, 1900. The effect of this was to make the mean length of the year 365·2425 days, a duration which was approximately correct for the time of Julius Cæsar, but which is slightly in excess of the present length of the year. The reform has the merit of treating the simple Julian system as correct for one or two centuries at a time and making corrections in centurial years only. The same simplicity marked the new treatment of the lunar month. The dates of the Easter full moons were put back three days, or advanced seven days if we include the reduction to the Gregorian year. If this involved placing the 14th day of the Easter moon later than April 19, the full moon of the previous lunation was accepted, so that the date of the Easter moon was put back 23 days in the calendar. If the shift involved placing the 14th day of the moon on April 19 it was placed on April 18 instead.

A similar shift was to be made in centurial years, if required. There was to be a forward shift of one day in every centurial year which was not a leap year, and a backward shift of one day in 8 out of every 25 centurial years. This backward shift was to be made for the first time in 1800, then at seven intervals of 300 years and one of 400 years, and so on. If a backward and forward shift were due in the same centurial year the dates of the full moons were to be the same in each year of the 19-year cycle as in the preceding century. The calendar was to be worked as if the dates of full moon for each year of the cycle were to range from March 21 to April 19 inclusive, except that all full moons which should have fallen on April 19 were to be put back to April 18, and, whenever this was done, a full moon which was due for April 18 in another year of the cycle was to be put back to April 17. The object of this exception was to retain April 18 as the last possible date for the Easter full moon.

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* *Paradiso*, XXVII, 142, 143.

But transferences of full moon dates under this exception do not affect the subsequent dates of full moon for the particular place in the 19-year cycle. Thus the full moon of the 14th year of the cycle which in the unreformed calendar had stood on April 12 was placed on April 18 after the reform and not on April 19, but the forward shift of one day in 1700 brought it to March 21 as if it had been on April 19. Similarly the full moon of the 6th year was shifted in 1700 from April 17 to April 18, but in 1900 it remained at April 18 instead of being shifted to April 19. The result of this was that the full moon of the 17th year which should have been shifted to April 18 in 1900 remained at April 17. Its next forward shift will be to April 18, taking the place of April 19, and then to March 21. The effect of this exception is that every full moon date gets two turns either on April 17 or on April 18, so that although the total range of full moon dates is only 29 days inclusive, it takes 30 forward shifts to bring the full moons back to their former positions.

Altogether 5,700,000 Gregorian years are made equal to 70,499,183 lunations and to 2,081,882,250 days, so that the mean length of the lunation is taken as 29·5305869 days, a value which is in error by the millionth part of a day at the present moment, but will be correct in the course of 300 years. Since 400 Gregorian years contain 146,097 days or 20,871 weeks, the days of the week recur on the same days of the year every 400 years, and there should therefore be a recurrence not only of Easter full moons, but also of Easter Sundays, after the lapse of a complete cycle of 5,700,000 years.

This calendar combines the merits of extreme accuracy in its mean values with extreme simplicity in its application, since for a period varying from one to three complete centuries it is able to determine the date of full moon as if all calendar years were of equal duration and as if the 19-year cycle were exactly applicable, so that a table as simple as that used for the unreformed calendar will hold good for that length of time. The calendar is independent of differences of meridian. It makes the moon full on one particular day for the whole world without specifying any particular moment. The astronomical Full Moon takes place at a particular moment, which will fall on different calendar days according to the meridian selected, being more often than not on a different calendar day in Australia and in Canada. The time of astronomical Full Moon is also affected by inequalities in the motion of the Sun and Moon. The calendar full moon is not affected by these inequalities, just as the time used in civil life is not affected by inequalities in the length of the day. It follows, therefore, that the simple tables of the Prayer Book and the elaborate tables used in H.M. NAUTICAL ALMANAC Office must occasionally differ in their final results.

The Gregorian calendar was adopted in Italy, France, Spain, Portugal and Poland in 1582, by most of the German Roman Catholic states and by Holland and Flanders in 1583, and by Hungary in 1587. The adoption in Switzerland was gradual; it began in 1584 and was completed in 1812. The German and Dutch Protestant states generally, along with Denmark, adopted it in 1700, the British dominions in 1752, Sweden in 1753, Japan in 1873, China in 1912, Bulgaria in 1915, Turkey and Soviet Russia in 1917, Yugoslavia and Romania in 1919, and Greece in 1923. The rules for Easter have not, however, been adopted by those oriental churches which are not subject to the papacy, although the Orthodox Greek Church has so far abandoned the older rules as to permit the date to be settled temporarily by direct ecclesiastical authority.

The German Protestants, in adopting the Gregorian calendar, did not adopt the Gregorian rules for the computation of Easter, but enacted that both the date of the equinox and the date of the Easter full moon should be determined astronomically with the Rudolfine tables and the meridian of Uranienborg (in the island of Hveen between Denmark and Sweden). This astronomically determined Easter was used by the German Protestants from 1700 to 1776 and by the Swedes from 1740 to 1844.

In the British dominions the change of calendar was effected by giving the name September 14 to the day after September 2 in 1752. The difference between the

Julian and Gregorian calendars, which was 10 days in 1582, is now 13 days, but the Alexandrine and Gregorian Easters may be as much as 5 weeks apart.

It is provided by the Easter Act, 1928, that " Easter-day shall, in the calendar year next but one after the commencement of this Act and in all subsequent years, be the first Sunday after the second Saturday in April." The Act is to commence and come into operation on a date to be fixed by Order in Council, but no such Order in Council is to be made until a draft order has been approved by resolution by both Houses of Parliament " either without modification or with such modifications to which both Houses agree." Before making such draft order, regard is to be had to any opinion officially expressed by any Church or other Christian body. The Act is to extend to the United Kingdom, the Isle of Man, and the Channel Islands, and may be extended by Order in Council to any other part of His Majesty's dominions with the exception of the self-governing dominions and their dependencies. The effect of these provisions is to expedite procedure, but to postpone final decision on the change in the calendar.

Differences of Style.—The Christian era invented by Dionysius Exiguus and popularised by Bede has been adopted at different times and in different countries with different initial days for the year. The most common initial dates have been December 25, January 1, March 1 and March 25. These different reckonings of the year were known as *styles*. Thus in late mediæval Italy in the Venetian style the years of the Christian era began on March 1, in the Pisan style on the preceding March 25, and in the Florentine style on the following March 25, while at Rome different styles were used for different purposes. In England the Nativity style beginning on December 25 was superseded in the fourteenth century by the Annunciation style (commonly called old style) beginning on March 25, but the Circumcision style (or new style) beginning on January 1 was substituted in 1753 by the Act which introduced the Gregorian calendar. In Scotland the year had begun officially on January 1 since 1600. The names old style and new style have, however, come to be used specially to distinguish not the different dates for the beginning of the year, but the Julian and Gregorian calendars, each of which has been used with different initial dates.

In the classical languages the numerical designation of years is always by ordinal numbers, so that the Christian era begins with the beginning of the year 1 or of the first year. The year immediately preceding is the year 1 B.C. or the first year before Christ. The year before 1 is styled 0 by astronomers, and the preceding year is —1, corresponding to 2 B.C. in the usage of historians. Therefore in converting years B.C. into astronomical dates it is necessary to subtract 1 and to prefix the minus sign. In converting negative astronomical dates into years B.C. it is necessary to remove the minus sign and to add 1 to the number of the year.

Sunday Letter, Solar Cycle, Golden Number, Epact.—The Roman calendar makers were accustomed to place the letters A, B, C, D, E, F, G and H in rotation against the days of the year. At first these letters referred to the Roman market week of eight days. Then if the first market day in any year were known, as for instance January 5, the letter E standing against that day would indicate all the market days in the year. The next device was to use the same series ending with G to indicate the seven days of the planetary week, which coincides in practice, though not in origin, with the Christian week. The letter which stands against the Sundays in any year is known as the *Sunday Letter* or *Dominical Letter* of that year. Since no letter is placed against the intercalary day, it follows that in leap years the Sunday Letter retrogrades by one place at the date of the intercalation. Thus in 1932 C will be the Sunday Letter in January and February, and B from March onwards. As the ordinary year contains 52 weeks and 1 day, the Sunday Letter also retrogrades one place at the beginning of each year. The series of letters has always been made to begin on January 1 as in the pre-Christian Fasti, whatever day may have been adopted for the beginning of the civil year.

In the Julian calendar the days of the year recurred on the same days of the week in 7 × 4 years, thus giving rise to the so-called *Solar Cycle* of 28 years, which could be used for the purpose of finding the day of the week for any day in a known year. The years of this cycle are commonly shown in almanacs, but it has been very little used in practice. There is mention in the Talmud of a 28-year cycle, at the close of which the vernal equinox, supposed to recur at intervals of 365¼ days exactly, would return both to the same planetary hour and to the same day of the week. The beginning of each 28-year cycle is still observed by the Jews, but has ceased to have any calendarial or astronomical significance. As has been seen above the solar cycle for correlating the week with the Julian calendar appears to have been first used by Maximus Confessor in A.D. 641. Supposed older works which mention this cycle have probably been misdated.

The tables for finding Easter according to the Alexandrine calendar tabulated the days from March 21 to April 18 and placed against each day the number of the year in the 19-year cycle in which the Easter full moon would fall on that day. The numbers so tabulated have from the later middle ages been known as *Golden Numbers.* The same tables placed against each day its Sunday Letter. So that to find the date of Easter all that was required was to see against which day the Golden Number of the year stood and then to see which was the next day against which the Sunday Letter of the year stood. The day so found would be Easter Day. This method is retained in the English Prayer Book, but the positions of the Golden Numbers have to be changed in the centurial years whenever the date of the Easter full moon corresponding to a given year of the 19-year cycle is changed.

In the tables issued by authority of Pope Gregory XIII, Easter is found by means of *Epacts* instead of by Golden Numbers. The Epact is the age of the moon on some fixed day of the calendar year. In the Alexandrine Easter tables the age on the first day of the Alexandrine calendar (August 29–30) was shown. Dionysius Exiguus and Bede, writing for a western public, preferred to describe this as the moon's age on March 22. Tables adapted to the Roman cycle of 84 years showed the moon's age on the first day of the Roman year, January 1. So also do the tables adapted to the Gregorian calendar. If the moon's age on the first day of the year is known, then by counting months of 30 days and 29 days alternately, the approximate age of the moon is known for every day of the year. The epacts in the Easter calendars vary in the same manner as the Golden Numbers. The English Prayer Book shows the epact, but makes no use of it.

Julian Period.—The French Protestant scholar and chronologist Josephus Justus Scaliger invented the Julian Period as a practically continuous measure of time. It combines the Solar Cycle of 28 years, the Lunar Cycle of 19 years and the Cycle of the Indiction comprising 15 years, thus containing 28 × 19 × 15 = 7980 years altogether. All these cycles are supposed to begin on January 1 of the Julian calendar, and it is found that they began together in 4713 B.C., so that one Julian Period includes all dates both in the past and in the future to which reference is likely to be made, and to that extent has an advantage over an era whose epoch lies within the limits of historical time.

The years of the Julian period are seldom employed now, but the day of the Julian period is frequently used in astronomy and in calendarial tables. It is the only method of enumerating days which is free from their combination into months and years, and is therefore particularly useful where an exact interval in days is required. The Julian days are numbered consecutively from Greenwich mean noon on January 1 4713 B.C., at which date the Julian Day was 0·0.

Mohammedan Calendar.—The Mohammedans use the Era of the Hegira beginning with the year of Mohammed's flight or Hegira in A.D. 622. The peculiarity of the Mohammedan calendar is that each year consists of 12 lunar months without intercalation, so that each month goes the round of the seasons in 33 years. For religious purposes the beginning of each month is fixed by observation of the lunar crescent. For the purposes of civil life there has never been an exact rule, and different beginnings of the month have been used by different people living in the same town. It is, therefore, impossible to give an exact interpretation to a date expressed in this calendar unless the day of the week is given as well as the day of the month. This applies both to public and to private documents. For astronomical purposes a more exact rule is followed. The months have 30 days and 29 days alternately, except the 12th month, which has 29 days nineteen times and 30 days eleven times in a cycle of 30 Mohammedan years. In consequence the calendar makes 360 lunations equal to 10631 days. Their real duration is 10631·012 days. The error, therefore, amounts to no more than a day in 2500 years.