

SOLI-LUNAR CYCLES

IN

GREEK RESEARCH

AND

JEWISH REVELATION

by

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TABLE OF CONTENTS

	<u>Page</u>
Introduction	1 - 2
Physical Cycles	3 - 31
Definitions	3 - 4
Results of Greek Research	5 - 9
Tables of Cycles	10 - 31
1. Cycles of the Solar Year and the Lunar Year	11 - 12
2. Cycles of the Solar Year and the Lunar Month	13 - 23
3. Soli-Lunar-Anomalistic Cycles	24 - 26
4. Soli-Lunar-Nodical Cycles	27 - 29
5. Soli-Lunar-Anomalistic- Nodical Cycles	30
6. Solar Year Sidereal Month Cycles	31
Moral Cycles	32 - 88
The Seventy Weeks	32 - 44
The Setting of the Other Moral Cycles	45 - 53
Daniel 7	45 - 47
Daniel 8	48 - 49
Daniel 11 and 12	49
The Book of the Revelation	51 - 53
The Chronologic Prophecies	54 - 63
Introduction - The Development of the Year - Day Principle	54 - 56
The 1260 Years	57 - 58
The 2300 Years	59 - 60
The 150 Years	60
The 391 Years	61
The 2520 Years	61 - 63
Adjustment of the Physical Cycles to the Moral	64 - 72
M. DeCheseaux's Discoveries	64 - 65
Dr. Guinness' Discoveries	66
Dr. W. Bell Dawson's Discovery	67
Evaluating the Biblical Cycles	68 - 71
Guinness' Anticipations	72 - 88
Conclusion	88 - 91
Appendix A	92 - 95
Bibliography	96 - 98

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Those who are acquainted with the work of the Foundation for the Study of Cycles⁽¹⁾ or who have otherwise investigated the subject know that rhythmic fluctuations or cycles pervade not only inanimate nature but also many departments of human activity and thought.

The present treatise is concerned with discoveries which indicate that such cyclic relationships extend into the realms of the moral and the theological.

Physical and moral phenomena are, of course, in some ways quite distinct. Modern investigation has demonstrated that in many spheres the moral bears little or no causal relation to the physical. Injustice does not occasion an eclipse, nor envy an earthquake. Physical elevation not moral depravation attracts lightning. Physical phenomena occur in accordance with established and uniform physical principles. So, likewise, the physical is no criterion of the moral. Degrees of holiness and sin cannot be measured by a ruler. Size is no criterion of moral worth. It is only figuratively that a man's character can be weighed in the balances. Moral phenomena are governed by moral laws.

Nevertheless, the moral and the physical are not entirely

(1) A purely secular scientific organization "created to pursue and foster research into rhythmic fluctuations in all branches of natural and social phenomena" and numbering amongst its members some of the greatest scientists of Britain and America.

separate realms. They do exist together and, however we explain it, must bear some inter-relationship. Either the moral has arisen from the physical, as materialists say, or the underlying substance of things has both physical and moral potentialities, or both the physical and moral realms owe their existence to a Divine Author. That there is some inter-relationship no one will deny.

Further, it is evident that in time we have an element common to both realms.

There is a physical time order. "The sun knoweth his going down." The moon and the planets have their appointed seasons. Eclipses occur at fixed times. Ancient Greek research long ago brought to light the fundamental elements of these physical cycles.

But time is related also to the moral realm. The righteous are not always oppressed. "The time of the promise draws nigh." "The fulness of time comes." In this moral realm the sacred literature of the Jews is supreme. Here we find professed revelations of great moral cycles, times appointed for the duration of empires and kings and for the deliverance of the righteous.

Centuries of independent research in regard to these appointed times or cycles of the physical and moral realms have culminated in the discovery of certain curious relationships between them. These relationships constitute the burden of this thesis and, we humbly hope, may seem of sufficient significance to some to strengthen their faith in a theological interpretation of nature and history.

Physical Cycles

The real and apparent motions of sun, moon, and planets form the basis of nature's time order. The day, the lunar month, the year, and the planetary periods are the principal units. The matter is complicated, however, by the fact that each of these heavenly luminaries possesses more than one type of periodic motion. The moon, for example, has four main periodic elements all producing easily observable effects, and all known centuries before the time of Christ. Each planet has two principal periods.

The four lunar periods or months are the sidereal, the synodic, the anomalistic, and the nodical.

The sidereal month is simply one complete revolution of the moon about the earth or, in other words, the mean time taken for the moon to return to the same place in regard to the fixed stars.

The synodic month is the mean time taken for the moon to return to the same position in relation to the earth and the sun. And as the earth itself is in motion about the sun, this does not correspond to the sidereal month. The synodic month is the time from full moon to full moon or from new moon to new moon.

The anomalistic month is the time taken for the moon to return to the corresponding point on its elliptical orbit. And as the ellipse itself is in motion the anomalistic month is not the same in length as the sidereal. The anomalistic fluctuation is the principal cause of the considerable difference in length observable between individual synodic months. It also affects the nature of eclipses. When a full solar eclipse occurs with the moon at apogee the eclipse is total, but when a

full solar eclipse occurs with the moon at perigee the eclipse is annular.

The nodical month is fundamental to eclipses. The moon in its revolution about the earth does not revolve in the same plane that the earth does in its revolution about the sun, but in a plane at an angle to it. The nodical month is the time taken for the moon to return to the corresponding point in its plane. And as the plane is in motion neither does this period correspond to the sidereal month. It is obvious, further, that eclipses can occur only when the sun, earth, and moon are in a straight line. Two conditions are therefore necessary:

- (1) The moon must be full (for a lunar eclipse) or new (for a solar eclipse);
- (2) The moon must be at a node, i.e., it must be cutting the ecliptic, the plane in which the earth revolves about the sun.

Hence it is evident that eclipses will recur only at intervals which are synodic nodical cycles.

The two principal planetary periods are the sidereal and the synodic. The sidereal period is the mean time taken by the planet to complete one revolution about the sun. The synodic period is the mean time taken for the planet to return to the same position in relation to the earth and the sun.

Of these various units in nature's time order the most important are those which are suited to calendareographical uses, viz., the day, the synodic month, and the tropical year. It is well known, further, that these units are not commensurate. One tropical year, for example, does not contain an exact number of synodic months. It is possible, however, to find periods which do contain very nearly exact

numbers of both tropical years and synodic months. Such periods are called soli-lunar cycles⁽¹⁾ and are of first importance in the formation of calendars based on the motions both of sun and moon.

The first cycle of this sort to be used in Greece⁽²⁾ was the eight years' cycle or octaeteris. Commenting upon the origin and nature of this cycle Geminus tells us⁽³⁾ that the period was considered to contain 99 months (of which 3 were intercalary) and 2922 days. These numbers were arrived at, he says, on the assumption that the lunar year contains 354 days⁽⁴⁾ and the solar year $365 \frac{1}{4}$ days. Thus the epact would be $11 \frac{1}{4}$ days, which in eight years would amount to a whole number of days and a whole number of months; viz., 90 days or 3 months. In other words, 8 solar years exceed 8 lunar years by 3 lunar months. If, then, the lunar years are not to lag farther and farther behind the solar, it will be necessary in the course of every eight years to make three of the lunar years leap years of 13 instead of 12 lunar months.

Geminus then proceeds to note certain modifications of the 8 years' cycle suggested by a more accurate estimate of the length of the lunar month. The true length of the lunar month is, he says, $29 \frac{1}{2}$ plus $\frac{1}{33}$ days.⁽⁵⁾ Hence 99 months contain not 2922 days but $2923 \frac{1}{2}$ days. Thus, he says, every 16 years 3 days will have to be added in

(1) Censorinus calls them great years (anni magni) cf. De Die Natali, 18/5.

(2) It was also the first cycle employed by the Babylonians in their calendar and the first cycle employed by the early Christians for fixing the date of Easter.

(3) Gemini Elementa Astronomiae 8/27 f. Manitius' edition p.110, l. 21, f. Geminus flourished in Rhodes c. B.C. 77.

(4) The lunar year consisted of 12 months alternately "full" and "hollow", i.e. of alternately 30 and 29 days.

(5) $29 \frac{1}{2} + \frac{1}{33} = 29.5303$ days, which is not far from 29.5306 days, the actual length of the synodic month.

order to harmonize the days with the lunar months. But since 8 solar years do contain 2922 days,⁽¹⁾ in 16 years the months will be in excess of the years by the 3 added days. This excess will increase to a full lunar month in 10 of the 16 year periods or in 160 years, when a full month will have to be dropped out to correct the cycle.⁽²⁾

Finally, Geminus notices the 19 years' or Metonic cycle⁽³⁾ and its modifications. This cycle equates 19 years, 235 months (7 of which are intercalary), and 6940 days. In order to obtain the correct proportion of "full" and "hollow" months the Greeks dropped every 64th day from an hypothetical calendar containing 235 months of 30 days each. Thus the omitted day in the "hollow" months did not always come at the end of the month. The 64th day was arrived at by dividing 7050 (the number of days in 235 months of 30 days each) by 110 (the difference between 7050 and 6940 and hence the number of days that had to be dropped out).⁽⁴⁾

Callippus suggested that the error of Meton's cycle could be corrected by dropping one day after four cyclic periods or 76 years.

(1) Actually 2921.94 days.

(2) This system of correcting the octaeteris on the basis of a 160 years' cycle seems to have been first suggested by the great Greek geometrician and astronomer, Eudoxus, and a system based upon it to have been actually introduced in Athens possibly in 381 or 373 B.C., cf. Heath, Aristarchus p.293. Judged by accurate modern values the 160 years' cycle has an error of slightly more than two days:

$$160 \text{ years} = 58,438.75 \text{ days}$$

$$1979 \text{ months} = 58,441.03 \text{ days}$$

(3) Named after Meton who discovered it c. 432 B.C. It has an error of less than a day (19 years = 6939.60 days, 235 months = 6939.69 days) and came to be the most widely used of all calendareographical cycles of the tropical year and the synodic month. It is still used in the Jewish calendar and also, for fixing the date of Easter, in our own calendar.

(4) Heath, Aristarchus, p.293. Geminus 8/50-56.