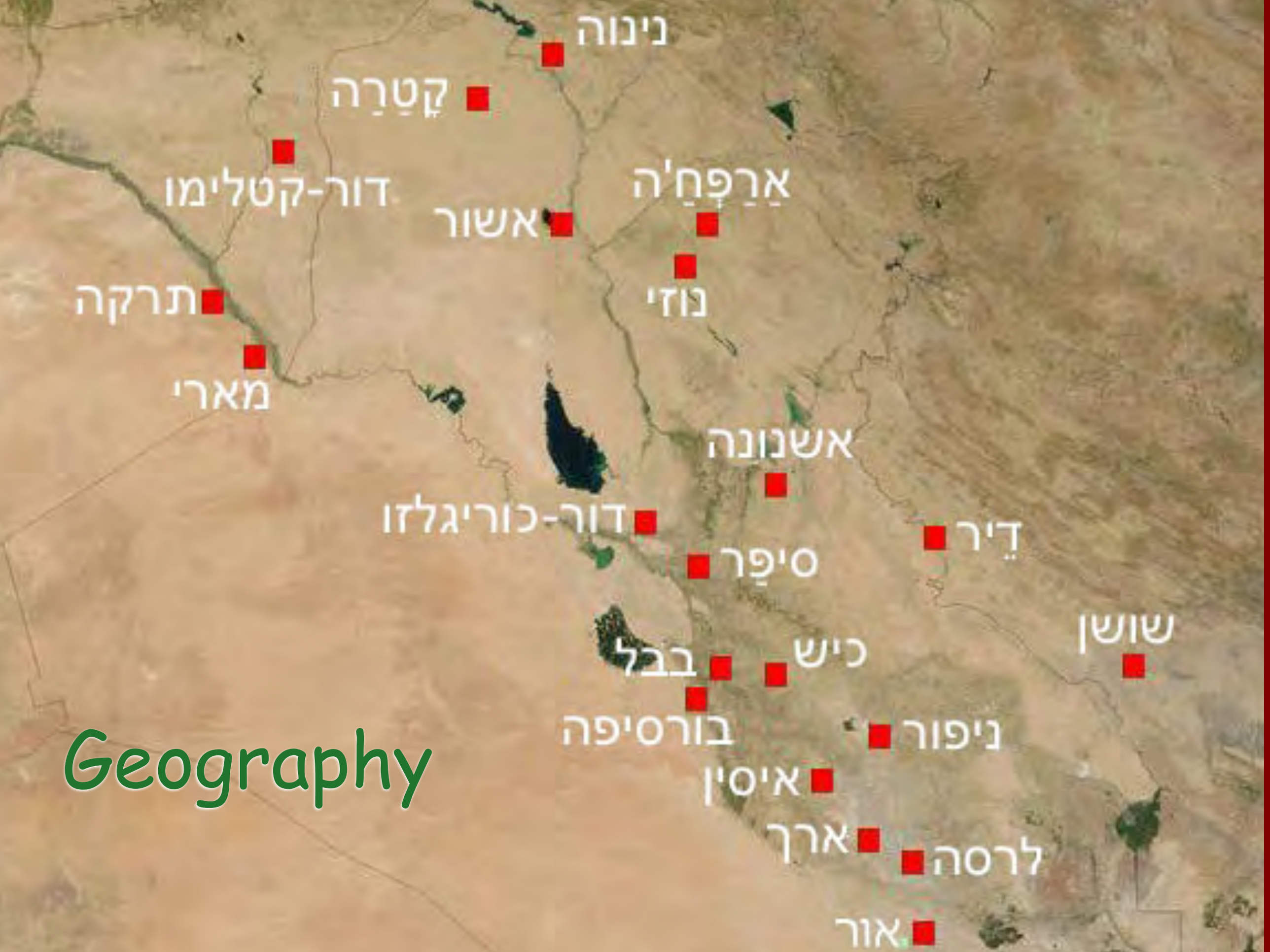
Babylonian Calendars

History

- Pre-Babylonian Sumero-Akkadian period
- First Babylonian/Amorite Dynasty 1894–1595 BCE (Hammurabi…)
- Kassite Dynasty, 1595–1155 BCE
- Native Rule, 1155–1026 BCE
- Period of Chaos 1026–911 BCE
- Assyrian rule, 911–619 BCE
- Neo-Babylonian Empire (Chaldean Era)
- Persian Babylonia
- Seleucid

Achaemenid (550-330)

Geography


נינוה
קָטַרָה
דור-קטלימו
אַרַפְחַ'ה
אשור
נוזי
תרקה
מארי
אשנונה
דור-כוריגלזו
דִיר
סִיפַּר
שושן
כיש
בבל
בורסיפה
ניפור
איסין
ארך
לרסה
אור

הממלכות הגדולות

בערך ש' 585 לפנה"ס

קנה המדה בק"מ

0 200 400 600 800 1000

- ממלכת בבל
- ממלכת מדי
- ממלכת מצרים
- ממלכת לוד
- אזורי השפעה יונית
- העיר התפשטות צור
- עיר

הים התיכון

הים הכספי

הים האדום

מדבר מצרים

ארץ הנשדים

ממלכת מדי

ממלכת לוד

ממלכת בבל

ממלכת מצרים

קיליקיה

לידיה

כתים

קולחים

האכרף הכרסי

(המשולש הכי מקאיפו)

ממלכת פרס בשיאה
בערך ש' 500 לפנה"ס
Copyright, The Westminster Press, International Copyright Secured. All Rights Reserved
קנה המידה בק"מ
0 200 400 600 800 1000
גבולות הממלכה
עיר
סקיתיה
תרקיה
סקודרה
(הים השחור)
קולכיס
ים הרקני (כספי)
בקטריה
סוגדינה
ארמניה
קפדוקיה
לוד
יוניה
קריה
קיליקיה
כתים
הים הגדול
הירקניה
פרתיה
אריה
אשור
מדי
דרנגינה
ארחוסיה
שושנה
שושן
בבל
פרספוליס
פרס
גדרוסיה
המפרץ הפרסי
ערב
לוב
מצרים
ממפיס
אילת
הר סיני
תמא
ים כספי


हिसाब
ता.
सुबह
शाम
17
18
19
20
21
22
23
24


DER ÄLTESTE DER JUDEN
FÜR DAS JAHR —
1942

AUTOMNE
VENDEMIAIRE.
1er Mois.
BRUMAIRE.
2e Mois.
FRIMAIRE.
3e Mois.
HYVER
NIVOSE.
4e Mois.
PLUVIOSE.
5e Mois.
VENTOSE.
6e Mois.
1re Décade
2e Décade
3e Décade

रवि
6
13
सोम
7
14

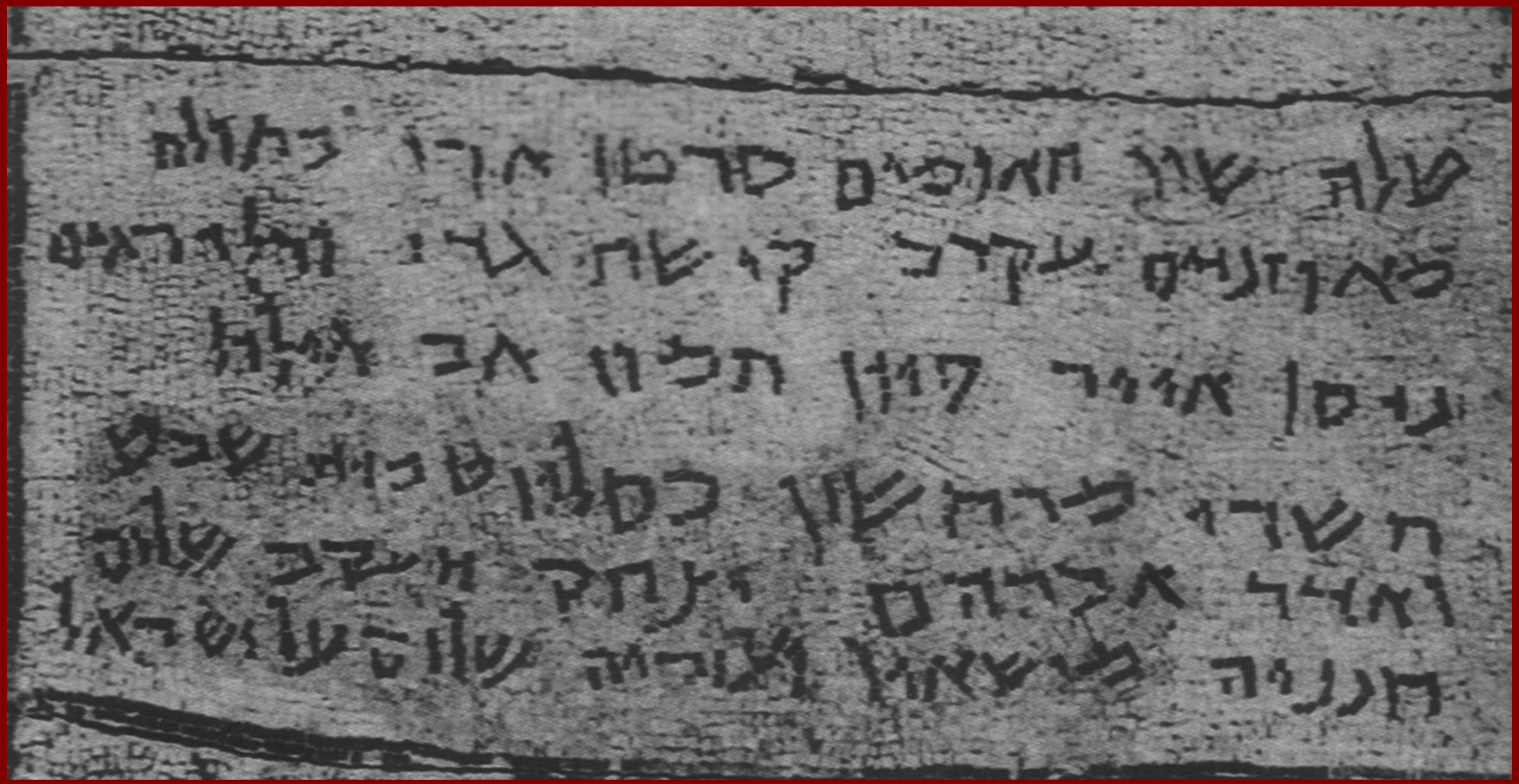
ירושלמי
ראש השנה א' הלכה ב'

- א"ר חנינה שמות חדשים עלו בידם מבבל. ... בראשונה, בירח בול שבו העלה נובל; והארץ עשויה בולות בולות; שבו בוללים לבהמה מתוך הבית.

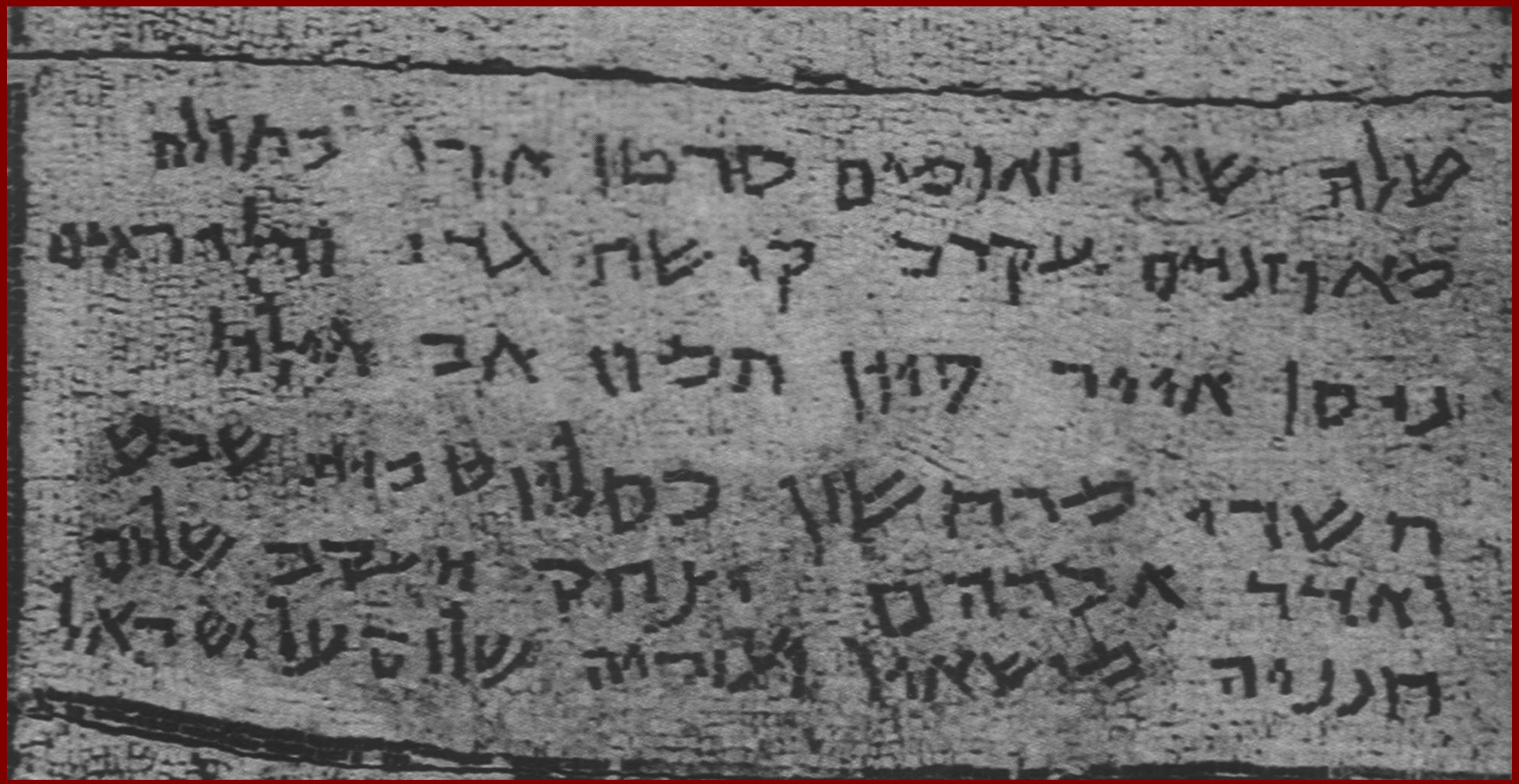
1. Nisanu
2. Ayaru
3. Simanu
4. Du'uzu
5. Abu
6. Ululu
7. Tashritu
8. Arakhsamna
9. Kislimu
10. Tebetu
11. Shabatu
12. Adaru

(1) Nisan	30 days	ניסן
(2) Iyyar	29 days	אייר
(3) Sivan	30 days	סיון
(4) Tammuz	29 days	תמוז
(5) Av	30 days	אב
(6) Elul	29 days	אלול
(7) Tishri	30 days	תשרי
(8) Ḥeshvan	29 or 30 days	חשון or מרחשון
(9) Kislev	29 or 30 days	כסלו
(10) Teveth	29 days	טבת
(11) Shevat	30 days	שבט
(12) Adar I	30 days	אדר ראשון
(12) (13) Adar II	29 days	ואדר or אדר שני

עין גדי



מֶרַח שְׂוָן



חשוון ומרחשוון

מאת עלי איתן, לשוננו לעם ט, א (תשי"ח), עמ' 6–7

איני יודע מתי כרתו את ראשו של מרחשוון והתחילו אומרים חשוון. בוודאי זה דורות רבים יש נוהגים כך, ואפשר להניח להם, לאומרי חשוון, משום "שבשתא ביוון דעל על". אולם לכולנו ראוי לדעת מה אירע כאן ומה טיבו של "מר" זה שנשמט.

בין הבריות שנתנו דעתם על כך מתהלכות שלוש דעות. יש סבורים שחודש חשוון זכה משום מה לתואר הכבוד מַר – בדיוק כמו מר שמואל ומר עוקבן – ומי שאינו מכבד ומבּזר חודש זה משאר חודשי השנה, יכול לקרוא לו בשמו הפשוט, בלי מר. אחרים משערים ש"מר" זה הוא לשון מרה, מרור ותמרורים, כדרך שאמרו "לבלתי רחוץ במרחץ וכו'... כי בחודש הזה ממשלת המרה השחורה בחזקת כוחה", כדברי אסף הרופא המובאים במילון בן־יהודה, ערך מרחשון; ואחרים רואים ב"מר" זה רמז לטיפות הגשם מלשון "מר מדלי" (ישעיהו מ, טו), ובין בעלי דעות אלו יש שכותבים את שם החודש בשתי תיבות מוקפות: מר־חשוון.

ולא היא ולא היא. כבר בשנת תרצ"ז הסביר נ"ה טורטשינר (טור־סיני) במאמרו על מלים שאולות ("לשוננו" כרך ח, עמ' 109) שמרחשוון הוא מילה שאולה מבבלית, ומעיקרו שתי מילים בבליות: וַרְחֶ שַמְנֶ, שפירושן הֵיֶרח השמיני [ואמנם מרחשוון הוא הירח השמיני כאשר מונים את החודשים מניסן]. הואיל ובבבלית נתחלפו תכופות ההגאים ו–מ, נולד בעברית צירוף מילים זה, שבראש המילה הראשונה באה מ במקום ו, ובתוך המילה השנייה ו במקום מ – מרחשון –, ועל ידי הגייה וכתיבה בתיבה אחת נוצר שם החודש מרחשוון. אין אפוא "מר" זה אלא שתי האותיות הראשונות של "מרח" (<ורח = יֶרח), ואין לו משמע משלו.

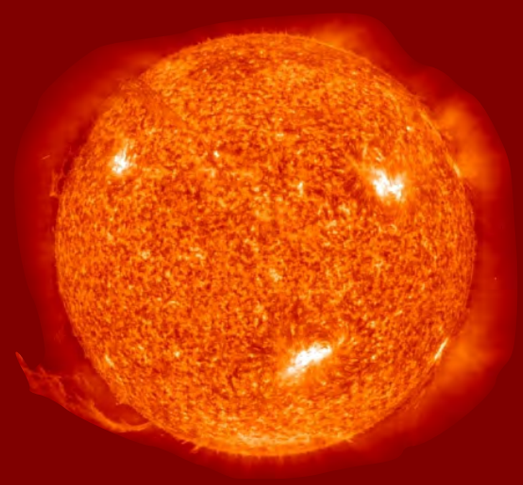
איירה: טל מור

Ethelbert William Bullinger
(1837–1913)

Typology

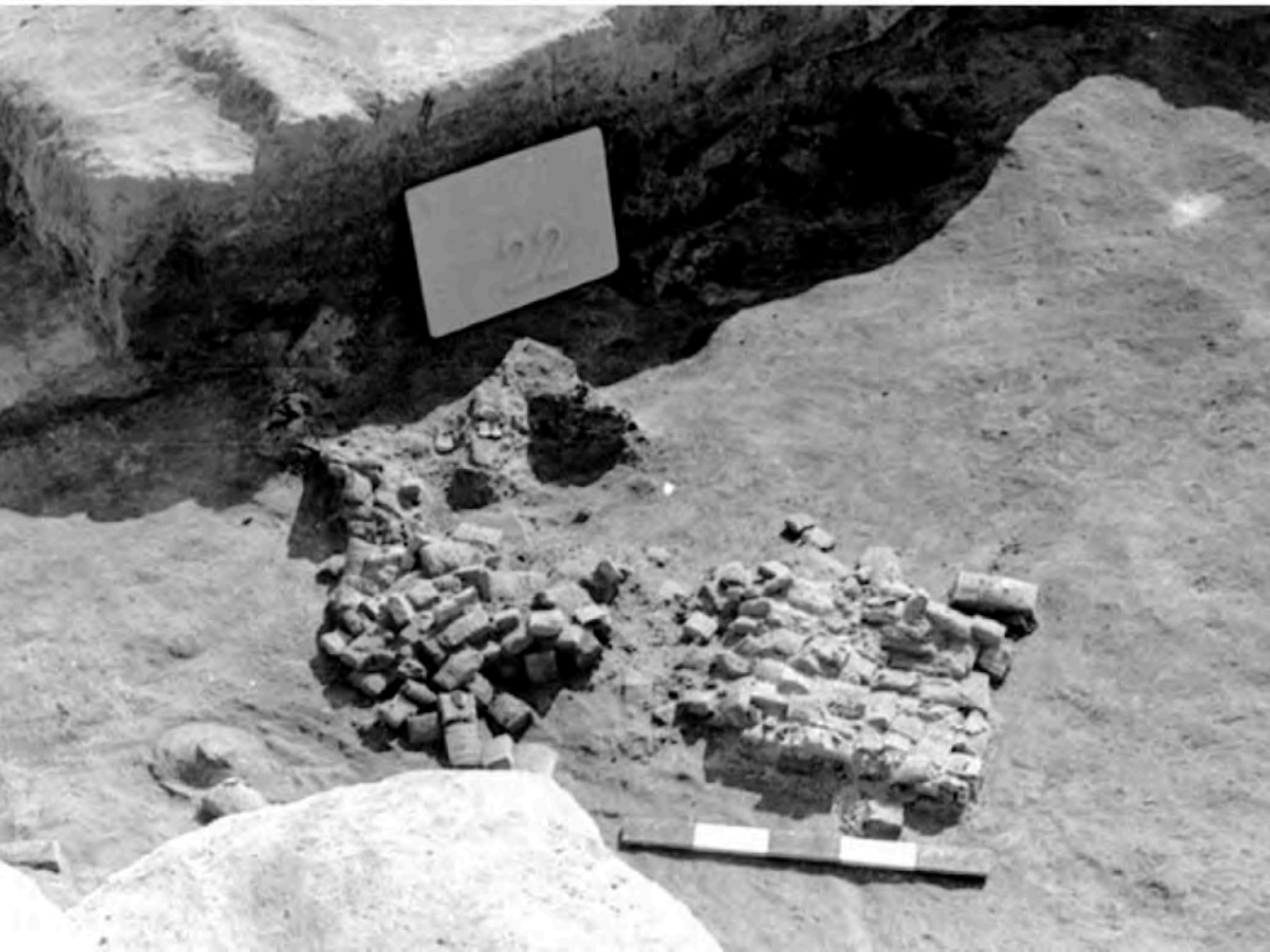
- Diurnal

- Solar



- Lunisolar

Diurnal Calendars



Ur-Utu's Old Babylonian Prayer

- . . . iš-tu ^{iti}bára.zag.gar ud 20.kam *a-di* ^{iti}bára.zag.gar ud 20.kam *ša ša-at-tim e-ri-ib-ti* 6 šu.ši u_4-ma-tim 6 šu.ši <ù> *mu-ši-a-tim*
- From the first month, 20th day, until the first month, 20th day, of the year to come 6 times sixty days and 6 times sixty nights.


JAN
SUN
0
7

Noah's Calendar

- 12 months
- 30 days per month
- 360 days per year

Mathematics 1

- Elapsed days since start =

360 x (year – 1)

+ 30 x (month – 1)

+ (day – 1)

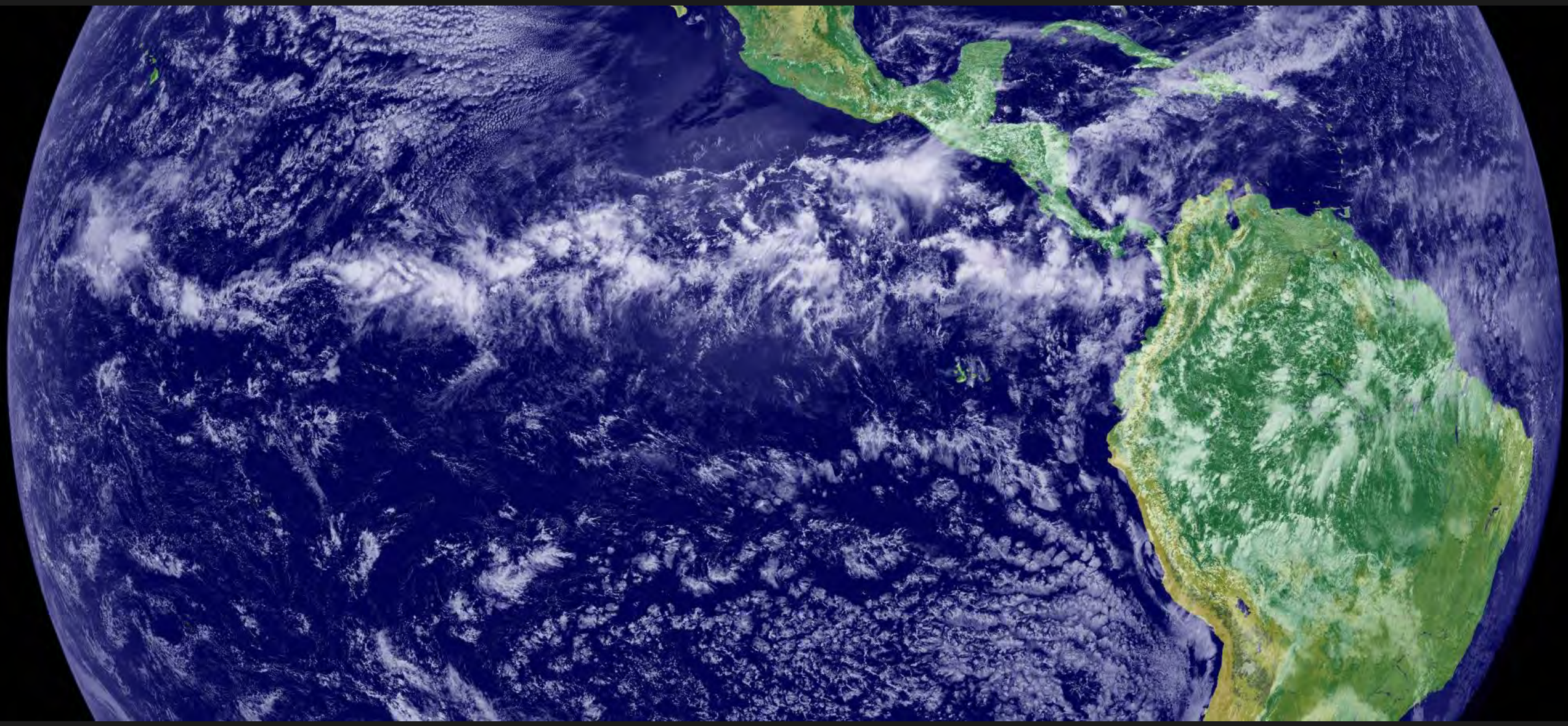
Mathematics 2

- Date if n days have elapsed:

year = (n ÷ 360) + 1

month = ((n mod 360) ÷ 30) + 1

day = (n mod 30) + 1

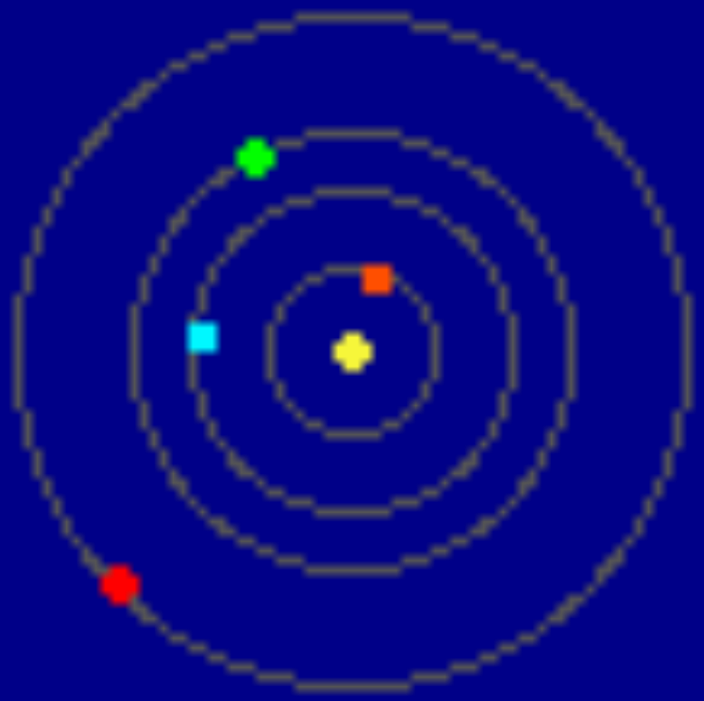


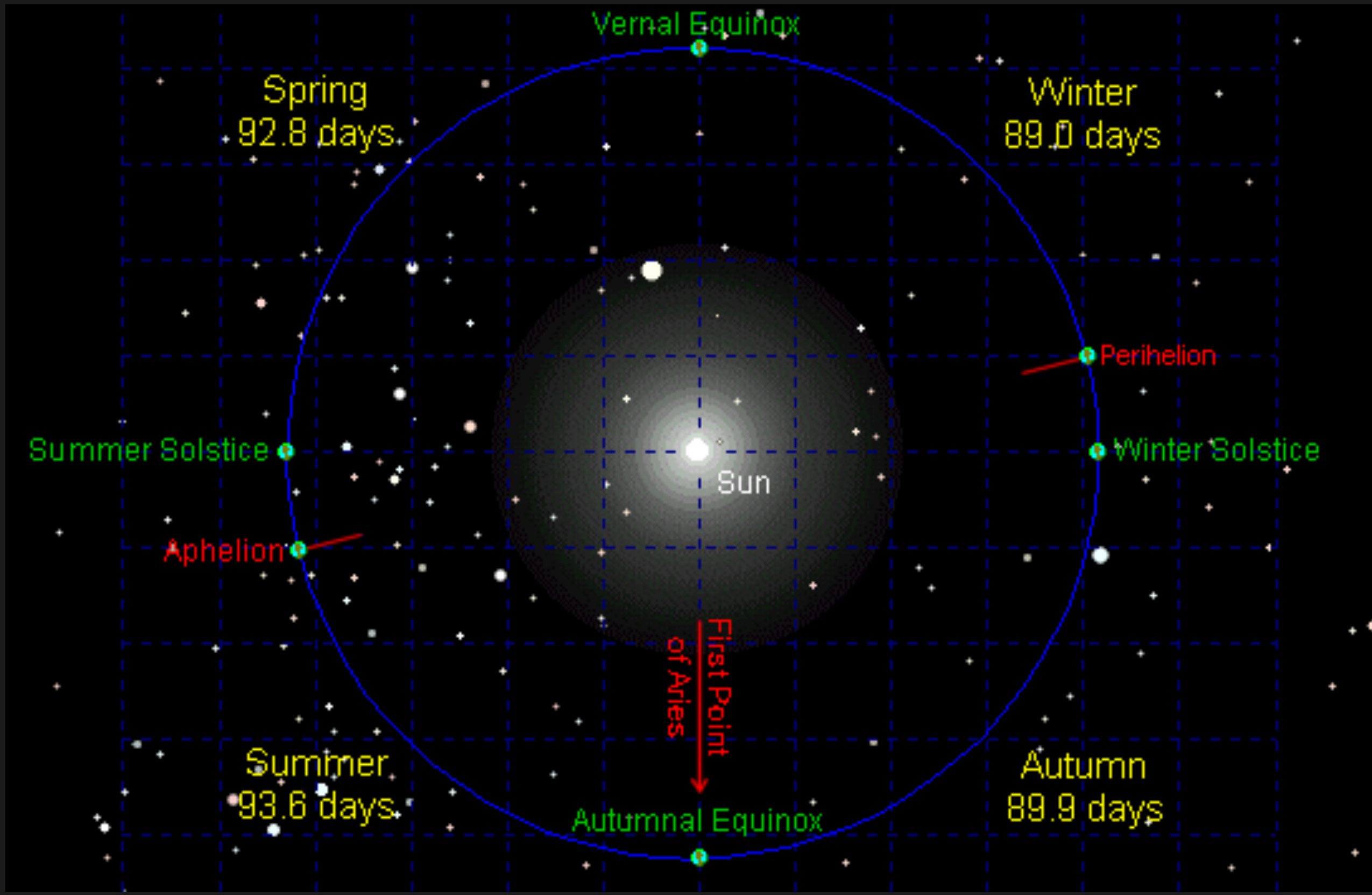
Diurnal Calendars

- 360 (Babylonian; Mayan count)
- 365 (Egyptian; Enoch; Mayan haab; astronomers)
- 364 (Jubilees; Qumran)
- 260 (Mayan tzolkin)
- 210 (Bali pawukon)
- "weeks"

Solar Calendars

Astro 101

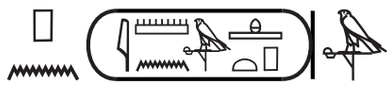



Vernal Equinox
Spring
92.8 days
Winter
89.0 days
Perihelion
Summer Solstice
Winter Solstice
Sun
Aphelion
First Point
of Aries
Summer
93.6 days
Autumn
89.9 days
Autumnal Equinox

יום הולדת את פרעה

And it came to pass the third day, which was Pharaoh's birthday, that he made a feast unto all his servants. -- Genesis 41

Egyptian Calendar

	Middle Kingdom	New Kingdom	
(1) Thoth			30 days
(2) Phaophi			30 days
(3) Athyr			30 days
(4) Choiak			30 days
(5) Tybi			30 days
(6) Mechir			30 days
(7) Phamenoth			30 days
(8) Pharmuthi			30 days
(9) Pachon			30 days
(10) Payni			30 days
(11) Epiphi			30 days
(12) Mesori			30 days
(13) (Unnamed)			5 days

365 Days

- 12 months
- 30 days
- 5 epagomenal days
  - Cursed days
  - Births of Osiris, Horus, Set, Isis, Nephtys
  - “During the five days at the end of the year do no work; abstain from everything"
  - Good to curse your enemies

Julian/Coptic/Ethiopic

- 366 days every 4th year

2 months harvest

2 months planting

2 months rain

1 month flax hoeing

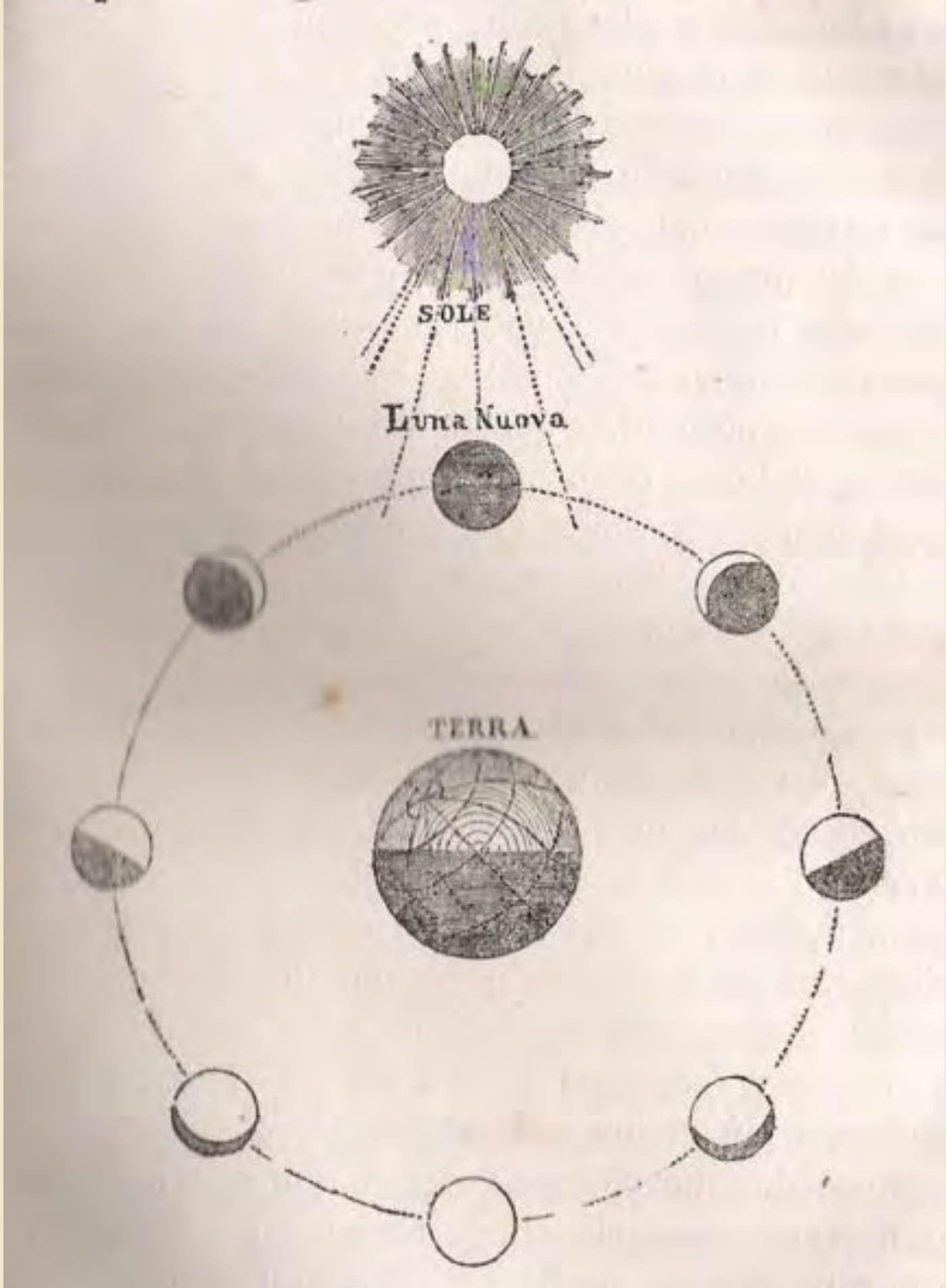
1 month barley harvest

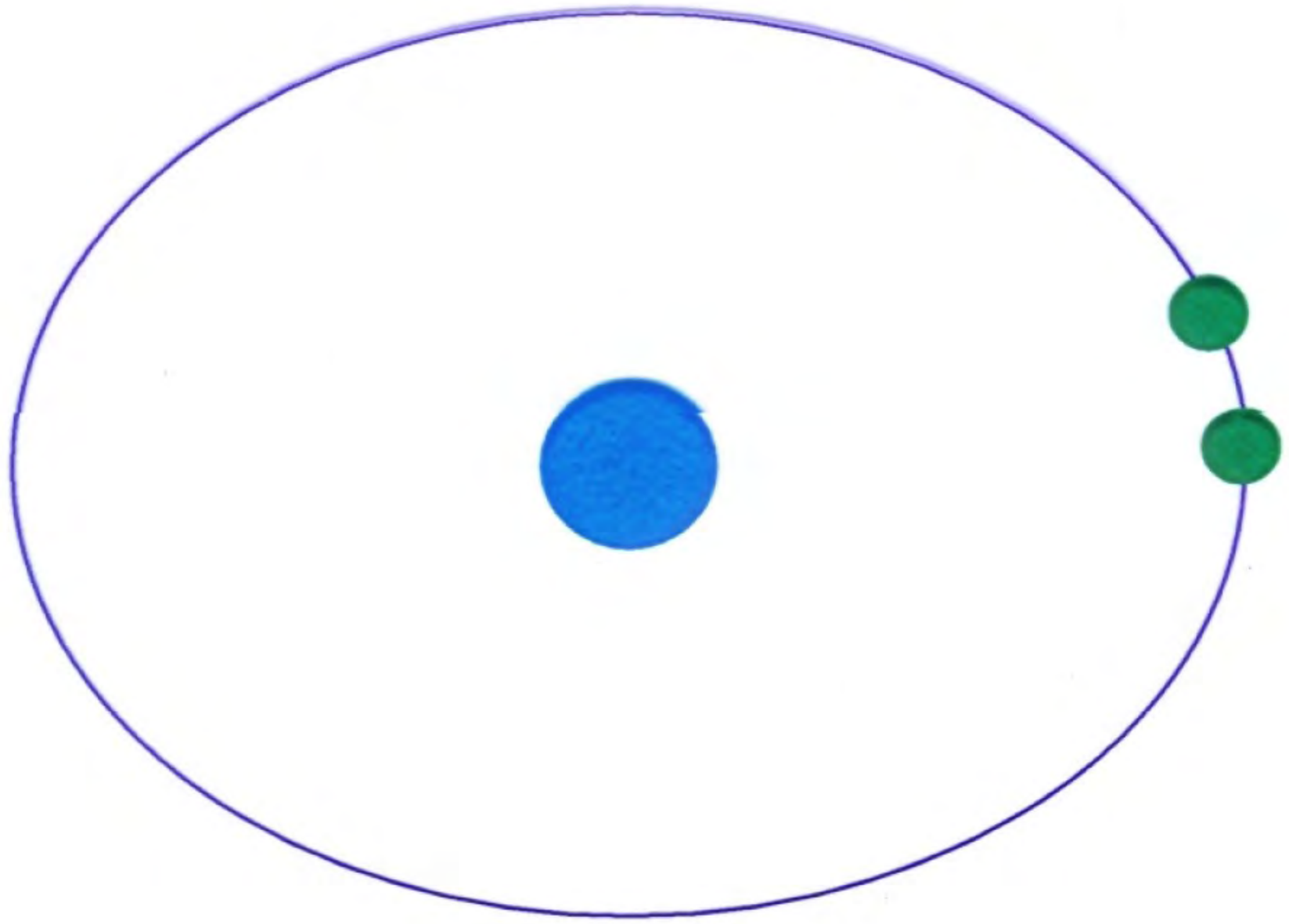
1 month harvest & feasting

2 months pruning

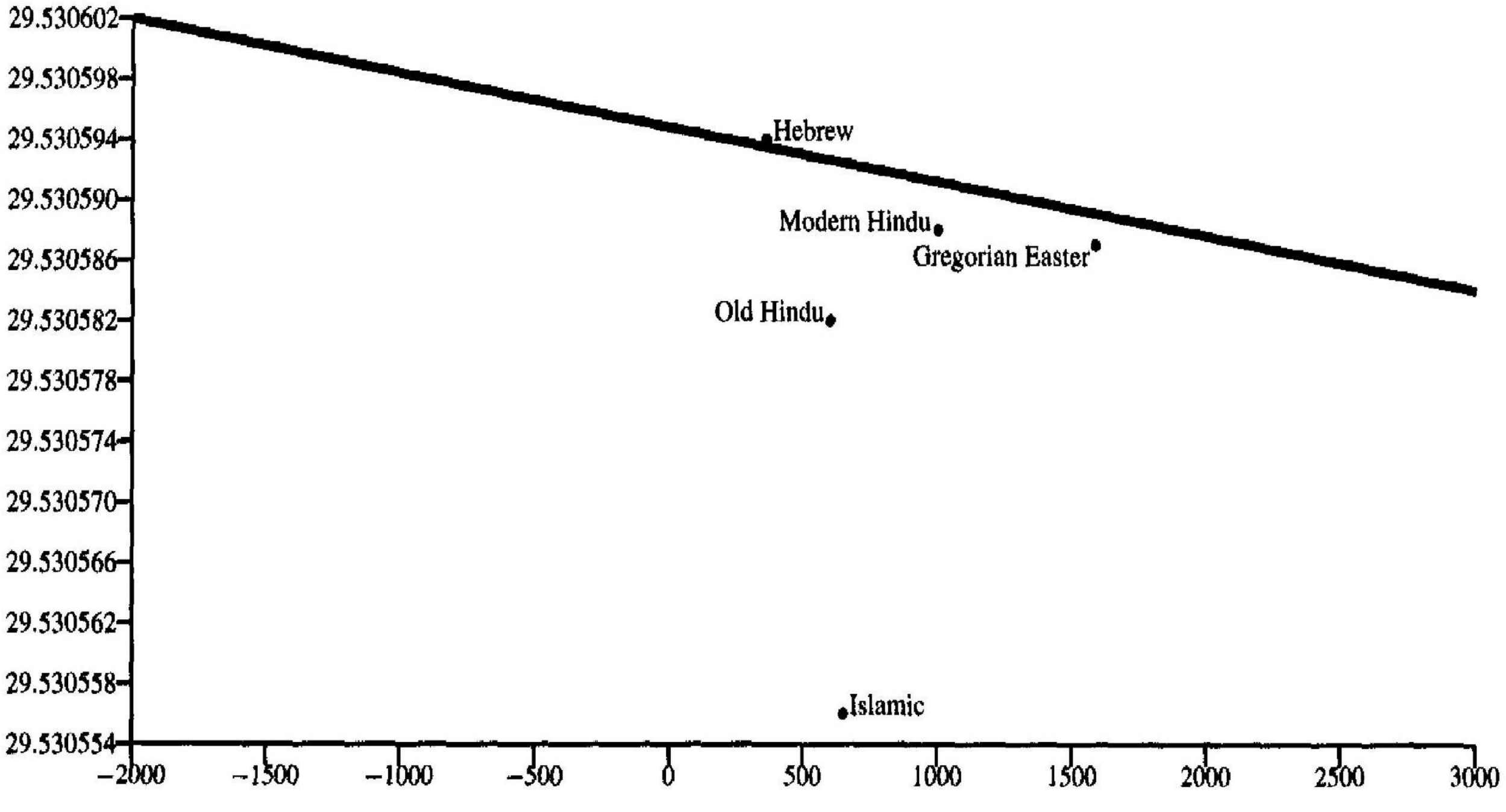
Lunisolar Calendars

Astro 102


SOLE
Luna Nuova
TERRA



Nature is Changing



Lunisolar

- Months are lunar
- Years are solar (on the average)
- 12 or 13 months

Night of spring full moon

Fierynecked nightjar egglaying

Lunisolar Calendars

- Ancient Egyptian
- Babylonian
- Ancient Greek
- Native American
- Hebrew
- Hindu
- Chinese…

	Sioux	Creek	Dakota
March	Worm	Little spring	Sore eyes
April	Plants	Big spring	Geese lay
May	Flowers	Mulberry	Planting
June	Hot	Blackberry	Strawberries
July	Buck	Little ripening	Midsummer
August	Sturgeon	Big ripening	Corn gathered
Sept	Corn	Little chestnut	Wild rice
Oct	Travelling	Big chestnut	Doe running
Nov	Beaver	Falling leaf	
Dec	Hunting	Big winter	Does shed horns
Jan	Cold	Little winter	Hard
Feb	Snow	Windy	Racoons run

The number of months with God is twelve in accordance with God's law since the day he created the heavens and the Earth….
Intercalating a month is adding to unbelief. -Quran

Start of Month

- Babylonian: First sighting (probably)
- Babylonian: Calculation (probably)
- Egypt: Last sighting (probably)
- Hebrew, Islamic: First sighting
- Hebrew: Calculation
- Hindu: New moon; Full moon
- Chinese: New moon

Generic Calendar

- Given <year,month,day>
- Determine n elapsed days
- Y year length
- M month length
- n_0 epoch
- δ offsets
- amod (mod with modulus instead of 0)

Ideal Lunisolar Calendar

fixed(y,m,d) =

epoch + 29a + ⌊a(M mod 1)⌋ + d

where

a = 12y + ⌊ry⌋ + m (elapsed months)

r = $\frac{Y}{M}$ mod 1 (month leftover)

Approximations

- 19-year cycle
  - Mesopotamian
  - Hebrew
  - Easter
  - Chinese once-upon-a-time

- 180,000 years
  - Old Hindu

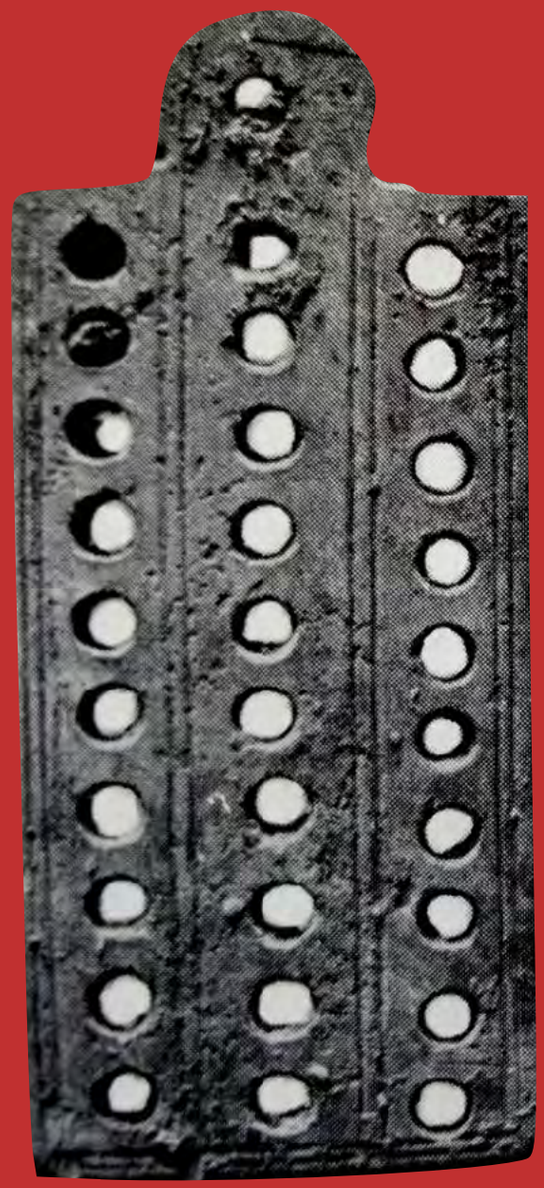
Nice Cycles

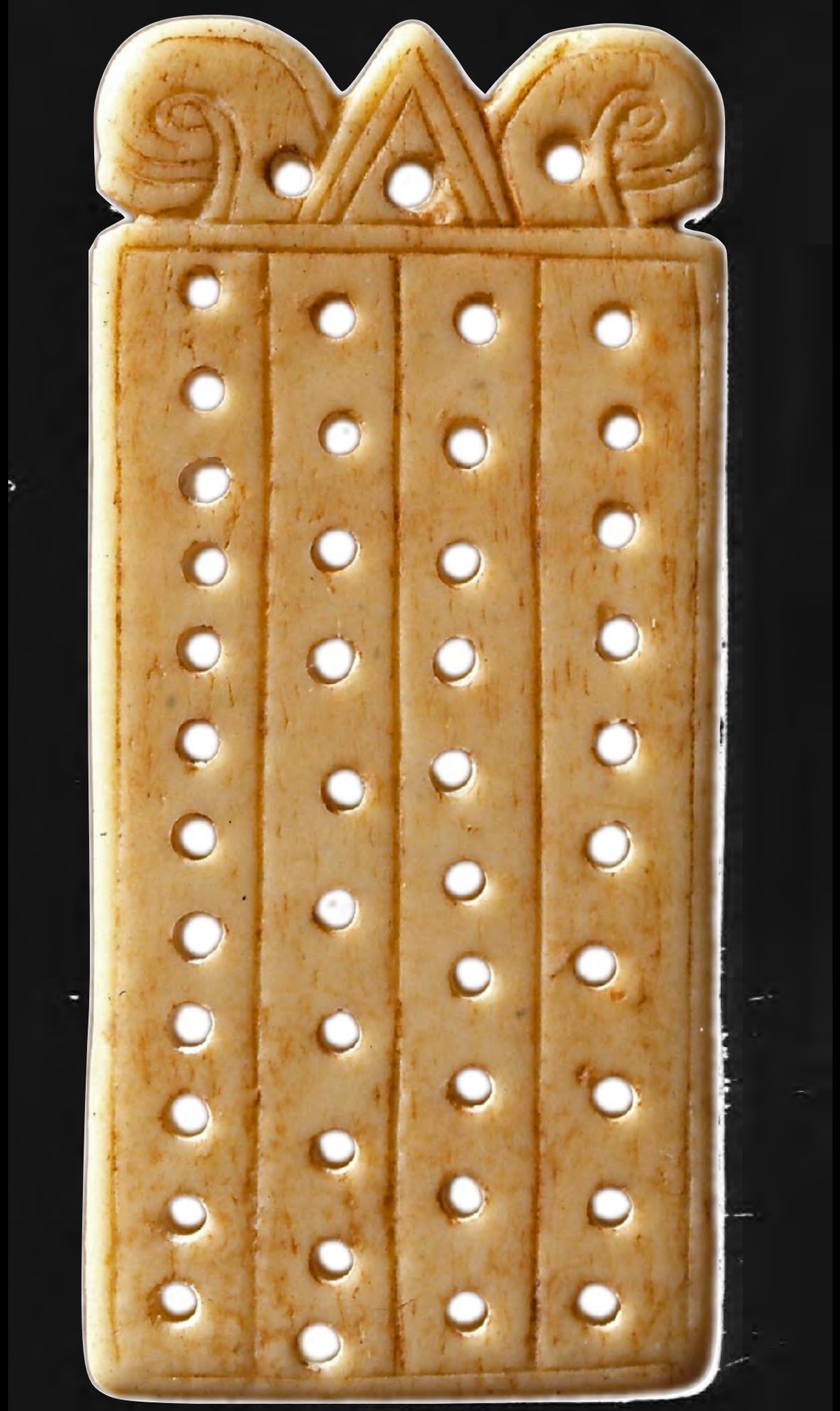
- Hebrew/Easter: 7 leap years out of 19
- Hindu Lunar (Old): 66,389 out of 180,000

City of David

cm

Lachish; Gezer; Far’ah





Tel Aroer

A Bone-Carved Calendar

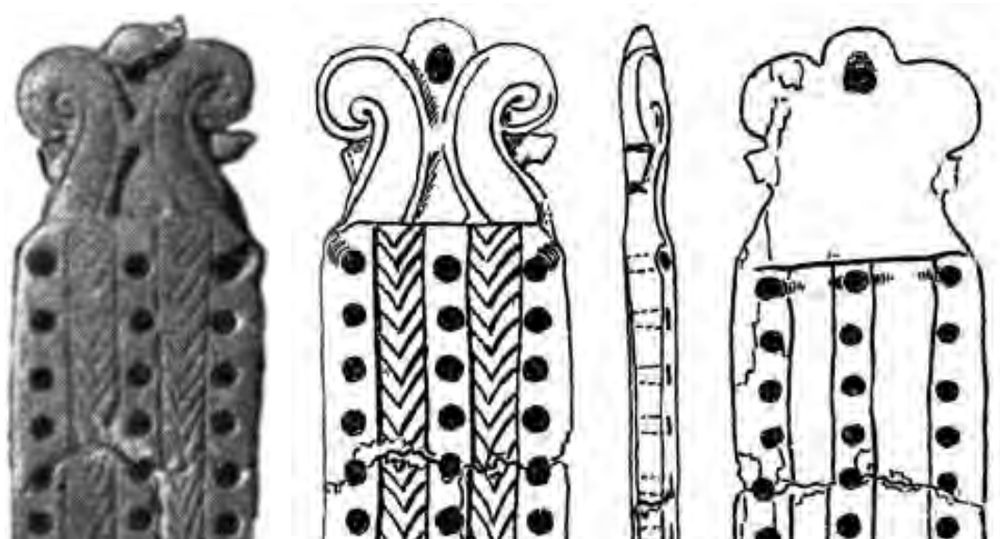
Nili Fox

Proto-Aeolic Bone Plaque, No. F/6073, Area B, Locus 1226, Phase B3, Stratum III (Plate VII; Pl. 63:3)

The tiny rectangular bone plaque (6.0 × 2.7 cm.), recovered in 1980, in debris inside the "pillared structure" at ʿAroer,[21] continues to raise questions concerning its identity and utility. The plaque displays a number of notable features: its surface is finely polished; the top of the plaque is carved in the form of a Proto-Aeolic capital with a hole in each of its two volutes and in the center chevron (3 total); the rectangular portion of the plaque is demarcated by four vertical rows, the left row is perforated with 12 holes; the three other rows have 10 holes each (30 total).

Initially, the excavators of ʿAroer suggested that this plaque is either a calendar or a gaming board (Biran and Cohen 1981: 131; and see Biran 1993: 91). However, in a subsequent publication, Biran (1983: 34) noted that the number of holes in the four rows of the plaque, 12 and 30, are indicative of a calendar–12 for the months of the year and 30 for the days in each month. He posited that a moveable peg could have been inserted

ones are perforated with three rows of 10 holes each, for a total of 30. Rounded projections at the top of the plaques each have a single bore hole, presumably for suspension (Tufnell 1953: Pls. 37:3, 15, 17; 55:27, 28; 56:23; 57:28). A similar bone plaque from Tel el-Farʿah (S) also has three rows of 10 holes each but with an added design consisting of two herringbone pattern columns separating the rows of holes (Fig. 3.135) (Petrie 1930: Pls. 36, 40:481). The top of that plaque, punctured by a single hole, is in the shape of a Proto-Aeolic capital closely resembling the ʿAroer plaque, though narrower.



Babylonian Calendar

- Lunisolar
  - Observational
  - Calculated

Babylon

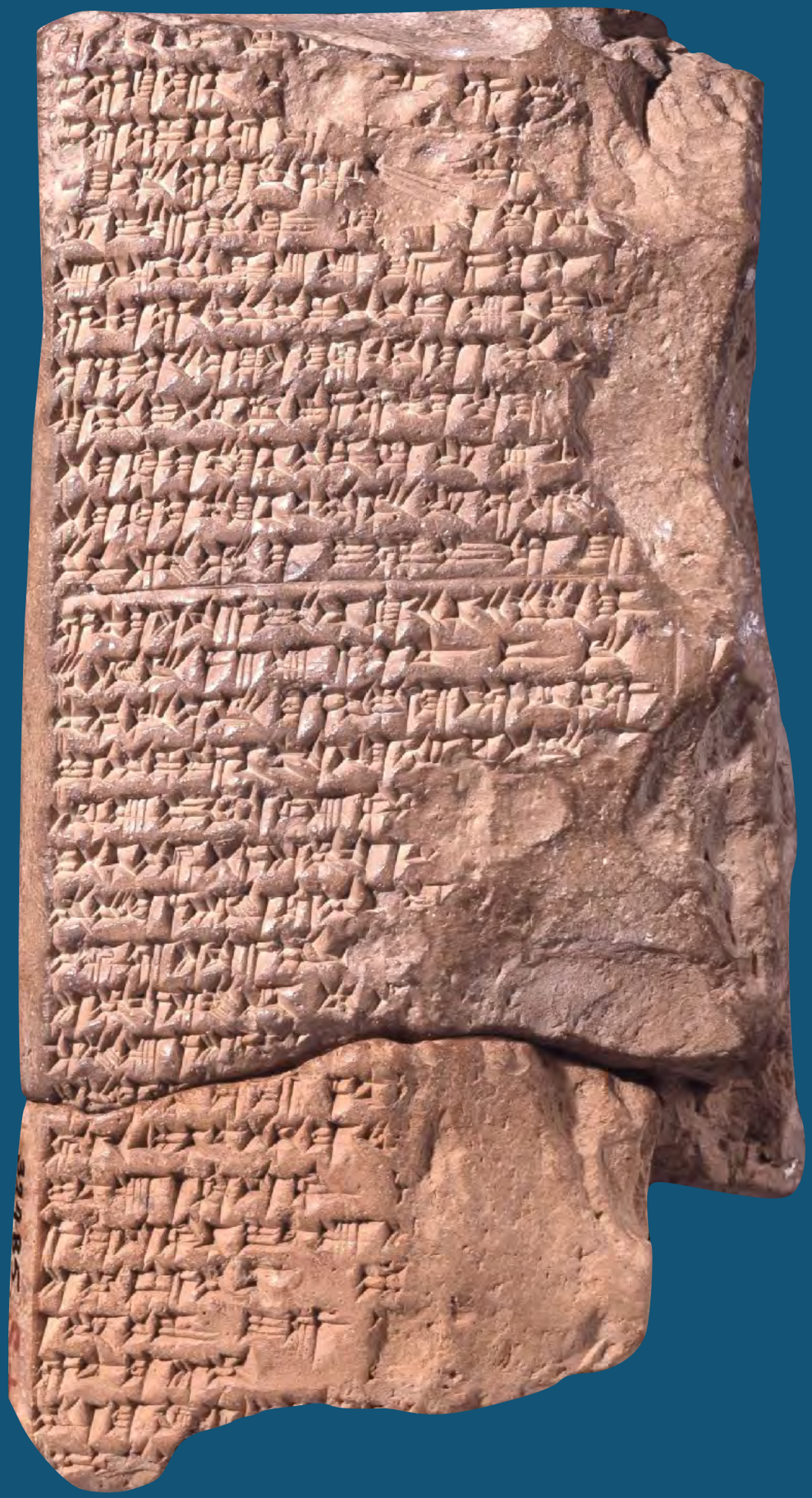
- 19 year cycle
- 6 times Adar is leap
- Elul is once
- Visibility of new moon is determined by observation and/or calculation

1-2 Million

3D

Eclipse in Ululu

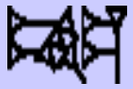
MS 4151
List of month names for the Lagash (Larsa?) calendar,
including the extra 13th month.
Babylonia, 2000-1600 BC



Announce New Year

6 *lu-ú ti- i- du*
7 ITU ŠE *a- ga- a*
8 *šá* MU. *15.* KÁM
9 *ud- di- ir- ri*

The Months of the Babylonian Calendar

Nr.	Month names								Approximate equivalent in the Julian calendar
	Babylonian		Hebrew	Old Persian	Achaemenian Elamite	Elamite	Macedonian(#)		
							earlier correlation	later correlation	
I		Nisannu	Nīsān	Ādukaniša	Hadukannaš	Zikli	Artemisios	Xanthikos	March-**April**-May
II		Ayyaru	Iyyār	Θūravāhara	Turmar	Zarpakim	Daisios	Artemisios	April-**May**-June
III		Simānu	Sīwān	Θāigarciš	Sākurriziš	Hadar	Panemos	Daisios	May-**June**-July
IV		Duʾūzu	Tammūz	Garmapada	Karmabataš	Hallime	Loös	Panemos	June-**July**-August
V		Abu	Āb	???	Turnabaziš	Zillatam	Gorpiaios	Loös	July-**August**-September
VI		Ulūlu	Elūl	???	Karbašiyaš	Belilit	Hyperberetaios	Gorpiaios	August-**September**-October
VII		Tašrītu	Tišrī	Bāgayādiš	Bakeyatiš	Manšarki	Dios	Hyperberetaios	September-**October**-November
VIII		Araḫsamna	Marḥešwān	*Vrkazana	Markašanaš	Lankelli	Apellaios	Dios	October-**November**-December
IX		Kislīmu	Kislēw	Āçiyādiya	Hašiyatiš	Šibari	Audynaios	Apellaios	November-**December**-January
X		Ṭebētu	Ṭēbēt	Anāmaka	Hanamakaš	Šermi	Peritios	Audynaios	December-**January**-February
XI		Šabāṭu	Šebāṭ	*Θwayauvā	Samiyamaš	Kutmama	Dystros	Peritios	January-**February**-March
XII		Addaru	Adēr	Viyax(a)na	Miyakannaš	Aššetukpi	Xanthikos	Dystros	February-**March**-April

 # epigraphical and numismatical sources indicate that, between 31 CE and 46/47 CE, the correlation of the Macedonian months with the Babylonian months underwent a shift of one month

Babylonian Calendar

- Seleucid Era
  - April 3, 311 BCE Julian
  - variants

Beginning of Month

- Observation
  - Phasis
  - Other …
- Calculation
  - Moonlag
  - Other …

- Historical records
  - Day number
  - Double dates
- (May have 30d by default)

Neo-Assyrian (8th-7th)

- Observational
  - King could overrule
- Omen lists
  - No first sightings on day 2
  - No mention of starting on day 30 without sighting

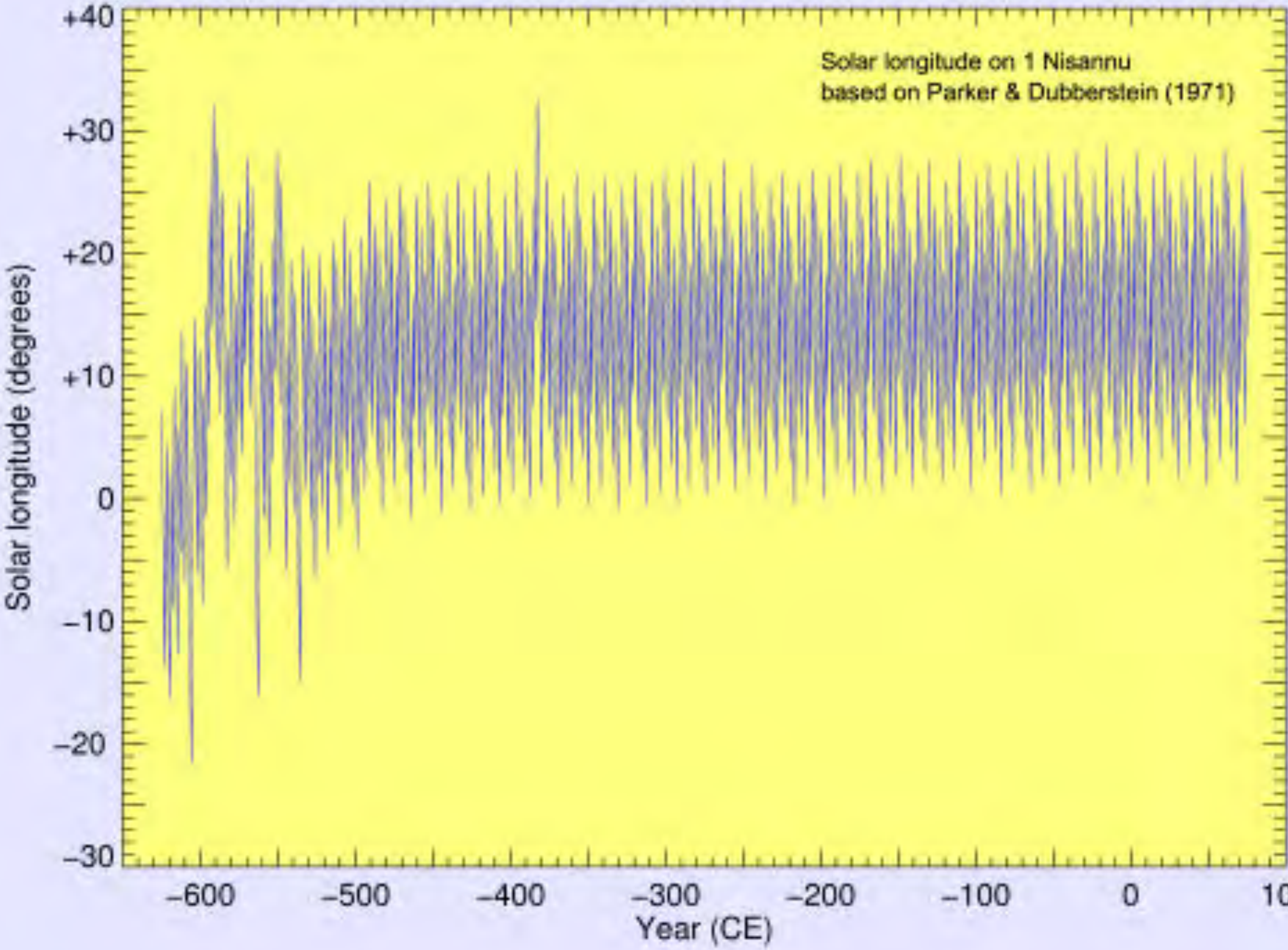
Accuracy (S Stern)

- Neo-Assyrian: sometimes visible on 28th or 29th

- Later diaries:
  - rare (1.5%) sighting before prediction
    - but modern agrees with prediction
  - some (6.5%) 1d after

Beginning of Year

- Observation
  - Barley
  - Equinox …
- Calculation
  - Cyclic …
- Historical records
  - Day number
  - Double dates
- Announcements


Solar longitude on 1 Nisannu
based on Parker & Dubberstein (1971)
Solar longitude (degrees)
+40
+30
+20
+10
0
−10
−20
−30
−600
−500
−400
−300
−200
−100
0
100
Year (CE)

19-Year Cycle

- Adaru
  - 1 4 7 9 12 15
- Ululu
  - 18

Leap Cycle

babylonian-leap-year?(*b-year*) :=

$(7 \times b\text{-}year + 13) \bmod 19 < 7$

Hebrew/Babylonian

- (4000 F T)
- (4001 T F)
- (4002 F T)
- (4003 F F)
- (4004 T F)
- (4005 F T)
- (4006 F F)
- (4007 T F)
- (4008 F T)
- (4009 T F)
- (4010 F T)
- (4011 F F)
- (4012 T F)
- (4013 F T)
- (4014 F F)
- (4015 T F)
- (4016 F T)
- (4017 T F)
- (4018 F F)

10	[illegible]					
11	[illegible]					
12	[illegible]					
13	[illegible]					
9	[illegible]	[illegible]	27	[illegible]	[illegible]	7.45
8	[illegible]	[illegible]	26	[illegible]	[illegible]	7.45
7	[illegible]	[illegible]	25	[illegible]	[illegible]	7.45
6	[illegible]	[illegible]	24	[illegible]	[illegible]	7.44
5	[illegible]	[illegible]	23	[illegible]	[illegible]	7.44
4	[illegible]	[illegible]	22	[illegible]	[illegible]	7.43
3	[illegible]	[illegible]	21	[illegible]	[illegible]	7.43
2	[illegible]	[illegible]	20	[illegible]	[illegible]	7.42
1	[illegible]	[illegible]	19	[illegible]	[illegible]	7.41
31	[illegible]	[illegible]	18	[illegible]	[illegible]	7.41
30	[illegible]	[illegible]	17	[illegible]	[illegible]	7.40
29	[illegible]	[illegible]	16	[illegible]	[illegible]	7.40
28	[illegible]	[illegible]	15	[illegible]	[illegible]	7.39
27	[illegible]	[illegible]	14	[illegible]	[illegible]	7.39
26	[illegible]	[illegible]	13	[illegible]	[illegible]	7.38
25	[illegible]	[illegible]	12	[illegible]	[illegible]	7.37
24	[illegible]	[illegible]	11	[illegible]	[illegible]	7.36

The Babylonian Calendar

this interval, the converter will give erroneous results.

Note that years before 1 CE are given both in historical as in astronomical notation, *i.e.* 0 = 1 BCE, –1 = 2 BCE, etc.

day	month	year [astronomical/historical]		
	January		CE	BCE

Chronological Julian Day Number	weekday [day of the week]
	Sunday [1st day]

day	month	regnal year
	Nisannu [I]	

Seleucid Era		Arsacid Era
Babylonian reckoning	Macedonian reckoning	

Nabonassar lunation number		length		days

+100y	+19y	+10y	+1y	+1m	+10d	+7d	+1d
–100y	–19y	–10y	–1y	–1m	–10d	–7d	–1d

van Gent's Calculator

- This calendar converter is based on the tables of the Babylonian calendar published in 1971 by Parker and Dubberstein. These tables were based on the computed first visibility of the lunar crescent as seen from Babylon using a lunar visibility algorithm published by the German astronomer Carl Schoch (1873-1929) in Langdon & Fotheringham's The Venus Tablets of Ammizaduga (1928).

BABYLONIAN CHRONOLOGY

626 B.C.–A.D. 75

BY RICHARD A. PARKER
AND WALDO H. DUBBERSTEIN

Brown University Studies XIX

BROWN UNIVERSITY PRESS
PROVIDENCE, RHODE ISLAND

-99	3	-410	5	27
-99	4	-410	6	25
-99	5	-410	7	25
-99	6	-410	8	24
-99	7	-410	9	23
-99	8	-410	10	23
-99	9	-410	11	21
-99	10	-410	12	20
-99	11	-409	1	19
-99	12	-409	2	17
-99	12b	-409	3	18

	Date of New Moon.			Date of Initial Sunset.			Difference, Sunset – New Moon. d
A	– 470	August	24·28	August	25·27		0·99
B	– 464	December	14·54	December	15·22		0·68
D	– 459	October	20·59	October	21·23		0·64
G	– 445	September	17·27	September	18·25		0·98
E	– 445	November	15·75	November	14·22		– 1·53
F	– 439	August	12·31	August	12·27		– 0·04
J	– 415	December	12·48	December	13·22		0·74
K	– 409	January	16·63	January	17·23		0·60

Sequences

- An analysis of these tables confirms earlier claims that sequences of more than two months of either 29 or 30 days in succession occur fairly commonly: so there are 63 sequences of three 29-day months in succession and 386 sequences of three 30-day months in succession. Even longer sequences are also present but only for 30-day months: there are 79 sequences of four 30-day months in succession and there is one sequence of five 30-day months in succession (Nabonassar lunation numbers 2961 to 2965).

31 Days

- There is also one lunation of unusual length: the month Arahsamna in the 10th year of Darius I (Nabonassar lunation number 2916) has a length of 31 days.

Criterion

moonlag(*date*,*loc*) :=

moonset(*date*,*loc*) - **sunset**(*date*,*loc*)

$$\textbf{babylonian-new-month-on-or-before}\,(date) \quad \stackrel{\text{def}}{=}$$

$$\underset{d \geqslant \tau}{\text{MIN}} \quad \left\{ \textbf{moonlag}\,(d-1, \textbf{babylon}) > lag \right\}$$

where

$$\begin{aligned}
approx \quad &= \quad \left\lfloor date - \frac{\textbf{lunar-phase}\,(date)}{12^\circ} \right\rfloor \\
lag \quad &= \quad 48^{\text{m}} \\
\tau \quad &= \quad \begin{cases} approx - 33 & \\ \quad \textbf{if } date - approx \leqslant 3 \text{ and } \textbf{moonlag}\,(date-1, \textbf{babylon}) \leqslant lag & \\ approx - 3 & \textbf{otherwise} \end{cases}
\end{aligned}$$

$$\textbf{fixed-from-babylonian}\left(\begin{array}{|c|c|c|c|}\hline year & month & leap & day \\ \hline\end{array}\right) \stackrel{\text{def}}{=}$$

$$\textbf{babylonian-new-month-on-or-before}\,(midmonth) + day - 1$$

where

$$month_1 = \begin{cases} month & \textbf{if } leap \text{ or } \{(year \bmod 19) = 18 \text{ and } month > 6\} \\ month - 1 & \textbf{otherwise} \end{cases}$$

$$months = \left\lfloor \frac{1}{19} \times ((year - 1) \times 235 + 13) \right\rfloor + month_1$$

$$midmonth = \textbf{babylonian-epoch} + \text{round}\,(\textbf{mean-synodic-month} \times months) + 15$$

babylonian-from-fixed $(date) \stackrel{\text{def}}{=}$ | *year* | *month* | *leap* | *day* |

where

$$
\begin{aligned}
\mathit{crescent} &= \textbf{babylonian-new-month-on-or-before}\,(\mathit{date}) \\
\mathit{months} &= \operatorname{round}\left(\frac{\mathit{crescent} - \textbf{babylonian-epoch}}{\textbf{mean-synodic-month}}\right) \\
\mathit{year} &= \left\lfloor \frac{1}{235} \times (19 \times \mathit{months} + 5) \right\rfloor + 1 \\
\mathit{approx} &= \textbf{babylonian-epoch} \\
&\quad + \operatorname{round}\left(\left\lfloor \tfrac{1}{19} \times ((\mathit{year} - 1) \times 235 + 13) \right\rfloor \times \textbf{mean-synodic-month}\right) \\
\mathit{new\text{-}year} &= \textbf{babylonian-new-month-on-or-before}\,(\mathit{approx} + 15) \\
\mathit{month}_1 &= \operatorname{round}\left(\frac{1}{29.5} \times (\mathit{crescent} - \mathit{new\text{-}year})\right) + 1 \\
\mathit{special} &= (\mathit{year} \bmod 19) = 18 \\
\mathit{leap} &= \begin{cases} \mathit{month}_1 = 7 & \textbf{if } \mathit{special} \\ \mathit{month}_1 = 13 & \textbf{otherwise} \end{cases} \\
\mathit{month} &= \begin{cases} \mathit{month}_1 - 1 & \textbf{if } \mathit{leap} \text{ or } \{\mathit{special} \text{ and } \mathit{month}_1 > 6\} \\ \mathit{month}_1 & \textbf{otherwise} \end{cases} \\
\mathit{day} &= \mathit{date} - \mathit{crescent} + 1
\end{aligned}
$$

```
(defun babylonian-new-month-on-or-before (date)
  ;; TYPE fixed-date -> fixed-date
  ;; Fixed date of start of Babylonian month on or before
  ;; Babylonian $date$.  Using lag of moonset criterion.
  (let* ((approx ; Approximate conjunction.
          (floor (- date (/ (lunar-phase date) (deg 12)))))
         (lag (mn 48)) ; 48 minutes
         (tau ; Check if not yet on $date$.
          (if (and (<= (- date approx) 3)
                   (<= (moonlag (1- date) babylon) lag))
              (- approx 33) ; Must go back a month.
            (- approx 3))))
    (next d tau (> (moonlag (1- d) babylon) lag))))
```

Comparison

- Historical dates often 1-2 days off
- Moonlag dates often 1 off from Parker/ Gent

Judah = Babylon

[3] See Eduard Mahler, *SKAW 101/II* March, 1892, 1–17, and "Das Kalenderwesen," in *9th ICO*, 1892; "Der Schaltcyclus der Babylonier," *ZA* 9 (1894), 42–61; "Der Saros-Canon der Babylonier und der 19-jähriger Schaltcyclus derselben," *ZA* 11 (1896), 41–46; "Der Schaltcyclus der Babylonier," *ZDMG* 52 (1898), 227–246; "Der Kalender der Babylonier," in *Hilprecht Anniversary Volume* (Chicago, 1909), 1–13.

Al-Yahudu

VISIBILITY OF THE NEW MOON IN CUNEIFORM AND RABBINIC SOURCES

BEN ZION WACHOLDER and DAVID B. WEISBERG

Hebrew Union College Annual
Vol. 42 (1971), pp. 227-242

בבלי ראש השנה יט, ב

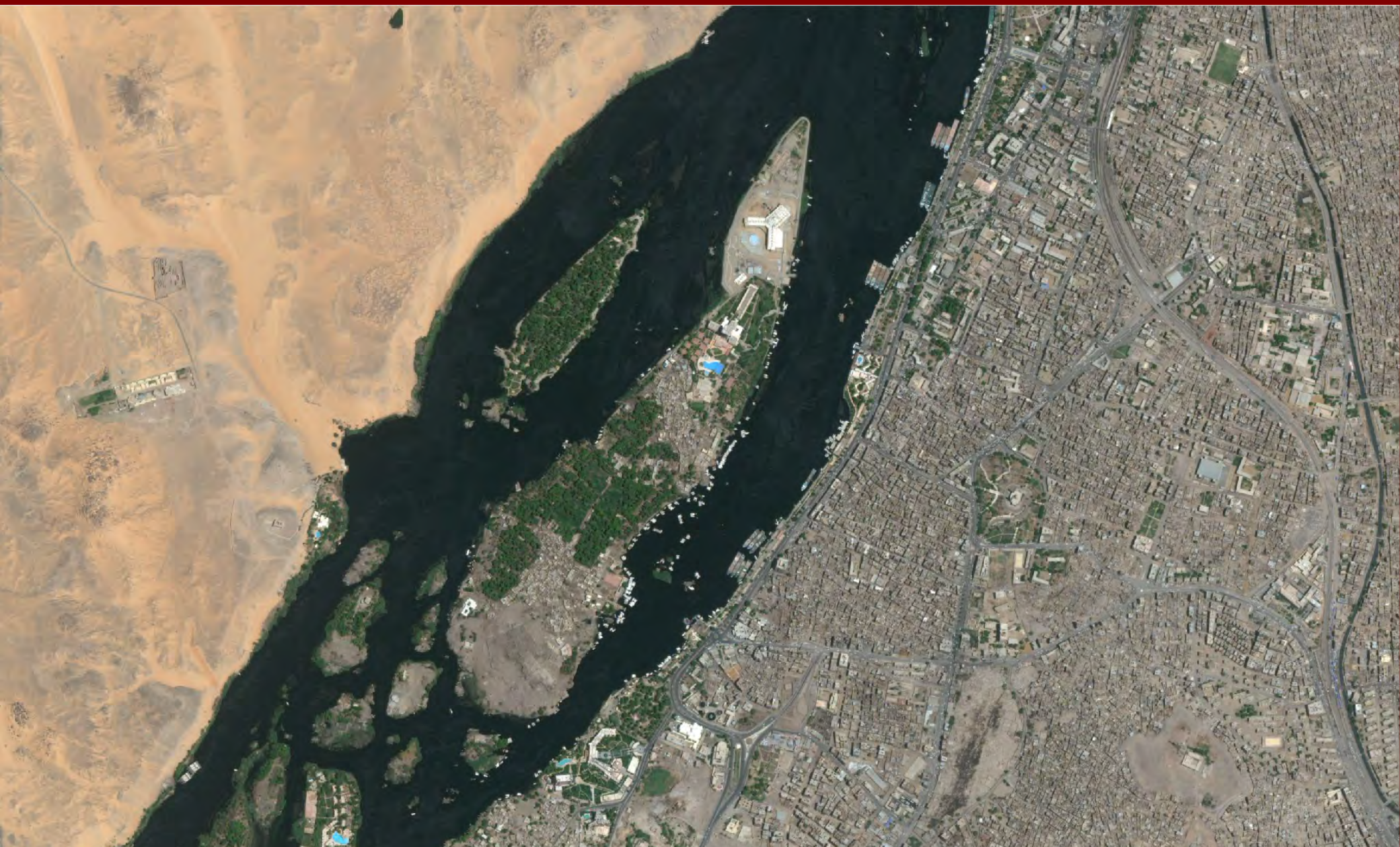
אמר רבי חינא בר כהנא א׳ רב/ רבי/ שמואל:

מימות עזרא ואילך לא מצינו אלול מעובר

בבלי סנהדרין יב, א

- אין מעברין את השנה לפני ר״ה
- אין מעברין אלא אדר

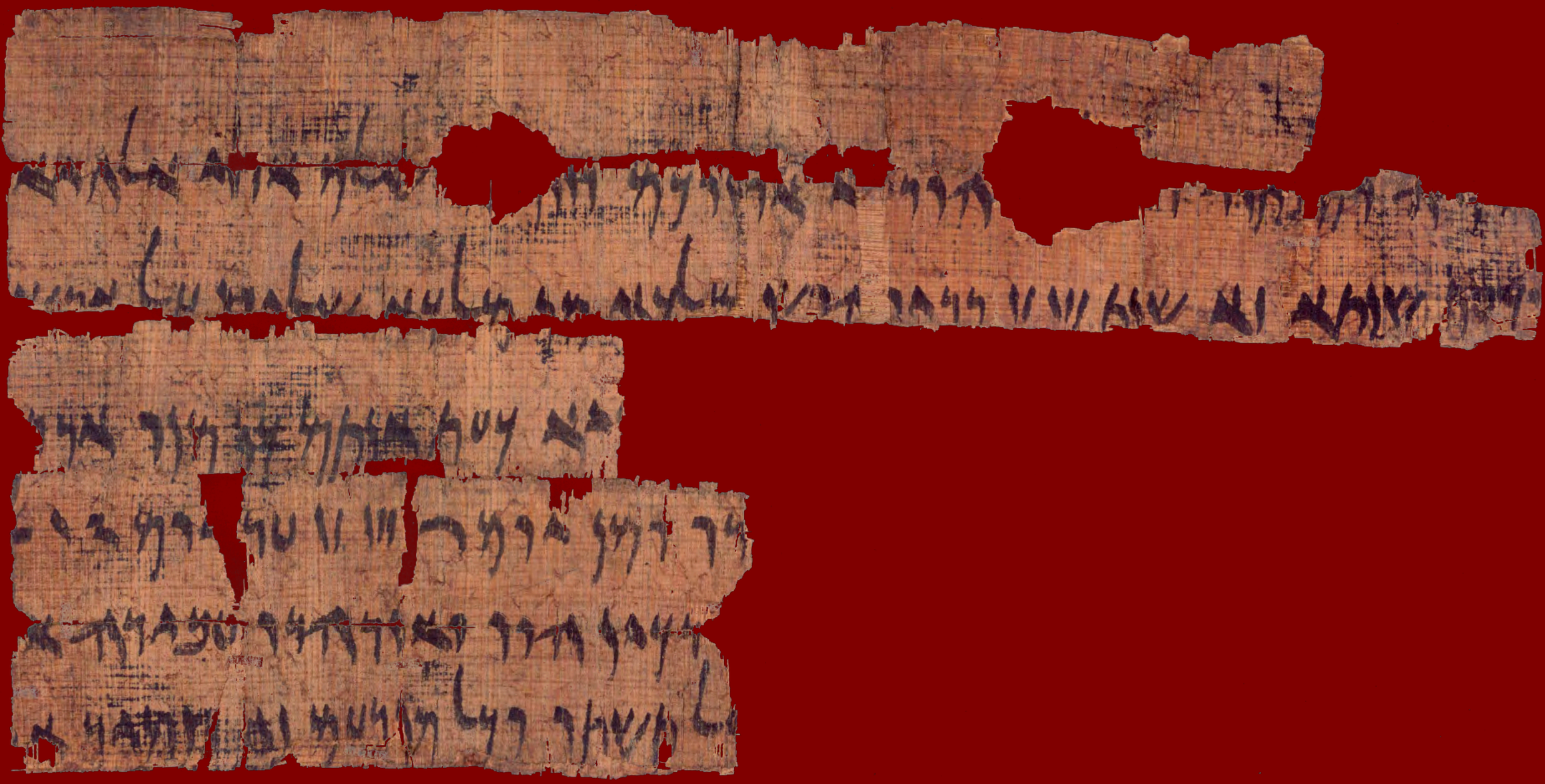
Elephantine



Document[18]	Egyptian date in document (with regnal year)	Equivalent Julian date (with year BCE)	Babylonian date in document	Babylonian date, Elephantine (E)	Babylonian date, Babylon (B)	Discrepancy
C5	28 Pahons, 15 Xerxes I	Sunday 12 September, 471	18 Elul	18 Elul	17 Elul	Nil (E), 1 day (B)
C6	17 Toth, 21 Xerxes	Monday 2 January, 464	18 Kislev	17 Kislev[19]	17 Kislev	1 day
C8–9[20]	21 Mesore, 6 Artaxerxes I	Thursday 1 December, 459	21 Kislev	21 ?	21 Marheshvan	1 month
C10	4 Toth, 9 Artaxerxes	Thursday 18 December, 456	7 Kislev	11 Kislev	11 Kislev	4 days
K1	25 Phamenoth, 14 Artaxerxes	Saturday 6 July, 451	20 Sivan	19 Sivan	19 Sivan	1 day
K2	[30] Pharmuthi, 16 Artaxerxes	Monday 9 August, 449	18 [Av]	16 Av	16 Av	2 days
C15	6 Epiph, [16[21] Artaxerxe]s	Thursday 14 October 449	24 Tishre	23 Tishre	22 Tishre[22]	1 day (E), 2 days (B)
K14	20 Tybi, [19 Artaxerxes]	Tuesday 1 May, 446	8 Iyyar	8 Iyyar	8 Iyyar[23]	Nil
C13	10 Mesore, 19 Artaxerxes	Saturday 17 November, 46	2 Kislev	29 Marheshvan	29 Marheshvan	2 days
C14	19 Pahons, 25 Artaxerxes	Monday 26 August, 440	14 Av	13 Av	12 Av	1 day (E), 2 days (B)
K3	9 Payni, 28 Artaxerxes	Wednesday 14 September, 437	7 Elul	6 Elul	6 Elul	1 day

K4	25 Epiph, 31 Artaxerxes	Wednesday 30 October, 434	25 Tishre	25 Tishre	25 Tishre	Nil
K5	7 Phamenoth, 38 Artaxerxes	Friday 12 June, 427	20 Sivan	20 Sivan	20 Sivan	Nil
K6	8 Pharmuthi, [4] Darius II	Monday 11 July, 420	8 Tammuz	8 Tammuz	7 Tammuz	Nil (E), 1 day (B)
C20	Payni, 4 Darius	2 September – 1 October, 420	Elul	Elul (2 September – 1 October)	Elul (2 September – 1 October)	Nil[24]
K7	Epiph	2–31 October, 420	Tishre	Tishre (2–31 October)	Tishre (2–31 October)	Nil
K8	22 Payni, 8 Darius	Tuesday 22 September, 416	6 Tishre	6 ?	6 Elul	1 month
C25	12 Toth, 9 Darius	Wednesday 16 December, 416	3 Kislev, 8 Darius[25]	2 Kislev	2 Kislev	1 day
C28	9 Athyr, 14 Darius	Tuesday 10 February 410	24 Shevat	23 Shevat	23 Shevat	1 day
K9	29 Mesore, 1 Artaxerxes II	Thursday 25 November 404	24 Marheshvan	23 Marheshvan	23 Marheshvan	1 day
K10	8 Choiak, 3 Artaxerxes	Thursday 9 March, 402	20 Adar	20 Adar	20 Adar I	Nil

Passover Papyrus



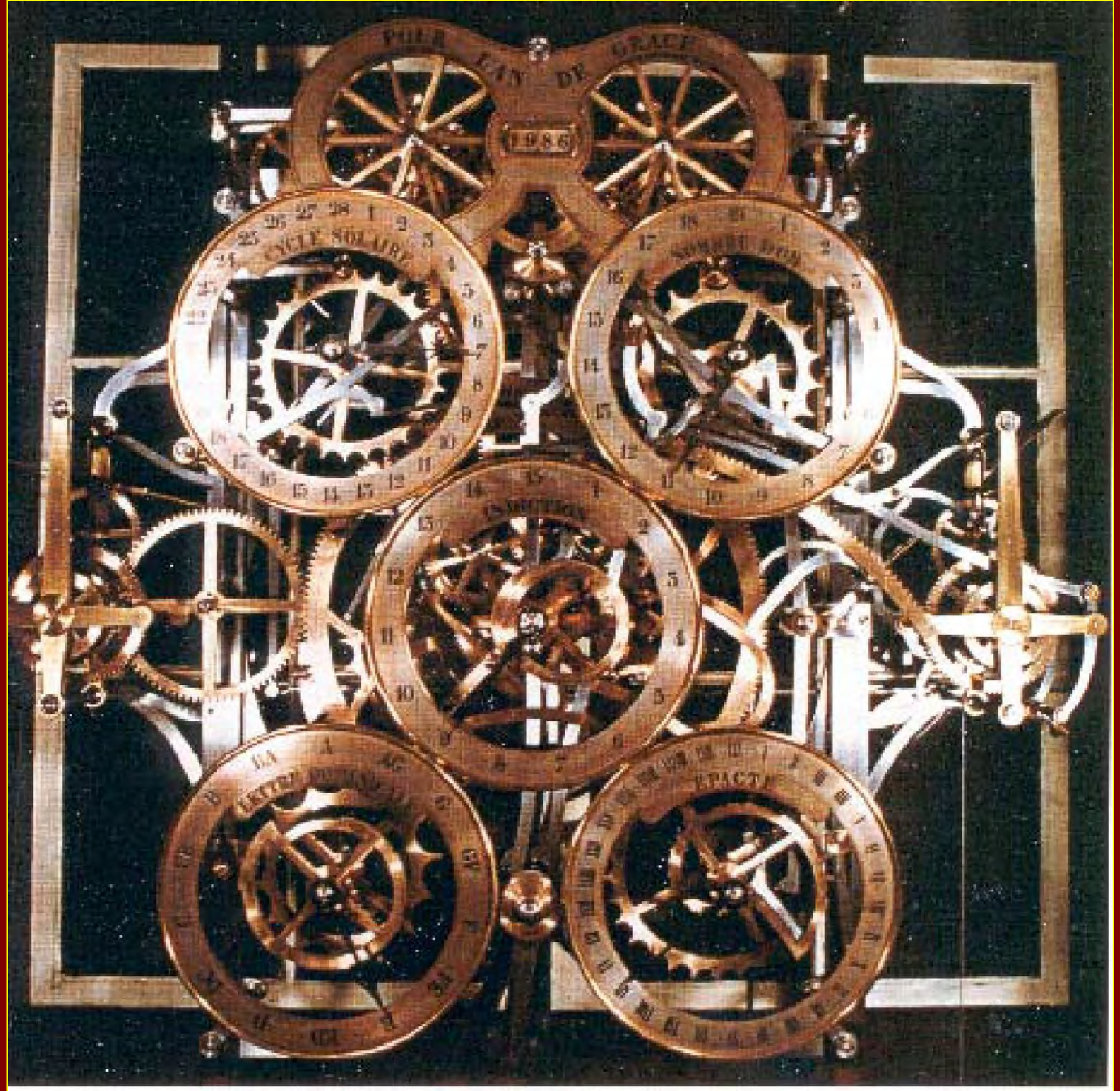
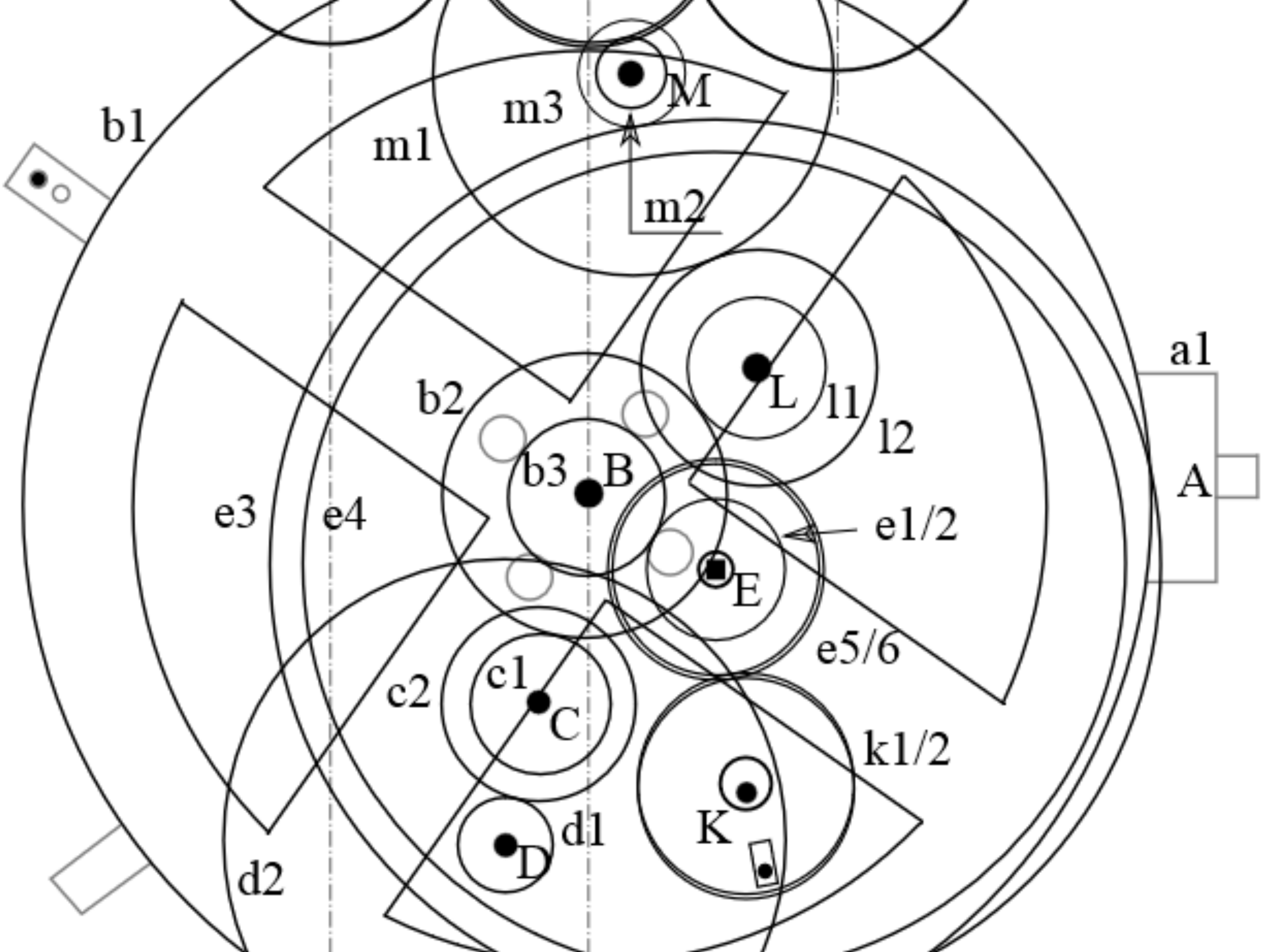
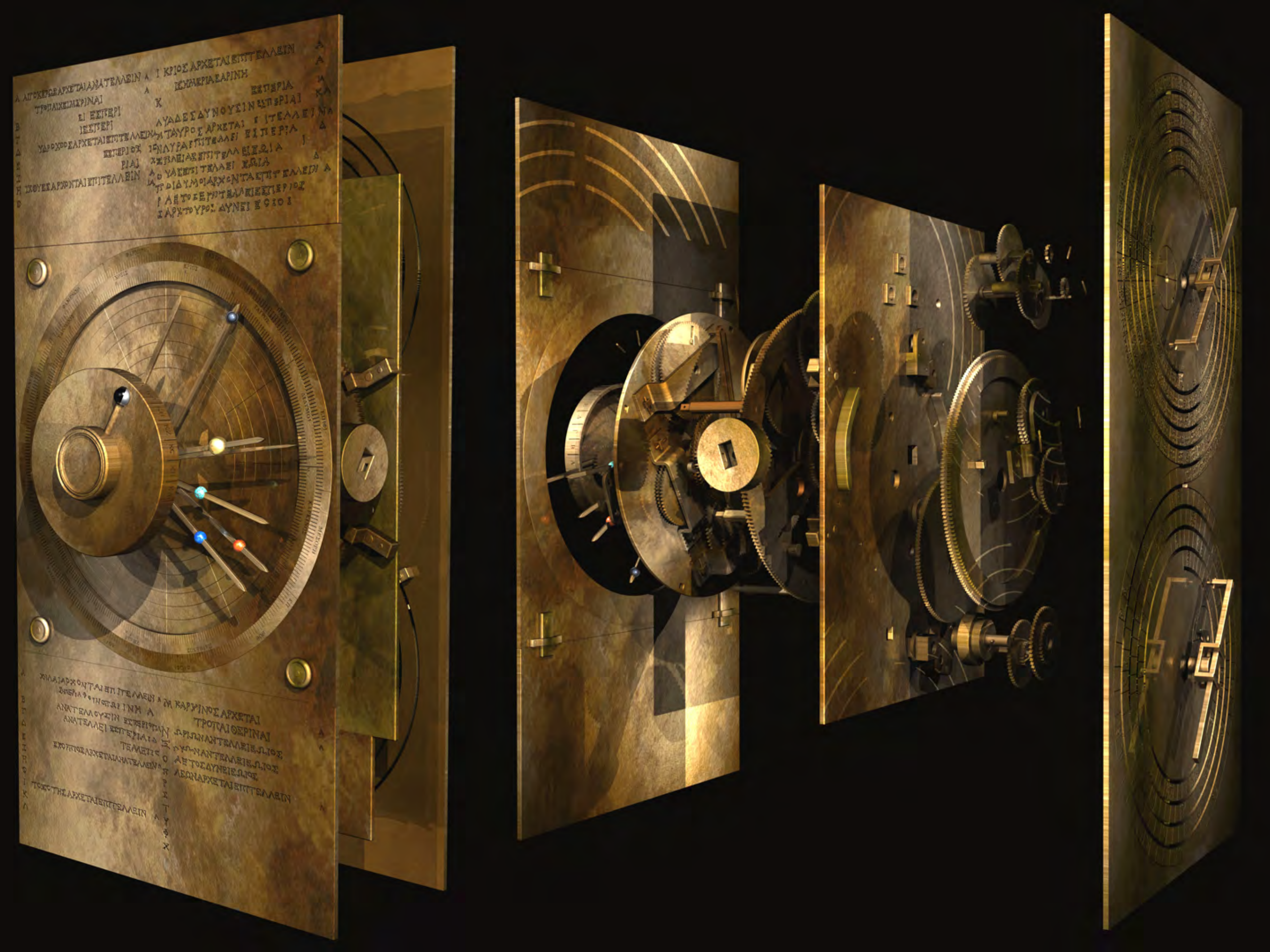

1985

Figure 1 | The surviving fragments of the Antikythera Mechanism. The 82


b1
m1
m3
M
m2
a1
A
l1
l2
L
b2
b3
B
e3
e4
e1/2
E
e5/6
c2
c1
C
k1/2
K
d1
D
d2



CROSS-CULTURAL COMPUTER

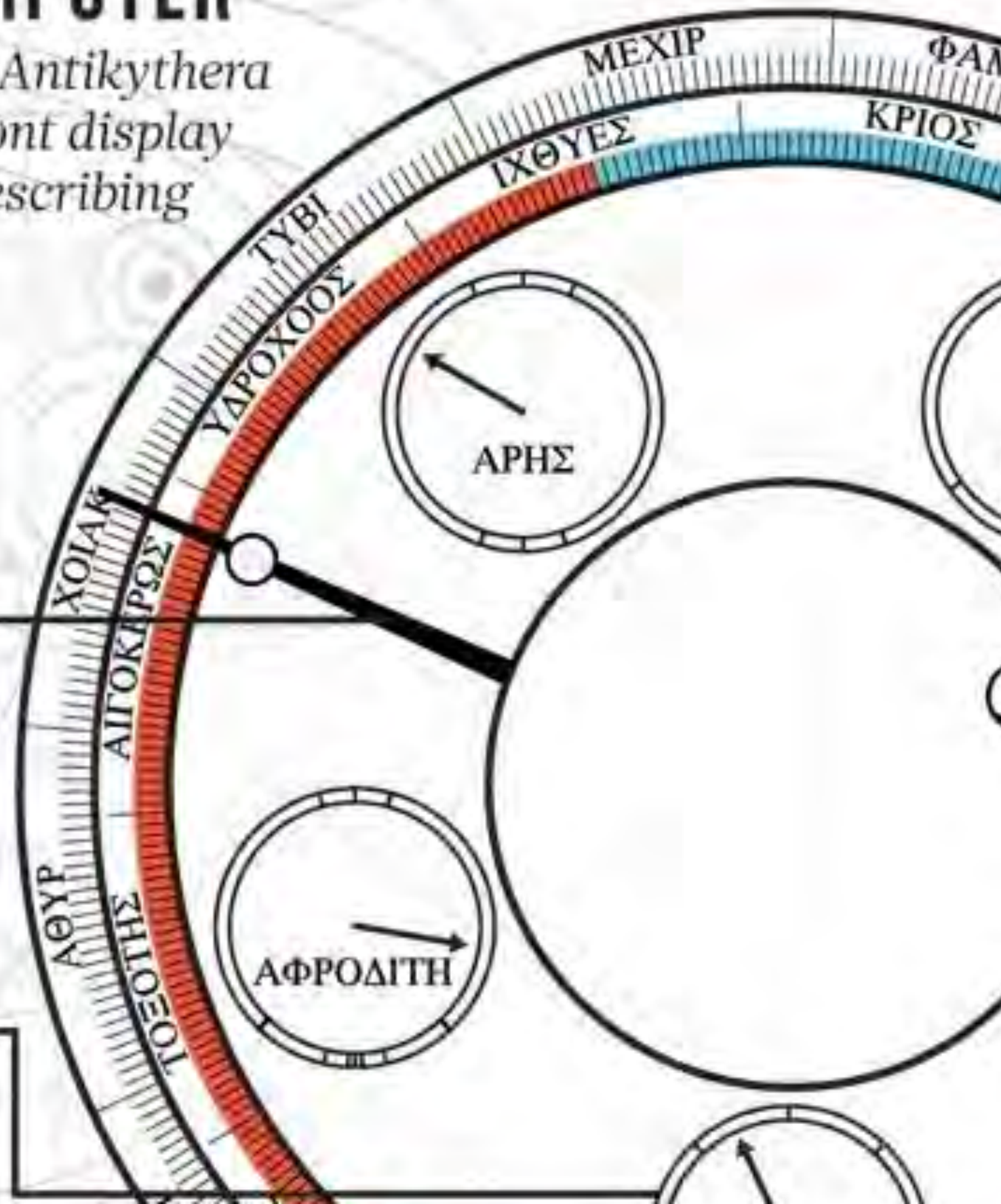
The latest reconstruction of the Antikythera mechanism suggests that its front display relied on Babylonian theories describing the Sun, Moon and planets.

SUN POINTER

Shows the date on the calendar scale, and the Sun's position in the sky on the zodiac scale. Makes one complete turn for each year.

PLANETARY DIALS

Five known planets — Mercury, Venus, Mars, Jupiter and Saturn — shown by individual dials. Might have shown the timing of key events in each planet's cycle, such as changes in direction.



The Hi
Calend

Hindu Month Names

(1) Chaitra	चैत्र	(7) Āśvina	आश्विन
(2) Vaiśākha	वैशाख	(8) Kārtika	कार्तिक
(3) Jyaishṭha	ज्यैष्ठ	(9) Mārgaśīrsha	मार्गशीर्ष
(4) Āshāḍha	आषाढ	(10) Pausha	पौष
(5) Śrāvaṇa	श्रावण	(11) Māgha	माघ
(6) Bhādrapada	भाद्रपद	(12) Phālguna	फाल्गुन

Veritable Variety

- Solar and Lunar
- Lunar in two flavors: new moon; full moon
- Ancient was simple; medieval, complicated
- Different authors used different values
- Some follow old methods; many use modern astronomical tables
- All are regionalized

Old Lunisolar Rule

$$y = \left\lceil \frac{m+1-c}{A} \right\rceil$$

where

$A = \frac{2223689}{180000}$ months (per year)

m = elapsed months

c = 2093611/2160000

Nice Cycles

- Coptic/Julian: 1 leap year out of 4
- Hebrew/Easter: 7 leap years out of 19
- Islamic (Arith.): 11 leap years out of 30
- Hindu Solar (Old): 149 out of 576
- Hindu Lunar (Old): 66,389 out of 180,000

Inversion

- Arithmetic
- By cases
- Linear search
- Binary search

Query: Sacha Stern

- The mean Hebrew month is 29 13753/25920 days.
- Given the day of week and time of a new moon, can one determine the date?

Solve

- $(m0 + mn) \bmod 7 = y$

- Use the Fermat-Euler Theorem and the totient function

- $\varphi(181440) = 41472$
- $n = (39673^{41471 \cdot 25920 \cdot y} - 92868) \bmod 181440$

Molad Seeker

Input day and time of molad

Monday 'ב | 23h (5pm) | 30m | 0p

**(day of week Sunday–Saturday, hours 0–23h [counting from prior eve], minutes 0–
parts 0–1079p)**

Click to compute year (starting with year 1 Anno Mundi) and month (Tishri–Elul)

First Hebrew date | 10262 AM | Tishri

Walther van Wijk (1924)

- Sometimes I cannot help regretting that only very few readers can rejoice with me in the simplicity of the method and the exactness of its results.