



Astronomy 350L

(Fall 2006)



The History and Philosophy of Astronomy

**(Lecture 2: Beginnings:
Prehistory, Egypt, Babylon)**

**Instructor: Volker Bromm
TA: Jarrett Johnson**

The University of Texas at Austin

The Beginning of Astronomy

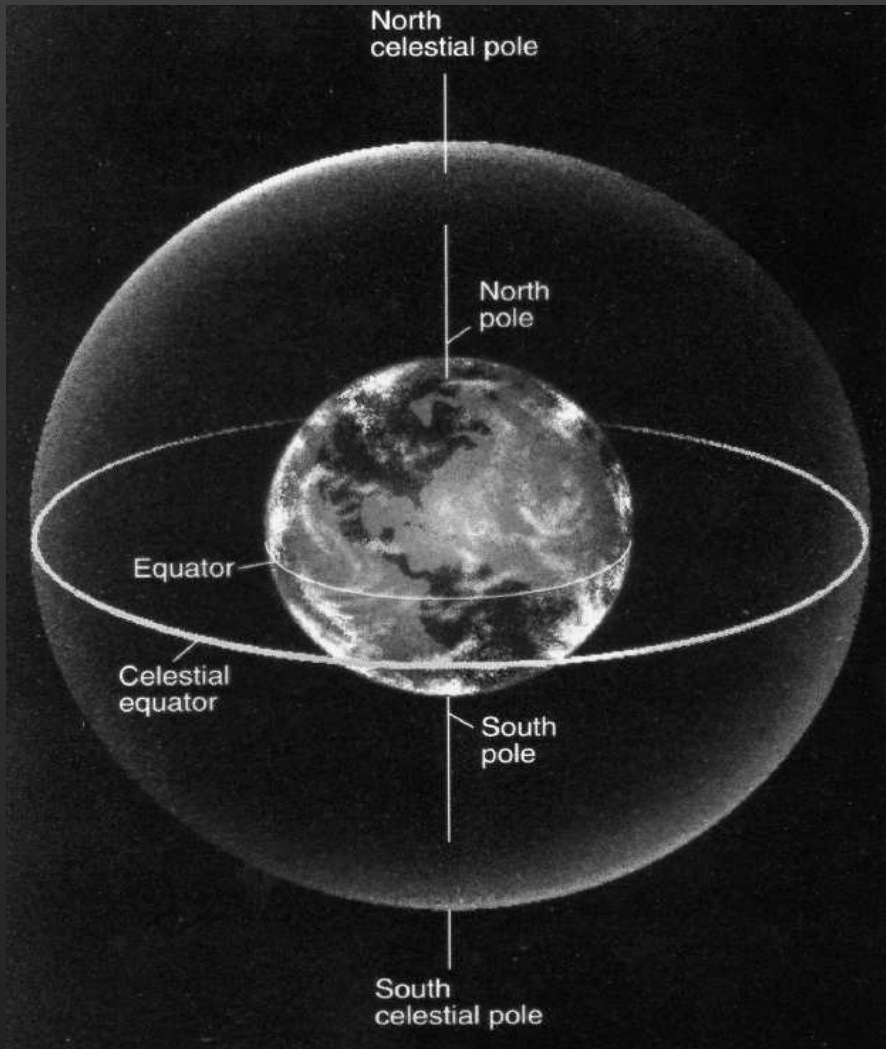
- Possible Motivations:

- Religion, creation myths, state ideology
- Timing of important events: rituals, agriculture
 - à calendars
- Navigation
- ...

- Early Astronomy:

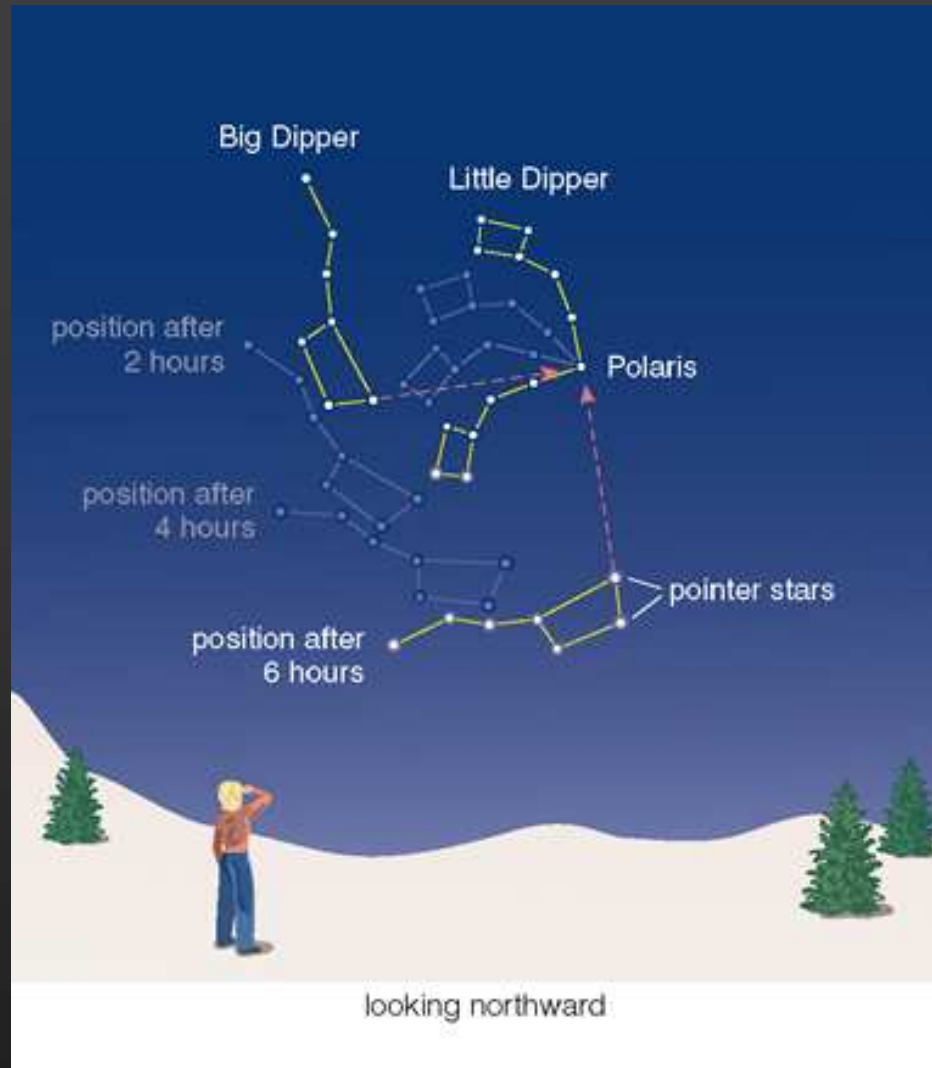
- Prehistory (e.g., Stone-Age Britain): no written record
 - à we can only speculate
- Ancient Egypt: calendar (to predict Nile flood)
- Mesopotamia/Babylon: search for patterns
 - à diligent gatherers of data

The Naked-Eye Sky: Basic Facts



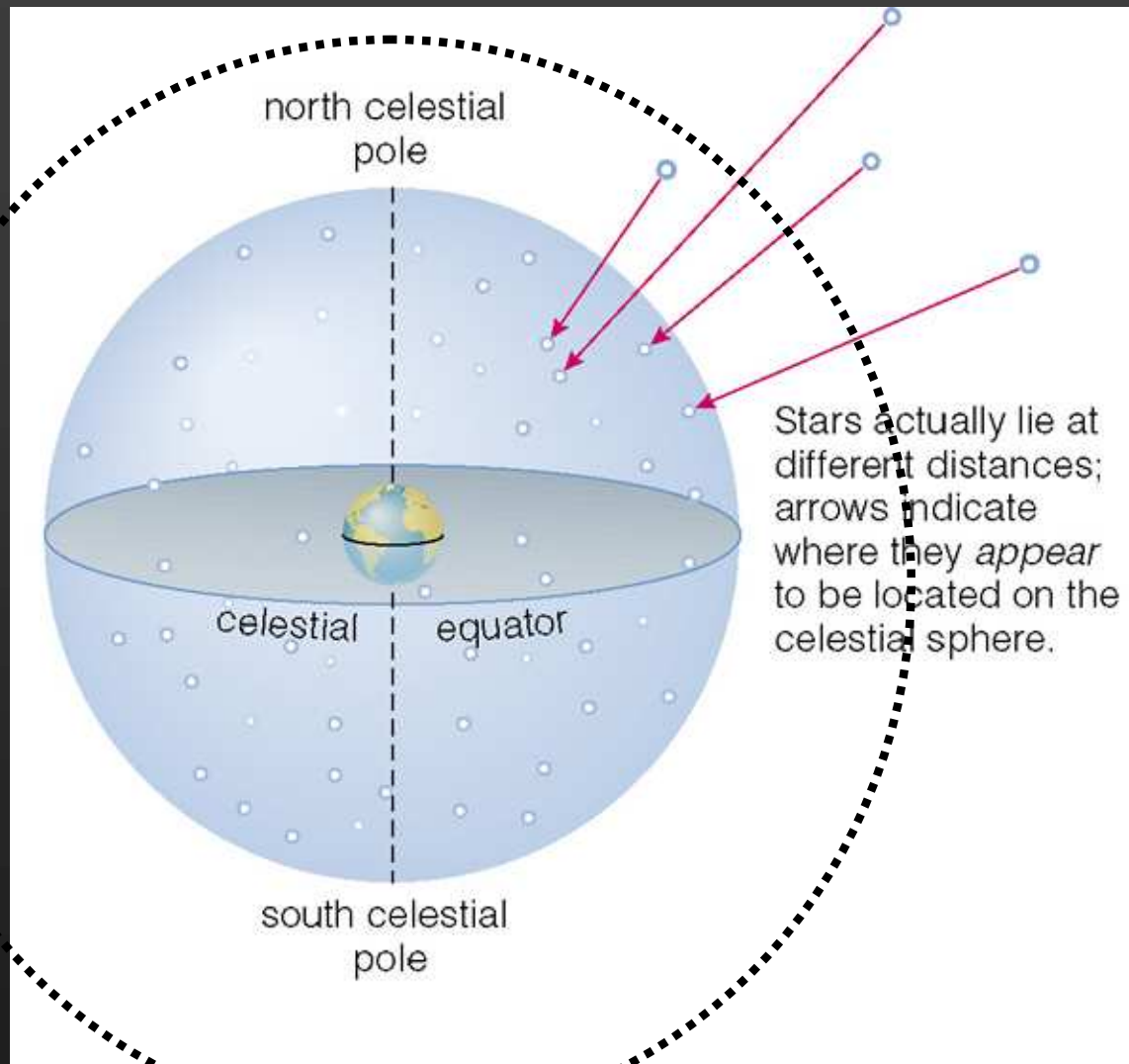
Earth's daily rotation à celestial sphere moves
East to West

Daily motion of the stars

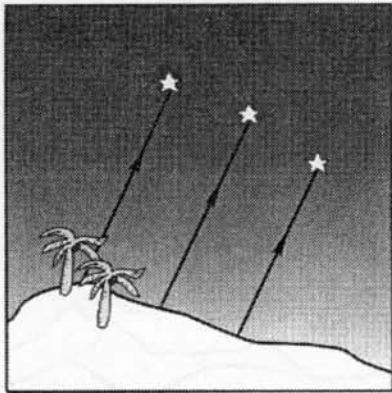


No change in relative positions $\longrightarrow$ fixed stars

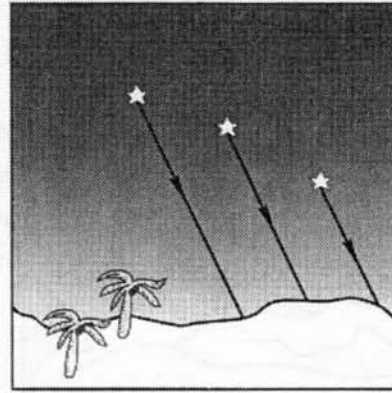
Quick reminder: Why does concept of celestial sphere work (from our present-day perspective)?



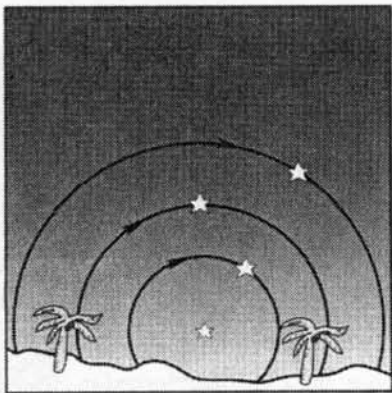
Tropic vs Temperate Sky



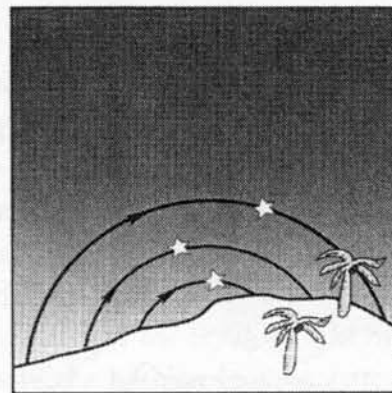
Looking east in the tropics
(a)



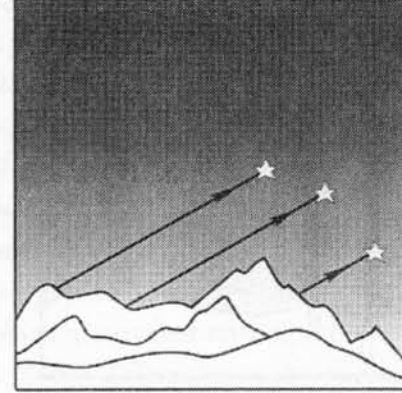
Looking west in the tropics
(b)



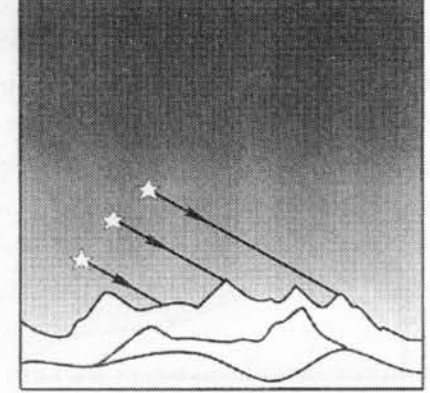
Looking north in the tropics
(c)



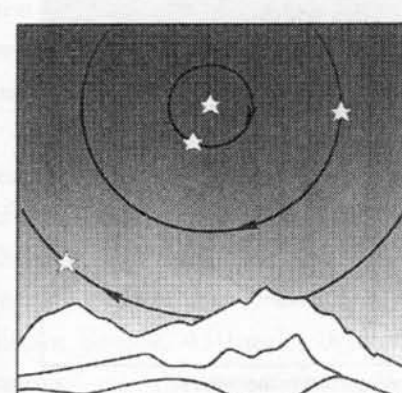
Looking south in the tropics
(d)



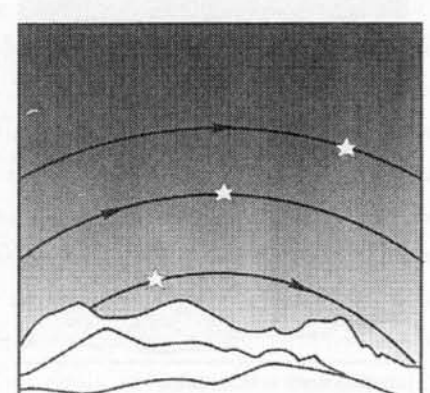
Looking east in the middle latitudes
(a)



Looking west in the middle latitudes
(b)



Looking north in the middle latitudes
(c)

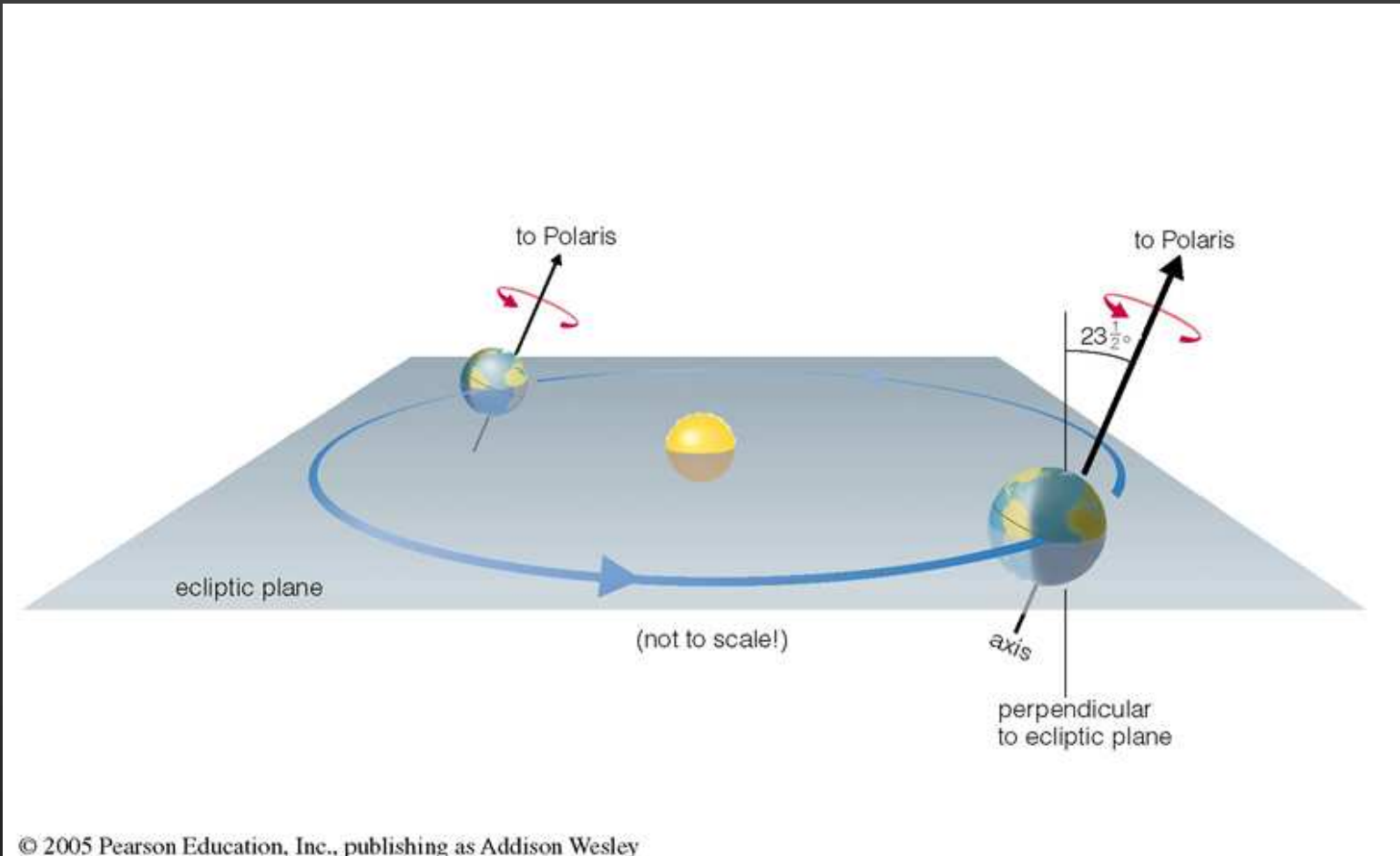


Looking south in the middle latitudes
(d)

Tropical Location
(e.g., Northern Yucatan)

High-latitude Location
(e.g., Britain)

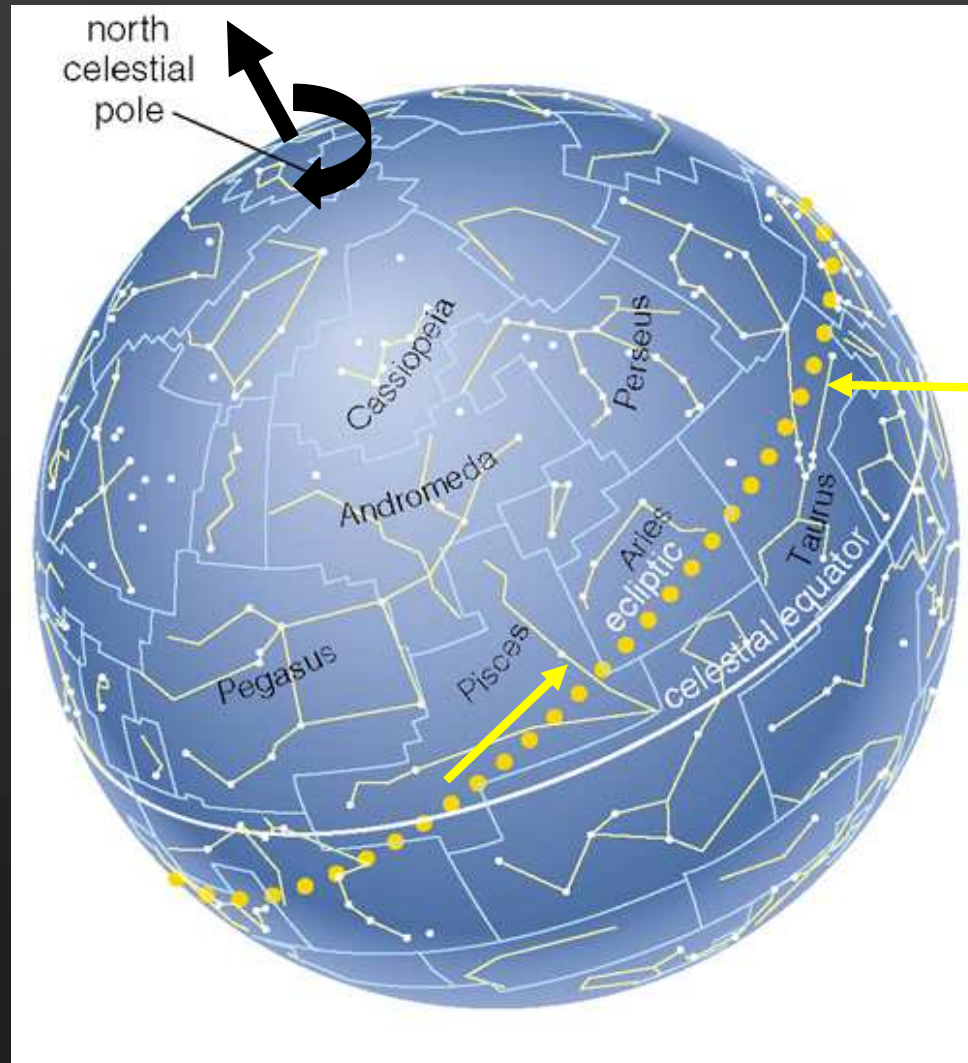
The Naked-Eye Sky: Basic Facts



Earth's annual motion around Sun:

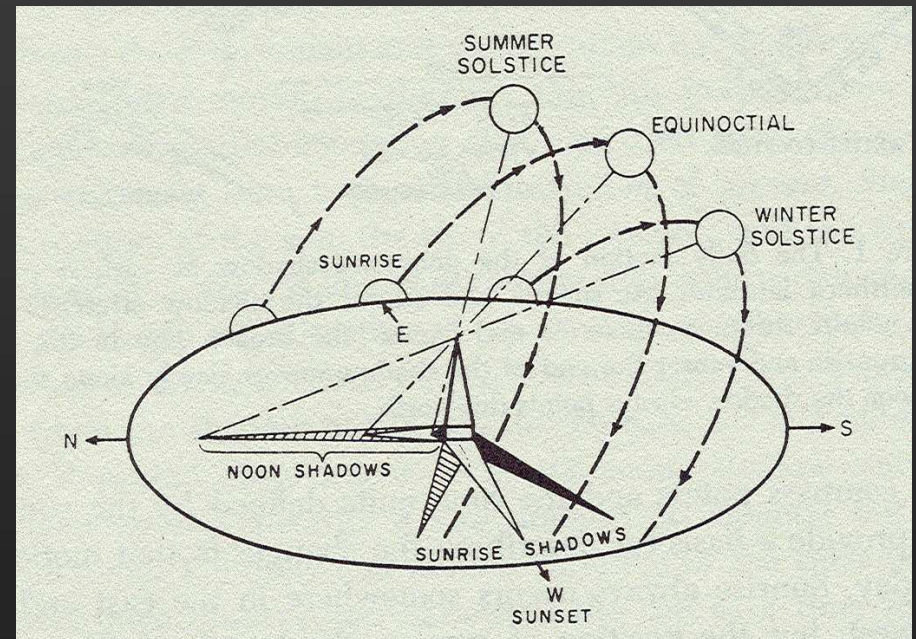
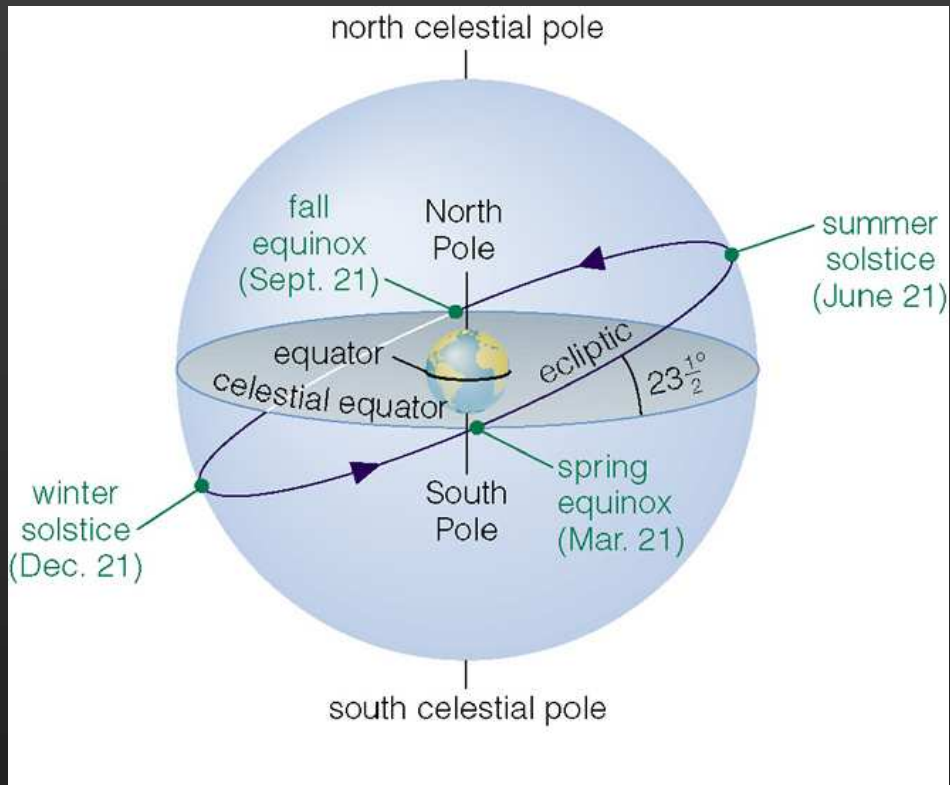
- in plane of the ecliptic
- Earth's axis of rotation is skewed toward ecliptic plane

Earth-Sun motion on Celestial Sphere:

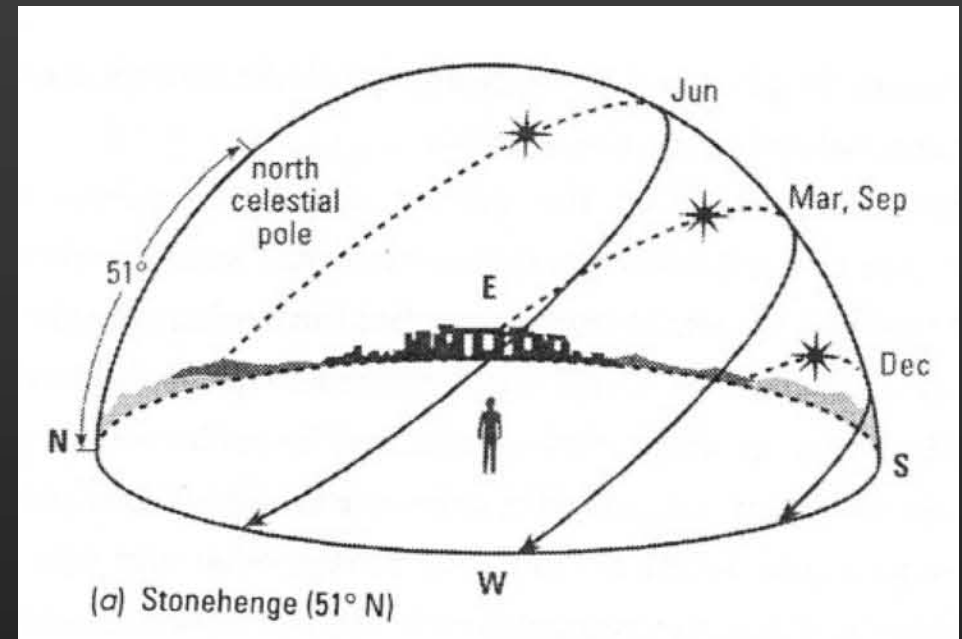
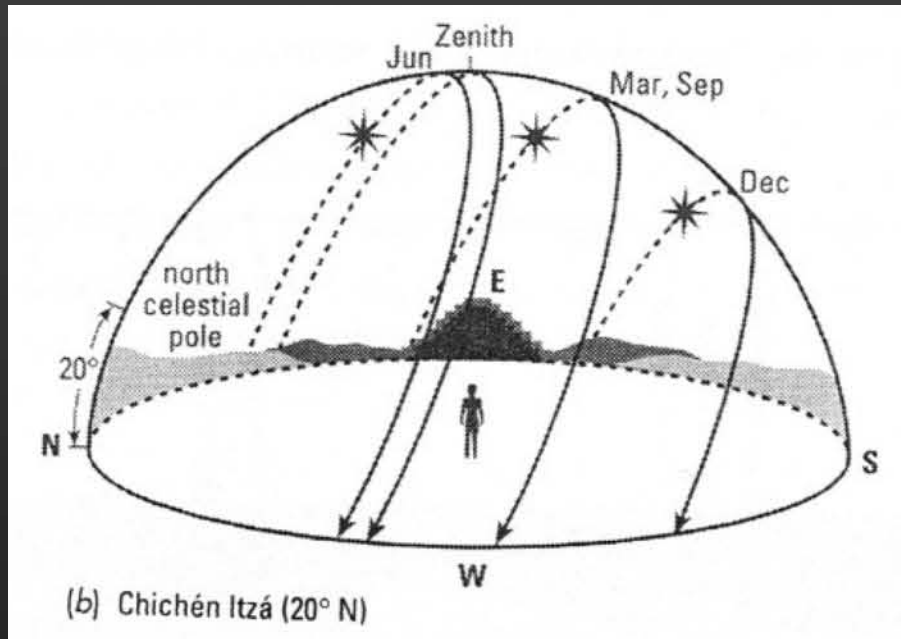


Sun moves
along ecliptic
once a year!

Sun's apparent motion and Seasons



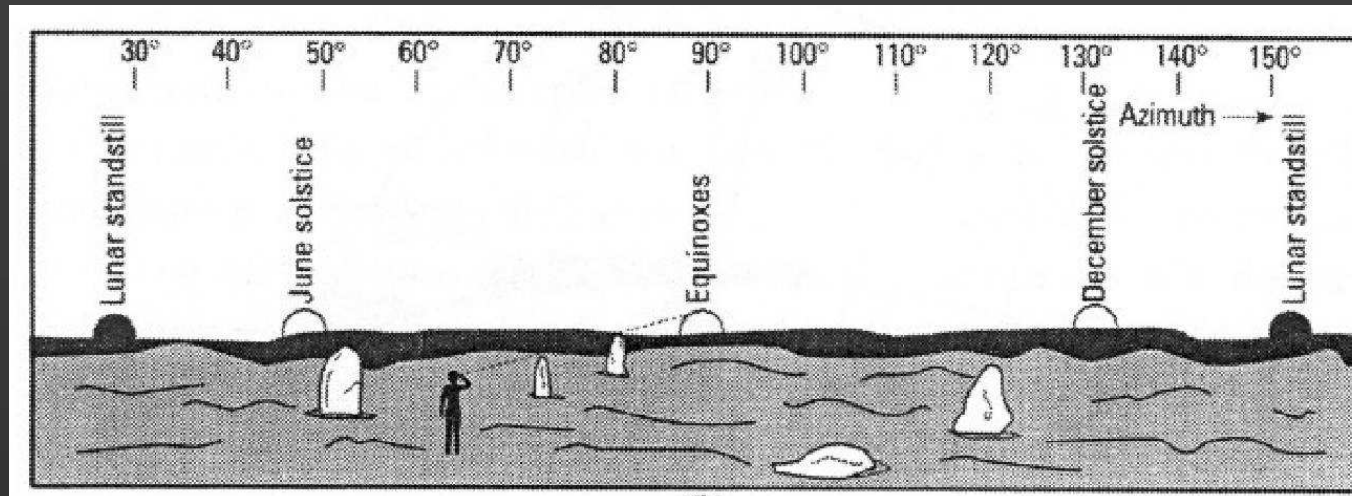
Tropic vs Temperate Sky



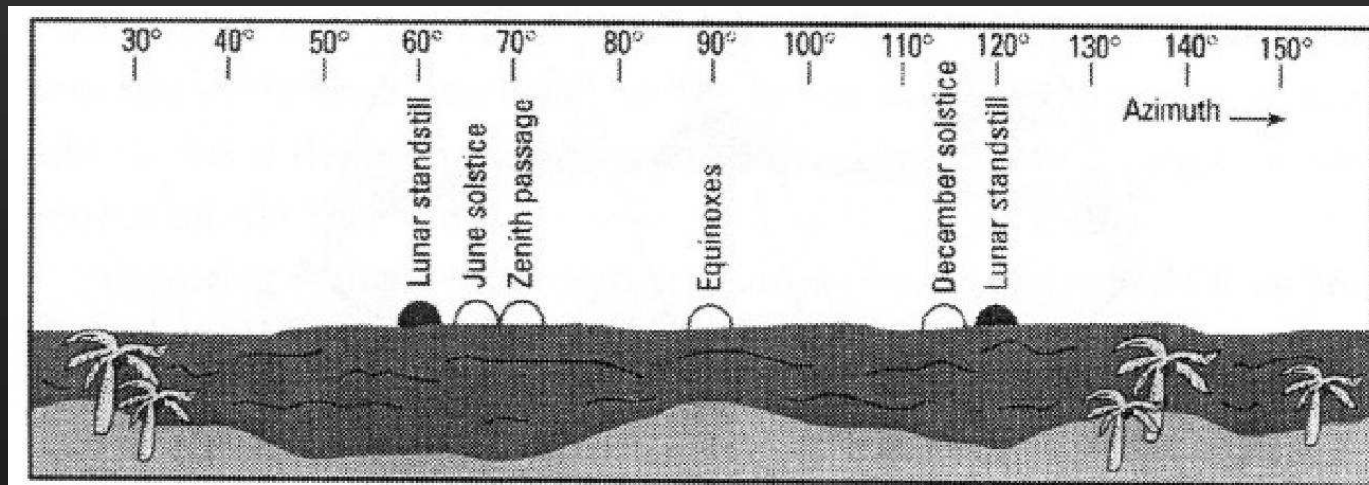
Tropical Location
(e.g., Northern Yucatan)

High-latitude Location
(e.g., Britain: Stonehenge)

Tropic vs Temperate Sky

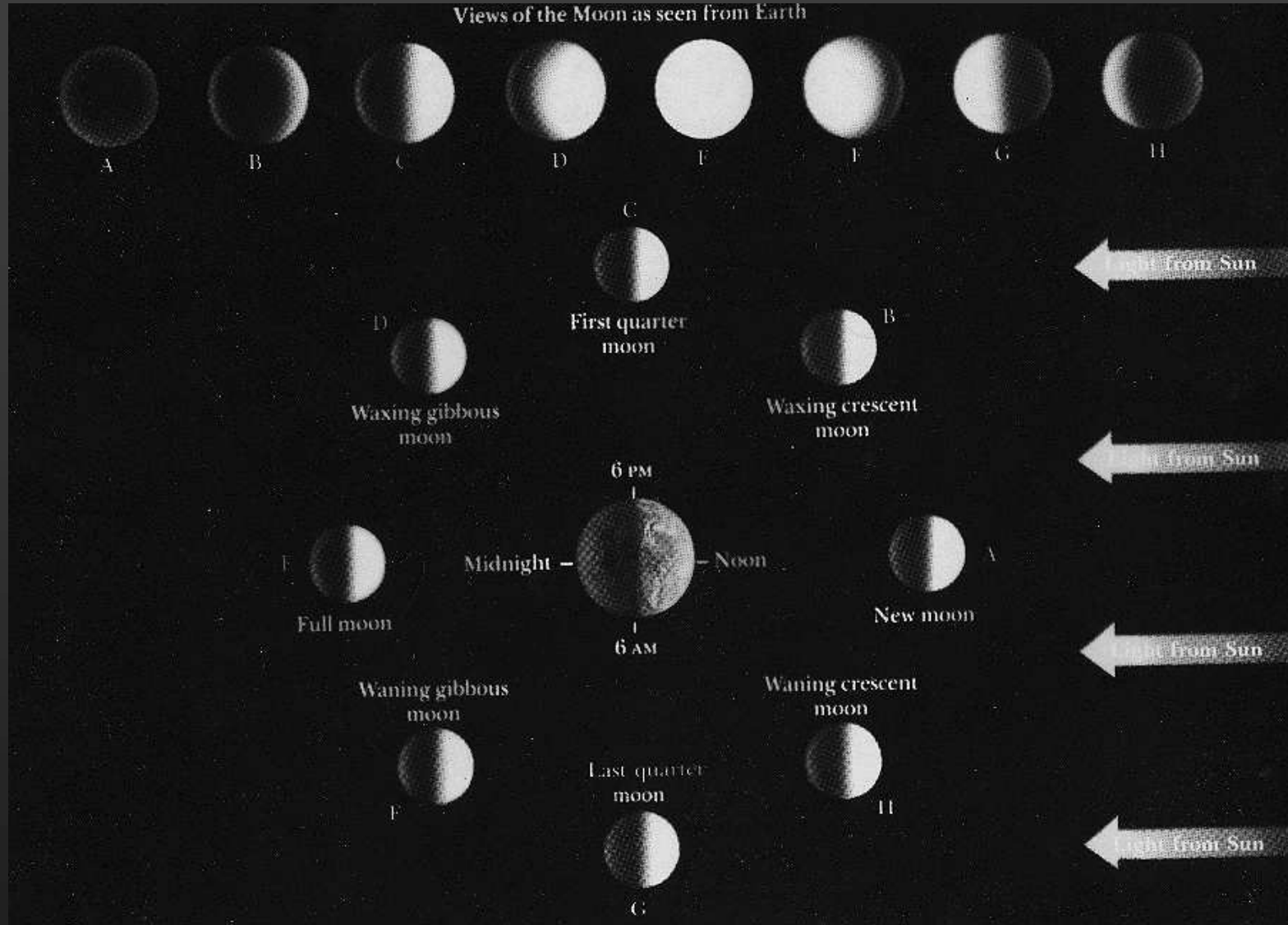


High-latitude Location (e.g., Britain: Stonehenge)



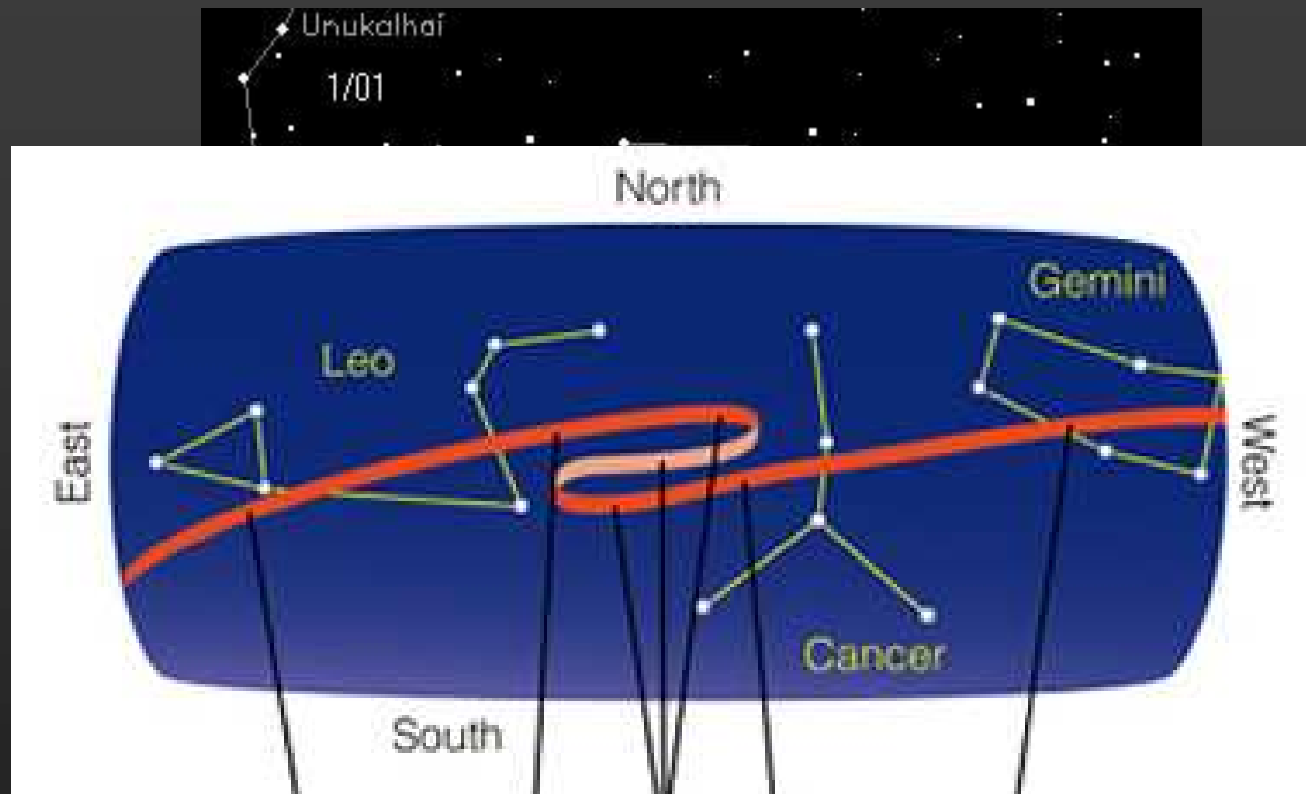
Tropical Location (e.g., Northern Yucatan)

The Naked-Eye Sky: Basic Facts



Lunar Cycle: ~29.5 days to reach same phase again!

Naked-Eye Sky: Irregular motion of planets



- Retrograde motion of planets, opposite direction to daily motion (E-W) of celestial sphere

Prehistory: Alignment Astronomy



Callanish, Hebrides (ca 3,000BC)

à Megalithic structures

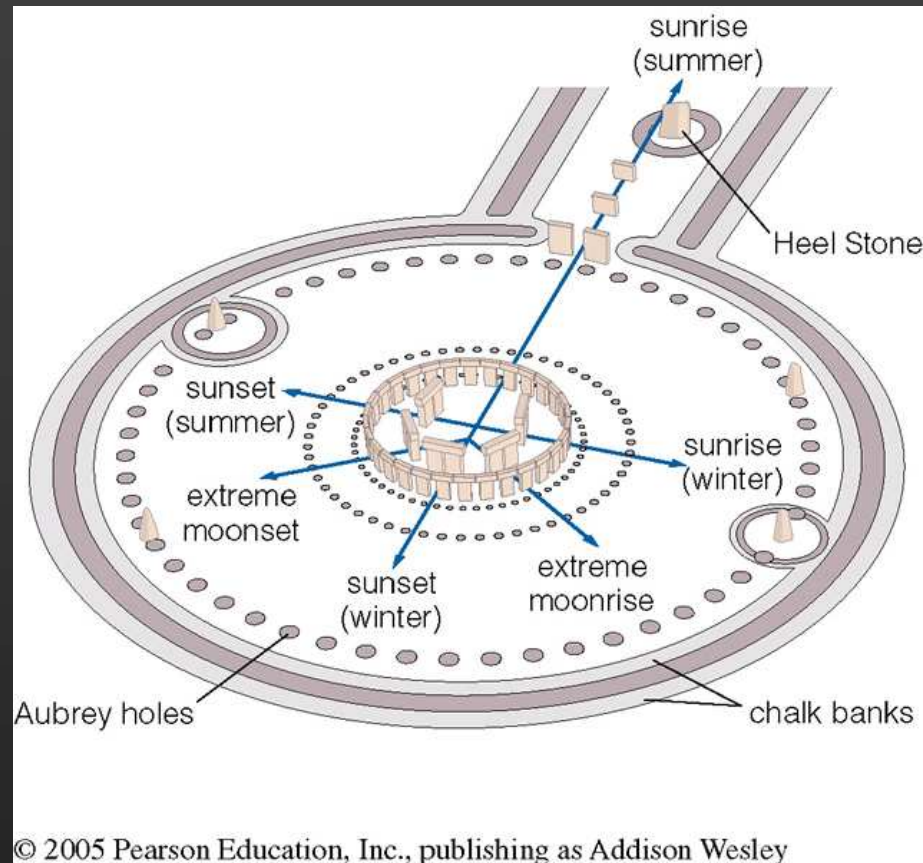
Full moon rises in this location once every 18.6 years!

Prehistory: Alignment Astronomy



Stonehenge à Late Neolithic-Early Bronze Age
(ca 3,000 -1,000 BC)

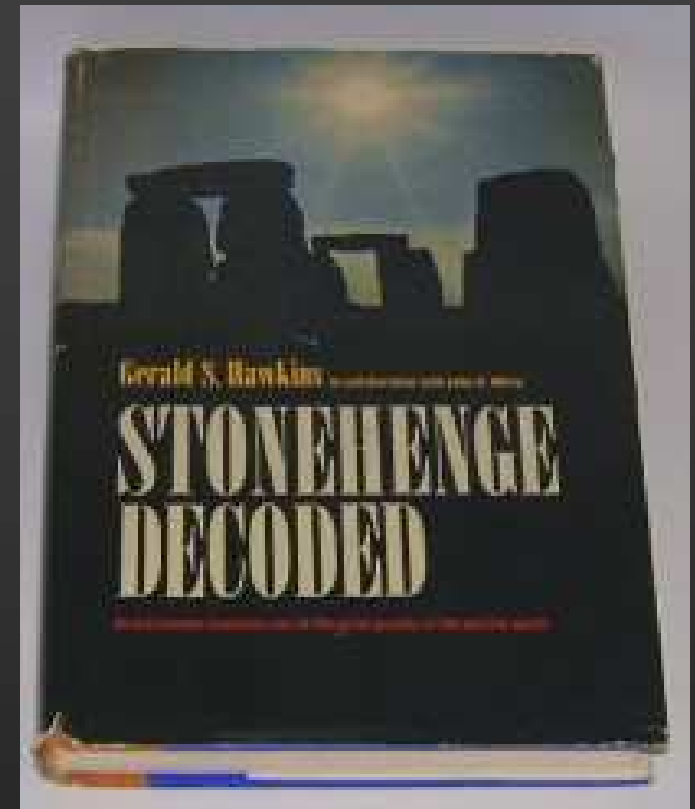
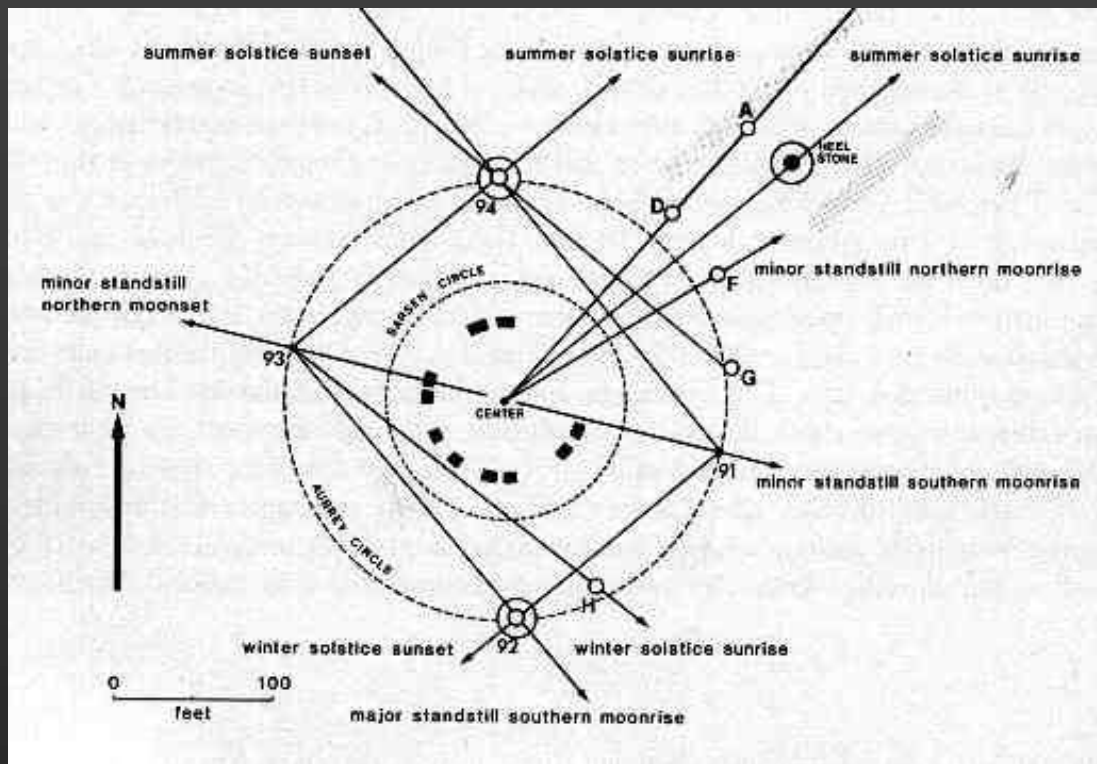
Prehistory: Alignment Astronomy



Architecture reflects cosmic symbolism!

à But was it a neolithic “precision observatory”?

Prehistory: Alignment Astronomy

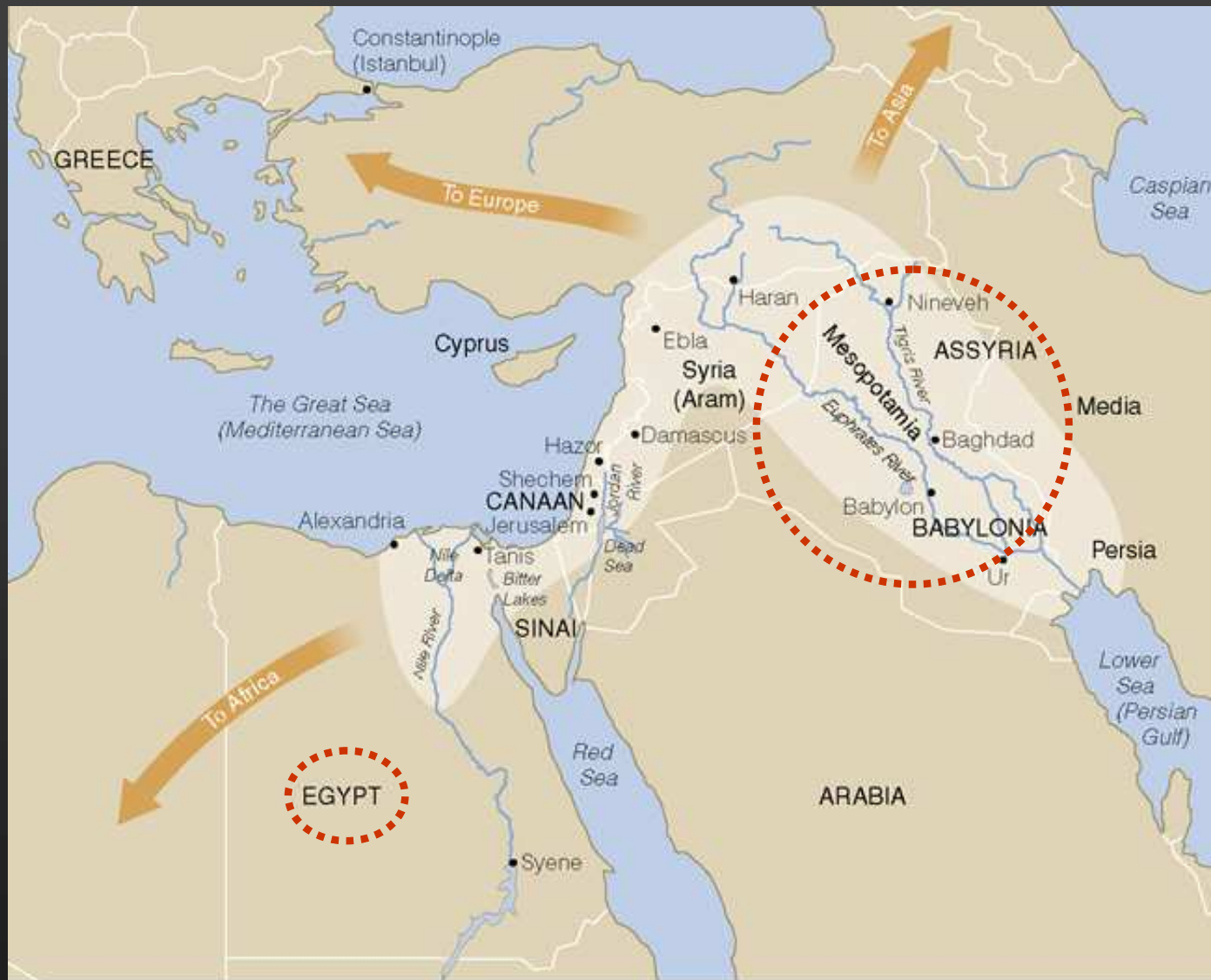


(Gerald Hawkins, 1965)

Was it a neolithic “precision observatory”?

à Probably not!

Dawn of Civilization (and of recorded history)



(~ 5,000 – 3,000 BC)

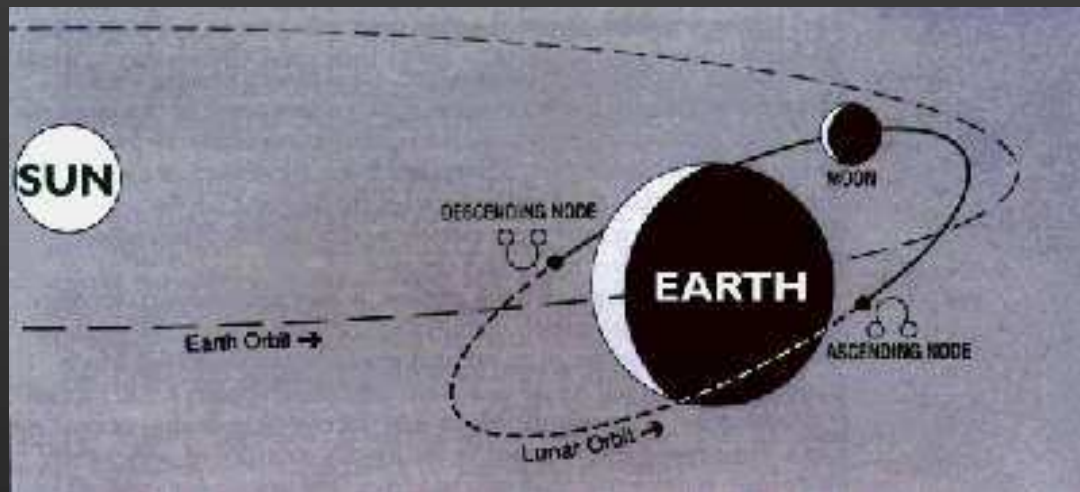
Ancient Egypt



Pre-eminent concern: Predict Nile flood
à need reliable calendar!

Ancient Egypt: Calendar

- Basic Problem: Day, month and year are no simple multiples of each other!



- Synodic (phase-to-phase) month = 29.5306 days
- Tropical (equinox-to-equinox) year = 365.2422 days

Ancient Egypt: Calendar

- Big idea: Fix time (define zero-point of calendar) by utilizing *heliacal rising* of Sirius!

Moment of Sunrise:

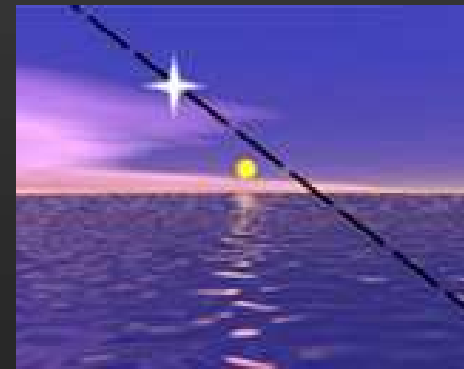


Day 1



Day 2

à Heliacal rising



Day 3

For Sirius (Dog Star): late July à close to Nile flood!

Ancient Egypt: Calendar

- Big idea: Utilize *heliacal rising* of Sirius!

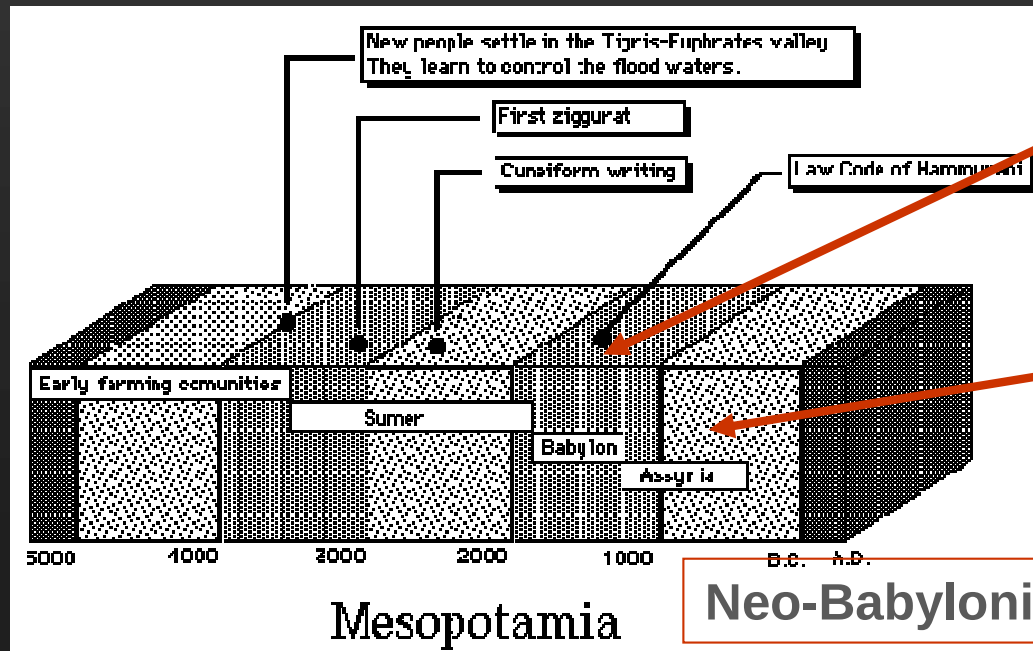


- demand: Sirius always must rise in 12th month!
- if Sirius were to rise late in 12th month, add extra (13th) month
à intercalation
- then: $365 = 12 \times 29.5 + 11$
à sequence: 12-12-13-12-12-13-...

- Egyptians had two calendars à religious (see above) and administrative: $12 \times 30 \text{ days} + 5 \text{ extra days} = 365$

Mesopotamia

- Birthplace of:
- writing (cuneiform)
 - advanced arithmetic (sexagesimal system)
 - first written law code (Hammurabi)
 - first known literature (Epic of Gilgamesh)



mathematics

astronomy

Neo-Babylonian=Chaldaean

Mesopotamia: Advanced Arithmetic



Fig. 1.1. A Babylonian clay tablet (ca. 1900–1600 B.C.), containing a mathematical problem text dealing with bricks, their volumes, and their coverage. Yale Babylonian Collection, YBC 4607. The text is translated and discussed in O. Neugebauer and A. Sachs, eds., *Mathematical Cuneiform Texts*, pp. 91–97.

1	11	21	31	41	51
2	12	22	32	42	52
3	13	23	33	43	53
4	14	24	34	44	54
5	15	25	35	45	55
6	16	26	36	46	56
7	17	27	37	47	57
8	18	28	38	48	58
9	19	29	39	49	59
10	20	30	40	50	

Meaning of Babylonian Symbols

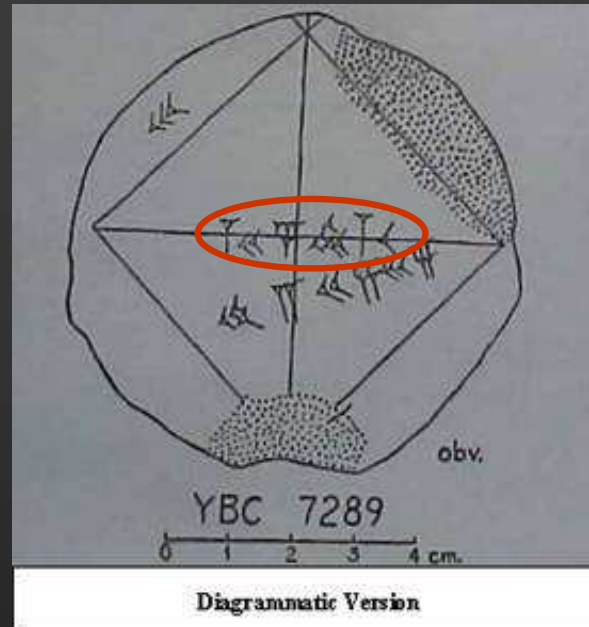
1,57,46,40 = 424000

$$1 \times 60^3 + 57 \times 60^2 + 46 \times 60 + 40$$

- sexagesimal system (base 60)
- advanced place-value system (like our base-10 one)

Mesopotamia: Advanced Mathematics

- “Pythagorean theorem” (~1,700 BC)



1.414213 à



Mesopotamia: Systematic Astronomy

- Patient, longterm recording of celestial positions (moon, Sun, planets...)
- Search for patterns/regularities
- Catalog of omens: *Enuma Anu Enlil*



à More than 7,000 omens recorded

Mesopotamia: Systematic Astronomy

- Metonic Cycle: (named after Meton of Athens, 432BC)

-19 tropical years = 6939.602 days

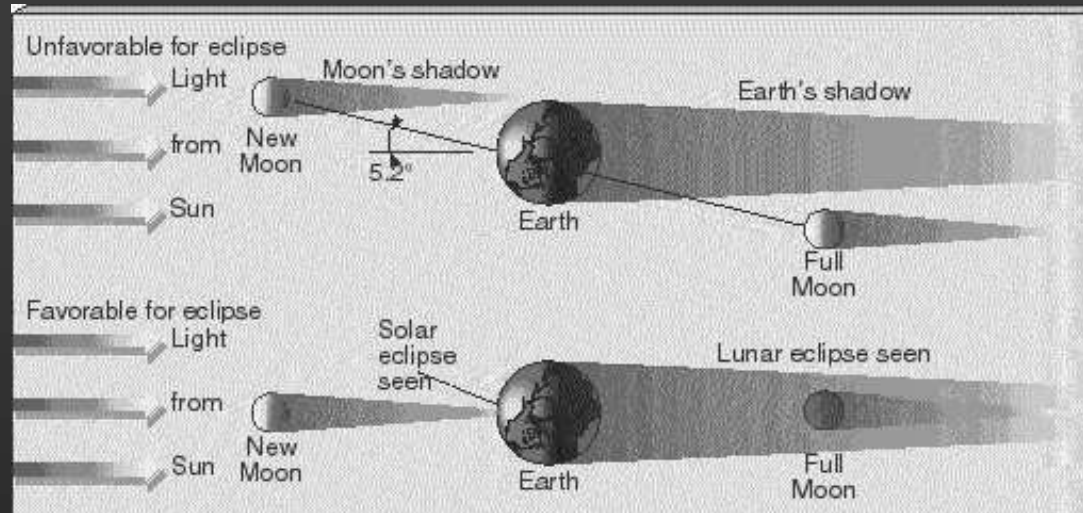
- 235 synodic months = 6939.688 days

à Introduce 7 intercalary months per
19-year cycle

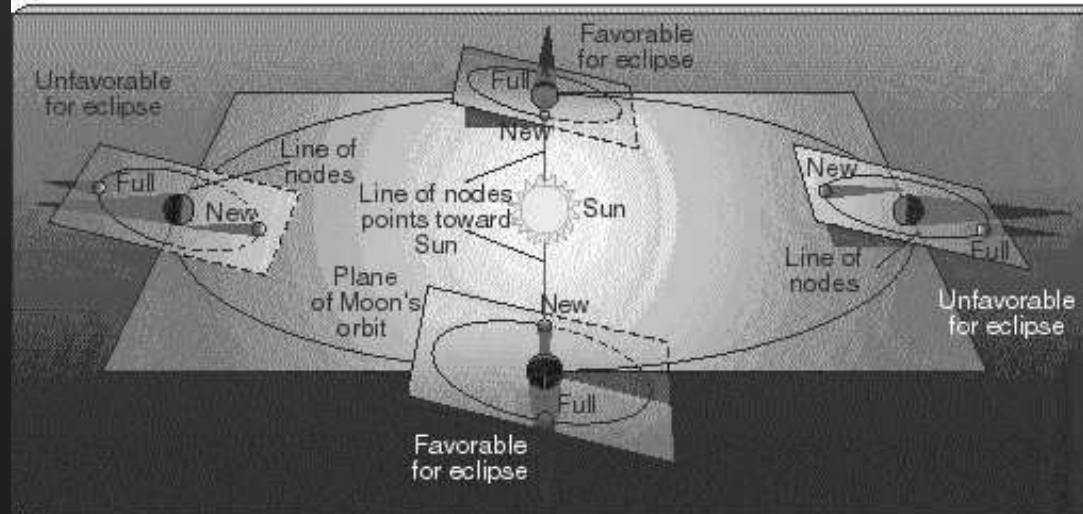
$$[19 \times 12 + 7 \sim 235]$$

Mesopotamia: Systematic Astronomy

- Saros Cycle: à eclipse cycle (~18 years)



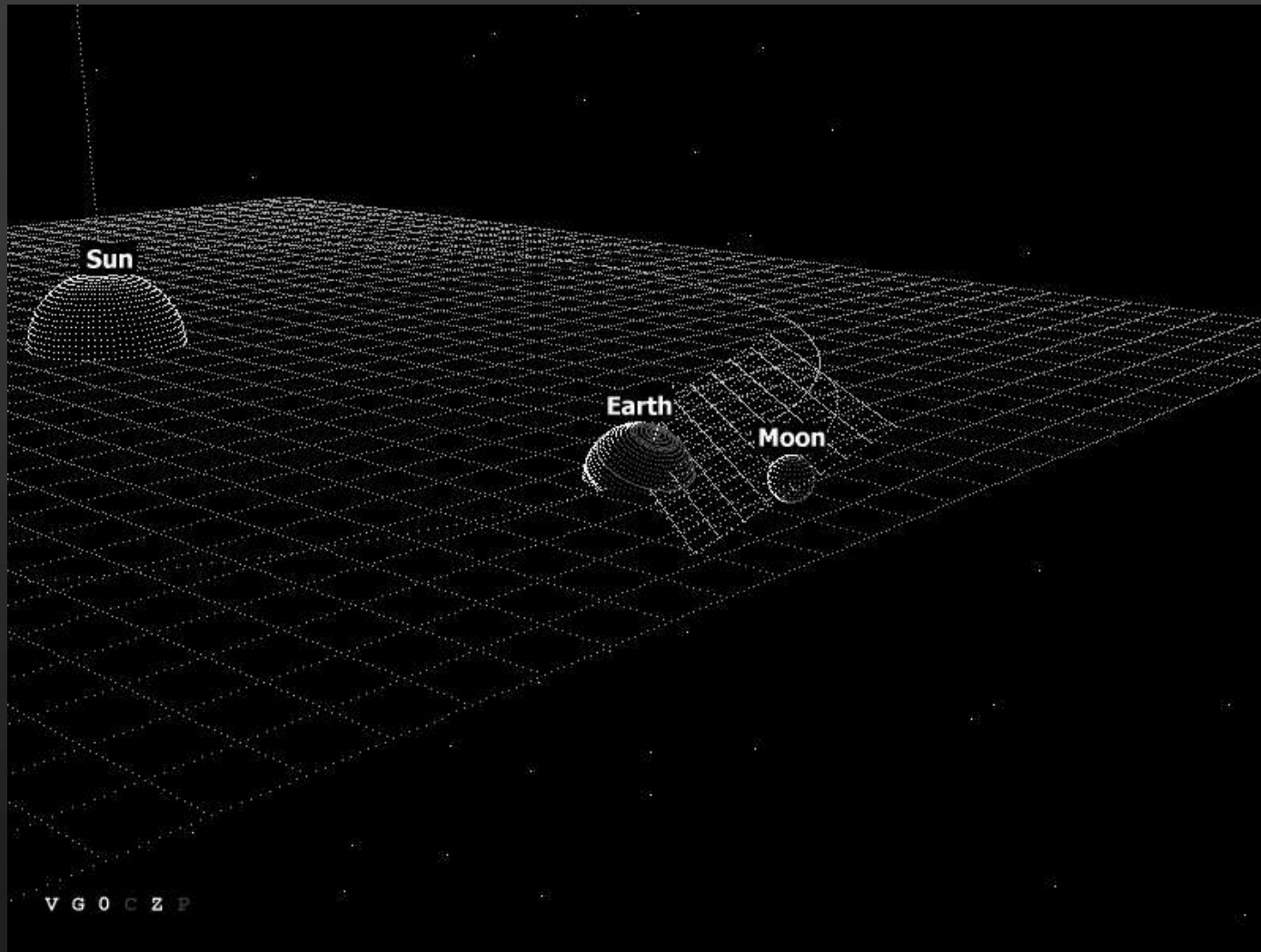
(a)



(b)

Mesopotamia: Systematic Astronomy

- Saros Cycle: à eclipse cycle (~18 years)



The Beginning of Astronomy:

- Prehistory:

- Alignment astronomy
- no written records → all inferences tentative

- Ancient Egypt:

- astronomy serves overruling need to time Nile flood
- Construction of sophisticated calendars: intercalation
- Heliacal rising of Sirius

- Mesopotamia/Babylon:

- sophisticated mathematics: sexagesimal, place-value arithmetic, algebra
- numerically precise, longterm recording of celestial patterns → *Enuma Anu Enlil* tablets, Metonic and Saros Cycles