Announcements

Homework is due next Tuesday (8/30/16)

Read Chapters 1-3 before next Tuesday

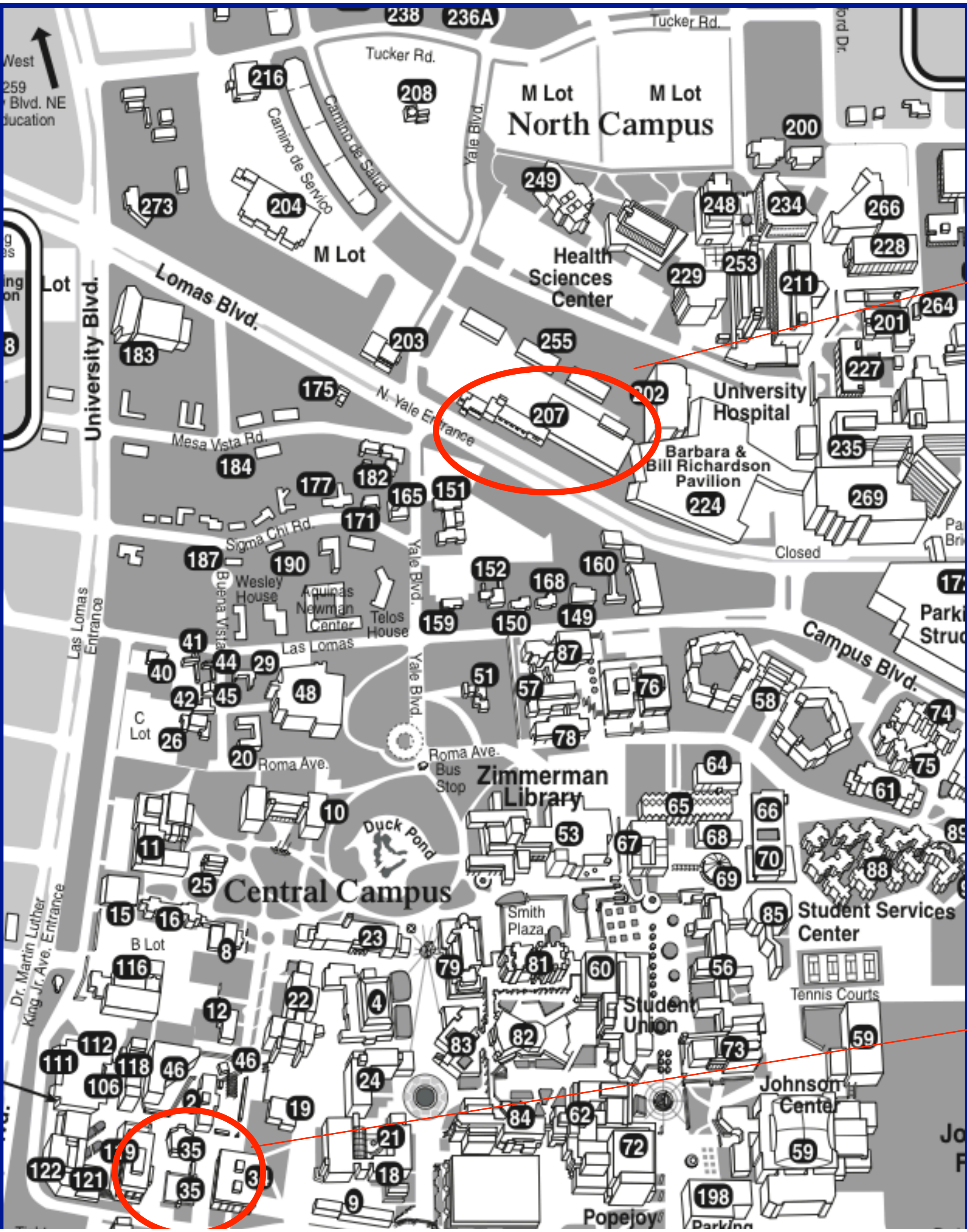
For help with iClicker setup see

https://learn.unm.edu and click on “support”

call the Technical Support Center toll free at 866-209-5698 or send an email to support@iclicker.com. You can also call UNM IT support at 277-5757

Do not pay to register your clicker!

My office hours are on Mondays 9-11am, please stop by



Physics and Astronomy

Room 180

Mondays 9-11am
or by appointment

you are here

Foundations of Astronomy

The Metric System
(used by scientists and foreigners)

Mass

1 kilogram (kg) = 1000 grams (g)

28 g = 1 ounce

If your mass is 220 lbs, it's also 100 kg.

We tend to use mass and weight interchangeably, but weight depends on gravity.

Distance

1 meter (m) = 100 centimeters (cm)
= 39.4 inches
(slightly longer than a yard - your professor is 1.8 m in height)

1 cm = 0.39 inches

Volume

1 cubic centimeter or 1 cm^3 = 0.06 cubic inches
(about the size of a sugar cube)

Sink or Float Game

<u>Density</u>

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} \quad (g / cm^3)$$

Densities of Substances

Balsa Wood	0.13 g / cm^3
Oak	0.7
Gasoline	0.7
Plastic	0.9-1.1
Water	1.0
Average Rock	2.4
Glass	2.6
Iron	7.9
Lead	11.3
Gold	19.3
Osmium	22.5

Temperature

The Celsius Scale:

$T(^{o}C) = 5/9\ [\ T(^{o}F) - 32\ ^{o}F\ ]$

so $32\ ^{o}F = 0\ ^{o}C$

$212\ ^{o}F = 100\ ^{o}C$

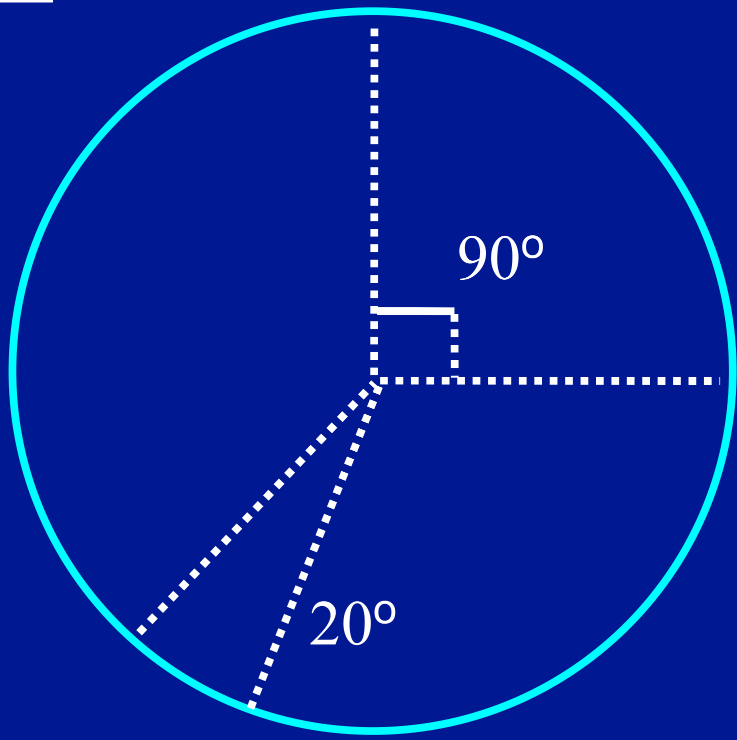
$68\ ^{o}F = 20\ ^{o}C$

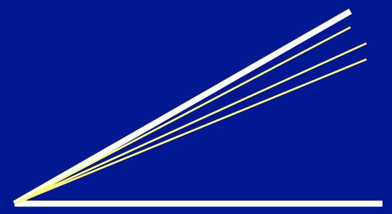
The Kelvin Scale:

$T(K) = T(^{o}C) + 273\ ^{o}C$

"Absolute zero" $0\ K = -273\ ^{o}C$

Angular Measure





360°, or 360 degrees, in a circle.

1° = 60' or arcminutes
1' = 60" or arcseconds
1" = 1000 mas or milli-arcseconds

THE QUEST FOR RESOLUTION

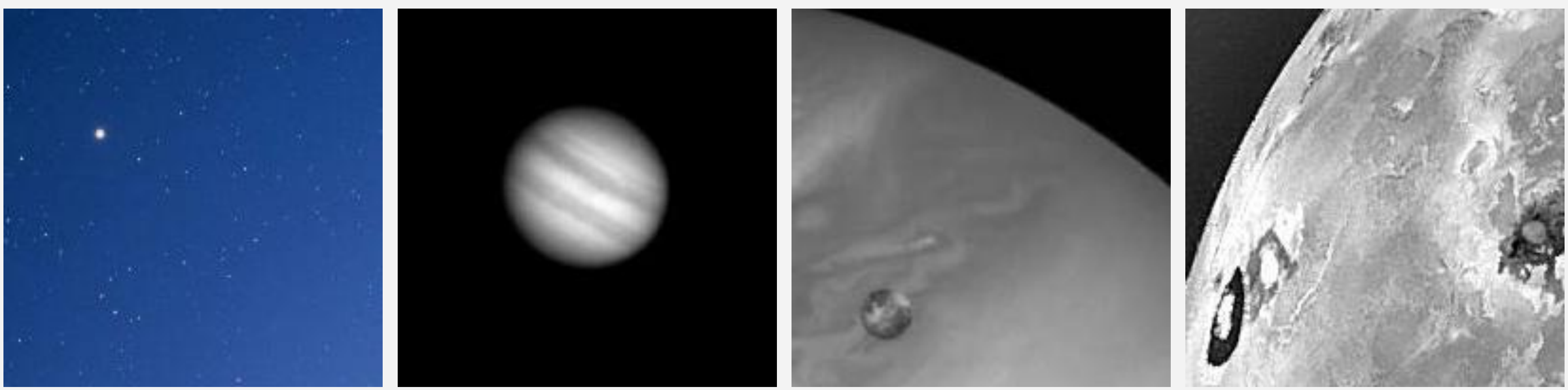
Resolution = Observing wavelength / Telescope diameter

Angular	Optical (5000A)		Radio (4cm)	
Resolution	**Diameter**	**Instrument**	**Diameter**	**Instrument**
1′	**2mm**	**Eye**	**140m**	**GBT+**
1″	**10cm**	**Amateur Telescope**	**8km**	**VLA-B**
0.″05	**2m**	**HST**	**160km**	**MERLIN**
0.″001	**100m**	**Interferometer**	**8200km**	**VLBI**

Atmosphere gives 1" limit without corrections which are easiest in radio

Jupiter and Io as seen from Earth

1 arcmin 1 arcsec 0.05 arcsec 0.001 arcsec



Simulated with Galileo photo

Scientific Notation

(A shorthand way of writing very large and small numbers, which occur often in astronomy).

We use powers, or exponents, of 10:

100	$= 10^2$ $(= 10 \times 10)$
1000	$= 10^3$ $(= 10 \times 10 \times 10)$
1,000,000	$= 10^6$
10	$= 10^1$
1	$= 10^0$
0.1	$= 10^{-1}$
0.0001	$= 10^{-4}$
0.007	$= 7 \times 10^{-3}$

Add the exponents

$$4000 \times 0.002 = (4 \times 10^3) \times (2 \times 10^{-3})$$
$$= 8 \times 10^0 = 8$$

In astronomy, we deal with:

1. Vast distances

- Radius of Earth = 6400 km = 6.4×10^8 cm

- Distance to Sun = 1.5×10^{13} cm = 23500 Earth radii = 1 Astronomical Unit (AU)

- Distance to next nearest star (Proxima Centauri): 270,000 AU = 4.3 "light years" (light year: distance light travels in one year, 9.5×10^{12} km. Speed of light $c = 3 \times 10^8$ m/sec)

- Size of Milky Way Galaxy: about 100,000 light years

- Distance to nearest cluster of galaxies (Virgo Cluster): 5×10^7 light years

2. Huge masses:

- Mass of Earth = 6×10^{24} kg = 6×10^{27} g = 1 M_{Earth}
  (or 6000 billion billion tons)

- Mass of Sun = 2×10^{30} kg = 2×10^{33} g = 1 M_{Sun}
  = 1 "Solar Mass"
  = 333,000 M_{Earth}

- Mass of Milky Way galaxy: more than 10^{11} M_{Sun}

- Mass of a typical cluster of galaxies: about 10^{15} M_{Sun}

3. Long ages and times:

- Age of Earth and Solar System: 4.5 billion years $= 4.5 \times 10^9$ years

- Lifetime of stars: about 10^6 - 10^{10} years

-Age of universe: about 10^{10} years

4. Very high and low temperatures:

- An interstellar "molecular cloud": $T = 10$ K

- Center of Sun: $T = 1.5 \times 10^7$ K

The Sky at Night

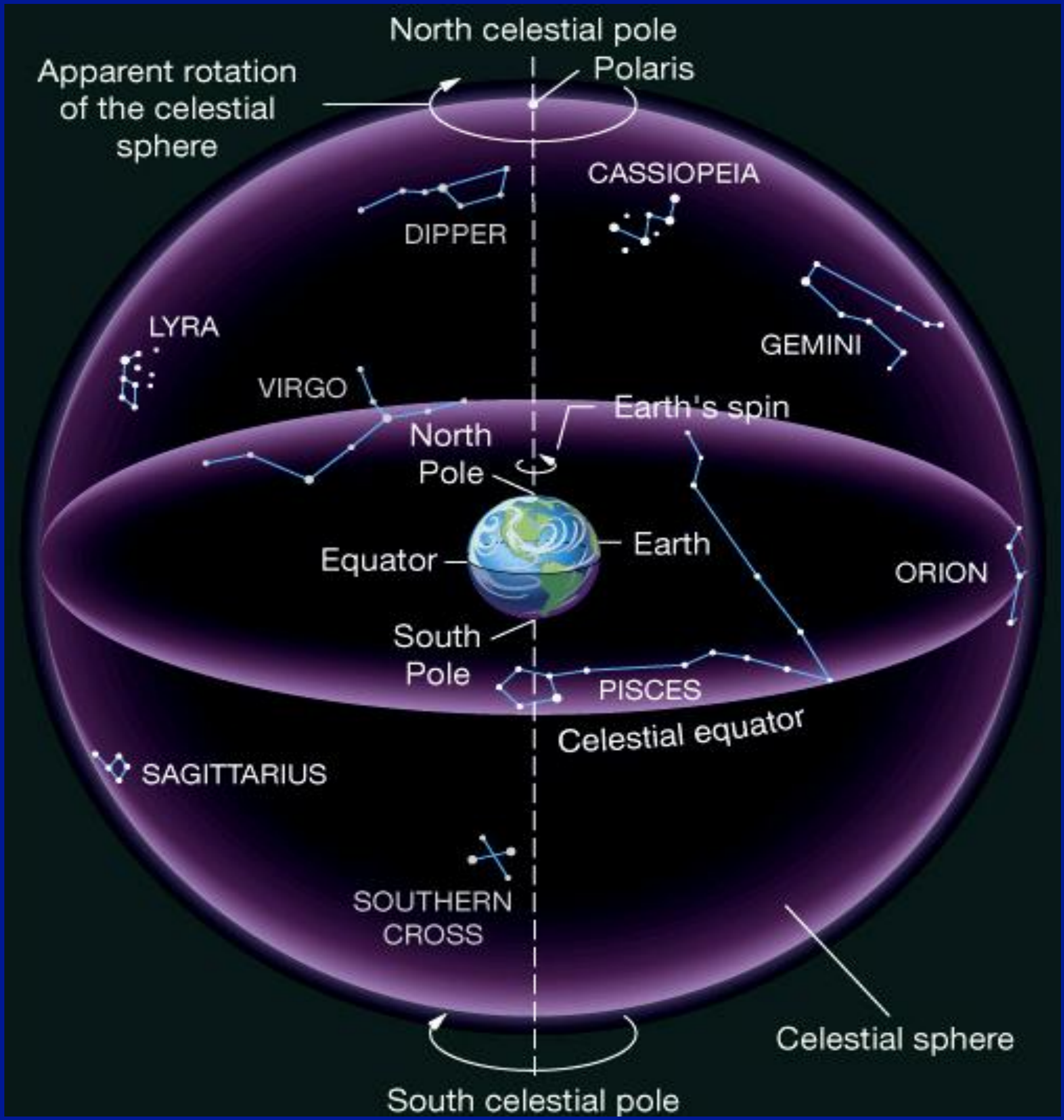
What do we see?

- The Moon
- Planets
- Perhaps a meteor, comet, or other rare event
- Stars - about 3000 visible
- Patterns of stars - constellations
  - 88 of them
  - Useful for finding our way around the sky, navigating the oceans
- Satellites, airplanes, clouds, lightning, light pollution ...

The Celestial Sphere

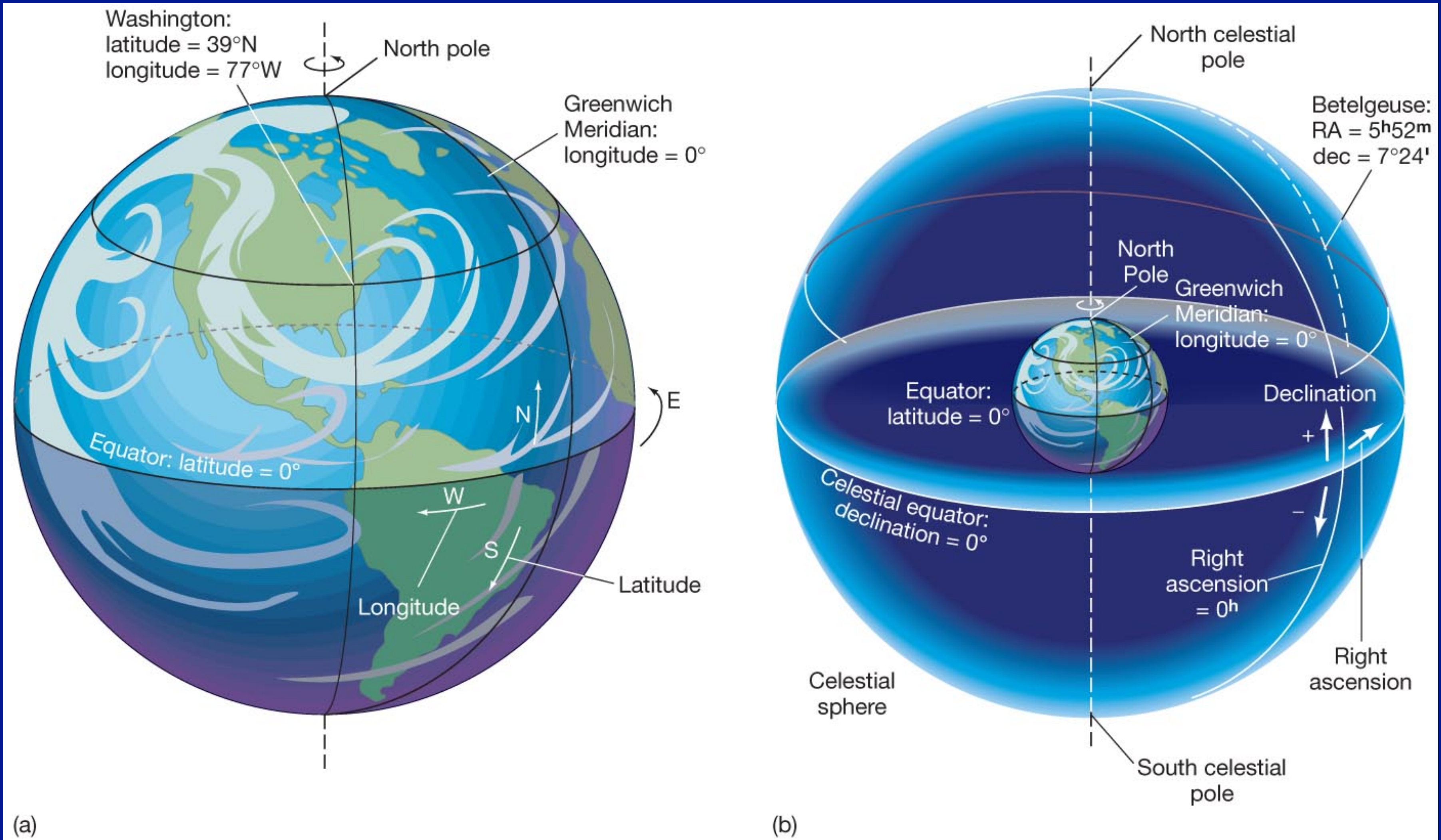
An ancient concept, as if all objects at same distance.

But to find things on sky, don't need to know their distance, so still useful today.



Features:
- Does not rotate with Earth
- Poles, Equator
- Coordinate System

The Celestial Sphere



latitude and longitude

Declination and Right Ascension

Declination: +90 (north pole) to -90 (south pole)
Right Ascension: 0 to 24 hours (1 hour = 15 degrees)

Clicker Question:

If Earth rotated twice as fast as it currently does, but its motion around the sun stayed the same, then which of the following is true:

A: the night would be twice as long

B: the night would be half as long

C: the year would be half as long

D: the year would be twice as long

E: the length of a day would be unchanged

Clicker Question:

The stars in the constellation Orion are:

A: physically near to each other in space

B: all at about the same distance from the Earth

C: close together in angle but actually far apart

D: all about the same age give or take a few million years.

Clicker Question:

The stars in the consellation Orion are:

A: physically near to each other in space

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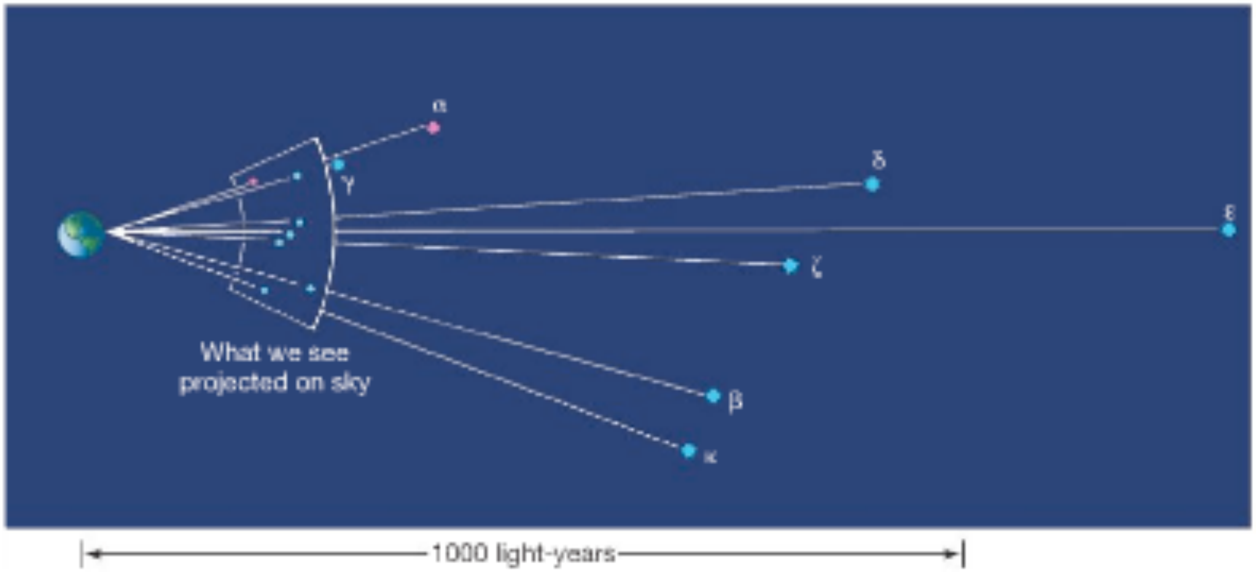


FIGURE 0.3 **Orion in 3D** The true three-dimensional relationships among the most prominent stars in Orion. The distances in light-years were determined by the *Hipparcos* satellite in the early 1990s. (*See Chapter 10.*)

Clicker Question:

What happens at a temperature of 0 K?

A: Water starts to freeze

B: All internal motions of a material come to a stop

C: Water comes to a boil

D: Nitrogen liquifies

The "Solar Day" and the "Sidereal Day"

Solar Day

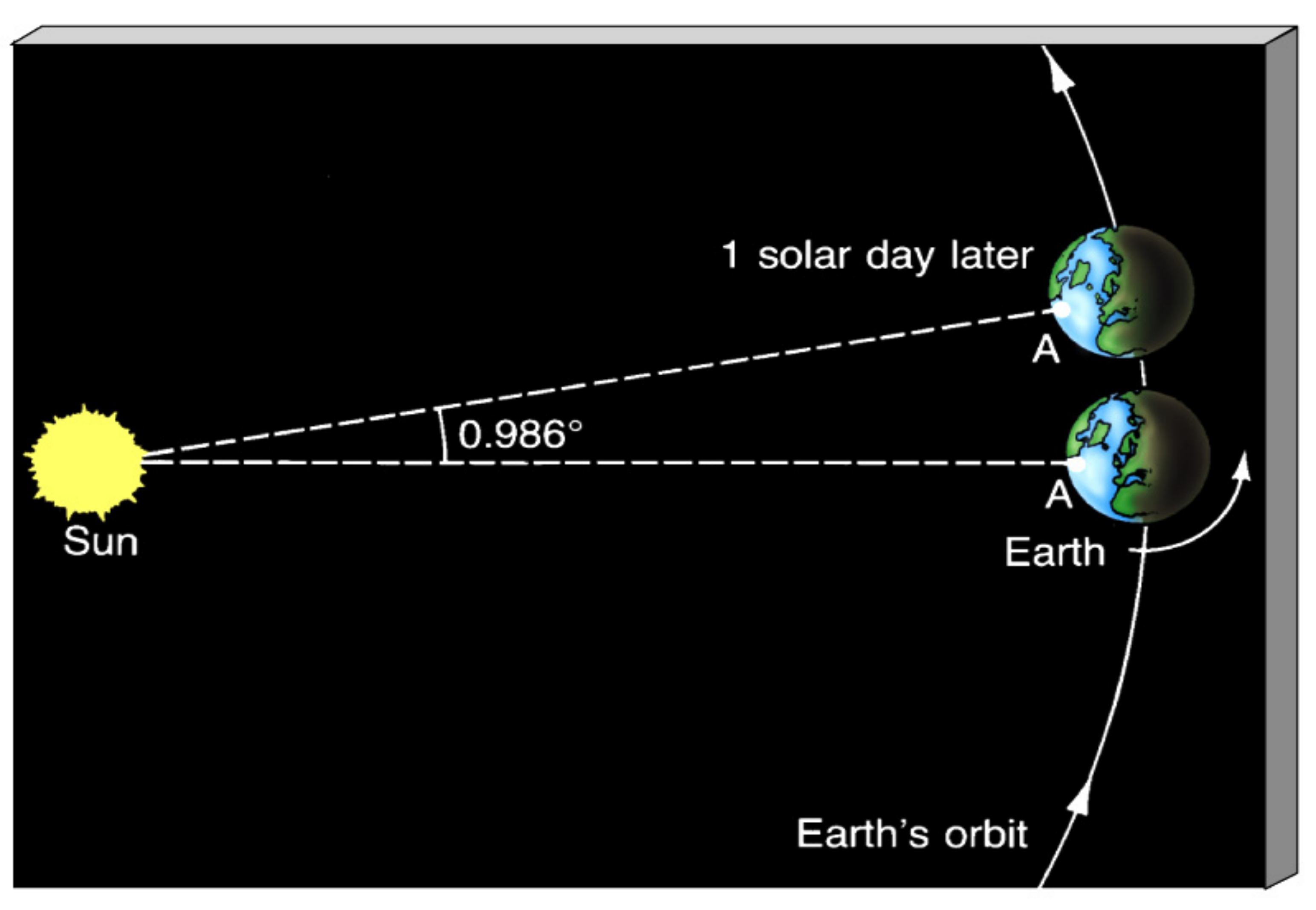
How long it takes for the Sun to return to the same position in the sky (24 hours).

Sidereal Day

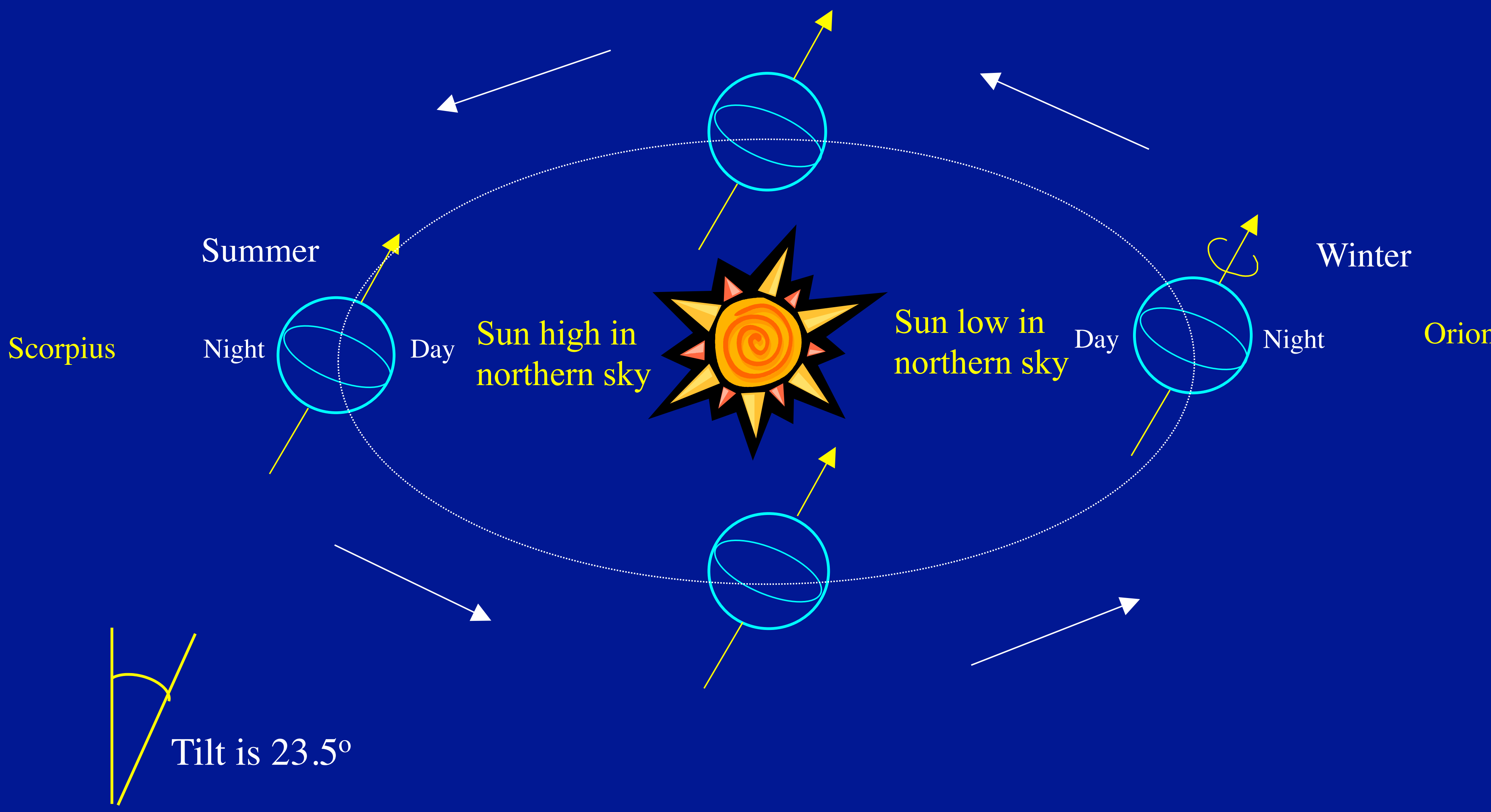
How long it takes for the Earth to rotate 360° on its axis.

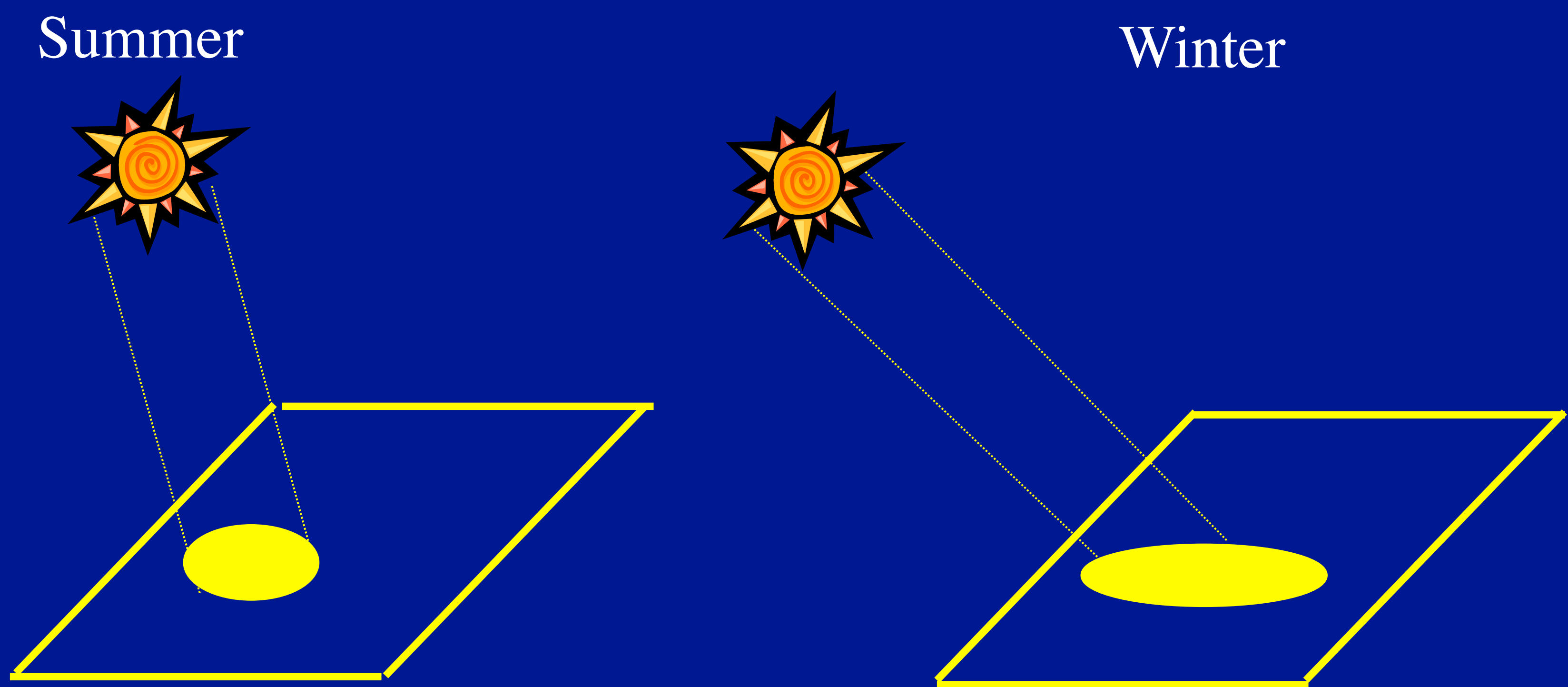
These are not the same!

One solar day later, the Earth has rotated slightly more than 360^o .
A solar day is longer than a sidereal day by 3.9 minutes
(24 hours vs. 23 hours 56 minutes 4.091 seconds).



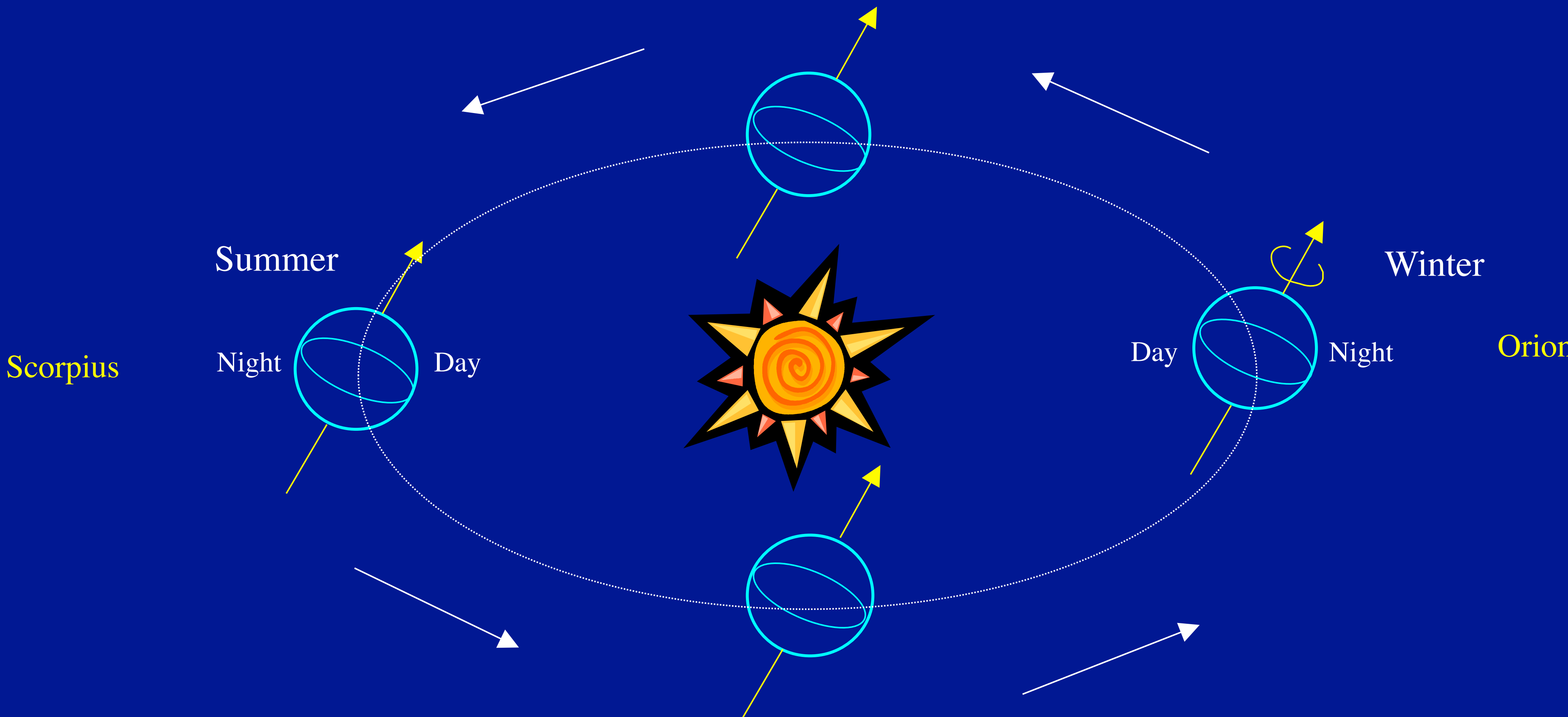
The Earth's rotation axis is tilted with respect to its orbit around the Sun => seasons.





In winter, sunlight is spread out more thinly across the ground
=> each bit of ground receives less radiation => cooler

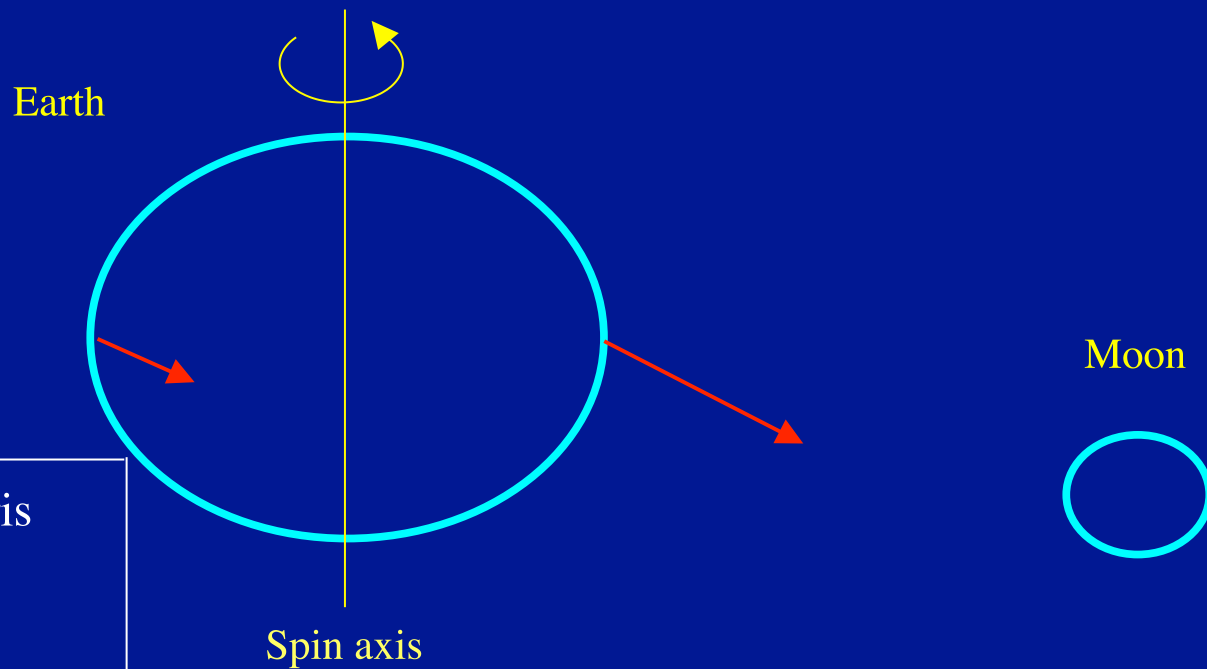
The Year

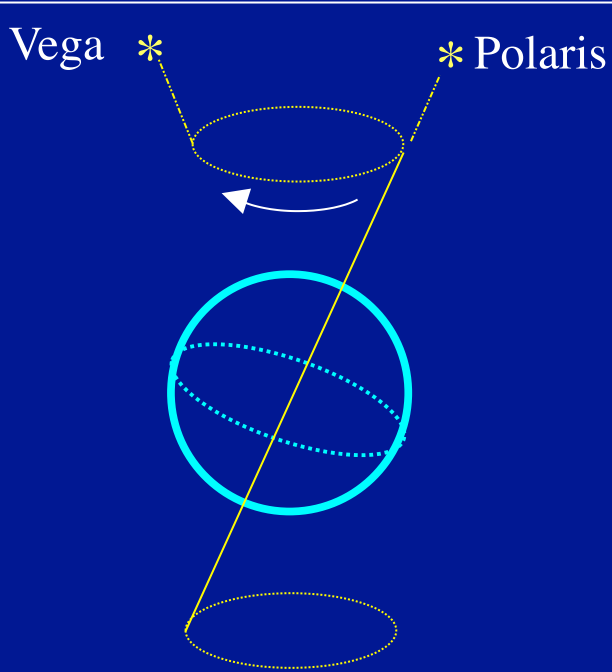


The Earth revolves around the Sun in 365.256 days ("sidereal year"). But the year we use is 365.242 days ("tropical year"). Why?

Precession

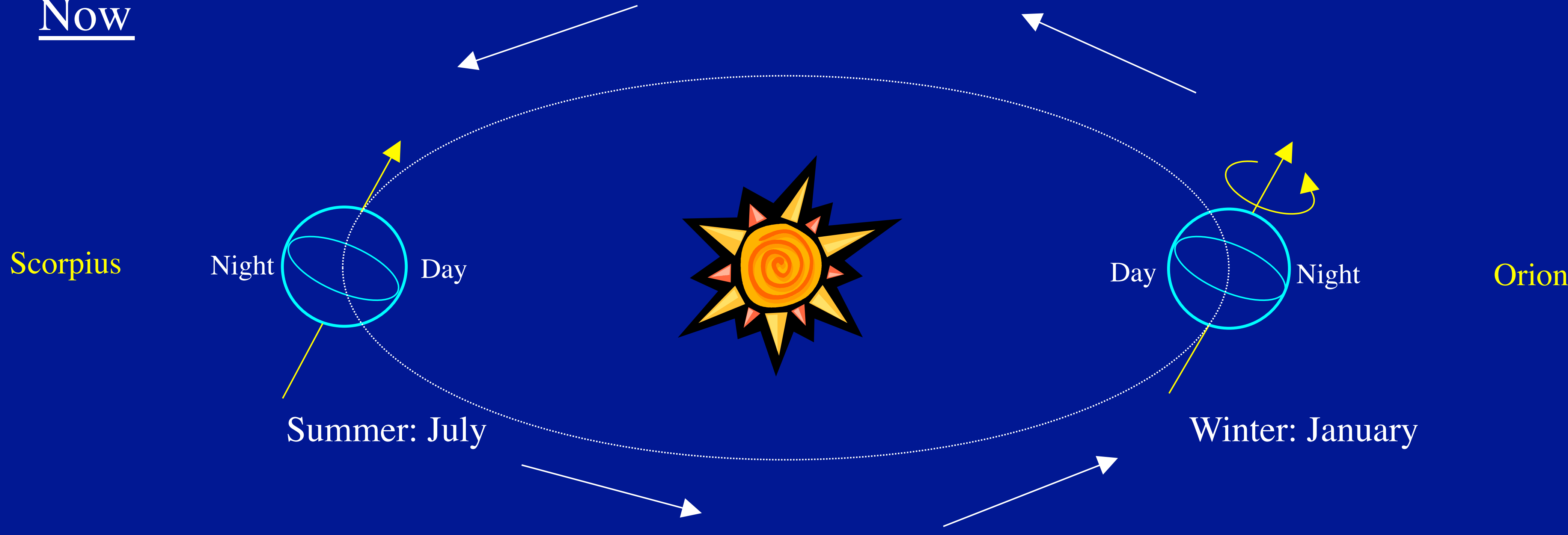
The Earth has a bulge. The Moon "pulls down" on the side of the bulge closest to it, causing the Earth to wobble on its axis (how do we know this?)



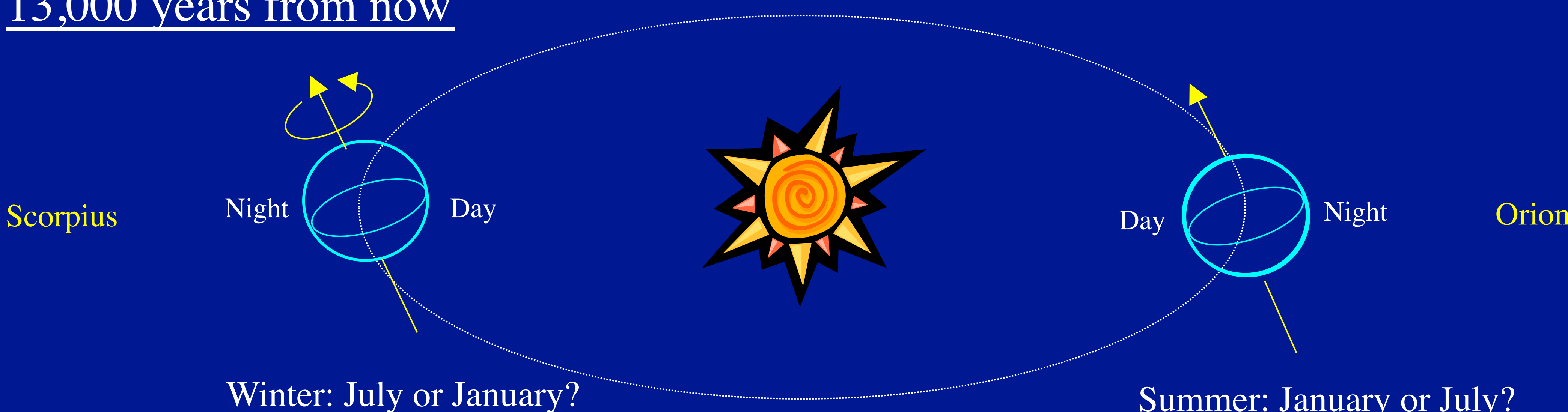


Precession Period 26,000 years!

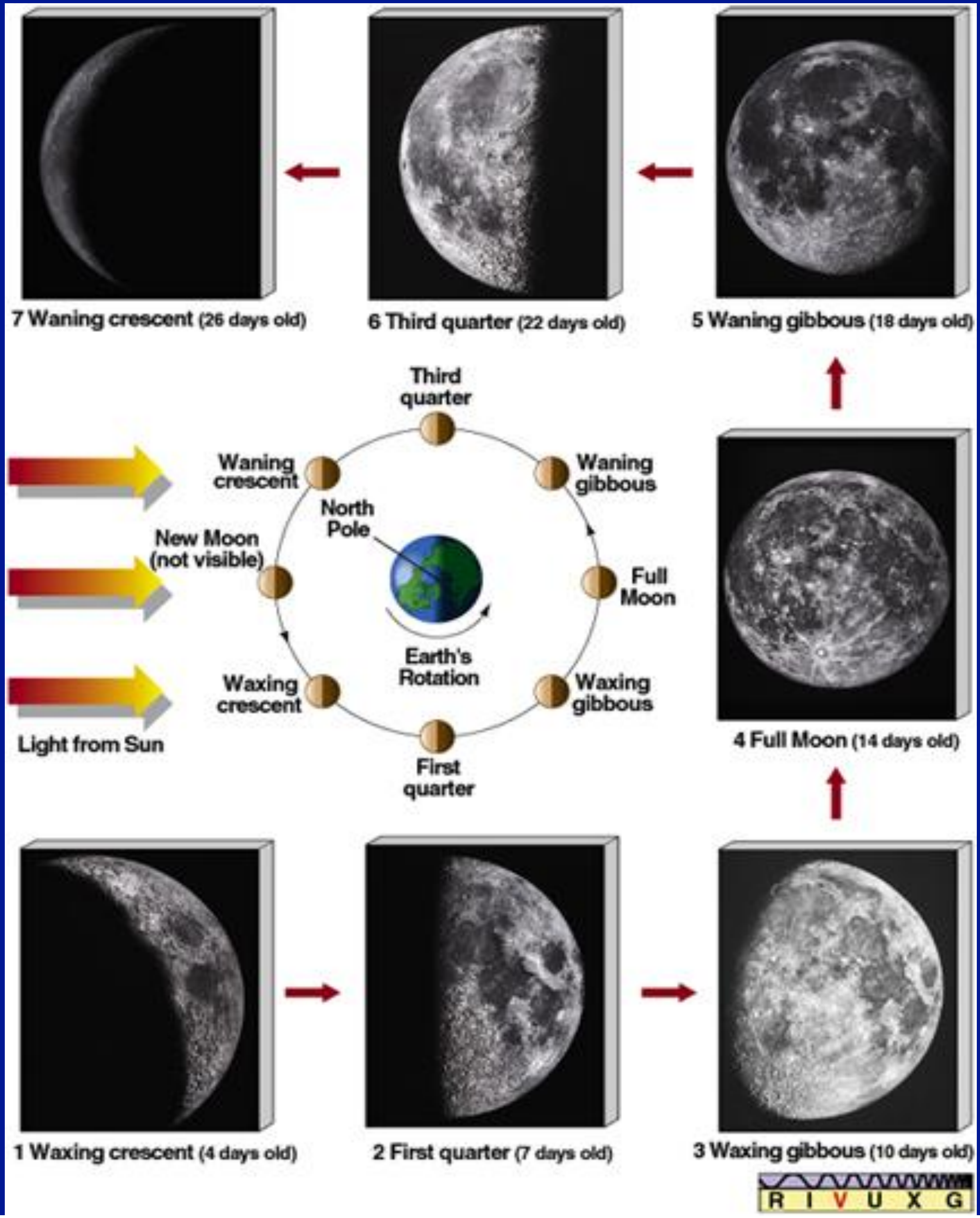
Now



13,000 years from now

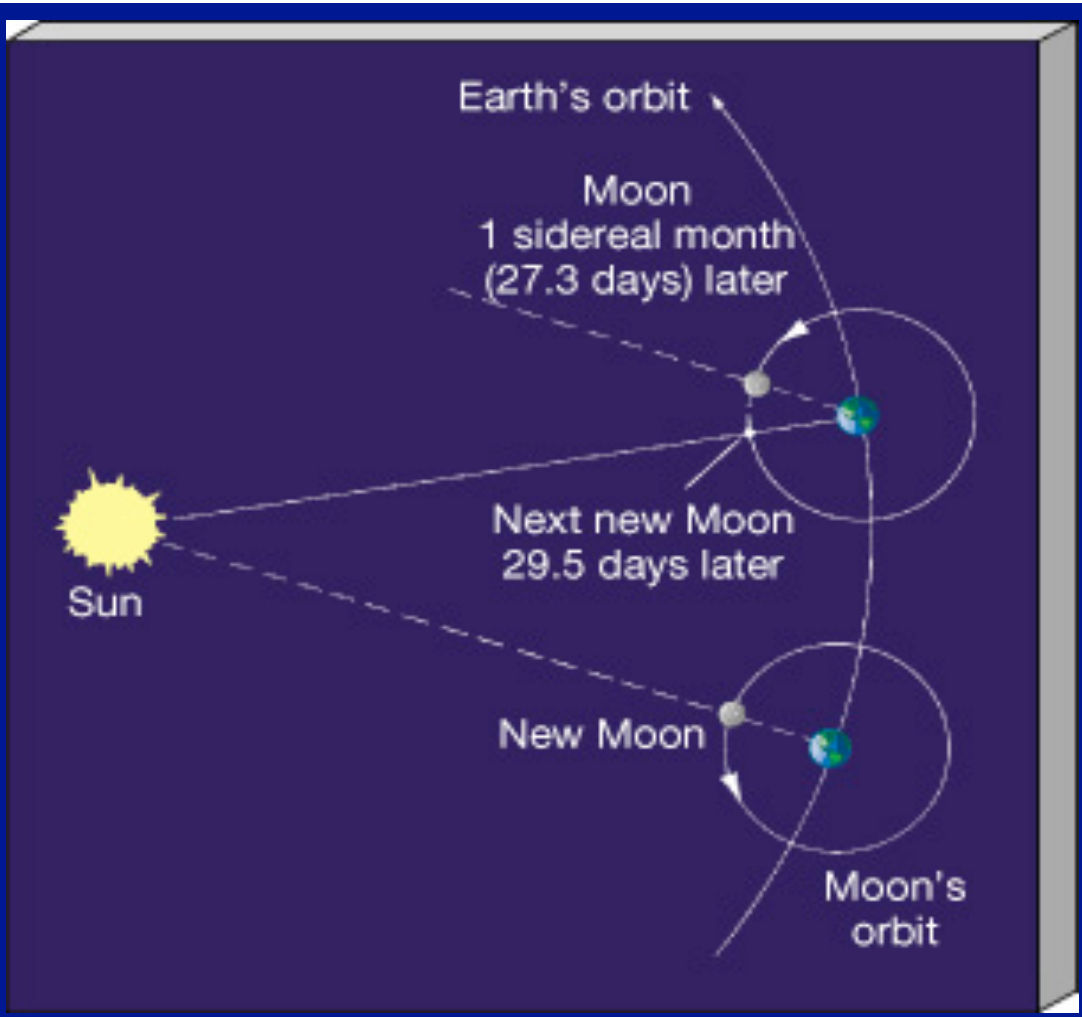


We choose to keep July a summer month, but then in 13,000 years, summer occurs on other side of orbit!



7 Waning crescent (26 days old)
6 Third quarter (22 days old)
5 Waning gibbous (18 days old)
Third quarter
Waning crescent
Waning gibbous
North Pole
New Moon (not visible)
Full Moon
Earth's Rotation
Waxing crescent
Waxing gibbous
First quarter
Light from Sun
4 Full Moon (14 days old)
1 Waxing crescent (4 days old)
2 First quarter (7 days old)
3 Waxing gibbous (10 days old)
R I V U X G

DEMO - Phases of the Moon



Cycle of phases slightly longer than time it takes Moon to do a complete orbit around Earth.

Cycle of phases or "synodic month"	Orbit time or "sidereal month"
29.5 days	27.3 days

Eclipses

Lunar Eclipse

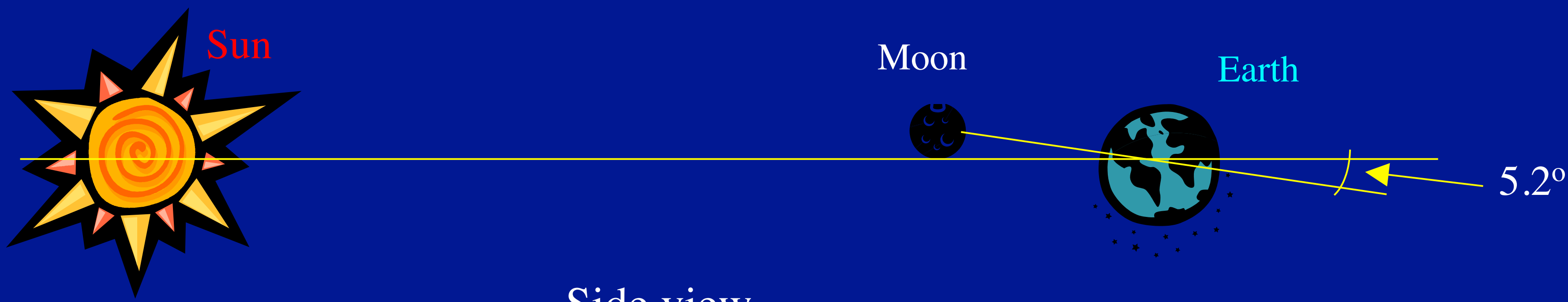
When the Earth passes directly between the Sun and the Moon.

Solar Eclipse

When the Moon passes directly between the Sun and the Earth.

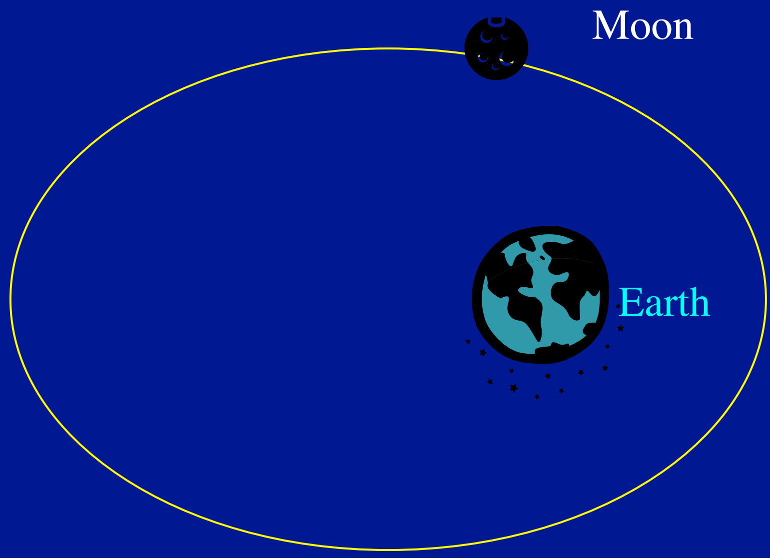
Lunar Eclipse

Moon's orbit tilted compared to Earth-Sun orbital plane:



Side view

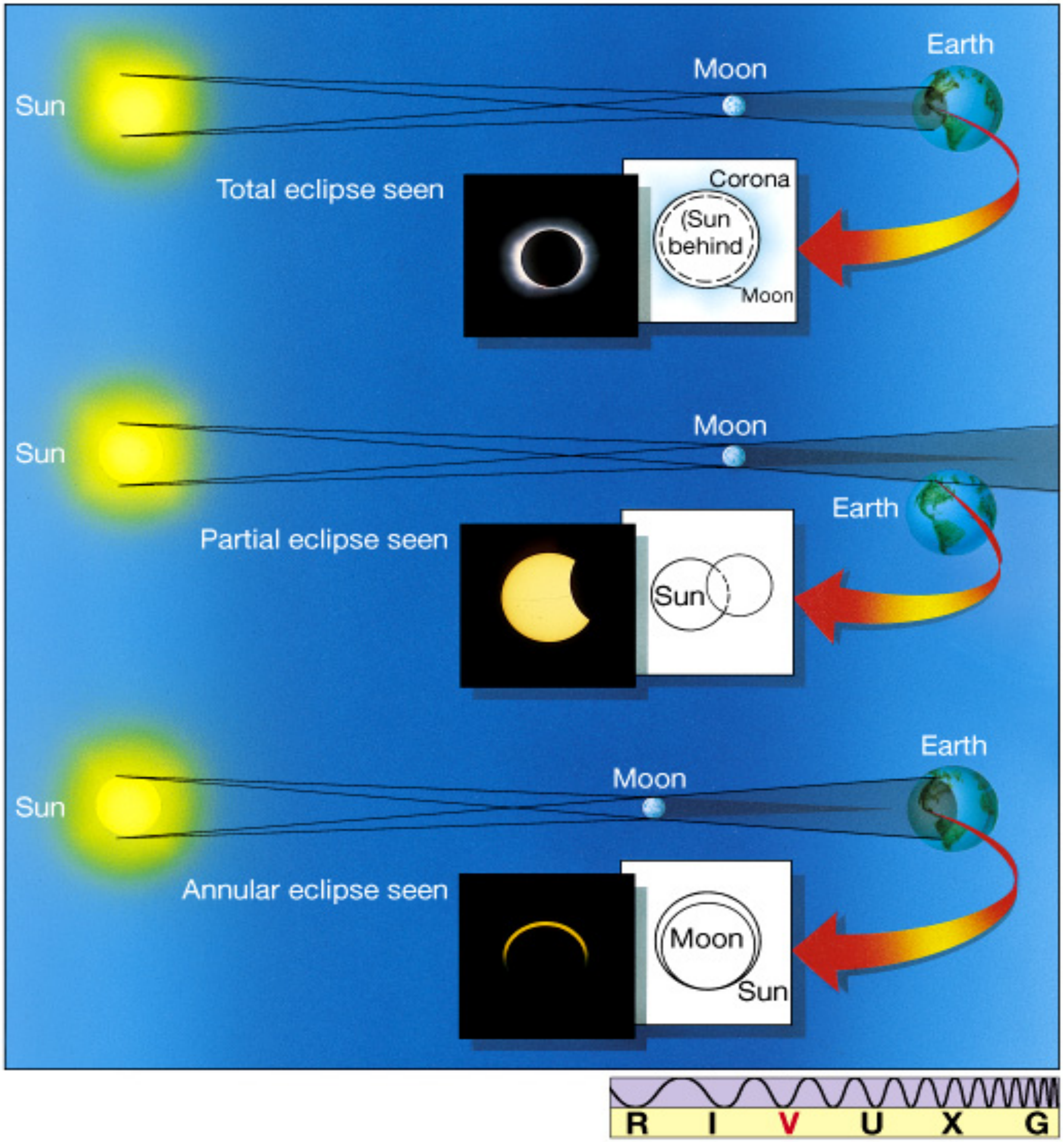
Moon's orbit slightly elliptical:

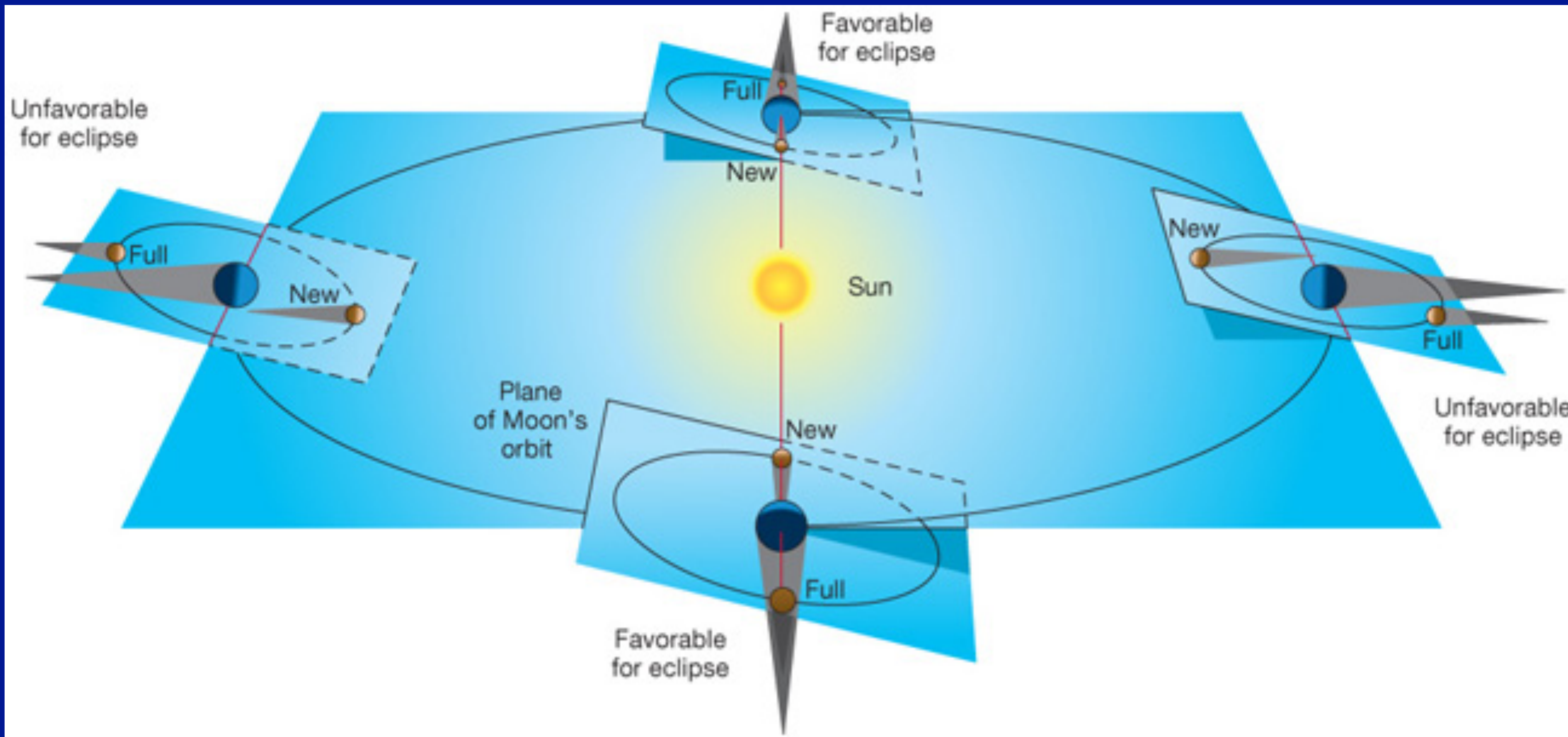


Distance varies by ~14%

Top view, exaggerated ellipse

Types of Solar Eclipses Explained




Favorable
for eclipse
Full
New
Unfavorable
for eclipse
Full
New
Sun
New
Full
Unfavorable
for eclipse
Plane
of Moon's
orbit
New
Full
Favorable
for eclipse

Clicker Question:

Why is it warmer in Albuquerque in the summer than winter?

A: The northern hemisphere is tilted towards the sun in summer.

B: The Earth is closer to the sun in summer.

C: The greenhouse effect increases in summer.

D: The sun increases its intrinsic luminosity in the summer.

E. All of the above.

Clicker Question:

What time does the 3rd quarter moon rise?

A: 6am

B: noon

C: 6pm

D: midnight

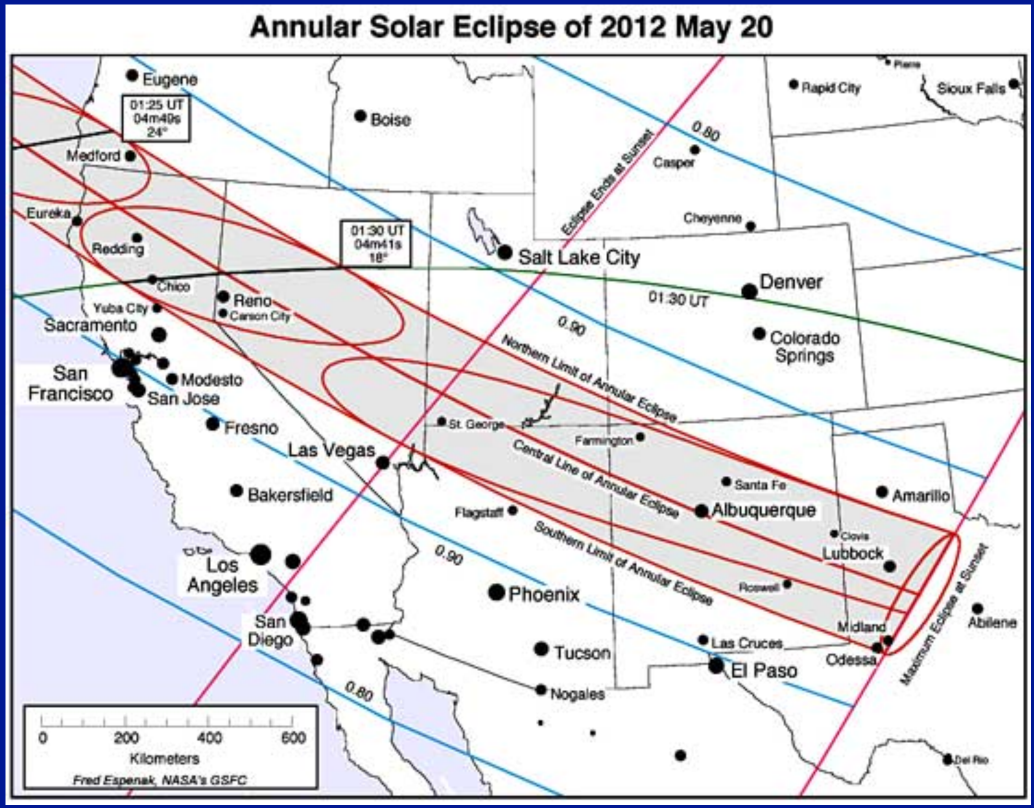
Clicker Question:

Have you ever seen a solar eclipse?

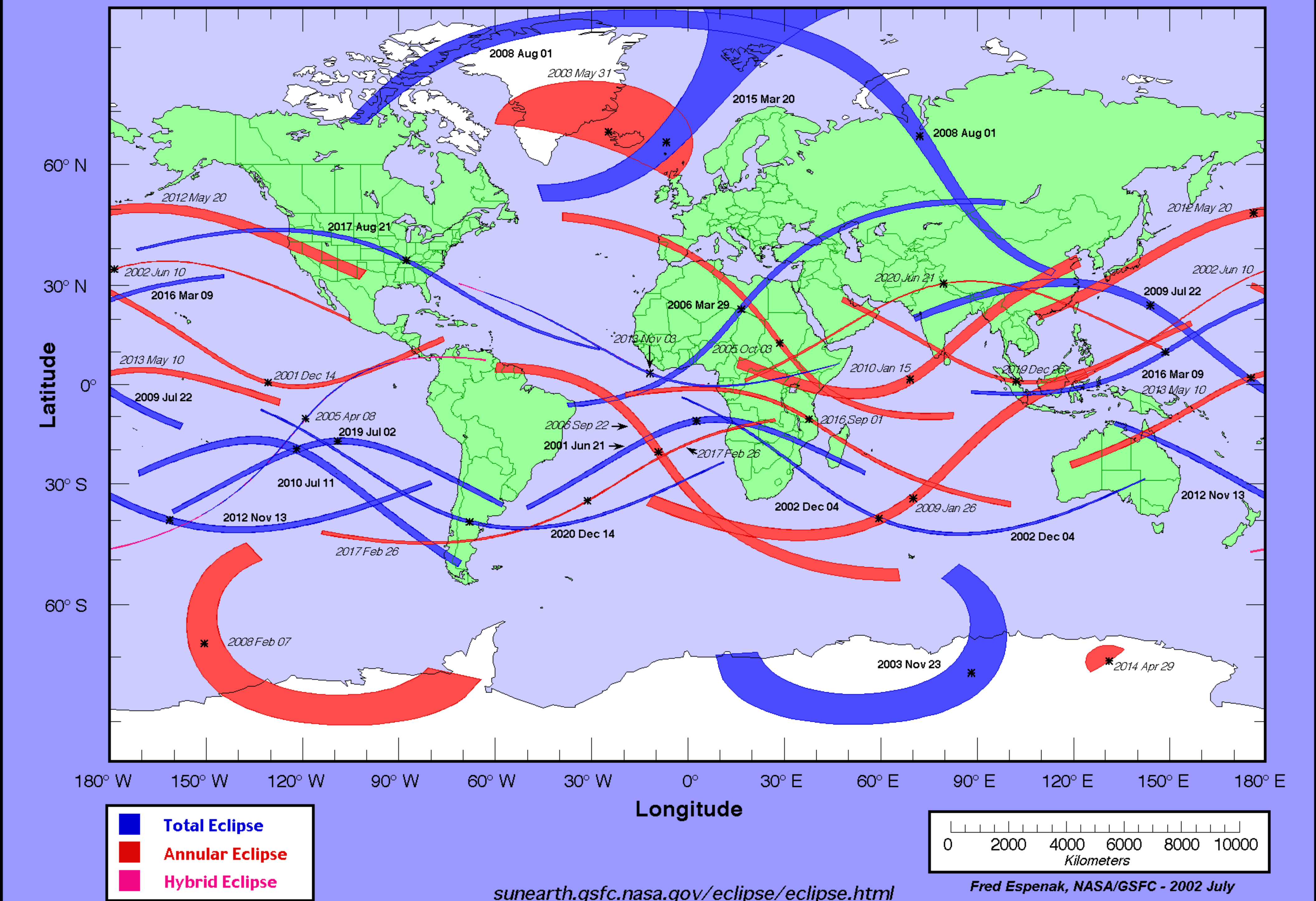
A: Total eclipse of the sun.

B: Partial solar eclipse.

C: None



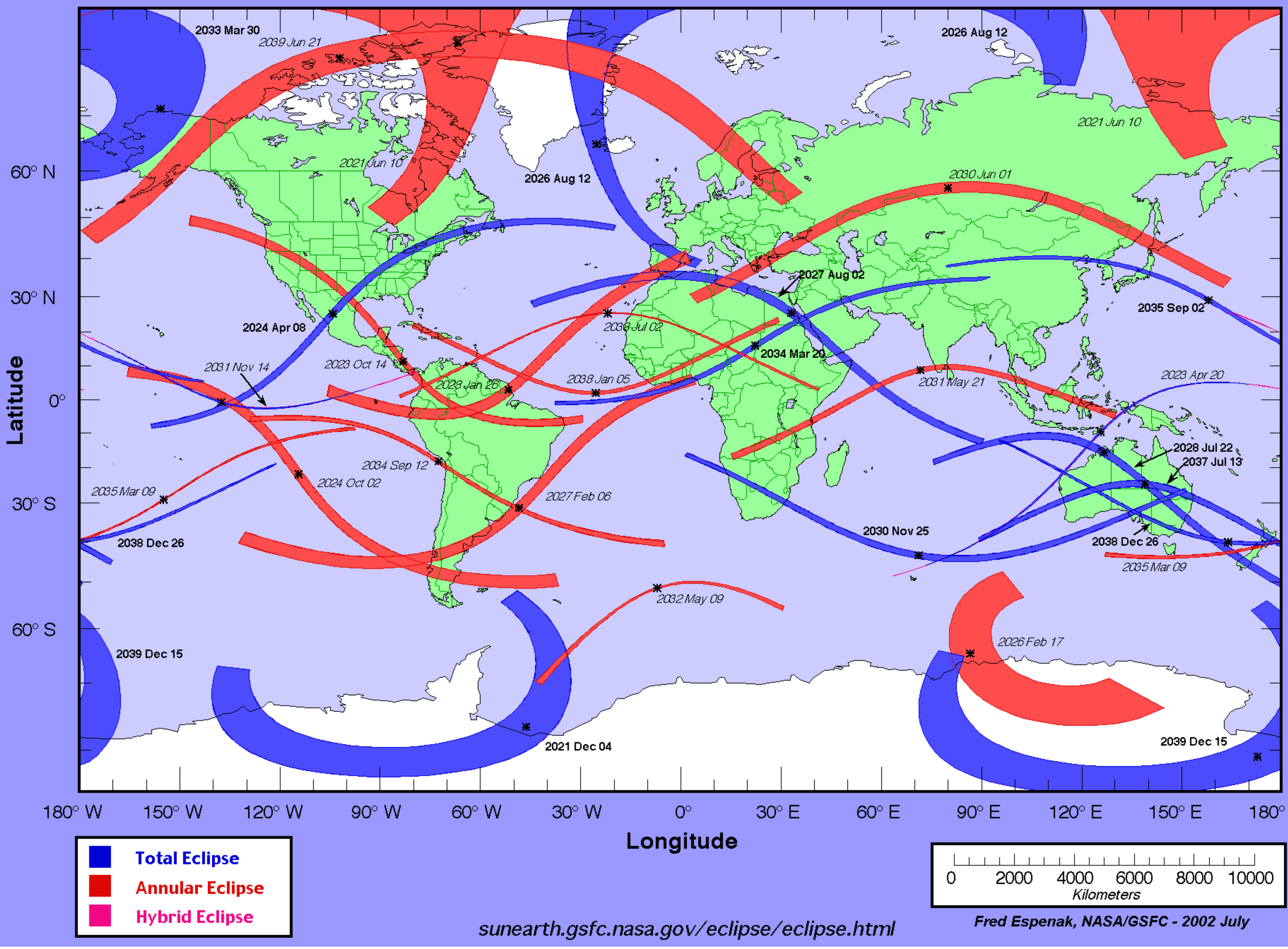
Total and Annular Solar Eclipse Paths: 2001 — 2020



sunearth.gsfc.nasa.gov/eclipse/eclipse.html

Fred Espenak, NASA/GSFC - 2002 July

Total and Annular Solar Eclipse Paths: 2021 —2040



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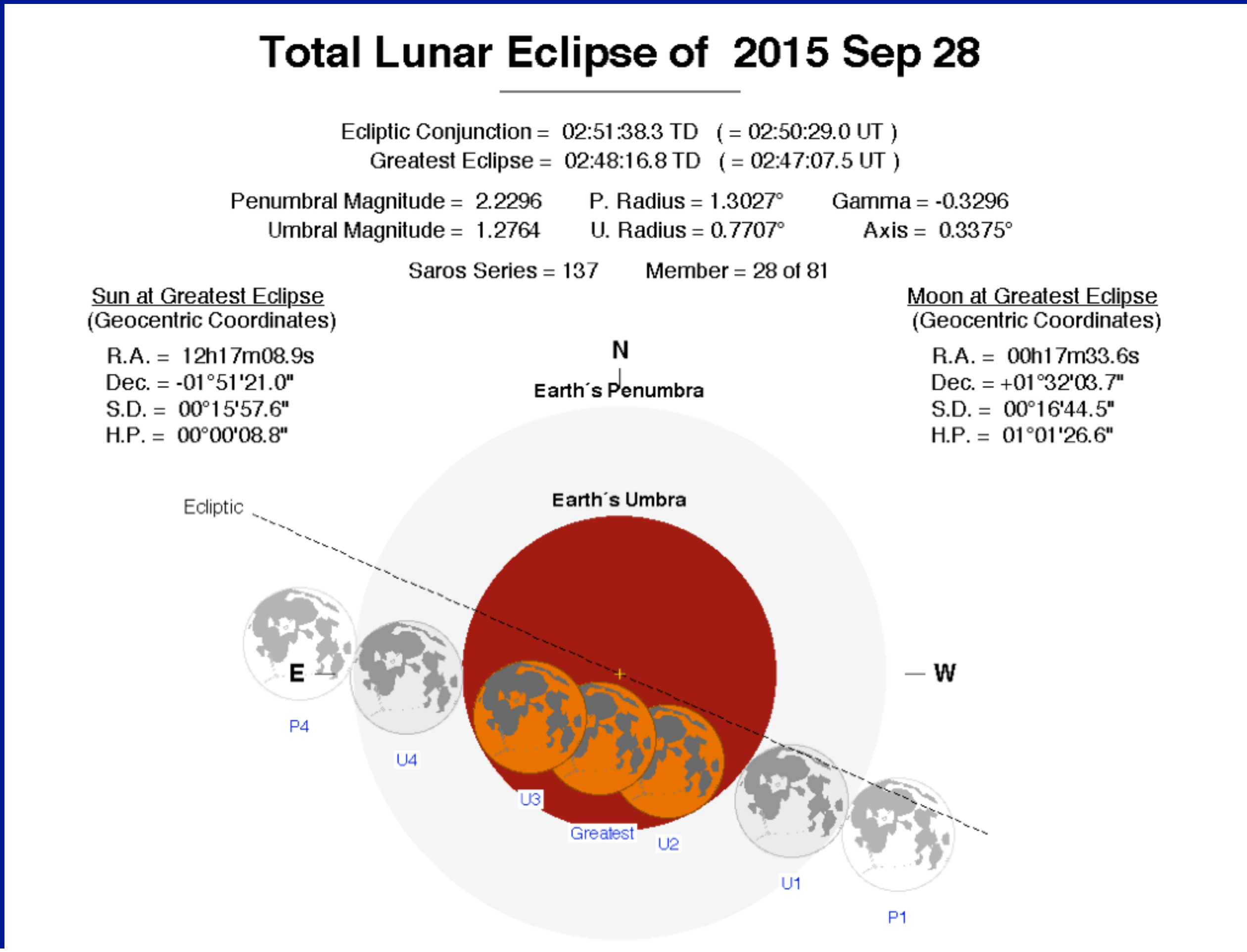
C: None



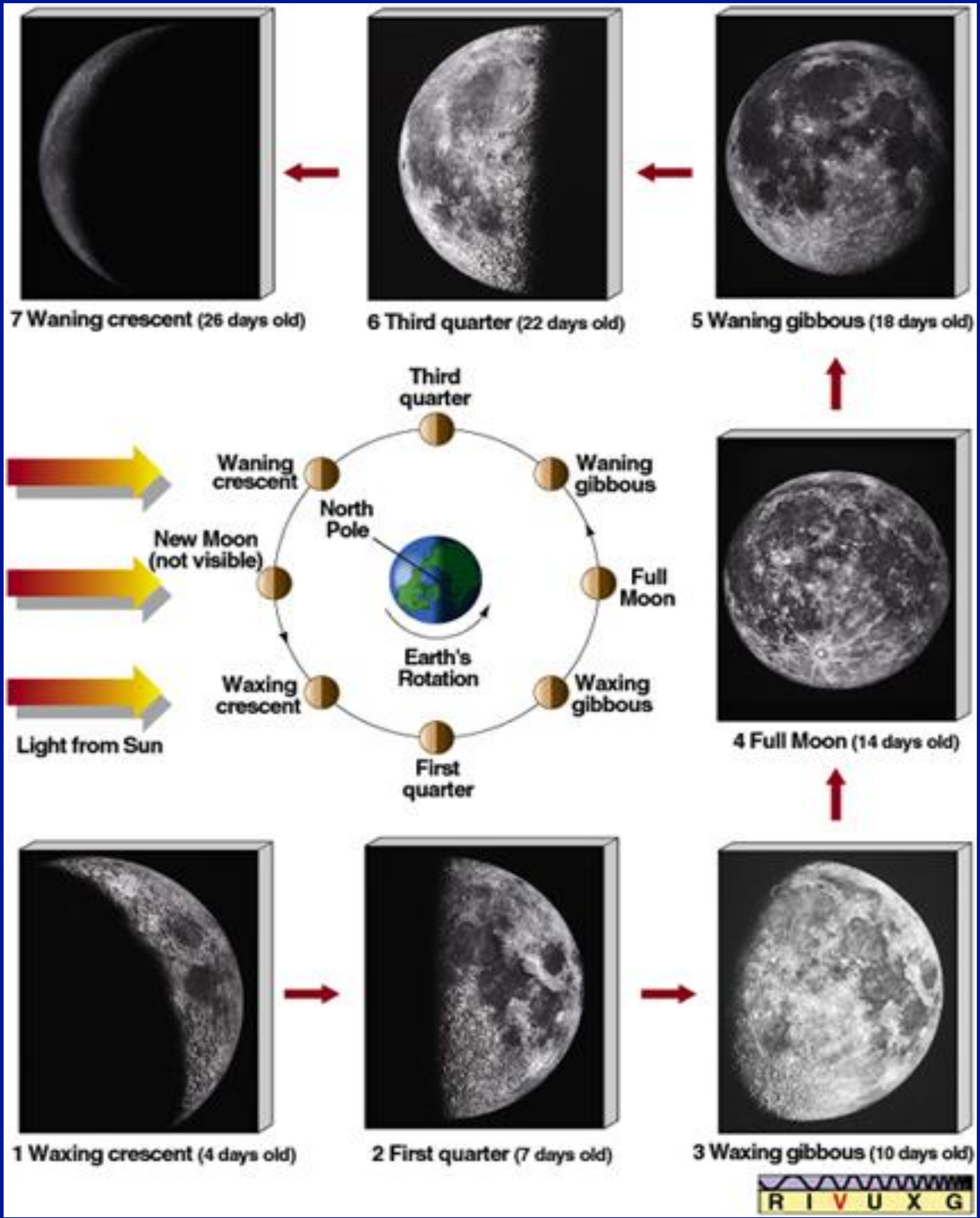
Why don't we get eclipses every month?

A: The moon has lots of holes in it.

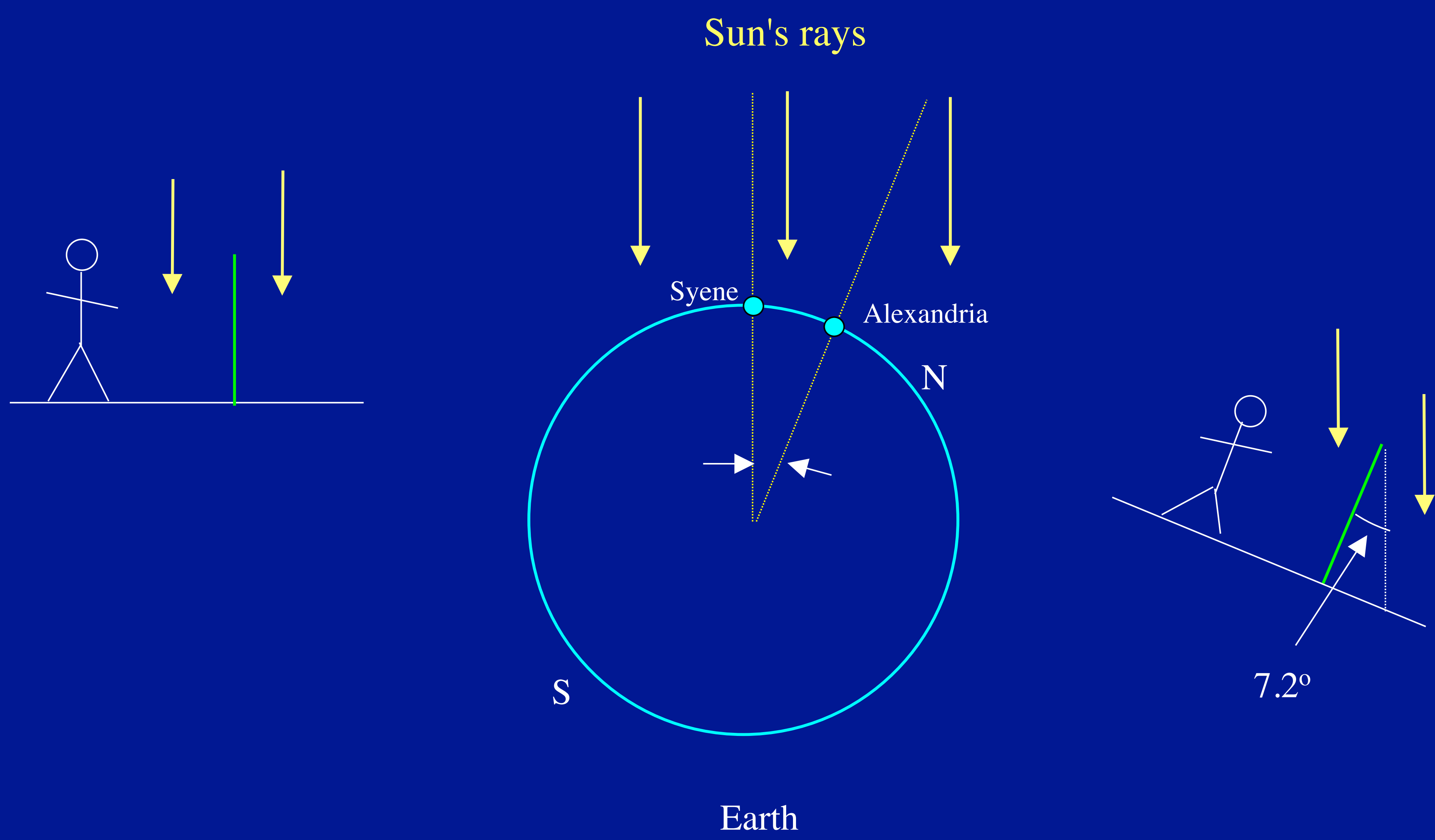
B: The moon moves too far away to block the sunlight.

C: The orbit of the moon is tilted.

D: We do get them every month but don't notice.



Eratosthenes Determines the Size of the Earth in about 200 B.C.



He knows the distance between the two cities is 5000 "stadia".

From geometry then,

$$\frac{7.2^{o}}{360^{o}} = \frac{5000 \text{ stadia}}{\text{Earth's circumference}}$$

=> circumference is 250,000 stadia, or 40,000 km.

So radius is:

$$\frac{40{,}000 \text{ km}}{2\pi} = 6366 \text{ km}$$

(very close to modern value, 6378 km!)