Observing & Understanding the Moon

OLLI Week #3

Question: Why does the Moon change its appearance?

A. The Earth's shadow covers the Moon
B. Clouds cover the Moon
C. The Moon turns its dark side towards us
D. We see different parts of the lighted face

Shadow line (“Terminator”) always goes . . . . .

Lets have a ball!

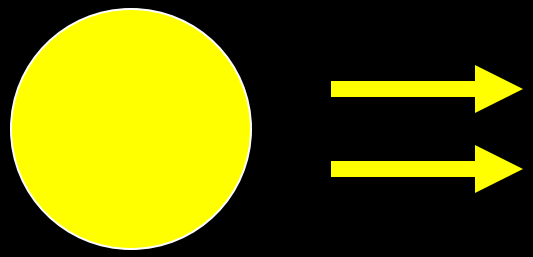
- How much is lit?

The Moon is ALWAYS* HALF LIT!!!

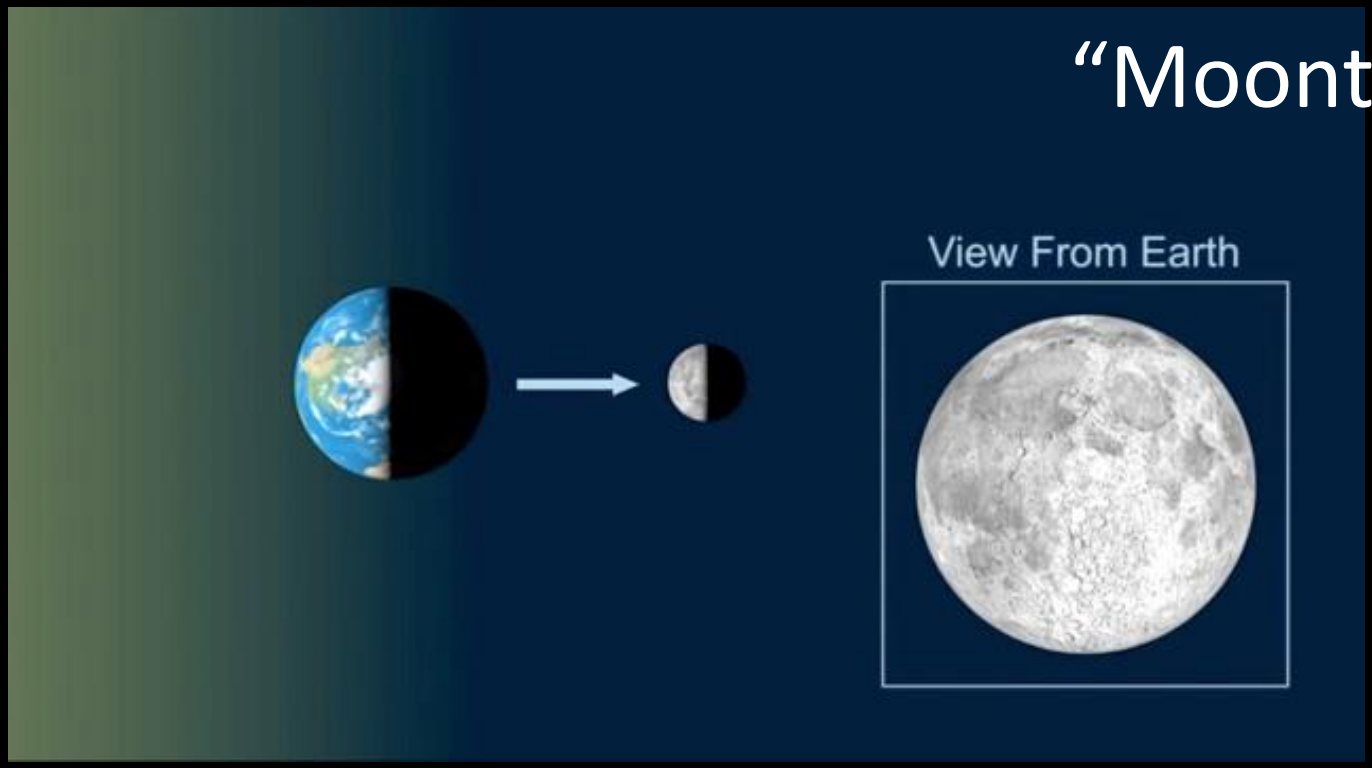
****exception: lunar eclipse***

But the Moon doesn't always look half-lit. What gives?

- Depends on where your eye is!



Phases of the Moon



MOON'S ORBITAL MOTION

EARTH'S ROTATION

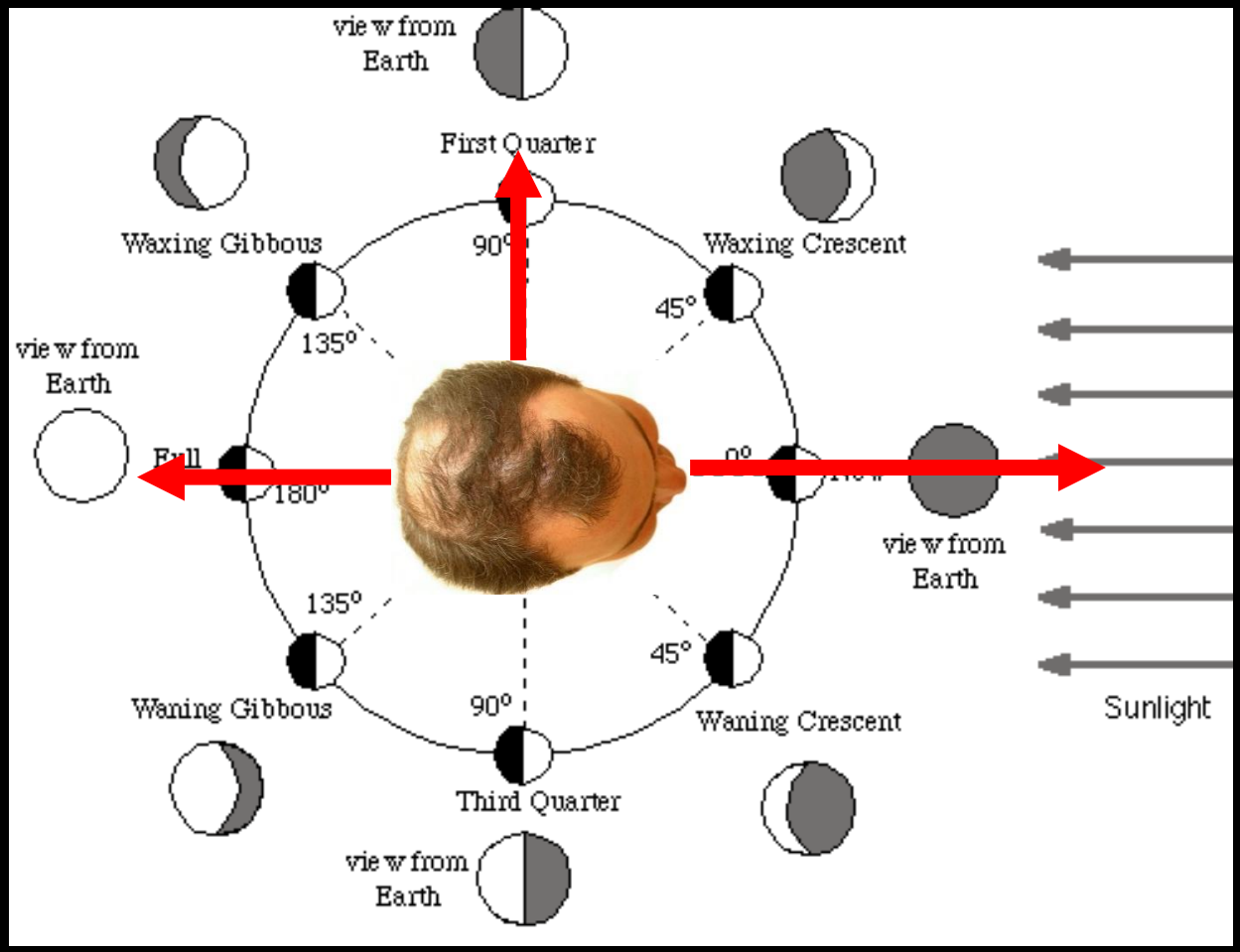
EAST

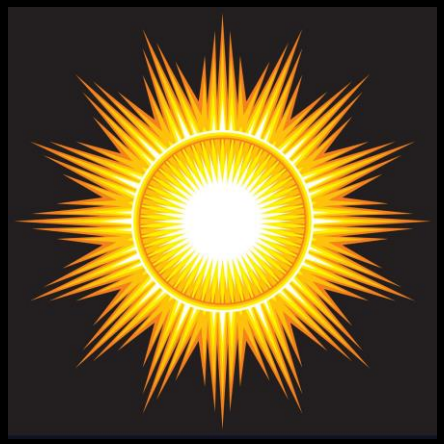
WEST

Does the Moon spin?

Rise/Set times

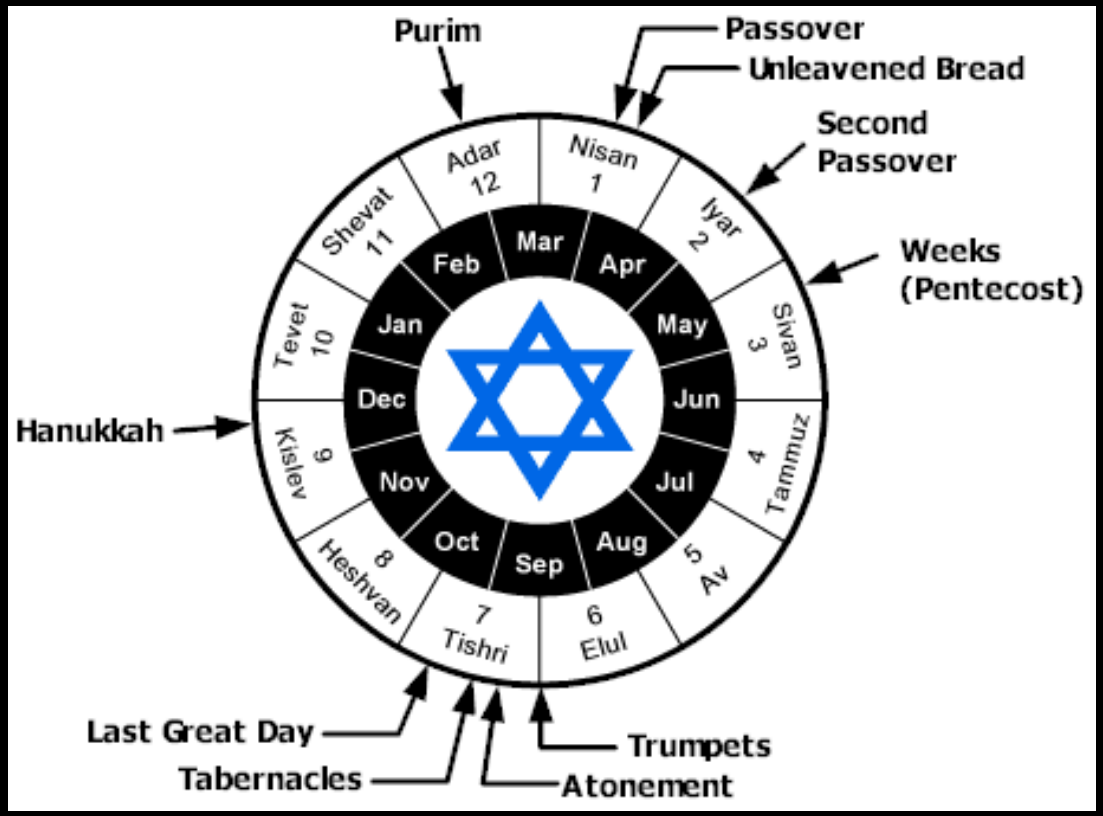
- “It’s a marvelous night for a Moondance”

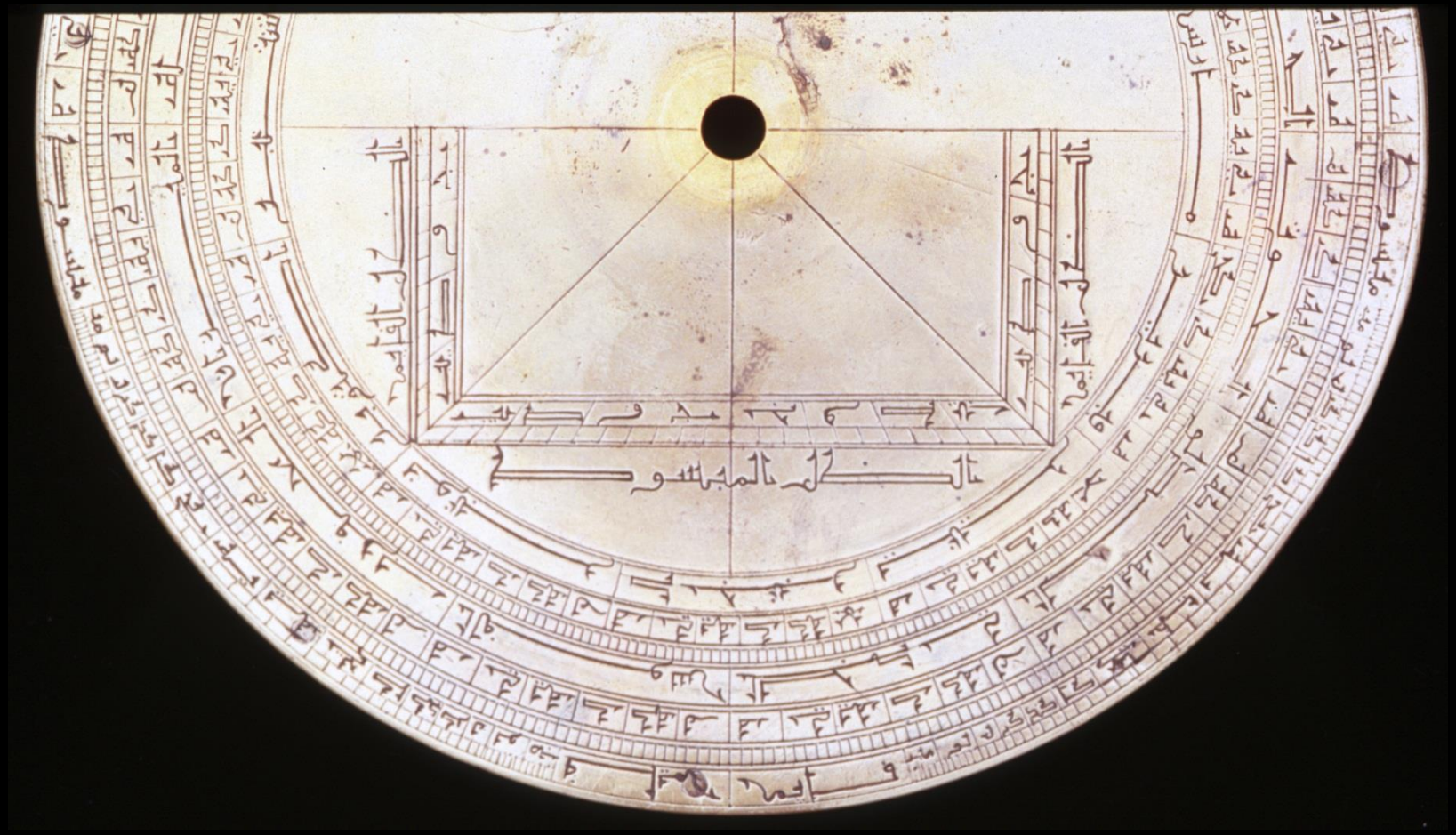




Lunar calendars

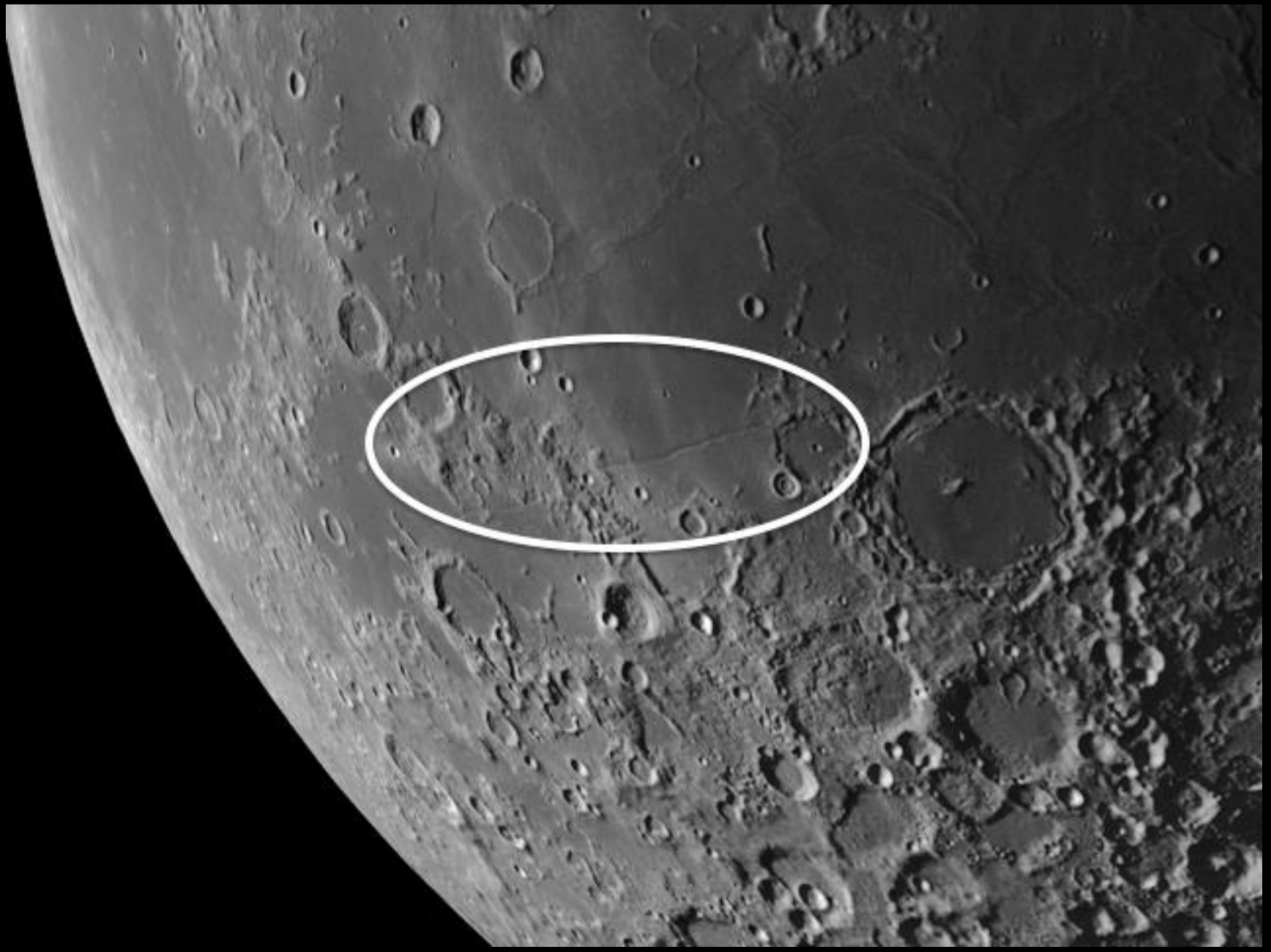
- 29.5 days x 12 months = 354 days

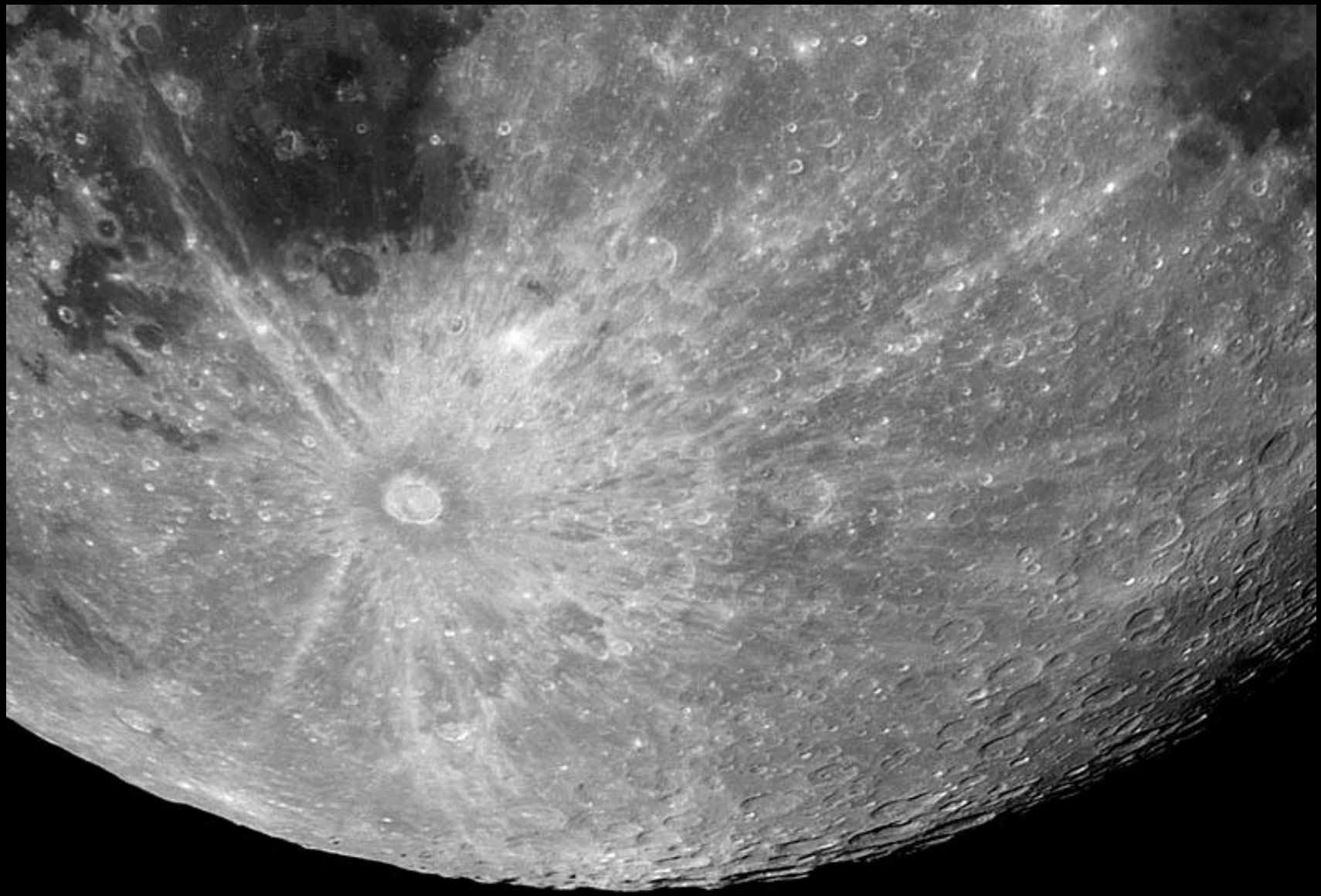


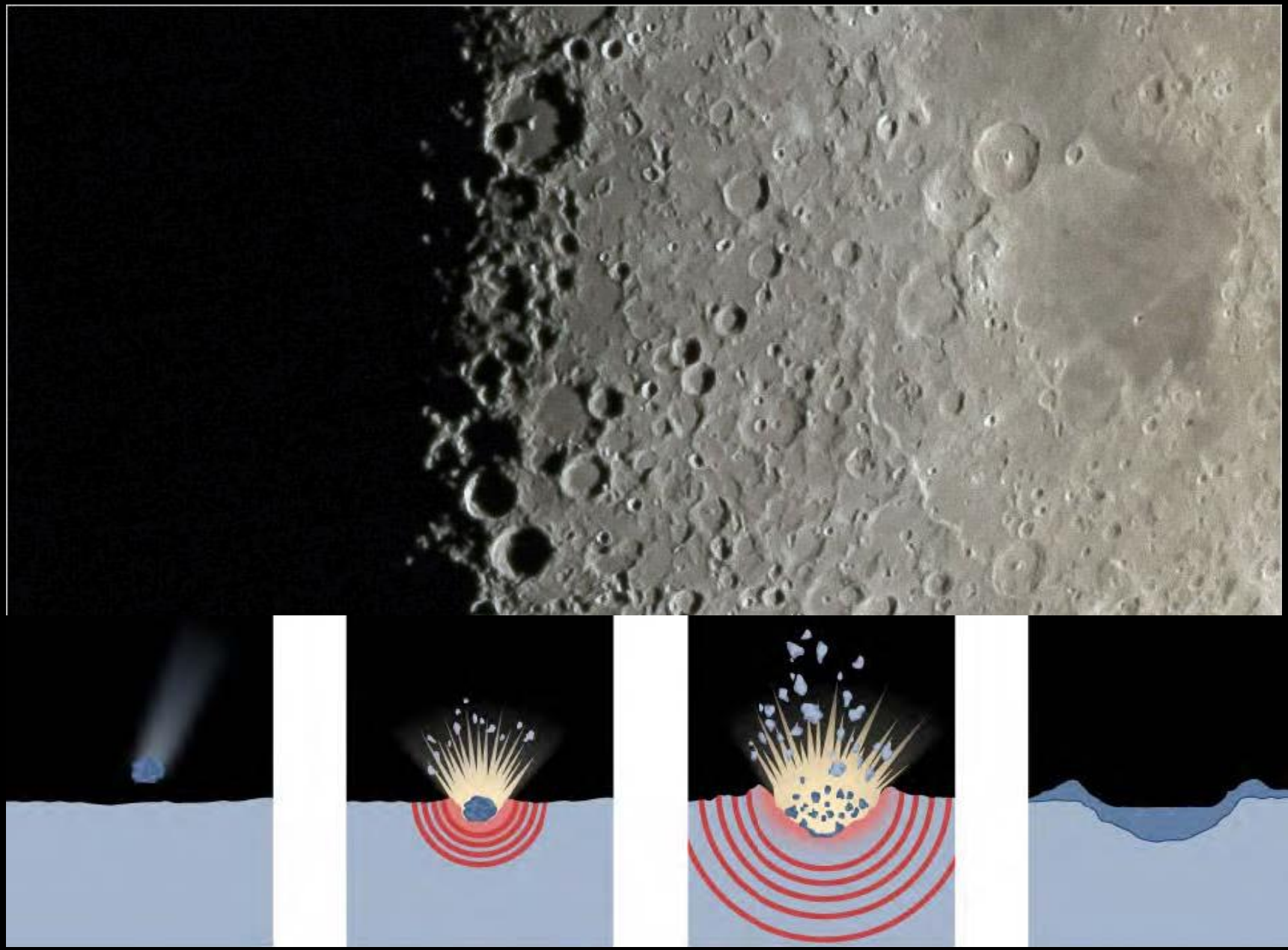


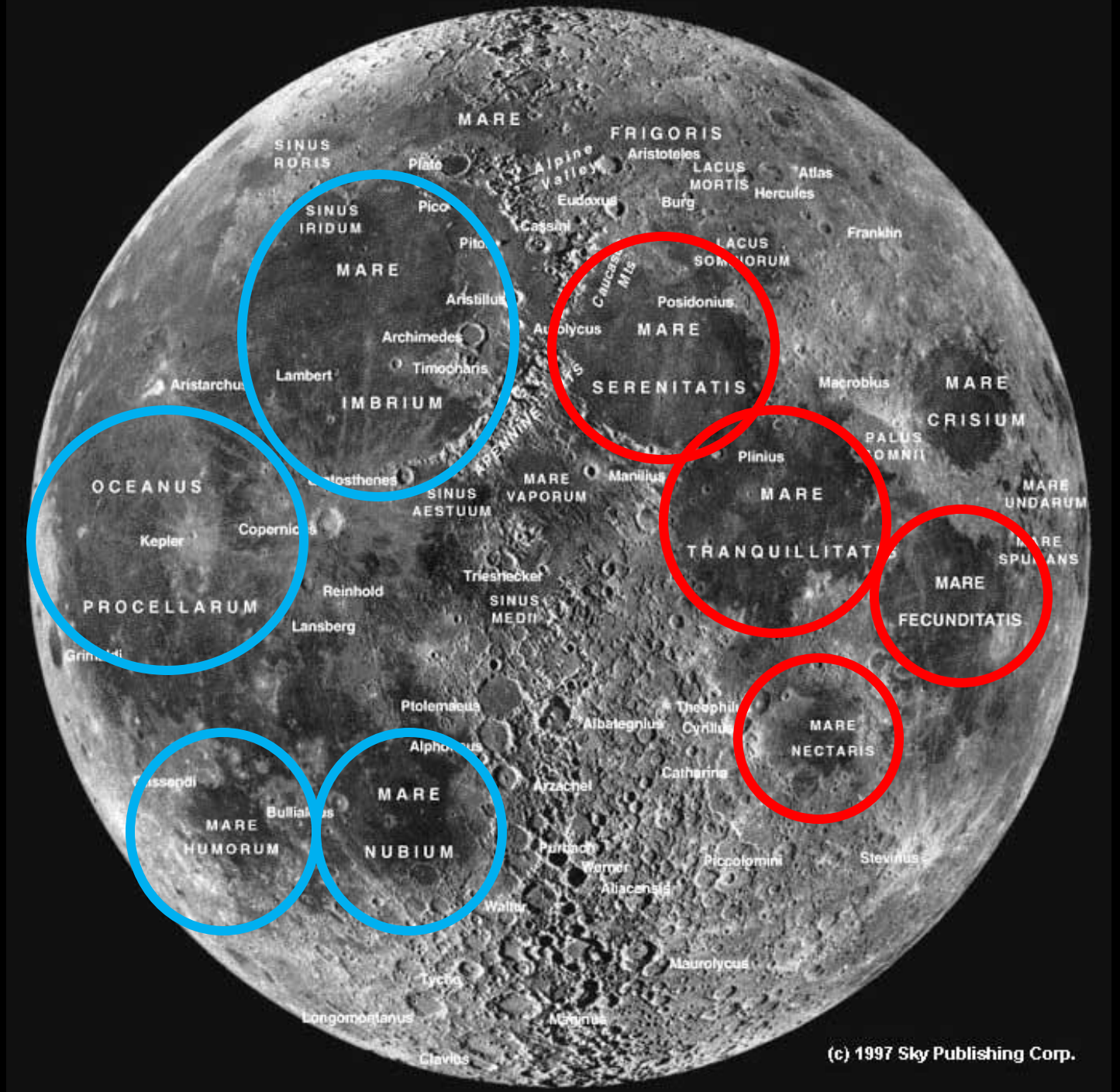
Ramadan – 9th month of Islamic calendar

Through a telescope . . .

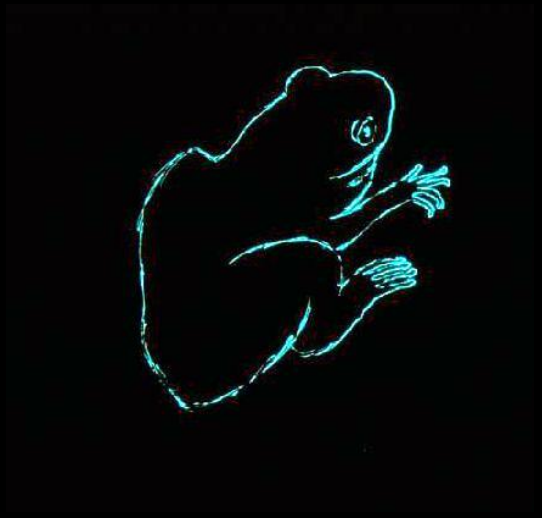




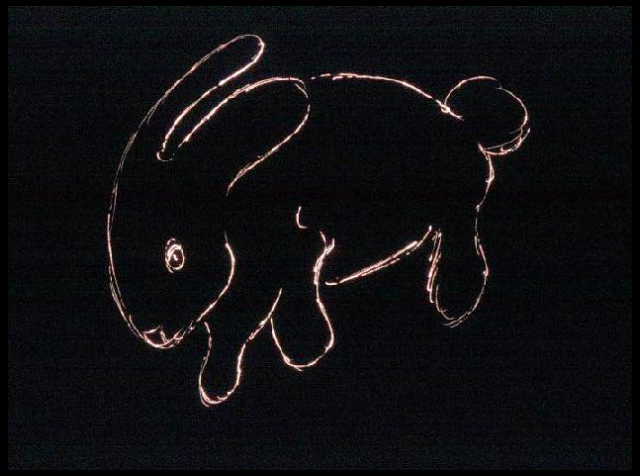



MARE
FRIGORIS
SINUS
RORIS
Plato
Alpine
Valley
Aristoteles
LACUS
MORTIS
Atlas
Hercules
Eudoxus
Burg
Cassini
Franklin
SINUS
IRIDUM
Pico
Pito
MARE
IMBRIUM
Aristillus
Archimedes
Timocharis
Lambert
Aristarchus
Caucasus Mts.
Posidonius
MARE
SERENITATIS
Macrobius
MARE
CRISIUM
PALUS
OMNII
Plinius
MARE
TRANQUILLITATIS
MARE
VAPORUM
Manilius
SINUS
AESTUUM
OCEANUS
Kepler
Copernicus
PROCELLARUM
Reinhold
Lansberg
Triesnecker
SINUS
MEDII
MARE
UNDARUM
MARE
SPUMANS
MARE
FECUNDITATIS
Ptolemaeus
Albategnius
Theophilus
Cyrillus
MARE
NECTARIS
Catharina
Arzachel
Alphonsus
Bullialdus
MARE
HUMORUM
MARE
NUBIUM
Purbach
Piccolomini
Stevinus
Werner
Aliacensis
Wallis
Maurolycus
Tycho
Longomontanus
Clavius
(c) 1997 Sky Publishing Corp.

Moon “Constellations”



Moon “Constellations”

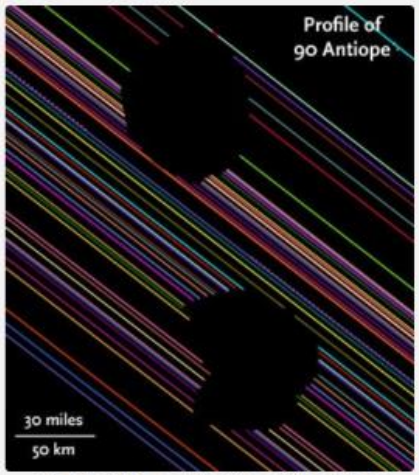


Moon “Constellations”

“Lunar occultations”

International Oc

HOME COMMUNITY OCCULTATIONS OBSERVING



Jul 19, 2011 occultation of the binary asteroid (90) Antiope

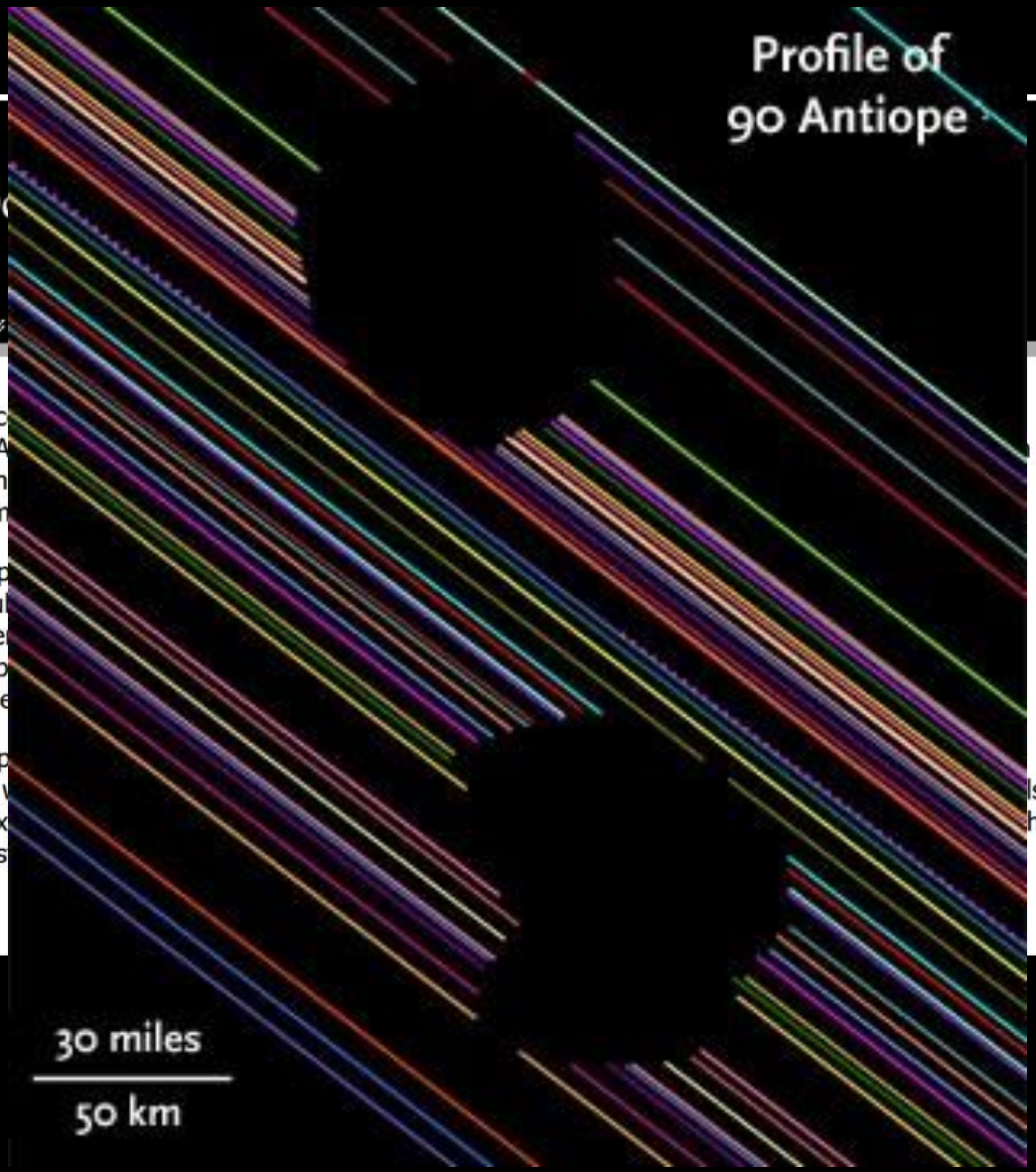
Welc
IOTA
timin
prom

We p
occu
obse
doub
helpe

We p
and
of ex
of as

ls
h

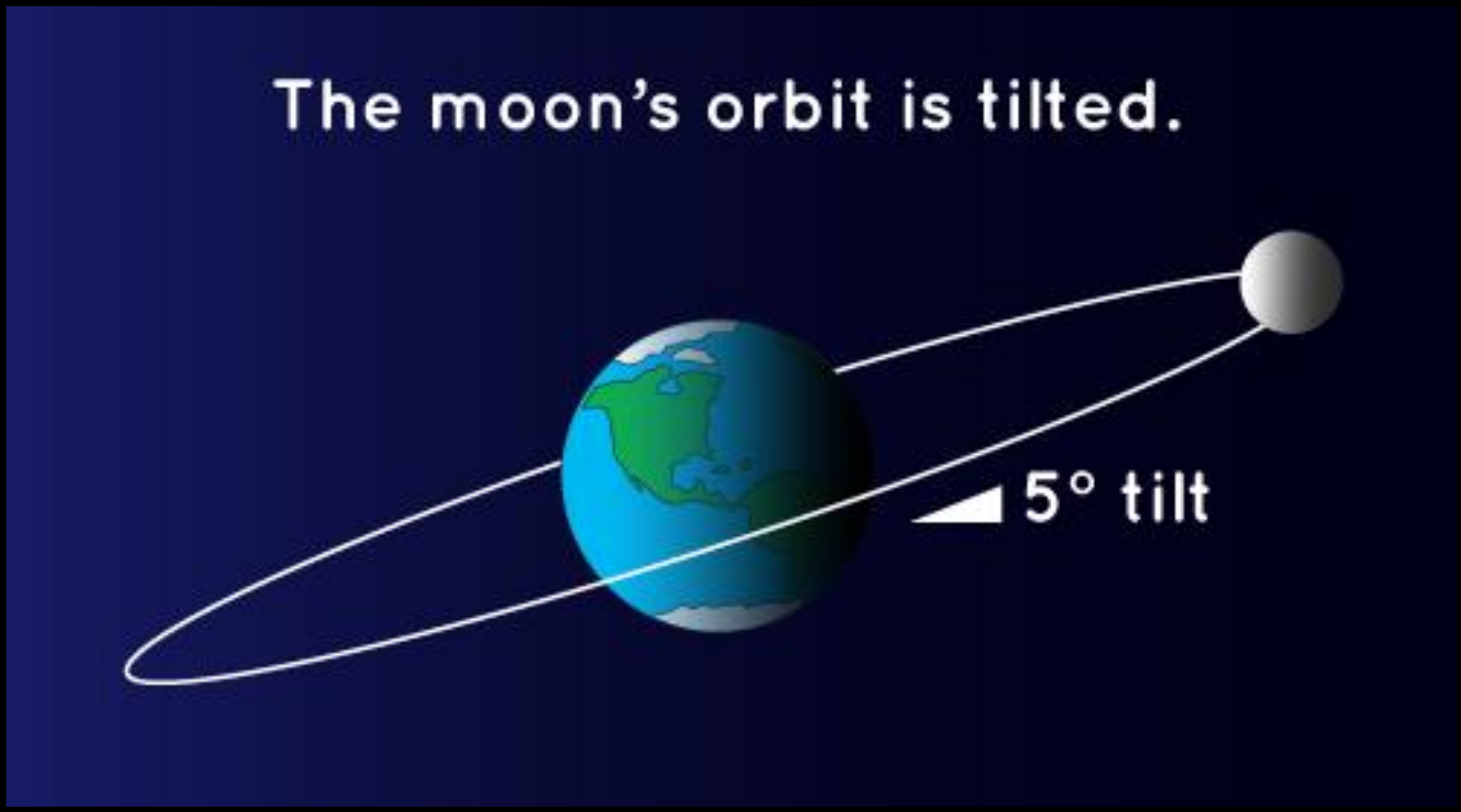
Join IOTA
Donate

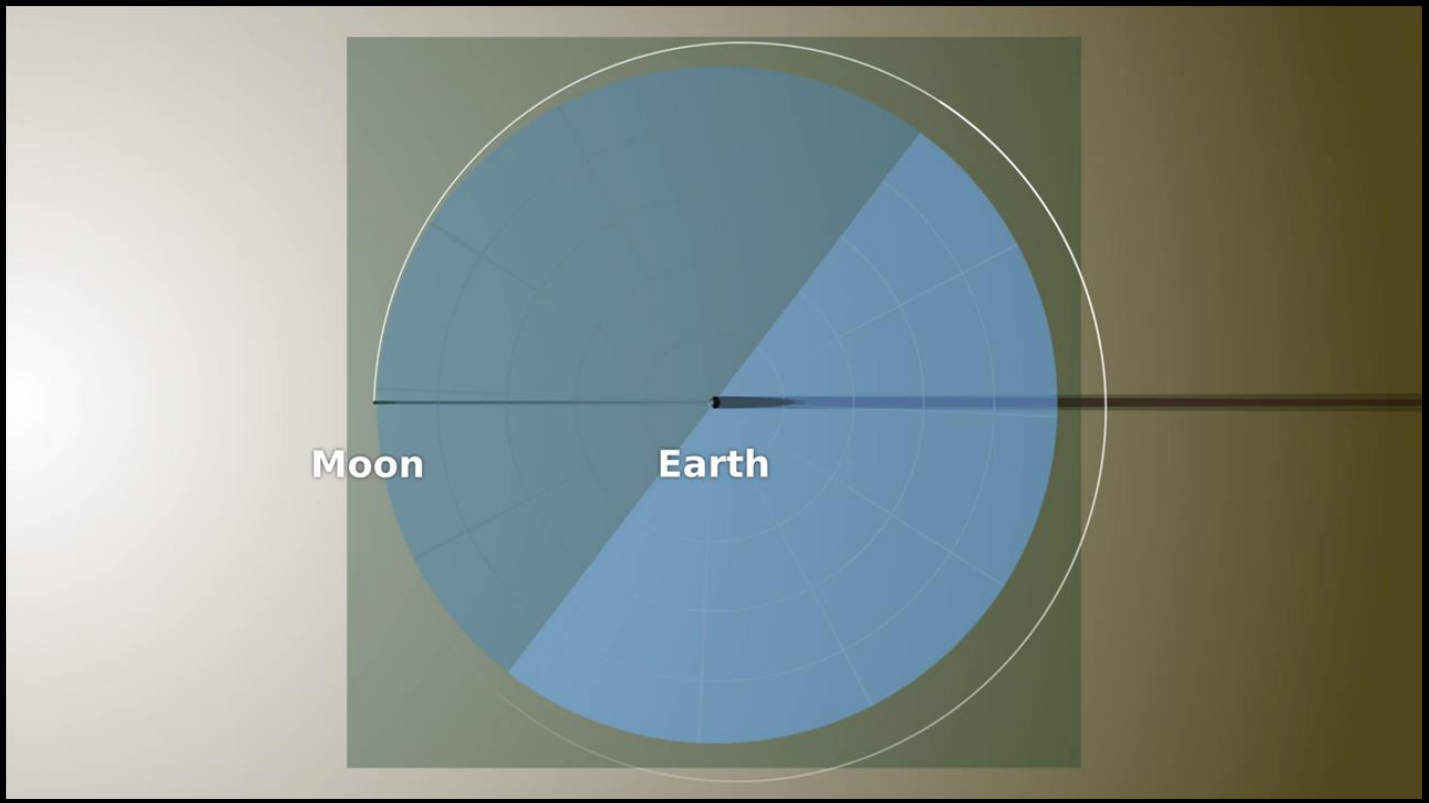


Eclipses

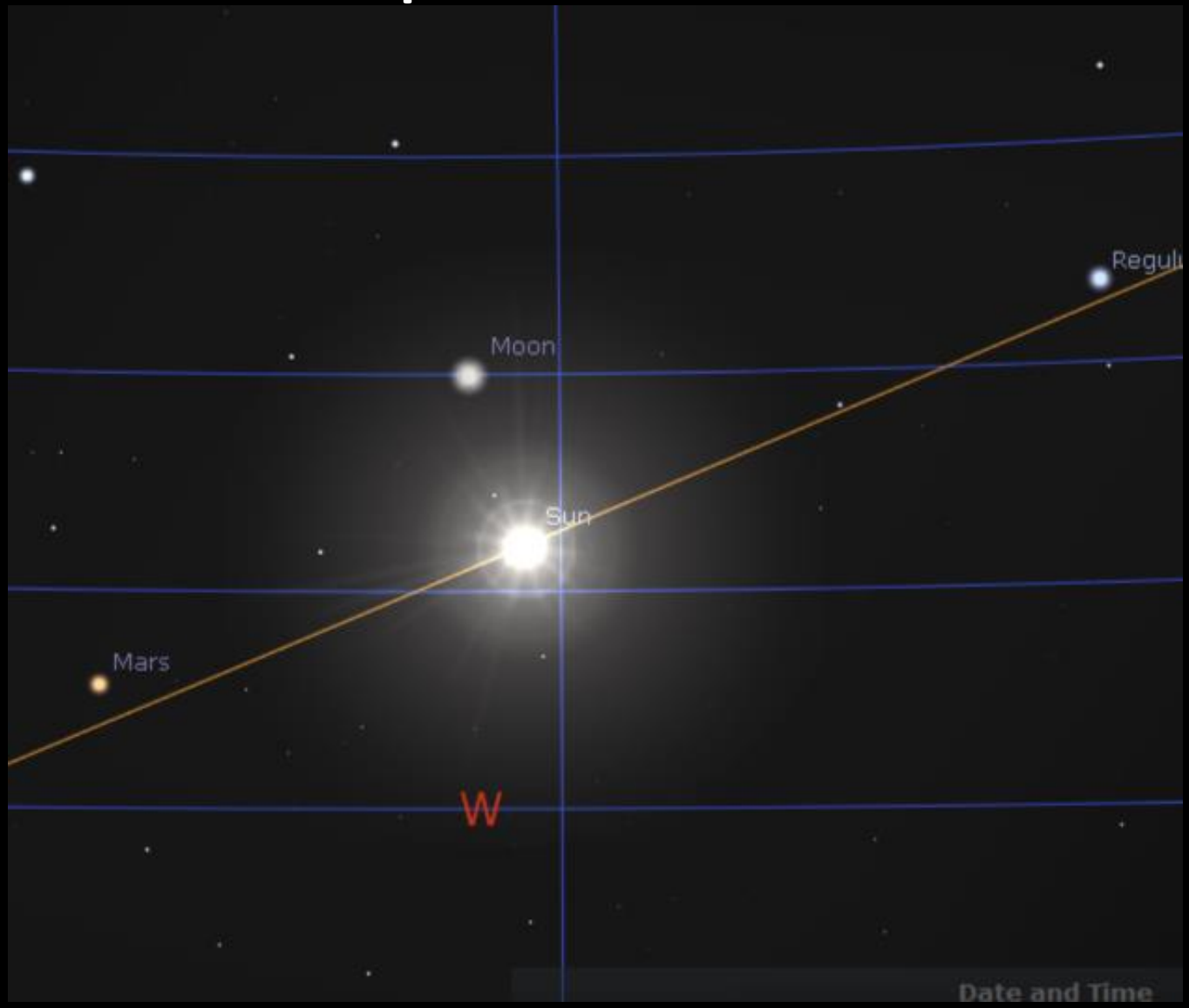
- Lunar (Full Moon)
  - total
  - penumbral
- Solar (New Moon)
  - Partial
  - Total
  - Annular

Why don’t eclipses happen <u>every</u> month?

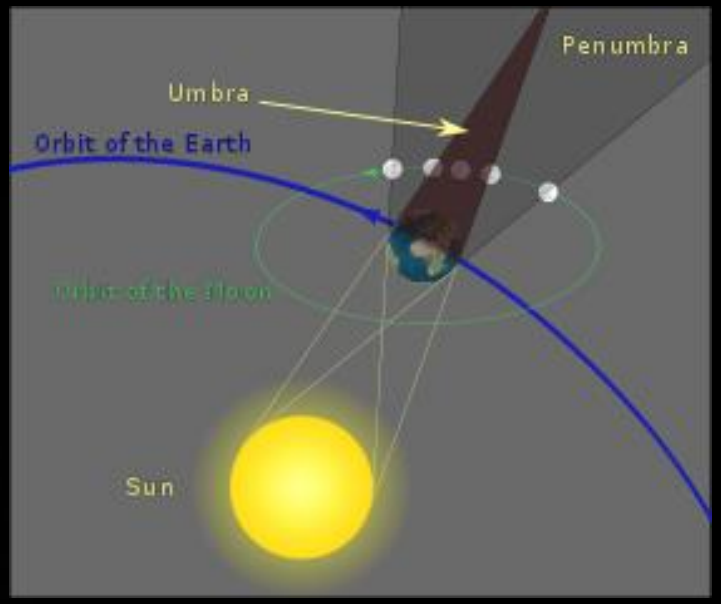


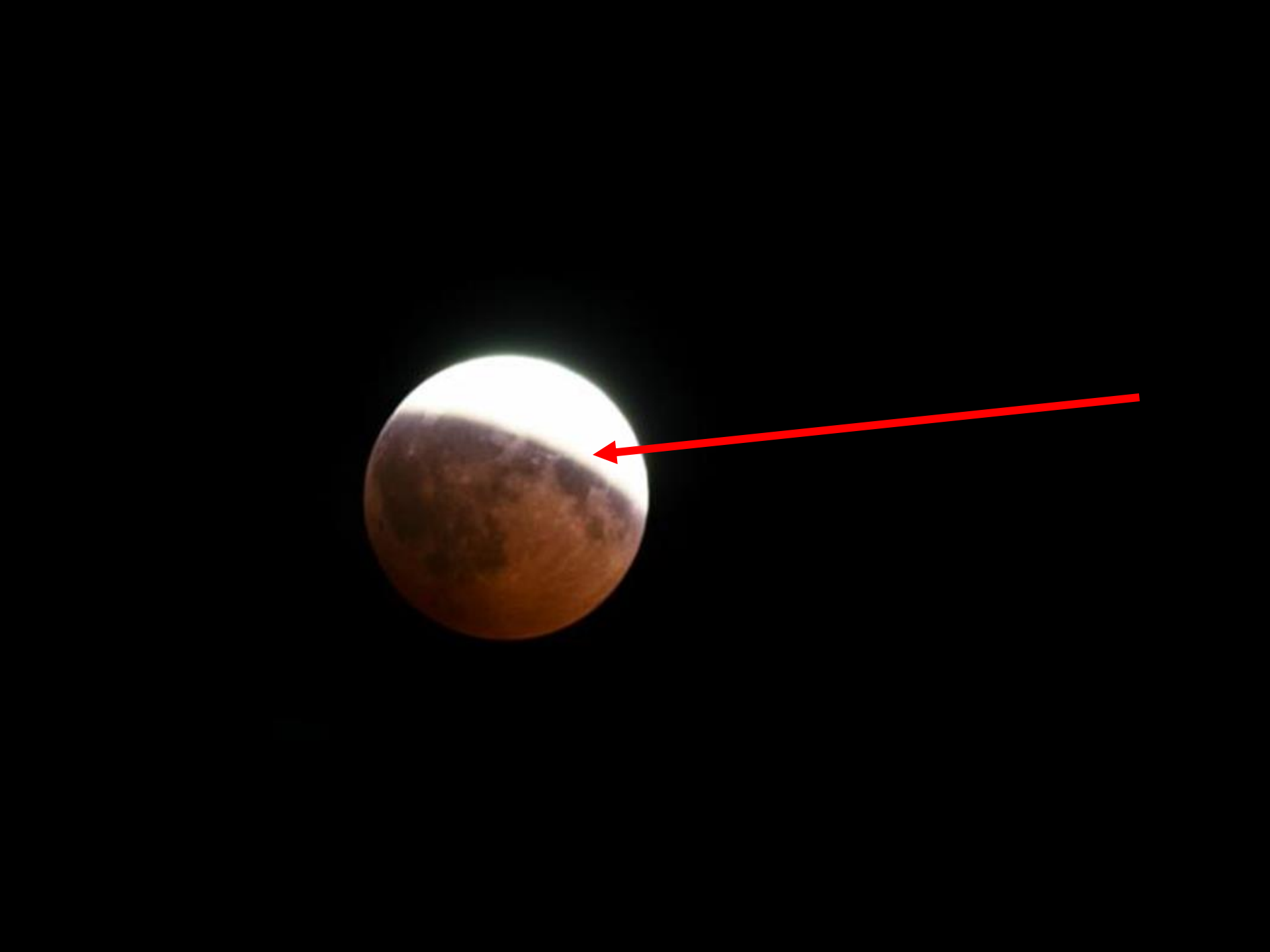

Moon
Earth

Sept 6, 2021

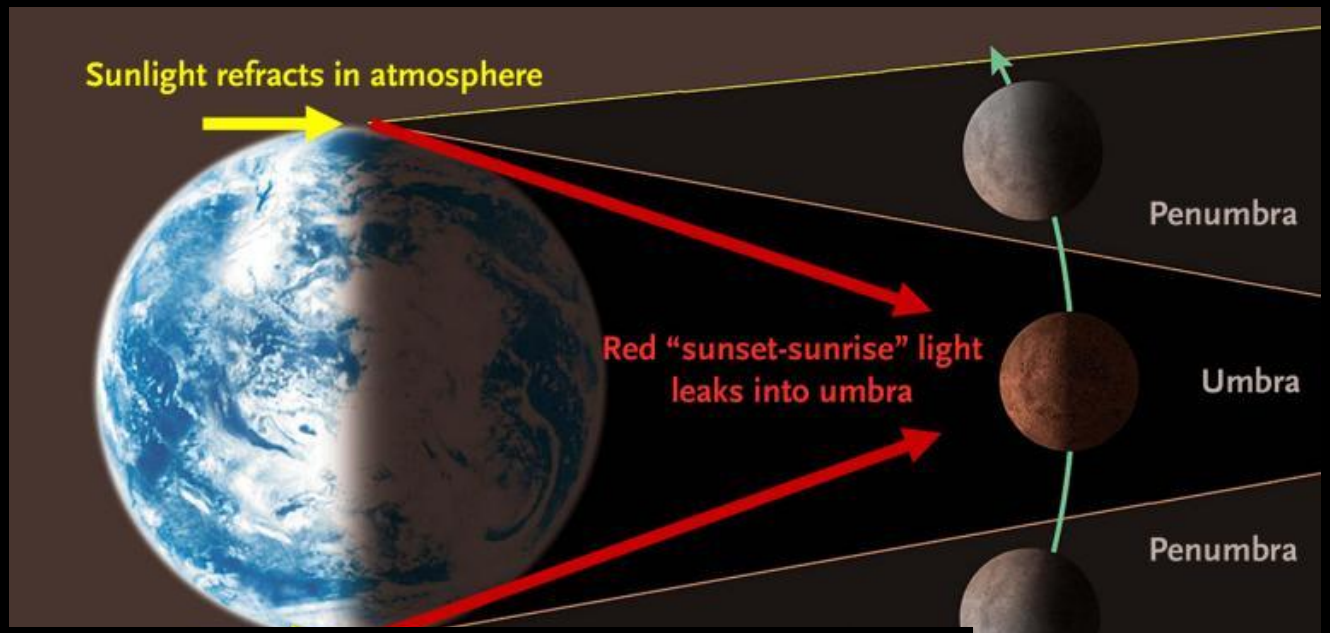


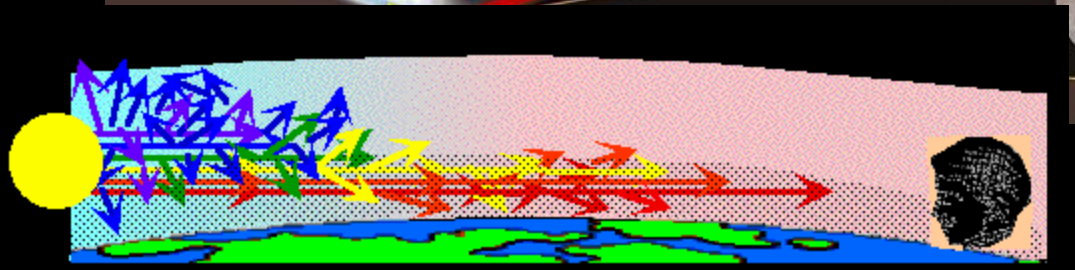
Lunar Eclipses



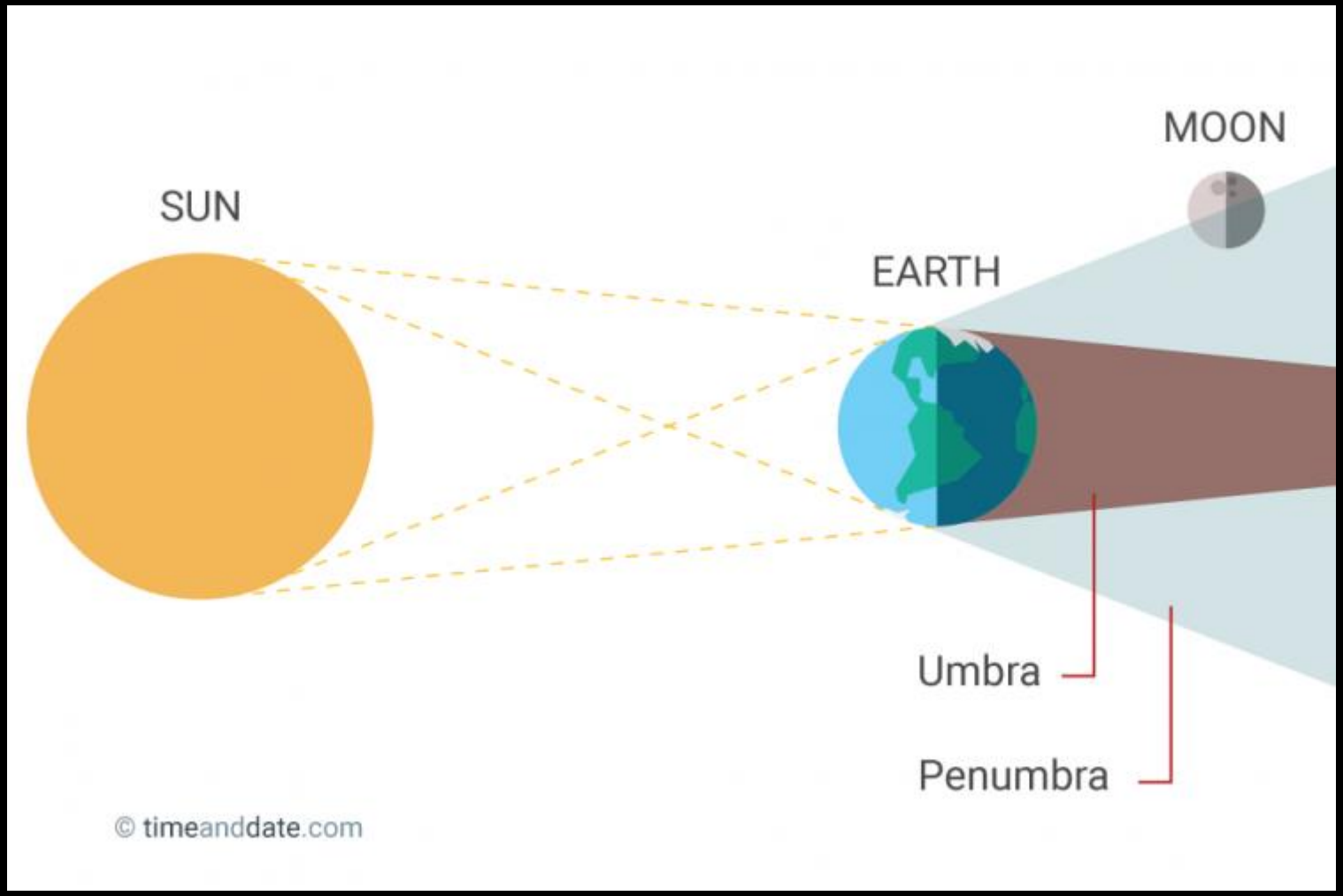


“Blood Moons?”


Sunlight refracts in atmosphere
Red “sunset-sunrise” light leaks into umbra
Penumbra
Umbra
Penumbra



Two parts of a shadow



https://eclipse.gsfc.nasa.gov

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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+ NASA Portal
+ Sun-Earth Day
+ Eclipse Bulletins
+ Eclipses During 2021

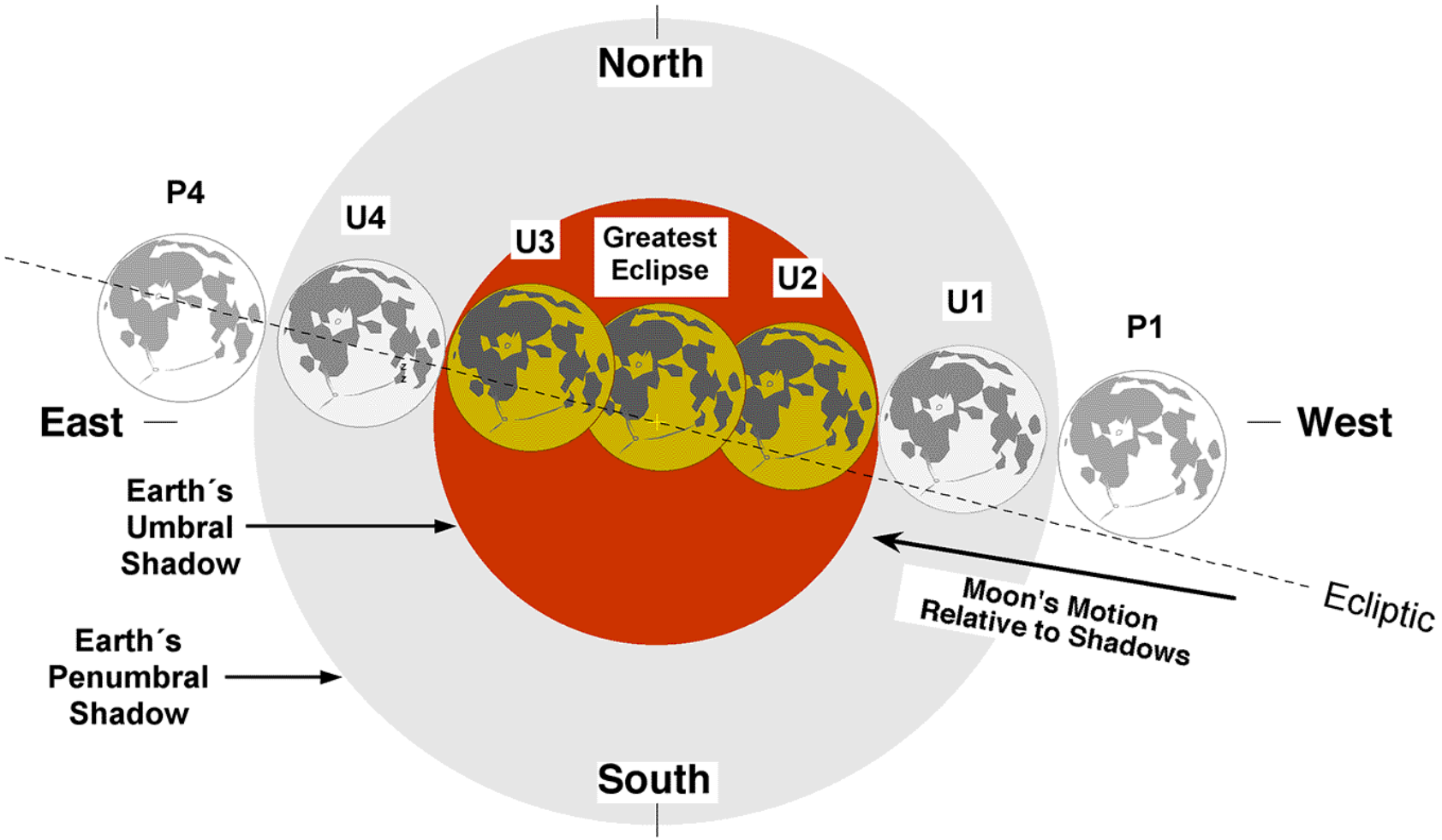
+ HOME | + SOLAR ECLIPSES | + LUNAR ECLIPSES | + TRANSITS

NASA GODDARD SPACE FLIGHT CENTER ECLIPSE WEB SITE

eclipse.gsfc.nasa.gov/eclipse.html

More on Eclipses at www.nasa.gov/eclipse

Figure 2–1. Lunar Eclipse Contacts

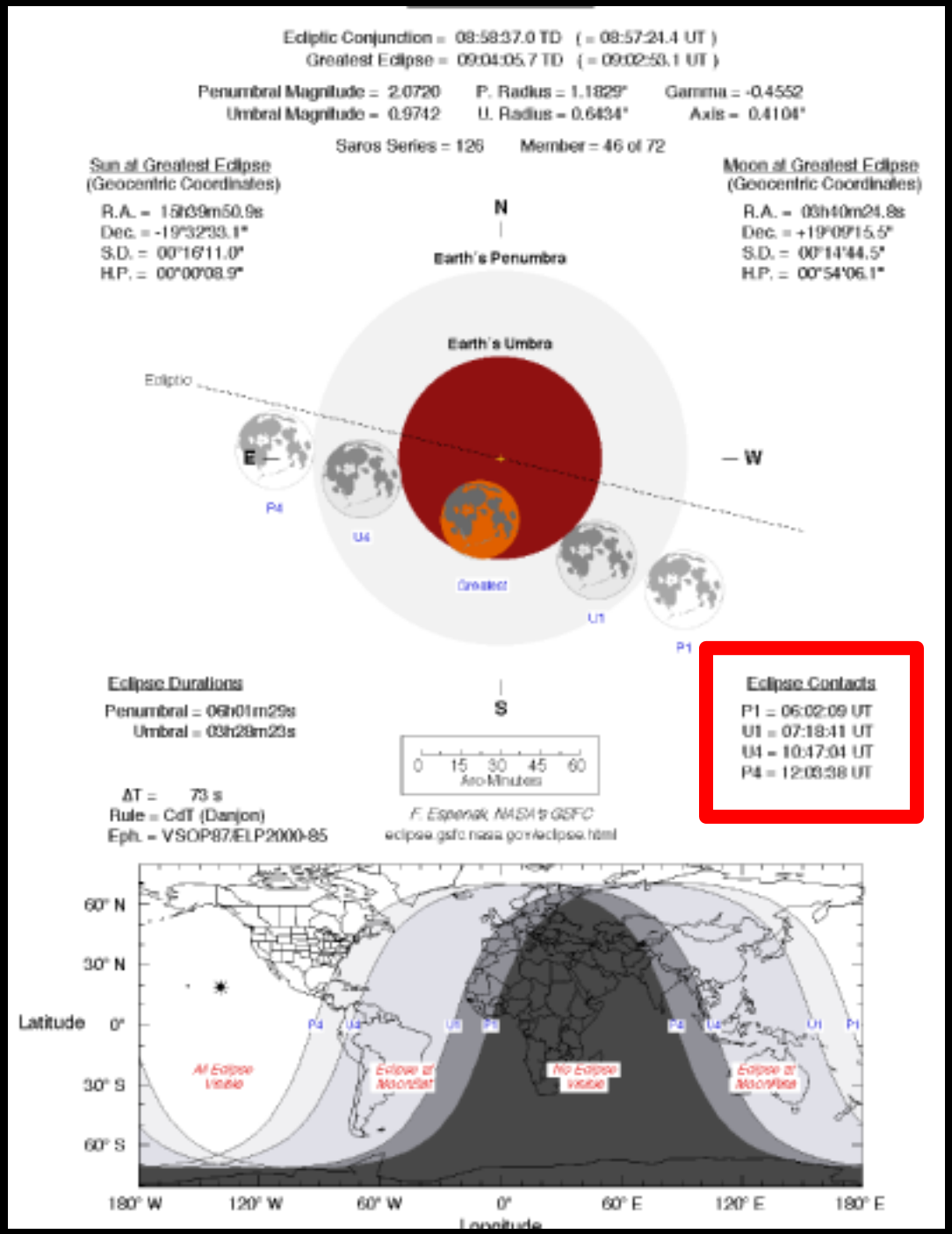


Courtesy of "Thousand Year Canon of Lunar Eclipses: 1501 – 2500", Fred Espenak, AstroPixels Publishing, 2015.

Lunar Eclipses: 2021 - 2030

Calendar Date	TD of Greatest Eclipse	Eclipse Type	Saros Series	Umbral Magnitude	Eclipse Duration	Geographic Region of Eclipse Visibility
2021 May 26	11:19:53	Total	121	1.009	03h07m **00h15m**	e Asia, Australia, Pacific, Americas
2021 Nov 19	09:04:06	Partial	126	0.974	03h28m	Americas, n Europe, e Asia, Australia, Pacific
2022 May 16	04:12:42	Total	131	1.414	03h27m **01h25m**	Americas, Europe, Africa
2022 Nov 08	11:00:22	Total	136	1.359	03h40m **01h25m**	Asia, Australia, Pacific, Americas
2023 May 05	17:24:05	Penumbral	141	-0.046	-	Africa, Asia, Australia
2023 Oct 28	20:15:18	Partial	146	0.122	01h17m	e Americas, Europe, Africa, Asia, Australia
2024 Mar 25	07:13:59	Penumbral	113	-0.132	-	Americas
2024 Sep 18	02:45:25	Partial	118	0.085	01h03m	Americas, Europe, Africa

Nov. 19


Ecliptic Conjunction = 08:58:37.0 TD (= 08:57:24.4 UT)
Greatest Eclipse = 09:04:05.7 TD (= 09:02:53.1 UT)
Penumbral Magnitude = 2.0720
Umbral Magnitude = 0.9712
P. Radius = 1.1829°
U. Radius = 0.6434°
Gamma = -0.4552
Axis = 0.4104°
Saros Series = 126
Member = 46 of 72
Sun at Greatest Eclipse
(Geocentric Coordinates)
R.A. = 15h39m50.9s
Dec. = -19°32'33.1"
S.D. = 00°16'11.0"
H.P. = 00°00'08.9"
Moon at Greatest Eclipse
(Geocentric Coordinates)
R.A. = 03h40m24.8s
Dec. = +19°09'15.5"
S.D. = 00°14'44.5"
H.P. = 00°54'06.1"
N
Earth's Penumbra
Earth's Umbra
Ecliptic
E
W
P4
U4
Greatest
U1
P1
S
Eclipse Durations
Penumbral = 06h01m29s
Umbral = 03h28m23s
ΔT = 73 s
Rule = CdT (Danjon)
Eph. = VSOP87/ELP2000-85
0 15 30 45 60
Arc-Minutes
F. Espenak, NASA's GSFC
eclipse.gsfc.nasa.gov/eclipse.html
Eclipse Contacts
P1 = 06:02:09 UT
U1 = 07:18:41 UT
U4 = 10:47:04 UT
P4 = 12:09:38 UT
60° N
30° N
Latitude 0°
30° S
60° S
180° W
120° W
60° W
0°
60° E
120° E
180° E
Longitude
All Eclipse Visible
Eclipse at Moonrise
No Eclipse Visible
Eclipse at Moonrise

A note about time . . . .

- Solar time = based on the position of the Sun
- Local Mean Time/Standard time = based on an "average Sun" (time on your phone)
- Universal Time = Time at prime meridian

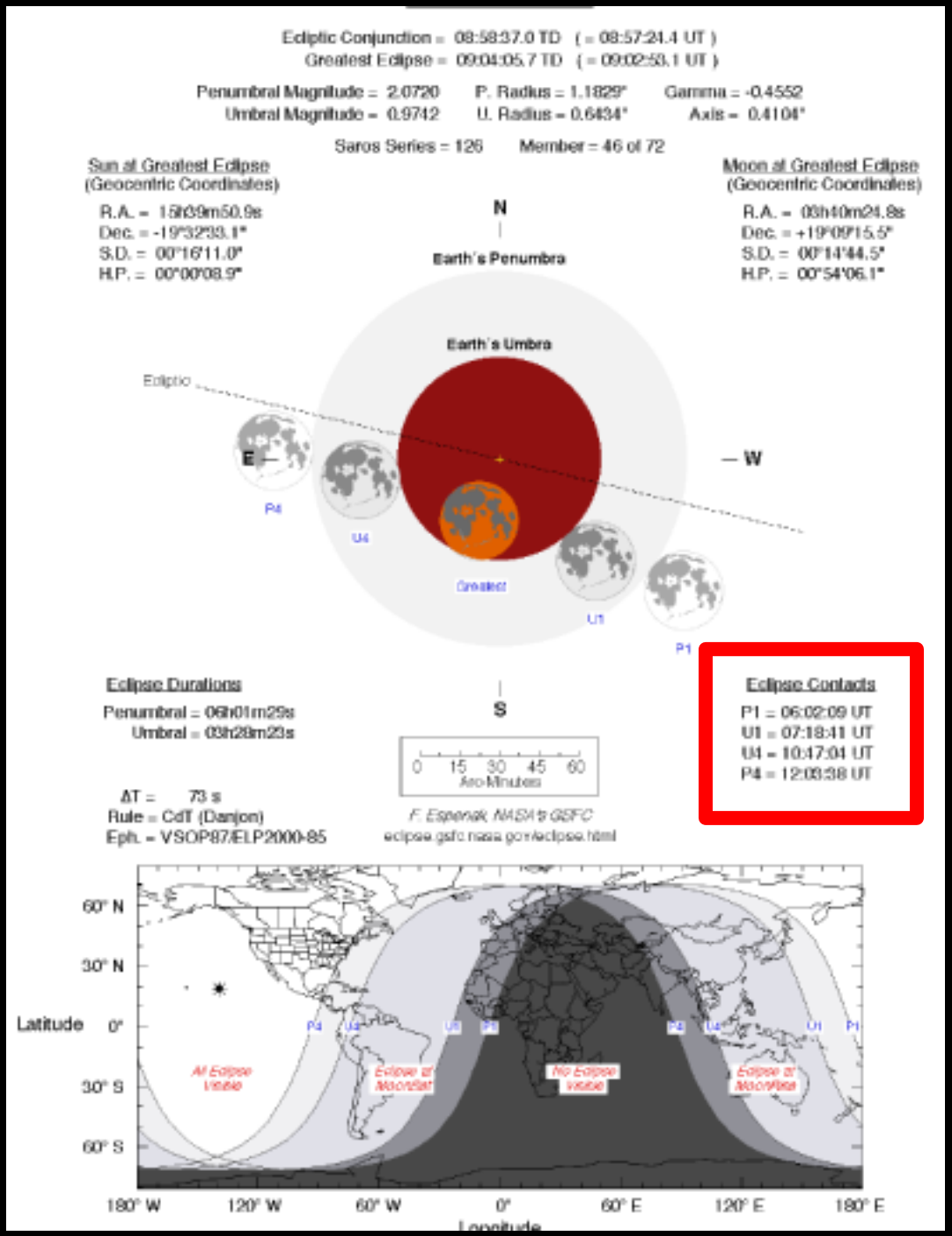
CST = UT – 6 hours

CDT = UT – 5 hours

Ex 1) Sept 3, 10 hrs UT = Sept 3, 5am CDT

Ex 2) Sept 3, 23 hrs UT = Sept 3, 6pm CDT

Ex 3) Sept 3, 2 hrs UT = Sept 2, 9pm CDT



Nov. 19, 2021

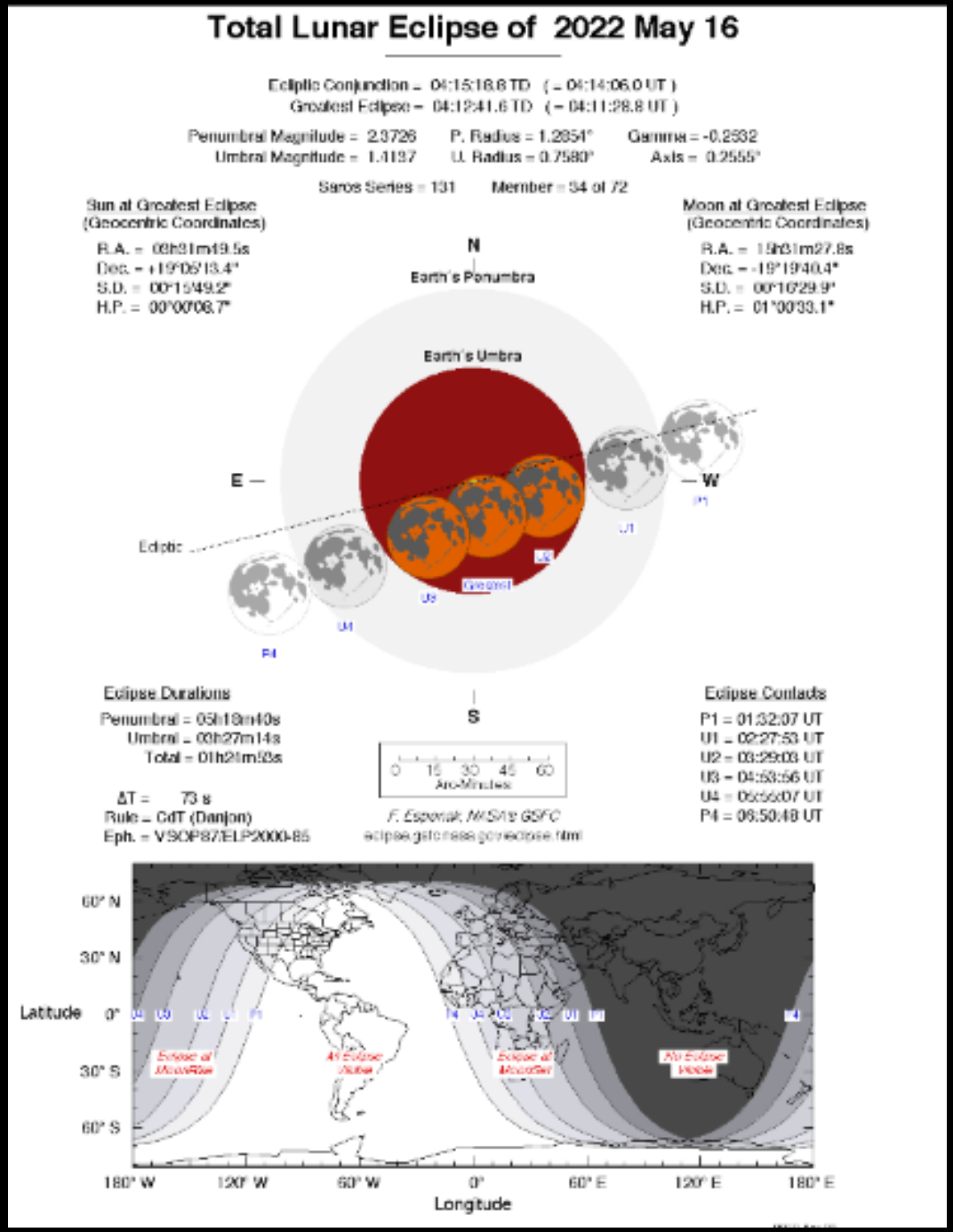
Start = 1:18am
Max = 3:04am
End = 4:47am

"Umbral magnitude" = 97%

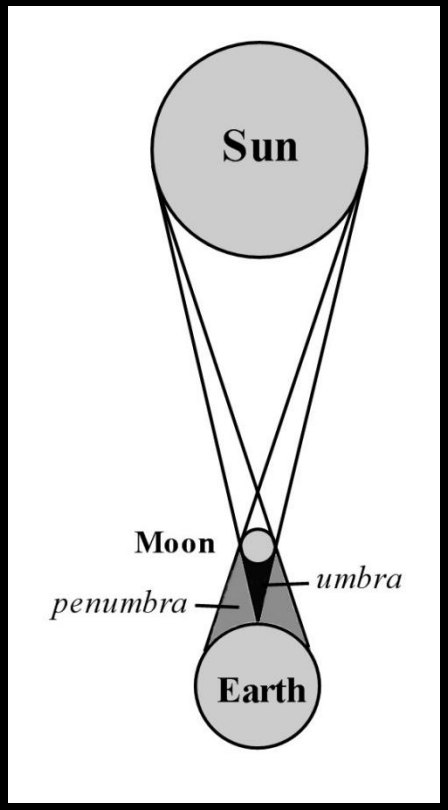
May 15, 2022

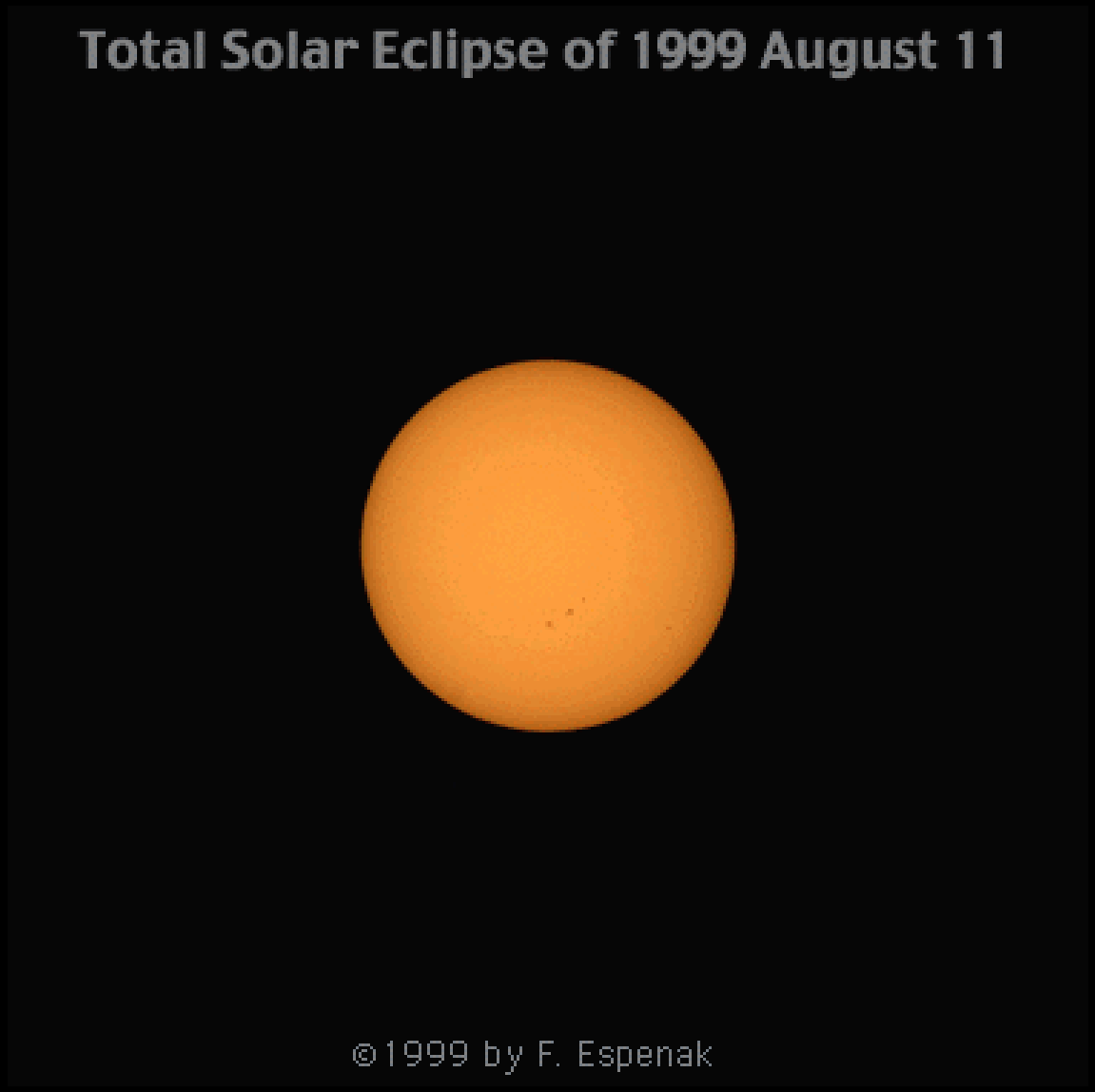
Umbral:

Start = 9:28pm
Fully in= 10:29pm
Max = 11:13pm
Start to leave = 11:54pm
Done = 12:55am



Solar Eclipses





Sun is 400 times larger than Moon,
but it is also 400 times further away!

So they appear about the same size in the sky!

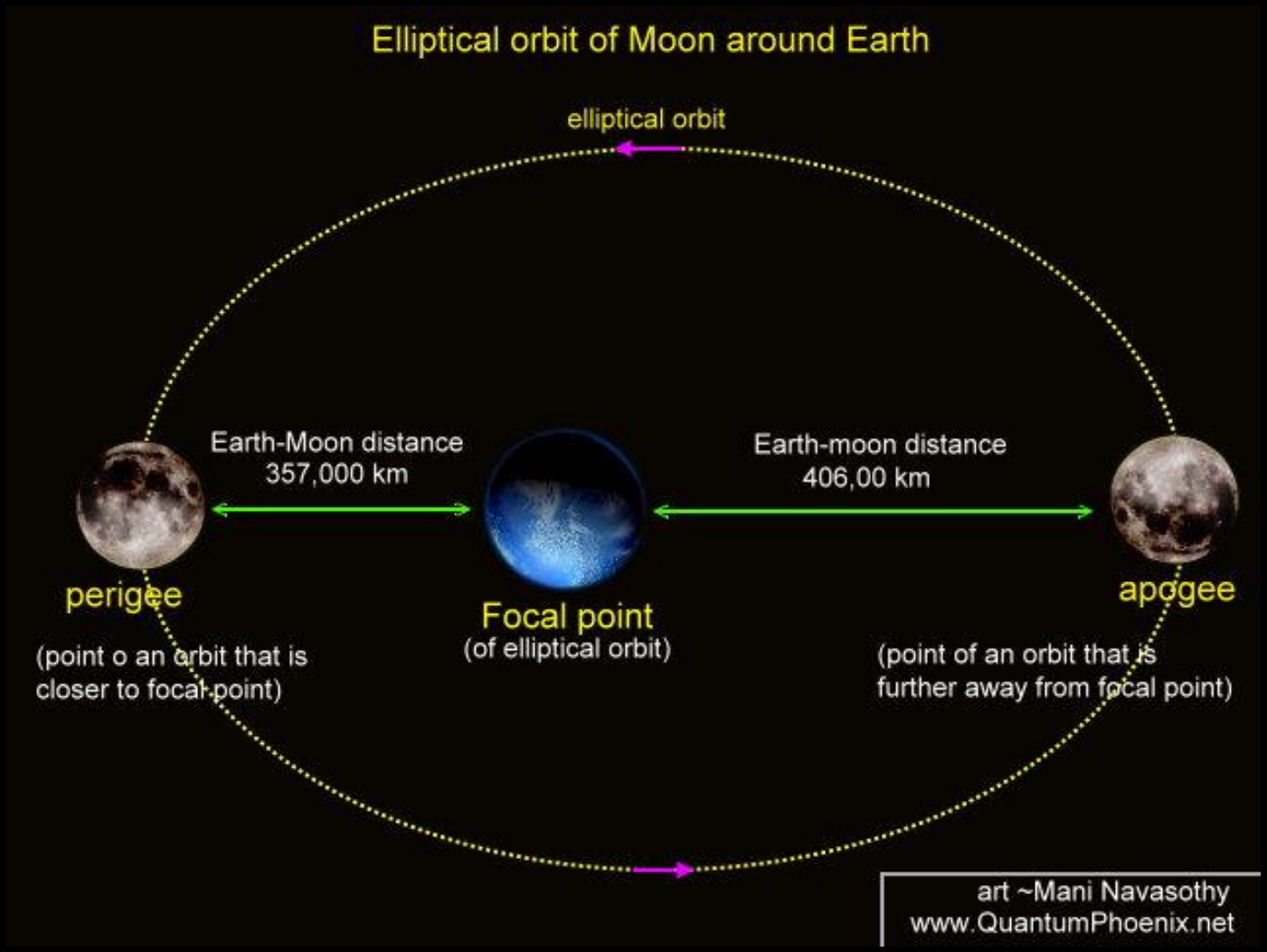
Astronomy “picture of the day”

October, 2014
Doyle Slifer

August, 2017

Image by Jeff Bryant

Moon’s orbit is not a perfect circle

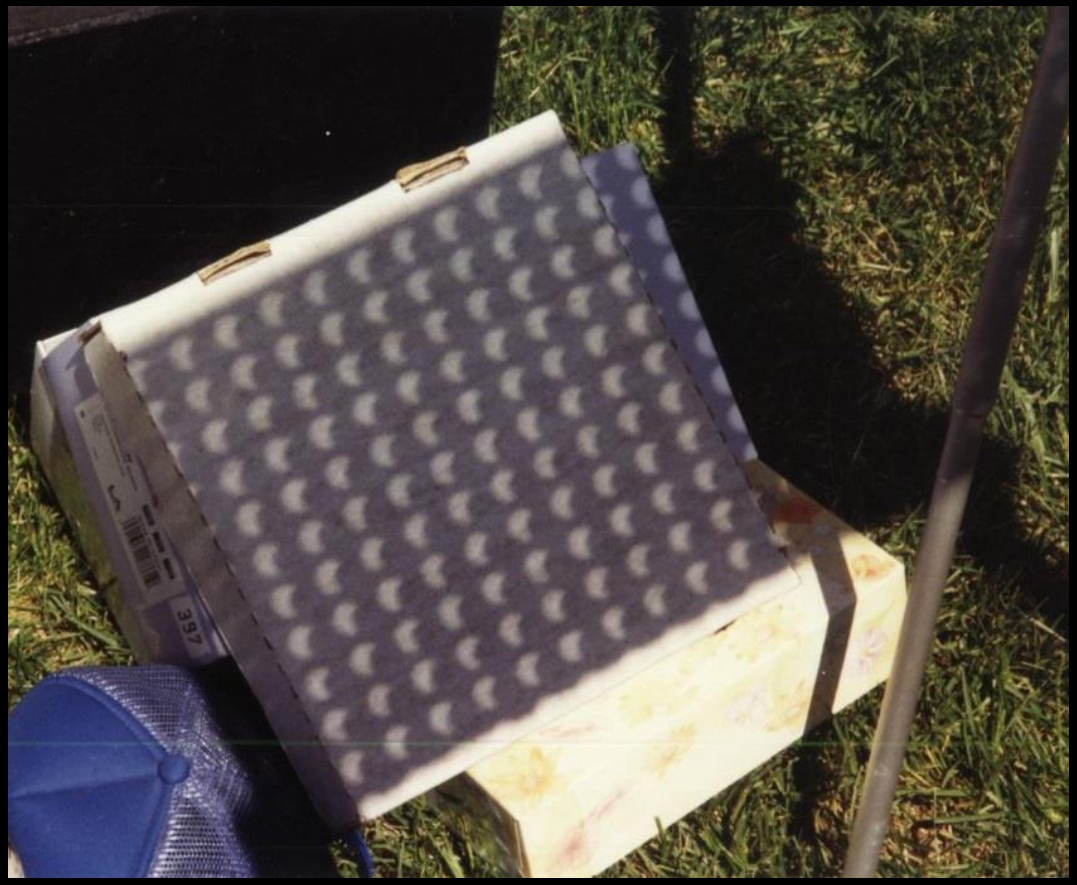


“SUPERMOON?”

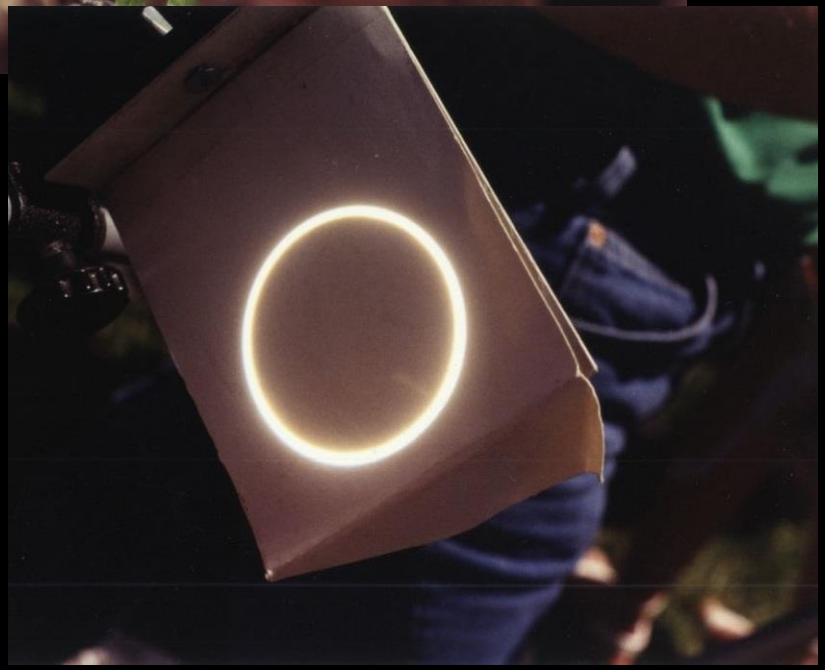
Annular eclipse

- Moon at “apogee” – appears smaller

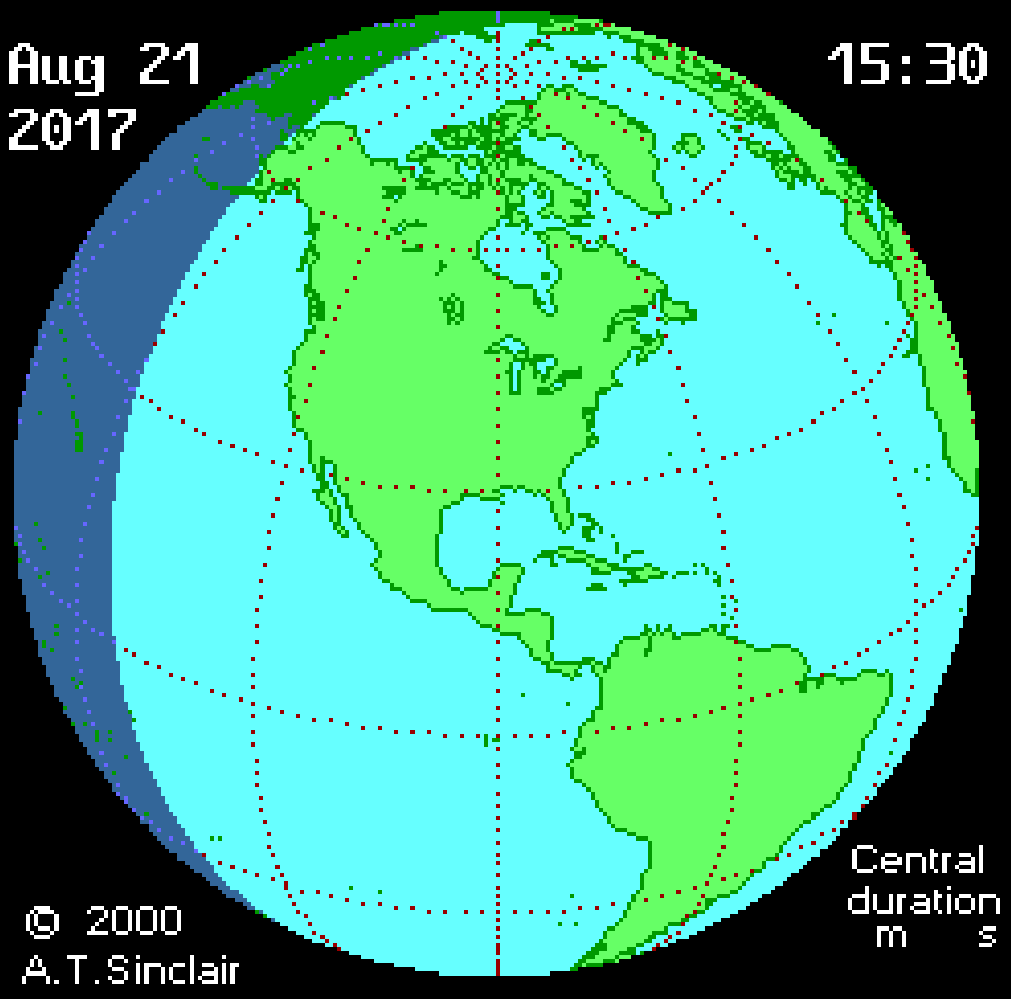
May 10, 1994



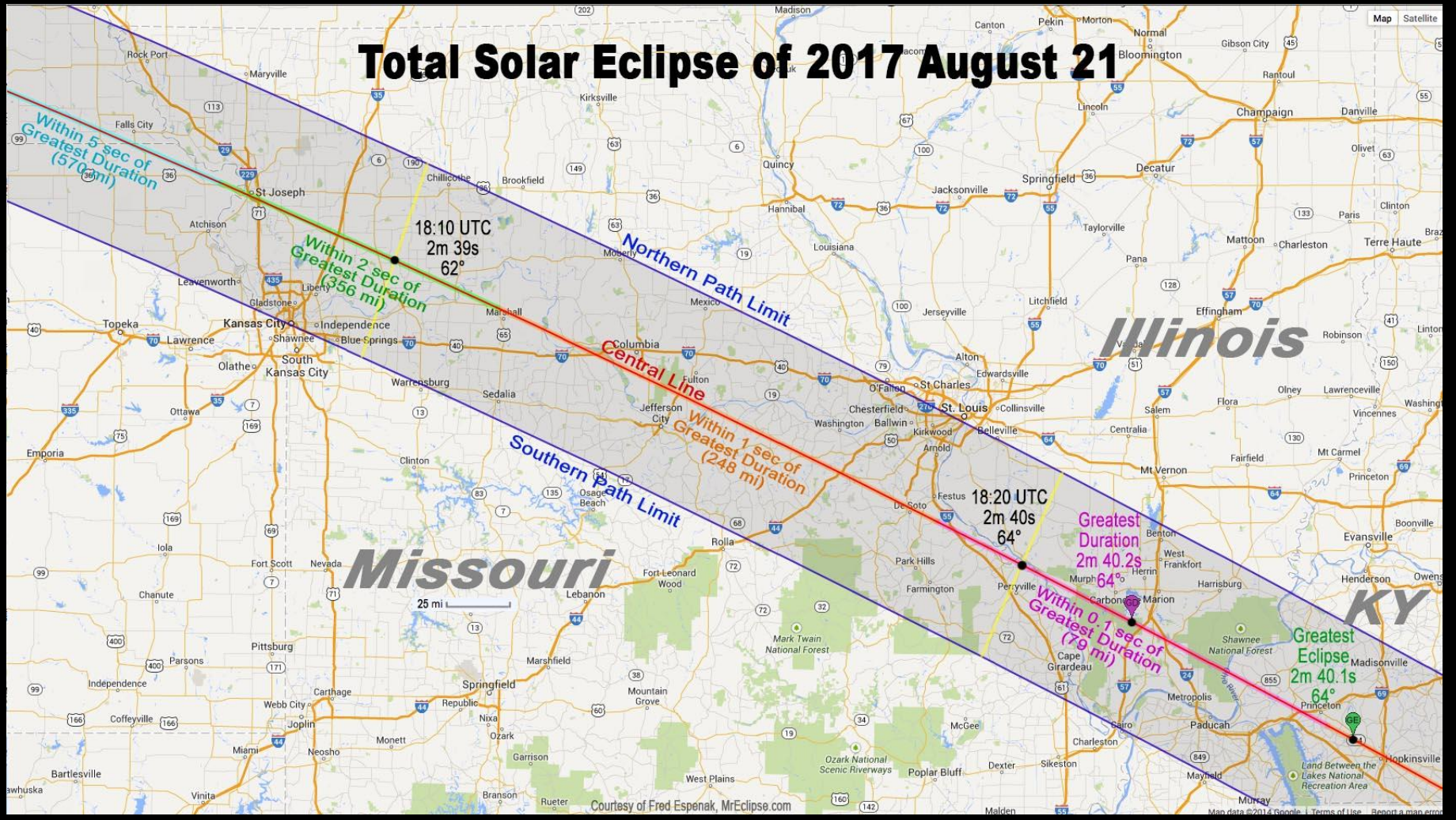
1994

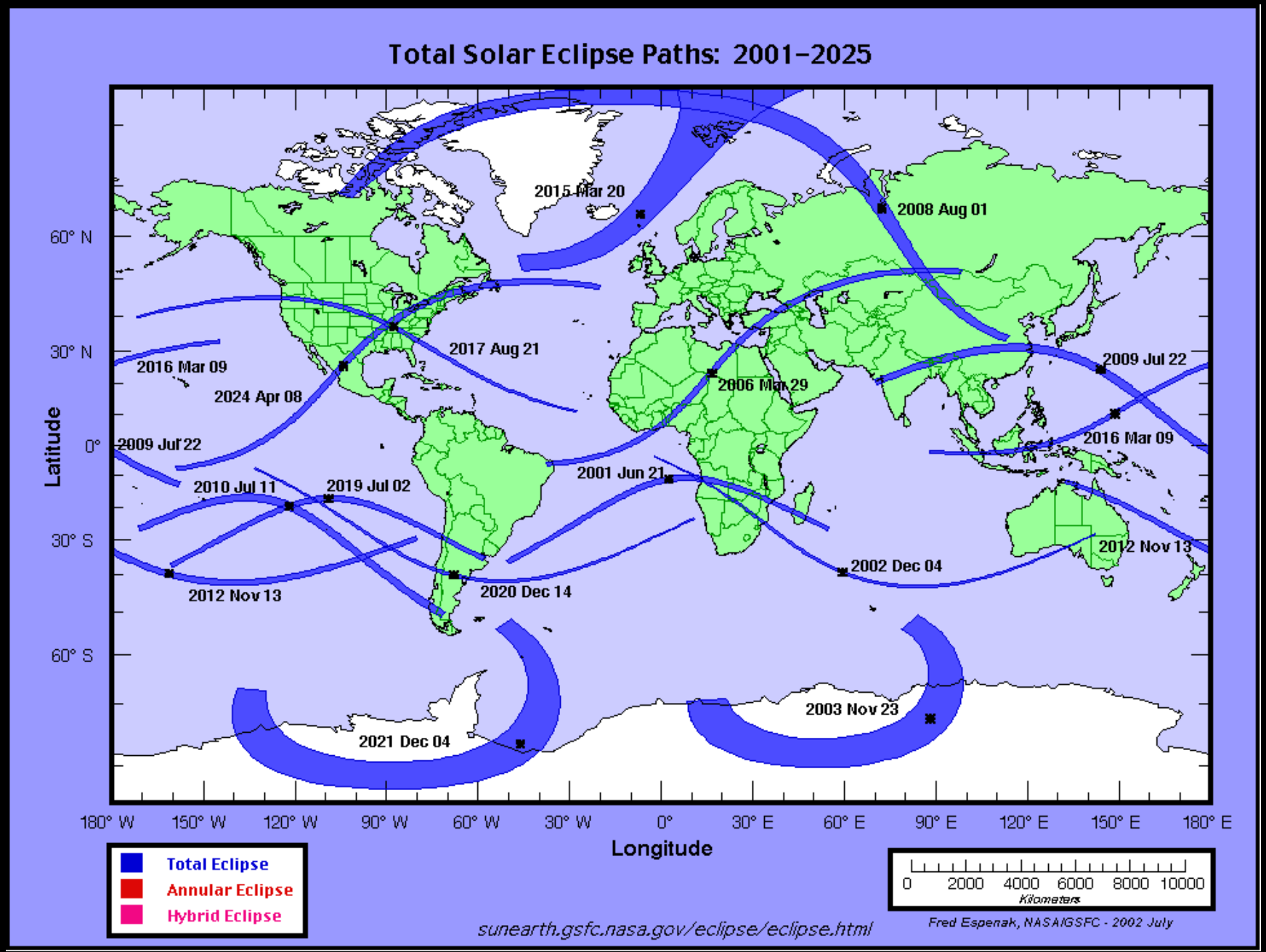


						Indian]
2017 Feb 26	14:54:32	Annular	140	0.992	00m44s	s S. America, Atlantic, Africa, Antarctica **[Annular: Pacific, Chile, Argentina, Atlantic, Africa]**
2017 Aug 21	18:26:40	Total	145	1.031	02m40s	N. America, n S. America **[Total: n Pacific, U.S., s Atlantic]**
2018 Feb 15	20:52:33	Partial	150	0.599	-	Antarctica, s S. America
2018 Jul 13	03:02:16	Partial	117	0.336	-	s Australia
2018 Aug 11	09:47:28	Partial	155	0.737	-	n Europe, ne Asia
2019 Jan 06	01:42:38	Partial	122	0.715	-	ne Asia, n Pacific
2019 Jul 02	19:24:07	Total	127	1.046	04m33s	s Pacific, S. America **[Total: s Pacific, Chile, Argentina]**
2019 Dec 26	05:18:53	Annular	132	0.970	03m39s	Asia, Australia **[Annular: Saudi Arabia, India, Sumatra, Borneo]**
2020 Jun 21	06:41:15	Annular	137	0.994	00m38s	Africa, se Europe, Asia **[Annular: c Africa, s Asia, China, Pacific]**
2020 Dec 14	16:14:39	Total	142	1.025	02m10s	Pacific, s S. America, Antarctica **[Total: s Pacific, Chile, Argentina, s Atlantic]**



sunearth.gsfc.nasa.gov/eclipse

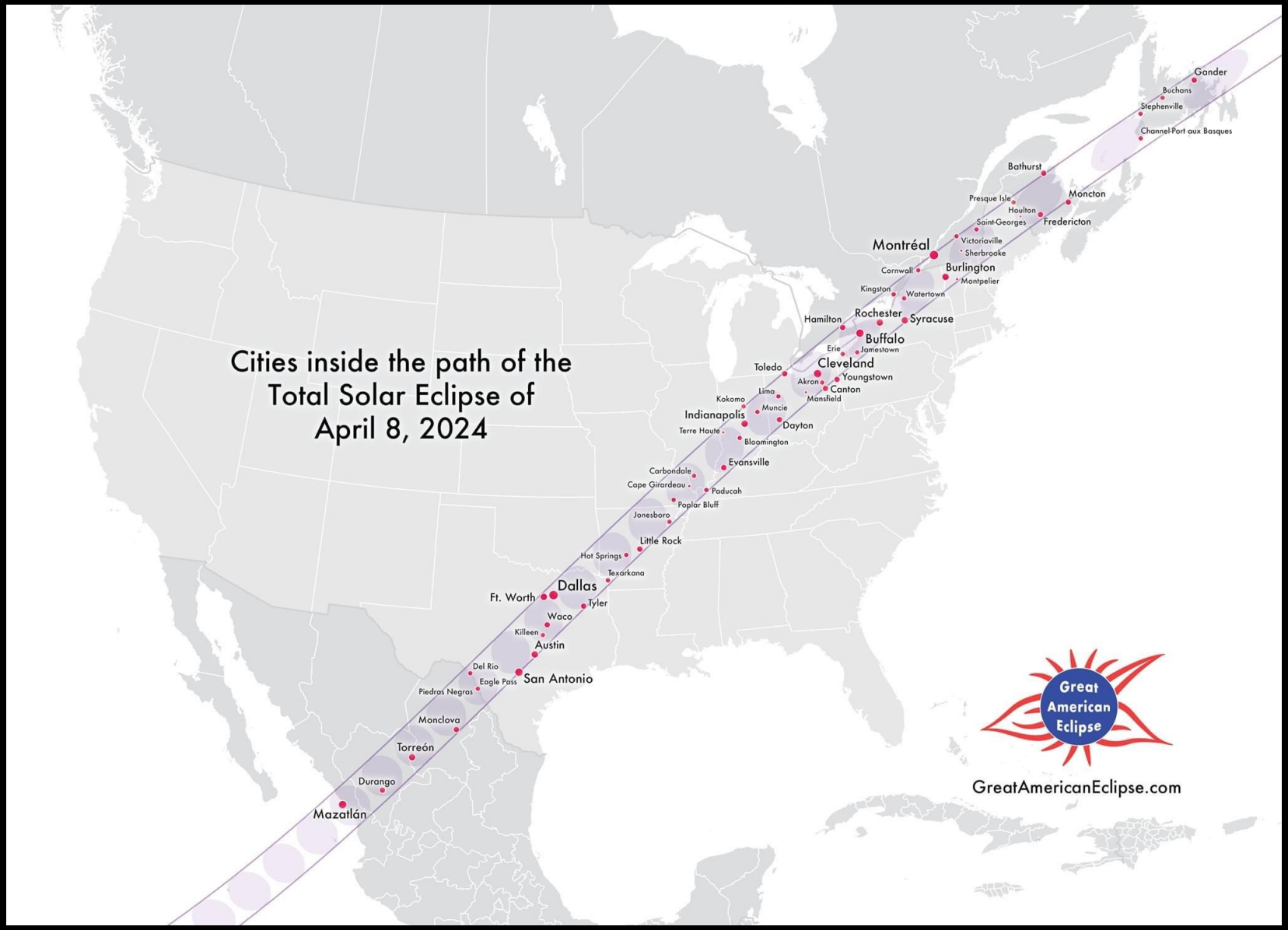

Total Solar Eclipse of 2017 August 21
Within 5 sec of Greatest Duration (570 mi)
Within 2 sec of Greatest Duration (356 mi)
Within 1 sec of Greatest Duration (248 mi)
Within 0.1 sec of Greatest Duration (79 mi)
Northern Path Limit
Central Line
Southern Path Limit
18:10 UTC
2m 39s
62°
18:20 UTC
2m 40s
64°
Greatest Duration
2m 40.2s
64°
Greatest Eclipse
2m 40.1s
64°
Missouri
Illinois
KY
Courtesy of Fred Espenak, MrEclipse.com


Total Solar Eclipse Paths: 2001–2025
2015 Mar 20
2008 Aug 01
2017 Aug 21
2016 Mar 09
2024 Apr 08
2009 Jul 22
2006 Mar 29
2009 Jul 22
2016 Mar 09
2001 Jun 21
2010 Jul 11
2019 Jul 02
2012 Nov 13
2002 Dec 04
2012 Nov 13
2020 Dec 14
2003 Nov 23
2021 Dec 04
60° N
30° N
0°
30° S
60° S
Latitude
180° W
150° W
120° W
90° W
60° W
30° W
0°
30° E
60° E
90° E
120° E
150° E
180° E
Longitude
Total Eclipse
Annular Eclipse
Hybrid Eclipse
0
2000
4000
6000
8000
10000
Kilometers
sunearth.gsfc.nasa.gov/eclipse/eclipse.html
Fred Espenak, NASA/GSFC - 2002 July

Safely observing the Sun

Next one . . . . April 8, 2024!

sunearth.gsfc.nasa.gov/eclipse


Cities inside the path of the
Total Solar Eclipse of
April 8, 2024
Gander
Buchans
Stephenville
Channel-Port aux Basques
Bathurst
Presque Isle
Moncton
Houlton
Fredericton
Saint-Georges
Victoriaville
Montréal
Sherbrooke
Cornwall
Burlington
Montpelier
Kingston
Watertown
Hamilton
Rochester
Syracuse
Buffalo
Erie
Jamestown
Toledo
Cleveland
Youngstown
Akron
Canton
Lima
Mansfield
Kokomo
Muncie
Indianapolis
Dayton
Terre Haute
Bloomington
Evansville
Carbondale
Cape Girardeau
Paducah
Poplar Bluff
Jonesboro
Little Rock
Hot Springs
Texarkana
Dallas
Ft. Worth
Tyler
Waco
Killeen
Austin
Del Rio
Eagle Pass
San Antonio
Piedras Negras
Monclova
Torreón
Durango
Mazatlán
Great American Eclipse
GreatAmericanEclipse.com

2024 Total Solar Eclipse

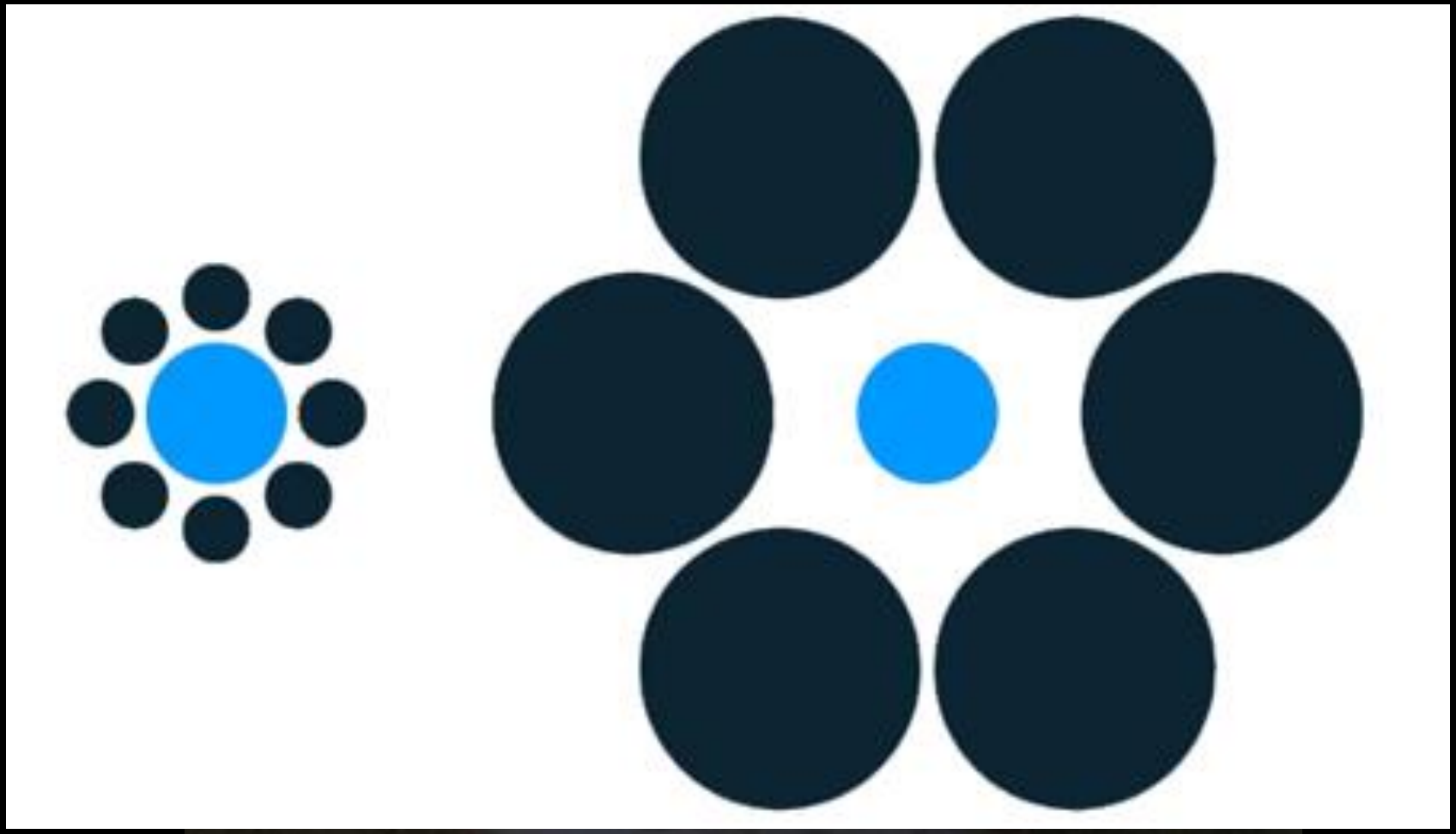
Destination	Drive Time	Distance (mi)	Totality	Magnitude
Carbondale	2h 56m	256	4m 08.6s	1.027
Olney	1h 54m	113	3m 52.7s	1.018
Ondessonk	3h 03m	213	3m 47.9s	1.016
Nazas, Mexico	25h	1642	4m 28s	1.057
Indianapolis	1h 59m	121	3m 47.6s	1.018
Vincennes	2h 27m	134	4m 05.0s	1.027

Partial starts: 12:46pm
Totality: 2:02 – 2:06pm
Partial ends: 3:20pm

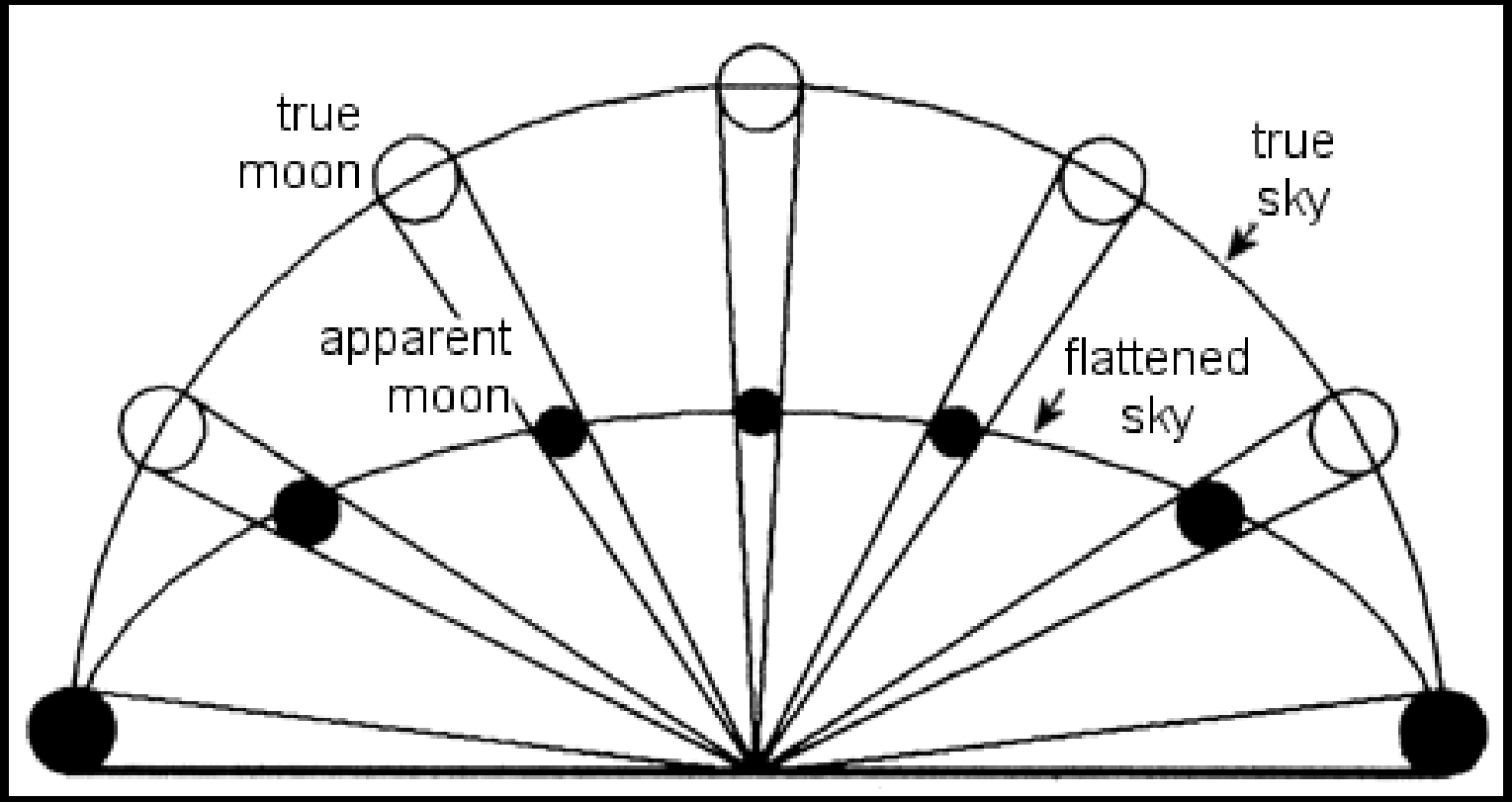
Question: Why does the Moon change its appearance?

A. The Earth's shadow covers the Moon
B. Clouds cover the Moon
C. The Moon turns its dark side towards us
D. We see different parts of the lighted face

“The Moon is huge!”



“Moon illusion”



OBSERVE the MOON

International OBSERVE THE MOON NIGHT 2021

SATURDAY 16TH OCTOBER

NORTHERN HEMISPHERE MOON MAP WITH LUNAR MARIA (SEAS OF BASALT)

Moon Map

This map was created for International Observe the Moon Night 2021. It depicts the Moon as it will appear from the northern hemisphere at approximately 11:00 PM EDT on October 16, 2021 (3:00 AM UTC on October 17).

Lunar Maria (Seas of Basalt)

You can see a number of maria tonight. Once thought to be seas of water, these are actually large, flat plains of solidified basaltic lava. They can be viewed in binoculars or even with the unaided eye. Tonight, you may be able to identify 18 maria on the Moon. This includes four seas along the eastern edge that are often hard to see. Because of libration, a slight apparent wobble by the Moon in its orbit around Earth, tonight we get to peek slightly around the northeast edge of the Moon, glimpsing a sliver of terrain normally on the Moon's far side.

Map generated with NASA's Dial-A-Moon (https://svs.gsfc.nasa.gov/4874)

A. Mare Frigoris (Sea of Cold)
B. Mare Imbrium (Sea of Rains)
C. Mare Insularum (Sea of Isles)
D. Oceanus Procellarum (Ocean of Storms)
E. Mare Cognitum (Known Sea)
F. Mare Humorum (Sea of Moisture)
G. Mare Nubium (Sea of Clouds)
H. Mare Vaporum (Sea of Vapors)
I. Mare Serenitatis (Sea of Serenity)
J. Mare Tranquillitatis (Sea of Tranquility)
K. Mare Nectaris (Sea of Nectar)
L. Mare Fecunditatis (Sea of Fertility)
M. Mare Crisium (Sea of Crises)
N. Mare Humboldtianum (Humboldt's Sea)
O. Mare Anguis (Serpent Sea)
P. Mare Marginis (Border Sea)
Q. Mare Undarum (Sea of Waves)
R. Mare Spumans (Sea of Foam)
S. Mare Smythii (Smyth's Sea)
T. Mare Australe (Southern Sea)

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