

The Moon

Moon Stuff

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Agenda

- Legends, Myths, Idiocy & Illusions
- Statistics, Geology, Geometry
- Nearside & Farside Features
- Phases & Types of Moon
- Tides
- Lunar Eclipses
- Solar Eclipses
- Resources/References

Stuff in RED is my
take for soundbites for
kids

Legends/Myths/Idiocy

- Moon is made of green cheese - ?!?!?!?!?!?
- Full Moons can make you crazy
(hence the terms *lunatic* and *lunacy*)
- The full Moon affects fertility and causes an increase in births and crimes at hospitals
- Super Moons can cause disasters on Earth

Legends/Myths/Idiocy (cont)

- The Moon doesn't rotate
- The backside of the Moon is always dark
- Full Moons bring out werewolves – false
(unless there really are werewolves ...)
- The 1969 Moon landing was a hoax
(give me a break !!)
- The Moon is actually a giant alien spacecraft (Google it – it might be true !)

Illusions

- Huge Harvest Moon is bigger on the horizon than it is in the sky – nope!
- “Man in the Moon” vs “Rabbit in the Moon”
These are pareidolic images - like seeing figures in clouds



Statistics

- **5th largest Moon in solar system but largest relative to its planet – the Earth/ Moon system is almost a double planet**
- **Diameter of Moon is 2161 miles vs Earth's 7918 miles – about $\frac{1}{4}$ the size**
- **Visually about $\frac{1}{2}$ degree - about the size of an aspirin held at arm's length - so 360 Full Moons would fit across the sky and 720 around horizon**

Statistics (cont)

- **Gravity is 17% of Earth's**
- **Temperatures range from +243F to -272F**
- **Coincidentally, the Moon at 240,000 miles and the Sun at 93 million miles appear almost exactly the same size**
 - **this permits the Moon to cause a solar eclipse – but barely.**
 - **If the Moon was ~200 miles smaller in diameter – no solar eclipse would be possible**

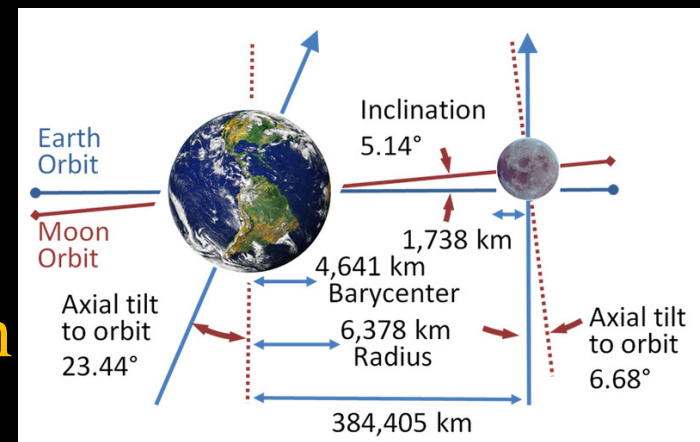
Geology

- **One theory is that the Moon was formed when a rock the size of Mars slammed into the forming Earth ~4.5 billion years ago**
- **Most craters formed about 4.1-3.8 billion years ago**
- **The dark areas are called *maria* (seas in Latin) They are actually very old lava flows**
- **Lighter areas are called highlands**
- **Rays are splashed highland material**



Earth-Moon Geometry

- If the Moon's orbit was in the same plane as the Earth's orbit, then there would be one Solar eclipse and one Lunar eclipse each month ... BUT
- Moon's orbit inclined 5° to plane of Earth's orbit AND
- Moon's orbit slowly rotates in the same direction of Moon with an 8.9 year cycle
- Because of this, Solar & Lunar Eclipses *can* only occur every 173 days but if Sun, Moon and Earth aren't aligned exactly right, not even then



Earth-Moon Geometry (cont)

- Moon's orbit is elliptical, varying from 225,623 to 252,088 miles
 - results in a 12% difference visually between far and near
 - about 240,000 miles average
- **THE DARKSIDE IS NOT DARK !!!**
(except at Full Moon)
Demo farside lighting using kids & flashlight
- Moon is 1.25 light seconds away from Earth
Sun is 8 light minutes away



Earth and Moon, showing their sizes and distance to scale. The yellow bar represents a pulse of light traveling from Earth to Moon in 1.26 seconds.

Geometry (cont)

- **The Moon steals rotational energy from the Earth**
 - This slows Earth's rotation about 1.5 thousandths of a second per century
 - That energy moves the Moon about 4cm away from Earth each year.
 - Eventually this would continue until the spin of the Earth and the orbital period of the Moon would match (if Moon didn't escape)
 - However, the Sun will become a red giant, melting both long before that
- **Moon is tidally locked – same side always faces Earth**
 - A lunar day = 27.3 days = lunar year

We Can See More Than Half

- Although tidally locked, the Moon does wobble (libration) so that we can actually see about 59% over the course of a lunar month
- The wobble (libration) is caused by
 - Orbital eccentricity
 - Moon's inclination
 - Earth's rotation



Libration without Phase

If the phase information is removed, the 12% size change is also visible as a single full orbit takes place over 27.3 days

2007 Apr 3 08:50:54 UT



How the Moon Looks ... Depends

- As you travel south the Moon will appear to tip over.
- At the equator it's sideways (N/S axis is horizontal)
- The Moon appears “upside down” in southern hemisphere

Definite proof that
we live on a ball

Mid latitudes
in Northern
Hemisphere



Hawaii

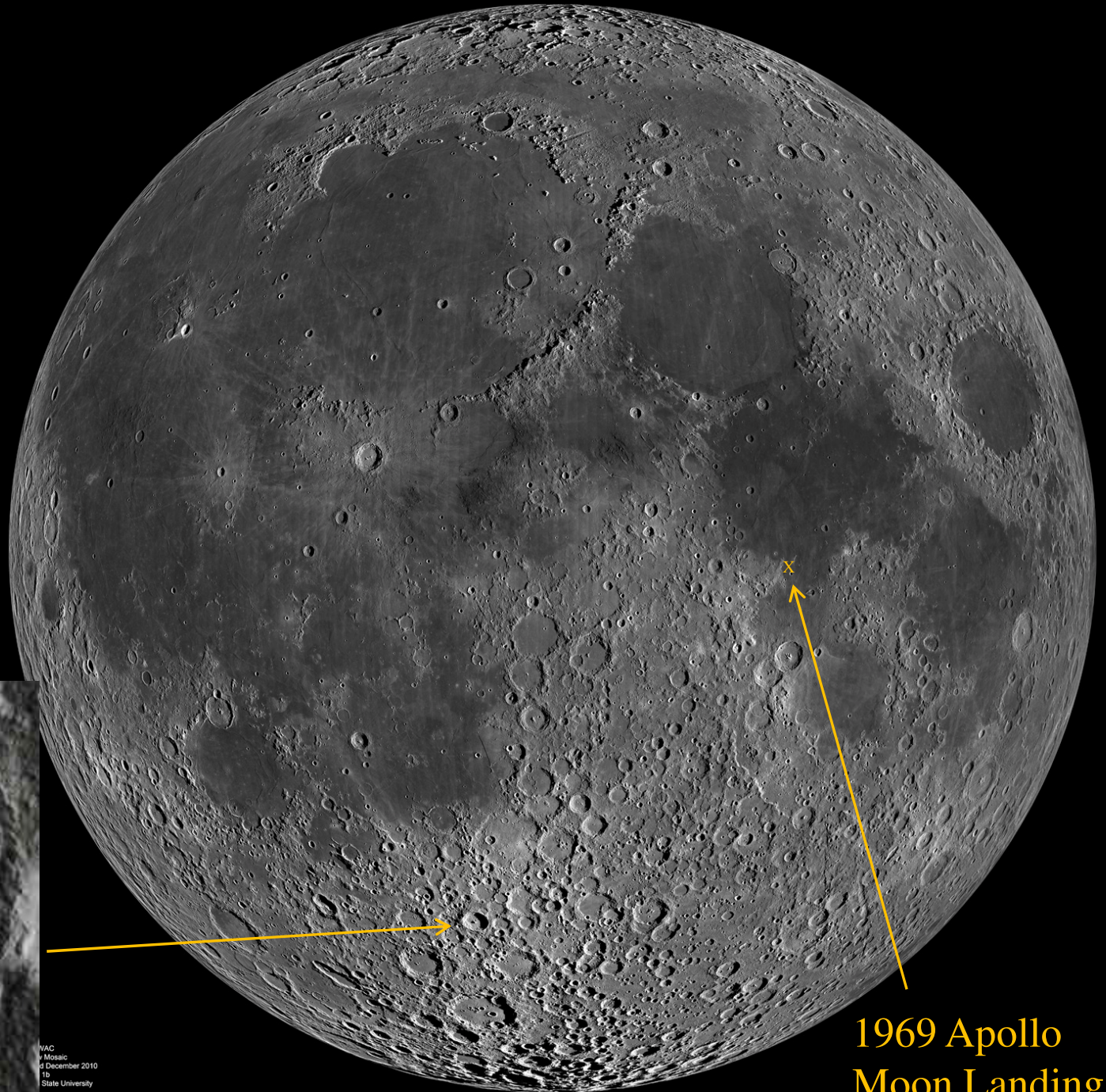


Mid Latitudes
in Southern
Hemisphere



Nearside Hi Resolution Image

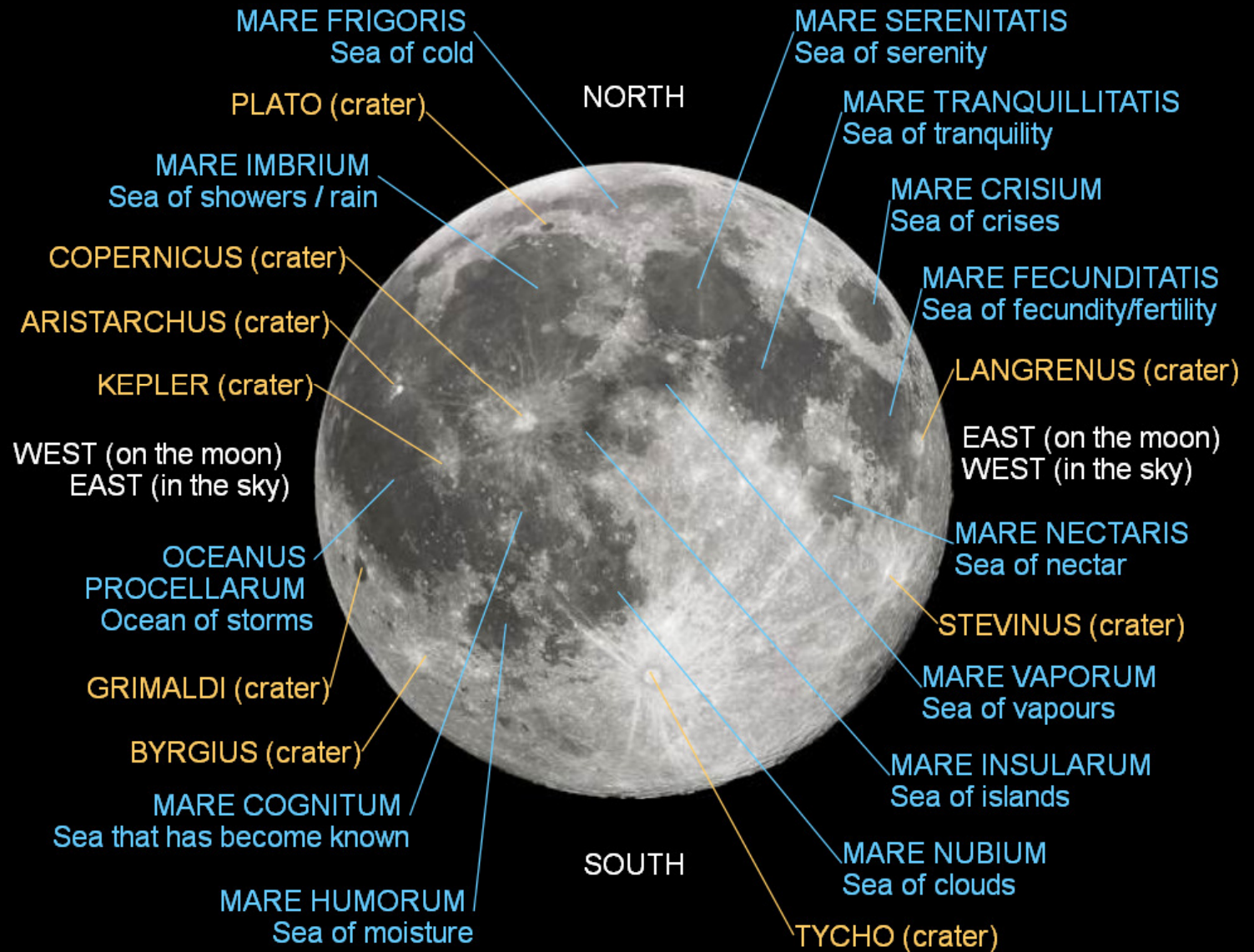
Tycho Crater
(2001 Space Odyssey)



1969 Apollo
Moon Landing

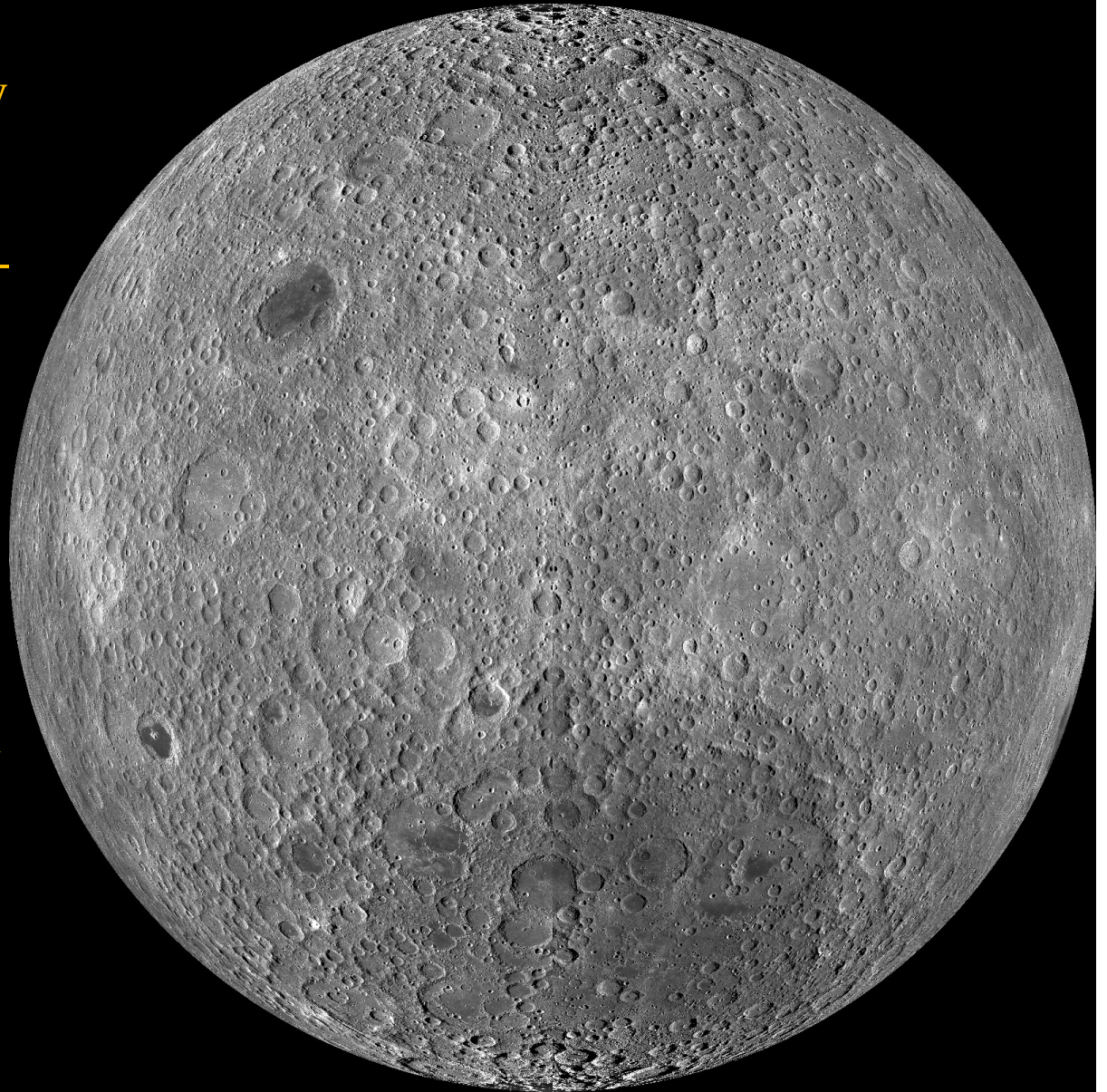
Nearside Features

Note that telescopes optically invert North and South so many Moon maps intended for astronomy use will be inverted



Farside Features

- First photographed by Soviets in 1959
- First seen by humans – Apollo 8 – 1968
- Very different from nearside with almost no Maria and many more smaller craters
- No generally accepted explanation why this difference exists



Named Moons

- **Syzygy Moon** – Scientific term for a full Moon
- **Perigee Moon** – Scientific term for the Moon at its closest
- **Apogee Moon** – Scientific term for the Moon at its furthest
- **Blue Moon**
 - Originally the third full Moon in a season of four - but this was misinterpreted in 1947 by *Sky and Telescope* and the new definition stuck when repeated on radio in 1980.
 - Commonly the 2nd full Moon in a month – occurs every 2-3 years
 - The last one was August 21, 2013
- **Visible Blue Moon**
 - Atmospheric conditions such as volcanic eruptions and very large fires can make the Moon appear blue as they absorb red light lengths.

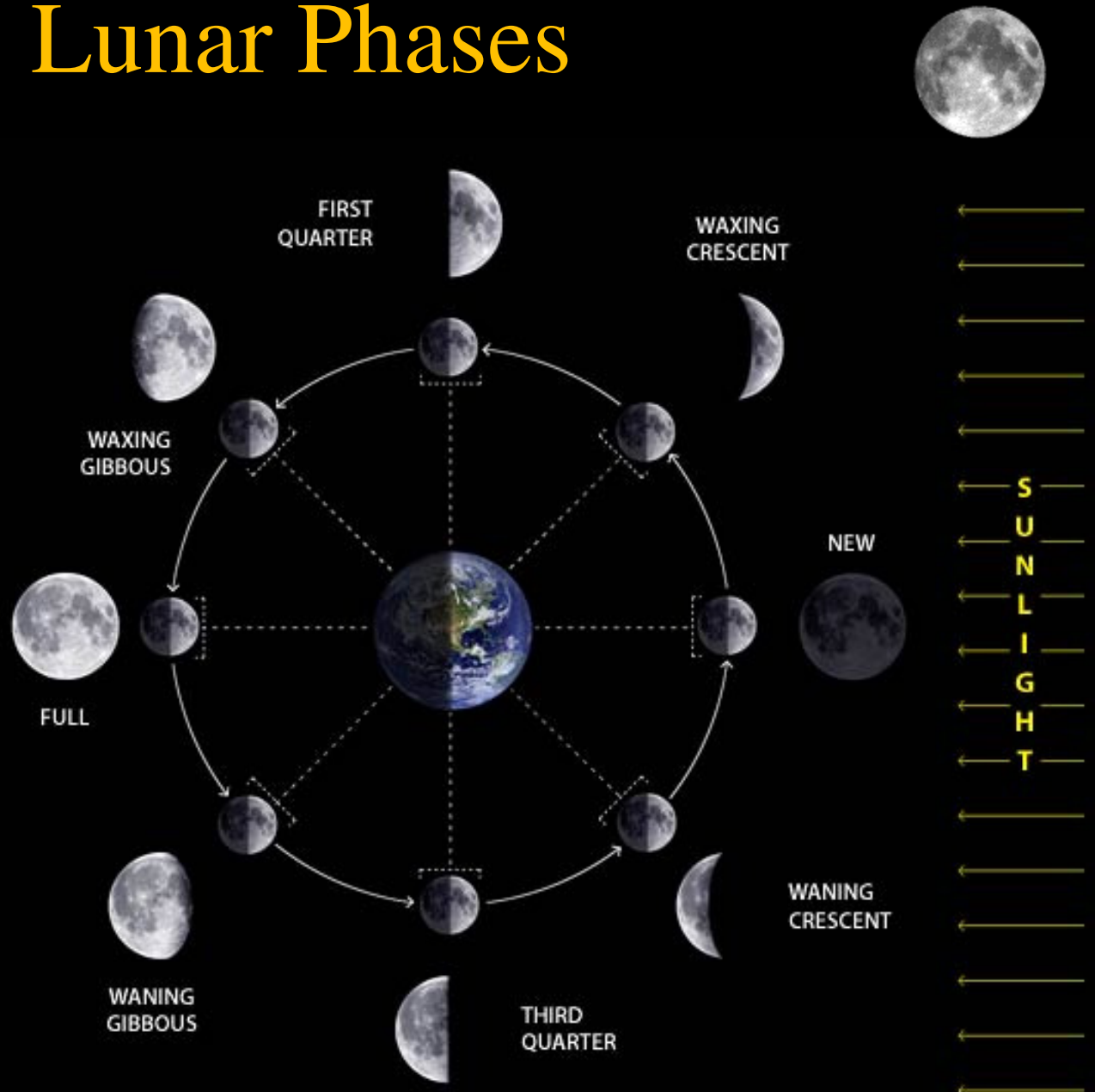
Named Moons (cont)

- **Harvest Moon**
 - **The Full Moon closest to the autumnal equinox – usually the one in September**
- **Hunter's Moon**
 - **The full Moon following the Harvest Moon – usually the one in October**
- **Super Moon – Syzygy-Perigee Moon**
 - **It's an astrological term, not an astronomic term.**
 - **The coincidence of a full Moon OR a new Moon with the closest the Moon gets to the Earth in its elliptical orbit.**
 - **The Moon will appear about 12% bigger than normal and 30% brighter than when it's at its farthest point**
 - **The last Super Moon was on June 23, 2013**

Lunar Phases

In the Northern Hemisphere,
the Moon
*Grows Bright
from the Right*

Demo Phases with people,
flashlight & basketball

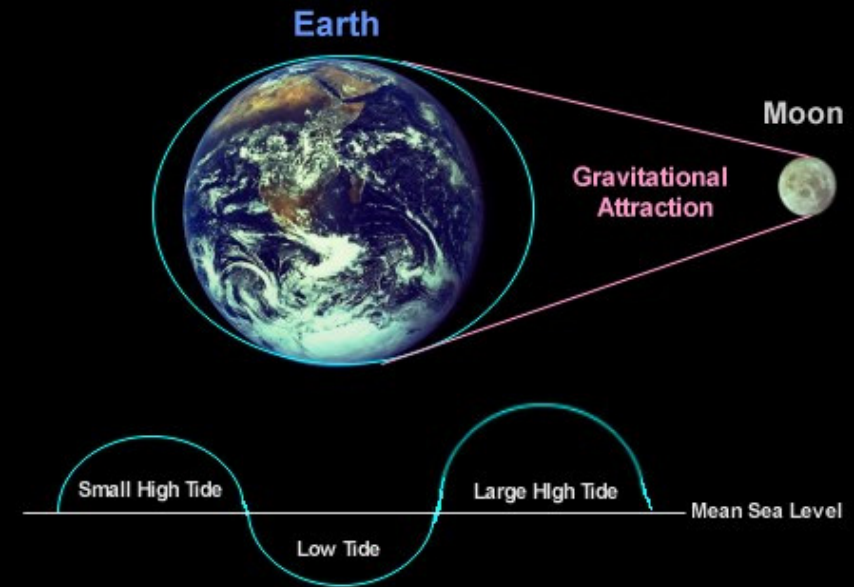


Things to Remember

- *The Moon Grows Bright from the Right*
- The New Moon always rises at Sunrise.
- The first quarter Moon rises at noon.
- The Full Moon rises at Sunset.
- The last quarter Moon rises at midnight.
- Moonrise takes place about 50 minutes later each day than the day before.

Tides – Daily Cycle

- **Moon causes the daily tides – the water bulges up toward the Moon *and* directly away from the Moon.**
- **High and Low Tides usually, in most places, each occur twice a day as the Earth turns – semi-diurnal**



- **Some locations have only one tide-set a day (diurnal tide)**
- **Some locations have uneven tides (mixed tide)**
- **Tide timescales and height also depend on the Sun as well as the Moon, on the rotation of the Earth, season, water depth and geographical characteristics of coast**

Tides - Monthly Cycle

•SPRING TIDES

At Full and New Moon, when Earth, Moon, Sun are aligned, then the highest high tides (and lowest low tides) occur

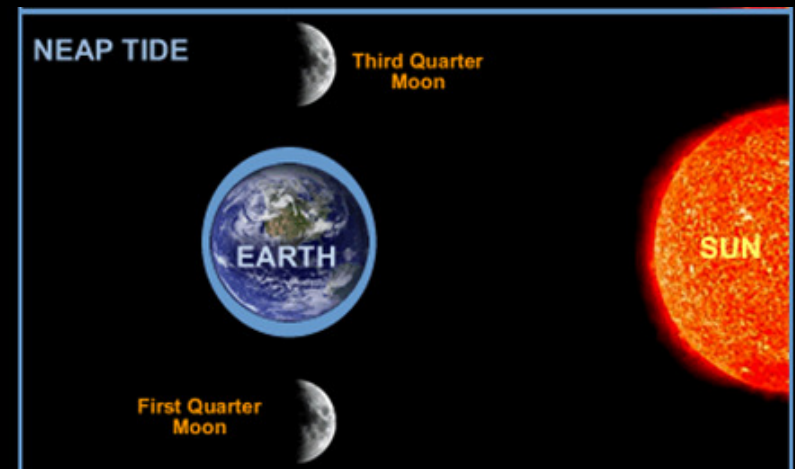
Spring refers to water springing high, not the season



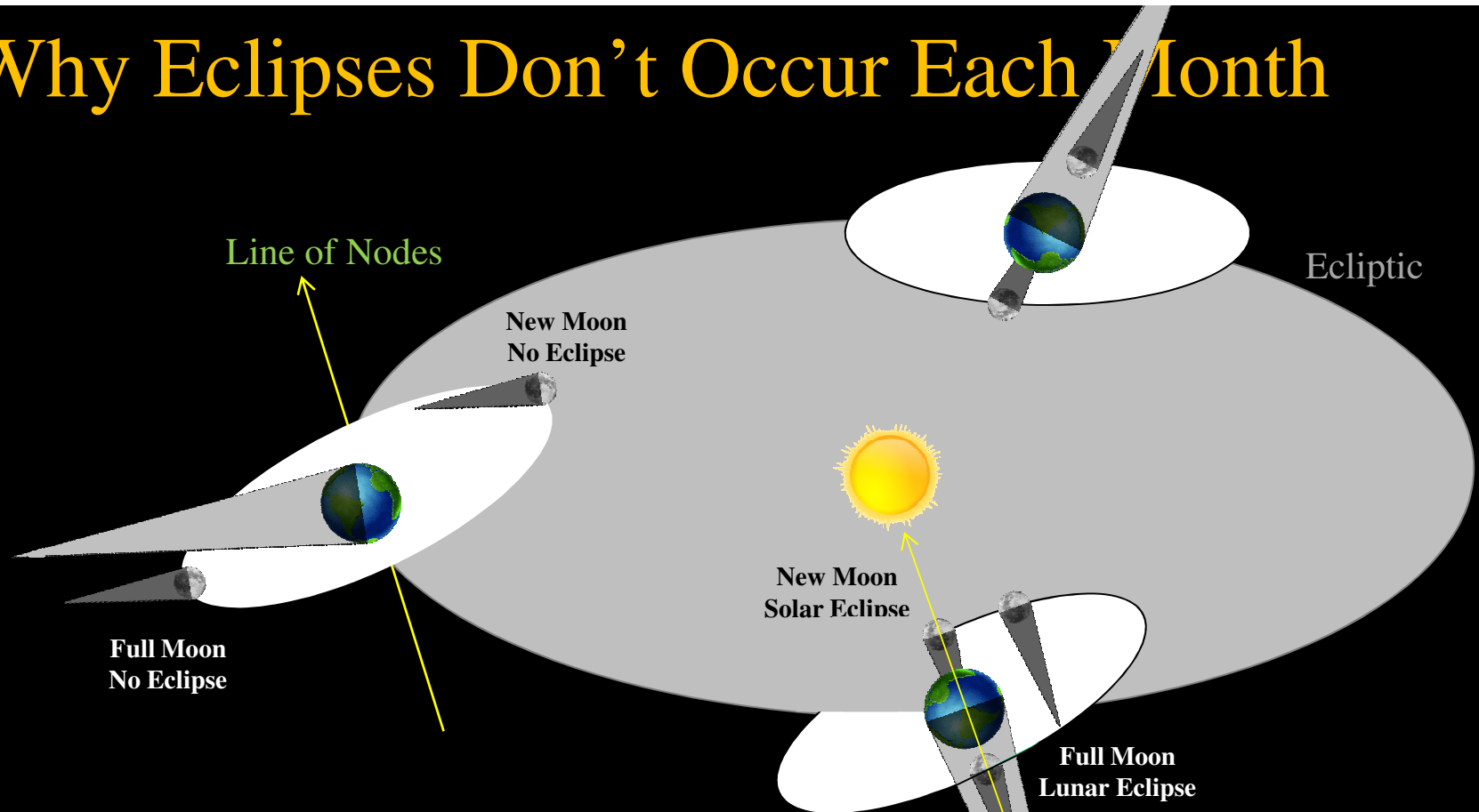
•NEAP TIDES

At 1st and 3rd quarter, when the Sun is at right angles to the Earth/Moon pair, then the smallest high tides (and highest low tides) occur

No one knows the origin of the word Neap – it's only used in conjunction with tides



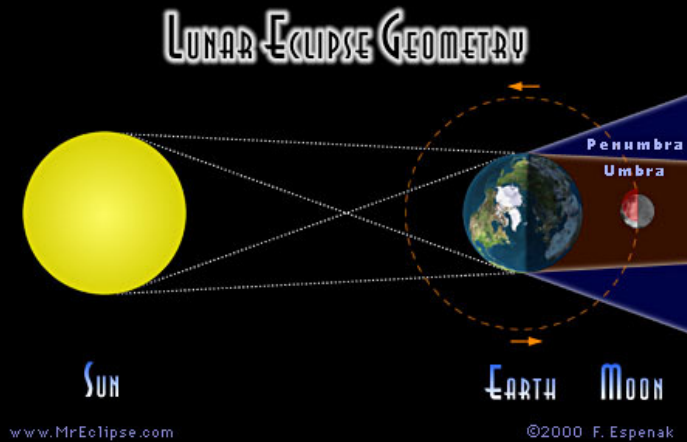
Why Eclipses Don't Occur Each Month



- If the Moon's orbit was in the same plane as the Earth's orbit, there would be a Solar eclipse at every New Moon and a Lunar Eclipse at every Full Moon
- But the Moon's orbit is tilted by 5° and only intersects the ecliptic at two points (called nodes)

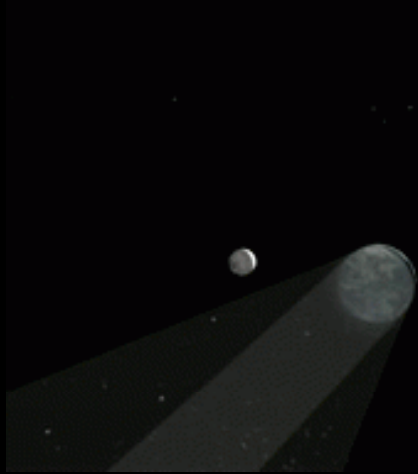
- As the Earth moves around the Sun, there are only two points where the Line of Nodes is *in the same plane as the ecliptic and lined up with the sun*. If the Moon is there when this occurs there will be an eclipse
- Otherwise not

Lunar Eclipse



- Can *only* occur at **Full Moon**, and only if the Moon passes directly behind the Earth with respect to the Sun – between 0-4 a year can occur
- Because the sun is not a point source of light, there are two shadows
 - The Umbra (about 2.5 times moon's diameter) is totally dark
 - The Penumbra gets reduced sunlight
- **Total eclipse** – Moon totally in umbral shadow at some point.
- **Partial eclipse** – Moon never totally in umbral shadow. All total eclipses include a partial eclipse at the start and finish of the event.
- **Penumbral eclipse** – Moon completely in penumbral shadow. Almost impossible to discern – only about a 10% reduction in light. Total and Partial eclipses include a Penumbral eclipse at the start and finish of the event.

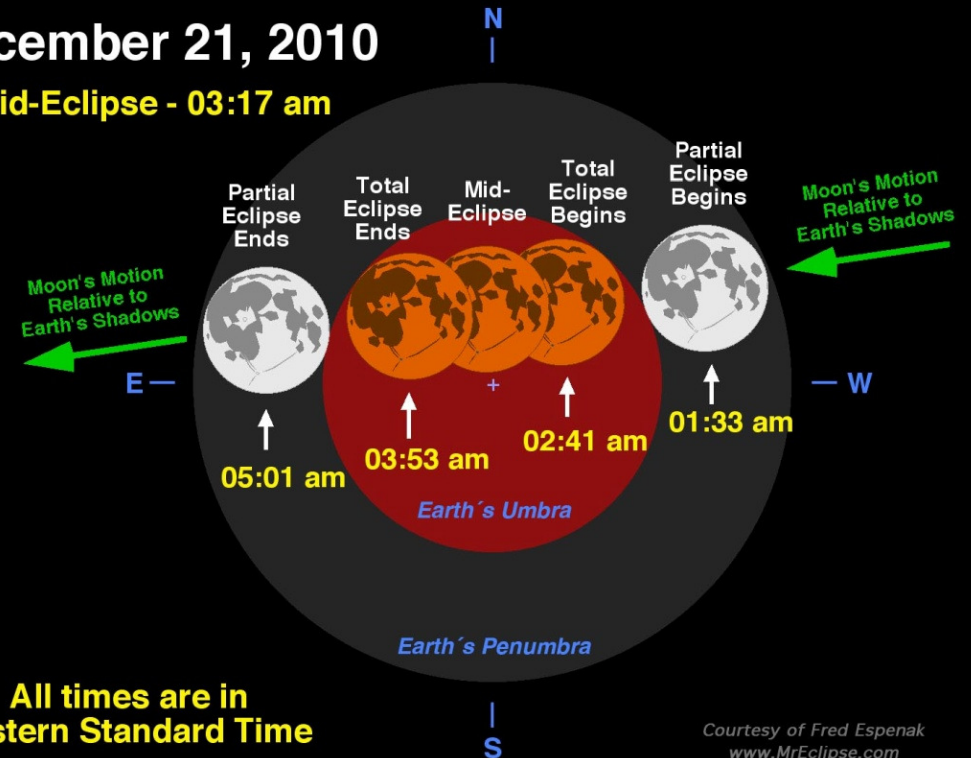
Lunar Eclipse



Lunar eclipses occur when the Earth shadows the Moon

Total Eclipse of the Moon December 21, 2010

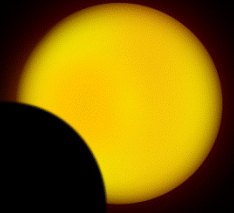
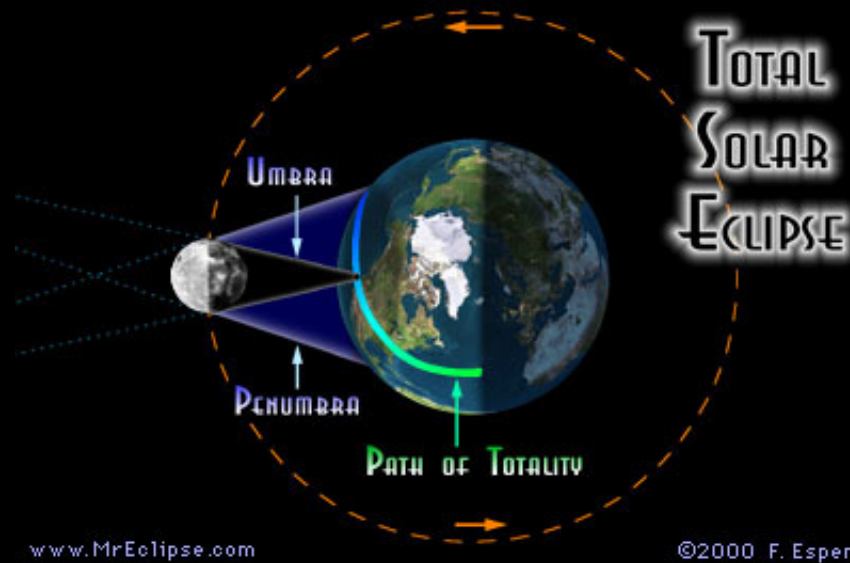
Mid-Eclipse - 03:17 am



All times are in Eastern Standard Time

Courtesy of Fred Espenak
www.MrEclipse.com

Solar Eclipse



- Why are we talking about Solar Eclipses? Because the Moon causes them.
- A Solar Eclipse can happen *only* during a New Moon when it passes directly in front of the Sun - happens every year or two

- A Total Eclipse occurs when the observer is completely in the umbra
 - The totality is typically 100 miles wide and can be 10,000 miles long (as Earth rotates) . The shadow is moving west to east at ~1400 feet/sec – faster than the speed of sound
- Total time of the shadow on Earth can be up to 10 hours – but not in one place
- At any one place, totality will only last for 5-7 minutes, usually less
- A Partial Eclipse occurs when the observer is in the penumbra – they last longer
- An Annular Eclipse occurs if the Moon is too far away to cover the Sun completely
- The path can include any part of the Earth – may even be over ocean

Total Solar Eclipse Images

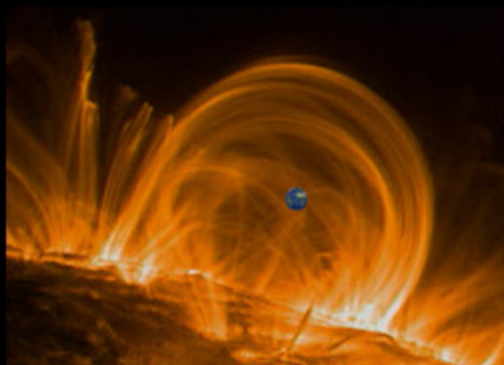
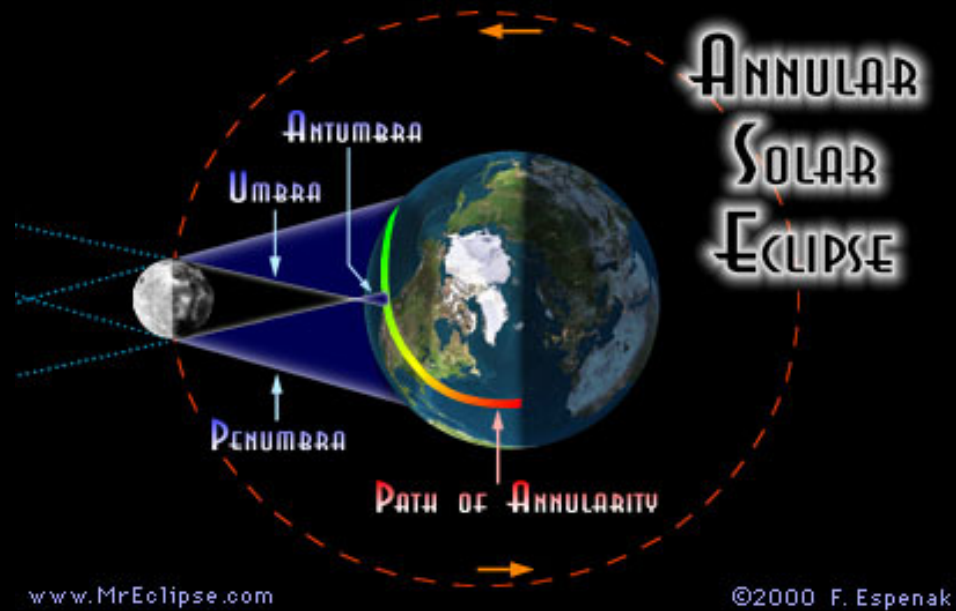


Image of a coronal loop, with the Earth for scale.
Photo: NASA

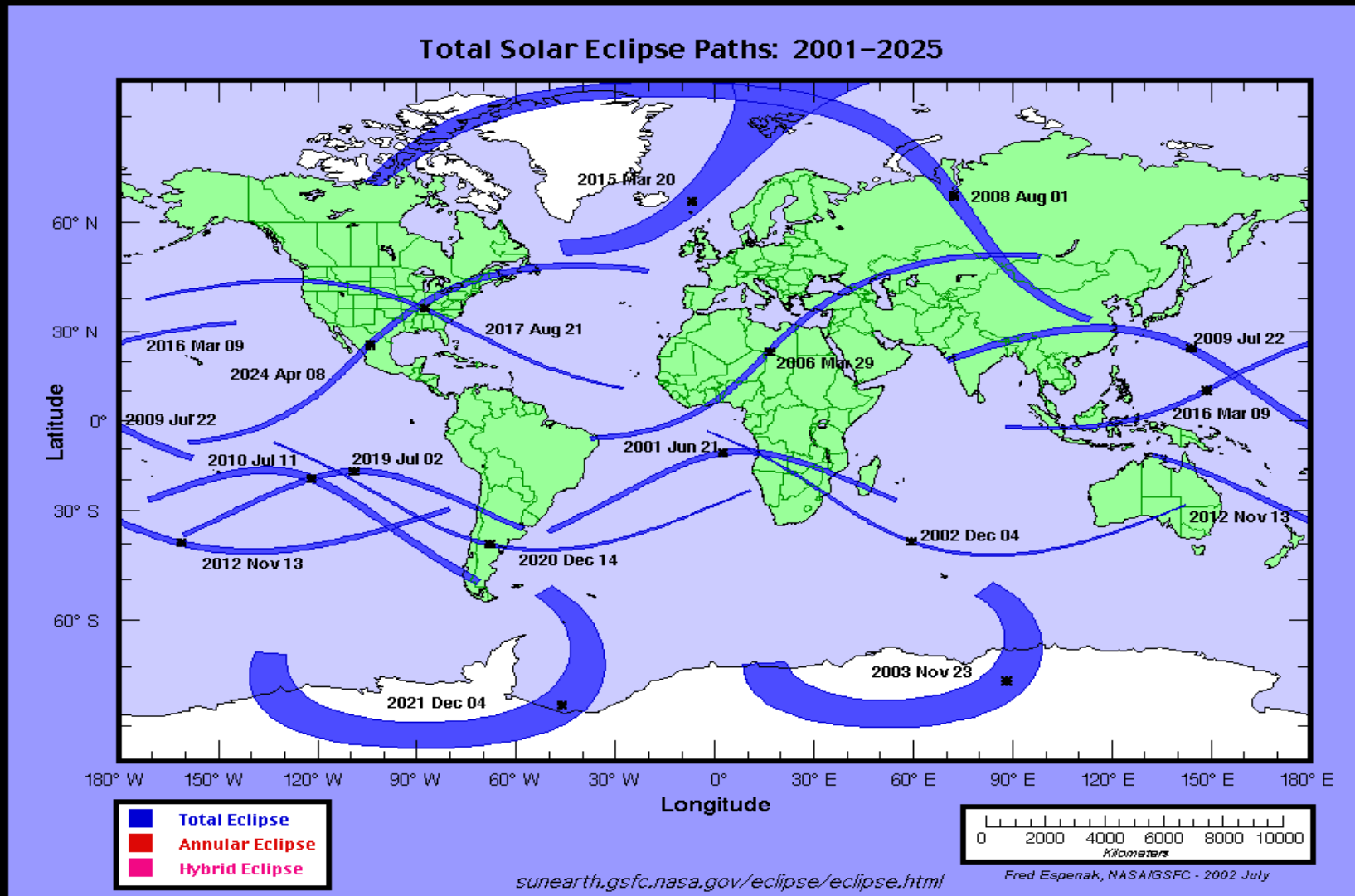


Solar Eclipse (cont)

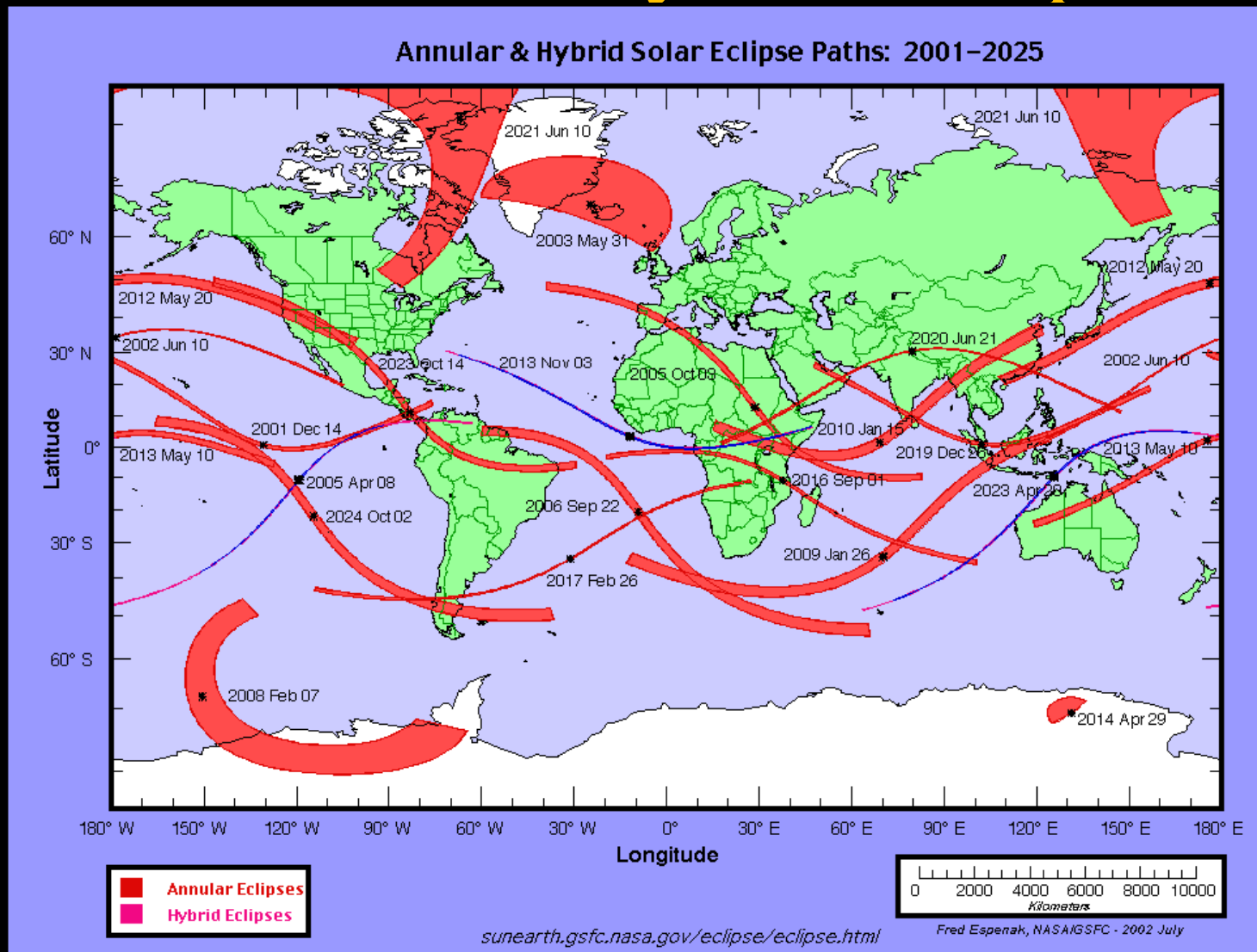


Because the Moon's orbit is elliptical, sometimes it is too close to the Sun to completely cover the Sun up.
This is an **Annular Eclipse**

Past & Future Total Solar Eclipses



Past & Future Annular & Hybrid Eclipses



Solar Analemma with Totality Turkey, 2005-2006



Credits, References & Resources

- Most of photos & images are public domain from NASA, NOAA, the USNO or Wikipedia (with caution – lots of *bad* info out there)
- <http://www.crcamp.com/astronomy> has links to this presentation as well as other links to astronomy related information
- **Solar/Lunar Eclipse info**
 - http://paulbourke.net/fun/solar_eclipse_2002/
 - <http://www.mreclipse.com>
 - <http://eclipse.gsfc.nasa.gov/SEcat5/SEcatalog.html> - 5000 year schedule of Solar eclipses
 - <http://eclipse.gsfc.nasa.gov/lunar.html> - 5000 year schedule of Lunar eclipses
 - <http://www.astronomy.ohio-state.edu/~pogge/Ast161/Unit2/eclipses.html>
- **Moon Phase & Tide info**
 - <http://www.Moonphases.info>
 - <http://www.nhn.ou.edu/~jeffery/astro/astlec/lec003.html> - lots of stuff
 - <http://www.Moonconnection.com/tides.phtml>
- **Moonrise, Moonset, Phases, Transit, Twilight info**
 - http://aa.usno.navy.mil/data/docs/RS_OneYear.php - info for a year
 - http://aa.usno.navy.mil/data/docs/RS_OneDay.php - info for a specific day
- **Outstanding Planetarium Program (Free)**
 - **Stellarium** - <http://www.stellarium.org>