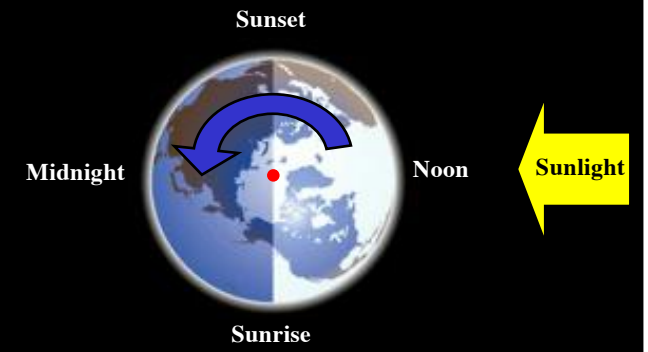
Phases of the Moon

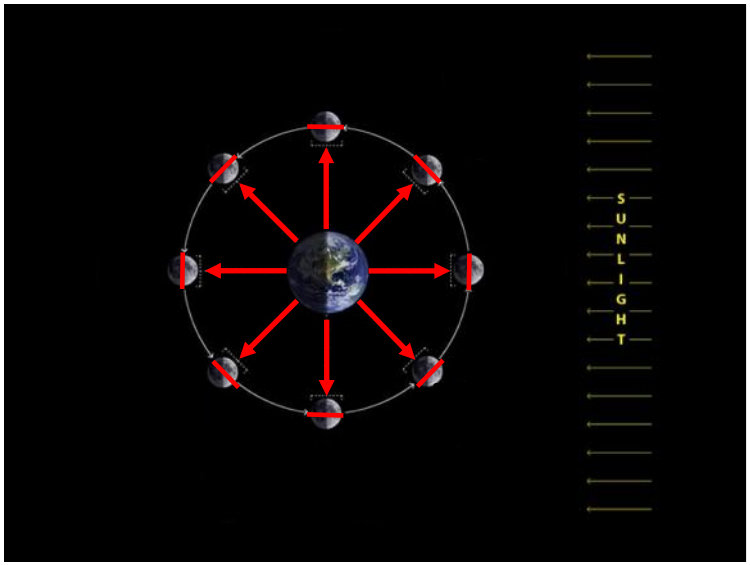
Phases of the Moon

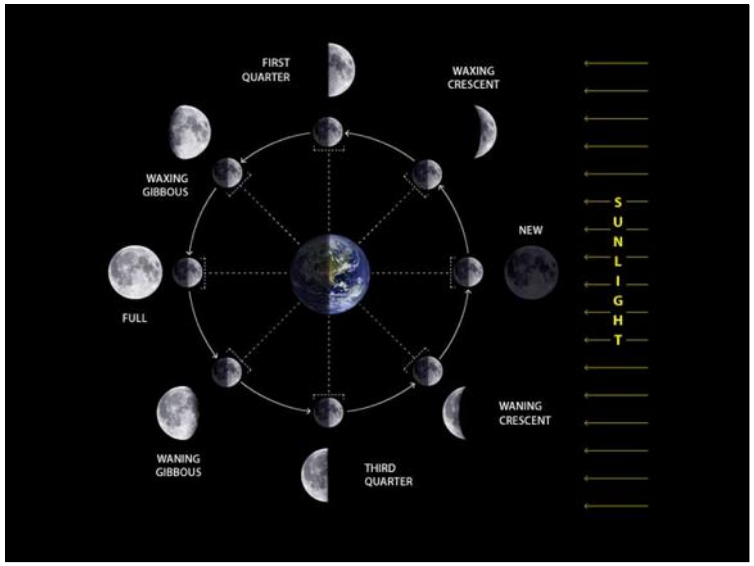
- Moon ***revolves*** around Earth & ***always half lit*** by Sun
- Earth ***rotates*** on its axis
- these motions *determine phase* & *when/where* we see *Moon* in the sky

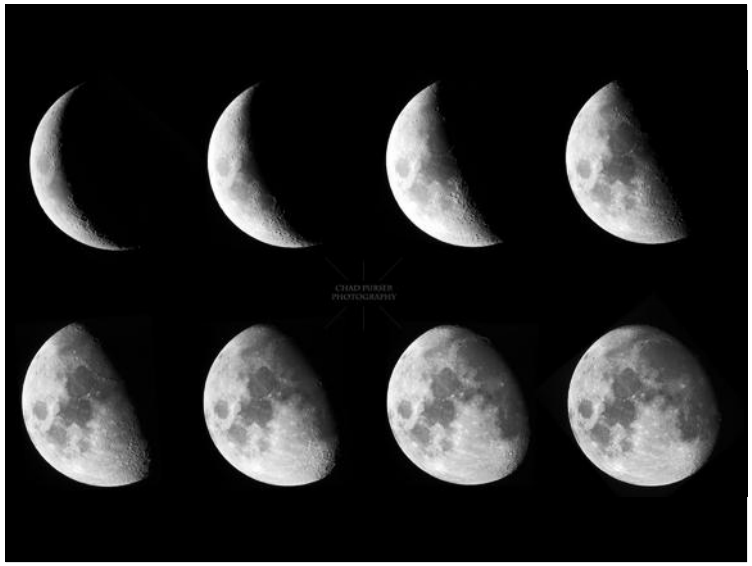
- *boundary* between lit/dark regions: ***terminator***

Rotation of the Earth

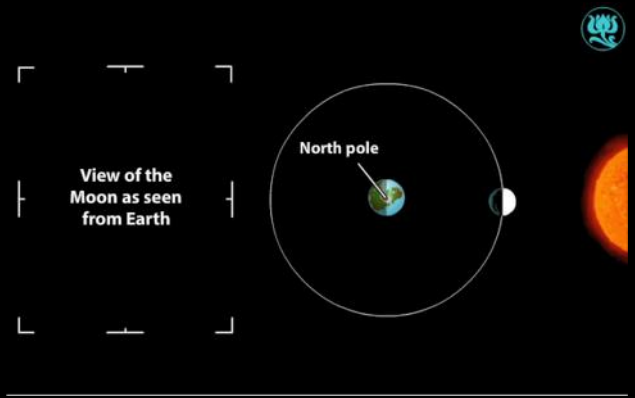






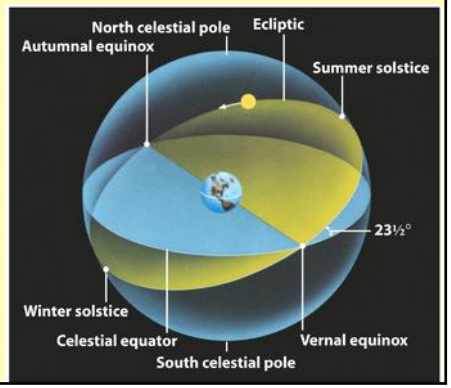


Phases of the Moon



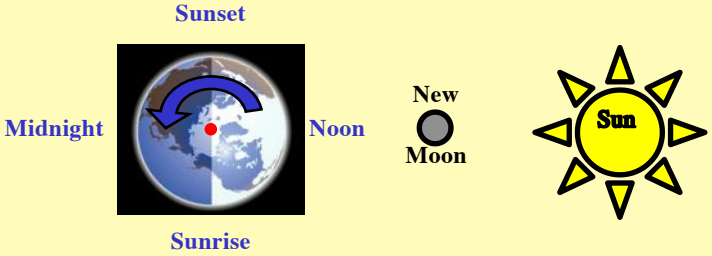
CLICKER: Where is the Full Moon located on the celestial sphere if it is the first day of spring for the northern hemisphere?

(a) autumnal equinox
(b) vernal equinox
(c) winter solstice
(d) summer solstice
(e) zenith



Rise & Set Times: *New Moon*

• New Moon in ***same*** region of sky as Sun, ***so***
New Moon rises & sets at same time as the Sun
• assume 12 hour day/night, *eg. Sun is up 6am - 6pm*



Rise & Set Times

6 AM	9 AM	Noon	3 PM	6 PM	9 PM	Midnight	3 AM
6 PM	9 PM	Midnight	3 AM	6 AM	9 AM	Noon	3 PM

• New Moon ***rises*** at ***6 AM*** & ***sets*** at ***6 PM***

• each *phase* ***adds*** ~ *3 hours* to rise & set time

• Moon is ***often*** visible *during daylight hours*

CLICKER: You look up in the sky at sunset and see the moon at its highest point in the sky. What phase must the Moon be in?

(a) New Moon
(b) Full Moon
(c) Third Quarter
(d) First Quarter

**** the picture is only decorative – don't go by the phase shown! ****

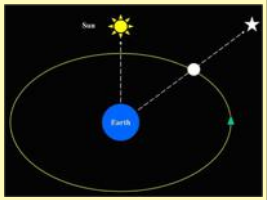
CLICKER: A friend tells you they saw the Moon rise right before the Sun did. What phase must the Moon have been in?

(a) New Moon
(b) Full Moon
(c) Third Quarter
(d) First Quarter
(e) Waning Crescent
(f) Waxing Gibbous

**** the picture is only decorative – don't go by the phase shown! ****

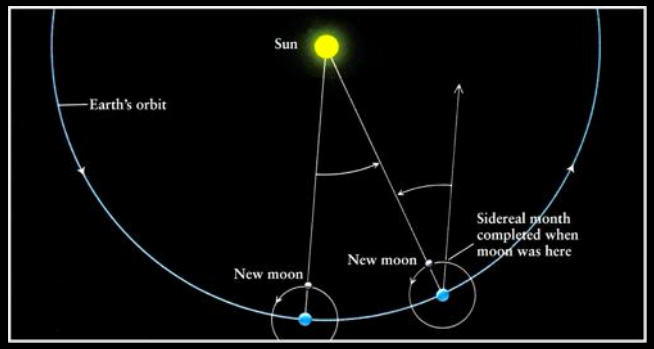
Moon's Orbital Periods

• ***sidereal period*** (27.3 days): time for ***one complete orbit around Earth*** (*eg. 360°, return to same location on sky wrt stars*)



• ***synodic period*** (29.5 days): time to ***go through one complete cycle of phases*** (*eg. New-to-New*)

Q: Why aren't the two periods the ***same***? (demo)



• periods are different because *the Earth moves (around the Sun) while the Moon orbits the Earth*

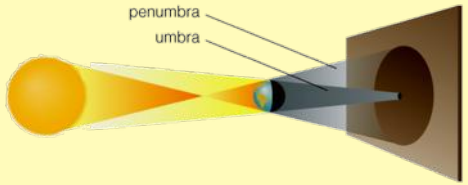
• Earth goes through phases too!

CLICKER: What phase is the Earth in when viewed from a New Moon?

(a) New Earth
(b) Full Earth
(c) Waxing Gibbous Earth
(d) Waning Crescent Earth

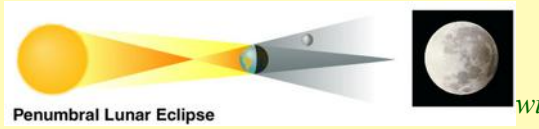
Lunar Eclipses

• occur when *Moon* passes through *Earth's shadow*
• *only* occur during ***Full Moon*** - *why?*
• need *Earth* to be ***between*** *Moon* & *Sun*

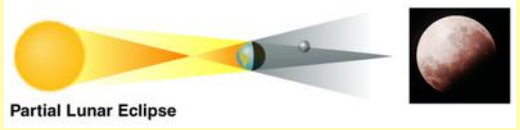


• *a shadow* has ***two parts***:
- ***umbra*** (***central*** *shadow; direct light* ***fully*** *blocked*)
- ***penumbra*** (***outer*** *shadow; light* ***partially*** *blocked*)

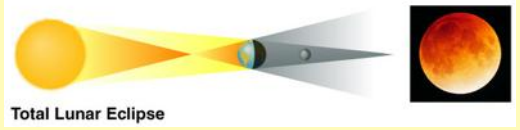
• *3* types of ***lunar eclipses***: **penumbral**, **partial**, **total**



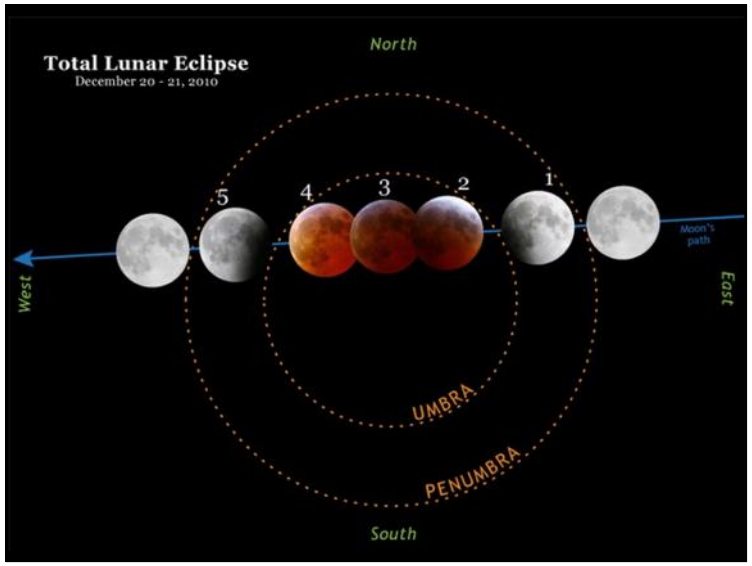
• ***penumbral***
• Moon ***only*** *within* ***penumbra***



• ***partial***
• Moon ***partially*** *within* ***umbra***



• ***total***
• Moon ***entirely*** within ***umbra***
• max *1h 47min*



Q: *Why can we see Moon during a total lunar eclipse?*

• ***(red) light bent into umbra by Earth's atmosphere***

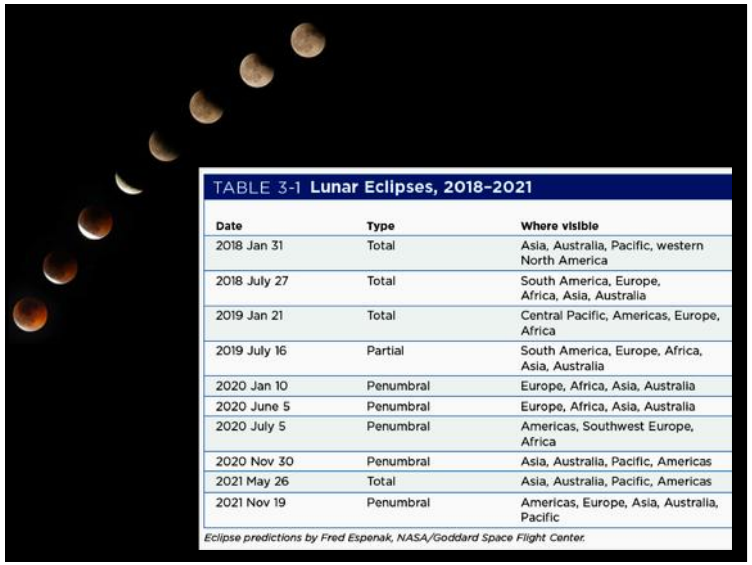


TABLE 3-1 **Lunar Eclipses, 2018–2021**

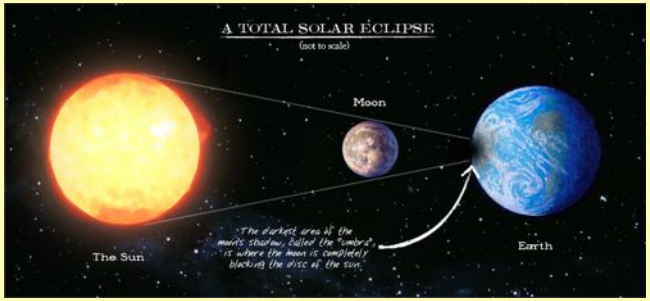
Date	Type	Where visible
2018 Jan 31	Total	Asia, Australia, Pacific, western North America
2018 July 27	Total	South America, Europe, Africa, Asia, Australia
2019 Jan 21	Total	Central Pacific, Americas, Europe, Africa
2019 July 16	Partial	South America, Europe, Africa, Asia, Australia
2020 Jan 10	Penumbral	Europe, Africa, Asia, Australia
2020 June 5	Penumbral	Europe, Africa, Asia, Australia
2020 July 5	Penumbral	Americas, Southwest Europe, Africa
2020 Nov 30	Penumbral	Asia, Australia, Pacific, Americas
2021 May 26	Total	Asia, Australia, Pacific, Americas
2021 Nov 19	Penumbral	Americas, Europe, Asia, Australia, Pacific

Eclipse predictions by Fred Espenak, NASA/Goddard Space Flight Center.

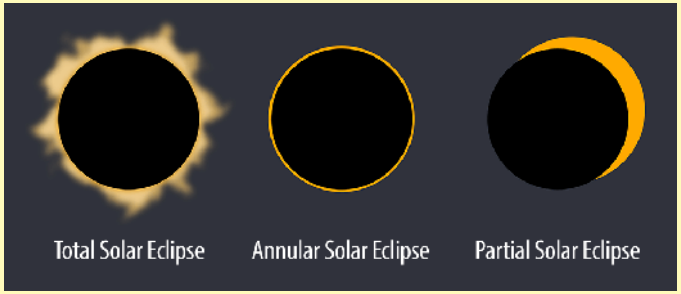
Super Blood Wolf Moon eclipse of Jan 2019

Solar Eclipses

- occur when *Moon's shadow* hits *Earth*
- occur *only* during ***New Moon*** - *why?*
- need *Moon* ***between*** *Earth* & *Sun*



- ***partial***: Moon ***partially*** blocks Sun
- ***total***: Moon ***totally*** blocks Sun
- ***annular***: Sun remains visible ***around*** Moon



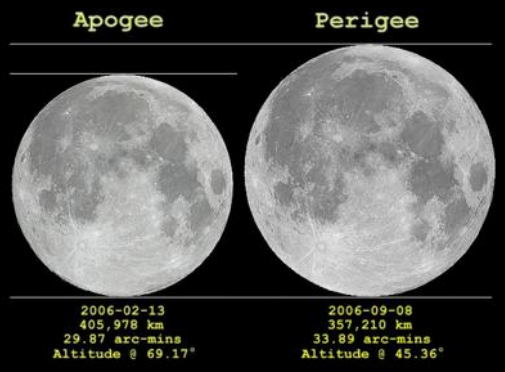
- ** ***not safe to view with the naked eye*** **

Partial Solar Eclipse

Annular Solar Eclipse

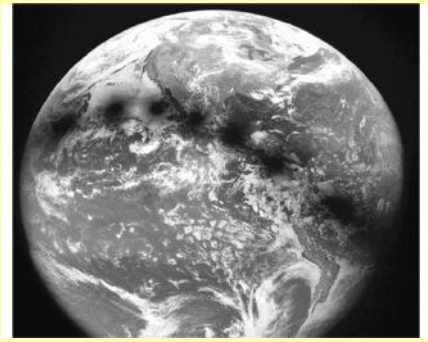
- both *Moon* & *Sun* appear to be ~ ½°
- *Earth's* & *Moon's orbits* are ***elliptical***, so ***apparent*** *size* of *Sun* & *Moon* ***relative*** to each other ***varies***
- *thin ring* ("*annulus*") *of light* around *Moon*

Variation of Lunar Size



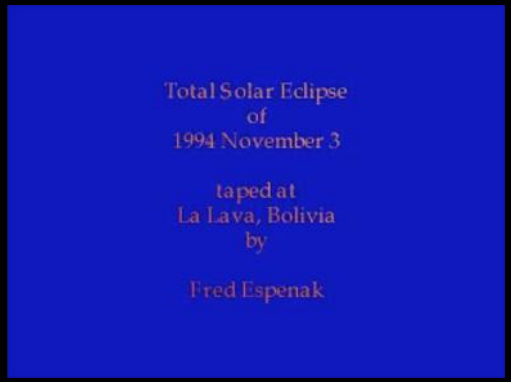
Total Solar Eclipse

- *Moon's* ***umbra*** must reach *Earth* for ***total eclipse***
- … at best it ***just barely*** does so!

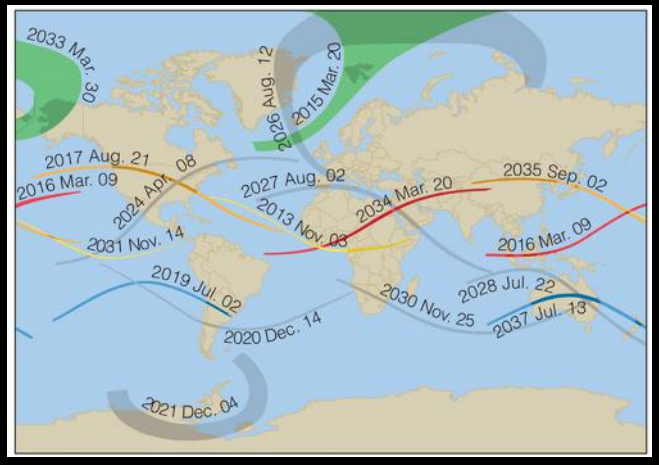


- ***totality*** *never* lasts longer than ~8 minutes

Q: Why so *short* compared to ***total lunar eclipses***?

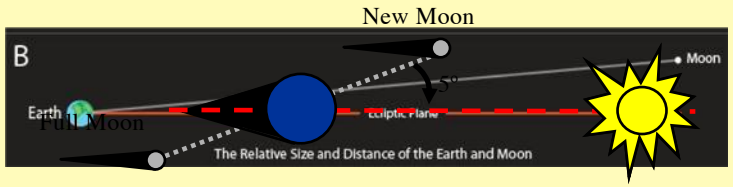


Total Solar Eclipses



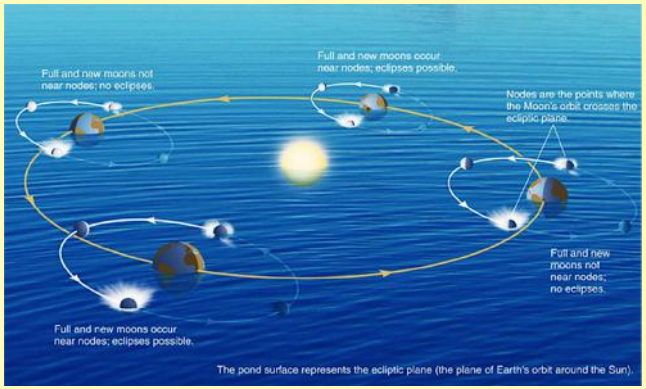
Why are Eclipses rare?

- eclipses ***do not*** occur ***every*** *New* & *Full Moon*
- *Moon's orbital plane* **inclined** *5°* vs. ***ecliptic***



- ***precise*** *alignment* of *Earth*, *Moon* & *Sun* is ***rare***

- ***node***: points along *Moon's* orbit where it ***crosses*** *Earth's* orbital plane (***ecliptic***)



- ***eclipses only occur*** when *Moon* is ***at a node*** and ***also*** in *New* **or** *Full* phase