Topic 3: The Earth-Moon-Sun System Part 1

Relative Sizes and Distances

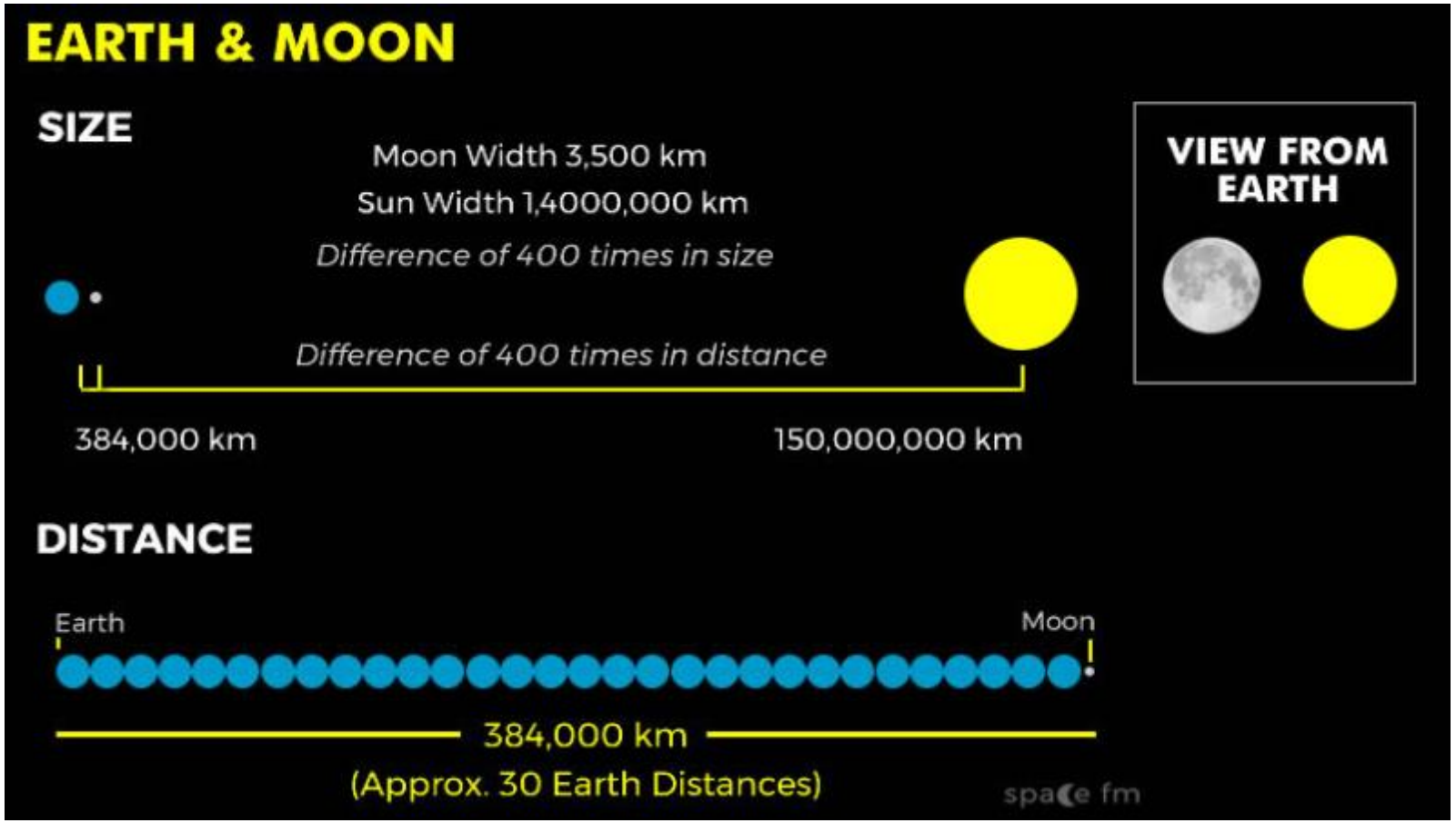
Earth's diameter: ~12,742 km

Moon's diameter: ~3,500 km (~27% of Earth's diameter)

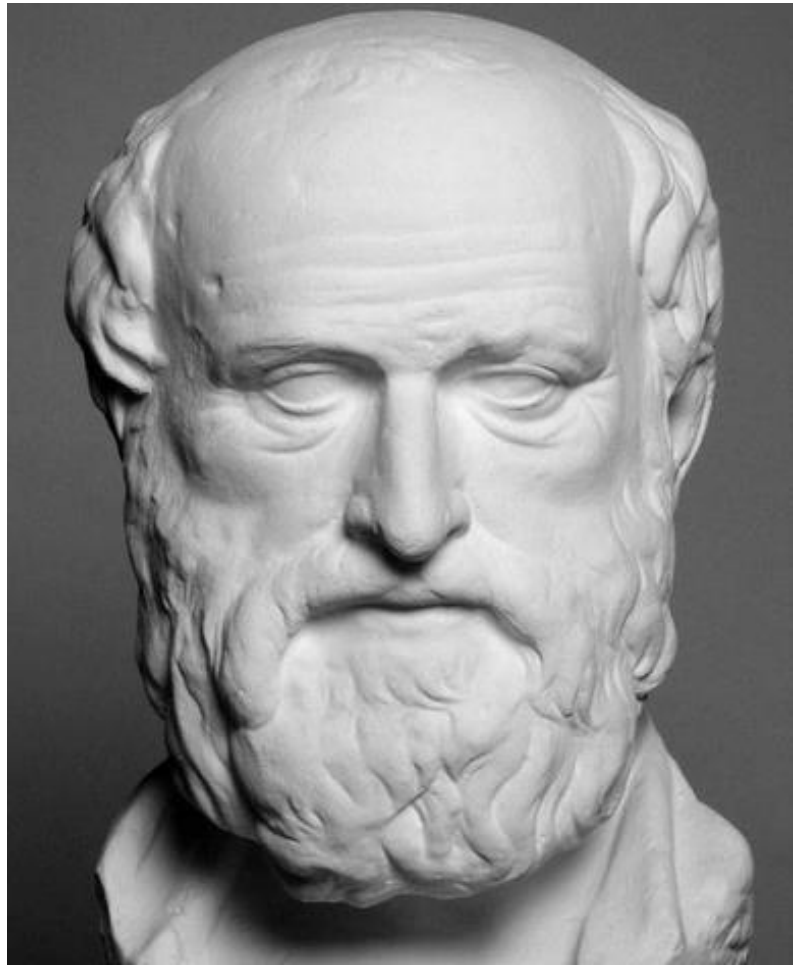
Sun's diameter: ~1.4 × 10^6 km (~109 times Earth's diameter)

Earth-Moon distance: ~384,400 km (~30 Earth diameters)

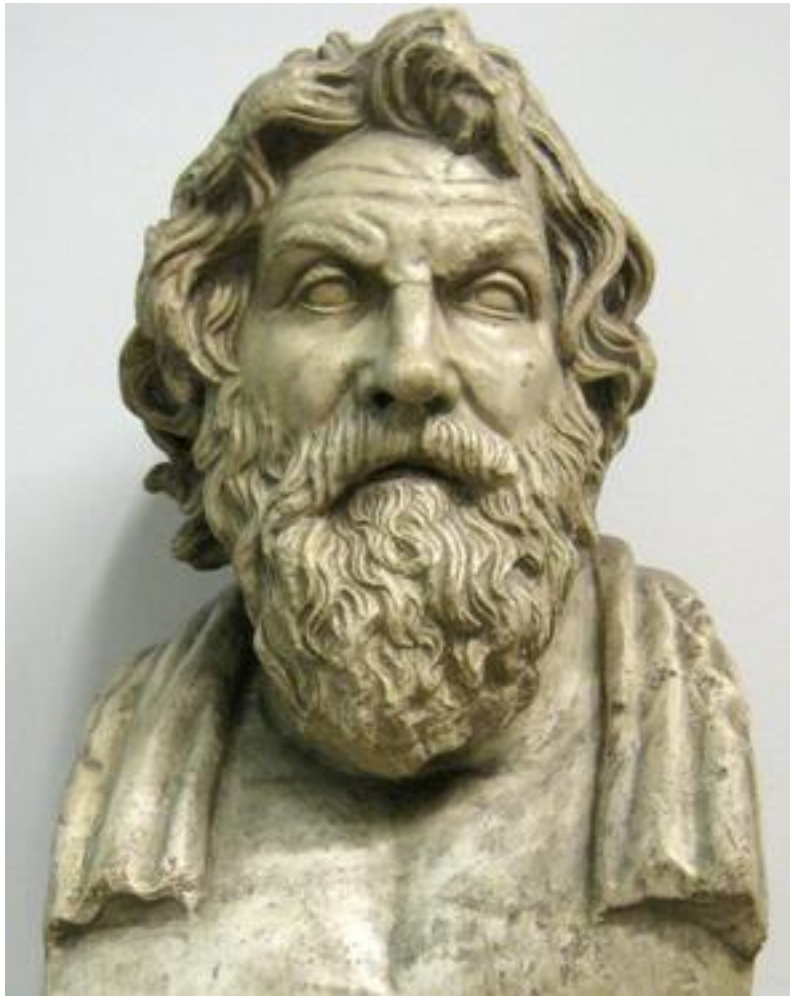
Earth-Sun distance: ~1 AU (~150 million km)



Eratosthenes



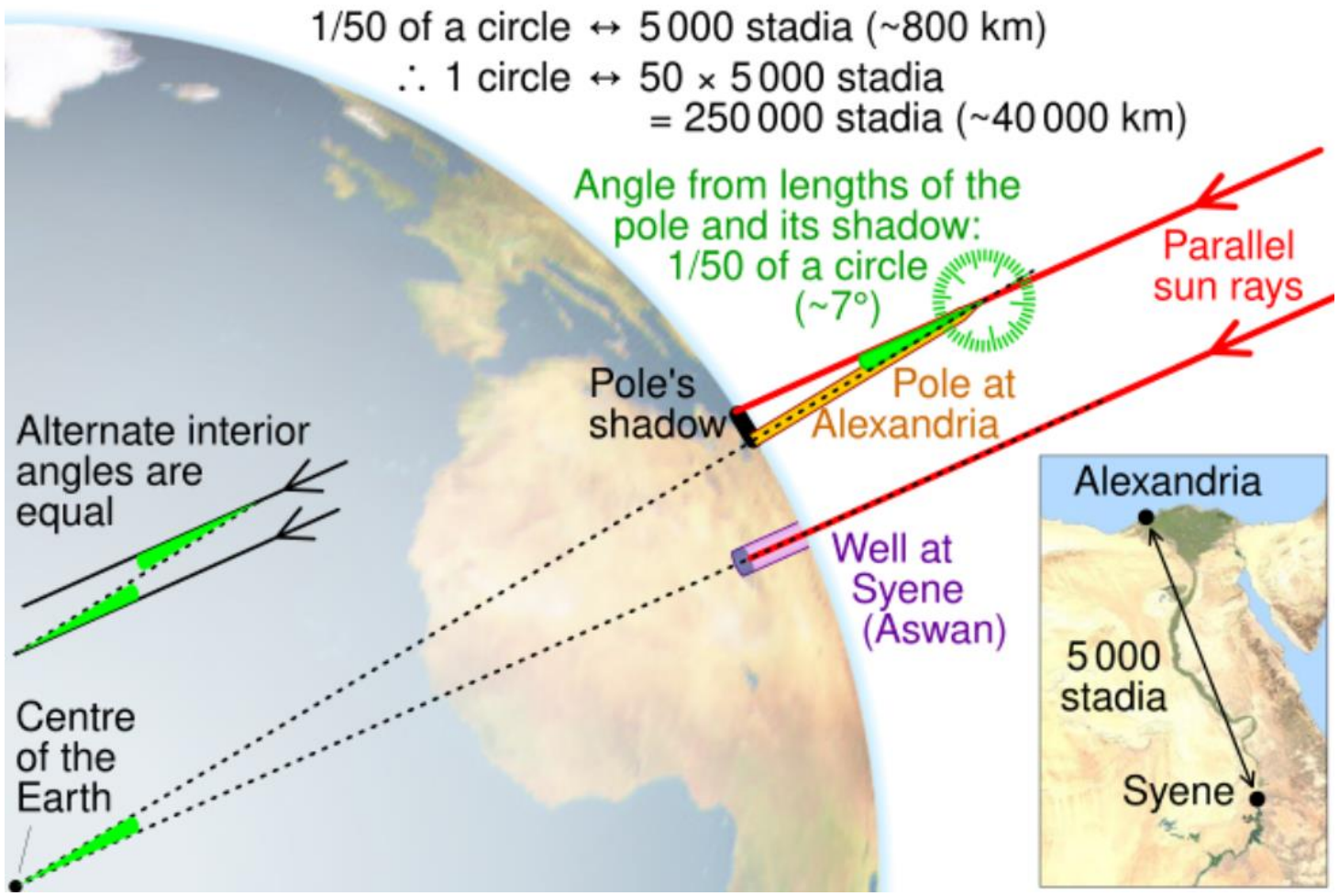
Aristarchus



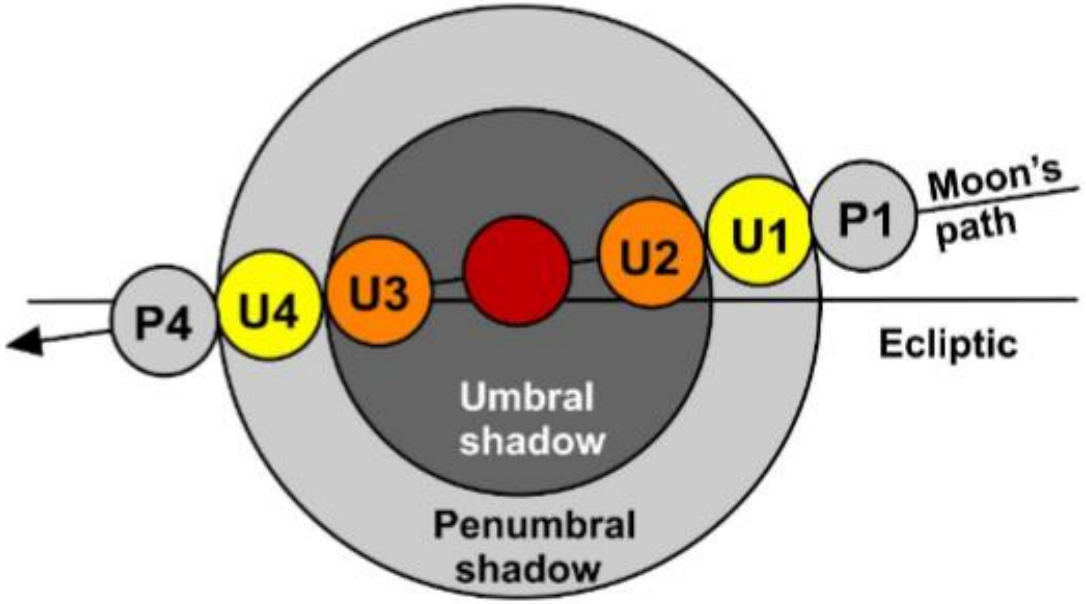
Eratosthenes – Earth's Diameter

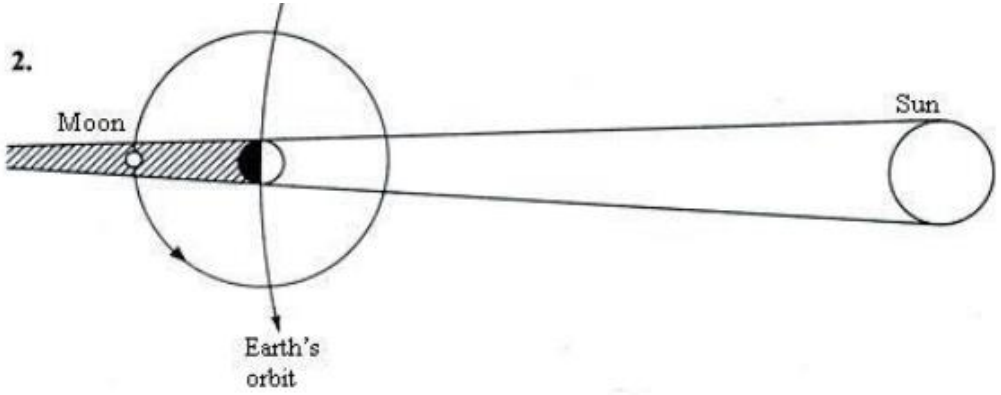
The Sun was directly overhead at Syene but cast a shadow on a pole at Alexandria.

Using the distance between the two locations and measured angles, he was able to calculate the circumference of the Earth



https://www.youtube.com/watch?v=f-ppBtuc_wQ





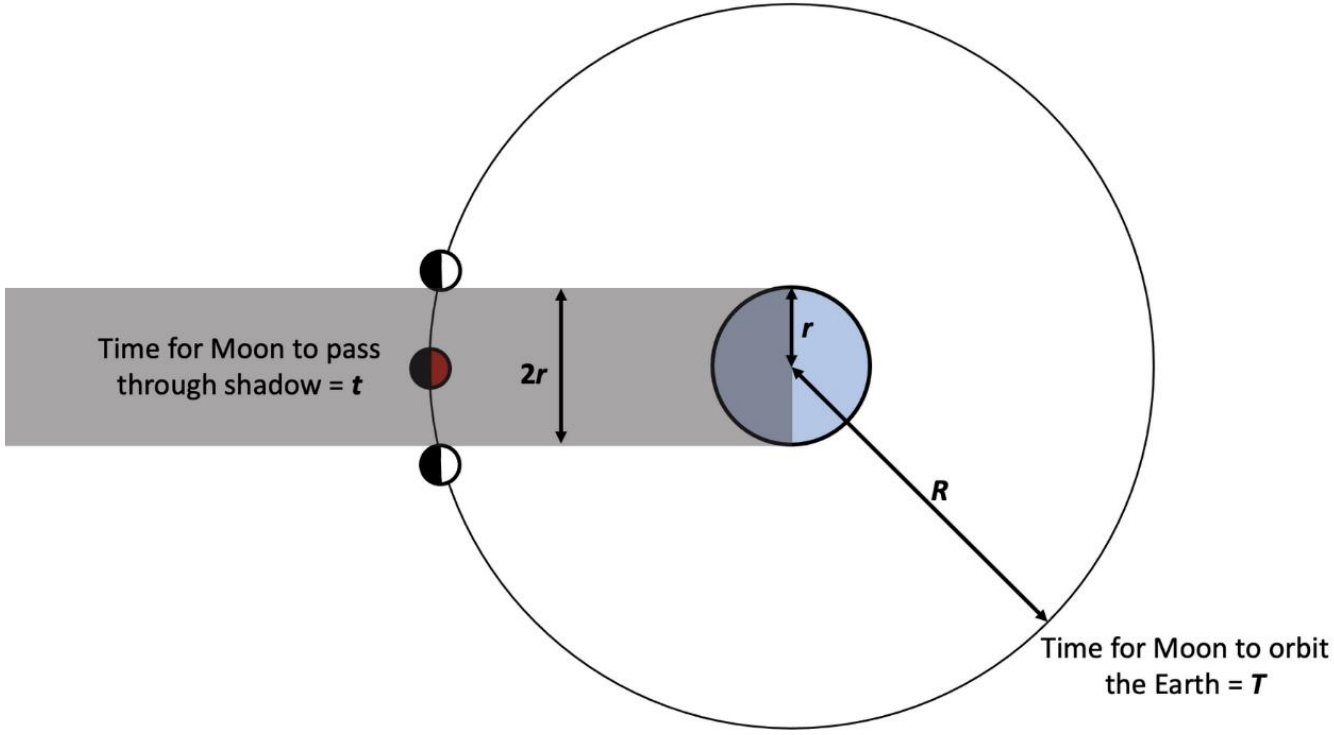
Aristarchus – Moon's Diameter

- He studied a lunar eclipse
- He noticed that the Moon takes several hours to pass through the Earth's shadow (umbra).
- This showed that the Moon is smaller than the Earth, if we assume the umbral shadow has roughly the same diameter as the Earth

Aristarchus – Moon's Diameter

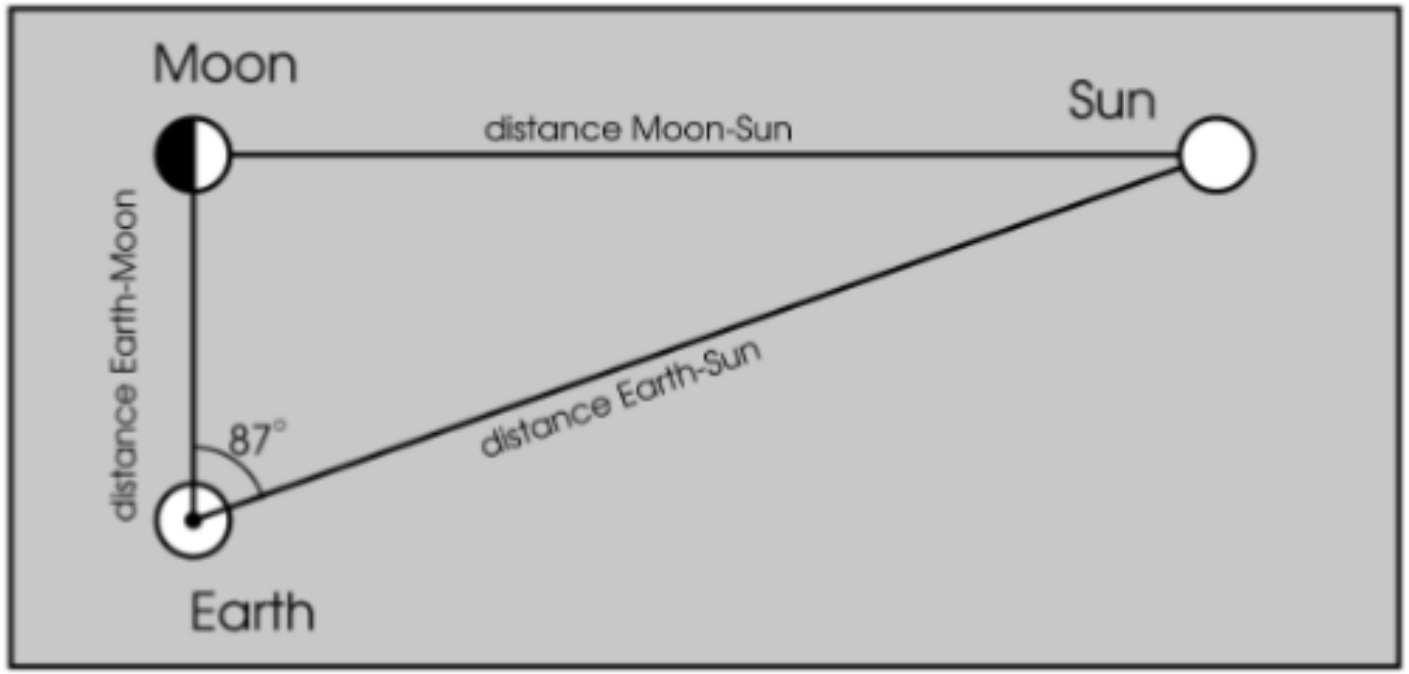
Compared the time it takes the Moon to pass through Earth's shadow (umbra) to the time for one full revolution around the Earth

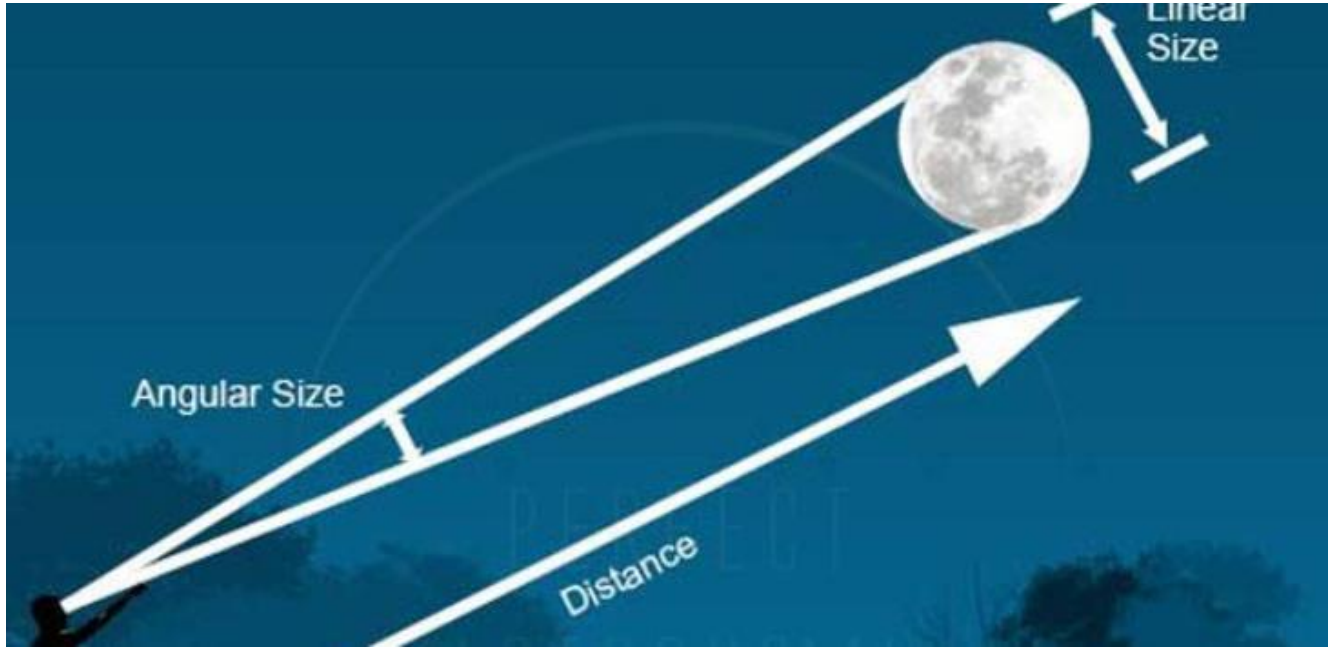
Used the ratio of the times to get the ratio of the distances



Aristarchus – Sun's Distance

- Estimated the angle between the Sun and the Moon during a quarter moon.
- Used this to estimate the ratio of the distance to the Moon and the distance to the Sun
- Large errors in distances even though only a small error in angle





Aristarchus – Sun's Diameter

- The Sun and the Moon have the same angular size in the sky
- Hence the ratio of the true diameters should relate to the true sizes

The Sun’s Size

- The Sun’s mean diameter is **1.4×10^6 km**.
- Modern methods of measurement include measurement of angular diameter and radar location using the inner planets to find the distance to the Sun.

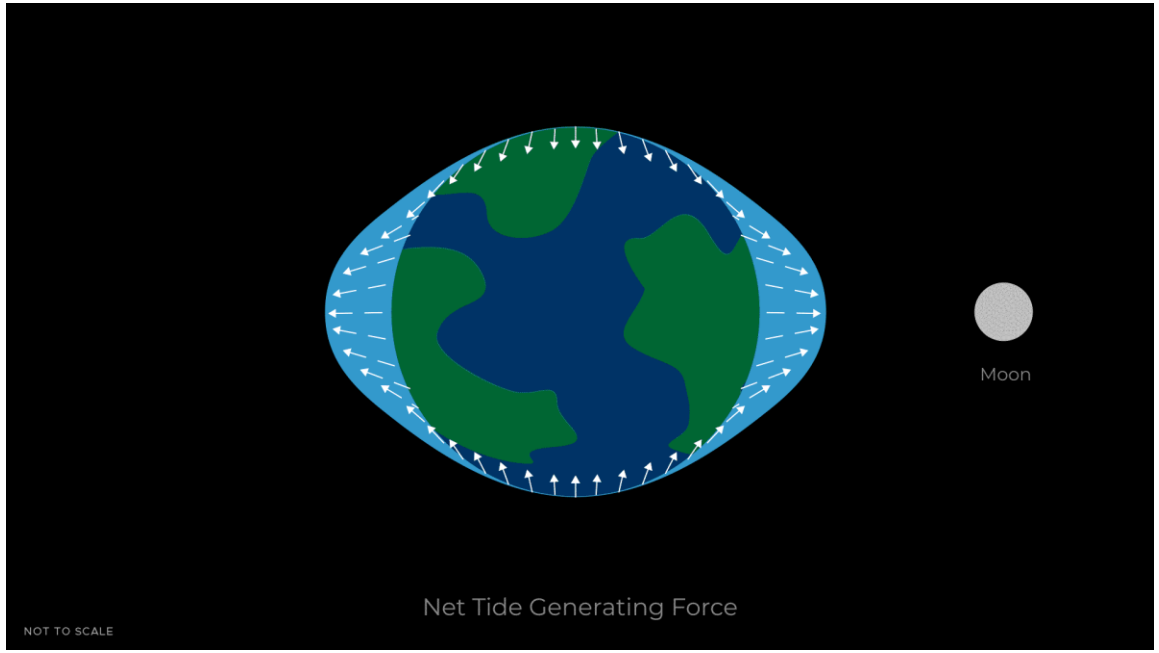
Topic 3: The Earth-Moon-Sun System Part 2

Tidal Effects

The Moon’s gravity pulls on the water on the surface of the Earth and the Earth itself with slightly different strengths.

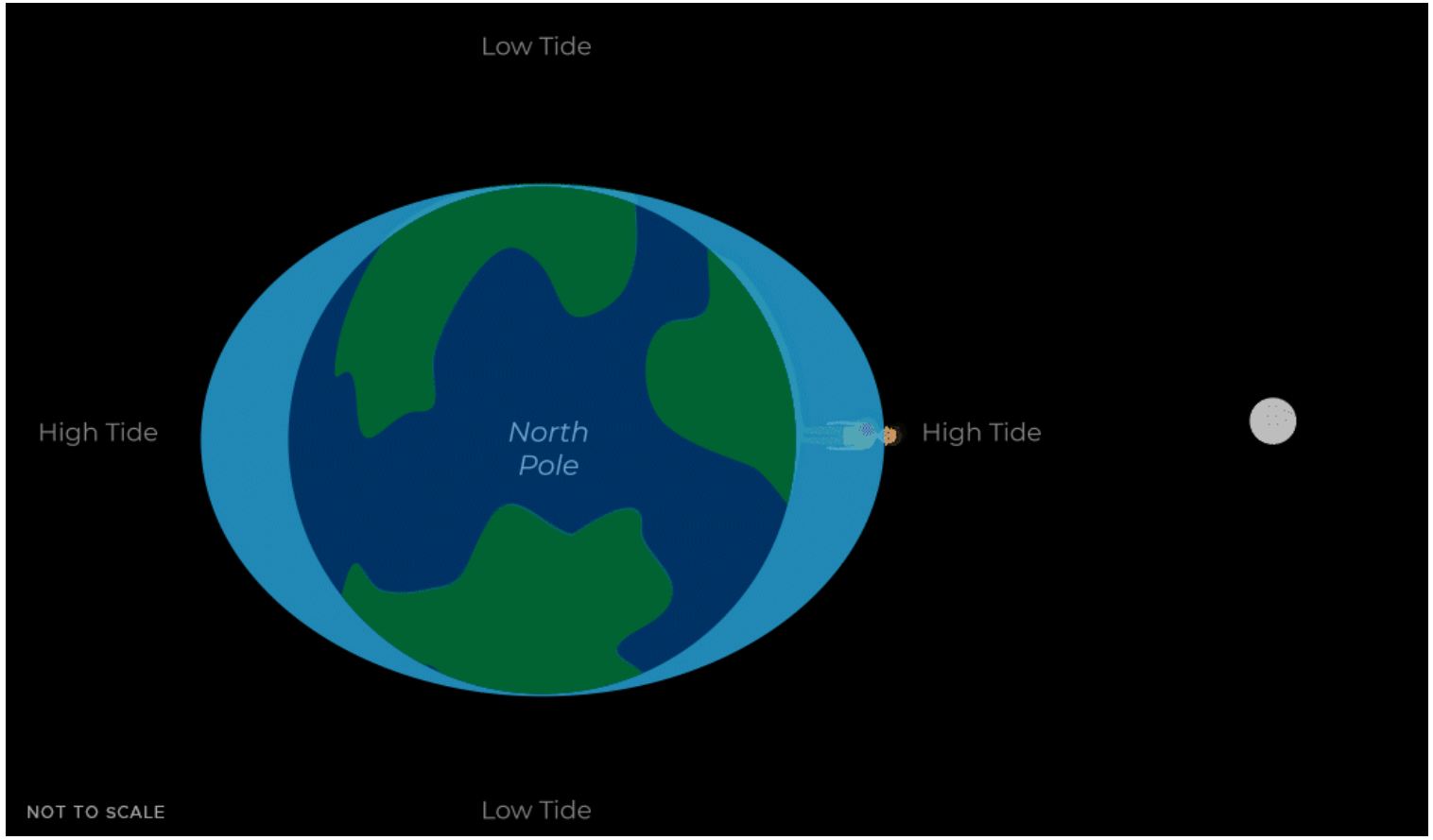
This causes a ‘bulge’ of water on either side of the Earth.

The Sun’s gravity has a similar effect.



Tidal Effects

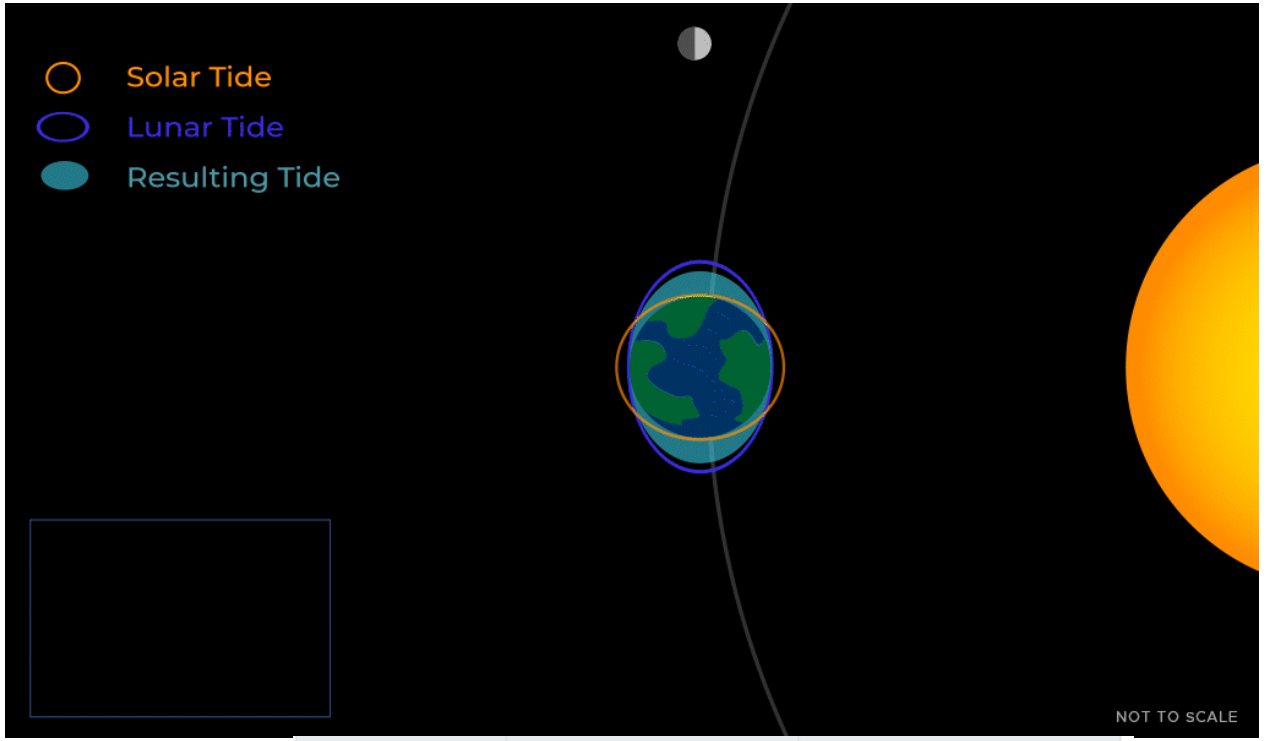
As the Earth rotates different locations on the surface experience high and low tides as they pass through these ‘bulges’.



Tidal Effects

When the Sun and the Moon align with the Earth, we get the biggest difference between high and low tides.

When the Moon is perpendicular to the Sun and the Earth gives us the lowest difference between high and low tides



Type	Feature	Timing
≋ Spring Tides	↑↑ Higher HIGH tides ↓↓ Lower LOW tides	☾ Full & New
= Neap Tides	↓↑ Lower HIGH tides ↑↓ Higher LOW tides	☾ First & Third Quarters

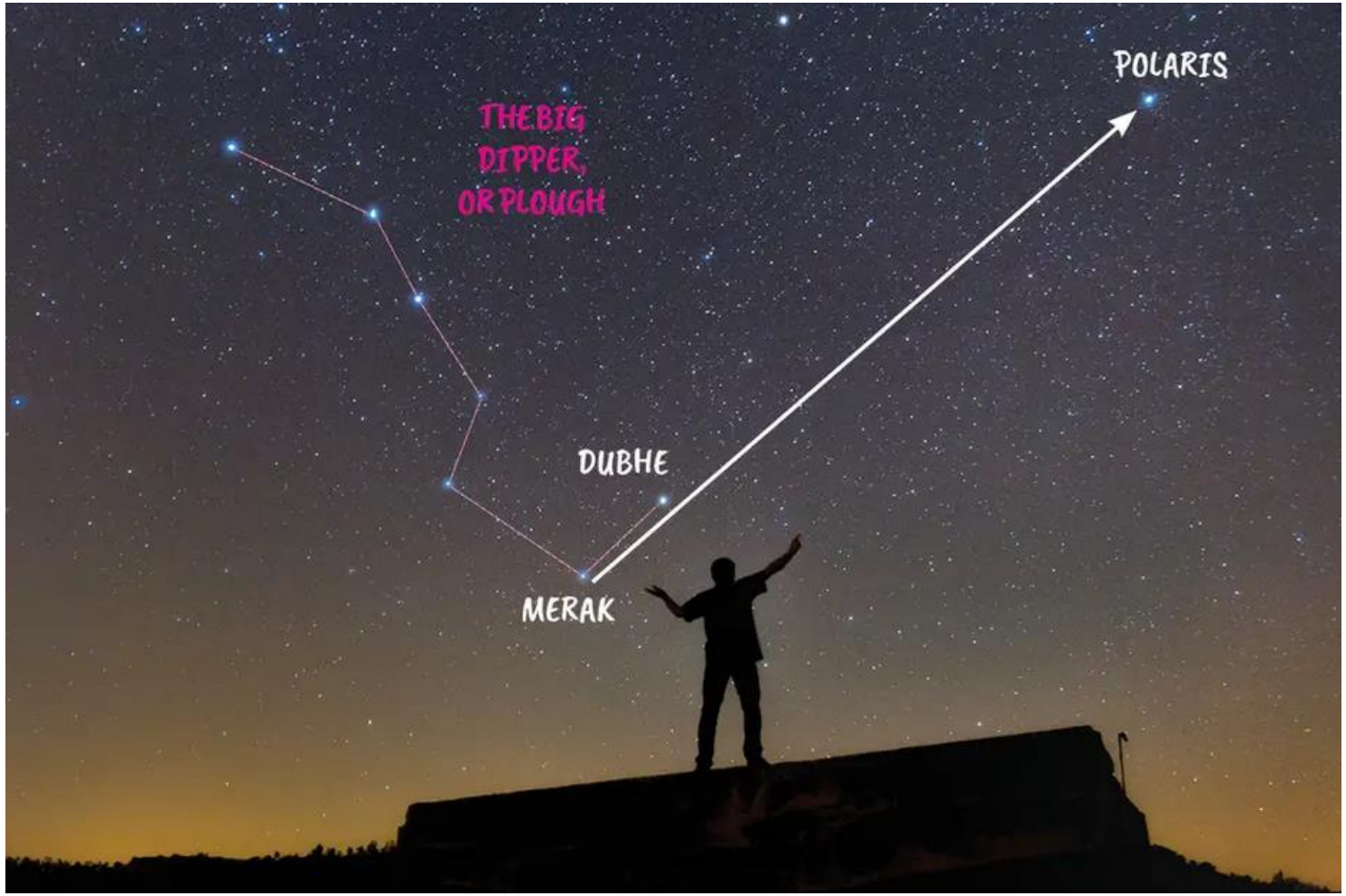
https://www.youtube.com/watch?v=mpRJhhbKLFc

Precession

Polaris is located very close to the North Celestial Pole, so appears to stay at a fixed position in the sky.

Often called the ‘North Star’.

https://www.youtube.com/shorts/7s_X0LBVVyA



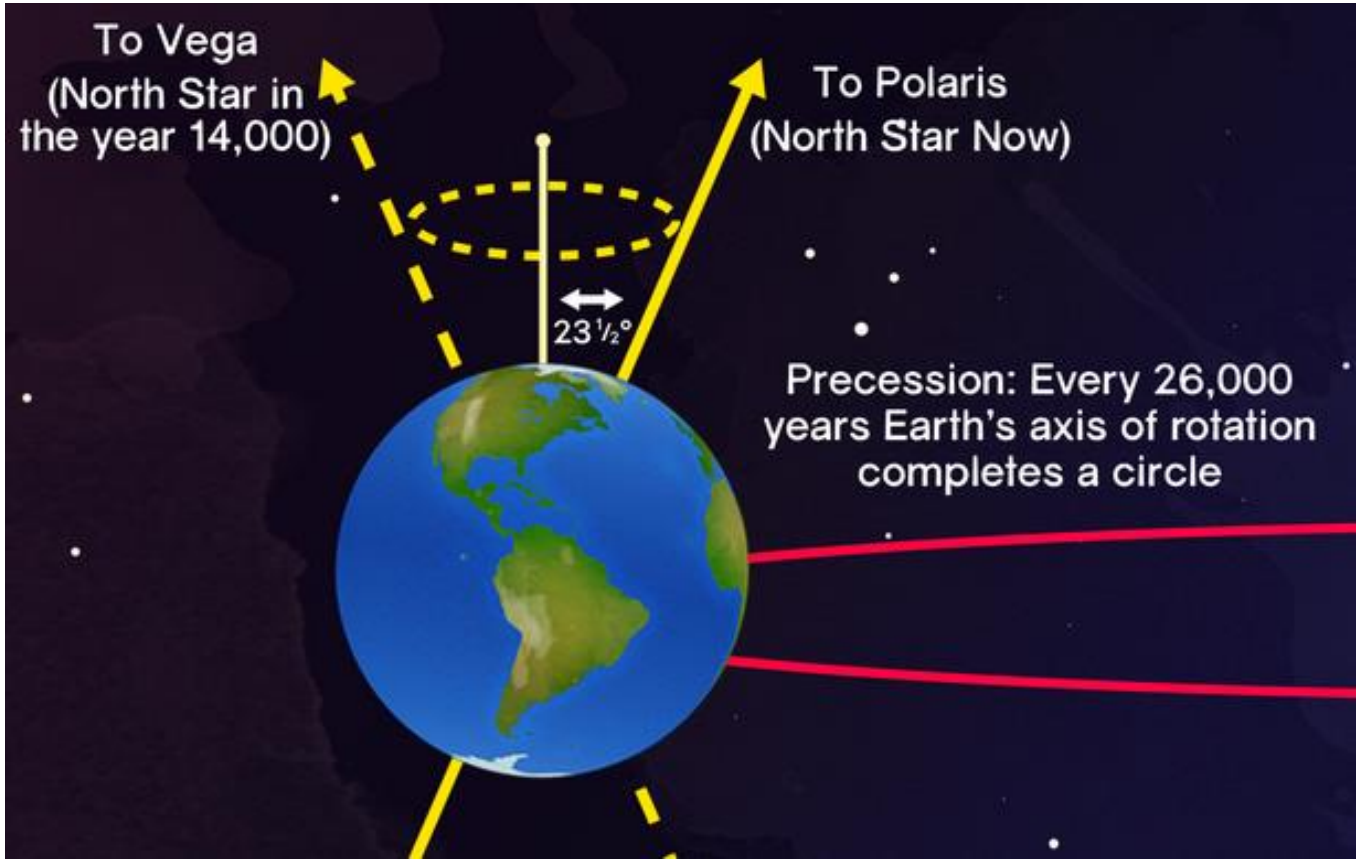
Precession

The Earth's axis slowly rotates and 'wobbles', completing one cycle every 26,000 years.

This is caused by the complex gravitational field of the Sun and the Moon

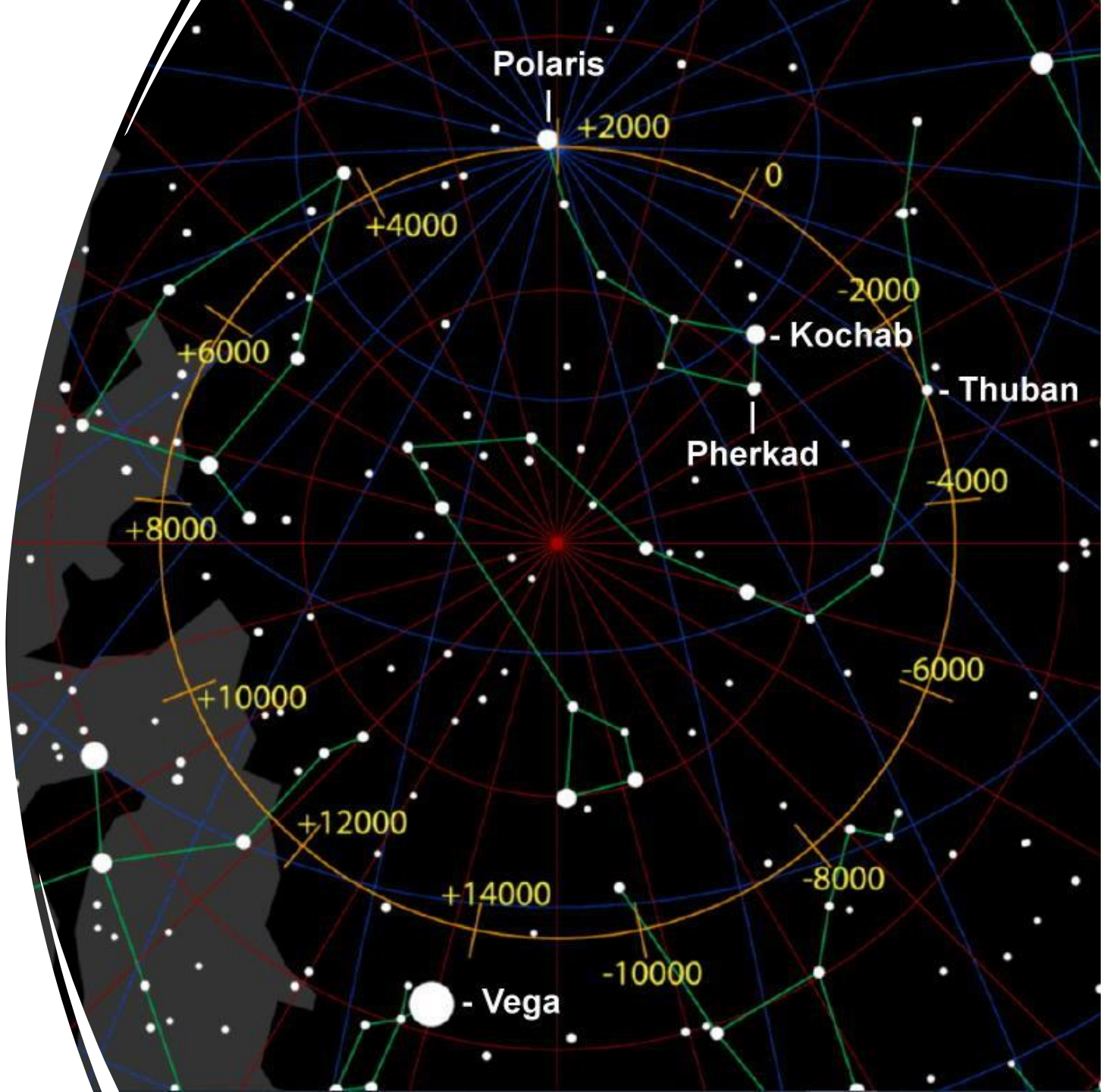
So, the 'North Star' won't be Polaris forever!

https://svs.gsfc.nasa.gov/20196/



Archeoastronomy

- Over thousands of years:
  - The position of the celestial poles changes.
  - The stars that are circumpolar (always visible from a location) also change.
  - The stars visible in each season shift very slowly.
  - Ancient monuments aligned to certain stars or the rising Sun no longer line up exactly today.



Eclipses

Solar eclipses are caused when the Moon is between the Sun and the Earth (during a New Moon)

Lunar eclipses occur when the Earth is between the Sun and the Moon (during a Full Moon)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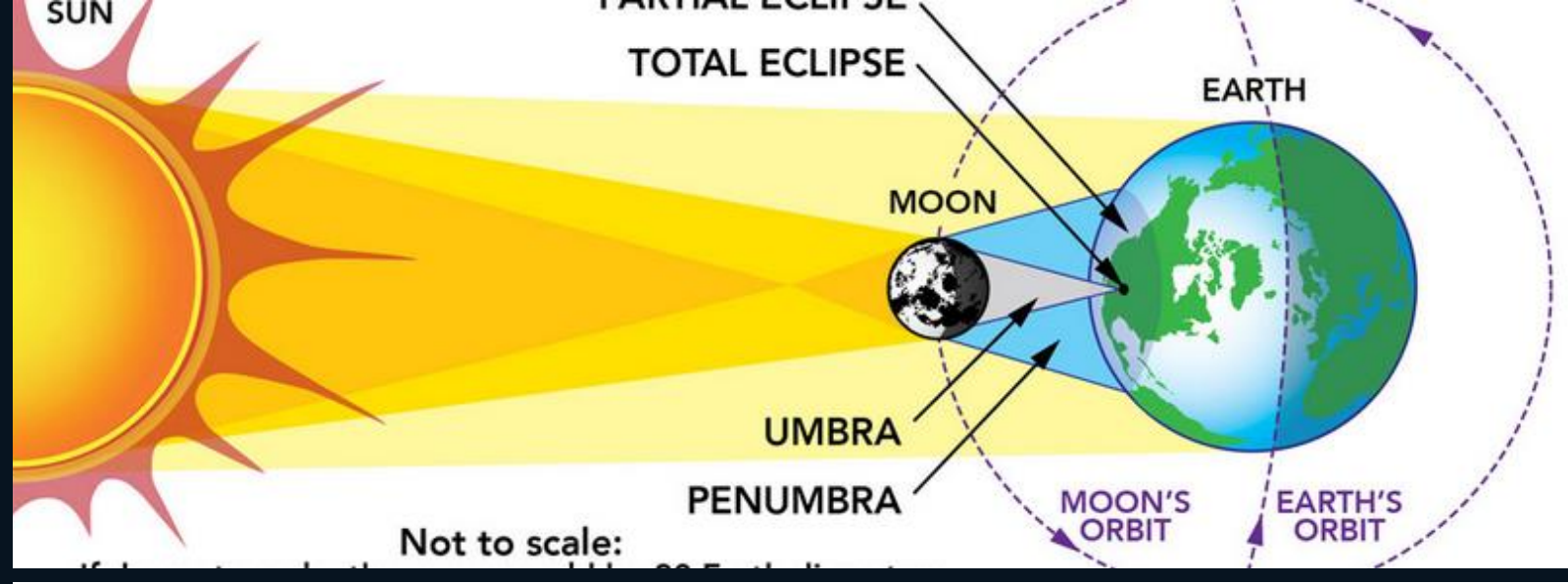
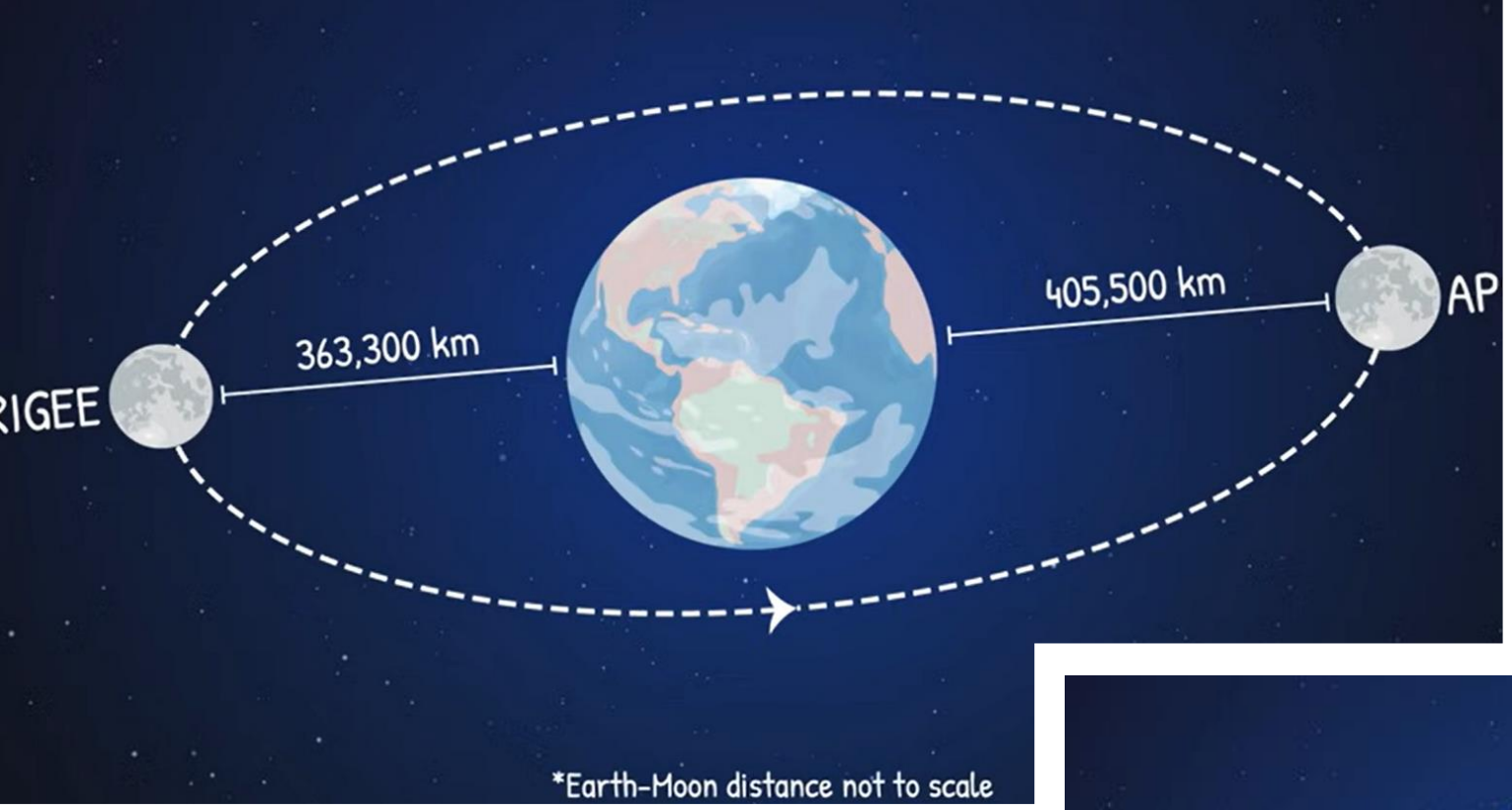
Total Solar Eclipse

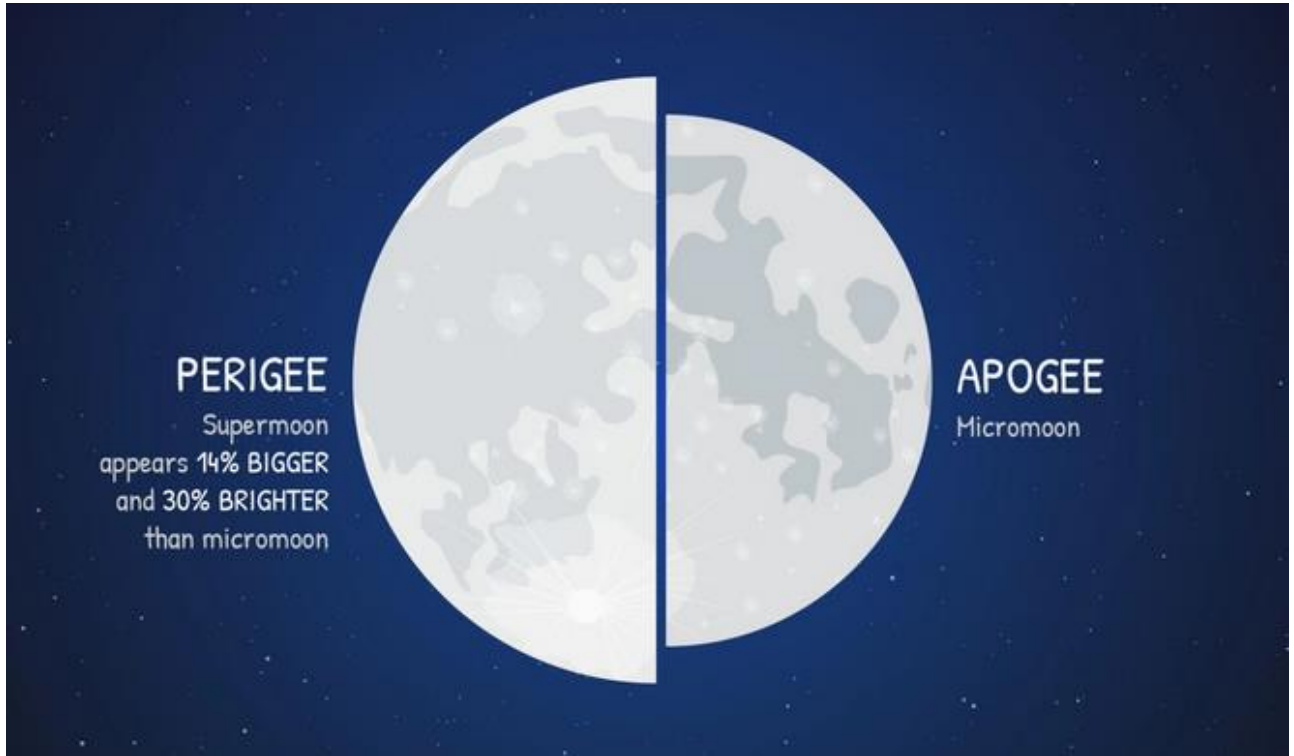
Partial Solar Eclipse



- This is seen by people not directly in the Moon's umbra (in the path of totality)

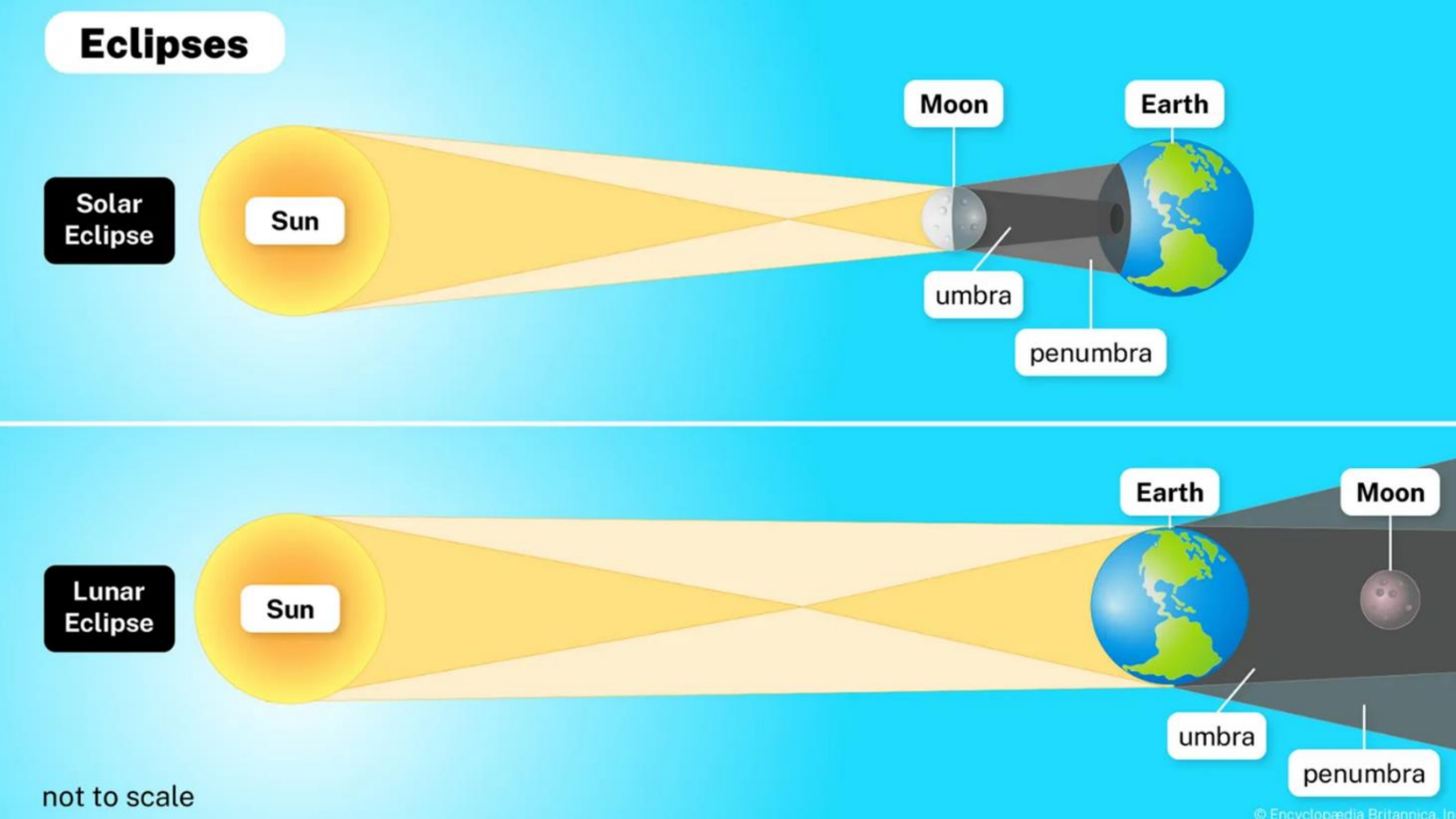
https://nso.edu/for-public/eclipse-map-2026/


RIGEE
363,300 km
405,500 km
AP
*Earth-Moon distance not to scale

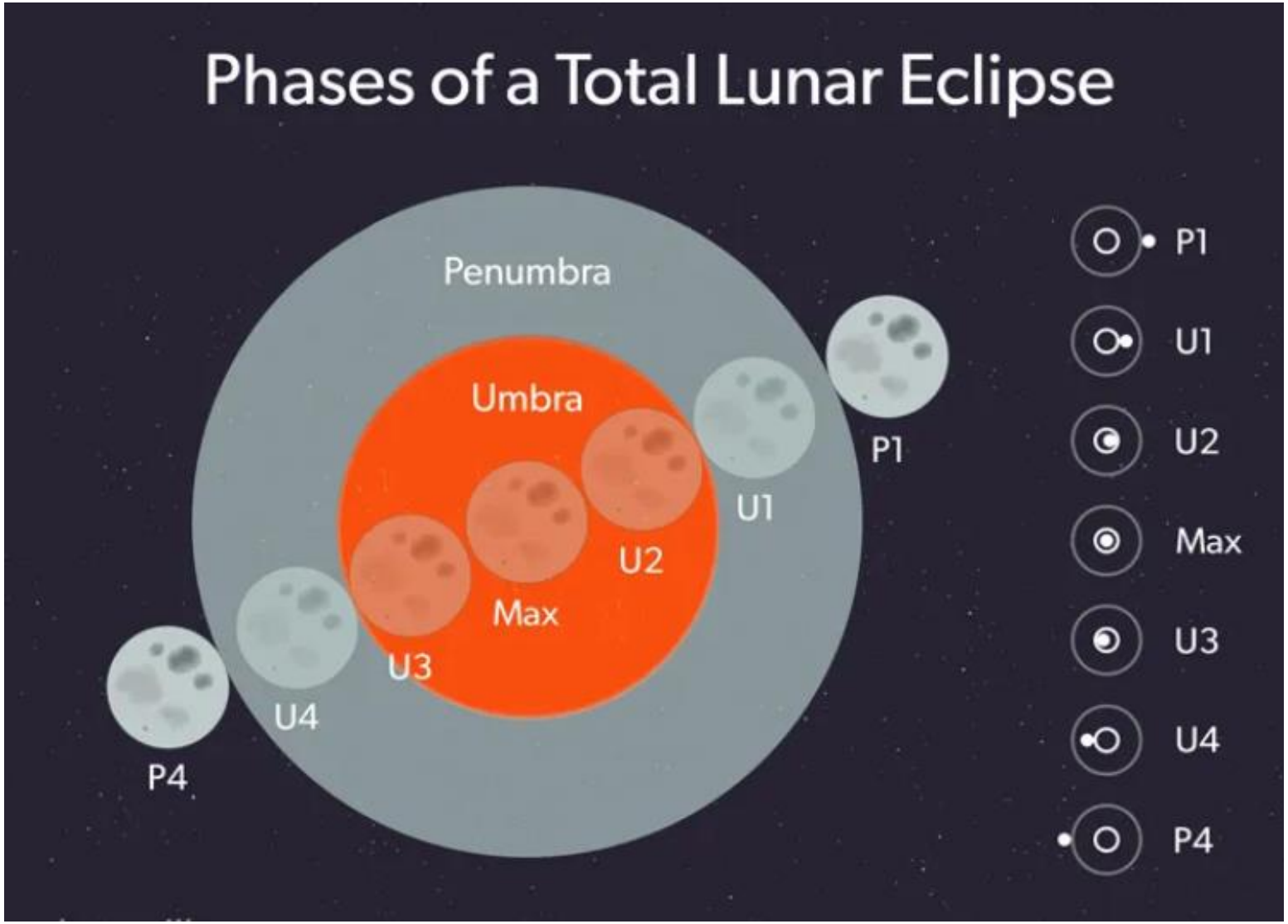

PERIGEE
Supermoon
appears 14% BIGGER
and 30% BRIGHTER
than micromoon
APOGEE
Micromoon

Annular Eclipse

- The Moon is farther from Earth (at apogee) and appears too small to cover the Sun completely.
- The result is a bright ring of sunlight, sometimes called a 'ring of fire’.
- The corona and prominences cannot be seen clearly.



Lunar Eclipse



(P1) – The Moon enters Earth's penumbra. It may appear darker or greyer.

(U1) – The Moon moves into Earth's umbra. Red light refracts through Earth's atmosphere and colours the Moon red, copper, orange, or burgundy.

(U3) – The Moon begins moving out of the Earth's umbra.

(P4)– The Moon leaves the penumbra.