"Winter is an etching, spring a watercolor, summer an oil painting and autumn a mosaic of them all"

- Stanley Horowitz

What We Will Learn Today

- What causes seasons on Earth?
- Why do we see phases of the Moon?

The Reason for Seasons

Why is summer is hotter than winter?

A. The Sun burns hotter during summer
B. We are closer to the Sun during summer
C. The Earth's axis is tilted with respect to the ecliptic
D. Earth rotates slower during summer, making for longer days

Clues Regarding Seasons

- Days are hotter in the summer
- Days are longer in the summer
- Seasons repeat with a period of one year
- Seasons are mild near the Equator and severe near the poles
- When it is summer here, it is winter in Australia!

The Reason for Seasons

Why is summer is hotter than winter?

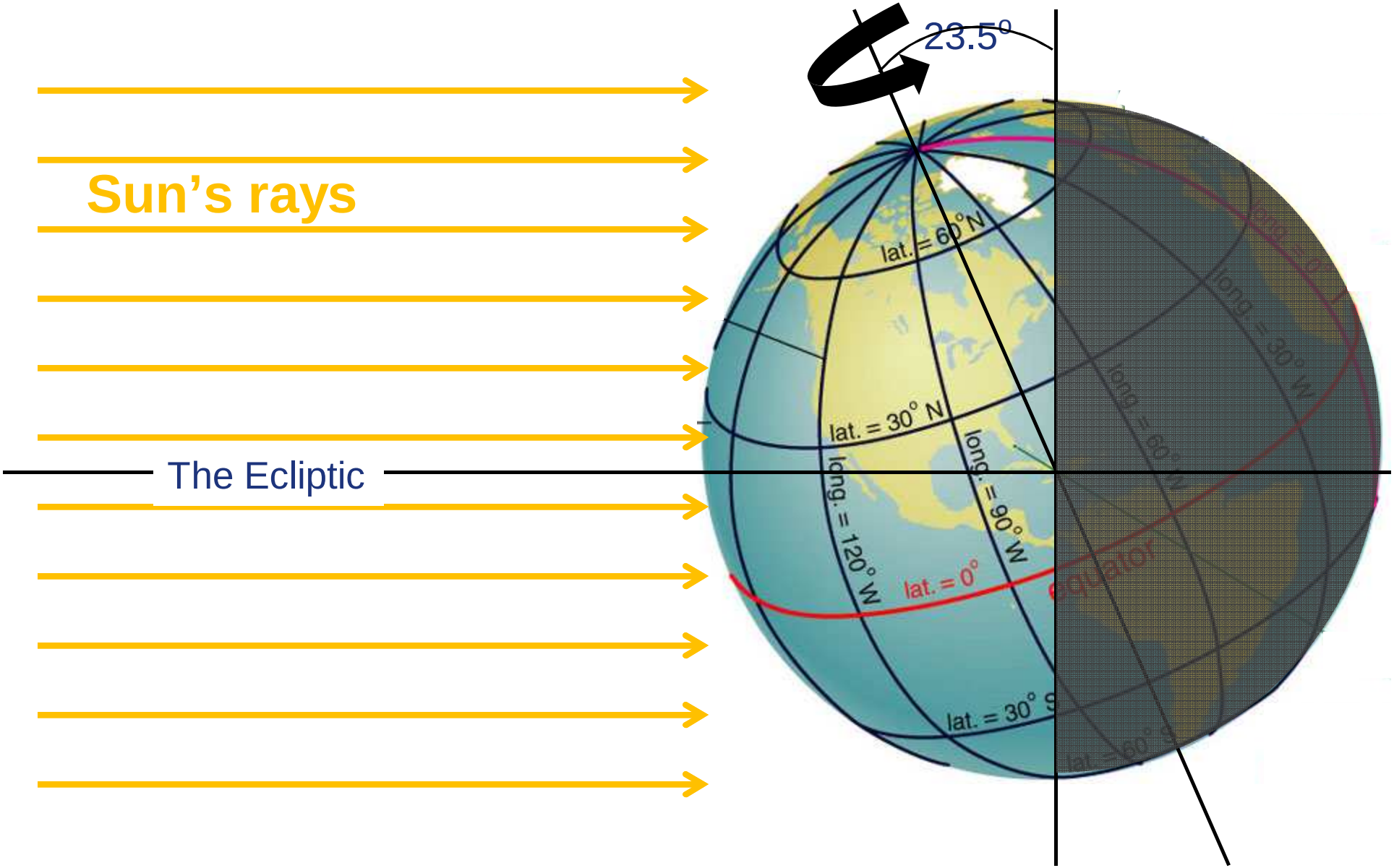
A. The Sun burns hotter during summer

B. We are closer to the Sun during summer

C. The Earth's axis is tilted with respect to the ecliptic

D. Earth rotates slower during summer, making for longer days

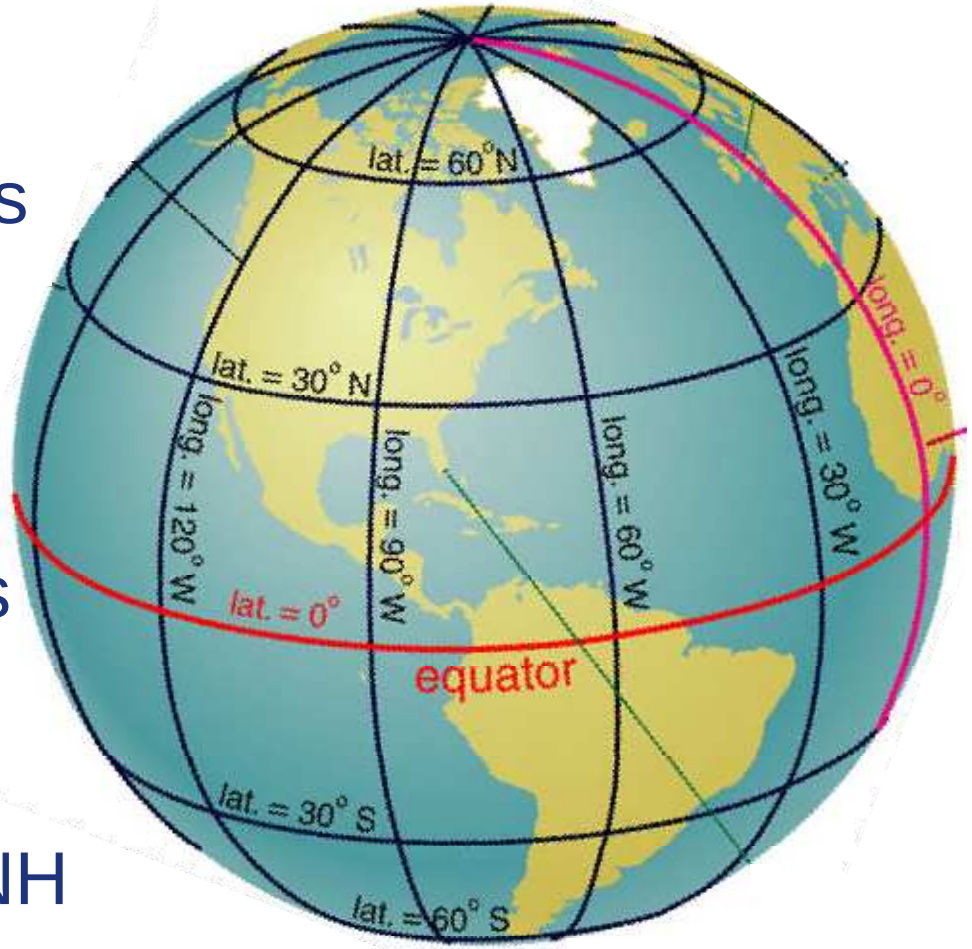
Northern Hemisphere Summer



Summer Days Are Hotter & Longer

Northern Hemisphere Summer

- View from the Sun
  - Northern Hemisphere is tilted towards the Sun
  - Can see more of the Northern Hemisphere
  - Can see it for longer as Earth spins (days are longer)
  - Rays concentrated in NH (days are hotter)



The Seasons

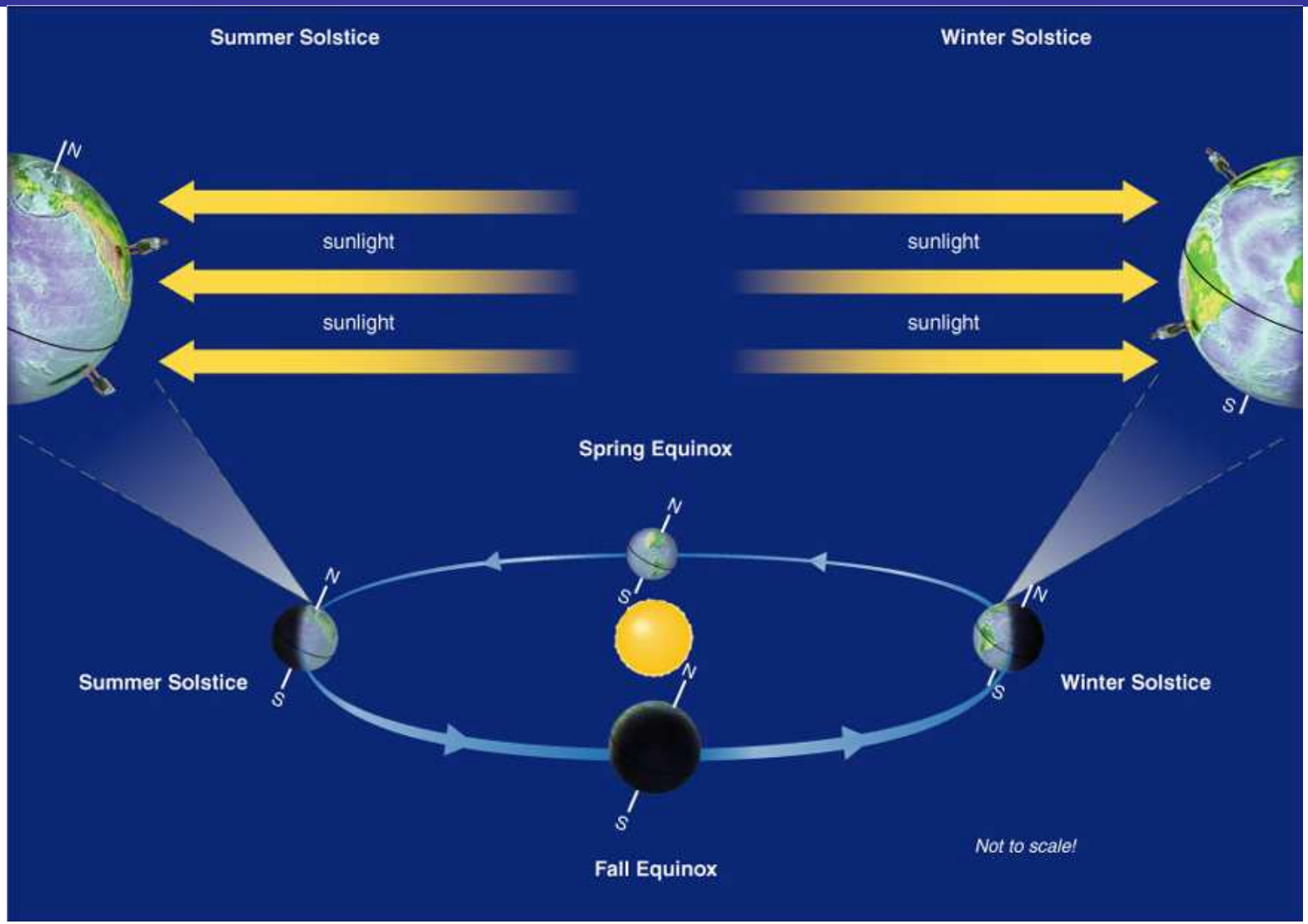


Fig 2.15

- Note: The seasons are named from the northern hemisphere's perspective

Sun's Path as Seen From Earth

- View from 40^{o} N (say Columbus, OH)
- Sun always rises due East, right? No!
  - NE in summer, SE in winter, E at equinoxes

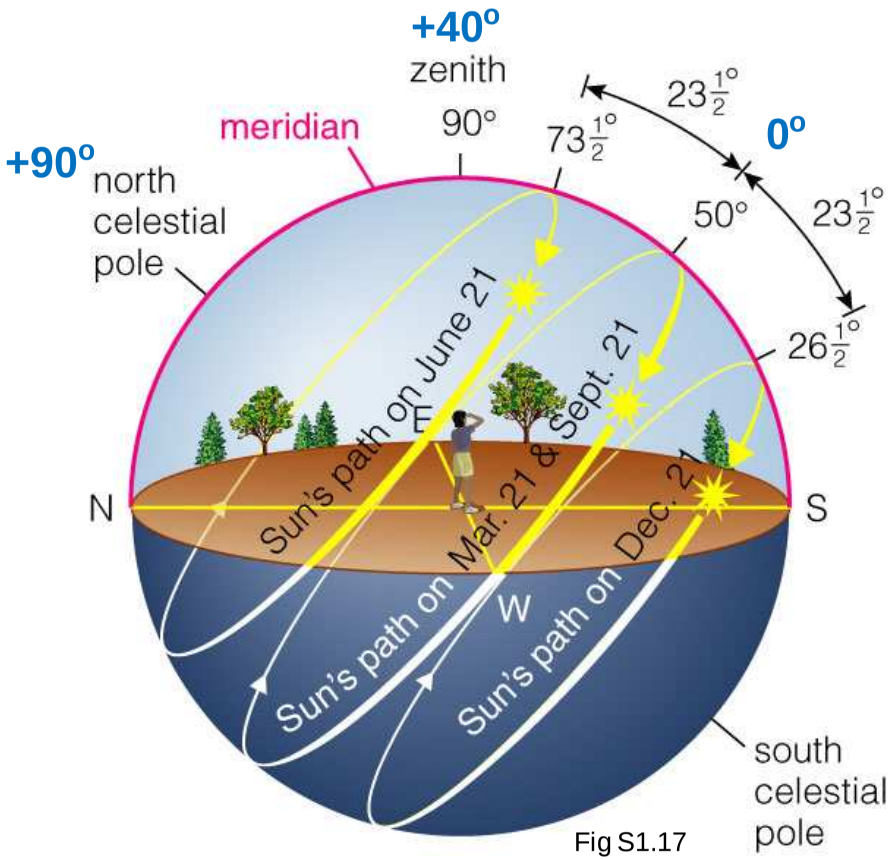


Fig S1.17

Declination

Sun's Path from Pole & Equator

- Sun rises & sets every day, right?
  - Not at the poles!

View from N pole

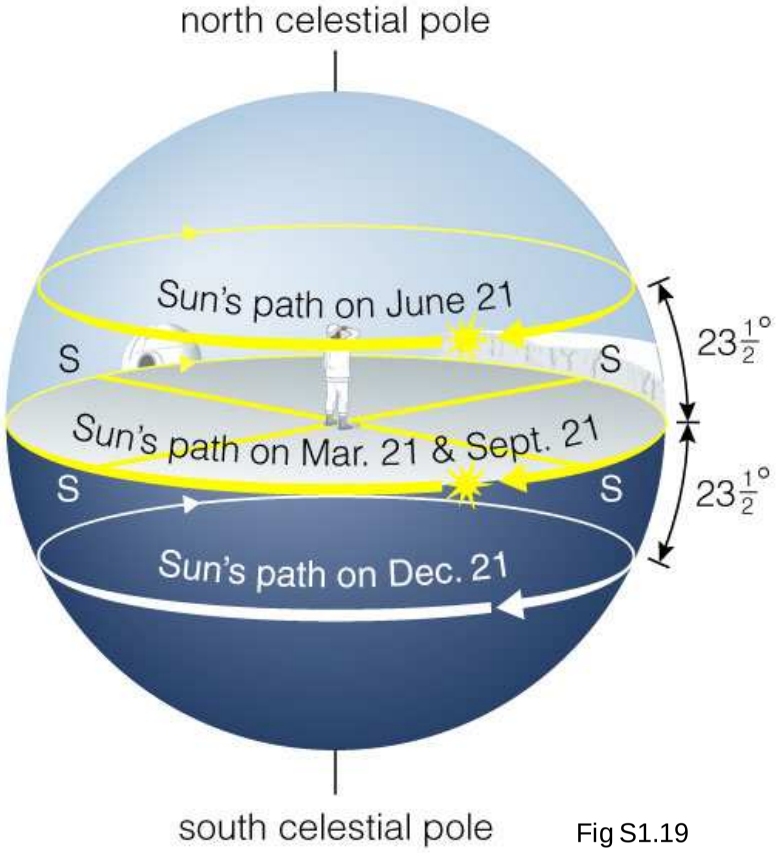


Fig S1.19

View from Equator

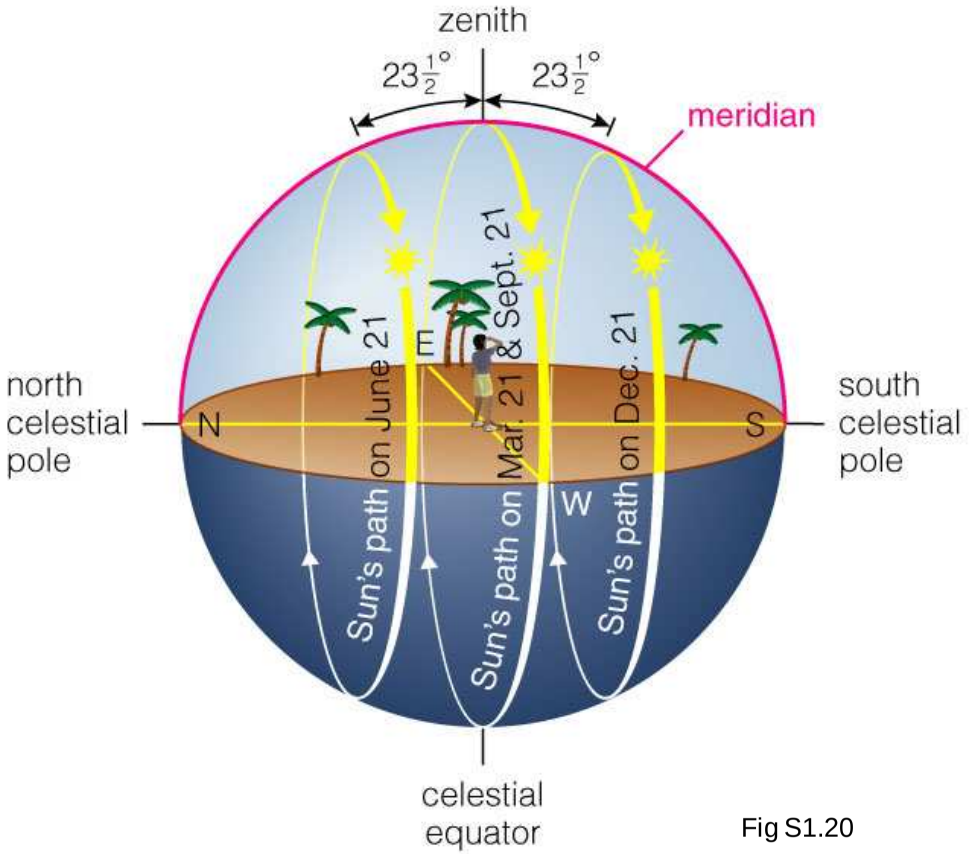


Fig S1.20

Special Latitudes on Earth

Based on Sun's path in the sky

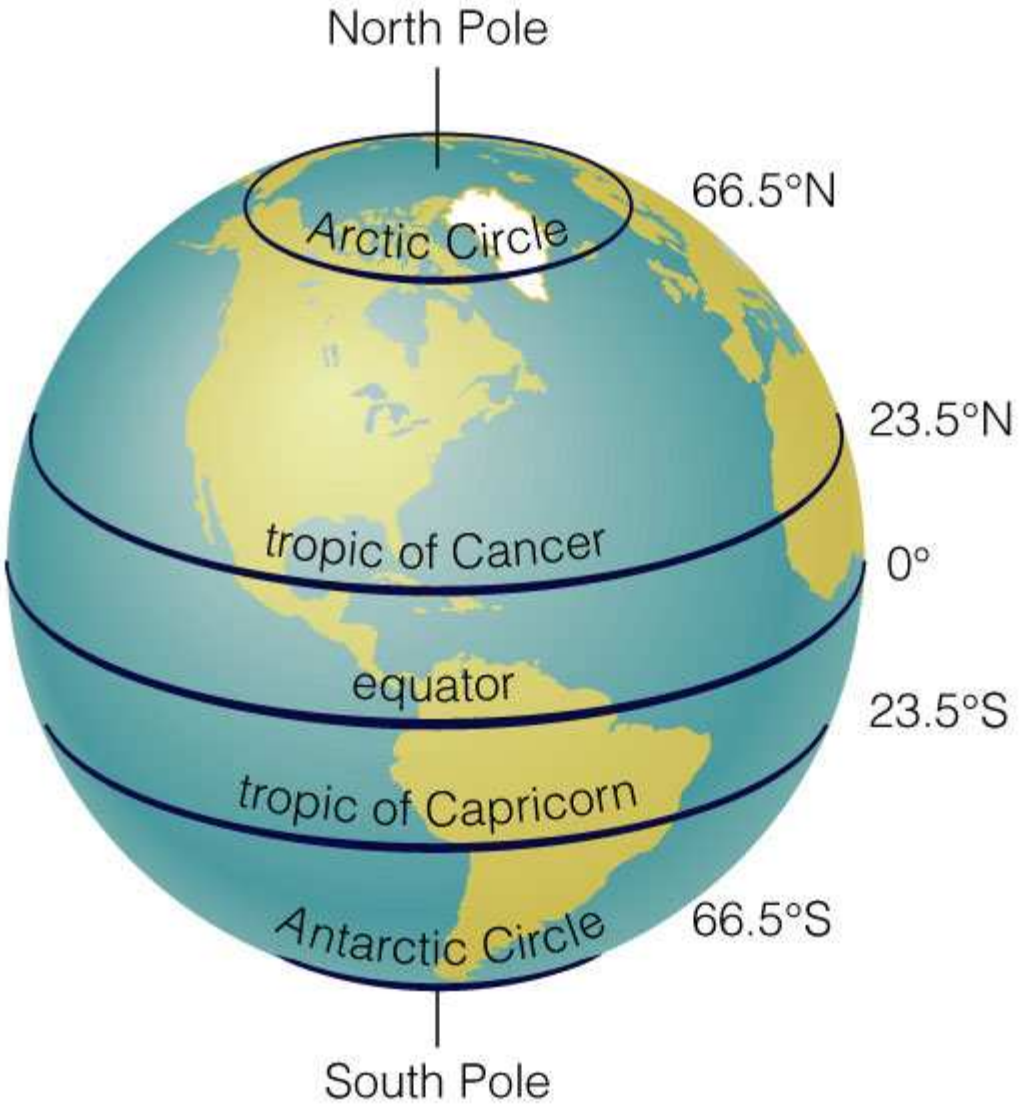


Fig S1.18

The Tropics

- Between the Tropics of Cancer an Capricorn
  - Sun will reach Zenith at noon on two days of the year

The Arctic & Antarctic Circles

- At these circles, the Sun stays above the horizon for at least one day per year
  - Also, below the horizon!
- At the poles, we have the extremes
  - 6 months of light and 6 months of darkness

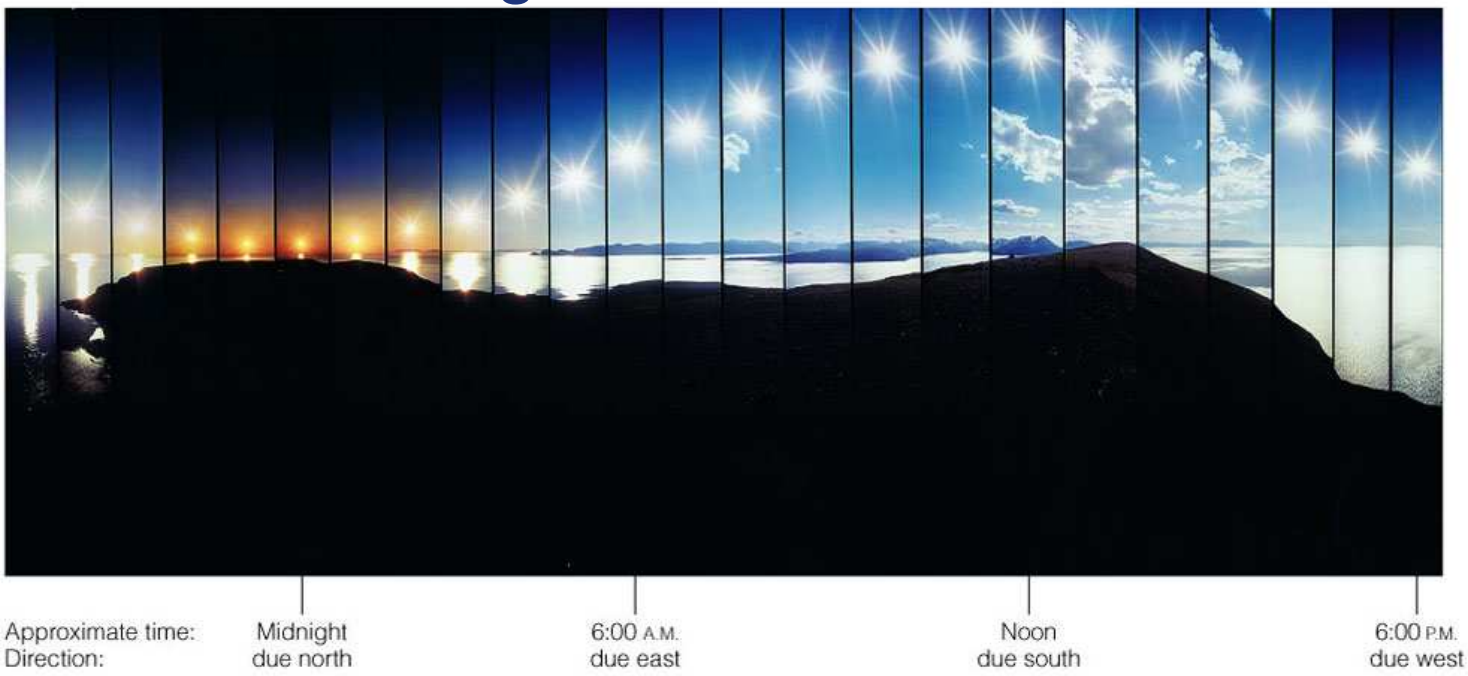


Fig 2.18

Phases of the Moon

- What causes the phases of the Moon?
- What are the phases?
- When does the Moon rise & set?

Moon's Motion in Our Sky

- Rises East, Sets West
  - Due to Earth's spin
- Moves West to East
  - Due to Moon's orbit around Earth
- Result
  - Moon rises 1 day *and* 51 minutes later each day (on average)

Moon Phase Demonstration

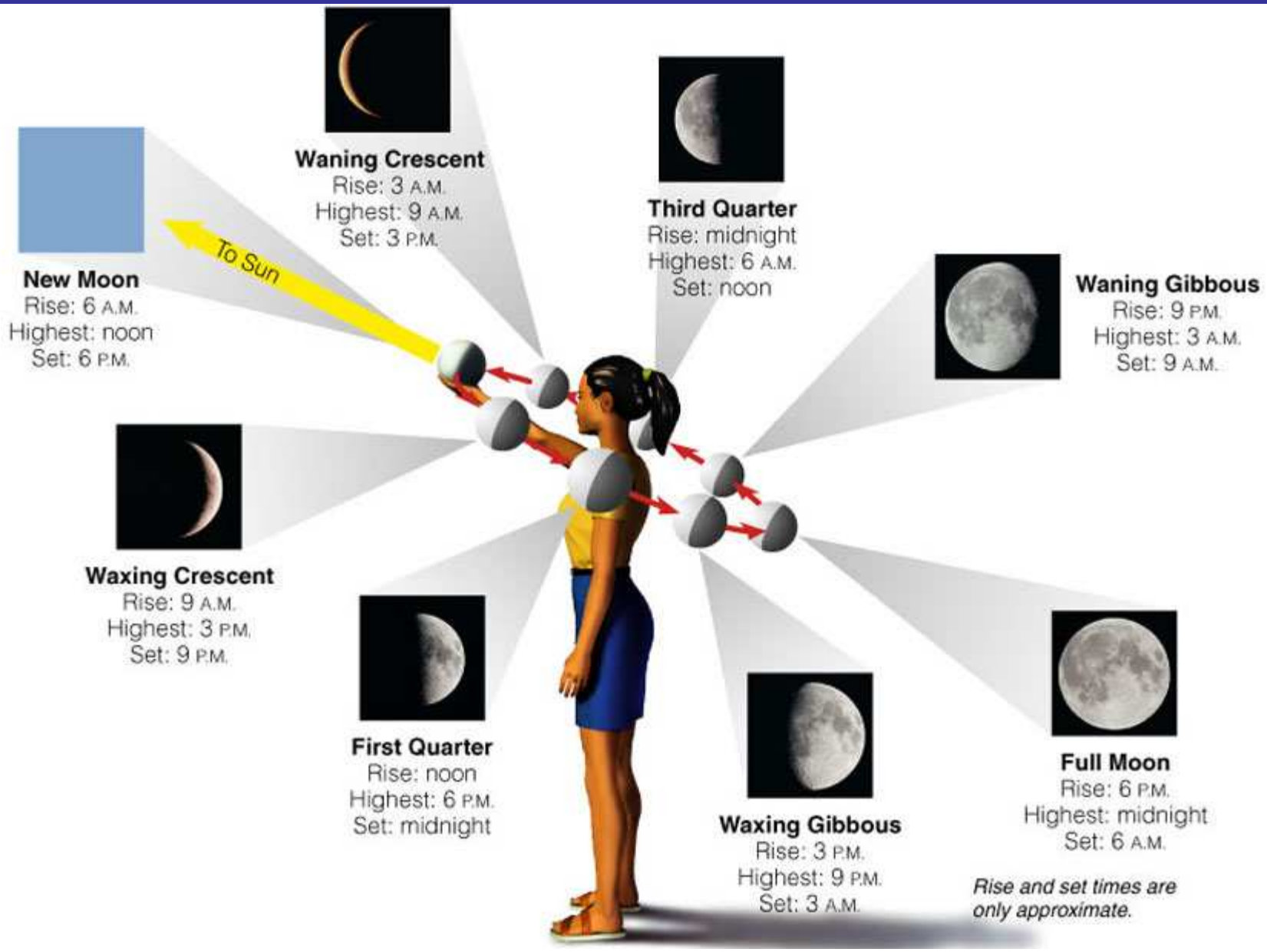
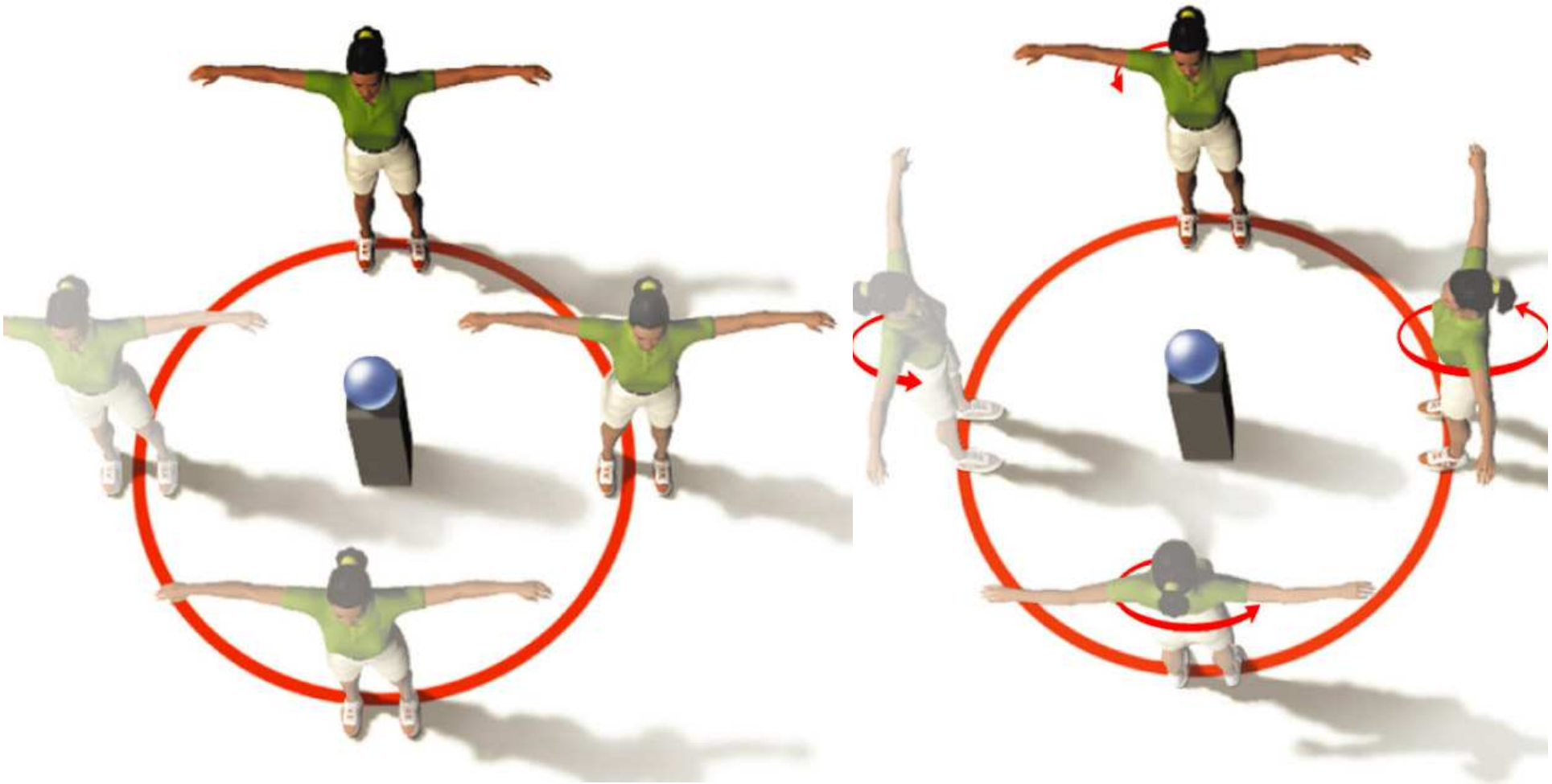


Fig 2.22

Moon's Synchronous Rotation



Misnomer: Dark side of the Moon

Fig 2.23