“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 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!
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Northern Hemisphere Summer

23.5°

Sun’s rays

The Ecliptic

The Sun's rays are directed towards the Northern Hemisphere, causing the 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

- Note: The seasons are named from the northern hemisphere’s perspective
Sun’s Path as Seen From Earth

- View from 40° N (say Columbus, OH)
- Sun always rises due East, right? No!
  - NE in summer, SE in winter, E at equinoxes
Sun’s Path from Pole & Equator

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

View from N pole

View from Equator

Fig S1.19

Fig S1.20
Special Latitudes on Earth

Based on Sun’s path in the sky

- North Pole
- Arctic Circle (66.5°N)
- Tropic of Cancer (23.5°N)
- Equator (0°)
- Tropic of Capricorn (23.5°S)
- Antarctic Circle (66.5°S)
- South Pole
The Tropics

• Between the Tropics of Cancer and 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
**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

New Moon
Rise: 6 A.M.
Highest: noon
Set: 6 P.M.

Waxing Crescent
Rise: 9 A.M.
Highest: 3 P.M.
Set: 9 P.M.

First Quarter
Rise: noon
Highest: 6 P.M.
Set: 3 P.M.

Waxing Gibbous
Rise: 3 P.M.
Highest: midnight
Set: 6 A.M.

Third Quarter
Rise: midnight
Highest: 6 A.M.
Set: noon

Waning Crescent
Rise: 3 A.M.
Highest: 9 A.M.
Set: 3 P.M.

Waning Gibbous
Rise: 9 P.M.
Highest: 3 A.M.
Set: 9 A.M.

Full Moon
Rise: 6 P.M.
Highest: midnight
Set: 6 A.M.

Rise and set times are only approximate.
Moon’s Synchronous Rotation

Misnomer: Dark side of the Moon