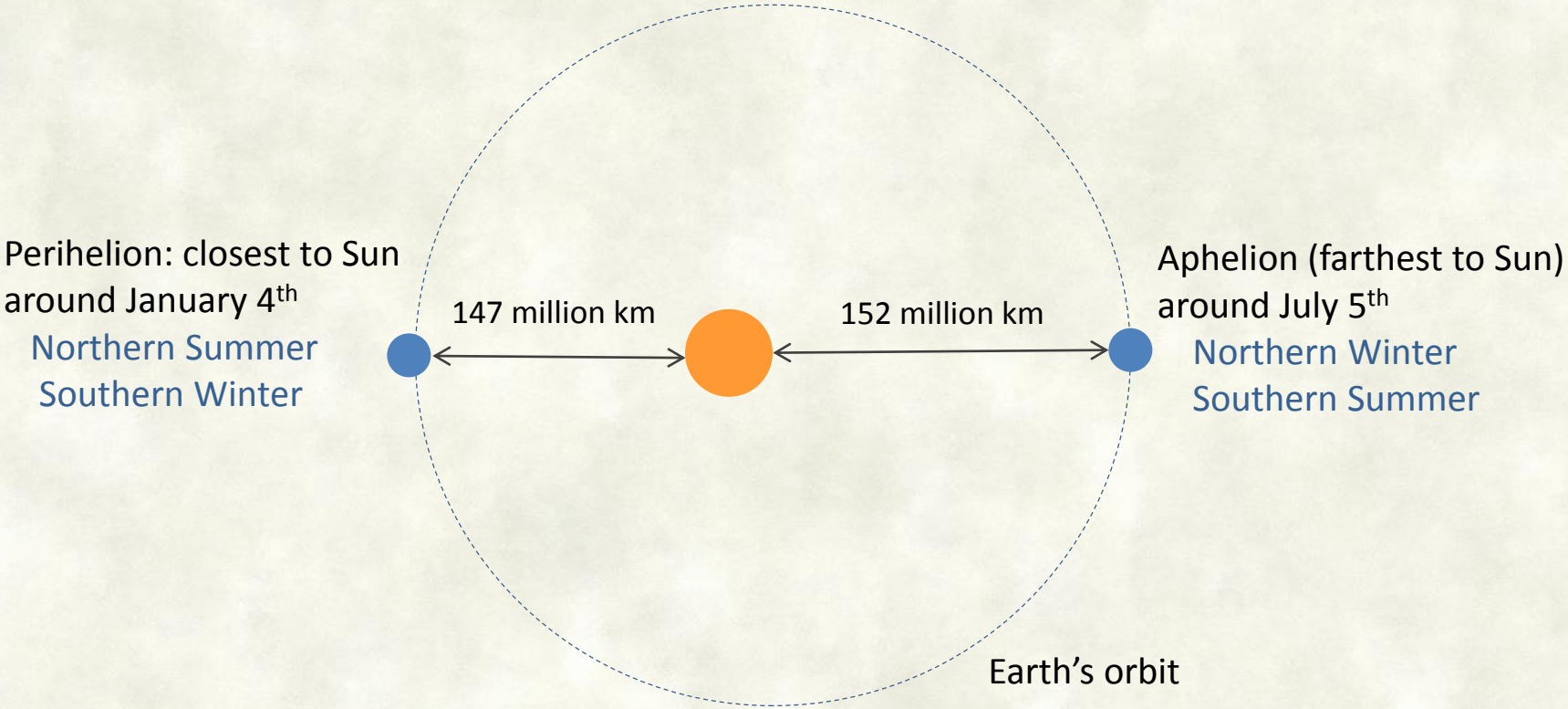
Seasons

ASTR 101

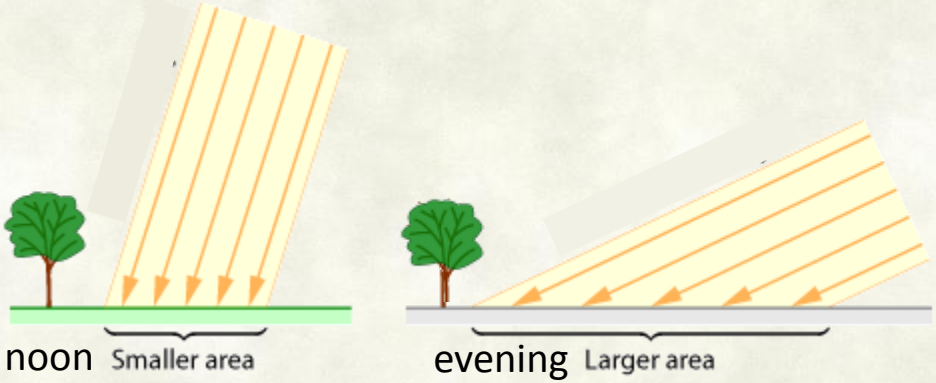
9/11/2018

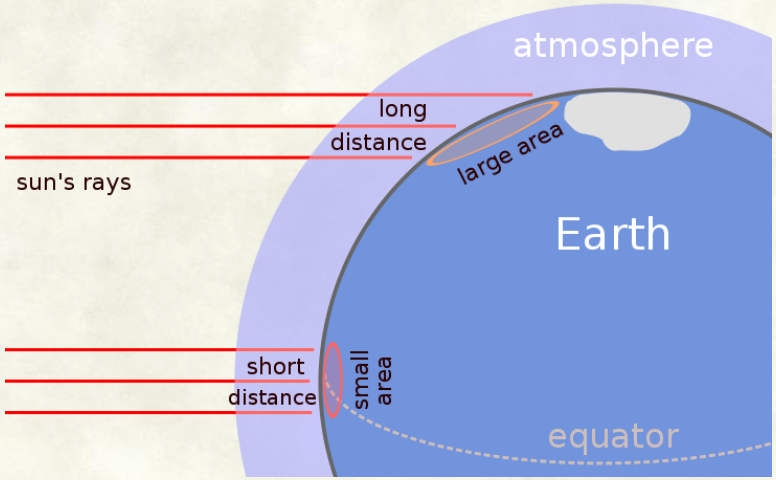
What causes the seasons?



- Earth's orbit is slightly elliptical
- The Earth-Sun distance changes a little as the Earth goes around the Sun.
- But that is not what causing the seasons.

The incident angle of sunlight determines the amount of surface heating:





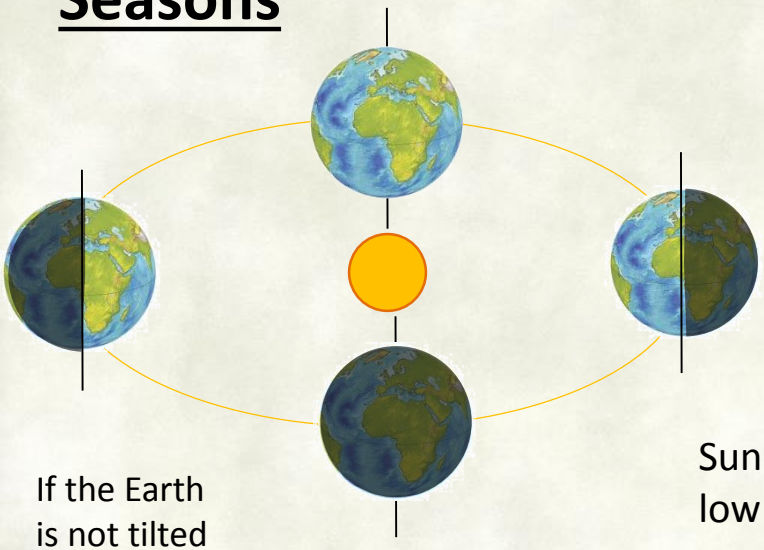
Tropics get more direct sunlight so warmer than the polar regions

- When sunlight shines directly on ground (normal to surface), sunlight (energy) is concentrated on a smaller area, and warms the surface.

- When sunlight shines at a lower angle, sunlight spreads over a larger area.
  - receives less energy per given area.
  - also there is more atmosphere it must pass through to reach ground

  ⇒ Less heat, colder.

Seasons

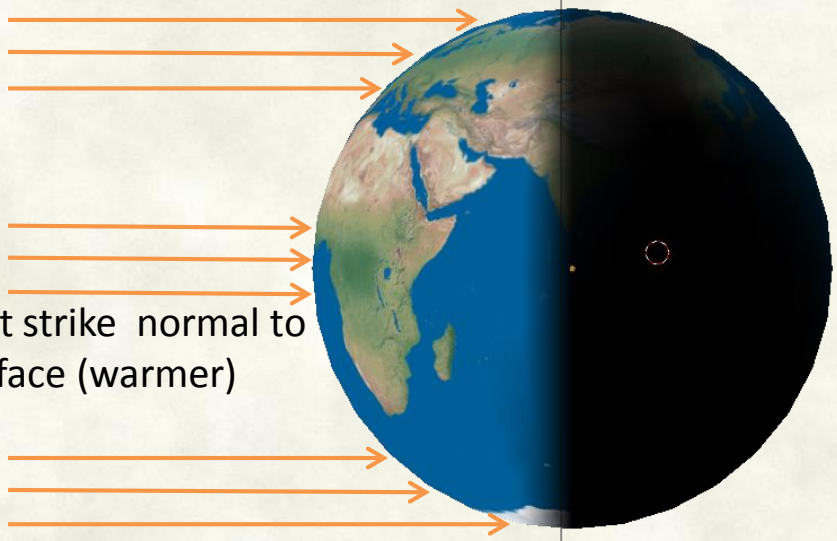


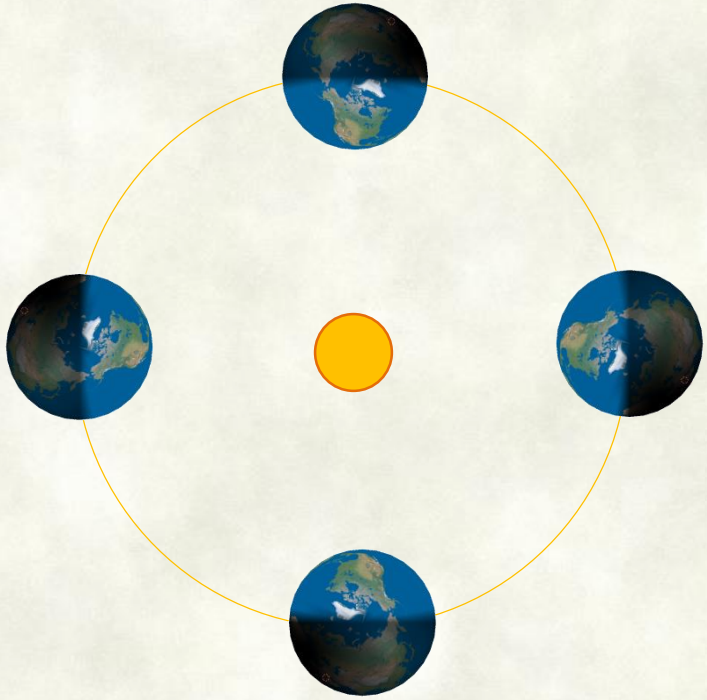
If the Earth is not tilted

- Seasons are caused by the tilt of the Earth's axis.
- If the Earth is not tilted:
  - Regardless of earth's location on the orbit, similar illumination throughout the year

Sunlight strike at a low angle (colder)

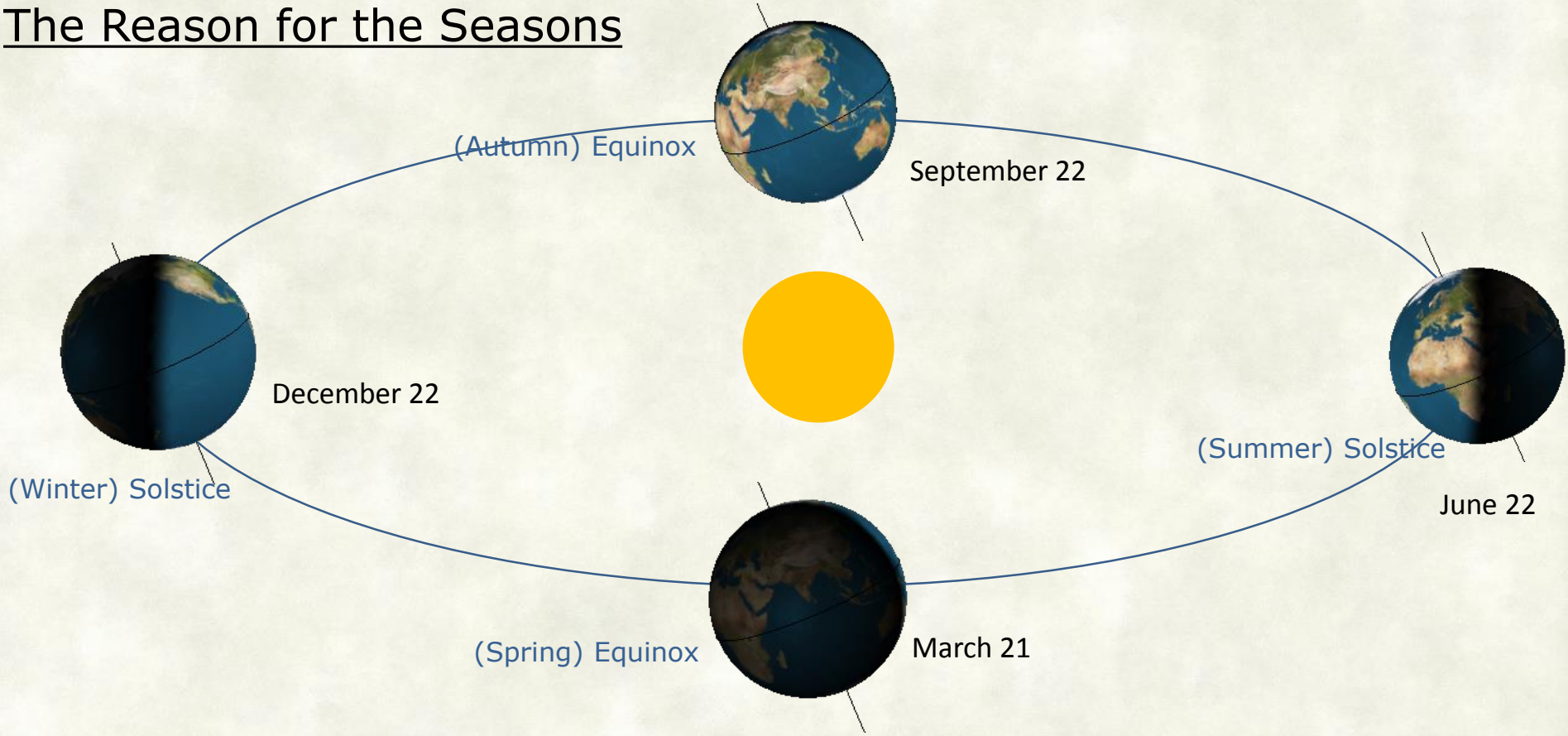
Sunlight strike normal to the surface (warmer)





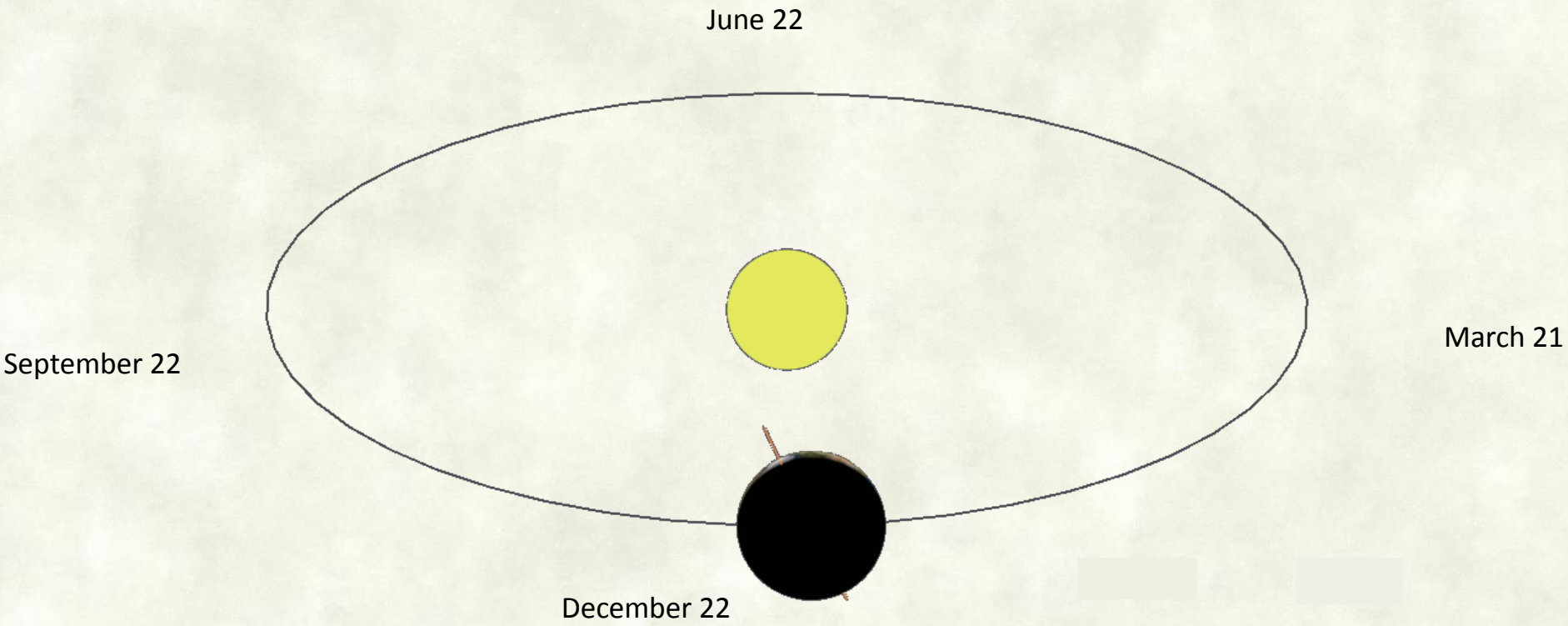
  - at the equator Sunlight falls normal to surface so gets more light (and heat) ⇒ warmer
  - Sunlight falls at an oblique angle near poles, gets less light ⇒ colder
  - It will be the same throughout the year.
    - ⇒ no seasons

The Reason for the Seasons



- Since earth's axis is tilted 23.5º with respect to orbit (axis), northern and southern hemispheres faces toward or away from the Sun as it goes around the Sun.
- The hemisphere facing the Sun receives more sunlight for a longer time

The Reason for the Seasons

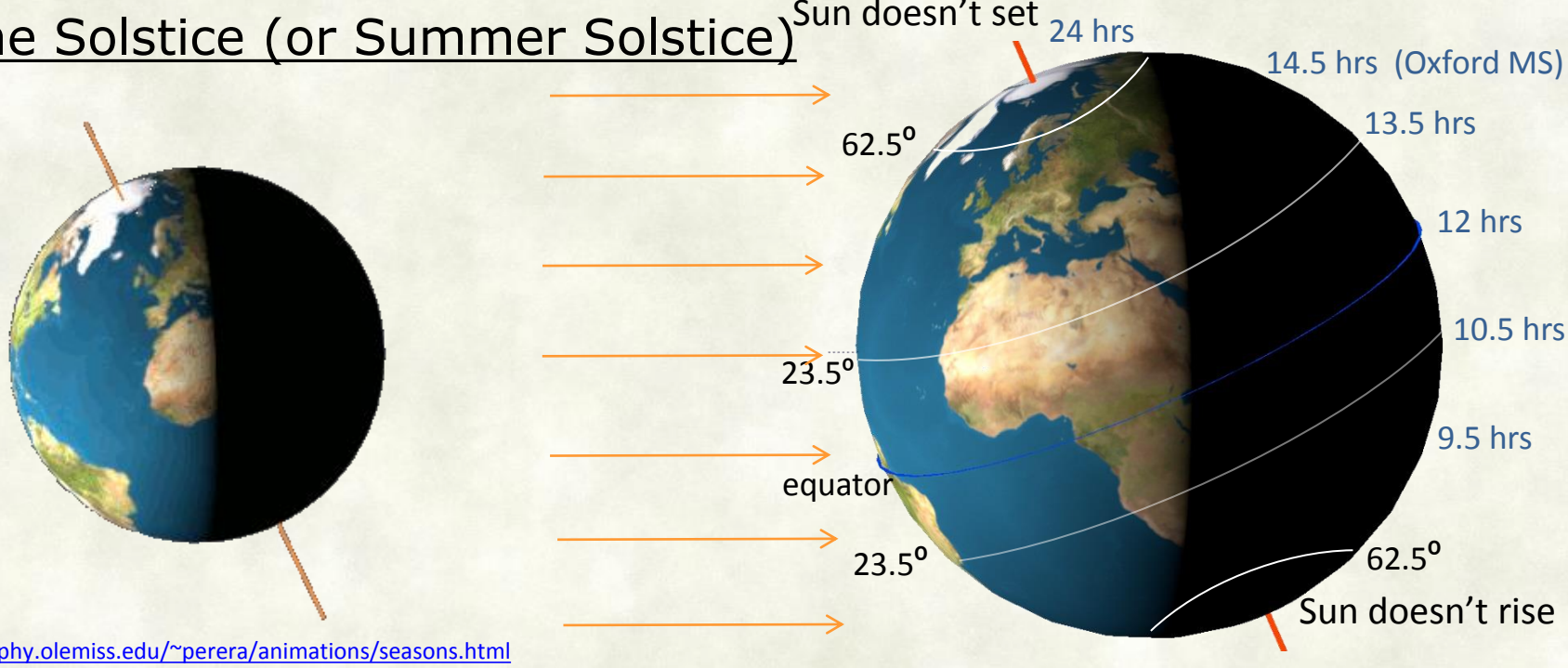


www.phy.olemiss.edu/~perera/animations/seasons.html

- Since the earth's axis is tilted 23.5° with respect to orbit (axis), northern and southern hemispheres faces toward or away from the Sun as it goes around the Sun.
- The hemisphere facing the Sun receives more sunlight and for a longer time.

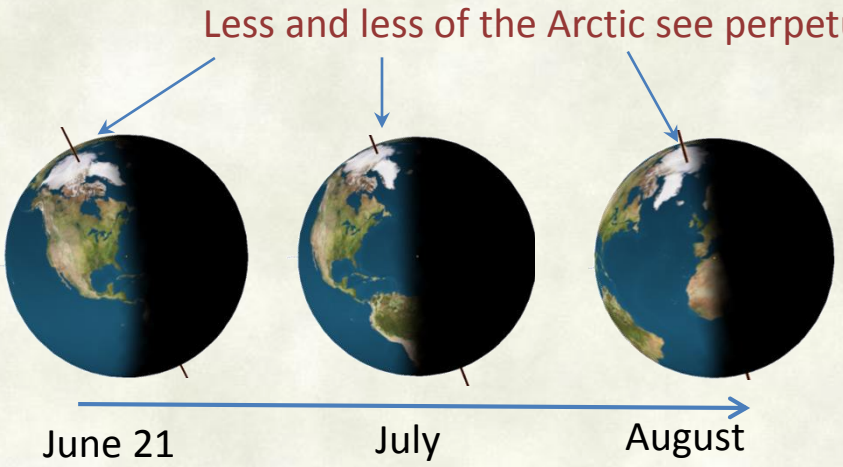
  ⇒ Summer in that hemisphere.

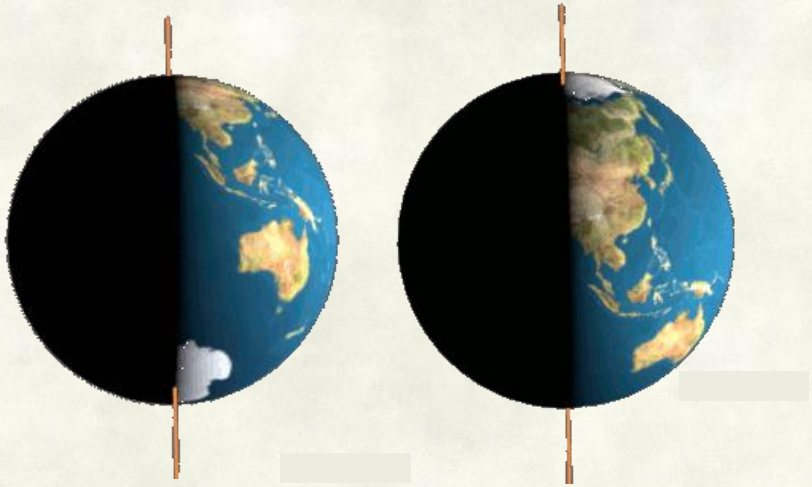
June Solstice (or Summer Solstice)



www.phy.olemiss.edu/~perera/animations/seasons.html

- Around June 21st, on the day of June solstice north pole is pointing in the closest direction towards the Sun:
  - Longest daytime in the northern hemisphere.
  - Within the Arctic circle (locations above the Northern latitude 62.5º) Sun doesn't set.
  - Within the Antarctic circle (locations below the Southern latitude 62.5º) Sun does not rise.
  - At latitude 23.5º, " on the Tropic of Cancer", sun shines directly overhead (at zenith) at noon.
    - This is the highest northern latitude where Sun would ever be directly overhead during the year.

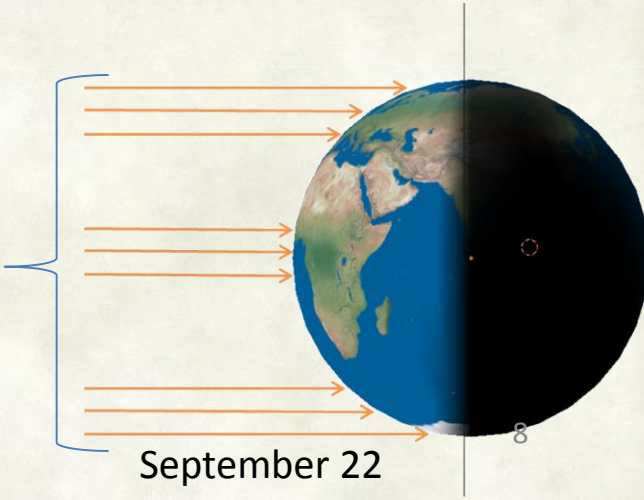




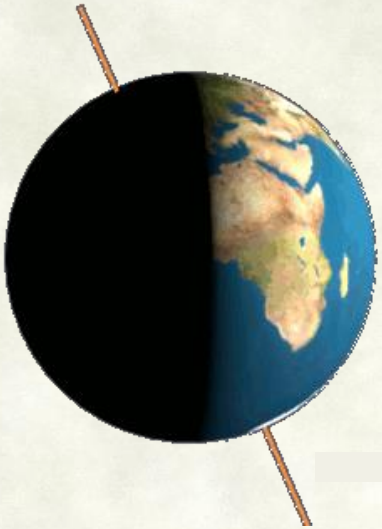
September (Autumn) Equinox

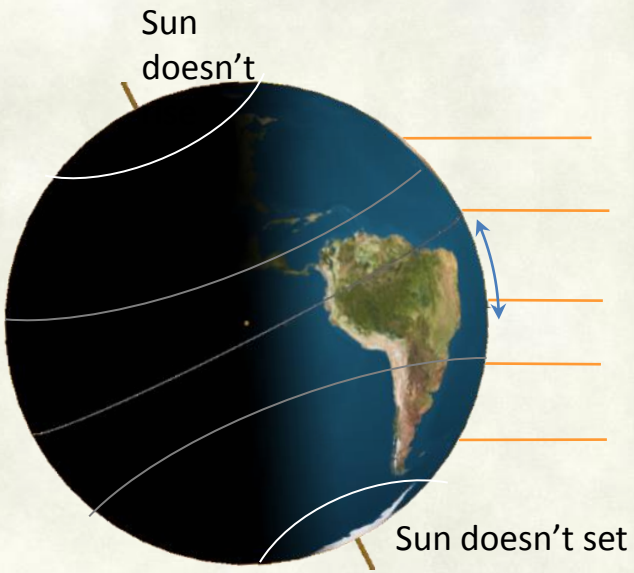
- As the year progresses, north pole moves away from the Sun. South pole moves towards the Sun
  - daytime in the northern hemisphere gets shorter.
  - nighttime in the southern hemisphere gets longer.

- Around September 22, on the day of September Equinox, both northern and southern hemispheres gets equal illumination.
  - Sun shines from the north pole to the south pole.
  - Sun shines directly over the equator.
  - Day and night are of equal length.



December Solstice





Around December 21 (Winter Solstice in the Northern hemisphere) :

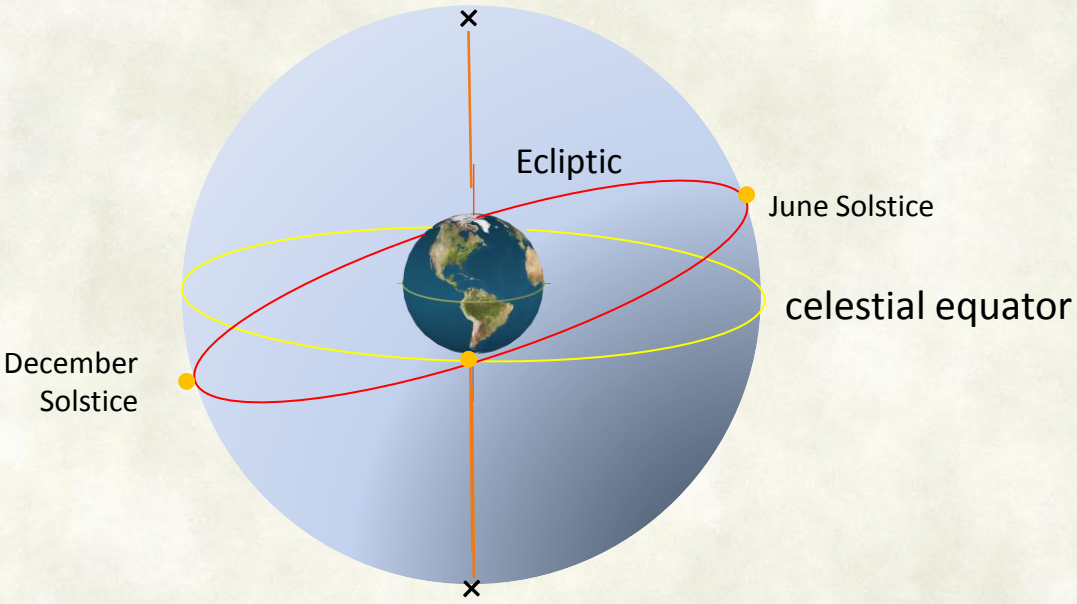
- The north pole is pointing furthest away from the Sun and the south pole is pointing closest to the Sun.
- Sun does not rise within the Arctic circle and does not set in the Antarctic circle.
- At the southern latitude 23.5 ° (the Tropic of Capricorn) Sun is overhead (at the zenith) at noon.
  - This is the highest southern latitude where Sun would ever be directly overhead during the year.
- Sun's lowest altitude at noon in the northern hemisphere.

Spring Equinox (Vernal or March Equinox)

On March 21st , Sun again shines from the North pole to the South pole

- Around March 21, on the day of the Spring Equinox, sun is again shining from the North pole to South pole, equal day and night times.
  - Beginning of the Spring in the northern hemisphere.
- After the Spring Equinox, length of daytime in north continues to increase until the Summer Solstice, and the cycle repeats.

The Sun in the Sky

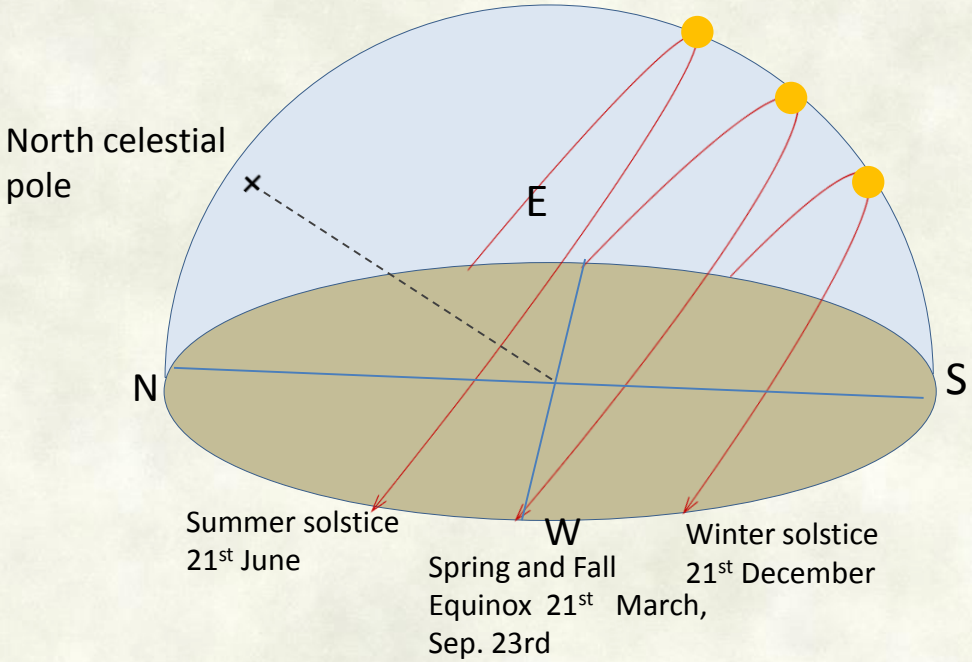


Sun's annual path in the sky (Ecliptic)

Position of the Sun at 12PM (at latitude 48°N) (Analemma) credit: apod.nasa.gov/apod/ap120922.html

- Position of the Sun in the sky changes throughout the year.
  - The Sun has the highest northern declination on the day of June (Summer) solstice
  - It has the highest Southern declination on the day of December (Winter) solstice
  - It is on the celestial equator (zero declination) on Equinoxes

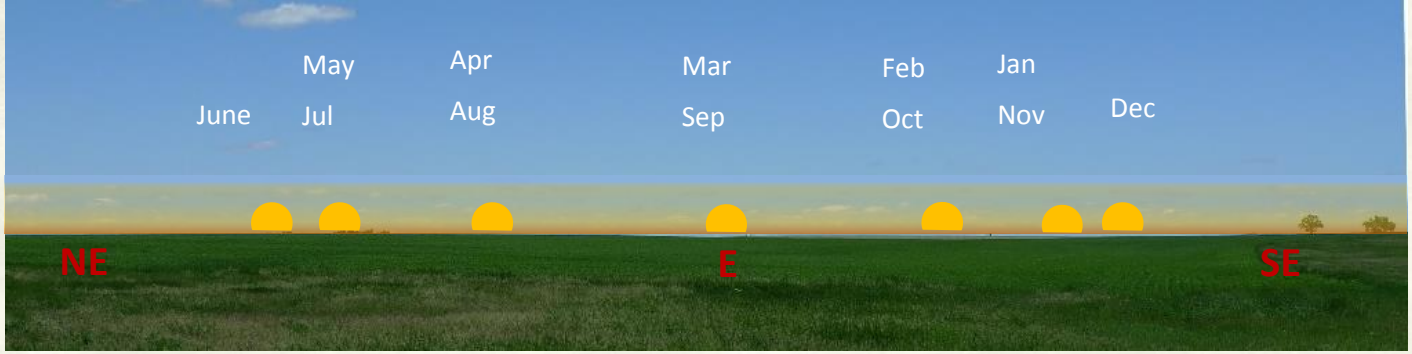
The Sun in the Sky



As a result, the Sun's daily path across the sky also changes throughout the year.

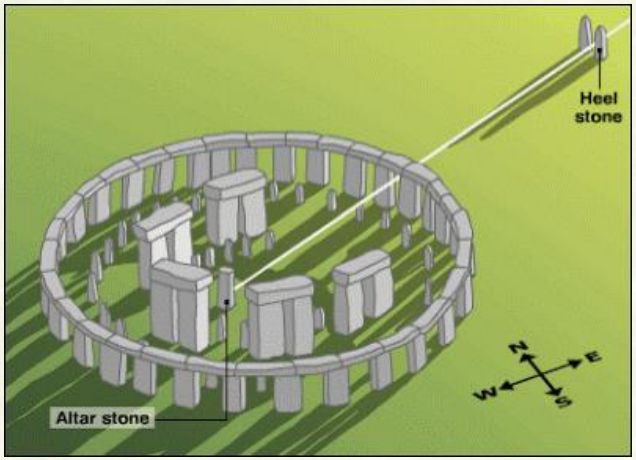
Which affects:

- Length of the day (longer days in the summer shorter days in the Winter)
- Sun's altitude at noon
- Position of the Sun on the horizon at sunrise (or sunset)
  - north most on the Summer solstice and south most on the Winter Solstice.
  - On the Equinoxes the Sun rises in due East and sets in due West.



The location where the sun rises over the horizon changes through the year.

Solstice means 'sun-stopping'. The point on the horizon where the sun rises (and sets), stops and reverses direction after this day.



Stonehenge: A prehistoric monument in England (2100 BCE): stones are aligned such that from center, one has a clear view of the summer solstice sun rising over the heel stone.

- Equinox and solstice were important days in many cultures. There have been many rituals and celebrations associated with them since ancient times.
- Observatories and monuments had been built to observe them since antiquity.
- (watch the video on Maya pyramid: http://maya.nmai.si.edu/maya-sun/maya-and-sun)

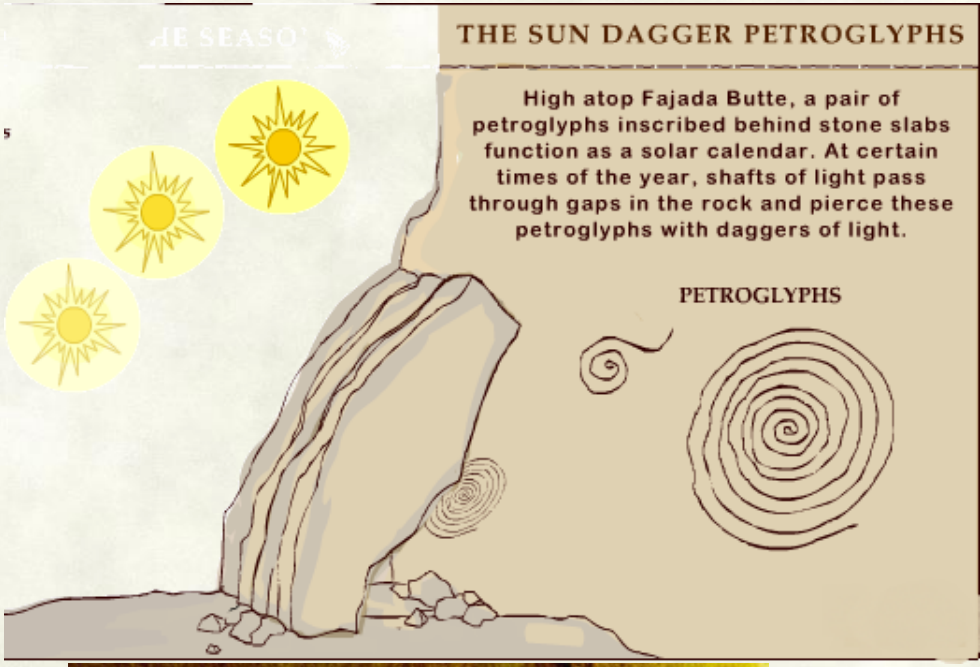
- Casa Rinconada: (an ancient Pueblo Indian site in New Mexico)
  - A possible summer solstice marker on an interior wall of great kiva.

Goseck Circle –Germany
5,000 BC

seasons. For agricultural people knowing when to plant crops or expect summer rains is vital for survival. Solstice days marked important points in the seasonal calendar and formed the cornerstones of annual ceremonial cycles. This importance persists in the ceremonial calendars of contemporary indigenous communities where the year is divided in two by the summer and winter solstices.

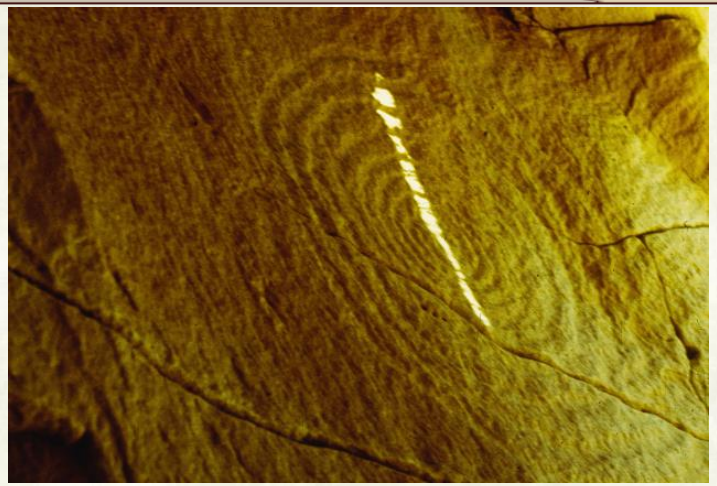
In Petrified Forest National Park researchers have identified over a dozen calendric petroglyph sites and many more exist throughout the Southwest. These features demonstrate the importance of marking the passage of the changing season to prehistoric peoples and their descendants.

A pueblo Indian Summer solstice marker ca. 1200 (Petrified Forest national park)

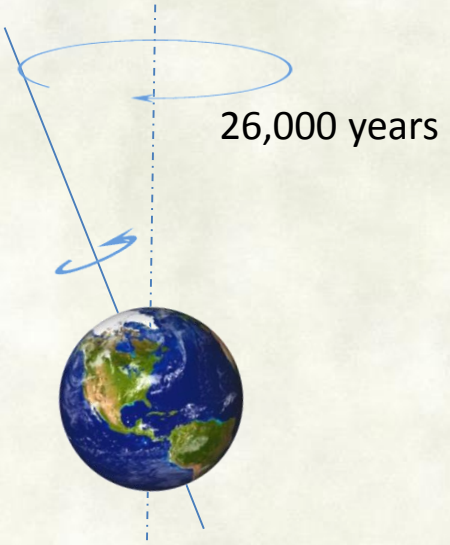


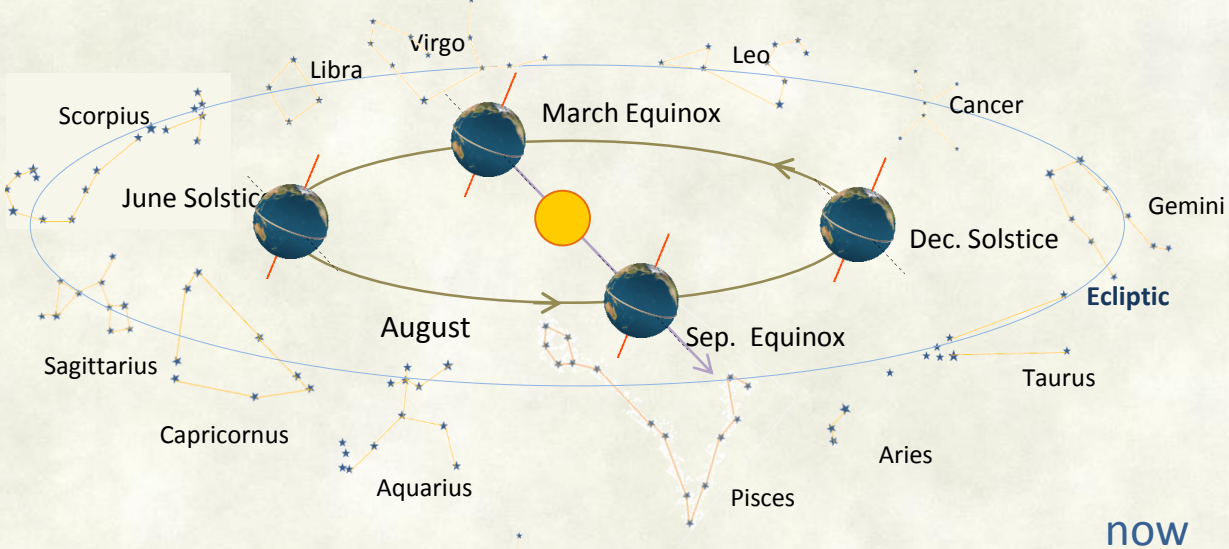
https://www.youtube.com/watch?v=I1qdhU5Lw2A&

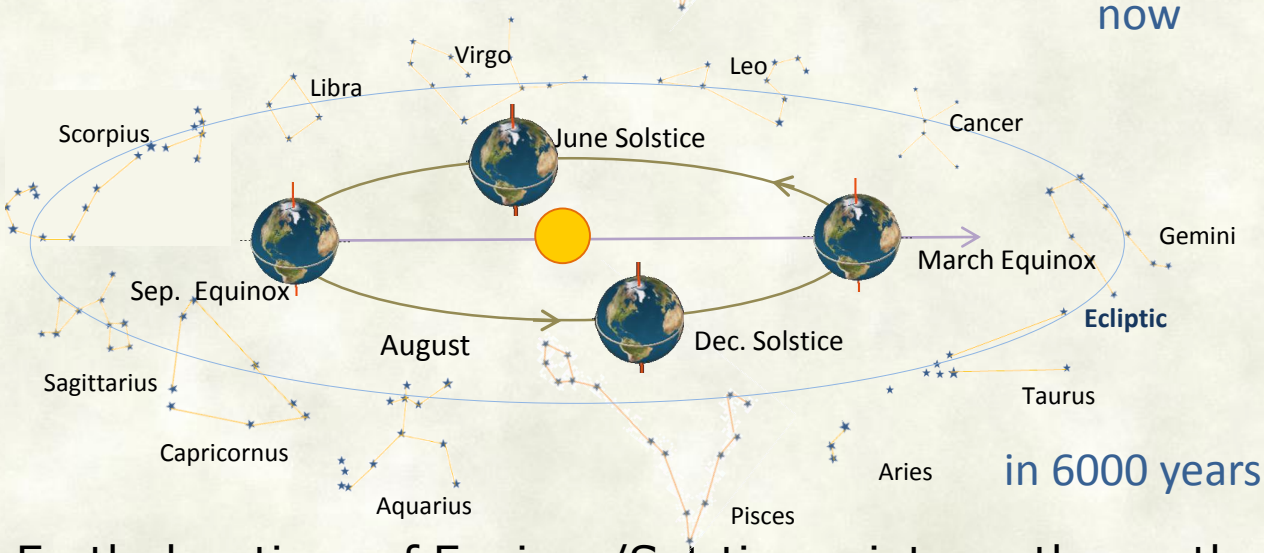
the Sun Dagger, Chaco Canyon, NM



Precession of Equinox/Solstice







- Due to precession of the Earth, locations of Equinox/Solstice points on the earth orbit also changes.
  - About 50.3 arc seconds arc per year (1^0 in 72 years)
- **Precession of the Equinox** was first discovered by Hipparchus in 2nd century BCE
- Length of the **tropical year** is defined as the time between two (March) Equinoxes.

Review Questions

- Could the changing distance between the Earth and the Sun be the cause for the seasons. When is the Sun closest/farthest to the Earth.
- What determines the intensity of Sunlight (energy) on the Earth surface.
- What is the main reason for seasons.
- Latitude of Oxford MS is about 34ºN. Can the Sun ever be visible overhead from Oxford.
- When it is the Summer Solstice in the northern hemisphere what is it in the Southern hemisphere.
- When it is the Spring Equinox in the northern hemisphere what is it in the Southern hemisphere.
- What is the length of daytime at the North Pole? What is the length of daytime at the South Pole?
- What are the Arctic/Antarctic circles?
- What are the tropic of Cancer/Capricorn? What is their significance? What is the origin of their names.
- Does the location of the Earth poles or the equator change due to the precession of earth.
- Can seasons change due to precession.