

# Planet Earth – Could There be Life?



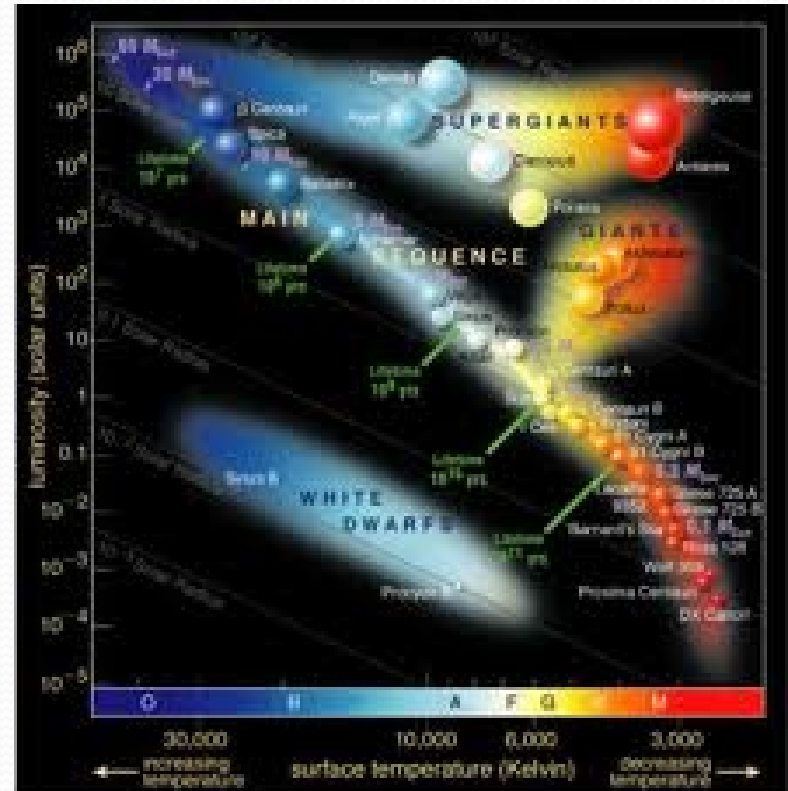
# Galactic Neighborhood

- Galactic environment impacts habitability
- Milky Way galaxy's edge is a life-favorable spot
  - Not near active gamma ray source
  - Not near galactic center with high star density and ionizing radiation
  - Loneliness in galaxy is helpful for life



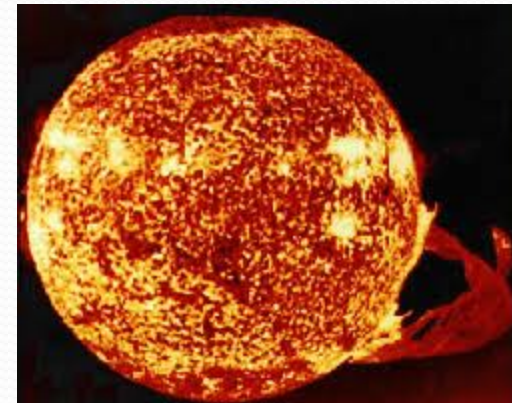
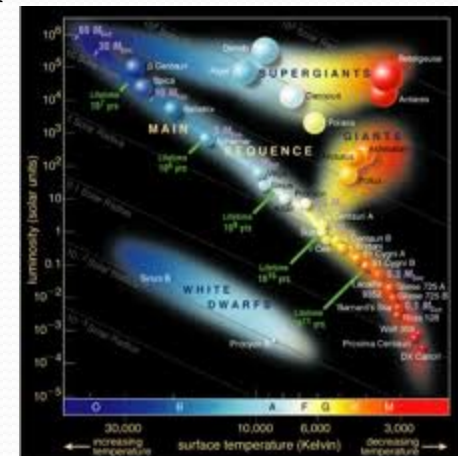
# Spectral Class of Star Needed for Life:

- Spectral class indicates photospheric temperature
- “HabStars” spectral range
  - Early F
  - G
  - Mid-K
  - 7000K to 4000K
- Emit high-frequency UV radiation to trigger atmospheric ozone formation
- Emits not so much that ionization destroys life



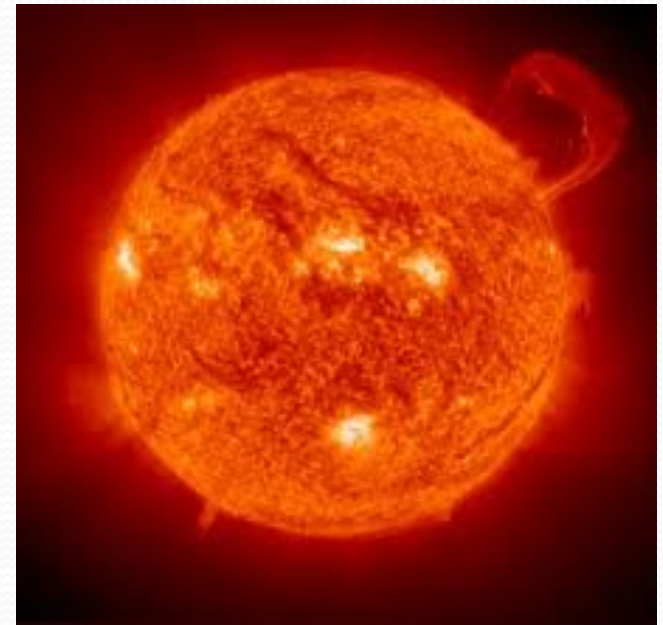
# Spectral Class of “Sun”

- Earth rotates around the star, the “Sun”
- Sun
  - G2 star
  - ~6,000K
- Sun is in “Habstar” range!
- Ozone can form in atmosphere
- Ionization is not deadly for life



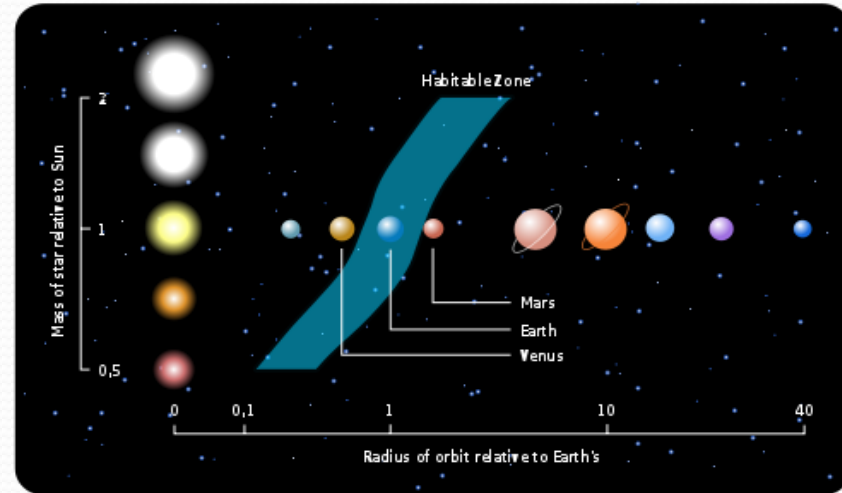
# Low Stellar Variation?

- All stars change luminosity
- Stars vary in stability... stars that fluctuate luminosity violently are poor candidates for hosting life
- The Sun is relatively stable!
  - Solar variation is  $\sim .1\%$  over 11-year cycle
  - Slight variations dramatically impact Earth
    - Little Ice Age – decline in Sun's luminosity



# Habitable Zone

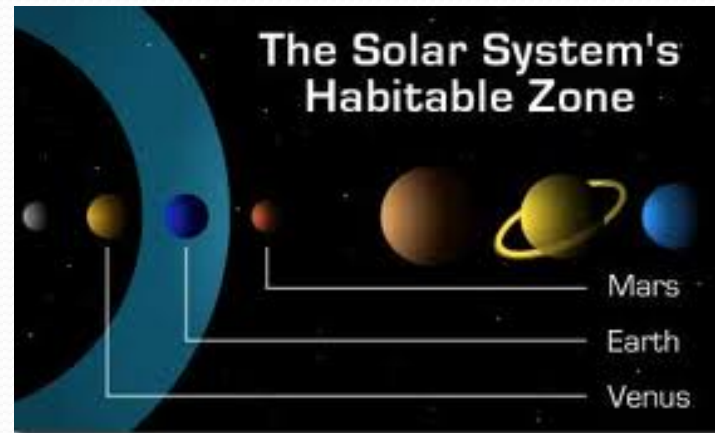
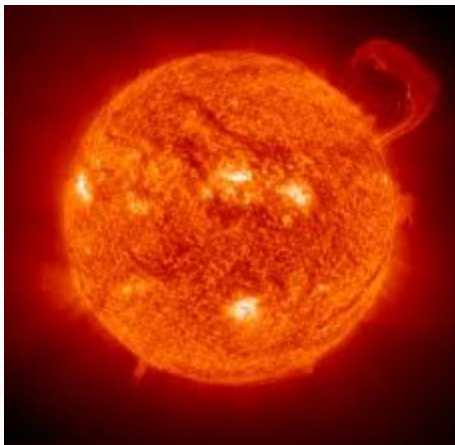
- Theoretical shell around a star where any planet present would have liquid water on its surface
- HZ range should not vary over time
  - Stars increase luminosity as they age
  - If this happens too quickly (super-massive star), planets are only in window for life for short amount of time
  - Lowers time to develop life





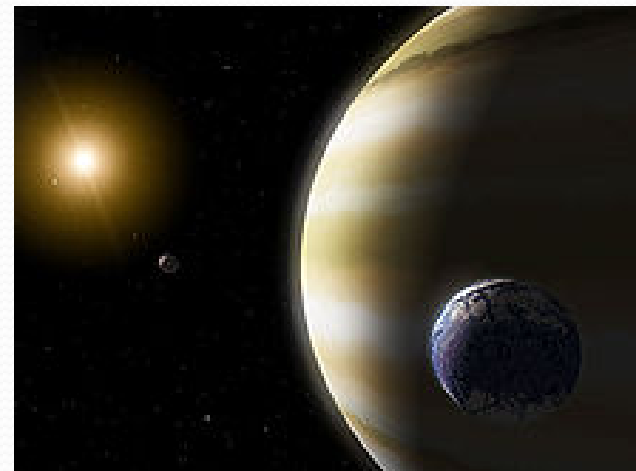
# Is Earth Located in Habitable Zone?

- Yes!
- Earth is located within the expected shell of distance in which liquid water can be on the surface of the planet!
- Pictures of the planet show liquid water covering a large portion of the Earth's surface!



# Planet Characteristics that Support Life

- Terrestrial
  - Silicate rocks
  - Rocks not accreted to gaseous outer layers
- Gas Giants = no life
  - No surface
  - Enormous Gravity
  - Satellites are good candidates, however





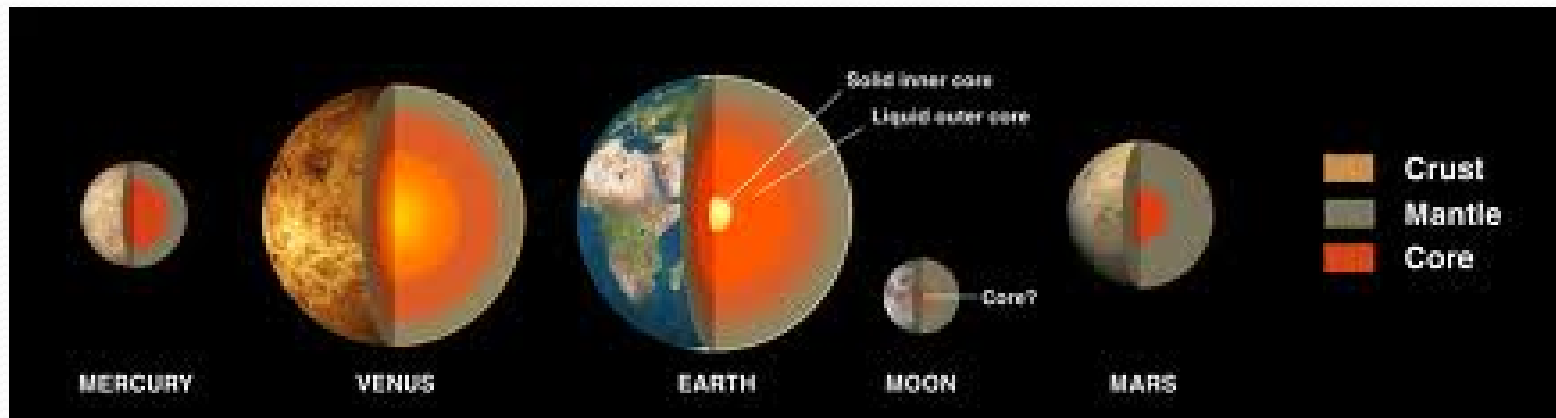
# Composition of Earth?

- Earth is a terrestrial planet, not a gas giant



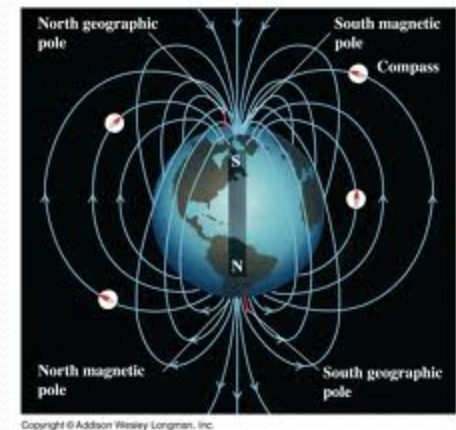
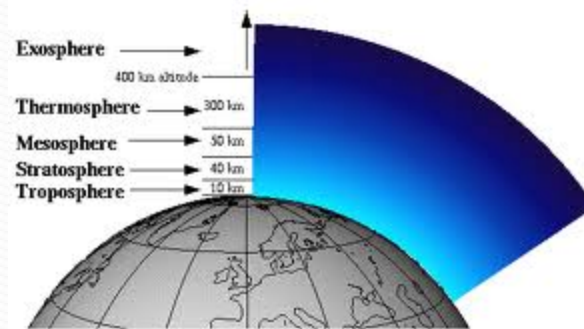
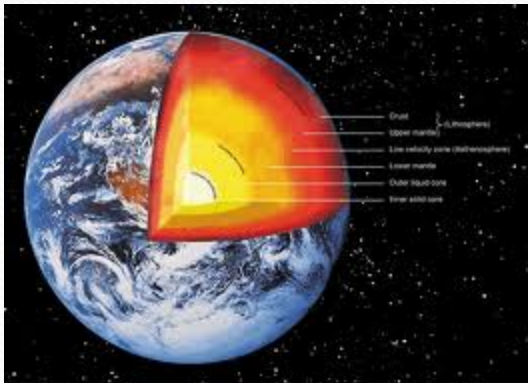
# Mass of Planets need to be Just Right for Life

- Low Mass
  - Bad news for life
  - Lesser gravity – difficult for atmosphere retention
  - Smaller planets lose energy from formation quickly → geologically dead
- Approximately 0.3 Earth masses needed to sustain life



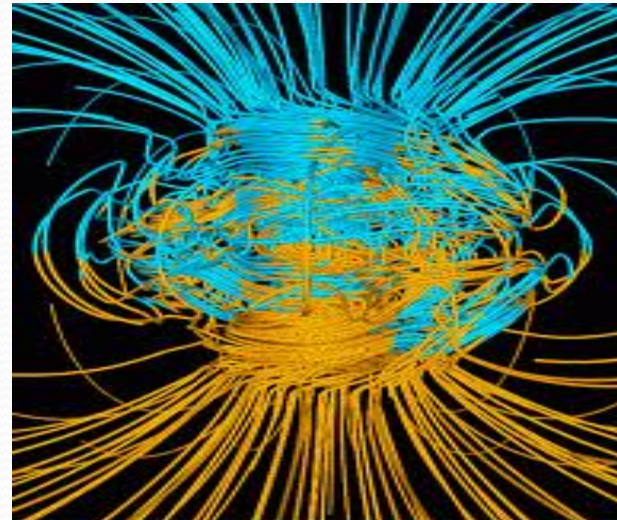
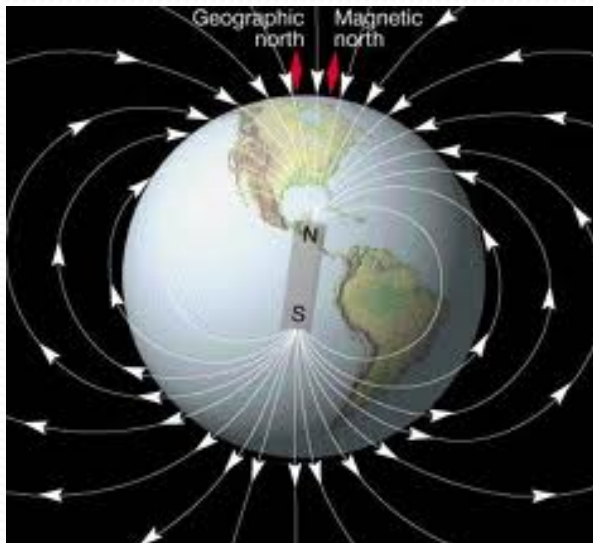
# Mass of Earth

- High Mass
  - Earth is largest by mass and density of terrestrial bodies in the Solar System
  - Large enough for molten core (heat engine)
  - Large enough for atmosphere through gravity
  - Large enough for liquid outer core and metal inner core (magnetic field)



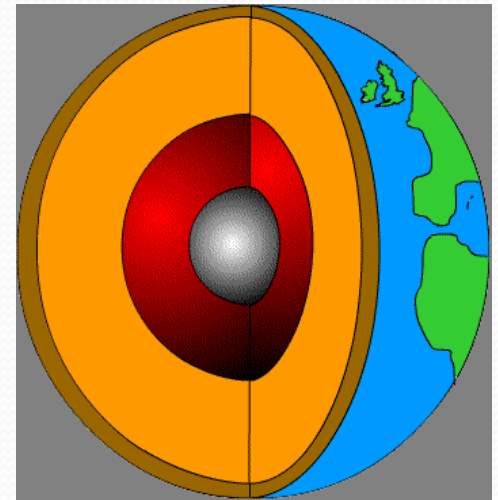
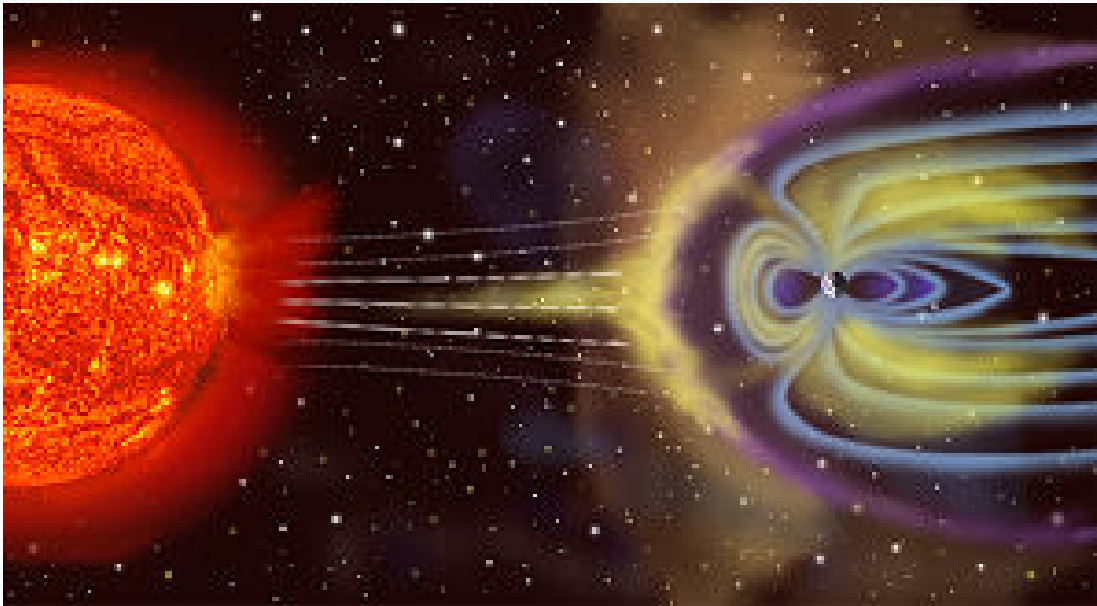
# Magnetic Fields and Life

- Planets need protection from solar wind
- Solar wind- stream of charged particles from stars consisting of electrons and protons
- Planet must have molten metal interior



# Does Earth have a Magnetic Field?

- Yes!
- Earth has solid metal core with liquid outer core, causing magnetic field
- Protects the Earth from solar wind



# Atmosphere and Life

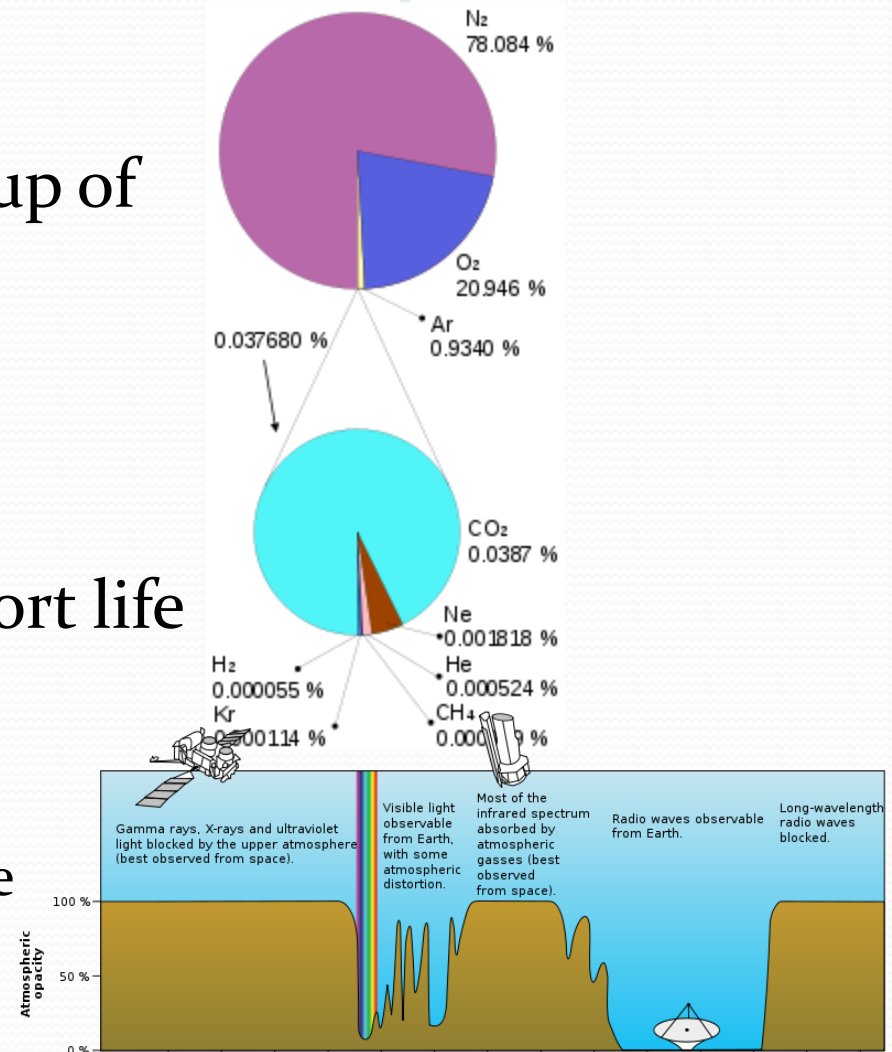
- Atmosphere – layer of gases that surround a material body of sufficient mass
- Held by gravity
- Helps regulate temperature
- Protects planet from meteors and radiation
- Composition favors life (oxygen and carbon dioxide)





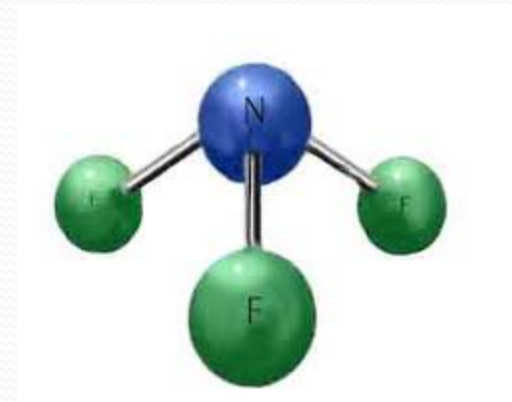
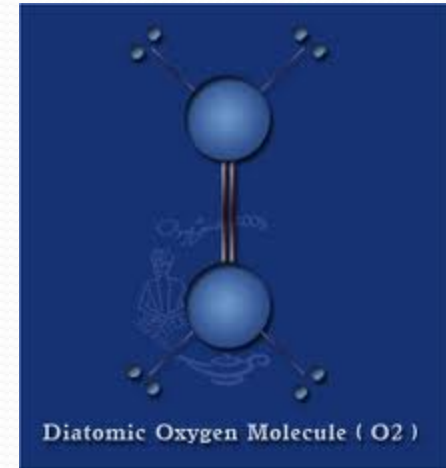
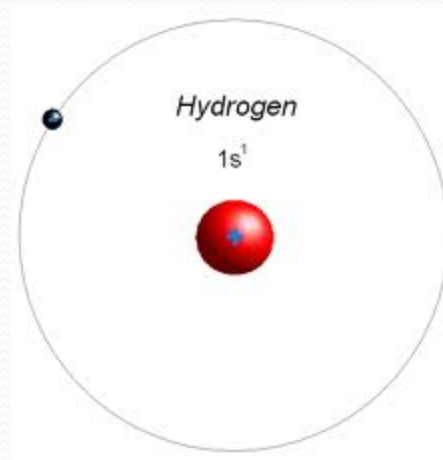
# Does Earth have an Atmosphere?

- Yes!
- Earth's atmosphere is made up of
  - Nitrogen (78%)
  - Oxygen (20.9%)
  - Argon (.93%)
  - Carbon Dioxide (.0390%)
- This composition could support life
- Atmosphere absorbs/reflects harmful radiation
  - Visible and Radio reach surface



# Composition of Planets

- Four elements vital for life
  - Carbon
  - Hydrogen
  - Oxygen
  - Nitrogen



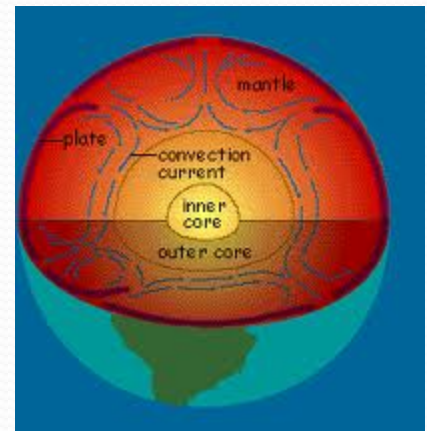
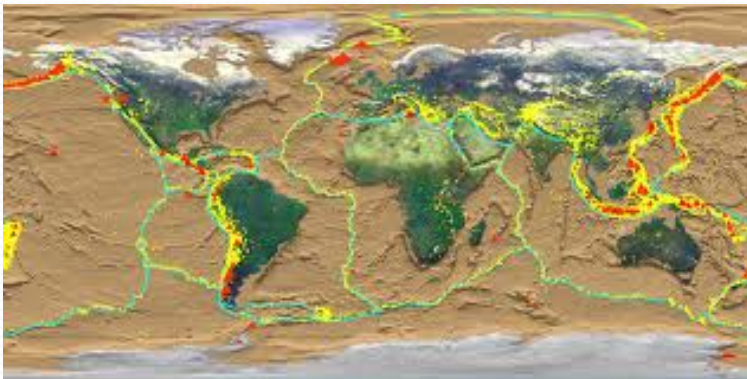
# Earth's Composition?

- Element oxygen alone found in Earth's crust...
- However, other life elements are found in atmosphere and water
- Make amino acids (building blocks of protein)
- Comets and outgassing from volcanoes brought these elements



# Tectonic Activity of Planet

- Supply surface with life-sustaining material
- Supply atmosphere with temperature moderators ( $\text{CO}_2$ )
- Recycles important chemicals/materials
- Helps increase environmental complexity
- Earth is tectonically active!!



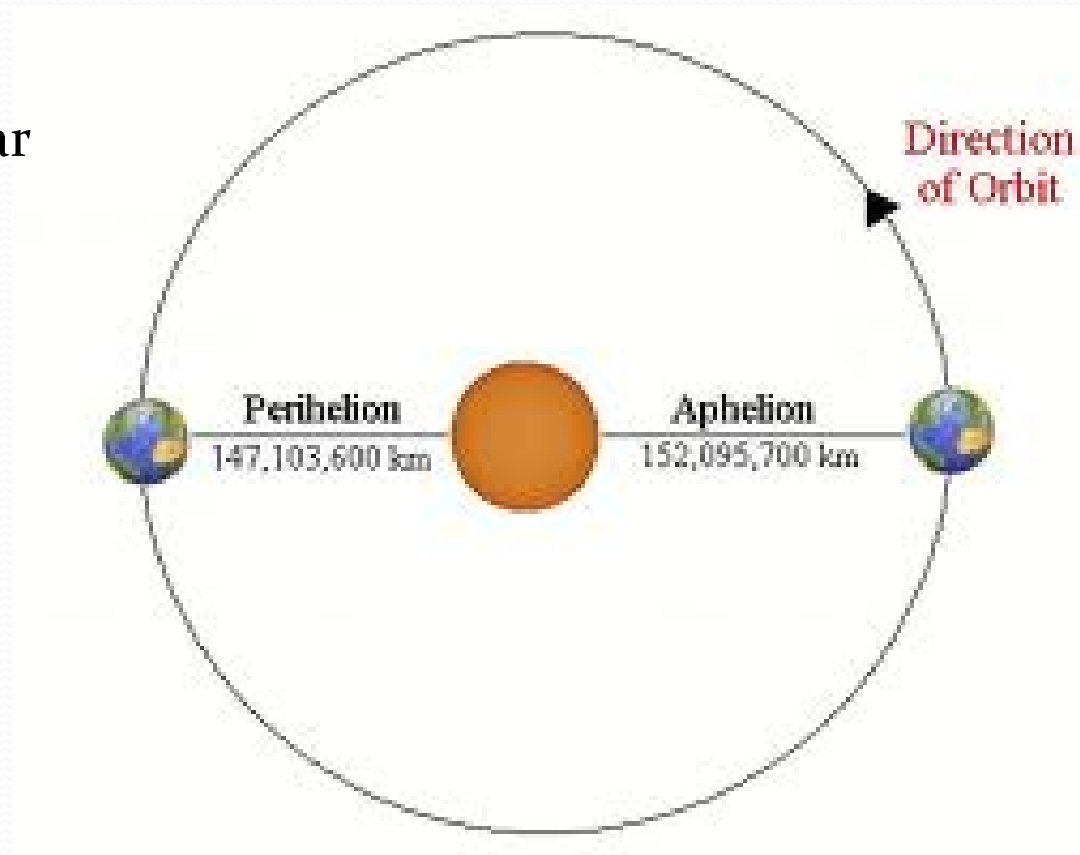
# Life-Supporting Orbits

- Stability is critical
- Eccentricity
  - Greater  $e$ , greater temperature fluctuation
  - Living organisms can only withstand certain fluctuations
  - Complex organisms have greater temperature sensitivity



# Is Earth's Orbit Suitable?

- Yes!
- Earth's Orbit
  - Almost circular
  - $E < .02$





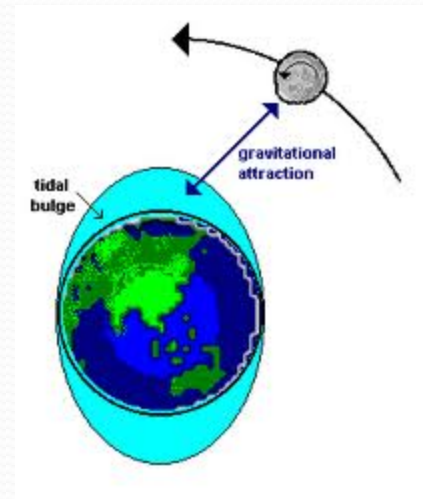
# Life-Supporting Rotation

- Rotation around axis at tilt
  - Planet should have moderate seasons or biospheric dynamism will disappear
  - Without tilt, planet would be colder (warm weather could not move poleward)
  - Should not be radically tilted because seasons would be extreme
- Speed of Rotation
  - Should be relatively quick so day-night cycle is not too long (temperature differences if long days/nights)



# Earth's Rotation?

- Earth's tilt varies between 21.5 and 24.5 degrees every 41,000 years
- Day is only 24 hours
- Moon plays crucial role
  - Moderates Earth's climate by stabilizing axial tilt



# Earth COULD have life!

- Galactic Neighborhood
  - Arm of Milky Way galaxy
- Star
  - Spectral class G2
  - Low stellar variation
- Distance from Star
  - Earth is located in Habitable Zone
  - Liquid Water
- Composition/Size
  - Terrestrial planet, relative high mass
  - Magnetic Field
  - Atmosphere
- Orbit
  - Nearly circular
- Rotation
  - Tilt allows seasons
  - Short night/day