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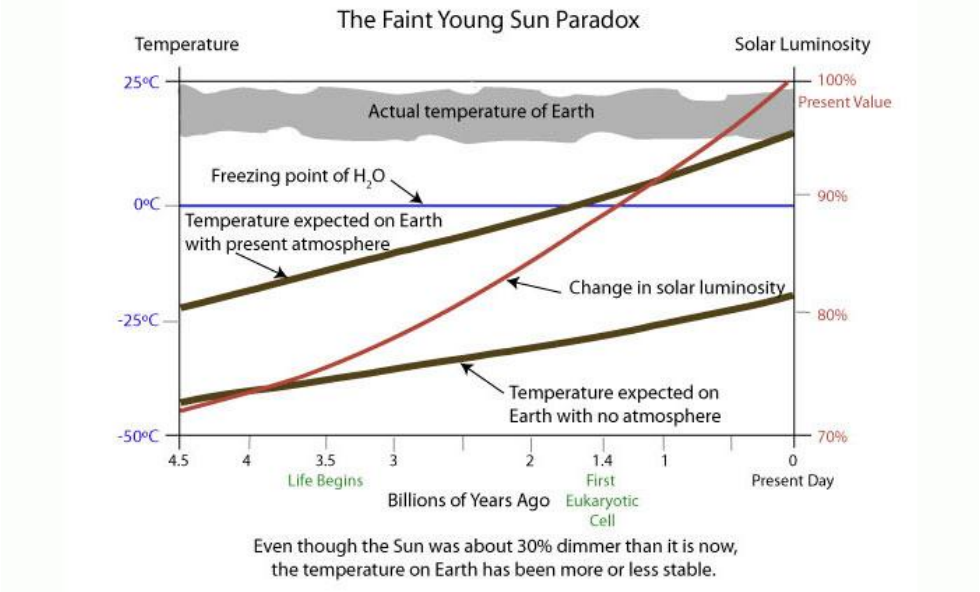
By: Shawna Fox-Anderson & Corrina Perez

- Habitable Planets
  - Building Materials
    - Hydrogen, carbon, oxygen, nitrogen
      - As the most abundant elements
  - There are restrictions on where habitable planets can occur
    - Location from their star (sun) is imperative to the habitability of the planet



http://www.learner.org/courses/envsci/visual/img_med/young_sun.jpg

  - Energy in some form
    - External (sunlight)
      - Places restrictions on locations where photosynthetic organisms (and organisms that live off photosynthesis organisms) can exsist
      - Earth in 1 AU from the sun & Jupiter is ~ 5AU-it receives $1/25^{th}$ as much sunlight
    - Internal Heat
      - Provides energy for volcanism & chemosynthesis and communities that survive on chemosynthetic organisms
      - There are two reasons a planet can have a hot interior
        - Size (mass)
        - Tides
      - Chemosynthetic materials have been found at the deepest parts of the ocean
        - include but are not limited to Tubeworms, fish, dandelion (easy to fall apart plant matter), octopus, zoarcid fish, crabs, shrimp
        - hot water under the ocean where organisms can survive

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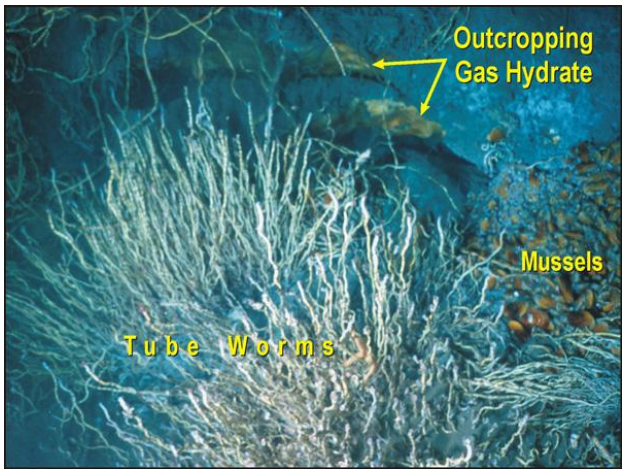
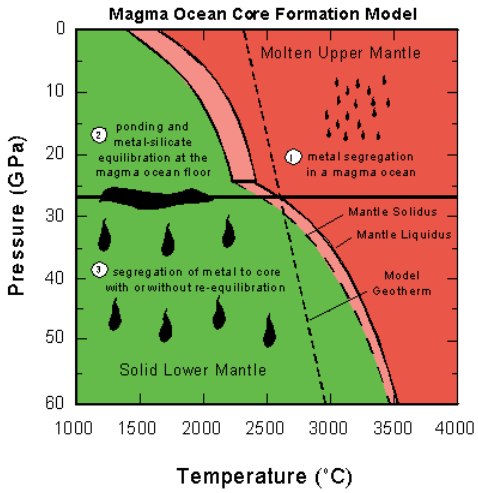


Zoradic Fish

http://www.hydrothermalvents.weebly.com

http://www.democraticunderground.com

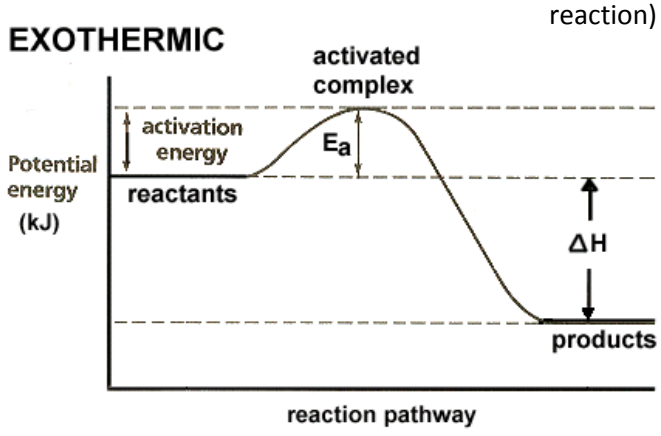
- Why would a planet be hot internally?
  - Size (earth and Venus both are large enough)
    - If the planet is large enough, internal heat to be active over a long period of time
    - Sources for heat
      - 1. Accertional heat
        - a. KE → heat
        - b. core formation (PE→heat)



"Core formation Energy - settling of Fe to centre of Earth converts P.E. of iron to heat energy."

http://bowfell.geol.ucl.ac.uk/~lidunka/GlobalGeophysics/Geophysics8%20-%20Thermal%20evolution/Heat.htm

- c. core solidification (exothermic reaction)



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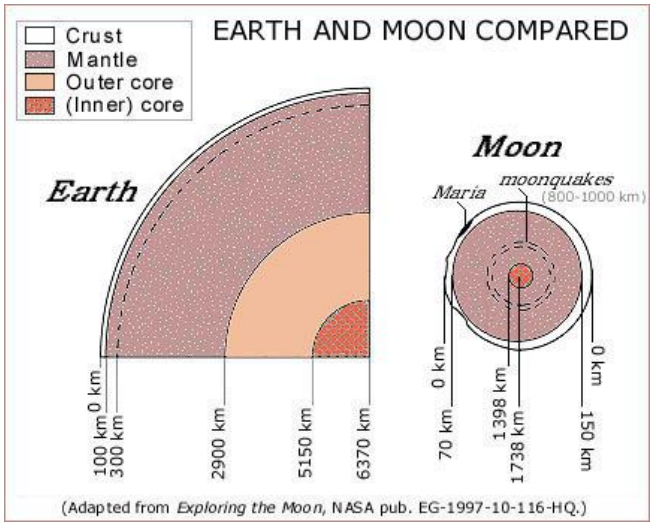
An exothermic reaction can show itself in the form of respiration, combustion or neutralization. It is a way in which the heat is released.

http://www.myadvocators.com/chemistry/quick-revision-series/energy-changes/exothermic-reactions/

- 2. Decay of radioactive elements
- The larger the planet the more internal heat it has

- Tidal energy (internal water)
  - Can provide internal heat for even the smallest planets
  - Understanding
    - 1. Orbits are elliptical, not circular-planets spend most of their time @ the farthest point from their star
    - 2. Any object orbiting another object will feel a gravitational pull from that object
- Lunar tide
  - Tides due to the moon's gravity, a balance between gravity and centrifugal force



-Inner core of the moon is made of metal

-Outer core of the moon is made of a plastic type rock

-The last layer of the moon is made up of a brittle rock material

http://www.psrd.hawaii.edu/Sept99/MoonCore.html

- Get two tidal bulges on either side of the planet (facing toward and away from the moon)
- Get body tide and ocean tide- body tide is much smaller
- Get 2 high tides per day

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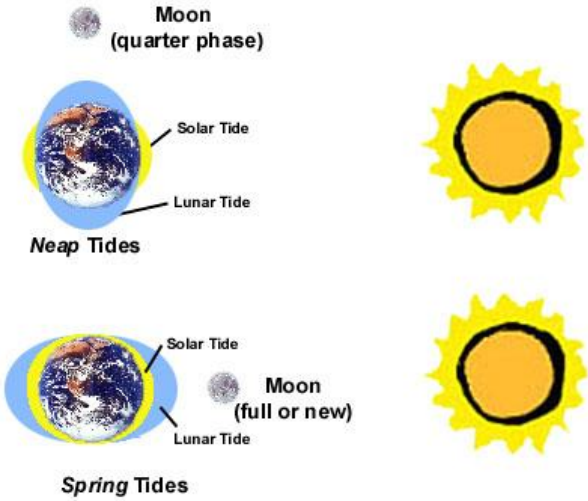
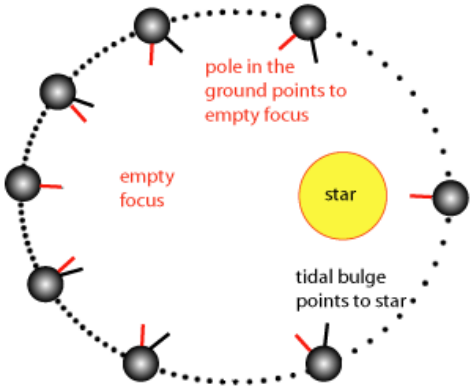
- Occur approximately 50 minutes later every 24 hours because of moon's orbit (moon is not stationary)
- Spring tide
  - Highest high tide gravity of moon
  - When the moon is full the tides are highest at high tide and lowest at low tides
- Neap tide
  - The bulges cease during the quarter moon phases
  - These are when the tides are at its weakest



http://www.rise.org.au/info/Res/tidal/index.html



- Eccentricity: depart of orbit round shape varies from 0 to about 1
- Simi major axis (size of the orbit is half of the longest orbit
- Revolution rate
  - Less then 28 day long
- Synchronous rotation
  - Rotation = revolution
- The average rotation is approximately equal to the rotation of the earth
- We can only see about 57-58% of the moons surface
- The tidal bugle creates tidal heating

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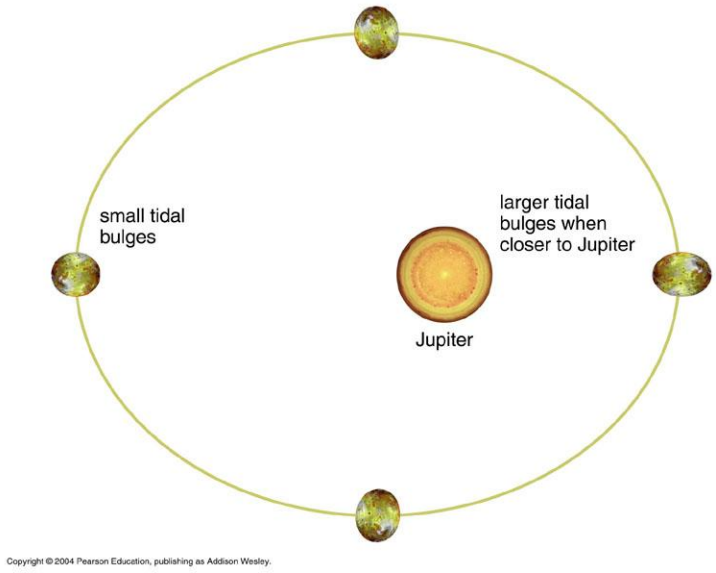
- Tidal Heating
  - "Tidal heating is the heating of the interior of one planetary body caused by stresses induced from the gravitational pull of another." http://www.planetaryexploration.net/jupiter/io/tidal_heating.html
  - Jovian systems have four large moons (Europa, Io, Ganymede, and Callisto) close to a massive planet. These are called Galileo satellites. They are elliptical orbits, therefore they receive tidal heating.
  - Tidal heating is responsible for heating the interior
  - Our Earth is heated by tidal forces.



"Since Io is being forced by Europa into an eccentric orbit, its distance from Jupiter constantly changes. When Io is close to Jupiter the tidal forces are greater so the distortion of Io is greater. When Io is further from Jupiter the tidal forces are less so the distortion of Io is less. "

- "In order to have Tidal Heating you need:
  - A massive central planet
  - A moon orbiting close to the massive planet
  - Another moon in resonance with the inner moon. (You have to force an eccentric orbit in order to keep the distance between the inner moon and the planet changing)"

Picture and text from:

http://www.astro.washington.edu/users/smith/Astro150/Tutorials/TidalHeat/

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- Since water is one of the main things that is required in order to have life, we need to know why water is so important.
  - Heat capacity: Moderates temperature by preventing extremes.
  - Heat vaporization: Highest heats of evaporation which also moderates temperature.
  - Surface tension: Regulates rain drops and clouds
  - Absorption of radiation: Controls biological activity (Photosynthesis)
  - Density: Prevents freezing up and causes seasonal stratification
  - Solvent properties: Important in transfer of dissolved substances
  - Melting and boiling points: Permits water to exist as a liquid at Earths surface.

  H2O is electronically neutral and is a polar molecule which means that it has electric charges that are unevenly distributed. This affects the way water dissolves certain materials.

- Other liquids that are useful for life:
  - Ammonia NH3
  - Methane CH4
  - Ethane C2H6

  These liquids are those found on comets.

  They are not polar molecules

  They dissolve cell membranes

- Habitable planets have abundant liquid water on its surface. There are two ranges for habitable zones in our solar system (conservative and optimistic).
  - Conservative: 0.95-1.4AU, Optimistic: 0.85-1.7AU
  - "The more conservative estimate is based on the assumption that a runaway greenhouse effect starts at a lower temperature, and that catastrophic freeze-out occurs just before the orbit of Mars." http://www.astronomy.ohio-state.edu/~pogge/Ast161/Unit7/life.html
  - "The more optimistic estimate has a higher temperature found closer in, and that the greenhouse effect helps keep a heavier atmosphere like Earth's warmer further away from the Sun." http://www.astronomy.ohio-state.edu/~pogge/Ast161/Unit7/life.html
  - All stars change brightness, location of the stars habitable zone will move from closer to the star to farther out with time. A habitable planet has to be in the stars continuously habitable zone.
  - A larger main sequence star has both a larger habitable zone and one that is farther from its star.

    Really big stars don't have habitable zones because they don't spend as much time in the main sequence

- Criteria for Habitable Planets:
  - Distance from its parent star (Habitable Zone)

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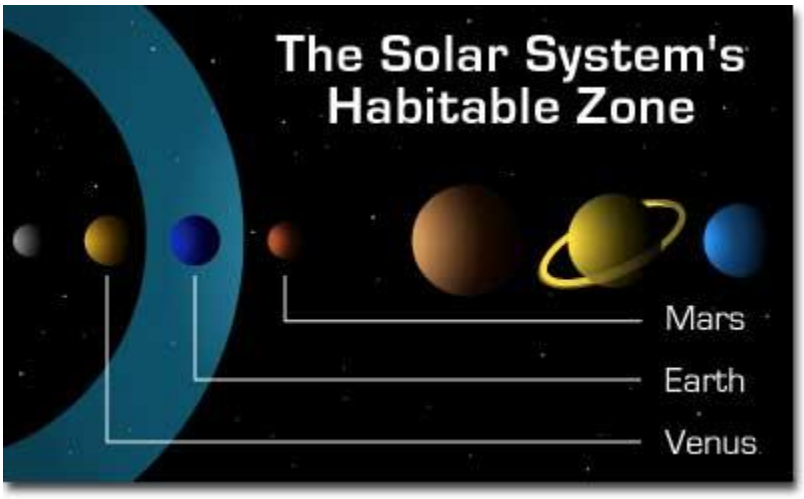
- Size of the Planet



The habitable zone (shown in blue) of our solar system is the region around the Sun in which a planet could potentially have surface temperatures that would support liquid water. (Image credit:

Picture and text from: http://phoenix.lpl.arizona.edu/mars141.php