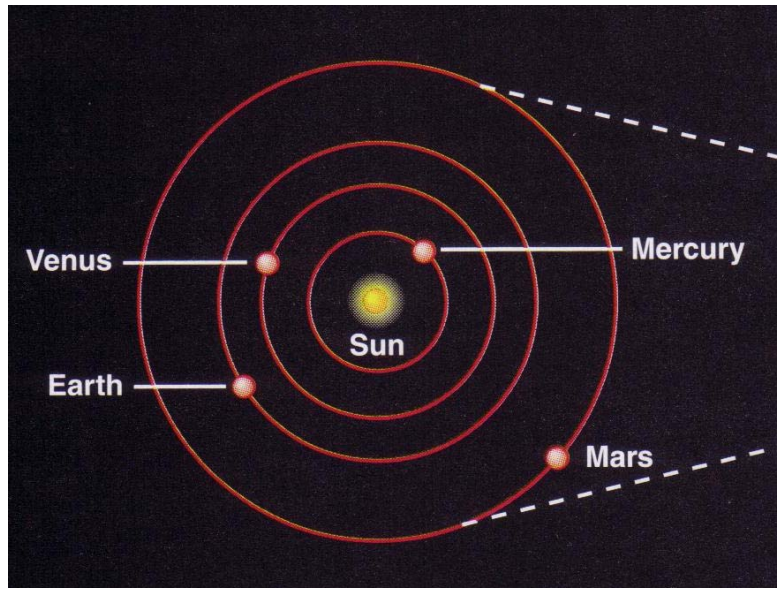
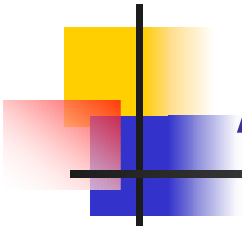
Inner Planets (Part II)

Sept. 18, 2002

1) Atmospheres
2) Greenhouse Effect
3) Mercury
4) Venus
5) Mars
6) Moon



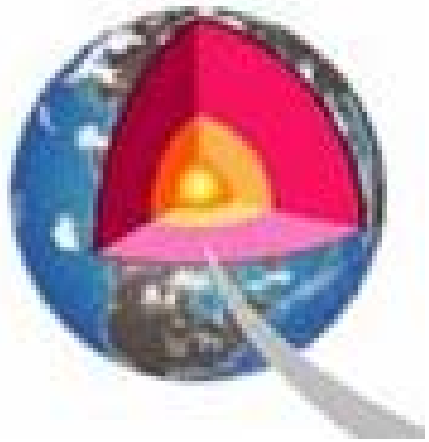


Announcements

- Due to technical difficulties, Monday's quiz doesn't count
- An extra credit problem is available on the course web site.
  - It is due Thurs. Sep 19 at 5pm

Review

- Fact vs Theory
- Inner Planets
  - Planet interiors
  - Magnetic fields
- Four Main Processes
  - Tectonics
  - Volcanism
  - Impact Cratering
  - Gradation



Gases – Some Basics

- Lighter gases rise
  - This is really because heavier gases sink and push the lighter gases upward
- Temperature of a gas is really the speed of the molecules
  - Faster gases are hotter
- Sunlight and heat from a planet's interior provide energy to heat atmospheres
  - Sunlight can also break up molecules
- Fast atoms/molecules in the outer atmosphere can escape the planet's gravitational pull
- Planets have a hard time hanging onto hydrogen and helium

Primary Atmospheres

- A planet's original atmosphere comes from the gas of the accretion disk
  - It is composed mainly of hydrogen and helium
    - same stuff the Sun is made of
- If a planet's gravity isn't strong enough, it can't hold onto these light gases
  - They escape and leave the planet without an atmosphere
  - Heating and solar wind help these processes
- This happened to the inner planets
  - We will see later it did not happen to the gas giants

Secondary Atmospheres

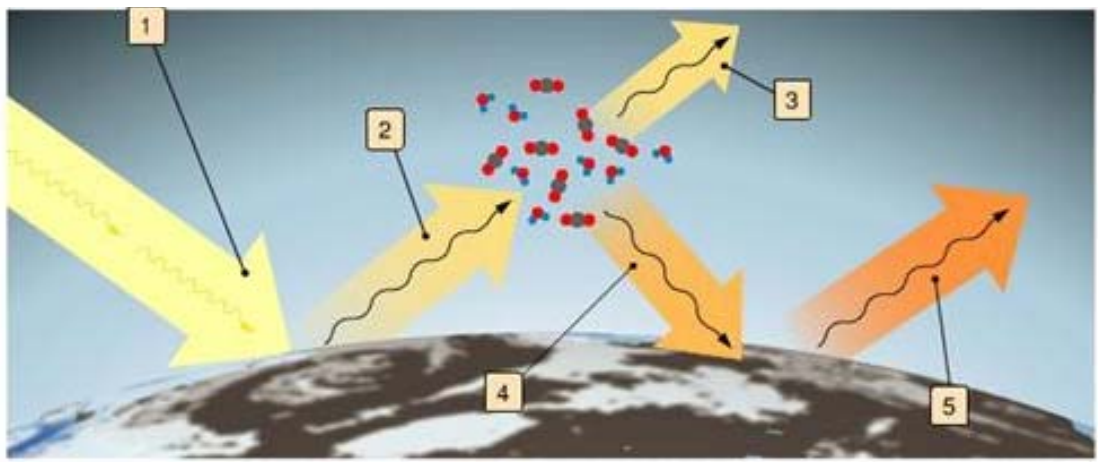
- The rocks and planetesimals which combined to form each planet had gases trapped within them
- During various phases of planetary formation, gases were released
  - differentiation caused them to "rise" to the outer surface of the planet
  - primarily carbon dioxide
- Also, comets and meteors which contain water and gas hit the planet
- These gases formed the secondary atmosphere

Solar Heating

- **Sunlight warms the atmosphere and surface of planets**
  - this heat is radiated back in the infrared
  - wavelength (color) of light depends upon temperature
- **Many gases in the atmosphere absorb infrared light**
  - these gases let visible light through
  - "greenhouse gases"
  - these gases include carbon dioxide and water vapor
  - also include methane and chlorofluorocarbons (CFCs)

Atmospheric Greenhouse Effect

- The greenhouse gases re-radiate the infrared light
  - much of it goes back towards the planet
  - this adds additional heat to the planet
  - Earth would be much colder it not for this
- Planets exist in an equilibrium between solar heating, greenhouse heating and radiation



Runaway Atmospheres

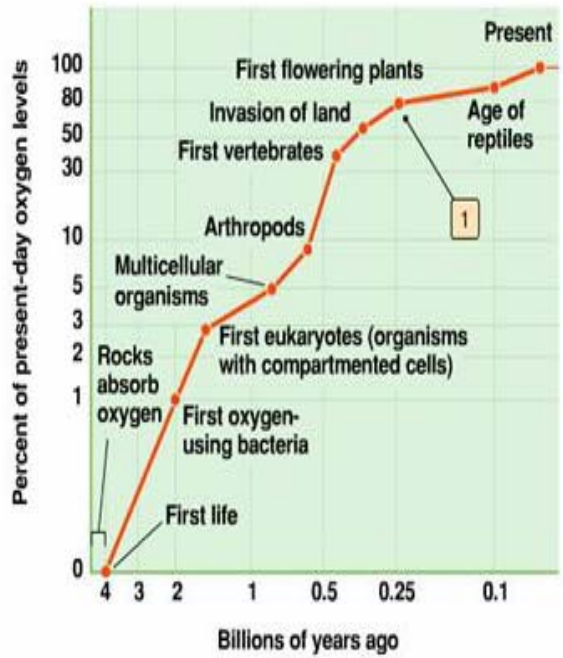
- Greenhouse Effect
  - greenhouse heating boils off surface water, increases greenhouse gases and clouds
  - additional water vapor increases planet temperature
  - boils off more water…
  - also, intense sunlight breaks apart water molecules and hydrogen escapes
  - probably happened on Venus – closer to the Sun
- Atmospheric leakage
  - lighter (outer) gases lost to space
  - less pressure from above, easier for heavier gases to escape
  - probably happened on Mars – low gravity

Comparative Atmospheres

	Venus	Earth	Mars
Pressure (bars)	92	1.0	0.007
Surface Temperature (K)	737	288	210
Carbon dioxide (%)	96.5	0.033	95.3
Nitrogen (%)	3.5	78.1	2.7
Oxygen (%)	0.00	20.9	0.13
Water (%)	0.02	0.1 to 3	0.03
Argon (%)	0.007	0.93	1.6
Sulfur dioxide (%)	0.015	0.02	0.00

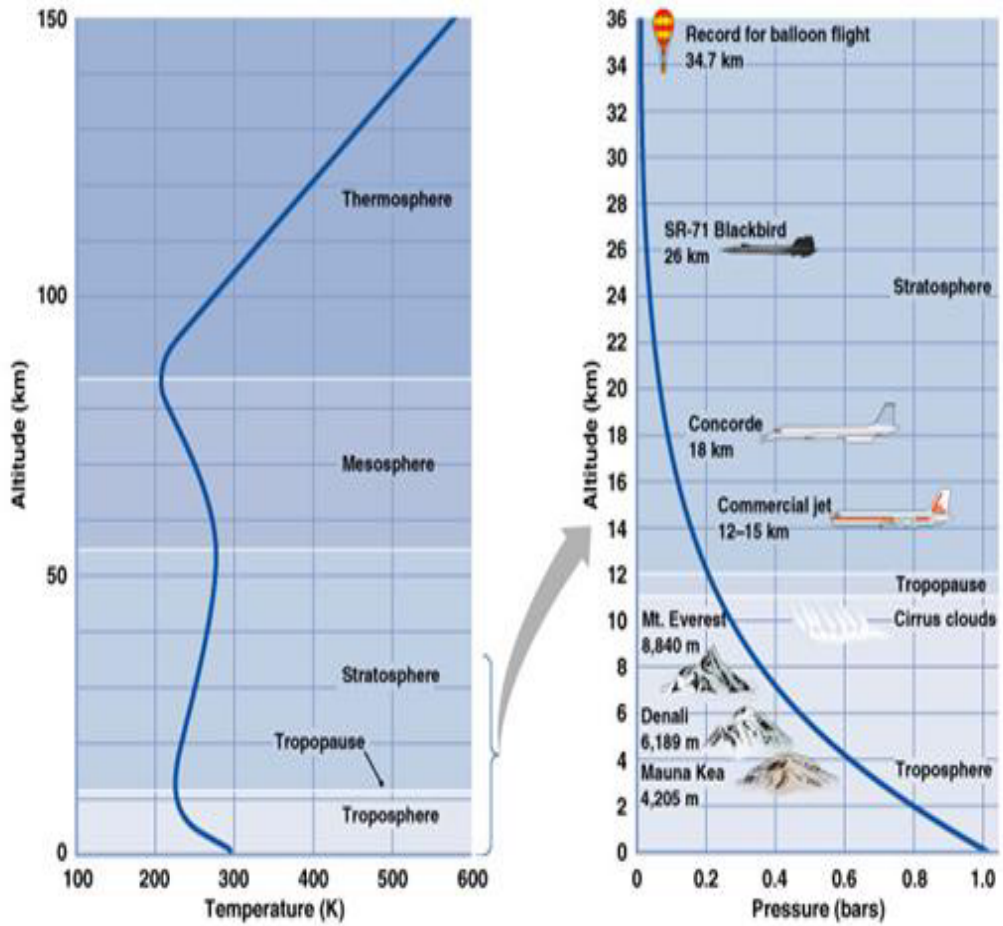
Earth – Just Right

- Massive enough to hold onto atmosphere
- Far enough from the Sun so water was able to remain in solid and liquid form
- Carbon-dioxide
  - erosion exposed fresh materials which absorbs CO_2 to form limestone
  - tiny sea creatures used carbonates to form protective shells which eventually became part of limestone sea beds
  - if all this CO_2 was released, we would have an atmosphere composition similar to Mars and Venus

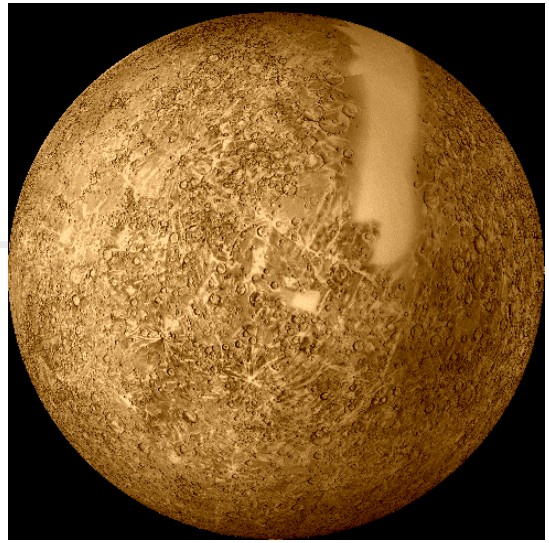


Layers of Atmosphere

- The Earth's atmosphere has layers
  - layers defined by temperature behavior
  - troposphere
  - tropopause
  - stratosphere
  - mesosphere
  - thermosphere
- Other planets have layered atmospheres
- We'll see more of this in stars and gas giants



Mercury



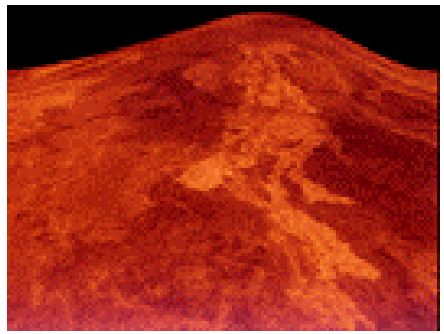
- Closest to the Sun – 0.39 AU
- Small – 2,440 km radius
- Little atmosphere
- Fast revolution – year is 88 days long
- Slow spin – day is 59 Earth days
- Dense – 61% iron
- Used to be volcanically active, but not now
- No moon
- Only visited by Mariner 10 flyby

Venus

- Orbit similar to Earth's – 0.72 AU radius
- Size similar to Earth – 6,051 km radius
- Mass slightly less than Earth
  - gravitational pull about the same
- Slow rotation – a day is 243 Earth days long
- Faster revolution - a year is 225 Earth days long
- Evidence of volcanic and tectonic activity

Venus (cont)

- Venus has an intense atmosphere
  - more than 90 times the pressure
  - intense surface temperature – 737 K
  - sulfuric acid in the clouds
  - limited water vapor
- No moon
- Mapped by radar (Magellan) and Soviet landers survived a short time
- Many physical characteristics to Earth, but environment is VERY different

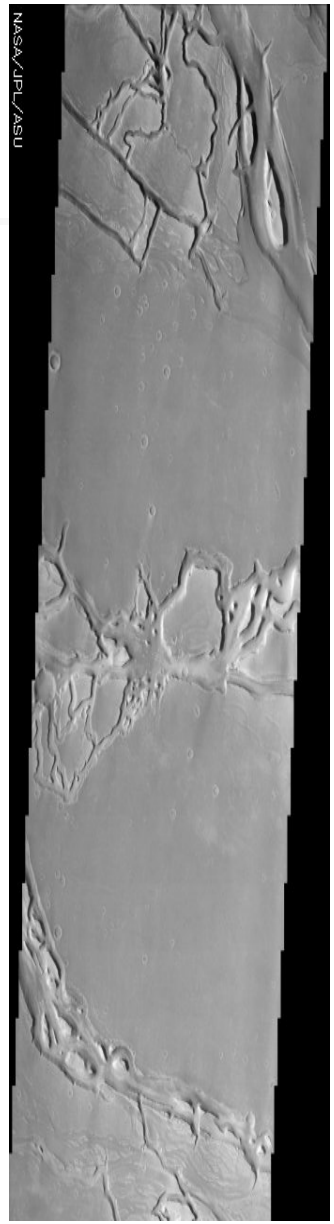


Mars

- 4th planet from the Sun – 1.52 AU orbital radius
- Half the size of Earth – 3,397 km radius
- About 1/10th the mass of Earth
- Light atmosphere – 0.7% of Earth's
- Martian day is slightly longer than an Earth day
- Tilt similar to Earth's
- Year is 1.9 times Earth's
- Has seasonal variations

Mars (cont.)

- Signs of past tectonic, volcanic and gratation processes
  - still going on?
- Has 2 moons, Phobos and Deimos
- Numerous unmanned missions to Mars in 1970s and current
- Planet most likely to be visited next by humans
  - need to bring our own oxygen, food and fuel to get back



Mars surface
from Global Surveyor

Moon

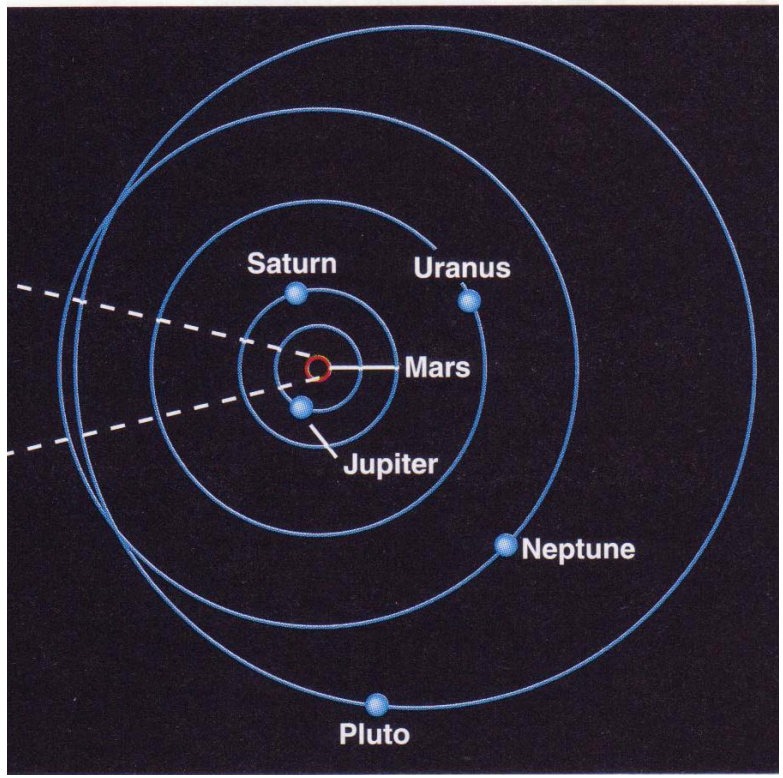
- Small compared to planets (1/100 the mass of the Earth), but large compared to other moons
- Orbit and spin are matched (once a lunar month)
- Composed of similar materials to Earth's mantle
- Volcanic activity long ago (formed maria)
- Essentially no atmosphere
- Surface dominated by cratering
- Only body other than Earth that humans have visited
  - 12 U.S. astronauts from 1969-1972 – Apollo 11-17

Earth

Pretty!

Intro to Outer Planets

- Planets beyond the asteroid belt
- Gas giants
  - Jupiter
  - Saturn
- Ice giants
  - Uranus
  - Neptune
- Other
  - Pluto
- Outer planets are much further from the Sun than the inner planets



Big, Bigger, Biggest

- Uranus and Neptune
  - about 15 Earth masses
  - radii about 4 times Earth's
- Saturn
  - about 95 Earth masses
  - radius about 9.5 times Earth's
- Jupiter
  - about 318 Earth masses
  - radius about 11 times Earth's