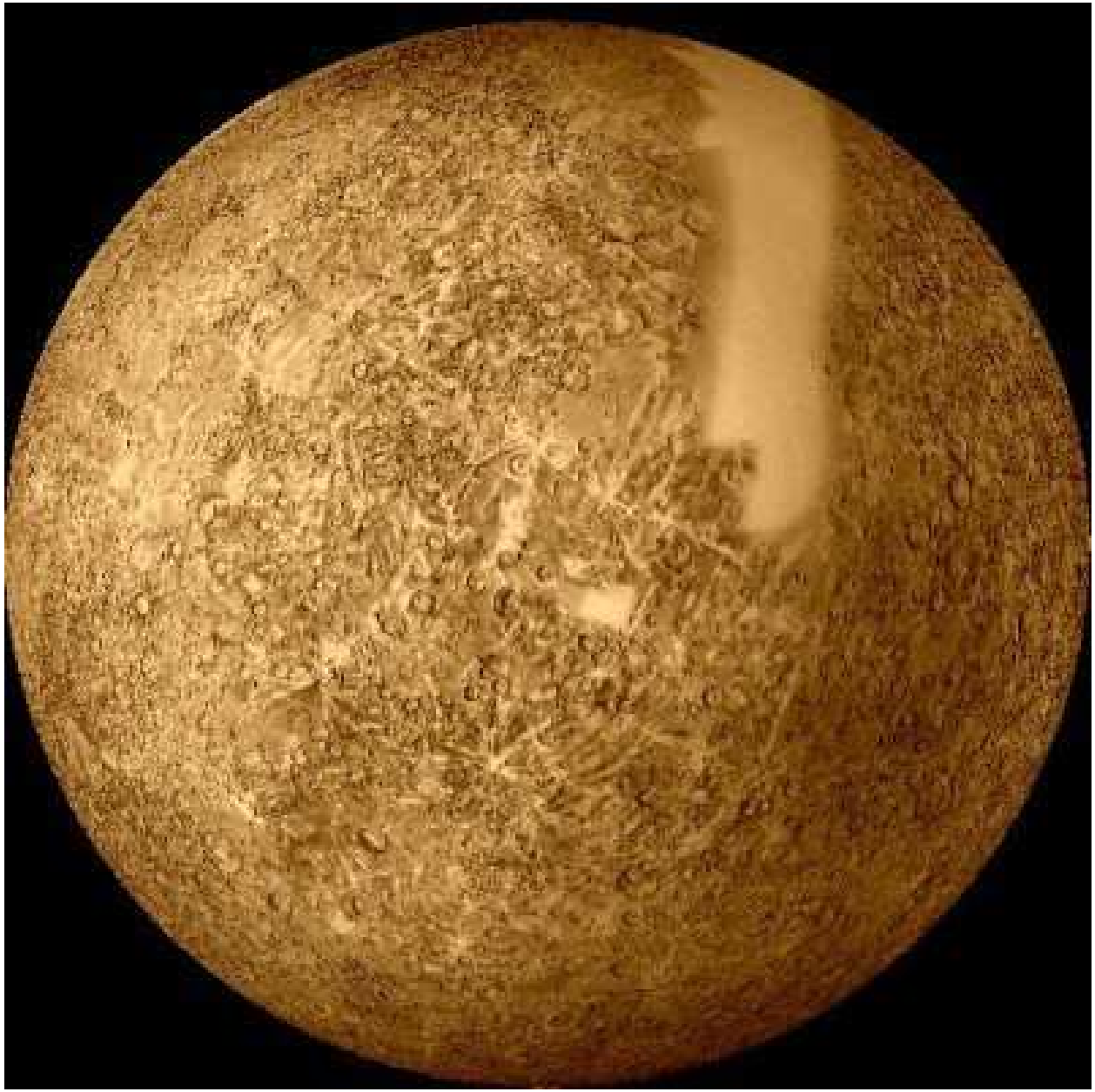


Mercury, the Iron Planet

What We Will Learn Today

- What are planet Mercury's features?
- How do we learn about planet interiors?
- Why do some planets have magnetic fields?
- How is Mercury unique in the solar system?

Planet Mercury Details

Property	Value
Semi-major axis	0.4 AU
Size (radius)	0.4 R_{Earth}
Mass	0.055 M_{Earth}
Average density	5.43 g/cc
Composition	Rocks, metals
Average surface temperature	700 K (day), 100 K(night)
Moons	None
Orbital period	87.6 days
Rotation period (sidereal)	58.6 days
Axis tilt	0^o
Orbital inclination	7.0^o
Orbital eccentricity	0.206

Smallest, lightest planet

Most extreme temps

Fastest planet

3:2 resonance, weird day/night

Highest among planets

From Earth, Mercury is never more than 28^o away from the Sun

The Interiors of Terrestrial Planets

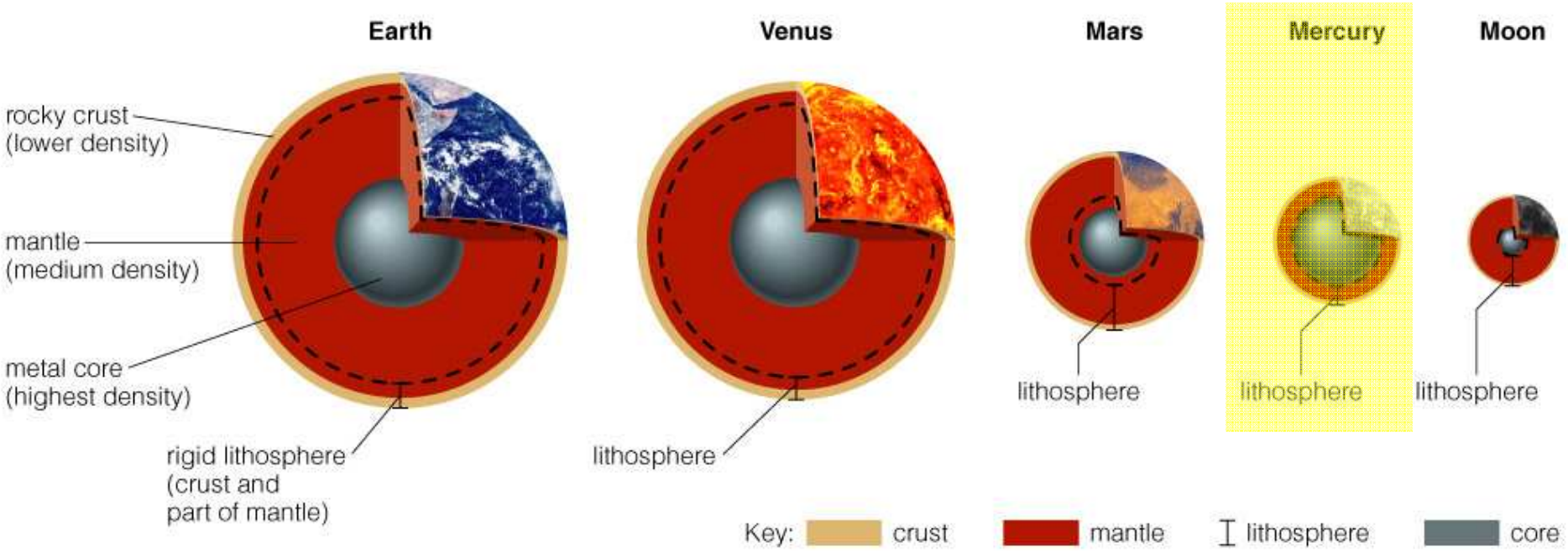


Fig 9.2

Core: Highest density material, mostly metals, in the center

Mantle: Rocky material, moderate density, silicon, oxygen etc.

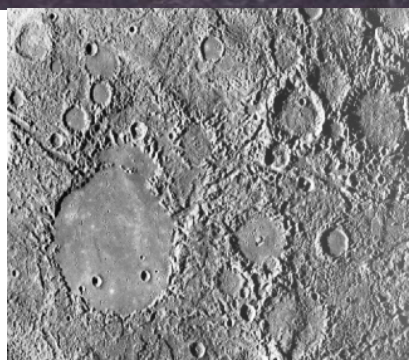
Crust: Thin outer layer, lowest density rock e.g. granite basalt

Lithosphere: Outer rigid layer (crust + part of mantle that floats on warmer, softer rock beneath)

- Thin lithosphere ➔increased volcanic activity

Mercury's Internal Structure

- Internal structure related to size
  - Smaller planets have smaller cores
  - Smaller planets have thicker lithosphere
  - Smaller planets cool fast, convection stops
    - Geological activity comes to a halt
- Mercury has a relatively huge core
  - Explained by a giant impact after differentiation
  - Blew away much of the original crust
- Caloris basin
  - Global effect of the impact
  - Rings seen all the way around the planet
  - "Weird terrain"
    - Hilly region on the opposite side of the planet from Caoris basin



Formation of the Internal Structure

- Planet's interior heats up
  - *Accretion*: Collapse of solar nebula remnants
  - *Differentiation*: Denser material sinks, lighter material floats; friction causes heating
  - *Radioactive decay*: *Fission* as opposed to *Fusion* in the Sun
    - $^{235}U + n \rightarrow {}^{144}Ba + {}^{90}Kr + 2n +$ energy
    - Remember radioactive dating?

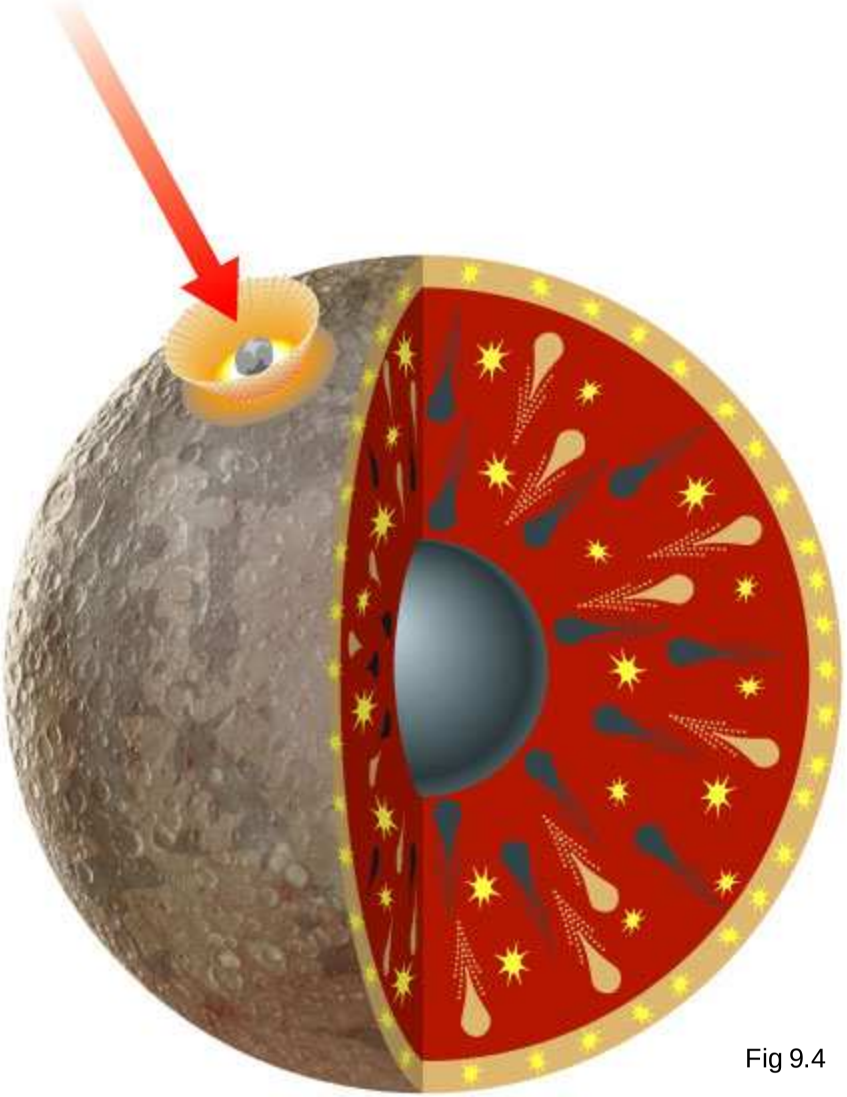


Fig 9.4

Cooling of the Interiors

- Convection
  - Hotter material rises, cooler falls
  - Requires strong heating
- Conduction
  - Energy transferred between adjoining molecules
- Radiation
  - Energy lost to planet via infrared radiation

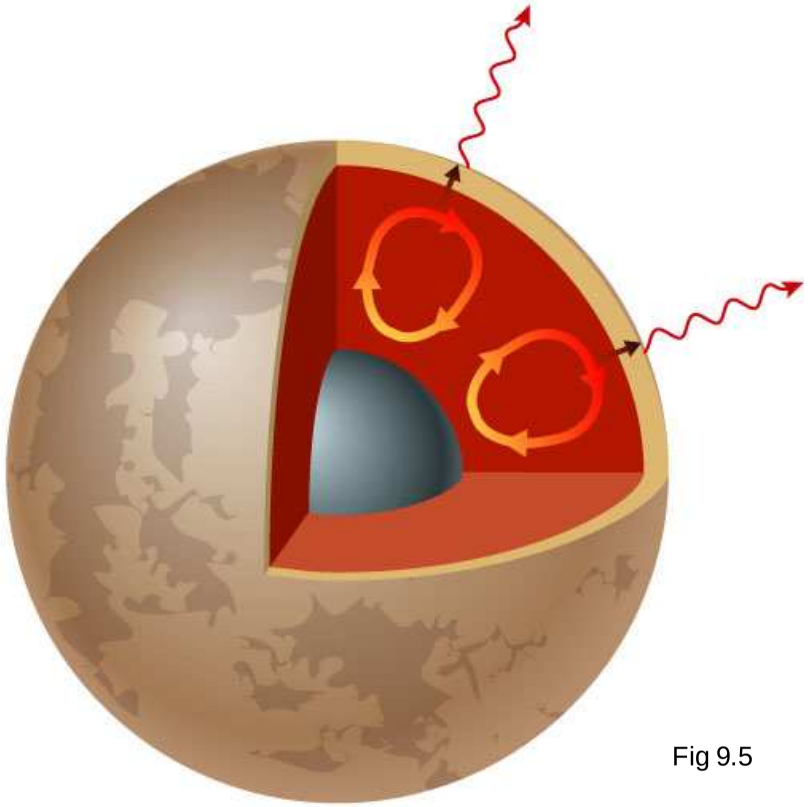
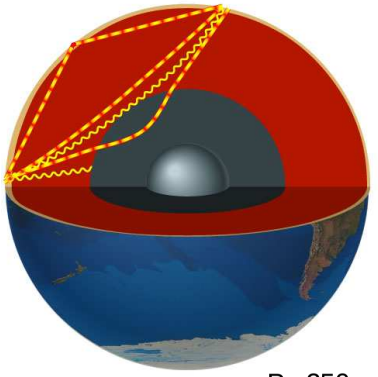


Fig 9.5

Clues to Internal Structure

- Two kinds of seismic waves
  - P-type (Primary)
    - Pressure or push waves
  - S-type (Secondary)
    - Shear or side-to-side
    - Can't pass through liquids
- P waves seen on opposite side of the planet, S waves not seen
  - Implies a liquid code
- Internal structure clues
  - Precise studies of timing and location of seismic waves
  - Precise measurements of gravity point to mass distribution
  - Studying rocks come up to surface from beneath also offer clues
- Exploration
  - Mariner 10 orbited Mercury, took pictures
  - Messenger is on its way (launched August 3, 2004)
    - First flyby January 14, 2008, orbit 2011



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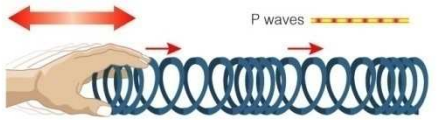

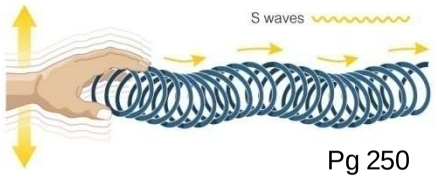

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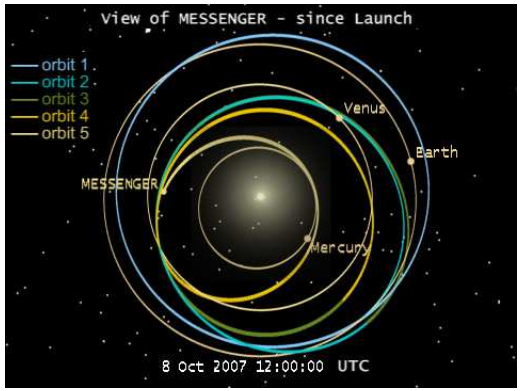
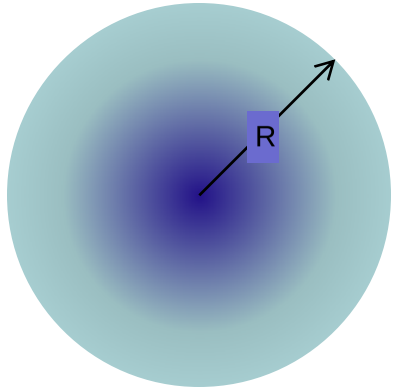


Models of Far Away Planets

- Seismic activity measured only for the Earth and Moon
- For other planets, relate surface density to average density

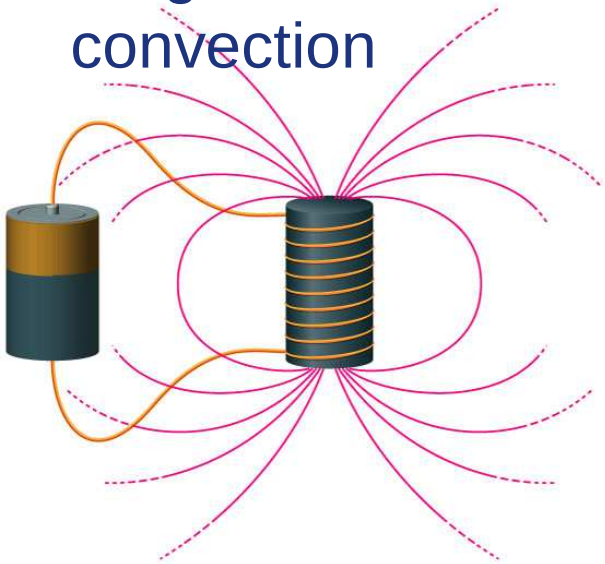
$$Volume_{sphere} = \frac{4}{3}\pi R^3$$

- Mercury's surface density is much lower than its average density
  - Must have a large, dense core



Planets' Magnetic Field

- Requirements for planetary magnetism
  - Conducting fluid in the core
  - Convection in the fluid
  - Moderately fast rotation
- Mercury has a detectable magnetic field
  - Bit surprising due to slow rotation
  - Large metallic core must be partly molten and have convection



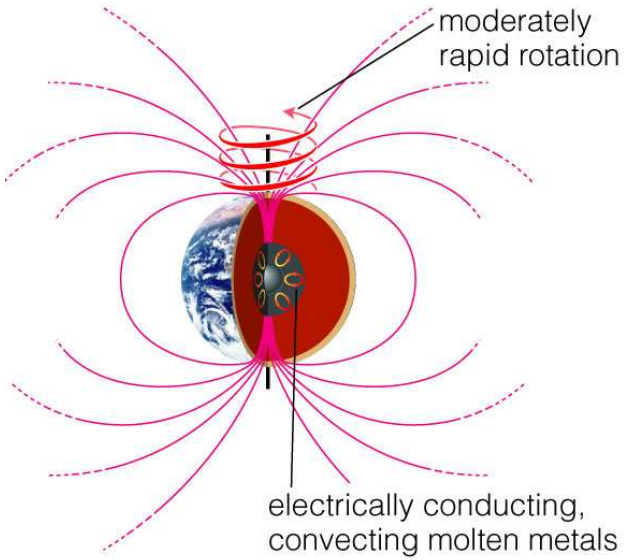


Fig 9.6

Mercury's Very Weak Atmosphere

- Almost non-existent atmosphere
  - Traces of Helium, Sodium, Oxygen
  - Geologically dead for most of history
    - No gases added to atmosphere
  - Proximity to the Sun heats up the day side
    - Speed of air molecules increases
  - Small gravity has low retaining power
  - Result: Atmosphere escapes into space
  - Thin wispy atmosphere extend out into space
- Dark sky with stars during broad daylight!
  - Sun is a bright ball in a dark sky

Fig 10.1

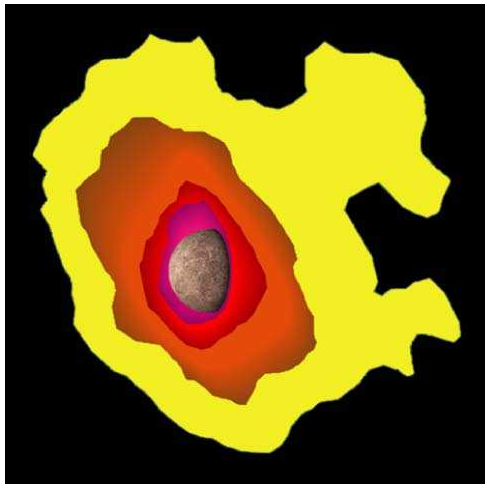
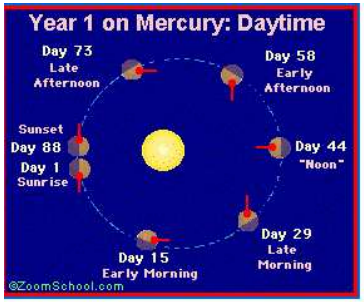
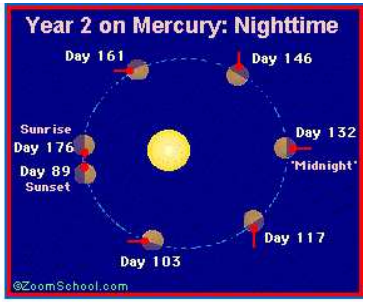


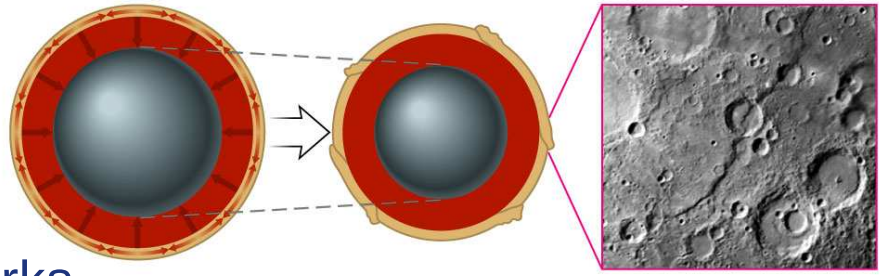
Fig 10.22 b

Unique Features of Mercury





- 3:2 orbit to rotation resonance
  - Not 1:1 due to high eccentricity
  - 1 day per 2 years (176 Earth days)!
- Most extreme temperature swing
  - Daytime 425 ^{o}C, Nighttime -150^{o}C
  - Coldest place in the solar system inside Saturn!
- Oversized core, large impact
- Most heavily cratered planet
- The whole planet shrunk!
  - Vertical cliffs seen, no stretch marks
    - 3 km high, 100s km long
  - Probably closed volcanic vents



Shrinkage not to scale!

Fig 9.23