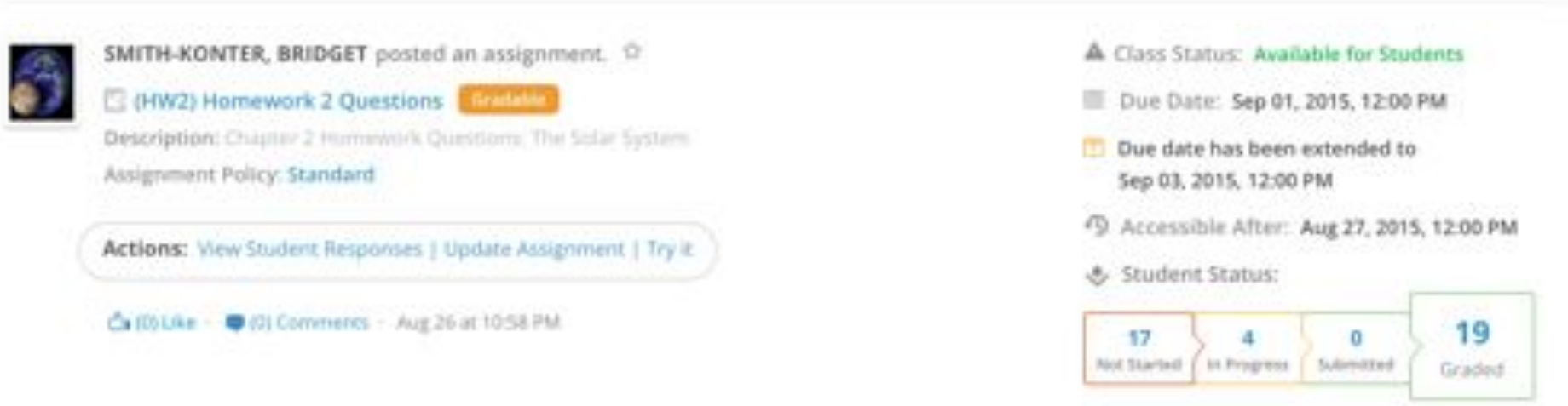
Lecture 3: The Solar System (finish up) + Planet Earth

1) WileyPLUS (online) – registration? homework?
2) Reminder: Final Exam scheduled **Tuesday, December 15** (12-2)
3) iClickers – assigned today (match your name with 3-digit number)

iClicker assignments – pick yours up

001 Abreu
003 Agena
004 Alber
006 Araki
007 Atiburcio
008 Buck
010 Byce
011 Clements
012 Colle
013 Comilla
014 Cuadrado
015 Dang
016 Duncan
080 Fujihara
018 Ganther
021 Guerrero
022 Haupt
025 Hedden
027 Higa
028 Hipolito
029 Inserra
031 Jadu
030 Johnasen
034 Kaaihue
036 Keanini-White
037 Kipi
038 Lee
039 Lockett
040 Manion
041 McTigue
042 Meyers
043 Mitamura
044 Morikawa
047 Nassiri
048 Ota
066 Pavao
067 Peahu
068 Santiago
069 Shigemitsu
070 Soares
071 Teramura
072 Tomaszek
073 Wu
074 Yamamoto
075 Yanagi
077 Yokota
079 Zoller

Please finish Homework #2 and #3 (both due Thursday)



Learning Objectives (LO)

Chapter 2: 2-4 to 2-6

Chapter 3: 3-1 to 3-2

What we'll learn today:

1. Describe each of the gas giants

2. Define a dwarf planet

3. Describe the sources of heat of early Earth and the consequences of heat build-up

4. Describe Earth's internal layers

5. Describe major processes of these layers

The Galilean Moons of Jupiter

Io:
Active volcanoes

Europa:
Icy surface
Liquid Water?
Life?

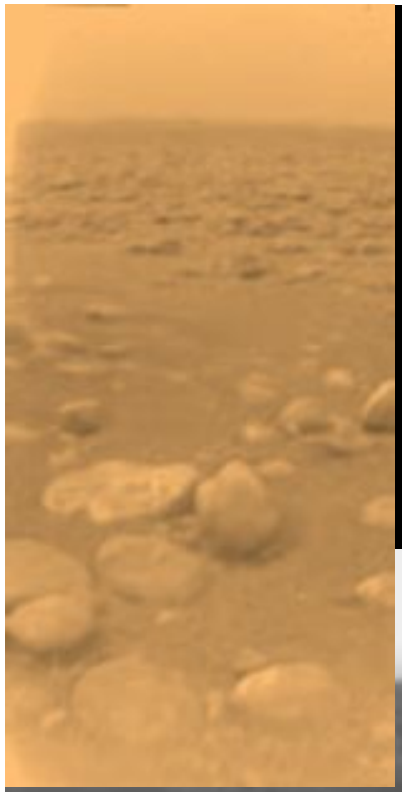
Ganymede:
Largest satellite in Solar System,
Many faults/grooves

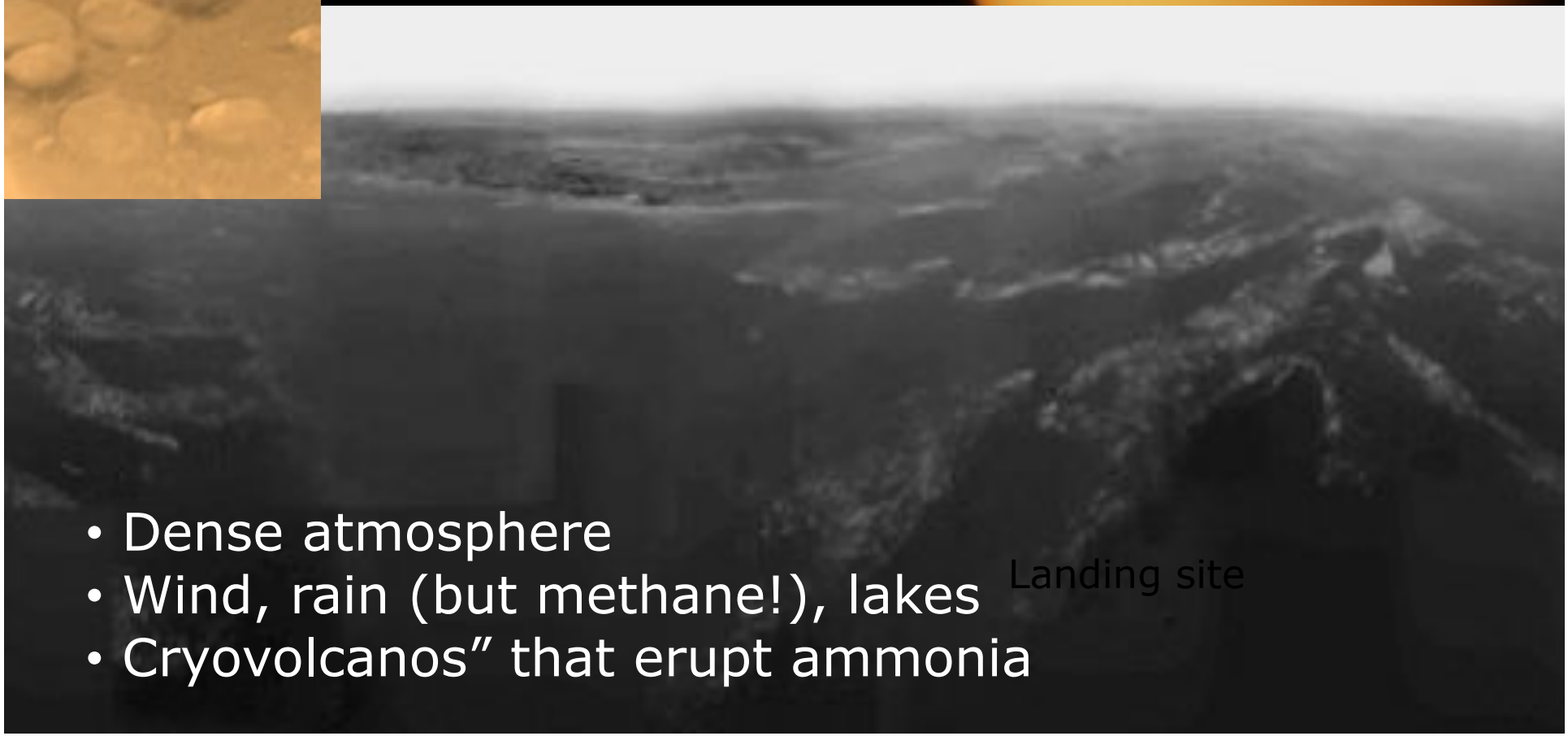
Callisto:
Ice and rock
Geologically dead?

Saturn

- 96% H, 4% He
- 9 rings of rock & ice particles, 10,000 km wide and 200 km thick
- 62 moons

Saturn’s Moon Titan

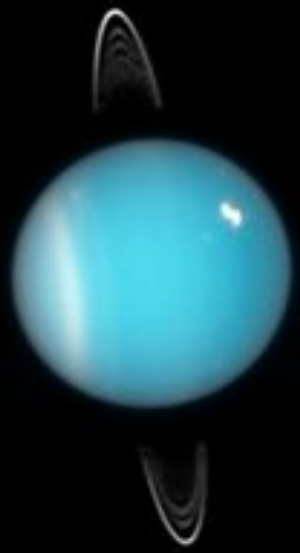




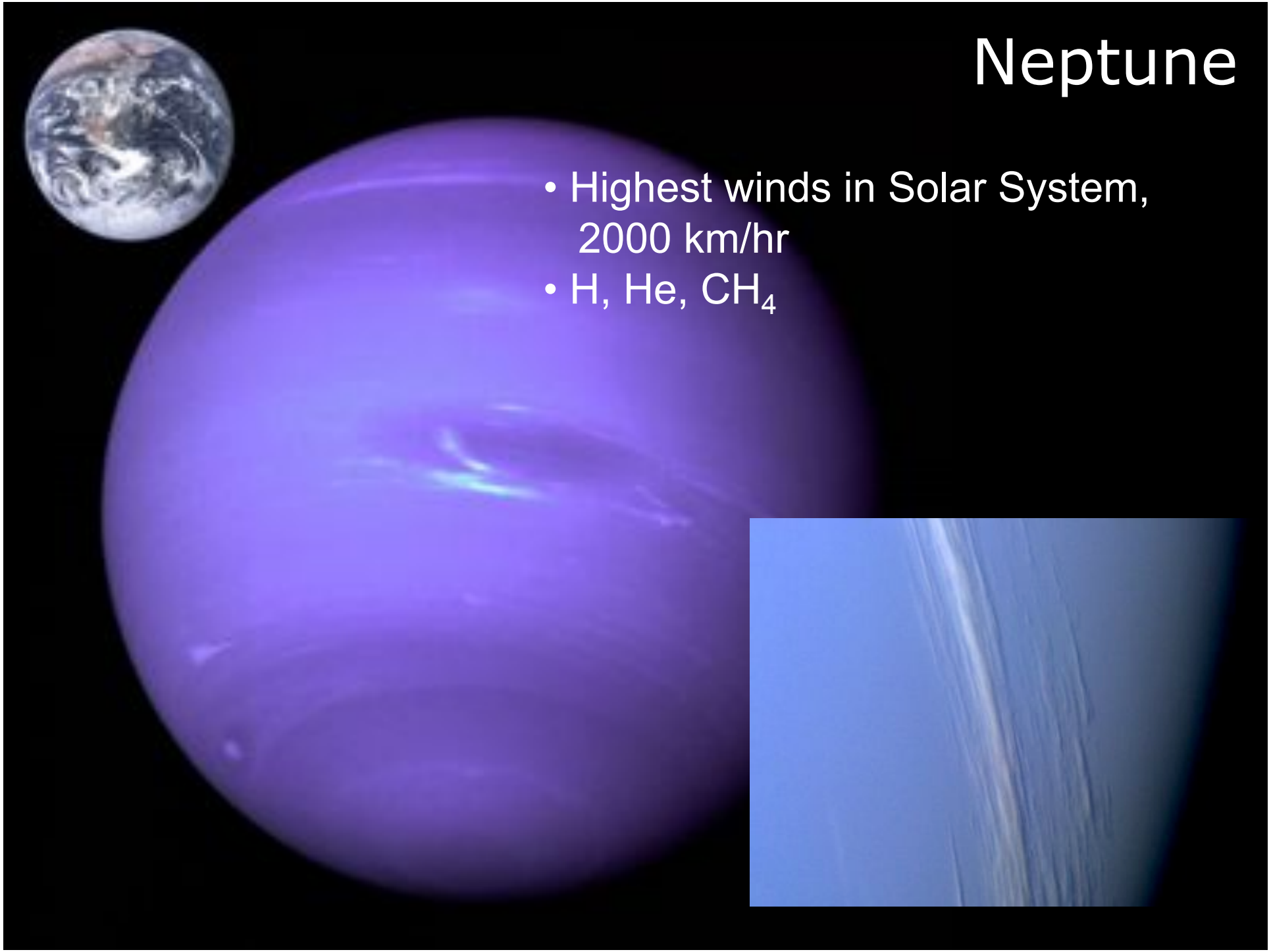
- Dense atmosphere
- Wind, rain (but methane!), lakes
- Cryovolcanos” that erupt ammonia

Uranus

- Rotation axis is tilted on its side
- Wind bands and clouds
- Thin rings (like Saturn)
- H (82%), He (15%),Methane (CH_4)



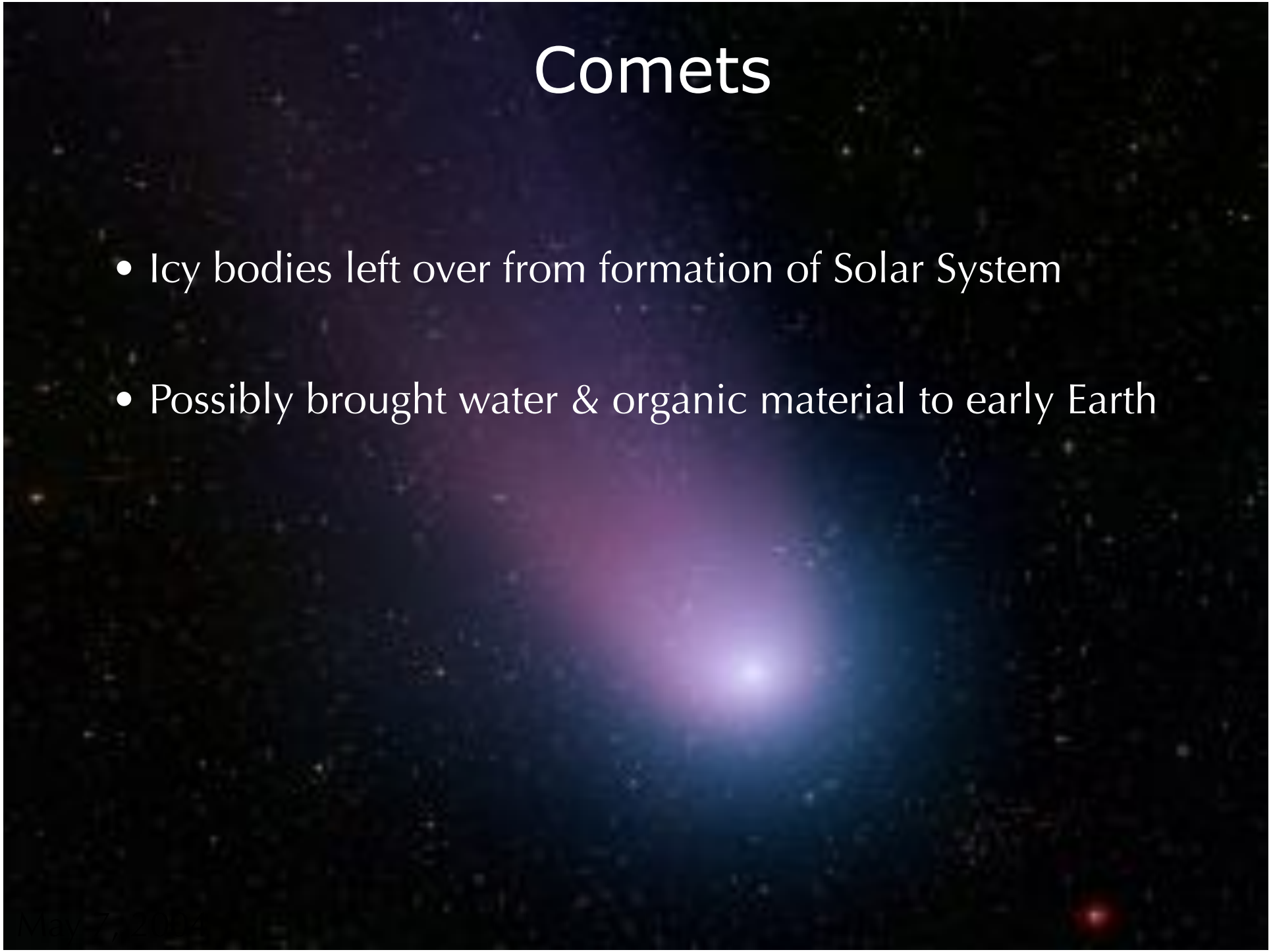
Neptune



- Highest winds in Solar System, 2000 km/hr
- H, He, CH_4

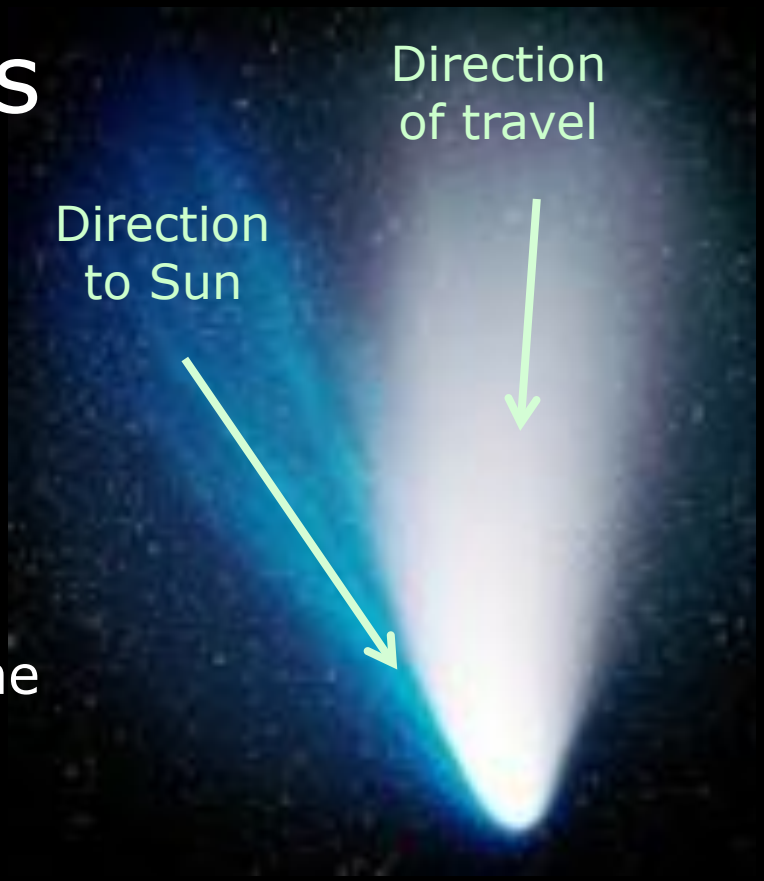
Comets

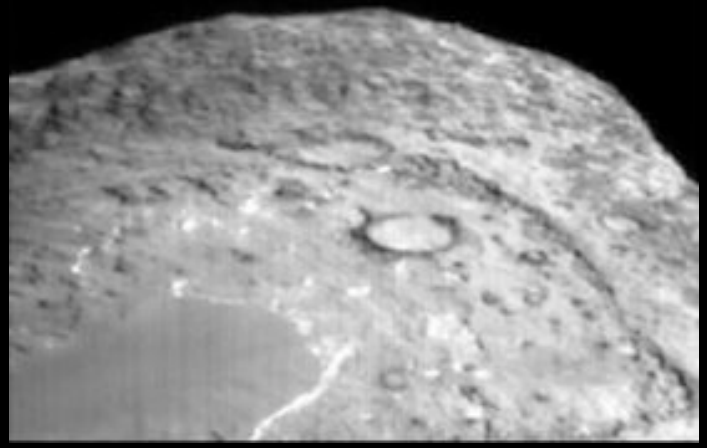
- Icy bodies left over from formation of Solar System
- Possibly brought water & organic material to early Earth



Comets

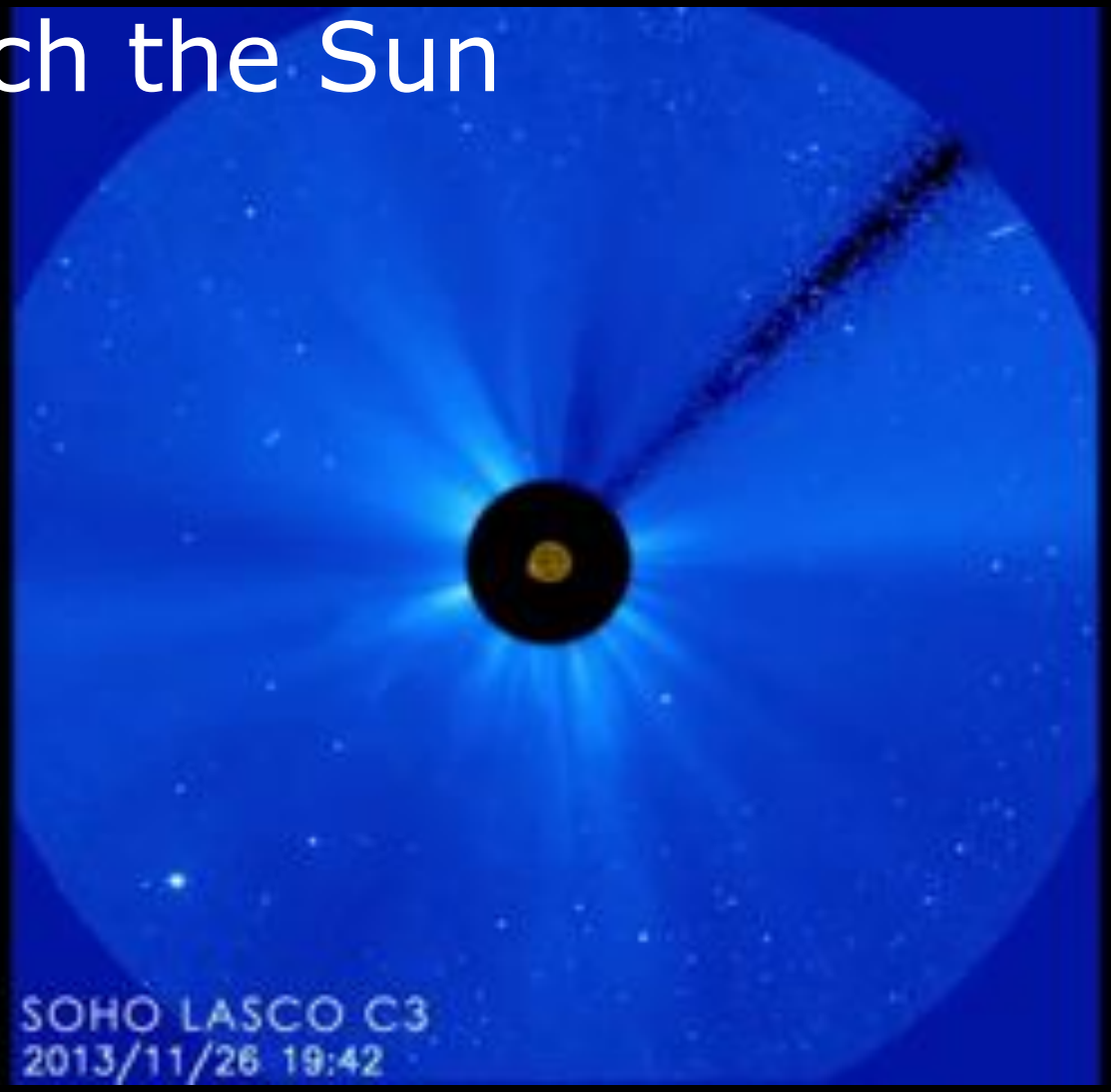
- "Dirty Snowballs" (rocks & ice)
- Gas tail: bluish, forms by solar wind basting off particles
- Dust tail: whitish, solid particles escaping behind the comet's path
- Likely delivered water and gases to the inner planets





Surface of comet Tempel 1 (2005)

Comets Grow As They Approach the Sun

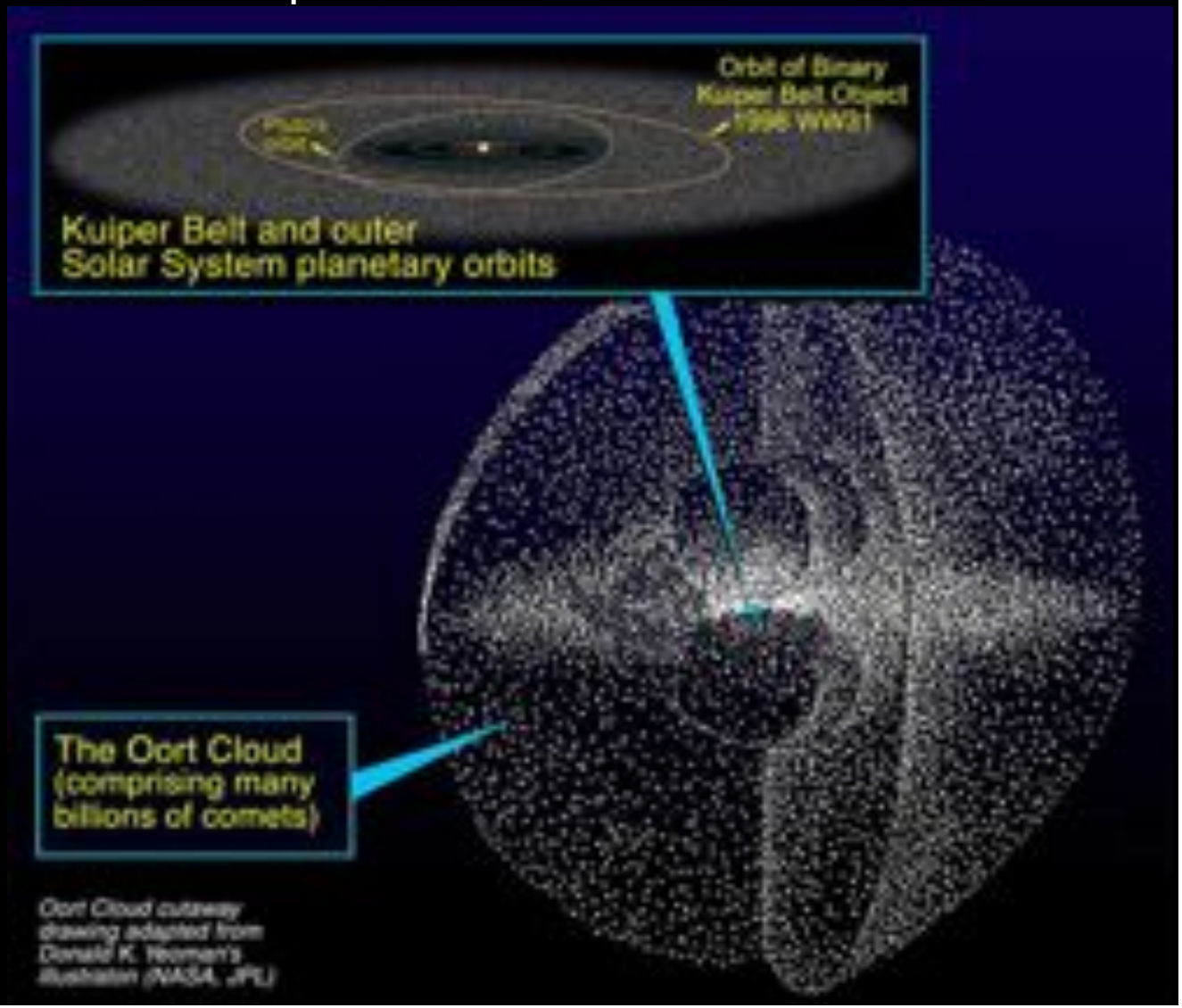


Comet ISON,
December 2013
https://www.youtube.com/watch?v=kcROVqmF9SY

Where Do Comets Live?

Outer Solar System

- (1) Kuiper Belt lies outside Neptune's orbit
- (2) Oort Cloud surrounds Solar System
- Contains billions of icy/rocky comets
- Comets can be deflected toward the inner planets



Dwarf Planets

Defined in 2006
- Orbit the sun (not a planet)
- Have a rounded shape
- Has not cleared its neighborhood of objects (unlike planets)

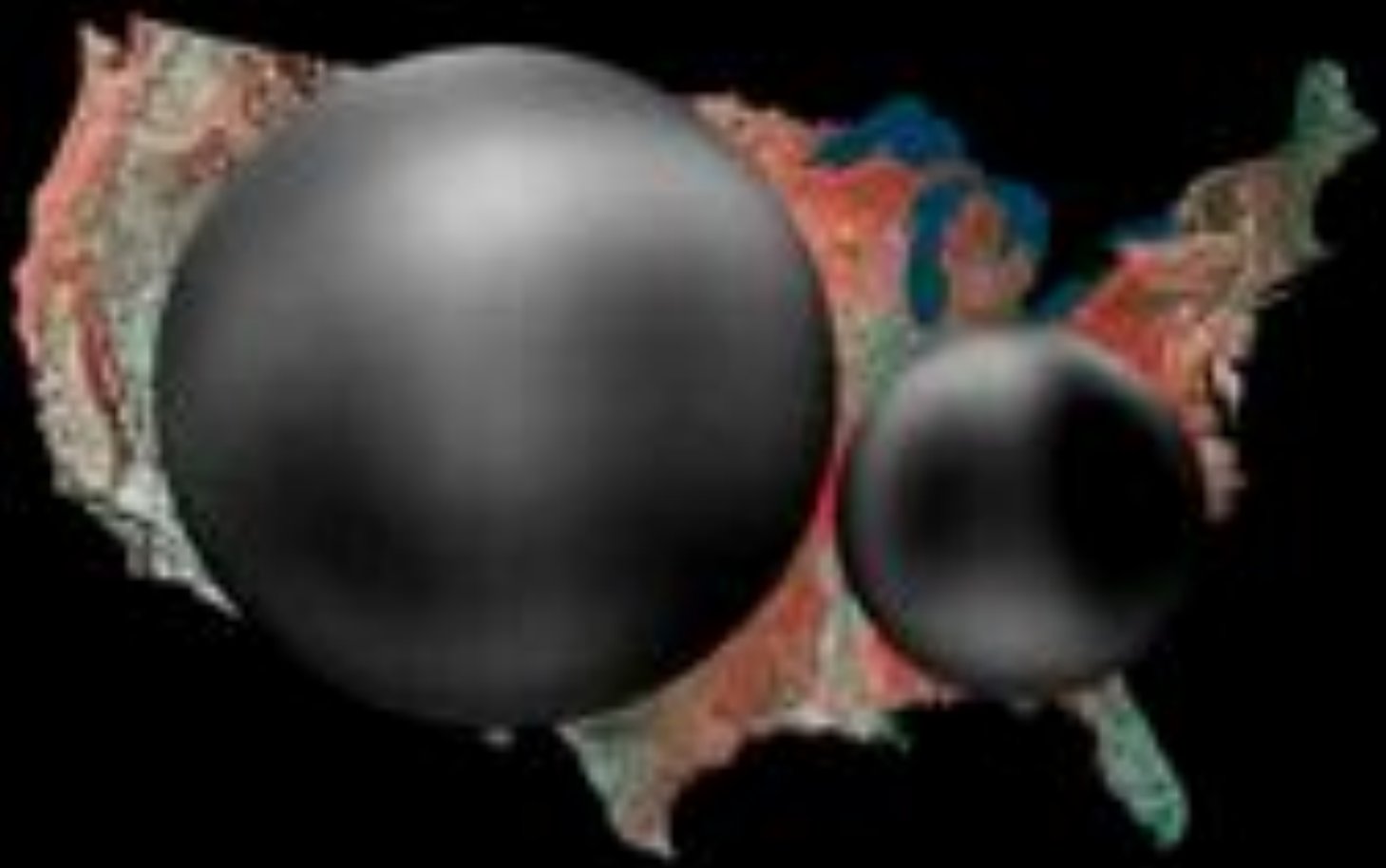
Asteroid belt:
- Ceres

Kuiper Belt:
- Pluto/Charon
- Eris
- Haumea
- Makemake

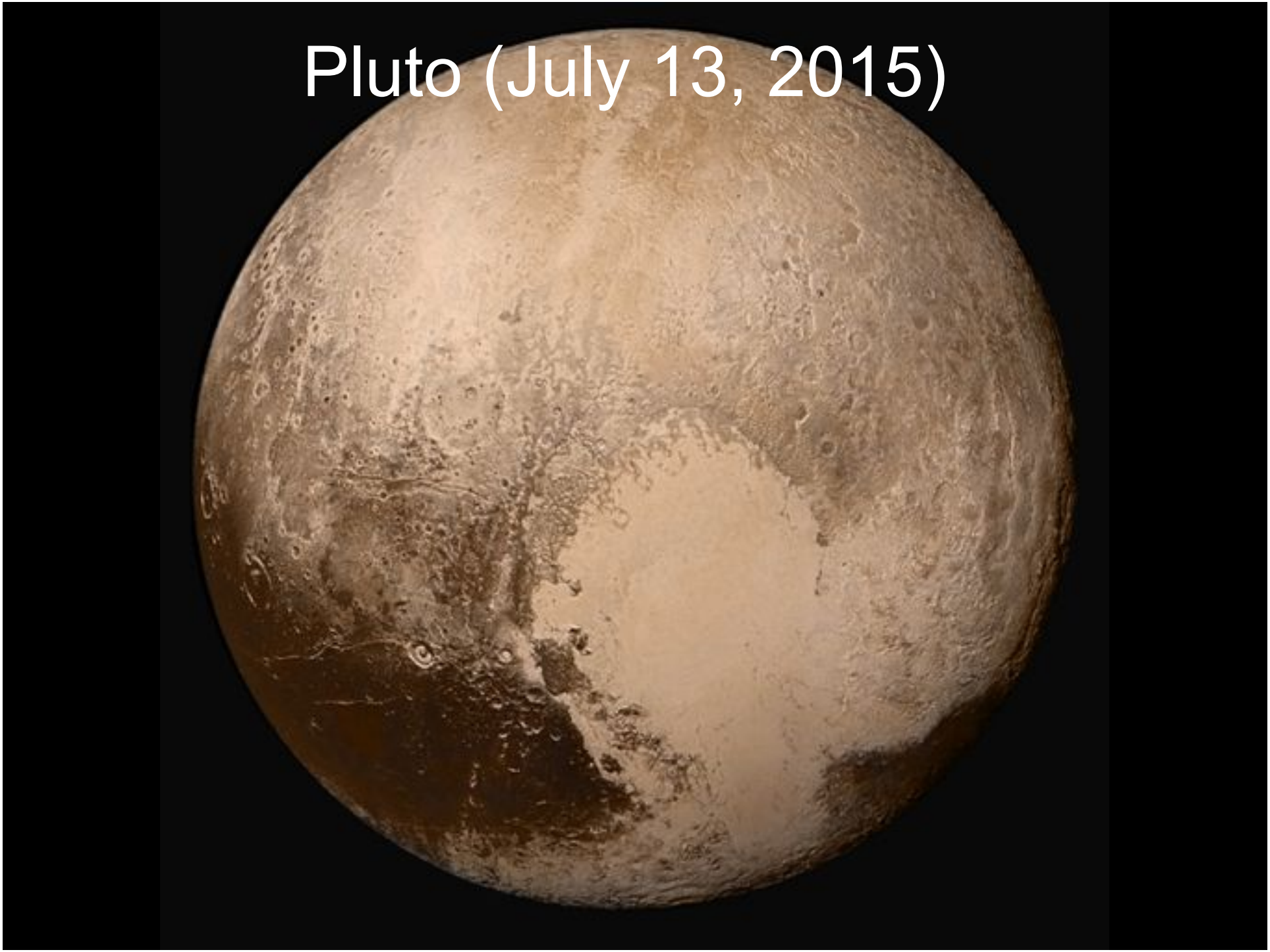
Probably hundreds more!


I CAN'T BELIEVE I HAVE TO SIT AT THE "LITTLE PLANETS" TABLE...
PLUTO

Pluto (before July 2015)

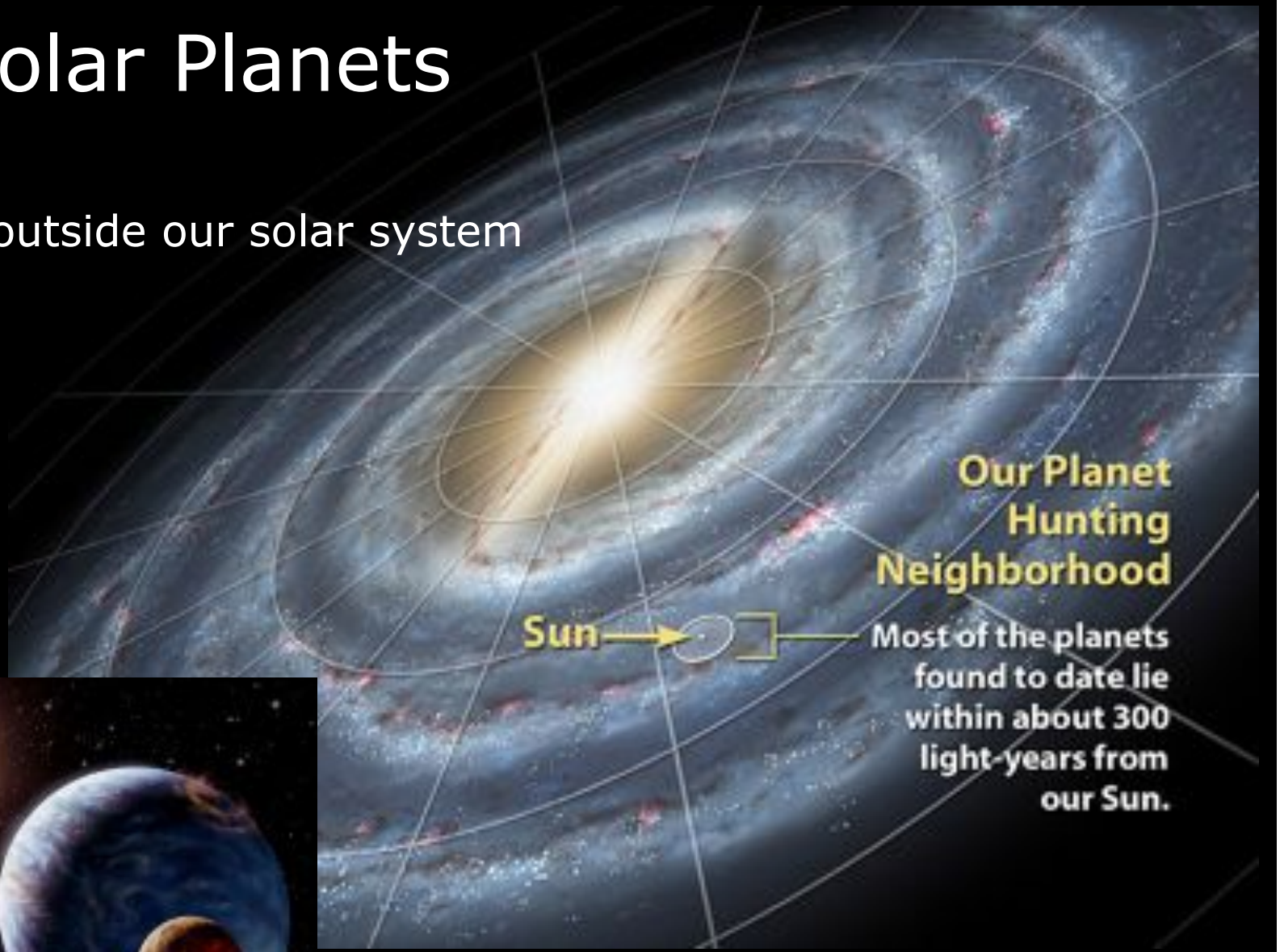


Pluto (July 13, 2015)



Extrasolar Planets

- Planets outside our solar system



Extrasolar Planets

- First planet detected in 1992
- 1000+ detected so far
- Billions of planets in the Milky Way (around almost every star)

https://www.youtube.com/watch?v=0WatNUka7OA

Chapter 2 – read!
Homework #2

What you should know
from today (and last week):

1. Describe the solar nebula hypothesis
2. Understand the Sun and how it works
3. State the ways that Mercury, Venus, and Mars are different from Earth
4. Describe each of the gas giant planets
5. Define a dwarf planet

The Geologic Time Scale

Time is divided into progressively shorter intervals defined by specific fossils and rock layers:

Eons
→Eras
→Periods
→Epochs

TABLE 1.1 Overview of the Geologic Time Scale

Began Years Ago	Notable Events	Epochs	Periods	Eras	Eons
10 thousand	Modern epoch	Holocene	Quaternary	Cenozoic	Phanerozoic
2.6 million	Global cooling	Pleistocene			
23 million	Earliest Hominids, first apes		Neogene		
65 million	Early modern mammals		Paleogene		
	Extinction of dinosaurs, Flowering plants abundant, Modern sharks		Cretaceous	Mesozoic	
	First birds and lizards Dinosaurs abundant		Jurassic		
251 million	First dinosaurs First mammals and crocodilians		Triassic		
	Major extinction of many life forms, Beetles and flies evolve, Reef ecosystems flourish, Pangaea forms		Permian	Paleozoic	
	First reptiles and coal forests		Pennsylvanian		
	First land vertebrates Early sharks		Mississippian		
	First insects and amphibians First ferns and seed-bearing plants		Devonian		
	First land plants First jawed fishes and vascular plants		Silurian		
	First green plants and fungi on land		Ordovician		
542 million	First abundant fossils		Cambrian		
2.5 billion	Oxygenated atmosphere				Proterozoic
3.8 billion	Earliest life (single-celled algae), oldest crust				Archean
4.6 billion	Oldest mineral grain, oldest asteroids and Moon rocks				Hadean

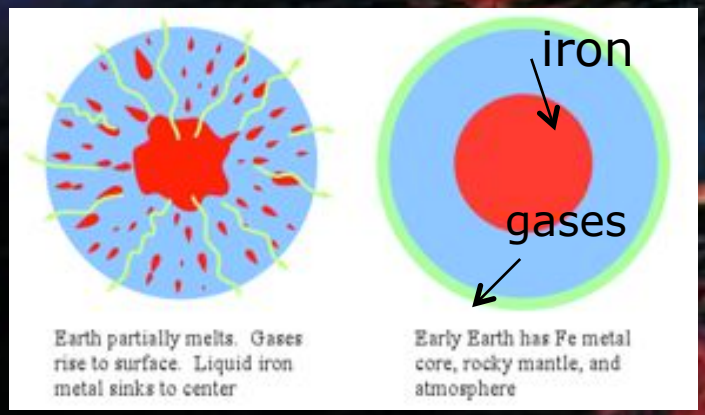
Planet Earth and its Heat

Earth formation: Lots of heat!

The earliest Earth
was a magma ocean

“Hadean Eon”
4.6-3.8 Billion Years Ago (Ga)

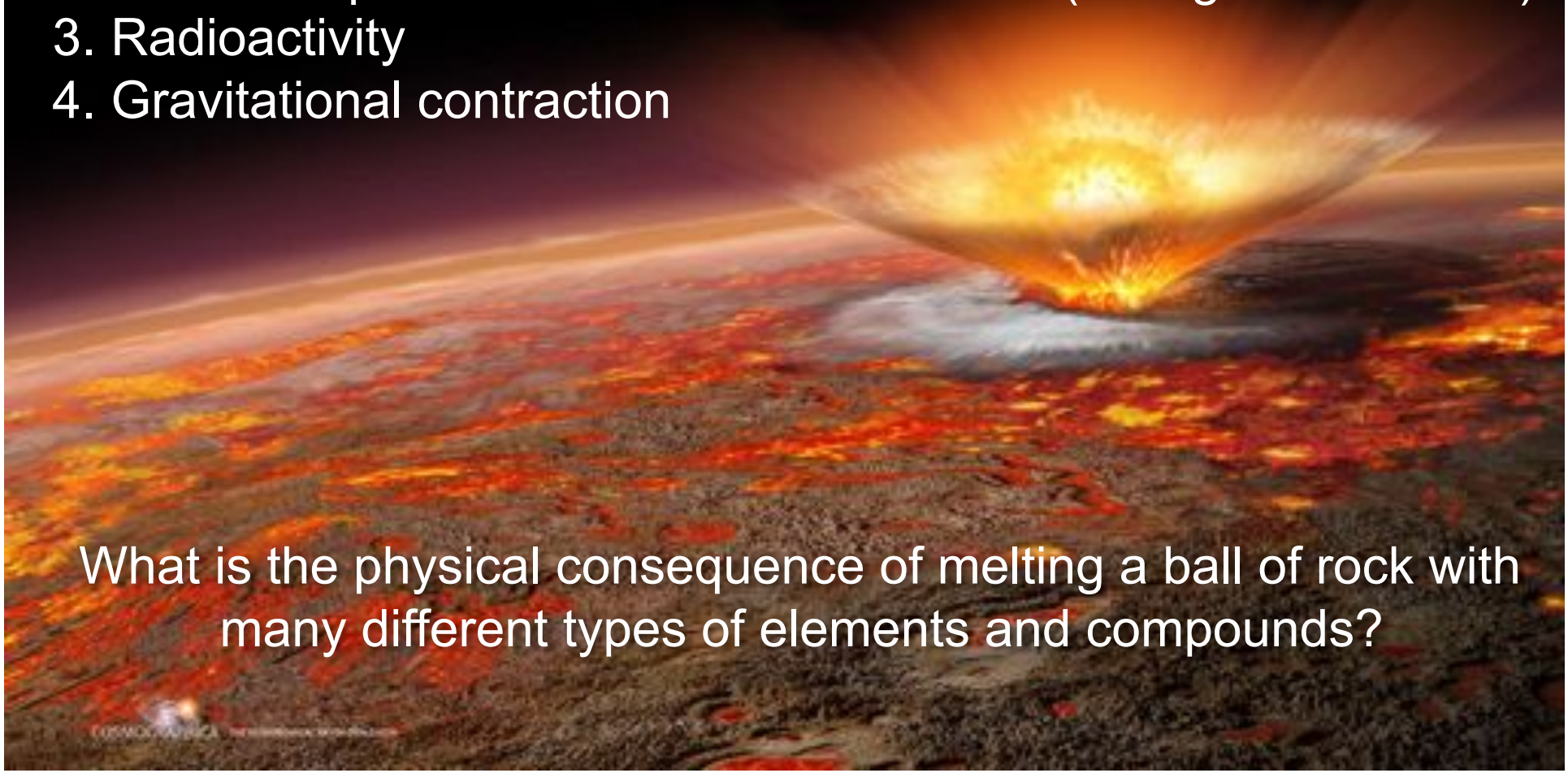
- Earth developed a hot magma sea
- Atmosphere created by
  - volcanic outgasing
  - delivery of gases & water by ice-covered comets
- Iron core formation



Early Heat Within The Earth

Early Earth began to heat as the last collisions subsided

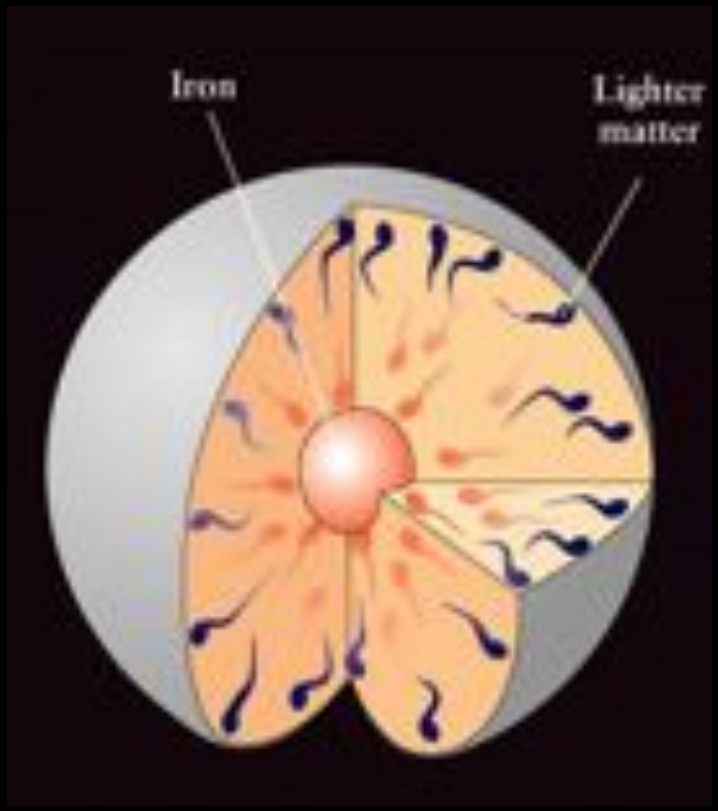
1. Initial heat from impacts (bombardment)
2. Collisions produced heat that was stored (rock good insulator)
3. Radioactivity
4. Gravitational contraction



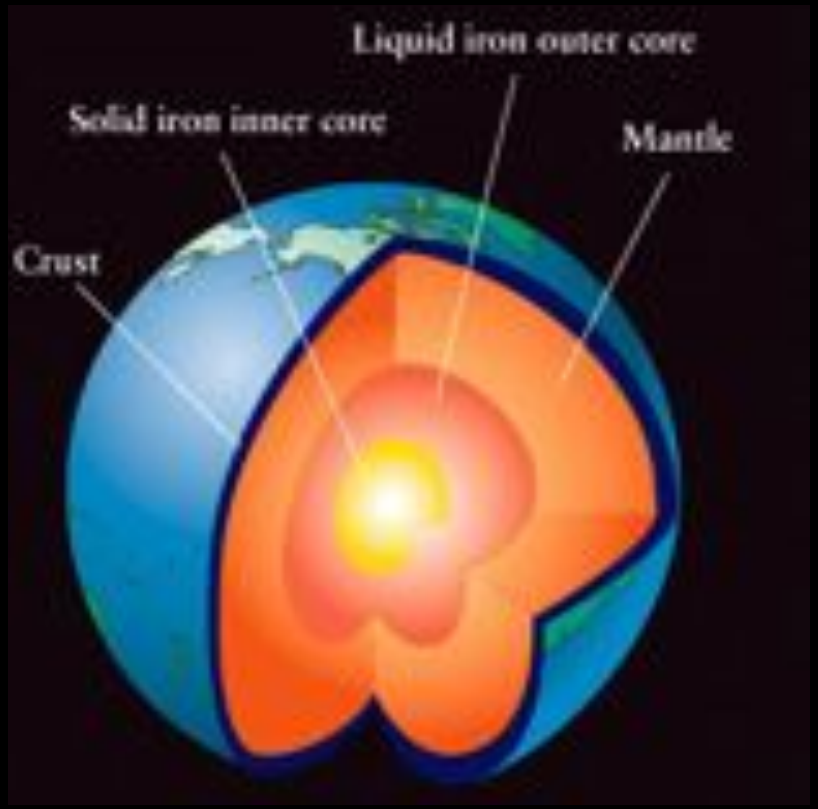
What is the physical consequence of melting a ball of rock with many different types of elements and compounds?

The Iron Catastrophe

- Began once Earth heated to melting point of iron (1538°C)
- Iron and nickel sink to the core – <u>chemical</u> <u>differentiation</u>



Friction & energy release from sinking iron releases even more heat!



Differentiation: A layered Earth
Archean Eon and ever since

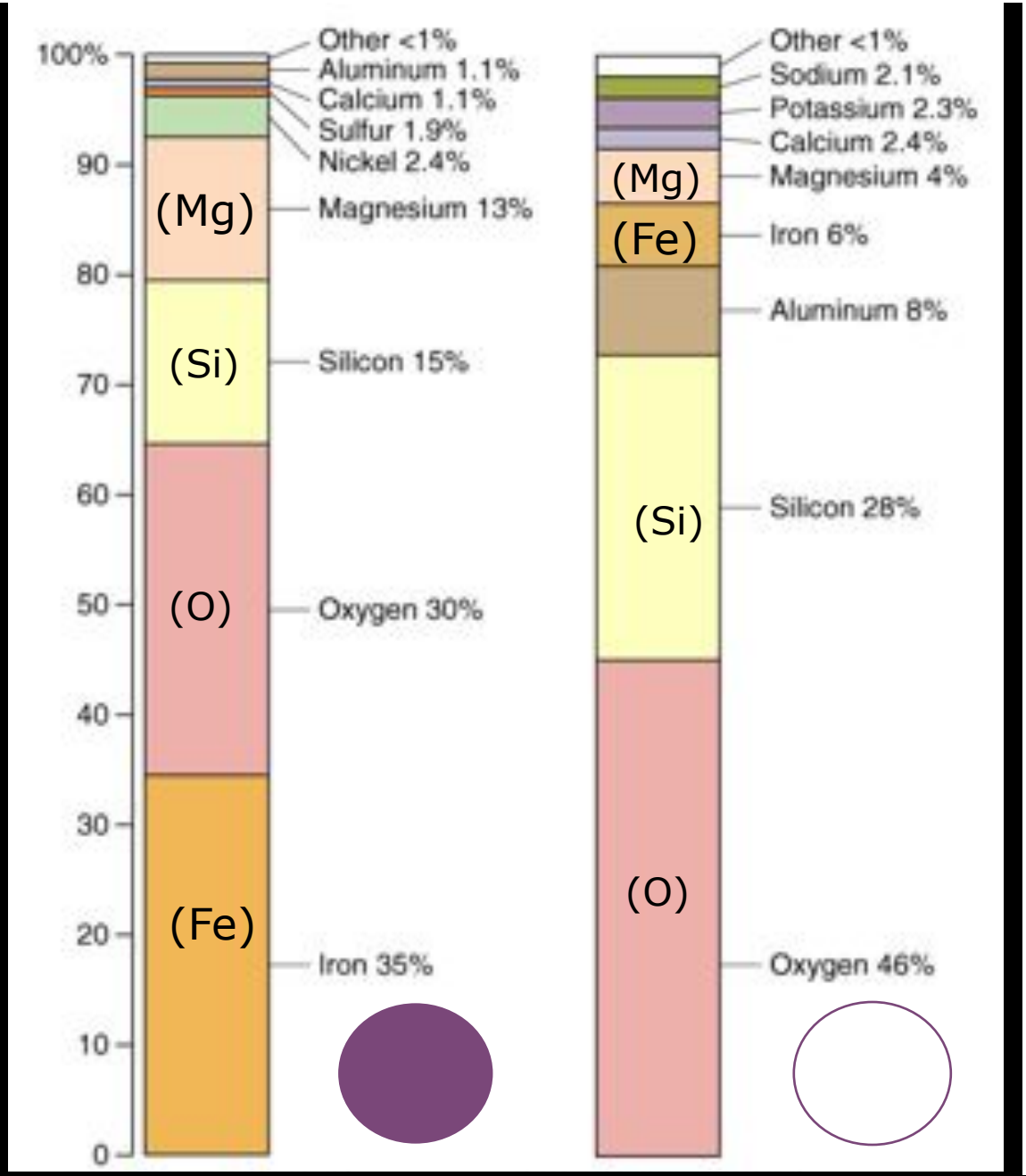
TABLE 1.1 Overview of the Geologic Time Scale

Began Years Ago	Notable Events	Epochs	Periods	Eras	Eons
10 thousand	Modern epoch	Holocene	Quaternary	Cenozoic	Phanerozoic
2.6 million	Global cooling	Pleistocene			
23 million	Earliest Hominids, first apes		Neogene		
65 million	Early modern mammals		Paleogene		
	Extinction of dinosaurs, Flowering plants abundant, Modern sharks		Cretaceous	Mesozoic	
	First birds and lizards Dinosaurs abundant		Jurassic		
251 million	First dinosaurs First mammals and crocodilians		Triassic		
	Major extinction of many life forms, Beetles and flies evolve, Reef ecosystems flourish, Pangaea forms		Permian	Paleozoic	
	First reptiles and coal forests		Pennsylvanian		
	First land vertebrates Early sharks		Mississippian		
	First insects and amphibians First ferns and seed-bearing plants		Devonian		
	First land plants First jawed fishes and vascular plants		Silurian		
	First green plants and fungi on land		Ordovician		
542 million	First abundant fossils		Cambrian		
2.5 billion	Oxygenated atmosphere				Proterozoic
3.8 billion	Earliest life (single-celled algae), oldest crust				Archean
4.6 billion	Oldest mineral grain, oldest asteroids and Moon rocks				Hadean

Table 1.1

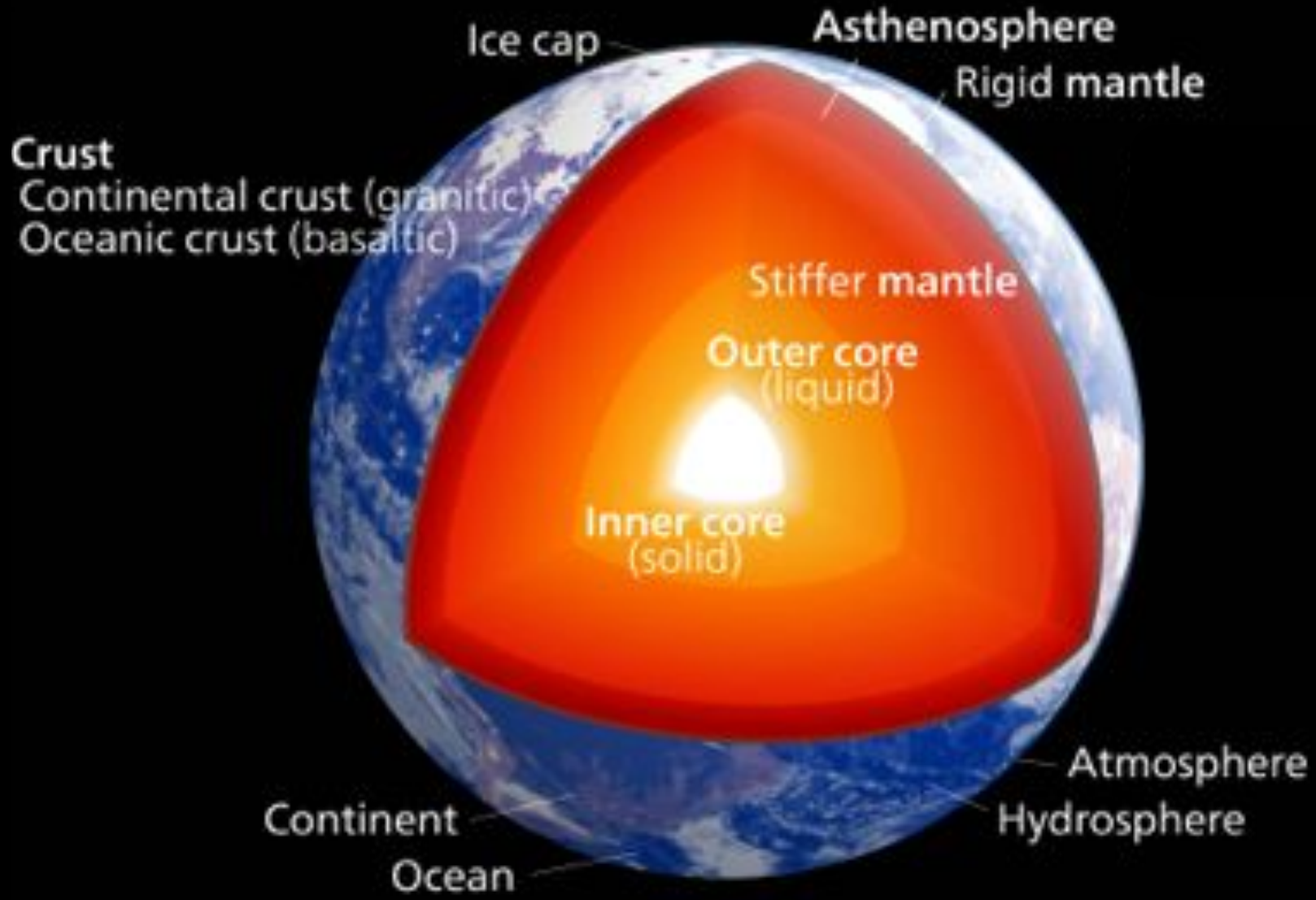
A Differentiated Earth
(Chemical Compositions)

- There are trends in Earth's chemistry
- The **crust** is relatively <u>depleted</u> in Fe, Mg but <u>enriched</u> in Si, O



Whole Earth Earth's Crust

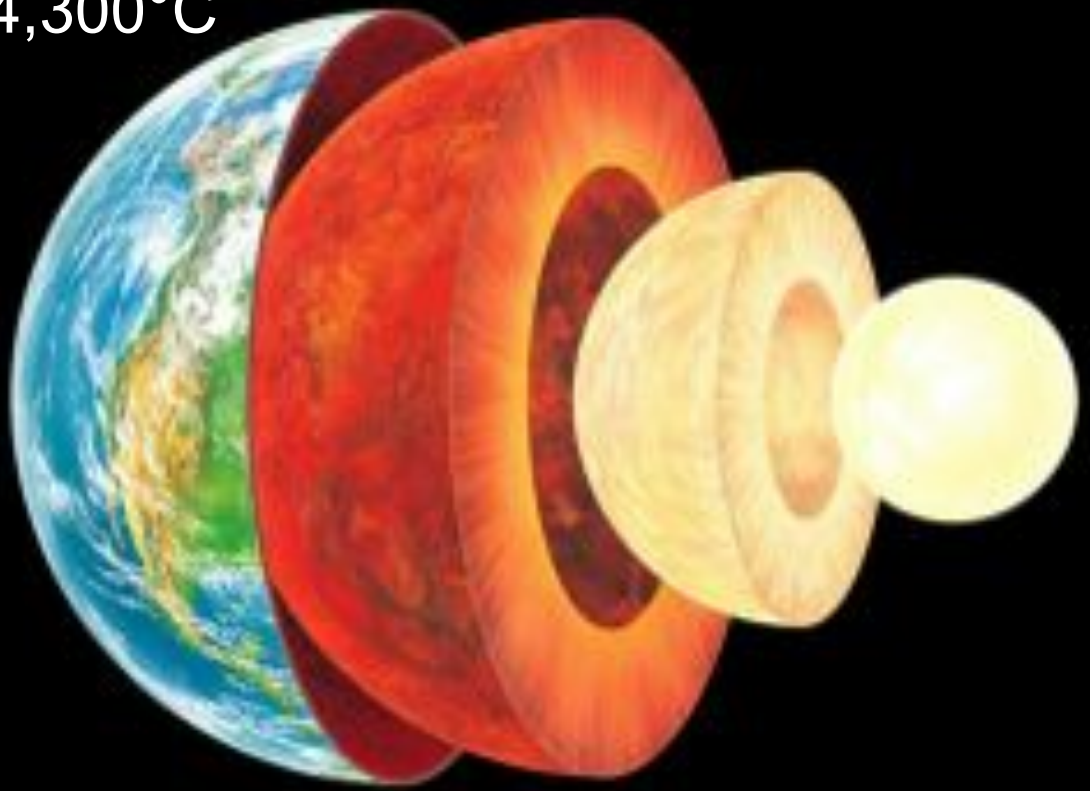
Earth's Major Layers: **Core, Mantle, Crust**



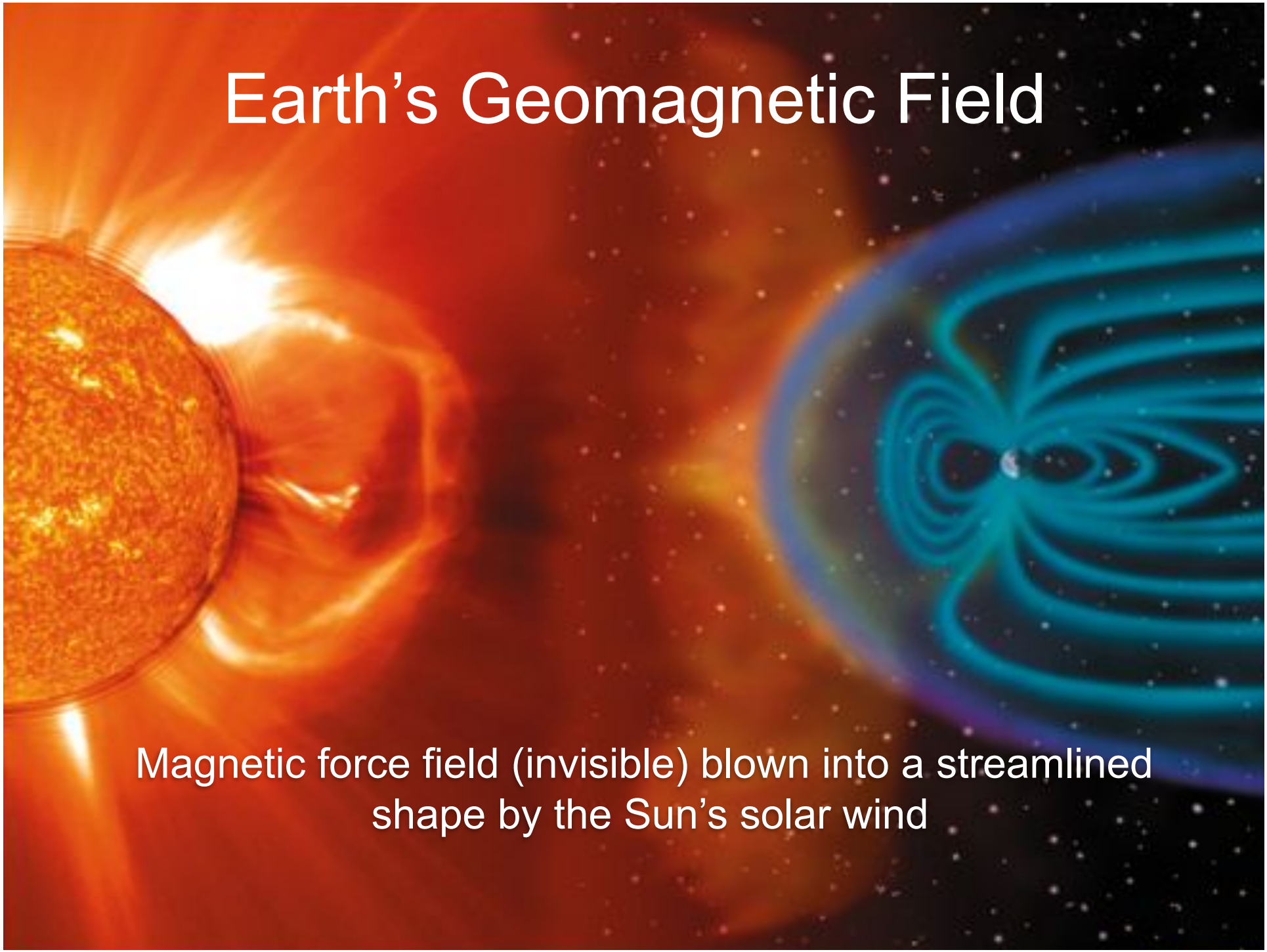
Earth's Core

- Iron mixed with nickel, oxygen – metallic
- 3500 km thick
- Outer core: liquid; convects heat & generates a magnetic field
- Inner core: solid; over 4,300°C

Iron-nickel



Earth's Geomagnetic Field

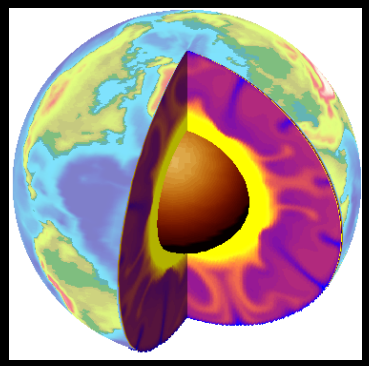


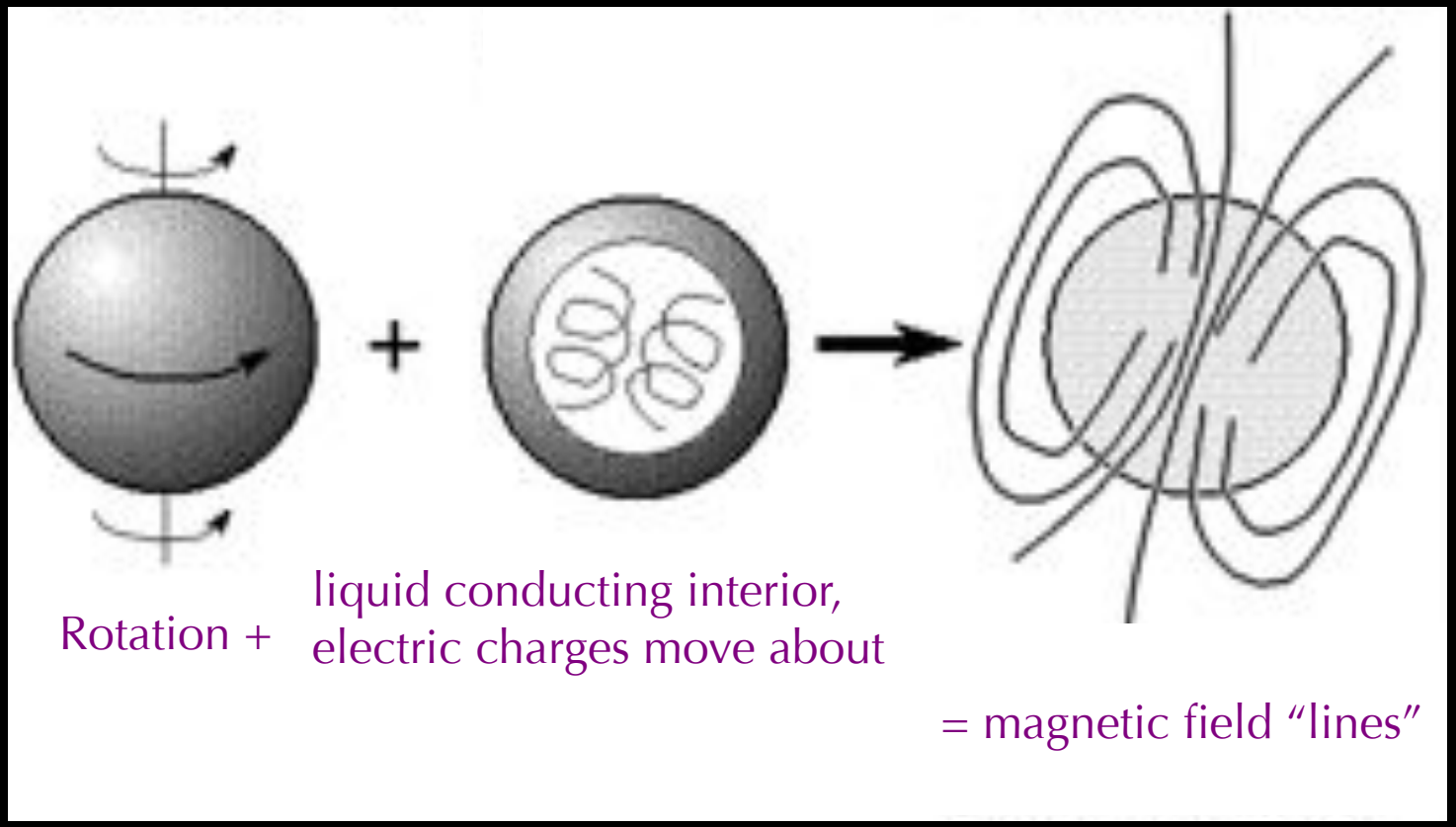
Magnetic force field (invisible) blown into a streamlined shape by the Sun's solar wind

How Do You Get a Magnetic Field?

Requirements:

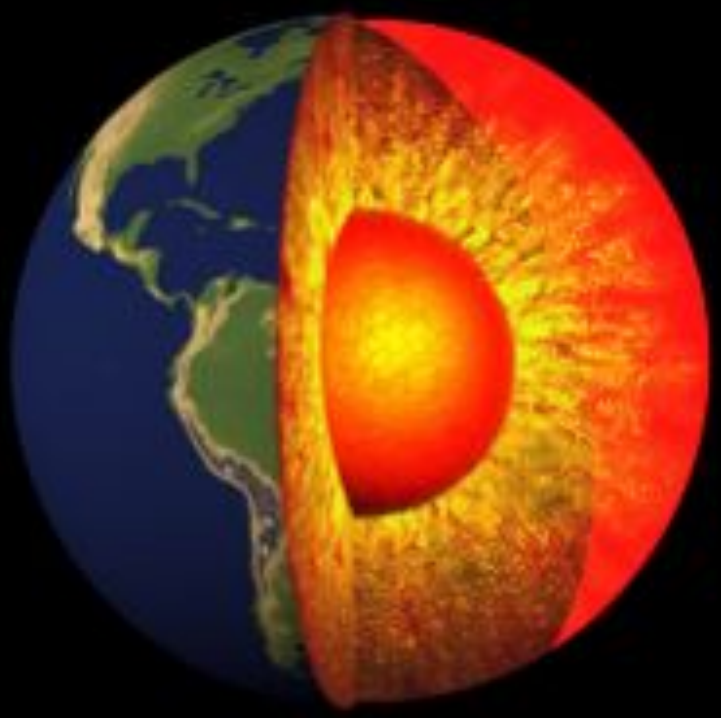
1. Rotation
2. A mobile conductor (iron in the core)

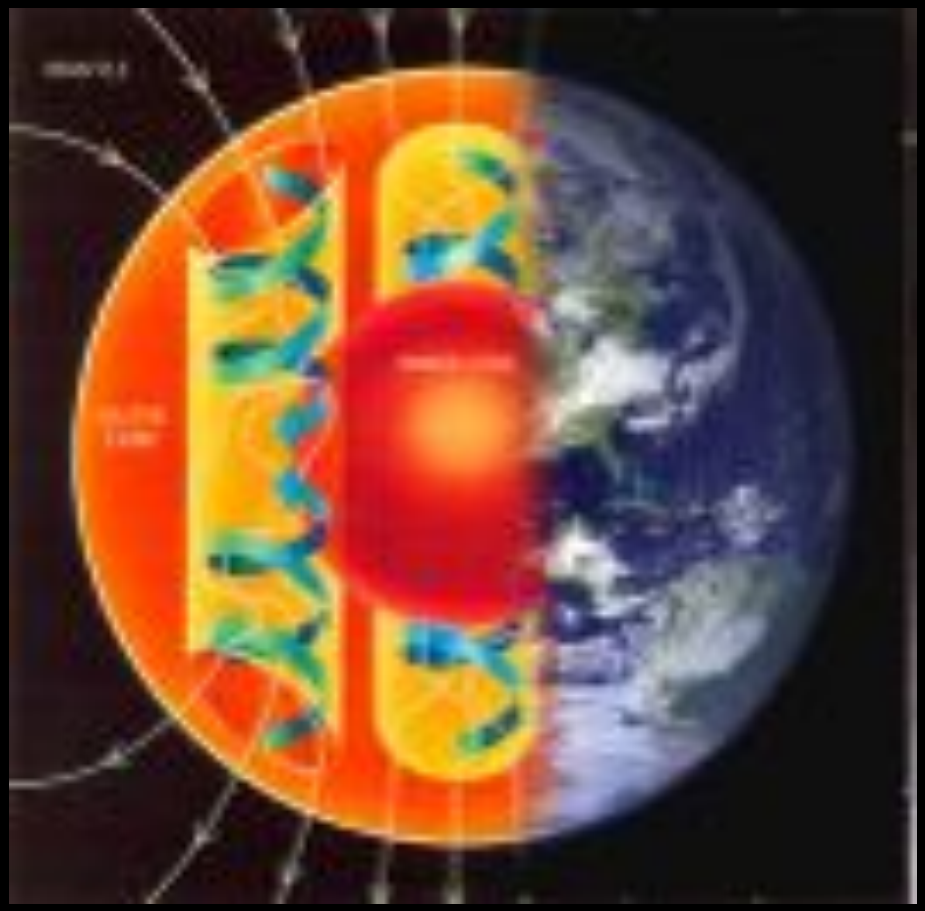




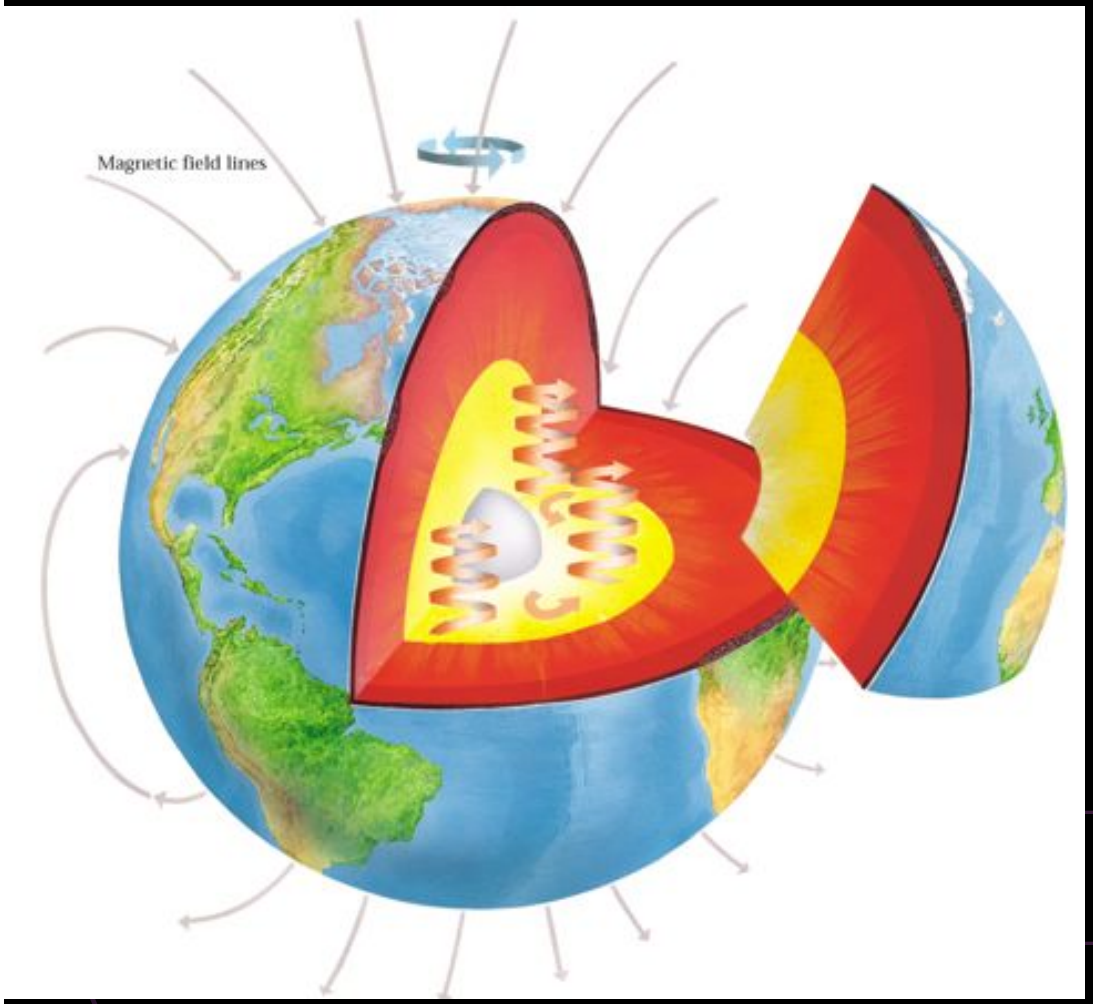
Earth's Core & Magnetic Field

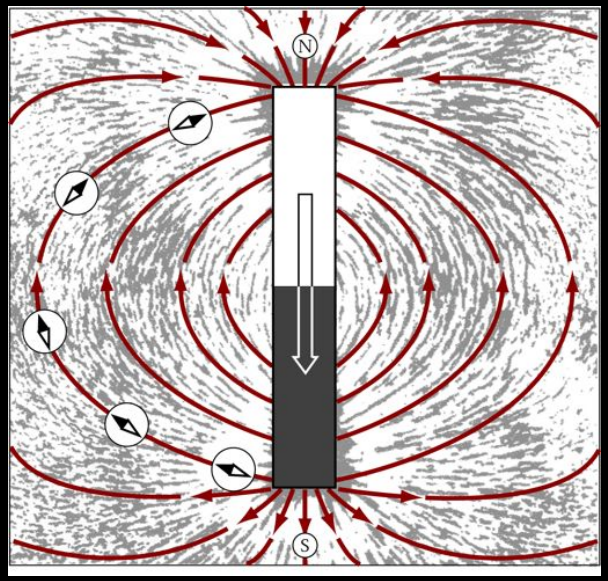
- Fluid motion of liquid iron in the outer core generates Earth's magnetic field





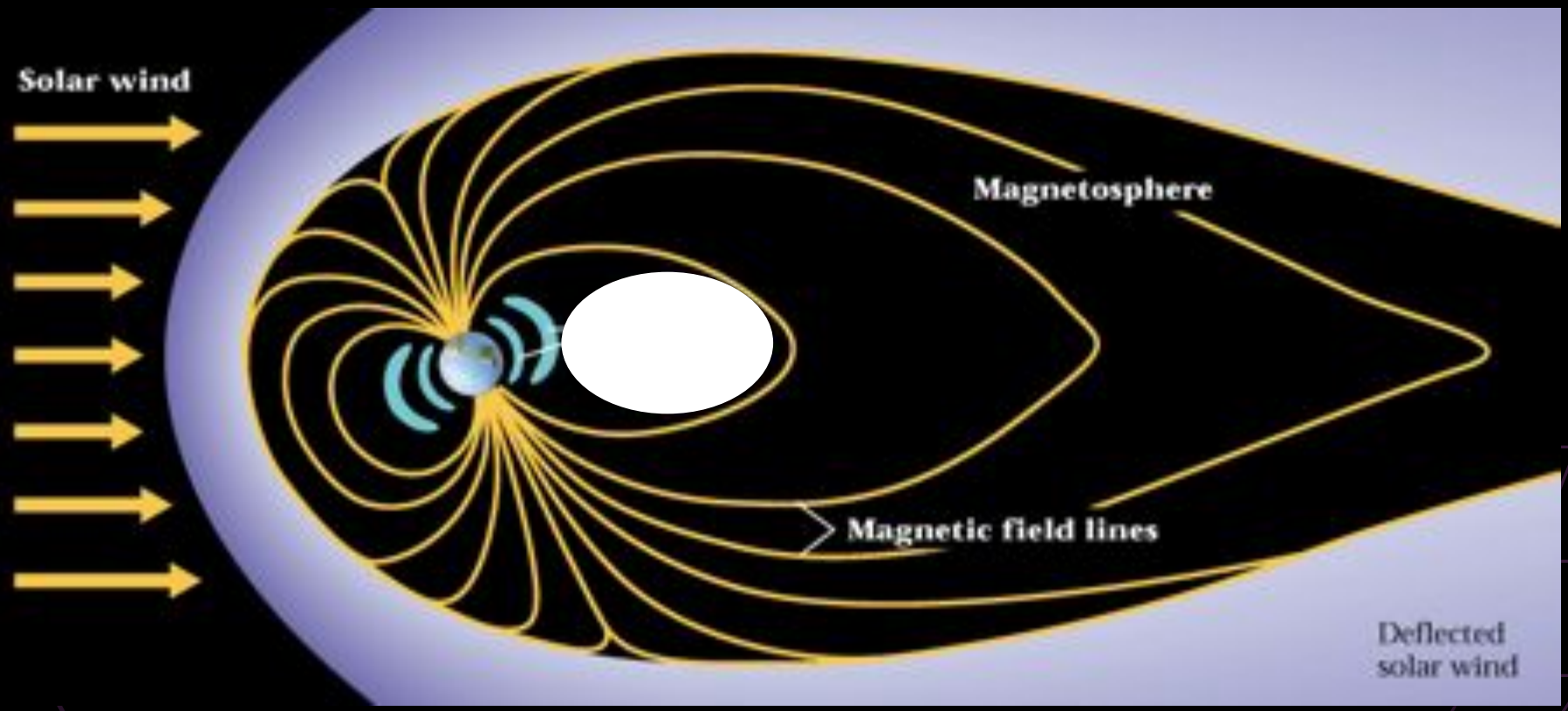
Earth's Magnetic Field





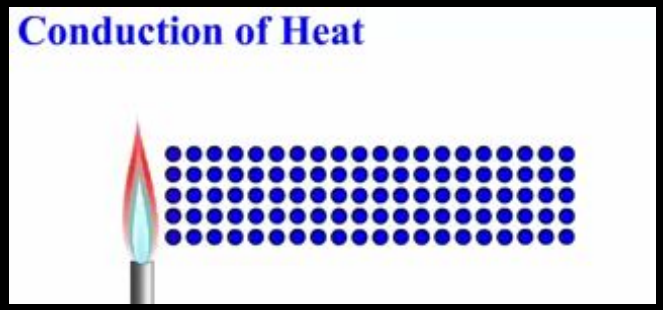
- Earth's magnetic field is like a bar magnet
- Has a **north** and **south** pole; reverses direction every ~ few million yrs

Earth's magnetic field shields us from charged particles in the solar wind

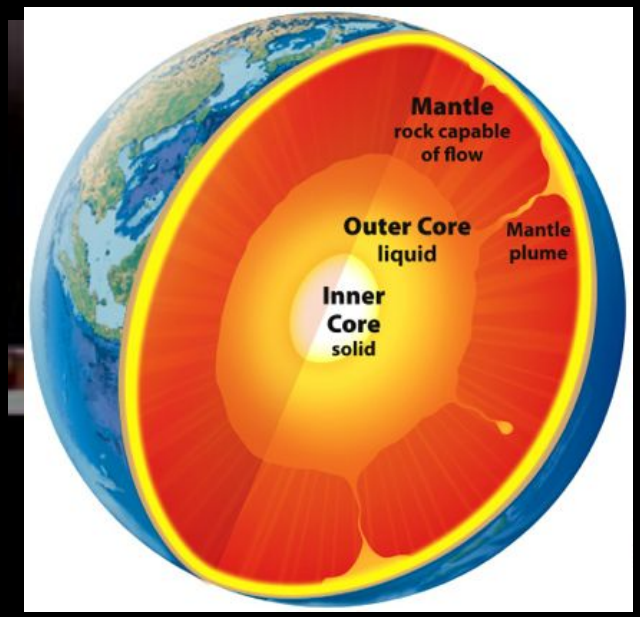


How Does Earth Cool Now?

Conduction: transport of energy in a solid
- molecules vibrate & collide, transferring energy (heat)



Convection: mass movement from a warmer to a cooler region (larger scale)
- implies flow of material



MANTLE PLUMES
warm rock rises,
cool rock descends

Earth's Mantle

- Made of solid rock: Silicate (silicon + oxygen)
- 2900 km thick
- Moves heat around through convection
- Mantle rock also deforms as a fluid

Like Silly Putty, behaves as a:
Solid – over short time
Fluid – over long time

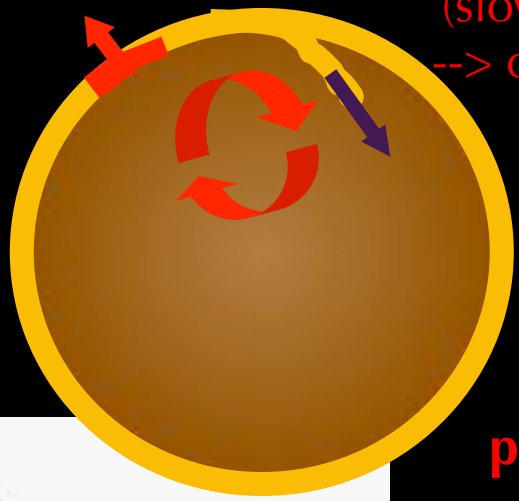
An Efficient Heat Mover - Convection

https://www.youtube.com/watch?v=ryrXAGY1dmE&list=PLEB59A86B25011A77&index=2

Mantle Convection

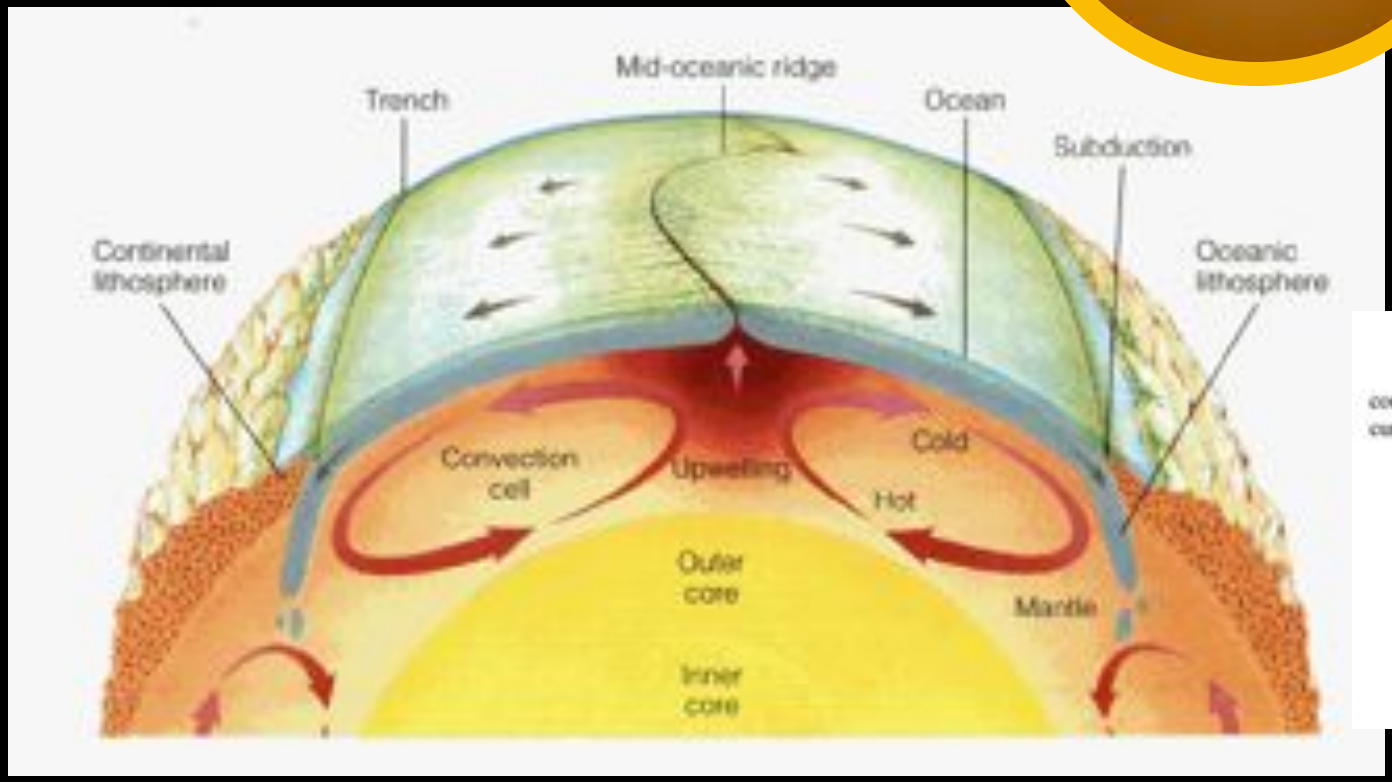
Cooling of rocks by moving them within in the planet's interior

Drives Plate Tectonics



recycling of plates
(slow convection)
--> cooling process

plate tectonics



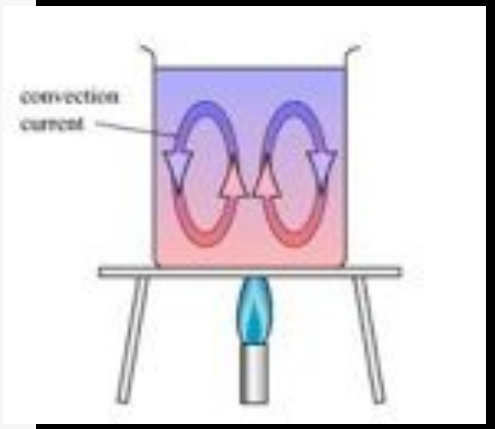
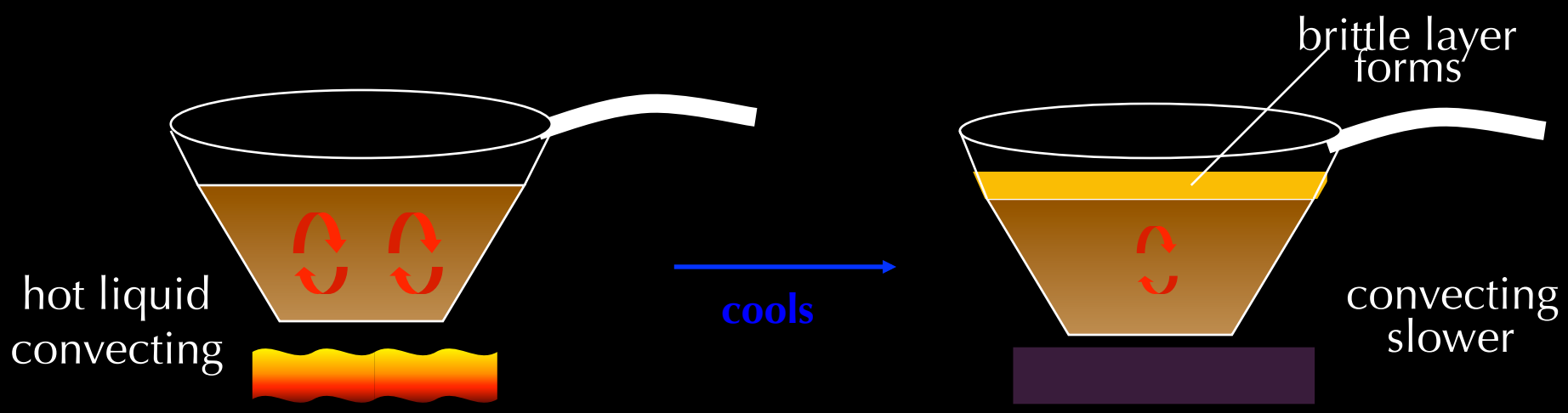
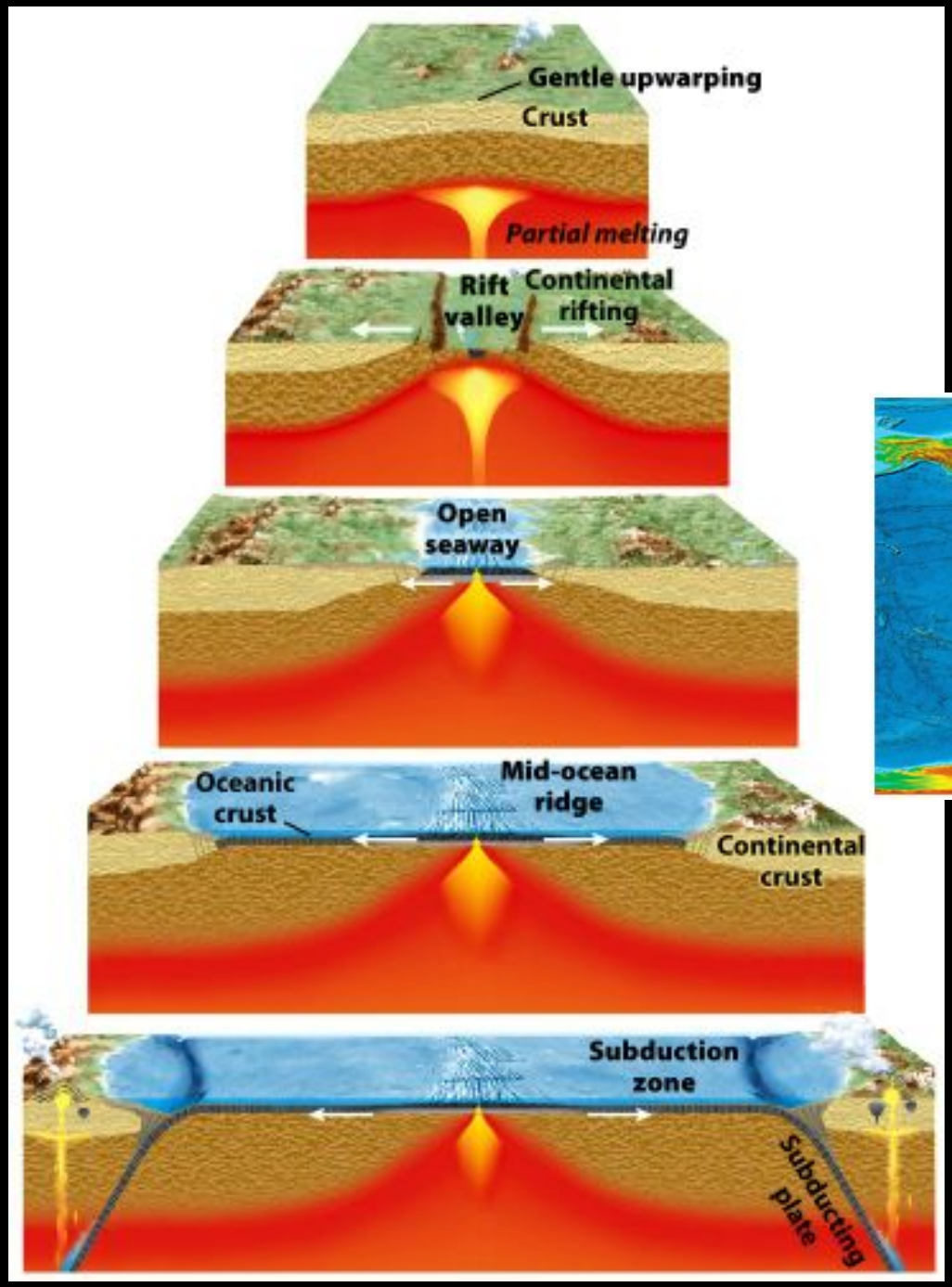
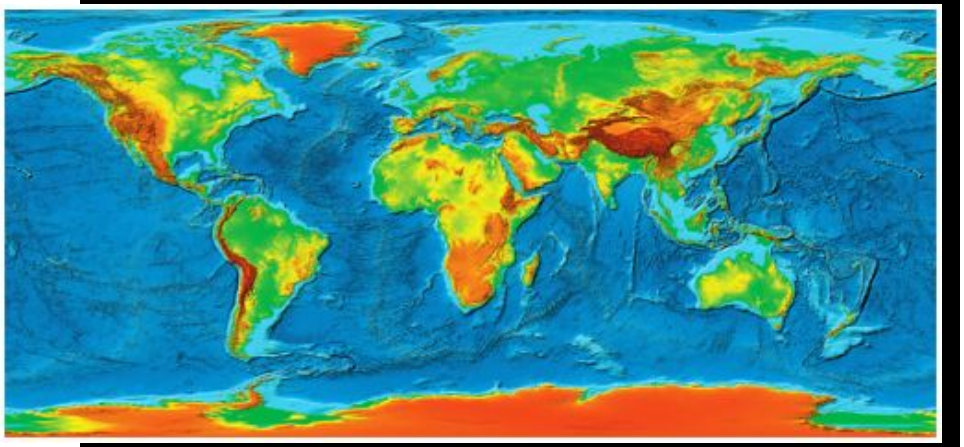


Plate Tectonics Assists Cooling

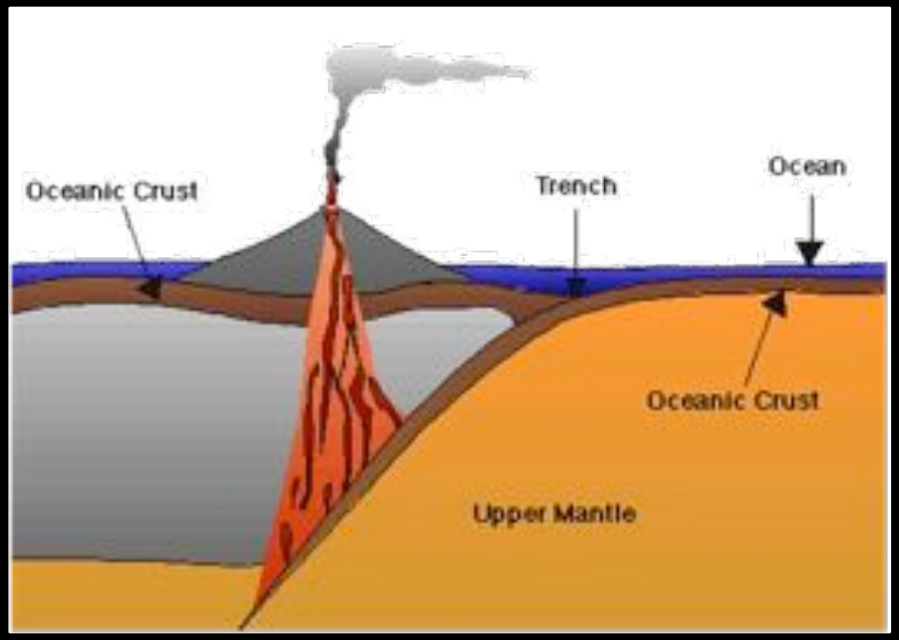


Cooling: The Continental Rifting Process

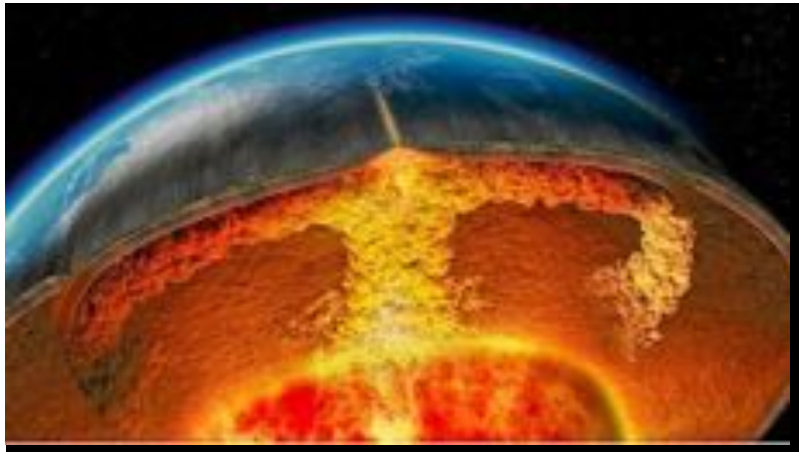




Cooling: Subduction Zone Volcanism



Mount St. Helens, USA:
May 1980



Action Items for Thursday, Sept. 3

1. Read Chapter 2 (2-4 to 2-6)
2. Read Chapter 3 (3-1 to 3-2)
3. Complete homework assignment #2
4. Complete homework assignment #3

What you should know from today:

1. Describe each of the gas giants

2. Define a dwarf planet

3. Describe the sources of heat of early Earth and the consequences of heat build-up

4. Describe Earth's internal layers

5. Describe major processes of these layers