• Three exams, 50% total
• 20 to 25 homeworks, 50% total
  ✓ All homeworks done on-line
  ✓ Assignments close on-line Sunday night by 11PM
  ✓ No late assignments taken
  ✓ Occasional additional assignments that will not be announced beforehand.
  ✓ Frequent movies in class that are on tests

Field trip to Big Island, Feb. 22-24; $150+your own plane ticket
Learning Objective

• Become familiar with fundamental characteristics of Earth and how these intersect your life.
  – Natural Resources
  – Natural Hazards
  – Climate Change
  – Critical Thinking
Core Concepts
You will inherit Earth.

http://www.earthscienceliteracy.org/
How is science done?

#1. Earth scientists use repeatable observations and testable ideas to understand and explain our planet. Any other method is based on faith.
How old is Earth?

#2. Earth is 4.6 billion years old.
#3. Earth's surface is a complex system of interacting rock, water, air, and life.
How does Earth behave?

#4. Earth is continuously changing.
What is special about Earth?

#5. Earth is the water planet.
What is life's role on Earth?

What is the human relationship to Earth?

#7. Humans depend on Earth for resources. Because of population growth the use of natural resources has increased 1000% since 1930.
What are natural hazards?

#8. Natural hazards pose risks to humans. Because of population growth, we are now developing areas previously considered too dangerous for human life.
What is the human impact on Earth?

#9. Humans significantly alter Earth.

Between 1930 and 2000 the number of humans on Earth tripled from 2 billion to 6.1 billion. Last Thanksgiving we reached 7 billion.

50% of Earths land is now disturbed by humans.
Humankind is faced with global challenges. How will we manage them?

**Peak oil** – We probably won’t “run out” of oil. But it is likely to get very expensive.

**Global warming** – How quickly will warming proceed and what are the potential consequences?

**Soil erosion** – It is estimated that 65% of Earths soil is degraded by erosion, desertification, and salinization.

**Fresh water** – Around the world drought, and overuse threaten water resources.

**Economic minerals** – Mineral resources are finite and increased demand can make some of them unaffordable.

Can you think of other global challenges?
http://thinkprogress.org/climate/2013/01/03/1393791/video-on-2012s-extreme-weather-a-jawdropping-year/
Assignments
on-line WileyPLUS
no late assignments accepted

• DUE WEDNESDAY
  – Read Chapter 1
    • Complete “Assessing Your Knowledge”

• DUE FRIDAY
  – Read Chapter 2
    • Complete “Assessing Your Knowledge”
The Universe
The **Milky Way Galaxy**, one of billions of other galaxies in the universe, contains about 400 billion stars and countless other objects.

Why is it called the “Milky Way?”
Welcome to your Solar System, how well do you know your neighbors?
The Solar System consists of

- 8 classical planets
- 5 dwarf planets
- 240 known satellites (moons)
- Millions of comets and asteroids
- Countless particles; and interplanetary space.

Earth, the Sun, and other objects in the Solar System originated at the same time from the same source and have evolved in varying ways since then.
Mercury

- Vertical axis (no seasons)
- Probable molten (Fe) core
- Silicate (SiO$_2$) shell
- Atmosphere created by solar wind
- $227^\circ$C to $-137^\circ$C
Venus
• Axis spin opposite to other planets (why?)
• Is core liquid or solid? - Unknown
• Active volcanism? - Probably
• Atmosphere 96.5% (CO₂)
• 477°C “runaway” Greenhouse Effect
Mars

- Iron core, partially liquid
- Silicate (SiO$_2$) mantle and crust
- Active volcanism? - Probably
- Atmosphere 95.3% (CO$_2$)
- Past “flooding” and fluvial erosion of surface
Water has flowed in the past. But is now locked up as ice in the ground and as polar ice caps. Drainage features due to short-lived melting events.
Between Mars and Jupiter lies the “Main Asteroid Belt”

There are millions of asteroids; ranging from icy to rocky; and several different groups.

Among the oldest materials in the Solar System
Terrestrial planets are small and rocky, with thin atmospheres, silicate and metallic shells.

O, Fe, Si, Mg, Ca, K, Na, Al
Jupiter's Great Red Spot - A hurricane the size of 2-3 Earths lasting several centuries

Does Jupiter have a hard surface?

Lack of hard surface may allow for different winds at different speeds – hence, banding

90% Hydrogen (H), 10% Helium (He)
• Saturn: 9 rings of rock and ice particles, 10,000 km wide and 200 km thick
• Outer layer of frozen ammonia (NH₃)
  96% Hydrogen, 3.35% Helium
• 62 moons
• Uranus: axis tilted completely on its side
• 82.5% Hydrogen, 15.2% Helium, 2.3% Methane (CH₄)
- Neptune: highest winds in Solar system, 2000 km/hr
- 80% Hydrogen, 18.5% Helium, 1.5% Methane (CH₄)
Neptune clouds
The internal structure of Neptune:

1. Upper atmosphere, top clouds
2. Atmosphere consisting of hydrogen, helium and methane gas
3. Mantle consisting of water, ammonia and methane ices
4. Core consisting of rock and ice
Gas Giants are massive planets with thick atmospheres. 
He, H, CO$_2$, H$_2$O, N$_2$, CO, NH$_3$, CH$_4$
Comets are thought to originate from regions of icy, mineral-rich bodies that lie beyond the orbit of Neptune.
What does a comet look like? They are “dirty snowballs.”

Comet Tempel, 19 seconds before impact
Edgeworth-Kuiper belt and Oort Cloud

The Oort Cloud (comprising many billions of comets)

Oort Cloud cutaway drawing adapted from Donald K. Yeoman's illustration (NASA, JPL)
Dwarf Planet

“An object in the Solar System that orbits the Sun, is not a satellite of another object, massive enough to be rounded by its own gravity, has not cleared its neighboring region of planetesimals.”
The beginning of the Solar System 6.9 billion years ago – nebula formation

An ancestral star – ended its life: Red Giant Explosion - Nebula
Formation of a nebula

May 20, 2002
September 2, 2002
October 28, 2002
December 17, 2002
Because the solar nebula was rotating, it contracted into a disc, and the planets formed with orbits lying in nearly the same plane.
Planetesimal accretion - ~5 to 4.6 billion yrs ago
When the Solar wind “turned on”, volatiles were expelled from inner Solar System
98% of the solar nebula is hydrogen (H₂) and helium (He) gas that does not condense anywhere.

Inner Region – Rocks and metals condense, hydrogen compounds (i.e., NH₃, CH₄, H₂O) stay gaseous.

Outer Region – Hydrogen compounds (i.e., NH₃, CH₄, H₂O), rocks, and metals condense.

Gas Giants
Our Sun: A Massive Hydrogen Bomb held together by gravity

- Solar core is site of nuclear fusion.
- H is converted to He, energy released (light and heat).
- Enough fuel to last another 4 to 5 billion years.
Earth’s Geomagnetic Field

Blown into a streamlined shape by the Solar Wind.
In time EARTH’S interior accumulated heat

New atmosphere created by volcanic outgassing and delivery of gases and water by ice-covered comets.
Early Earth

Near Moon...

Earliest phase of Earth heating...
Early Bombardment

2 phases?

Relative dating
http://www.youtube.com/watch?v=Uh
y1fucSRQI
Early Earth began to heat as the last extraterrestrial collisions subsided
1. Rock is a good insulator – stores heat
2. Collisions produced heat that was stored
3. Radioactivity
4. Gravitational contraction

Earth Developed a Magma Sea
4.5-4.0 billion years ago

What is the physical consequence of melting a ball of rock with many different types of elements and compounds?
Temperature reached melting point of iron:

- Liquid iron flowed inward
- Friction raised temperature
- Less dense compounds flowed outward (SiO$_2$ and others)

“Iron Catastrophe”

Planet became chemically differentiated
There are certain trends in Earth's chemistry. The crust is relatively depleted in Fe, Mg and enriched in Si, O.
Earth is probably not built of uniform layers, it is likely mixed somewhat by convection.
MANTLE PLUMES
warm rock rises, cool rock descends

How will the lithosphere respond to a plume?