• 1 Planet Earth

MAIN IDEA
The major geologic features of Earth's surface are (1) the surface fluids (air and water), (2) the continents, and (3) the ocean basins. The characteristics of these features indicate that Earth is undergoing constant change. Earth is unique in the Solar System.

SUPPORTING IDEAS
1. A comparison of Earth with other terrestrial planets provides an insight into the distinguishing characteristics of our planet and what makes it unique.

2. Earth's atmosphere is a thin shell surrounding the planet and is in constant motion. It is unique in the Solar System in that it is composed of 78% nitrogen and 21% oxygen.

3. The hydrosphere is another feature that makes Earth unique. It moves from the ocean to the atmosphere and over the surface in a great cycle.

4. The biosphere exists because of water. Although it is relatively small compared with other major layers of Earth, the biosphere has been a major geologic force operating at the surface.
5. Continents and ocean basins are the principal surface features of Earth.

6. The continents consist of three major components: (a) shields, (b) stable platforms, and (c) belts of folded mountains. All these components show the mobility of the crust.

7. The ocean floor contains several major structural and topographic divisions: (a) the oceanic ridge (b) the abyssal floor, (c) seamounts, (d) trenches, and (e) continental margins.

8. Earth is a differentiated planet, with its materials segregated and concentrated into layers according to density. The internal layers based on composition are (a) crust, (b) mantle, and (c) core. The major internal layers based on physical properties are (a) lithosphere, (b) asthenosphere, (c) mesosphere, (d) outer core, and (e) inner core. Material within these units is in motion, making Earth a changing, dynamic planet.
Earth’s Outermost Layers

• The most dynamic portion of the Earth
  – Atmosphere
    • Thin gaseous envelope surrounding Earth
  – Hydrosphere
    • Water layer dominated by the oceans
  – Biosphere
    • All living things on the planet
  – Lithosphere
    • Rocky outer shell
The Atmosphere

• Insignificant fraction of Earth’s total mass (<0.01%)
  – Moves easily, interacts with oceans and landmasses
    • Circulation patterns are evident from space
    • Solar heat drives this circulation
    • Evaporation and precipitation of water play a role in circulation
The Atmosphere

• Composition is unique in our solar system
  – 78% nitrogen
  – 21% oxygen (not present in early atmosphere)
  – Minor amounts of carbon dioxide, argon and water vapor
• Formation of limestone in the ocean has trapped large amount of CO₂
The Hydrosphere

• Total mass of water on or near the Earth’s surface
  – Covers 71% of Earth’s surface
  – ~98% in oceans
  – 2% in glaciers, groundwater, lakes and streams (fresh water)
  – The presence of water moderates climates and shapes the Earth’s surface
Earth
Antarctica
the cyrosphere
Infrared satellite image of the Gulf Stream

Iceberg
The Biosphere

• All life on Earth
  – Animals & plants on land, in the sea and air
  – Microorganisms, the most common form of life
  – Forms a narrow zone near the Earth’s surface
Higher Plants
Microorganisms
Animals
Marine Reptiles
Ammonoids - Parapuzosia
The Biosphere

• The diversity of life
  – 1.6 million known species
    • insects account for over one-half
    • mammals only ~4000 species (0.025%)
  – 30 million or more may exist
  – Local environment controls distribution
    • Temperature, pressure & chemistry
    • Wide range of environmental conditions
The Biosphere

• The biosphere as a geologic force
  – *Current atmosphere produced by biosphere (Oxygen)*
  – *Ocean composition influenced by biosphere* - precipitation of calcium carbonate
  – *Fossils* fuels
  – *Fossils* record past Earth environments
    • *Current living species account for only 10% of known species throughout geologic history*
Earth’s Internal Structure

• The solid Earth has a layered structure
  – Layers defined by composition and physical properties
  – Compositional layers
    • crust - mantle - core
  – Physical layers
    • lithosphere - asthenosphere - mesosphere - outer core - inner core
Compositional Layers

• **Crust**
  – Outermost compositional layer
  – Definite change in composition at the base of the crust
  – Crust may be divided into 2 types
    • Continental crust
    • Oceanic crust
Compositional Layers

• Crust
  – Continental crust
    • Thicker than oceanic crust - up to 75 km
    • Less dense - 2.7 g/cm$^3$
    • Strongly deformed
    • Much older - may be billions of years old
Compositional Layers

• Crust
  – Oceanic crust
    • Thinner than continental crust - about 8 km
    • More dense - 3.0 g/cm³
    • Comparatively undeformed
    • Much younger - < 200 million years old
    • Composed of basalt
## Crustal Properties

<table>
<thead>
<tr>
<th></th>
<th>Density $\text{g/cm}^3$</th>
<th>Composition</th>
<th>Thickness</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>continental</strong></td>
<td>~2.8</td>
<td>Felsic</td>
<td>Thick: 20-70 km</td>
<td>Old: up to 4 Byrs</td>
</tr>
<tr>
<td><strong>oceanic</strong></td>
<td>~3.2</td>
<td>Mafic</td>
<td>Thin: 2-10 km</td>
<td>Young: &lt;200 Mys</td>
</tr>
</tbody>
</table>
Compositional Layers

• **Mantle**
  – **Largest** layer in the Earth
    • 2900 km thick
    • 82% by volume
    • 68% by mass
  – Composed of **silicate rocks with abundant iron and magnesium**: Mafic
    • Density ranges from 3.2 to 5 g/cm³
    • Fragments found in some volcanic rocks
Compositional Layers

• Core
  – Central mass about 7000km in diameter
  – Average density of 10.8 g/cm³
  – 16% by volume, 32% of mass
  – Indirect evidence of composition
    • Metallic iron
Majors Features of the Continents

• **Shields**
  – Large, flat areas of highly deformed crystalline rock - most more than 1 billion years old
  – *Baseline* complex

• **Stable platforms (cratons)**
  – Areas where the basement complex is covered by layered sedimentary rocks

• **Folded Mountain Belts**
  – Young, linear regions of deformed rocks
Figure 2. Physiographic features. Extent of northern ice sheets from Fullerton and others (2004), and Locke and Smith (2004).

Major Features of the Oceans

• Oceanic Ridge
  – 70,000 km long continuous feature
  – Broad ridge, highly fractured with a central rift valley
  – Fractures, perpendicular to the ridge, are common

• Trenches
  – Lowest areas on Earth
  – Adjacent to chains of volcanoes
Major Features of the Oceans

• Abyssal Floor
  – Abyssal hills - small hills up to 900 m high
    • Cover 80+% of ocean floor
    • Most common landform on Earth
  – Abyssal plains - smooth area adjacent to continents
    • Sediment covered abyssal hills

• Seamounts
  – Isolated peaks of submarine volcanoes
Major Features of the Oceans

• Continental Margins
  – Continental shelf - submerged portions of continents
    • Part of the continent, not the ocean basin
    • Arial extent has varied throughout geologic history
      – 11% of continents are submerged today
  – Continental slope
    • Long slope from continents to ocean basin
RotatingGlobeLQ.mov

http://www.ngdc.noaa.gov/mgg/image/2minrelief.html
Heat driven convection

1. Bottom water is warmed
2. It expands and is therefore less dense
3. It rises to the surface and then spreads out
4. Cooler water at the sides descends to fill the void
A convective thunderstorm
Earthquakes60-95_Nasa.mpg

30_SeaFloor.swf
Plate Tectonics

- Basic idea of *plate tectonics* - Earth’s surface is composed of a few large, thick plates that move slowly and change size.

- Intense geologic activity is concentrated at *plate boundaries*, where plates move away, toward, or past each other.

- Combination of *continental drift* and *seafloor spreading* hypotheses in late 1960s.
The ‘Ring of Fire’
Juan de Fuca plate
Intraplate volcanism
Rising mantle plumes can produce localized hotspots and volcanoes when they produce magmas that rise through oceanic or continental crust. Hawaii is an example.

Composition?
Hurricanes

http://www.youtube.com/watch?v=_SLXYRJnYm0

http://www.rap.ucar.edu/weather/satellite/
What do you need for hurricane formation?
SST > 26.5 C; Coriolis force; weak wind shear

Where and when do these conditions exist in the Atlantic?
Surface Water Temperature (SST)
Hurricanes are “Warm-Core Lows”

Note where rising and sinking motion occurs.
Energy Conversion!

- Hurricanes (a.k.a. Typhoons, Tropical cyclones) are giant machines for converting latent heat to kinetic energy!
- Consider rain rate of 5 cm/day over an area of 500 km radius (typical for tropical depression, tropical storm, and hurricane)
- Over a 7 day lifecycle, the energy released is equal to 50,000 1 MT nuclear explosions!
- This is equivalent to the total explosive yield of the nuclear arsenals of the US and USSR at the height of the Cold War!
“Storm Surge”

causes some of the worst damage
Folly Beach, South Carolina (After Hugo)