Planet Earth: An Owner’s Manual

Unit 1: The Composition, Structure and Functioning of Planet Earth

- Earth Systems
- Earth Materials and Resources (minerals)
- Structure of Planet Earth
- Earth’s Interior Machine
- The Magnetic Field
Unit 2: Understanding the Dynamics of Earth’s Lithosphere – Plate Tectonic Theory and the Scientific Method

- The Rock Cycle
- Continental Drift
- Seafloor Spreading
- Plate Tectonics

Unit 3: Earth Systems that Sustain Humanity - Climate

- The Carbon Cycle
- Earth’s Climate System
- Global Warming and Climate Change

“Civilization exists by geological consent, subject to change without notice.”
- Will Durant (U.S. Historian)

Public Policy
- ✓ Health
- ✓ Insurance
- ✓ Taxation

Foreign Policy
- ✓ Political Instability
- ✓ War

- Energy resources
- Water resources
- Mineral commodities
- Agriculture
- Climate change
- Hurricanes
- Earthquakes
- Flooding
- Mass Wasting
After years of legal entanglements arising from environmental messes and increased scrutiny of banks that finance the dirtiest industries, several large commercial lenders are taking a stand on industry practices that they regard as risky to their reputations and bottom lines.

Mountaintop removal coal mining, West Virginia

Banks Grow Wary of Environmental Risks
NY Times, 8/31/2010

More than 25,000 Long Island homeowners may have to buy flood insurance that costs up to $2,000 because their homes are in newly designated flood-prone areas in federal maps that go into effect next month. Most of the homes moved into flood areas are in southern portions of Nassau County.

New Maps Add 25,000 LI Homeowners in Flood Zones
Newsday, 8/12/2009

Recent war games and intelligence studies conclude that over the next 20 to 30 years, vulnerable regions, particularly sub-Saharan Africa, the Middle East and South and Southeast Asia, will face the prospect of food shortages, water crises and catastrophic flooding driven by climate change that could demand an American humanitarian relief or military response.

The conflict in southern Sudan, which has killed and displaced tens of thousands of people, is partly a result of drought in Darfur.

Climate Change Seen as Threat to U.S. Security
NY Times, 9/08/2009
What are the principal systems or “layers” of Planet Earth?

- Hydrosphere - water
- Atmosphere - air
- Biosphere - life
- Geosphere - rock

What are these composed of? How do they interact with each other?

**Hydrosphere**

- Liquid water in oceans and above and below surface of continents.
- Ice in polar regions and at high elevations.
- Water Vapor in the atmosphere.
- 1.3 Billion cubic kilometers of water on Earth
- 97.5% is saltwater
- 2.5% is freshwater
Questions for Discussion

Why are oceans salty but rivers and lakes are fresh?
Where does the water go when it rains?
Where can you find most of the fresh water on Earth?
Why do streams continue to flow even after it hasn’t rained for weeks?

The Hydrologic Cycle

Distribution of Earth’s Water

<table>
<thead>
<tr>
<th>Water source</th>
<th>Water volume, in cubic miles</th>
<th>Water volume, in cubic kilometers</th>
<th>Percent of fresh water</th>
<th>Percent of total water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oceans, Seas, &amp; Beaches</td>
<td>311,360,309</td>
<td>1,196,500,580</td>
<td>72.5%</td>
<td>51.3%</td>
</tr>
<tr>
<td>Ice caps, Glaciers, &amp; Permanent Snow</td>
<td>3,773,000</td>
<td>9,496,800</td>
<td>8.7%</td>
<td>1.3%</td>
</tr>
<tr>
<td>Groundwater</td>
<td>5,614,000</td>
<td>13,929,000</td>
<td>13.4%</td>
<td>2.7%</td>
</tr>
<tr>
<td>Fresh</td>
<td>1,029,000</td>
<td>2,492,000</td>
<td>5.8%</td>
<td>1.9%</td>
</tr>
<tr>
<td>Saline</td>
<td>1,988,000</td>
<td>46,800,000</td>
<td>1.2%</td>
<td>0.9%</td>
</tr>
<tr>
<td>Soil Moisture</td>
<td>9,959</td>
<td>23,590</td>
<td>0.2%</td>
<td>0.2%</td>
</tr>
<tr>
<td>Ground Ice &amp; Permafrost</td>
<td>71,970</td>
<td>1,722,000</td>
<td>0.3%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Lakes</td>
<td>42,300</td>
<td>1,008,000</td>
<td>0.9%</td>
<td>0.6%</td>
</tr>
<tr>
<td>Fresh</td>
<td>12,690</td>
<td>31,000</td>
<td>0.2%</td>
<td>0.1%</td>
</tr>
<tr>
<td>Saline</td>
<td>96,490</td>
<td>2,290,000</td>
<td>0.1%</td>
<td>0.1%</td>
</tr>
<tr>
<td>Atmosphere</td>
<td>8,095</td>
<td>19,200</td>
<td>0.1%</td>
<td>0.1%</td>
</tr>
<tr>
<td>Steams Water</td>
<td>2,712</td>
<td>66,400</td>
<td>0.01%</td>
<td>0.01%</td>
</tr>
<tr>
<td>Rivers</td>
<td>909</td>
<td>2,120</td>
<td>0.01%</td>
<td>0.01%</td>
</tr>
<tr>
<td>Biologically Fresh Water</td>
<td>260</td>
<td>6,200</td>
<td>0.01%</td>
<td>0.01%</td>
</tr>
<tr>
<td>Total</td>
<td>352,930,000</td>
<td>1,196,500,580</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Questions for Discussion

- Why is the ozone layer important?
- What is the “Greenhouse Effect”?
- Where does the oxygen in our atmosphere come from?
- What processes produce greenhouse gases (CO₂, methane)?

Atmosphere
- Nitrogen 78%
- Oxygen 21%
- Water vapor
- Carbon dioxide
- Methane

Greenhouse gases
Most of the gas in our atmosphere is in the troposphere.

Ozone layer is in the mid-stratosphere

Mt. Everest

Questions for Discussion

How does the biosphere impact the atmosphere?

How does the biosphere impact the geosphere?
The Solar System

- Sun
- Inner Rocky Planets
  - Mercury, Venus, Earth, Mars
  - Moon, Asteroids
- Gas Giants
  - Jupiter, Saturn
- Ice Giants
  - Uranus, Neptune
- Outer “dwarf planets”
  - Pluto, Eris, Quaoar, Sedna

What are the unique features of the Earth?
Kyusha volcano
Japan

Active volcanism

Mountain Belts
- extensive linear tracks of folded and uplifted crust.

Digital Elevation Map of the Moon
What are the most distinctive features of the Moon's Geosphere?
<table>
<thead>
<tr>
<th>Questions for Discussion</th>
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</thead>
<tbody>
<tr>
<td><strong>Why isn't the surface of the Earth covered in craters like the Moon is?</strong></td>
</tr>
<tr>
<td><strong>What is the origin of the craters on the surface of the Moon?</strong></td>
</tr>
</tbody>
</table>

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**Barringer Meteor Crater, Arizona**

- 50,000 years old
- 1200 meters across, 750 meters deep
- Iron meteoroid - app. 50 meters diameter, 300,000 tons
- Impact speed 26,800 mph (12 km/sec)
- Excavated 175 million tons of rock
- Fireball from impact scorched everything up to 10 km

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**Peekskill Fireball, Oct. 9, 1992**
Peekskill Meteorite

Jackson Lakes Fireball, 1972

El Paso bolide, Oct. 9th, 1997
2 meters in diameter
Airburst at 36 km altitude = 500 tons of TNT
**Tunguska Event**

• 1908 explosion of bolide over Siberian forest.
• Several tens of meters at app. 10 km altitude.
• 10–100 megaton explosion.
• 2000 km$^2$ of forest devastated.
• Most likely a small, stony asteroid.

**Chesapeake Bay Bolide Impact**

• Eocene Epoch, 35 ma
• 85 km in diameter
• 1.3 km deep
• Rock fractured to depth of 8 km
• 3–5 km bolide
• Crater is now buried 300 meters below the surface under post-Eocene strata.
Chesapeake Bay Crater

K-T Bolide Impact

- Cretaceous - Tertiary Boundary
- 65 million years ago
- App. 180 km diameter
- Mult-ring impact basin
- 10 km bolide
- 200,000 km³ of the Earth’s crust vaporized, melted or ejected by impact.
- Possible cause of mass extinction (dinosaurs, ammonites, pterosaurs, etc.)
The K-T Mass Extinction Event
The end of the Age of Dinosaurs?

Impact Size-Frequency Graph

Peekskill
every hour
every day
every year
every century
every millennium
every million years
every hundred million years
once in Earth's history

1 m 10 m 100 m 1 km 10 km 100 km
impactor size
(at crater is about 10 times larger)

atmospheric explosion or small crater
Tunguska
tsunamis, widespread devastation, climate change
Chesapeake
mass extinction

K-T

Earth is the “Goldilocks” planet - just right.

Big bowl: too hot. Medium bowl: too cold. Small bowl: just right. This goes against all of the thermodynamics I ever learned!
Venus – too hot!

- almost as large as the Earth.
- very thick atmosphere of carbon dioxide and sulfuric acid – NO WATER.
- hottest planet: 890° F at surface.
- Surface pressure = 90 atm
- geologically active (fewer craters) – shield volcanoes.
- Two relatively elevated regions (“continents”) – Ishtar and Aphrodite terra.
- Several broad depressions (planitia).

Mars – too cold!

- Most Earth-like of all planets.
- Very thin carbon dioxide atmosphere, .01 Atm.
- Cold: -200° F to 40° F. CO$_2$ freezes at the surface.
- Water and carbon dioxide ice – possible liquid water underground.
- Shield volcanoes.
- Evidence for ancient rivers, oceans, and lake basins.
- Sedimentary strata.

Planetary Atmospheres

- 96% CO$_2$
- 3% N$_2$
- Sulfuric Acid
- trace H$_2$O
- 90 atm at surface
- 78% N$_2$
- 21% O$_2$
- H$_2$O
- < 1% CO$_2$, CH$_4$
- 1 atm at surface
- 95% CO$_2$
- 4% N$_2$
- .13 % O$_2$
- .01 atm at surface
Earth - Digital Elevation Model

Hypsographic Curve for the Earth's Surface

Moon - DEM
Questions to Keep in Mind

- Why does the surface of the Earth have a bimodal distribution of elevation?
- What is Earth’s atmosphere so depleted in carbon dioxide?
- Do Earth’s Hydrosphere and Biosphere have anything to do with the evolution of the Geosphere and Atmosphere?