7.014
Lecture 16: Introduction to Ecology and the Biosphere
March 11, 2005

Hierarchical Organization & Ecology

Atom → Molecule → Cell

Ecosystem → Community → Population

Biosphere

Figure by MIT OCW.

Figure removed due to copyright reasons.
Please see:
The Global Nitrogen Cycle

**1 Gt “gigaton”**
- $10^9$ ton
- $10^{15}$ g
- 1 billion

**Gigatons yr$^{-1}$**

**SOIL**
- Industrial N fixation: 100
- Denitrification: 200
- Biological fixation: 140
- Internal cycling: 1200
- Burial: 36
- River flow: 1200

**ATMOSPHERE**
- Denitrification: 110
- Biological fixation: 15

**OCEANS**
- Internal cycling: 8000
- Burial: ?

Nitrogen “Cycle” Without Microbes

**ATMOSPHERE**
- Industrial N fixation: 100
- Fixation by lightning: <3
- Denitrification: 200
- Biological fixation: 140
- Biological fixation: 15

**SOIL**
- Groundwater: ?
- River flow: ?

**OCEANS**
- Internal cycling: 8000
- Burial: ?
Life on Earth Today: Abridged

(Photosynthesis = Respiration)

Photosynthesis

Solar energy

Plants
Phytoplankton

CO₂

Carbon dioxide
gas

H₂O

Water

“CH₂O”

Organic carbon
(mass)

“CH₂O”

Organic carbon
(mass)

N,P,S,Fe,…

Animals
Bacteria

Respiration

Chemical energy or heat

Figure removed due to copyright reasons.

Please see:

**EARLY Life on Earth: Abridged**
*(Photosynthesis > Respiration)*

**Photosynthesis**

- **Plants**
- **Phytoplankton**

**Respiration**

- **Animals**
- **Bacteria**

**CO₂** (carbon dioxide) + **H₂O** (water) → **“CH₂O”** (organic carbon) + **O₂** (oxygen)

**N, P, S, Fe...**

**N, P, S, Fe...**
Figure by MIT OCW.

Figure removed due to copyright reasons.
Please see:
### Present Day Planetary Atmospheres

<table>
<thead>
<tr>
<th></th>
<th>Mars</th>
<th>Earth</th>
<th>Venus</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂</td>
<td>95 %</td>
<td>0.035 %</td>
<td>98 %</td>
</tr>
<tr>
<td>N₂</td>
<td>2.5 %</td>
<td>78 %</td>
<td>2 %</td>
</tr>
<tr>
<td>O₂</td>
<td>0.25 %</td>
<td>21 %</td>
<td>Trace</td>
</tr>
<tr>
<td>H₂O</td>
<td>0.1 %</td>
<td>1 %</td>
<td>0.05 %</td>
</tr>
<tr>
<td>Temp (°C)</td>
<td>-53</td>
<td>16</td>
<td>474</td>
</tr>
</tbody>
</table>


The same processes operate at all scales

Figures removed due to copyright reasons.

Figure by MIT OCW.
Molecular Ecology

Viewing the Biosphere as a network of genes

- 1 billion microbes per liter
- 99.9% have not been cultivated
- Information content of 1 liter = that in human genome
- Most of unknown function

A Sea of Organisms Is... A Network of Genes ("dissolved information")
Cover of Wired Magazine featuring photo of Craig Venter, August 2004, removed due to copyright considerations.

Screenshots of the Sorcerer II web site have been removed due to copyright considerations. Please see: http://www.sorcerer2expedition.org/version1/HTML/main.htm
Take Home Messages

- Ecology – life at different scales
- Emergent Properties
- Organism ↔ Environment \( TWO \) WAY
- Life has shaped Earth’s features
- Biosphere - geosphere have co-evolved
- Genetic inventory unknown
- Microbes Rule!