Lecture 1: Introduction to Ecology and the Biosphere
Feb. 7 2007

Hierarchical Organization and Ecology
One successional pathway:

- Soils exposed less than 20 years: willow and Dryas
- Soils exposed 45-80 years: sitka alder, scattered cottonwood
- Soils exposed 100 years: sitka, alder, scattered spruce
- Soils exposed 150-200 years: dense sitka spruce and western hemlock

Glacier Bay

Direction of glacial retreat

Figure 50.12a

Youngest Community

Soils exposed less than 20 years: willow and Dryas

Soils exposed 45-80 years: sitka alder, scattered cottonwood

Soils exposed 100 years: sitka, alder, scattered spruce

Soils exposed 150-200 years: dense sitka spruce and western hemlock

Oldest Community

N$_2$ fixation

20 km
Primary Succession at Glacier Bay

Alder – roots fix nitrogen
Hemlock
Spruce

Early-mid successional Late-mid successional Climax

Youngest Moraine Oldest Moraine

Nitrogen Concentration
(g per m² of surface)

Nitrogenase enzyme
Substrate, N₂

Binding of Substrate
Reduction

Product:
 released from Free Nitrogenase can bind another molecule of N₂
Ammonia, NH₃

Adapted from: LIFE: The Science of Biology, Purves, Orians, and Heller, 2001
The Global Nitrogen Cycle

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

Nitrogen “Cycle” Without Microbes
Life on Earth Today: Abridged

(Photosynthesis = Respiration)

**Photosynthesis**

Plants
Phytoplankton

\[
\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{“CH}_2\text{O”} + \text{O}_2 \quad \text{(N,P,S,Fe….)}
\]

**Respiration**

Animals
Bacteria

Chemical energy or heat

Solar energy

Freeman, Figures 6.9, 7.10a, and 7.13
The Global Carbon cycle

- Combustion: 5.3
- Land use changes: 0.6-2.6
- Respiration: 90-120
- Photosynthesis: 100-120
- Net accumulation in ocean: 1.6-2.4
- Gas exchange between air and ocean: 100-115
- Geological Reservoir

After Post et al., 1998
Emergent Property

Atmospheric Carbon Dioxide (Mauna Loa)

from SeaWiFs Project website
**EARLY Life on Earth: Abridged**
*(Photosynthesis > Respiration)*

Solar energy

**Photosynthesis**

Plants
Phytoplankton

\[
\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{"CH}_2\text{O}" + \text{O}_2
\]

Carbon dioxide (gas)
Water
Organic carbon (solid)
Oxygen

Chemical energy or heat

**Respiration**

Animals
Bacteria

\[
\text{CH}_2\text{O} \rightarrow \text{N, P, S, Fe} \ldots
\]

Formation of Earth
4.5 billion years ago

Chemical evolution

Origin of life – 3.8 billion years ago

Anoxygenic phototrophs
(photosynthetic bacteria)

Oxygenic phototrophs
(cyanobacteria)

Prokaryotes

Eubacteria

Archaeabacteria

Eukaryotes

Modern eukaryotes

Development of ozone shield

Carbon burial

Today: Release of fossil carbon

% O\(_2\) in atmosphere

Marine origin of life
Formation of Red beds

Terrestrial origin
Formation of fossil fuels

Billions of years before present

0

1

2

3

4

Chemical evolution

Photochemical synthesis

Formation of Earth 4.5 billion years ago

Adapted from Brock and Madigan, *Biology of Microorganisms*
Banded iron formations

Red beds

Oceanic origin

Terrestrial origin

\[ \text{Fe}^{2+} + \text{O}_2 \rightarrow \text{FeO}_3 \]

Absorption of Oxygen Released to Primitive Atmosphere

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>

Similar processes at all scales

Molecular Ecology

Viewing the Biosphere as a network of genes
A Sea of Organisms is...
A Network of Genes ("dissolved information")

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

Craig Venter
Wired Magazine
August 2004
Scorcerer II Expedition

Overview

The Scorcerer II Expedition is the highlight of the Nature Institute’s preponderant 3 Event Series. This event is well known as the scientist who pioneered methods of aquatic gene analysis used to elucidate the human genome. The event features the development of revolutionary techniques and a detailed study of the art of taxonomy. The program also includes a series of lectures by world-renowned experts in the field.

“Scorcerer II Expedition: World Sampling Route”

Latest News

02/14/19 [2:10 PM]

The Nature Institute announces a new expedition set to explore marine DNA and RNA sequencing of marine life. The expedition will focus on sampling from various oceans and seas, aiming to identify over 1,000 species and 50 million new species. The project is expected to span several years.

In one drop of water are found all the secrets of the oceans.

— Matthew Cullen

Institute for Biological Diversity Alternatives
Challenger Expedition

Craig Venter Takes on the Challenge

Environmental Genome Shotgun Sequencing of the Sargasso Sea


2 April 2004 Science

- 1.2 million new genes
- 1800 new ‘species’

Estimated genetic inventory of the planet: 20-30 billion genes.
Most of them microbial
Take Home Messages

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