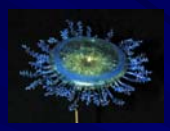


Water and Life

How large is the earth?

Radius: 3986 mi (4000 mi)

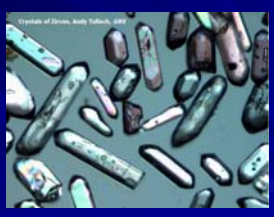
Diameter: 7973 mi (8000 mi)

Circumference: 25,048 mi (25,000 mi)

Volume of Water: 400 billion billion gallons
326 million mi^3

Earliest Evidence of liquid Water on Earth ~ 4.3 bya

Western Australia, 2001



Zircon Crystals

Earth's oldest terrestrial materials

Pillow Lavas

Basaltic Extrusive Rock

3.5 bya




Sources of Earth's Water

Earth's Mantle

Asteroids

Comets



Setting the stage for the evolution of life

Water is an essential precursor to life.

Water and Life

The most abundant substance in living systems

70%

Plants	~ 80%
New born baby	~ 77%
Grown man	~ 65%
Grown woman	~ 58%
The elderly	~ 50%

Average person has about 50 quarts of body water

A loss of just 5 percent of the body's total water will cause the mouth to go dry, the surface of the skin to shrink, and may even cause hallucinations

A loss of more than 12 - 15 percent total body fluid would be fatal.

The longest anyone has ever survived without water is **12 days**

Water Loss

15 percent of human water loss is through respiration

20 percent is lost through perspiration

65 percent is lost by excretion

Water and Life

Water is an ideal medium for life processes.:

1. retains heat, moderates temperature
2. excellent solvent: transports nutrients, life compounds
4. Participates in biochemical reactions

Water and Life's Beginnings

Water, Carbon, and Life

Living organisms consist of assemblages of similar complex carbon compounds (organic) and require water to develop.

- To grow and develop, organisms must assemble complex carbon compounds from external sources of carbon.
- Assembling complex carbon compounds requires energy and reaction with water.
- Metabolism and reproduction are controlled by proteins. Protein synthesis requires reaction with water.

Water, Life, and the Earliest Organisms

Early Organisms and Conditions on Earth

Ammonium
Carbon Dioxide
Hydrogen
Helium
Water Vapor

What's missing?

Oxygen

The Earliest Organisms

Anaerobic

live in low-oxygen environments or in the absence of oxygen.

Autotrophic

Self-feeding. Cannot consume other organisms for energy.

Two Types of Autotrophs

Photoautotroph

Use light energy to assemble complex carbon compounds (organic) from simpler carbon-containing molecules (CO_2)

Chemoautotroph

Use energy from chemical reactions to assemble complex carbon compounds (organic) from simpler carbon-containing molecules

Photoautotroph

A **photoautotroph** is an organism that assembles complex organic compounds from simple carbon-containing molecules using energy from **light**.

Photosynthetic Algae

Photo = light

Complex organic compounds
(initially sugars $C_6H_{12}O_6$)

Simple carbon molecule: **CO_2**

Plants
Photosynthetic Bacteria

Chemoautotroph

A **chemoautotroph** is an organism that produces complex organic compounds from simple carbon-containing molecules using energy from **chemical reactions**

Energy from Chemical Reactions

Zinc/manganese

Sulfur/potassium nitrate

The Earliest Organisms: Chemoautotrophs

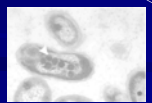
A **chemoautotroph** is an organism that produces complex organic compounds from simple carbon-containing molecules using energy from **chemical reactions**

simple inorganic molecule

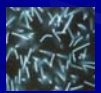
CO_2

Chemical Reactants (energy)

Iron
Sulfur



complex organic compounds



Evidence for Earliest Organisms

Chemoautotrophs

Embedded in the lava are numerous tubular structures left behind by ancient microbes

~ 3.5 bya

tubes contain carbon that represents organic material left behind by early organisms.

Photoautotrophs

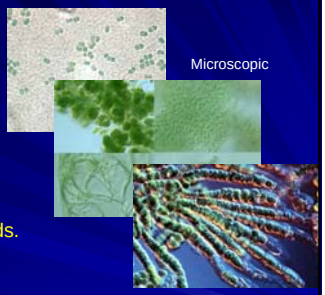
2.5 – 3.0 bya

Cyanobacteria

(Blue-green algae)

Photosynthetic

Fix carbon dioxide into complex organic compounds.



$$6CO_2 + 6H_2O \xrightarrow{\text{light}} C_6H_{12}O_6 + 6O_2$$

(Simplified)

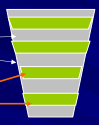
- removed carbon dioxide
- **production of oxygen**

Stromatolites

The oldest **macroscopic** evidence of life on Earth, at least 2.5 billion years old

Colonies of Photosynthetic Cyanobacteria

Stromatolites



Cyanobacteria colonies

Effect? Produced billions of tons of O_2

Increase in atmospheric O_2?

Little Alteration of the Earth's Atmosphere

Ammonium
Carbon Dioxide
Hydrogen
Helium
Water Vapor
Oxygen = 0.21%

Photosynthesis

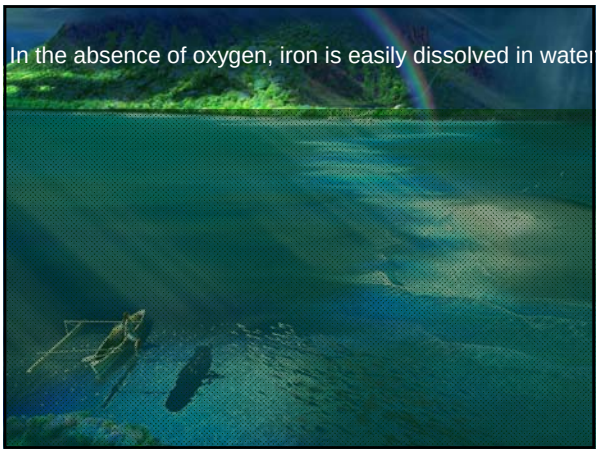
$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$$

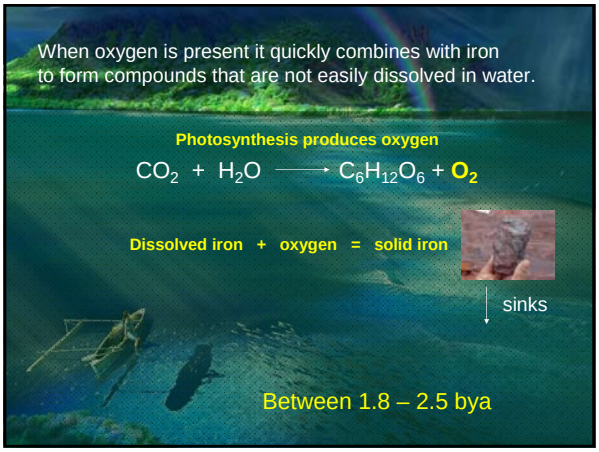
Billions of tons of oxygen

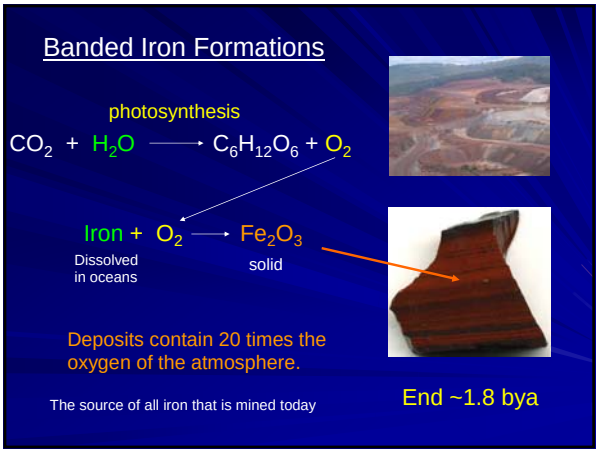
Iron

Iron oxide

Does not dissolve in water: insoluble

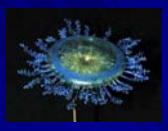

In the absence of oxygen, iron is easily dissolved in water


When oxygen is present it quickly combines with iron to form compounds that are not easily dissolved in water.
Photosynthesis produces oxygen
$CO_2 + H_2O \rightarrow C_6H_{12}O_6 + O_2$
Dissolved iron + oxygen = solid iron
sinks
Between 1.8 – 2.5 bya


Banded Iron Formations
photosynthesis
$CO_2 + H_2O \rightarrow C_6H_{12}O_6 + O_2$
Iron + $O_2 \rightarrow Fe_2O_3$
Dissolved in oceans
solid
Deposits contain 20 times the oxygen of the atmosphere.
The source of all iron that is mined today
End ~1.8 bya

Oxygen in the Atmosphere/Oceans

Emergence of more complex cells
Multicellular Organisms
Increased complexity/diversity of organisms



Diversification of Aquatic Life
- all modern phyla of animals develop
- first vertebrates emerge
- fishes diversify

480-400 Mya - first land plants and animals arise

Why did it take so long?

Water Screens Out Ultraviolet Radiation

~ 500 million years ago

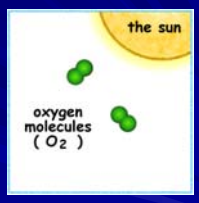
Higher Oxygen Levels

Ozone Layer

The ozone layer screens out harmful UV radiation

Terrestrial Life

First land plants ~480 mya



Carboniferous Period

About 350 million years ago

"the age of swamps and coal"

245 mya – 65 mya

Age of Reptiles

Warm
Wet
Productive

Subsequent Timeline

Reptiles ~ 245 million years ago

Mammals ~65 million years ago

Primates ~30 million years ago

Pre-humans ~5-8 million years ago

Homo sapiens ~200,000 years ago