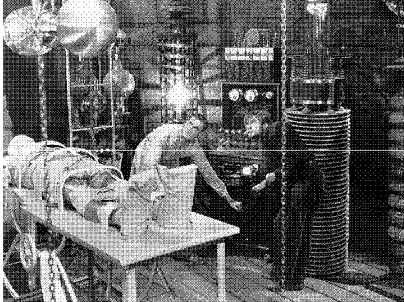


Tuesday, October 19
The Evolution of Life

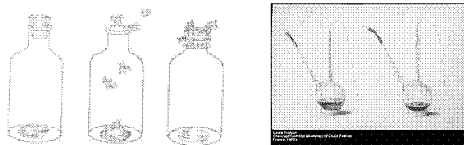


Quiz #2 will be on Friday.

The Evolution of Life
Key Concepts

- 1) Raw materials for life (complex carbon compounds) came from multiple sources.
- 2) The “**RNA World**” hypothesis states that replicating RNA was the precursor to life.
- 3) Eukaryotic life and an oxygen atmosphere began during the Proterozoic Eon.

The problem of how life arose from non-life is called “abiogenesis”.

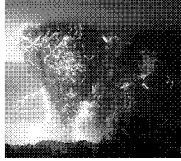


Redi & Pasteur showed that abiogenesis is **not** an everyday occurrence.

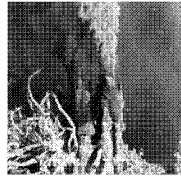
How were simple raw materials assembled into the first life forms?

Before life existed on Earth, complex carbon compounds could have come from:

1) Lightning discharges in volcanic gases (verified experimentally).



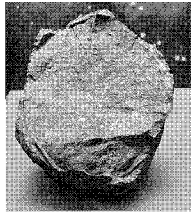
2) Chemical reactions near deep-sea volcanic vents.



3) Carbon-rich meteorites from space.

Amino acids, and other carbon compounds, are found in some meteorites.

One class of meteorites, called "carbonaceous chondrites", are rich in carbon compounds.



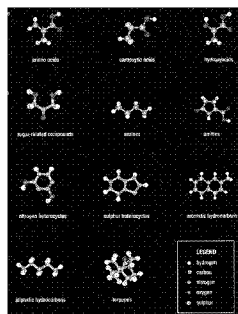
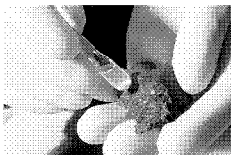
About 5% of meteorites are carbonaceous chondrites.

The Murchison Meteorite, a carbonaceous chondrite

Over 70 amino acids have been found in meteorites.

Isotope ratios show an extraterrestrial origin.

Mix of left- and right-handed molecules shows a non-biological origin.

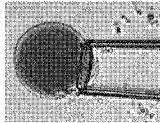
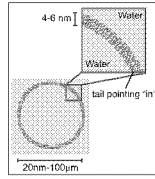


Building a cell: **Lipid vesicles** are a naturally occurring precursor to cell membranes.

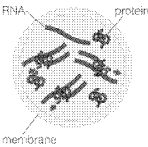
Spherical lipid membranes (or "vesicles") assemble spontaneously in liquid water (like soap bubbles in air).

They split in two if they grow large enough.

Perfect containers for proto-life!



Vesicles + carbon compounds don't necessarily lead to life.

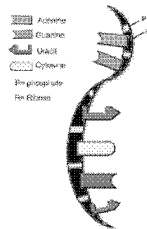


One possible scenario for how life began is the "**RNA world**" hypothesis: RNA is the precursor to life.

RNA is easier to make than DNA, & probably came first.

RNA has many useful properties.

It stores information.
It catalyzes its own replication.
It catalyzes other reactions, too.

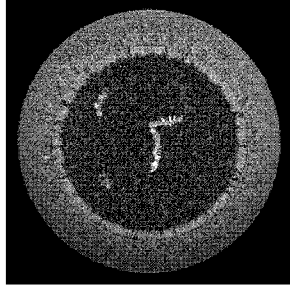


Simple chains of RNA are seen to form in water in the presence of phosphates; RNA can be made in the absence of life.

A free-floating strand of RNA enclosed in a lipid vesicle is a sort of "proto-cell".

Inside the protective vesicle, the RNA can duplicate itself.

When the vesicle grows & splits, each new vesicle encloses copies of RNA.



Evolution by natural selection:
proto-cells with **more efficient** reproduction paths reproduce more rapidly, and dominate numerically.

If the proto-cell contains amino acids, then RNA catalyzes protein formation.

Proteins fold into enzymes that are **more efficient** catalysts than RNA.

Proteins take over as catalysts.

One final step to modern life:
DNA becomes the agent of information storage & transmission.

DNA is more stable than RNA, and is a less error-prone replicator.

RNA is relegated to a subsidiary role, carrying instructions to the site of protein synthesis.



Welcome to DNA World!
Home of the first true prokaryotes.

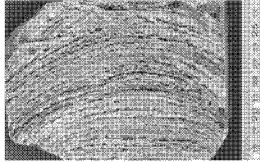
The Archaean Eon: Time of prokaryotes.

(From 3.8 Gyr ago until 2.5 Gyr ago.)

DNA now stores information,
proteins act as enzymes.

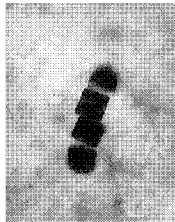
Energy source either
photosynthesis or
chemosynthesis.

No oxygen in atmosphere:
no air-breathers.



The Proterozoic Eon: Time of single-celled life
and the rise of oxygen.

(From 2.5 Gyr ago until 0.54 Gyr ago.)



The emergence of **photosynthesis**:

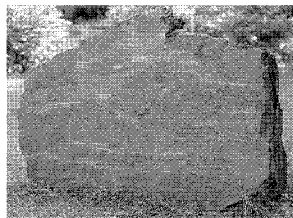
First, it used H_2S instead of H_2O ,
so no oxygen was produced.

Then, it used $CO_2 + H_2O$ to make O_2 .

At first, O_2 produced by photosynthesis went
to oxidize minerals such as iron.

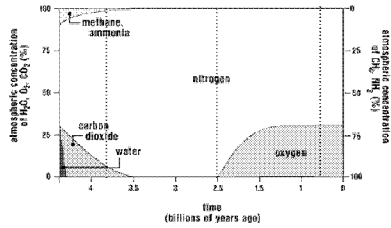
Banded Iron Formations
dating to this era are rich
in iron oxide.

They contain 20× as much
oxygen as the Earth's
current atmosphere!



2.1 Gya banded iron formation

Atmospheric oxygen rose rapidly once the surface minerals were all oxidized.



Bad News for anaerobic (non-air-breathing) prokaryotes, but Good News for emerging eukaryotes!

Tomorrow's Lecture:
The Evolution of Us:
Living in the Phanerozoic

This Week's Reading:
Chapter 6

