

The Early Fossil History

- **Microscopic Fossil Prokaryotes (3.375 Gya)**
Non-Nucleated Cells: Prokaryotes
(Archaea & Bacteria)
Anaerobic Photosynthesis
- **Fossil Mats (Stromatolites) (3.0 Gya)**
Colonial Cyanobacteria
Aerobic Photosynthesis
- **Fossil Algae (2.1 Gya)**
(Nucleated Cells: Eukaryotes)
- **Multicellular Fossils (Sponges) (0.60 Gya)**
- **Complex Animals (and tracks on land) (0.53 Gya)**
“The Cambrian Explosion”
followed eventually by
- **Primates (0.060 Gya) and *Homo Erectus* (0.001 Gya)**
Extinction of the Dinosaurs at 0.065 Gya

Biochemistry and the History of the Earth's Atmosphere

First Chemical Indicators (δC^{13}) of Carbonaceous Life: (3.85 Gya)

Atmospheric Constituents : CO_2 , CO , N_2 , H_2O , $H_2(\uparrow)$ **Note: No O_2 or O_3**

Anoxygenic Photosynthesis & Biological Methane (CH_4) Production

Anoxygenic Photosynthesis: Uses H_2 , H_2S , S , or other molecules in place of H_2O

Slow Oxygenation (3.85 to 2.33 Gya)

Oxygen increases from 10^{-12} to 10^{-5} PAL (PAL = 21% Oxygen)

Anaerobic Decomposition: $CO_2 + 2H_2O \rightarrow CH_4 + 2O_2 \uparrow$

Oxygenic Photosynthesis: $CO_2 + H_2O + h\nu \rightarrow "CH_2O" + O_2 \uparrow$

" CH_2O " = $(1/6) C_6H_{12}O_6$ (Glucose)

and

Anoxic Fermentation & Methanogenesis: $2CH_2O \rightarrow CH_3COOH \rightarrow CH_4 + CO_2$

but also

Methane (and oxygen) Eaters: $CH_4 + 2O_2 \rightarrow 2H_2O + CO_2$

Iron Oxidation: $Fe + H_2O \rightarrow FeO + H_2 \uparrow$ **and** $3FeO + H_2O \rightarrow Fe_3O_4 + H_2 \uparrow$

Banded Iron Formations at 3.4 Gya

• The Great Oxygenation (2.33 Gya)

Oxygen increases from 10^{-5} to 10^{-2} PAL

Extinction of many species by Oxygen Poisoning

Ozone Formation $3O_2 + h\nu \rightarrow 2O_3$

Evolution: The History of Life On Earth

A Summary

The Earth was formed 4.57 Gya

Life appeared on Earth about 3.85 Gya

Microscopic fossil evidence of life at 3.47 Gya

Eukaryotes (nucleated cells) appear at 2.1 Gya

Complex animals of diverse types appear at 0.53 Gya

and

The last 0.5 Gyr has produced an increasing number and diversity of species*.

***Species:** A group of organisms capable of interbreeding and producing fertile offspring.

Evolution as a Fact

- Life has been present on the Earth for at least 3.5 Gyr,
- and probably for 3.85 Gyr.
- The paleontological fossil record clearly shows temporal evolution - both within species and as speciation.
- The evolutionary trend has been toward greater diversity and complexity with increasing numbers of species.
 - Evolutionary sequencing and time scales can be established through radio dating techniques. (*cf . supra*)
- Evolution and Speciation continues to the present day
- and is observed to occur in nature and the laboratory

Evolution as Theory

Evolutionary Theory attempts to explain the facts of evolution in terms of natural processes.

- The strength of any scientific hypothesis lies in its ability to explain the observational evidence in this way.
- The success of a scientific theory lies in its predictive ability - and its testability or falsifiability

Darwin's Theory of Evolution possesses great explanatory and predictive power.

Its precepts and predictions have been extensively tested.

The same cannot be said for the various alternative hypotheses which have been proposed.

Darwin & The Theory of Evolution

Evolutionary Theory attempts to explain the facts of evolution and speciation in terms of natural processes.

Charles Robert Darwin (1809-1882)

1839:

“Journal and Remarks”, a.k.a. “The Voyage of the Beagle”

1859:

“On the Origin of Species by Means of Natural Selection, or The Preservation of Favored Races in the Struggle for Life”

1871:

“The Descent of Man, and Selection in Relation to Sex”

Evolutionary Theory: Observational Background

Note that the time scales associated with the formation and evolution of the Earth and of Life were essentially unknown in Darwin's time. The same is true of chemical and isotopic indicators of life. The fossil record was also sparse.

Charles Lyell (1797-1875)

“Principles of Geology” (1830-33)

“Geological Evidences of the Antiquity of Man” (1863”

- Stratification and classification of rocks
- Igneous, Sedimentary, and Metamorphic formations
 - Indications of long-term processes: “Deep Time”
- Geophysical Theory: Catastrophism *versus* Uniformitarianism

Charles Darwin (1809-1882)

“Journal and Remarks” or “The Voyage of the Beagle” (1839)

- Fossils of large extinct mammals - related to living species
 - Fossil seashells and Petrified Wood at altitude
- Geological Activity: Earthquakes and sea floor rising (Theory of Coral Atolls)
- Speciation: Argentine Rheas; Galápagos Tortoises, and “Darwin's Finches”

Hypotheses Regarding the Mechanisms of Evolution

Stasis *ab initio*

Exogenesis & Panspermia

Abiogenesis & Spontaneous Generation

Predestination & “Preprogrammed Evolution”

Transmission of Acquired Characteristics

Jean-Baptiste Lamarck (1744-1829)

Descent with Modification and Natural Selection

Charles Darwin and

Alfred Russell Wallace (1823-1913)

**“On the Tendencies of Varieties to Depart Indefinitely From the Original Type”
(1858)**

But what are the “details” of these mechanisms?

Mendelian genetics: The gene

DNA & RNA: Molecular replication GC &TA(or U)

3 bases per codon' AAA, UGA, UAG are “stops”