

# **The Origins of Life and the Precambrian Evolution**

## **Chapter 14**

### **I) Before Life Began**

#### **A) Important Dates**

- 1) Universe formed — ~16 billion years ago**
- 2) Solar System (i.e., Earth) forms — ~4.6 billion years ago**
- 3) Solid Rock formed on Earth — ~3.8 billion years ago**
- 4) Life on Earth — ~3.8 billion years ago (primarily cyanobacteria [i.e., blue green algae]).**

#### **B) The General Environmental Conditions**

- 1) Molten and cooling rock**
- 2) Lots of water and water vapor but little oxygen**
- 3) No oxygen, but methane (CH<sub>4</sub>), hydrogen (H<sub>2</sub>), and ammonia (NH<sub>3</sub>) or carbon dioxide (CO<sub>2</sub>) and molecular nitrogen (N<sub>2</sub>) atmosphere.**
- 4) Oceans with small continents**
- 5) Hot (i.e., energy)**

### **II) The Emergence of Life on Earth**

**A) The essential problem – to have biological life, there must have been some way to start the system by which unlikely synthetic events occur. Most of the reactions that we know as “biological synthesis” are possible through spontaneous combination given energy and time.**

#### **B) What is needed**

- 1) Inorganic synthesis of amino acids and nucleotides**
- 2) Assembly of polymers**

- 3) Concentration and protection
  - 4) Self-replication of biomolecules
  - 5) Mechanism for variety within limits (i.e., need to have variation but at the same time maintaining useful combinations).
- C) Inorganic synthesis of biologically important molecules — The Oparin-Haldane Model**
- 1) Formation of simple molecules
    - a) Miller experiment – water, methane, ammonia, hydrogen, electricity, heating and cooling.
    - b) Formation of amino acids, nucleotides and sugars can be done abiotically
    - c) atmosphere may not have been reducing but containing carbon dioxide and molecular nitrogen. This environment can also produce biologically important (i.e., formaldehyde ( $\text{H}_2\text{CO}$ ) molecules.
  - 2) Polymer Assembly
    - a) Monomers of nucleotides (A, T, U, C, and G) can be made spontaneously.
    - b) Difficulties in producing polymers
      - i) only one stereoisomer is needed but both are formed
      - ii) “wrong” stereoisomer inhibits polymerization of “correct”
      - iii) multiple equally probable attachment points for nitrogenous base with significant differences in functionality
      - iv) each monomer must be energetically activated
    - c) Aqueous environments hydrolyze (i.e., break down) polymers during synthesis
      - i) activated monomers quickly stick to aluminum-silicate clay
      - ii) clay acts as a catalyst joining monomers into polymers
  - 3) Lipid membranes form spontaneously and can act to concentrate and protect newly synthesized molecules.

## **D) Replication of Biologically Important Molecules**

### **1) Standard Paradigm**



**2) The RNA World – it is believed that RNA may have been the first biologically important molecular to evolve and DNA and Proteins came later.**

- a) RNA is catalytic — RNA can act as an enzyme and cause the formation of reactions (i.e., synthesis) that otherwise would not readily happen**
- b) RNA can form and break phosphodiester bonds in both RNA and DNA**
- c) RNA is ubiquitous and central to replication mechanism of the cell (mRNA, tRNA, rRNA, SNRPs, etc.)**
- d) RNA stores information**
- e) RNA mutates (i.e., can evolve)**

## **III) The Tree of Life**

### **A) Traditional View**

#### **1) Five Kingdoms**

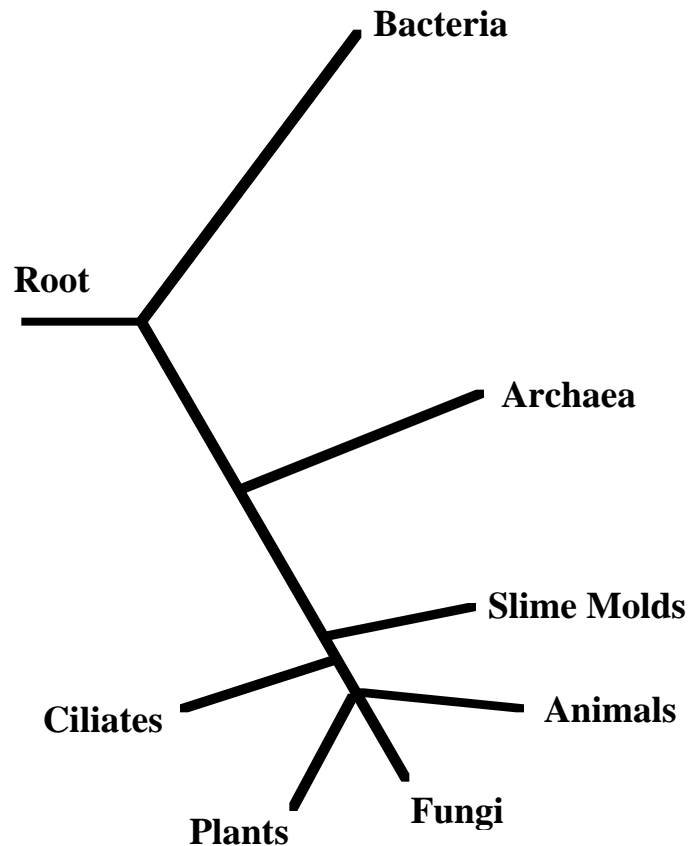
- a) Monera – bacteria and single celled prokaryotes**
- b) Protocista – unicellular eukaryotes**
- c) Plantae – plants**
- d) Fungi – fungus**
- e) Animalia – animals**

### **B) Molecular Tree of Life**

#### **1) Small subunit ribosomal RNA DNA gene**

- a) all organisms have ribosomes of similar composition (i.e., RNA and proteins).**
- b) ribosomal RNA sequences are vitally important to the function of the cell (i.e., translation)**
- c) considerable conservation throughout living organism.**

## 2) Tree of Life According to rRNA DNA sequences



- a) Requires a revision to either three Kingdoms (Bacteria, Archaea, and Eucarya) or several more (i.e., several within Archaea, elimination of the Protista and several new ones for single celled eukaryotes).

### C Rooting the Tree of Life

- 1) Very difficult – what is the ancestor to life, non-life?
- 2) Somewhere between Archaea and Bacteria
- 3) Likely highly evolved, using DNA, similar to Bacteria
- 4) According to the fossil record at least 3.5 billion years old

## **D) Evolution of Organelles**

### **1) Endosymbiotic Theory — (1970; Lynn Margulis)**

- a) mitochondria and chloroplast both have their own DNA molecule**
- b) similar to bacteria in form and structure**
- c) DNA sequence data indicate that mitochondria are closely related to proteobacteria (purple bacteria) and chloroplast are related to cyanobacteria**