

# Genomics and Bioinformatics

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- **Genomes in terms of earth's history:**
  - Earth's environment & cellular evolution
- **Genomes in terms of natural relationships:**  
(Technology driven perceptions!!!!)
  - Early human perceptions of relationships of life forms
  - Modern perceptions based on molecular analysis of genes
    - Single genes (structural [rRNA] or functional [mRNA])
    - Proteins
    - Genomes
  - Bioinformatics (Data mining)
    - Single gene analysis
    - Comparative genomics (why?)
- **Genomes in terms of diversity:**
  - Microbes colonise all corners of the earth (and beyond)
    - Temp-113°C; Radiation; Deserts; Hypersaline; 10 km depth; pH 2; pH 11
    - Nano to mm in size
    - Good, bad and ugly

# Genomes in terms of earth's history

## Earth's environment & cellular evolution:

Understanding evolutionary processes requires familiarisation of time scales and geographical history of our planet (temporal and spatial framework for evolutionary processes). Use of fossil and molecular data is used to test evolutionary hypothesis.

## Timetable of evolution

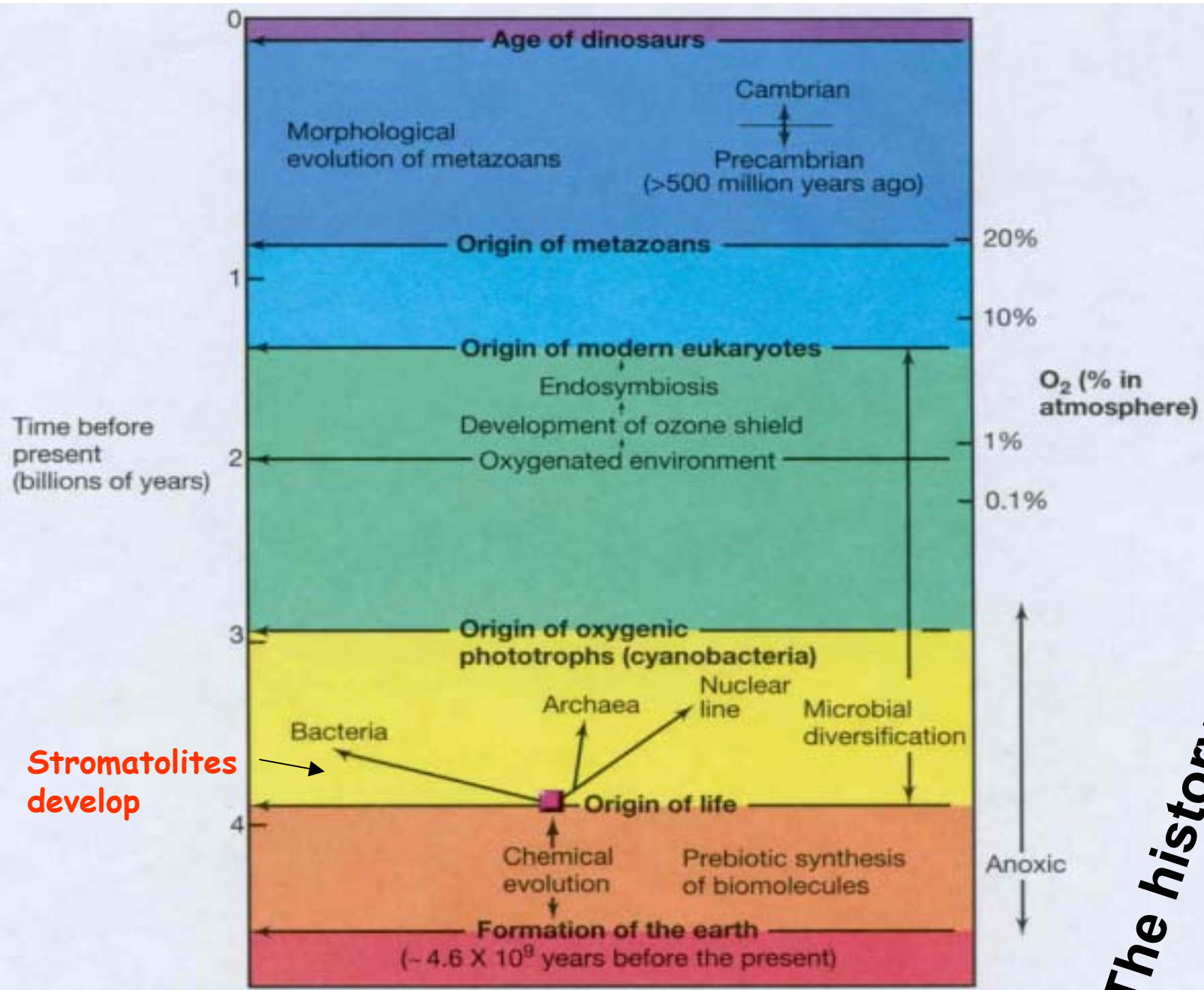
The geology of earth is divided into 4 Eons, which are then further subdivided into eras, periods, subperiods and epochs:

- ◆ Earth is 4.5 billion yrs old (the age of the universe is 10 – 16.5 billion yrs)
- ◆ The earth's history is divided into 4 periods (eons)
- ◆ Priscoan - 4.5 – 4 billion yrs ago
- ◆ Archean - 4 – 2.5 billion yrs ago
- ◆ Precambrian (Proterozoic) – 2,500 – 590 million yrs ago
- ◆ Phanerozoic – 590 million yrs ago to present day)

**Note** that the geological nomenclature (time scales) can vary with geographical regions and many more divisions can be found in the literature.

## Geological History

## Species Diversity



Stromatolites develop

The history of earth and origin of life

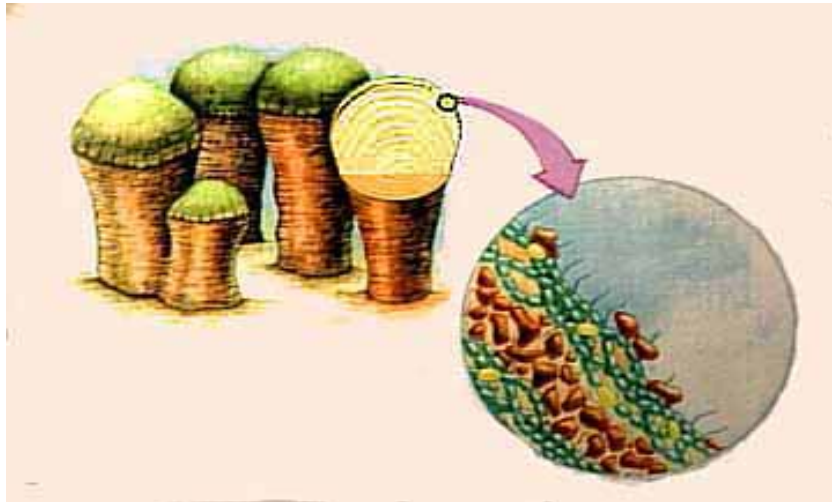
## Ancient Life on our planet

Life on earth started at least 3.5 billion years ago

Stromatolites = Cyanobacteria layers +  $\text{CaCO}_3$  + sediments (A)

The 60 cm Hamlin stromatolites are 3.5 billion yrs old (B)

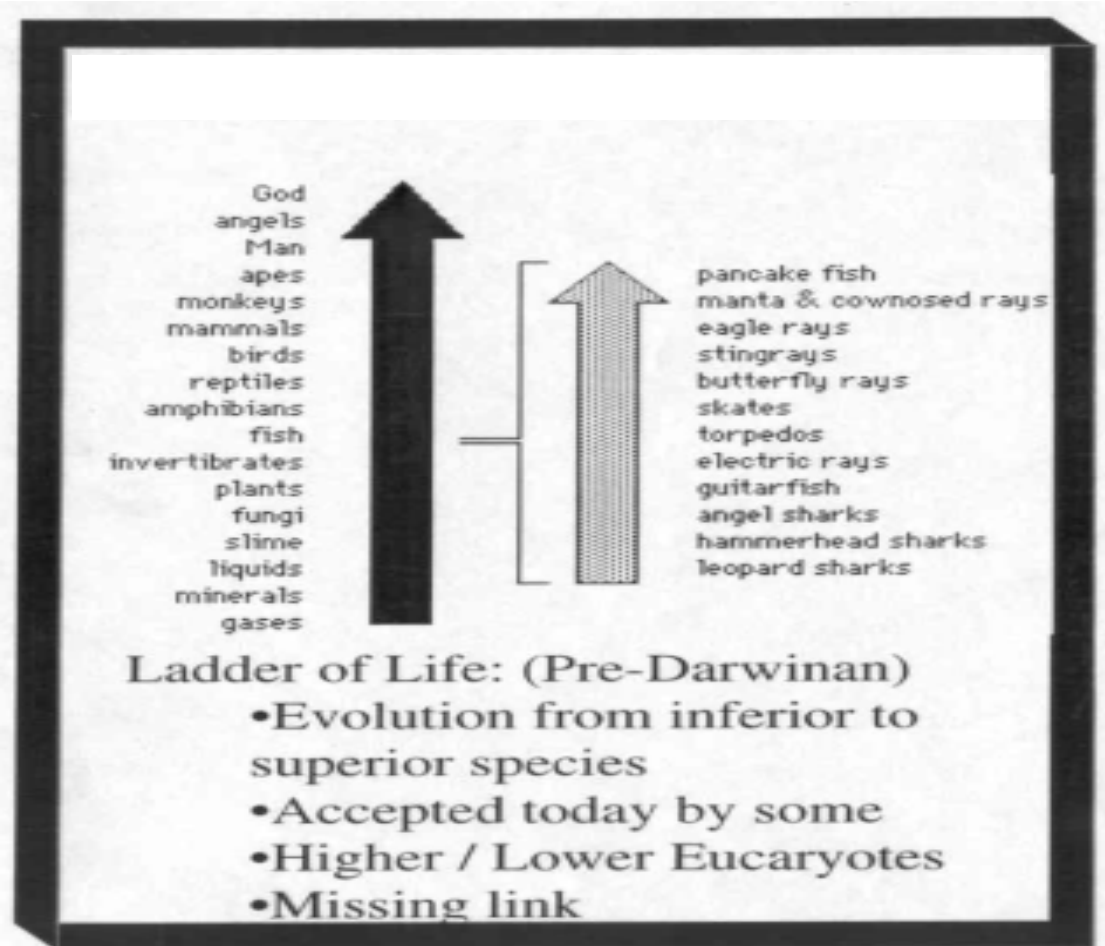
The Sharks Bay stromatolites are 3000 yrs old



# Genomes in terms of natural relationships

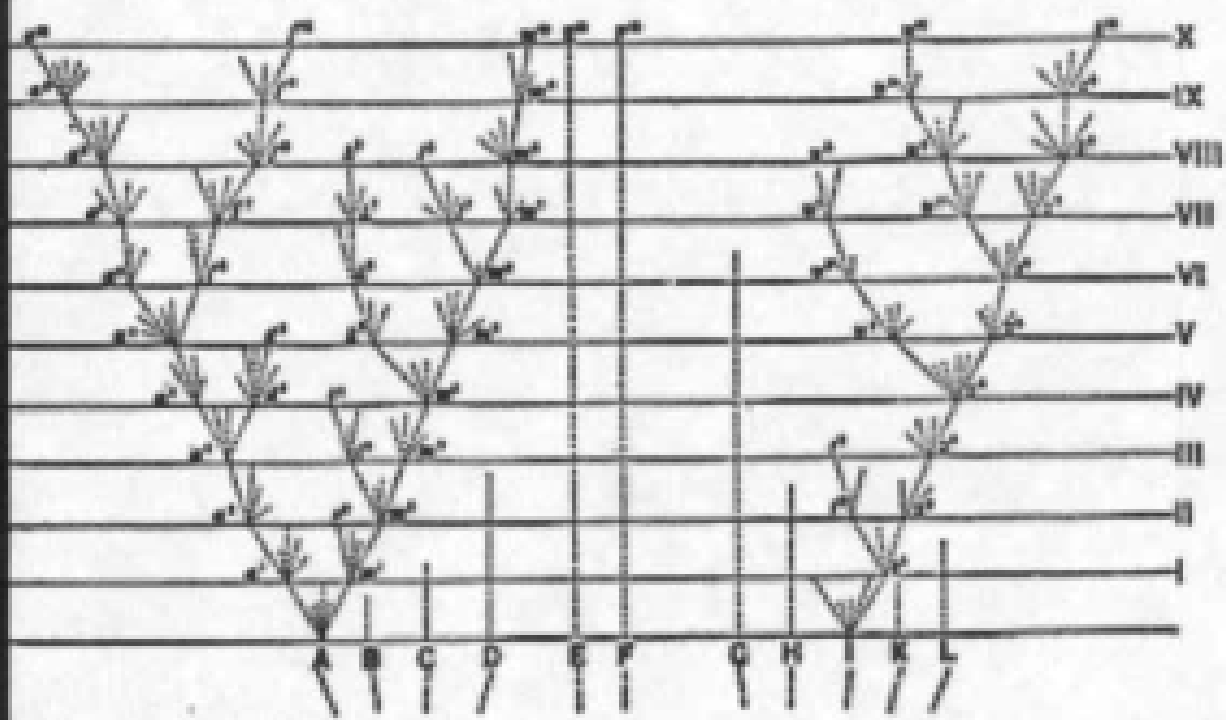
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  - Genomes
- Bioinformatics (Data mining)
  - Single gene analysis
  - Comparative genomics (how, why & what do they tell us?)

- Mankind has always been intrigued with evolution
- A number of theories on relationships of life forms has been proposed
  - The ladder of life (pre Darwinian)



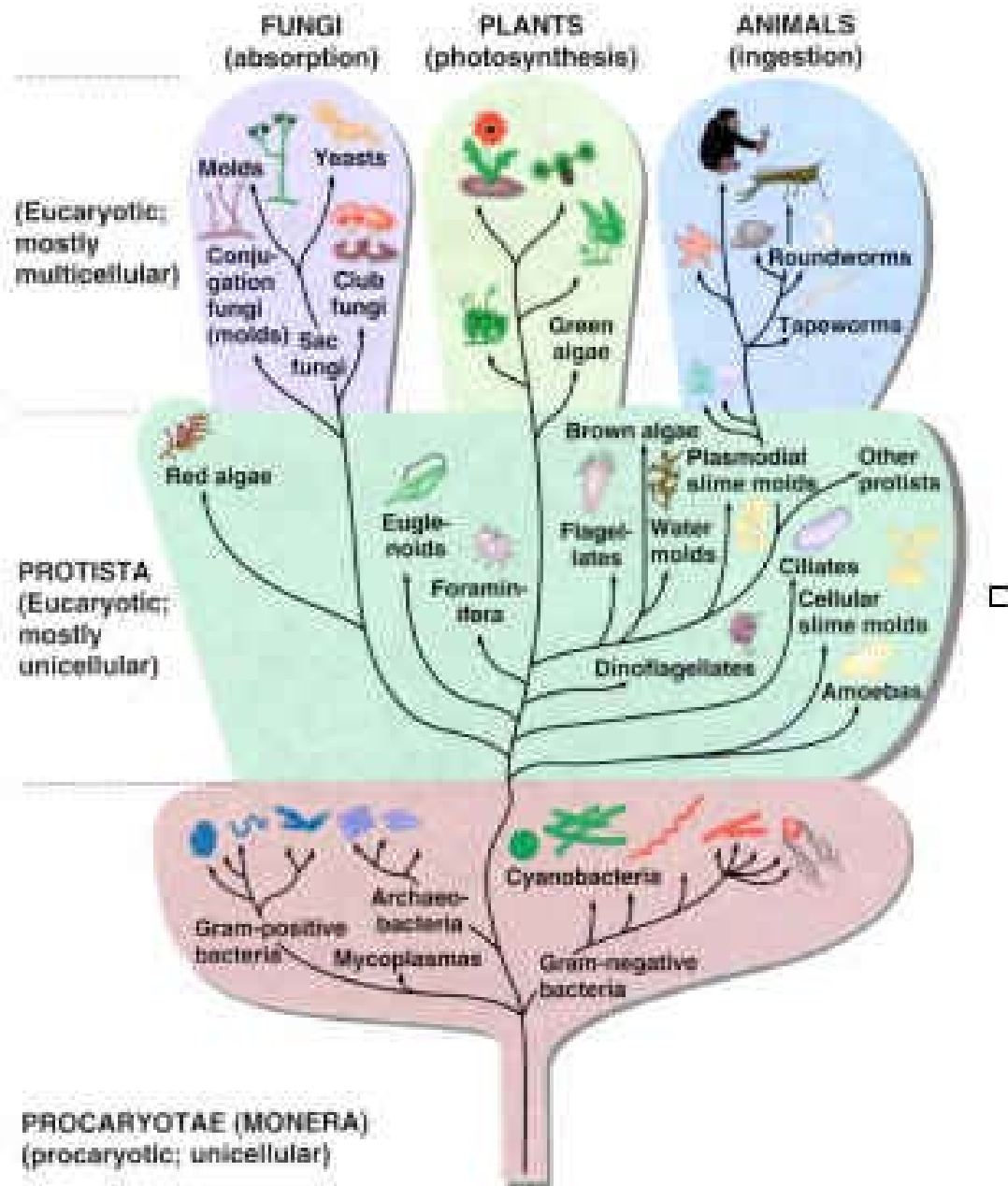




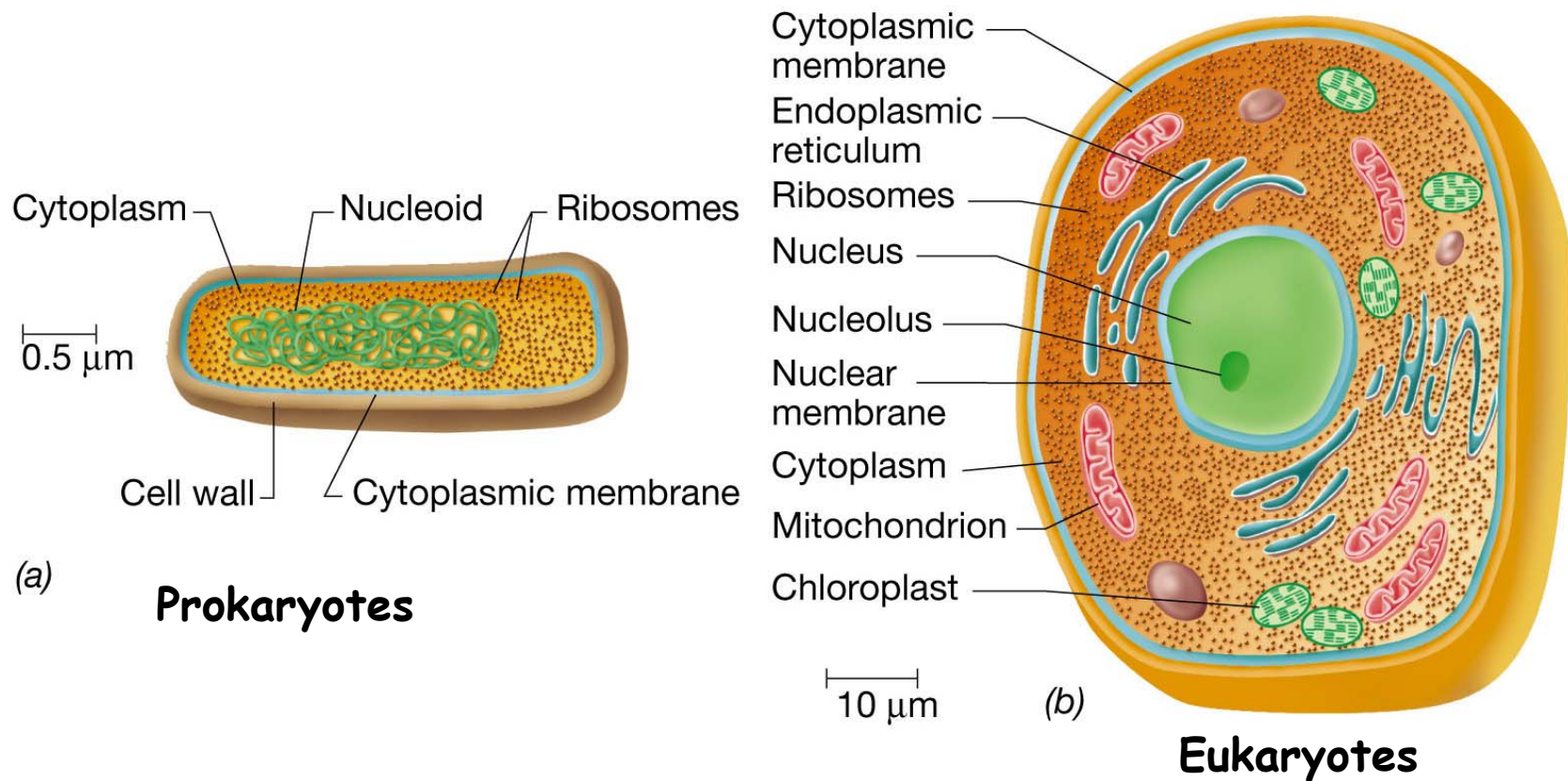


The post Darwinian tree of life

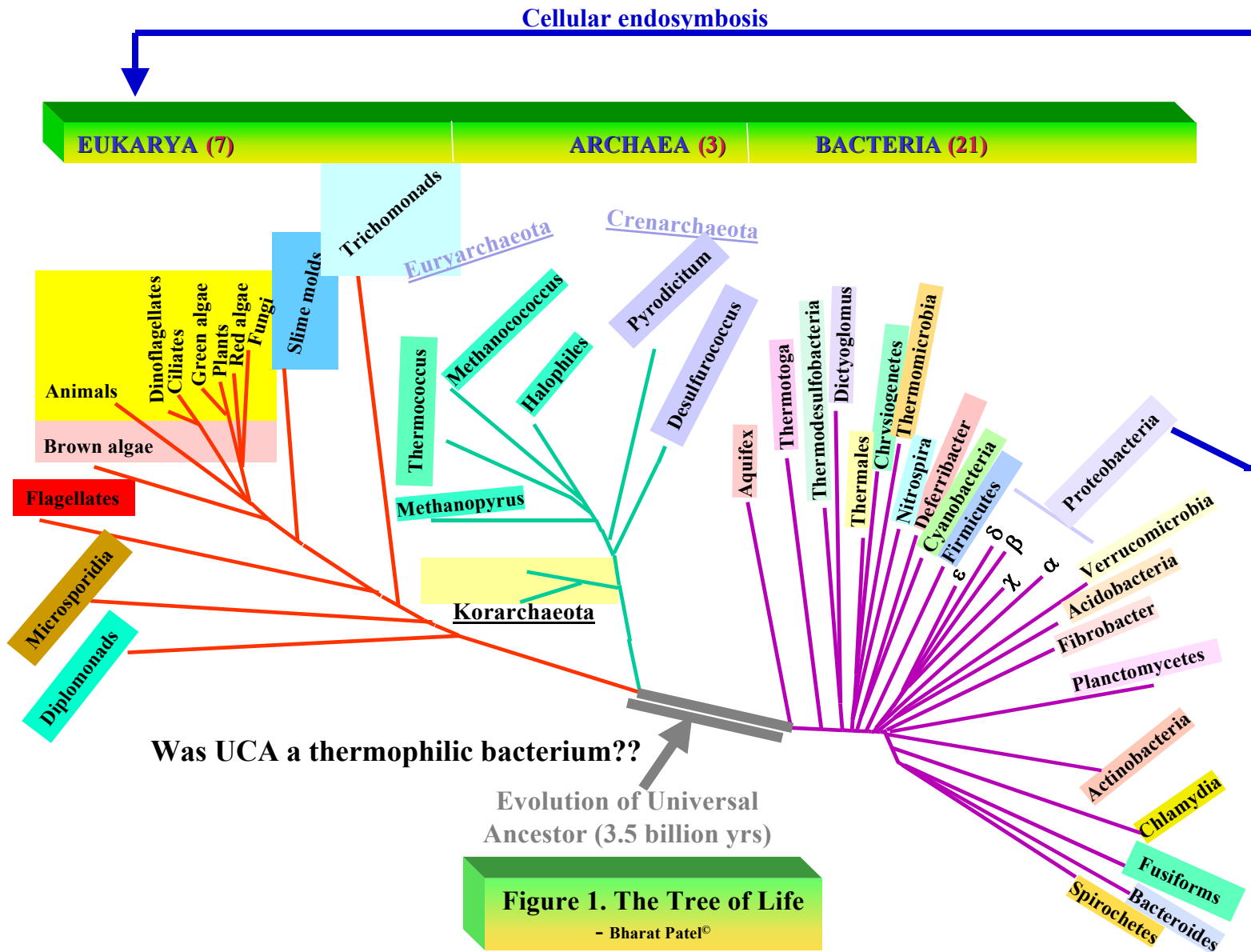


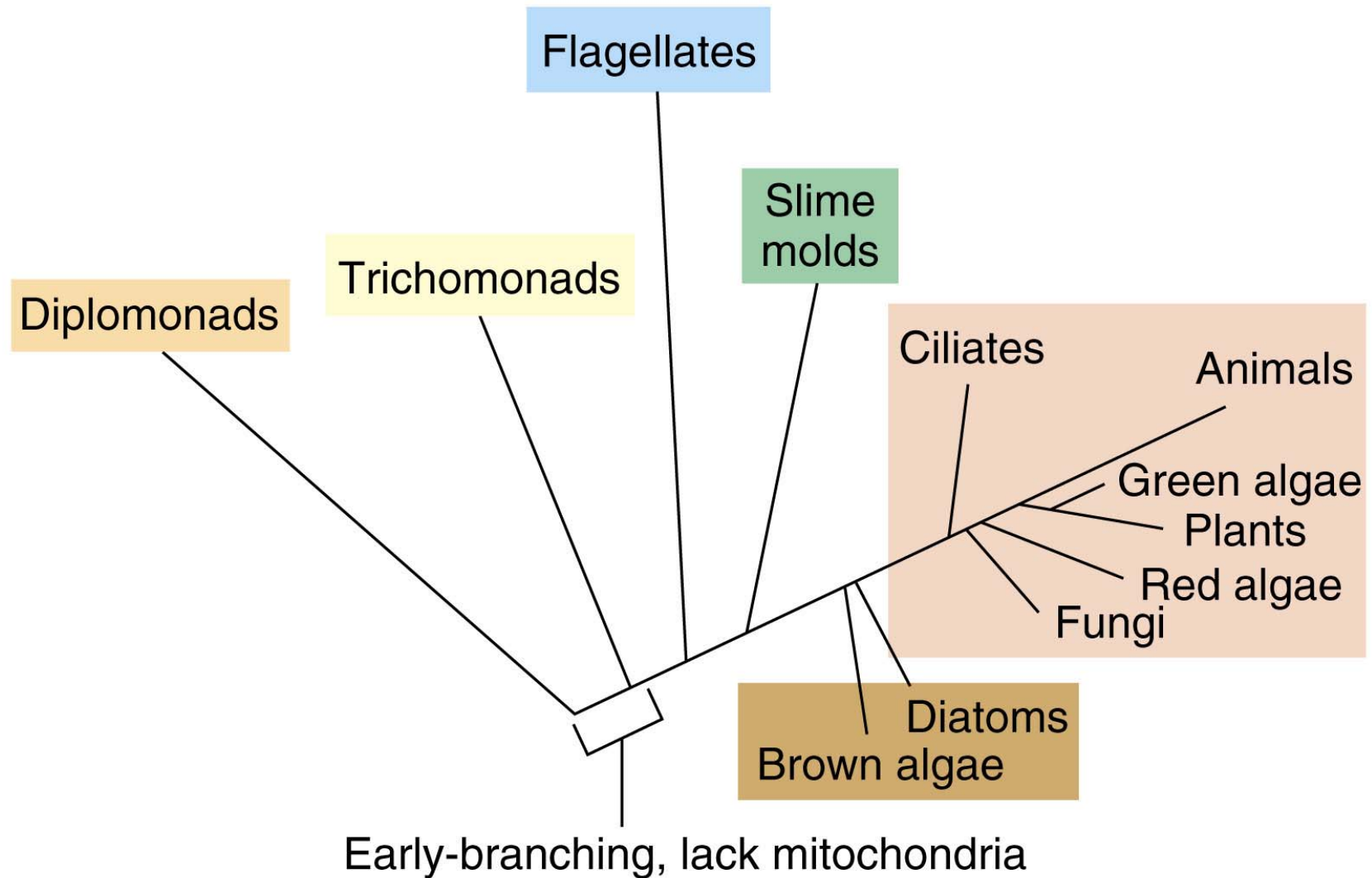


# Procaryotic-Eucaryotic dichotomy by Electron Microscopy



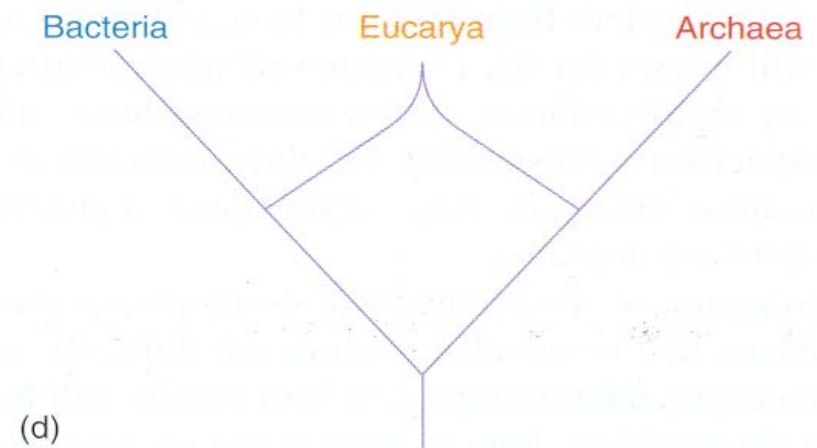
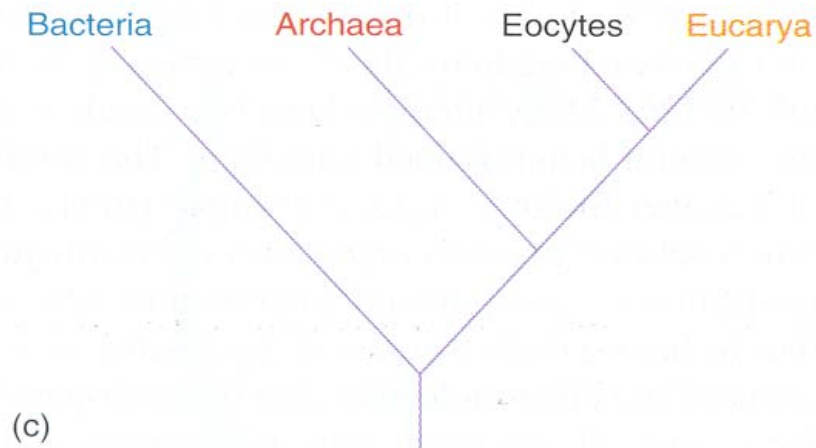
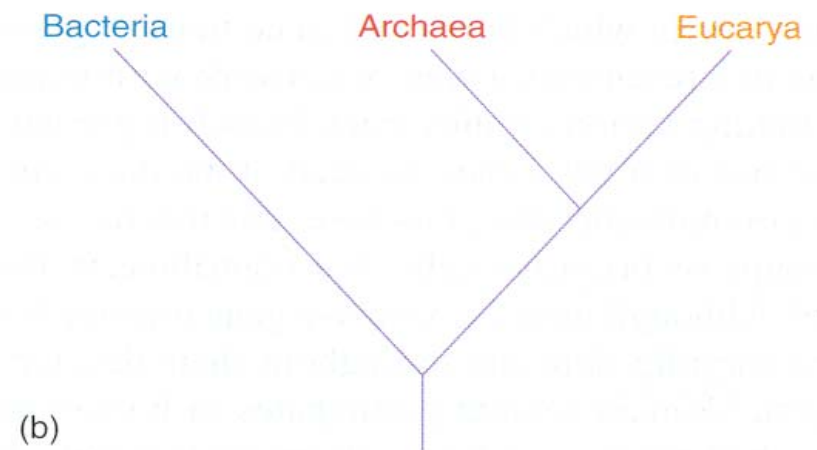
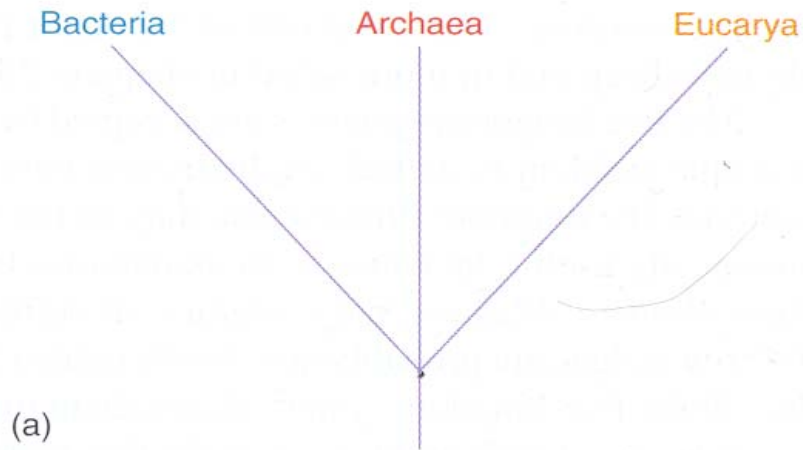
# Woese's 3 domain rRNA gene tree





**The early branching and therefore “ancient” eucaryotes lack mitochondria but contain hydrosomes - power house of the cells**

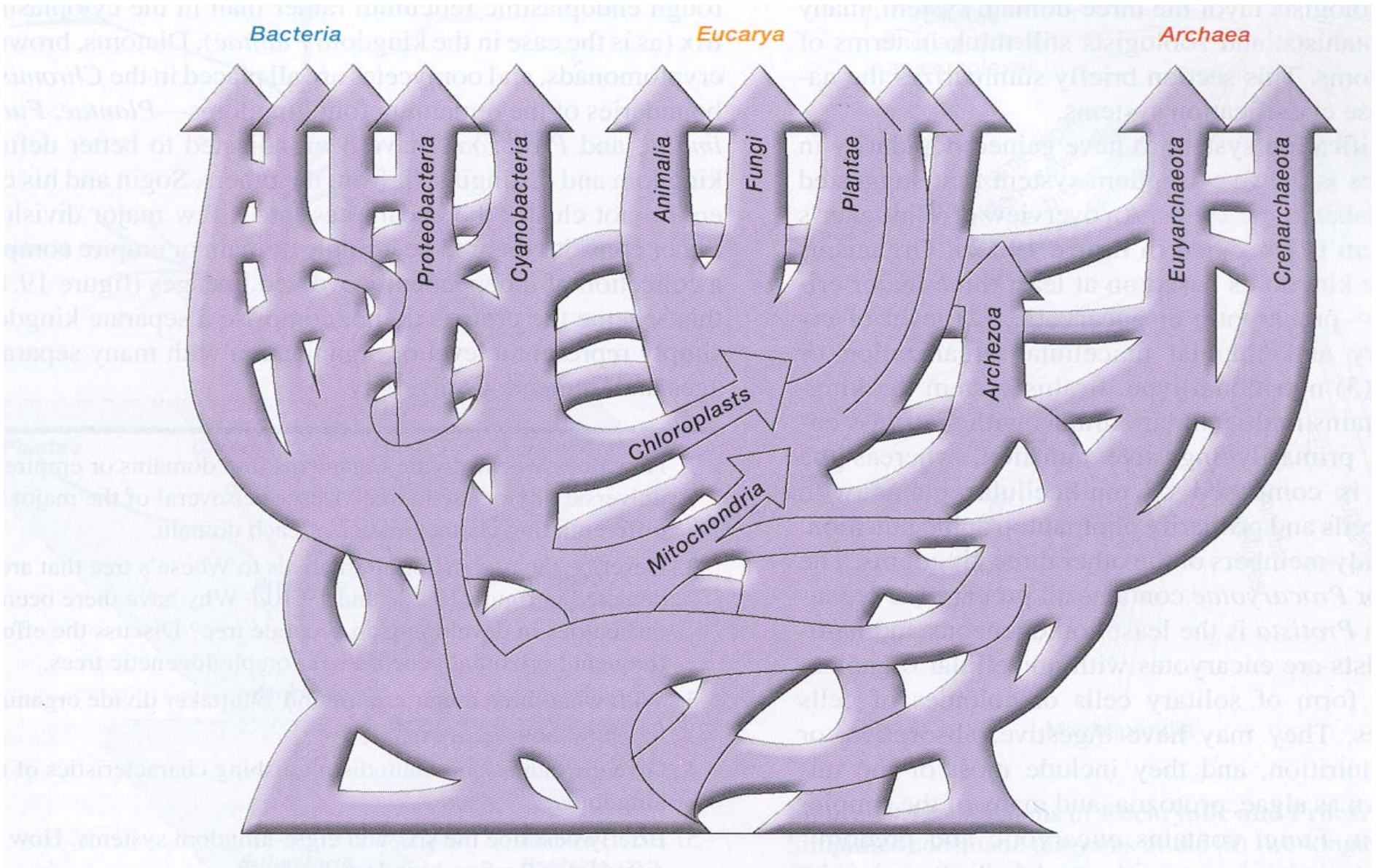
# Modifications of Woese's rRNA gene tree



**Which path did evolution take? - determining the root of life.  
Refer to Genome evolution questions slide later**



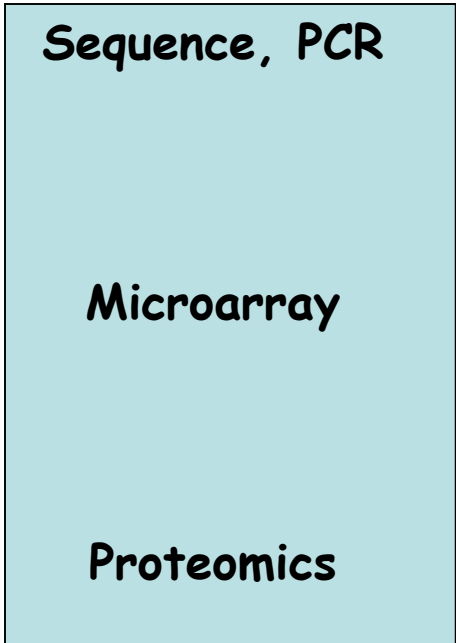
# Genome trees



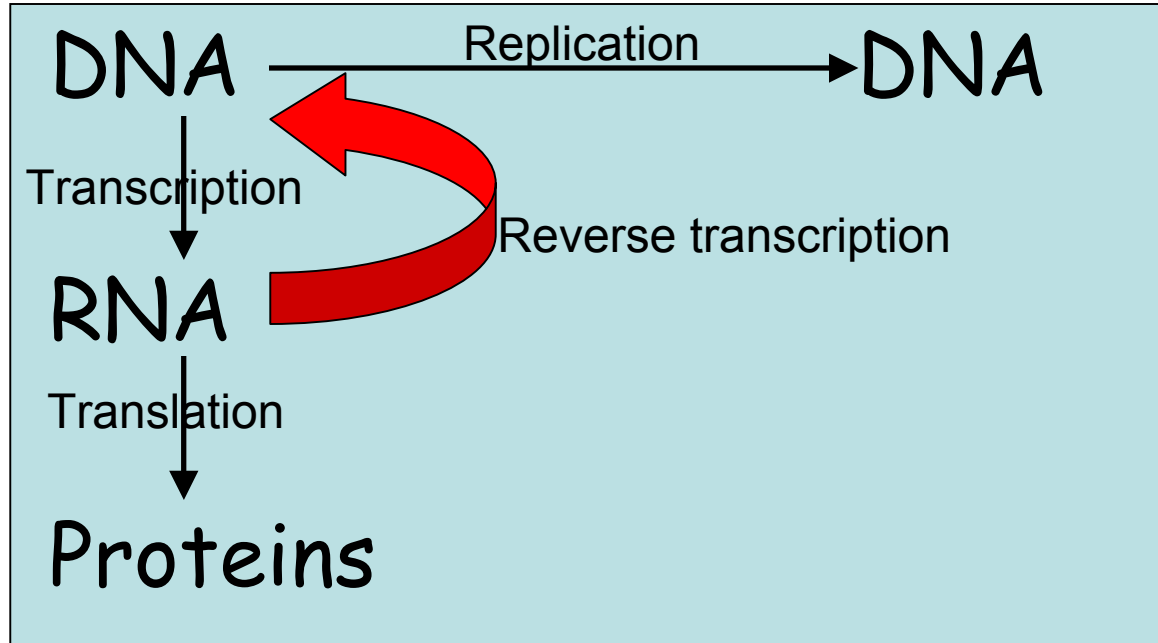
# **Microbes Rule the World - Diversity of Life**

**From Microbes in Motion CD-ROM**





Technologies



The Central Dogma

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## **Genome Evolution:**

Microbial (domain Archaea and Bacteria) genomes and eucaryotic genomes exhibit very distinct genome structures and will be dealt with separately as far as possible.

1. Enormous variations in genome sizes amongst different organisms
    - ◆ How did this happen
    - ◆ Mechanisms that increase or decrease genome sizes
  
  2. Genome information within the genome
    - ◆ Genic or nongenic sequences?
    - ◆ Nongenic sequences are junk or have functions?
      - Repetitive sequence function and distribution in the genome
  
  3. Gene order and dynamics of evolutionary change in gene order
    - ◆ Distribution of genes along and among genomes (chromosomes)
    - ◆ Mechanisms which reshape gene order during evolution
  
  4. Heterogeneity in composition amongst different regions of the genome
    - ◆ Mechanisms that give rise to localised differences in nucleotide composition
  
  5. Evolution of the genetic code
- Rules of translation change without deleterious effects under certain conditions.

# Genes in genomes

## Comparative genomics is difficult:

- "Genetic" symbiosis between two organisms
- Lateral gene transfer
- Horizontal gene transfer
- Gene duplication (paralogs)
- Loss of genes (original or a paralog)
- Gene fusion
- Evolution of new functions
- Domain shuffling within genes give rise to new functions