MCBG2039A – CELLS AND ORGANISMS

INTRODUCTORY MICROBIOLOGY

THE MICROBIAL WORLD

CHAPTER 1

MOLECULAR BIOLOGY AND THE UNITY AND DIVERSITY OF LIFE

1.14 - Molecular Basis of Life

1.15 - Woese and the Tree of Life

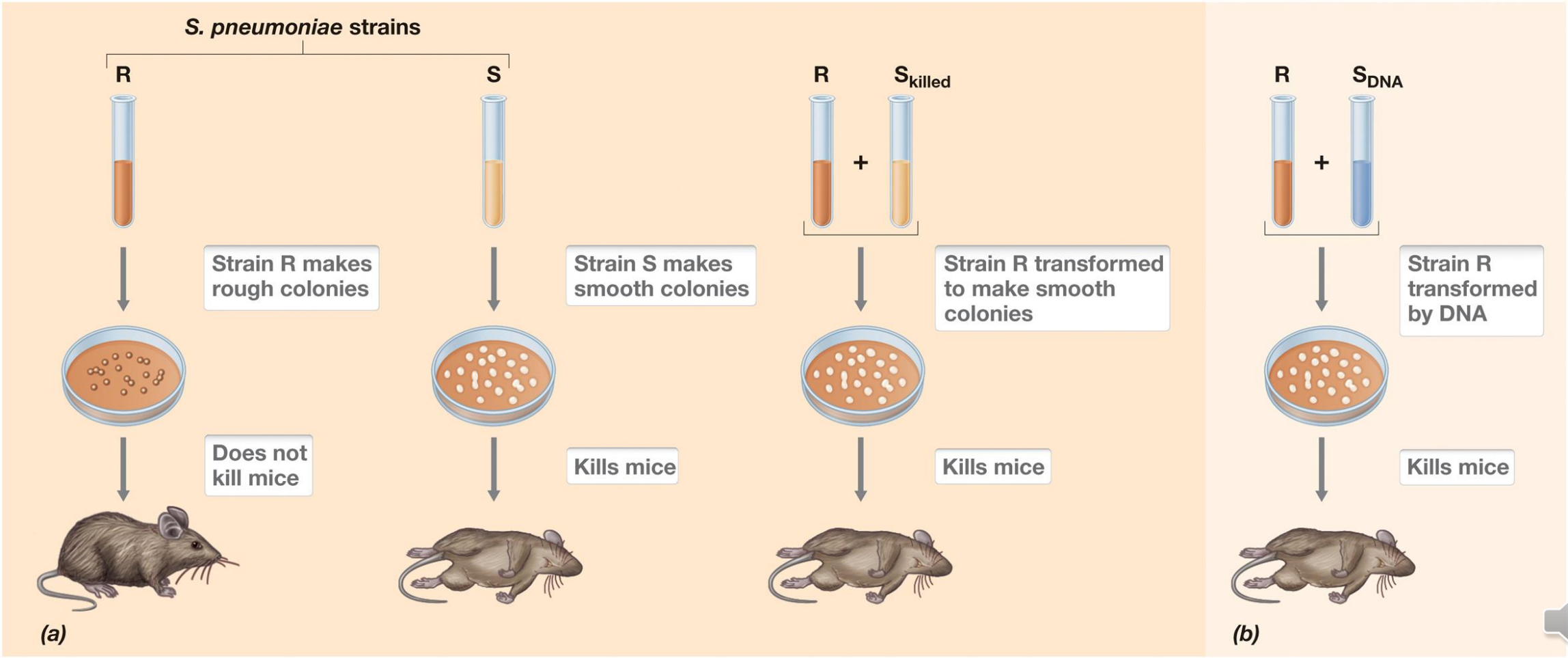
MOLECULAR BASIS OF LIFE

- Ability to grow bacteria rapidly under controlled conditions makes them excellent models for fundamental nature of life
- Led to foundations of molecular biology, genetics, and biochemistry
- Metabolic model chemistry: Certain macromolecules and reactions are universal

MOLECULAR BASIS OF LIFE

- Cracking the Code of Life
  - Bacteria can transfer DNA amongst each other – horizontal gene transfer
    - Frederick Griffith, *Streptococcus pneumoniae* and **transformation**
    - Avery-MacLeod-McCarty experiment (1944)
    - James Watson, Francis Crick, Rosalind Franklin: structure of DNA
    - Emile Zuckerkandl and Linus Pauling: molecular sequences and evolutionary relationships

Early Evidence That DNA Is the Molecular Basis of Heredity



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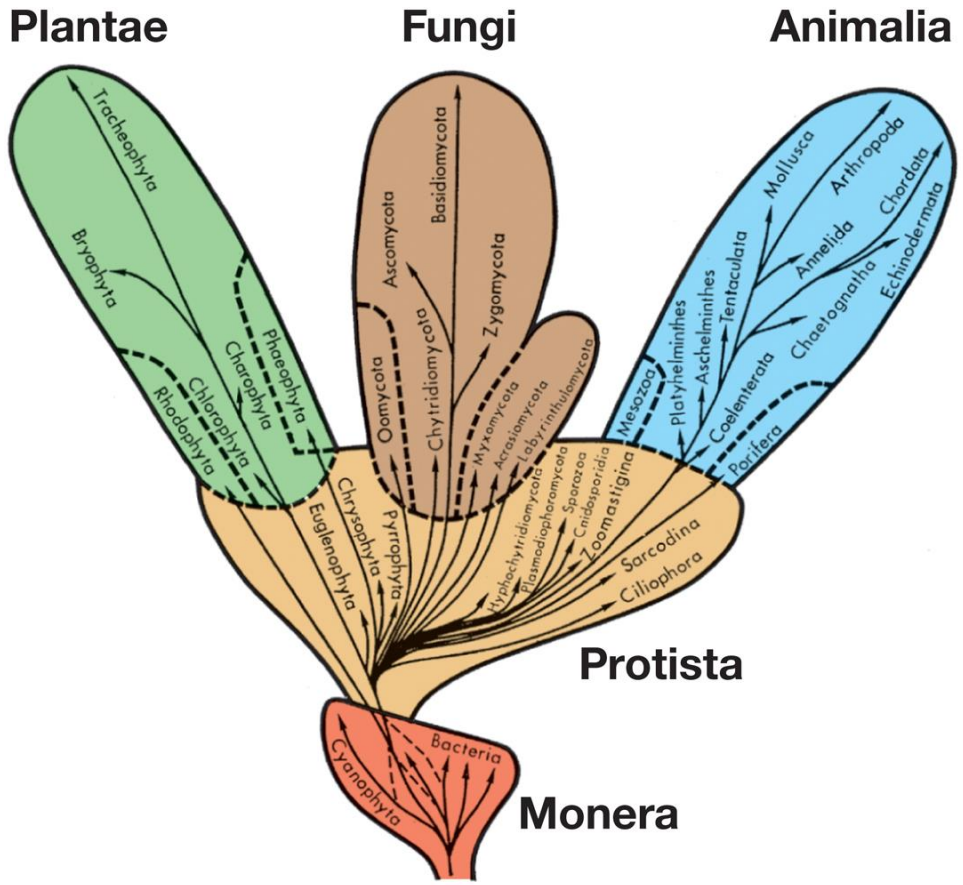
WOESE AND THE TREE OF LIFE

- **Ribosomal RNA (rNA)** present in all cells made it possible to build the first tree of life
- First attempt by Ernst Haeckel (1866)
- Robert Whitaker (1969) Five kingdom classification scheme



From Science 163:150–160, 1969
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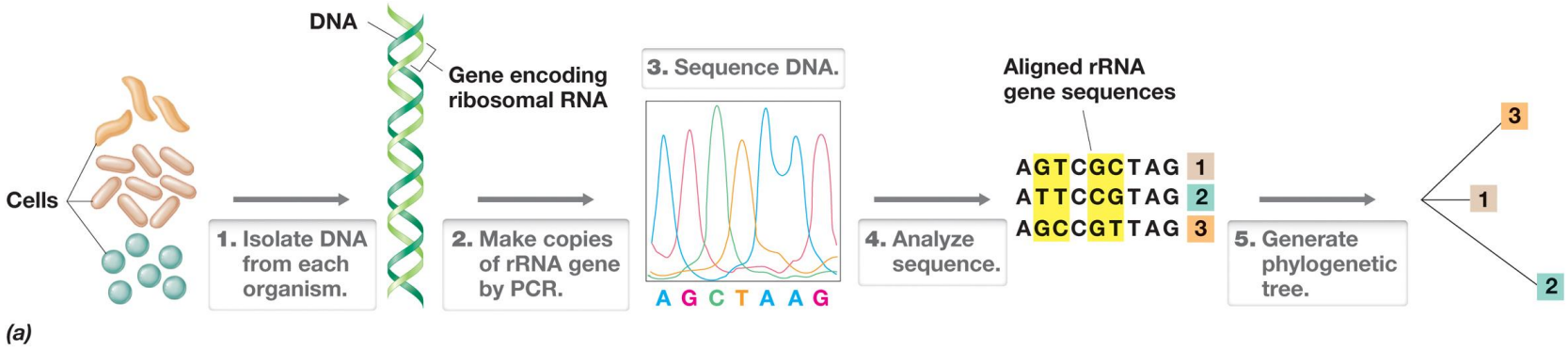
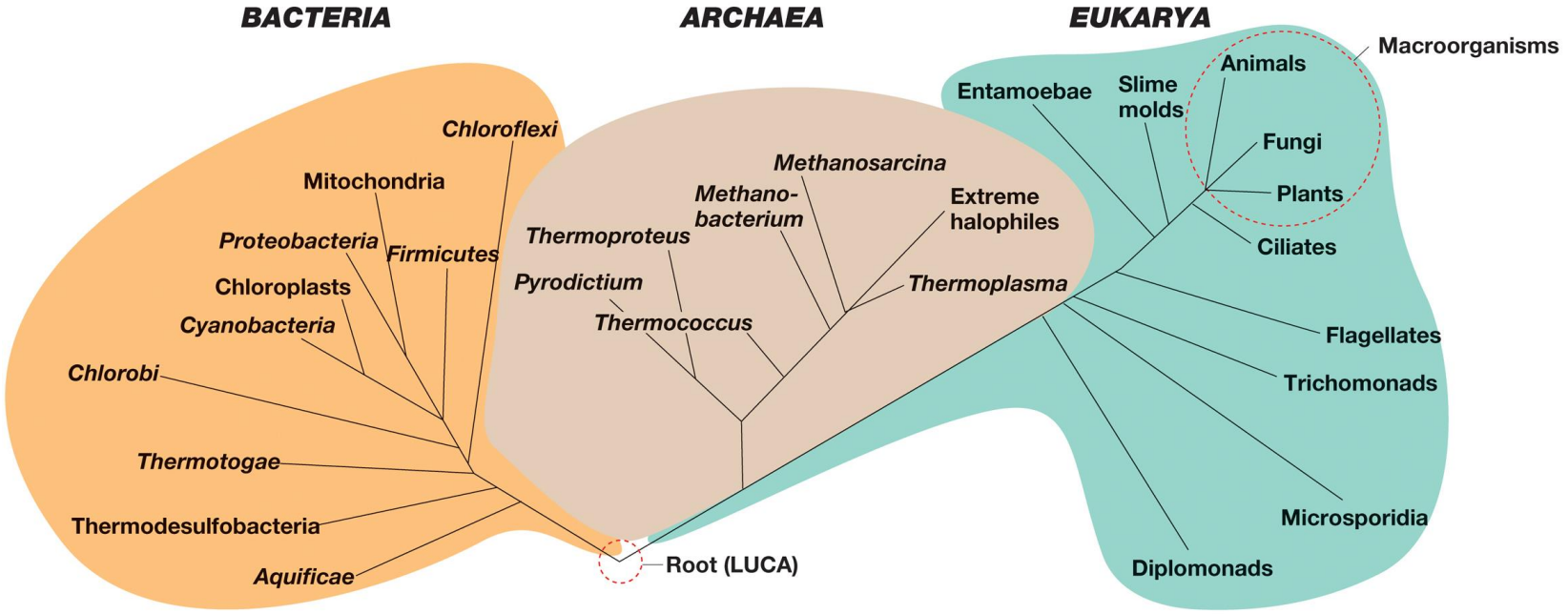
WOESE AND THE TREE OF LIFE

- Carl Woese (1928–2012) realized rRNA sequences could be used to **infer evolutionary relationships**
  - discovered rRNA from methanogens distinct from Bacteria and Eukarya
  - named new group Archaea
  - found evolutionary relationships between all cells could be revealed by rRNA analysis

Evolutionary Relationships and the Phylogenetic Tree of Life



(a)

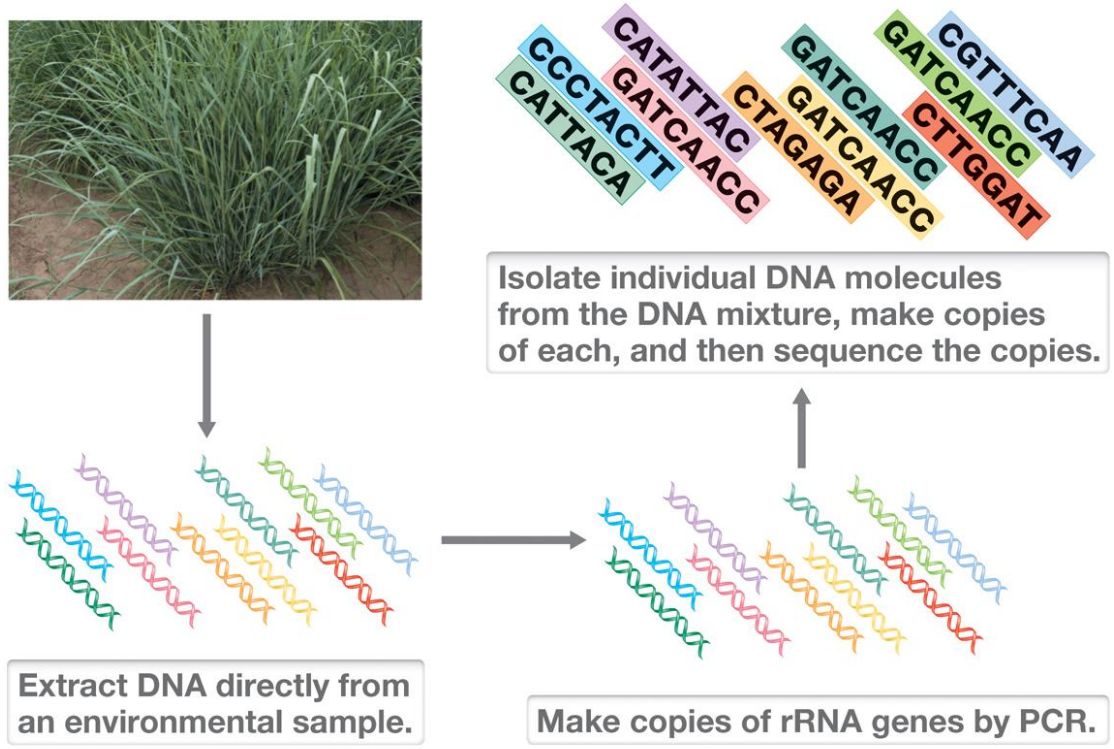


(b)

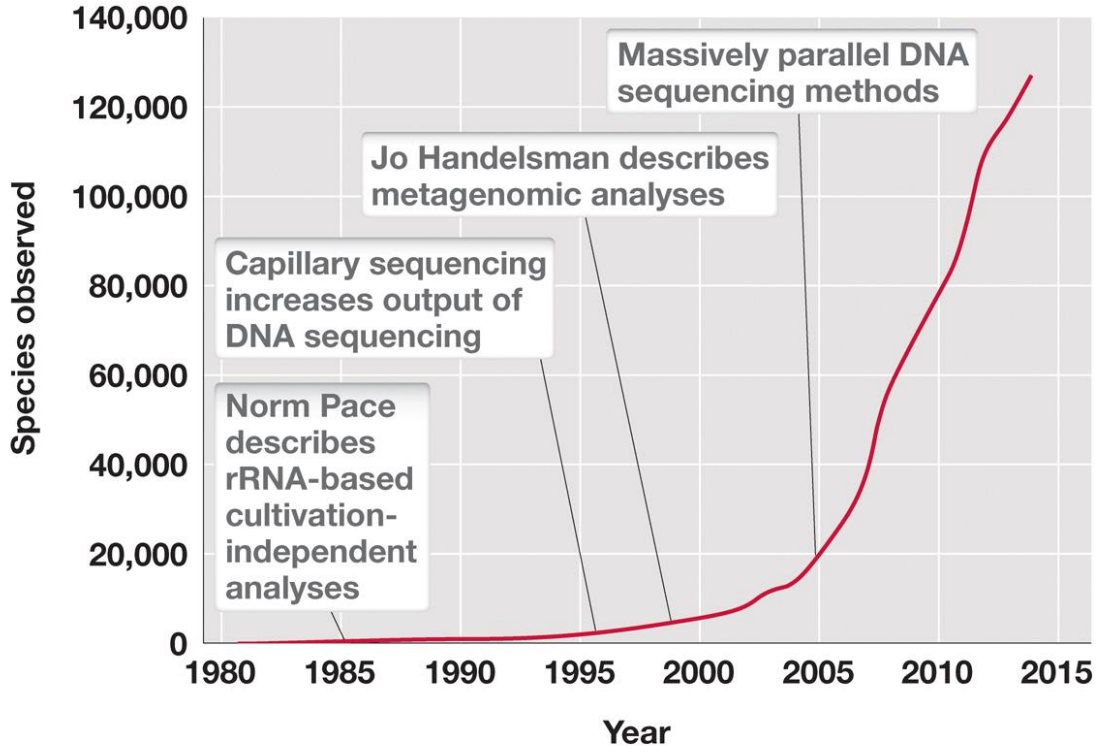
WOESE AND THE TREE OF LIFE

- Phylogenetic tree: depicts **phylogeny** (evolutionary history) of all cells
  - clearly shows three domains
  - Root is **LUCA** (last universal common ancestor)
  - evolution along two paths to form **Bacteria** and **Archaea**
  - Archaea later diverged to distinguish **Eukarya** from **Archaea**
- Cultivation-independent methods show most microbes have not been cultured yet

Analysis of Environmental rRNA Genes Leads to Discovery of New Microbial Species



(a) **Cultivation-independent analysis of rRNA genes**



(b) **Revealing the extent of microbial diversity**

WOESE AND THE TREE OF LIFE

- DNA sequencing technology improvements have improved ability to study Bacteria and Archaea
  - Can sequence entire genomes
  - **Metagenomics**: microbial genomes/fragments can be recovered from environmental DNA samples