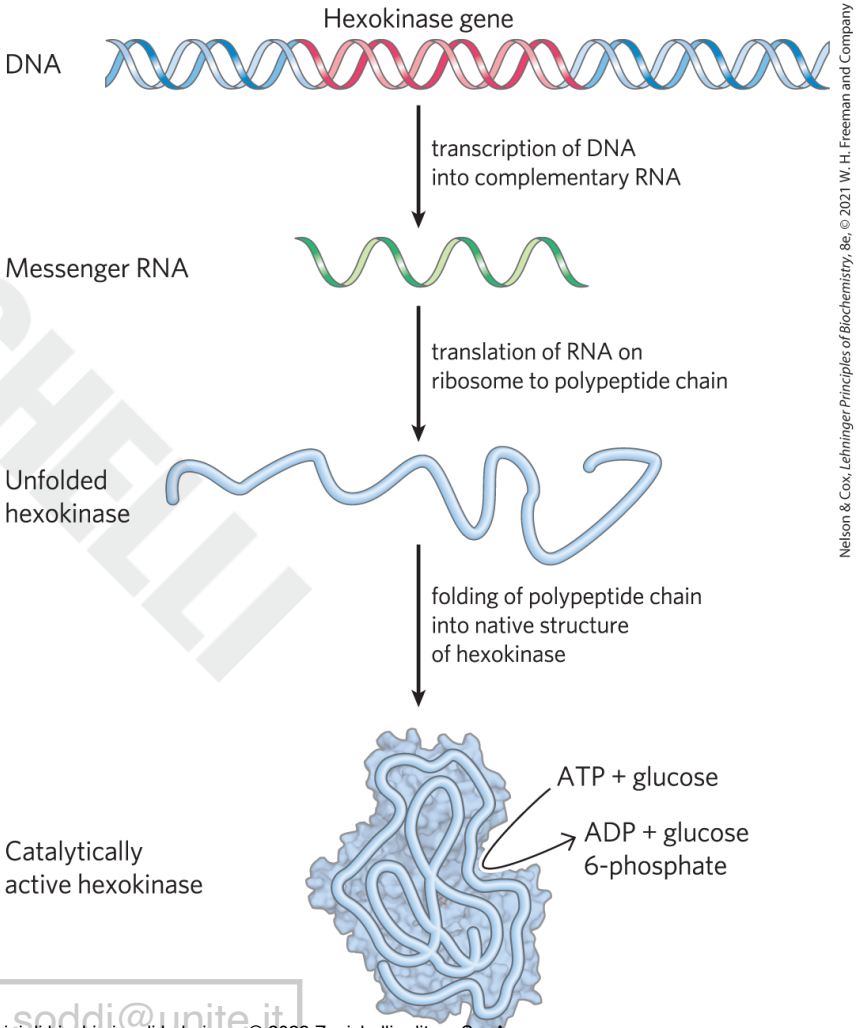
1.5 Evolutionary Foundations

P5 Principle 5 (2 of 3)

Living organisms change over time by gradual evolution. The result of eons of evolution is an enormous diversity of life forms, fundamentally related through their shared ancestry, which can be seen at the molecular level in the similarity of gene sequences and protein structures.

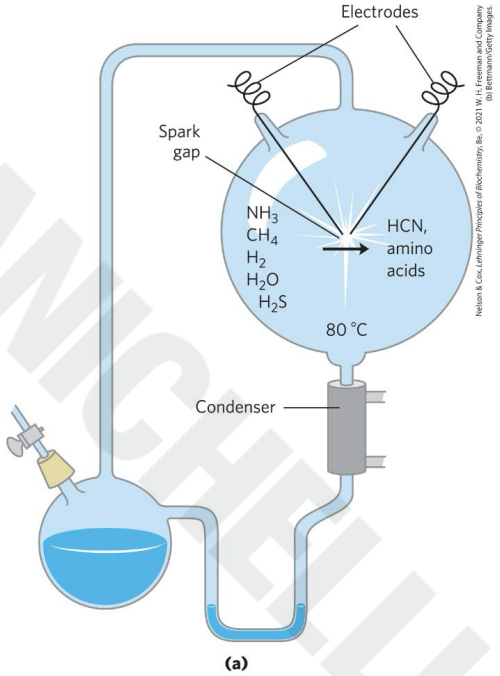
Changes in the Hereditary Instructions Allow Evolution

- **mutation** = changes in the nucleotide sequence of DNA
  - changes the instructions for a cellular component
  - can be beneficial
- **wild type** = unmutated cells



Biomolecules First Arose by Chemical Evolution

- Miller and Urey experiments found that biomolecules may have been produced near hydrothermal vents at the bottom of the sea or by the action of lightning and high temperature on gaseous mixtures

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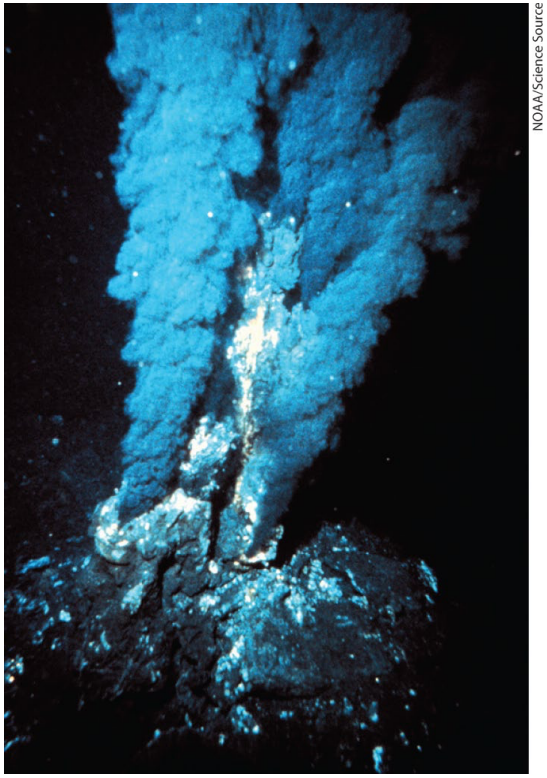
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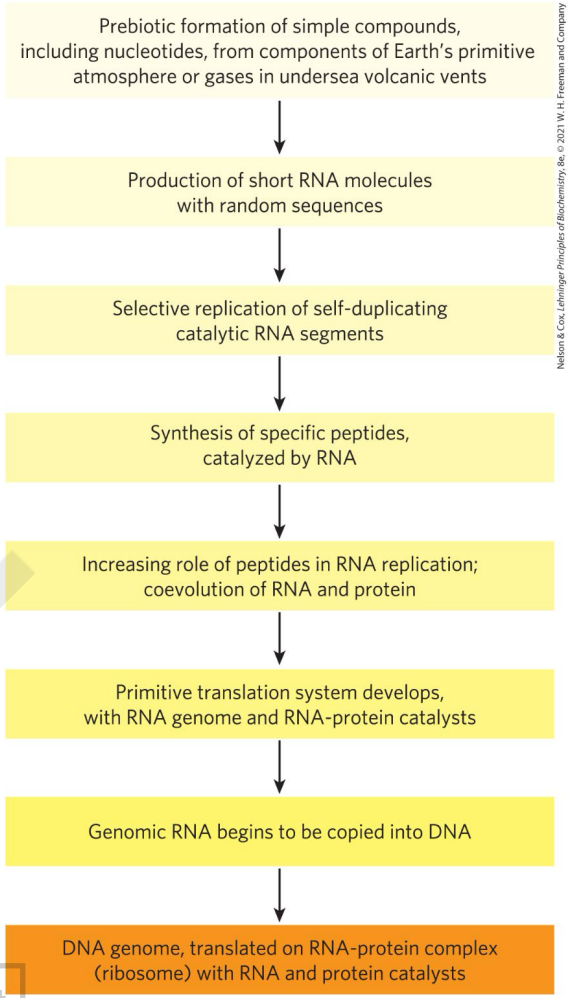
The Role of RNA in Prebiotic Evolution

- **RNA (ribonucleic acid)** = can act as catalysts in biologically significant reactions

- likely played a crucial role in prebiotic evolution, both as catalyst and as information repository

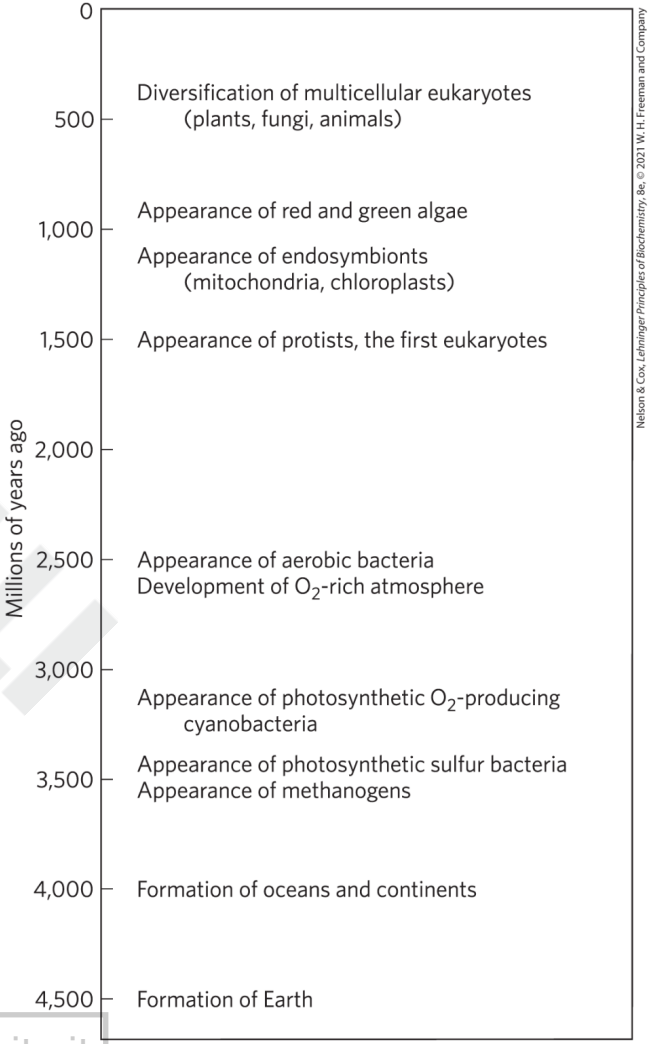
RNA or Related Precursors May Have Been the First Genes and Catalysts

- RNA or similar molecule may have been the first gene and the first catalyst
- alternatively, simple metabolic pathways may have evolved first, perhaps at the hot vents in the ocean floor



Biological Evolution Began More Than Three and a Half Billion Years Ago

- lipid vesicles containing organic compounds and self-replicating RNA gave rise to protocells
- protocells with the greatest capacity for self-replication became more numerous



The First Cell Probably Used Inorganic Fuels

- earliest cells probably obtained energy from inorganic fuels, such as ferrous sulfide and ferrous carbonate

- **photosynthetic** processes:
  - arose from evolution
  - pigments capture energy of light from the sun and reduce CO_2 to organic compounds

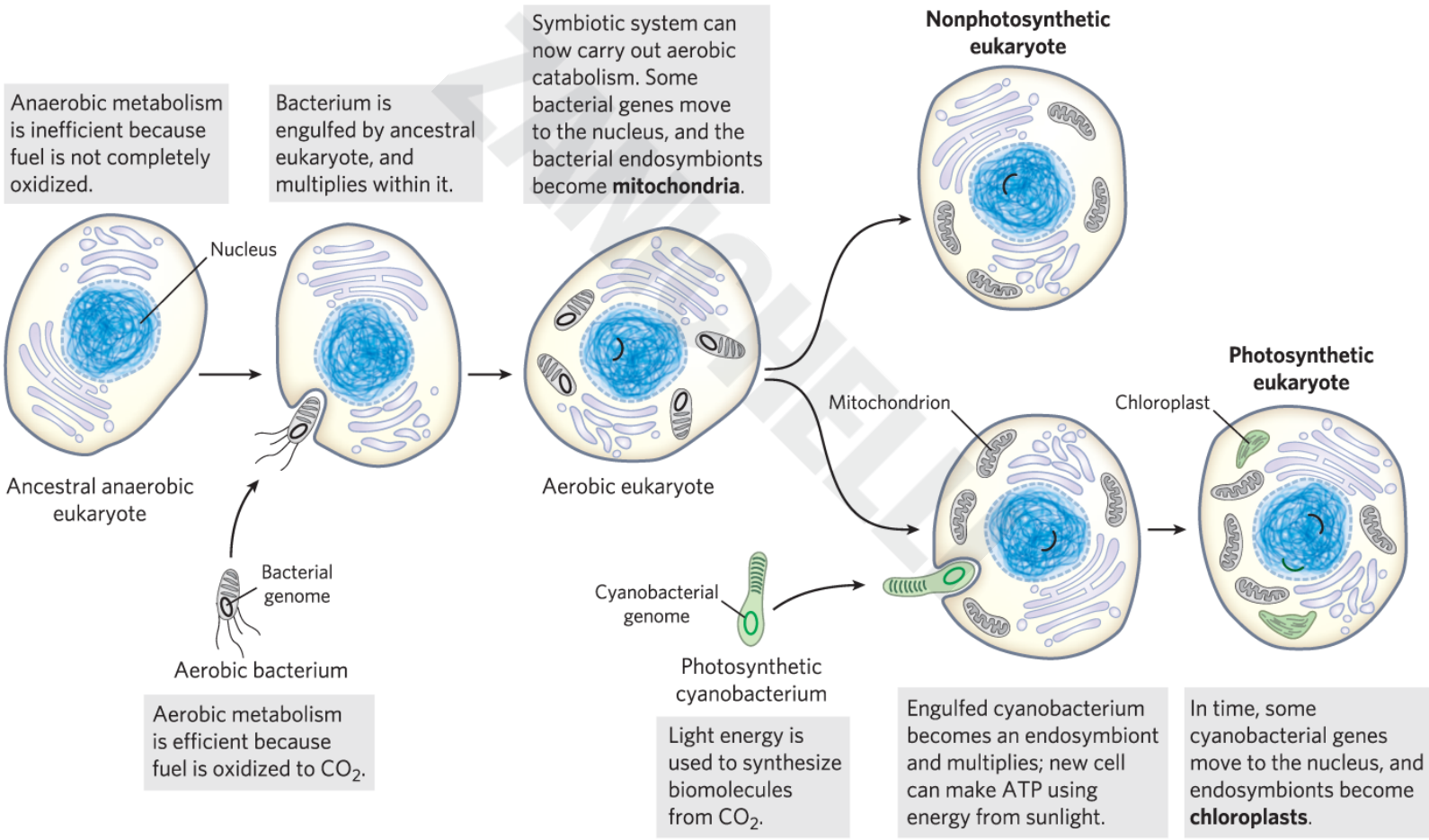
- atmosphere became richer in O_2 with the rise of O_2-producing photosynthetic bacteria

Eukaryotic Cells Evolved from Simpler Precursors in Several Stages

- three major changes led to the evolution of eukaryotes:
  - evolution of the chromosome
  - evolution of the nucleus
  - formation of **endosymbiotic** associations between early eukaryotic cells and aerobic or photosynthetic bacteria

- in multicellular organisms, differentiated cell types specialize in functions essential to the organism's survival

Evolution of Eukaryotes through Endosymbiosis



P5 Principle 5 (3 of 3)

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Molecular Anatomy Reveals Evolutionary Relationships

- **homologs** = proteins encoded by genes that share ready detectable sequence similarities

- gene or protein sequence similarities between organisms can determine phylogenetic relationships

Functional Genomics Shows the Allocations of Genes to Specific Cellular Processes

- genes can be grouped according to the specific process in which they function
  - can approximate the proportion of the genome dedicated to a specific process
  - genes involved in regulation of cellular processes tend to increase with organism complexity

- **housekeeping genes** = expressed under all conditions, not subject to much regulation

Genomic Comparisons Have Increasing Importance in Medicine

- large-scale sequencing studies have identified many genes in which mutations correlate with a medical condition
- the proteins these genes encode might become the target for drugs to treat a given condition