THE CELL

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Introduction

BIOLOGY AND CELL

EVOLUTION

MOLECULES OF LIFE

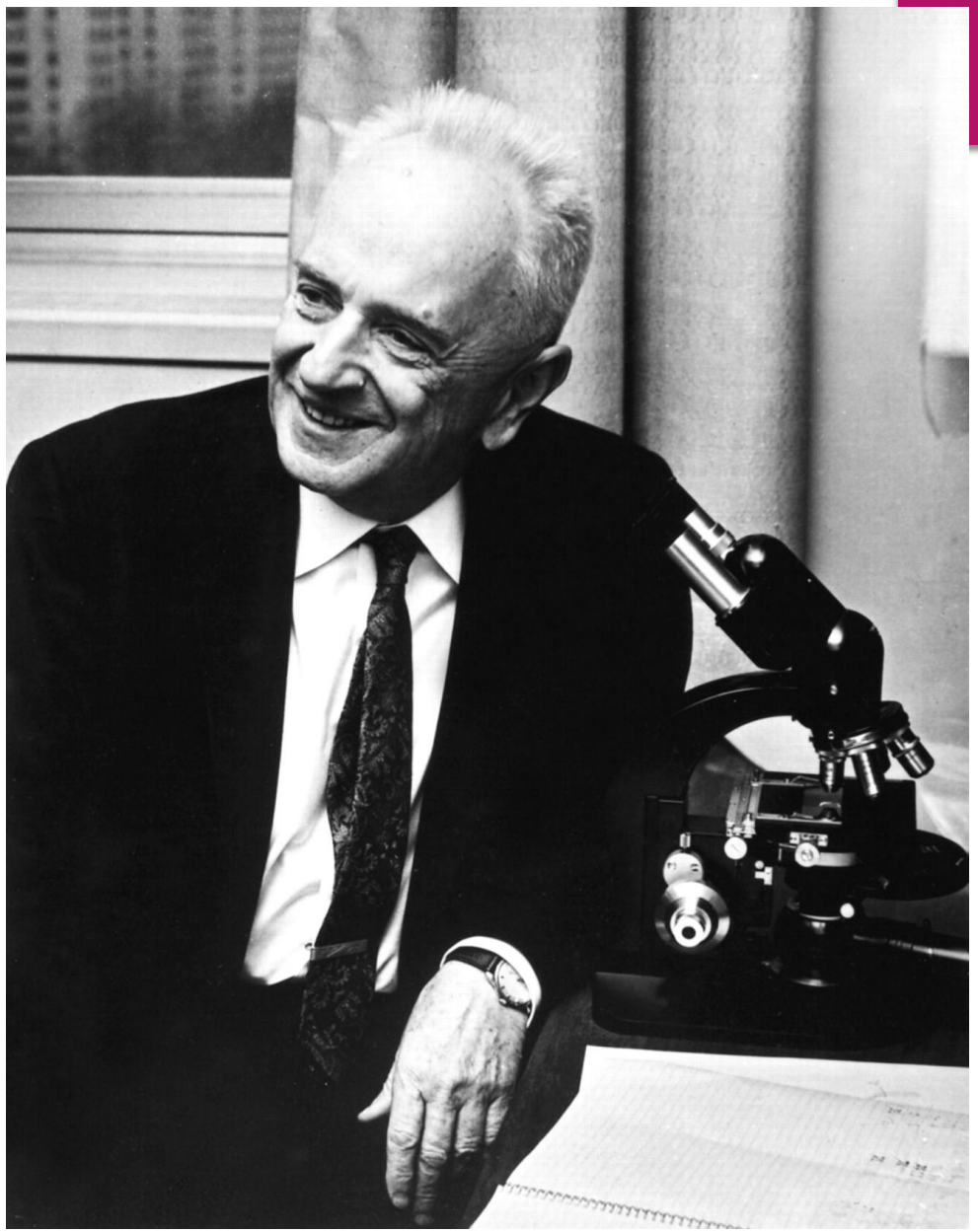
PROKARYOTIC CELLS

EUKARYOTIC CELL

Nothing in biology makes sense except in the light of evolution.

Theodosius Dobzhansky, 1973, essay in

American Biology Teacher **35**:125–129

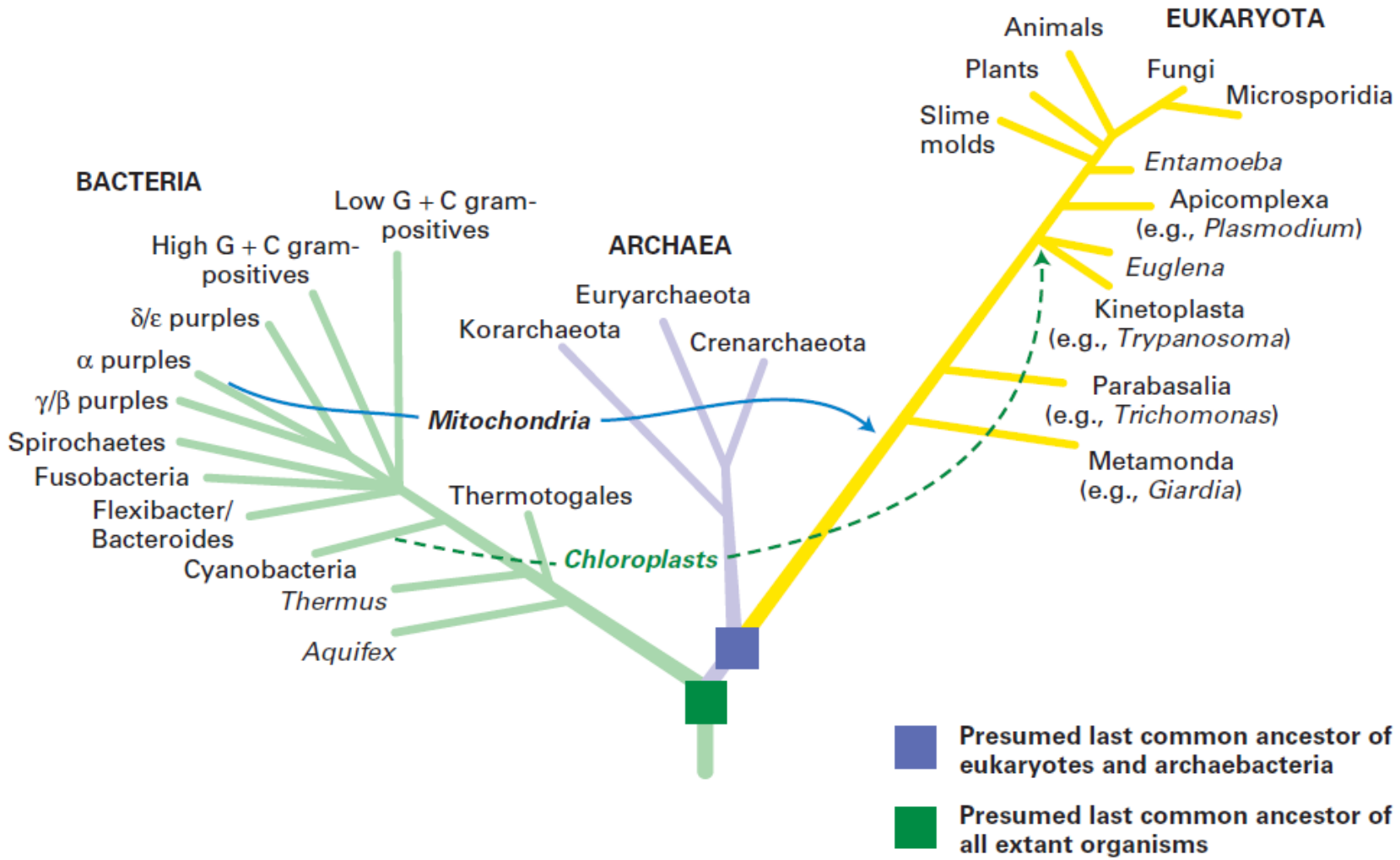


Biology is a science fundamentally different from physics or chemistry, which deal with unchanging properties of matter that can be described by mathematical equations.

Biological systems, of course, follow the rules of chemistry and physics,

but biology is a historical science, as the forms and structures of the living world today are the results of billions of years of evolution.

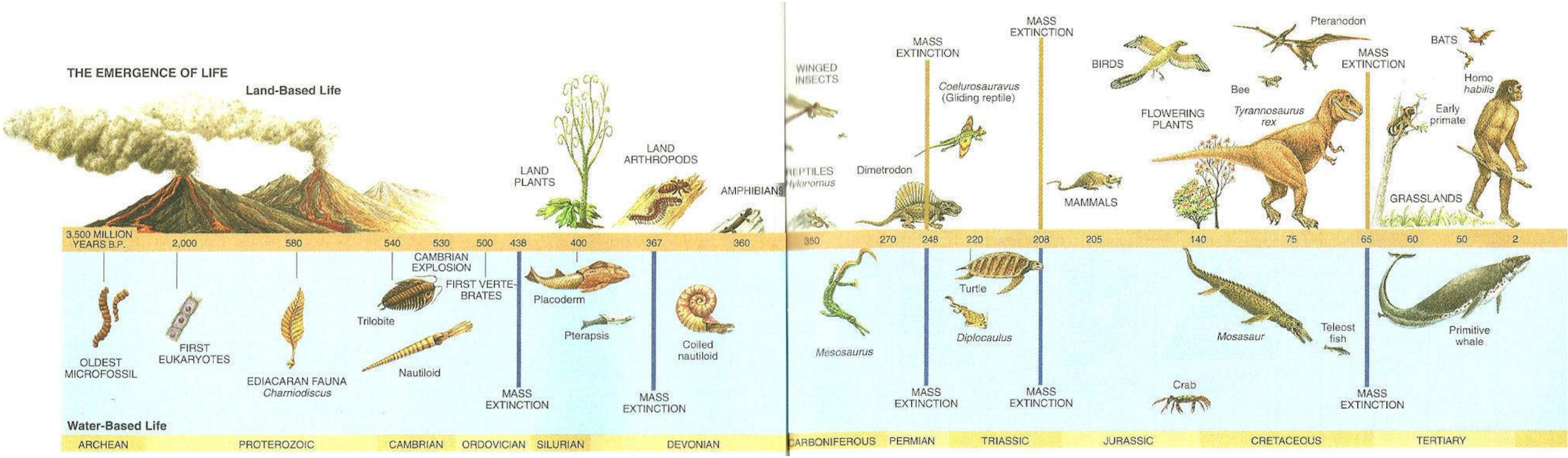
Through evolution, all organisms are related in a family tree extending from primitive single-celled organisms that lived in the distant past to the diverse plants, animals, and microorganisms of the present era



All living organisms descended from a common ancestral cell. All organisms, from simple bacteria to complex mammals, probably evolved from a common single-celled ancestor.

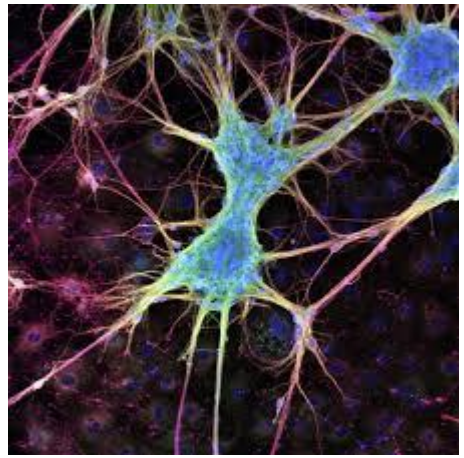
TABLE 1-1 Timeline for Evolution of Life on Earth, as Determined from the Fossil Record

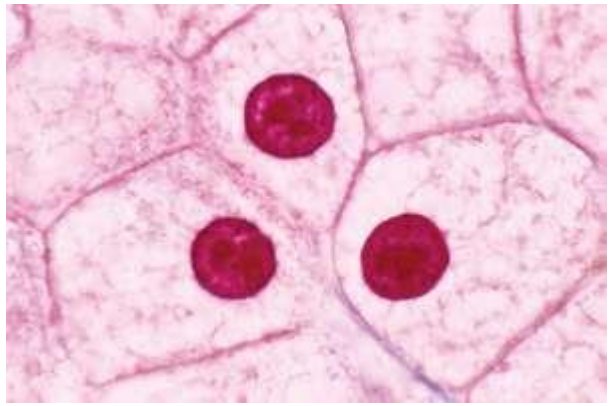
4600 million years ago	The planet Earth forms from material revolving around the young Sun.
~3900–2500 million years ago	Cells resembling prokaryotes appear. These first organisms are chemoautotrophs: they use carbon dioxide as a carbon source and oxidize inorganic materials to extract energy.
3500 million years ago	Lifetime of the last universal ancestor; the split between Eubacteria and Archaea occurs.
3000 million years ago	Photosynthesizing cyanobacteria evolve; they use water as a reducing agent, thereby producing oxygen as a waste product.
1850 million years ago	Unicellular eukaryotes appear.
1200 million years ago	Simple multicellular organisms evolve, mostly consisting of cell colonies of limited complexity.
580–500 million years ago	Most modern phyla of animals begin to appear in the fossil record during the Cambrian explosion.
535 million years ago	Major diversification of living things in the oceans: chordates, arthropods (e.g., trilobites, crustaceans), echinoderms, mollusks, brachiopods, foraminifers, radiolarians, etc.
485 million years ago	First vertebrates with true bones (jawless fishes) evolve.
434 million years ago	First primitive plants arise on land.
225 million years ago	Earliest dinosaurs (prosauropods) and teleost fishes appear.
220 million years ago	Gymnosperm forests dominate the land; herbivores grow to huge sizes.
215 million years ago	First mammals evolve.
65.5 million years ago	The Cretaceous-Tertiary extinction event eradicates about half of all animal species, including all of the dinosaurs.
6.5 million years ago	First hominids evolve.
2 million years ago	First members of the genus *Homo* appear in the fossil record.
350 thousand years ago	Neanderthals appear.
200 thousand years ago	Anatomically modern humans appear in Africa.
30 thousand years ago	Extinction of Neanderthals.

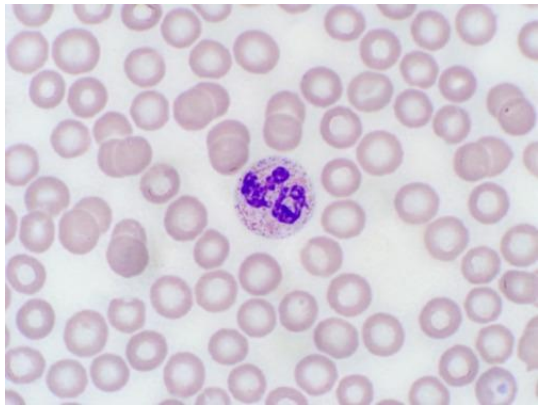


Timeline for Evolution of Life on Earth, as Determined from the Fossil Record

All cells use the same molecular building blocks, similar methods for the storage, maintenance, and
expression of genetic information, and similar processes of
energy metabolism, molecular transport, signaling, development, and structure.

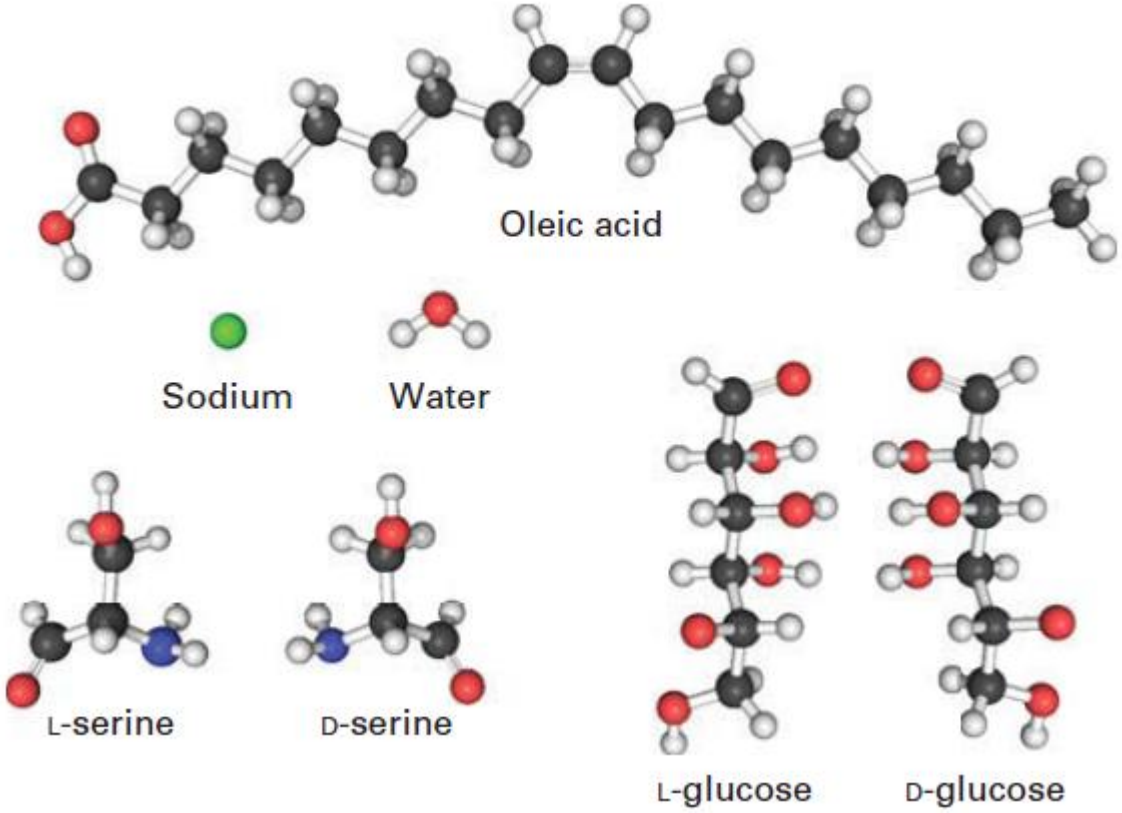






The Molecules of Life

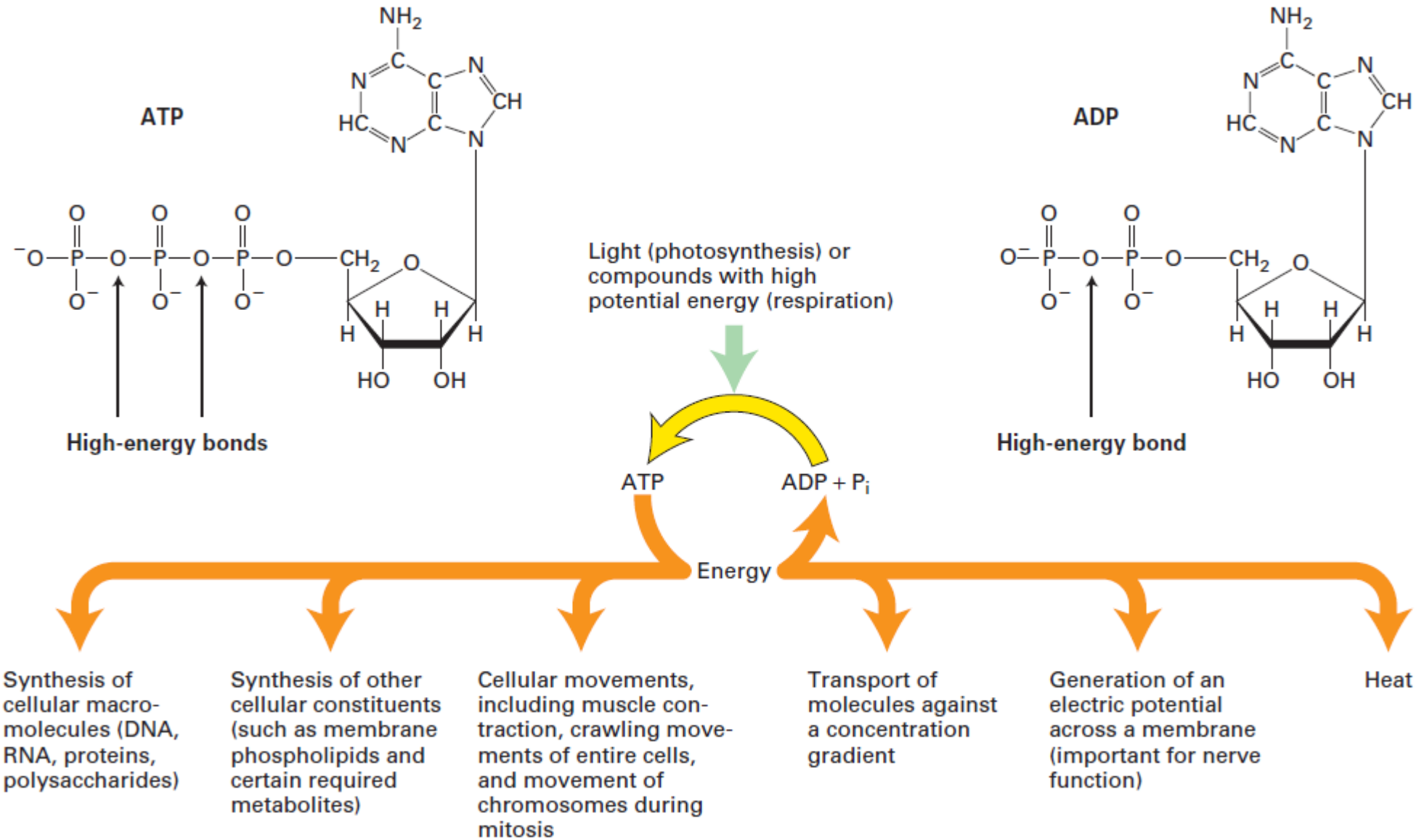
- Small molecules
  - Water, inorganic ions, and small organic molecules
  - 75 to 80 percent of cell weight
  - Substrate for many biochemical reactions (energy metabolism, cell signaling)



The Molecules of Life

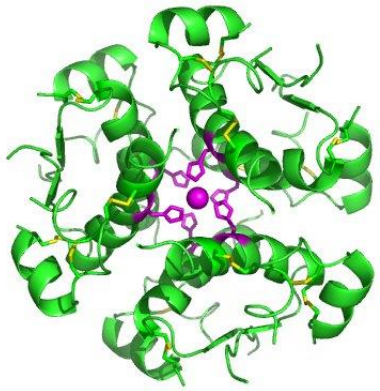
- At an early stage of biological evolution, our common cellular ancestor evolved the ability to catalyze reactions with one stereoisomer instead of the other. How these selections happened is unknown, but now these choices are locked in place.

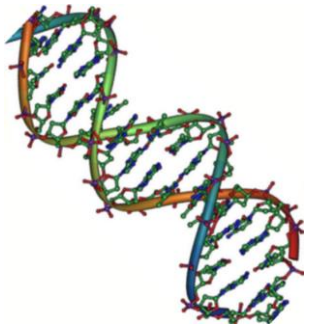
- An important and universally conserved small molecule is **adenosine triphosphate** (**ATP**), which stores readily available chemical energy in two of its chemical bonds


ATP
ADP
High-energy bonds
High-energy bond
Light (photosynthesis) or compounds with high potential energy (respiration)
ATP
ADP + Pi
Energy
Synthesis of cellular macro-molecules (DNA, RNA, proteins, polysaccharides)
Synthesis of other cellular constituents (such as membrane phospholipids and certain required metabolites)
Cellular movements, including muscle con-traction, crawling move-ments of entire cells, and movement of chromosomes during mitosis
Transport of molecules against a concentration gradient
Generation of an electric potential across a membrane (important for nerve function)
Heat

The Molecules of Life

- Macromolecules
  - Polysaccharides
  - Proteins
  - nucleic acids
  - Lipids





Carbohydrates

Proteins

Proteins

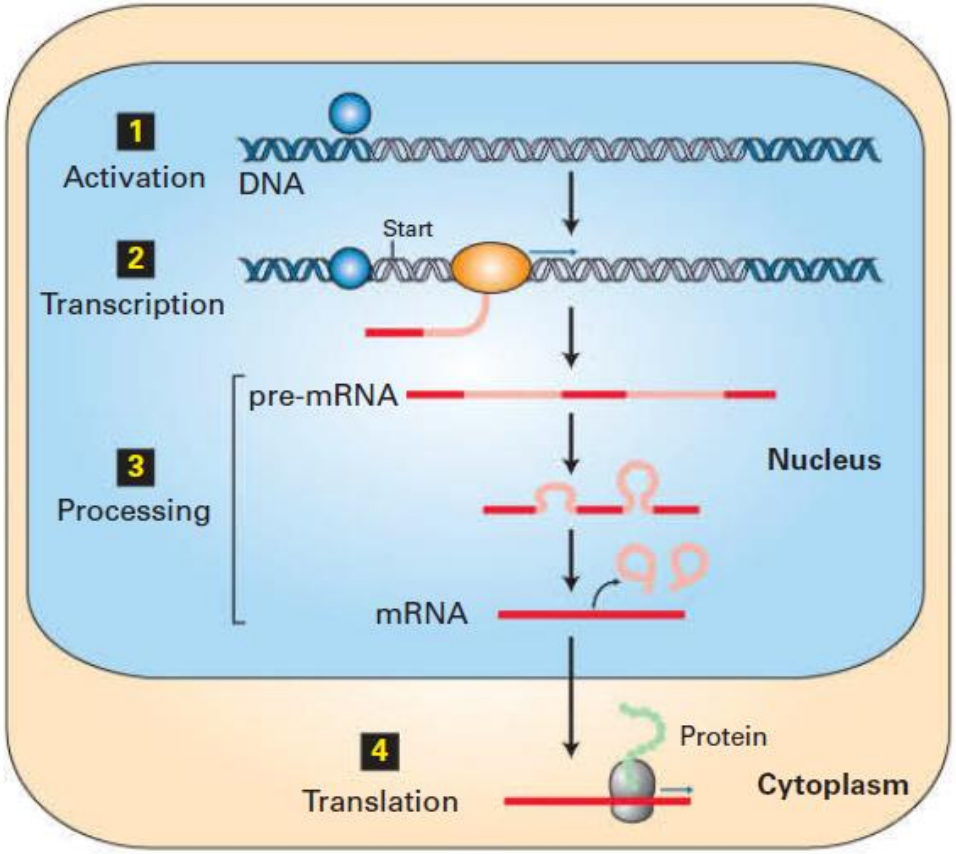
- Cells string together 20 different **amino acids** in linear chains, each with a defined sequence, to form proteins
- Protein functions:
  - Enzymes (catalyze for synth. Of other pro. And other macromolecules).
  - Cytoskeleton proteins. (structural pro. , movement of subcellular structures,
  - sensors that changes shape of the cell,
  - cell-surface proteins,
  - hormones , hormone receptors
  - bind to specific segments of DNA, turning genes on or off

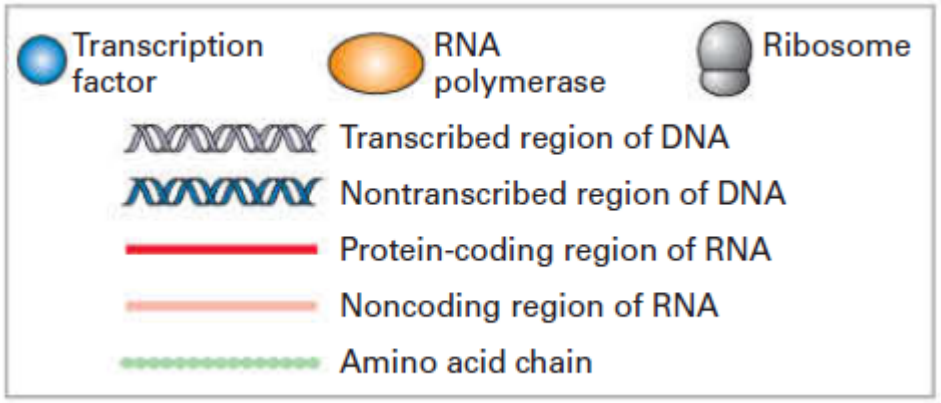
Nucleic Acids

Nucleic acids

- master molecule
- first proposed by James D. Watson and Francis H. C. Crick in 1953
- **heredity**, the transfer of genetically determined characteristics from one generation to the next
- Specific segments of DNA, termed genes, carry instructions for making specific proteins.
- Gene regions:
  - coding region: specifies the amino acid sequence of a protein
  - regulatory region binds specific proteins and controls when and in which cells the gene's protein is made

Nucleic acids





Step 1 : Transcription factors and other proteins bind to the regulatory regions of the specific genes they control to activate those genes

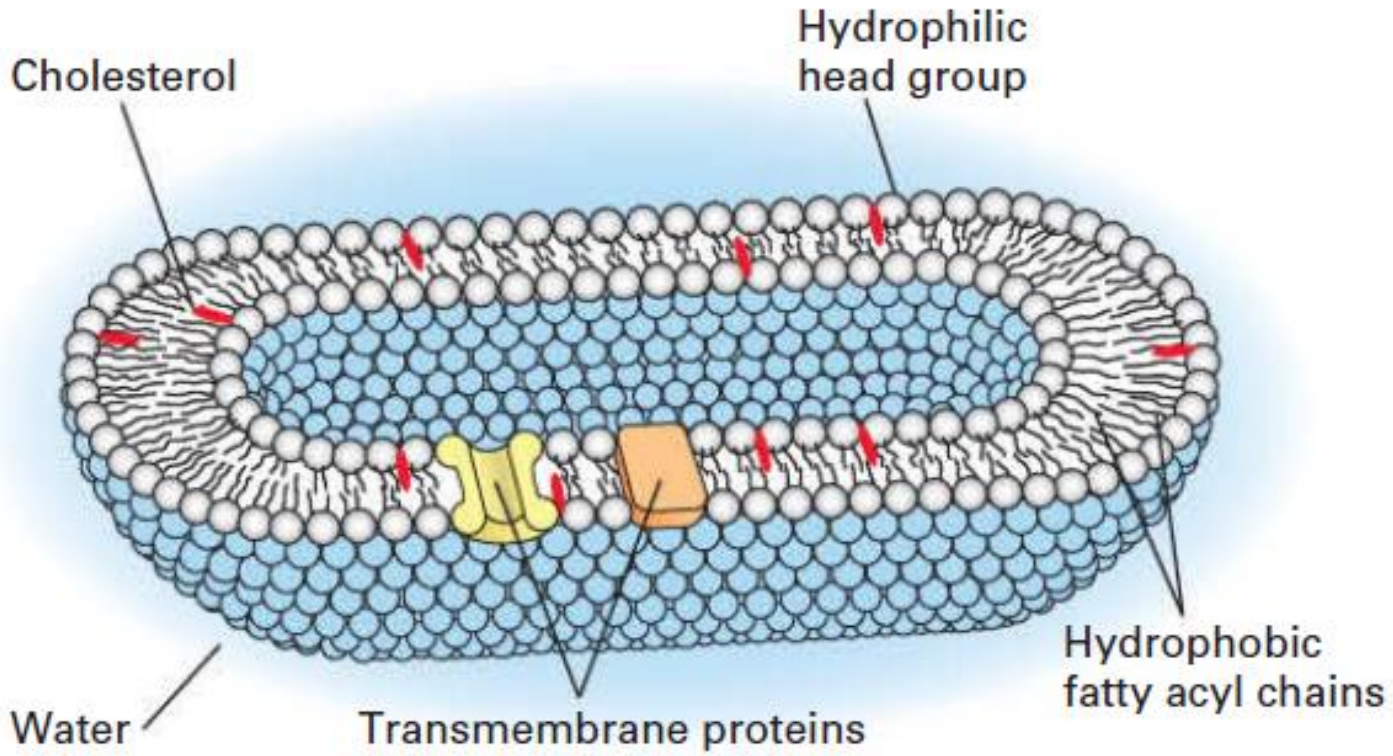
Step 2 : RNA polymerase begins transcription of an activated gene at a specific location, the start site. The polymerase moves along the DNA, linking nucleotides into a single-stranded pre-mRNA transcript using one of the DNA strands as a template.

Step 3 : The transcript is processed to remove noncoding sequences.

Step 4 : In a eukaryotic cell, the mature mRNA moves to the cytoplasm, where it is bound by ribosomes that read its sequence and assemble a protein by chemically linking amino acids into a linear chain.

Lipids

Lipids


Cholesterol
Hydrophilic
head group
Water
Transmembrane proteins
Hydrophobic
fatty acyl chains