BCM210 Biochemistry

Semester 1

TOPICS

Semester 1: Structure & Function of Biological Macromolecules

- Topic 1 - Foundations of biochemistry
- Topic 2 - The role of water in biochemistry
- Topic 3 - Amino acids, peptides and proteins
- Topic 4 - Structure and function of proteins
- Topic 5 - Enzymes
- Topic 6 - Carbohydrates
- Topic 7 - Nucleic Acids
- Topic 8 - Lipids

Semester 2: Bioenergetics and Metabolism of Biological Macromolecules

- Topic 9 - Energy & metabolism
- Topic 10 - Glycolysis and gluconeogenesis
- Topic 11 - Principles of metabolic regulation: glucose and glycogen
- Topic 12 - The citric acid cycle
- Topic 13 - Oxidative phosphorylation
- Topic 14 - Lipid metabolism
- Topic 15 - Amino acid metabolism

TOPIC 1: Foundations of Biochemistry

Nelson, D., & Cox, M. (2017). *Lehninger Principles of Biochemistry (7th ed.) (International ed): W. H. Freeman. Chapter 1. pp.3-21*

Learning Objectives:
1. Describe the common features of all cells, distinguish between different prokaryotic and eukaryotic cells
2. Recognise the major structures found in eukaryotic cells, and ascribe a function to the major subcellular organelles
3. Name the major classes of biomolecules which make up living cells
4. Understand the meaning of the terms monomer and polymer, and identify the monomeric and polymeric forms of each of the major classes of biomolecules
5. Recognise the chemical basis of the major functional groups in biomolecules
6. Recognise stereoisomers, chiral carbons, and geometric isomers

Describe the common features of all cells, distinguish between different prokaryotic and eukaryotic cells.

Biochemistry is the chemistry of living matter.
Living matter is characterized by:
- High degree of complexity and organization
- Extraction, transformation, and systematic use of energy to create and maintain structures and to do work
- Interactions of individual components are dynamic and coordinated
- Ability to sense and respond to changes in surrounding
- A capacity for fairly precise self-replication while allowing enough change for evolution

The basis of all life is the chemical reactions that take place within the cell.
Chemistry allows for:
- A high degree of complexity and organization
- Extraction, transformation, and systematic use of energy to create and maintain structures and to do work
- The interactions of individual components to be dynamic and coordinated.
- The ability to sense and respond to changes in surrounding
- A capacity for fairly precise self-replication while allowing enough change for evolution

Living systems extract energy from sunlight (plants, green bacteria, cyanobacteria) and from fuels (animals, most bacteria), which is needed as an input in order to maintain life.

Biochemistry looks at the chemistry that is behind:
- Accelerating reactions
- Organisation of metabolism and signalling
- Storage and transfer of information

The **cell** is the universal unit of life.
- Living organisms are made of cells
- Simplest living organisms are single-celled
- Larger organisms consist of many cells with different functions
- Not all of the cells are the same

The three distinct domains of life are defined by cellular and molecular differences.

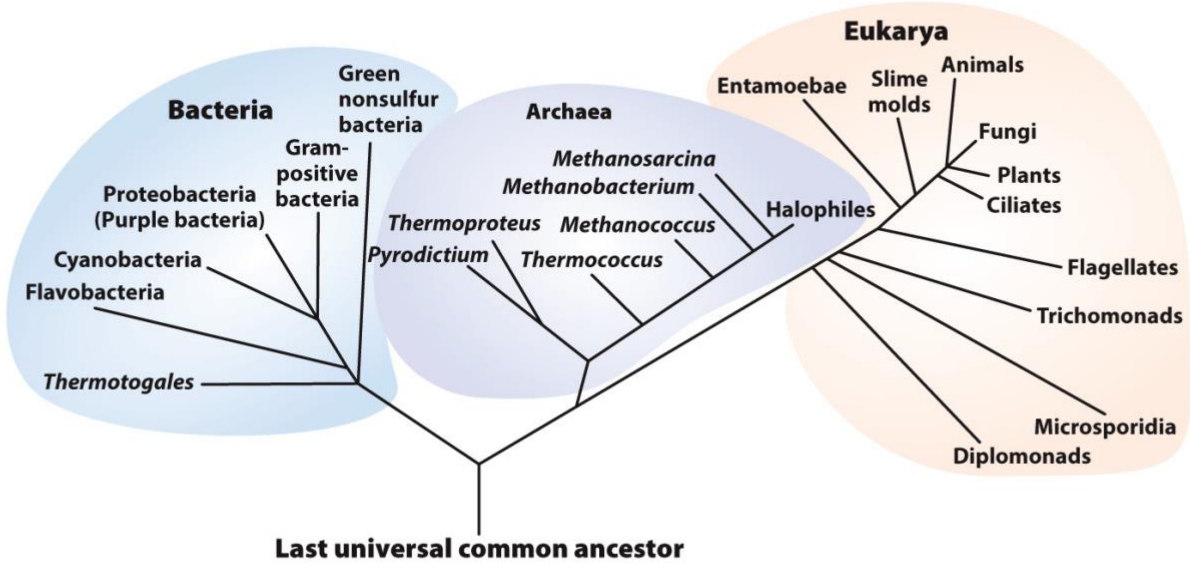

Figure 1-5
Lehninger Principles of Biochemistry, Seventh Edition

FIGURE 1-5 Phylogeny of the three domains of life. Phylogenetic relationships are often illustrated by a "family tree" of this type. The basis for this tree is the similarity in nucleotide sequences of the ribosomal RNAs of each group; the more similar the sequences, the closer the location of the branches, with the distance between branches representing the degree of difference between two sequences. Phylogenetic trees can also be constructed from similarities across species of the amino acid sequences of a single protein. For example, sequences of the protein GroEL (a bacterial protein that assists in protein folding) were compared to generate the tree in Figure 3-35. The tree in Figure 3-36 is a "consensus" tree, which uses several comparisons such as these to derive the best estimates of evolutionary relatedness among a group of organisms. Genomic sequences from a wide range of bacteria, archaea, and eukaryotes also are consistent with a two-domain model in which eukaryotes are subsumed under the Archaea domain. As more genomes are sequenced, one model may emerge as the clear best fit for the data.

Prokaryotic vs Eukaryotic Cells

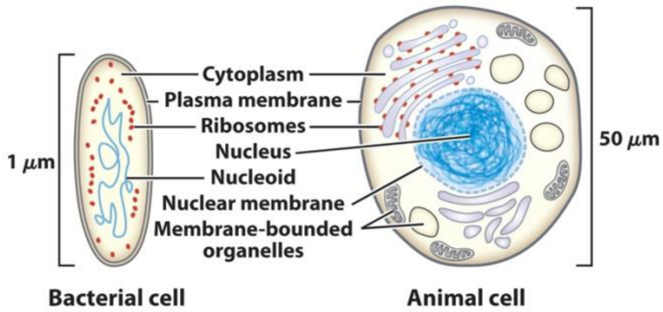

Figure 1-3
Lehninger Principles of Biochemistry, Seventh Edition

FIGURE 1-3 The universal features of living cells. All cells have a nucleus or nucleoid containing their DNA, a plasma membrane, and cytoplasm. The cytosol is defined as that portion of the cytoplasm that remains in the supernatant after gentle breakage of the plasma membrane and centrifugation of the resulting extract at 150,000 *g* for 1 hour. Eukaryotic cells contain a variety of membrane-bounded organelles (including mitochondria, chloroplasts) and large particles (ribosomes, for example), which are sedimented by this centrifugation and can be recovered from the pellet.

Prokaryotic	Eukaryotic
e.g. bacteria, cyanobacteria, archaea	e.g. Animals, plants, fungi, protists
Small (generally 1-10 μm)	Larger (generally 5-100 μm)
Single cell organism (usually)	Single or multicellular organism (most eukaryotes are prostists)
Nucleoid- no membrane, cytoplasmic DNA	Nucleus with nuclear envelope, DNA condensed into nucleus
Low DNA content	High DNA content (more genes)
Cytoplasmic DNA plasmids	No **cytoplasmic** DNA plasmids
No membrane bound organelles	Organelles: eg. Golgi, ER, mitochondria, peroxisomes, lysosomes

Bacterial cell structure

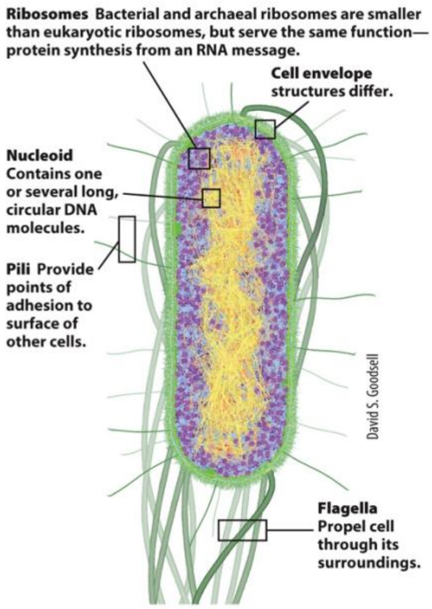

Figure 1-7a
Lehninger Principles of Biochemistry, Seventh Edition

Recognise the major structures found in eukaryotic cells, and ascribe a function to the major subcellular organelles

Eukaryotic cells are more complex.

- Have nucleus by definition
    - protection for DNA; site of DNA metabolism
    - selective import and export via nuclear membrane pores
    - some cells become anuclear (red blood cells)
- Have membrane-enclosed organelles
    - Mitochondria for energy in animals, plants, and fungi
    - Chloroplasts for energy in plant

- o Lysosome for digestion of un-needed molecules
- Spatial separation of energy-yielding and energy- consuming reactions helps cells to maintain homeostasis and stay away from equilibrium

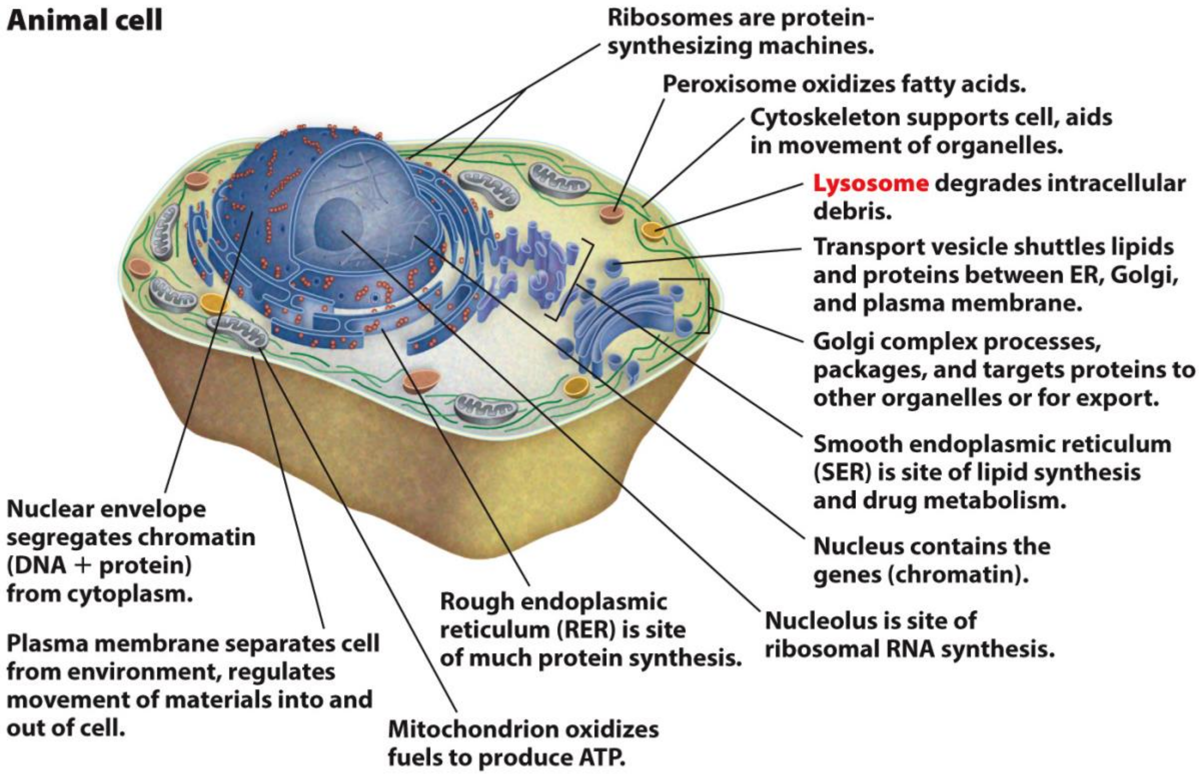

Figure 1-8a
Lehninger Principles of Biochemistry, Seventh Edition

FIGURE 1–8a Eukaryotic cell structure. Schematic illustrations of two major types of eukaryotic cell: (a) a representative animal cell, and (b) a representative plant cell. Plant cells are usually 10 to 100 μm in diameter—larger than animal cells, which typically range from 5 to 30 μm. Structures labeled in red are unique to either animal or plant cells. Eukaryotic microorganisms (such as protists and fungi) have structures similar to those in plant and animal cells, but many also contain specialized organelles not illustrated here.

Cytoplasm is highly viscous solution where many reactions take place.
Cytoskeleton consists of microtubules, actin filaments, and intermediate filaments. It maintains cellular organization which is dynamic, changing drastically at different stages:

- o Cell shape
- o Intracellular organization
- o Intracellular transport paths
- o Cellular movement

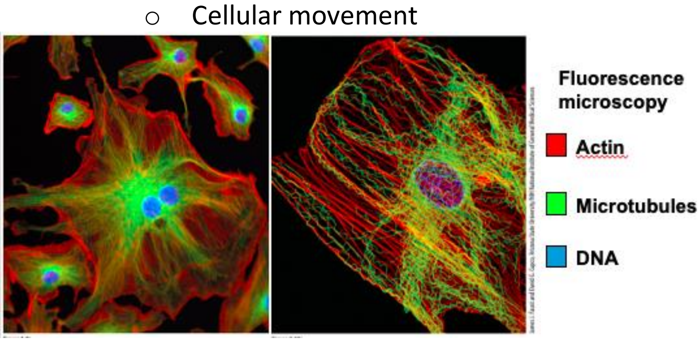

FIGURE 1–9a (6th ed) The three types of cytoskeletal filaments: actin filaments, microtubules, and intermediate filaments. Cellular structures can be labeled with an antibody (that recognizes a