

Chapter 2

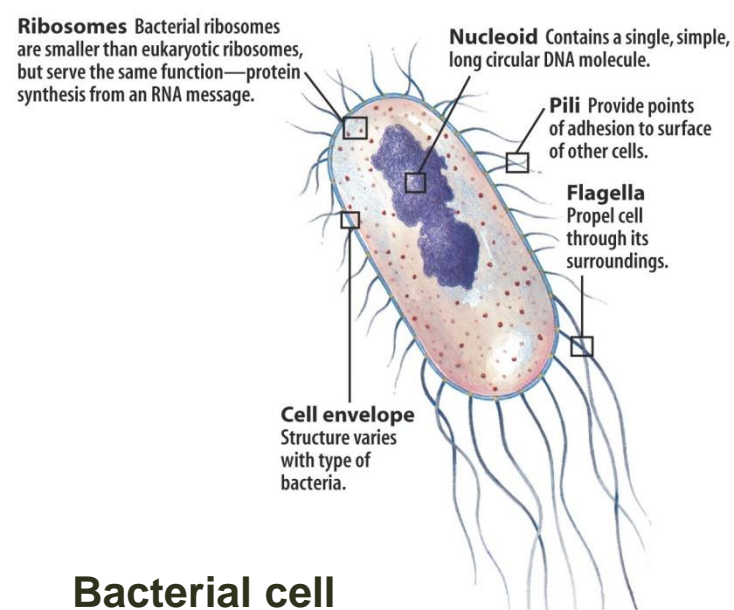


An overview of biological basics

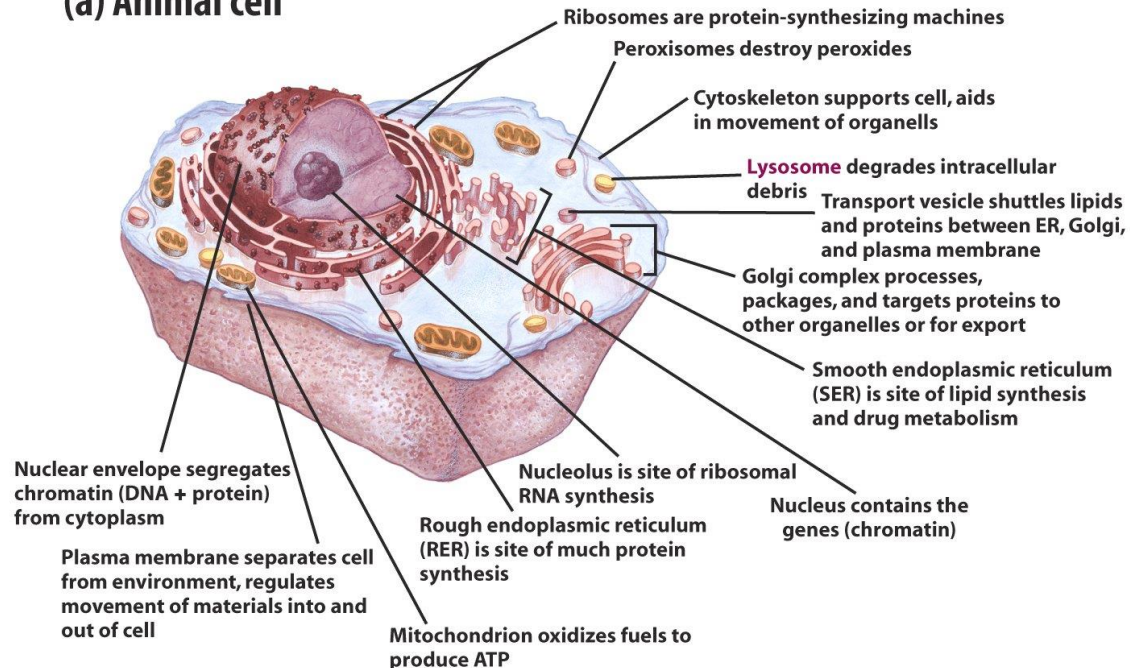
Are all cells the same?

■ Cells

- Basic unit of all living organisms
- Different types, but the same essential properties

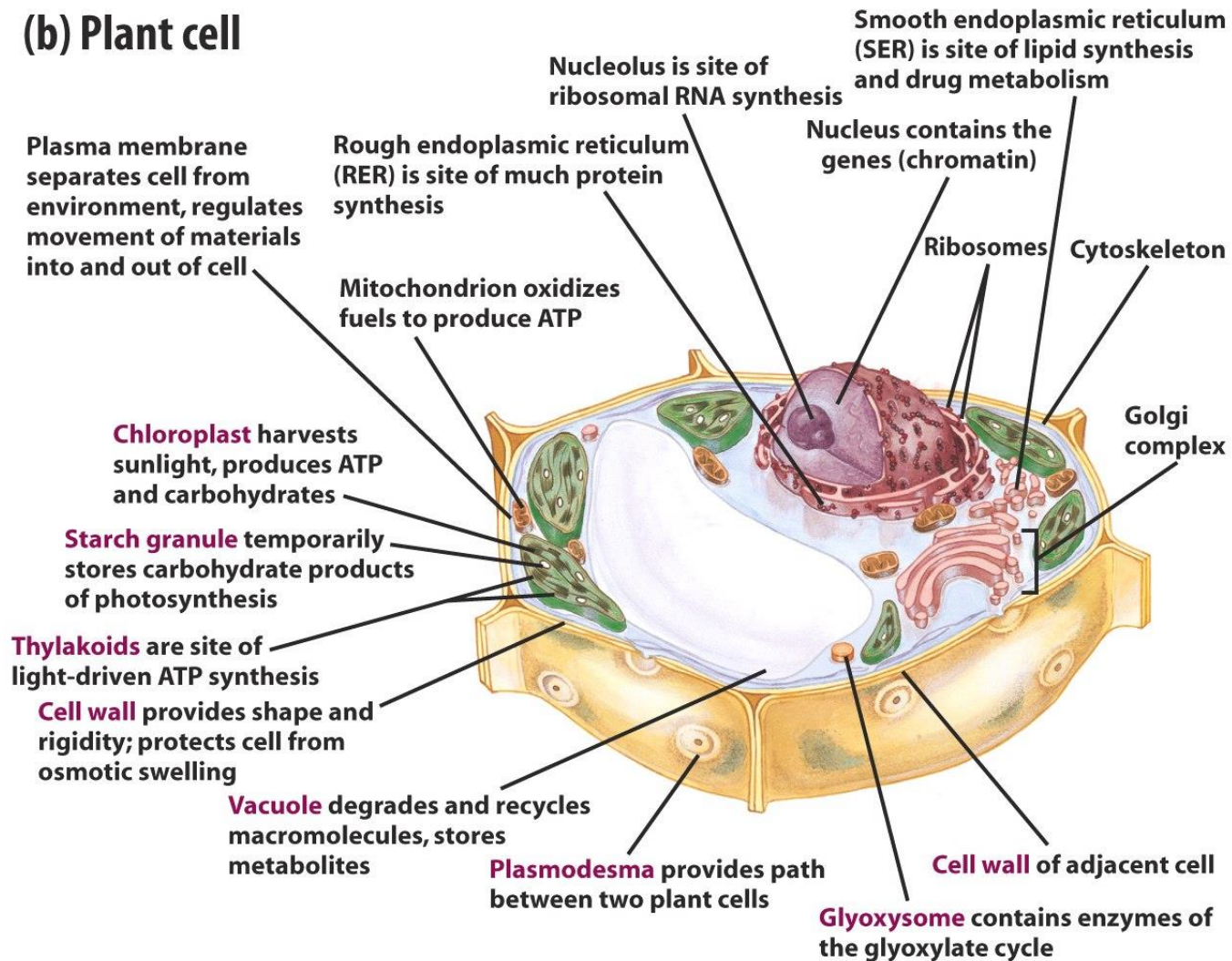


(a) Animal cell



Are all cells the same?

(b) Plant cell



Three Domains of Life

■ Three domains (kingdoms, 계)

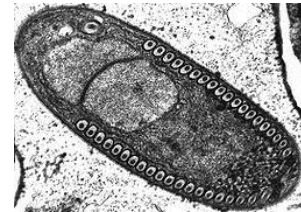
- Eukaryotes (진핵생물)
- Prokaryotes (원핵생물)
 - Eubacteria (진정세균)
 - Archaeobacteria (고세균)



Ciliate
(섬모충)



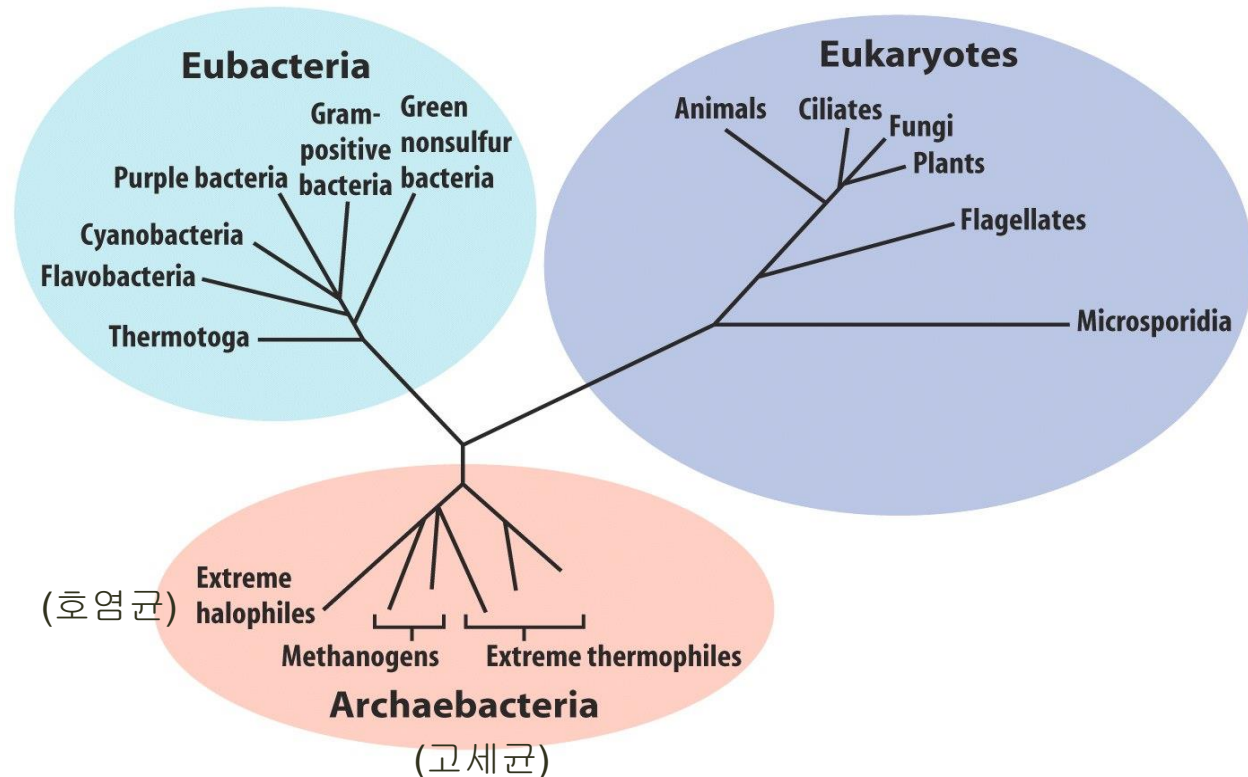
Flagellate
(편모충)



Microsporidia
(미포자충)



Cyanobacteria (남조류)

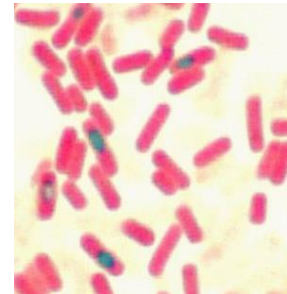


Microbial Diversity

- **Classification of prokaryotes depending on optimal temperature**
 - psychrophile: $< 20^{\circ}\text{C}$
 - mesophile: $20^{\circ}\text{C} \sim 50^{\circ}\text{C}$
 - thermophile: $50^{\circ}\text{C} <$
- **Classification of prokaryotes depending on oxygen need**
 - aerobic: grow in the presence of oxygen
 - anaerobic: grow without oxygen
 - facultative: grow under either circumstances
- **Classification of prokaryotes depending on size and shape**
 - coccus: spherical or elliptical
 - bacillus: cylindrical or rod
 - spirillum: spiral



coccus



bacillus

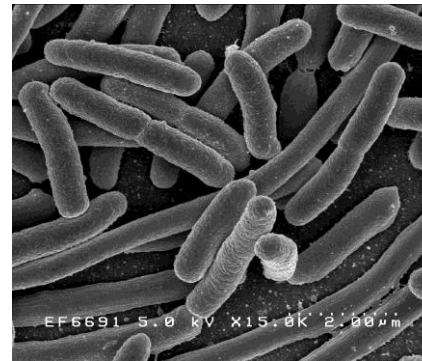


spirillum

Naming Cells (microorganisms)

■ *Escherichia coli* (*E. coli*)

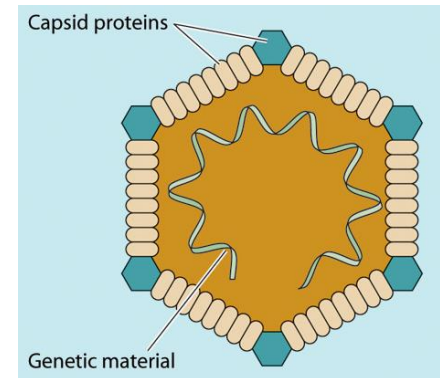
- Given in Latin
- written in italic
- *Escherichia*: genus (속, a group of related species)
- *coli*: species (종)
- various strains (종족) of *E. coli* --- (ex) *E. coli* K12 , *E. coli* B/rA



■ Genus (scientific name) of humans : *Homo sapiens*

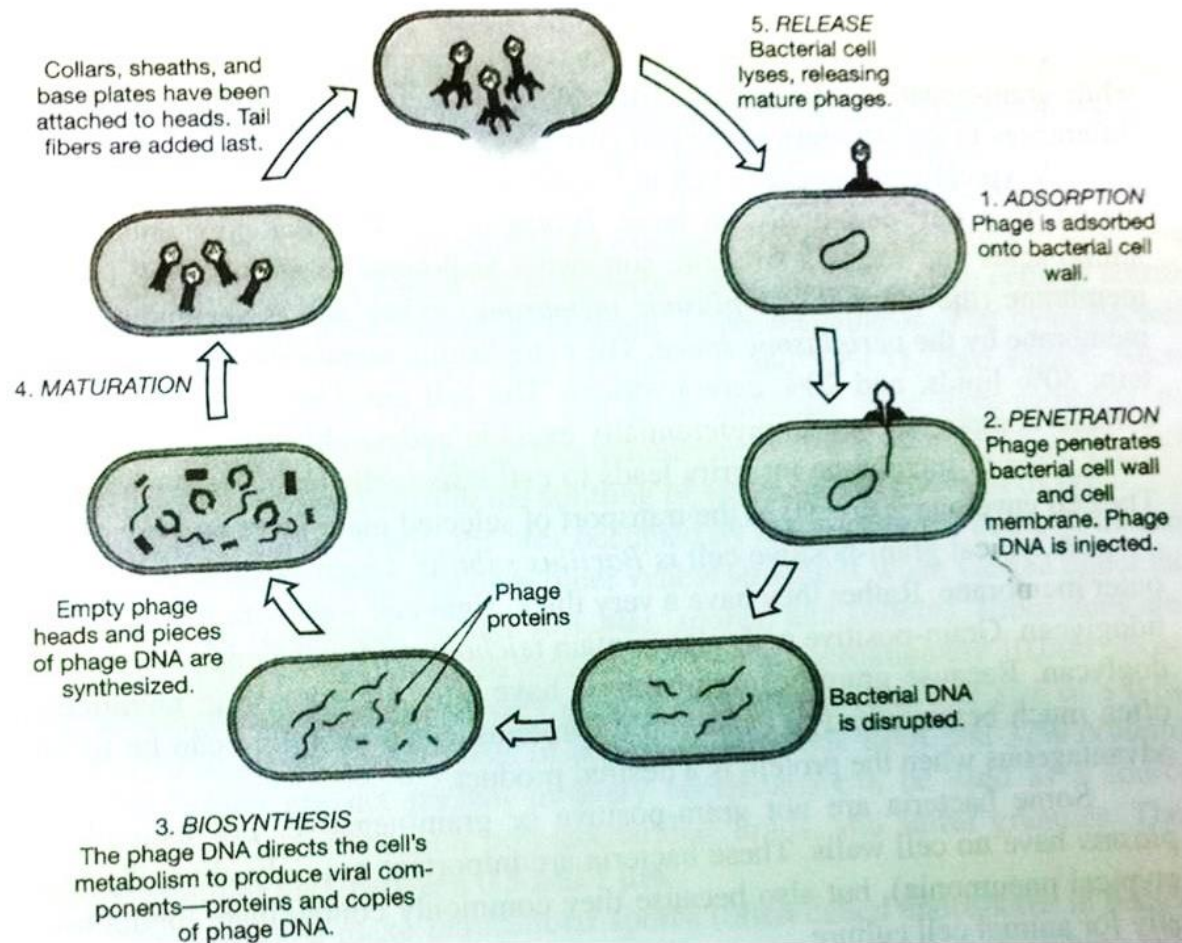
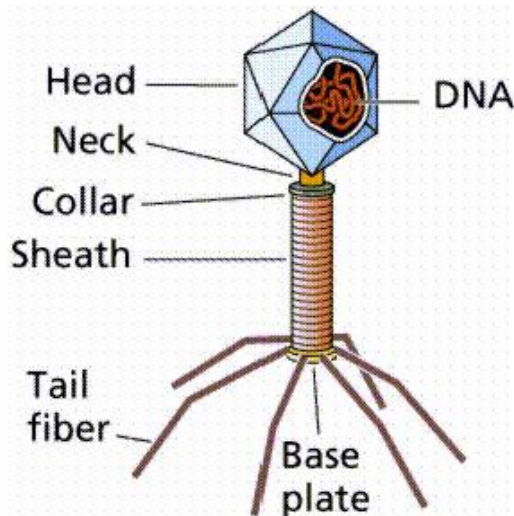
Viruses

- **Used as vaccine**
- **Not cells**
- **No independent reproduction (not alive by itself)**
 - Genetic material (DNA or RNA)
 - Proteins (Capsid)
- **“Viruses are in the semantic (의미적) fog between life and non-life.”**
(Campbell and Reece, *Biology*, 6th Ed, p 339.)
- **Are viruses living beings?**
“The answer to that question is ‘no’, inasmuch as viruses are incapable of independent life.” (de Duve, *Life Evolving*, p.313)
- **Conclusion:**
Viruses do not fit the basic definition of cellular life.
 - Require host for all cellular activities
 - No metabolic capability of their own



Bacteriophage

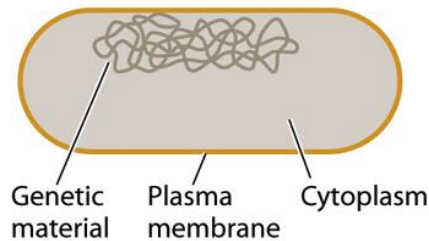
- **Bacteriophage:** bacteria-infecting virus
 - Lytic cycle: reproduction of phase (virus)
 - Phage DNA is incorporated into the host DNA
 - Could be used to kill bacteria



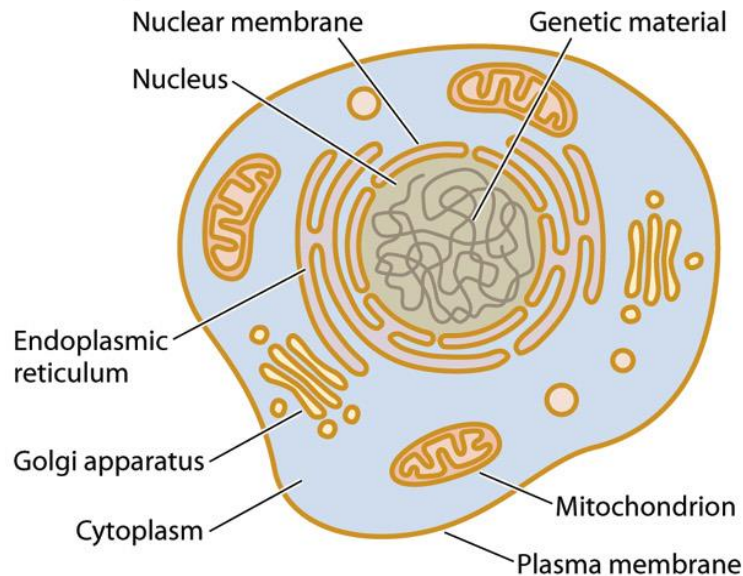
Cell Types by Cell Structure

- Prokaryote & Eukaryote
 - Primary Difference: presence or absence of nucleus (more details in Table 2.1 and 2.2)

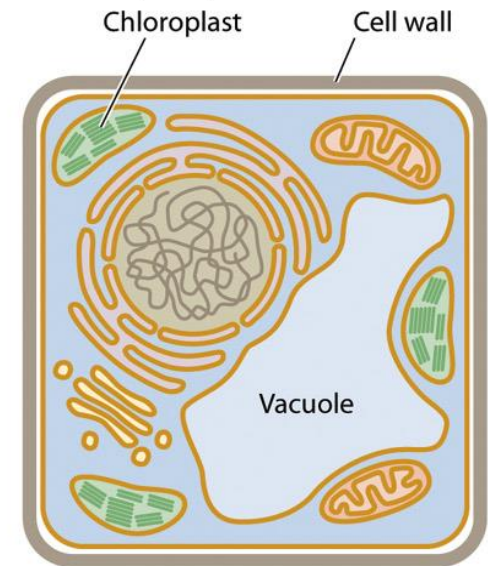
A. Prokaryotic cell



B. Eukaryotic animal cell



C. Eukaryotic plant cell



Prokaryotic Cells

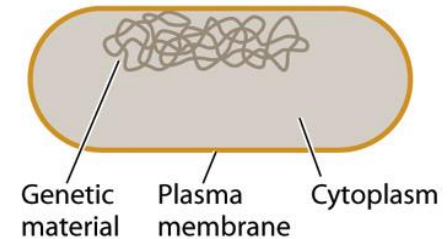
■ Prokaryote

- pro; before
- karyon: kernel(씨앗의 알맹이) or nucleus

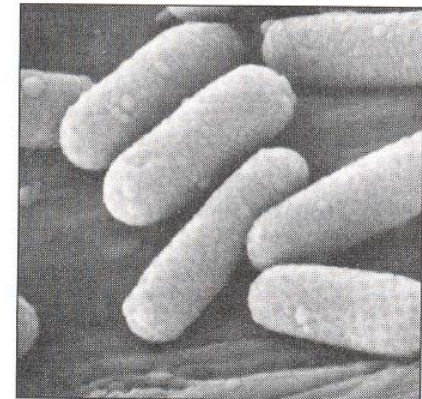
■ No nuclear membrane

■ Small (0.5-3 μm), mostly single-celled organisms

- Eubacteria : common bacteria (e.g. *E. coli*)
- Archaeobacteria
 - methanogens (methane-producing), thermoacidophiles, and halobacteria (high salt)
 - Live in extreme environments



E. coli

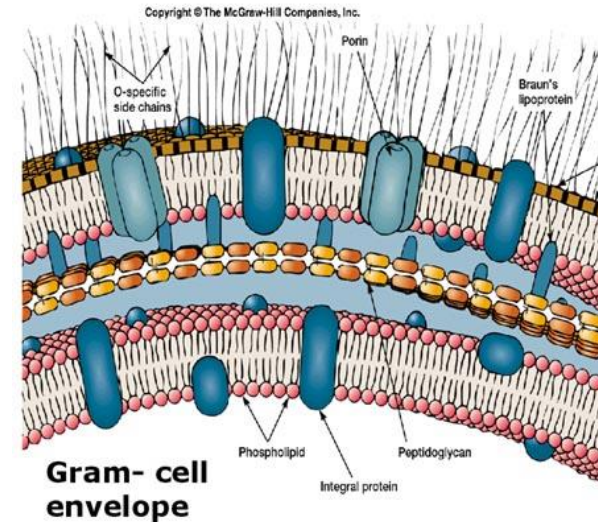


Eubacteria

■ Divided into two groups by gram stain

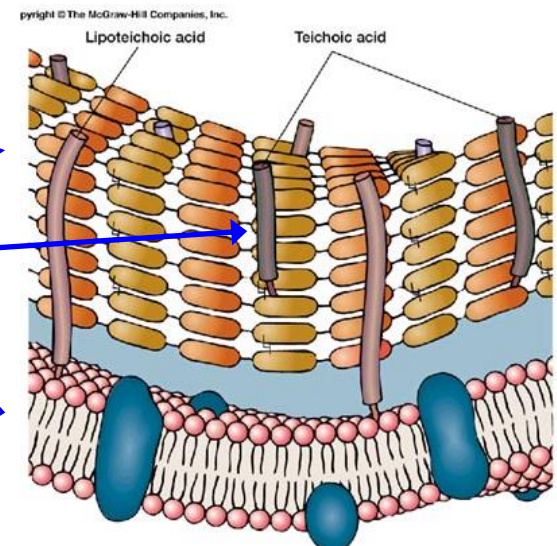
■ Gram-negative cell (e.g. *E. coli*)

- Outer membrane
- Peptidoglycan
- Cytoplasmic (inner) membrane
- Periplasm
 - Between inner and outer membranes

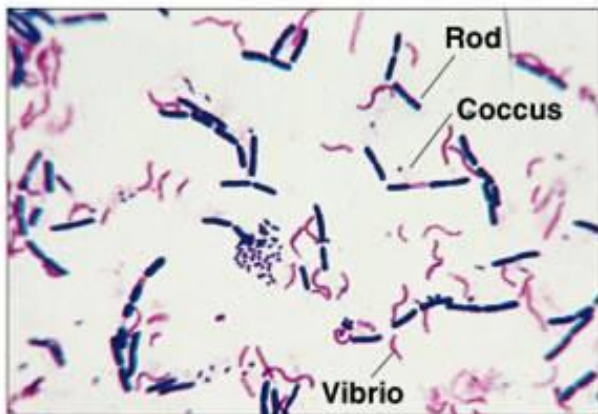
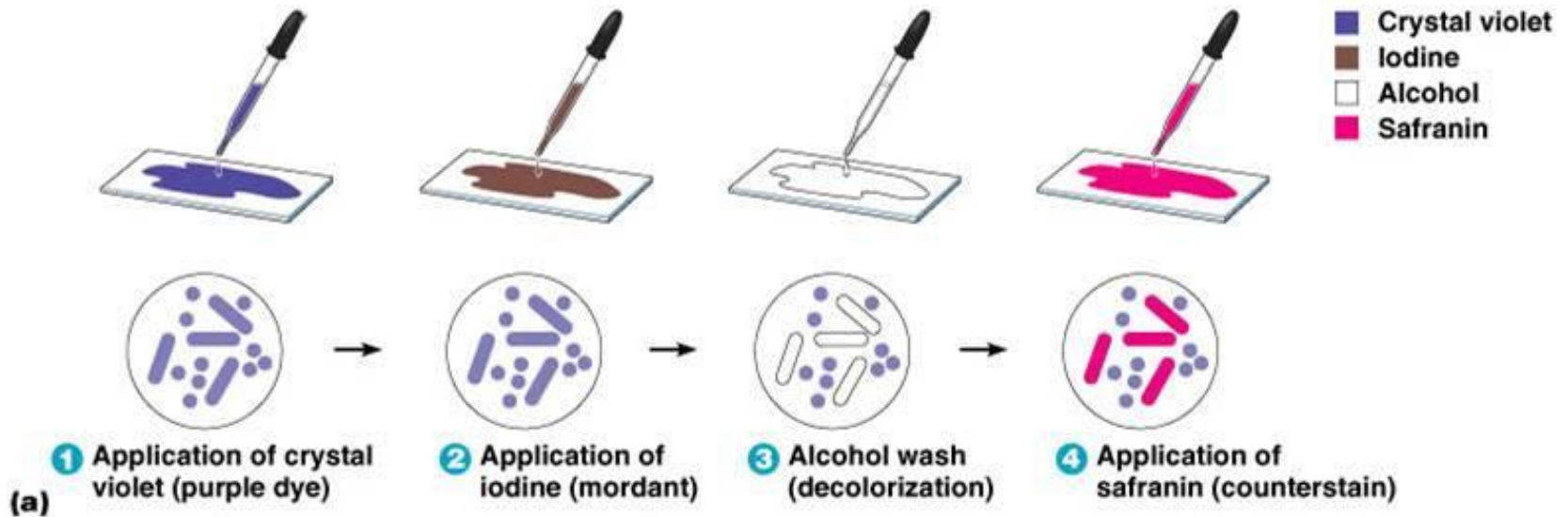


■ Gram-positive cell (e.g. *Bacillus subtilis*)

- No outer membrane
- Peptidoglycan
- Teichoic acid
- Cytoplasmic membrane



Gram Staining



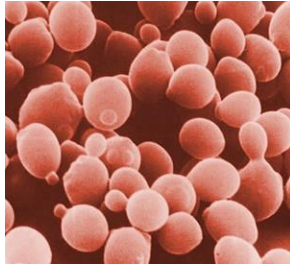
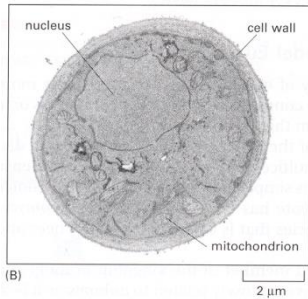
Coccus : gram positive
Vibrio : gram negative

(b)

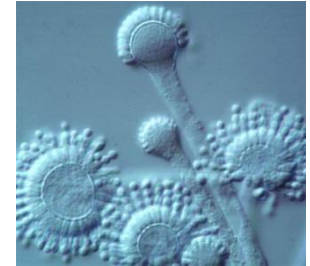
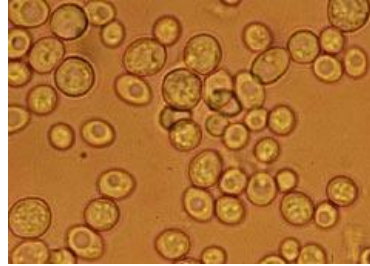
Eukaryotic Cells

■ Fungi

- Yeasts --- single small cells of 5- to 10- μm size
- Molds --- filamentous fungi, have a mycelial (균사) structure



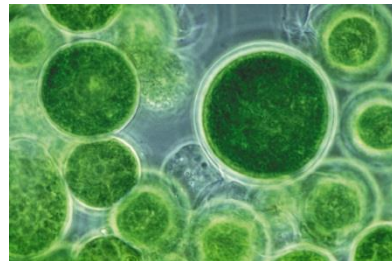
Yeast



Mold

■ Algae (조류)

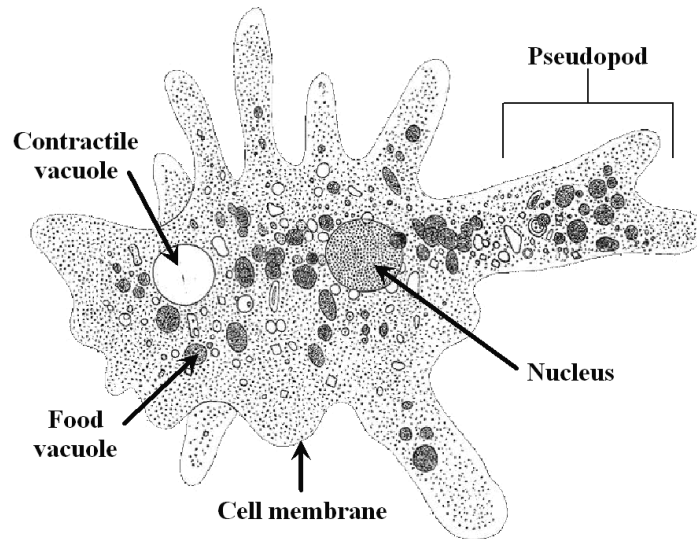
- Unicellular algae (microalgae) --- 10 to 30 μm
- Plantlike multicellular algae



Eukaryotic Cells

■ Protozoa (원생생물)

- Unicellular, motile, relatively large (1 - 50 mm) --- amoeba



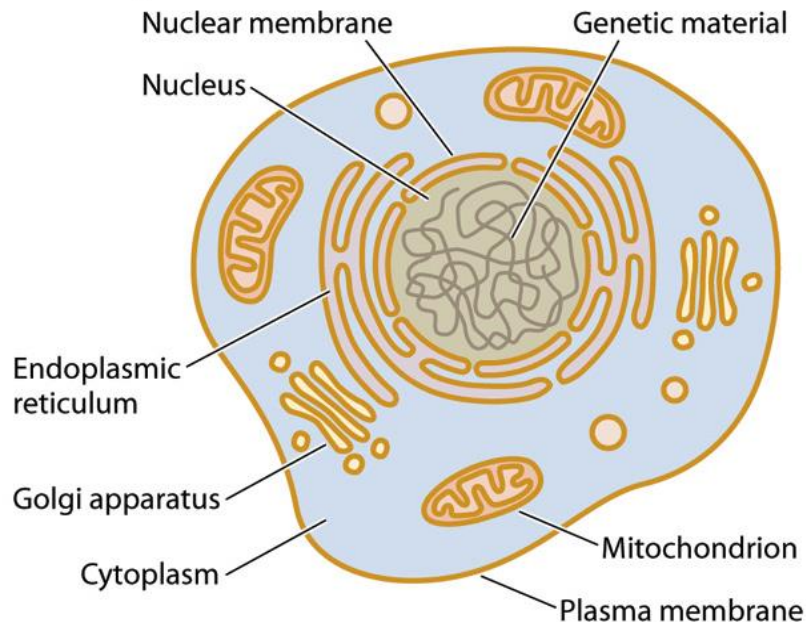
■ Plant cells

■ Animal cells

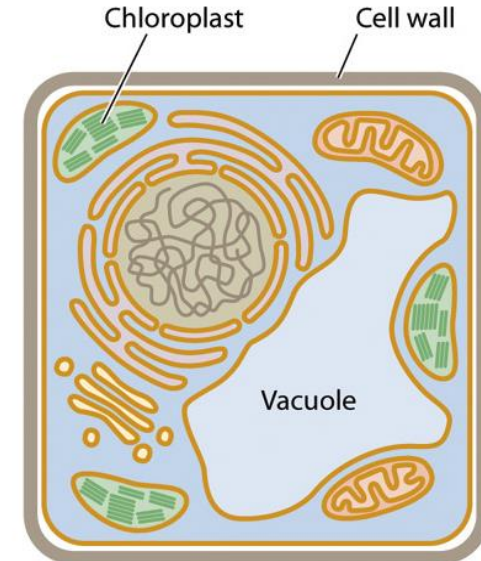
Eukaryote

- **Eukaryote (well-formed nucleus)**
- **Larger than prokaryotes (10-100 μm)**
 - Single-celled : yeast, green algae, amoebae
 - Multicellular : fungi, plant, animal

B. Eukaryotic animal cell



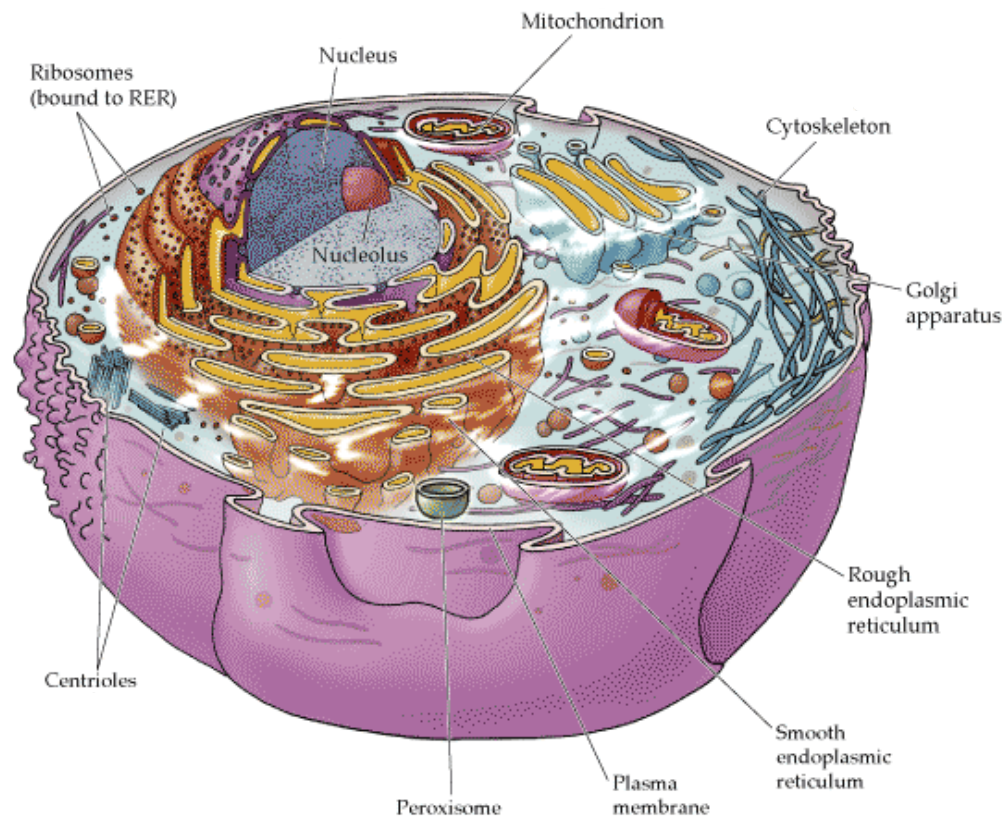
C. Eukaryotic plant cell



Eukaryote

■ Internal membranes → organelles

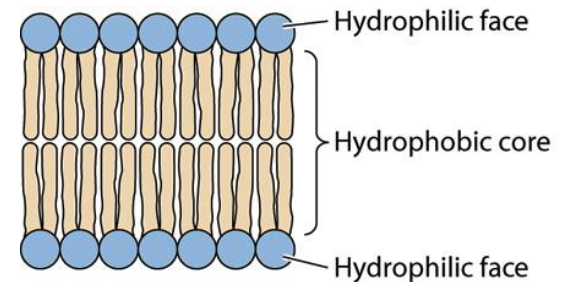
- Nucleus --- contains chromosomes as nuclear material
- Mitochondria --- powerhouse of a cell
- Golgi body --- responsible for the secretion of certain proteins
- Vacuole --- responsible for food digestion, osmotic regulation, and waste-product storage
- Chloroplast --- responsible for photosynthesis
- endoplasmic reticulum, lysosome, peroxysome ...



Cellular Membranes

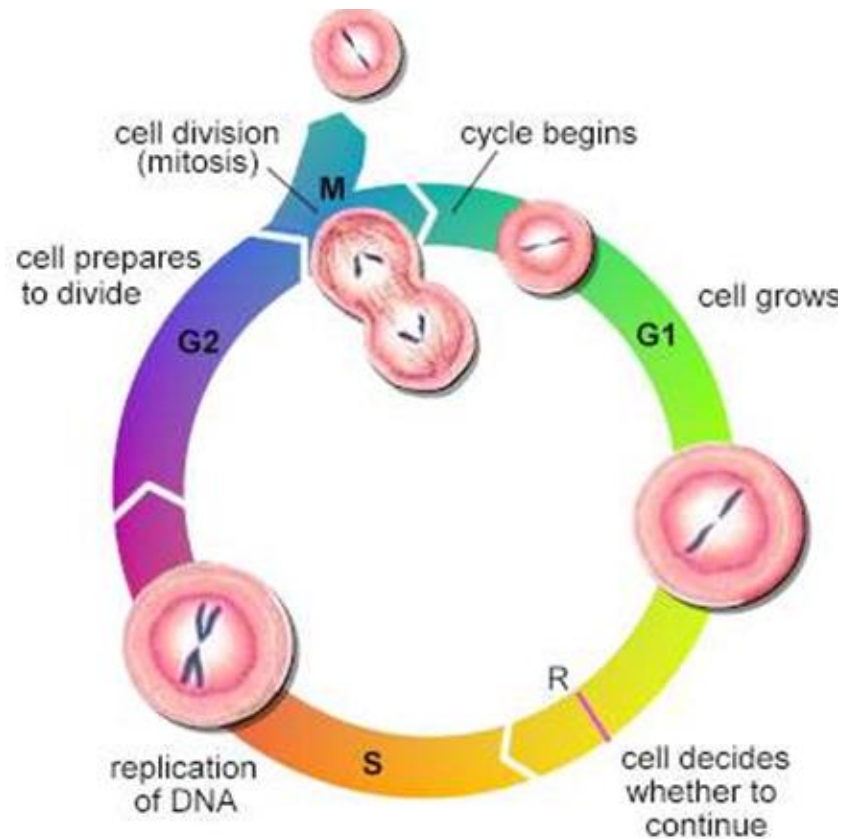
■ Provide structural organization

- Lipid bilayer with hydrophobic core and hydrophilic face
- Plasma (cell) membrane: Hydrophobic barrier between inside (cytoplasm) and outside of the cell
- Internal membranes for **eukaryote**
 - Nucleus
 - Endoplasmic reticulum, Golgi apparatus
 - Mitochondria
 - Chloroplast

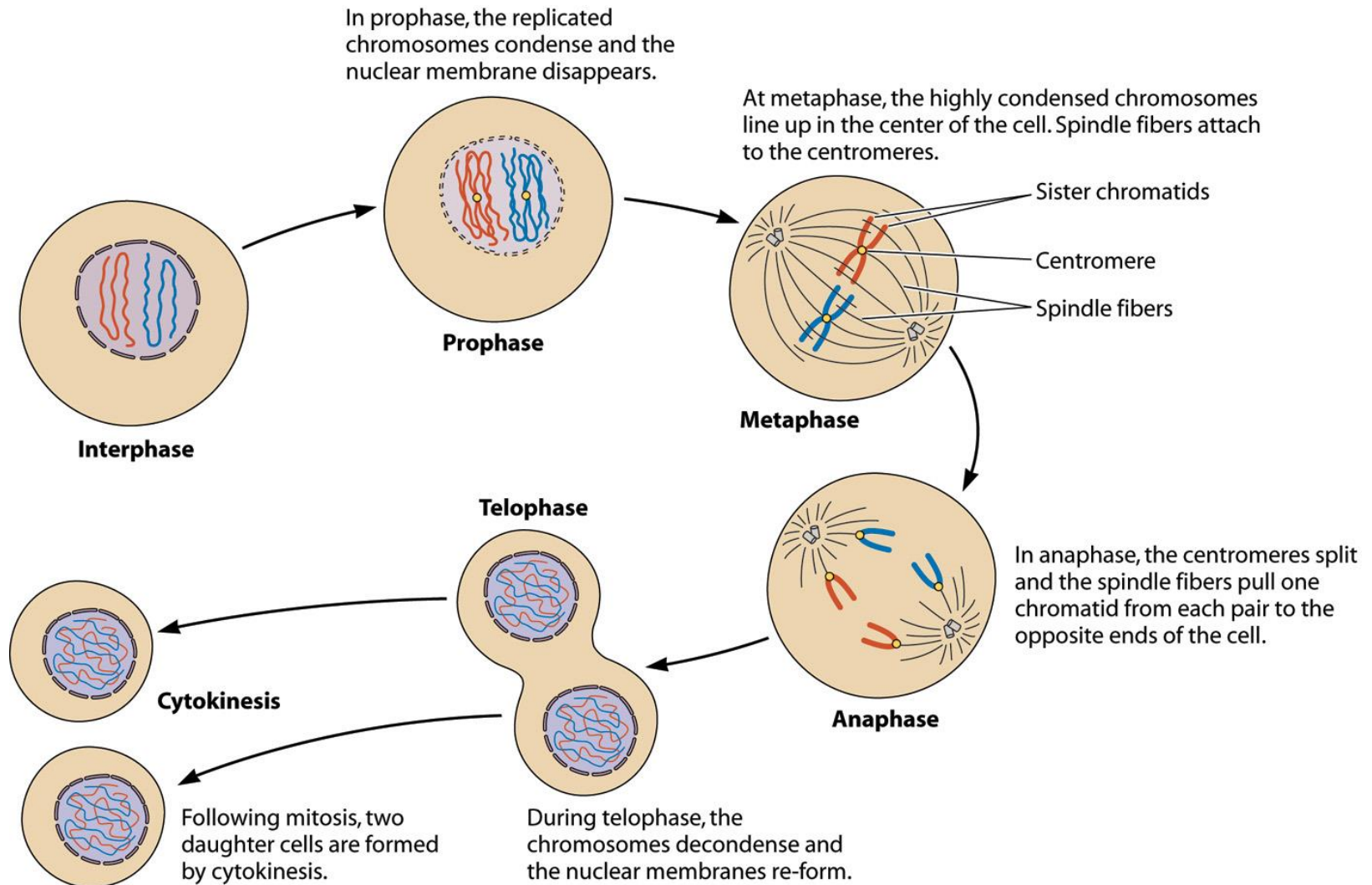


Cell Cycle in Eukaryote

- S phase: DNA **s**ynthesis
- M phase: **m**itosis
- G_1 , G_2 (**g**ap between S and M phase)



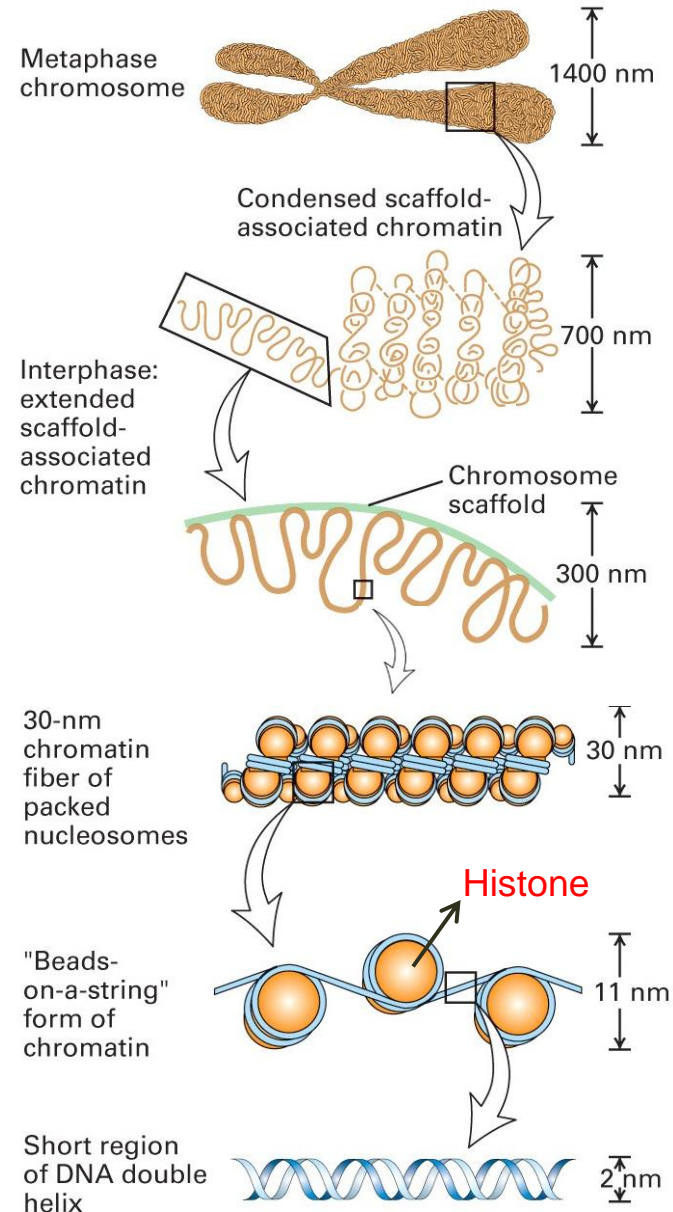
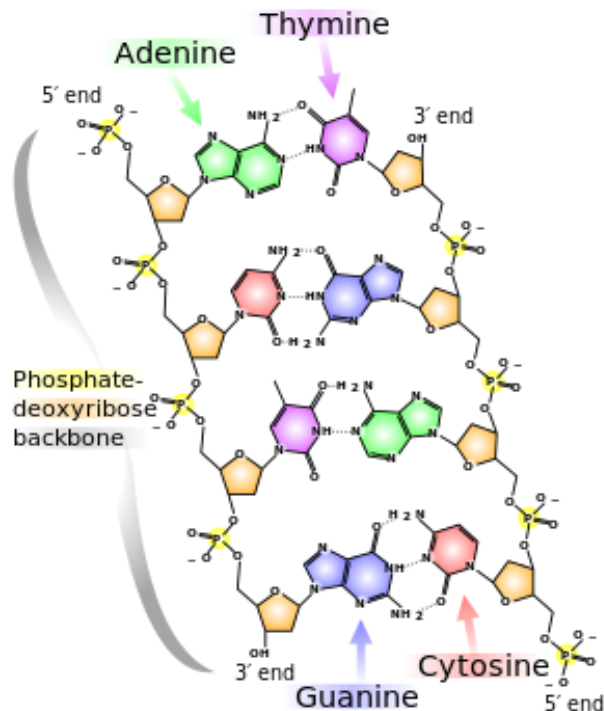
Mitosis



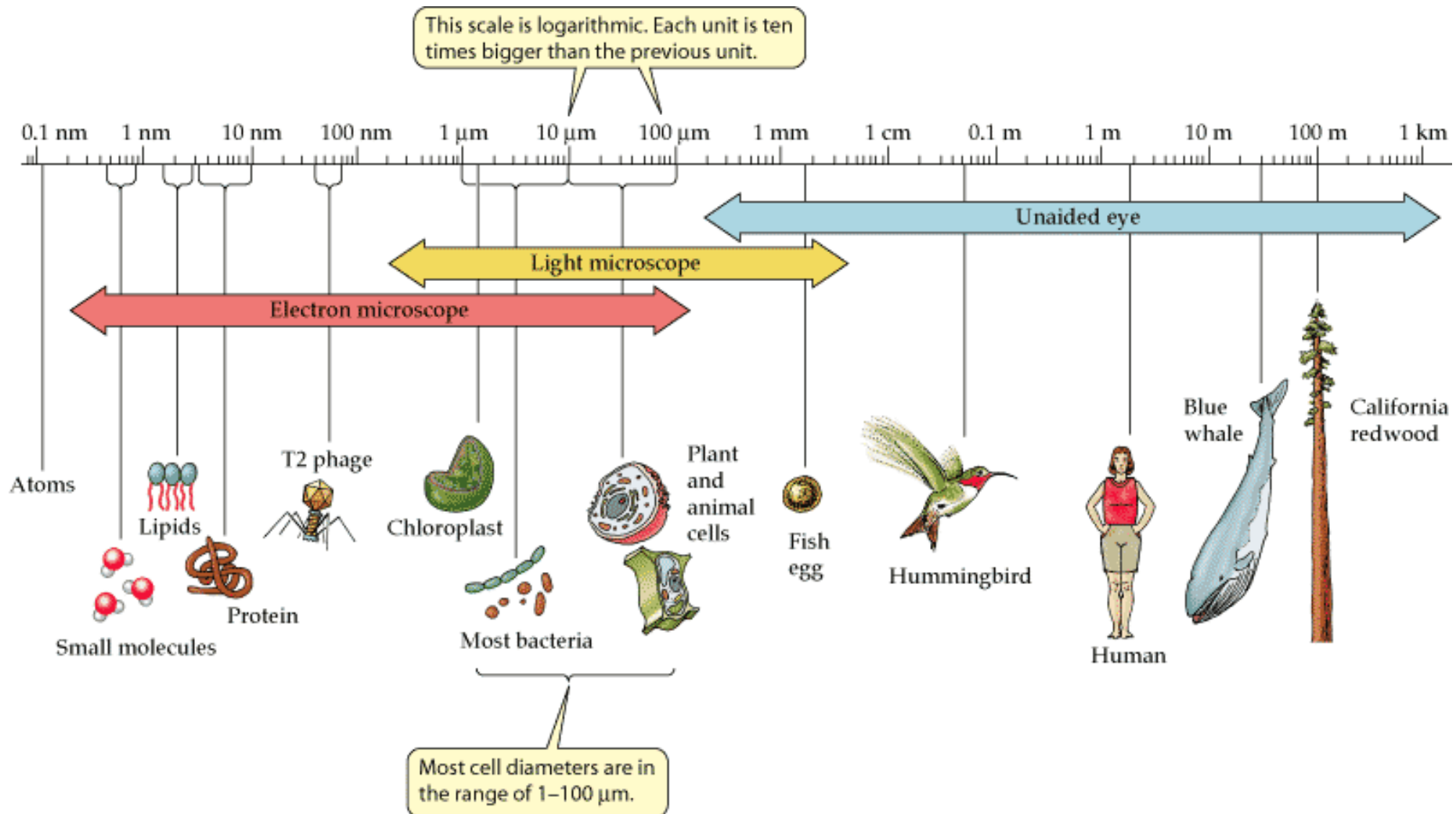
Chromosome

- One eukaryotic cell contains 46 chromosomes
- Tightly packed complex of DNA and histone proteins

deoxyribonucleic acid (DNA)



The Scale of Life



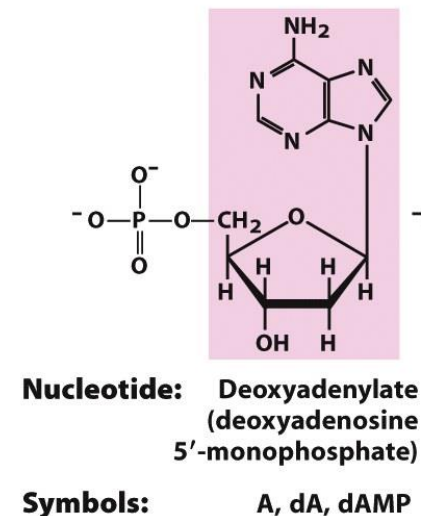
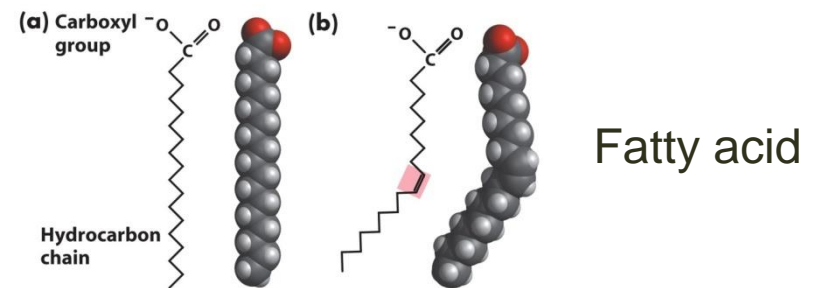
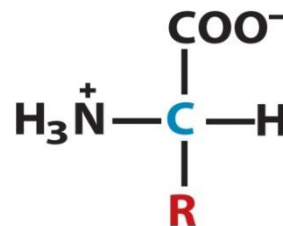
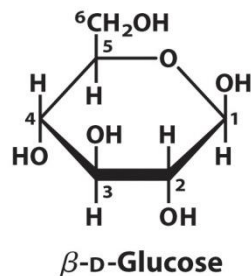
Cell Construction

■ Elemental composition of typical bacterial cell

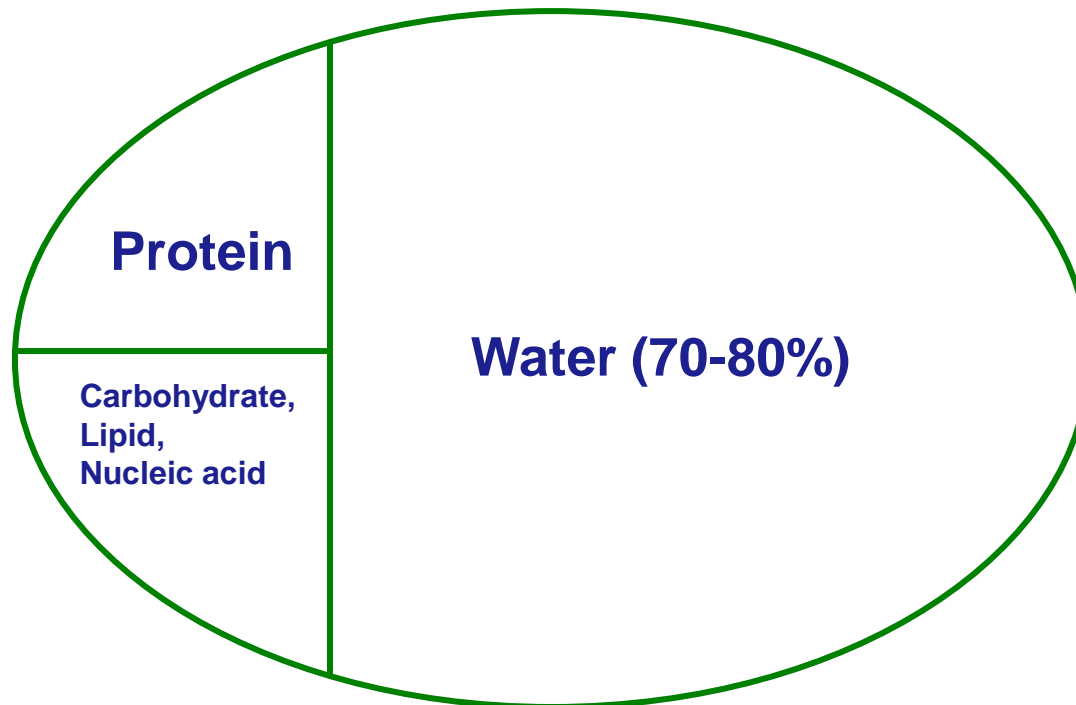
- C 50%, O 20%, N 14%, H 8%, P 3%, S 1%, and others (K^+ , Na^+ , Ca^{2+} , Mg^{2+} , Cl^- , vitamin)

■ Molecular building blocks

- Lipids
- Carbohydrates
- Proteins
- Nucleic acid
 - DNA (deoxyribonucleic acid)
 - RNA (ribonucleic acid)



Molecular Components of Cells



Subunits of Biological Molecules

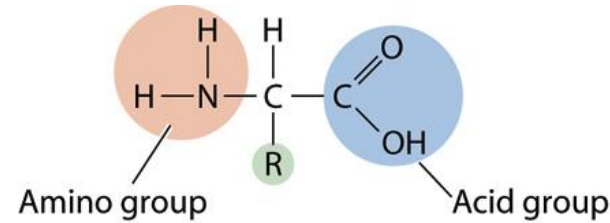
Molecular building blocks	Examples	Smallest Repeating Unit
Lipid	Membrane, fats, oils	Glycerol, fatty acid
Carbohydrate	Sugars, starch, cellulose, cell wall, glycogen	Simple sugars
Nucleic acid	DNA, RNA	Nucleotide
Protein	Enzymes	Amino acids

others : inorganic salts, metabolic intermediates, vitamins, etc.

Amino Acids and Primary Structure

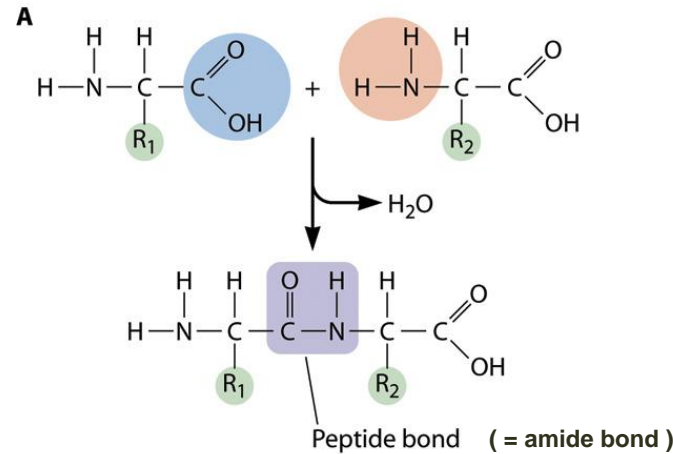
Amino acids

- Amino group
- Carboxyl group
- R group; 20 Side chains



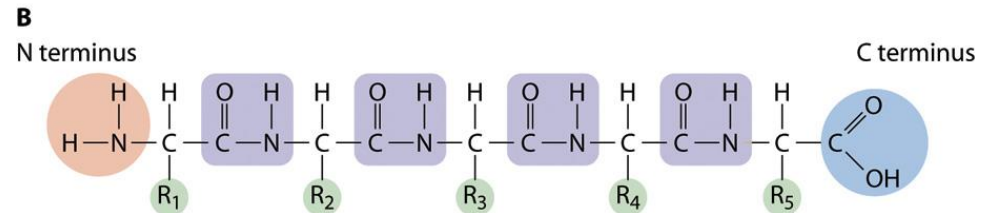
Peptide bond

- Between NH_2 and COOH



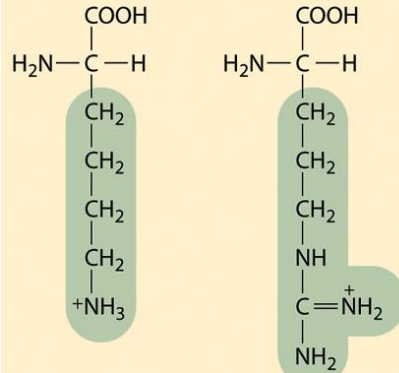
Polypeptide

- A chain of amino acids
- N terminus and C terminus



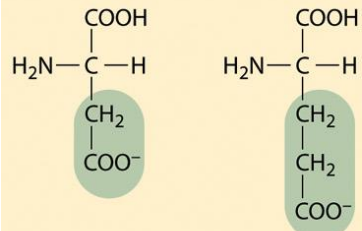
Amino Acids

Charged R groups



Lysine (Lys)

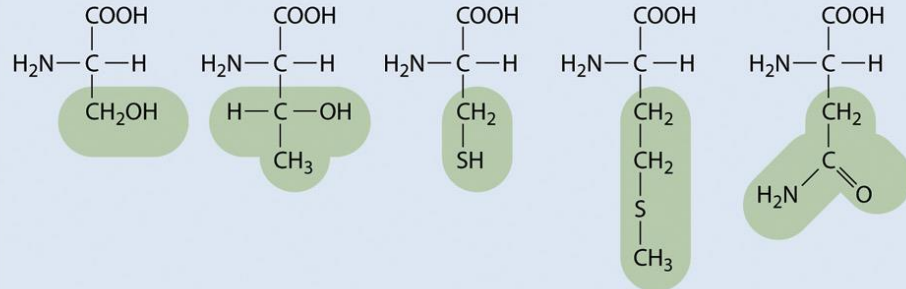
Arginine (Arg)



Aspartate (Asp)

Glutamate (Glu)

Polar R groups



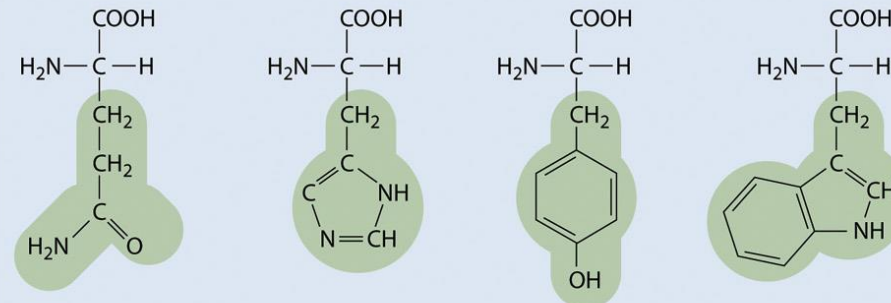
Serine (Ser)

Threonine (Thr)

Cysteine (Cys)

Methionine (Met)

Asparagine (Asn)



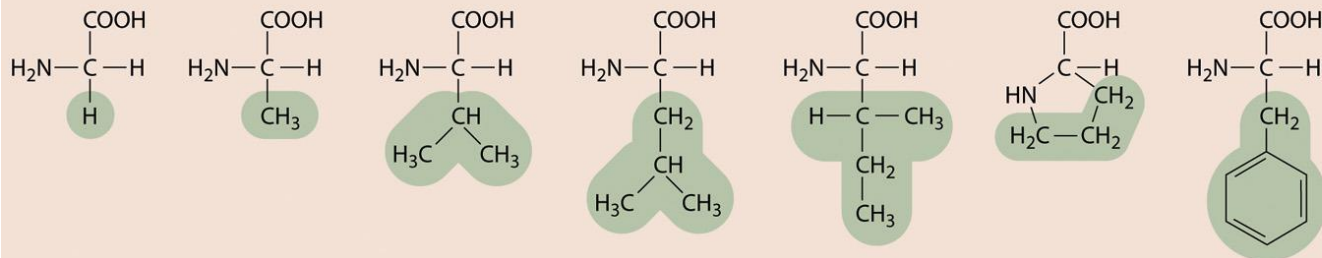
Glutamine (Gln)

Histidine (His)

Tyrosine (Tyr)

Tryptophan (Trp)

Nonpolar R groups



Glycine (Gly)

Alanine (Ala)

Valine (Val)

Leucine (Leu)

Isoleucine (Ile)

Proline (Pro)

Phenylalanine (Phe)

Proteins

Amino acids

- Building blocks of proteins
- Hydrophilic backbone + 20 side chains

Polypeptide

- Amino acid chains linked by peptide bond

Polypeptide vs. protein

- Polypeptide: $M_r < 10,000$

Three-dimensional structure :

- Determines protein function
- Determined by amino acid sequence

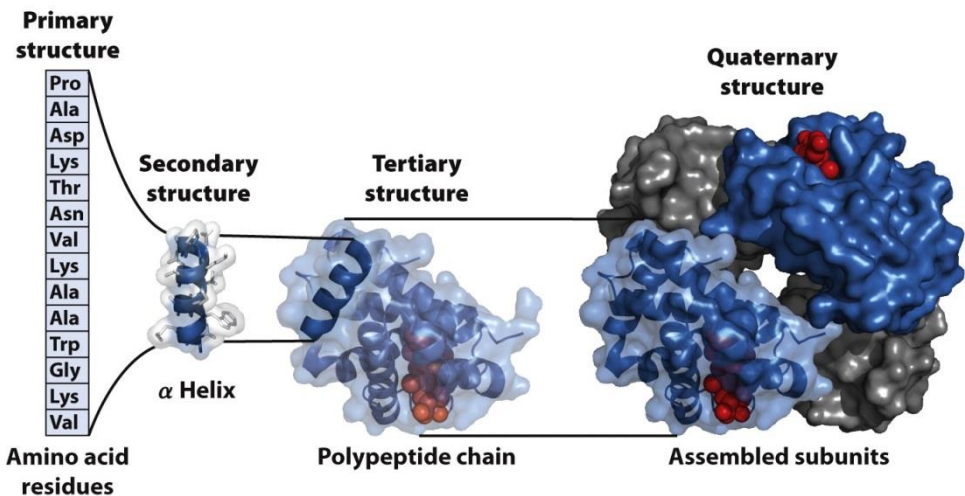
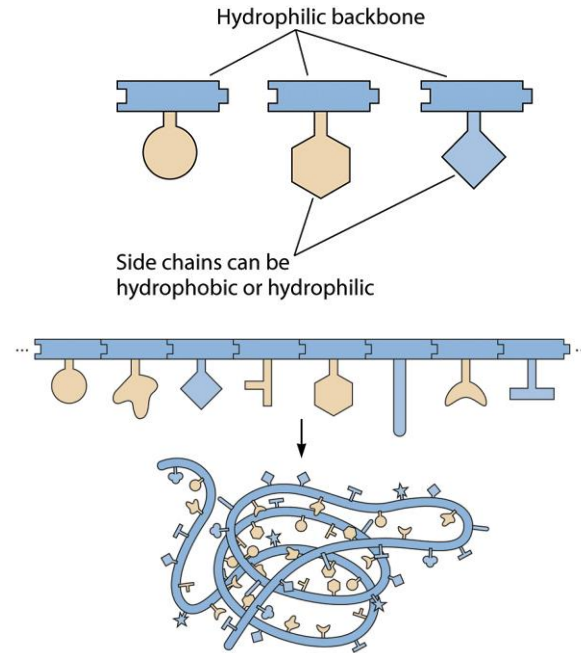


Figure 3-23
Lehninger Principles of Biochemistry, Fifth Edition
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Biological Function of Proteins

- **Structural proteins (e.g., collagen, keratin)**
- **Catalytic proteins (e.g., enzyme)**
- **Transport proteins (e.g., Hemoglobin)**
- **Regulatory proteins (e.g., hormone)**
- **Protective proteins (e.g., antibody)**