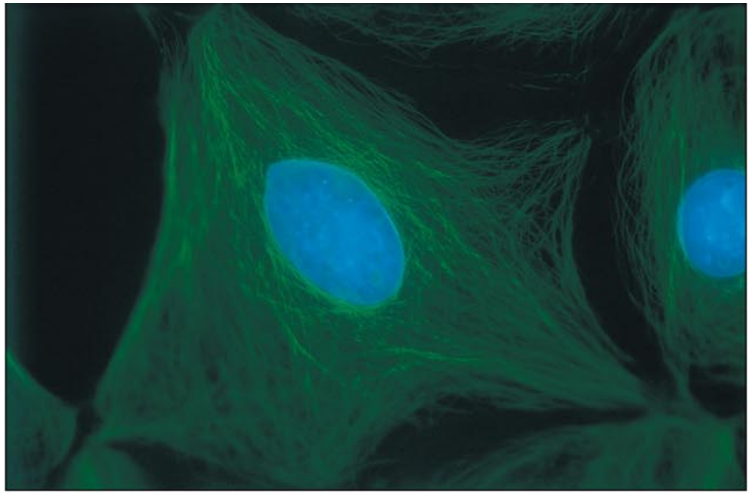
Chapter 2

Overview

- **Structural unit of organism –** living cell and it's biological activities
- Structure of Prokaryotic Cells
  - Single-celled, lack nucleus (nucleoid)
  - Two types: bacteria and archaea
- Structure of Eukaryotic Cells
  - Large cells possess nucleus
  - More complex due to Organelles
- Common Features
  - Similar chemical composition
  - Universal use of DNA



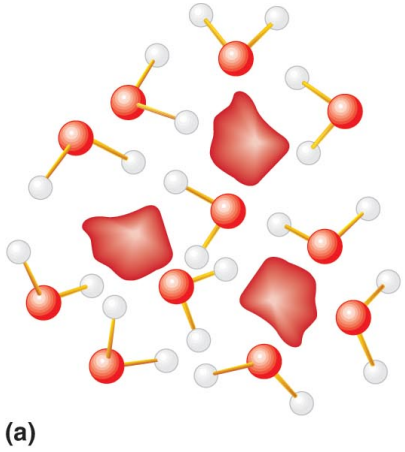
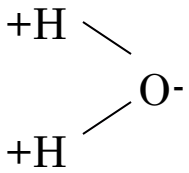


Figure 2.2 Hydrophobic Interactions Between Water and a Nonpolar Substance

- **Water**
  - Unique polar structure



  - Hydrophilic – water loving
    - Hydrogen bond
  - Hydrophobic - water fearing
    - Coalesce into droplets

Section 2.1: Basic Themes

- **Biological Membranes** – provide support & control flow in/out
  - Thin, flexible, and stable sheet-like structures enclosing cells & some internal cellular components
    - Selective physical barrier between external/internal environment
  - Two-dimensional supramolecular complexes consist of lipid bilayers
    - Held together by noncovalent intermolecular forces
  - Chemically reactive
    - Polar surfaces; attached proteins
    - Phospholipid bilayer with **integral** and **peripheral** membrane proteins
      - Involved in: transport, response to stimuli, cell-cell contact catalytic functions

Phospholipid bilayer

- Uniquely suited for structure role
  - Hydrophilic head – charged or uncharged polar group
  - hydrophobic tail – fatty acid chains
- Membrane Proteins
  - Integral proteins – embedded within membrane
  - Peripheral proteins – attached to outside of bilayer
  - Functions:
    - Channel proteins – transport specific ions
    - Carrier proteins – transport specific molecules
    - Receptors – binding sites for extracellular ligands

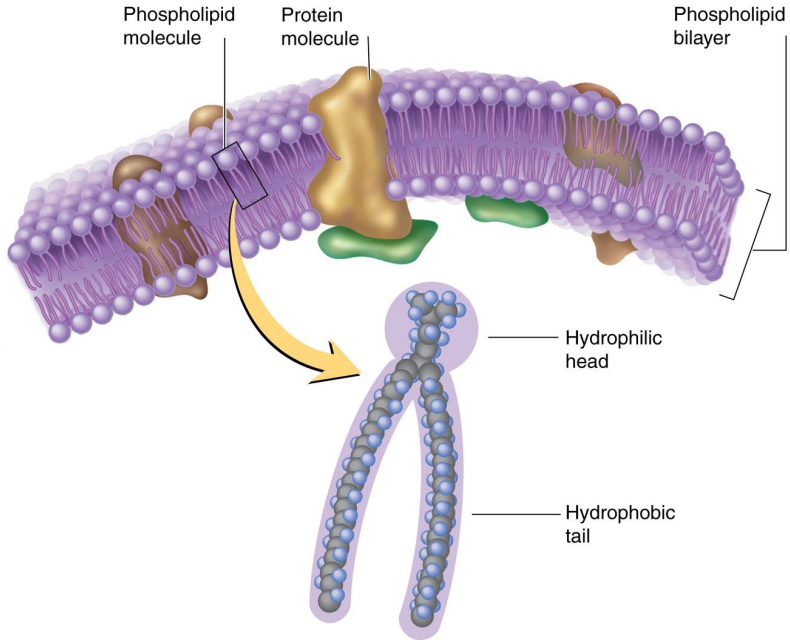


Figure 2.3 Membrane Structure

- **Self-Assembly**
  - Many biomolecules spontaneously undergo self-assembly into supermolecular structures
- **Molecular Machines**
  - Many multisubunit complexes involved in cellular processes function as molecular machines

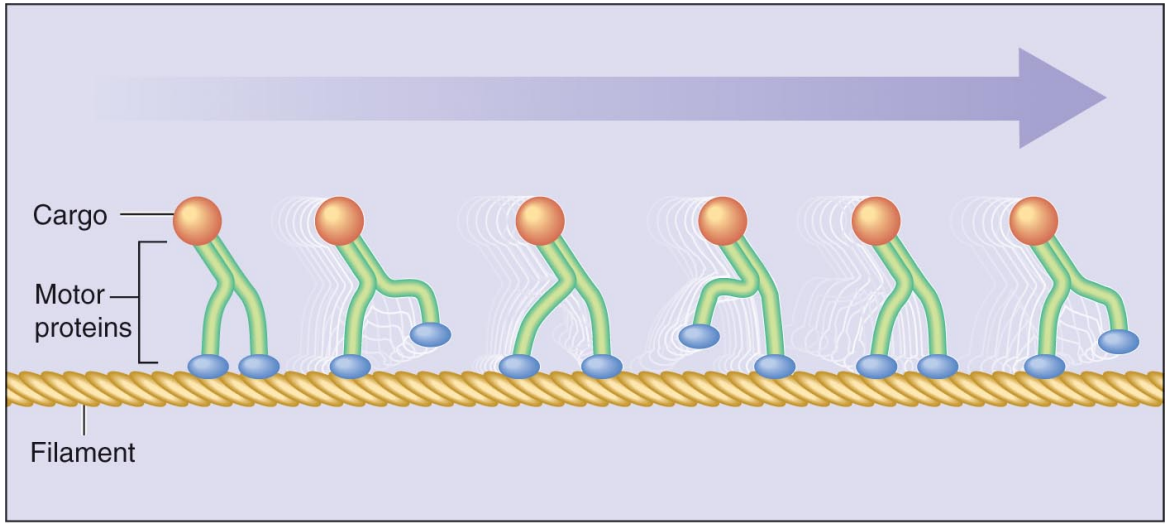
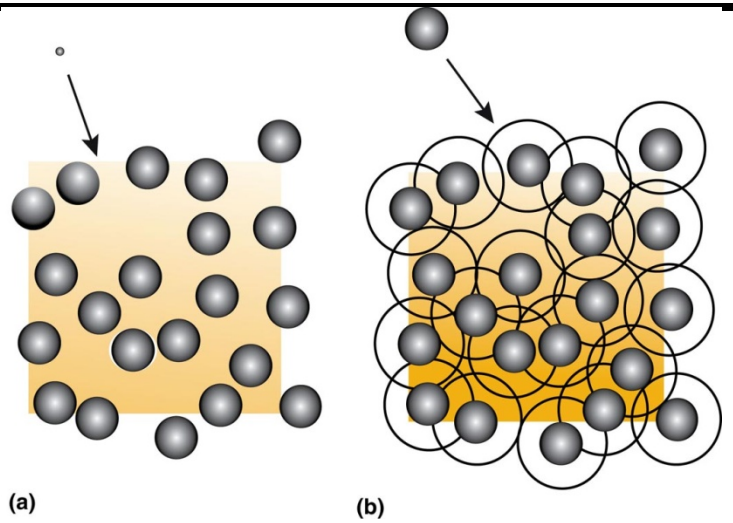


Figure 2.5

Biological Machines

Figure 2.6

Volume Exclusion



Macromolecular Crowding

- Lots macromolecules exist in low concentrations in a confined space
  - ✓ **Excluded volume: volume occupied by macromolecules;** between 20% and 40%

Signal Transduction – process for receiving & interpreting information, Ca^{2+} universal signaling device

- Reception – signal molecule binds to receptor
- Transduction – conversion of primary message to secondary message
- Response – signaling cascade
- Termination – efficiency & effectiveness signal mechanisms require timely termination

Section 2.2: Structure of Prokaryotic Cells

- Prokaryotes – immense/heterogeneous group
  - Structure: Bacillus-cylindrical/rod-like; Cocci-spheroidal
  - Two types: Bacteria and Archaea
- Common features: cell wall, plasma membranes, circular DNA, and no membrane-bound organelles

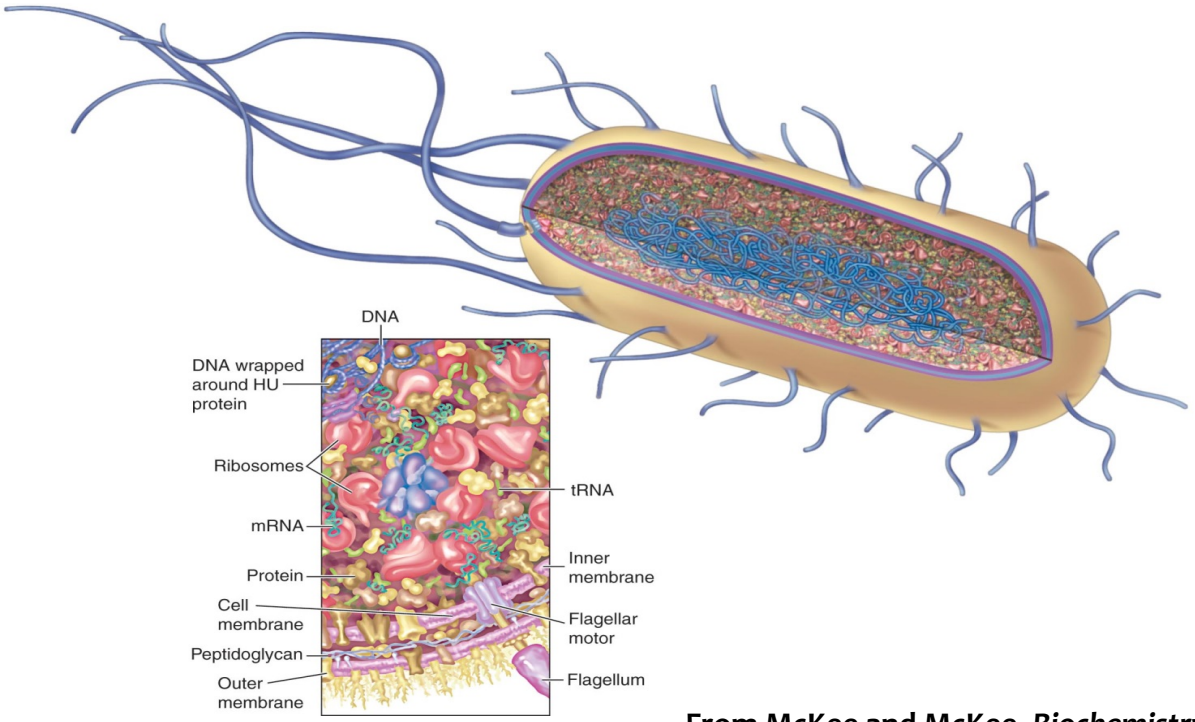
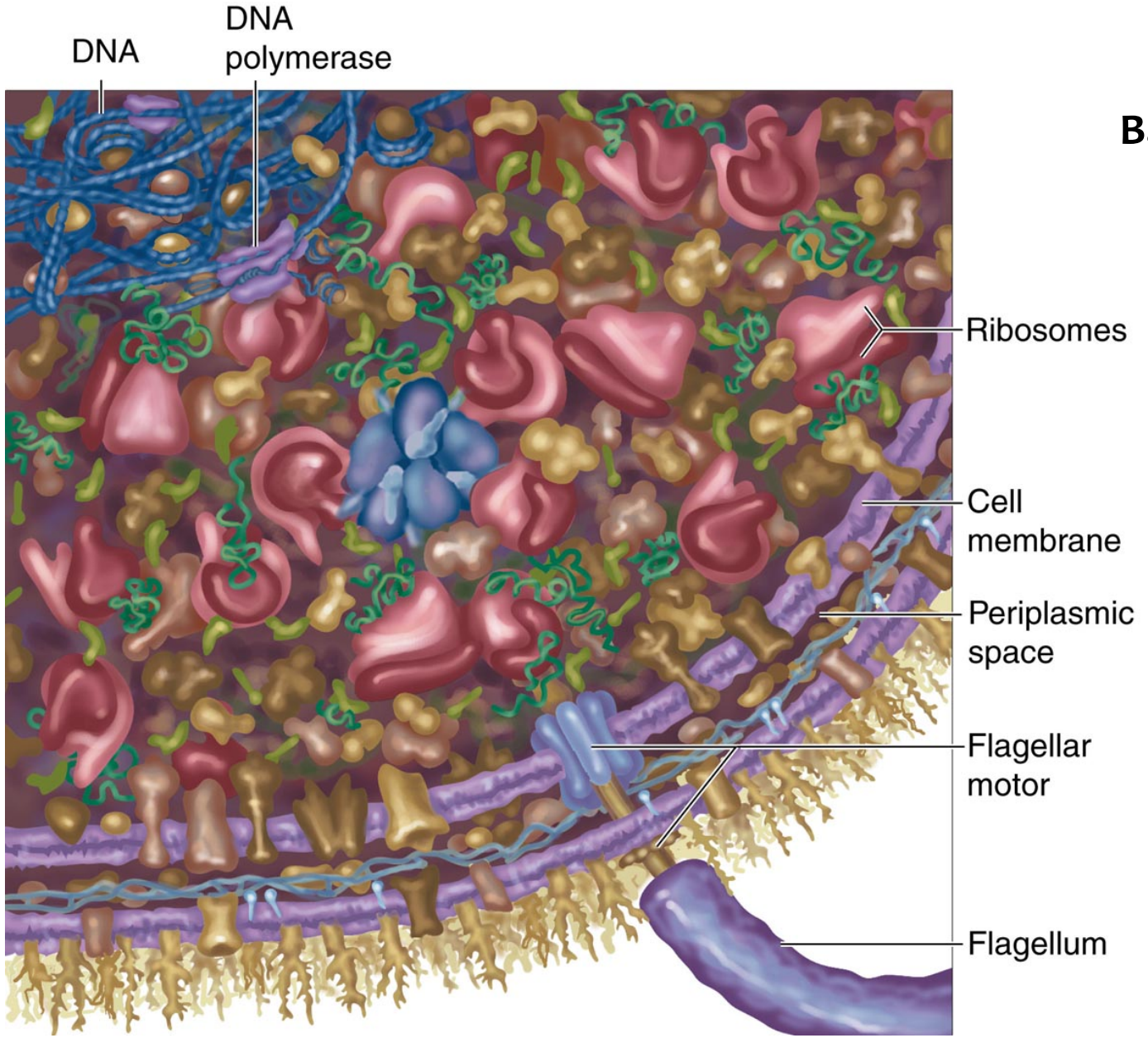


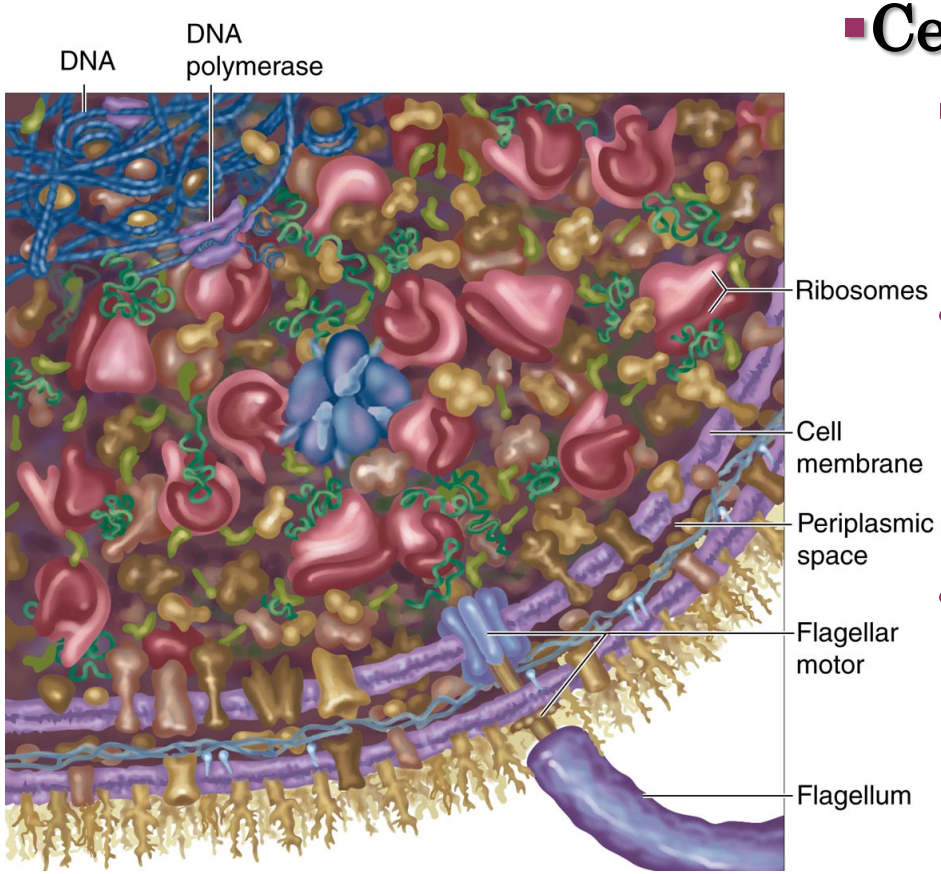
Figure 2.7 Typical Bacterial Cell

Section 2.2: Structure of Prokaryotic Cells



Bacterial Cell

Section 2.2: Structure of Prokaryotic Cells

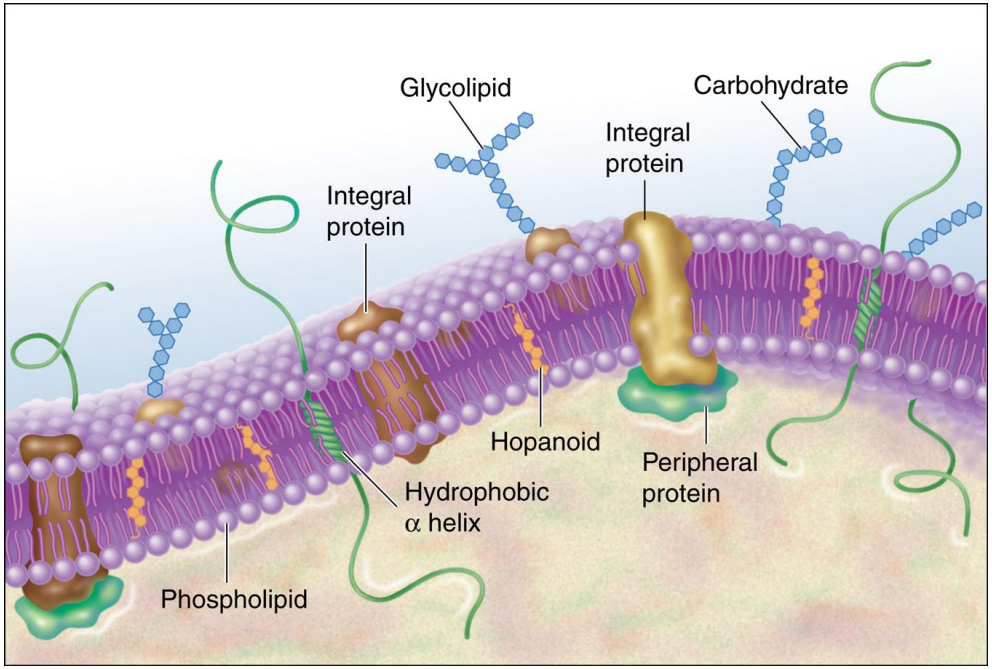


Bacterial Cell

- **Cell Wall**
  - Complex semi-rigid structure primarily for support and protection
  - Primarily composed of **peptidoglycan**
    - **Covalent complexes of short peptide chains linking long carbohydrate chains**
  - **Cell differentiation -retaining crystal violet stain**
    - **Gram positive – carbohydrates take up stain**
    - **Gram negative – no carbohydrates**

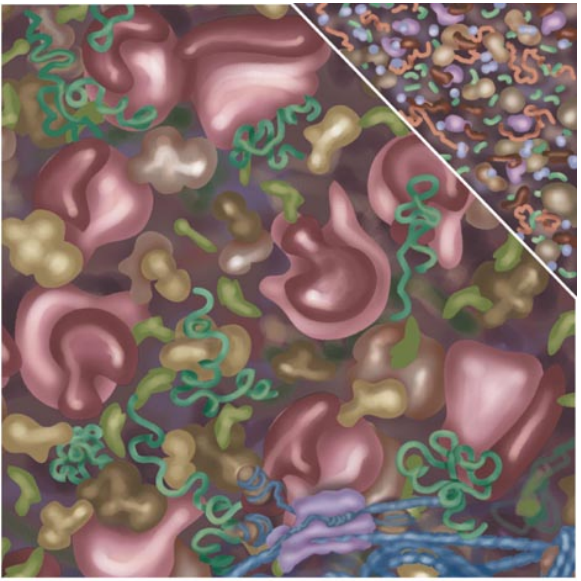
Section 2.2: Structure of Prokaryotic Cells

Figure 2.8 Bacterial Plasma Membrane



- **Plasma Membrane**
  - Phospholipidbilayer held together by weak noncovalent forces
    - ✓ Covalent bonds would provide more stability but less flexibility & movement in and out
  - Integral proteins - selectively permeable for nutrient uptake and waste disposal
  - Photosynthesis – light energy to chemical energy
  - Respiration – oxidation of fuel molecules to generate energy

Section 2.2: Structure of Prokaryotic Cells



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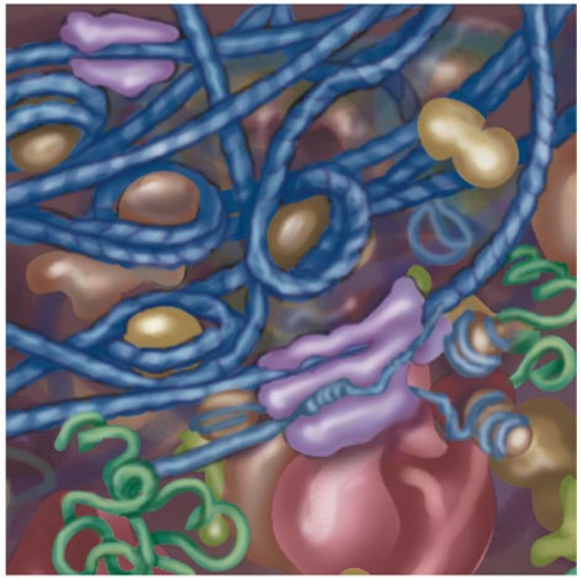


(b)

- **Cytoplasm**
  - Functional compartments
    - **Nucleoid** – centrally located and contains the circular **DNA (chromosome)**
    - Contains small DNA **plasmids**
      - **Exist outside nucleoid; replicates independent of chromosome**
    - **Ribosomes give uniform, grainy appearance**
      - **RNA & proteins – synthesize polypeptides, macromolecules, smaller metabolites**
    - **Inclusion bodies** - large granules contain organic or inorganic compounds

Figure 2.9 Bacterial Cytoplasm

Section 2.2: Structure of Prokaryotic Cells

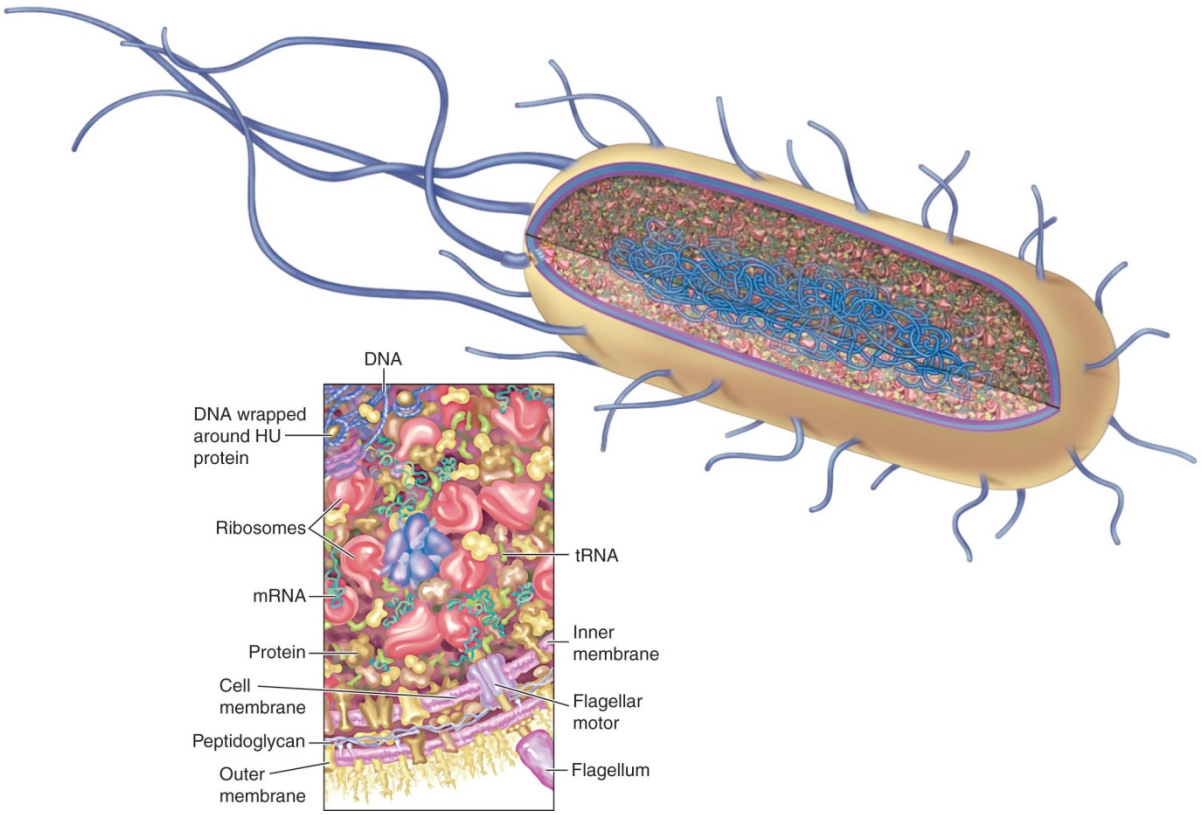


Figure 2.7 Typical Bacterial Cell

- **Pili and Flagella**
  - Many bacteria have external appendages
    - Pili (pilus) are for attachment and sex
    - Flagella (flagellum) are used for locomotion

Section 2.3: Structure of Eukaryotic Cells

Structurally complexity – more sophisticated regulation

- **Larger** - increase surface area for chemical reactions
- **Membrane-bound organelles**
  - Contain biomolecules specialized to specific functions
- **Endomembrane system** – interconnecting internal membranes that divide cell into functional compartments
  - **Vesicles** – transports molecules
- Compartments devoid of membranes
  - **Ribosomes** – protein synthesizing machines
  - **Cytoskeleton** – complex of filaments giving shape, structural support

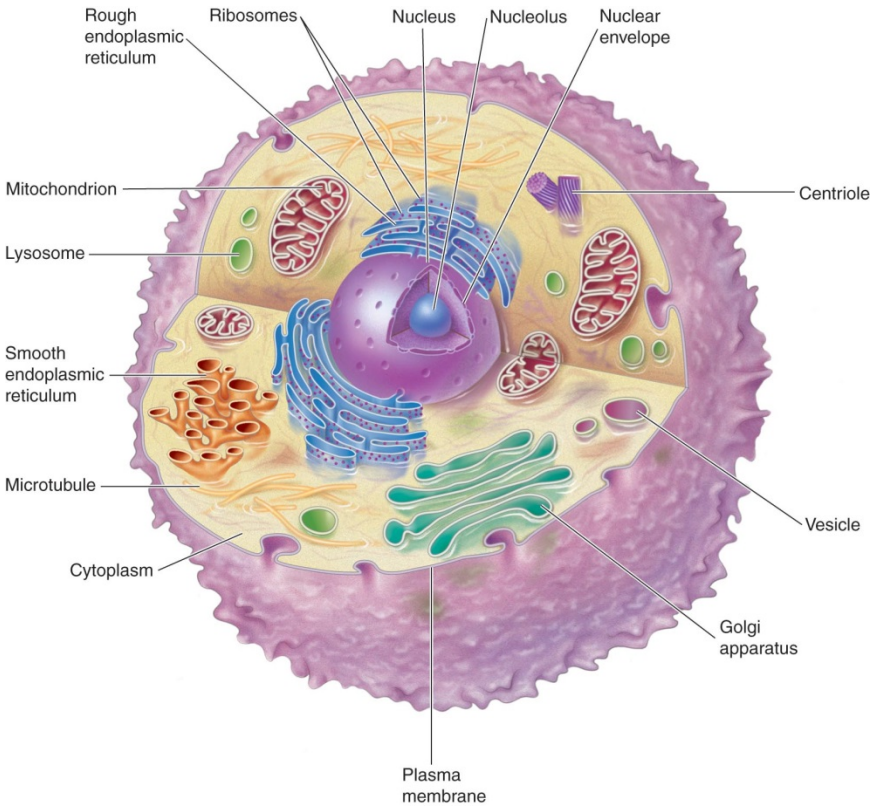


Figure 2.10 Animal Cell

Section 2.3: Structure of Eukaryotic Cells

- Plasma membrane
- Endoplasmic reticulum
- Golgi apparatus
- Nucleus
- Lysosomes
- Mitochondria
- Ribosomes,
- Cytoskeleton
- Chloroplasts
  - Plant only

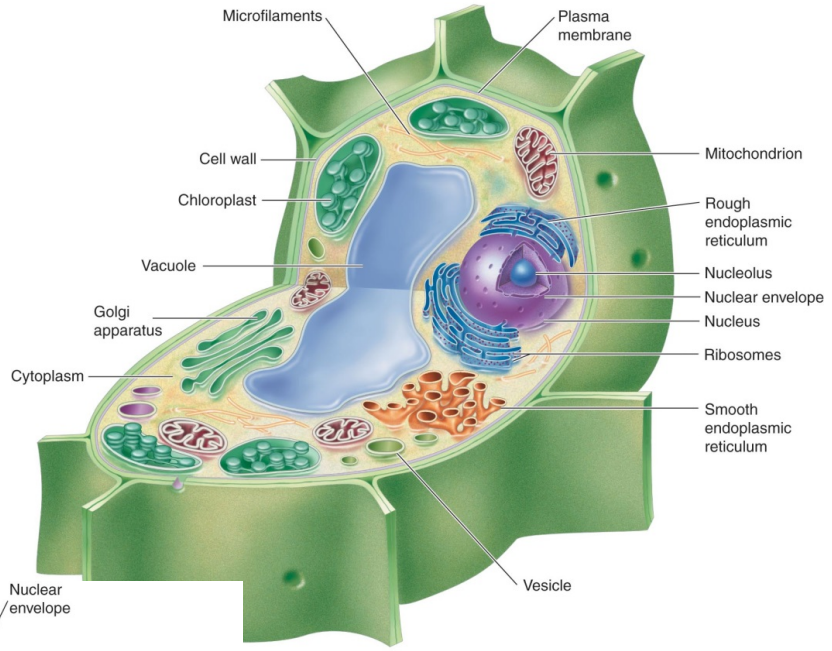


Figure 2.11 Plant Cell

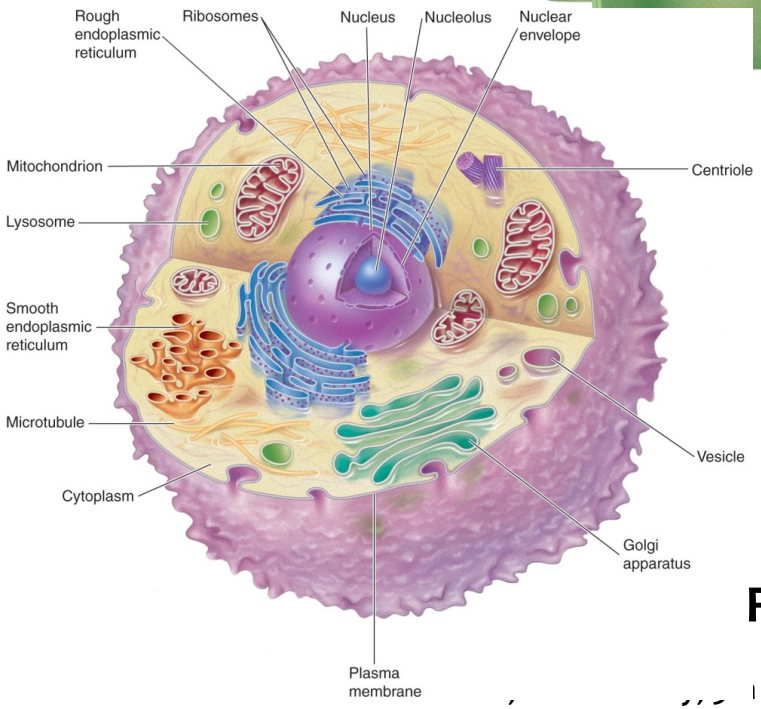
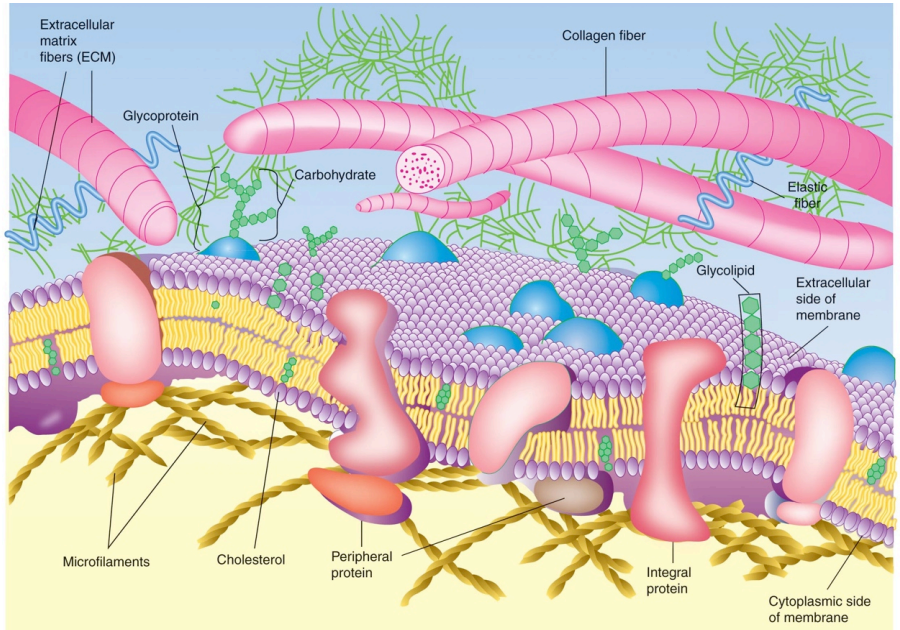


Figure 2.10 Animal Cell

Section 2.3: Structure of Eukaryotic Cells

- **Plasma Membrane**
  - Isolates the cell and is selectively permeable
  - Composed of lipid bilayer with associated integral & peripheral proteins
  - Extracellular face contains **glycocalyx – proteins & lipids that contain** covalently attached carbohydrate
  - **Extracellular matrix protects exterior**
  - Membrane skeleton – 3-D meshwork of proteins attached to peripheral proteins



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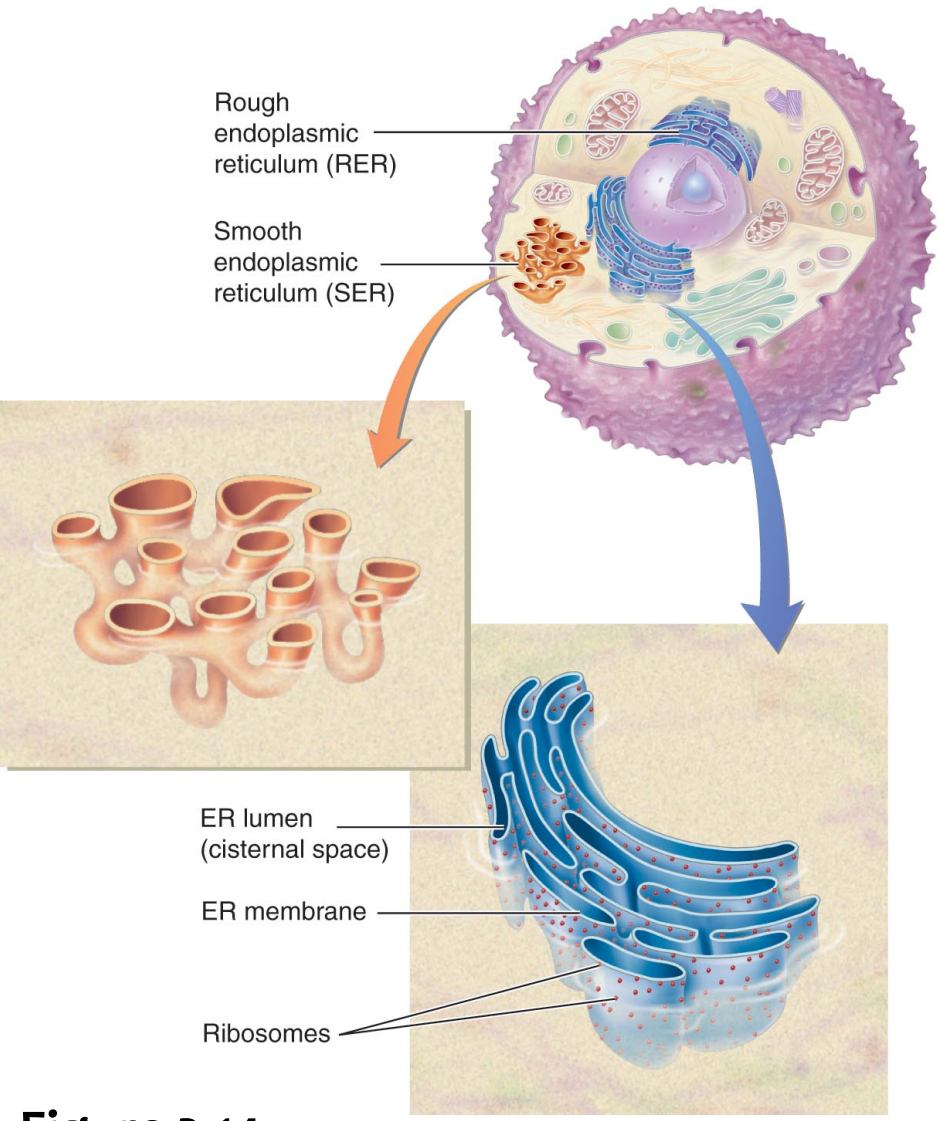


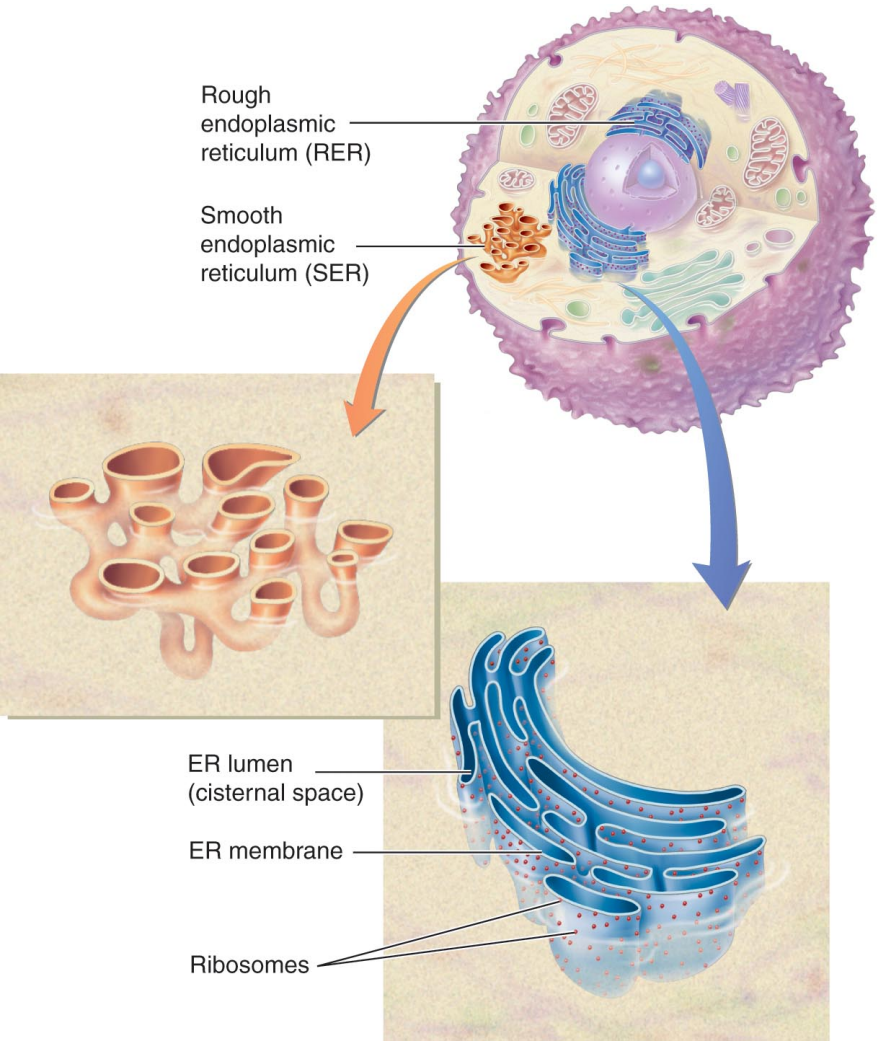
Endoplasmic Reticulum

- Series of membranous tubules, vesicles, and flattened sacks
- **ER lumen** -internal space enclosed in ER membrane
- **Rough ER – due to ribosomes on surface**
  - **Ribosomes** – consist of 2 subunits (40S/60S); protein synthesis; chaperones facilitate folding process; **glycosylation reactions**
- **Smooth ER** – no ribosomes; continuous with RER
  - Key functions: lipid biosynthesis; Ca^{2+} storage

Figure 2.14

Endoplasmic Reticulum

Section 2.3: Structure of Eukaryotic Cells



Rough ER

- **ER stress** – accumulation of misfolded molecules
- **ER-associated protein degradation** – mechanism of degradation

Smooth ER

- **Hepatocytes** - biotransformation & synthesis of lipid components of very-low-density lipoproteins
- **Biotransformation reactions** – convert water insoluble metabolites & xenobiotics into soluble products for excretion

Figure 2.14

Endoplasmic Reticulum

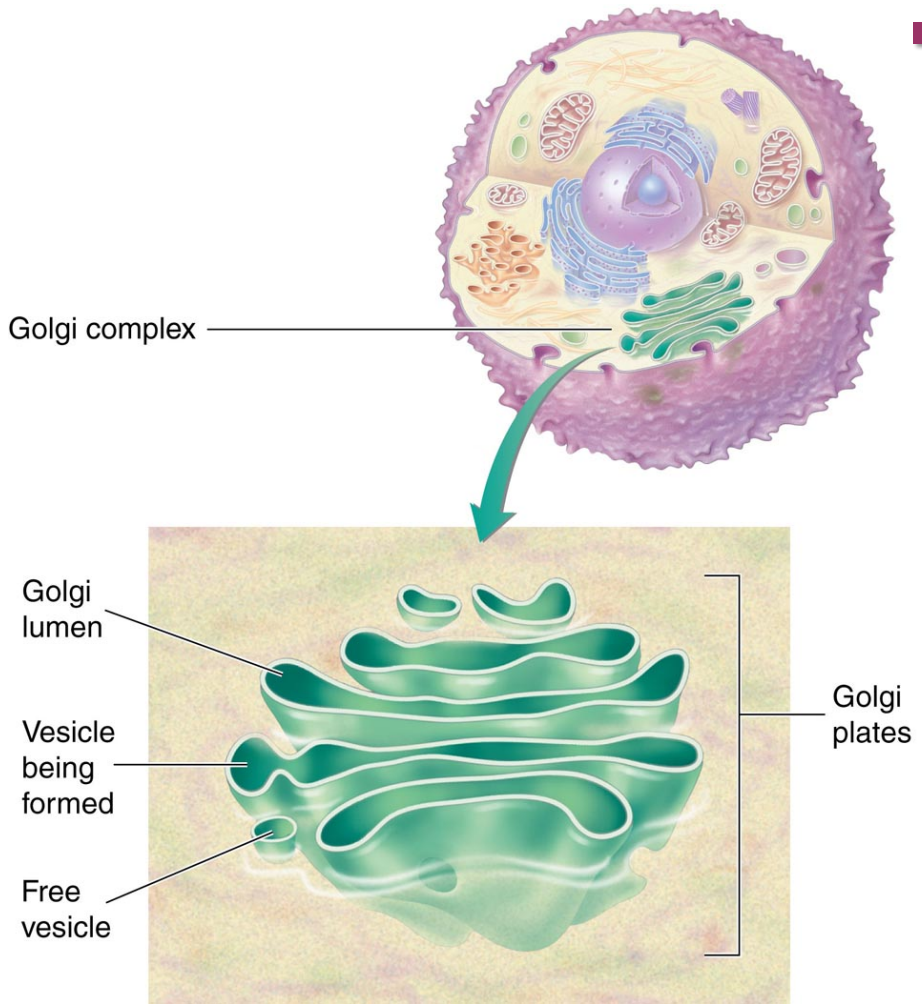
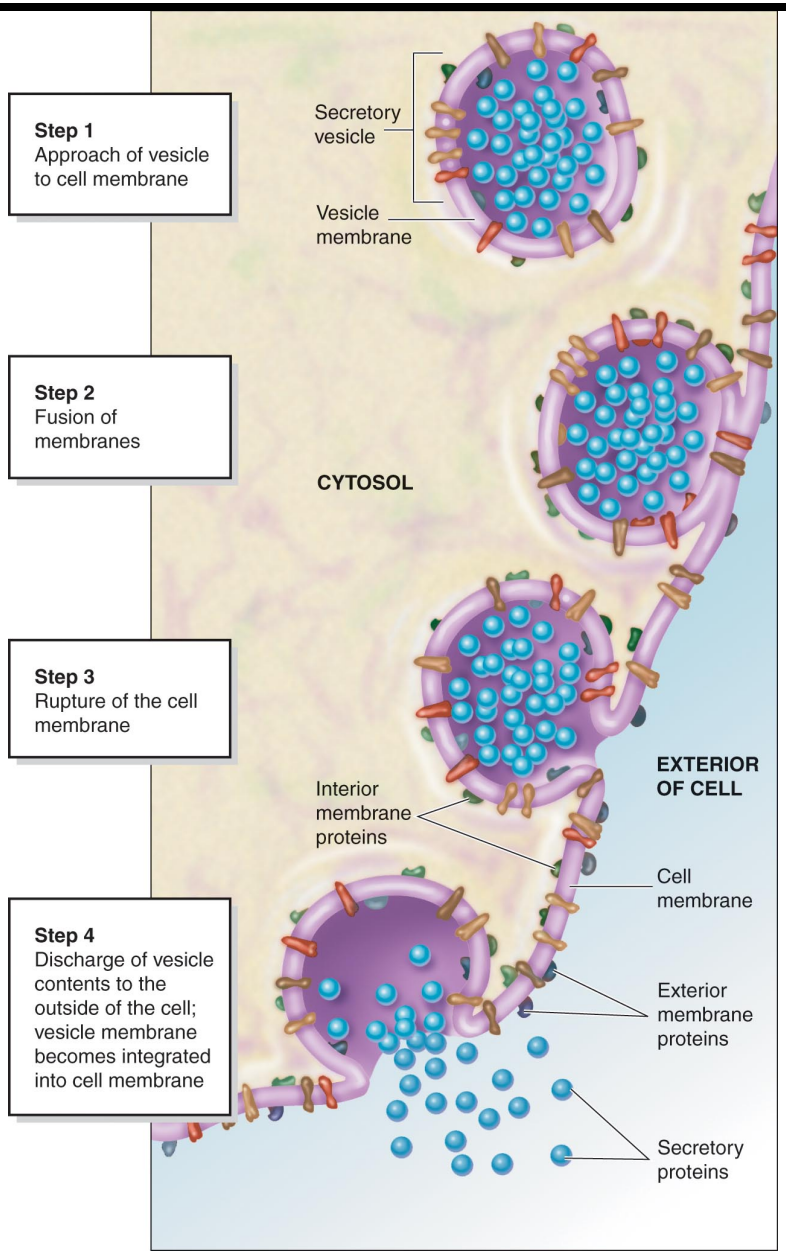


Figure 2.16 The Golgi Apparatus

- **Golgi Apparatus**
  - **Golgi apparatus** - large, flattened, sac-like membranous vesicles
    - Processes, packages, and distributes cell products
    - Two faces: cis (**cisternae**) and a trans face

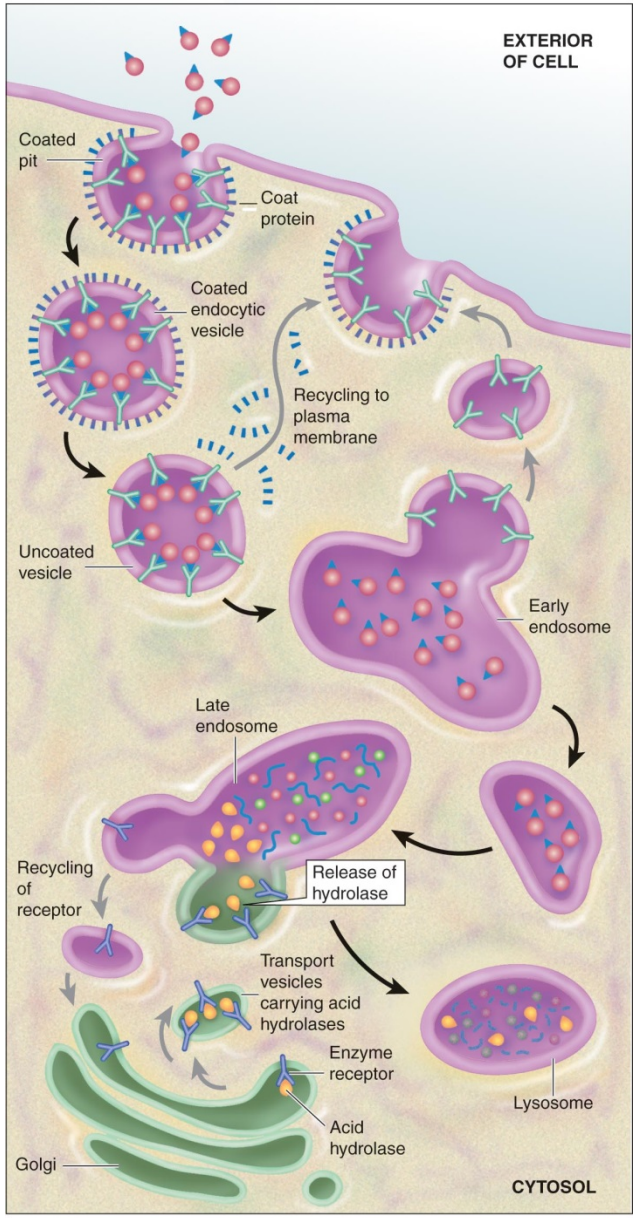
Section 2.3: Structure of Eukaryotic Cells



- **Cisternal maturation** model
  - vesicles are recycled back to the cis Golgi from the trans Golgi
- Secretory products concentrated at the trans Golgi into secretory vesicles
- Involved in **exocytosis**
  - ✓ Movement of membrane-bound vesicles from Golgi apparatus to plasma membrane

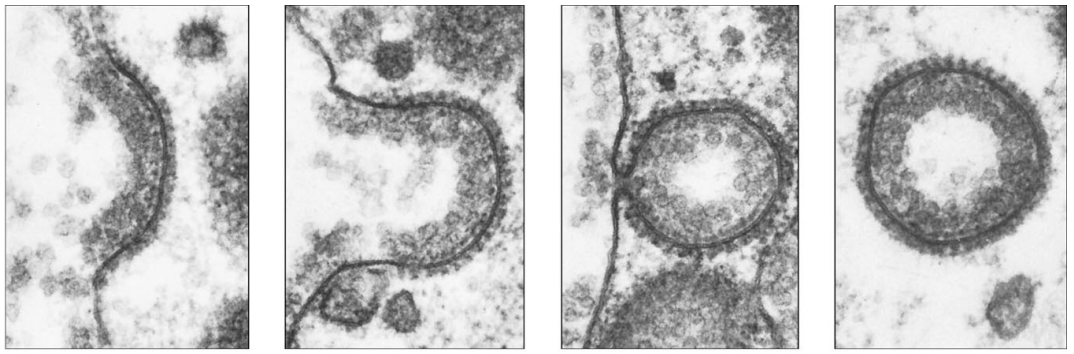
Figure 2.15 Exocytosis

Section 2.3: Structure of Eukaryotic Cells



(a)

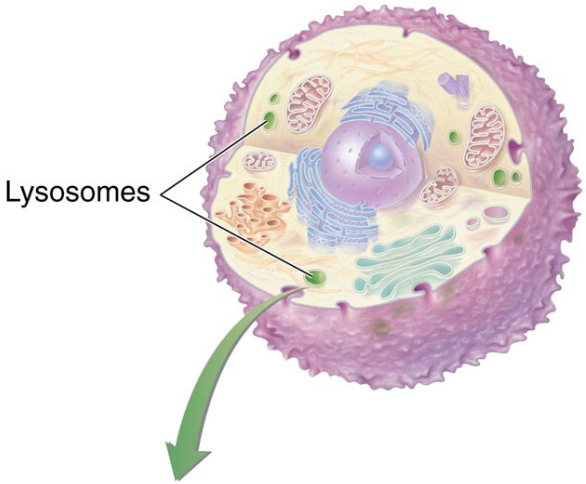
- **Vesicular Organelles**
  - Eukaryotic cell has **vesicles**
  - Vesicles originate in the ER, Golgi and/or via **endocytosis**



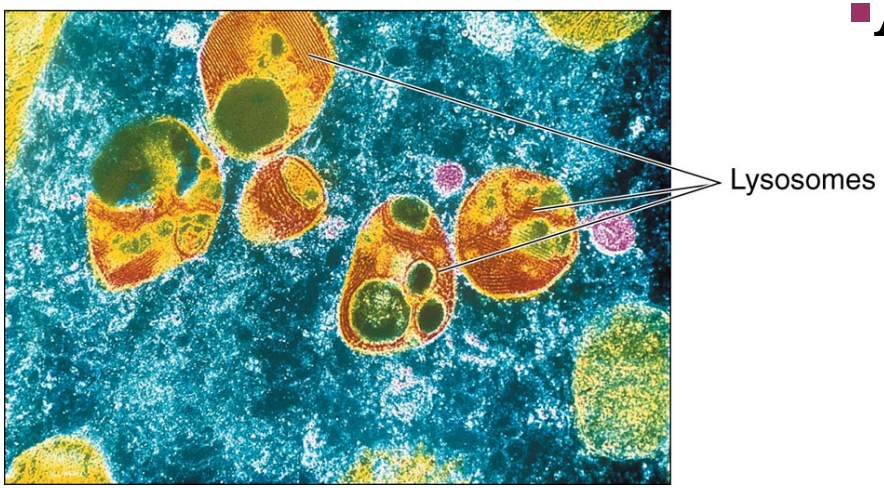
(b)

Figure 2.17 Receptor-Mediated Endocytosis

Section 2.3: Structure of Eukaryotic Cells

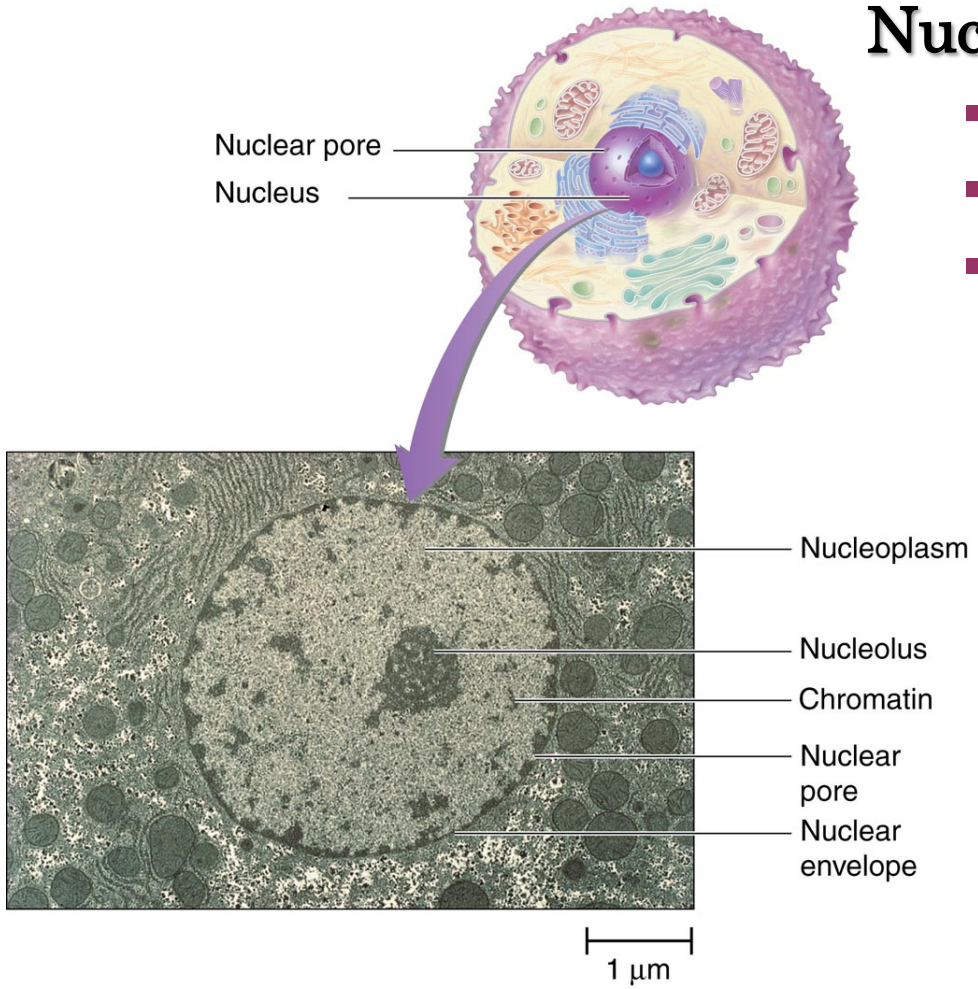


- **Lysosomes** are vesicles that contain digestive enzymes
  - Enzymes are acid hydrolases
  - Degrade encapsulated materials
  - **Autophagy** degradation of debris in cells



Lysosomes

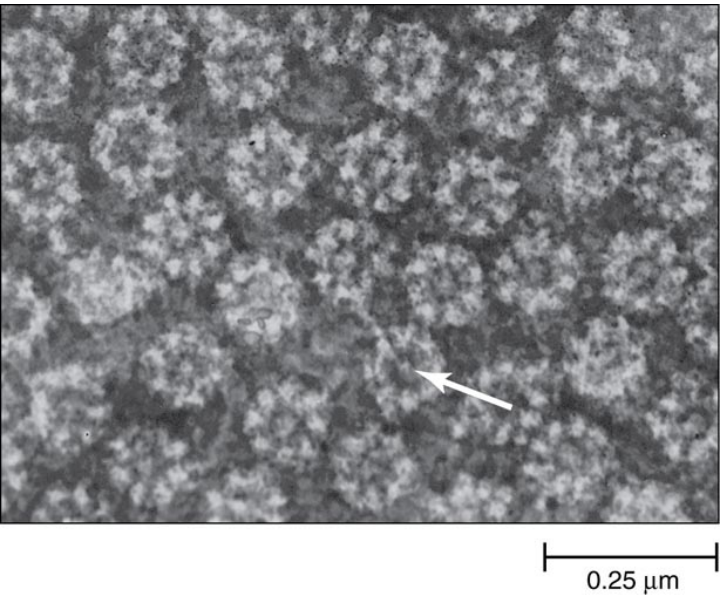
Section 2.3: Structure of Eukaryotic Cells



Nucleus

- Contains the hereditary information
- Site of transcription
- Nuclear components:
  - **Nucleoplasm – surrounded by membrane, contains chromatin fibers & DNA**
    - **Chromatin (genome)**
  - **Nuclear envelope – barrier; outer/ inner nuclear membrane**
  - **Nucleolus – transcription of rRNA genes**
  - **Nuclear matrix – scaffold of proteins on which chromatin organized**

Figure 2.19 Eukaryotic Nucleus



- **Nuclear envelope** surrounds the nucleoplasm
- **Nuclear pores** (nuclear pore complexes)
  - Molecules enter and leave the nucleus

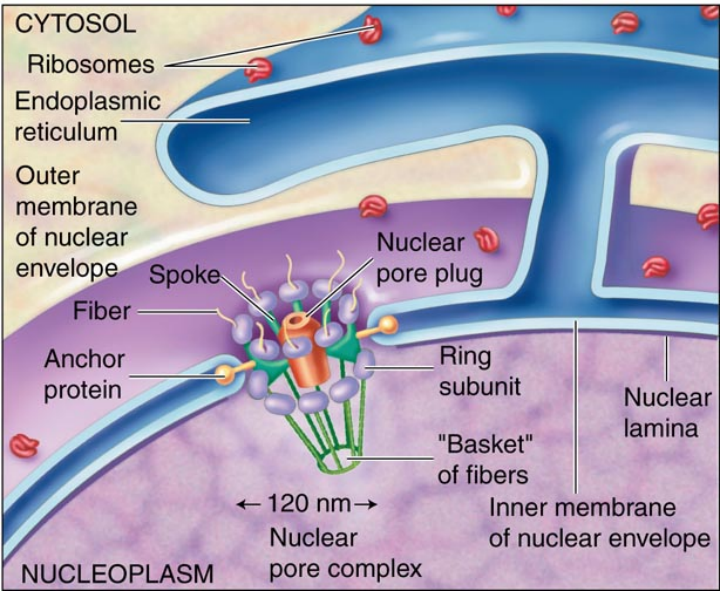
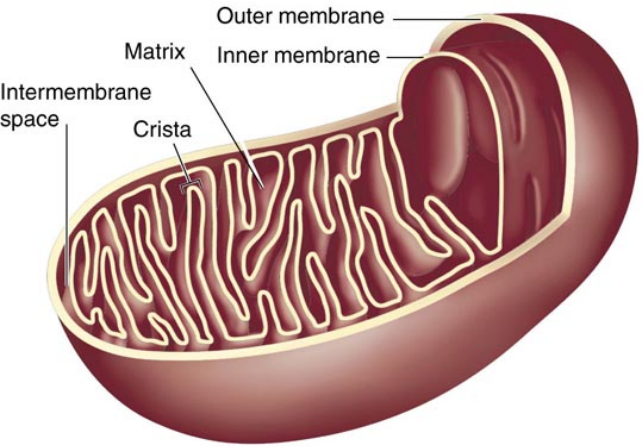


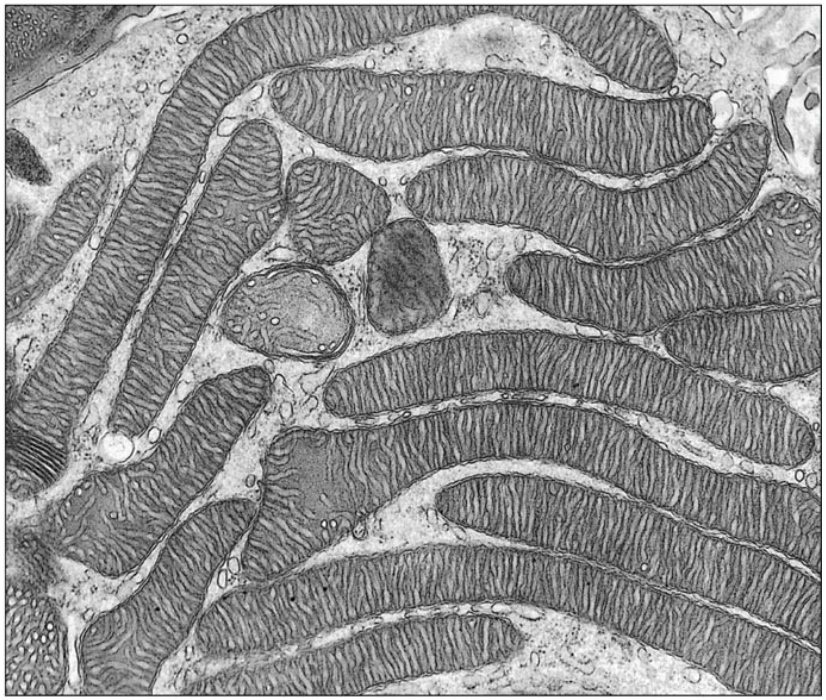
Figure 2.20 The Nuclear Pore Complex

Section 2.3: Structure of Eukaryotic Cells



(a)

Figure 2.24 The Mitochondrion



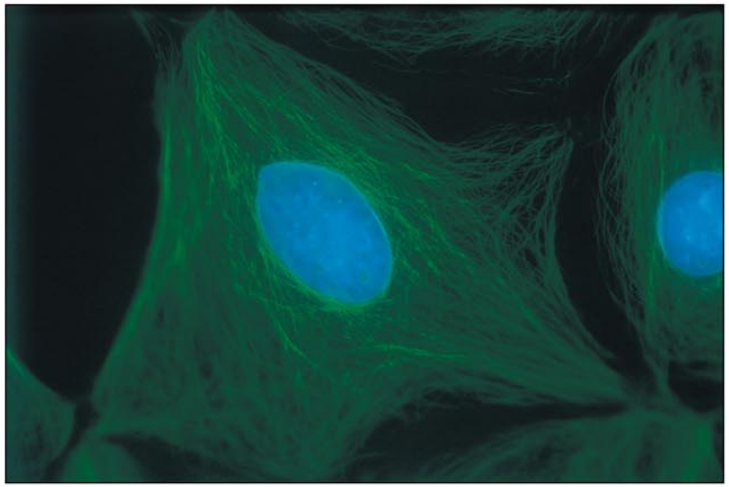
(b)

- **Mitochondria**
  - Site of **aerobic metabolism**
  - Principle source of cellular energy
  - **Outer membrane** surrounds **matrix**
    - **Smooth, porous <10,000 Daltons**
  - **Inner** membrane projects inward into folds, **cristae**
    - Premeable to O_2, CO_2, H_2O; not ions

- **Peroxisomes**
  - Small organelle containing oxidative enzymes
  - Detoxifies peroxides (e.g., H_2O_2)

Section 2.3: Structure of Eukaryotic Cells

- **Cytoskeleton**
  - Intricate supportive network of fibers, filaments, and associated proteins
  - Three main components:
    - **Microtubules**
    - **Microfilaments**
    - **Intermediate filaments**
  - Main functions
    - Cell shape and structure
    - Large- and small-scale cell movement
      - Cell movement; organelle movement
    - Solid-state biochemistry
      - Enzymes assemble on solid surface, improves efficiency and control
    - Signal transduction
      - Filaments facilitate & support signal transduction processes



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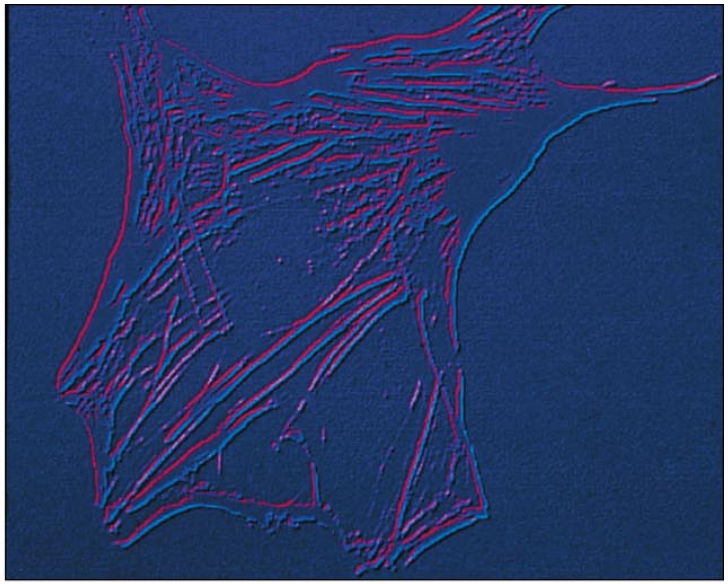

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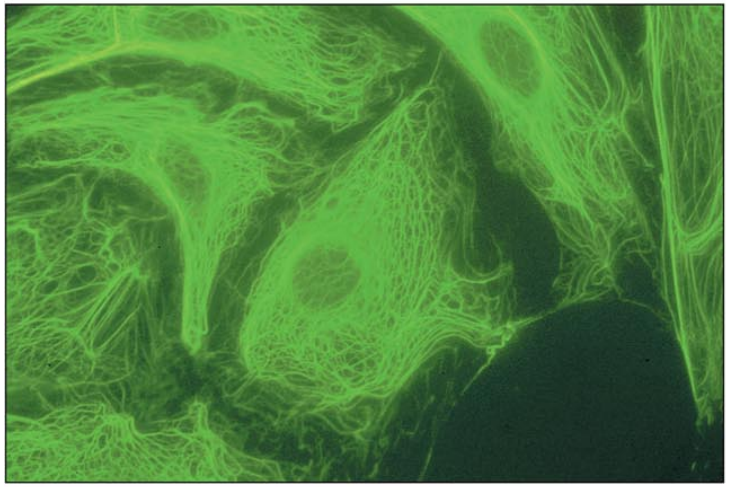

(c)

Figure 2.27 The Cytoskeleton

- **Cytoskeleton**
  - Cilia and flagella, whip-like appendages encased in plasma membrane, are highly specialized for their roles in propulsion
    - Undulating motion occurs via ATP-driven structural changes in dynein molecules (arms)