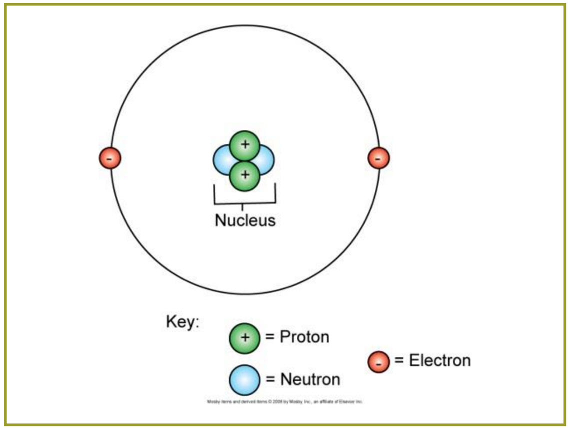
Animal Anatomy and Physiology 1

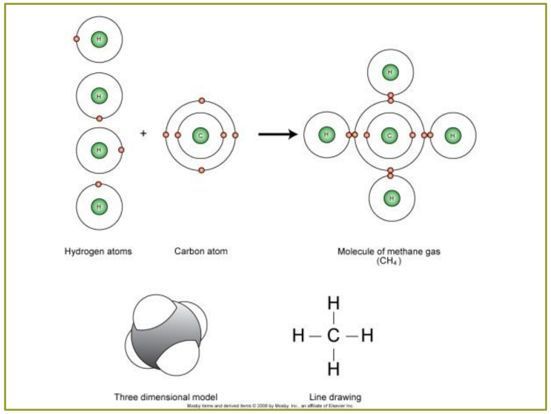
Webinar
Chapters 2 & 3

Simplified Chemistry

Cell Morphology & Physiology

Chemical Basis of Life
Chapter 2





Pages 9-38

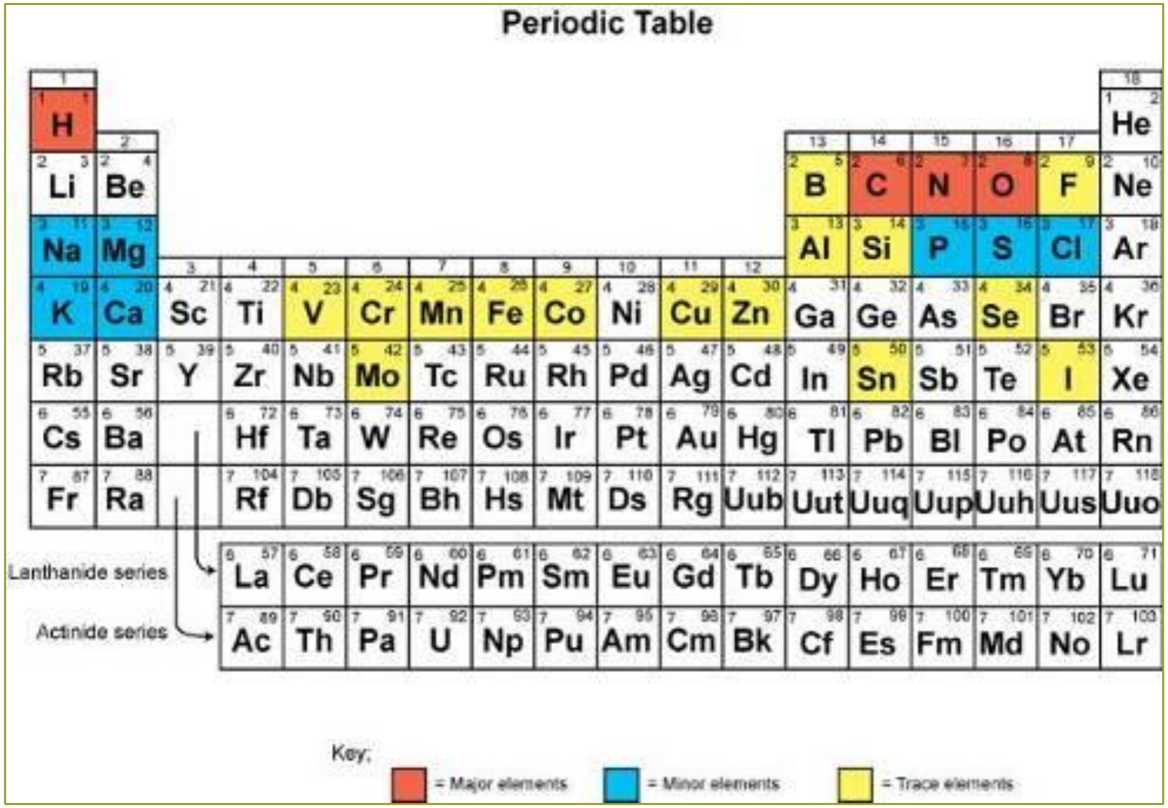
Textbook Learning Objectives

Chapter 2 – Page 9

- List the characteristics of each of the subatomic particles.
- Differentiate between a molecule and a compound.
- List and describe the types of chemical bonds that may form between elements.
- Give the general equations for synthesis, decomposition, and exchange reactions.
- Differentiate between organic and inorganic compounds; hydrophobic and hydrophilic molecules; acids and bases.
- List the unique properties of the water molecule.
- Describe the actions of a buffer system.
- List the components of carbohydrates, lipids, proteins, and nucleic acids.
- List the functions of body proteins.
- Describe the actions of enzymes.

Elements – The "Big 4"

- Nitrogen, oxygen, hydrogen, and carbon make up 96% of all matter found in living organisms

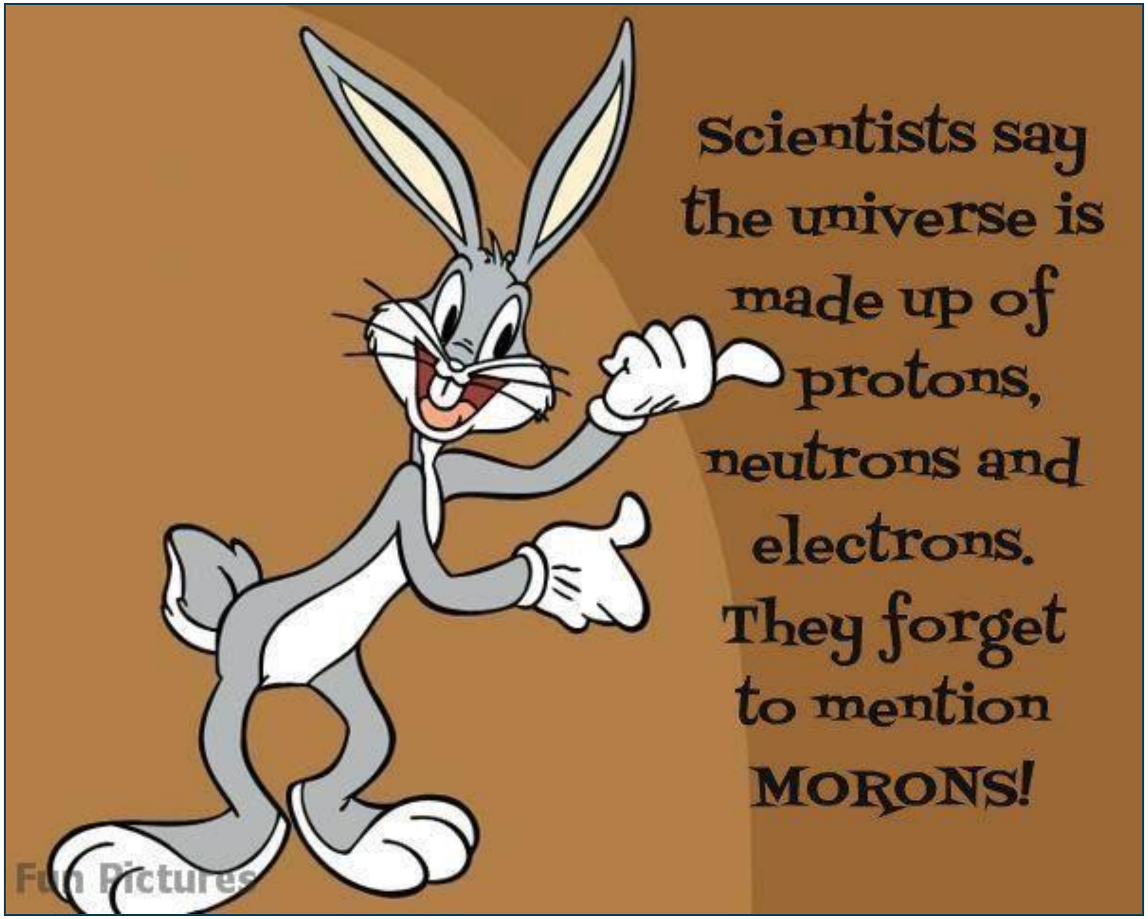


Periodic Table of the Elements

Figure 2-5, Page 11

- The Periodic Table of the Elements gives us important information about each element: the **chemical symbol**, **atomic number**, and **atomic weight**. The Table groups elements with similar properties. The elements shaded in **red** are the **major elements** that make up 96% of the matter in the animal body. The elements shaded in **blue** are the **minor elements**, and those shaded in yellow are **trace elements**.

Thought You Might Like This! ☺



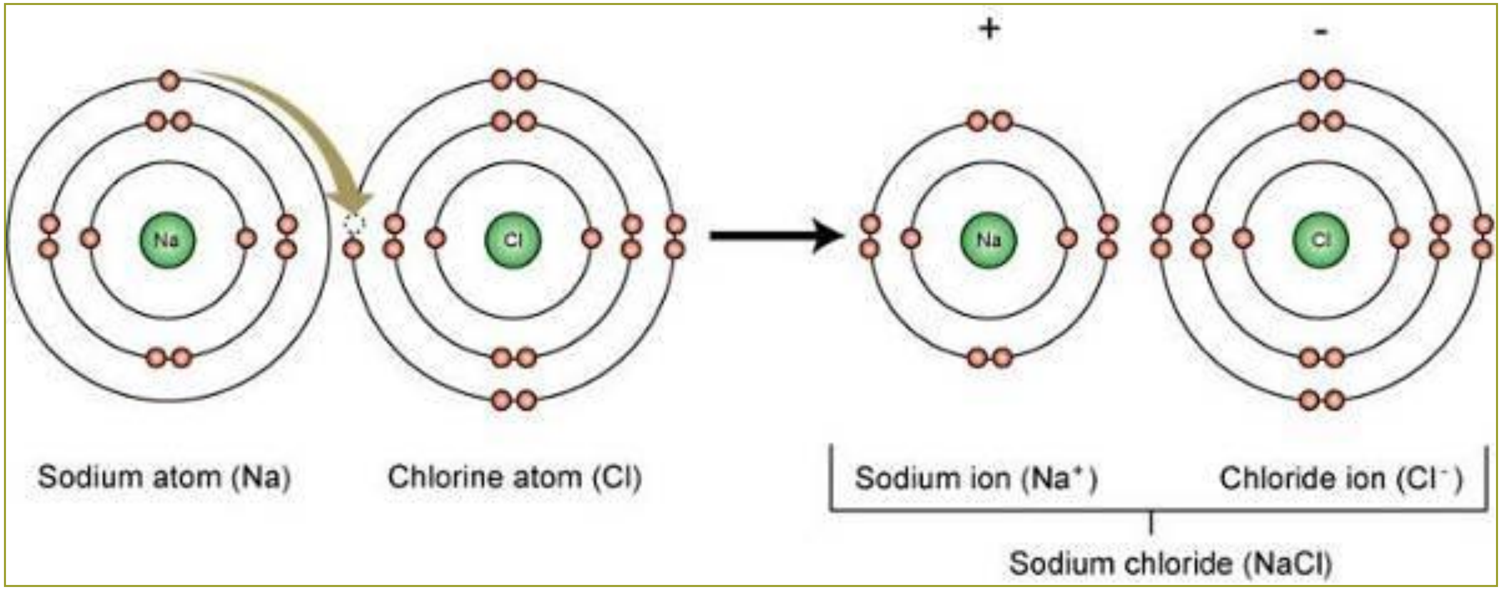
Atomic Bonding

Ionic, Covalent, and Hydrogen Bonds

Molecules and Compounds

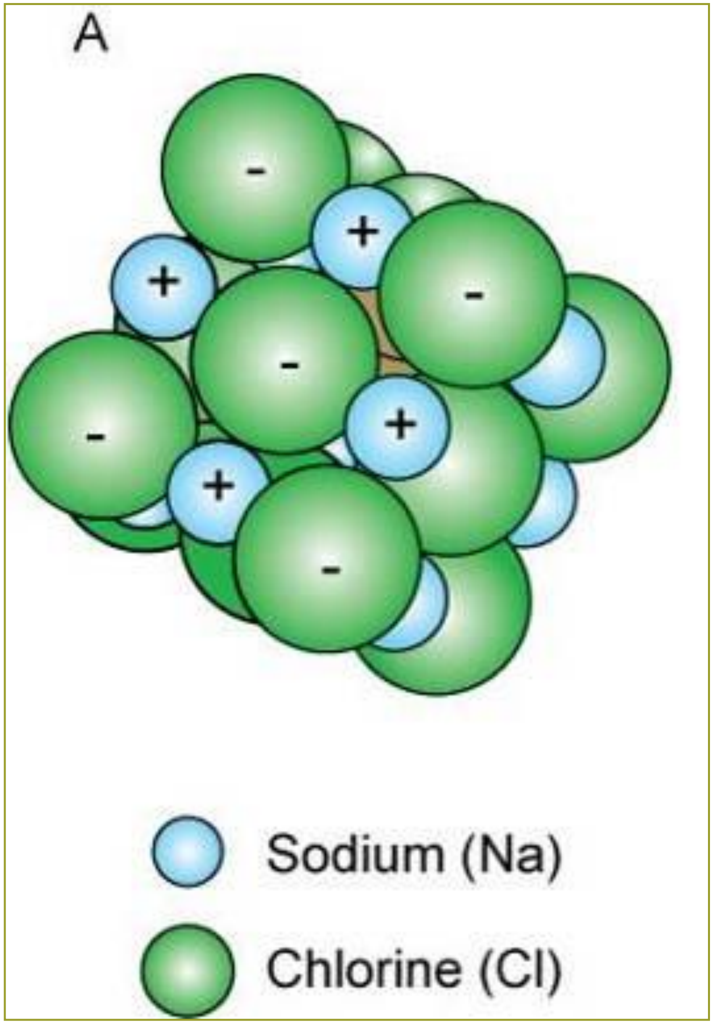
Figure 2-12, Page 17

- If two or more atoms of different elements are joined, the result is a molecule
- A molecule is the smallest unit of a compound that retains the properties of that compound



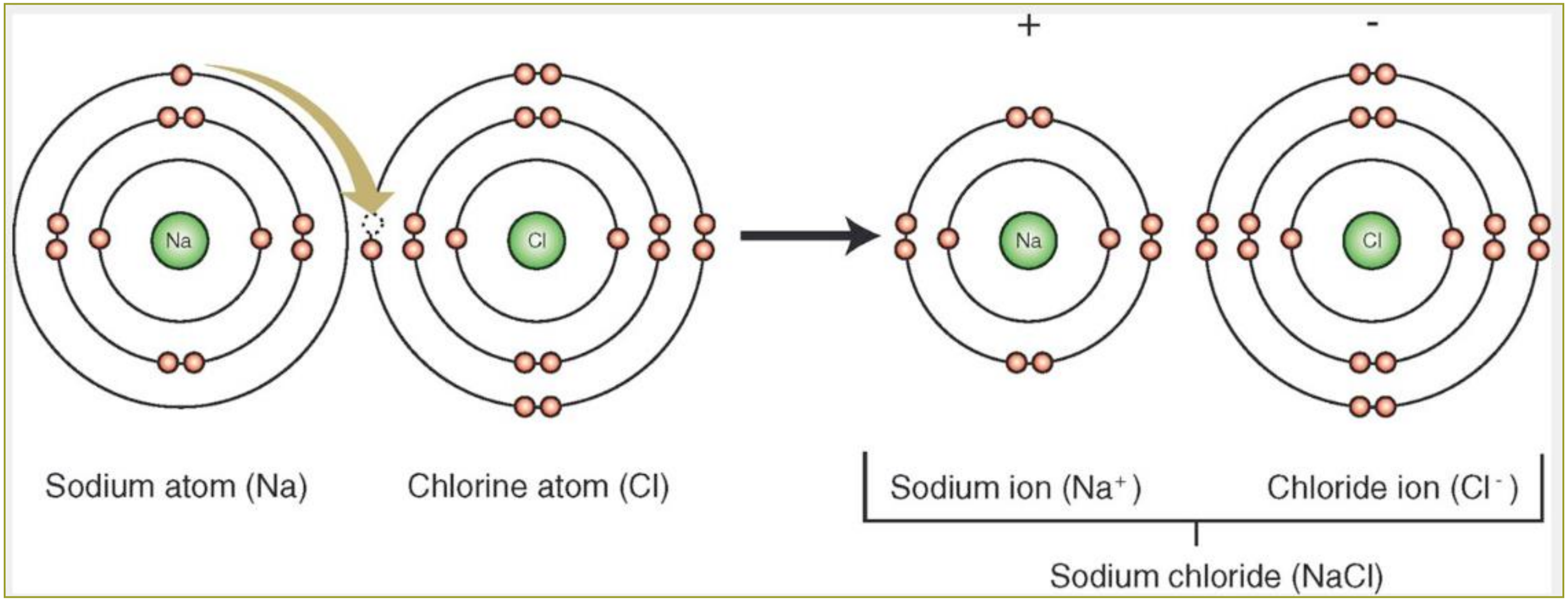
Ionic Bond
Figure 2-16A, Page 20

- Charged atoms
- Formed when electrons are **transferred** from one atom to another
- Creates **electrolytes**



Sodium Chloride – Ionic Bonding

Figure 2-12, Page 17



Ions (Electrolytes) in the Animal Body

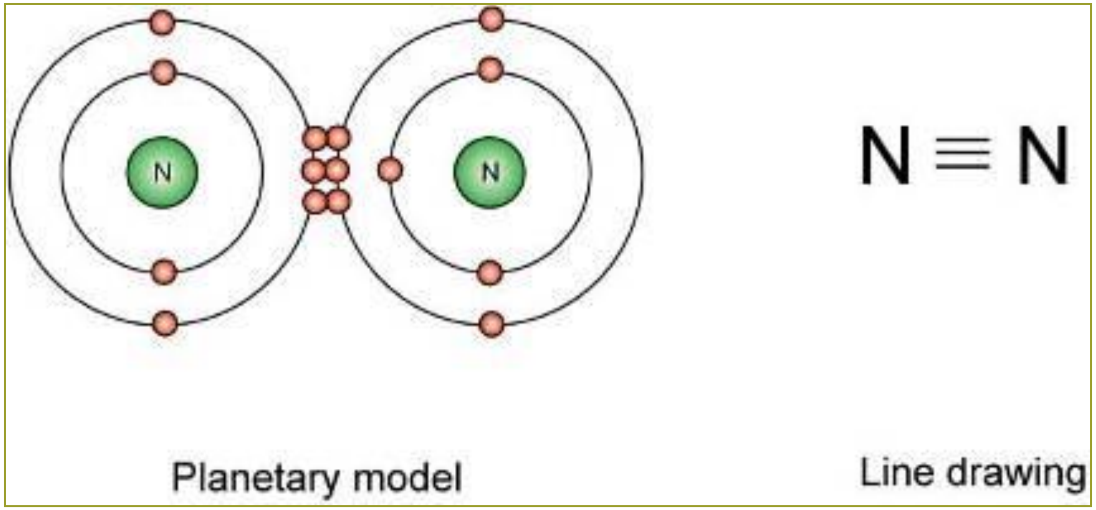
Table 2.2 Important Ions

Common Ions	Symbols	Significance
Calcium	Ca^{2+}	Part of bones and teeth, blood clotting, muscle contraction, release of neurotransmitters
Sodium	Na^{+}	Membrane potentials, water balance
Potassium	K^{+}	Membrane potentials
Hydrogen	H^{+}	Acid–base balance
Hydroxide	OH^{-}	Acid–base balance
Chloride	Cl^{-}	Water balance
Bicarbonate	HCO_3^{-}	Acid–base balance
Ammonium	NH_4^{+}	Acid–base balance
Phosphate	PO_4^{3-}	Part of bones and teeth, energy exchange, acid–base balance
Iron	Fe^{2+}	Red blood cell formation
Magnesium	Mg^{2+}	Necessary for enzymes
Iodide	I^{-}	Present in thyroid hormones

The ions are part of the structures or play important roles in the processes listed.

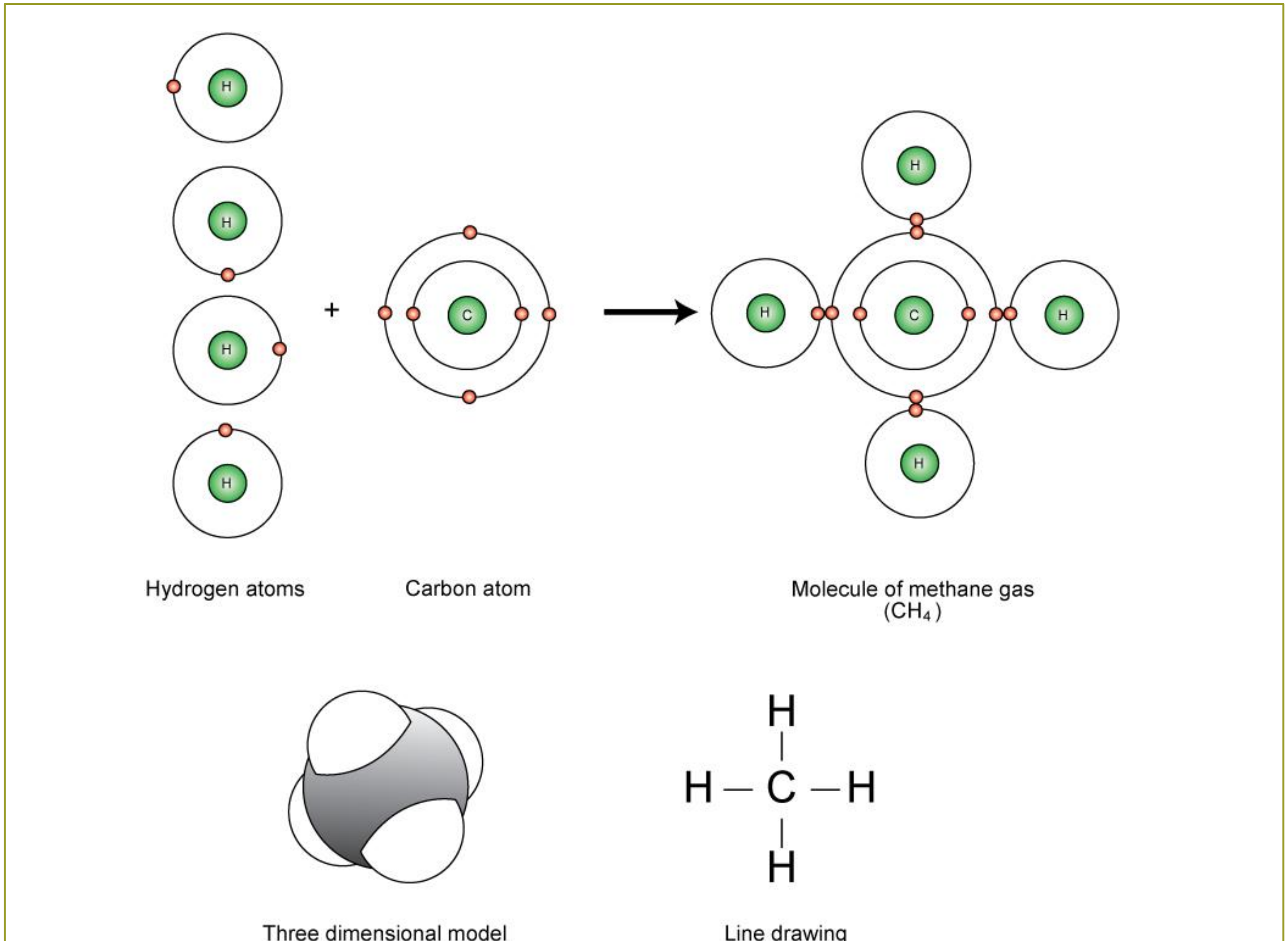
Covalent Bonds
Figure 2-14, Page 19

- A **covalent bond** is formed when atoms **share** electrons.
  - ***single*** *covalent bond* — one electron is shared
  - ***double*** *covalent bond* — two electrons are shared
  - ***triple*** *covalent bond* — three electrons are shared



Covalent Bonding to Form Organic Molecules

Figure 2-13, Page 18



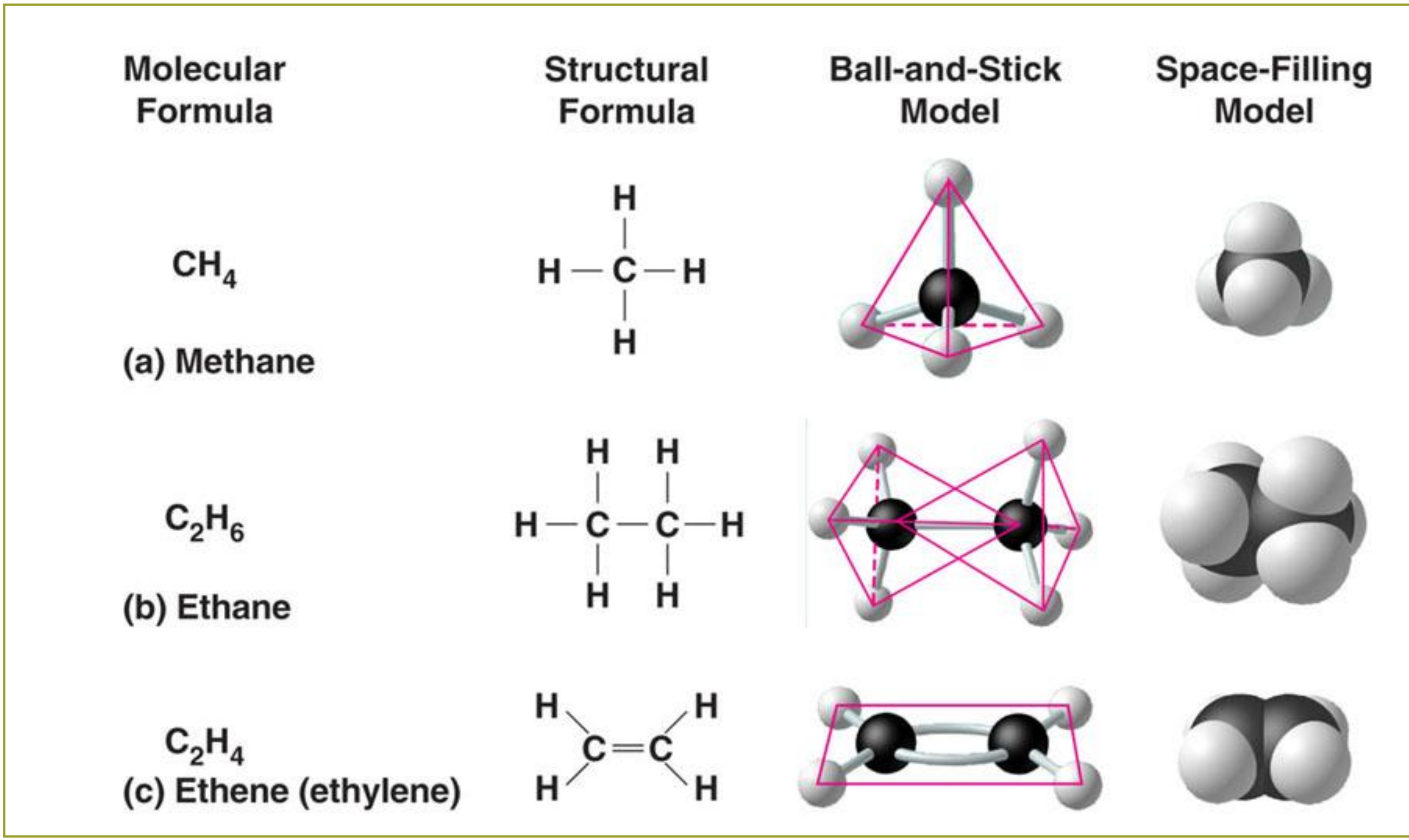
Organic and Inorganic Molecules

With or without Carbon Atoms

Organic & Inorganic Molecules

- **Organic molecules**
  - Contain hydrocarbon groups
  - Usually are **covalently bonded**
  - Examples: carbohydrates, lipids, proteins, and nucleic acids
  - Many of the organic molecules used in the body are **macromolecules.**
- **Inorganic molecules**
  - Do not contain hydrocarbon groups
  - Often have **ionic bonding**
  - Examples: water, salts, acids, and bases.

Organic Compounds



The “Big 4” Macromolecules

- Carbohydrates
  - C, H, O
- Lipids
  - C, H, O
- Proteins
  - C, H, O, N
- Nucleic Acids
  - C, H, O, N, P

Table 2.3 Important Organic Molecules and Their Functions

Molecule	Elements	Building Blocks	Function	Examples
Carbohydrate	C, H, O	Monosaccharides	Energy	Monosaccharides can be used as energy sources. Glycogen (polysaccharide) is an energy-storage molecule.
Lipid	C, H, O (P, N in some)	Glycerol and fatty acids (for fats)	Energy	Fats can be stored and broken down later for energy; per unit of weight fats yield twice as much energy as carbohydrates.
			Structure	Phospholipids and cholesterol are important components of cell membranes.
			Regulation	Steroid hormones regulate many physiological processes (e.g., estrogen and testosterone are responsible for many of the differences between males and females).
Protein	C, H, O, N (S in most)	Amino acids	Regulation	Enzymes control the rate of chemical reactions. Hormones regulate many physiological processes (e.g., insulin affects glucose transport into cells).
			Structure	Collagen fibers form a structural framework in many parts of the body.
			Energy	Proteins can be broken down for energy; per unit of weight they yield the same energy as carbohydrates.
			Contraction	Actin and myosin in muscle are responsible for muscle contraction.
			Transport	Hemoglobin transports oxygen in the blood.
			Protection	Antibodies and complement protect against microorganisms and other foreign substances.
Nucleic acid	C, H, O, N, P	Nucleotides	Regulation	DNA directs the activities of the cell.
			Heredity	Genes are pieces of DNA that can be passed from one generation to the next generation.
			Protein synthesis	RNA is involved in protein synthesis.

The "Big 4"

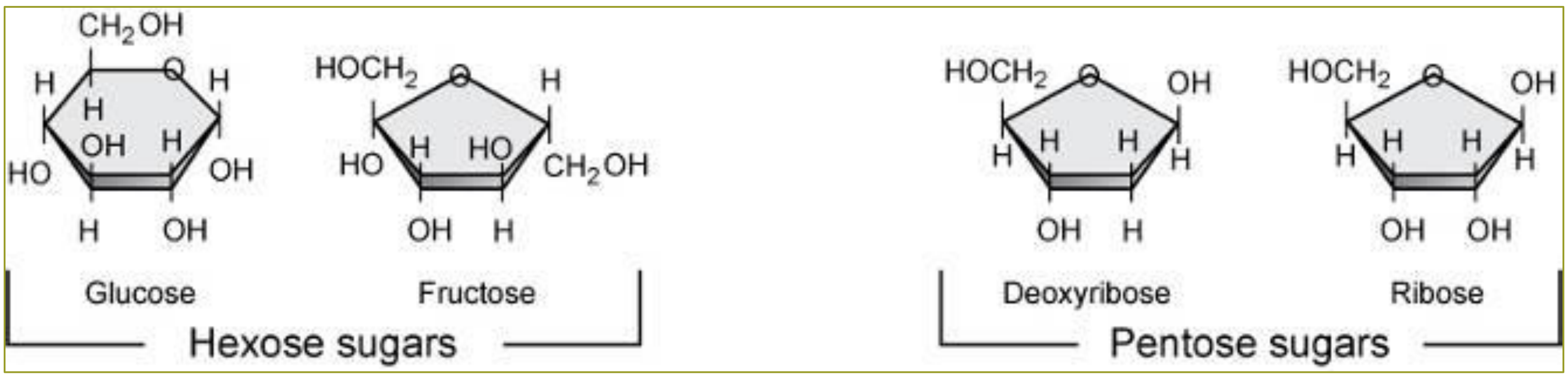
Table 2-2, Page 26

Molecule	Unit	Function
Carbohydrates		
Glycogen	Glucose	Stores energy as liver glycogen
Ribose	Pentose sugars	Backbone of DNA and RNA
Lipids		
Triglycerides	Glycerol and three fatty acids	Stores energy (eg., in body fat)
Phospholipids	Glycerol, three fatty acids, and phosphate	Primary cell membrane molecules
Steroids	Four rings of carbon	Cell membrane, hormone synthesis
Prostaglandins	20-carbon unsaturated fatty acids with a 5-carbon ring	Regulate hormone synthesis, enhance immune system, inflammatory response
Proteins		
Globular	Amino acids	Regulate chemical reactions, enzymes
Fibrous	Amino acids	Body support tissues: muscle, cartilage, tendons (collagen), skin, hair (keratin)
Nucleic Acids		
DNA	Nucleotides	Chromosomes
RNA	Nucleotides	Messenger, transfer
Adenosine triphosphate (ATP)	Adenine nucleotide and two phosphate groups	Stored energy in phosphate bonds

Carbohydrates

Figure 2-26, Page 27

- The sugar unit is the building block for carbohydrates
- "Good Carbs" & "Bad Carbs"



Carbohydrates

- Functions: used for energy, storage of energy, and cellular structures
- Monosaccharides: contain three to seven carbon atoms in a chain or ring
  - Example: glucose, chemical formula $C_6H_{12}O_6$
- Disaccharides: two monosaccharides joined together
  - Example: glucose + fructose = sucrose
- Polysaccharides: combinations of many monosaccharides
  - Examples: glycogen, starch, and cellulose

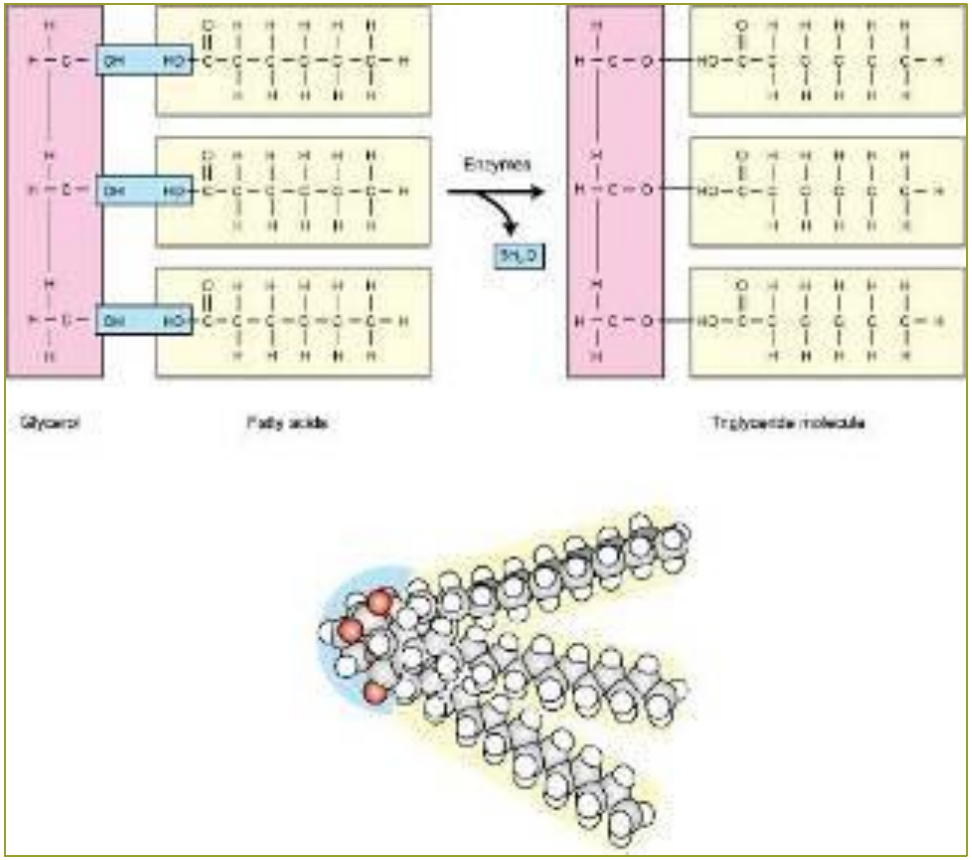
Lipids

- Functions: used in the body for **energy** and **stored in fat** for future energy needs
- Four classes of lipids:
  - Neutral fats
    - "Good fats"
  - Phospholipids
  - Steroids
  - Eicosanoids

Neutral Fats (Triglycerides)

Figure 2-30, Page 29

- Contain three fatty acids and a glycerol molecule
- A **glycerol** molecule is a modified three-carbon simple sugar
- A **fatty acid** is a chain of carbon atoms with one or two hydrogen atoms attached to each carbon by single or double bonds



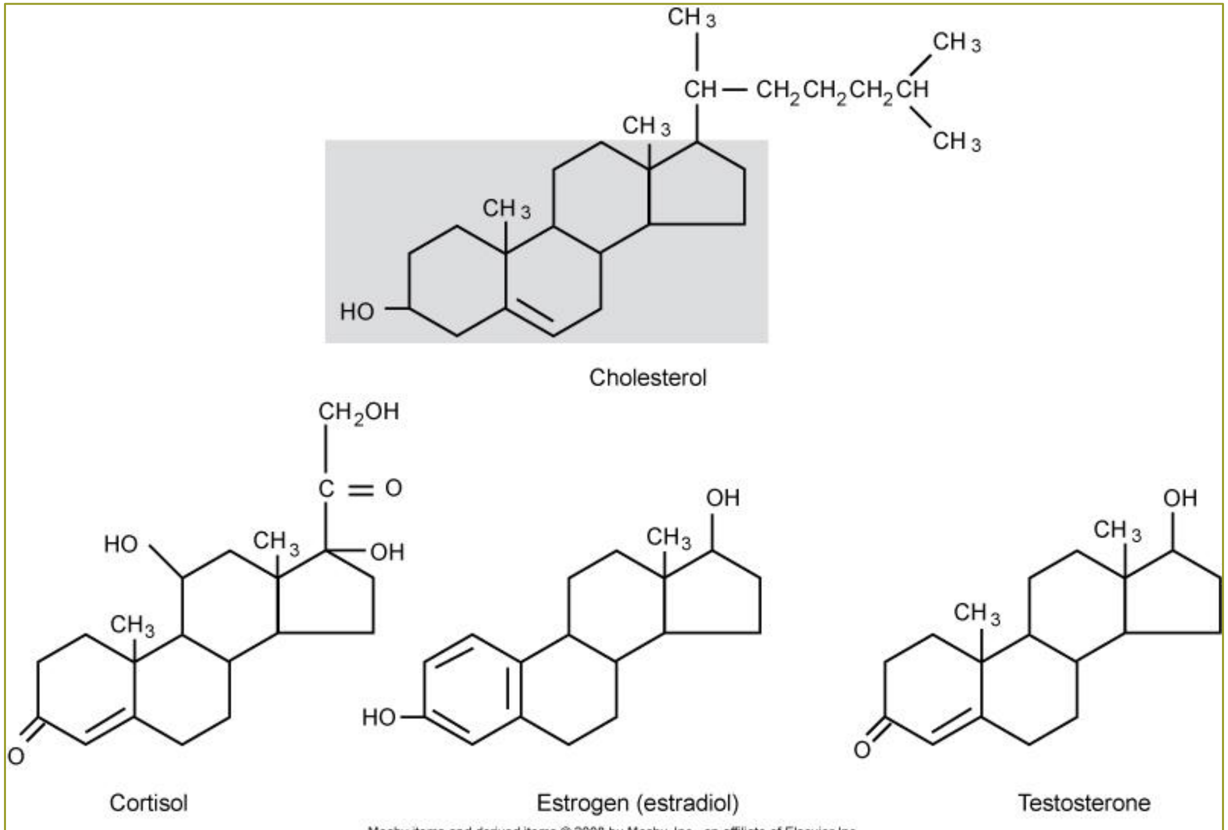
Saturated & Unsaturated Fats

- A fatty acid is called **saturated** when all the bonds in the hydrocarbon chain are single bonds and as many hydrogen atoms as possible are attached to carbon
- A fatty acid is called **unsaturated** when there are some double bonds between the carbon and hydrogen atoms

Steroids

Figure 2-32, Page 31

- Lipids that take the form of four interlocking hydrocarbon rings



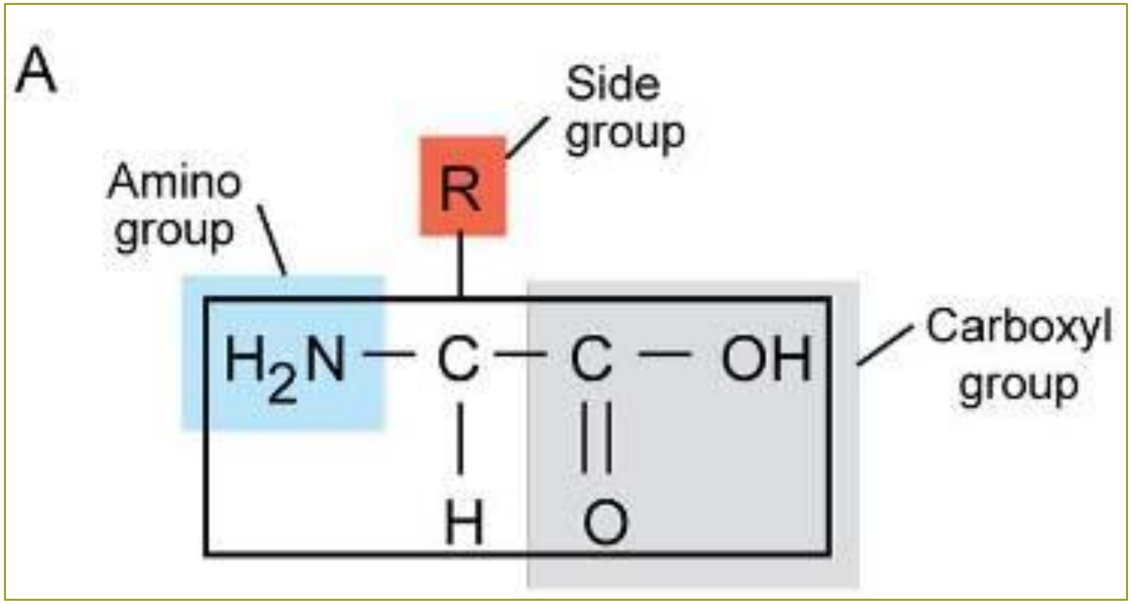
Proteins

- **Proteins** are the most abundant organic molecules in the body
- Composed primarily of **C, O, H, and N**
- Made of amino acids
- **Functions**: used for cell structures and structural body tissues, for controlling chemical reactions, for regulating growth, for transporting molecules, for defending the body against invaders, for catalyzing all reactions occurring in the body

Amino Acids

Figure 2-34A, Page 32

- 20 different amino acids used by the animal's body
- Contains a central carbon atom attached to a hydrogen atom, an *amino group* (NH_2), a *carboxyl group* (COOH) and a side chain (designated by the letter "R")
- The R group defines each amino acid.



Amino Acids

- The specific combination of amino acids is determined by the cell's DNA
- Two amino acids are linked together by a peptide bond
- A polypeptide is a chain of ten or more amino acids linked together
- Essential amino acids
  - Definition

Nucleic Acids

- **Nucleic acids** are the largest molecules in the body
- Composed of C, O, H, N, and P
- Two classes of nucleic acids:
  - **DNA (deoxyribonucleic acid)** – exists mainly in the nucleus (but also in mitochondria) and is the molecule that contains all the instructions needed by the cell to build protein
  - **RNA (ribonucleic acid)** – transfers instructions out of the nucleus and into the cytoplasm of the cell; builds proteins

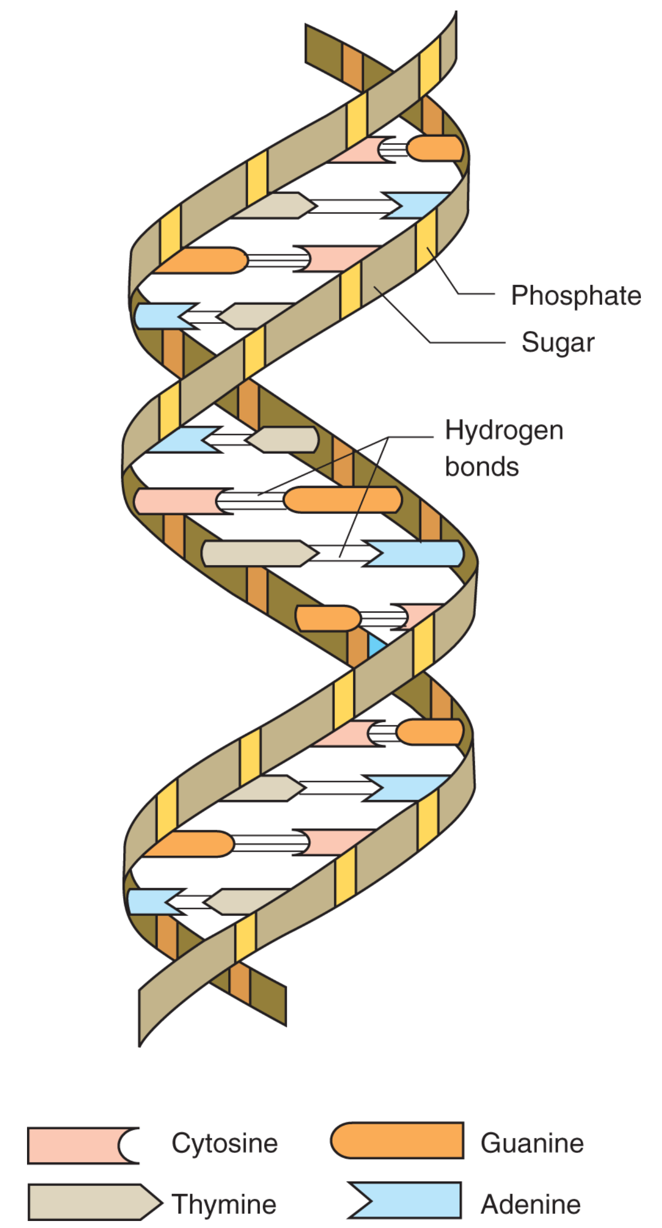
Nucleotides

- Molecular building blocks of nucleic acids
- Consist of a nitrogenous base plus a 5-carbon (pentose) sugar plus a phosphate group
- The sugar in DNA is deoyxribose and in RNA, ribose

DNA

Figure 2-41, Page 37

- DNA is constructed of two parallel strands of the nucleotides A, G, C, and T
- The two strands of bonded nucleic acid twist around each other in a spiral called a ***double helix***



RNA

- RNA consists of a single strand of the nucleotides

  A, G, C, and U
- Three types of RNA
  - Transfer
  - **Messenger**
  - Ribosomal RNA

2 Parts to Metabolism

Catabolism

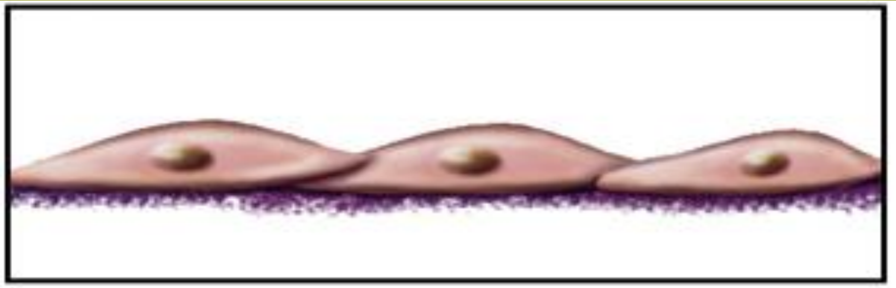
Anabolism

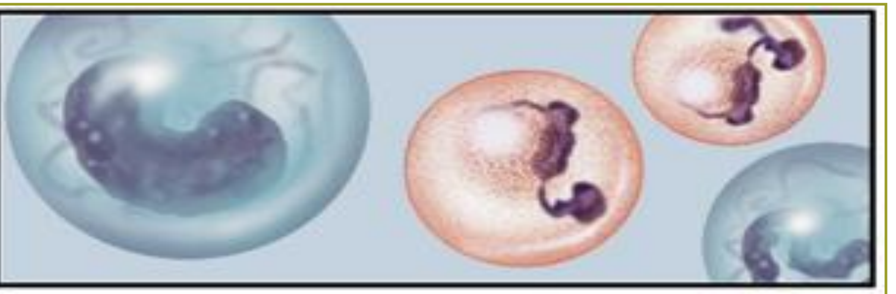
Catabolism

- Definition – **breakdown of molecules** in animal's body
- Releases energy (ATP)
- Examples
  - Digestion
  - Cellular respiration

Anabolism

- Definition – **Building of molecules** in animal's body
- Requires energy (ATP)
- Formation of macromolecules
  - Protein
  - Glycogen
  - Fat
- Anabolic steroids (Winstrol-V)



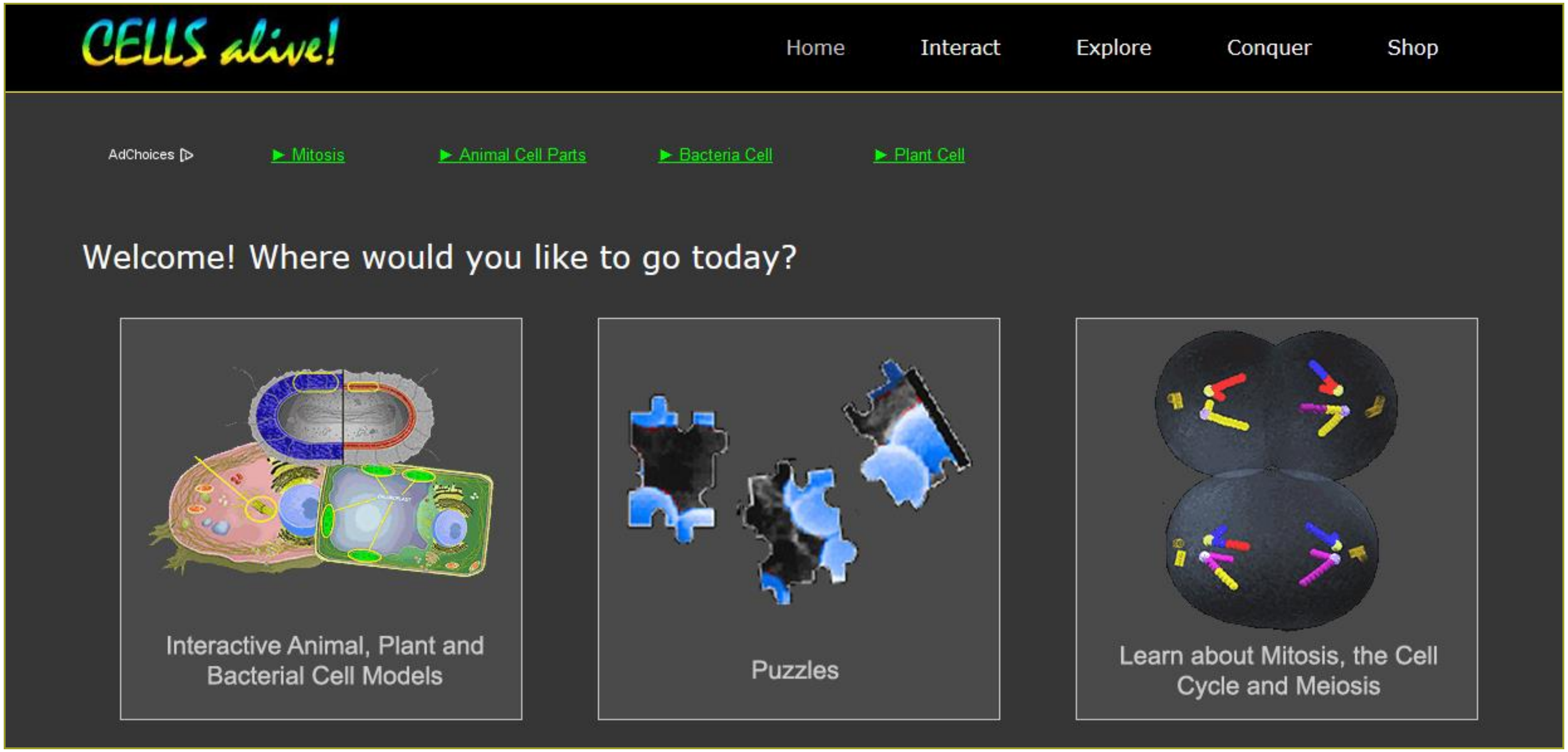


The Amazing Cell
Chapter 3

Pages 39-89

“Cells Alive” Website

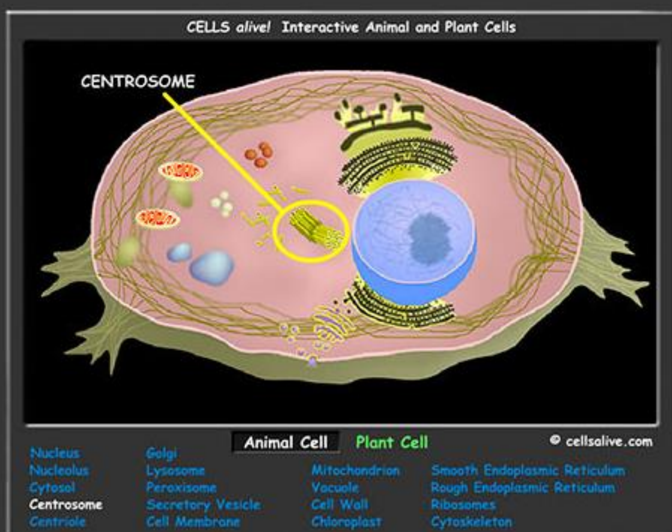
http://www.cellsalive.com/

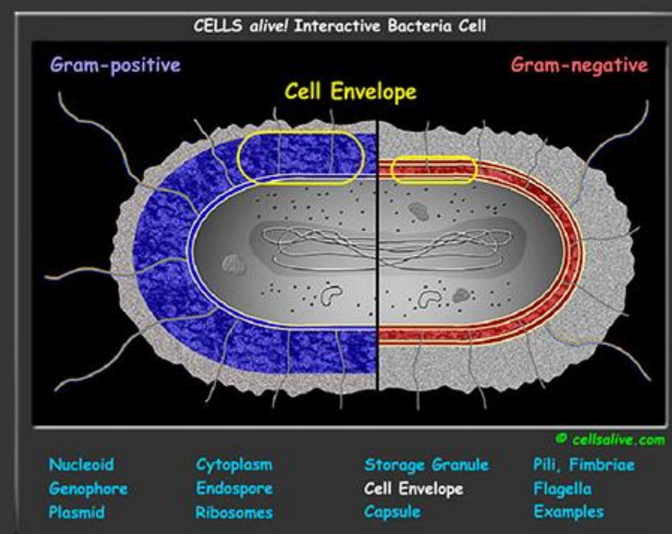


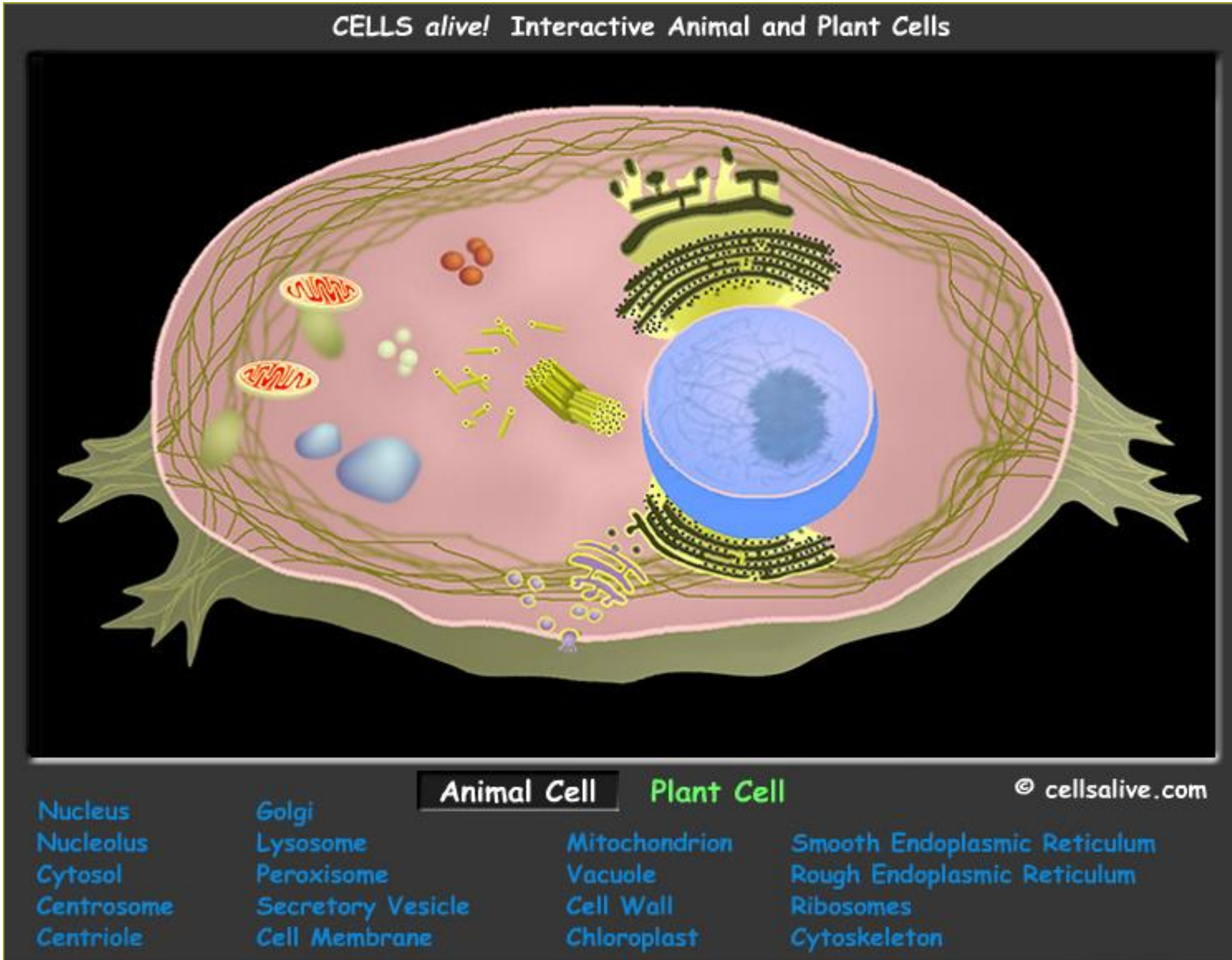
Cell Models

Plant, Animal and Bacteria Cell Models

Living cells are divided into two types - prokaryotic and eukaryotic (sometimes spelled procaryotic and eucaryotic). This division is based on internal complexity. The following interactive animations provide graphic roadmaps to the organization of both of these cell types.







CELLS alive! Interactive Animal and Plant Cells
Animal Cell
Plant Cell
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Nucleus
Nucleolus
Cytosol
Centrosome
Centriole
Golgi
Lysosome
Peroxisome
Secretory Vesicle
Cell Membrane
Mitochondrion
Vacuole
Cell Wall
Chloroplast
Smooth Endoplasmic Reticulum
Rough Endoplasmic Reticulum
Ribosomes
Cytoskeleton


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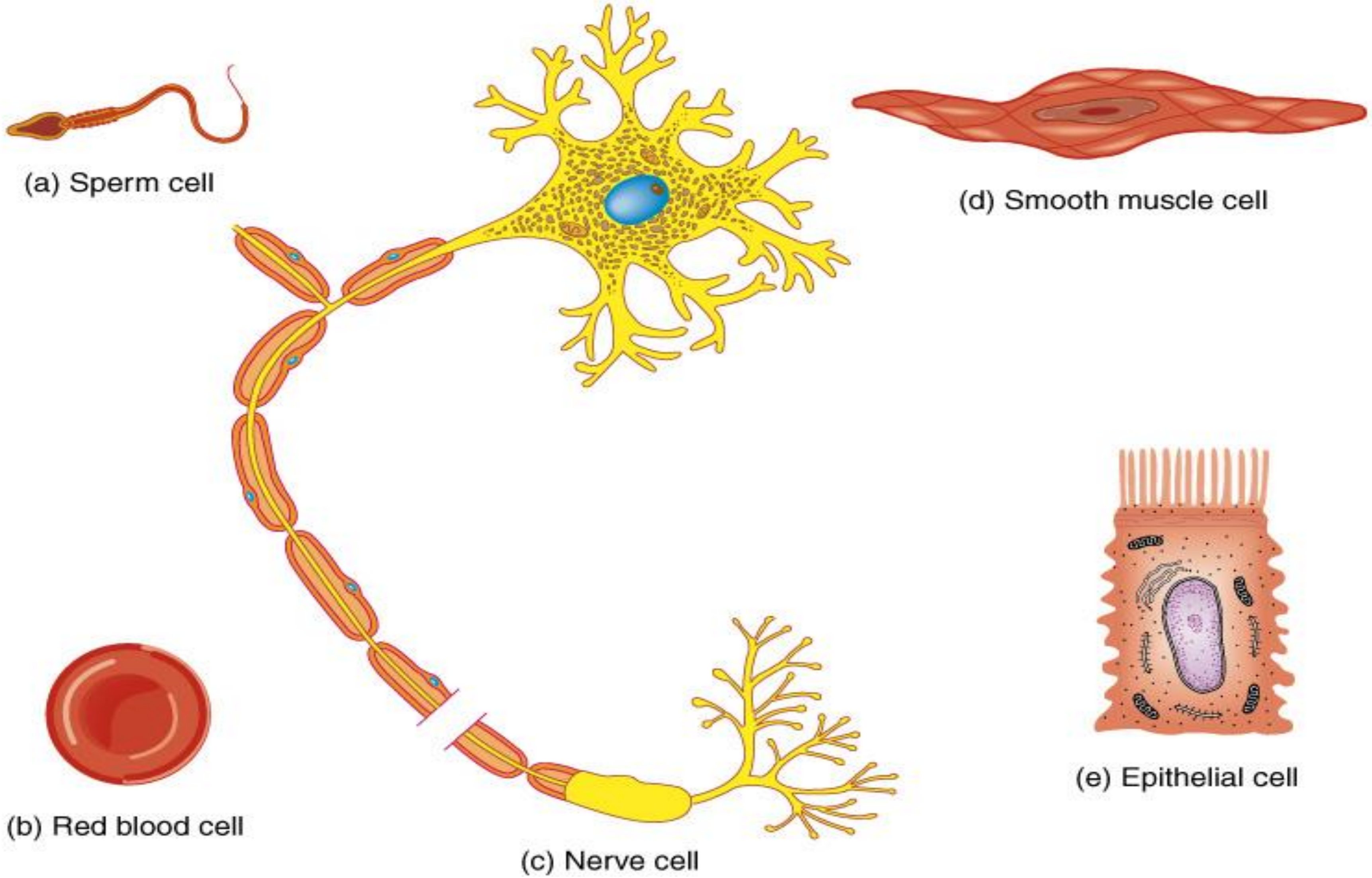
Ribosomes
Cytoskeleton

Textbook Learning Objectives

Chapter 3 – Page 39

- Differentiate between prokaryotic and eukaryotic cells.
- Describe the structure of the plasma membrane.
- List and describe the components of the cytoskeleton.
- Describe the structure and functions of each of the cellular organelles.
- Differentiate between active and passive transport processes.
- Describe the factors that determine whether a molecule can pass through a plasma membrane by passive diffusion.
- Differentiate between diffusion and facilitated diffusion.
- Describe the processes of osmosis, active transport, endocytosis and exocytosis.
- Describe the role of ions in maintaining a cell’s resting membrane potential.
- List the phases of mitosis and describe the events that occur in each phase.
- List the steps in replication of DNA and the synthesis of proteins.

Cell Diversity
Figure 3-1, Page 40



Important Concepts!

Healthy Cells = Healthy Animal

Diseased Cells = Diseased Animal

Cell Anatomy (Morphology)

Cell Membrane

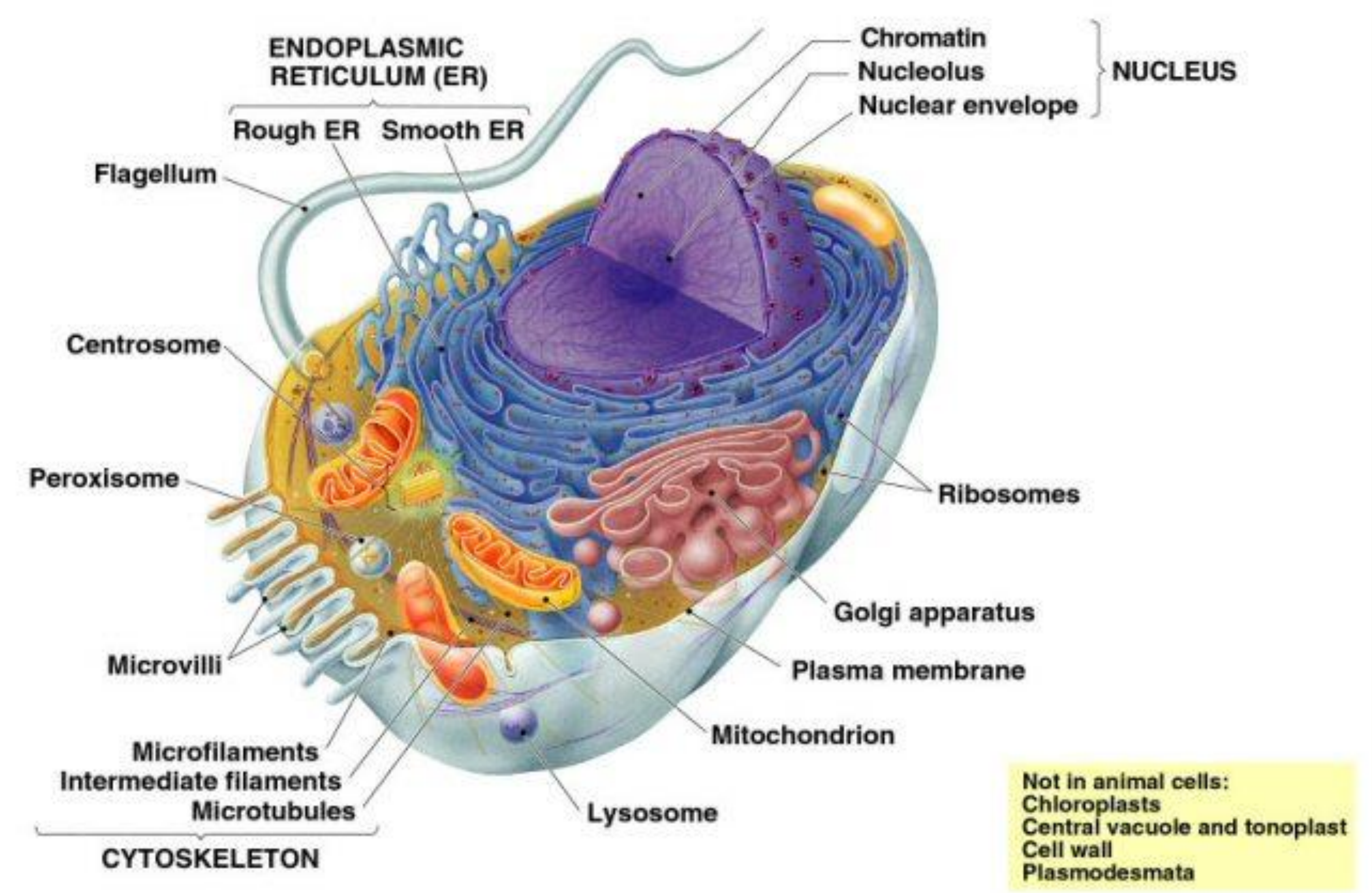
Nucleus

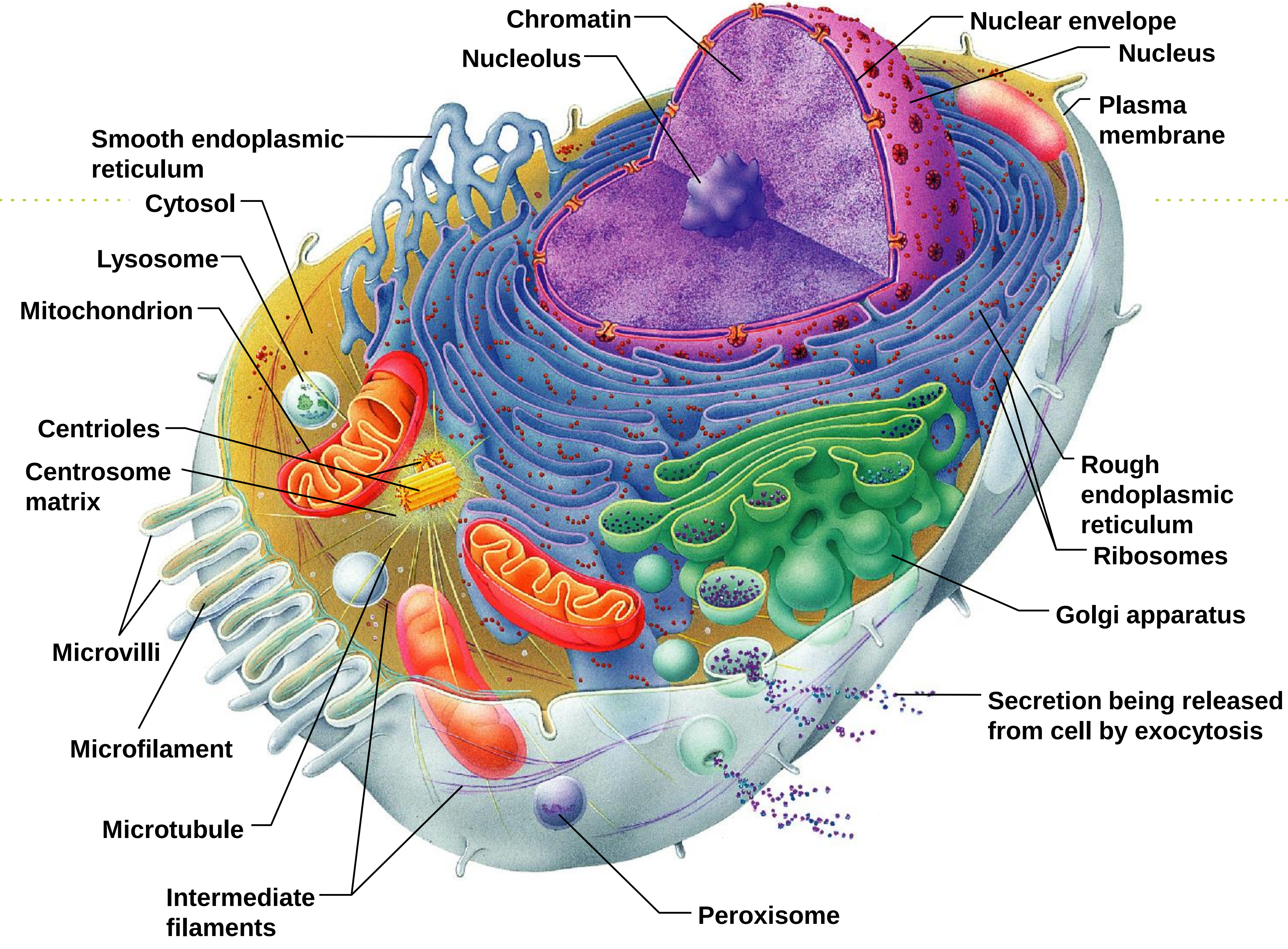
Cytoplasm

Mammalian Cell Anatomy

- Structures found in all mammalian cells include the **cell membrane**, the **cytoplasm**, and the **nucleus**
- Everything inside the cell membrane other than the nucleus and genetic material is known as the ***cytoplasm***
- Cytoplasm is composed of proteins, electrolytes, metabolites, a flexible cytoskeleton, and organelles

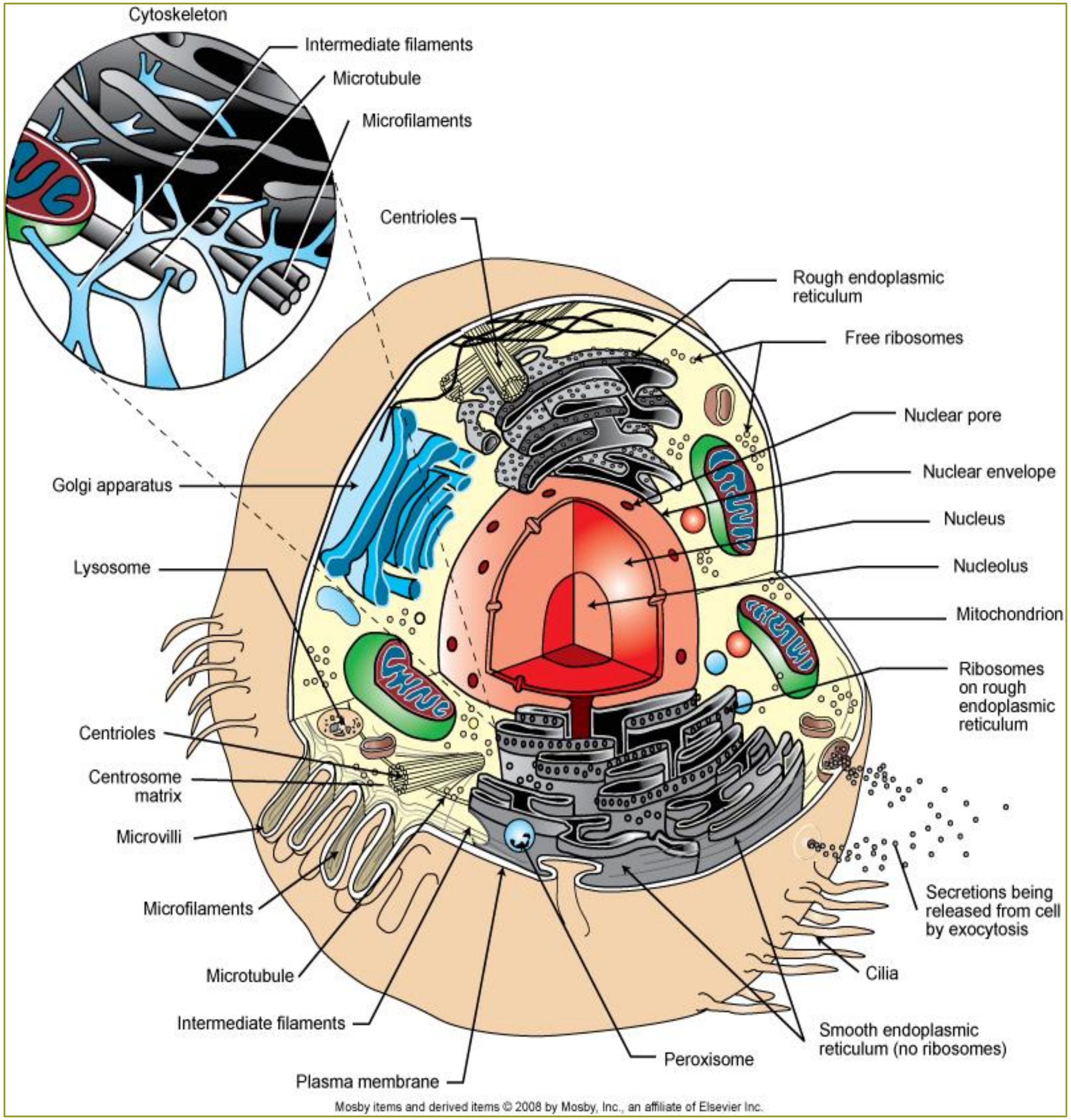
Mammalian Cell Anatomy
Figure 3-2; Table 3-1 – Pages 46-48




Chromatin
Nucleolus
Nuclear envelope
Nucleus
Plasma membrane
Smooth endoplasmic reticulum
Cytosol
Lysosome
Mitochondrion
Centrioles
Centrosome matrix
Microvilli
Microfilament
Microtubule
Intermediate filaments
Rough endoplasmic reticulum
Ribosomes
Golgi apparatus
Secretion being released from cell by exocytosis
Peroxisome

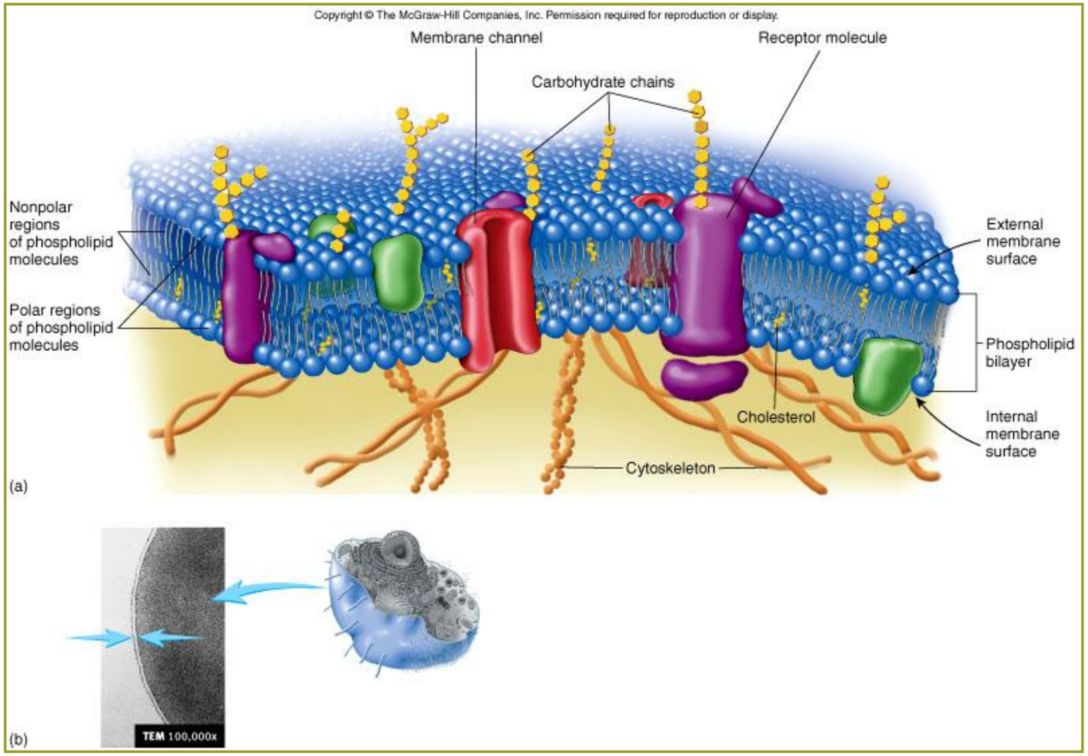
Mammalian Cell

Figure 3-2, Page 46

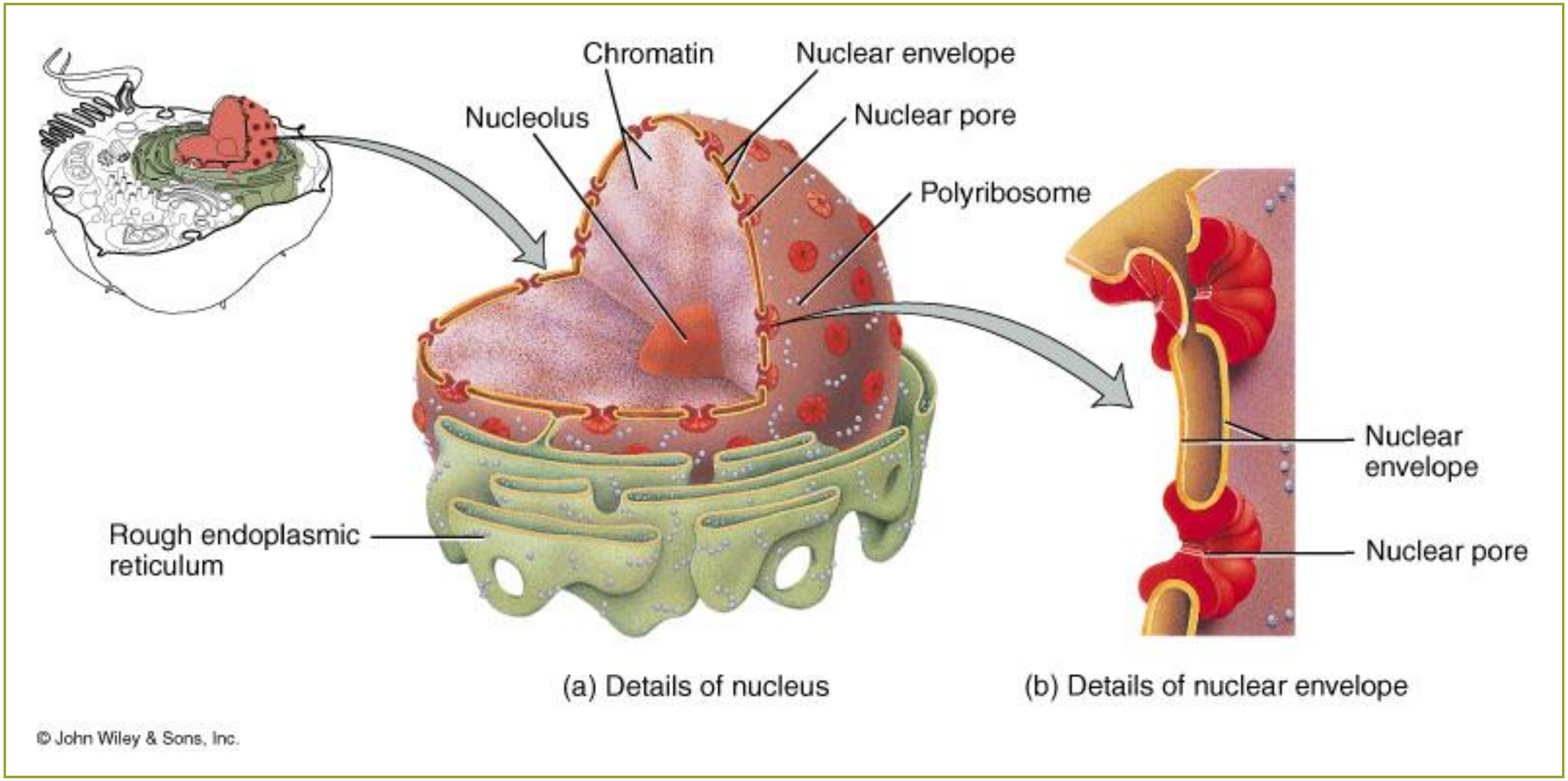


Cell Membrane
Figure 3-3, Page 49

- Phospholipid bilayer
- Protein “iceburgs” ☺



The Nucleus



Chromatin
Nuclear envelope
Nucleolus
Nuclear pore
Polyribosome
Rough endoplasmic reticulum
Nuclear envelope
Nuclear pore
(a) Details of nucleus
(b) Details of nuclear envelope
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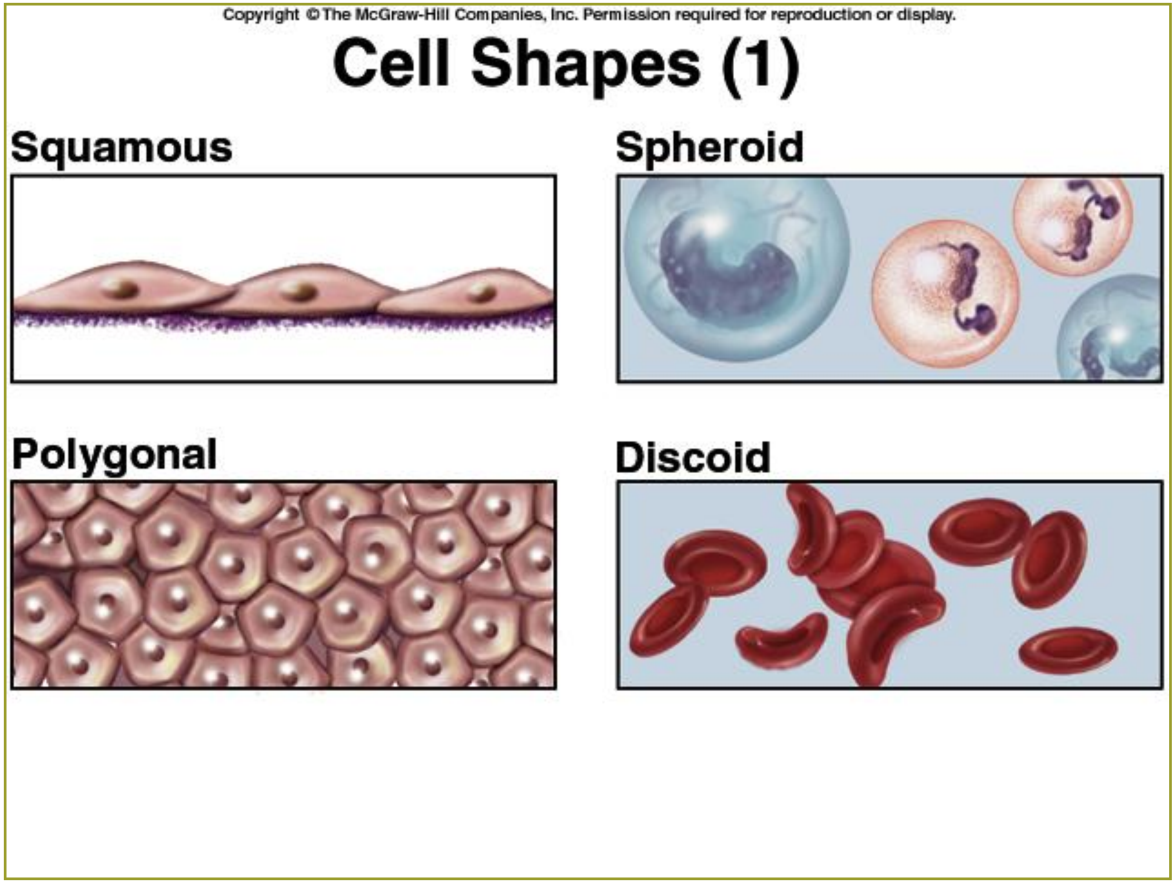
Cytoplasm

- Cytosol (ICF)
- Cytoskeleton
- Organelles in cytoplasm



1. Cell Membrane

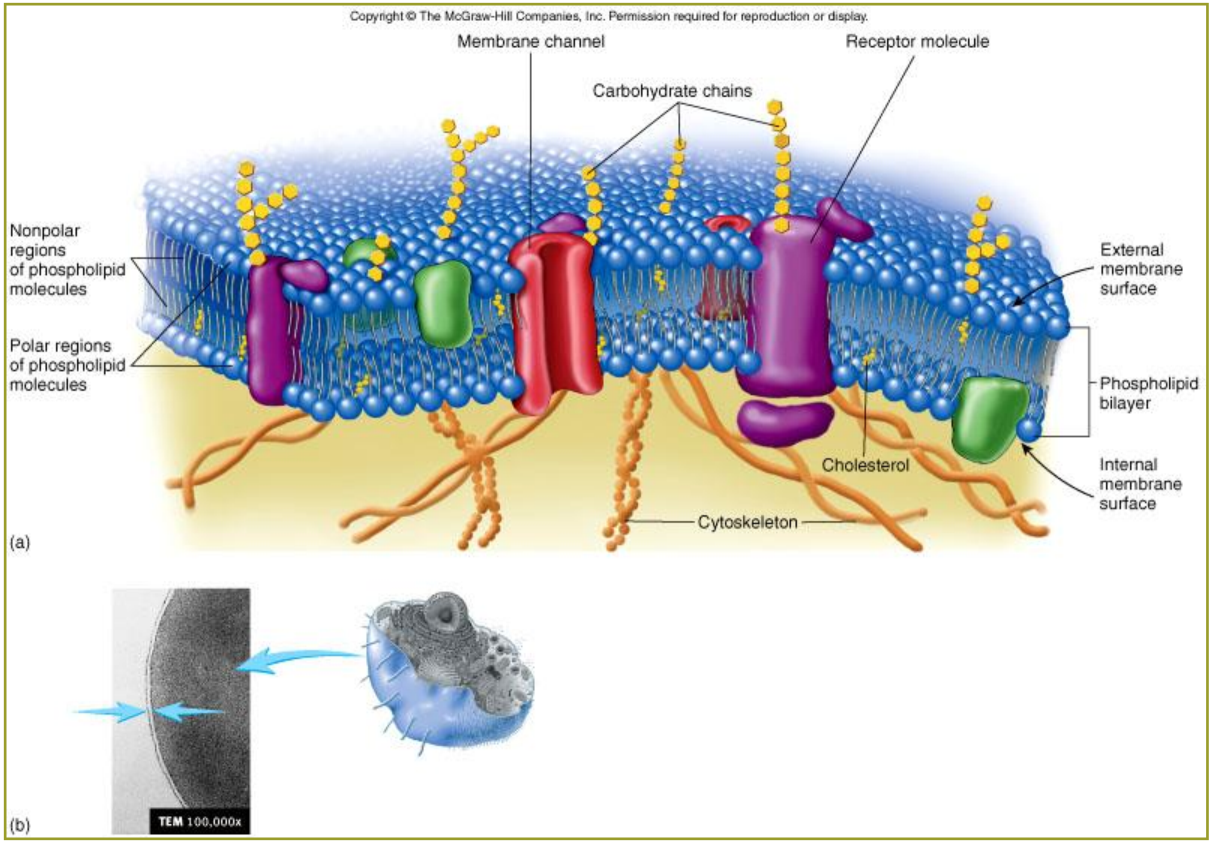
Phospholipid Bilayer

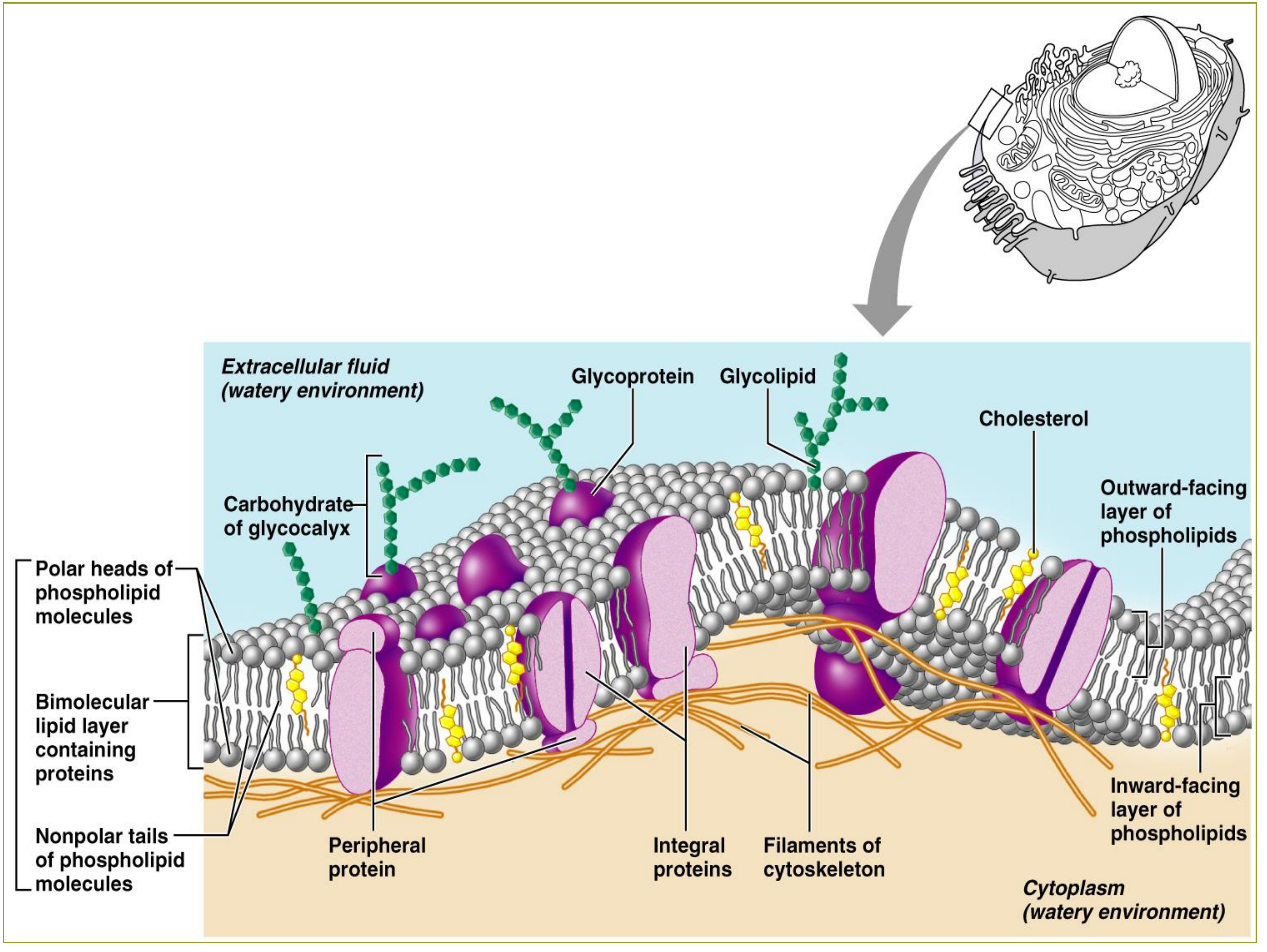
“Floating” Proteins

Cell Membrane

Figure 3-3, Page 49

- Phospholipid bilayer
- Protein "iceburgs" ☺




Extracellular fluid
(watery environment)
Glycoprotein
Glycolipid
Cholesterol
Carbohydrate of glycocalyx
Outward-facing layer of phospholipids
Polar heads of phospholipid molecules
Bimolecular lipid layer containing proteins
Nonpolar tails of phospholipid molecules
Peripheral protein
Integral proteins
Filaments of cytoskeleton
Inward-facing layer of phospholipids
Cytoplasm
(watery environment)

Cell Membrane

- Functions: acts as a flexible, elastic barrier between the inner cytoplasm and the outside environment
  - Governs the movement of atoms and molecules in and out of the cell
- Consists primarily of protein and phospholipids
  - Also includes cholesterol, other lipids, and carbohydrates

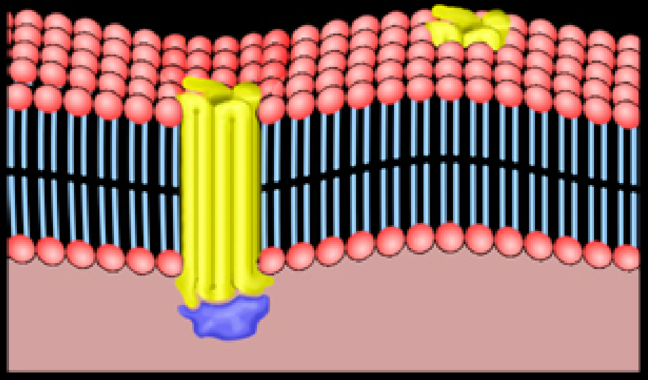
Membrane Structure

- **Lipid bilayer**: composed of two layers of phospholipid molecules arranged so that the hydrophilic “heads” are on the outside and the hydrophobic fatty acid “tails” are on the inside
- **Fluid mosaic**: Proteins are suspended in the bilayer and move easily throughout the membrane to create a constantly changing pattern

Cells Alive! –
Their Take on the Cell Membrane

CELLS *alive!* Interactive Animal and Plant Cells

CELL MEMBRANE



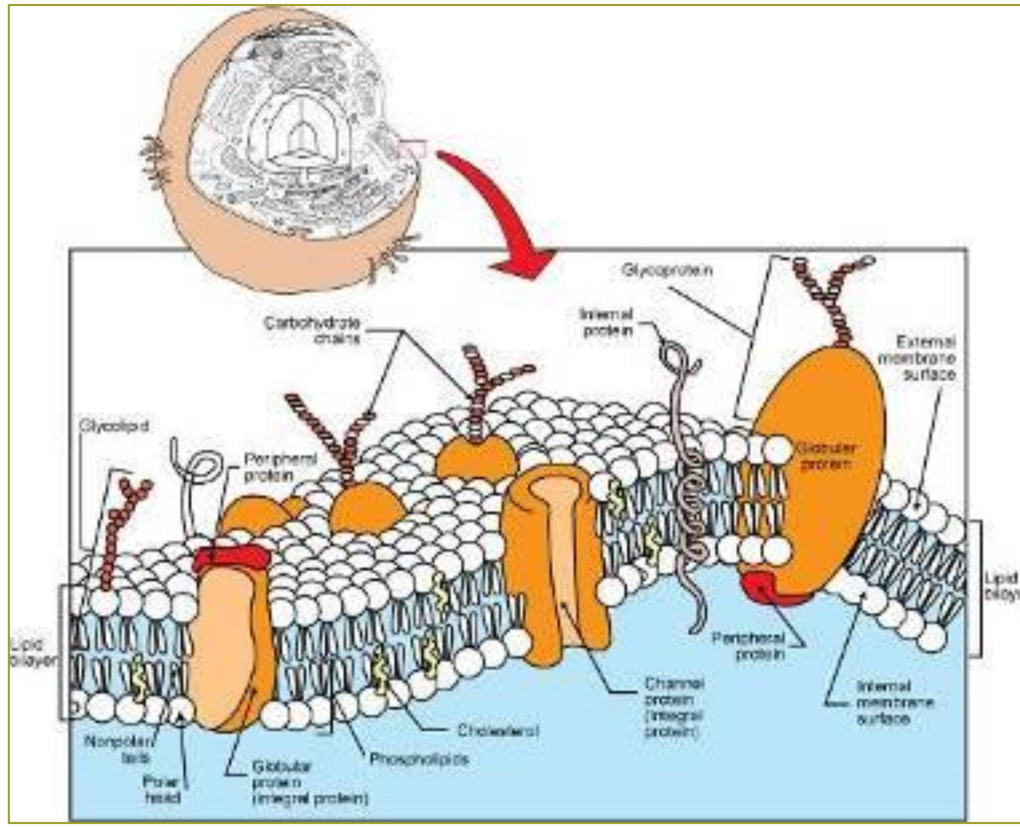
Every cell is enclosed in a membrane, a double layer of phospholipids (lipid bilayer). The exposed heads of the bilayer are "hydrophilic" (water loving), meaning that they are compatible with water both within the cytosol and outside of the cell. However, the hidden tails of the phospholipids are "hydrophobic" (water fearing), so the cell membrane acts as a protective barrier to the uncontrolled flow of water. The membrane is made more complex by the presence of numerous proteins that are crucial to cell activity. These proteins include receptors for odors, tastes and hormones, as well as pores responsible for the controlled entry and exit of ions like sodium (Na+) potassium (K+), calcium (Ca++) and chloride (Cl-).

RETURN to CELL DIAGRAM

Membrane Structure

Figure 3-3, Page 49

- Most lipid-soluble materials easily pass through the membrane
- Water-soluble molecules do not readily pass through
- Remember this for Pharmacology!



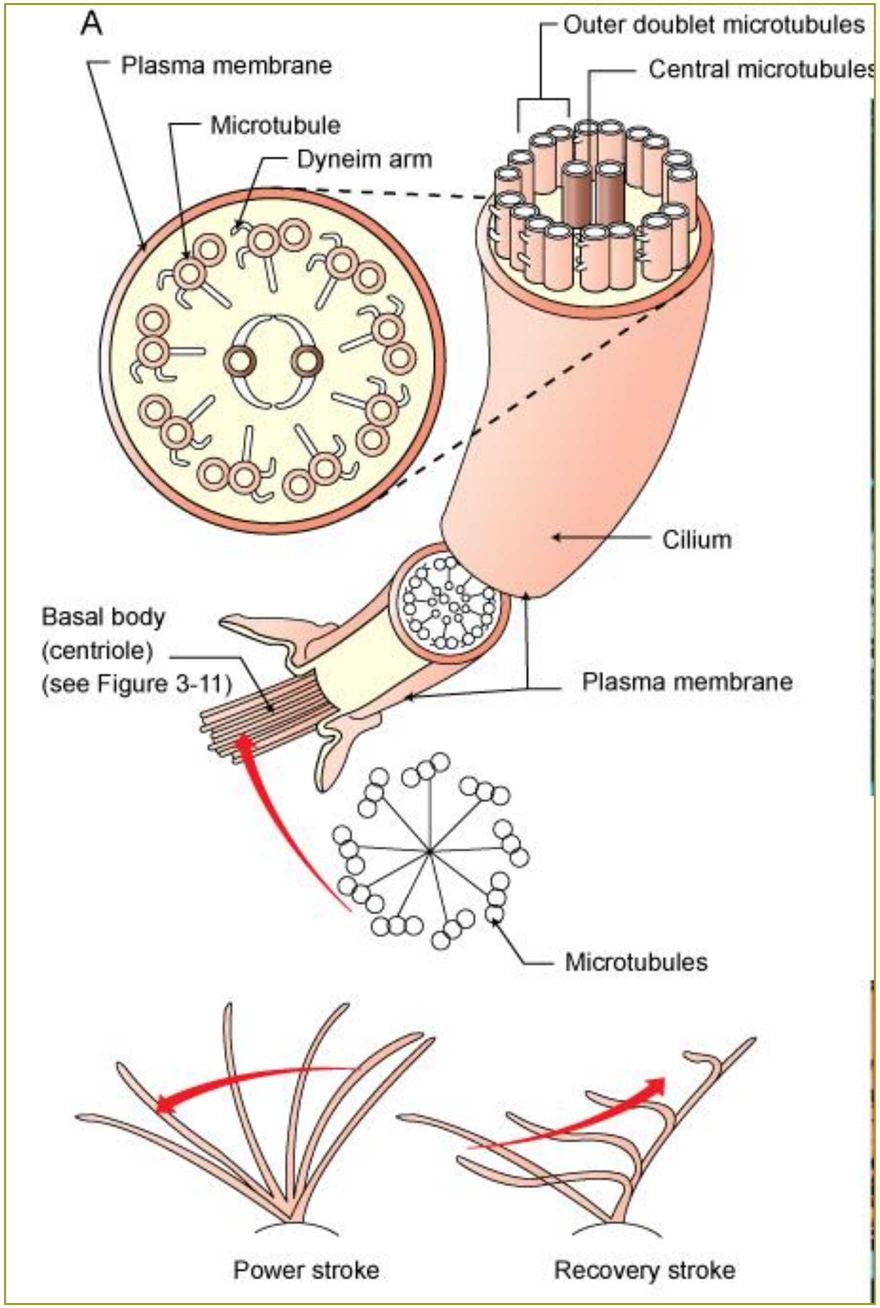
What about Drugs?

- High lipid solubility
- Low lipid solubility

Cilia and Flagella

Figure 3-5A, Page 52

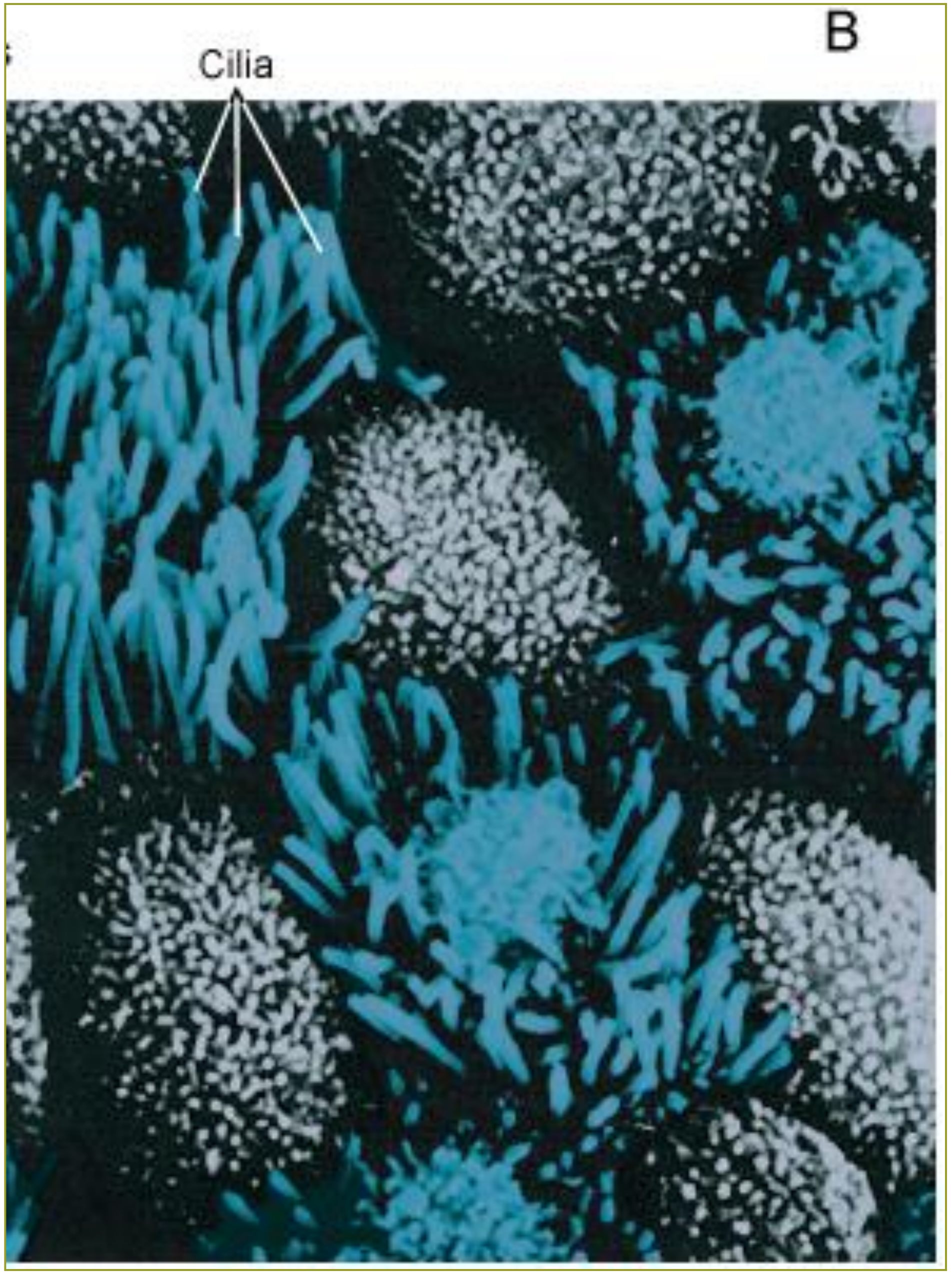
- Extensions of the plasma membrane that extend into the extracellular space
- Composed of nine pairs of microtubules that encircle a central pair of microtubules
- "9 + 2" arrangement



Cilia

Figure 3-5B, Page 52

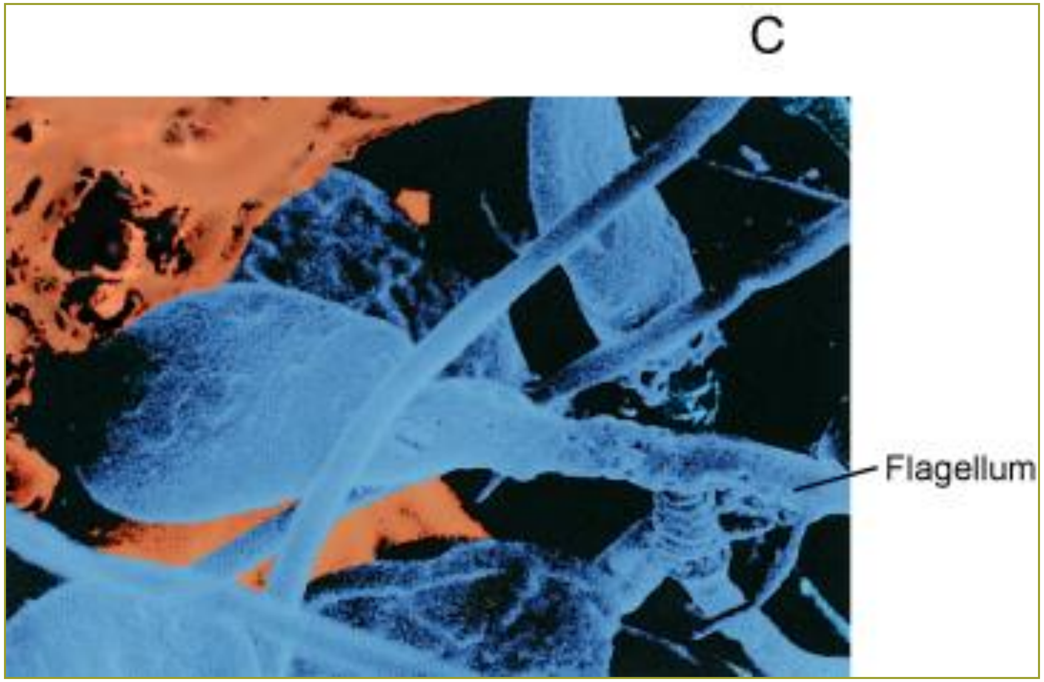
- Cilia occur in large numbers on the exposed surface of some cells
  - Move synchronously creating waves of motion that propel fluid, mucus, and debris across the cellular surface



Flagella

Figure 3-5C, Page 52

- Usually occur singly and are significantly longer than cilia
- Attached to individual cells and propel the cell forward by undulating



2. Cytoplasm

Mitochondria

Ribosomes

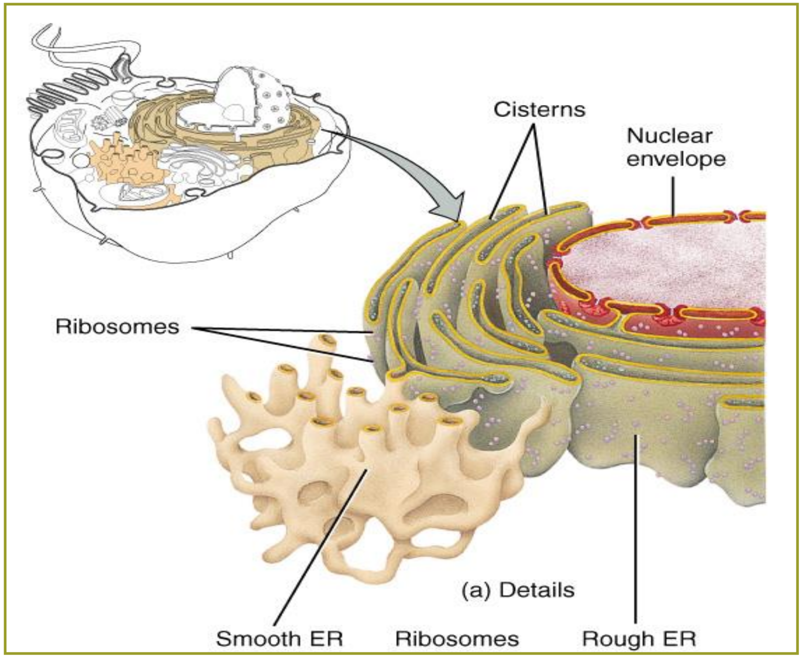
Endoplasmic Reticulum (ER)

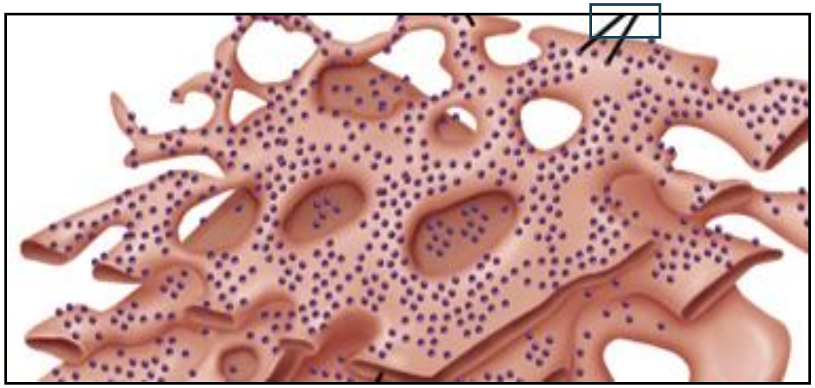
Golgi Apparatus

Lysosomes

Cytoplasmic Organelles

- Mitochondria
- Ribosomes
- Endoplasmic reticulum (ER)
  - Smooth ER
  - Rough ER

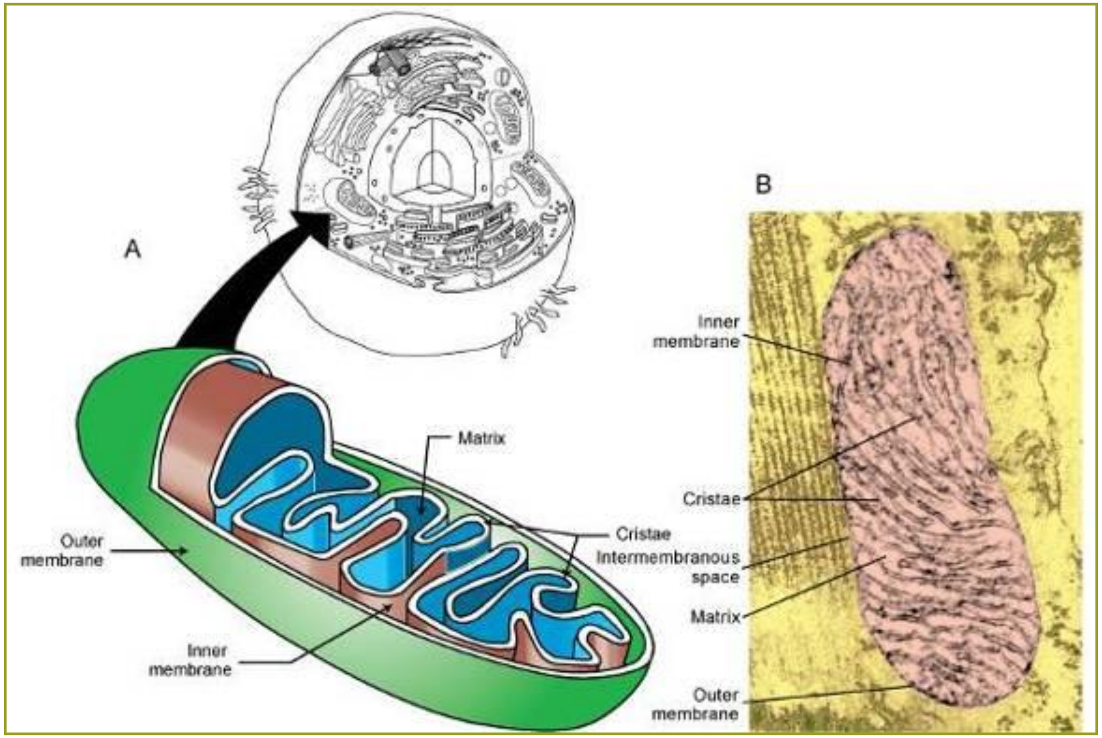




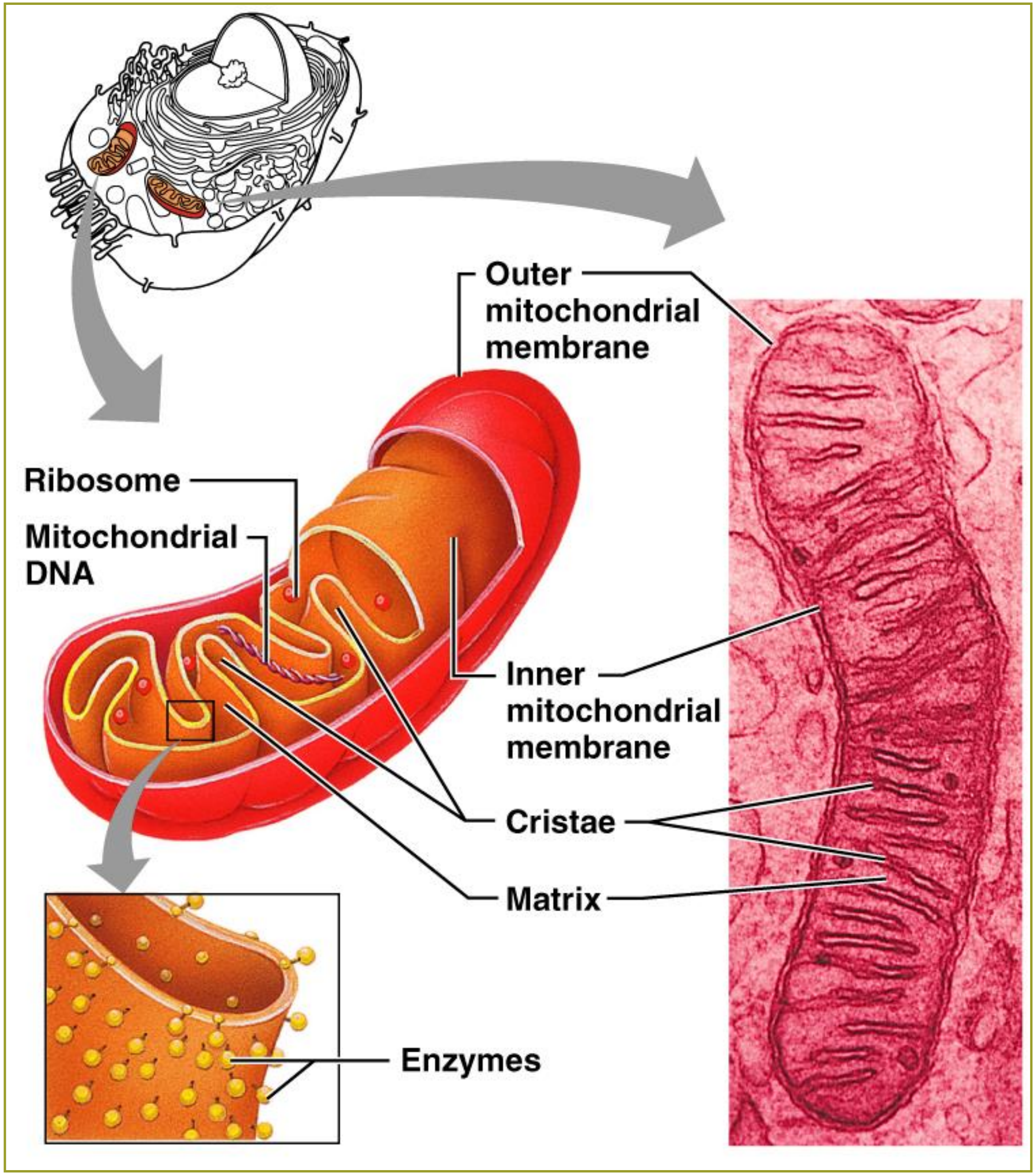
Mitochondria

Figure 3-7, Page 54

- Produces most of the energy that fuels the cell
- Site of aerobic cellular respiration



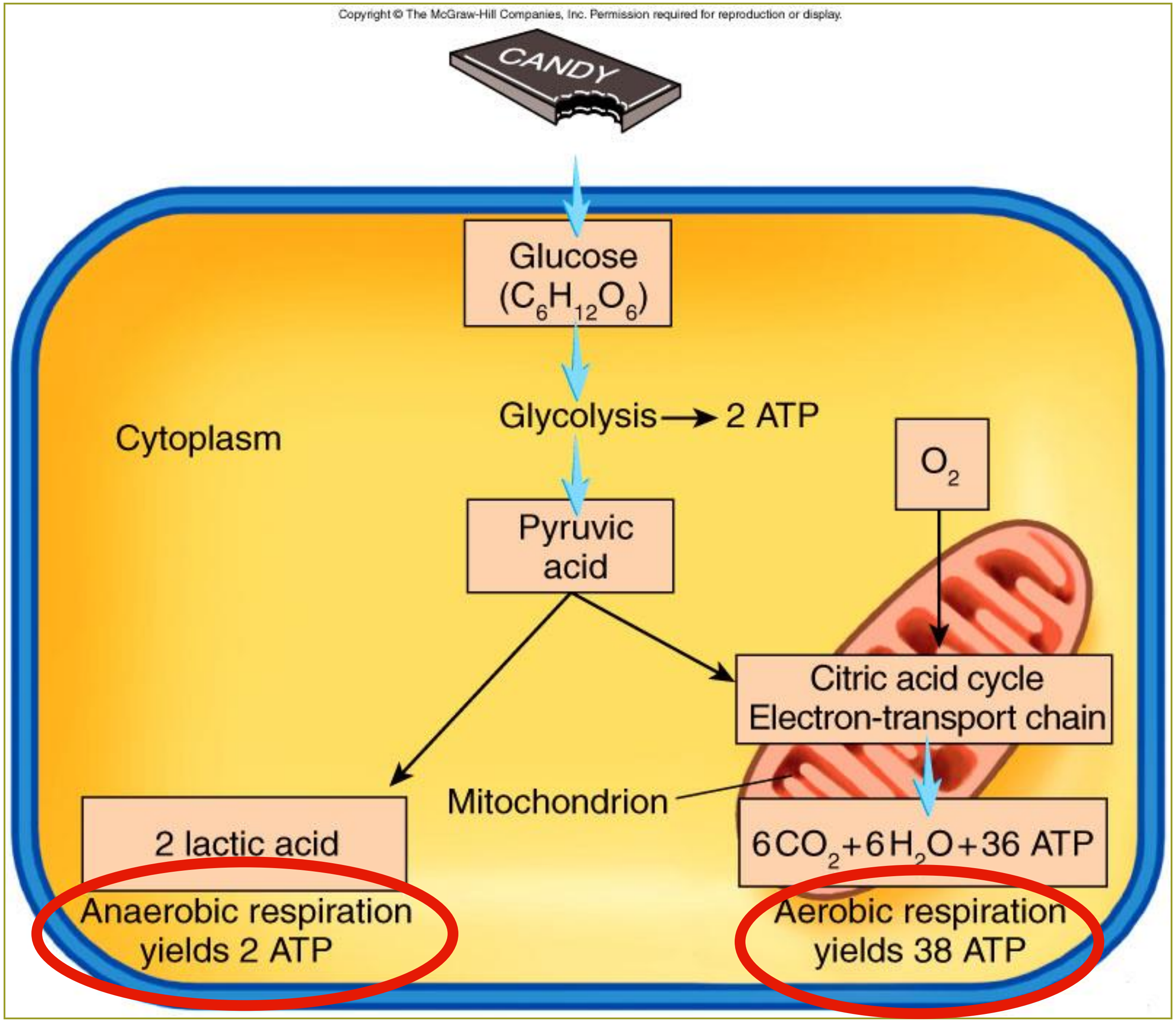
Mitochondria

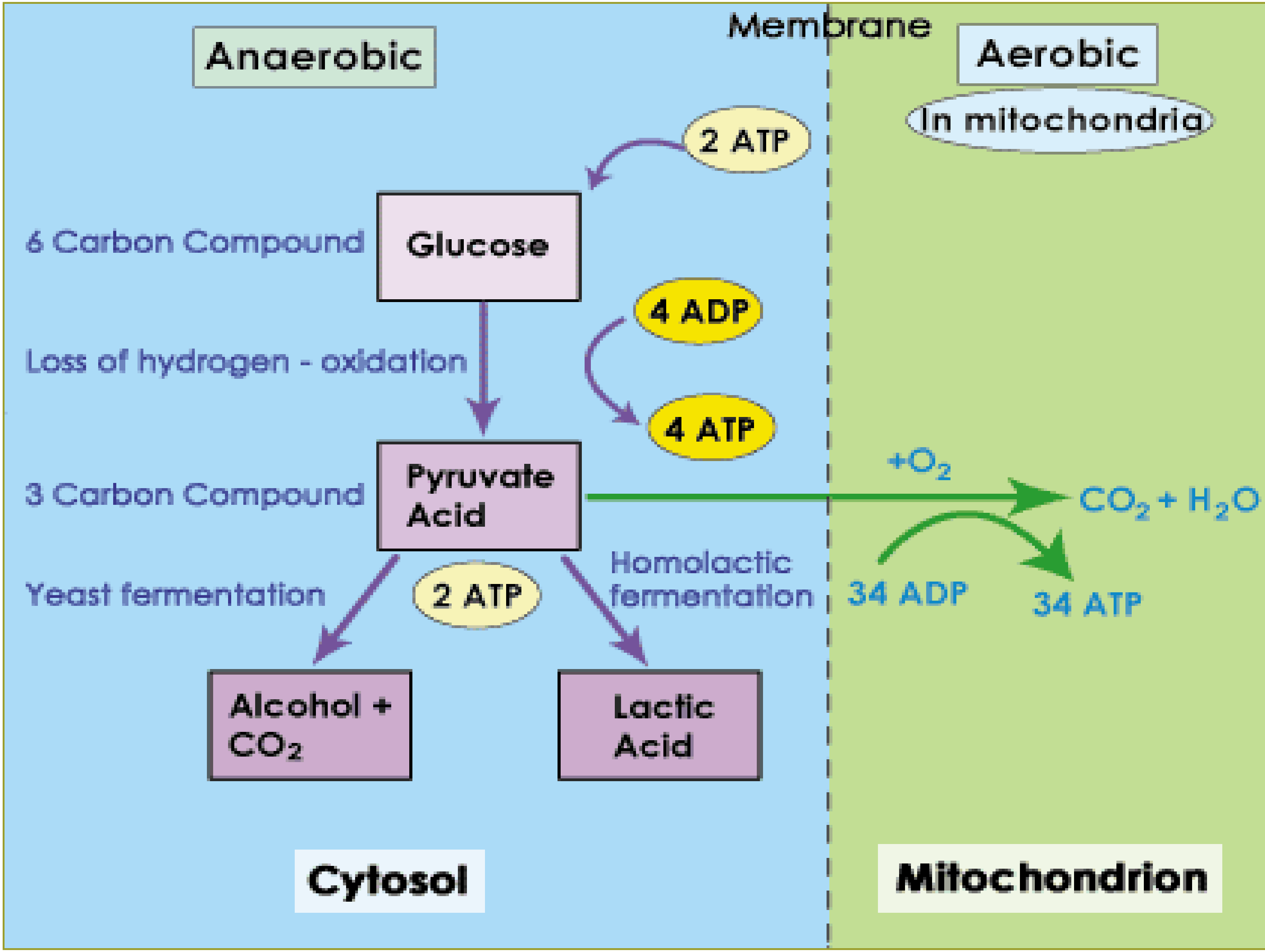


Aerobic Cellular Respiration

- In mitochondria
- Formula – **Glucose + Oxygen → Water + Carbon Dioxide + 36-38 ATP**

Cellular Respiration



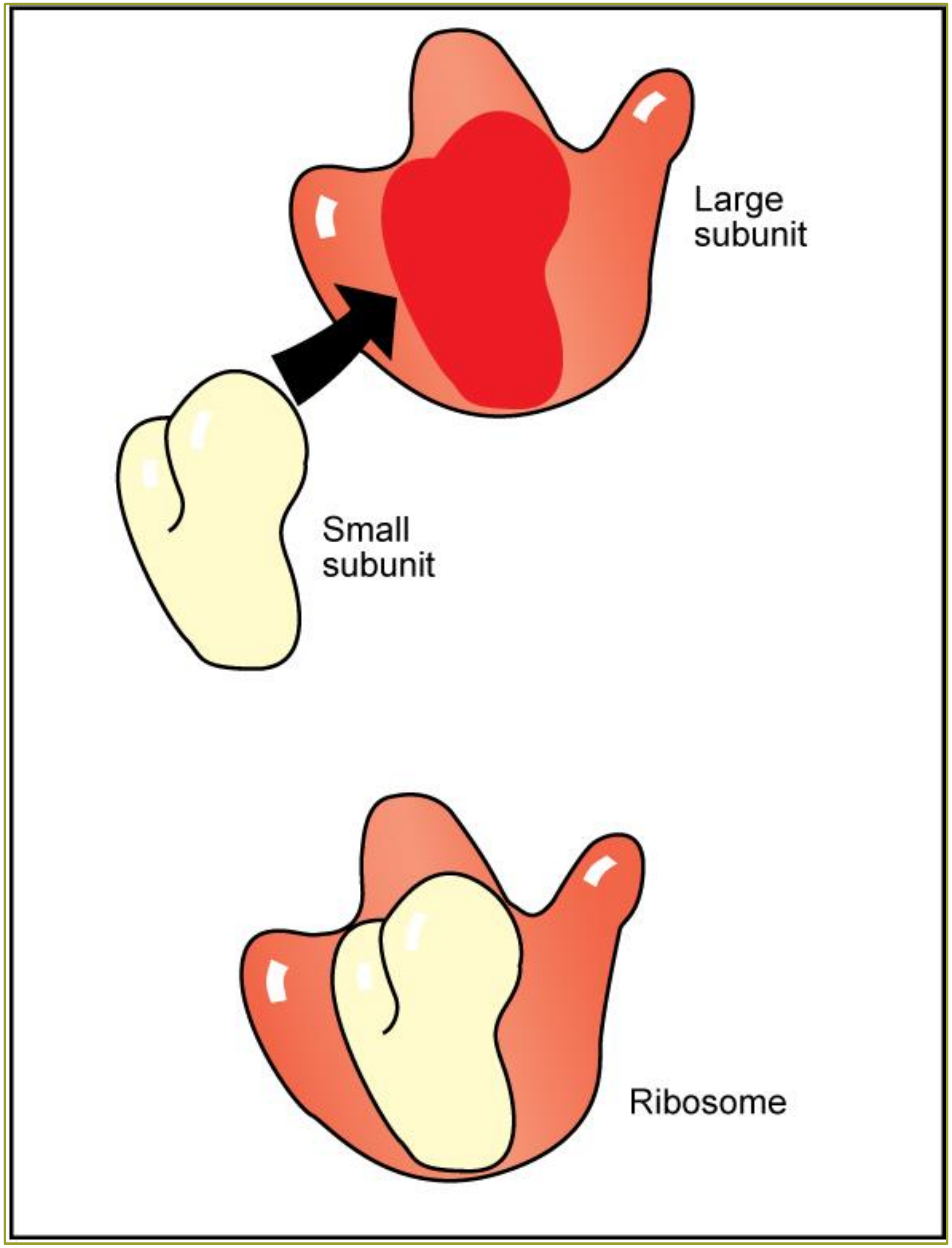


Membrane
Anaerobic
Aerobic
In mitochondria
2 ATP
6 Carbon Compound
Glucose
4 ADP
Loss of hydrogen - oxidation
4 ATP
$+O_2$
3 Carbon Compound
Pyruvate Acid
$CO_2 + H_2O$
Homolactic fermentation
Yeast fermentation
2 ATP
34 ADP
34 ATP
Alcohol + CO_2
Lactic Acid
Cytosol
Mitochondrion

Ribosomes

Figure 3-8, Page 55

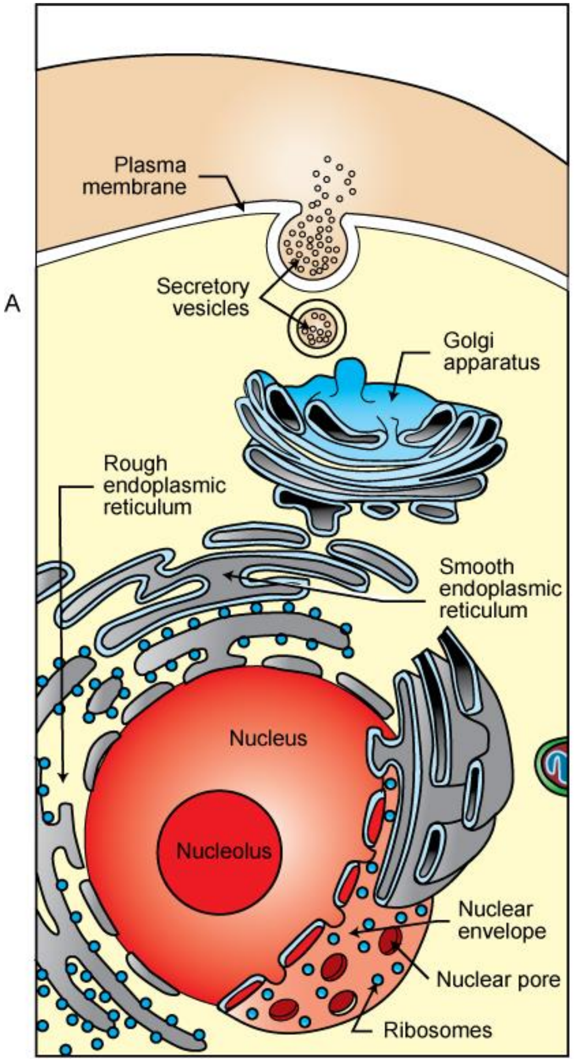
- Important site for protein synthesis
- Individuals in cytoplasm
- Attached to **endoplasmic reticulum (rough ER)**



Endoplasmic Reticulum (ER)

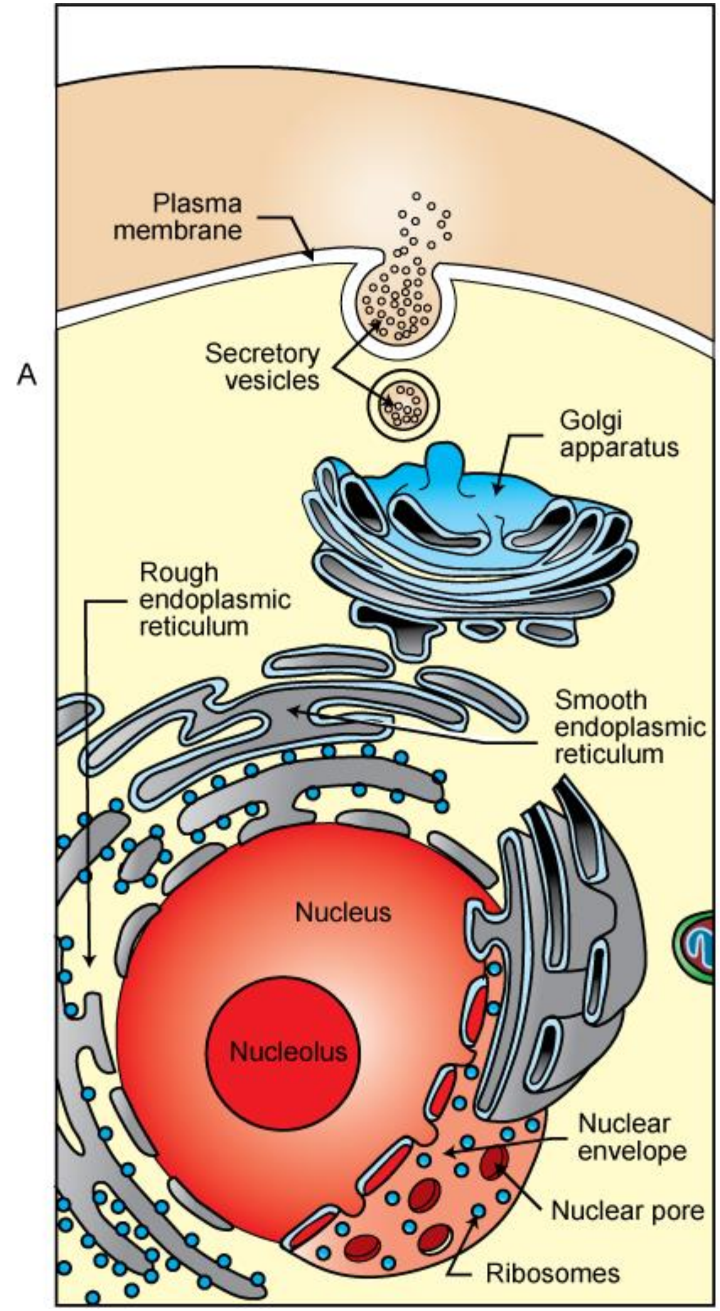
Figure 3-9A, Page 56

- Series of flattened tubes stacked on one another and bent into a crescent shape
- The walls of the ER are composed of a single lipid bilayer and are continuous with the membranes of the nucleus and Golgi apparatus



ER

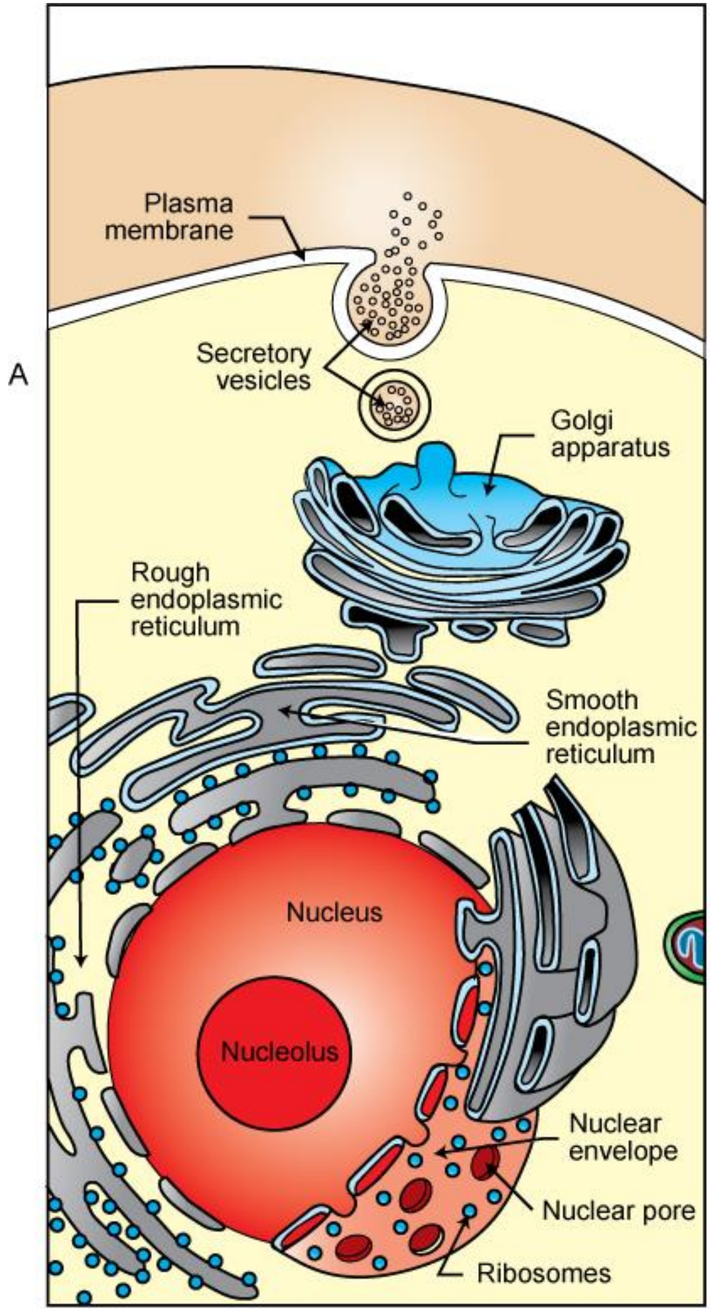
- Rough ER – ribosomes on its surface and is involved in production of protein
- Smooth ER – involved in the synthesis and storage of lipids



Golgi Apparatus

Figure 3-9, Page 56

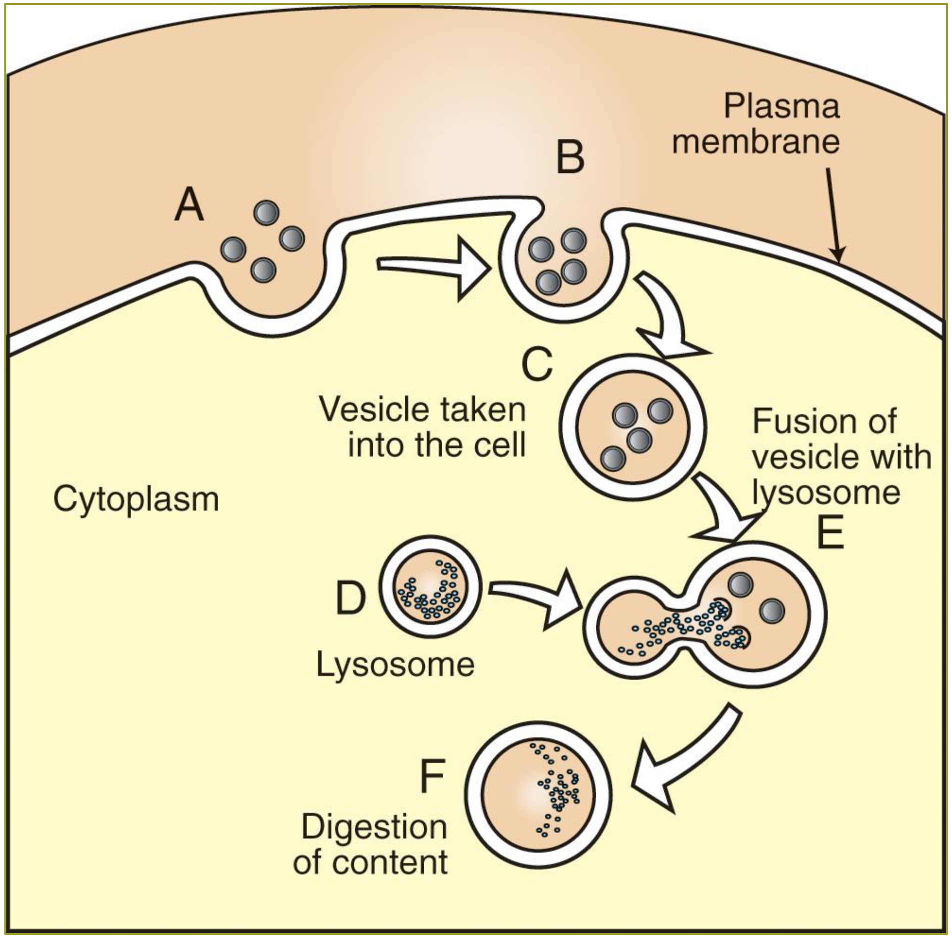
- Composed of stacks of flattened, crescent-shaped tubes called *cisternae*
- Acts as a modification, packaging, and distribution center for molecules



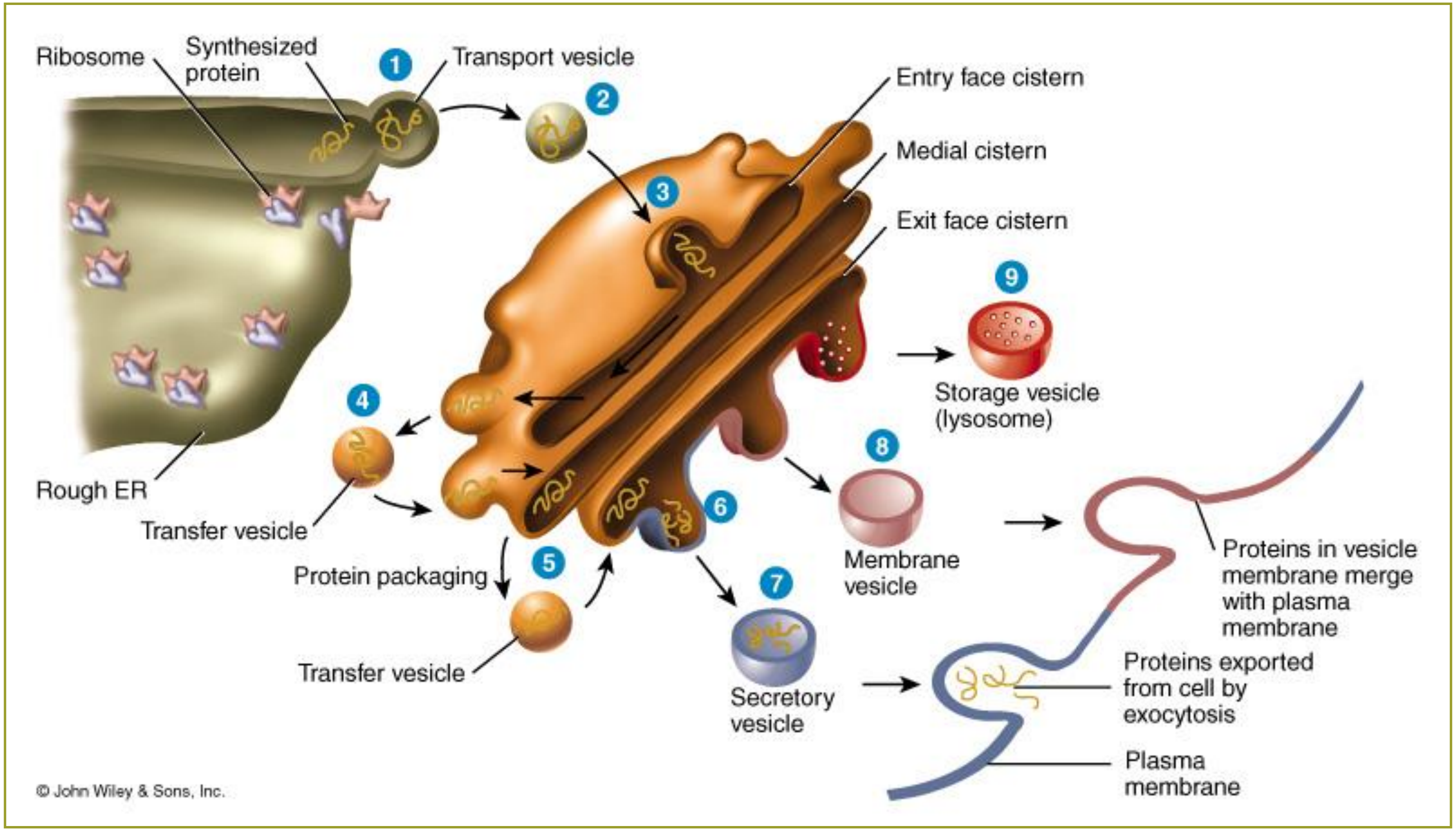
Lysosomes

Figure 3-10, Page 57

- Specialized vesicle formed by the Golgi apparatus
- Contains hydrolytic enzymes enclosed in a single protective membrane
- Function: to breakdown nutrient molecules into usable smaller units and to digest intracellular debris



Golgi Apparatus; Lysosomes



Inclusions

- **Metabolic products or substances that the cell has engulfed**
- May have a single-layer membrane (e.g., secretory granules, vacuoles, and vesicles)
- May be non-membrane-bound (e.g., lipid droplets and fat globules)

3. The Nucleus

Nuclear Envelope

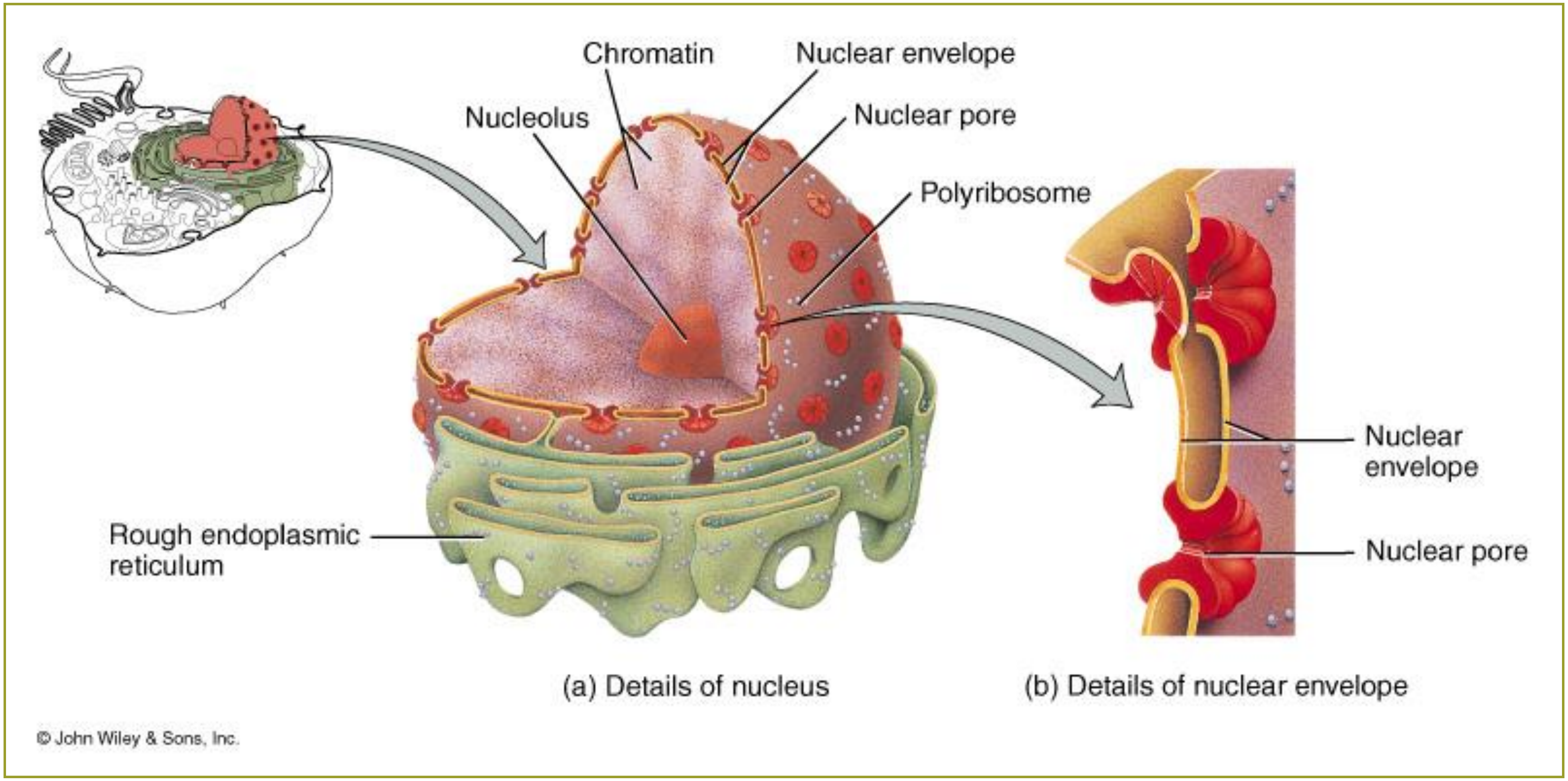
Chromatin (Chromosomes)

DNA (Genes)

Protein

Nucleolus

The Nucleus



Chromatin
Nuclear envelope
Nucleolus
Nuclear pore
Polyribosome
Rough endoplasmic reticulum
Nuclear envelope
Nuclear pore
(a) Details of nucleus
(b) Details of nuclear envelope
© John Wiley & Sons, Inc.

Nucleus

- Dark-staining, spherical or multi-segmented body
- Primary functions: maintain the **hereditary information** of the species and control cellular activities through **protein synthesis**
- Large cells are multinucleated
- Mature mammalian red blood cells (RBC’s) are non-nucleated

Nucleus

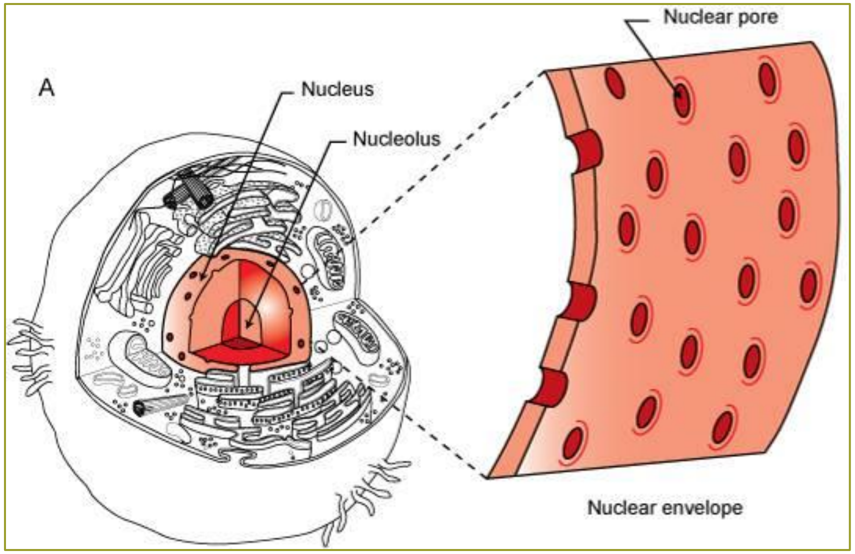
- The anatomy (morphology) of the nucleus is divided into the following four parts:

1. **Nuclear envelope** or membrane
2. **Nucleoplasm**: gel-like substance similar to cytoplasm
3. **Chromatin**
4. **Nucleolus**

Nuclear Envelope

Figure 3-12A, Page 58

- Composed of two lipid bilayers
- Outer layer is continuous with the **ER** and is studded with ribosomes
- Also consists of **nuclear pores** where the two layers of the nuclear envelope have fused to form a channel



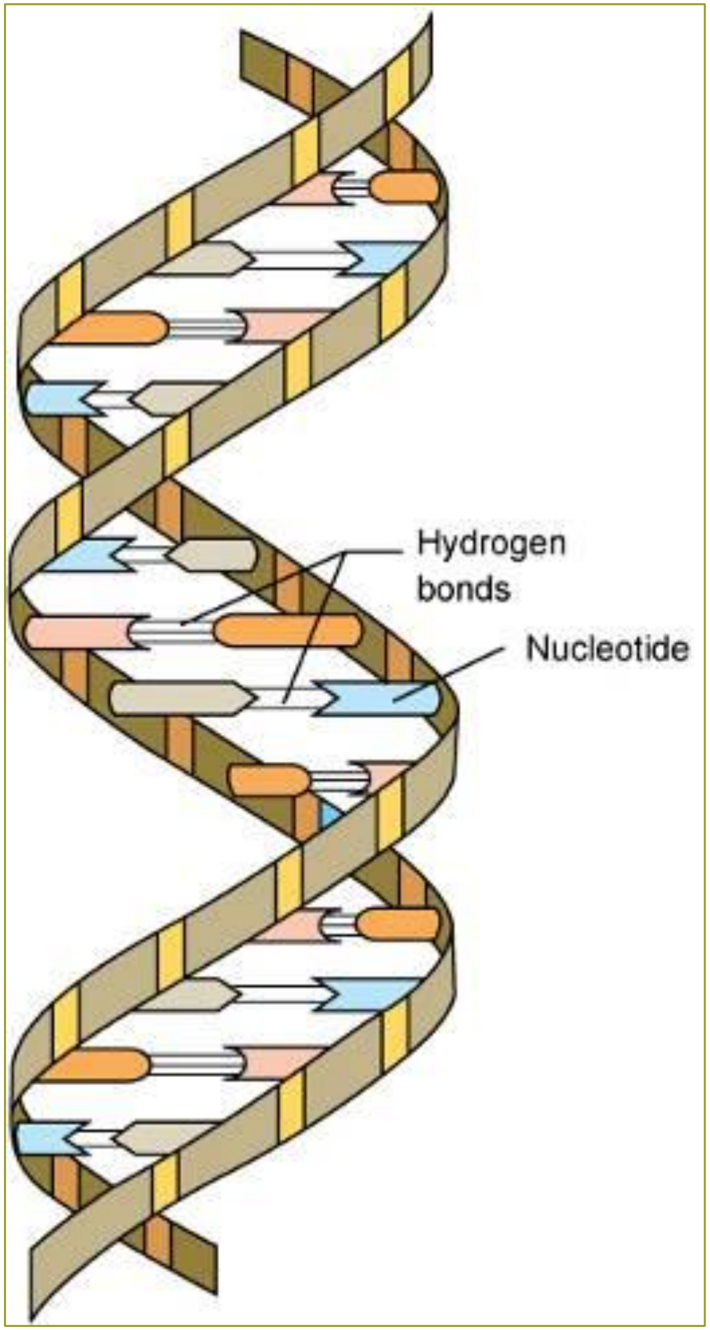
DNA and RNA

- DNA and RNA are made up of chains of nucleotides.
- Composed of three subunits: a nitrogenous base, a five-carbon sugar, and a phosphate group
- DNA and RNA nucleotides are linked to form a “backbone” of alternating sugar and phosphate groups.

DNA and RNA

Figure 3-13, Page 61

- DNA forms a double stranded molecule called the ***double helix***
- RNA is a single-stranded molecule that has no opposing strand
- The single strand of RNA is similar in structure to each of the strands found in DNA



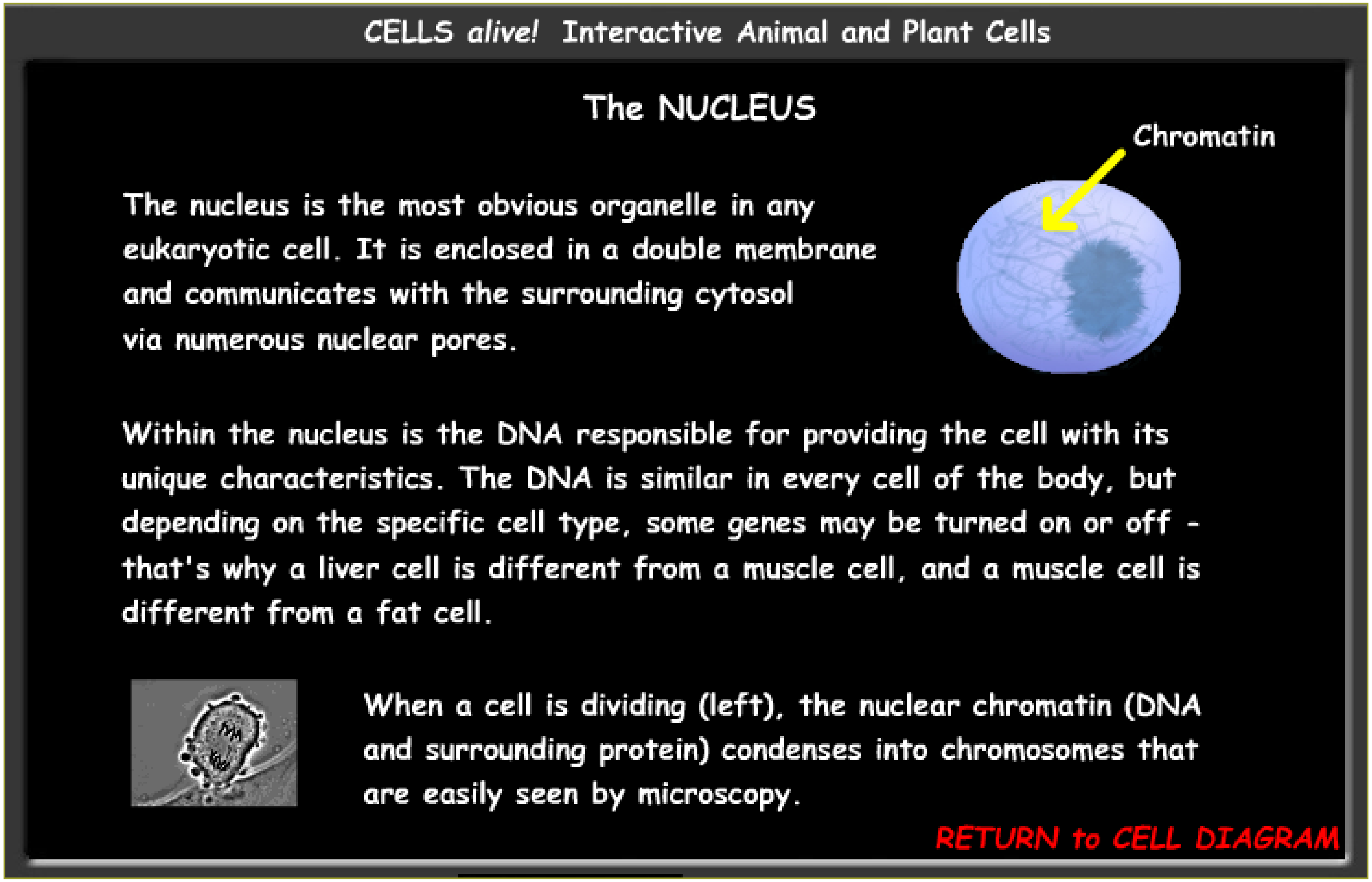
Chromatin

- Light or dark fibers in the nucleoplasm
- Made up of **DNA and histones**
  - Histones play an important role gene regulation
- A single strand of DNA winds around eight (8) histone molecules forming a granule called a nucleosome
- The nucleosomes are held together by short strands of DNA called *linker DNA*

Nucleolus

- Small, dark-staining spherical patches in the nucleus
- Not membrane bound
- Located **where ribosomal subunits are made**
  - These subunits are exported from the nucleus and are assembled in the cytoplasm to form functional ribosomes
- Nucleoli also contain the DNA that governs the synthesis of ribosomal RNA (rRNA)

How Cells Alive! Sees the Nucleus



CELLS *alive!* Interactive Animal and Plant Cells

The NUCLEUS

The nucleus is the most obvious organelle in any eukaryotic cell. It is enclosed in a double membrane and communicates with the surrounding cytosol via numerous nuclear pores.

Chromatin

Within the nucleus is the DNA responsible for providing the cell with its unique characteristics. The DNA is similar in every cell of the body, but depending on the specific cell type, some genes may be turned on or off - that's why a liver cell is different from a muscle cell, and a muscle cell is different from a fat cell.

When a cell is dividing (left), the nuclear chromatin (DNA and surrounding protein) condenses into chromosomes that are easily seen by microscopy.

RETURN to CELL DIAGRAM

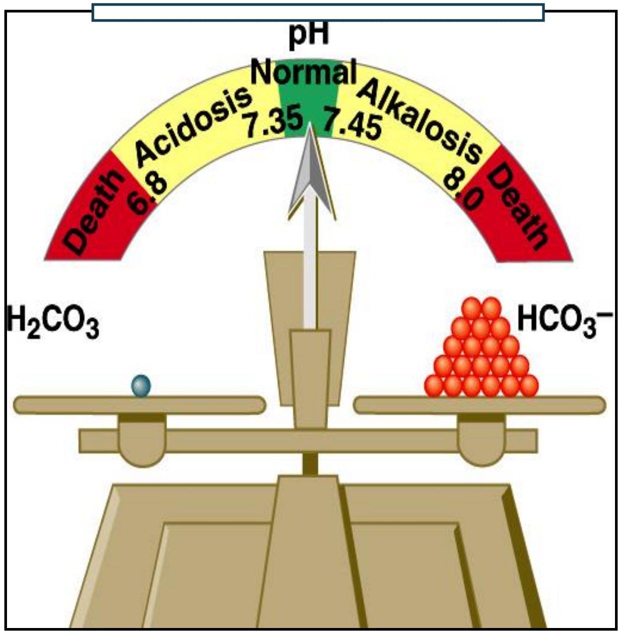
Table 3.1 Organelles and Their Locations and Functions

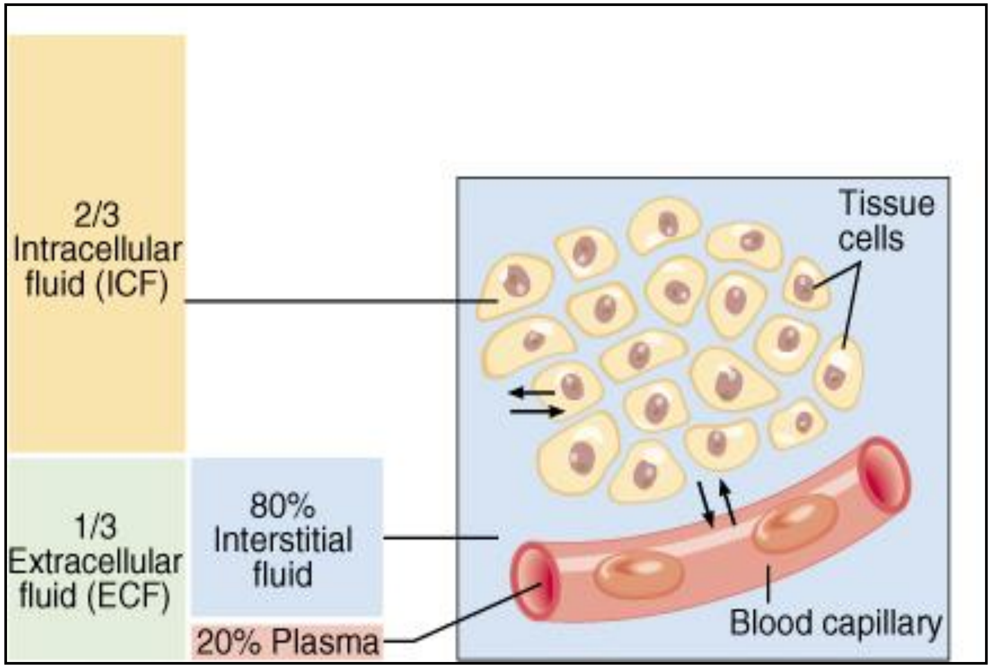
Organelles	Location	Function(s)
Nucleus	Often near center of the cell	Contains genetic material of cell (DNA) and nucleoli; site of ribosome and messenger RNA synthesis
Nucleolus	In the nucleus	Site of ribosomal RNA synthesis and ribosomal subunit assembly
Rough endoplasmic reticulum (rough ER)	In cytoplasm	Many ribosomes attached to rough ER; site of protein synthesis
Smooth endoplasmic reticulum (smooth ER)	In cytoplasm	Site of lipid synthesis; detoxification
Golgi apparatus	In cytoplasm	Modifies protein structure and packages proteins in secretory vesicles
Secretory vesicle	In cytoplasm	Contains materials produced in the cell; formed by the Golgi apparatus; secreted by exocytosis
Lysosome	In cytoplasm	Contains enzymes that digest material taken into the cell
Mitochondrion	In cytoplasm	Site of aerobic respiration and the major site of ATP synthesis
Microtubule	In cytoplasm	Supports cytoplasm; assists in cell division and forms components of cilia and flagella
Cilia	On cell surface with many on each cell	Cilia move substances over surfaces of certain cells
Flagella	On sperm cell surface with one per cell	Propels sperm cells
Microvilli	Extensions of cell surface with many on each cell	Increase surface area of certain cells

Cellular Physiology

Cellular Physiology

- **Secrets of Life!!! ☺**
- Body fluid compartments
  - ECF
    - Plasma
    - Interstitial fluid
  - ICF (cytosol)
- Ions (electrolytes)
- pH

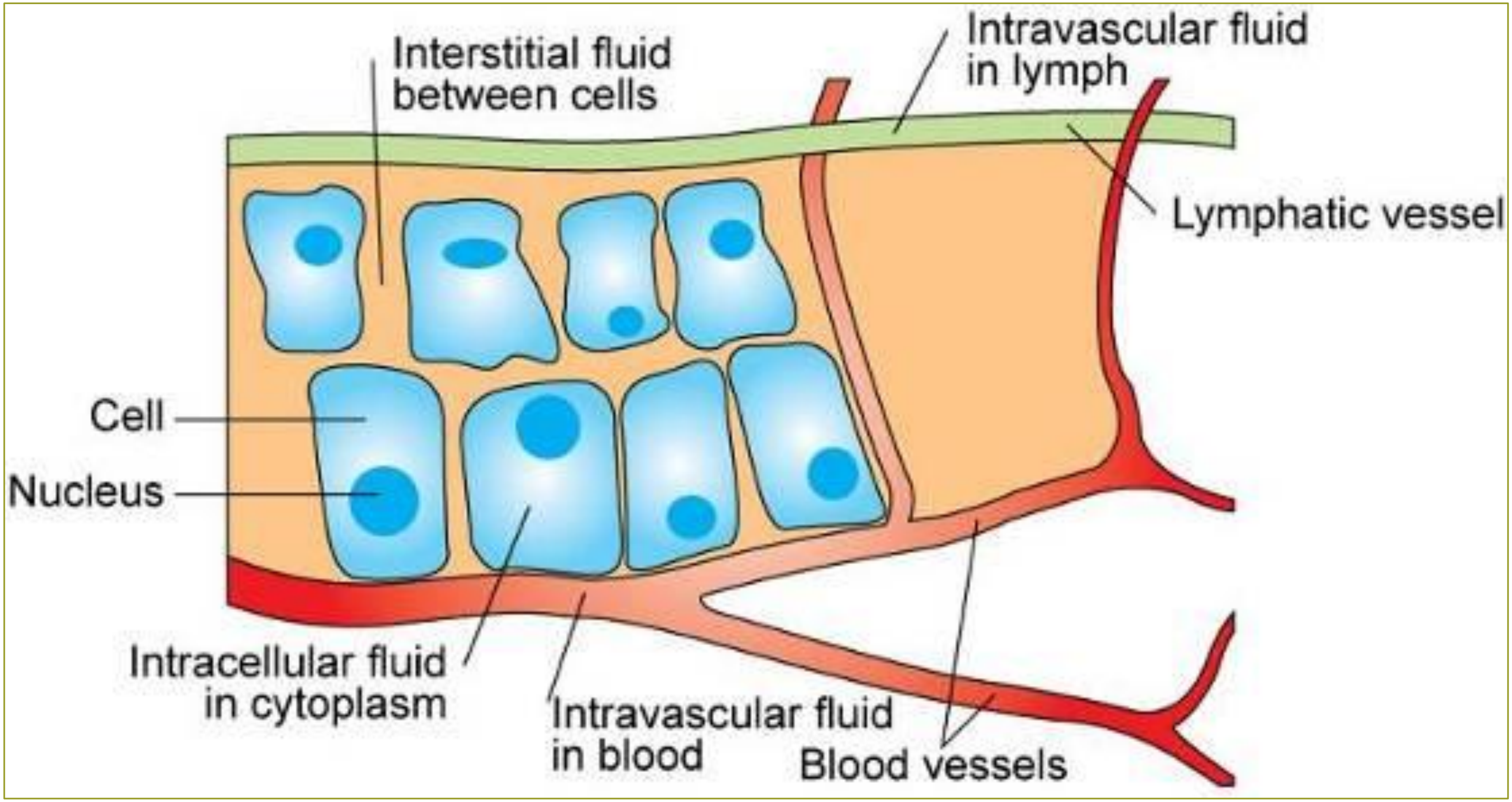




Body Fluids

- **Intracellular fluid (ICF)**: inside the cell
  - Cytosol
- **Extracellular fluid (ECF)**: outside the cell
  - Interstitial fluid: extracellular fluid specifically found in tissues
  - Plasma: extracellular fluid surrounding blood cells in the blood

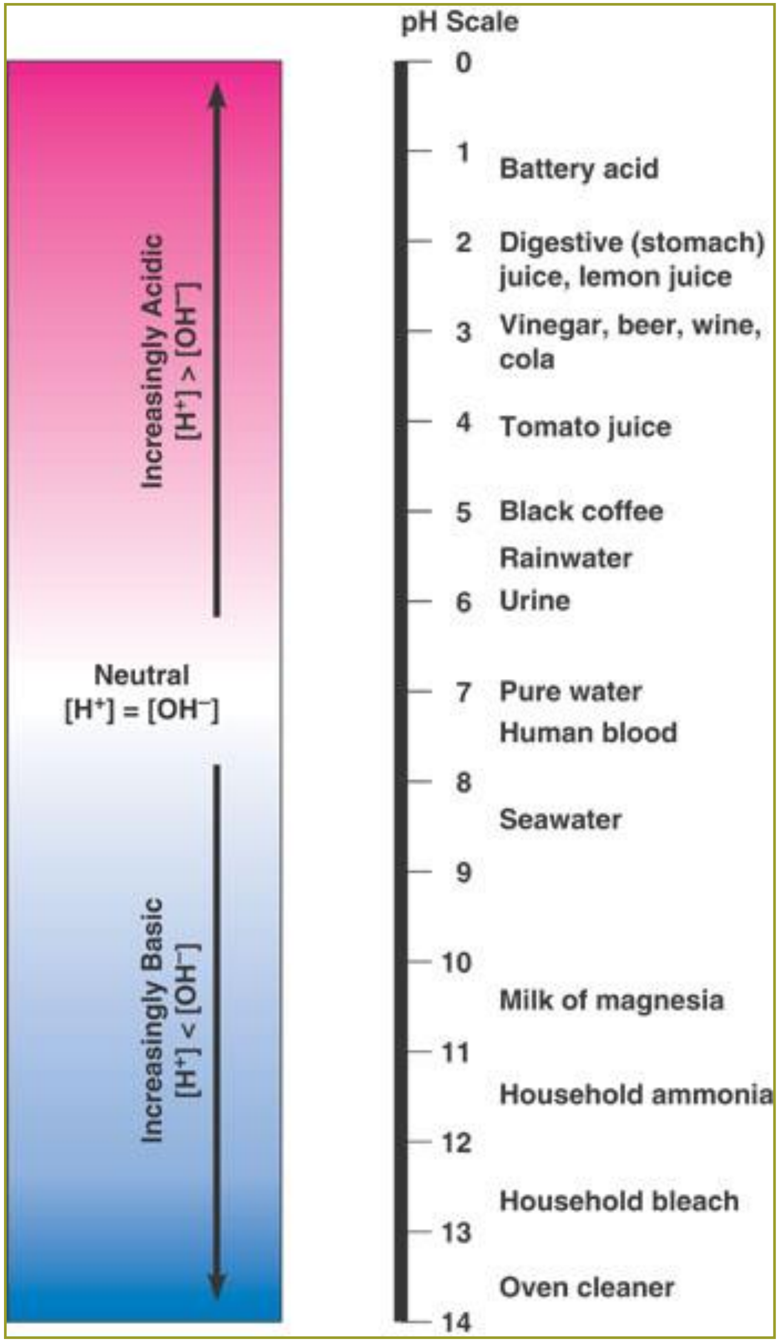
Fluid Spaces
Figure 3-16, Page 63



Ions, Electrolytes, and pH

- Extracellular and intracellular fluid contains cations and anions
- These ions are electrolytes
- Acids and bases are also electrolytes
- In sick or injured animals, the electrolyte concentrations and pH of intracellular and extracellular fluid can become abnormally high or low. **(Walking Salt Water Aquariums!)**

pH


pH Scale
Increasingly Acidic
[H+] > [OH−]
Neutral
[H+] = [OH−]
Increasingly Basic
[H+] < [OH−]
0
1 Battery acid
2 Digestive (stomach) juice, lemon juice
3 Vinegar, beer, wine, cola
4 Tomato juice
5 Black coffee
Rainwater
6 Urine
7 Pure water
Human blood
8
Seawater
9
10
Milk of magnesia
11
Household ammonia
12
Household bleach
13
Oven cleaner
14

Membrane Processes

- The absorption of nutrients or excretion of waste may occur with or without the expenditure of energy by the cell
- Absorptive or excretory processes that require energy are considered active, whereas those that do not require energy are passive

Cell Membrane Transportation

Passive Processes

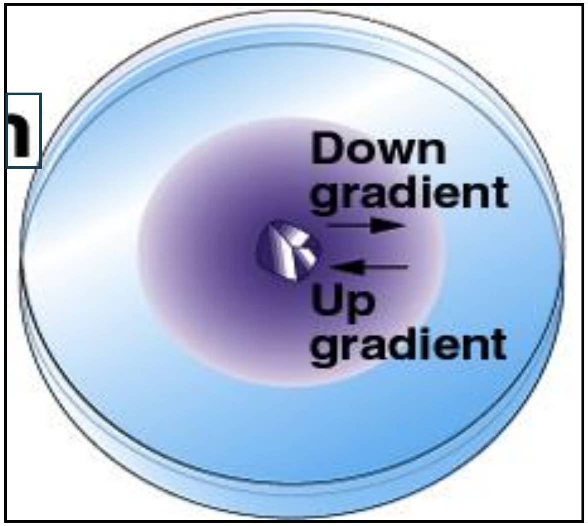
Active Processes

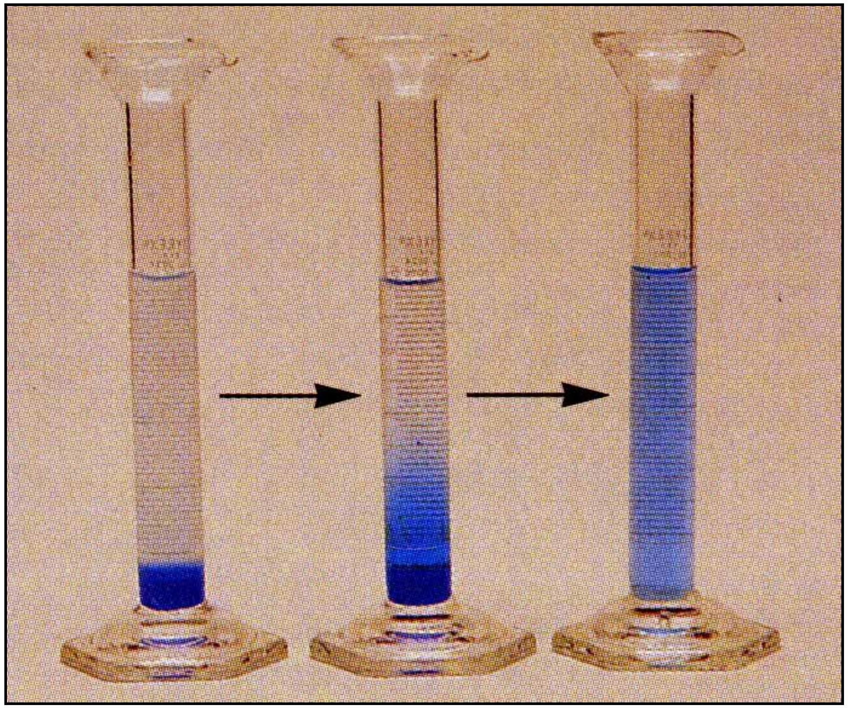
Membrane Processes
Table 3-2, Pages 64-65

- **Passive** Transport **(No ATP Needed)**
  1. Diffusion
  2. Facilitated Diffusion
  3. Osmosis (Tonicity)
  4. Filtration
- **Active** Transport **(ATP Needed)**
  1. Sodium/Potassium pump
  2. Endocytosis
  3. Exocytosis

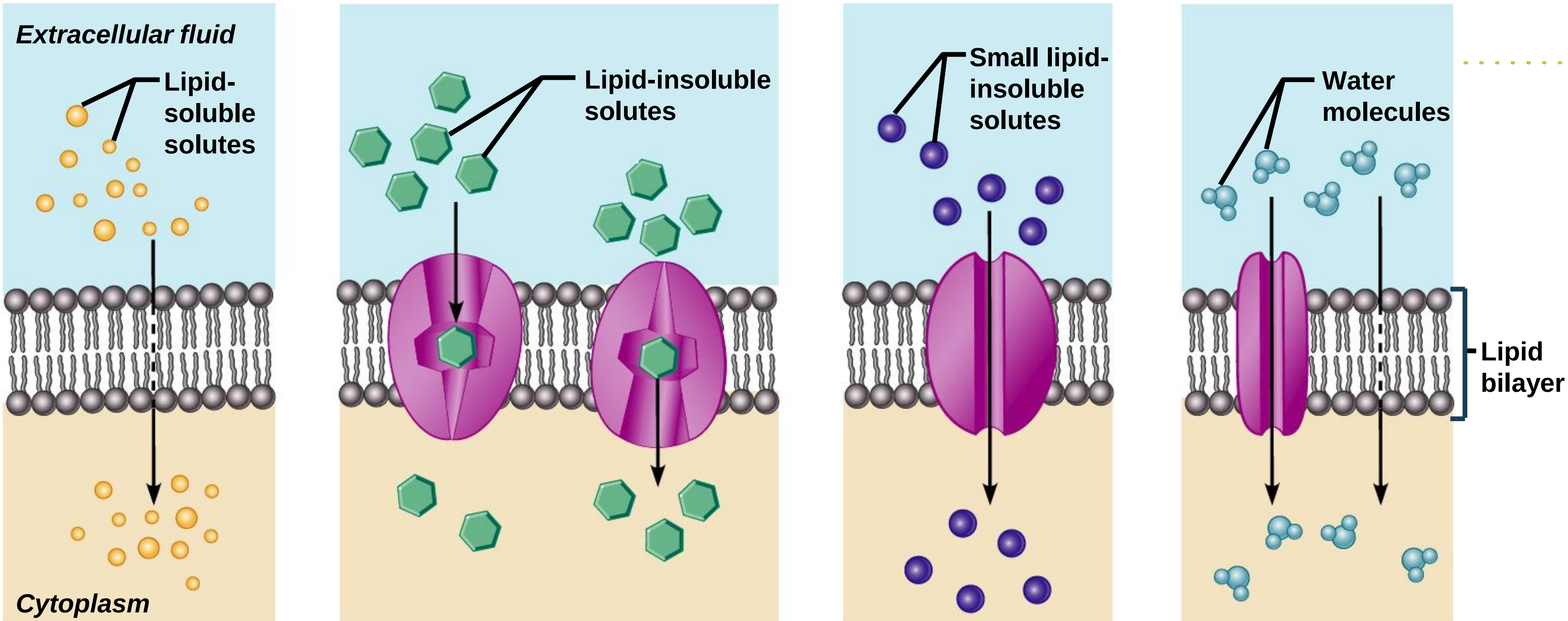
Passive Processes

- [No ATP needed]
- Diffusion
- Osmosis
- Facilitated diffusion
- Filtration (kidneys)





Diffusion through the Plasma Membrane



(a) Simple diffusion directly through the phospholipid bilayer

(b) Carrier-mediated facilitated diffusion via protein carrier specific for one chemical; binding of substrate causes shape change in transport protein

(c) Channel-mediated facilitated diffusion through a channel protein; mostly ions selected on basis of size and charge

(d) Osmosis, diffusion through a specific channel protein (aquaporin) or through the lipid bilayer

Diffusion

1. When a salt crystal (*green*) is placed into a beaker of water, there is a concentration gradient for salt from the salt crystal to the water that surrounds it.
2. Salt ions (*green*) move down their concentration gradient into the water.
3. Salt ions and water molecules are distributed evenly throughout the solution. Even though the salt ions and water molecules continue to move randomly, an equilibrium exists, and no net movement occurs because no concentration gradient exists.

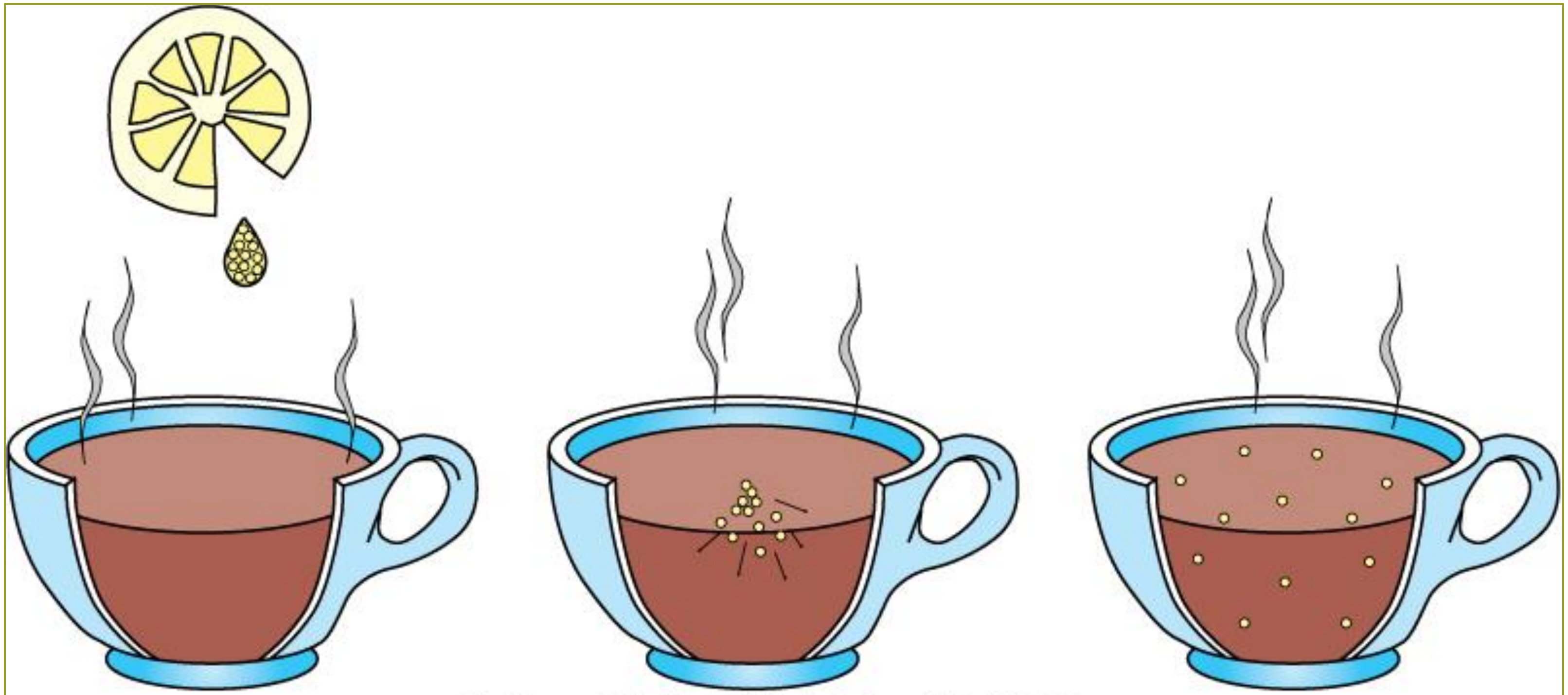
Diffusion

- Movement of molecules from an area of higher concentration to an area of lower concentration
- Various factors determine whether a molecule may pass through the cell membrane by passive diffusion:

  1. *Molecular size*
  2. *Lipid solubility*
  3. *Molecular charge*

Diffusion

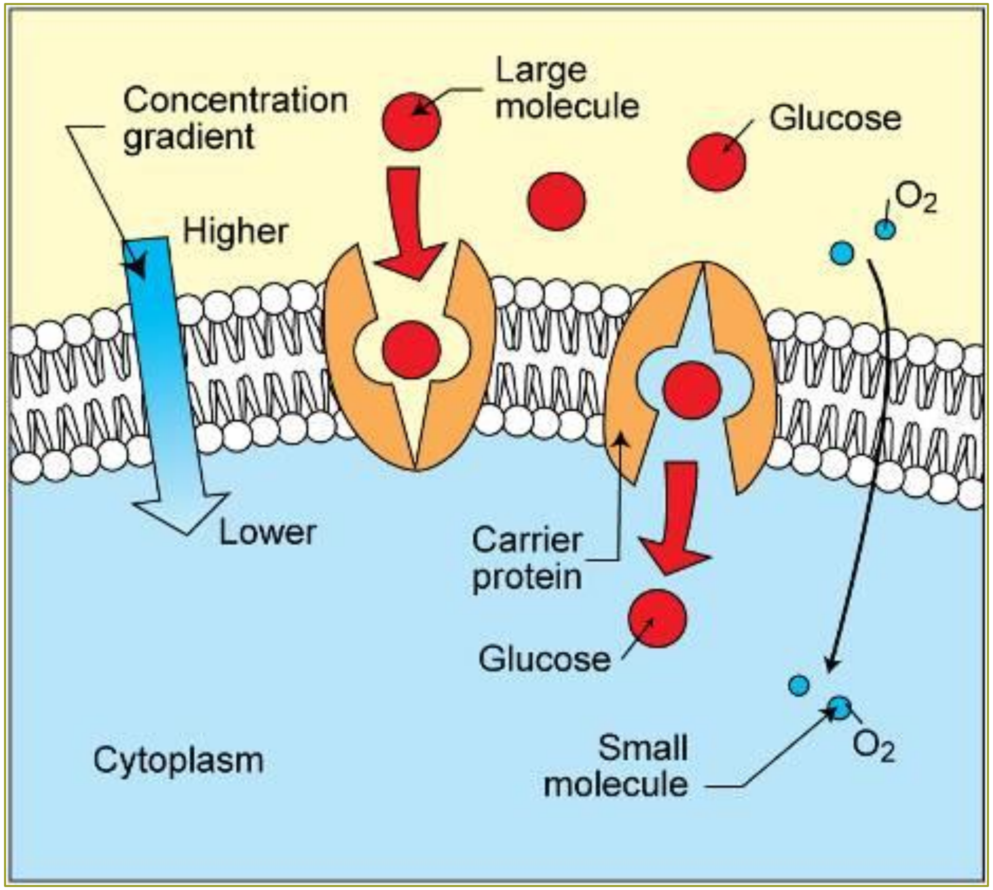
Figure 3-17, Page 66



Facilitated Diffusion

Figure 3-18, Page 66

- Movement of molecules through the cell membrane with the assistance of an integral protein or carrier protein located in the bilayer
- **Requires no energy from the cell**



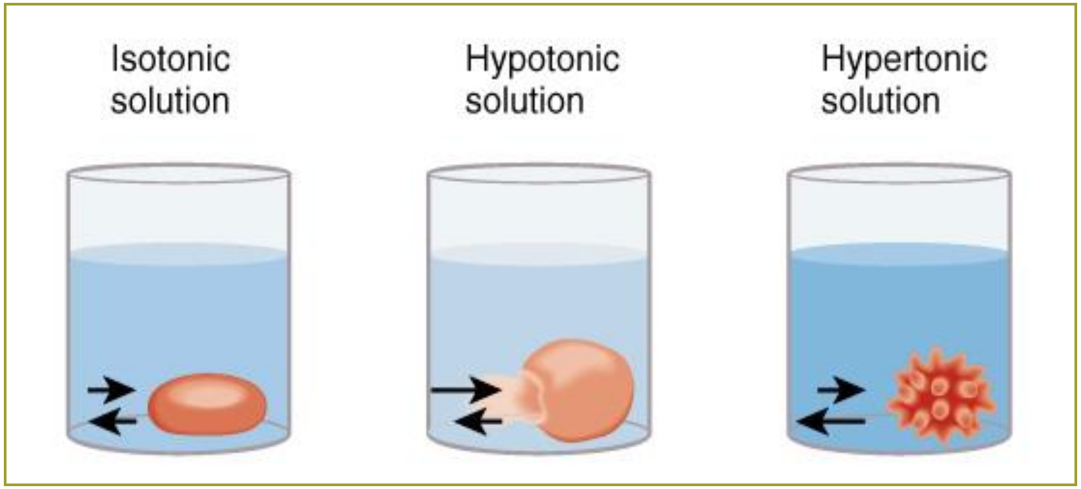
Osmosis

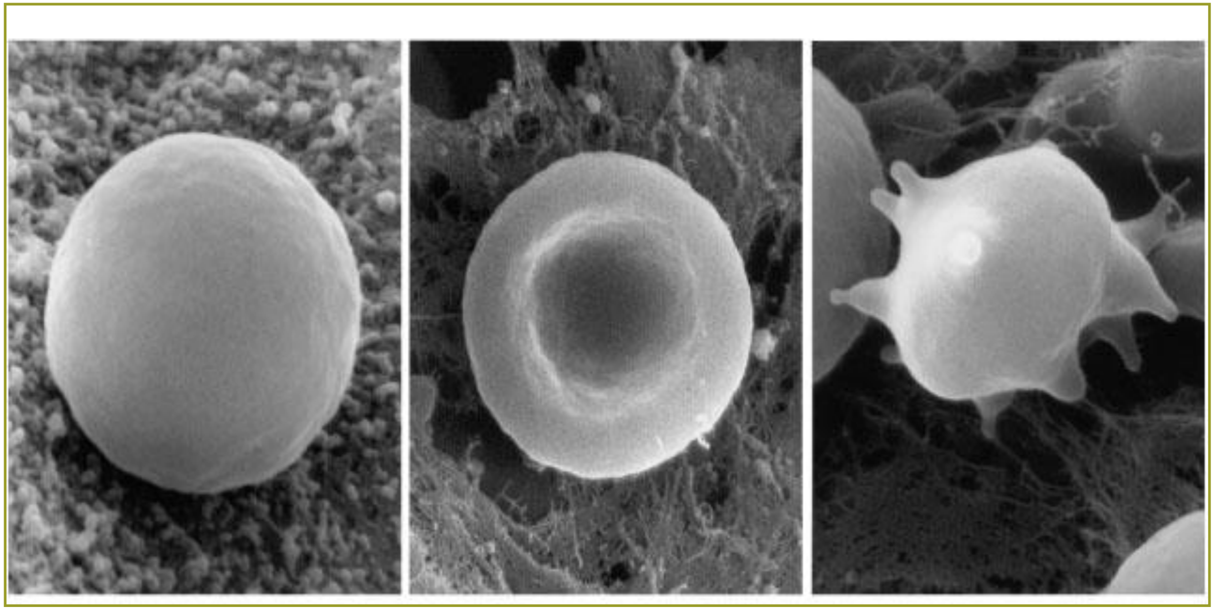
- Passive diffusion of water through a semipermeable membrane into a solution where the water concentration is lower
- The force of water moving from one side of the membrane to the other is called the osmotic pressure

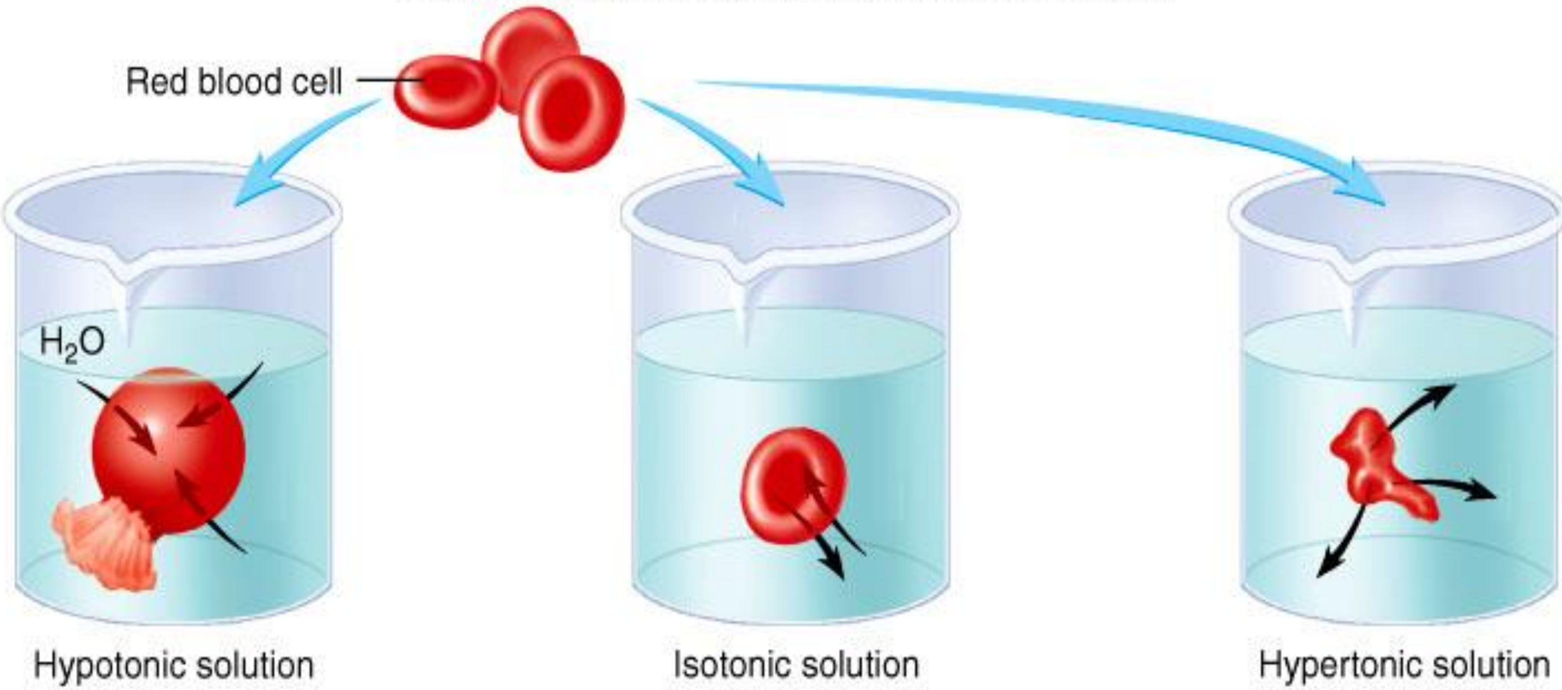
Solutions

Figure 3-20, Page 68

- Definition
- Tonicity
  - Isotonic
  - Hypertonic
  - Hypotonic







(a) A hypotonic solution with a low solute concentration results in swelling of the red blood cell placed into the solution. Water enters the cell by osmosis (*black arrows*), and the red blood cell lyses (*bursts; puff of red in the lower part of the cell*).

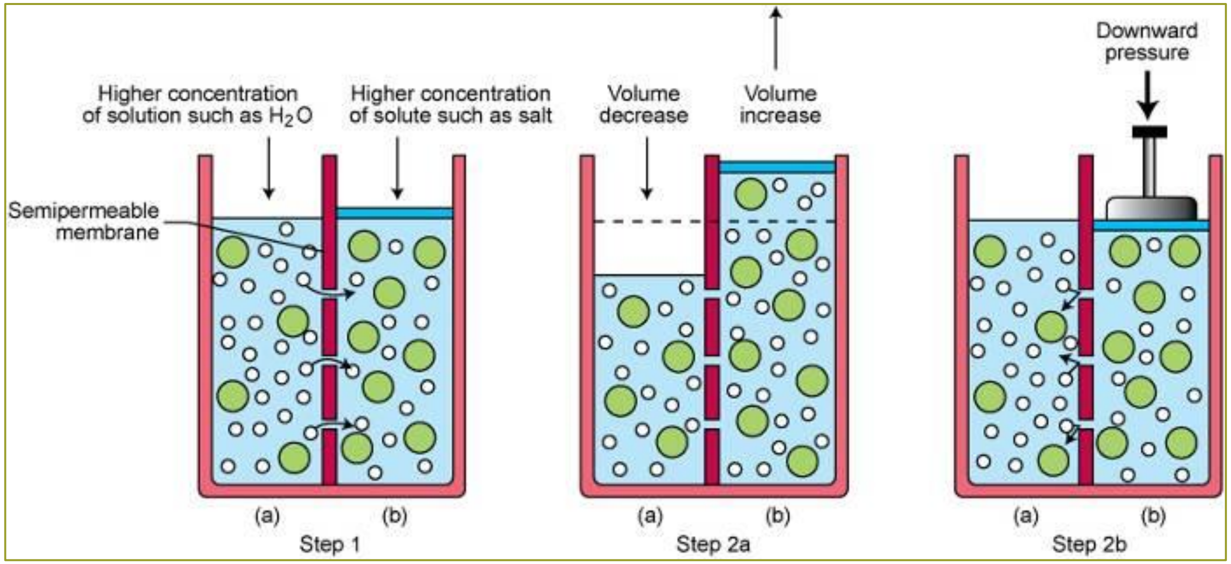
(b) An isotonic solution with a concentration of solutes equal to that inside the cell results in a normally shaped red blood cell. Water moves into and out of the cell at the same rate (*black arrows*), but there is no net water movement.

(c) A hypertonic solution, with a high solute concentration, causes shrinkage (crenation) of the red blood cell as water moves by osmosis out of the cell and into the hypertonic solution (*black arrows*).

Osmosis

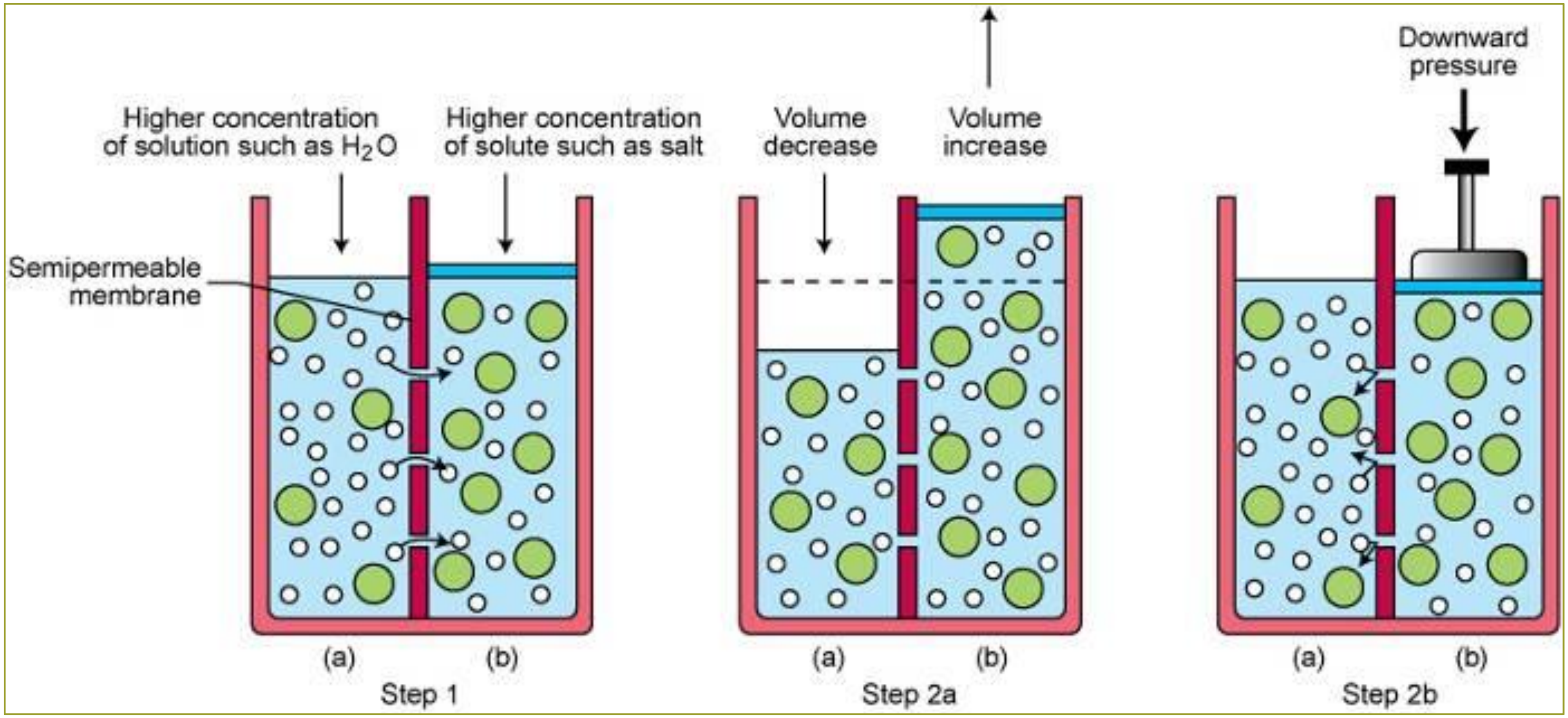
Figure 3-19, Page 67

- Osmosis occurs in the opposite direction of diffusion
  - Unlike diffusion, the **water**, not solute, is moving
  - Osmosis requires a selective membrane, whereas diffusion does not



Osmosis

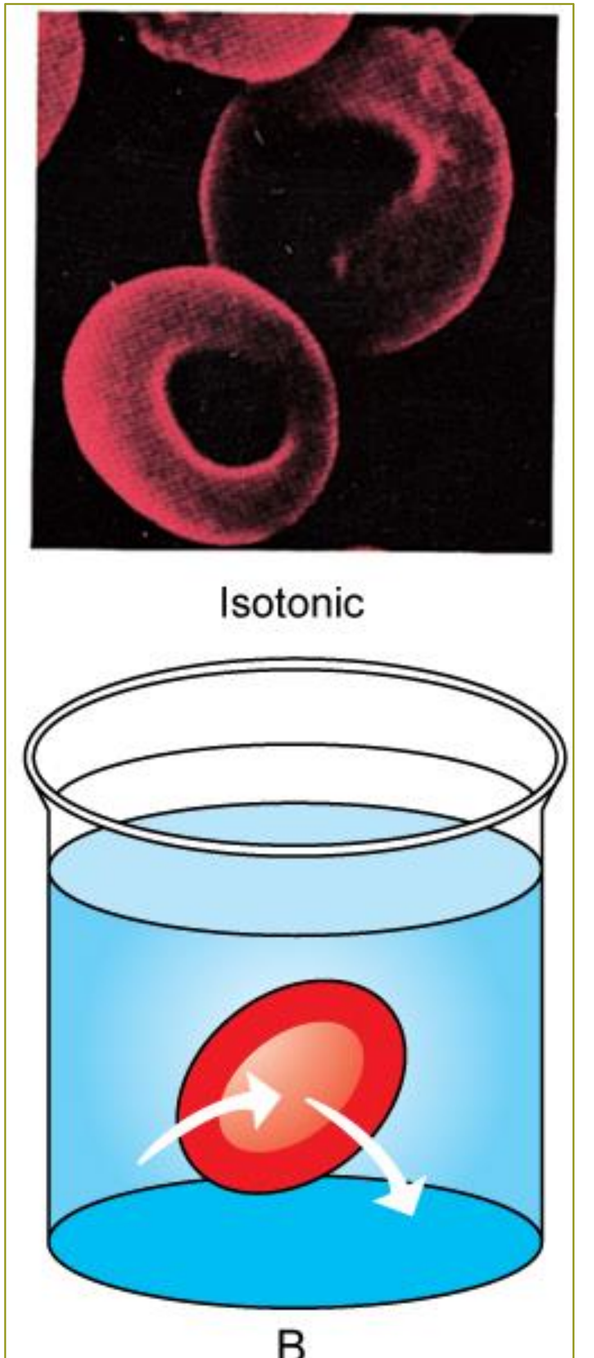
Figure 3-19, Page 67



Tonicity

Figure 3-20B, Page 68

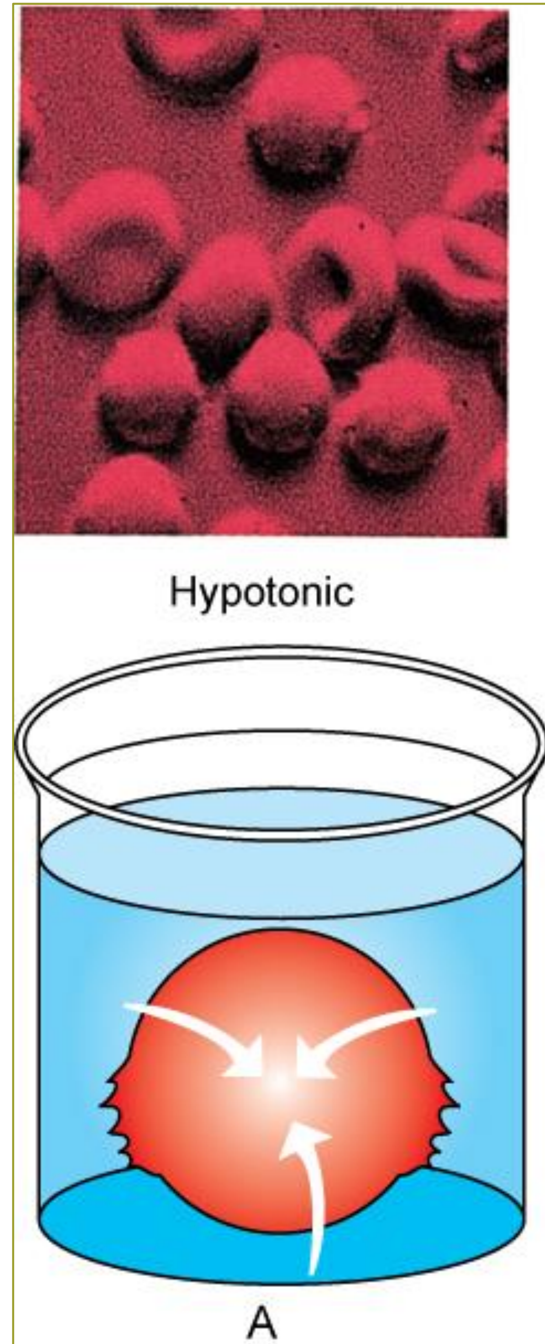
- **Isotonic** : Extracellular fluid has the same concentration of dissolved substances as intracellular fluid



Tonicity

Figure 3-20A, Page 68

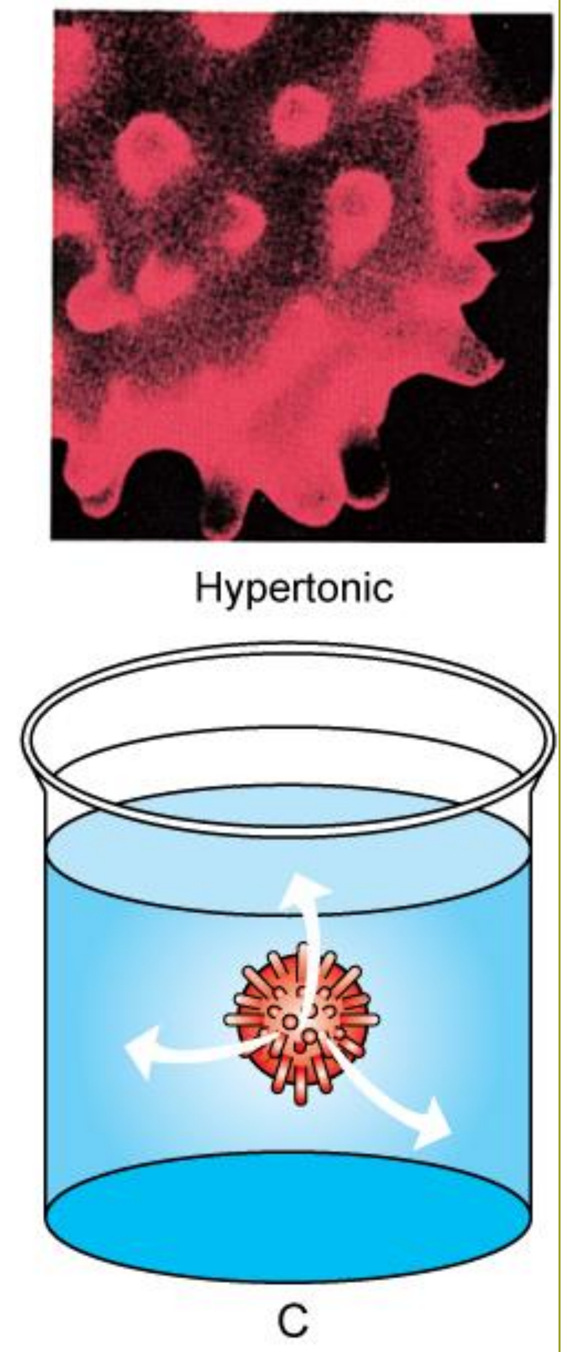
- Hypotonic: The cytoplasm of the cell is more concentrated than the extracellular fluid
  - Water flows into the cell and causes it to swell and possibly **burst**



Tonicity

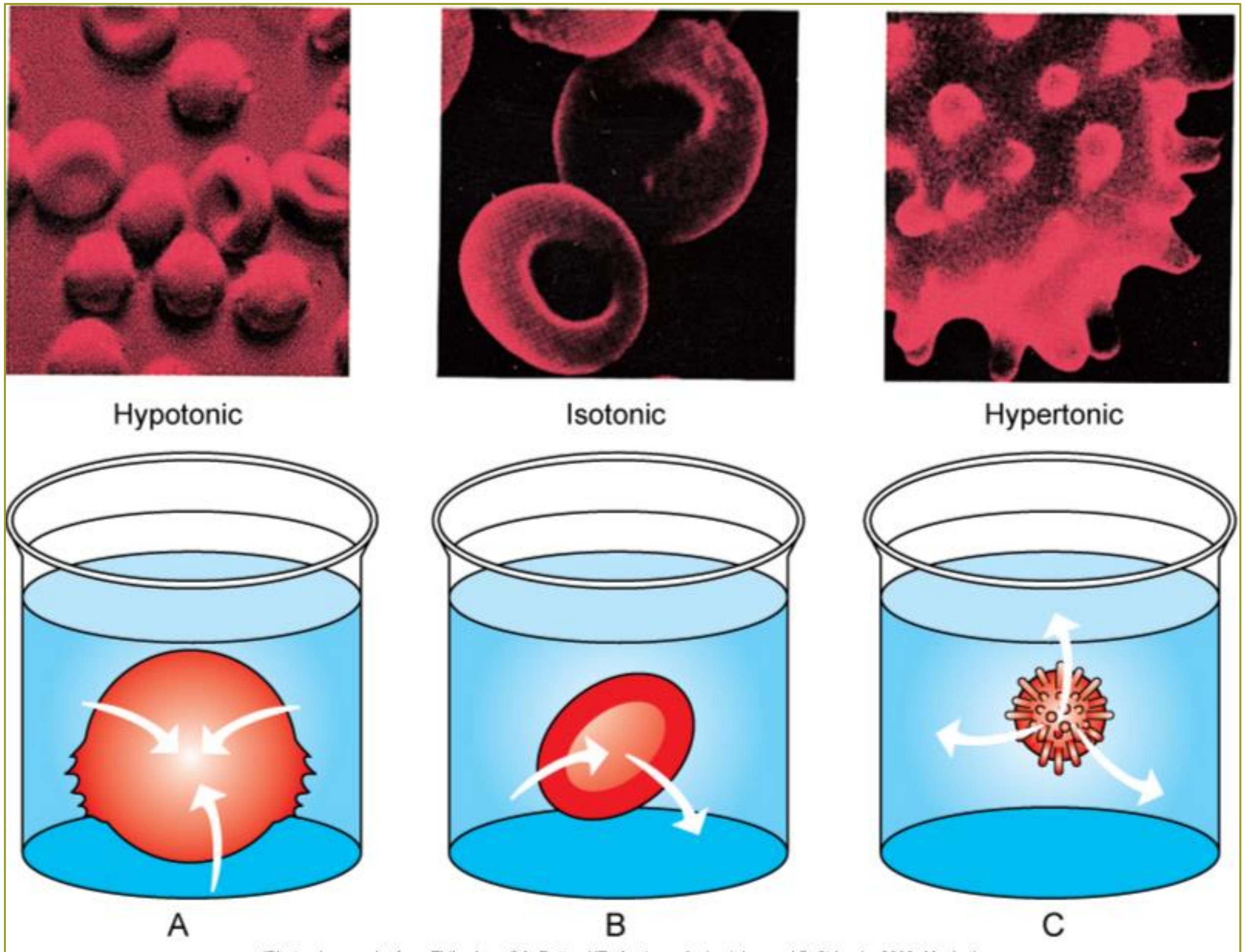
Figure 3-20C, Page 68

- **Hypertonic**: The extracellular fluid is more concentrated than the cytoplasm
  - Water shifts into the extracellular space, causing the cell to shrink and become shriveled



Osmosis (Tonicity) Summary

Figure 3-20, Page 68



(Photomicrographs from Thibodeau GA, Patton KT: *Anatomy & physiology,* ed 5, St Louis, 2003, Mosby.)

Filtration

- Based on pressure, not concentration
- Example – blood pressure causes filtration through kidneys

Active Processes

- **<u>ATP needed</u>**
- Active transport
  - Sodium-potassium pump (neurons)
- <u>Endo</u>cytosis
  - Phagocytosis
- <u>Exo</u>cytosis

Types of Active Transport

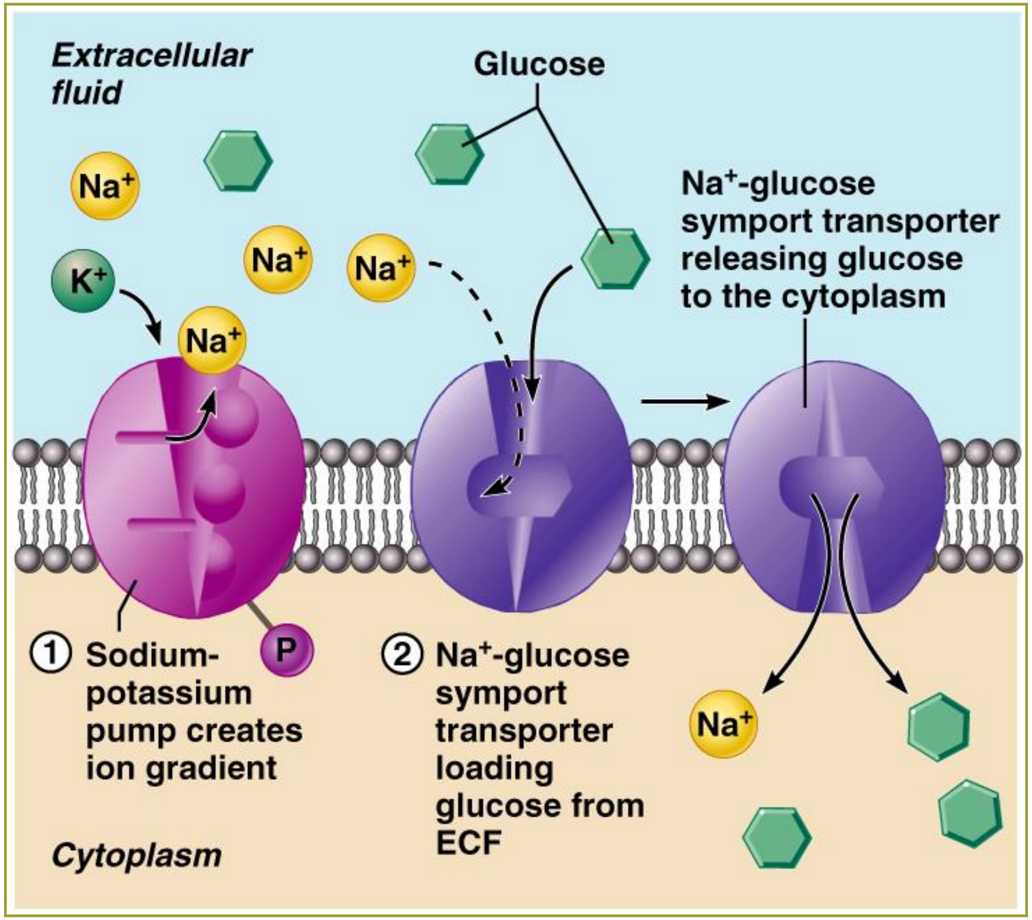
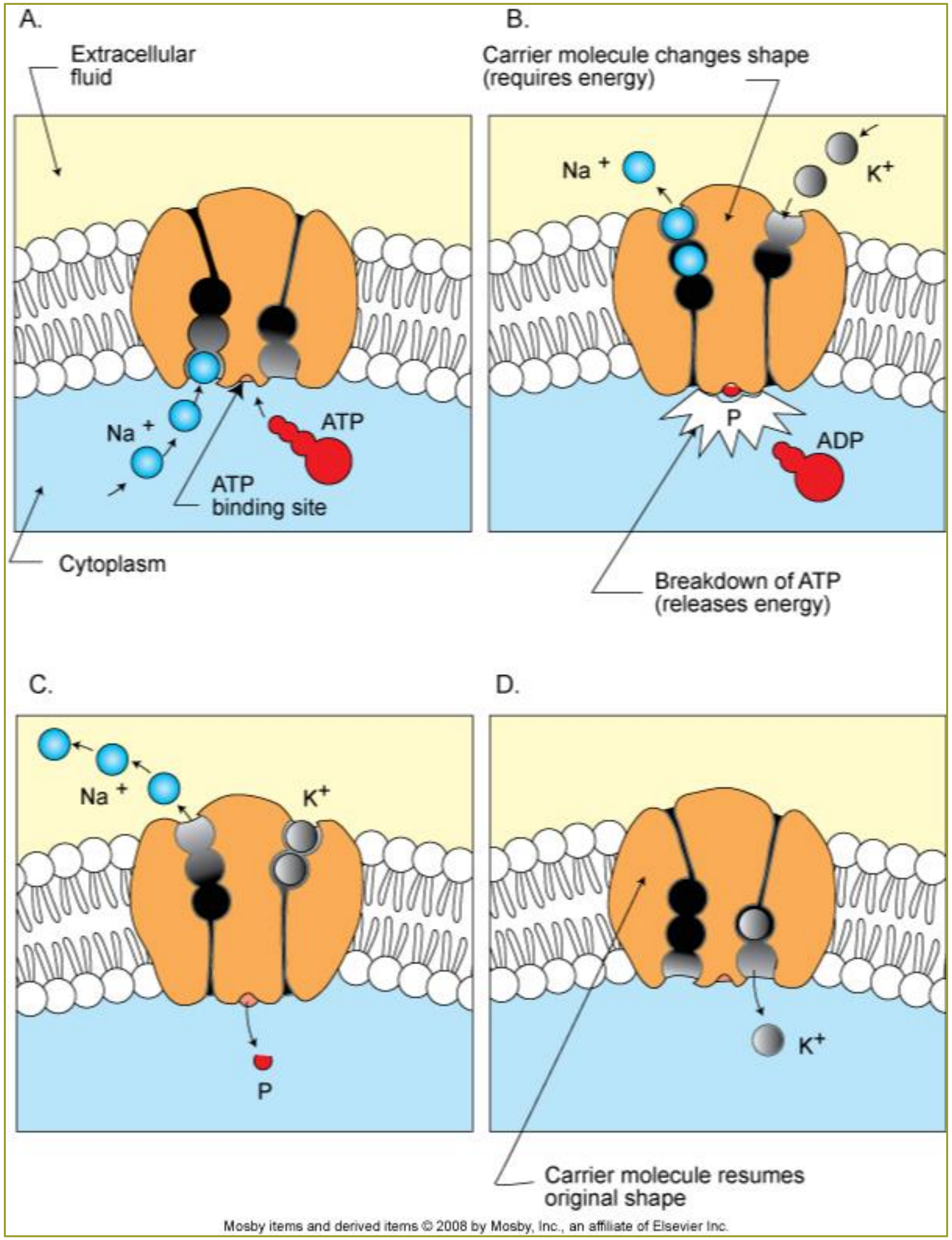


Figure 3.11

Active Transport – Sodium/Potassium Pump

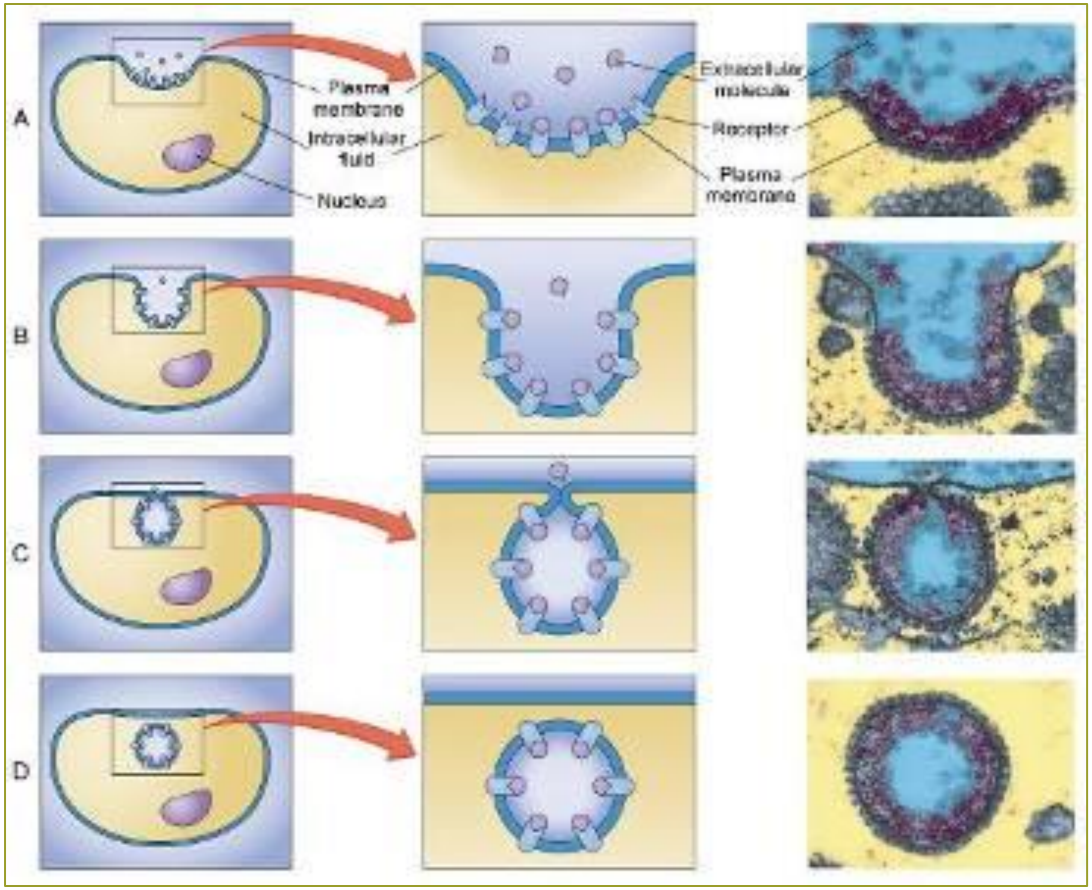
Figure 3-21, Page 71



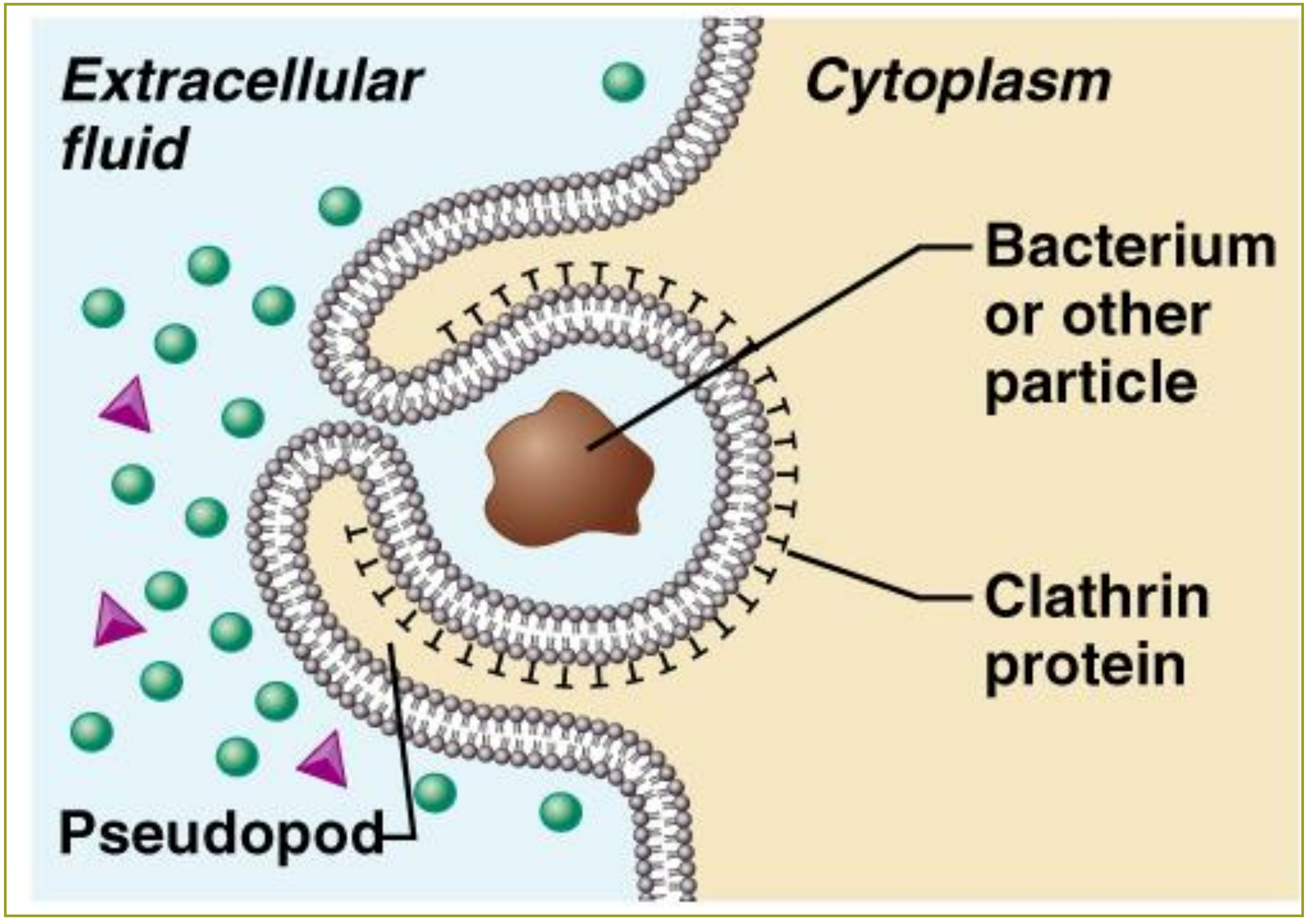
Endocytosis – "Receptors"

Figure 3-22, Page 72

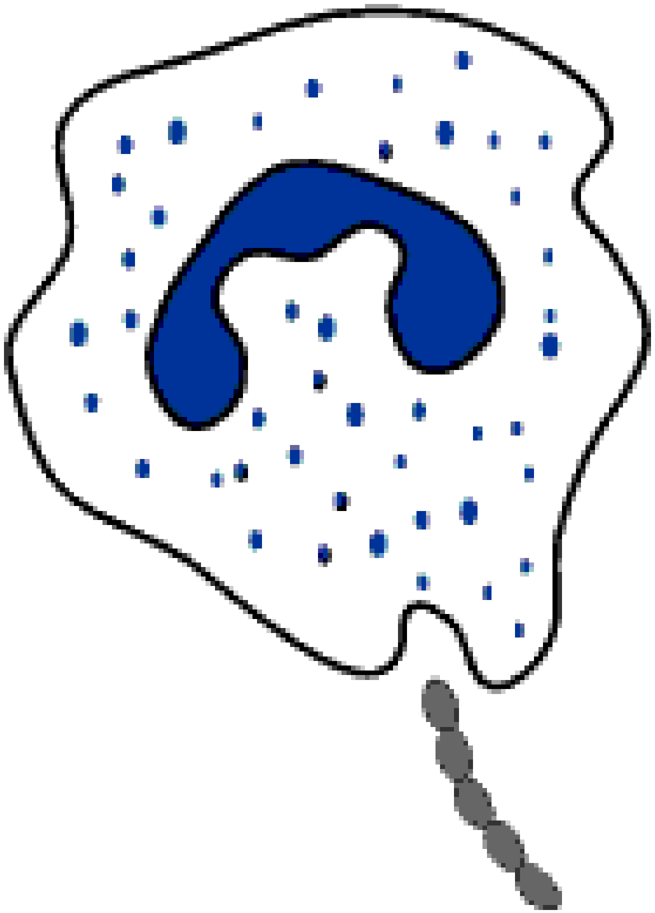
- Transports large particles or liquids into the cell by engulfing them
  - Solid material: *phagocytosis*
  - Liquid: *pinocytosis*



Phagocytosis (WBC's)



Neutrophil Engulfing Bacteria



Exocytosis

- Excretion
  - Waste products
- Secretion
  - Cell manufactures molecules, such as sebum, hormones, etc.

Exocytosis

- **Neurotransmitter** into synapse
- Secretion of **hormones** into blood

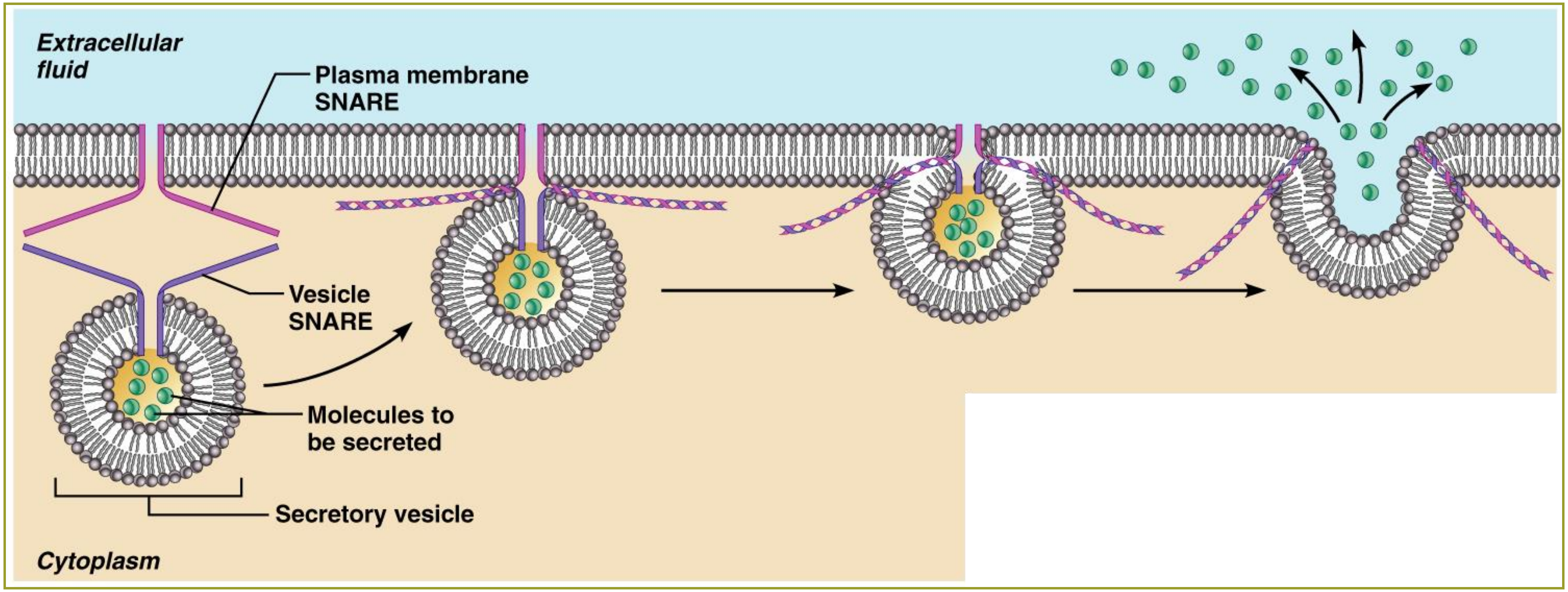
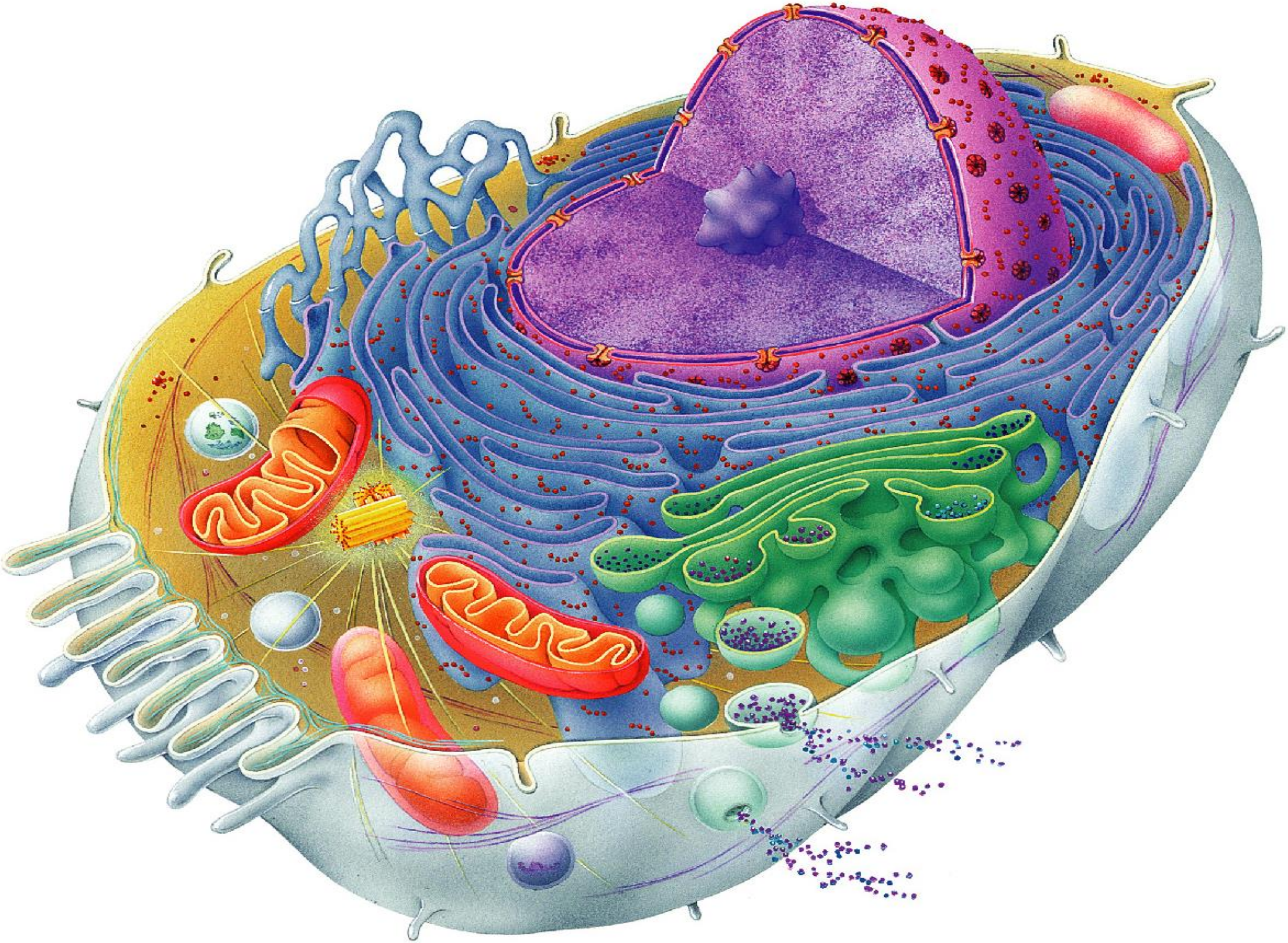


Figure 3.12a



Cell Membrane Transportation

Process	**Energy Source**	**Example**
Simple diffusion	No ATP needed	Movement of O_2 through membrane
Facilitated diffusion	No ATP needed	Movement of glucose into cells
Osmosis	No ATP needed	Movement of H_2O in & out of cells
Filtration	Hydrostatic pressure	Formation of kidney filtrate
Active Transport	ATP	Movement of ions across membranes
Endocytosis	ATP	WBC phagocytosis
Exocytosis	ATP	Neurotransmitter release

Table 3.2 Types and Characteristics of Movement Across Membranes

Type	Transport	Requires ATP	Examples
Diffusion	With the concentration gradient through the lipid portion of the cell membrane or through membrane channels	No	Oxygen, carbon dioxide, chloride ions, and urea
Osmosis	With the concentration gradient (for water) through the lipid portion of the cell membrane or through membrane channels	No	Water
Filtration	Movement of liquid and substances by pressure through a partition containing holes	No	In the kidneys, filtration of everything in blood smaller than proteins and blood cells
Facilitated diffusion	With the concentration gradient by carrier molecules	No	Glucose in most cells
Active transport	Against the concentration gradient* by carrier molecules	Yes	Na^+, K^+, Ca^{2+}, and H^+; amino acids
Secondary active transport	Against the concentration gradient by carrier molecules; the energy for secondary active transport of one substance comes from the concentration gradient of another	Yes	Glucose, amino acids
Endocytosis	Movement into cells by vesicles	Yes	Ingestion of particles by phagocytosis or receptor-mediated endocytosis and liquids by pinocytosis
Exocytosis	Movement out of cells by vesicles	Yes	Secretion of proteins

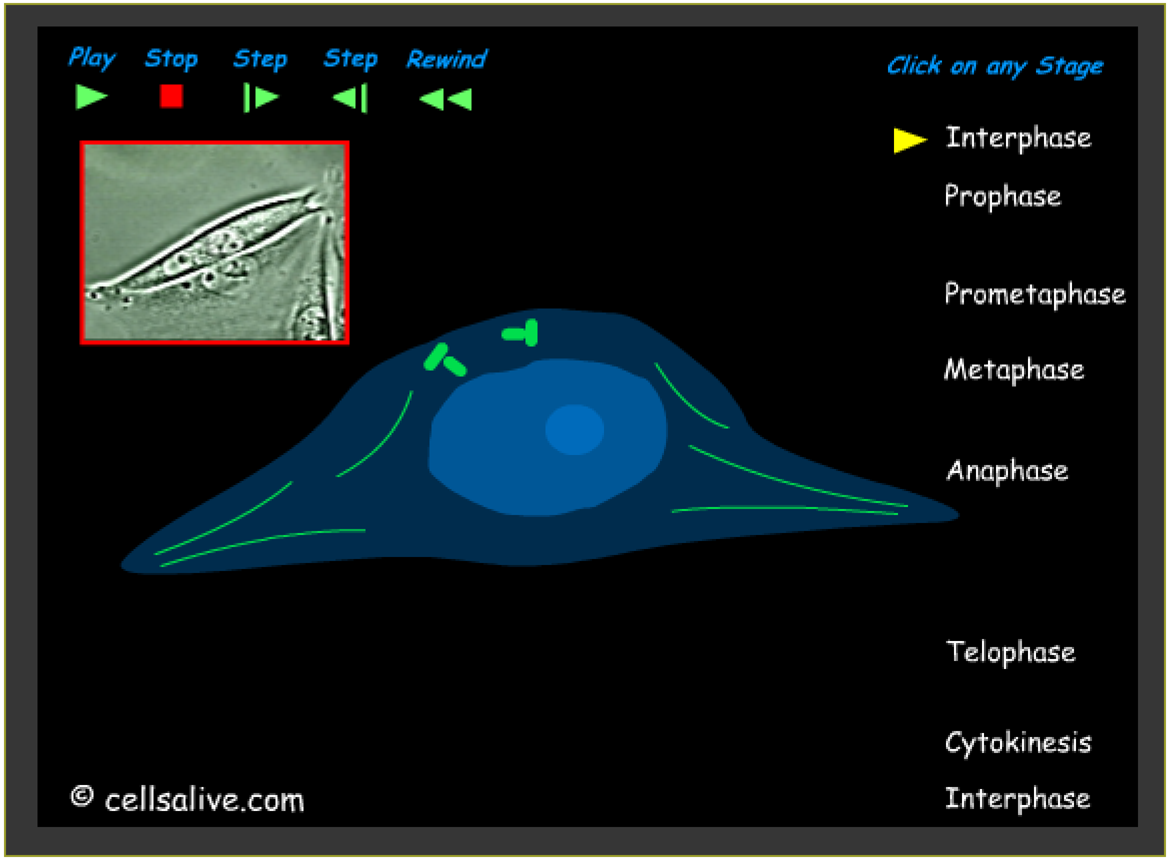
*Active transport normally moves substances against their concentration gradient, but it can also move substances with their concentration gradient.

Mammalian Cell Division

Mitosis

Meiosis

Cells Alive! Mitosis
http://cellsalive.com/mitosis.htm

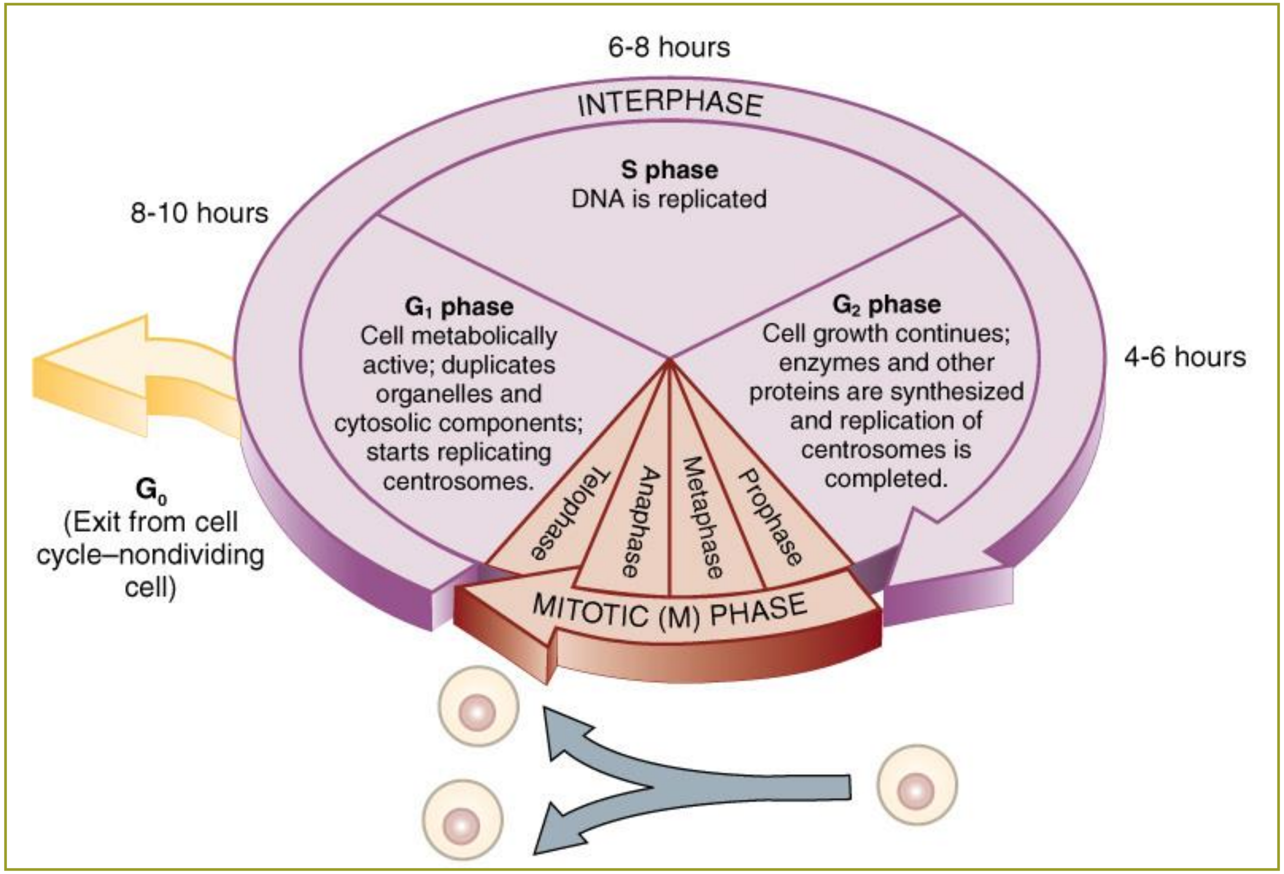


Mitosis (Cell Cycle)

- The life cycle of the cell has been divided into two major periods:
  - Interphase: The cell is growing, maturing, and differentiating
  - Mitotic phase: The cell is actively dividing

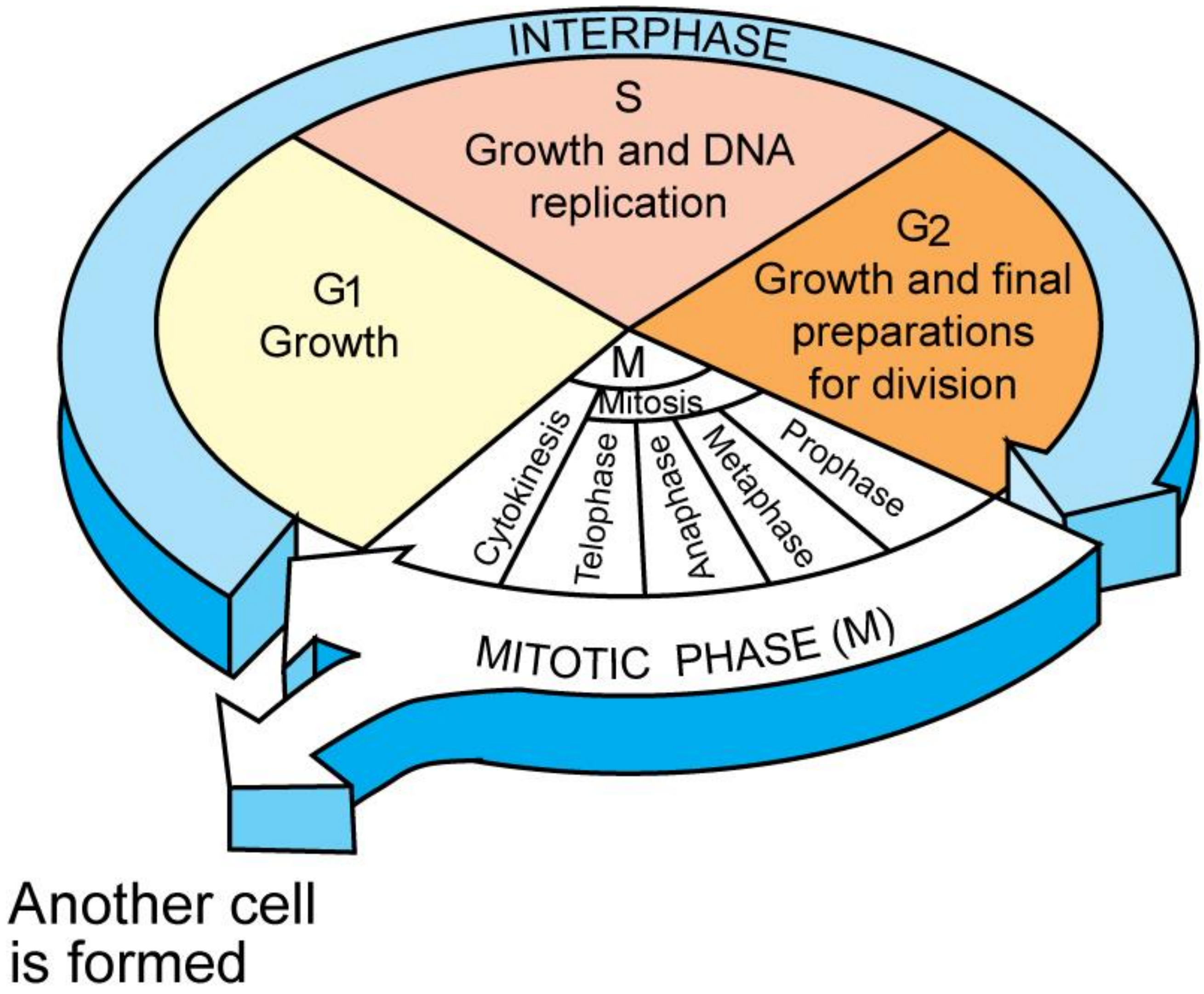
The Cell Cycle

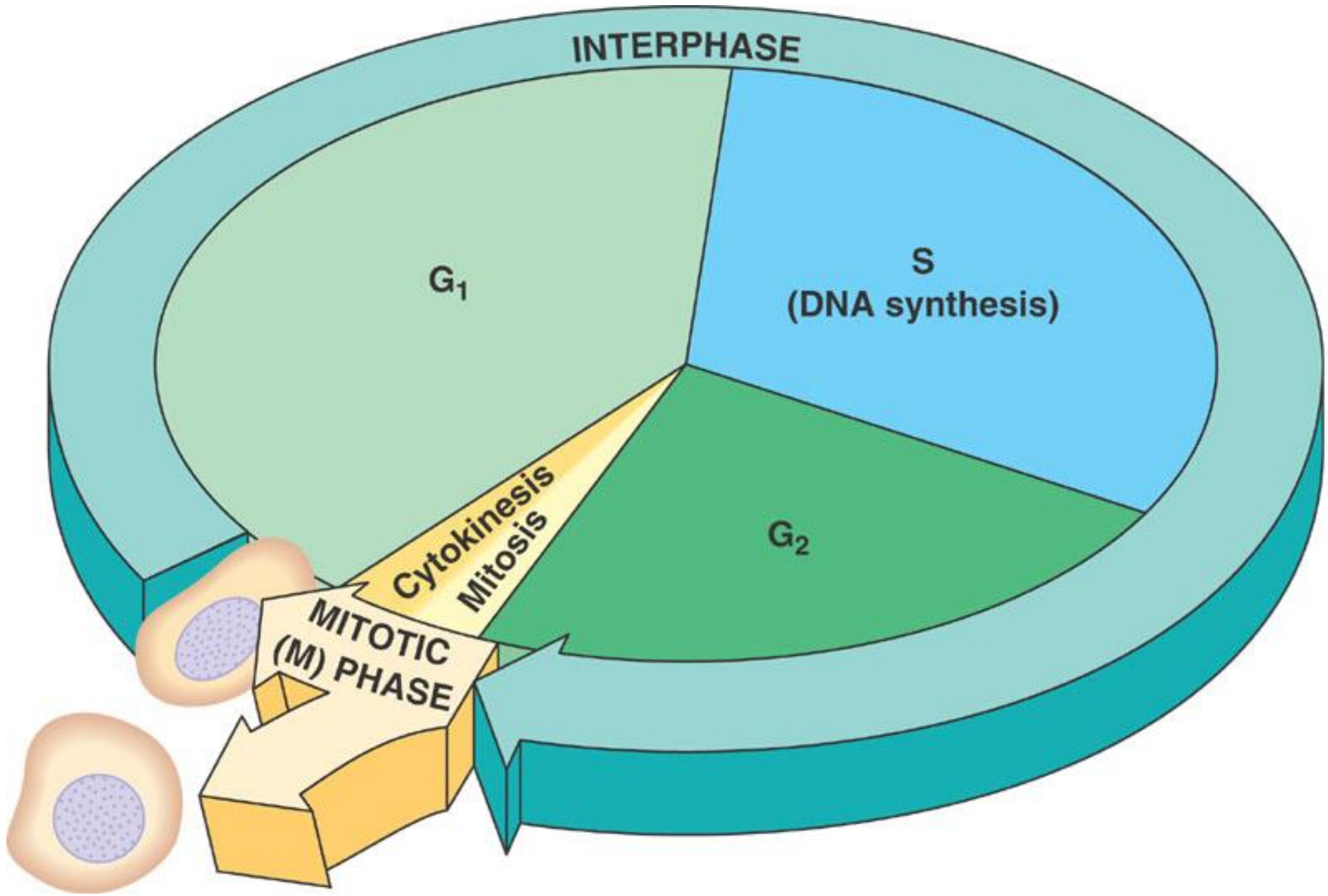
- Interphase
- Prophase
- Metaphase
- Anaphase
- Telophase



Cell Cycle

Figure 3-24, Page 74




INTERPHASE
G_1
S
(DNA synthesis)
G_2
Cytokinesis
Mitosis
MITOTIC
(M) PHASE

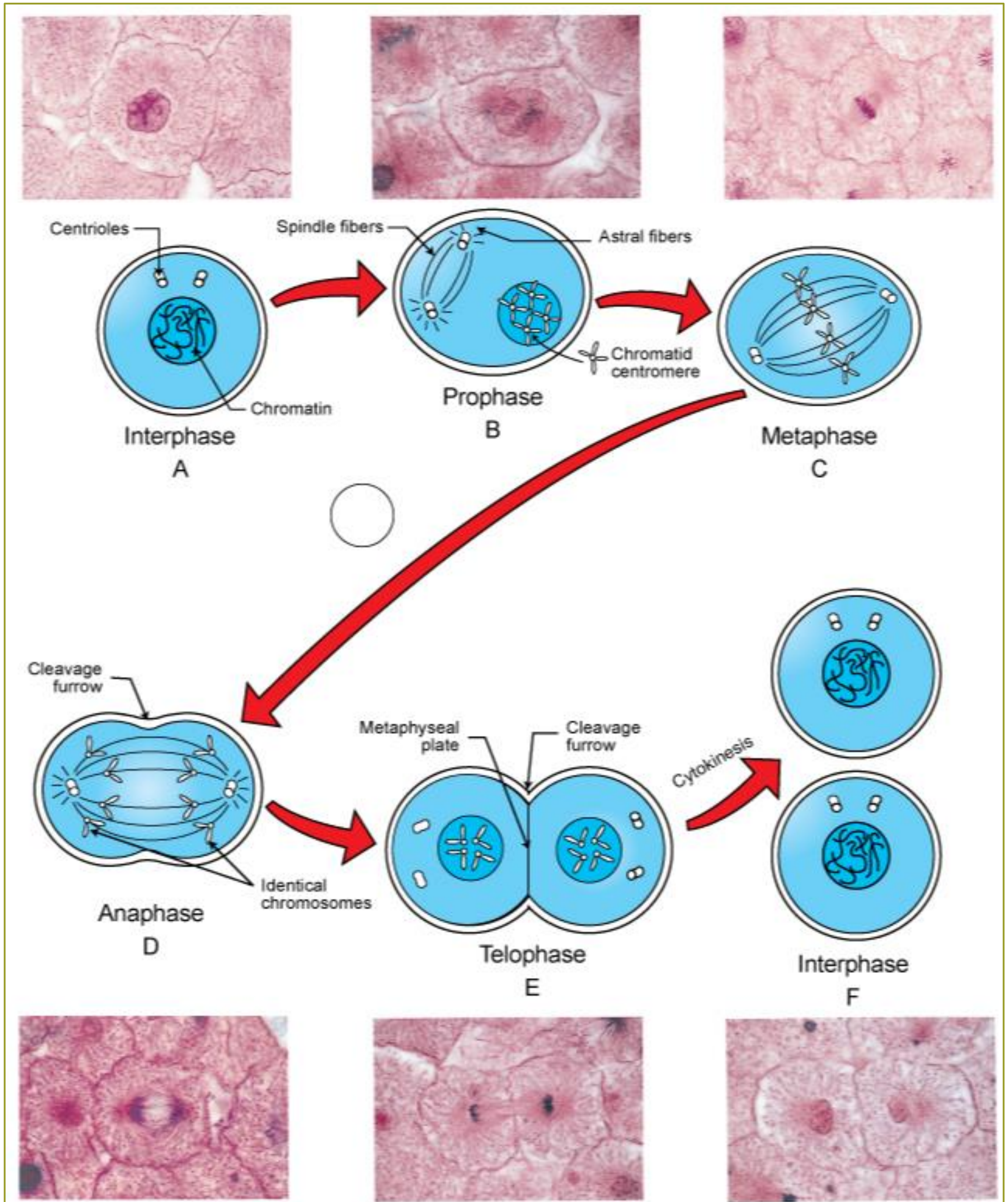
Mitosis

Figure 3-26, Page 77

- Prophase
- Metaphase
- Anaphase
- Telophase

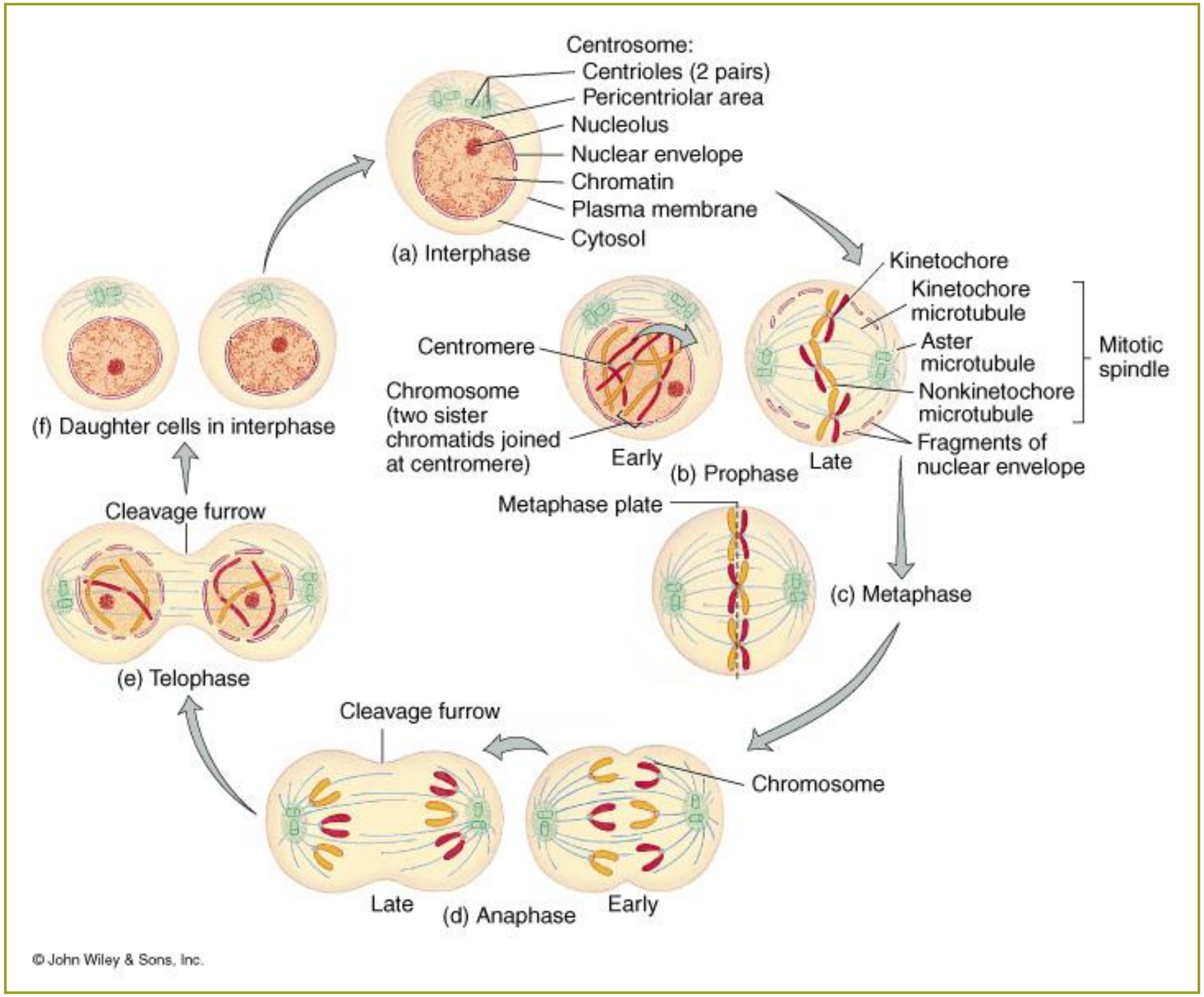
Mitosis

Figure 3-26, Page 77



(Photomicrographs from Thibodeau GA, Patton KT: *Anatomy & physiology*, ed 5, St Louis, 2003, Mosby.)

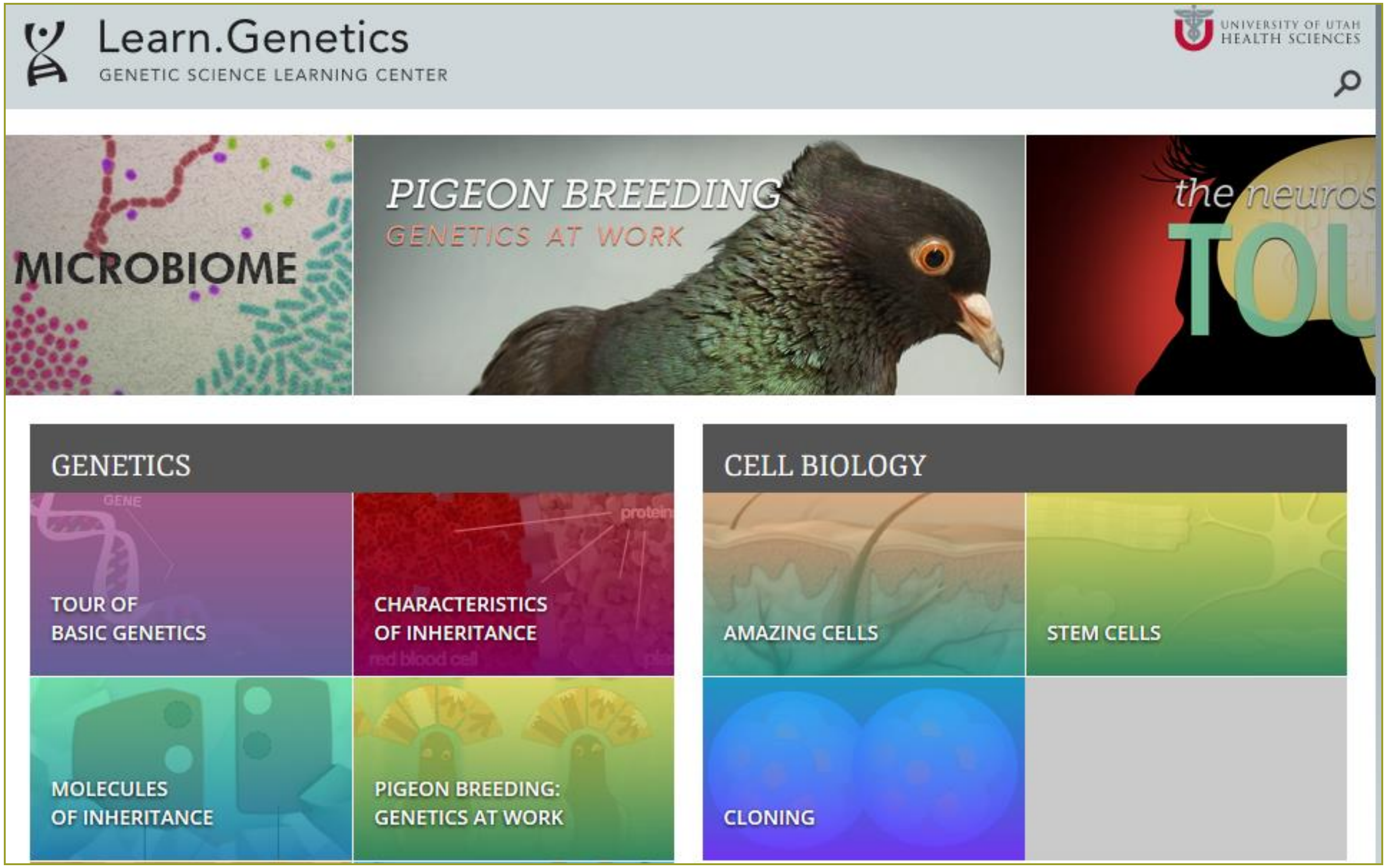
Mitosis Summary



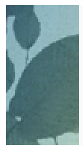
Stem Cells?
http://learn.genetics.utah.edu/

- **KOOOOOL Genetics Website, with info on Stem Cells, Cloning, and more!!!!**
- Stem cells – what are they?
- Stem cell research
- The future in veterinary medicine?

Learn.Genetics website



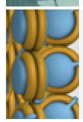
Stem Cells



explore

THE NATURE OF STEM CELLS

Stem cells play many important roles in our bodies from embryonic development through adulthood.



learn more

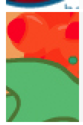
REVERSING CELL DIFFERENTIATION

Stem cells can now be created from differentiated cells.

learn more

STEM CELL QUICK REFERENCE

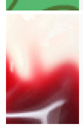
Learn about some different types of stem cells and their potential for treating diseases.



interactive explore

GO, GO, STEM CELLS

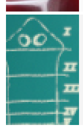
Send activating signals to stem cells and watch them get to work!



learn more

STEM CELLS IN USE

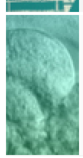
Stem cell therapies have been curing diseases for decades.



explore

UNLOCKING STEM CELL POTENTIAL

Researchers are working on new ways to use stem cells in medicine.



learn more

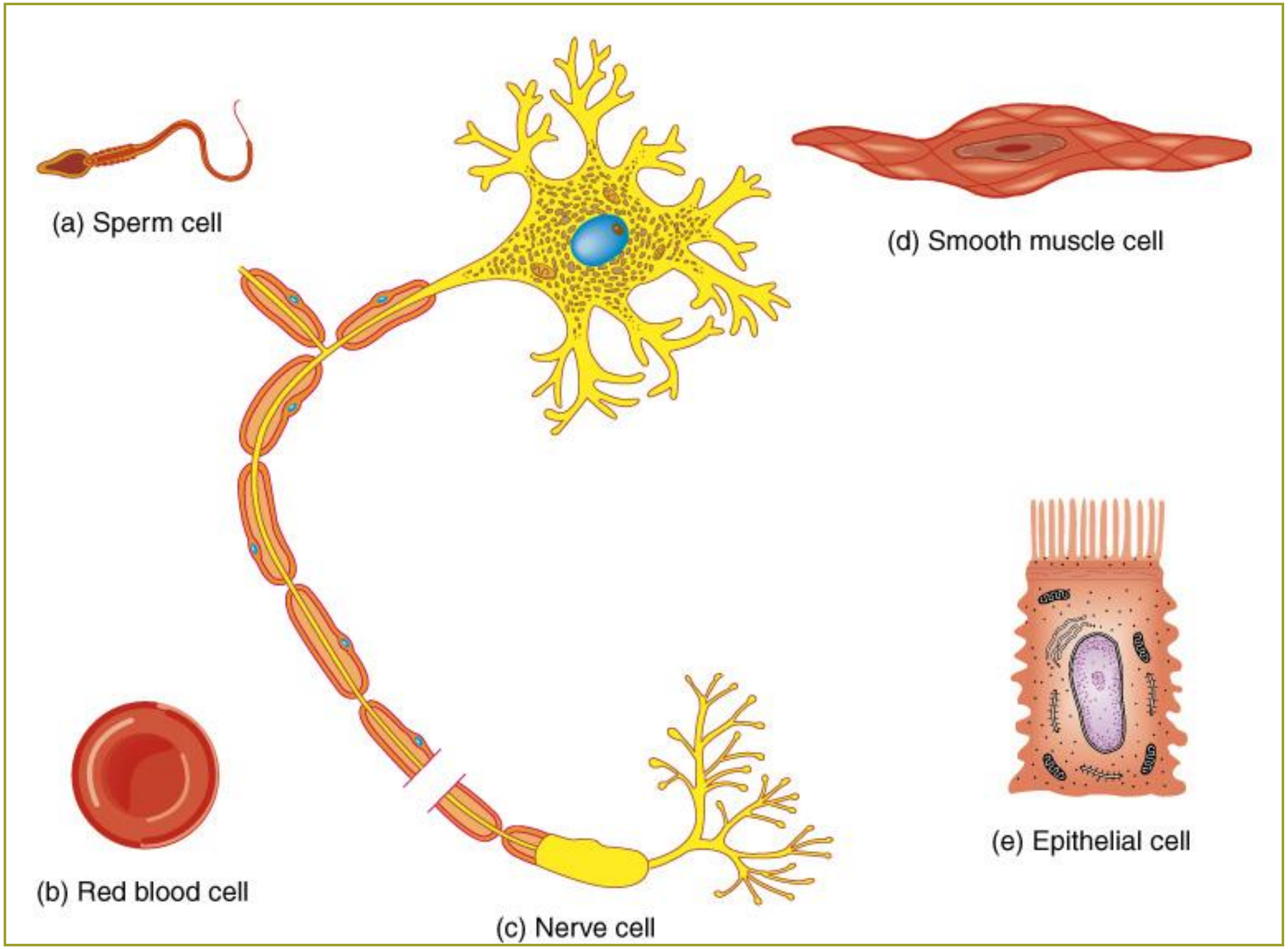
THE STEM CELL DEBATE: IS IT OVER?

New developments in research are changing the conversation about stem cells.

Cell Differentiation

- Involves the temporary or permanent inhibition of genes that may be active in other cells

Cell Diversity – Deja Vu



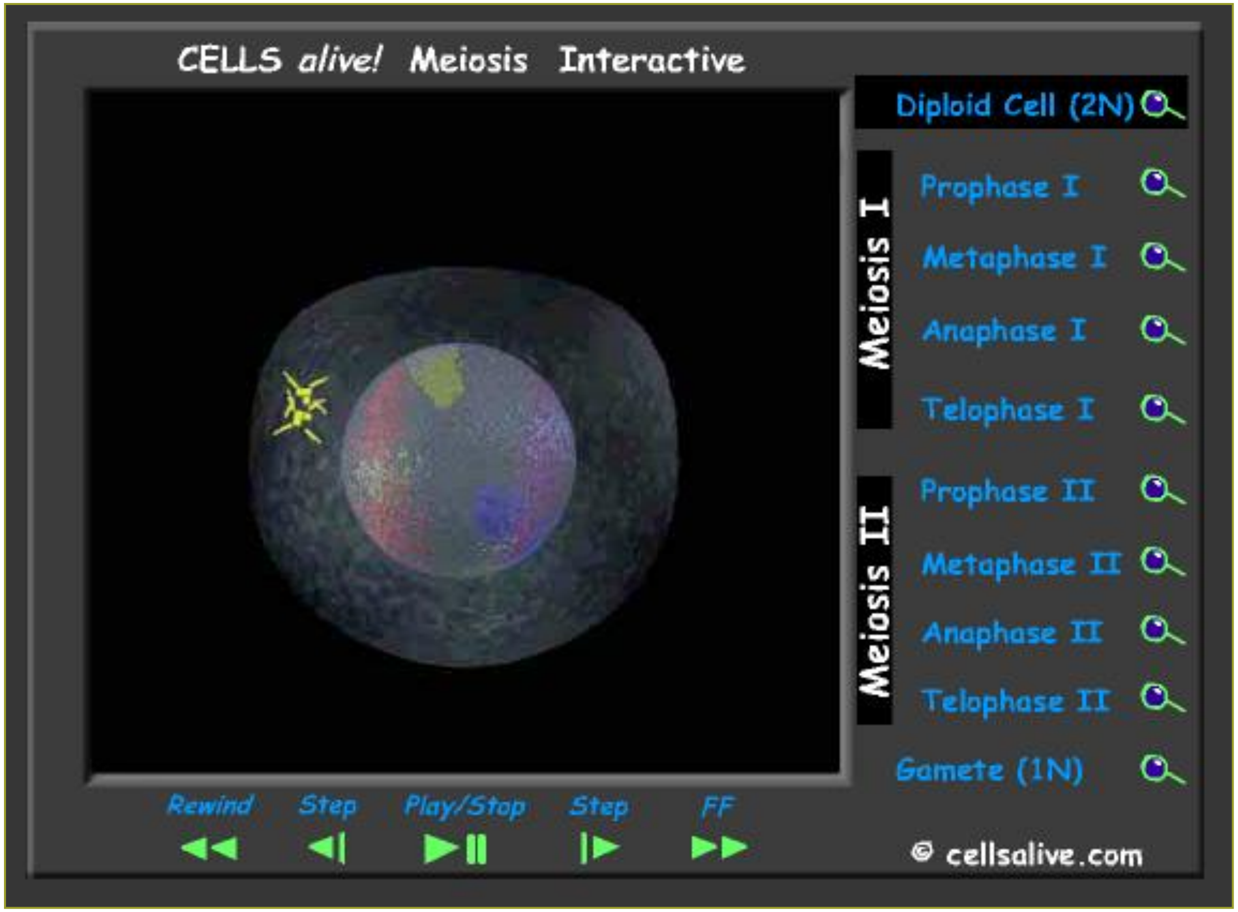
Genetic Mutations

- Errors in DNA replication
- Mutagen: anything that causes genetic mutation
  - Viruses, ionizing radiation, and certain chemicals
  - Spontaneous mutation

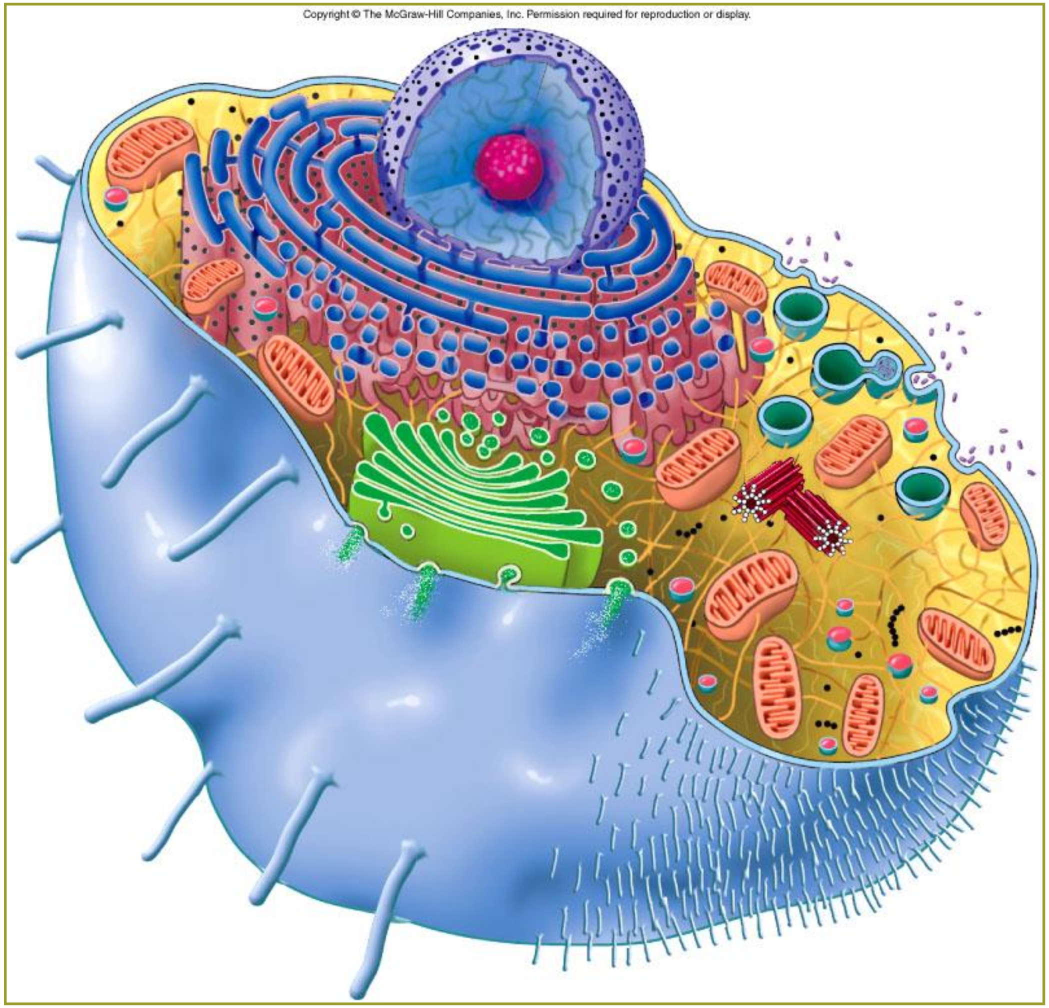
Meiosis

- Creation of gametes
  - Sperm & egg
- Diploid number → haploid number
- Meiosis I
  - Tetrads
  - Crossing over
- Meiosis II
  - Like mitosis

Cells Alive! Meiosis
http://cellsalive.com/meiosis.htm



Review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