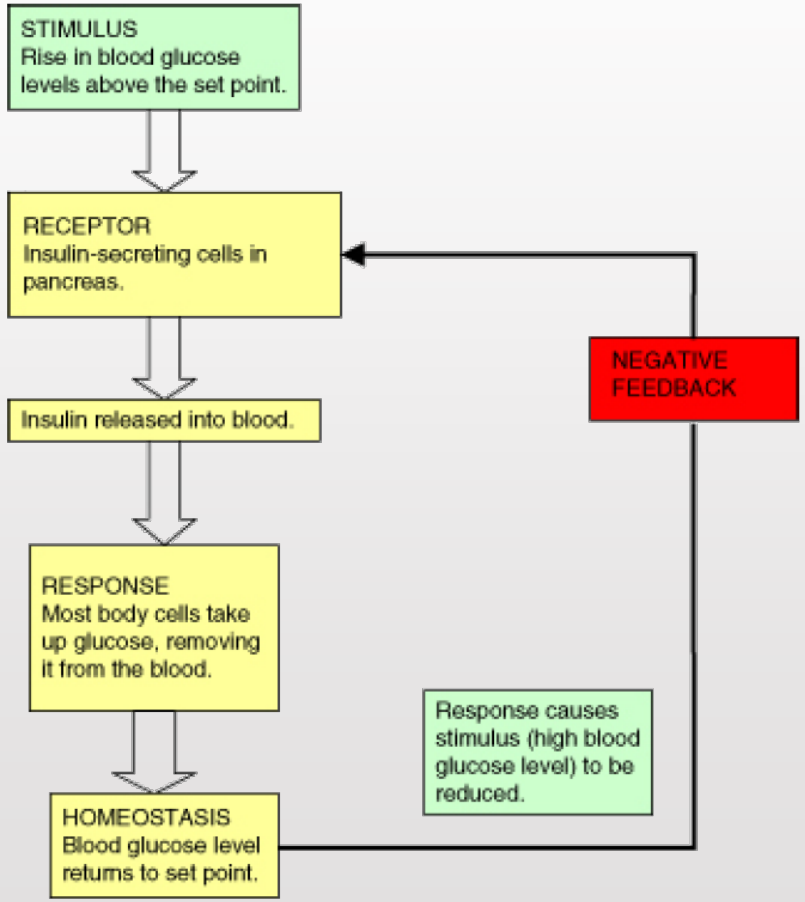
UNIT 1: Biological Molecules

Homeostasis

- Homeostasis is when a system or process is used to maintain a normal state.
- Negative feedback cycles help to maintain homeostasis in the body.
- Positive feedback is a cycle which take the body further and further away from homeostasis; example = oxytocin during childbirth



Review of Bonds

Ionic Bonds

- Electrons are transferred from one atom to another
- Ions are created which are electrostatically attracted to each other
- Example = NaCl (Salt/sodium chloride)

Covalent Bonds

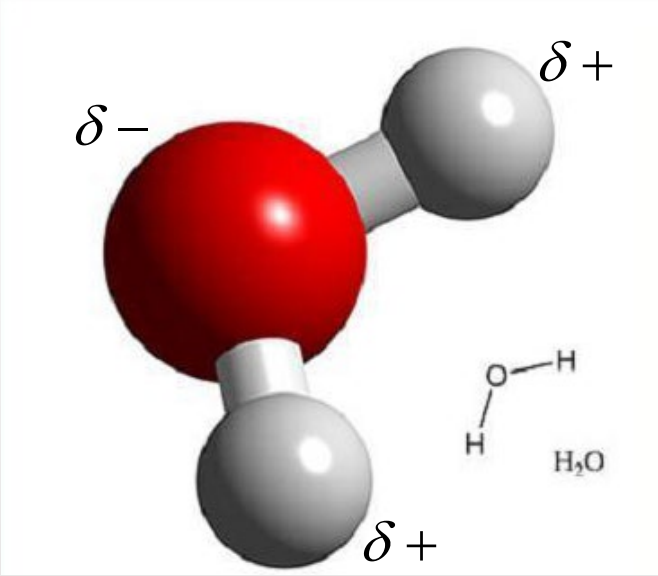
- Electrons are shared between atoms
- Equal sharing of electrons is a non-polar covalent bond
- Example: O_2, CO_2
- Unequal sharing of electrons is a polar covalent bond
- Example: H_2O

Hydrogen Bonds

- A weak attraction between polar molecules
- Usually an attraction between hydrogen atoms and another slightly negative atom
- Example: H_2O

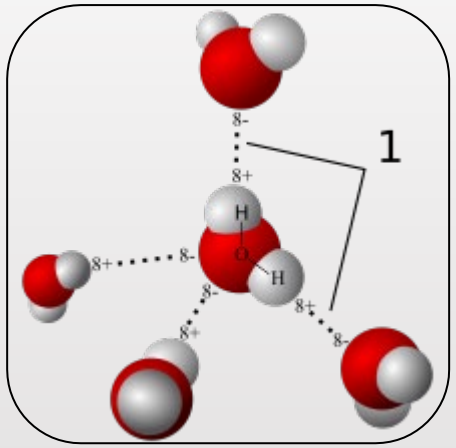
Water

- H_2O
- Polar = unequal sharing of electron creates opposite charges
  - → Hydrogen is slightly positive
  - → Oxygen is slightly negative
- Properties of Water
  - Universal solvent
  - Lubricant and cohesive
  - Temperature regulator
  - Liquid at room temp
  - Frozen water less dense than liquid water
  - High surface tension



Water

Hydrogen Bonds



pH

- $H_2O \rightleftarrows H^+ + OH^-$ water dissociates
- The level of H^+ compared to OH^- helps us to determine the pH of a solution.

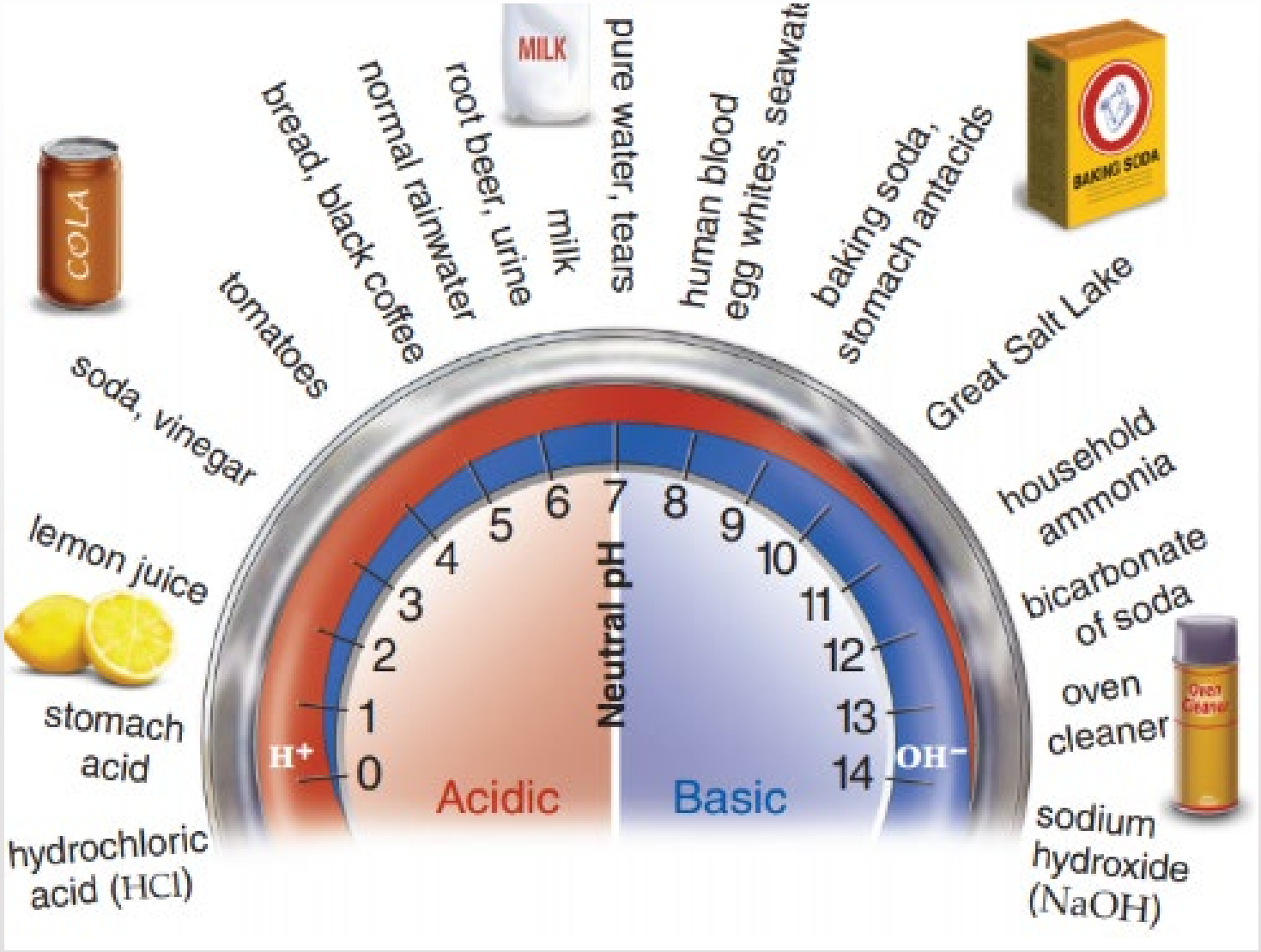
If $[H^+] > [OH^-]$ = acidic

If $[H^+] < [OH^-]$ = basic

- Buffers:
  - Bicarbonate ion buffers when too much acid (↑ H^+)
    - $H^+ + HCO_3^- \longrightarrow H_2CO_3 \longrightarrow CO_2 + H_2O$
  - Carbonic acid buffers when too much base (↑ OH^-)
    - $OH^- + H_2CO_3 \longrightarrow HCO_3^- + H_2O$

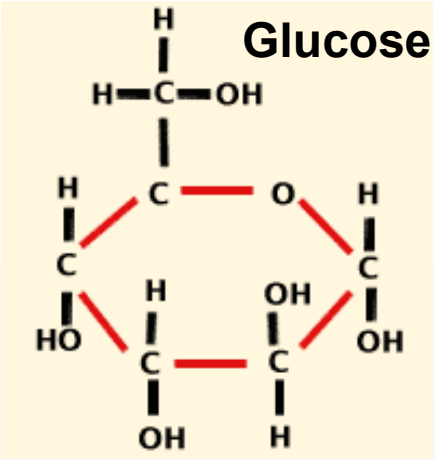
pH Scale

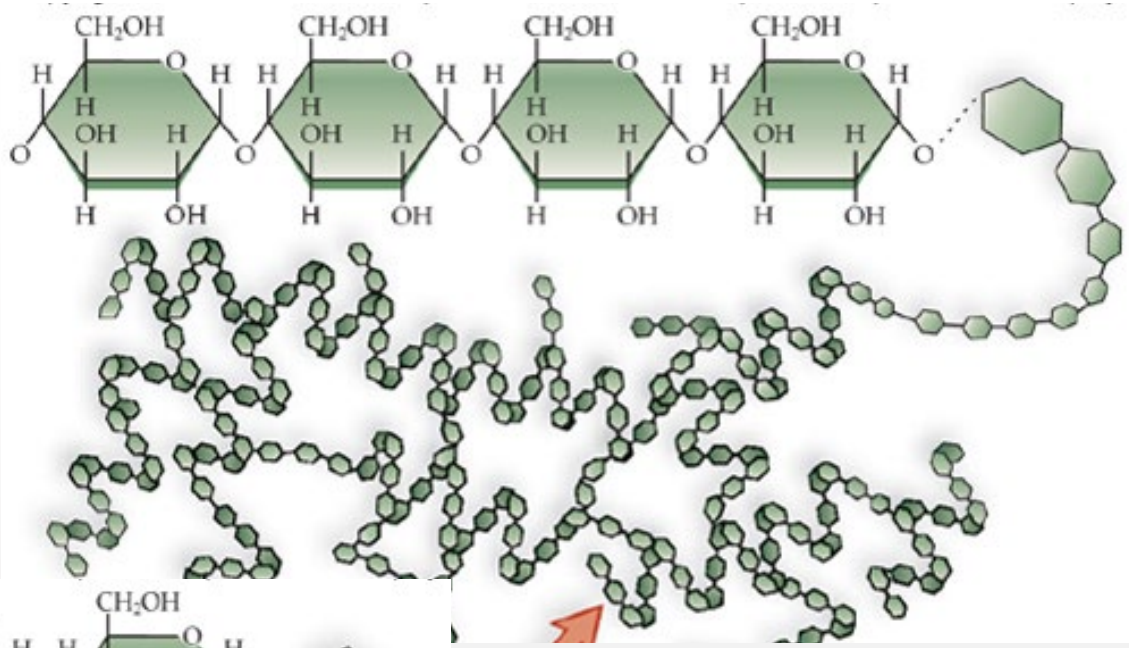
- This is a logarithmic scale of hydrogen ion (H+) concentration
- >7 is acidic
- >7 is basic
- 7 is neutral
  - (pure water: equal H+ and OH- concentrations



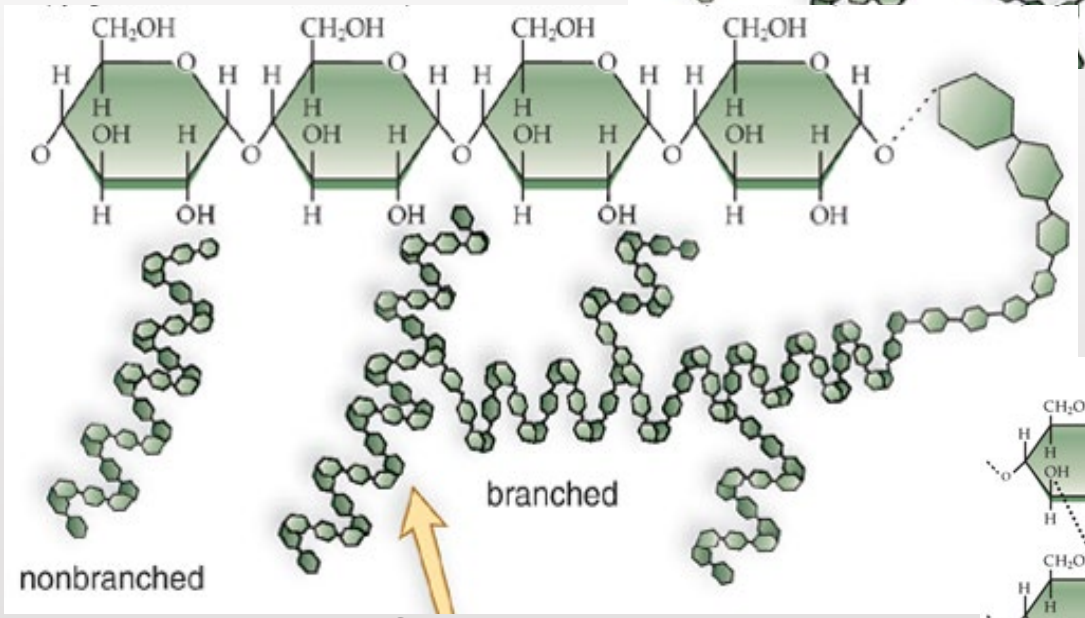
Carbohydrates

- Monomer = glucose
- Polymer
  - Maltose = disaccharide of 2 glucose monomers
  - Starch = stored form of glucose in plants & less branching
  - Glycogen = stored form of glucose in animals (liver) & more branching
  - Cellulose = =in plant cell walls for structure
- Functions
  - Short-term energy
  - Stored energy
  - Cell-to-cell recognition
  - Structure in plants and some animals



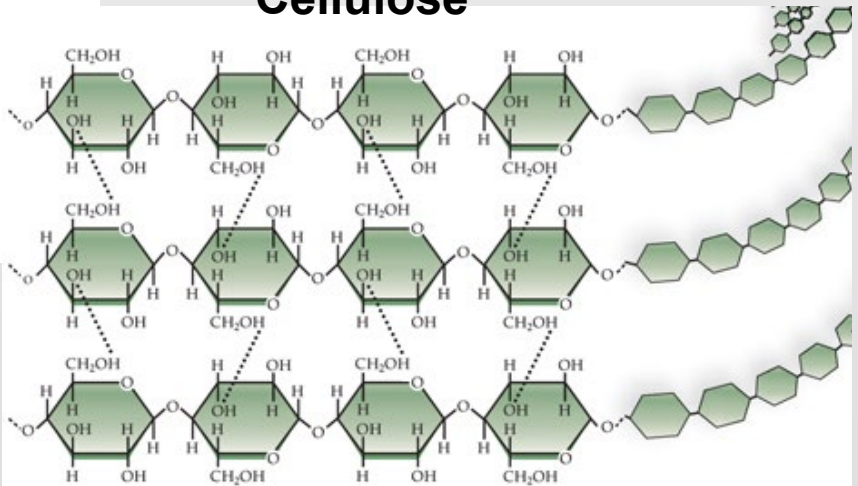


Glycogen



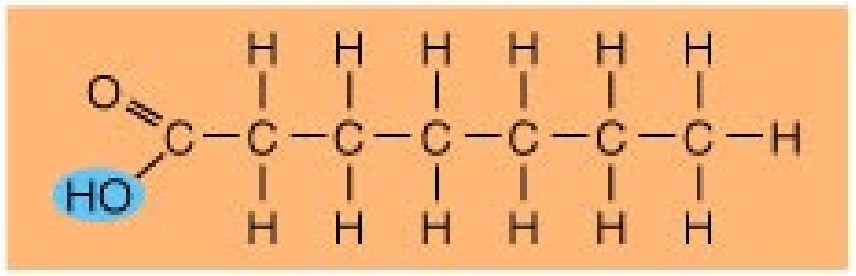
Starch

Cellulose

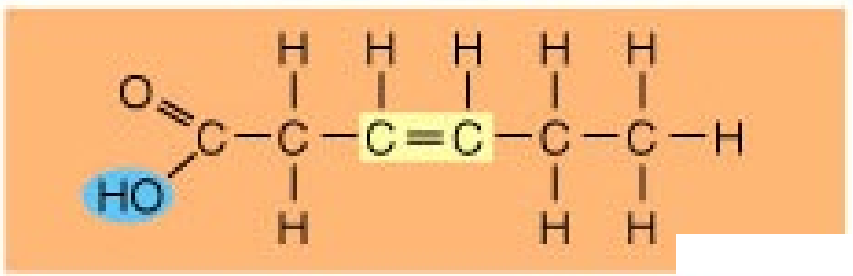


Lipids

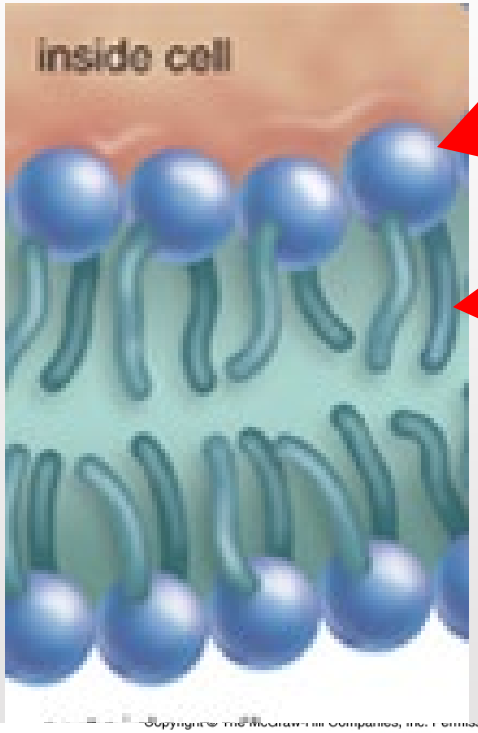
- Monomer = glycerol and fatty acids
- Polymer
  - Triglyceride (Neutral Fat) = long-term energy source: ex. Body fat
  - Phospholipids = forms plasma membranes and regulated movement of molecules in/out of cell
  - Steroids = derived from cholesterol and are chemical messengers: ex. Testosterone, estrogen



Saturated fatty acid

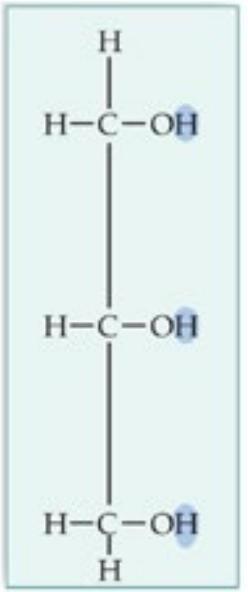


Unsaturated fatty acid



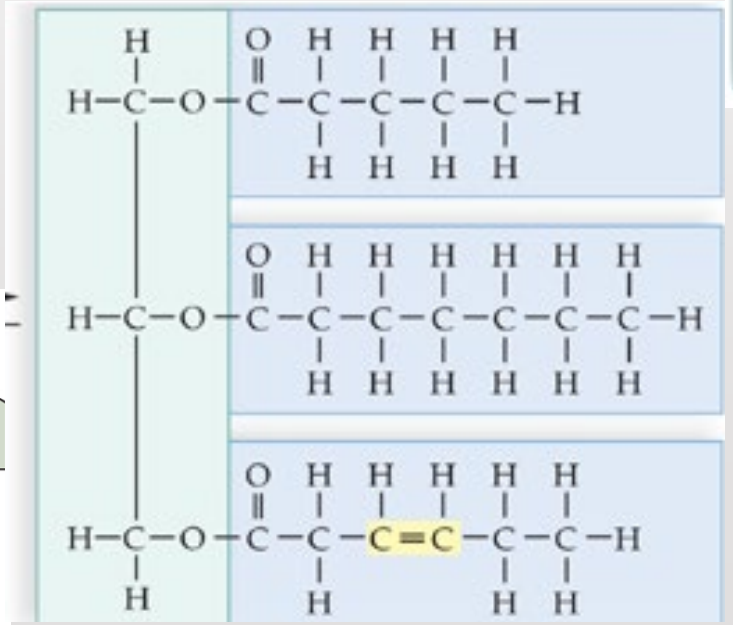
Hydrophilic (polar)

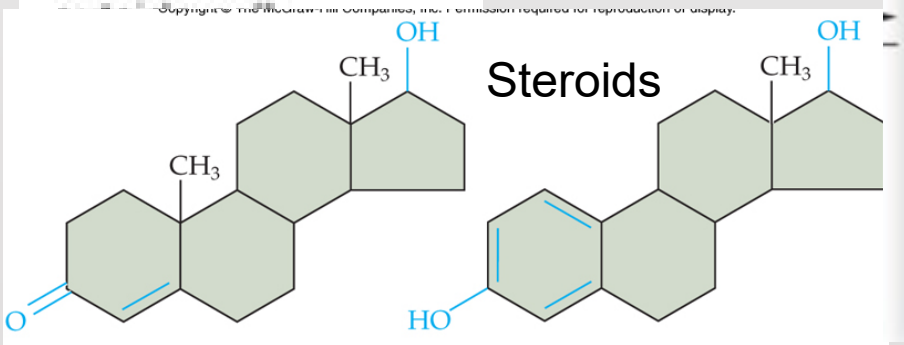
Hydrophobic (non-polar)



glycerol

Triglycerides (Neutral Fat)



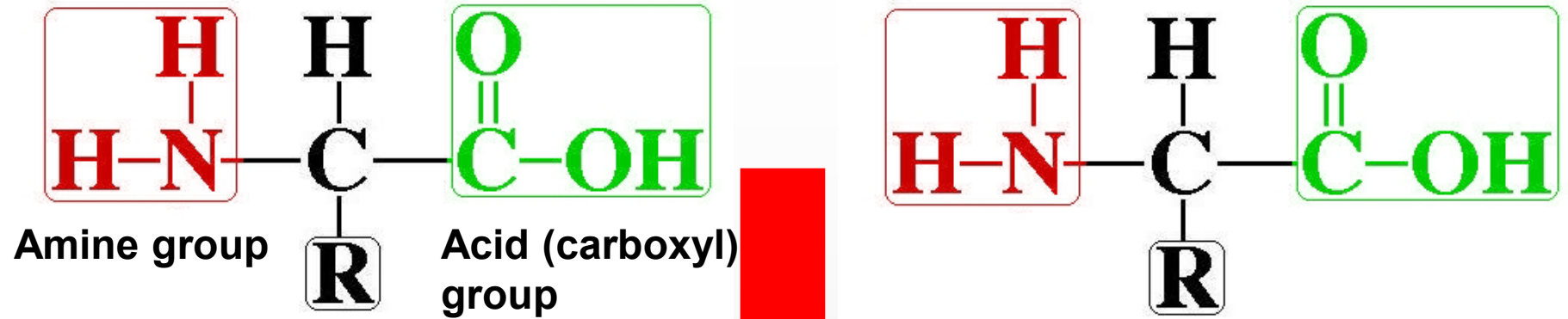


Steroids

Proteins

- Monomer = amino acids
- Functions
  - Transport molecules = through cell membranes and in the blood (oxygen on Hemoglobin)
  - Provide structure: ex. Keratin in hair and nails
  - Provide movement: ex. myosin & actin in muscles
  - Speed up chemical reactions: ex. Enzymes
  - Are chemical messengers: ex. Hormones like insulin
  - Allow for cell-to-cell identification
  - Help with immunity: ex. Antibodies are proteins

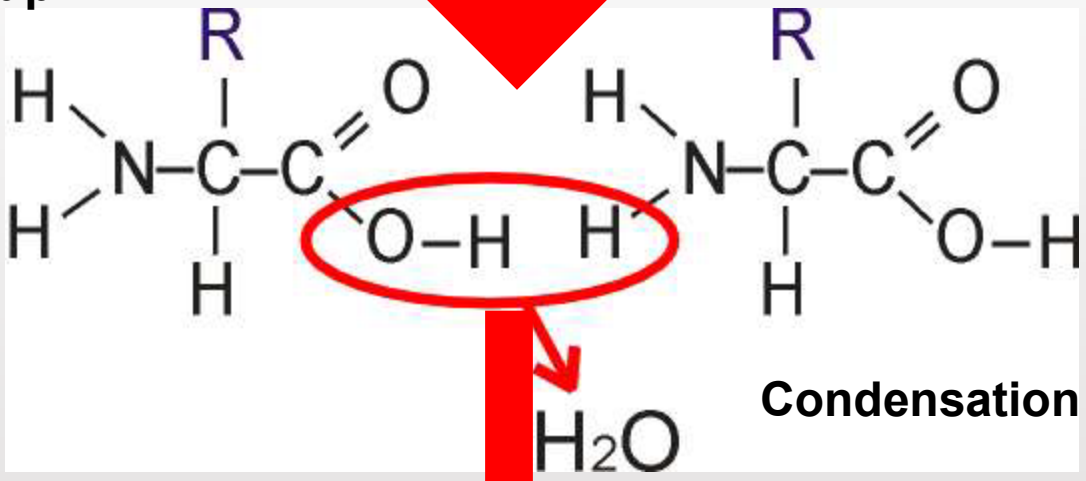
Amino acids



Amine group

Acid (carboxyl) group

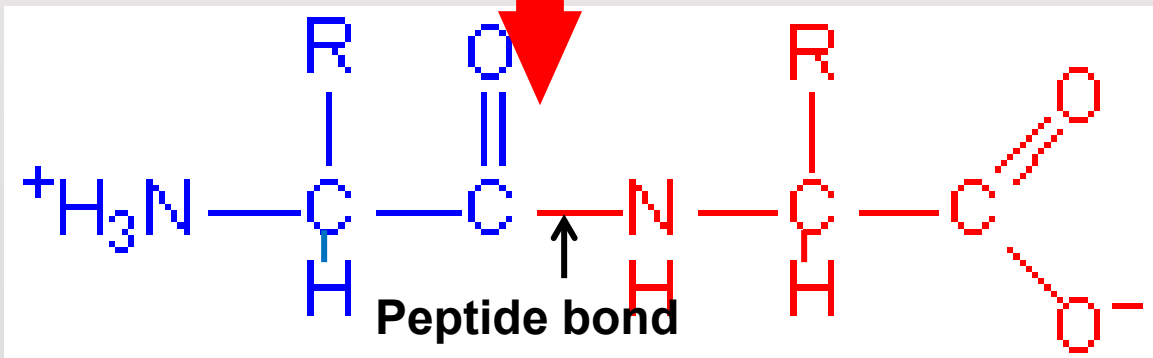
Remainder group



H_2O

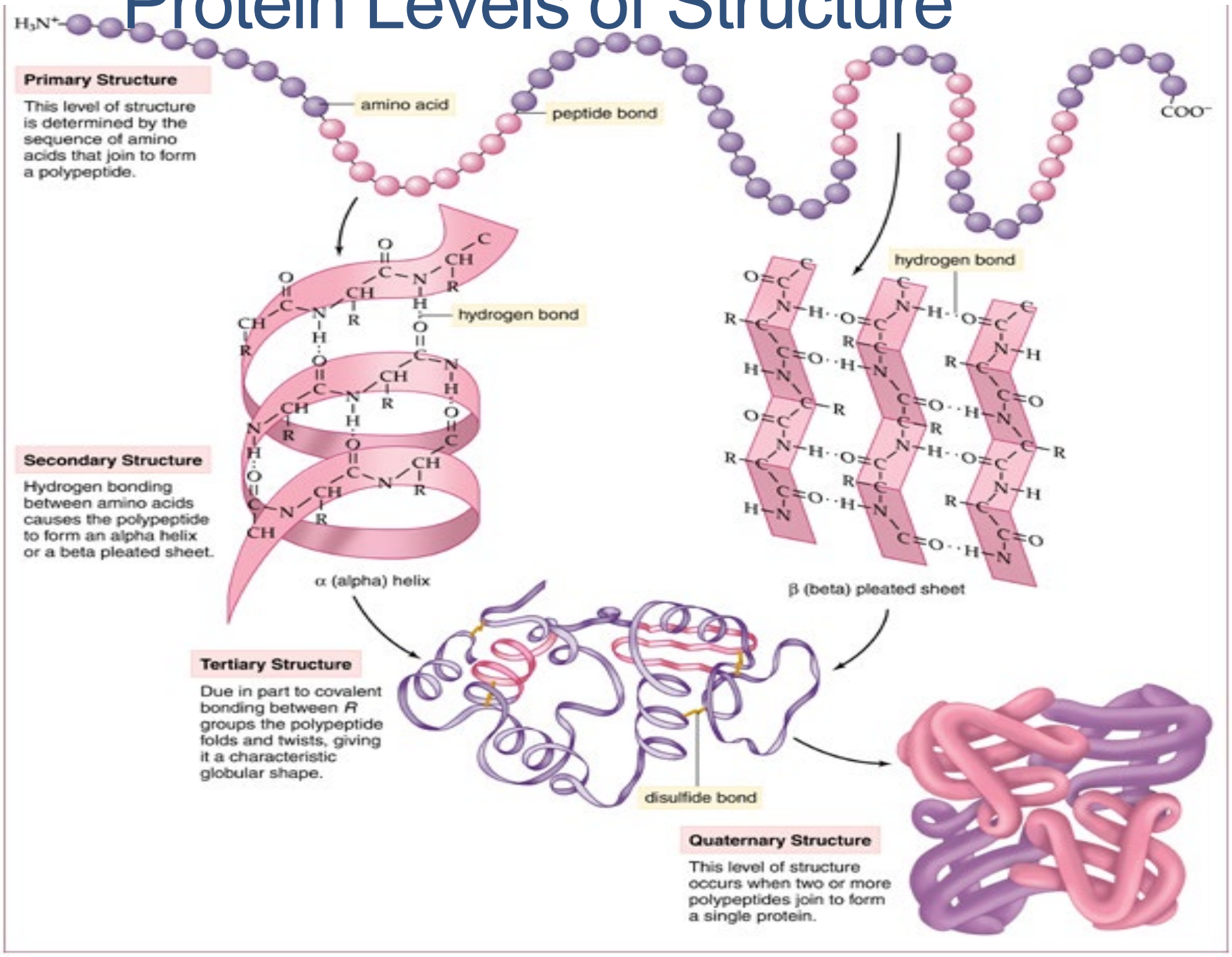
Condensation synthesis

dipeptide



Peptide bond

Protein Levels of Structure



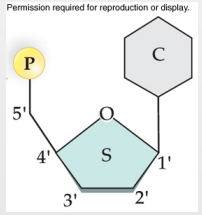
Nucleic Acids

- Monomer = nucleotides (phosphate group, pentose sugar, nitrogenous base)
- Polymers
  - DNA (Deoxyribonucleic Acid)
  - RNA (Ribonucleic Acid)
  - ATP (Adenosine Triphosphate)
- Functions
  - Replication, cell division, directing cell functions, gene expression for protein synthesis, mutations
  - Protein synthesis
  - Energy for cell functions

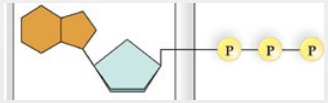
TABLE 2.1 DNA Structure Compared to RNA Structure

	DNA	RNA
Sugar	Deoxyribose	Ribose
Bases	Adenine, guanine, thymine, cytosine	Adenine, guanine, uracil, cytosine
Strands	Double stranded with base pairing	Single stranded
Helix	Yes	No

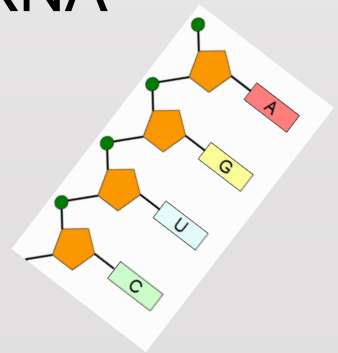
Nucleotide



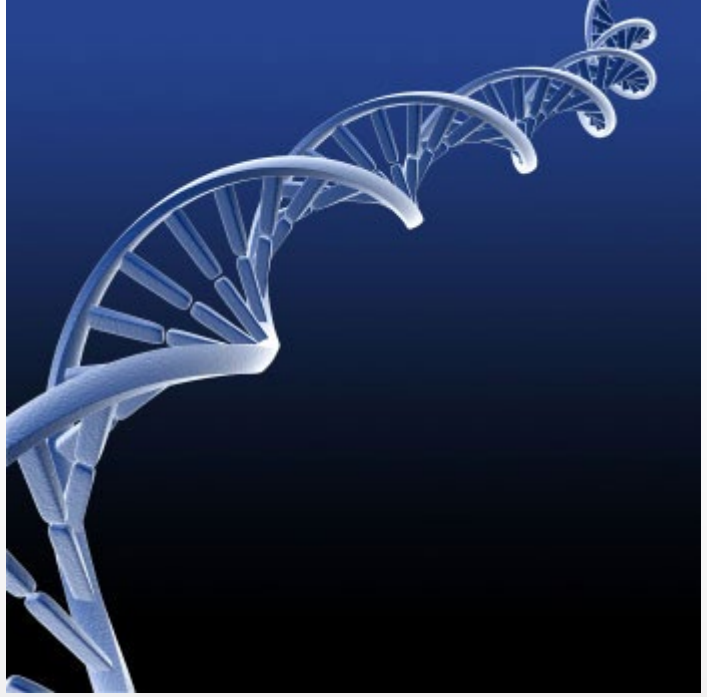
ATP



RNA



DNA



Complimentary Base Pairing

Adenine pairs with Thymine with 2 hydrogen bonds

Guanine pairs with Cytosine with 3 hydrogen bonds

Adenine and Guanine are purine bases with a double ring structure
Thymine and Cytosine are pyrimidine bases with single ring structure

Write the complimentary strand to the DNA strand given below.

ATP

- Adenosine Triphosphate
- Energy molecule
- Produced in the mitochondria of cells
- Cellular Respiration is the reaction that produces ATP

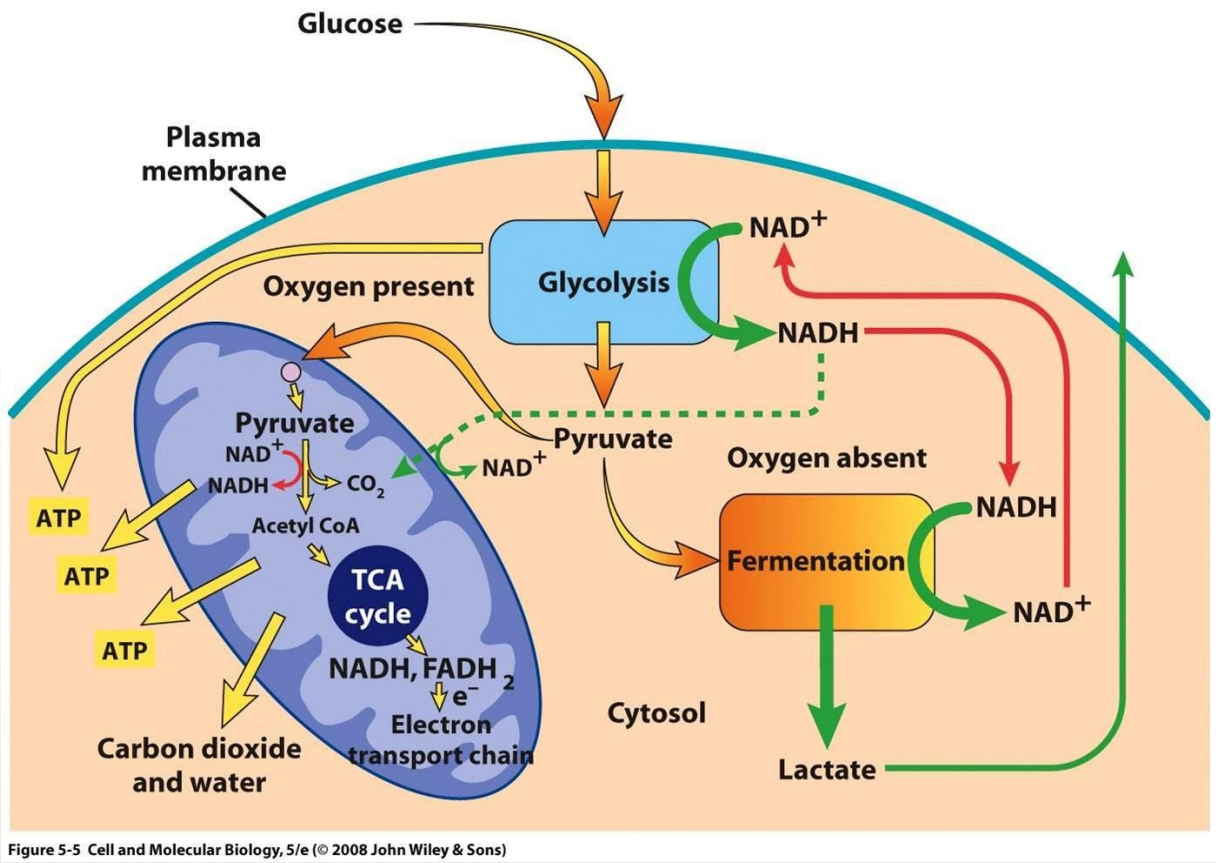
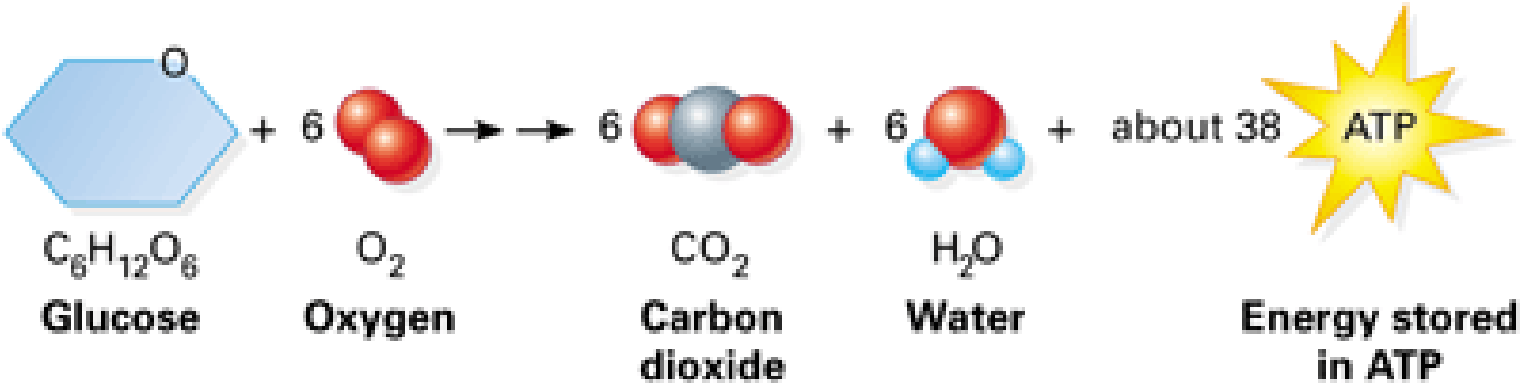
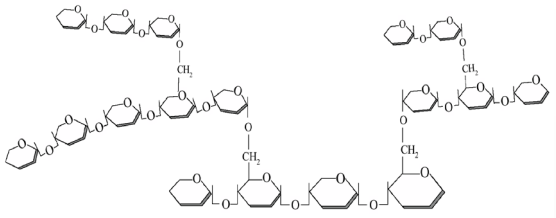


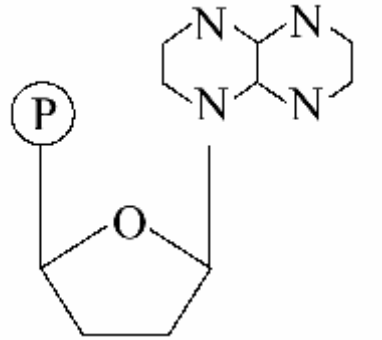
Figure 5-5 Cell and Molecular Biology, 5/e (© 2008 John Wiley & Sons)



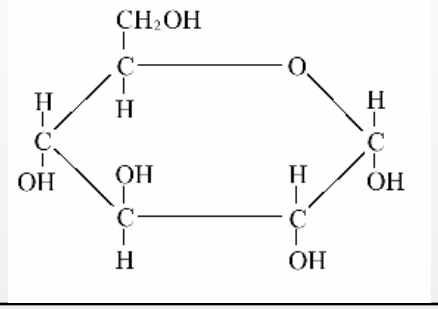
Identify each of these molecules



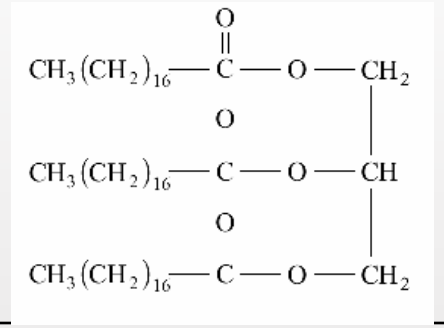
2 glycogen



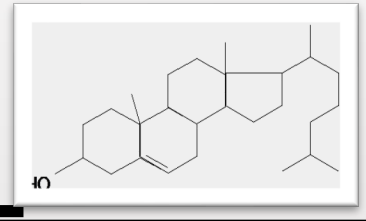
3 nucleotide



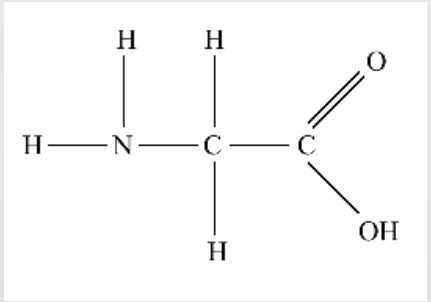
1 glucose



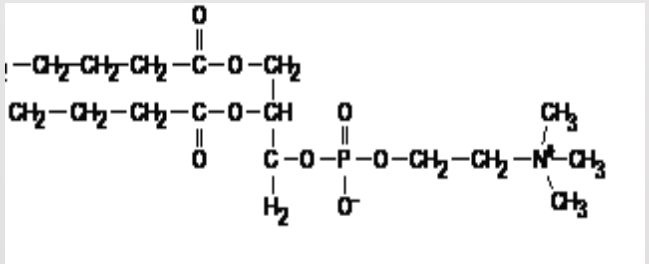
4 triglyceride



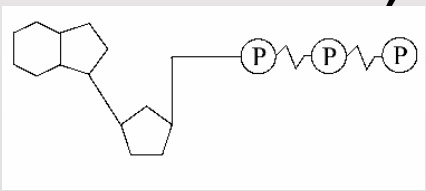
5 steroid (cholesterol)



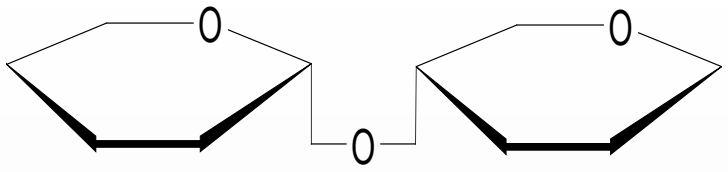
6 amino acid



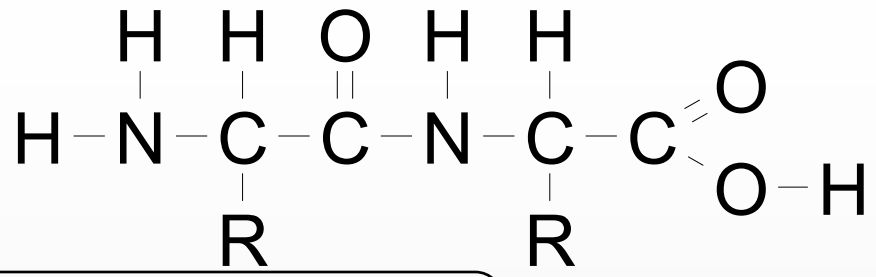
7 phospholipid



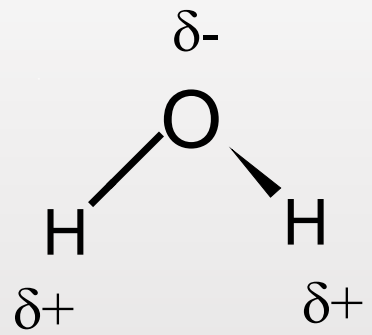
8 ATP


O
O
O

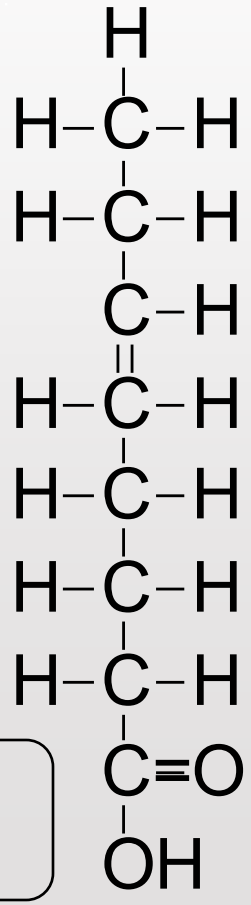
1


H H O H H
H N C C N C C O
O H
R R

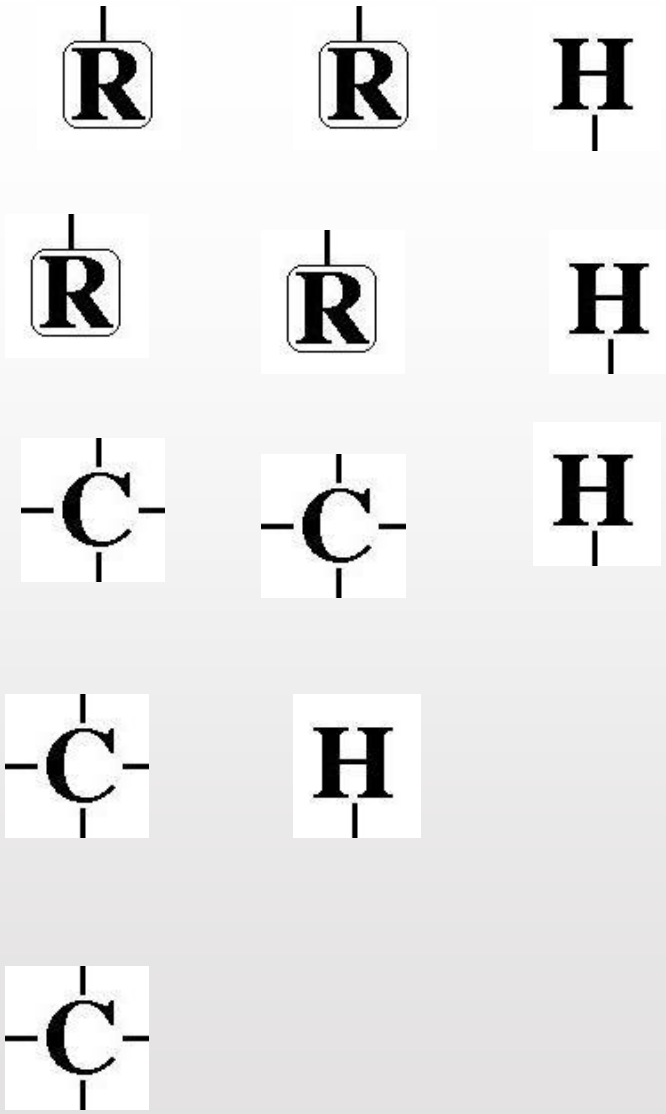
2

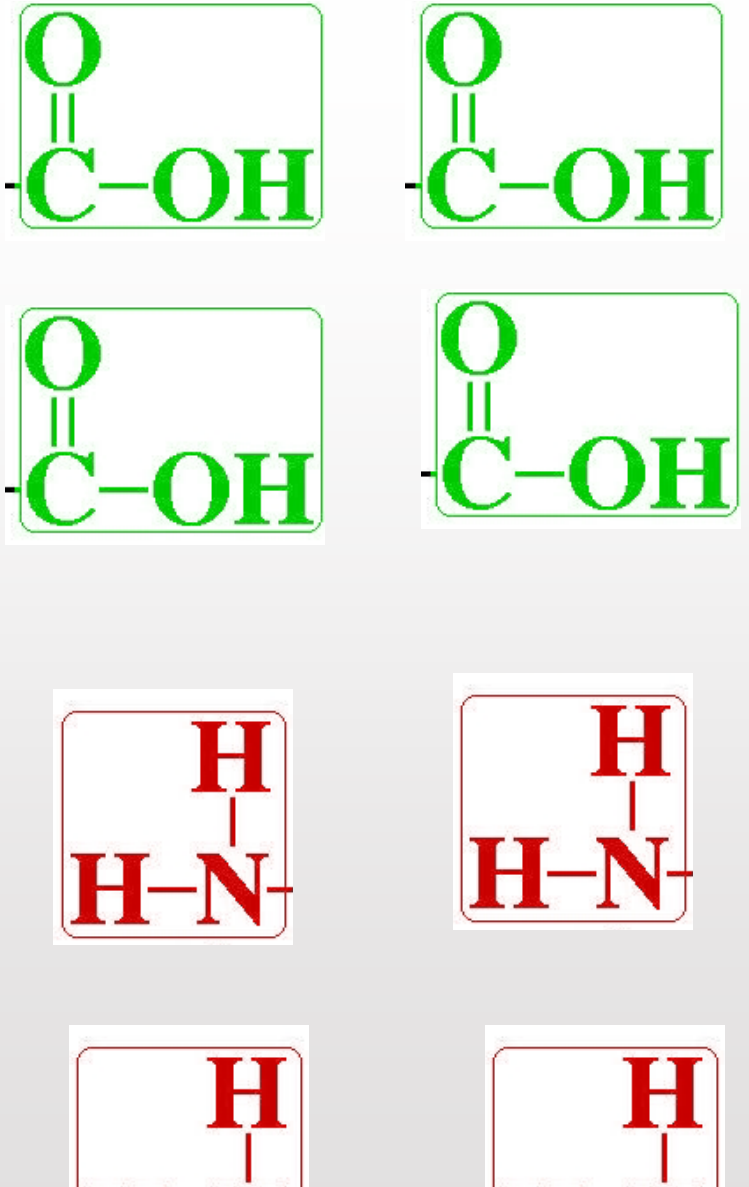

δ-
O
H
H
δ+
δ+

3


H
H C H
H C H
C H
H C H
H C H
H C H
H C H
H C H
C O
OH

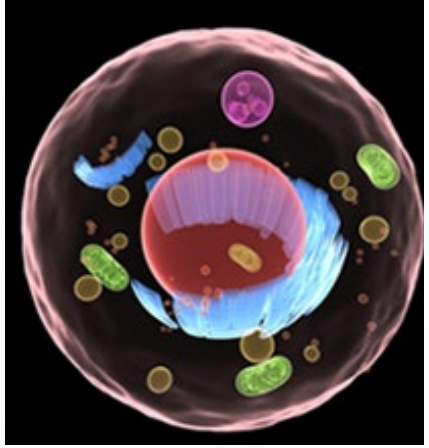
4


R
R
H
R
R
H
C
C
H
C
H
C

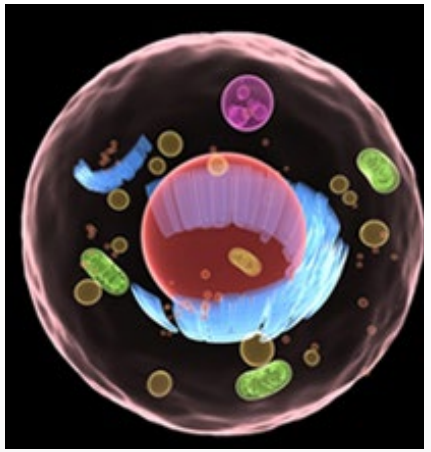

O
C–OH
O
C–OH
O
C–OH
O
C–OH
H
H–N
H
H–N
H
H–N
H
H–N

Unit 2: Cell Structure, Function & Transport

Structures, Functions and Organelle Relationships



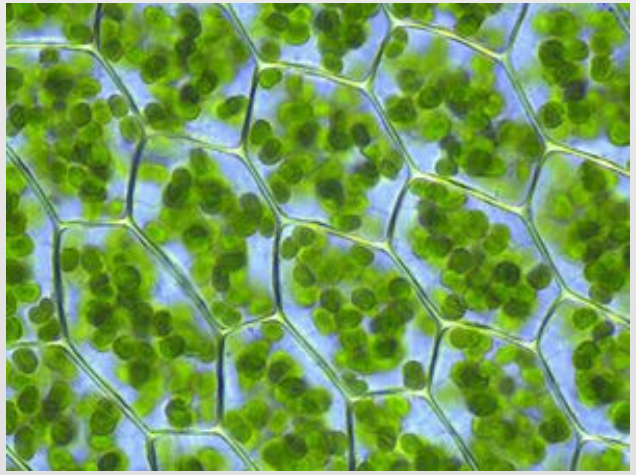
Cell Theory



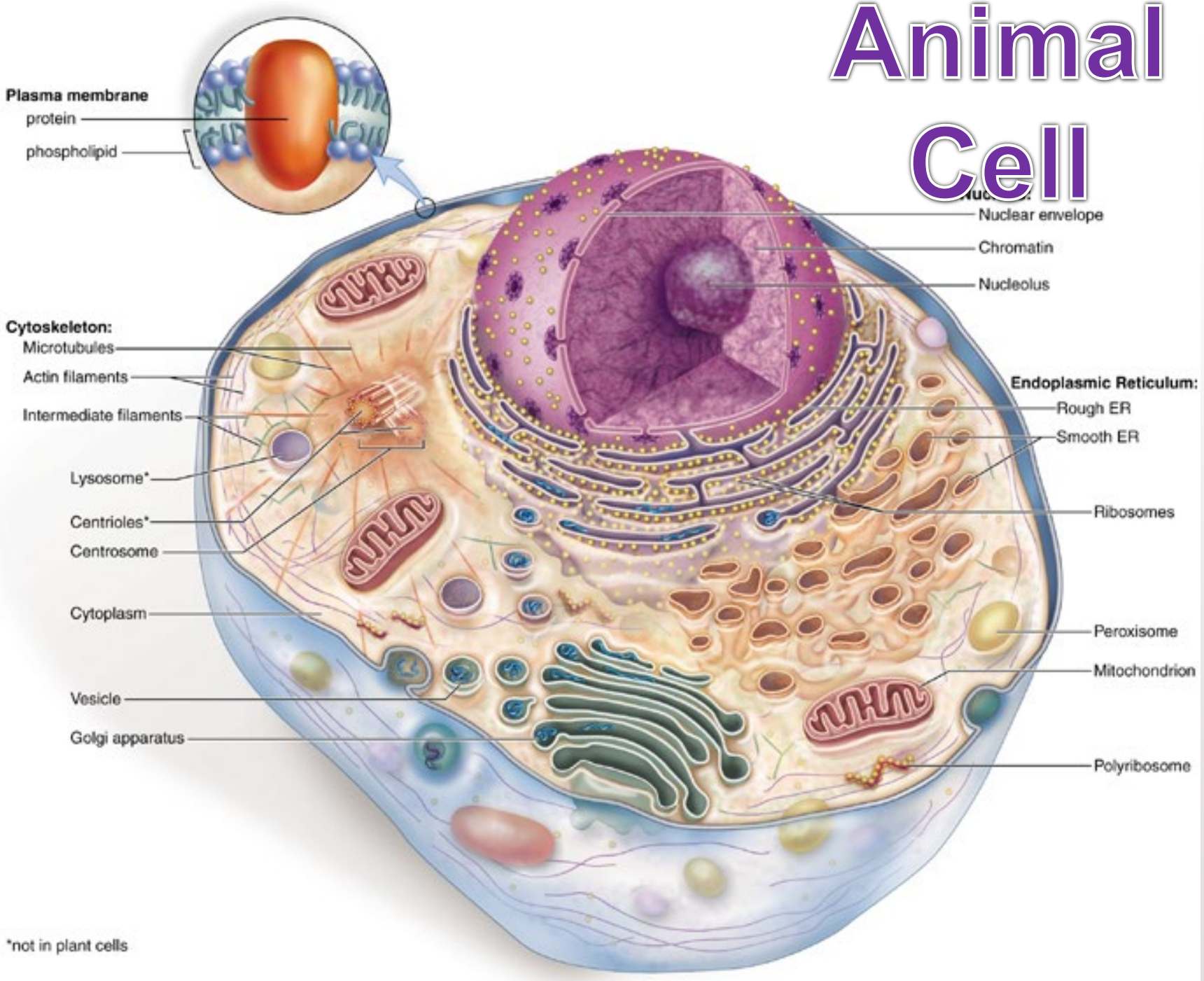
- All organisms are composed of one or more cells
- Cells are the basic living unit of structure and function in organisms
- All cells come only from other cells

Eukaryotic Organelles

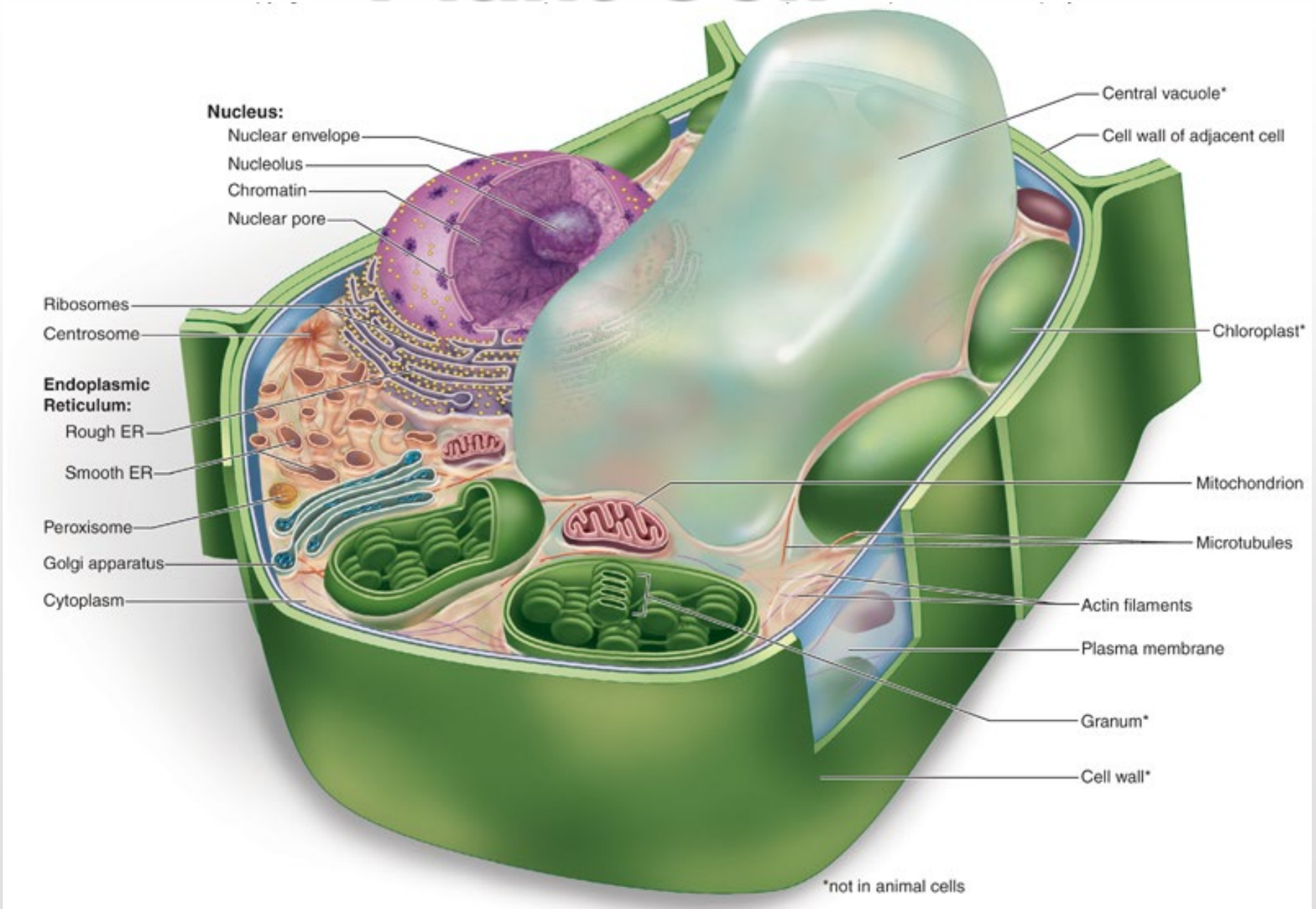
- **What defines a eukaryotic cell?**
  - Has a nucleus
- **How do plant cells differ from animal cells?**
  - Cell wall
    - Primary cell wall→ Cellulose = strength
    - Secondary cell wall → Lignin = even stronger
  - Chloroplasts
    - Chlorophyll → Photosynthesis



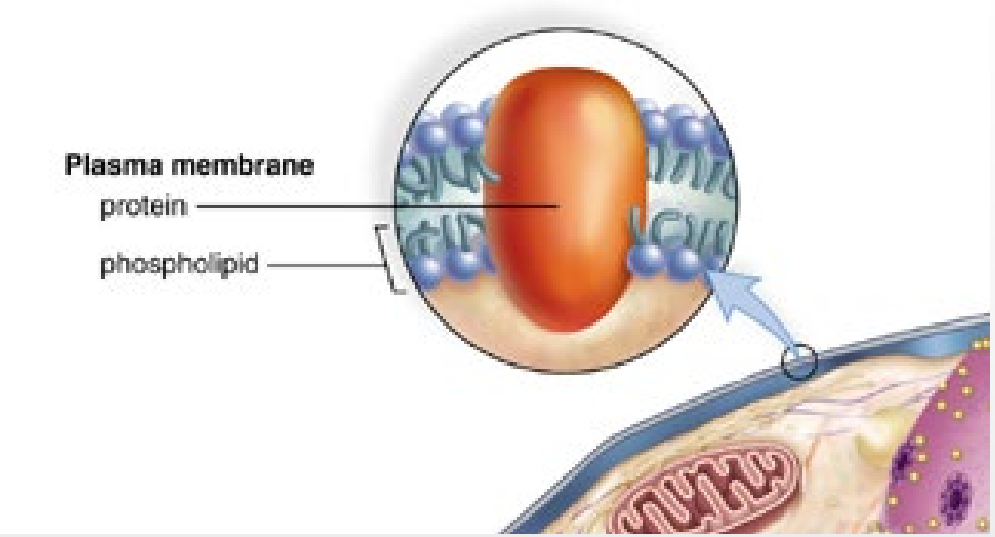
Animal Cell

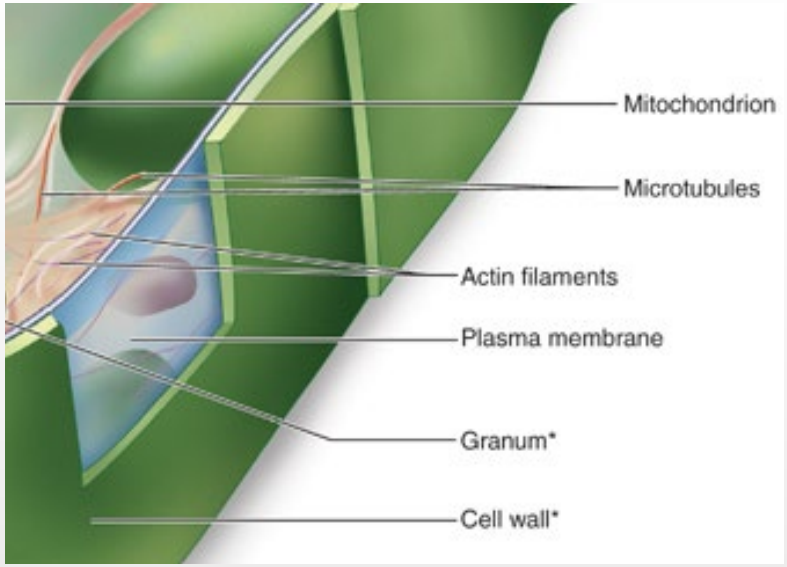

Plasma membrane
protein
phospholipid
Nuclear envelope
Chromatin
Nucleolus
Cytoskeleton:
Microtubules
Actin filaments
Intermediate filaments
Lysosome*
Centrioles*
Centrosome
Cytoplasm
Vesicle
Golgi apparatus
Endoplasmic Reticulum:
Rough ER
Smooth ER
Ribosomes
Peroxisome
Mitochondrion
Polyribosome
*not in plant cells

Plant Cell


Nucleus:
Nuclear envelope
Nucleolus
Chromatin
Nuclear pore
Ribosomes
Centrosome
Endoplasmic Reticulum:
Rough ER
Smooth ER
Peroxisome
Golgi apparatus
Cytoplasm
Central vacuole*
Cell wall of adjacent cell
Chloroplast*
Mitochondrion
Microtubules
Actin filaments
Plasma membrane
Granum*
Cell wall*
*not in animal cells

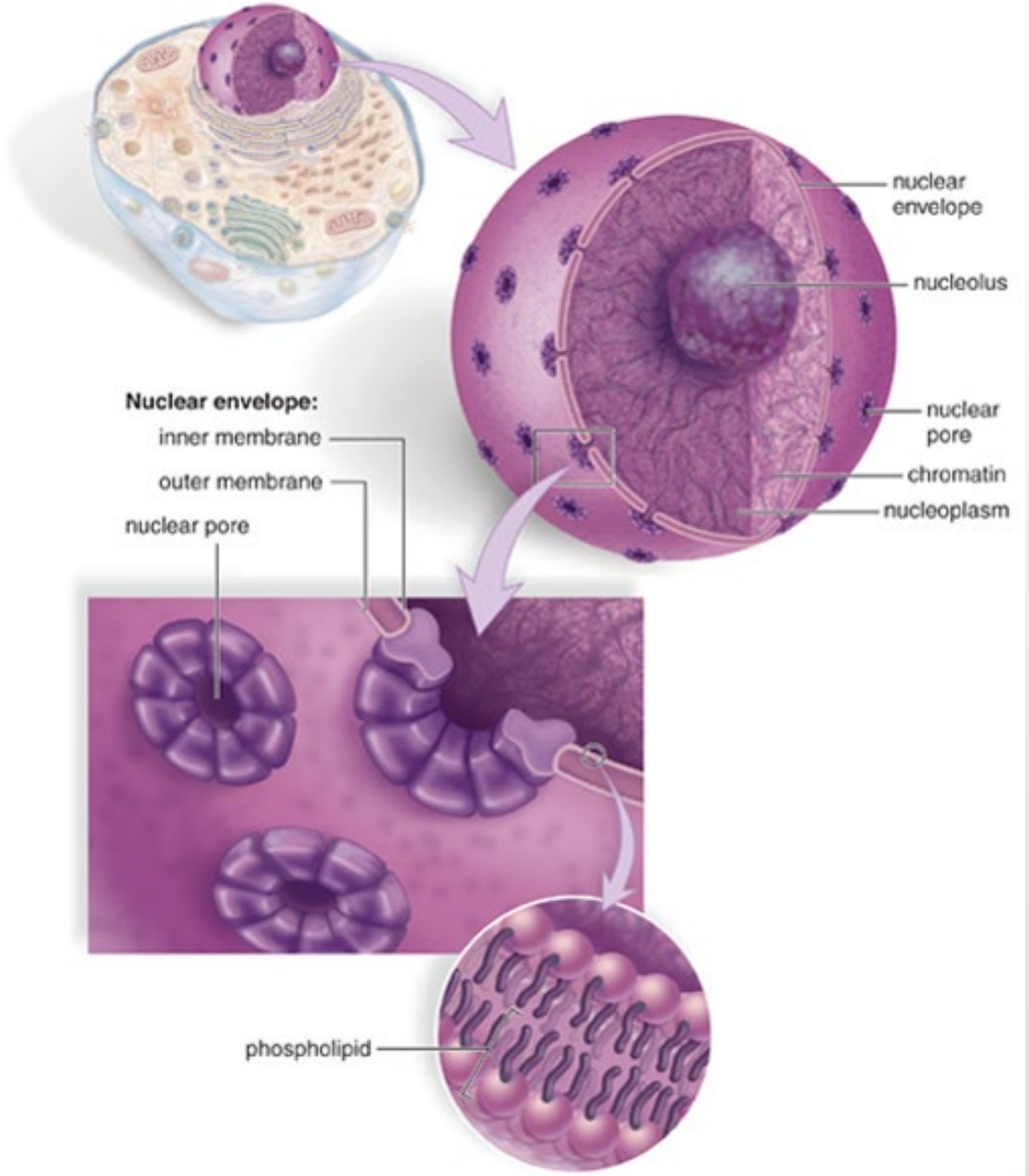
Cell Membrane & Cell wall





- The cell membrane (plasma membrane) creates a cell boundary and helps to regulate the transport of molecules in and out of the cell (in plant & animal cells)
- The cell wall is only found in plants and provides a rigid structure for plant cells – it is made of cellulose

- Stores DNA
  - Controls all cell activities
- Nucleolus
  - site of production and storage of rRNA which join with proteins to form ribosomal subunits
- Nuclear Envelope
  - Nuclear pores for transport of molecules in and out of the nucleus



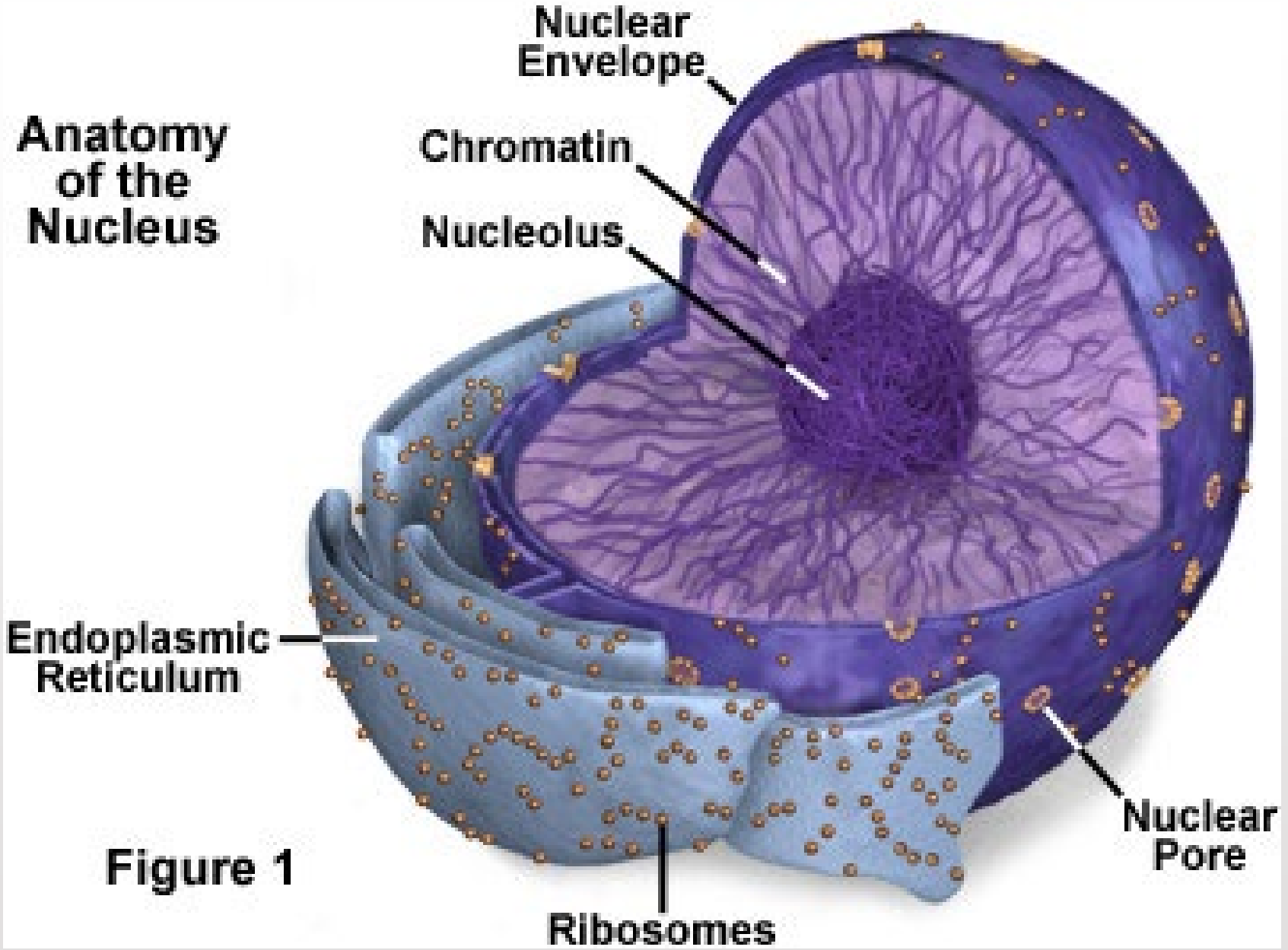
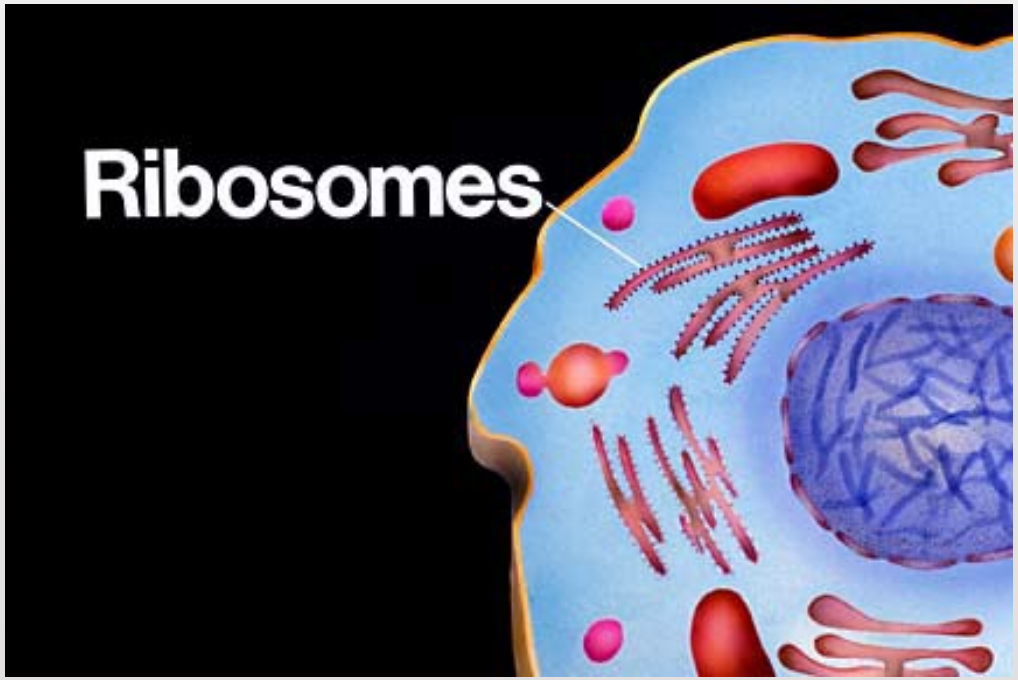
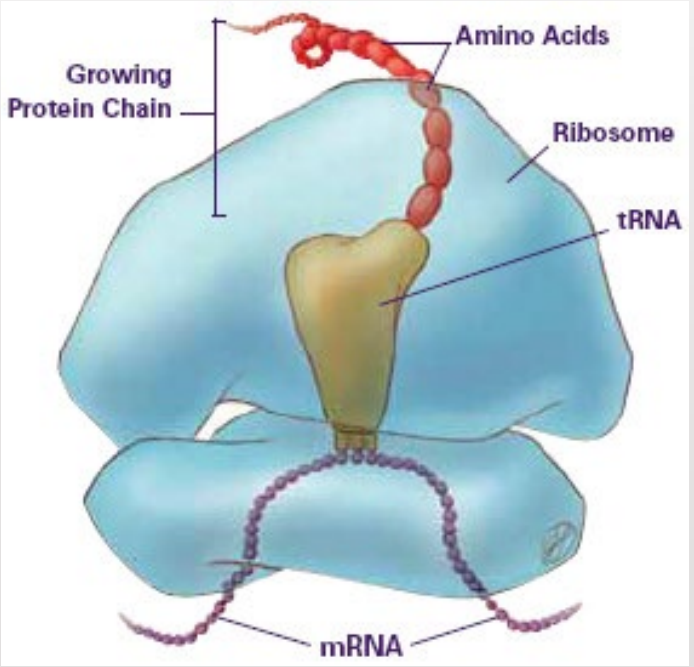

Anatomy of the Nucleus
Nuclear Envelope
Chromatin
Nucleolus
Endoplasmic Reticulum
Nuclear Pore
Ribosomes

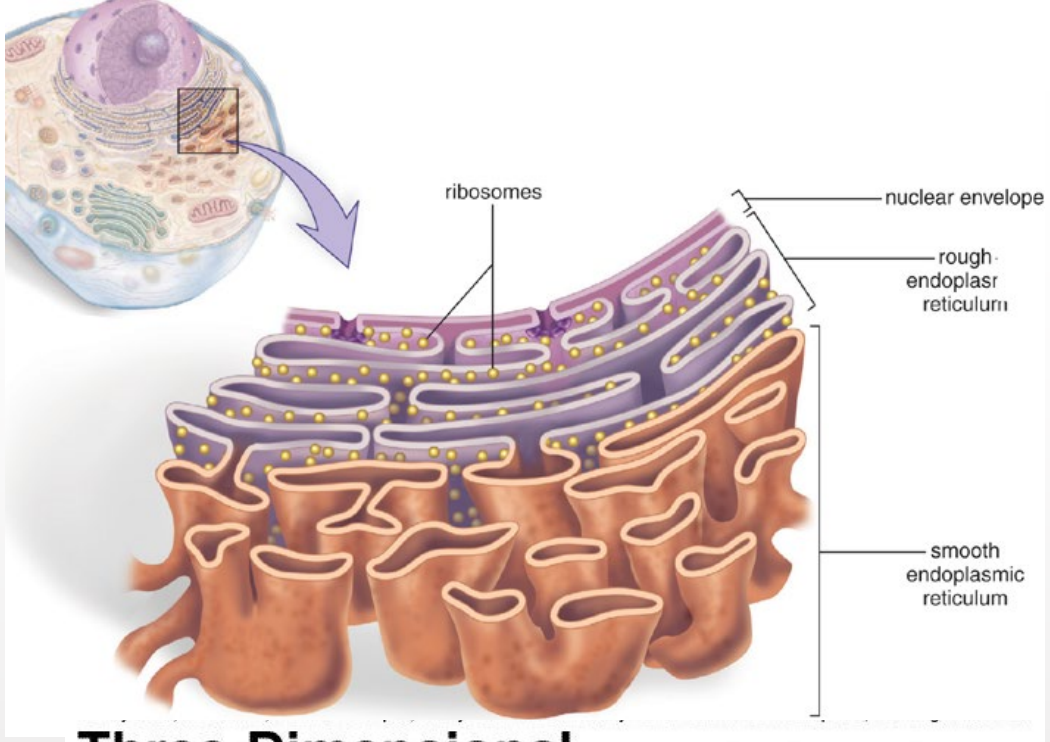
Figure 1

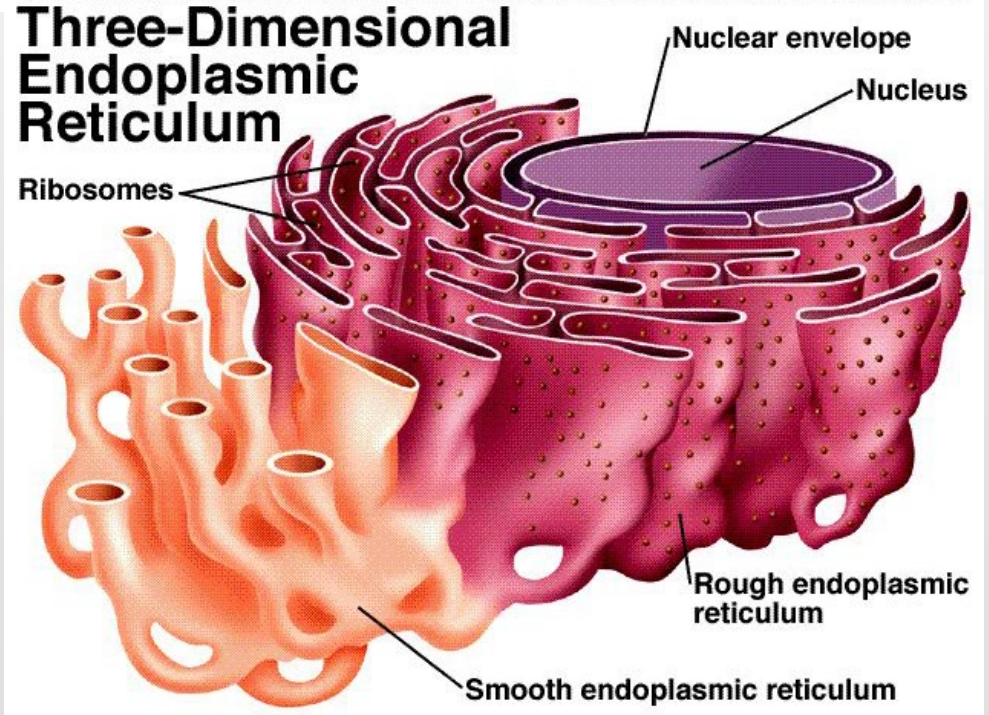
- Site of protein synthesis (where translation occurs)
- Can be free-floating or attached the endoplasmic reticulum
- Two subunits (large and small)
  - Subunits consist of rRNA and protein molecules
- Polyribosomes
  - Several ribosomes translating a single mRNA molecule



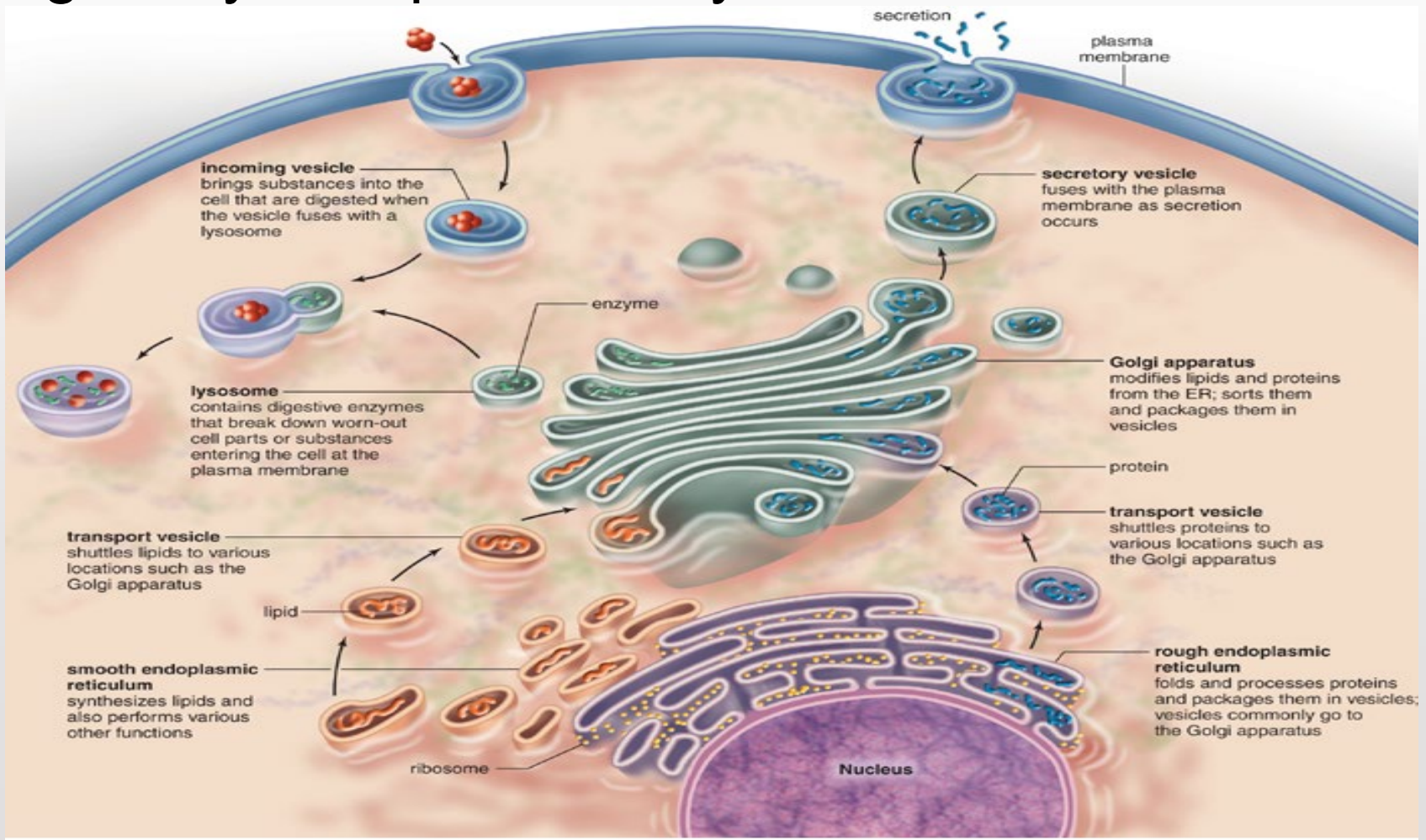


- Consists of membranous channels and saccules
- Rough ER
  - Studded with ribosomes therefore, functions in processing and modification of proteins
- Smooth ER
  - No Ribosomes
  - Synthesizes phospholipids and steroids
  - Also involved in detoxification



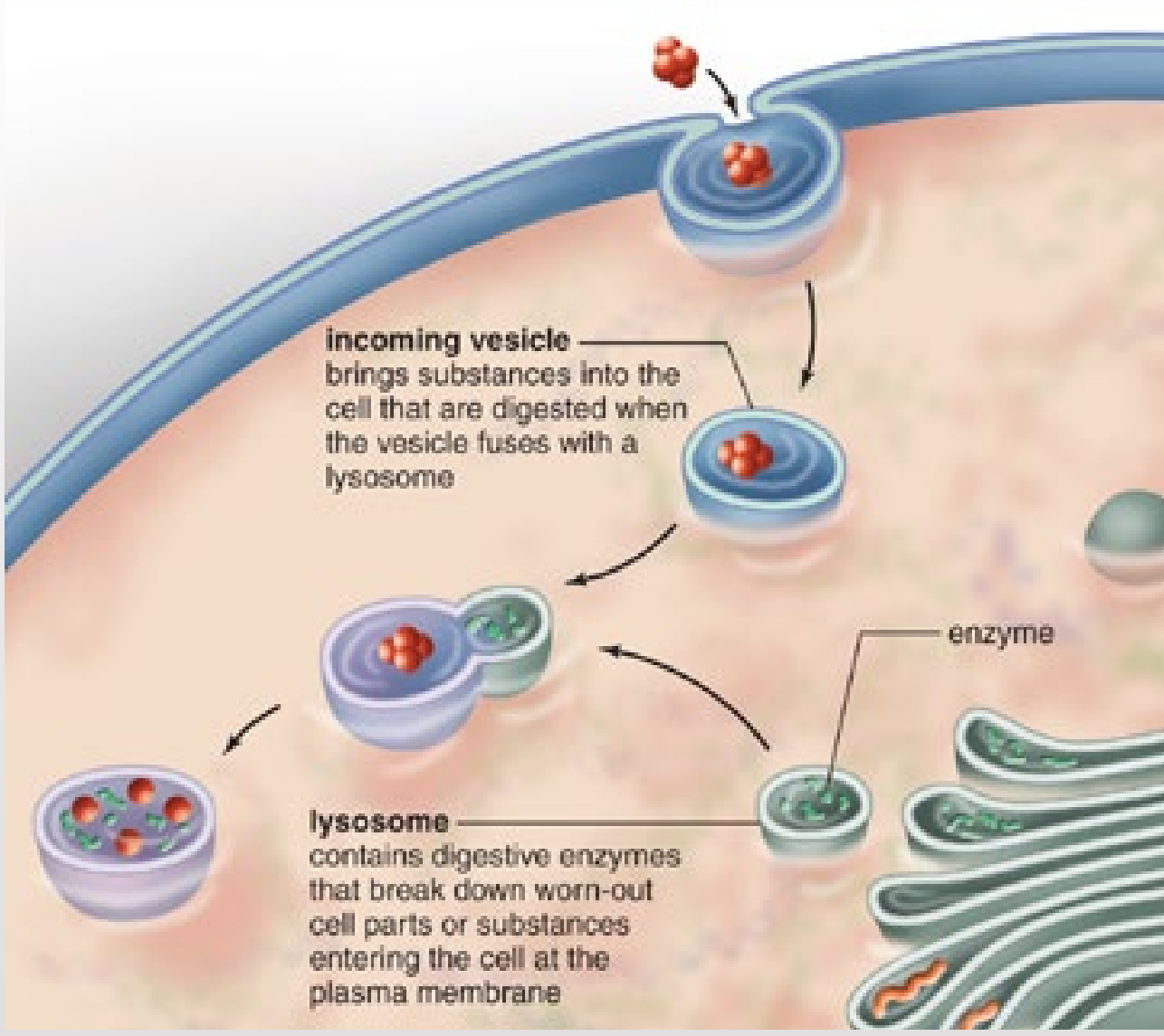


- The Golgi apparatus processes, assembles, modifies, stores and secretes molecules such as proteins and lipids.
- These molecules enter and exit the Golgi Body by vesicles
- The Golgi body also produces lysosomes

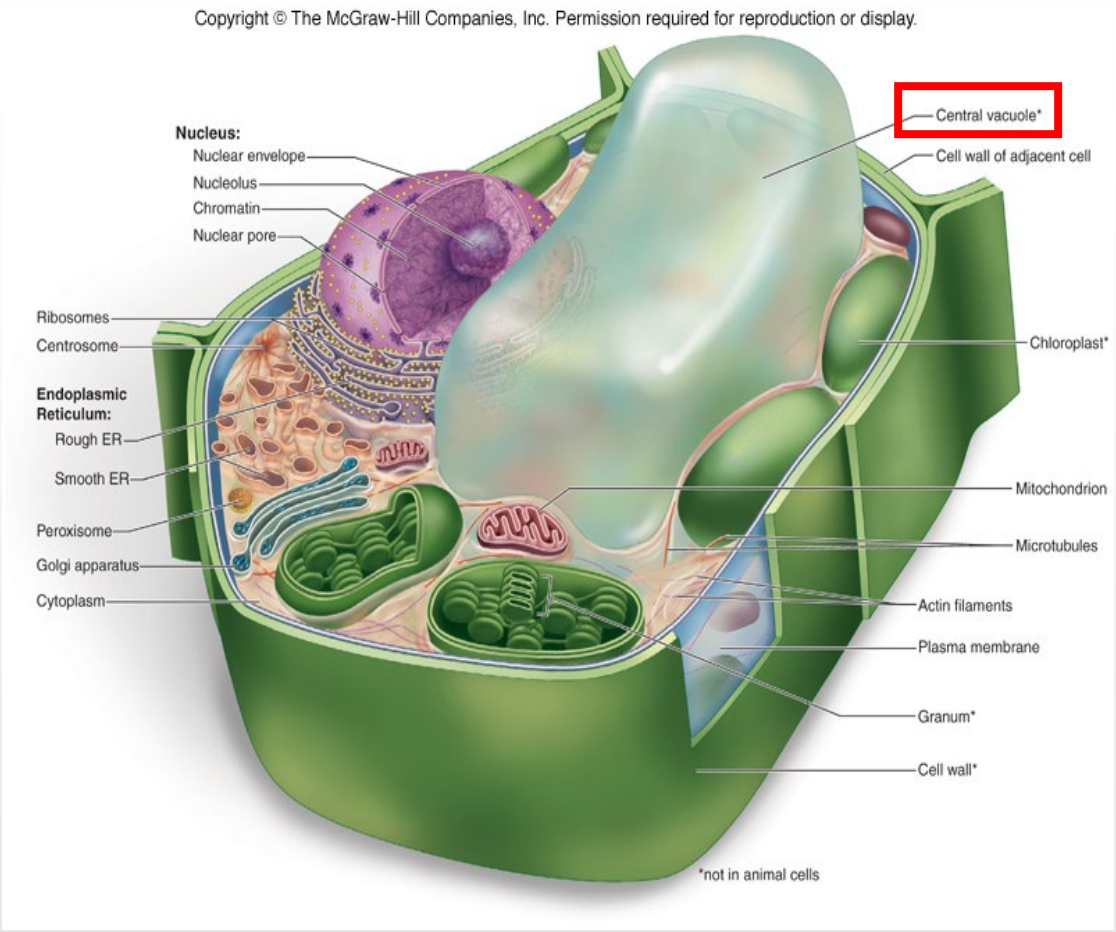


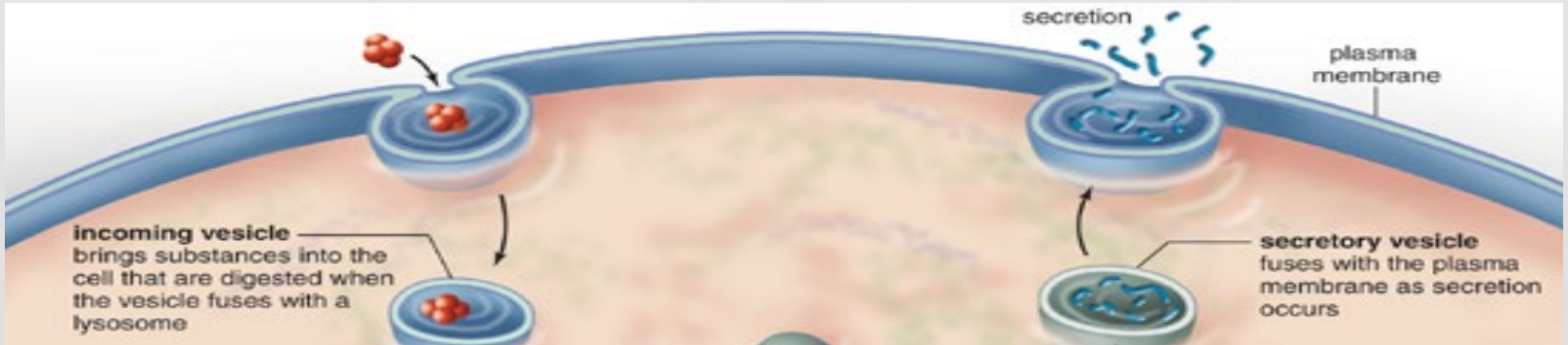
- Lysosomes contain digestive enzymes that break down or hydrolyze unwanted substances, foreign substances or worn- out parts of cells

- Peroxisomes
- Also contain enzymes and fuse with vesicles containing toxins
- Enzymes deactivate substances by forming hydrogen peroxide (H_2O_2)
- H_2O_2 quickly dissociates in the cell into O_2 and H_2O



- Vacuoles and vesicles are membranous sacs that store and/or transport substances.
  For example:
  - Water, Pigments, Toxins, Proteins & Lipids, Foreign molecules, hormones
  - Vesicles are smaller than vacuoles.
  - A large central vacuole is found in the plant cell to store water and other nutrients like starch.

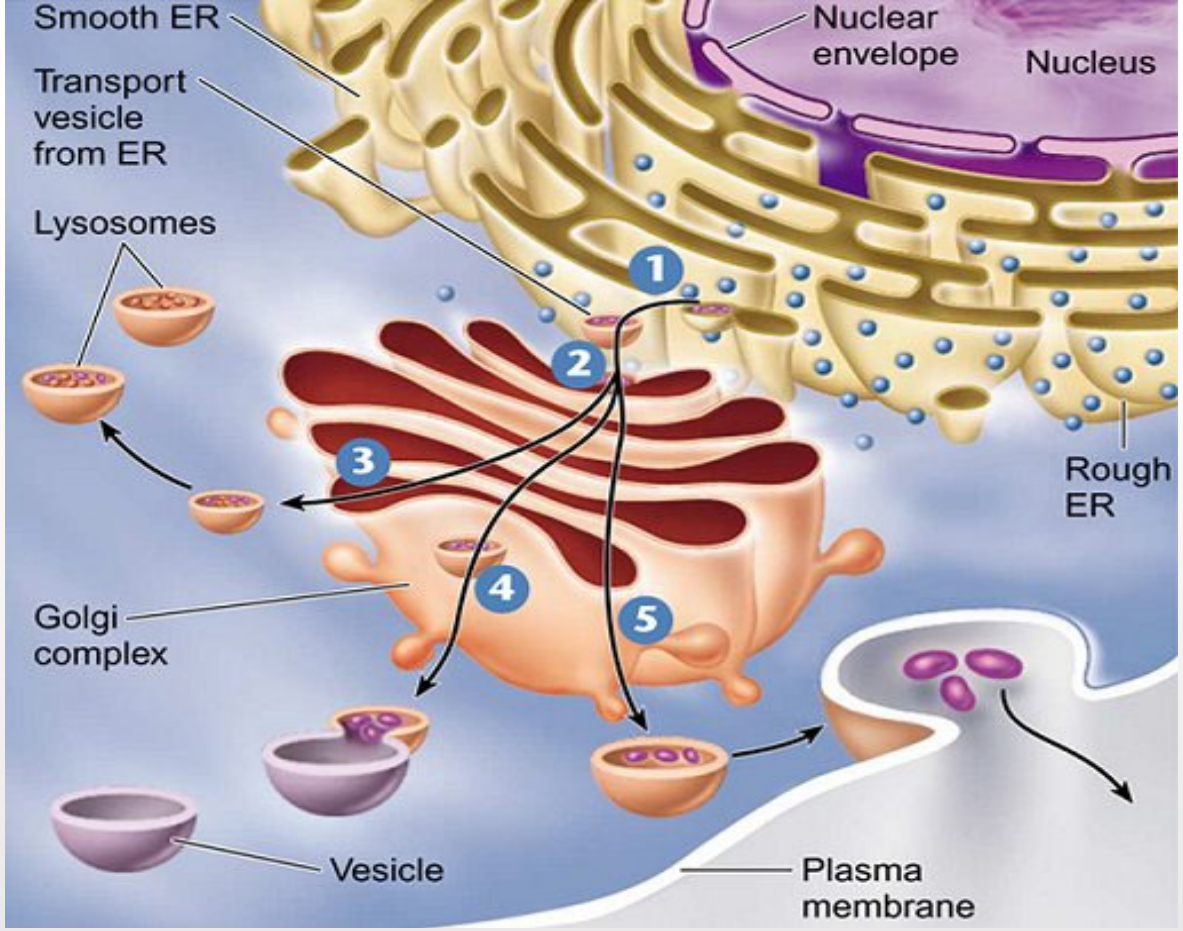




The Endomembrane System

Consists of:

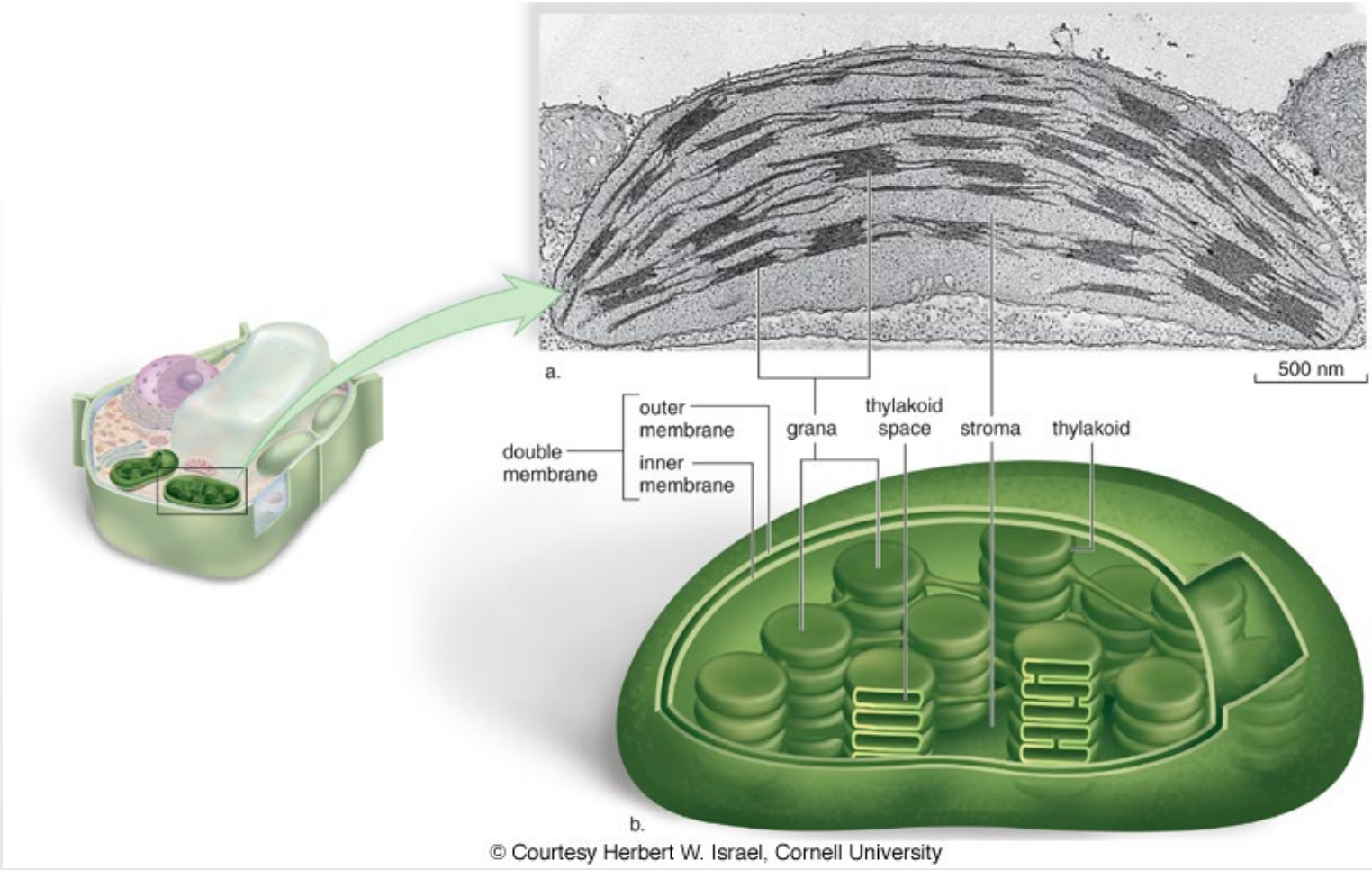
- Nuclear envelope
- Endoplasmic Reticulum
- Golgi Apparatus
- Lysosomes
- Transport Vesicles



1. Molecules like proteins from the RER and lipids from the SER are produced at the ER and are then packaged into transport vesicles
2. These vesicles fuse with the GB where the molecules go through modifications and assembly
3. Some proteins can become enzymes which function in lysosomes for intercellular digestion
4. Some of these molecules can fuse with vesicles and vacuoles for storage
5. Some of the molecules are packaged into secretory vesicles for exocytosis (secretion) out of the cell at the cell membrane

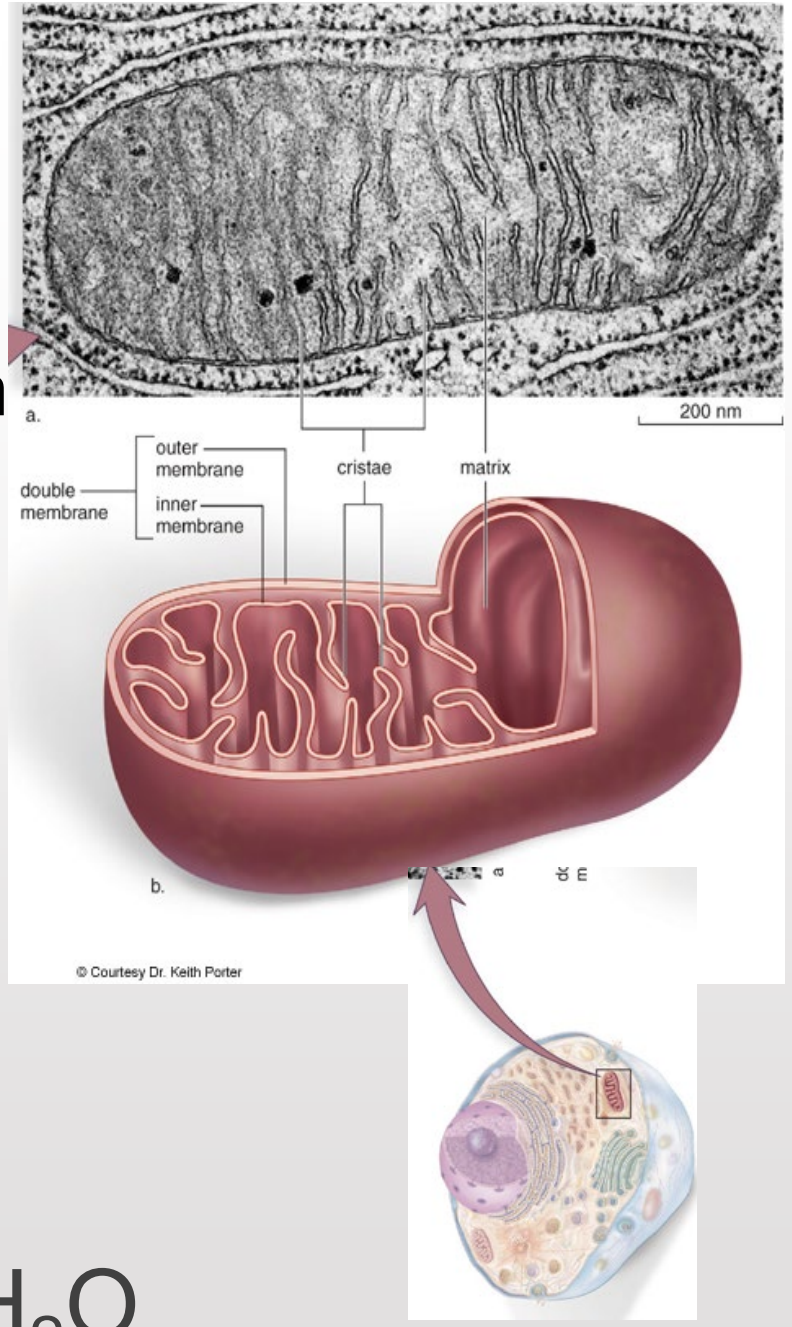
- Only found in plants
- Site of photosynthesis where suns energy, along with carbon dioxide and water is converted into oxygen and glucose for the mitochondria to produce cell's energy ATP.

- Structure:
  - Double-membrane with extensive folding forming the grana, which are stacks of thylakoids
  - Increased surface area for maximal photosynthesis



$$\text{Sunlight} + CO_2 + H_2O \rightarrow O_2 + C_6H_{12}O_6$$

- Found in all animal and plant cells
- Site of cellular respiration (cell metabolism) where oxygen and glucose are converted to ATP for cell energy
- In animals, Oxygen is from the respiratory system and glucose is from digestion
- In plants, oxygen and glucose are produced from the chloroplast during photosynthesis
- Structure:
  - Double-membrane where the inner membrane folds to increase surface area for cellular respiration
  - The folded membrane is call the cristae and the inner space is the matrix



$$O_2 + C_6H_{12}O_6 \rightarrow ATP + CO_2 + H_2O$$

Chloroplasts

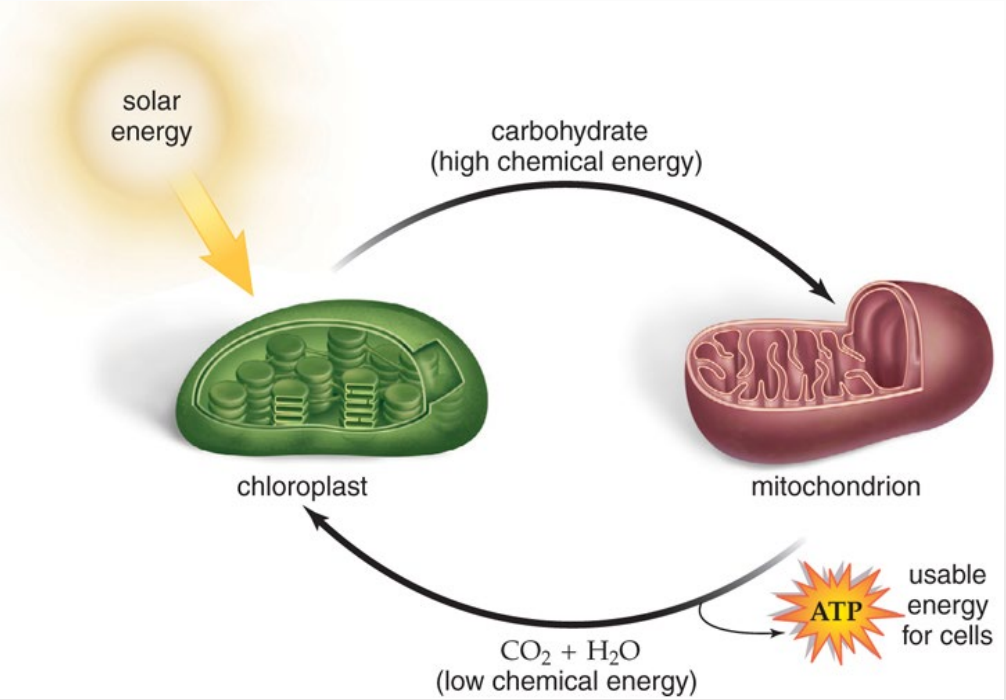
Photosynthesis

Sunlight + CO_2 + H_2O → O_2 + $C_6H_{12}O_6$

Mitochondria

Cellular Respiration

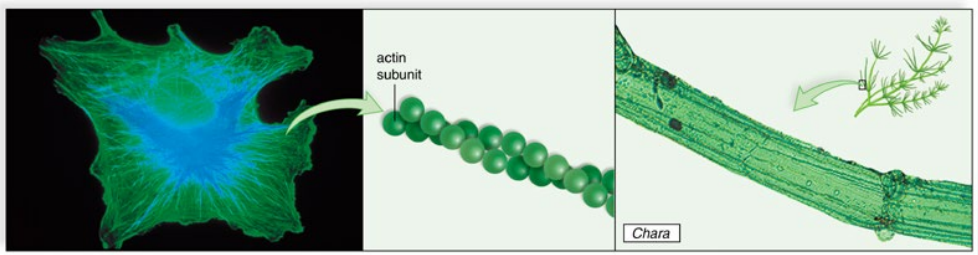
O_2 + $C_6H_{12}O_6$ →ATP + CO_2 + H_2O



During photosynthesis, sunlight, CO2, & water are used to make the glucose & O2 that the mitochondria uses for cellular respiration to produce the cell's ATP supply.

The wastes, CO2 & H2O can be reused in the chloroplast for photosynthesis.

- Maintains cell shape & assists in movement of the cell and organelles within it
- The cytoskeleton is attached to the inside of the cell membrane and vesicles move to and from the cell membrane on the cytoskeleton
- Three types of macromolecular fibers
  - Actin Filaments
    - Thin protein strands
  - Intermediate Filaments
    - Medium protein strands
  - Microtubules
    - Thick protein strands
    - Also forms structure of centrioles, basal bodies, cilia & flagella



a. Actin filaments

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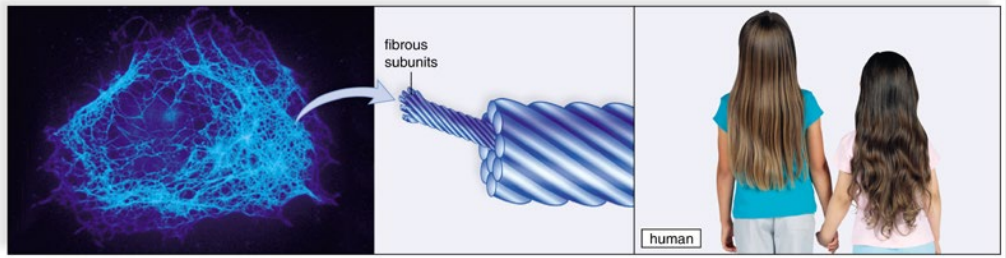

b. Intermediate filaments

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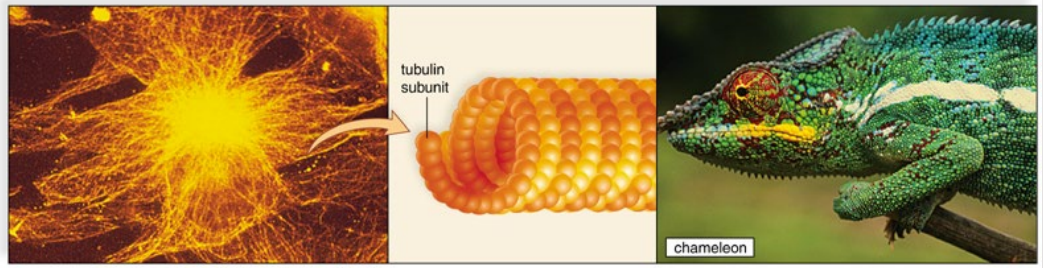
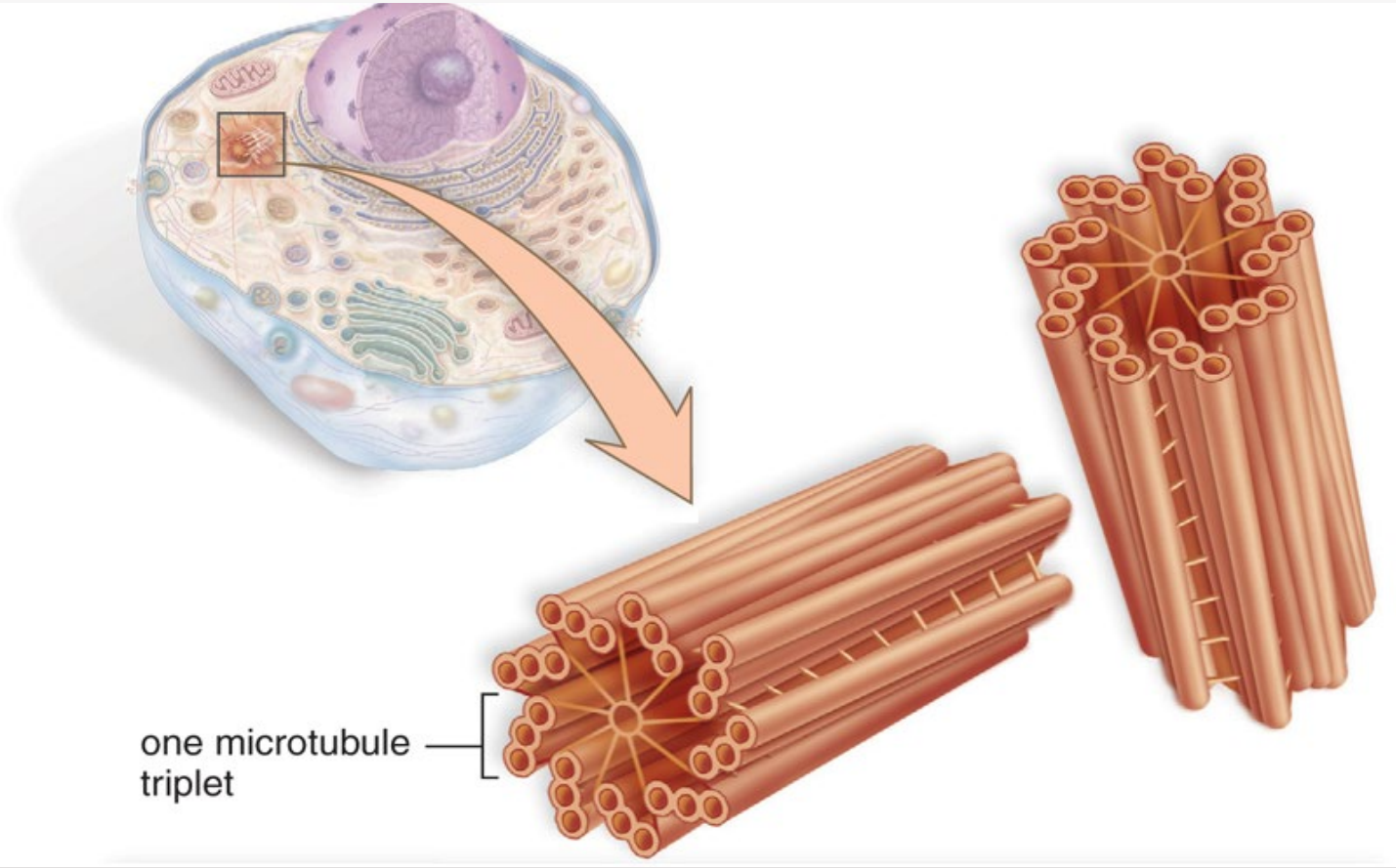


c. Microtubules

© K.G. Murti/Visuals Unlimited

- Short cylinders with a 9 + 0 pattern of microtubule triplets
- Help organize microtubules during animal cell division
- Form the structure of basal bodies which also have a 9+0 pattern
- Basal Bodies: may be involved in microtubule formation and in the organization of microtubules used to make cilia and flagella



- Hair-like projections that aid in cell movement
- cilia are usually shorter than flagella
- Cilia move in an oar-like motion whereas flagella move in a whip-like action
- The microtubules are arranged in a 9 + 2 pattern

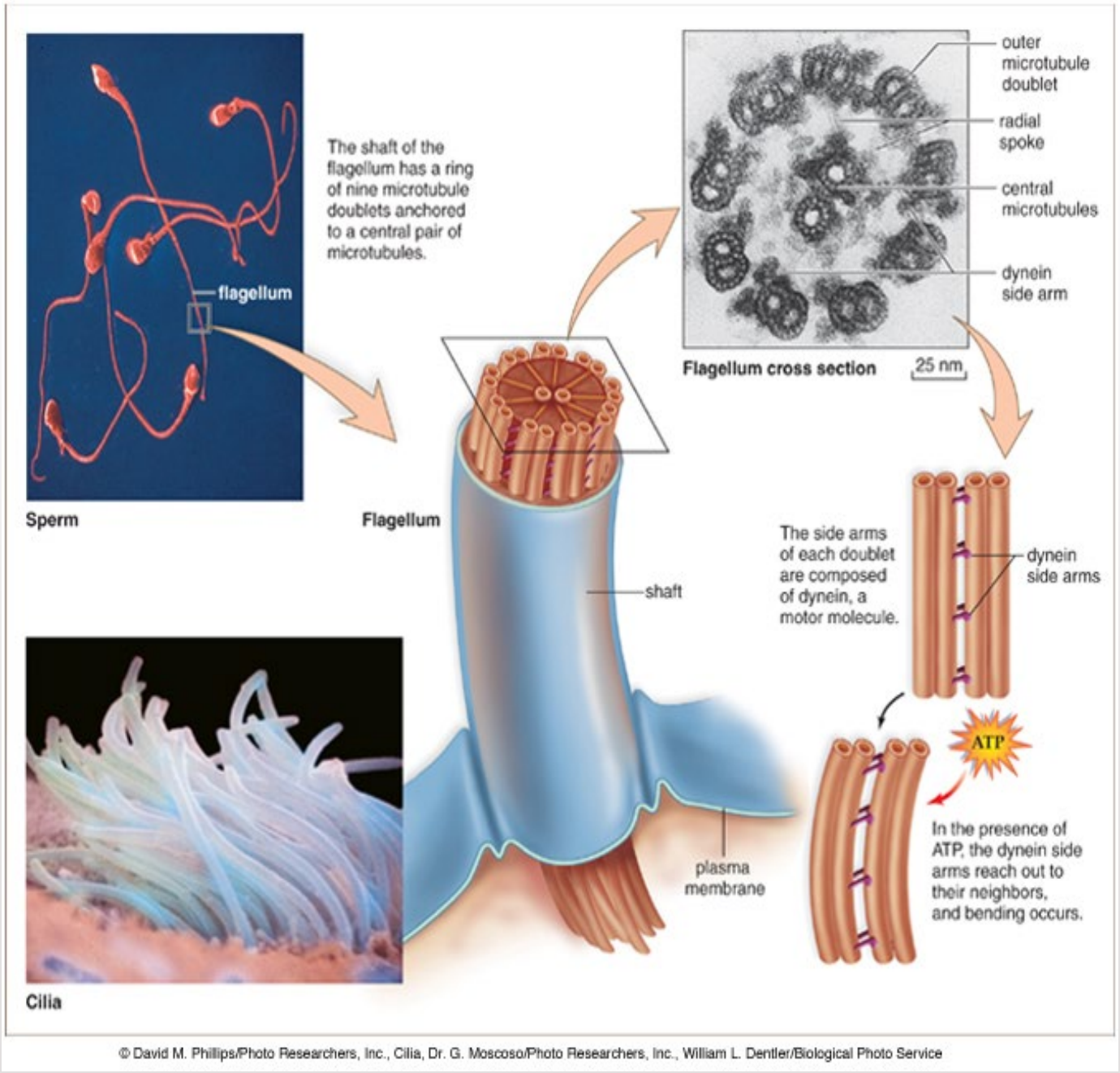


TABLE 3.2 Eukaryotic Structures in Animal Cells and Plant Cells

Structure	Composition	Function
Cell wall*	Contains cellulose fibrils	Support and protection
Plasma membrane	Phospholipid bilayer with embedded proteins	Defines cell boundary; regulates molecule passage into and out of cells
Nucleus	Nuclear envelope, nucleoplasm, chromatin, and nucleoli	Storage of genetic information; synthesis of DNA and RNA
Nucleolus	Concentrated area of chromatin, RNA, and proteins	Ribosomal subunit formation
Ribosome	Protein and RNA in two subunits	Protein synthesis
Endoplasmic reticulum (ER)	Membranous flattened channels and tubular canals	Synthesis and/or modification of proteins and other substances, and distribution by vesicle formation
Rough ER	Network of folded membranes studded with ribosomes	Folding, modification, and transport of proteins
Smooth ER	Having no ribosomes	Various; lipid synthesis in some cells

TABLE 3.2 Eukaryotic Structures in Animal Cells and Plant Cells

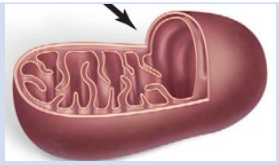
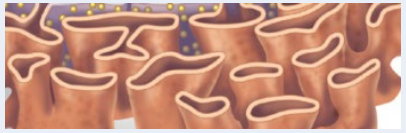
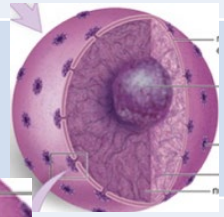
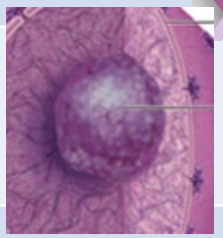
Structure	Composition	Function
Golgi apparatus	Stack of membranous saccules	Processing, packaging, and distribution of proteins and lipids
Lysosome**	Membranous vesicle containing digestive enzymes	Intracellular digestion
Vacuole and vesicle	Membranous sacs	Storage of substances
Peroxisome	Membranous vesicle containing specific enzymes	Various metabolic tasks
Mitochondrion	Inner membrane (cristae) bounded by an outer membrane	Cellular respiration
Chloroplast*	Membranous grana bounded by two membranes	Photosynthesis
Cytoskeleton	Microtubules, intermediate filaments, actin filaments	Shape of cell and movement of its parts
Cilia and flagella	9 + 2 pattern of microtubules	Movement of cell
Centriole**	9 + 0 pattern of microtubules	Formation of basal bodies

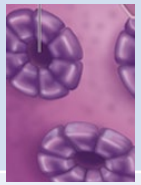
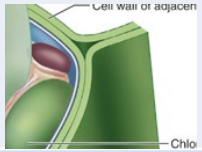
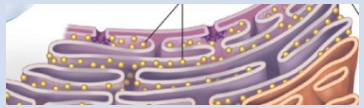
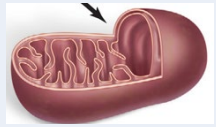
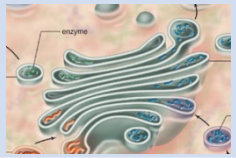
* *Plant cells only.*
** *Animal cells only.*

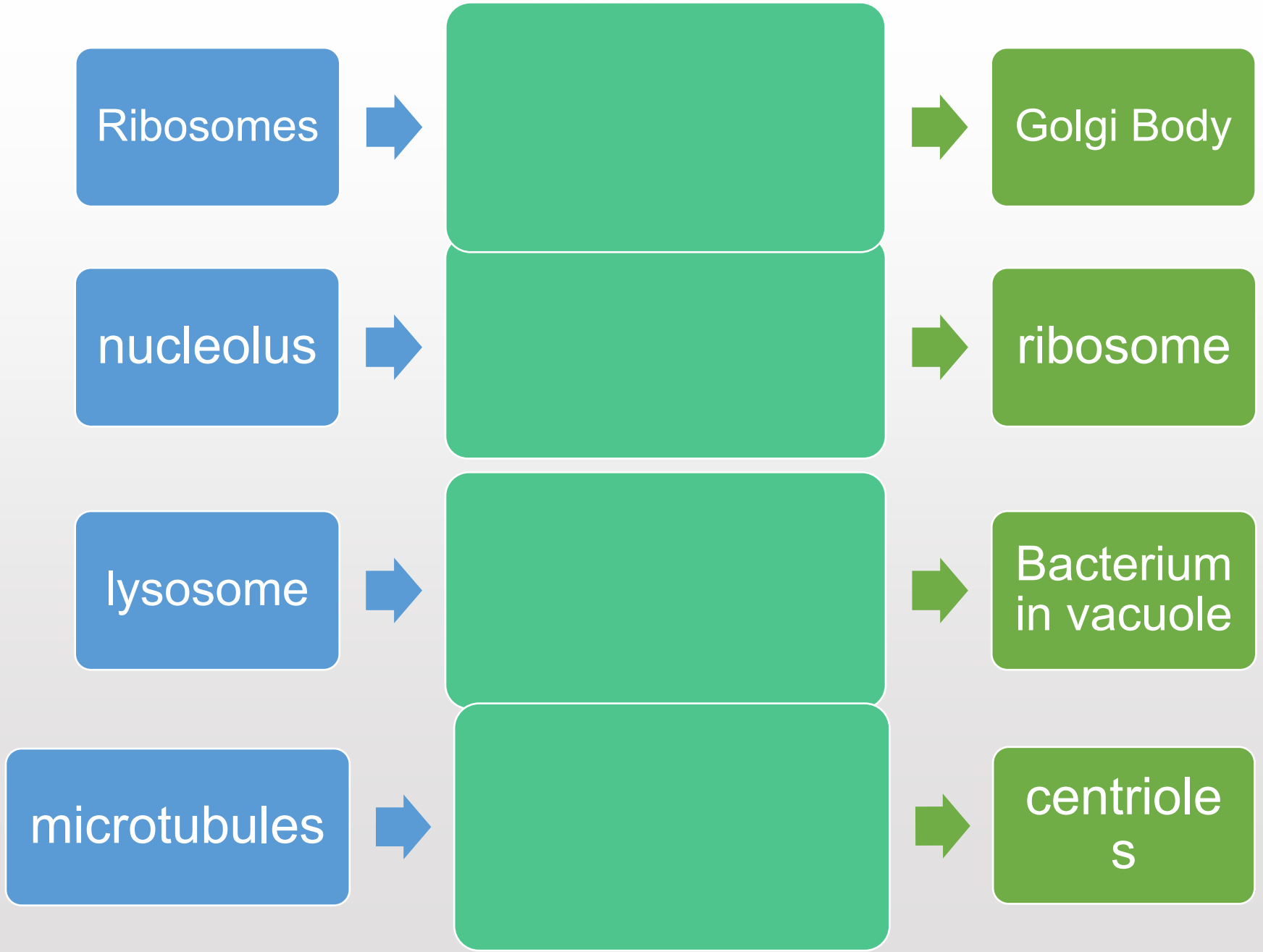
Organelle	Plant or Animal	Function
	Both	Regulate transport of molecules in/out of cell
	Plant only	Provides structure to plant cell
	Both	Jelly-like fluid where organelles & molecules move
	Both	Transports molecules around the cell
	Both	Site of protein synthesis; attached to ER
	Both	Processes, modifies & packages proteins and lipids
	Both	Studded with ribosomes & site of protein synthesis
	Both	Site of lipid synthesis & detoxification
	Plant only	Stores water, starch and other molecules
	Plant only	Site of photosynthesis – converting sunlight & CO_2 to glucose & O_2

	Both	Site of cellular respirations – converting glucose & O_2 to H_2O, CO_2 & ATP energy
	Both	Controls all cell functions
	Both	Where rRNA & proteins form the subunits of ribosomes
	Both	Surrounds DNA and is continuous with the endoplasmic reticulum
	Animal only	Involved in making spindle fibers during cell division & forms basal bodies
	Animal only	Fuse with vesicles, vacuoles & old organelles for intercellular digestion
	Both	Forms the cytoskeleton for anchoring & transporting organelles and forms structure cilia & flagella for cell movement (also forms structure of centrioles & basal bodies)
	Both	Openings in nucleus that allow molecules like proteins & RNA to exit the nucleus

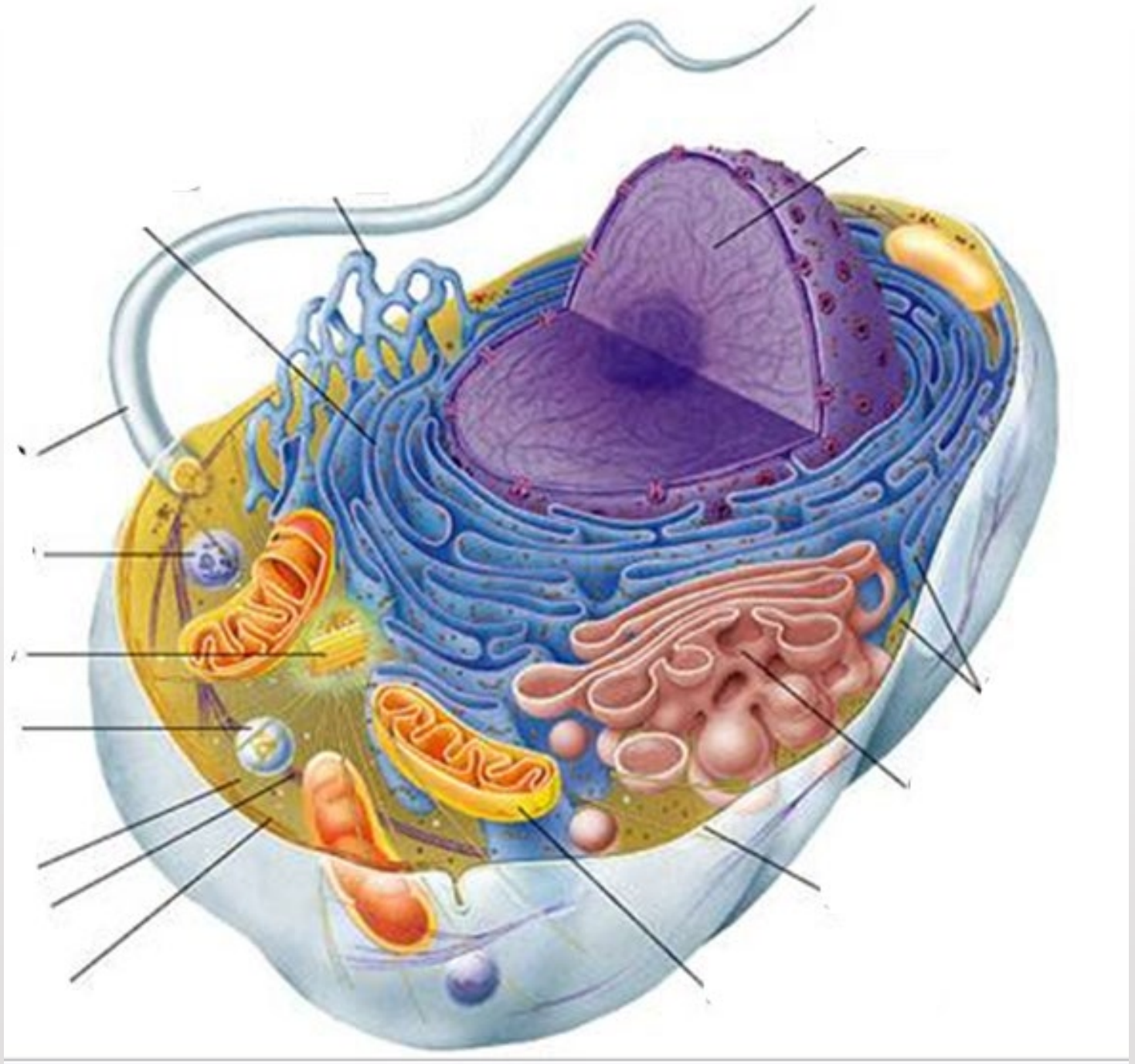
Organelle ANSWERS	Plant or Animal	Function
Cell membrane	Both	Regulate transport of molecules in/out of cell
Cell wall	Plant only	Provides structure to plant cell
Cytoplasm	Both	Jelly-like fluid where organelles & molecules move
Vacuole & vesicle	Both	Transports molecules around the cell
Ribosome	Both	Site of protein synthesis; attached to ER
Golgi	Both	Processes, modifies & packages proteins and lipids
Rough ER	Both	Studded with ribosomes & site of protein synthesis
Smooth ER	Both	Site of lipid synthesis & detoxification
Central Vacuole	Plant only	Stores water, starch and other molecules
Chloroplast	Plant only	Site of photosynthesis – converting sunlight & CO_2 to glucose & O_2
Mitochondria	Both	Site of cellular respirations – converting glucose & O_2 to H_2O, CO_2 & ATP energy
Nucleus	Both	Controls all cell functions
Nucleolus	Both	Where rRNA & proteins form the subunits of ribosomes
Nuclear membrane	Both	Surrounds DNA and is continuous with the endoplasmic reticulum
Centrioles	Animal only	Involved in making spindle fibers during cell division & forms basal bodies
Lysosomes	Animal only	Fuse with vesicles, vacuoles & old organelles for intercellular digestion
Microtubules	Both	Forms the cytoskeleton for anchoring & transporting organelles and forms structure cilia & flagella for cell movement (also forms structure of centrioles & basal bodies)
Nuclear pores	Both	Openings in nucleus that allow molecules like proteins & RNA to exit the nucleus

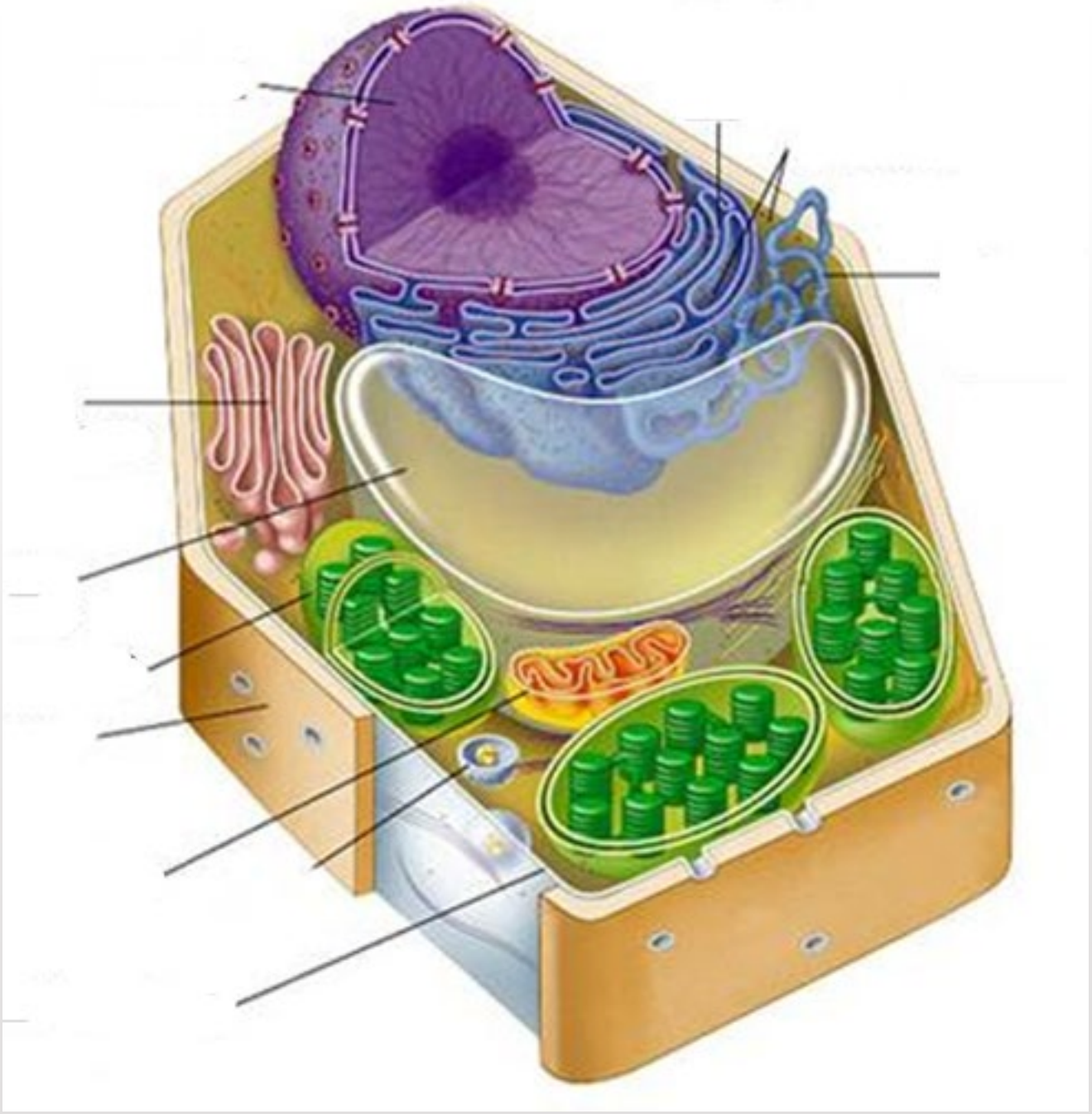
Organelle	Function
	$O_2 + C_6H_{12}O_6 \rightarrow CO_2 + H_2O + ATP$
	$CO_2 + H_2O + ATP \rightarrow O_2 + C_6H_{12}O_6$
	Contains hydrolytic enzymes and fuses with vesicles/vacuoles to digest contents
	Produces steroids and detoxifies
	Stores genetic information which determines cell functions
	rRNA & proteins form the subunits of ribosomes here
	Produces lysosomes

Organelle	Function
	Openings allow molecules to enter and exit the nucleus
	Made of cellulose and gives structure to plant
	High surface area for producing proteins
	Transports small molecules throughout the cell
	Involved in cell division and forms basal bodies
	High surface area for cellular respiration
	Packages and assembles proteins and lipids


Ribosomes
nucleolus
lysosome
microtubules
Golgi Body
ribosome
Bacterium in vacuole
centrioles

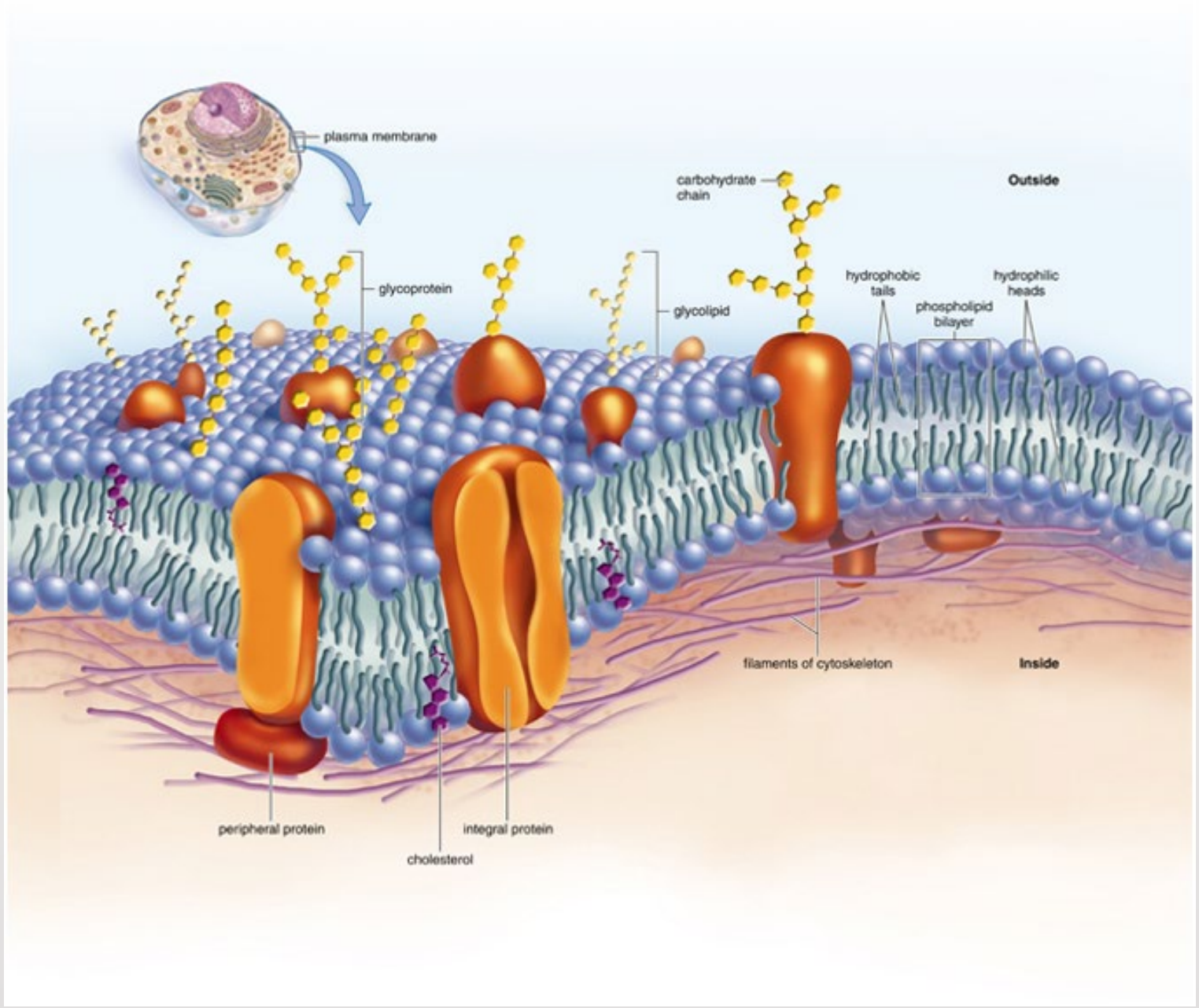
1.	**The cells of the adrenal glands would contain high numbers of which organelle and why?**
2.	Describe (briefly) the functions of the cell membrane.
3.	How do the mitochondria and chloroplast relate?
4.	How do microtubules relate to the cytoskeleton, cilia and flagella?
5.	What's the difference between the Smooth ER and the Rough ER?





Chapter 3 continued: Cell Membrane Transport

- Phospholipid bilayer
- Proteins
  - Carrier
  - Channel
  - Cell recognition
  - Receptor
  - Enzymatic
- Carbohydrate chains
  - Glycolipid
  - glycoprotein
- Cholesterol



channel protein

Enzymatic protein

Receptor protein

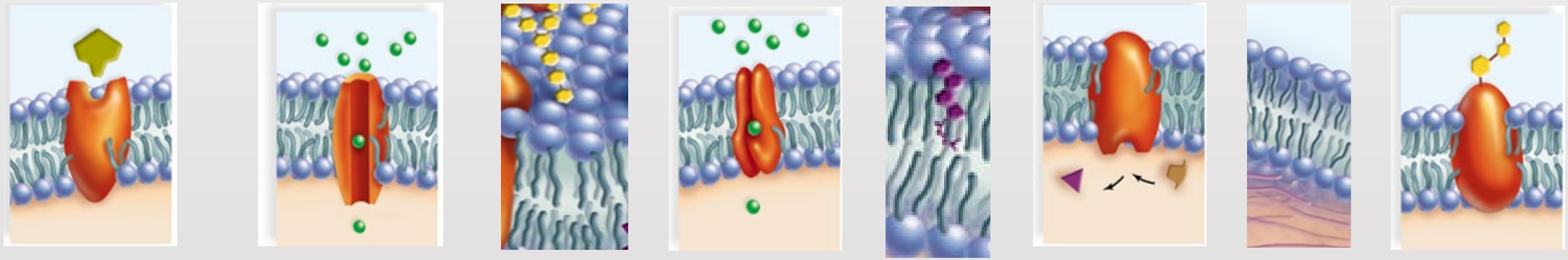
Phospholipid bilayer

Carrier protein

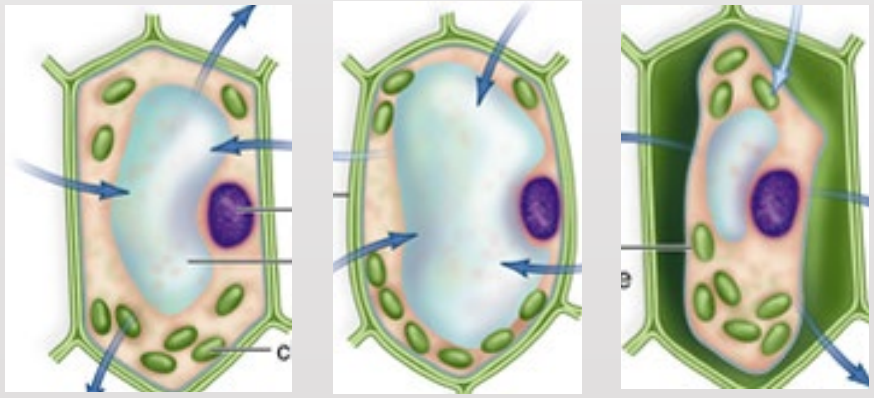
glycoprotein

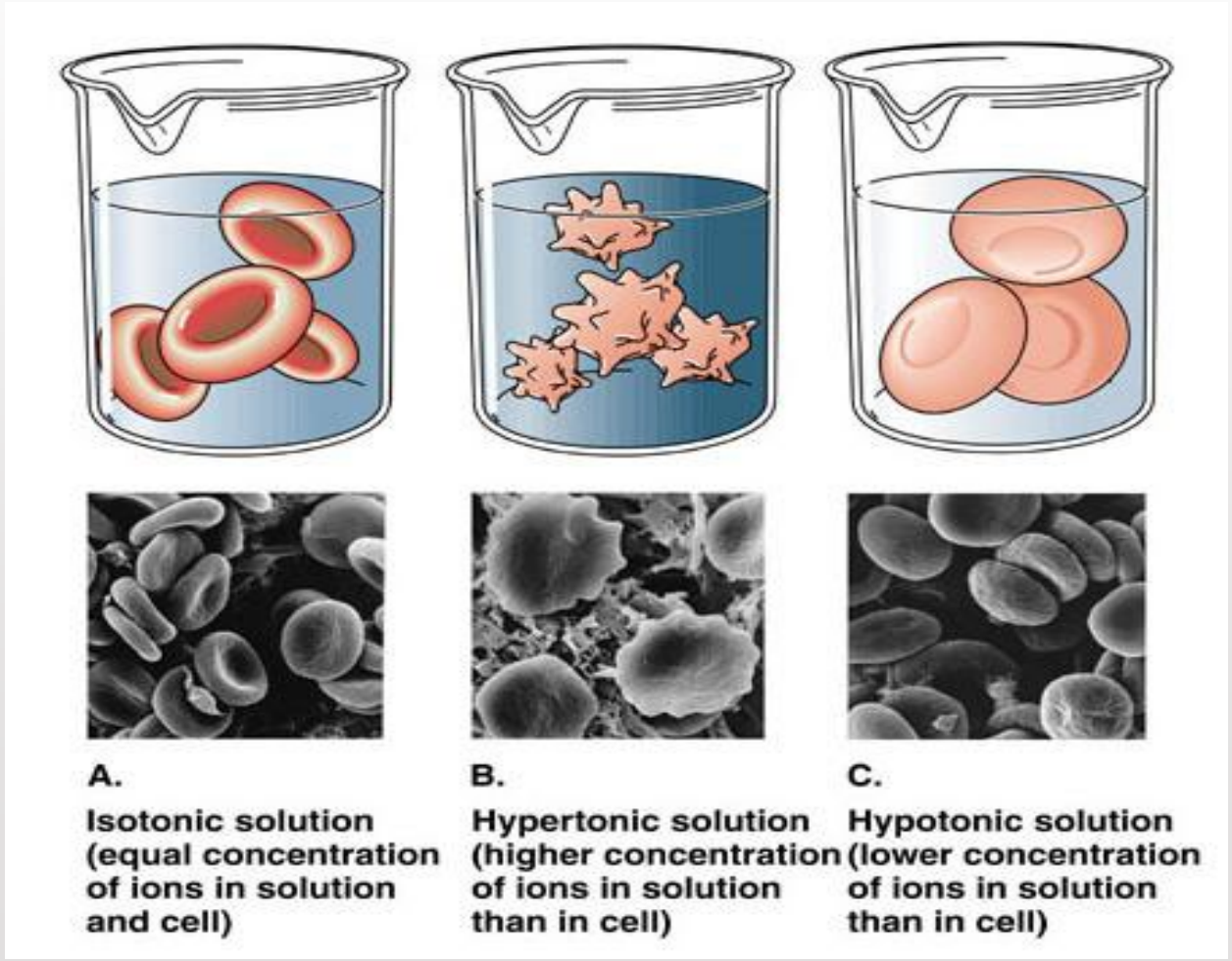
glycolipid

cholesterol



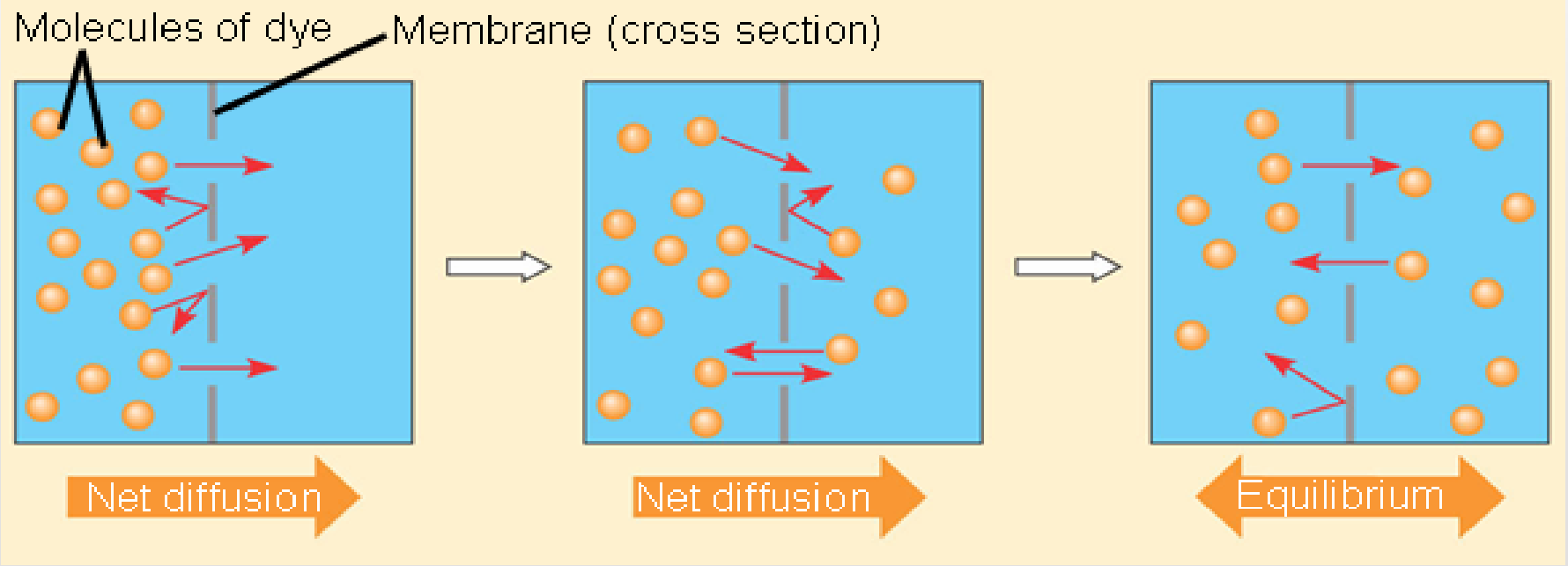
- Diffusion
  - Molecules go from high to low concentration
  - Small lipid- soluble molecules (ex. O2, CO2)
- Osmosis
  - Diffusion of water
  - Isotonic
  - Hypotonic
  - Hypertonic





Diffusion

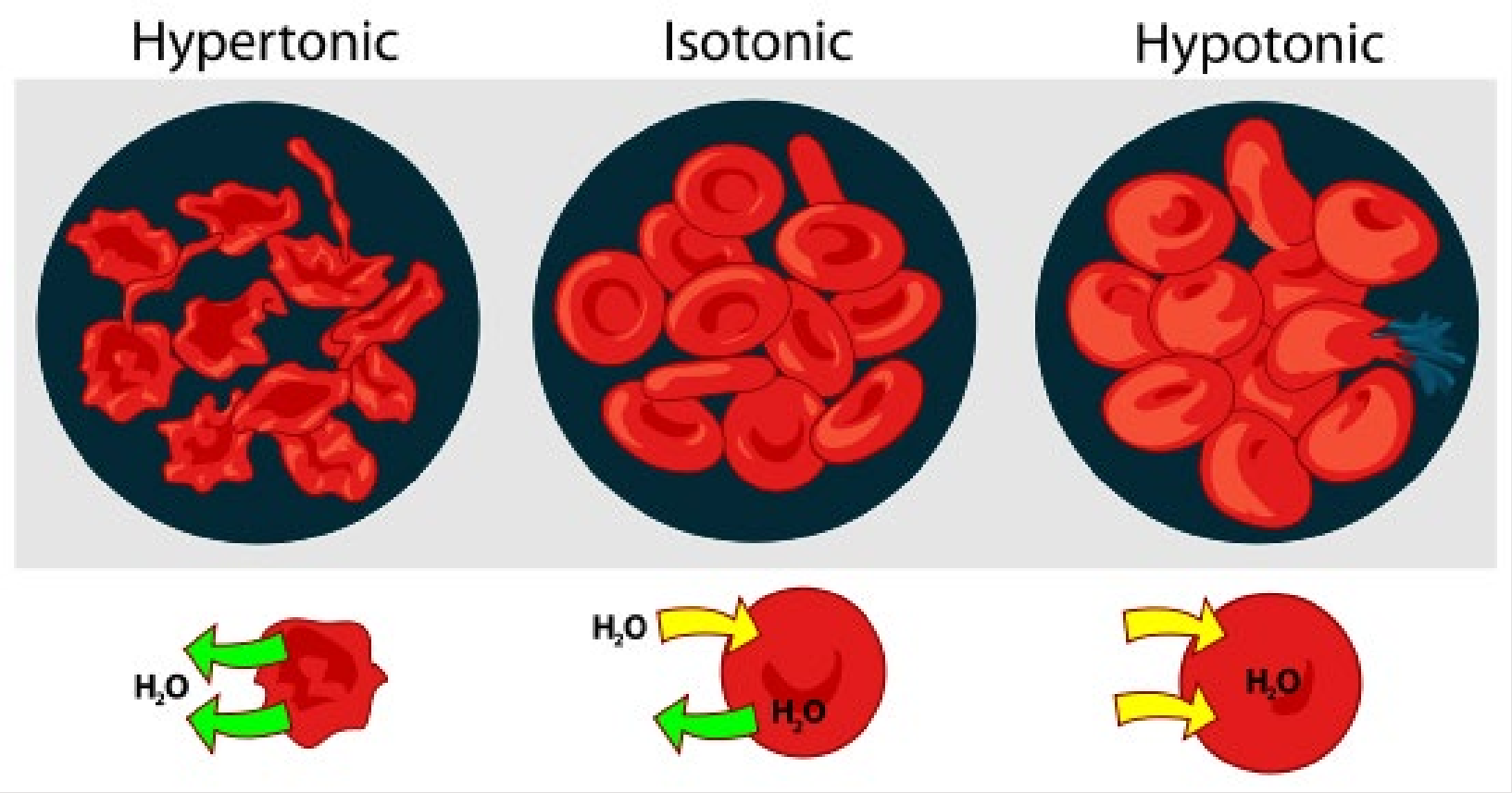
- Diffusion
  - Is the tendency for molecules of any substance to spread out evenly into the available space
  - Move from high to low concentration
  - Down the concentration gradient



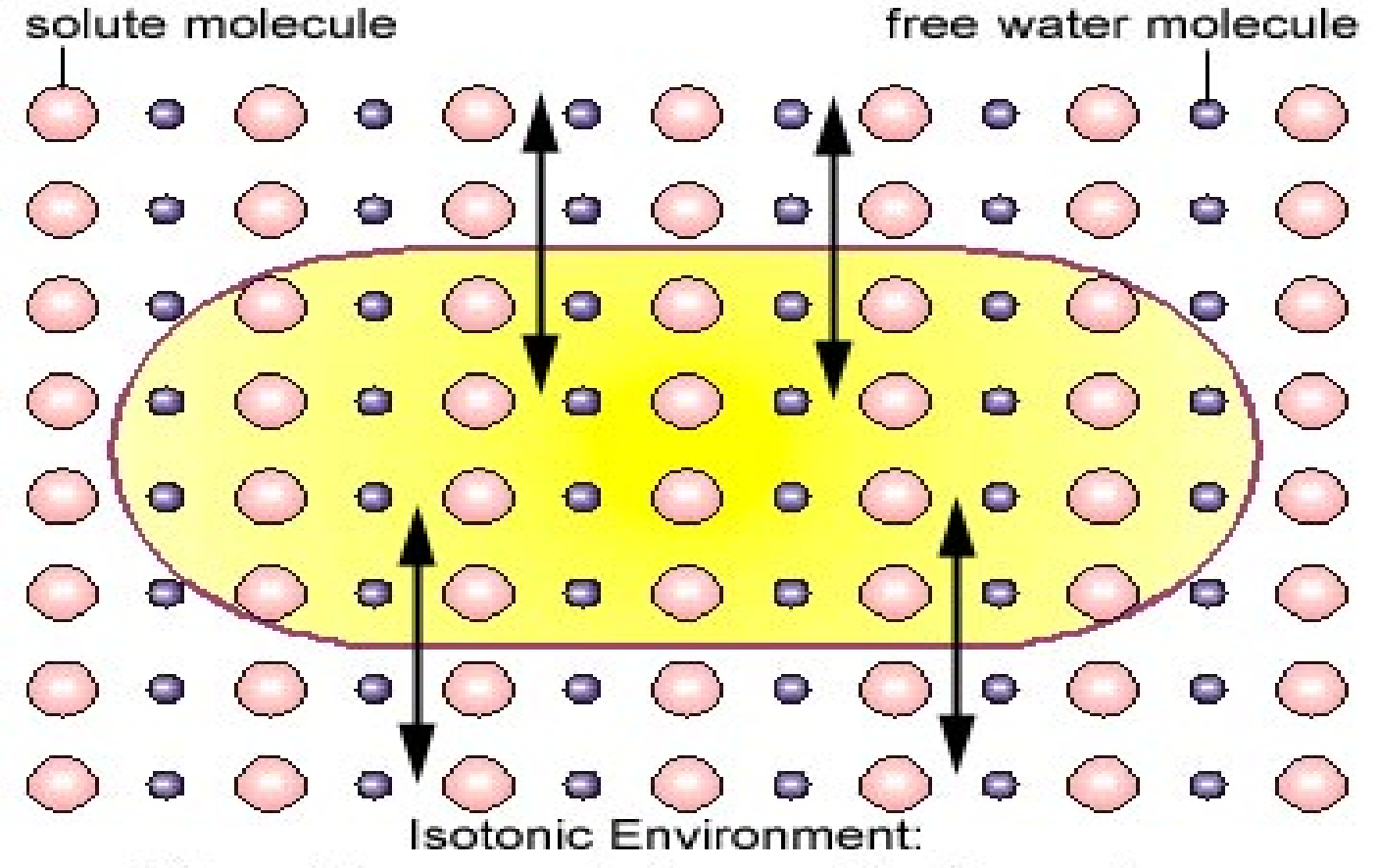
Tonicity

Is the ability of a solution to cause a cell to gain or lose water

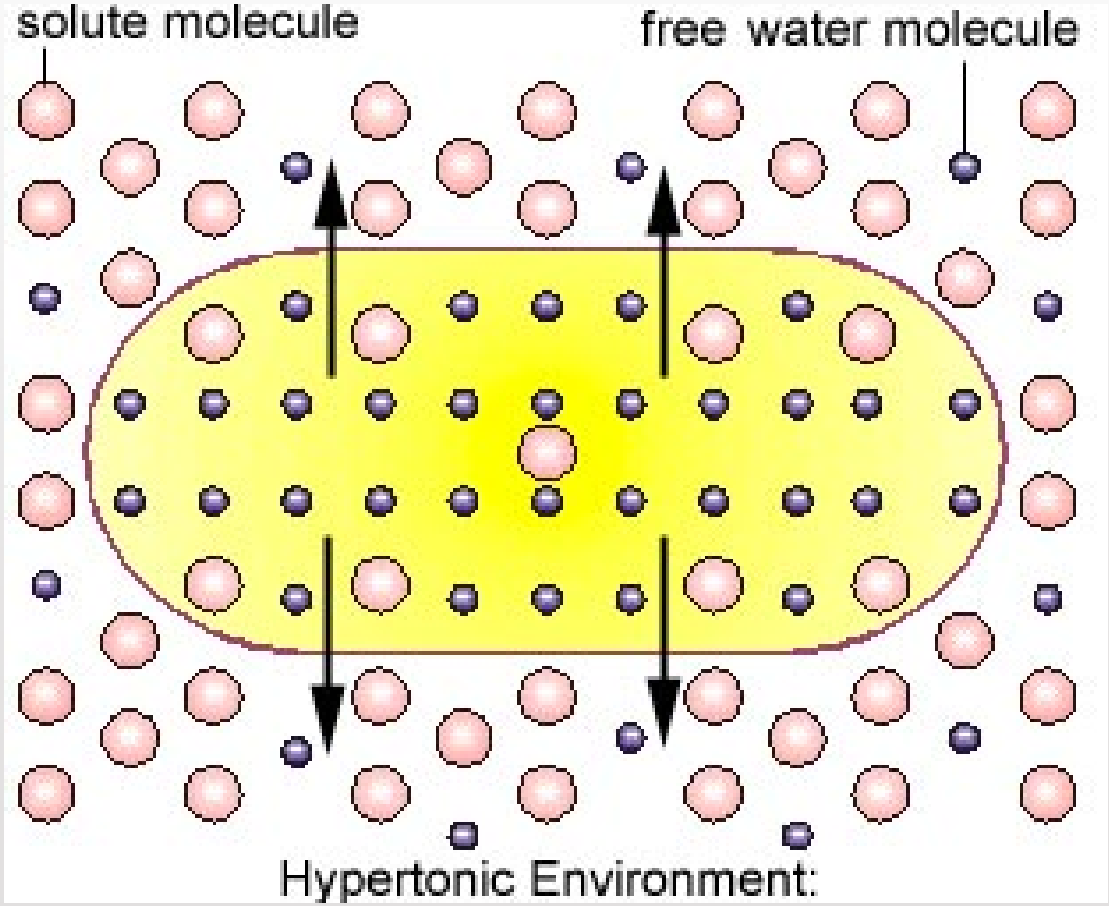
Has a great impact on cells without walls



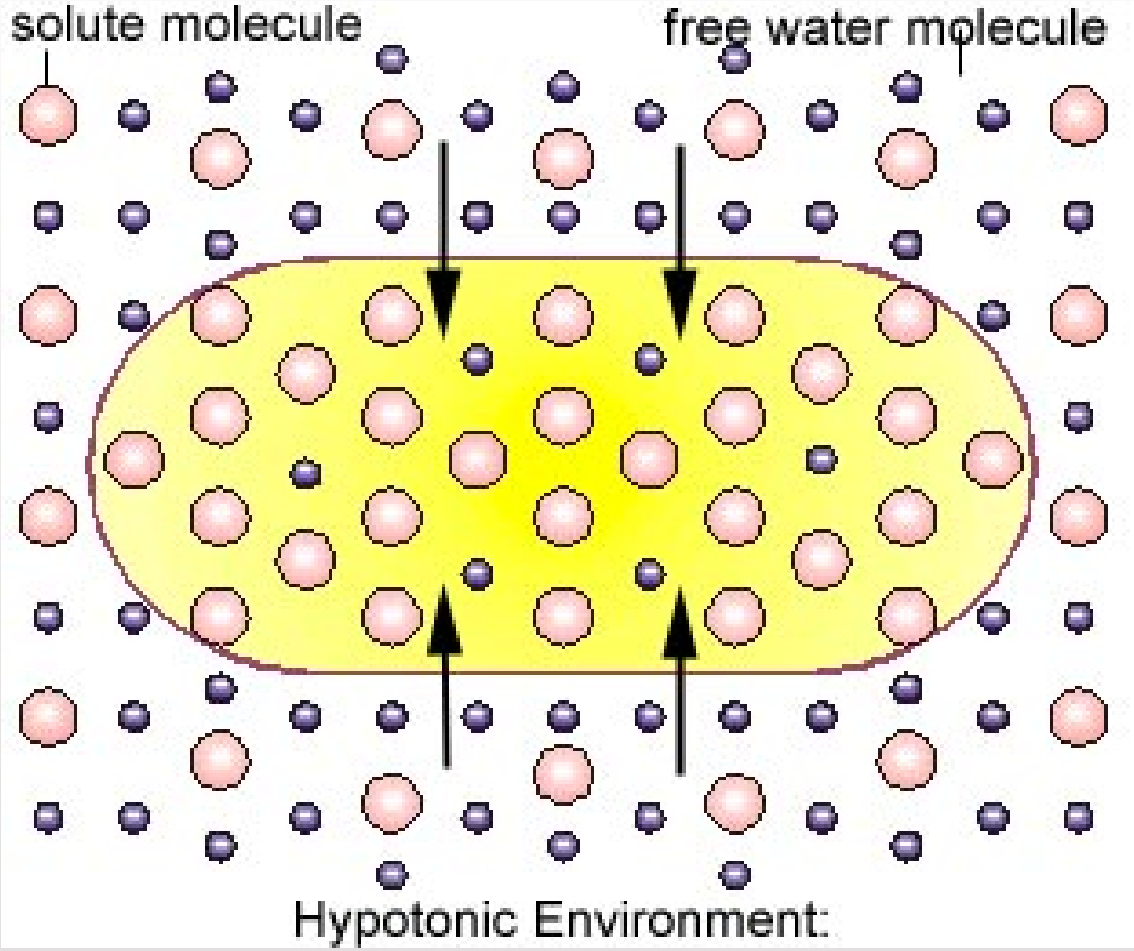
- If a solution is isotonic
  - The concentration of solutes is the same as it is inside the cell
  - There will be NO NET movement of WATER



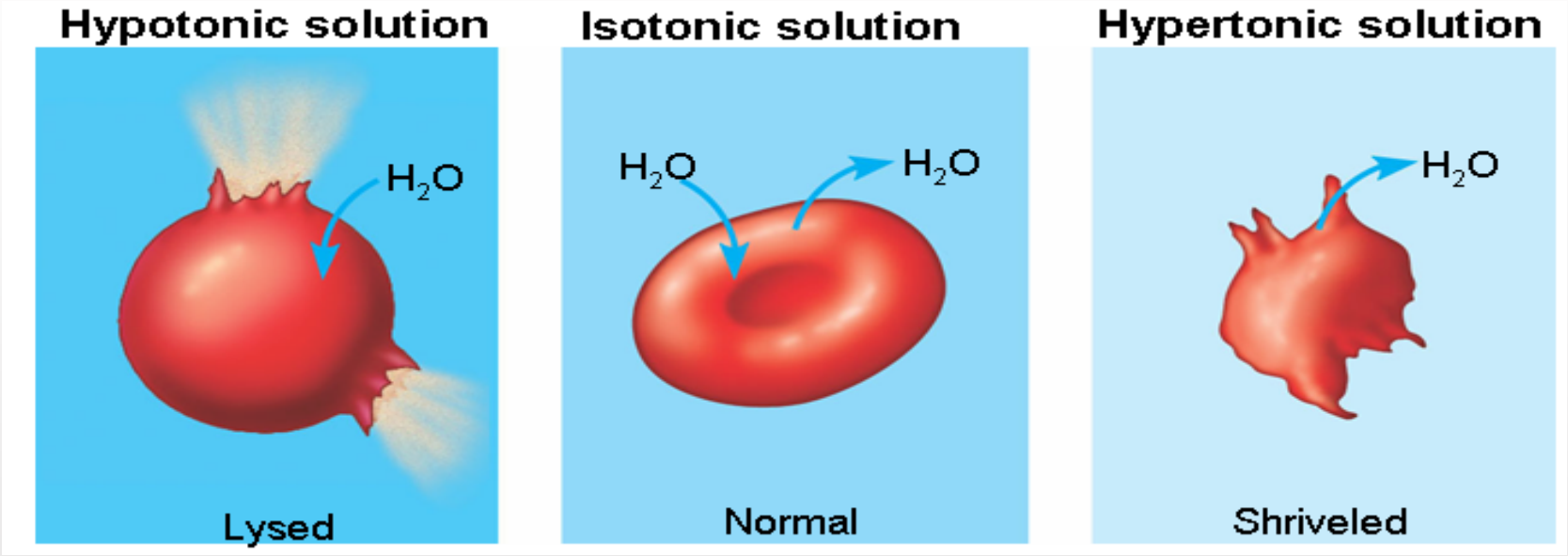
- If a solution is hypertonic
  - The concentration of solutes is greater than it is inside the cell
  - The cell will lose water (PLASMOLYSIS)



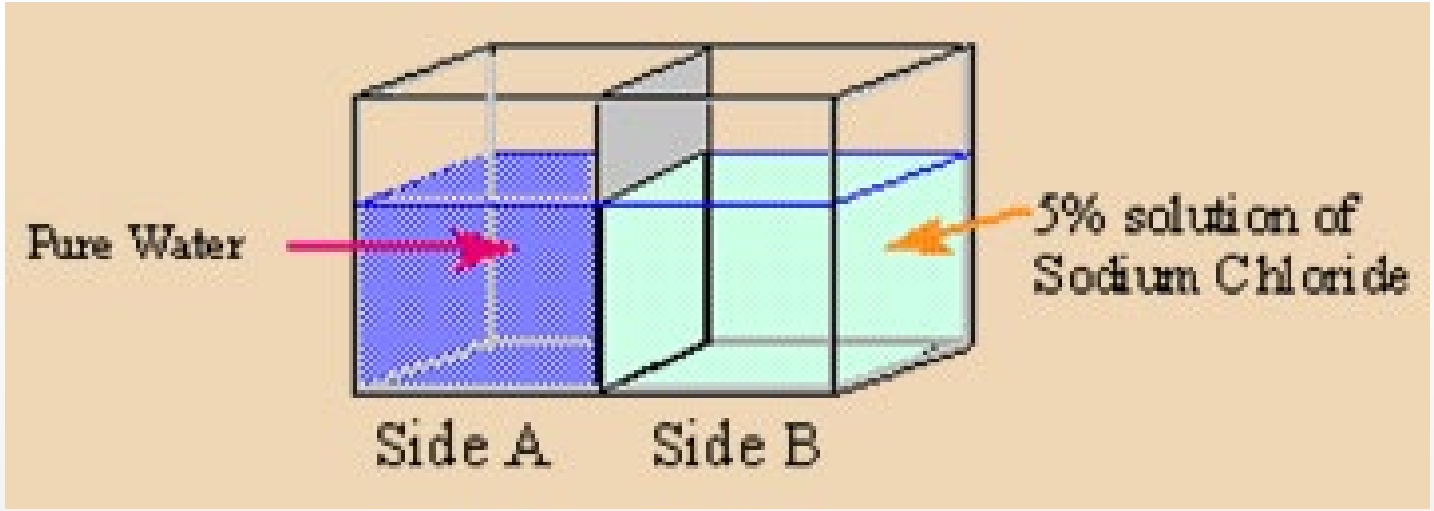
- If a solution is hypotonic
  - The concentration of solutes is less than it is inside the cell
  - The cell will gain water

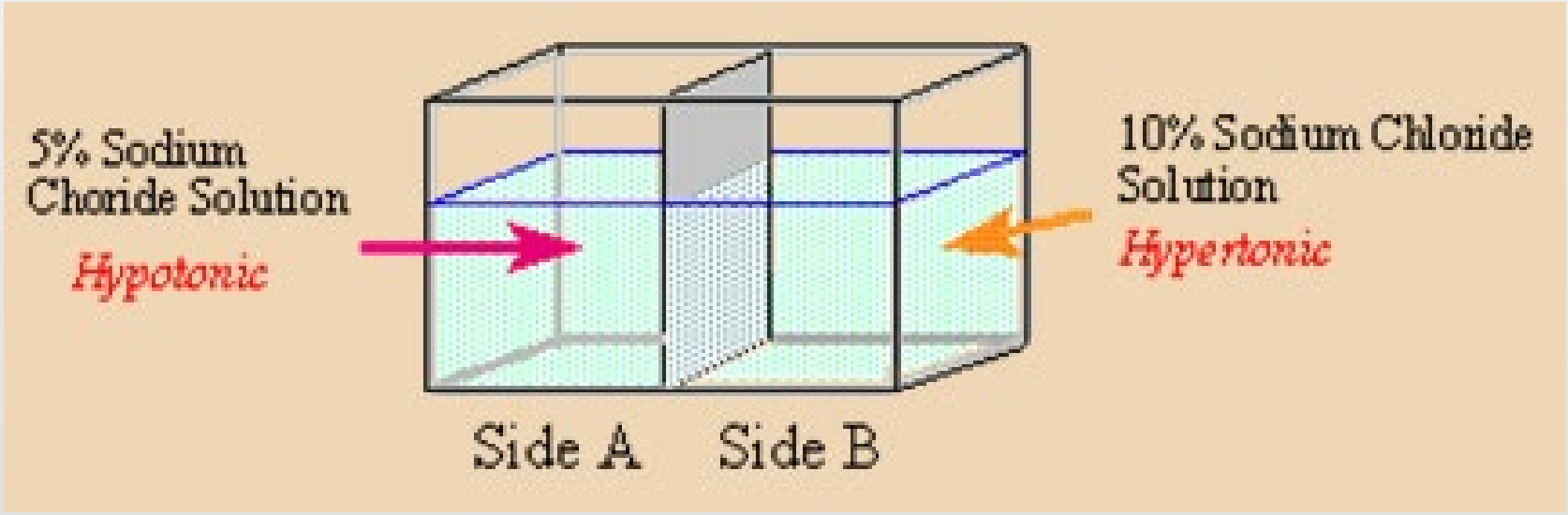


Water Balance in Cells Without Walls



Animal cell. An animal cell fares best in an **isotonic** environment unless it has special adaptations to offset the osmotic uptake or loss of water.


Pure Water
5% solution of
Sodium Chloride
Side A
Side B


5% Sodium
Choride Solution
Hypotonic
10% Sodium Chloride
Solution
Hypertonic
Side A
Side B

Transport Across Semi-Permeable Membrane

- Solution A has 10% starch
- Solution B has 10% sucrose

- **How will the water molecules move?**

Starch and sucrose CANNOT diffuse (too large)

There will be no net movement of water since the concentration of solute in each solution is equal

You can say these solutions are isotonic to each other.

Transport Across Semi-Permeable Membrane?

- Solution A has 30% protein
- Solution B has 10% protein

- **How will the water molecules move?**

Proteins CANNOT diffuse (too large)

Water will move by osmosis from Solution B to Solution A until the solutions are isotonic

You can also say that:

Solution A is hypertonic to Solution B

or Solution B is hypotonic to Solution A

Transport Across a Semi-Permeable Membrane?

- Solution A has 20% glucose
- Solution B has 10% glucose

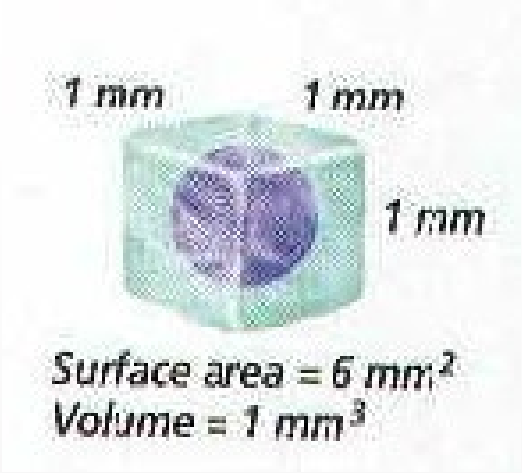
- **What will happen here?**

Glucose CAN diffuse → Glucose diffuses from solution A to solution B until it becomes isotonic

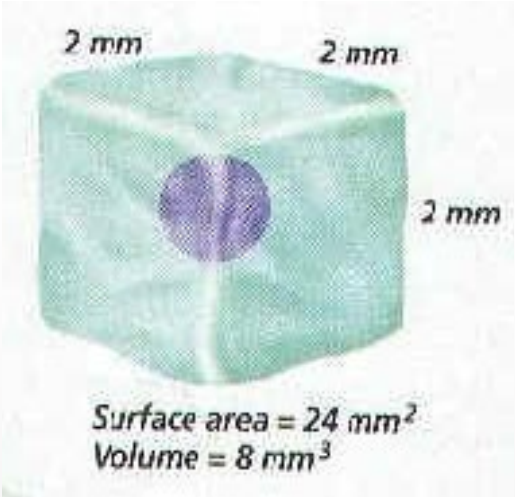
Initially, water will move by osmosis from solution B to A until isotonic, then the net movement of water will be equal.

Factors that impact the rate of diffusion

- Temperature
- Concentration Gradient
- Molecule Size
- Molecule Shape
- Polarity
- Surface area of membrane

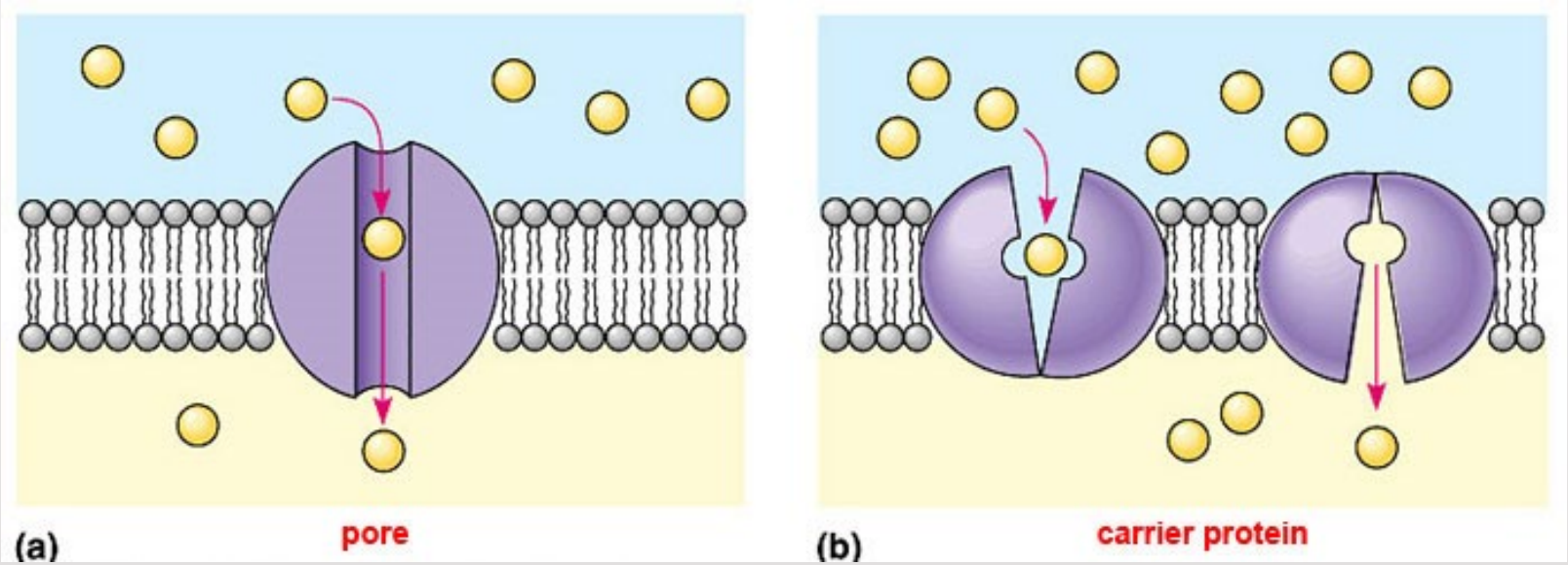


Cell Size

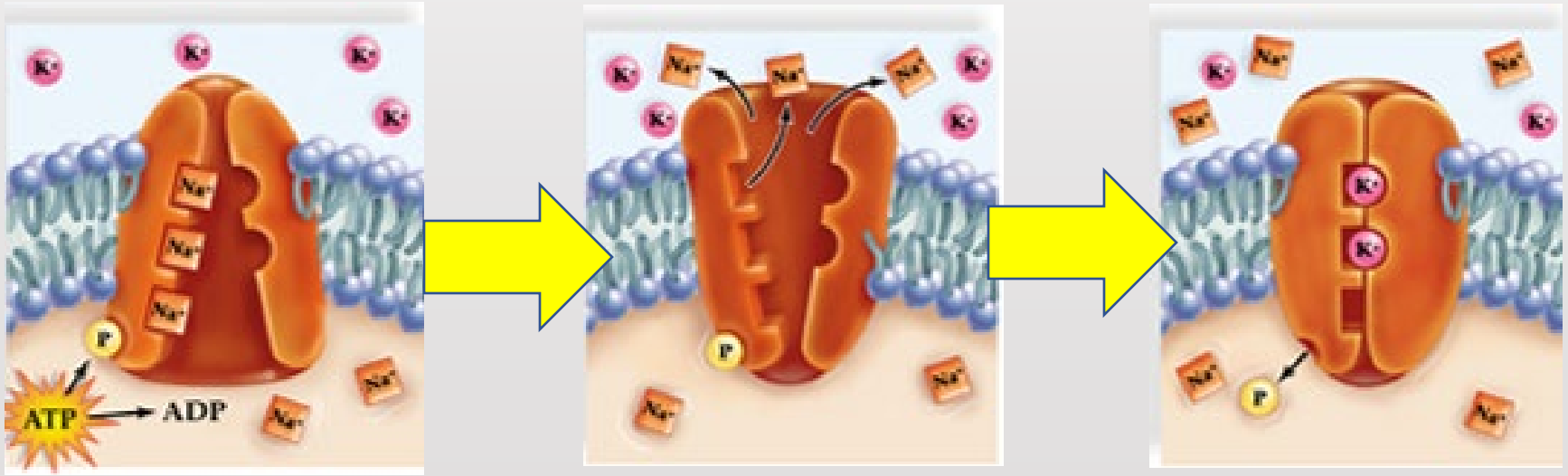


- Surface Area to Volume Ratio (SA:Vol)
- Surface area affects the ability of nutrients to get into the cell and wastes to get out
- Large cells need more nutrients and produce more wastes than small cells
- Small cells have more surface area per volume (high surface area to volume ratio)
- Large cell have more surface area but not as high a volume (low surface area to volume ratio)

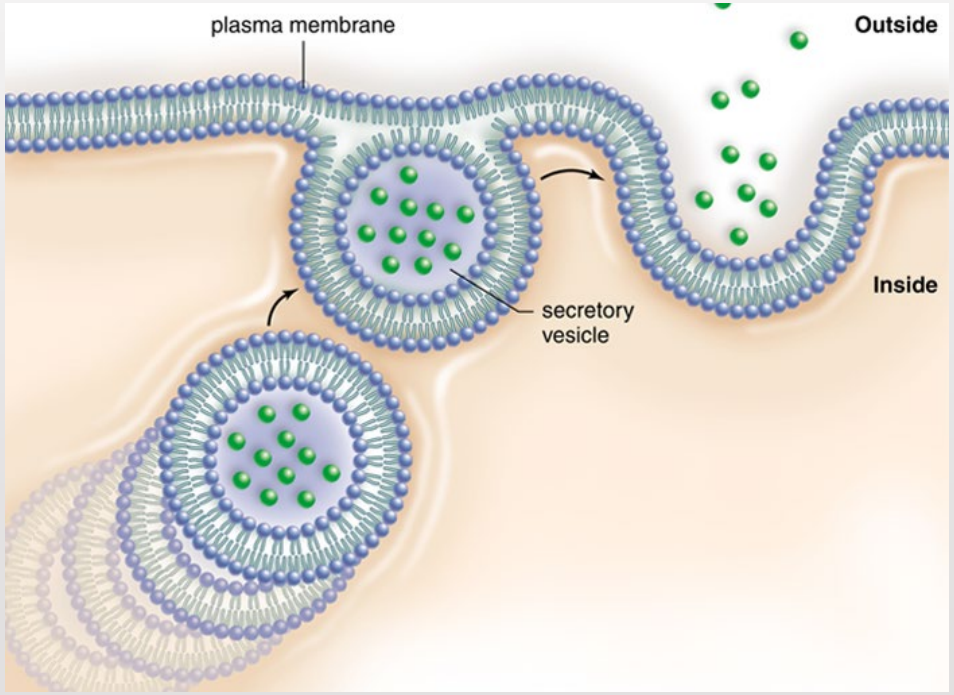
- Facilitated Transport
  - Molecules move from high to low concentration
  - Uses protein channel or carrier
  - Small molecules and ions
  - Ex. glucose



- Active Transport
  - Molecules move from low to high concentration
  - Uses protein carrier
  - Small molecules and ions
  - Ex. Sodium-potassium pump

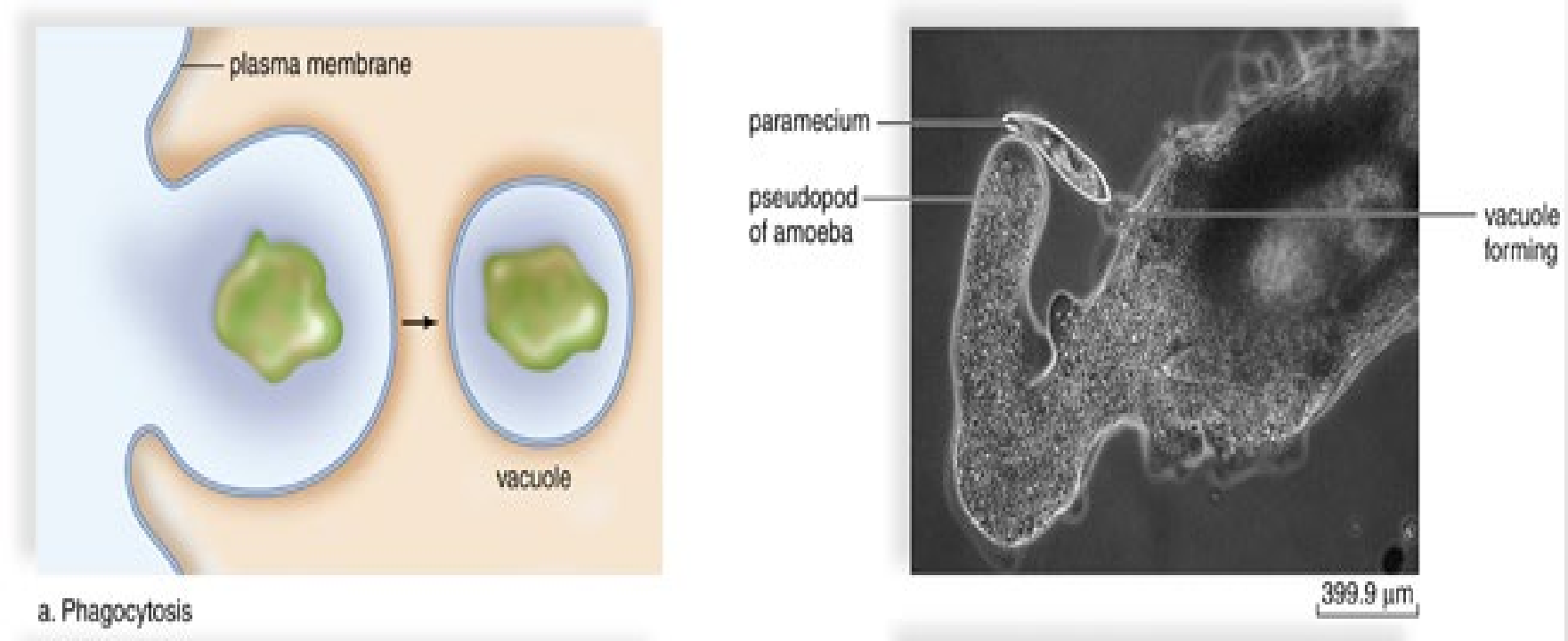


- Exocytosis
  - Requires ATP due to the movement of vesicles
  - A vesicle from inside the cell fuses with the cell membrane and the contents are released from cell
  - Vesicle plasma membrane becomes a part of the cell membrane
  - Ex. Exocytosis of insulin

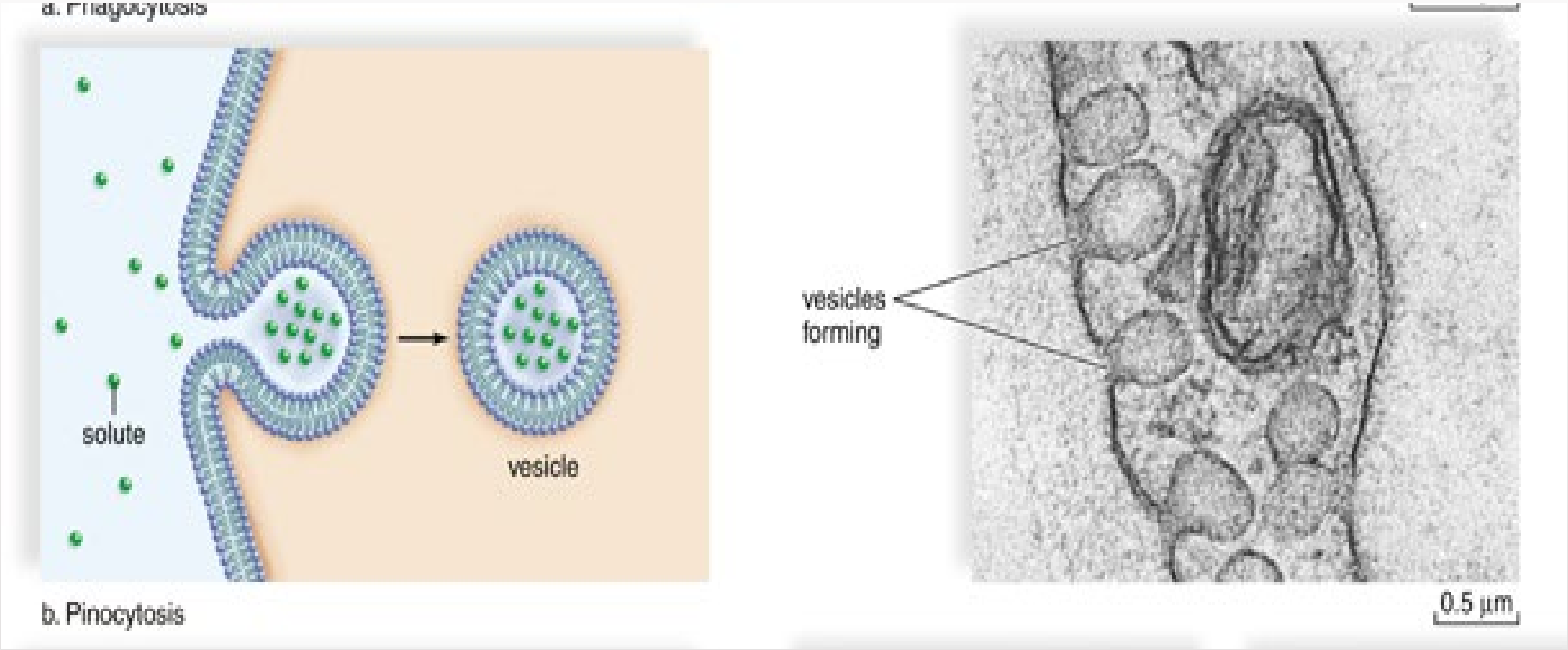


- **Endocytosis**
  - Requires ATP due to the movement of vesicles
  - A vesicle forms when a molecule or substance is entering into the cell
  - Vesicle forms around the molecule engulfing it

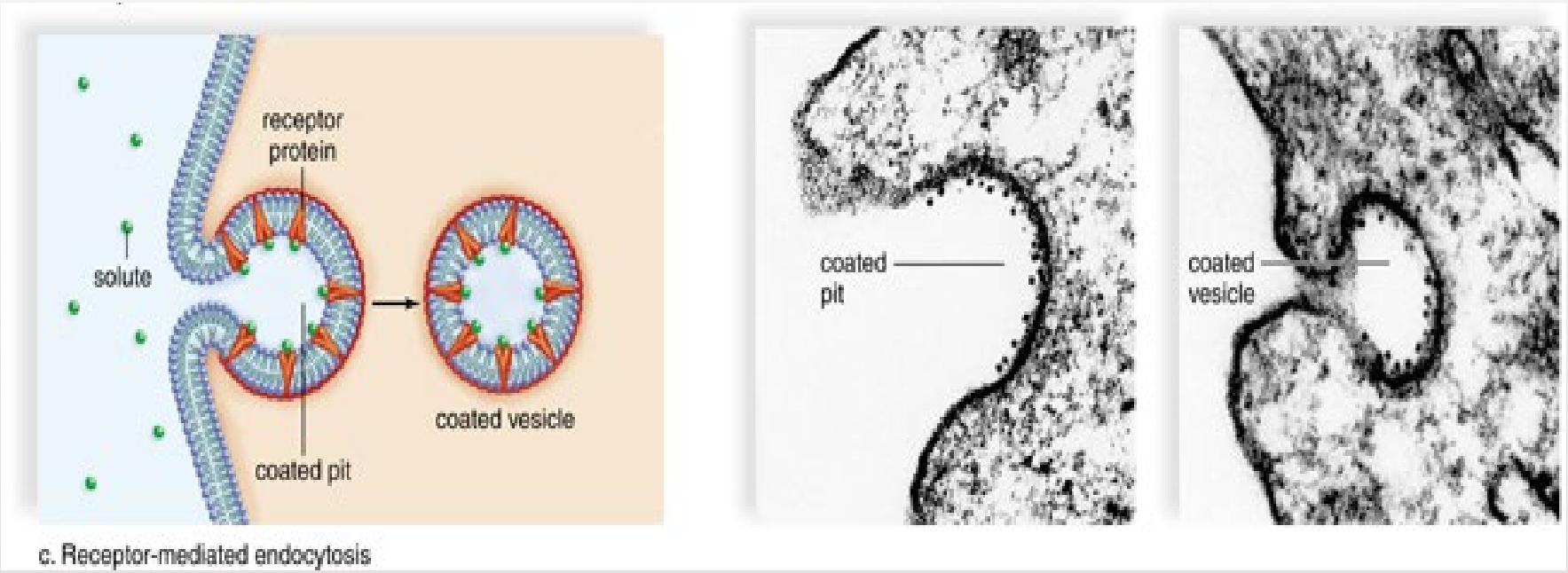
- **3 Types of endocytosis**
  - ❑Phagocytosis = large molecules enter



- Pinocytosis = small molecules or liquids enter



- Receptor-mediated endocytosis = receptor attaches causing invagination of cell membrane and vesicle or vacuole forms around the substance to bring it into cell.

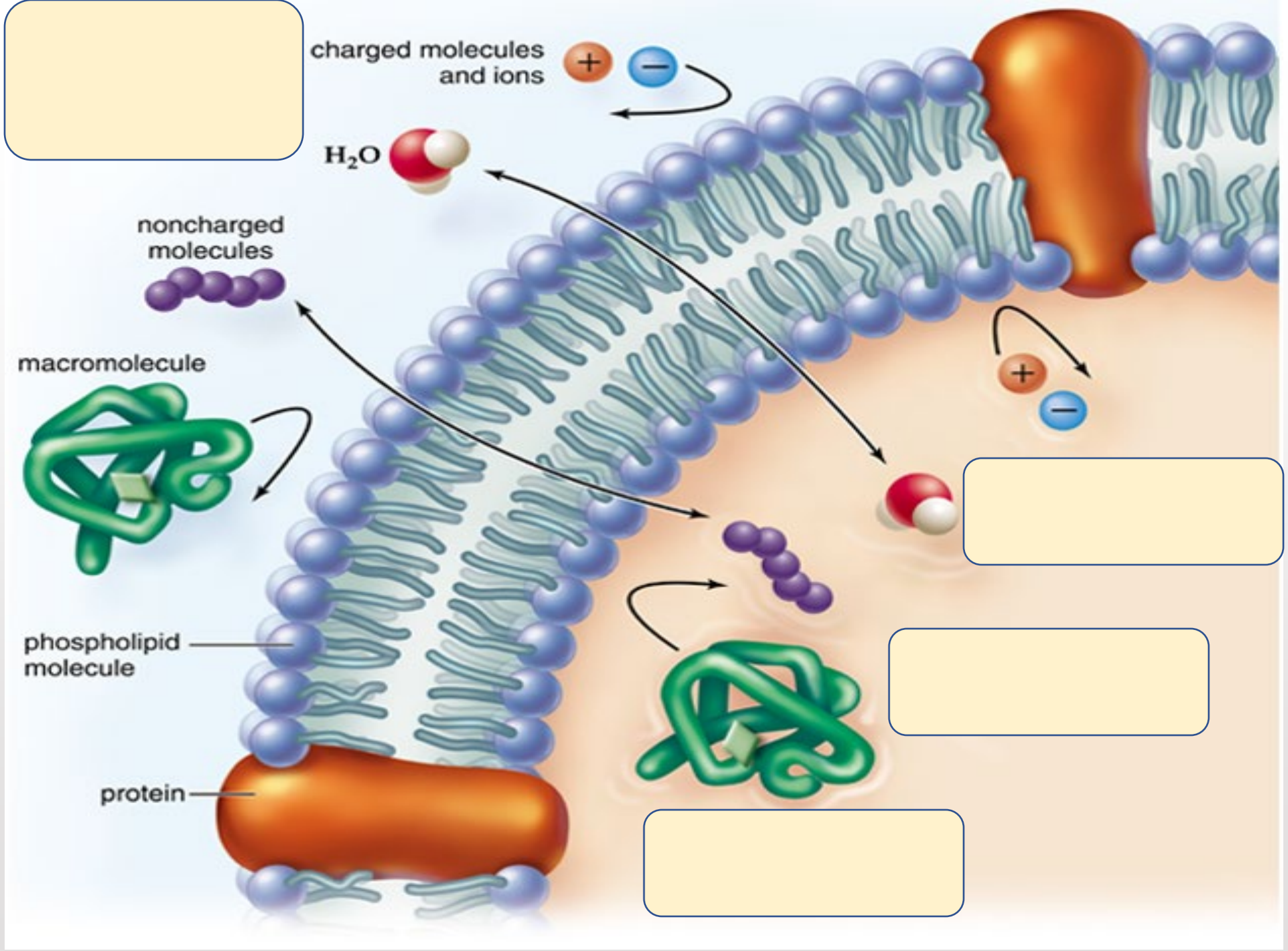


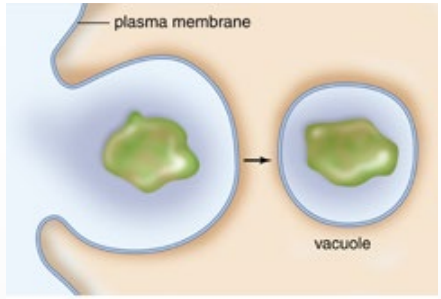
c. Receptor-mediated endocytosis

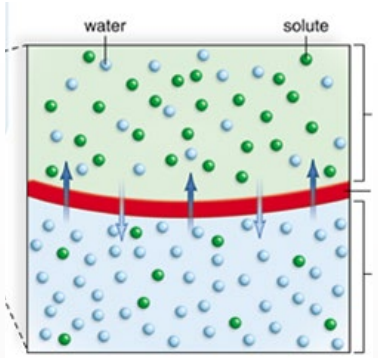
Summary of Membrane Transport

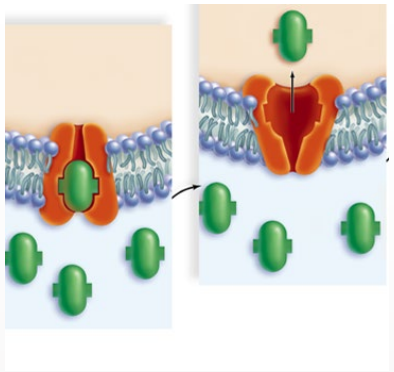
TABLE 4.1 Passage of Molecules Into and Out of the Cell

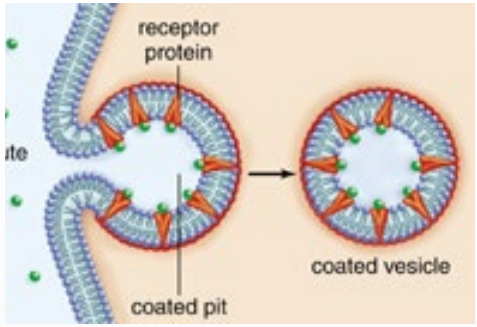
	Name	Direction	Requirement	Examples
Energy Not Required	Diffusion	Toward lower concentration	Concentration gradient	Lipid-soluble molecules, water, and gases
	Facilitated transport	Toward lower concentration	Channels or carrier and concentration gradient	Some sugars and some amino acids
Energy Required	Active transport	Toward higher concentration	Carrier plus energy	Sugars, amino acids, and ions
	Exocytosis	Toward outside	Vesicle fuses with plasma membrane	Macromolecules
	Endocytosis	Toward inside	Vesicle formation	Macromolecules

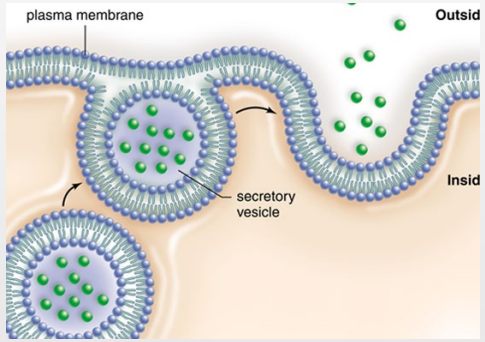

charged molecules and ions
H_2O
noncharged molecules
macromolecule
phospholipid molecule
protein

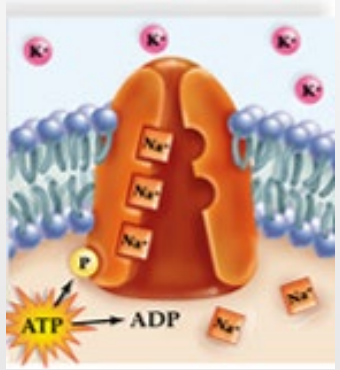


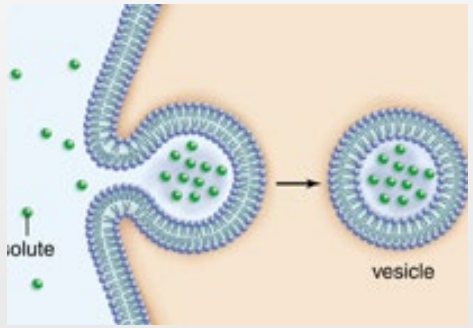


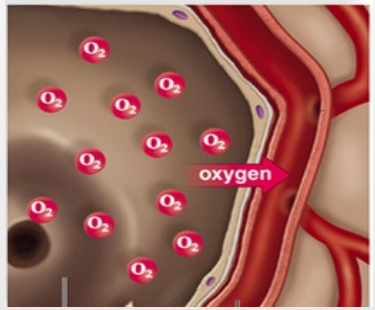












Active transport

pinocytosis

exocytosis

osmosis

diffusion

phagocytosis

Receptor-mediated Endocytosis

Facilitated transport

Passive Transport vs. Active Transport

High to low concentration

No ATP required

lipid-soluble molecule

Small molecule

Phospholipid bilayer

diffusion

Ex. O2 & CO2

osmosis

Ex. water

Isotonic solution

Hypertonic solution

Hypotonic solution

Facilitated diffusion

Ex. glucose

Channel proteins

Carrier proteins

Low to high concentration

ATP required

macromolecules

Polar molecule

macromolecules

Receptor used

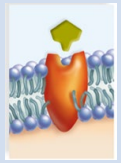
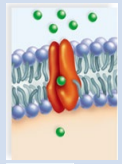
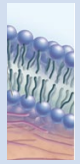
Endocytosis & Exocytosis

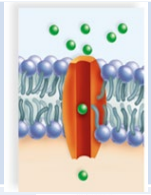
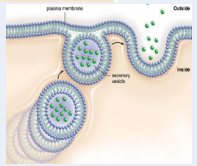
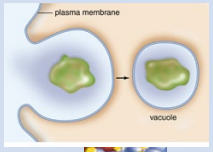
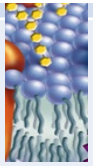
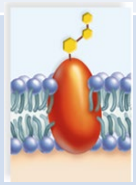
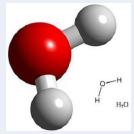
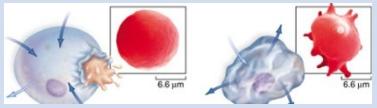
Vesicles involved

Carrier proteins

Ex. bacteria

Ex. Na+/K+ pump

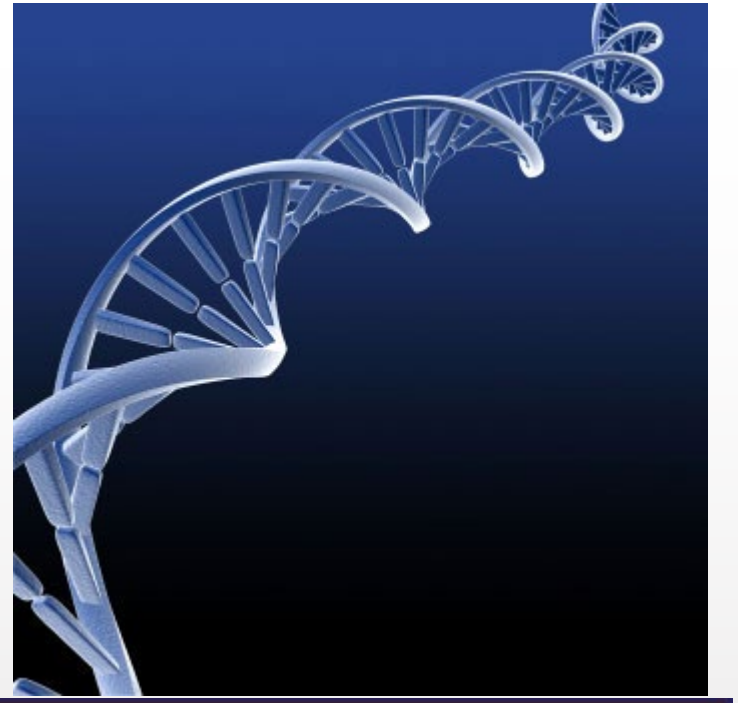
Structure/Process	Function
 Receptor Protein	Molecule attaches to it and causes some change in the cell
 ycolipid (in image) & Glyoprotein	Involved in cell recognition
 Carrier Protein Facilitated Transport	Glucose is transported by this structure in the cell membrane
 Phospholipid bilayer Diffusion	Oxygen & Carbon Dioxide travels through the cell membrane by this process
 Phospholipid bilayer Diffusion	When small molecules move from high to low concentration through the plasma membrane
 Enzymatic protein	When a molecule attaches to it, it catalyzes a reaction and products are formed
 Phospholipids Cell membrane Plasma membranes	The tails are hydrophobic/non-polar and the heads are hydrophilic/polar

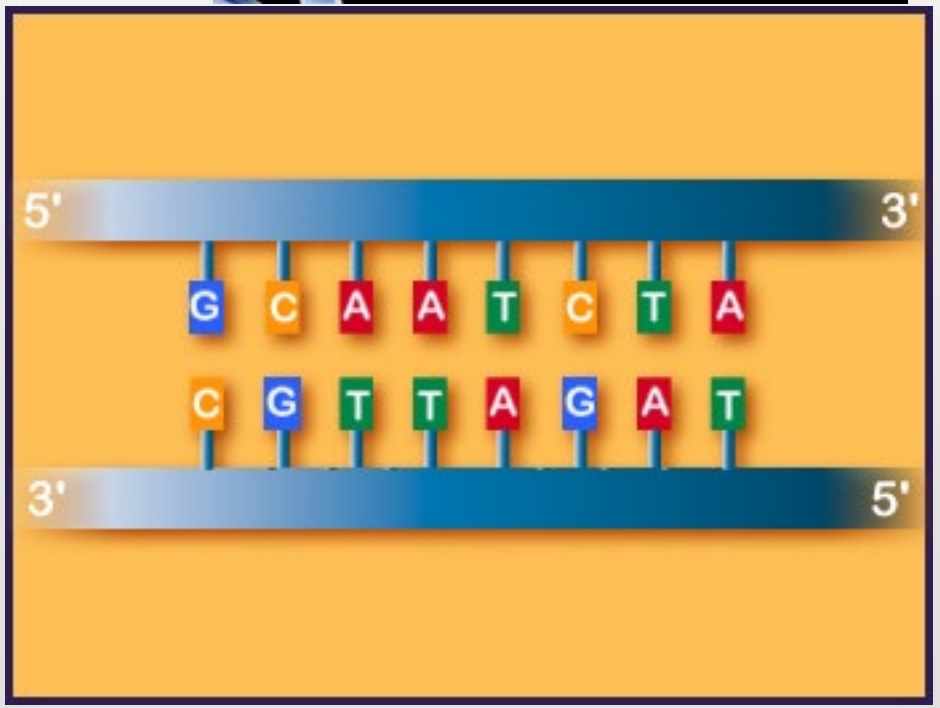
Structure/Process	Function
 Channel protein Facilitated Transport	Transports molecules through the cell membrane via an open pore
 Exocytosis	Uses ATP to transport molecule in vesicles out of the cell
 Endocytosis Phagocytosis	Large molecule enters the cell and a vacuole forms around it
 Glycolipid	Carbohydrate chain attached to a lipid on the cell membrane
 Glycoprotein	Carbohydrate chain attached to a protein on the cell membrane
 Osmosis	Water travels through the membrane by this process
 Hypotonic & Hypertonic	The 2 environments where the net change in water is not zero (either water gained or lost)

UNIT 3: DNA REPLICATION, PROTEIN SYNTHESIS, RECOMBINANT DNA & ENZYMES

Structure & Function of DNA

- **Double helix of nucleotides**
- **Sugar-phosphate backbone connected with covalent bonds**
- **Nitrogenous bases held together with hydrogen bonds**
- **Functions to direct protein synthesis as well as all cell functions**
- **Goes through replication and can mutate**
- **Located in nucleus and replicates during cell division**
- **rDNA is recombinant DNA = it is DNA made from 2 or more sources (ex. Human and cow) and is used in biotechnology products & cloning.**





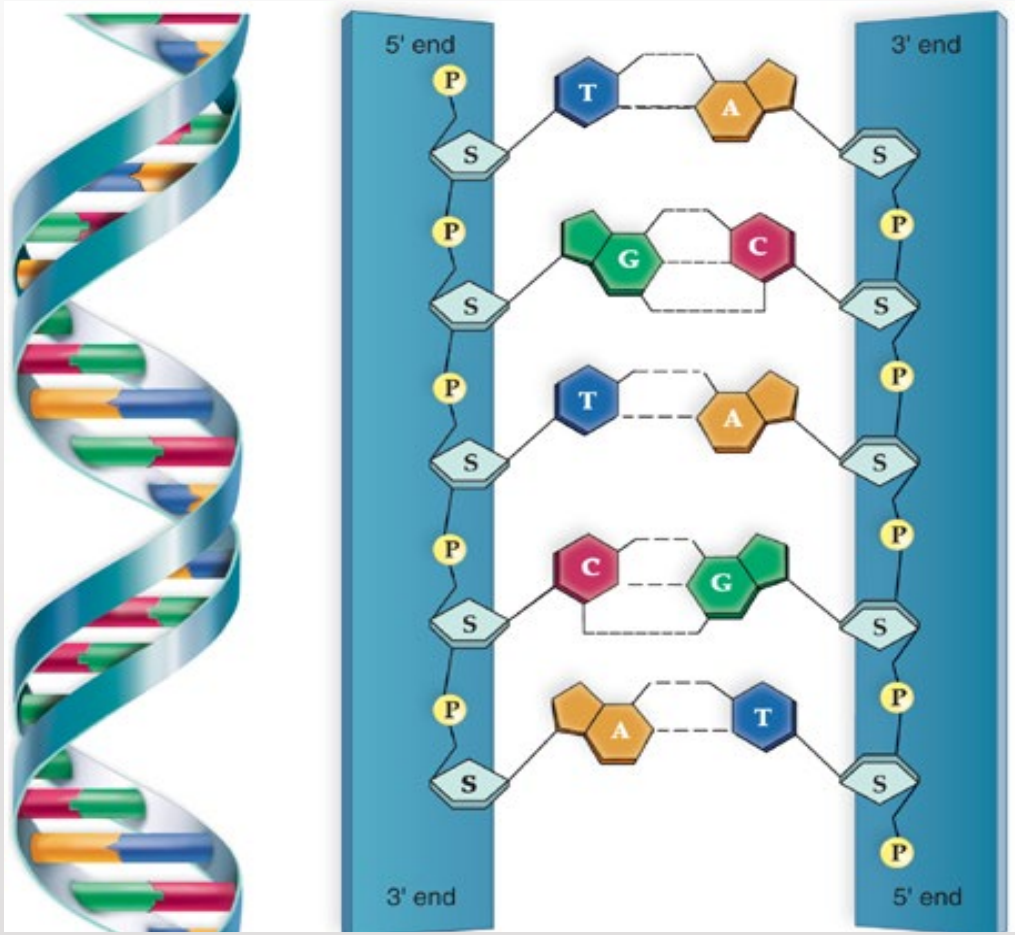
Bases:

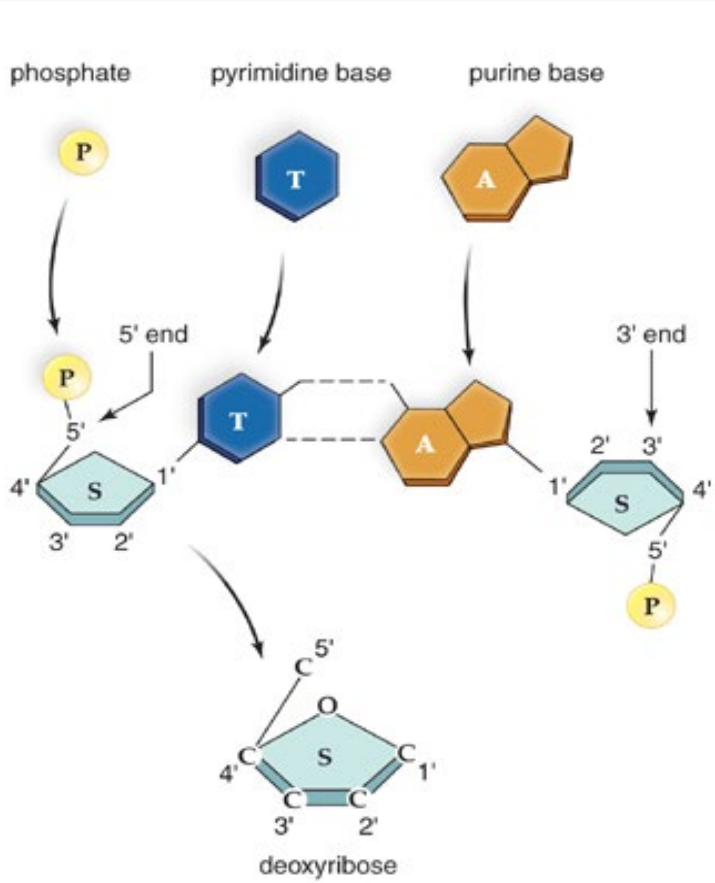
***Adenine pairs with Thymine with 2 hydrogen bonds**

***Guanine pairs with Cytosine with 3 hydrogen bonds**

****Adenine and Guanine are purines (2 ring base)**

****Thymine and Cytosine are pyrimidines (1 ring bases)**



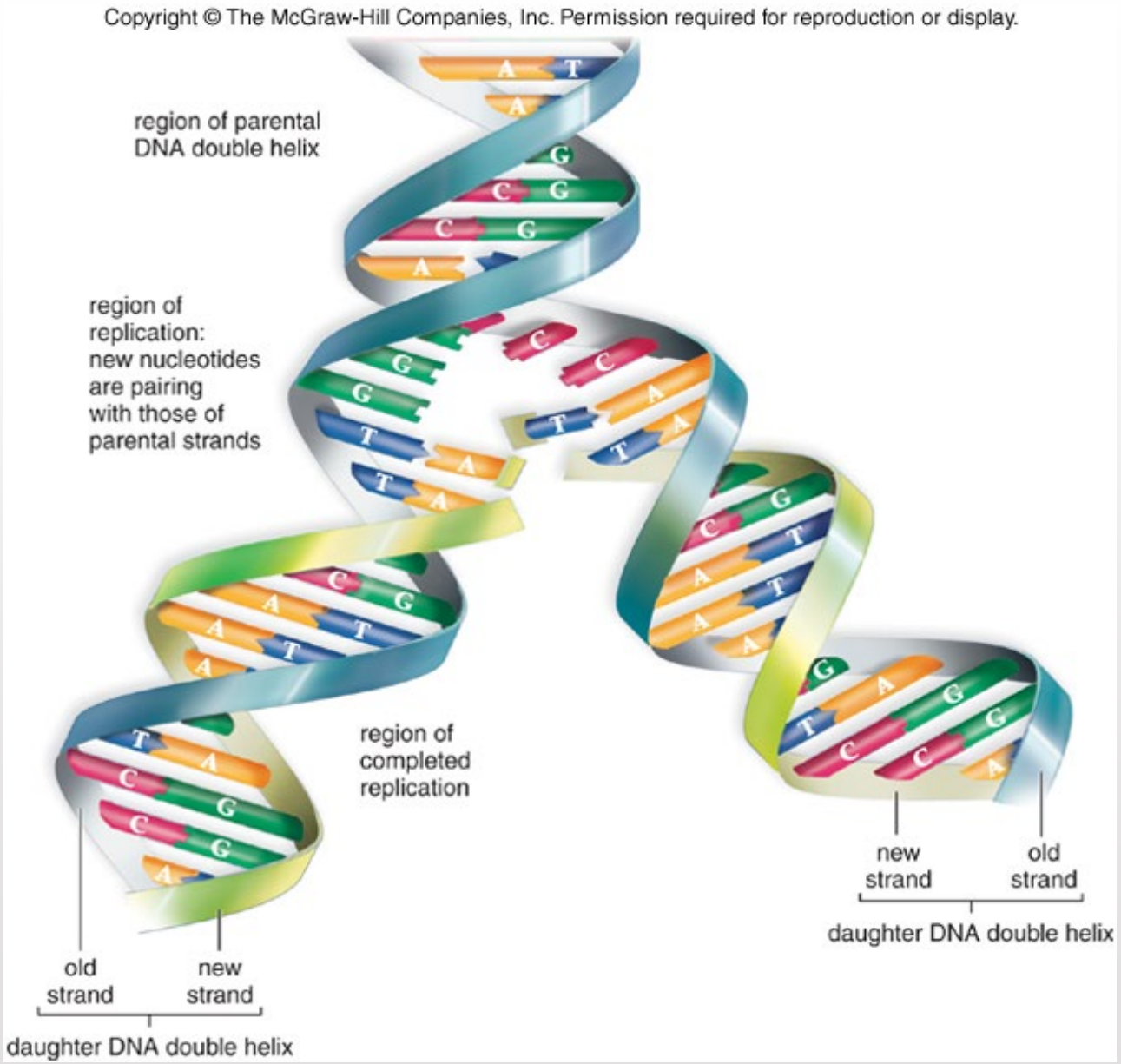


	DNA	RNA
Full Name:	Deoxyribonucleic Acid	Ribonucleic Acid
Location:	Nucleus only	Nucleus and Cytoplasm (at Ribosomes)
Function:	Controls cell functions, direct protein synthesis, replicate	Protein Synthesis
Shape:	Helix	Linear
Strands:	2 strands	1 strand
Bases:	Adenine =====Thymine Guanine ≡≡≡ Cytosine	Adenine =====Uracil (replaces Thymine) Guanine ≡≡≡ Cytosine
Sugar:	Deoxyribose	Ribose
Name of synthesis:	DNA Replication or Semi-conservative Replication	Transcription
Size:	Large (contains many genes in each chromosome)	Small (only size of 1 gene)
Amount	Fixed at 46 chromosomes	Unlimited – constantly transcribed
Enzymes:	Helicase for unzipping DNA polymerase for attaching nucleotides	RNA polymerase for unzipping and for attaching nucleotides

Process of Replication

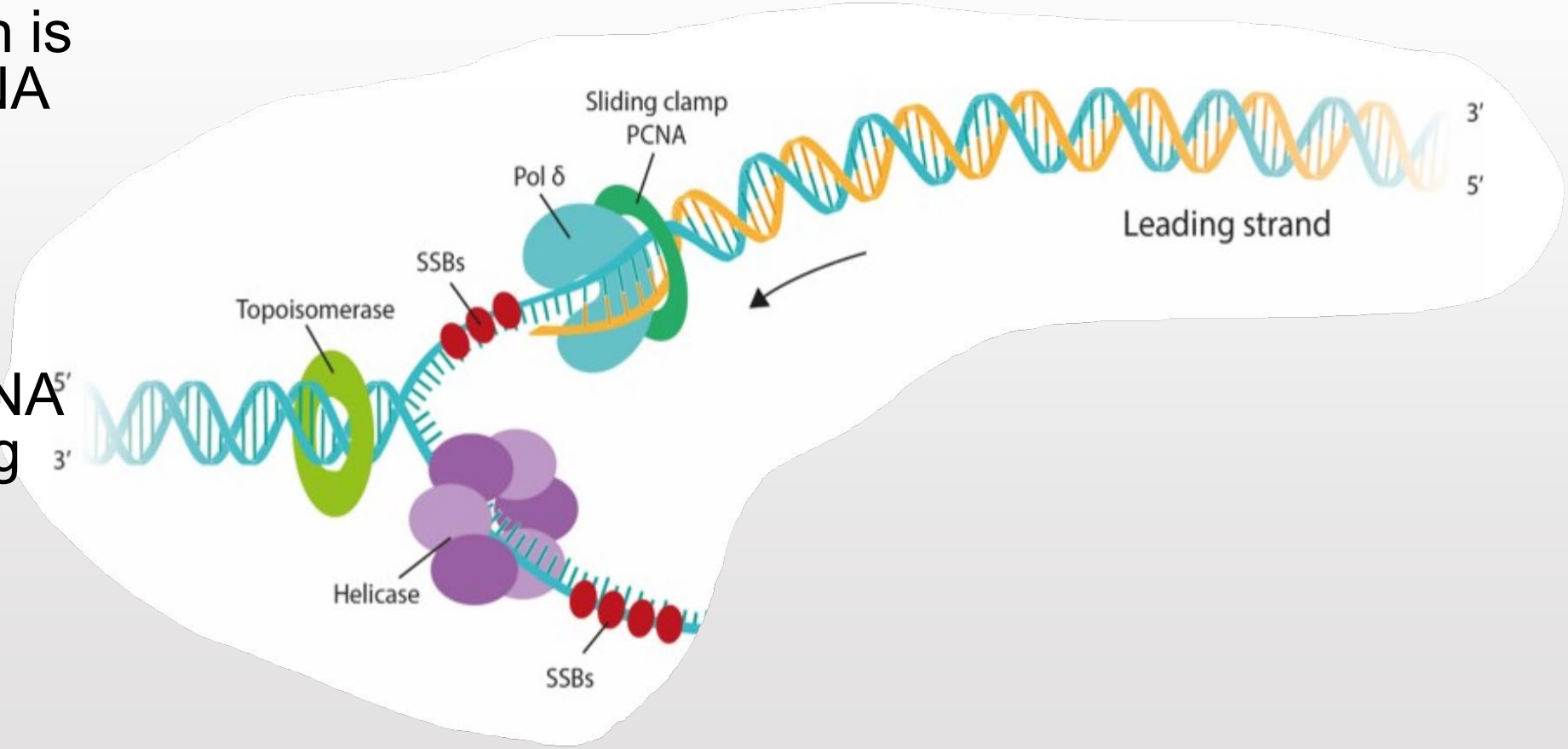
1. DNA unzips with **helicase** enzyme
2. Complimentary base pairing occurs
3. The nucleotides attach along the backbone with the **DNA polymerase** enzyme
4. DNA Replication results in 2 identical DNA molecules = **semi-conservative replication**

Replication 1 Replication 2



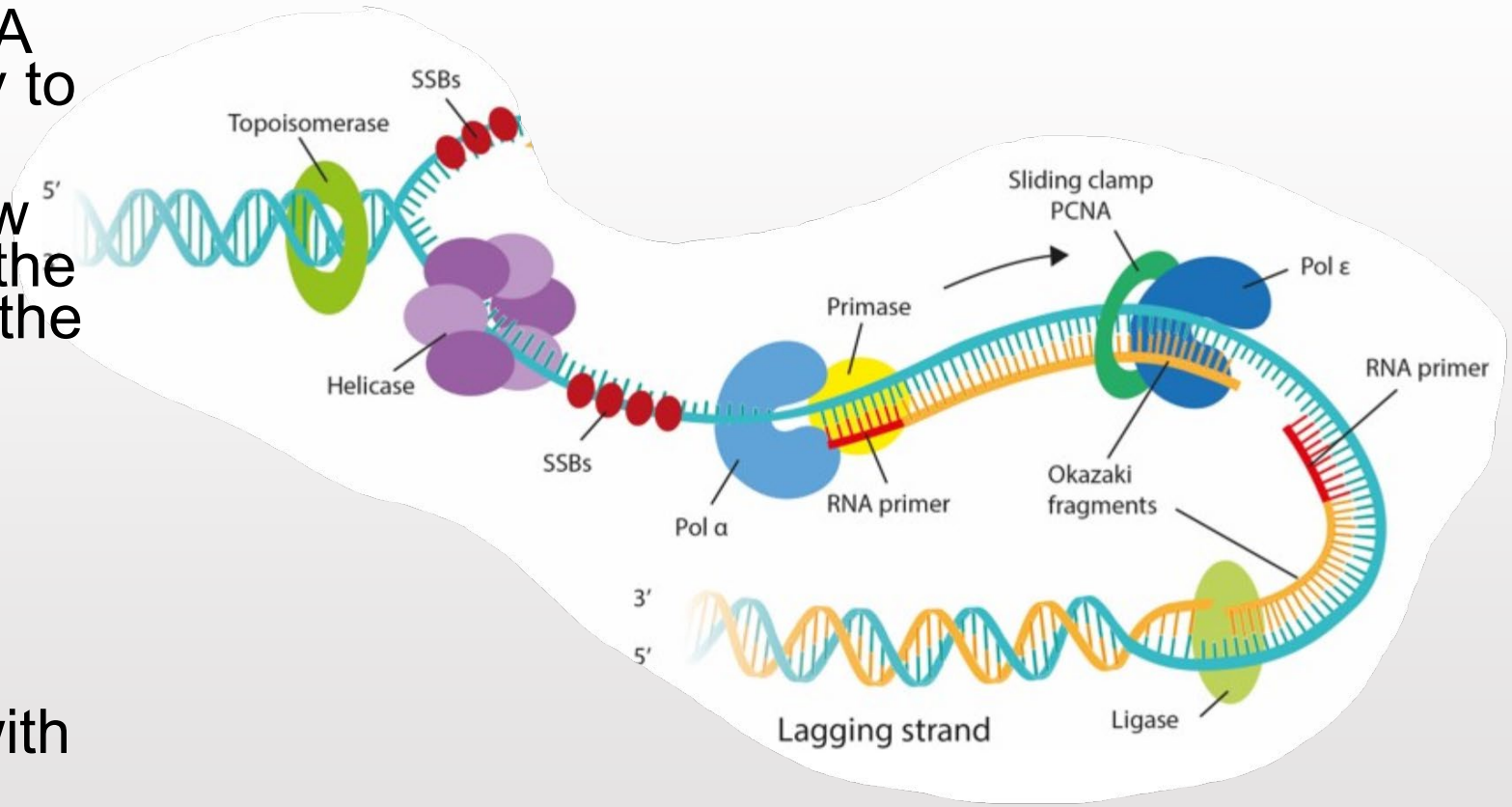
DNA Replication: leading strand

- RNA primase attaches an RNA primer which is complimentary to DNA to begin replication
- DNA polymerase attaches new complimentary nucleotides to the DNA parent strand forming the DNA daughter strand
- The RNA primer is replaced with DNA nucleotides to complete replication

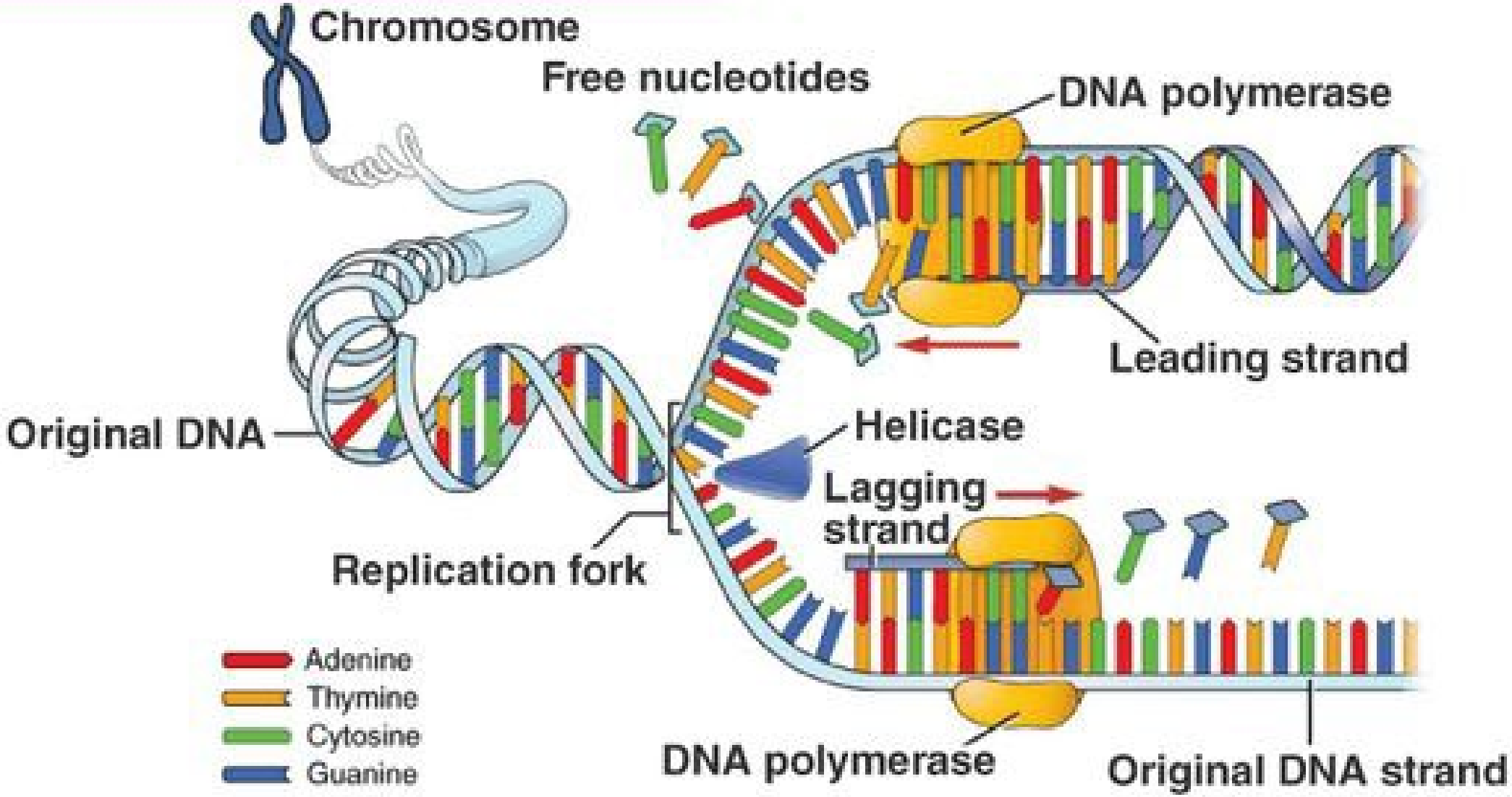


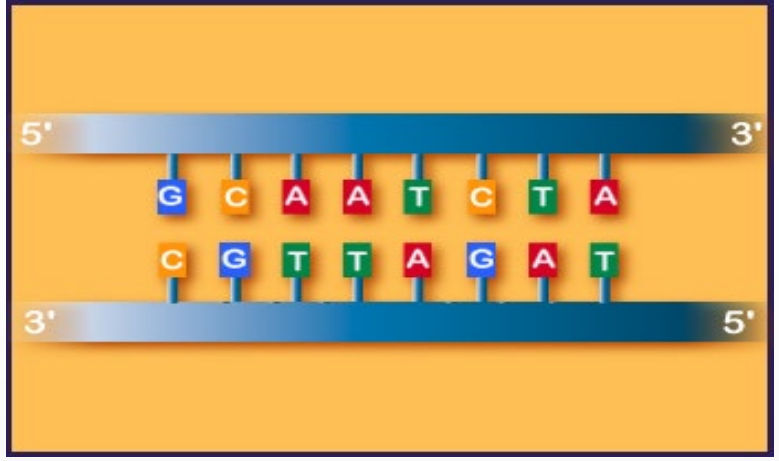
DNA Replication: lagging strand

- RNA primase attaches an RNA primer which is complimentary to DNA to begin replication
- DNA polymerase attaches new complimentary nucleotides in the opposite direction, away from the helicase enzyme.
- When more DNA template is exposed, another primer and section DNA is added – these segments are called Okazaki fragments.
- The RNA primer is replaced with DNA nucleotides
- The gaps between the Okazaki fragments are sealed with the DNA ligase enzyme.



DNA REPLICATION





Replication Example:

Original Template Strand = TTCTACGGTACCATAGGAATCCATCA

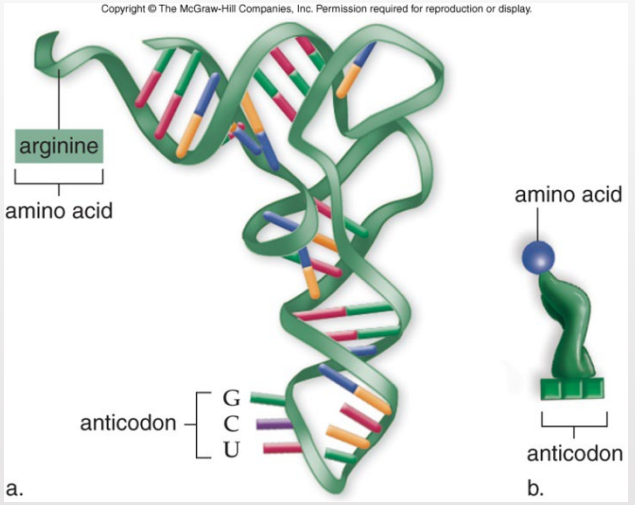
New Complimentary Daughter Strand = AAGATGCCATGGTATCCTTAGGTAGT

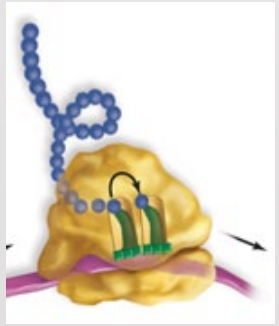
New Complimentary Daughter Strand = TTCTACGGTACCATAGGAATCCATCA

Original Complimentary Strand= AAGATGCCATGGTATCCTTAGGTAGT

Protein Synthesis: RNA

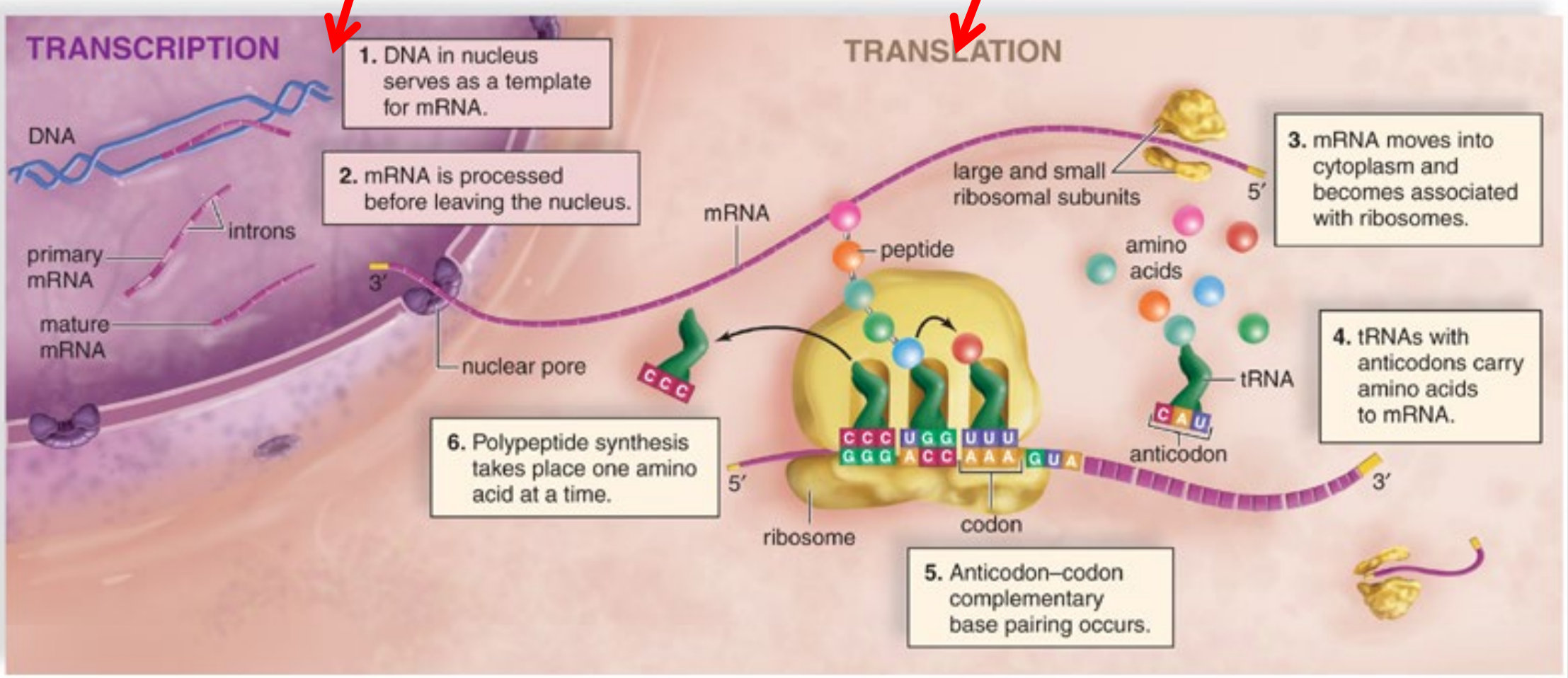
- mRNA = messenger RNA for carrying DNA (genetic) code out of nucleus to ribosome; contains codons (3 bases)
- tRNA = transfer RNA carries amino acids to the ribosome to assemble the polypeptide; contains anti-codons
- rRNA = ribosomal RNA which along with proteins forms the structure of ribosomes where protein synthesis occurs.





Protein Synthesis

1.Transcription 2. Translation

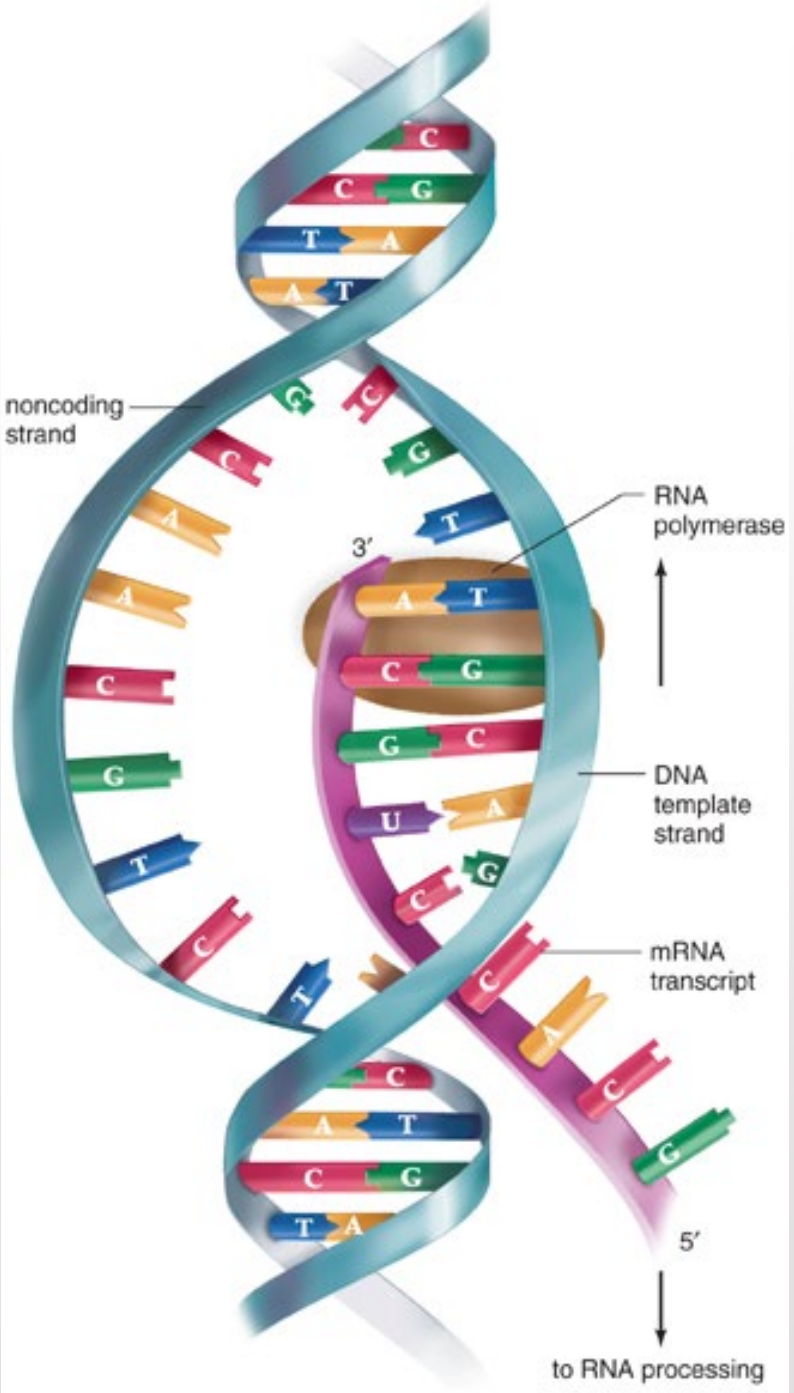


Transcription

1. RNA polymerase enzyme attaches to DNA at the beginning of a gene and causes it to unzip Complimentary base pairing occurs with template strand
2. mRNA nucleotides enter and complimentary base pair with the DNA template strand.
3. RNA polymerase attaches the new nucleotides together and when it reaches the end of the gene, transcription stops, and the completed mRNA leaves the nucleus via nuclear pores.

https://www.youtube.com/watch?v=vLz2A1cjPH8

https://www.stolaf.edu/people/giannini/transcription.html

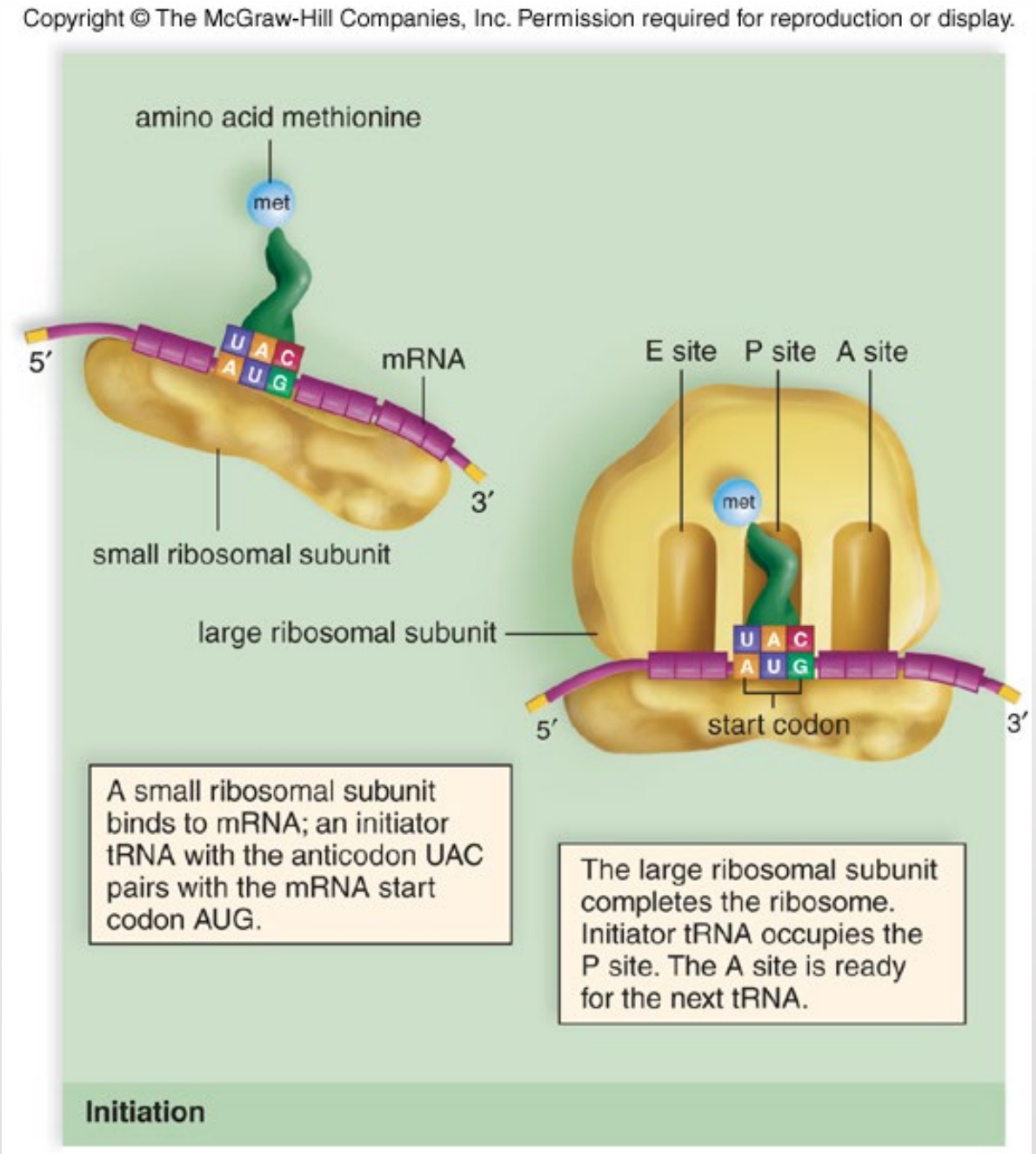


https://www.stolaf.edu/people/giannini/translation.html

https://www.youtube.com/watch?v=5bLEDd-PSTQ

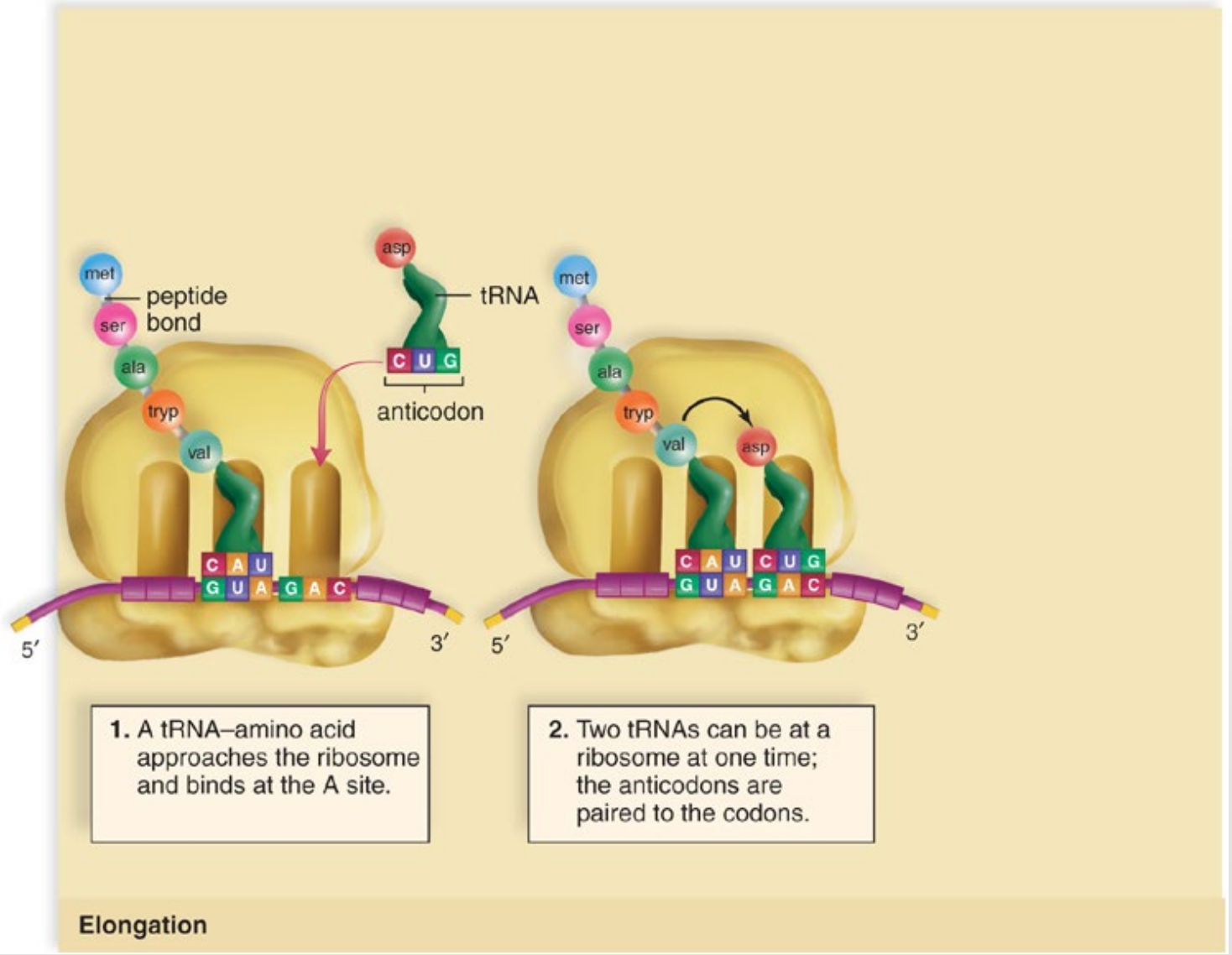
Translation

1. Initiation: small and large ribosomal subunits join mRNA at AUG start codon. The tRNA carries the first amino acid methionine to the ribosome and the codon and anticodon base pair and attach at the first side on the ribosome (P-site)



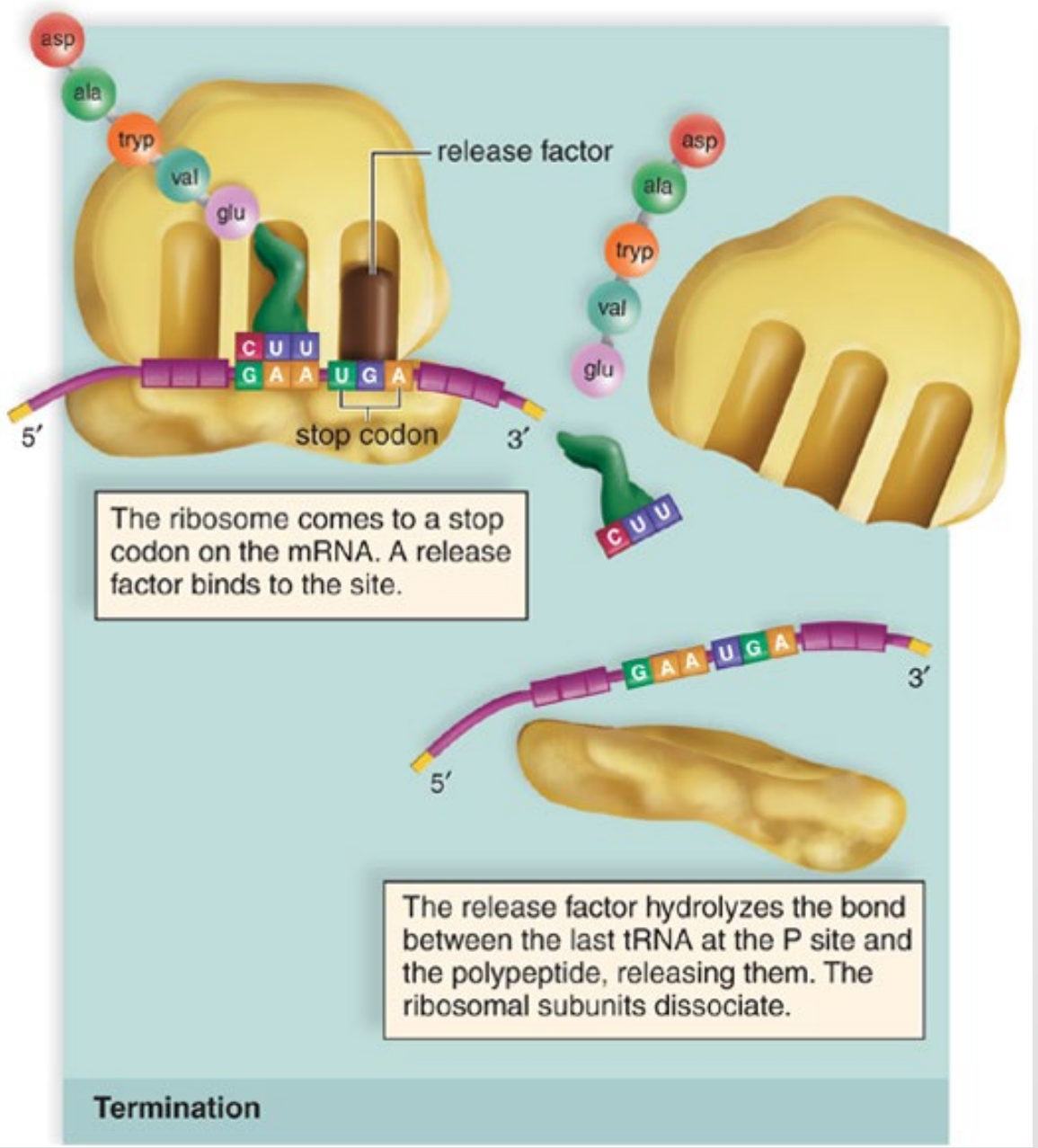
Translation

2. Elongation: the ribosome moves along the mRNA reading one codon at a time. tRNA bring the next amino acid and the amino acids join by peptide bonds.



Translation

3. Termination: when the ribosome reaches the stop codon on the mRNA strand, a release factor comes in and causes all parts to separate and the completed polypeptide is released. It will be used inside the cell or transported to the Golgi Body for modification and processing.



Protein Synthesis Link

Mutations

1. Frameshift:
    1. Base is lost or gained
    2. All codon after mutation are different
    3. Different sequence of aa's result
    4. Non-functional protein is produced
2. Point:

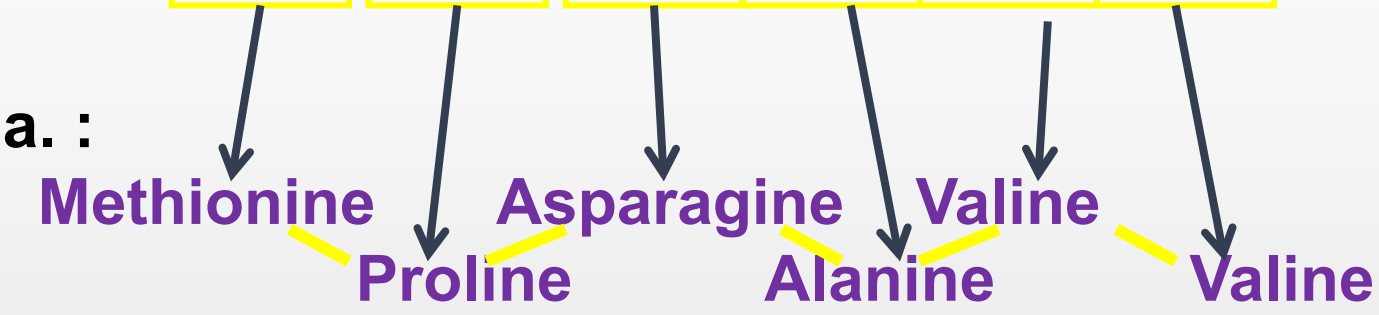
    A base is replaced with a different one
    1. Silent = same aa results; therefore, no change in the polypeptide/protein
    2. Non-sense = Stop codon results; therefore, the polypeptide is cut short (translation stopped prematurely) and a non-functional protein is produced
    3. Missense = a different aa is used and can result in a protein that does not for a proper structure and cannot function properly.

Example:

DNA: T A C G G A T T A C G C C A T C A A

mRNA: A UG C C U A A U G CG G UAG UU

a.a. :



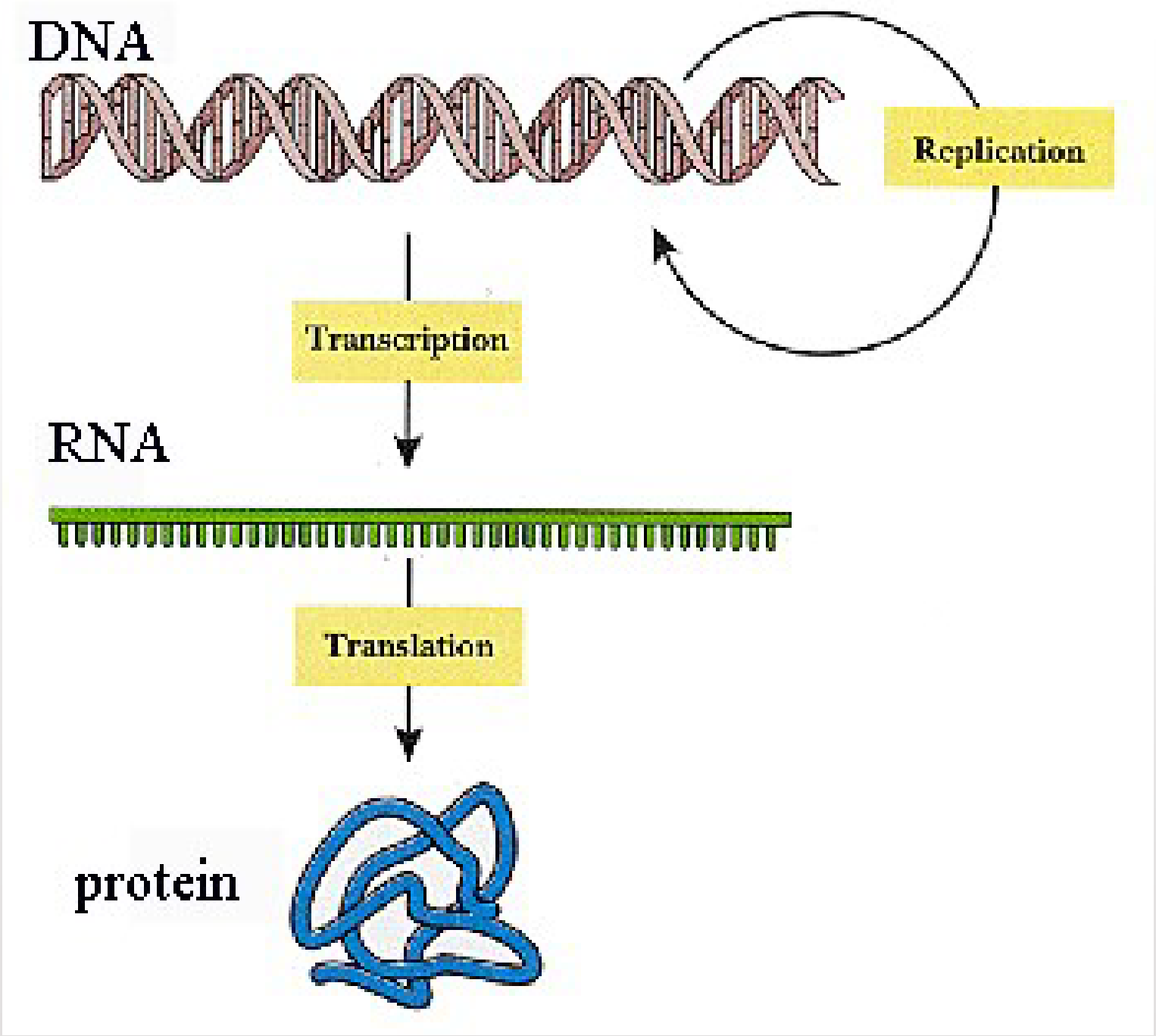
Amino acids attach with peptide bonds to form polypeptide (protein)

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU phenylalanine	UCU serine	UAU tyrosine	UGU cysteine	U
	UUC phenylalanine	UCC serine	UAC tyrosine	UGC cysteine	C
	UUA leucine	UCA serine	UAA *stop*	UGA *stop*	A
	UUG leucine	UCG serine	UAG *stop*	UGG tryptophan	G
C	CUU leucine	CCU proline	CAU histidine	CGU arginine	U
	CUC leucine	CCC proline	CAC histidine	CGC arginine	C
	CUA leucine	CCA proline	CAA glutamine	CGA arginine	A
	CUG leucine	CCG proline	CAA glutamine	CGG arginine	G
A	AUU isoleucine	ACU threonine	AAU asparagine	AGU serine	U
	AUC isoleucine	ACC threonine	AAC asparagine	AGC serine	C
	AUA isoleucine	ACA threonine	AAA lysine	AGA arginine	A
	AUG *(start)* methionine	ACG threonine	AAG lysine	AGG arginine	G
G	GUU valine	GCU alanine	GAU aspartate	GGU glycine	U
	GUC valine	GCC alanine	GAC aspartate	GGC glycine	C
	GUA valine	GCA alanine	GAA glutamate	GGA glycine	A
	GUG valine	GCG alanine	GAG glutamate	GGG glycine	G

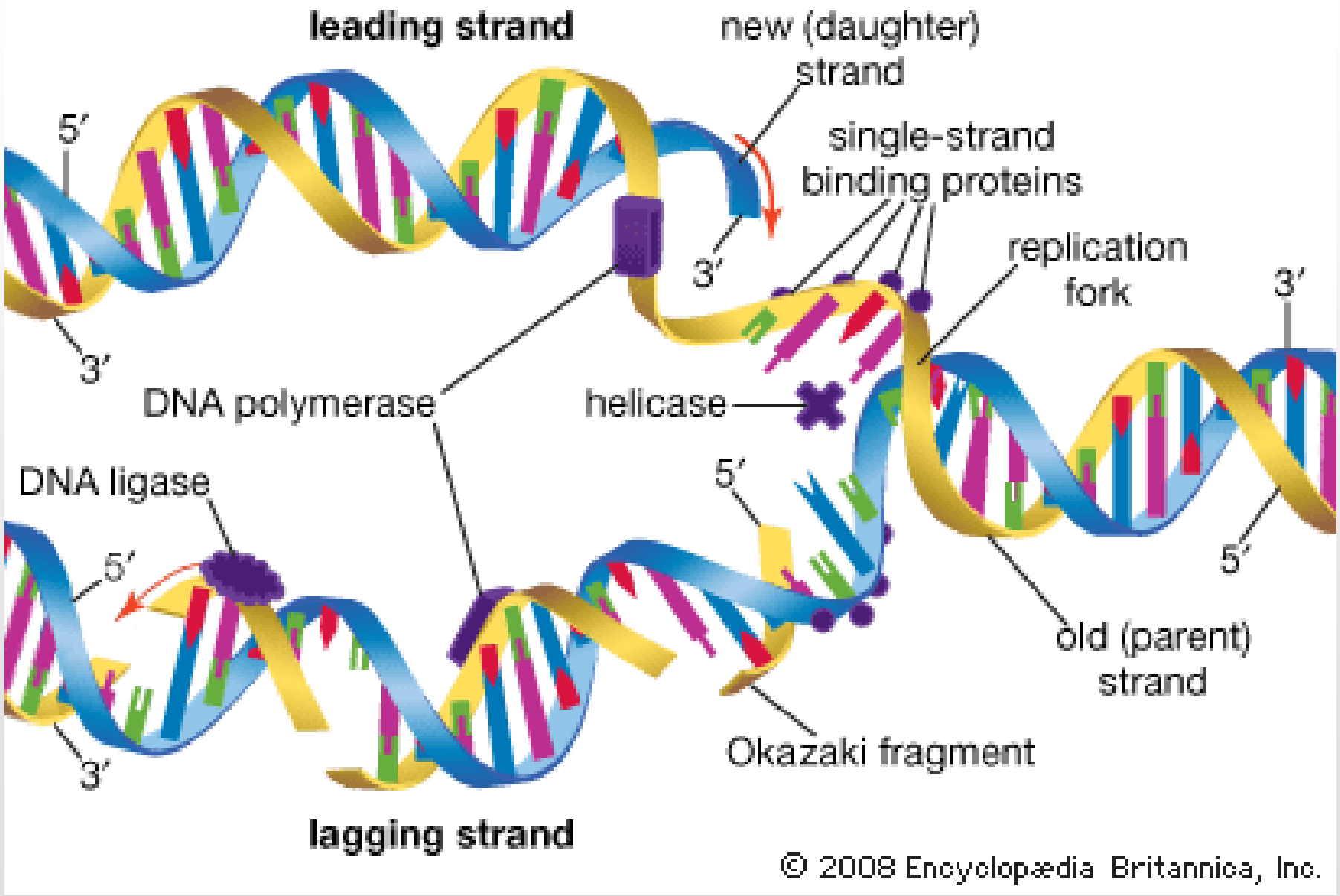
https://tinyurl.com/Translation-Example-AD

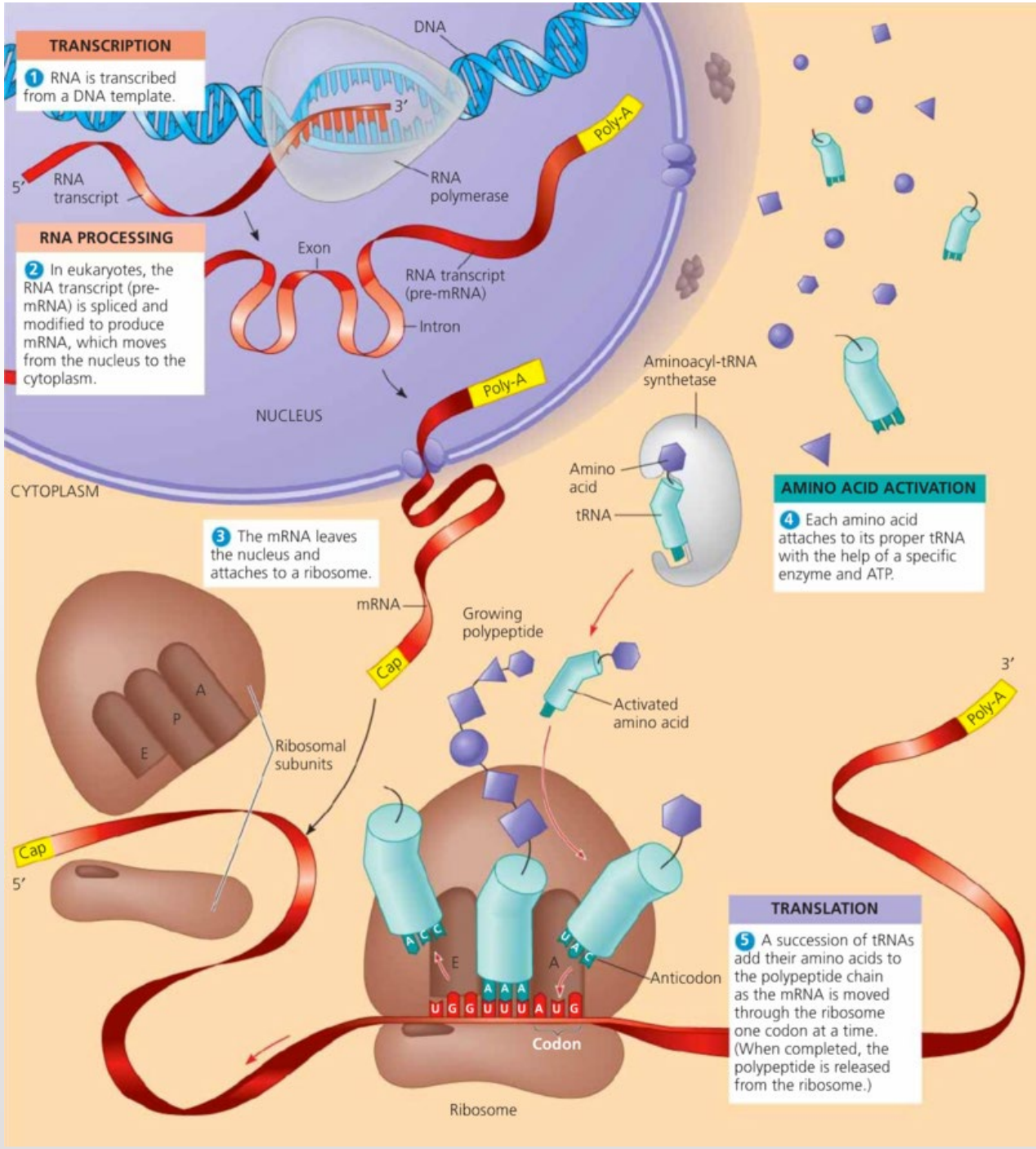
DNA = T A C G G T A C A A T G A C T
mRNA =
tRNA =
a.a. =

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU phenylalanine	UCU serine	UAU tyrosine	UGU cysteine	U
	UUC phenylalanine	UCC serine	UAC tyrosine	UGC cysteine	C
	UUA leucine	UCA serine	UAA *stop*	UGA *stop*	A
	UUG leucine	UCG serine	UAG *stop*	UGG tryptophan	G
C	CUU leucine	CCU proline	CAU histidine	CGU arginine	U
	CUC leucine	CCC proline	CAC histidine	CGC arginine	C
	CUA leucine	CCA proline	CAA glutamine	CGA arginine	A
	CUG leucine	CCG proline	CAA glutamine	CGG arginine	G
A	AUU isoleucine	ACU threonine	AAU asparagine	AGU serine	U
	AUC isoleucine	ACC threonine	AAC asparagine	AGC serine	C
	AUA isoleucine	ACA threonine	AAA lysine	AGA arginine	A
	AUG *(start)* methionine	ACG threonine	AAG lysine	AGG arginine	G
G	GUU valine	GCU alanine	GAU aspartate	GGU glycine	U
	GUC valine	GCC alanine	GAC aspartate	GGC glycine	C
	GUA valine	GCA alanine	GAA glutamate	GGA glycine	A
	GUG valine	GCG alanine	GAG glutamate	GGG glycine	G


DNA
Replication
Transcription
RNA
Translation
protein

Semiconservative DNA replication

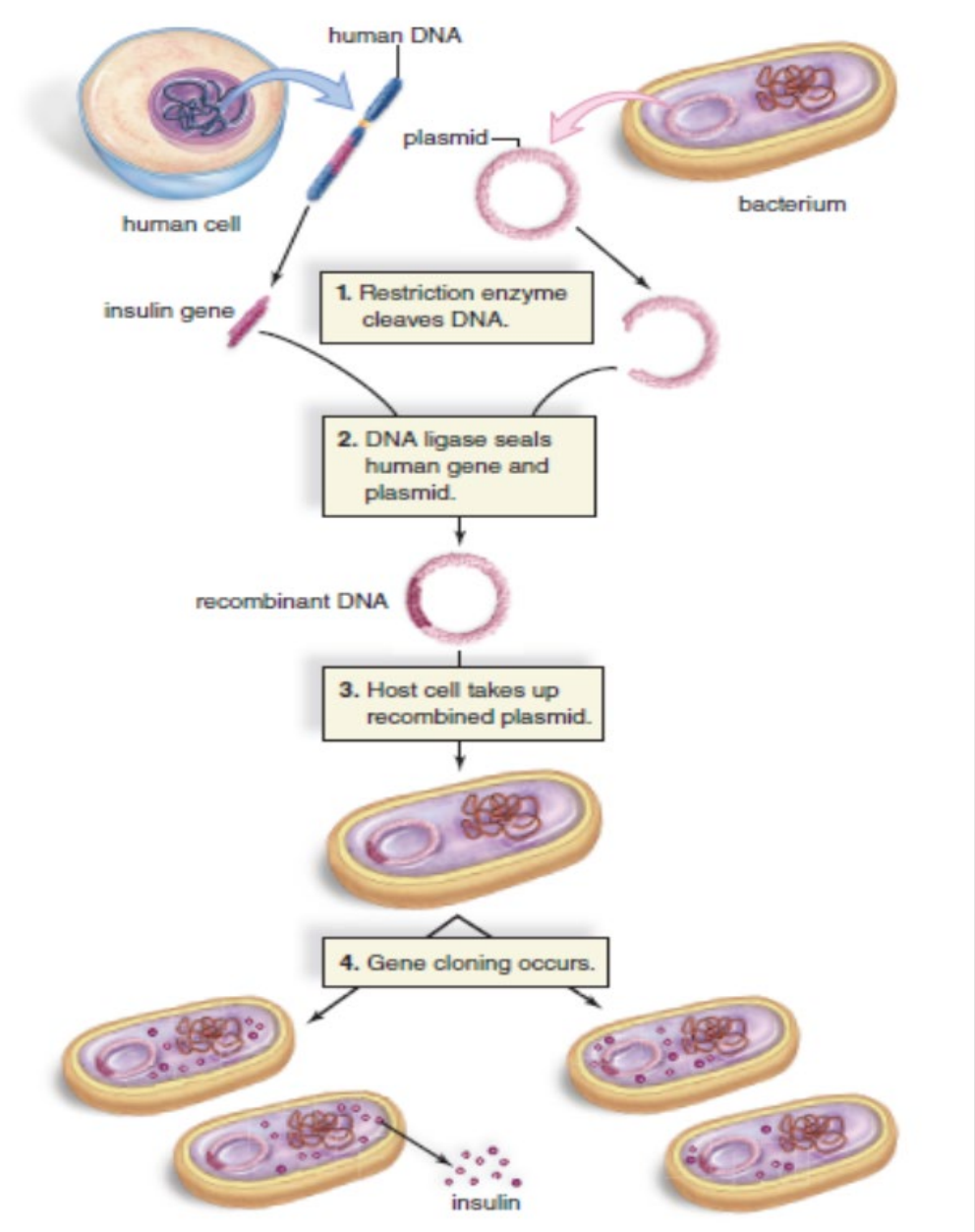



TRANSCRIPTION
1 RNA is transcribed from a DNA template.
DNA
3′
5′
RNA transcript
RNA polymerase
Poly-A
RNA PROCESSING
2 In eukaryotes, the RNA transcript (pre-mRNA) is spliced and modified to produce mRNA, which moves from the nucleus to the cytoplasm.
Exon
RNA transcript (pre-mRNA)
Intron
Poly-A
NUCLEUS
CYTOPLASM
Aminoacyl-tRNA synthetase
Amino acid
tRNA
AMINO ACID ACTIVATION
4 Each amino acid attaches to its proper tRNA with the help of a specific enzyme and ATP.
3 The mRNA leaves the nucleus and attaches to a ribosome.
mRNA
Cap
Growing polypeptide
Activated amino acid
3′
Poly-A
A
P
E
Ribosomal subunits
Cap
5′
A C C
E
A
U A C
Anticodon
A A A
U G G U U U A U G
Codon
TRANSLATION
5 A succession of tRNAs add their amino acids to the polypeptide chain as the mRNA is moved through the ribosome one codon at a time. (When completed, the polypeptide is released from the ribosome.)
Ribosome

Biotechnology

- Recombinant DNA (rDNA) is a genetically engineered type of DNA that is created in a lab and consists of DNA from TWO OR MORE SOURES OF DNA.
- Examples include:
  - GMOs = transgenic organisms
  - Cloning
  - Gene Therapy

Example of rDNA = cloning and mass-producing human insulin



[Link to Recombinant DNA technology video]

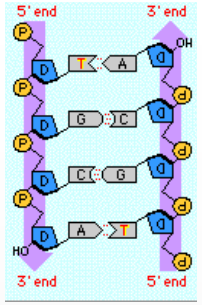
[How to make rDNA video]

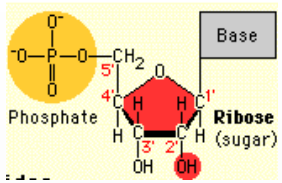
[Link to funny What's a GMO video]

Section 2.1: DNA vs. RNA

DNA	RNA

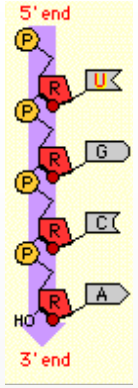
T

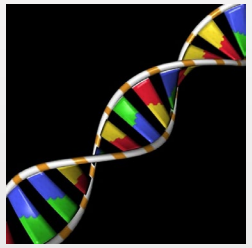

5' end
3' end
OH
HO
3' end
5' end


Base
Phosphate
Ribose
(sugar)

U

C

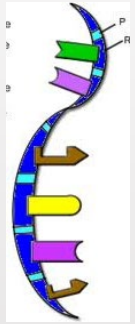

5' end
U
G
C
A
HO
3' end



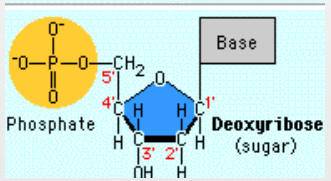
A

G

C



G

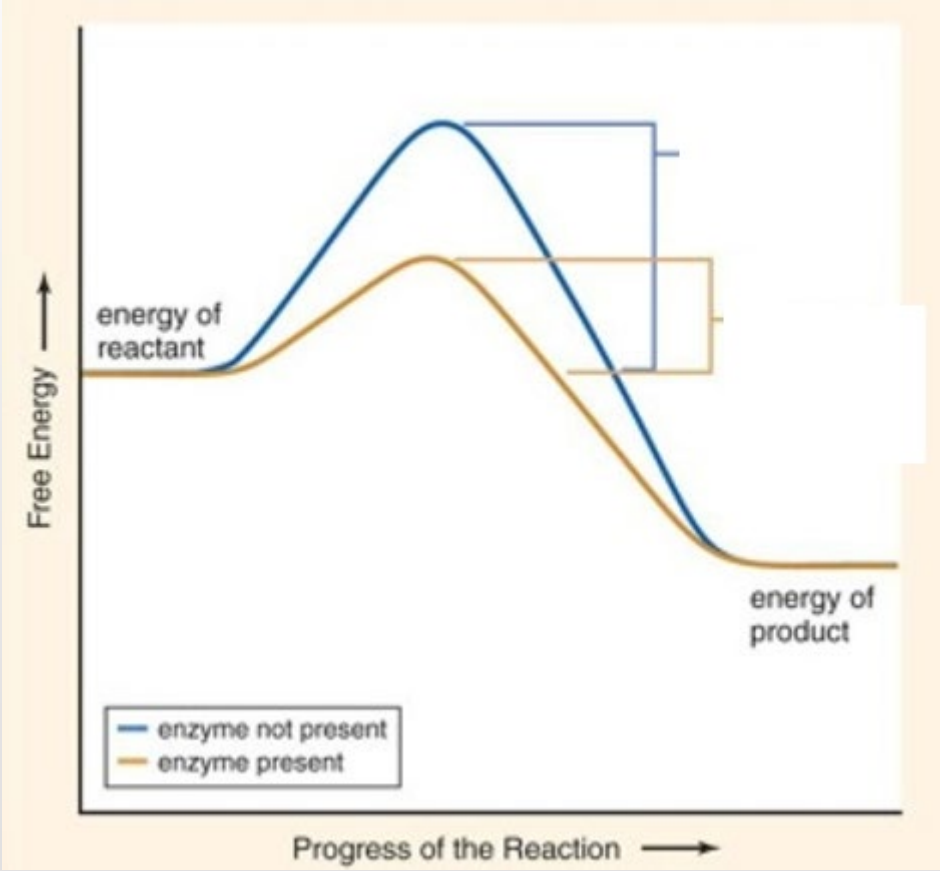

Base
Phosphate
Deoxyribose
(sugar)

A

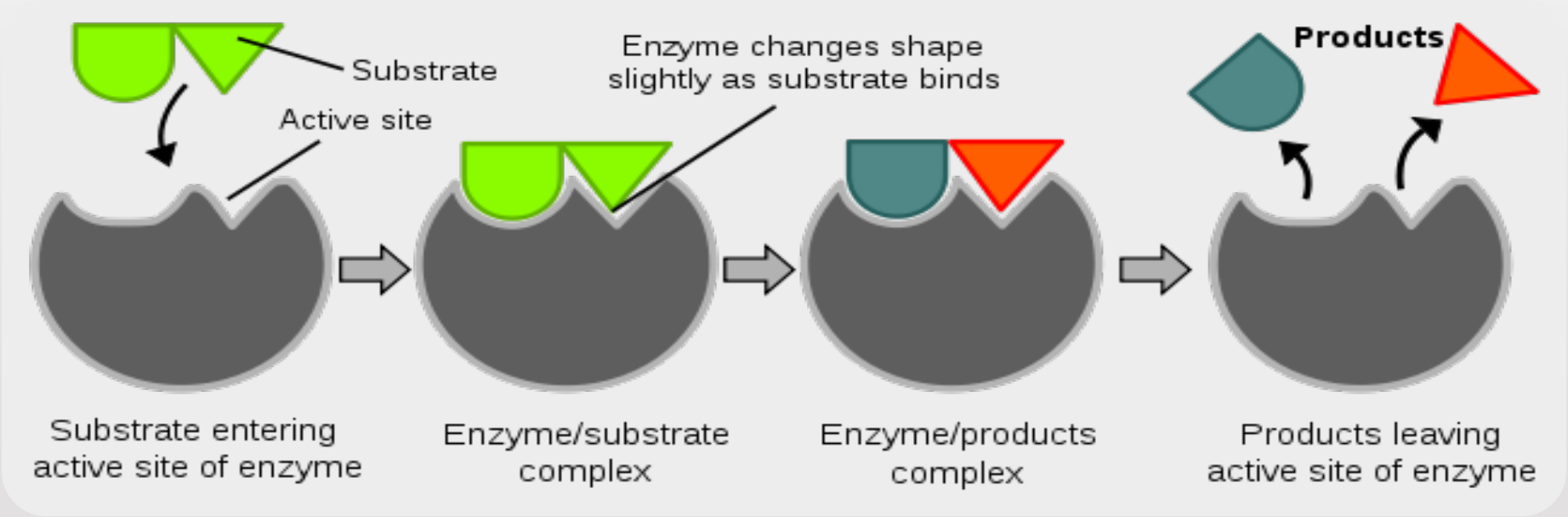
UNIT 3 CONTINUED: ENZYMES

Structure & Function of Enzymes

- Enzymes are made of proteins
- It catalyzes reaction by speeding them up and lowering the energy it take to have a reaction proceed = lowers Energy of Activation (E_a)



- Enzymes can help build up molecules (condensation synthesis reactions) OR help breakdown molecules (hydrolysis/digestion)
- Substrates are the reactants and enter the enzymes active site.
- The enzyme-substrate complex (ES complex) allows a reaction to occur and produce the product(s)



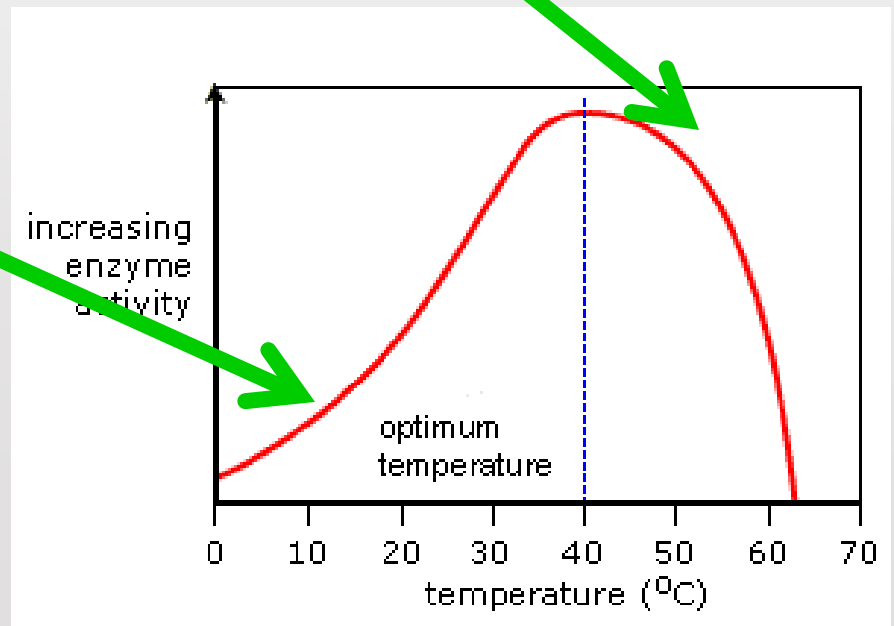
Factors that affect enzyme activity

- Temperature https://www.youtube.com/watch?v=D2j2KGwJXJc

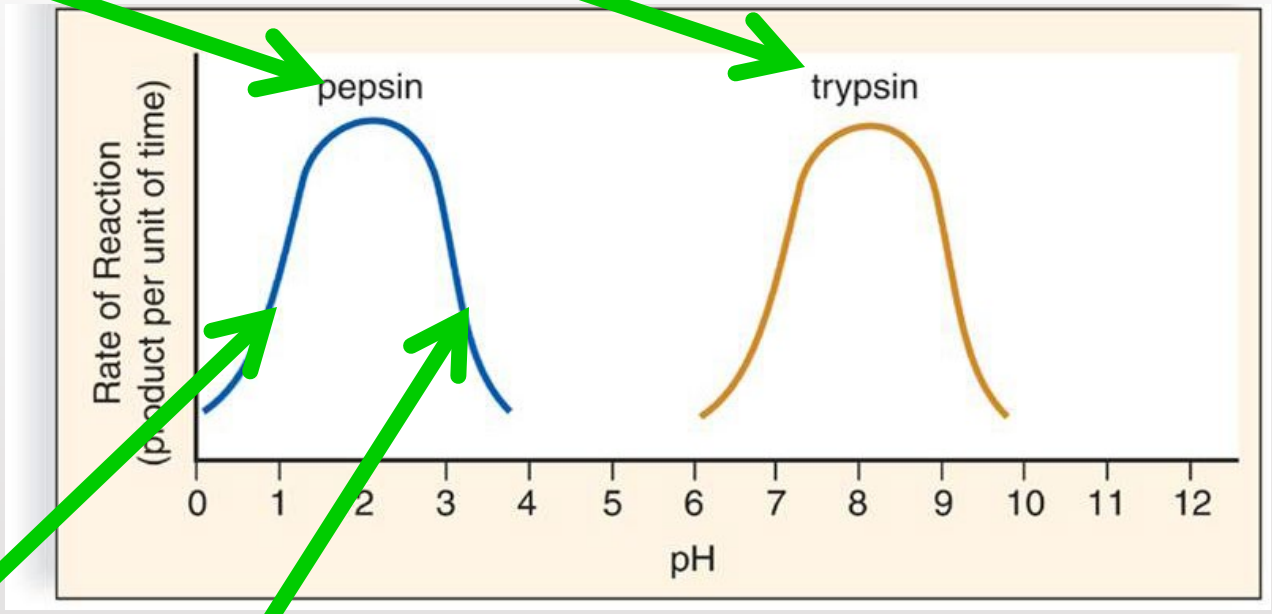
☆Optimal temperature for enzymes in human bodies is at 37.5 – 40^{0}C where the enzymes and substrates collide at a high speed resulting in the maximal ES complexes for the optimal reaction rate.

☆Temperatures greater than 40^{0}C can increase kinetic energy and increase collisions between enzymes and substrates; however, the reaction rate lowers as the enzymes denature and no ES complex can form.

☆Temperatures lower than 40^{0}C result in lower kinetic energy and cause molecules to move more slowly resulting in fewer collisions between enzymes and substrates; therefore a lowered number of ES complexes and a lower reaction rate



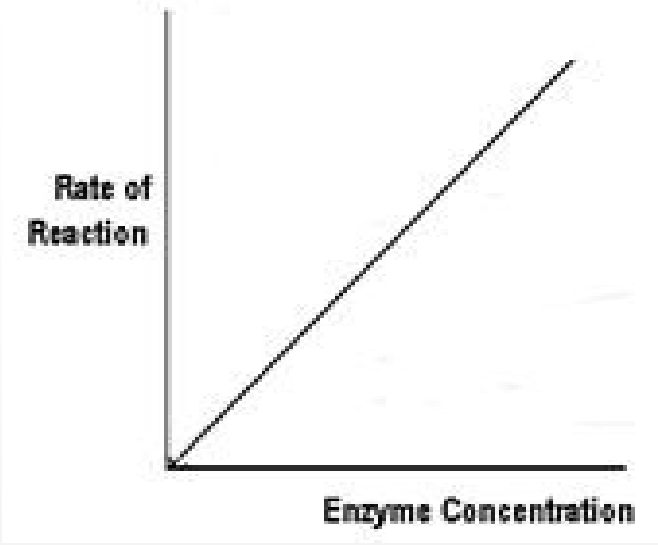
- pH
  - ☆ Every enzyme works at an optimal pH.
  - ☆ The optimal pH varies for different areas of the body
  - ☆ For example, a pH of 2 in the stomach is optimal for the gastric enzyme pepsin and a pH of 7 is optimal for salivary enzyme amylase in the mouth and a pH of 8 is optimal for trypsin in the small intestine.



  - ☆ If pH decreases or increases from optimal, the enzymes denature which results in fewer to no ES complexes forming and therefore a lowered reaction rate.

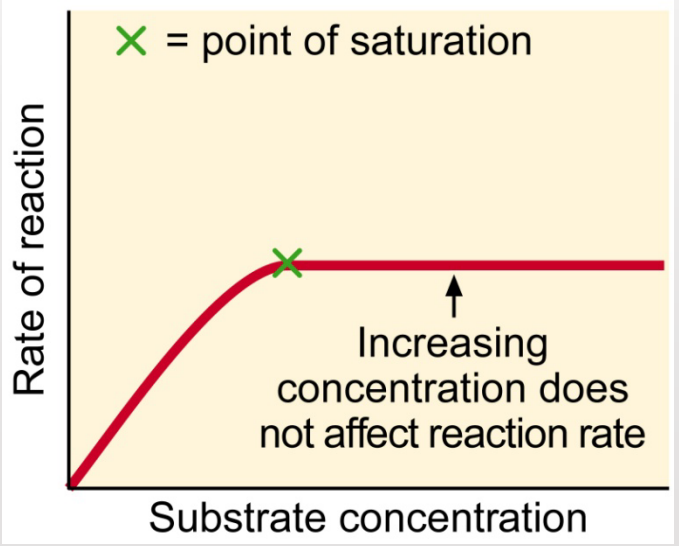
Enzyme Concentration

- As enzyme concentration increases, this increases collisions between enzymes and substrates resulting in increased ES complexes and an increased reaction rate



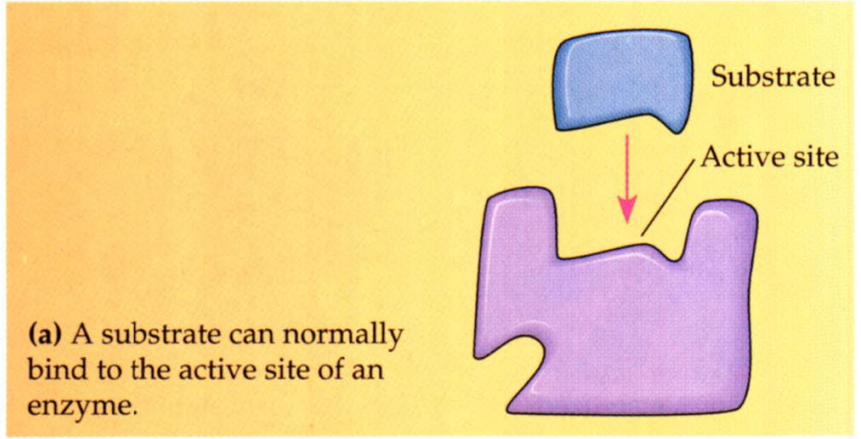
Substrate Concentration

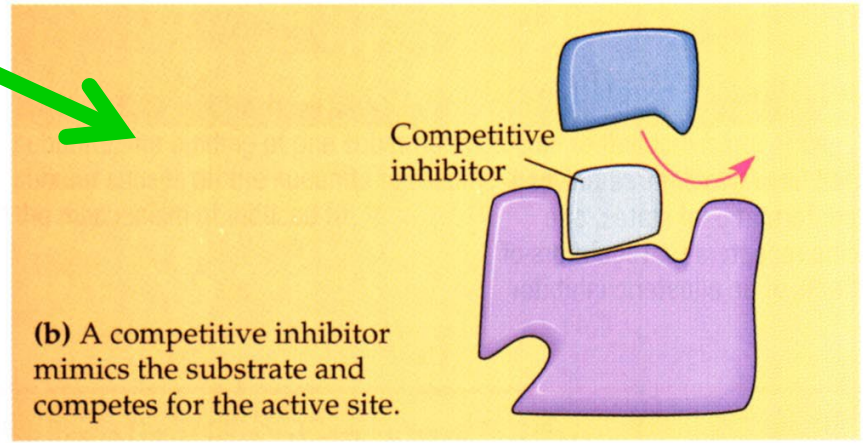
- As substrate concentration increases, there is an increased number of ES complexes due to increased collisions; hoever, the reactionrate maximises at the point where all enzymes are saturated with substrate
- An increase in substrate does not increase the reaction rate
- If more enzymes were added the reaction rate would again increase

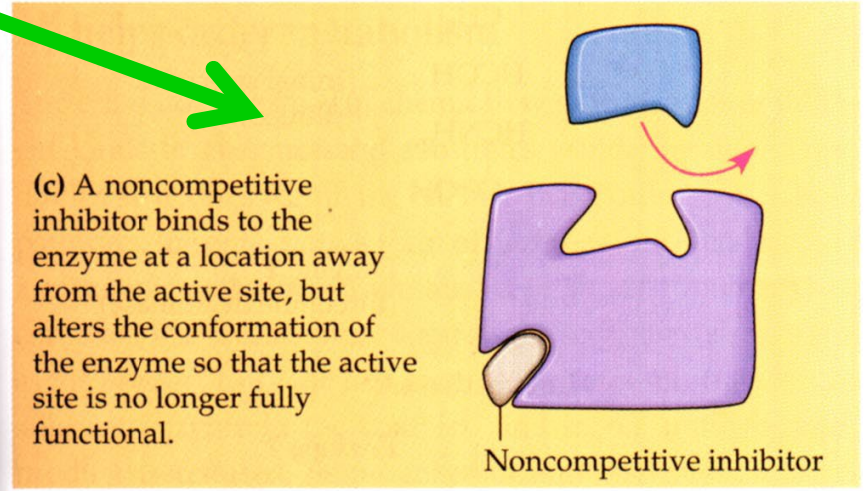


Inhibitors

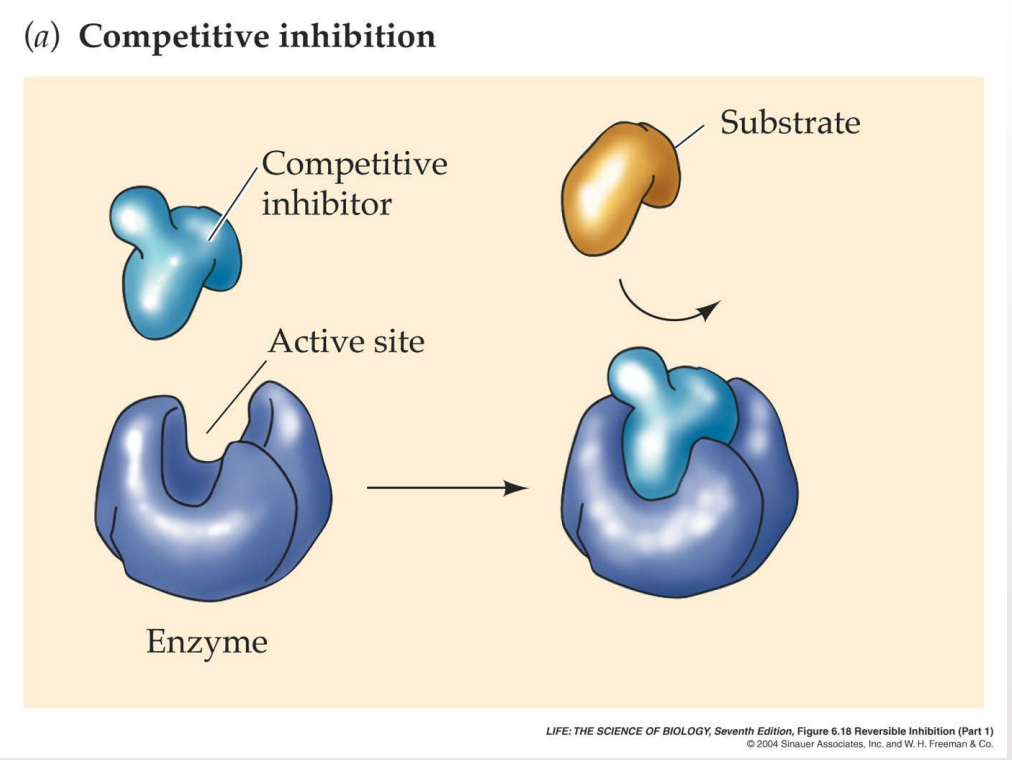
- Competitive Inhibitors
  - This inhibitor attaches to the active site and blocks the substrate from attaching
  - No ES complex forms therefore there is a lowered or zero reaction rate
- Non-competitive Inhibitors
  - This inhibitor attaches at the other site or allosteric site on the enzyme and causes the active site to change
  - The substrate cannot attach; therefore no ES complex forms and there is a lowered or zero reaction rate

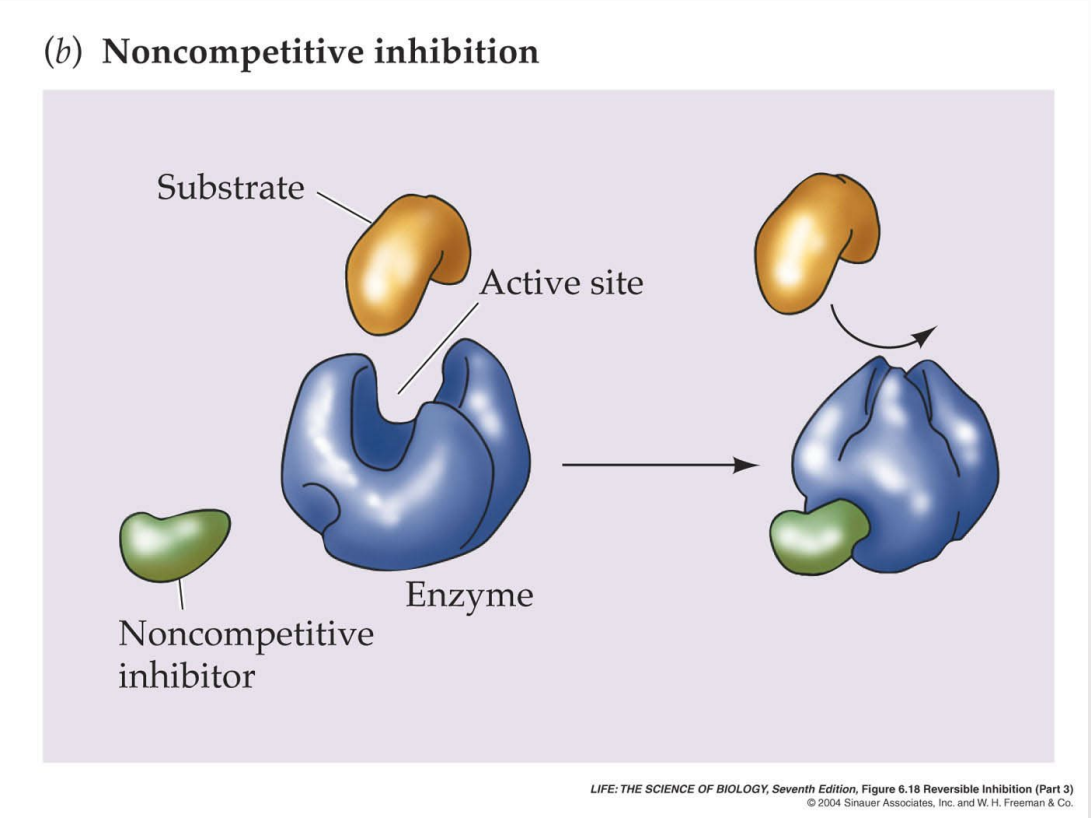






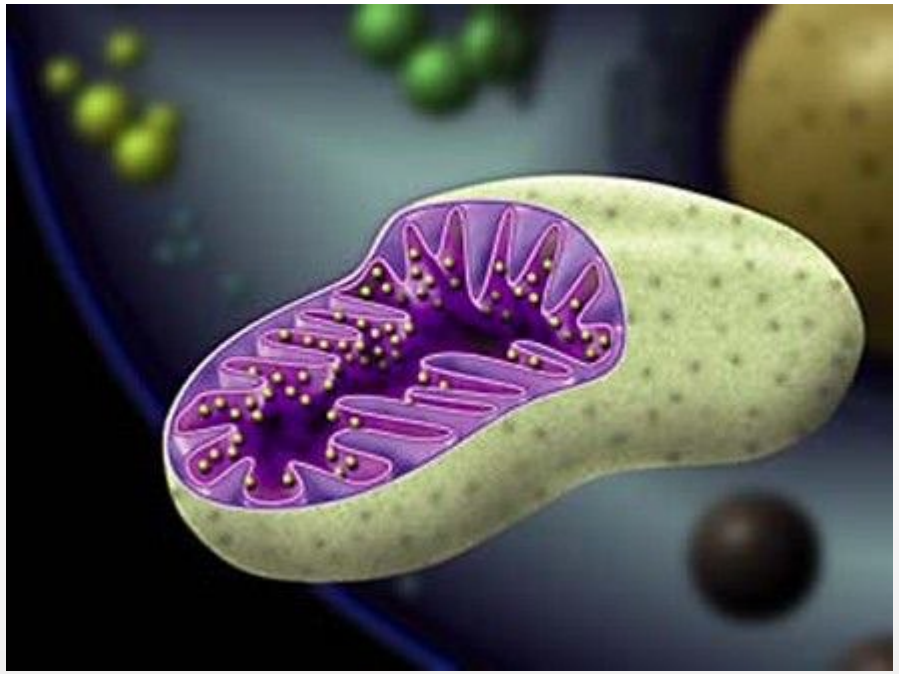
INHIBITION SUMMARY





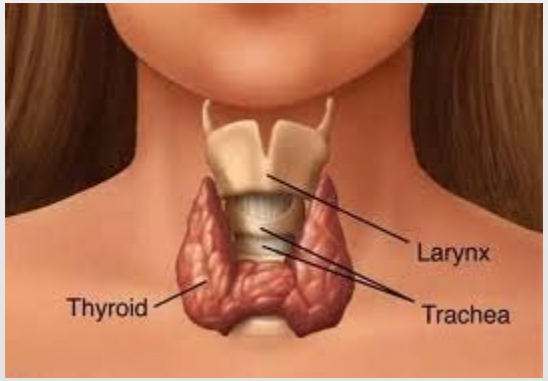
Metabolism

- Cellular Respiration
  - ☆ This is a metabolic reaction that occurs in the mitochondria of all cells
  - ☆ Each step of the reaction requires specific enzymes



The reaction is :

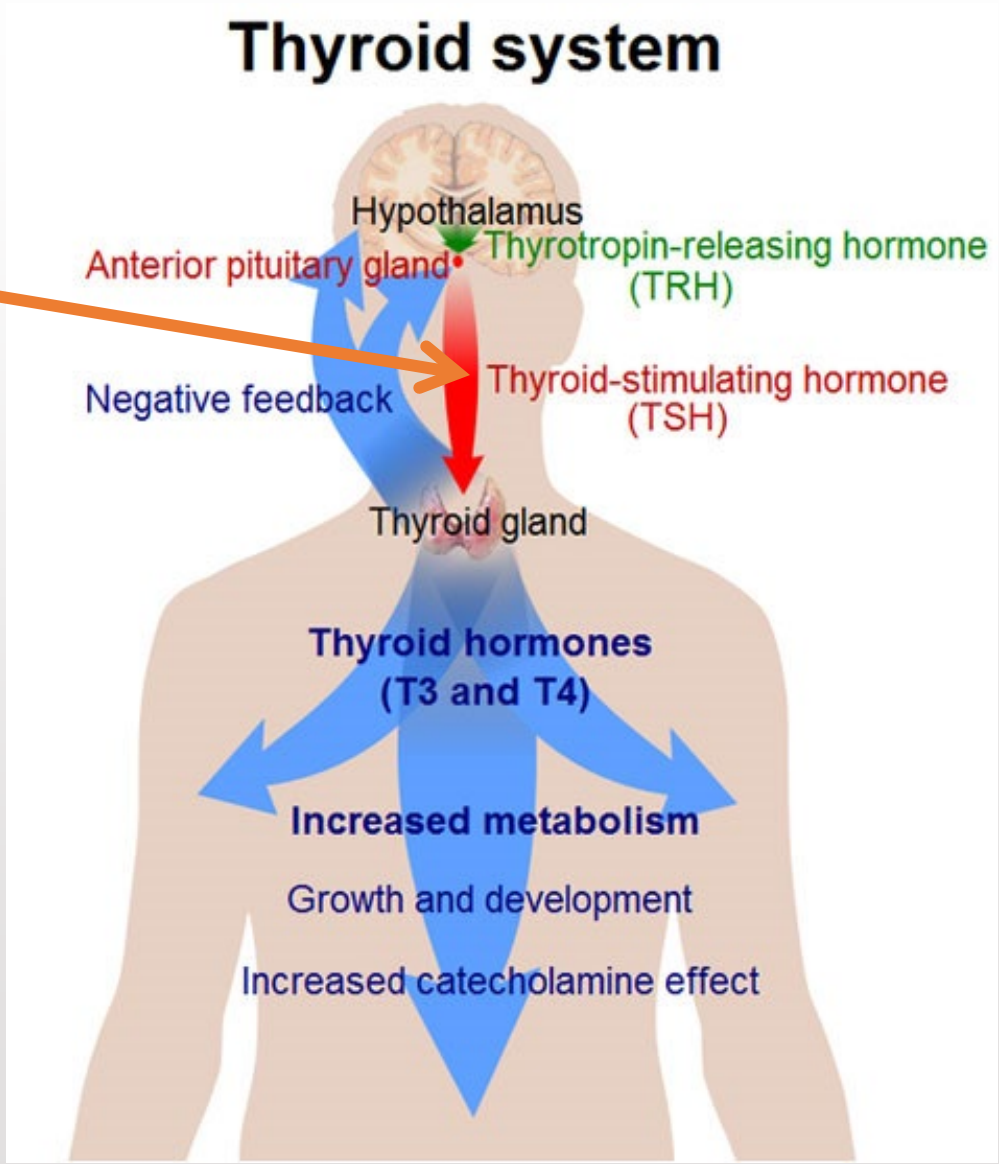
$$O_2 + C_6H_{12}O_6 \rightarrow CO_2 + H_2O + ATP$$



- ☆ This reaction is regulated by the hormone thyroxin which is produced in the thyroid gland (in your neck)

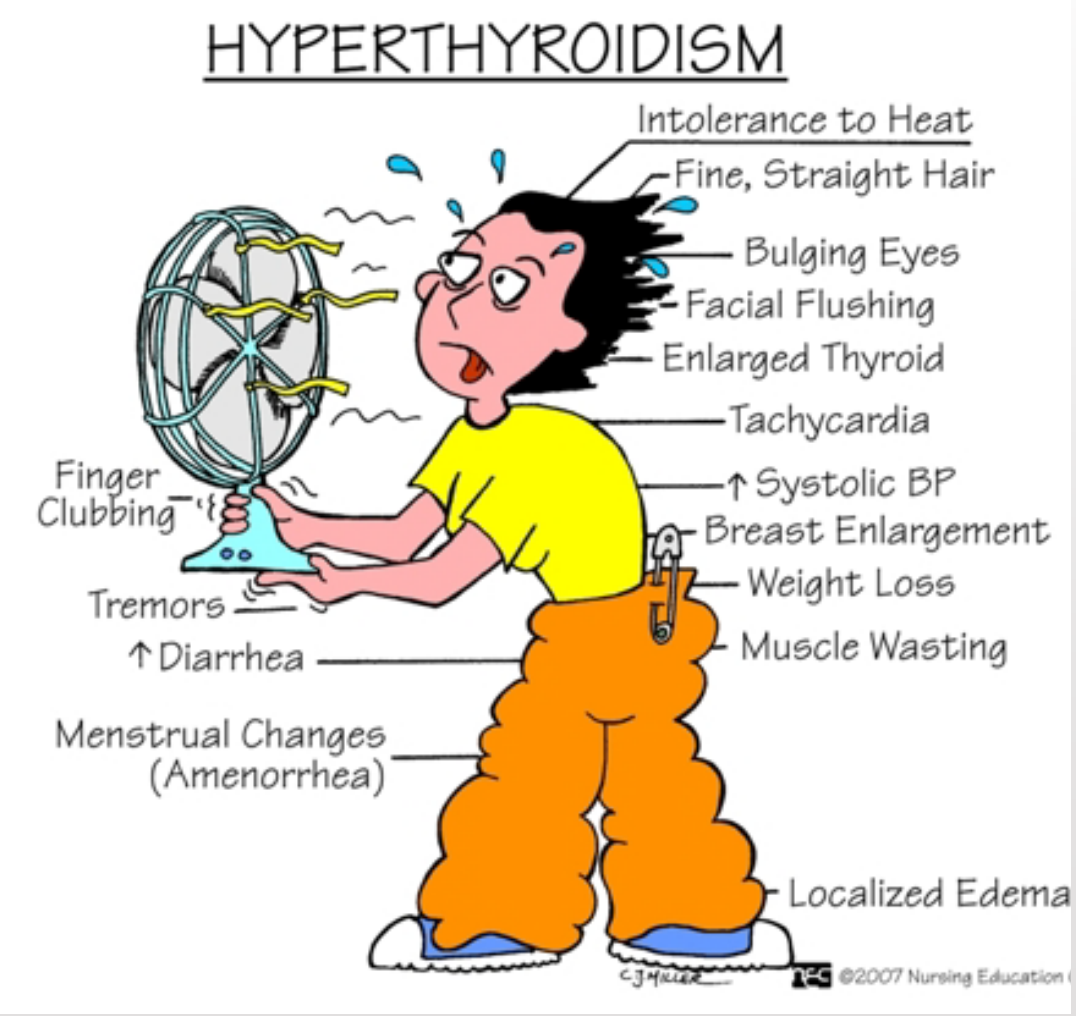
Thyroxin Pathway

- The hypothalamus controls the release of thyroxin from the thyroid gland by TSH

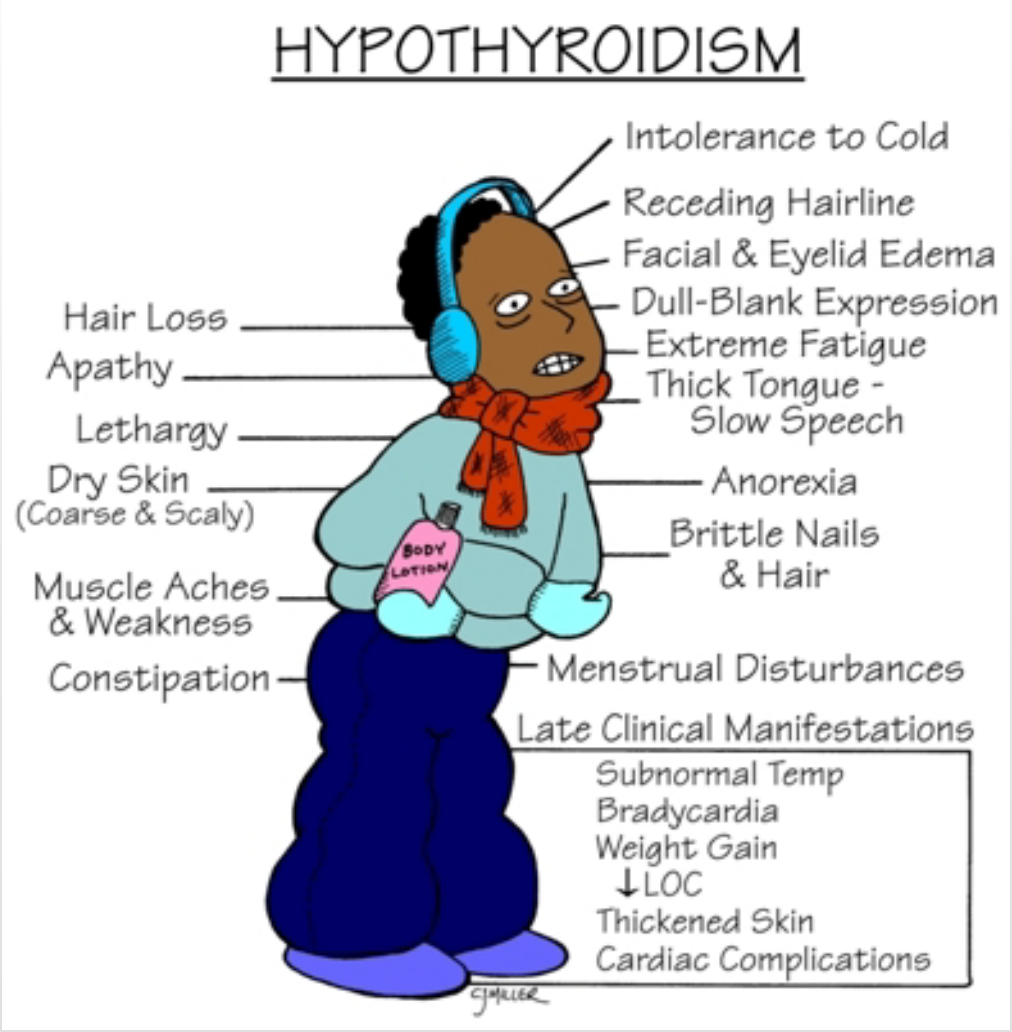


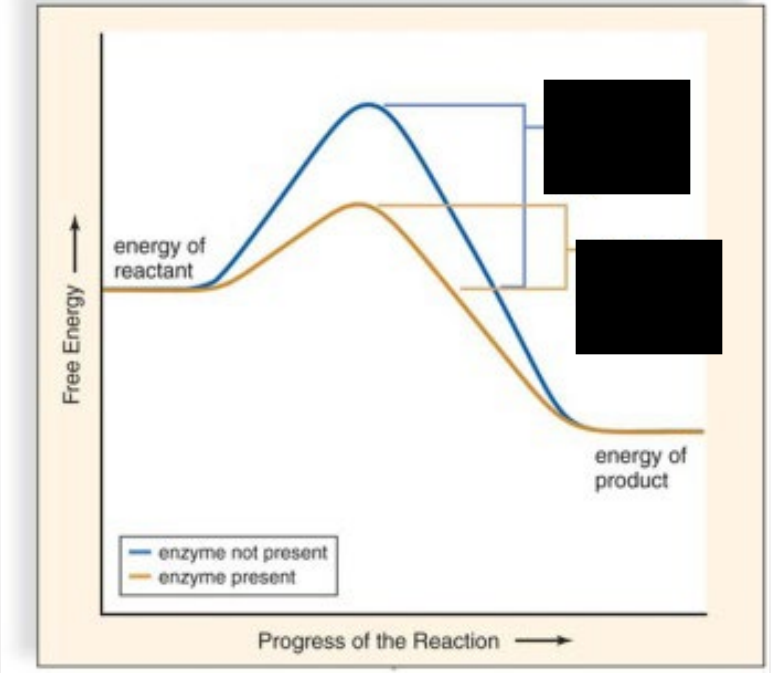
Thyroid Conditions

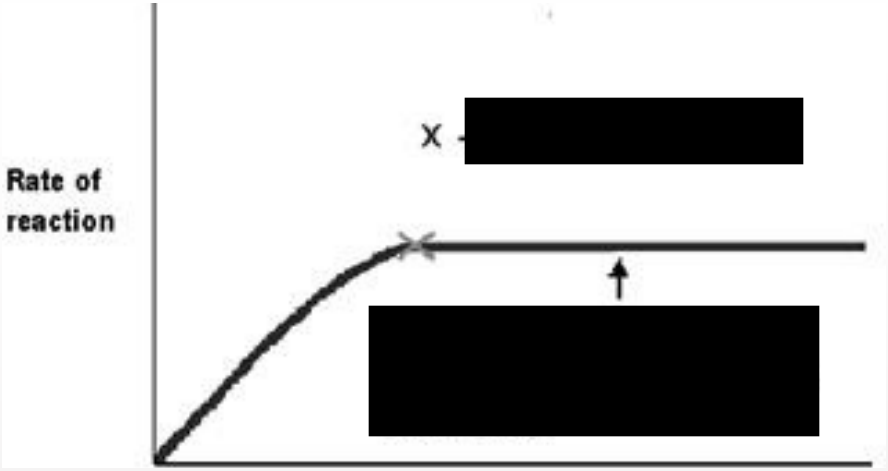
Hypothyroidism is a low thyroxin

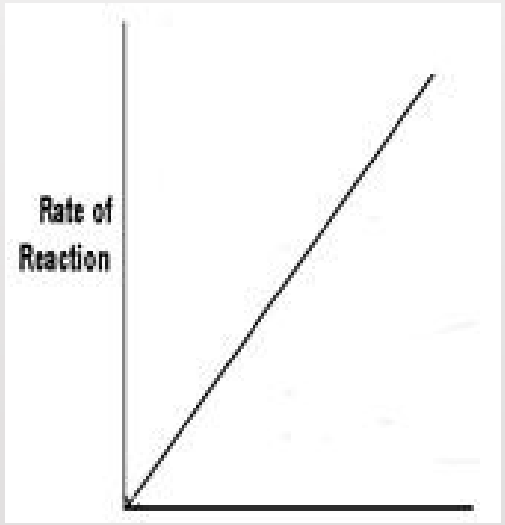


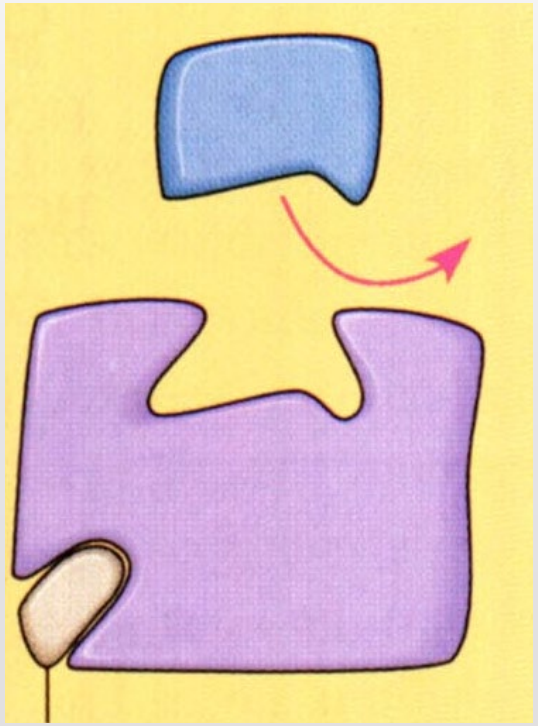
Hyperthyroidism is a high thyroxin

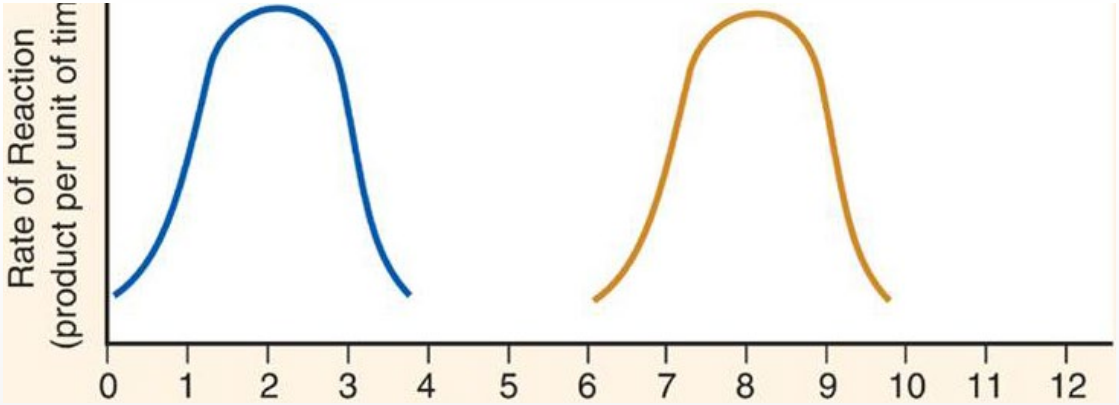


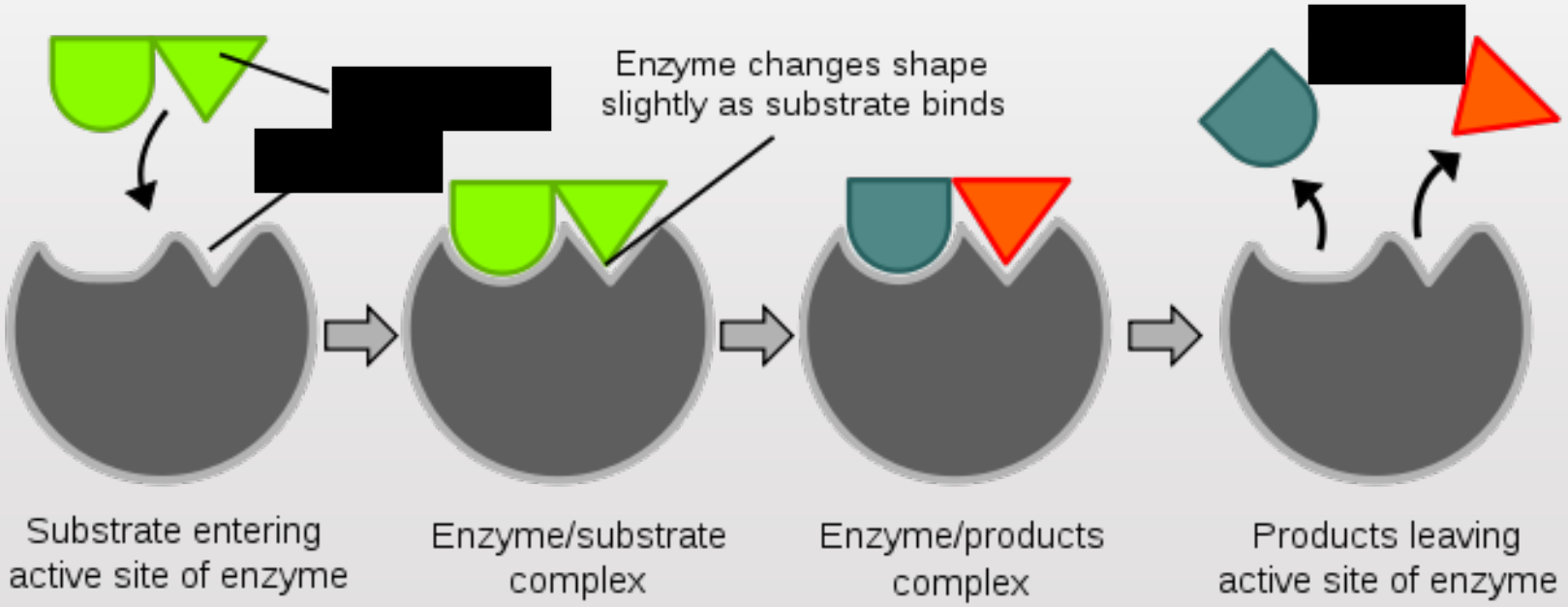


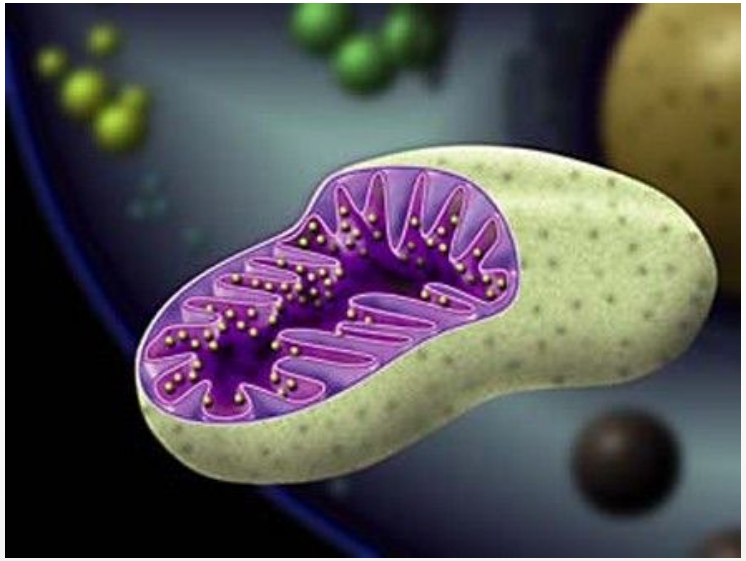


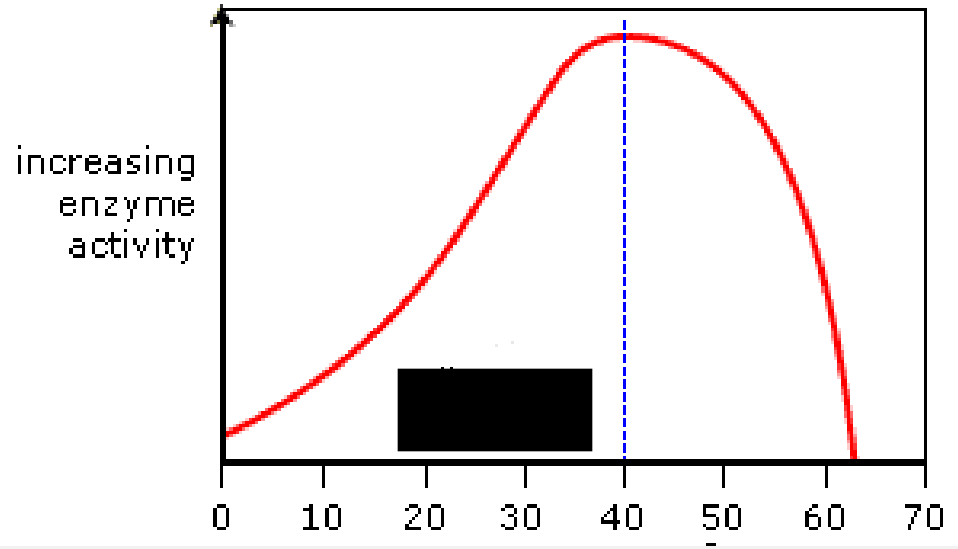


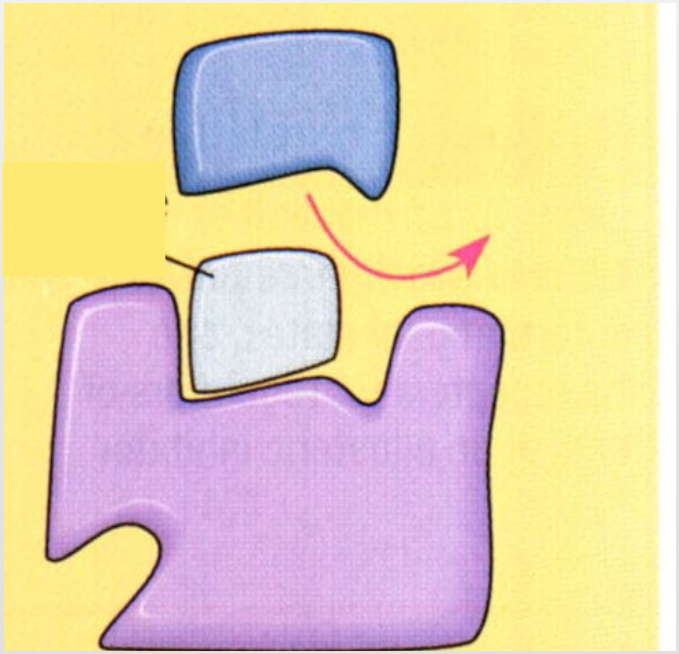


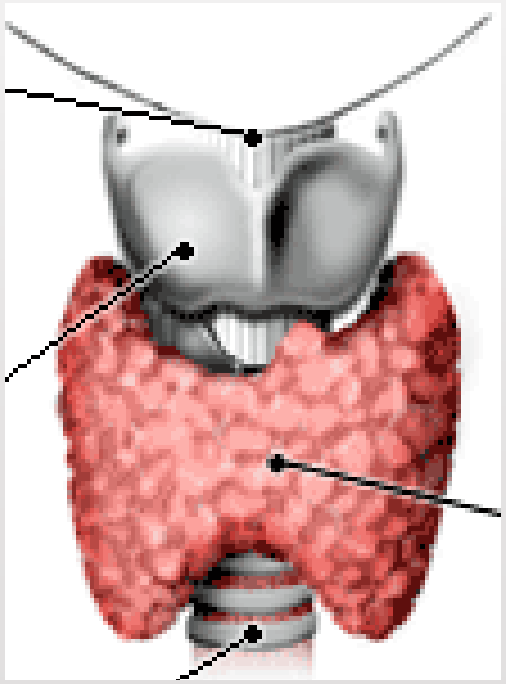

Rate of Reaction
(product per unit of tim
0
1
2
3
4
5
6
7
8
9
10
11
12

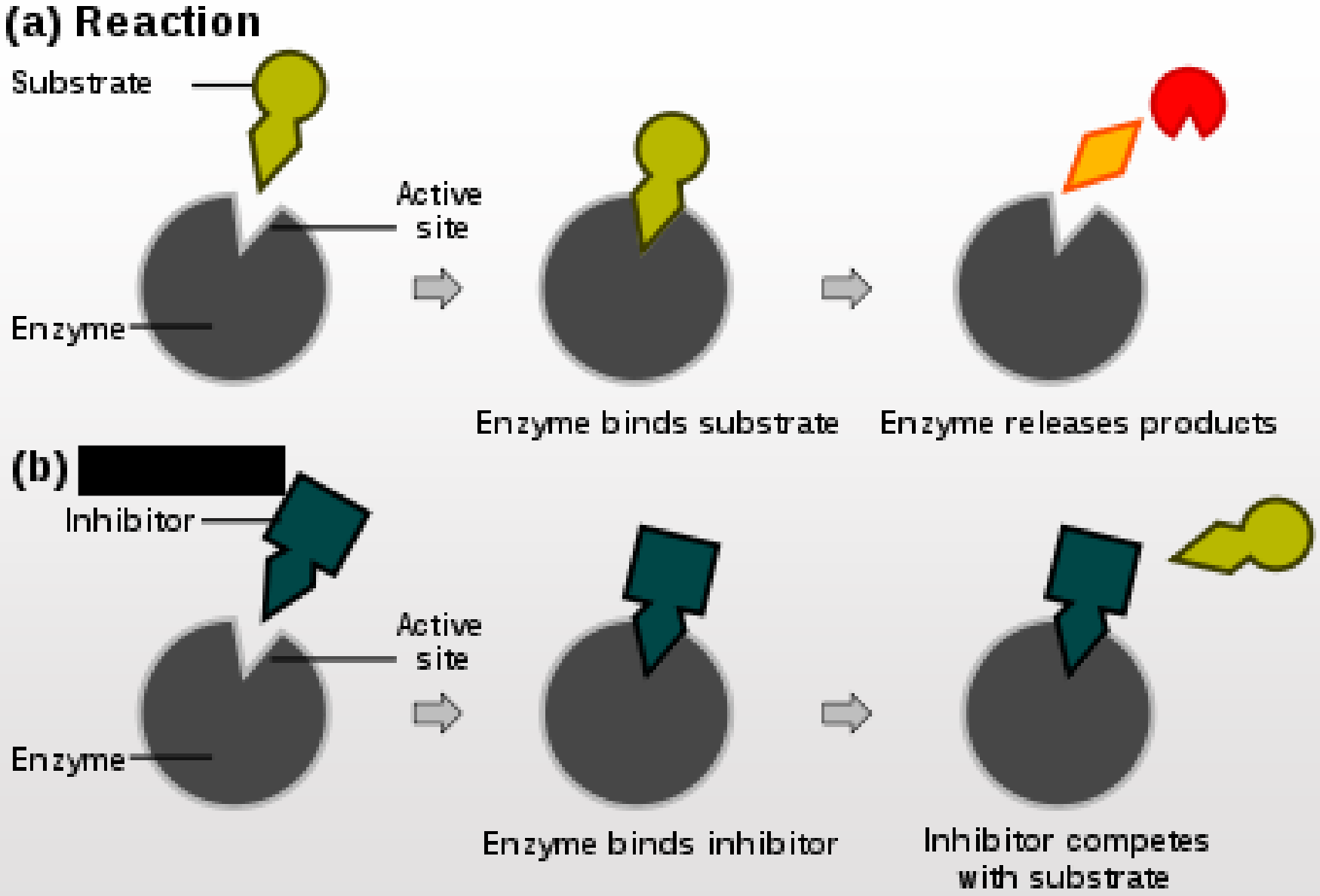

Enzyme changes shape
slightly as substrate binds
Substrate entering
active site of enzyme
Enzyme/substrate
complex
Enzyme/products
complex
Products leaving
active site of enzyme

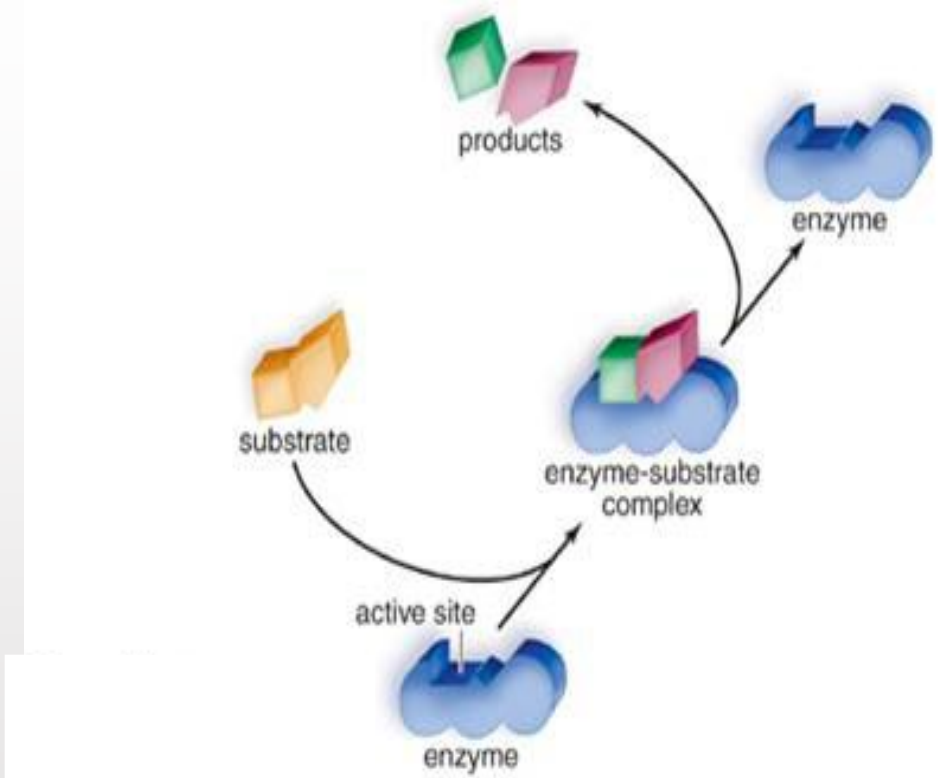


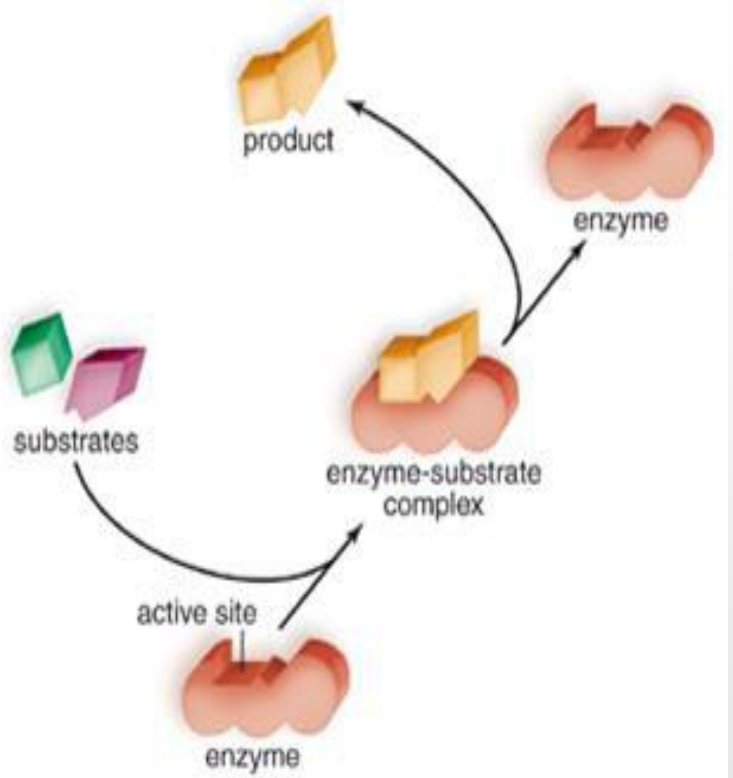

increasing
enzyme
activity
0
10
20
30
40
50
60
70






(a) Reaction
Substrate
Active site
Enzyme
Enzyme binds substrate
Enzyme releases products
(b)
Inhibitor
Active site
Enzyme
Enzyme binds inhibitor
Inhibitor competes with substrate


products
enzyme
substrate
enzyme-substrate
complex
active site
enzyme


product
enzyme
substrates
enzyme-substrate
complex
active site
enzyme