Cell Biology

Macromolecules & Transport

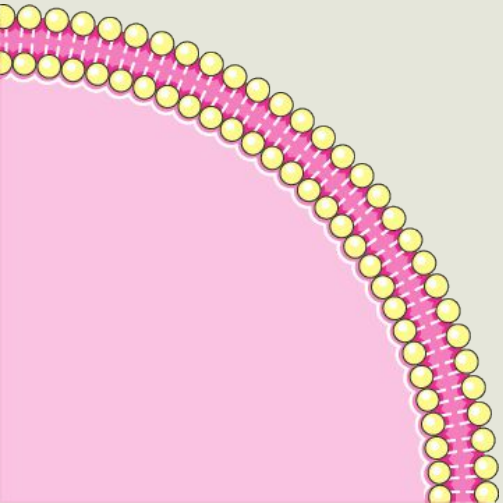

1
Review from Last Week

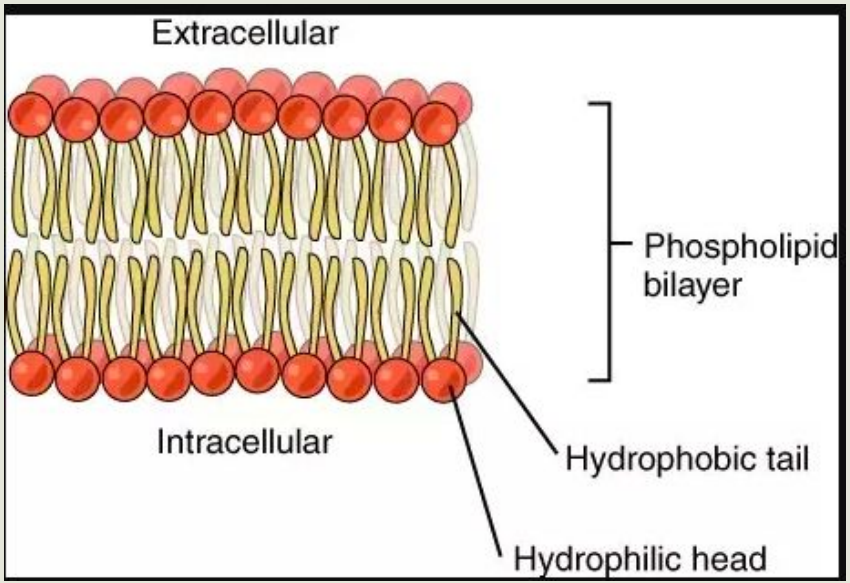
2

Passive Transport

Cell Transport

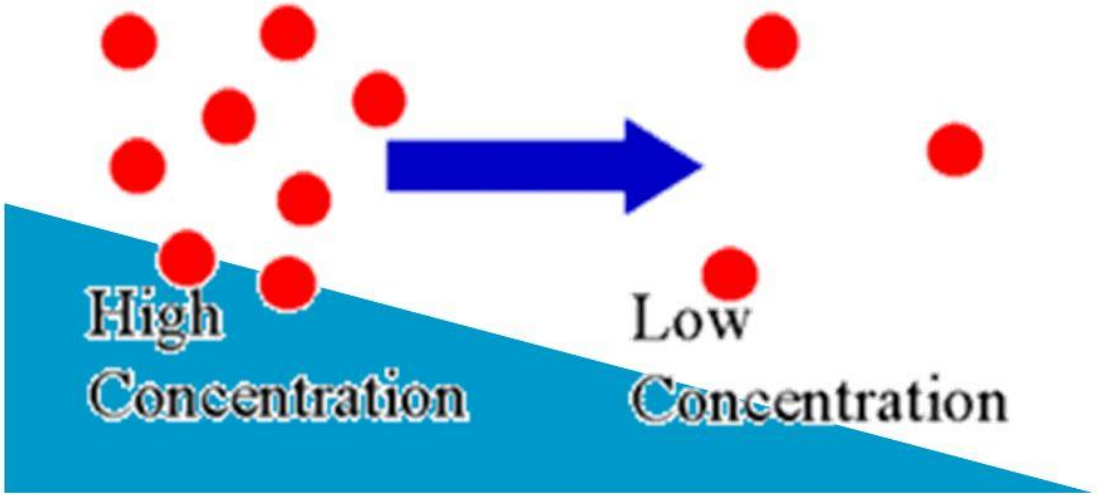
is the movement of materials across **cell** membranes to help maintain homeostasis





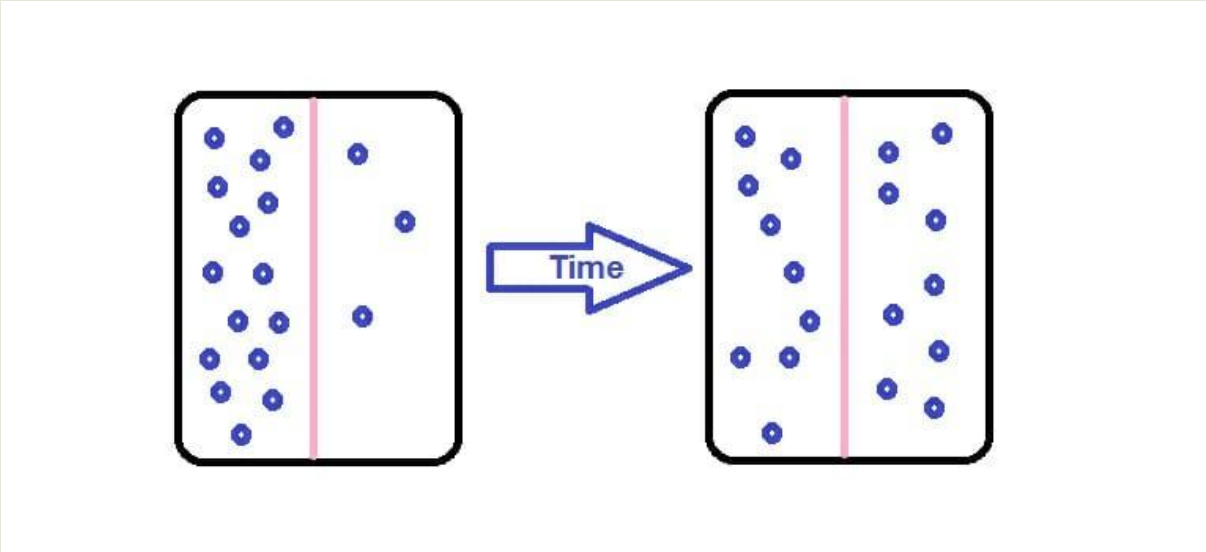
Concentration Gradient

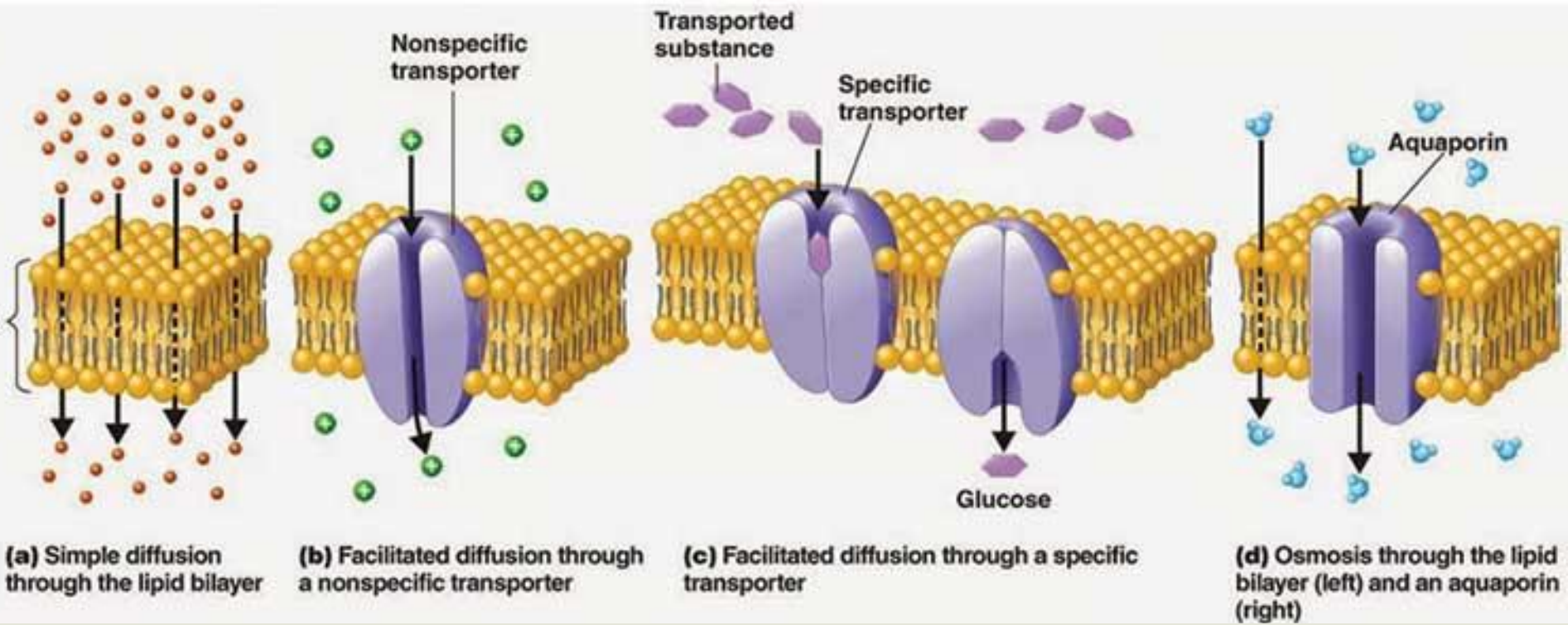
- The difference in concentration of molecules across a space



Passive = No Energy Used

o Diffusion – movement of materials across the membrane from an area of higher concentration to an area of lower concentration (Osmosis – the diffusion of water)





o Simple diffusion – from high to low concentration- small and uncharged/non-polar move freely through phospholipids, ex. CO_2, O_2

o Facilitated diffusion – large or charged from high to low, ex. glucose, K^+ (channels and carriers)

3

Active Transport

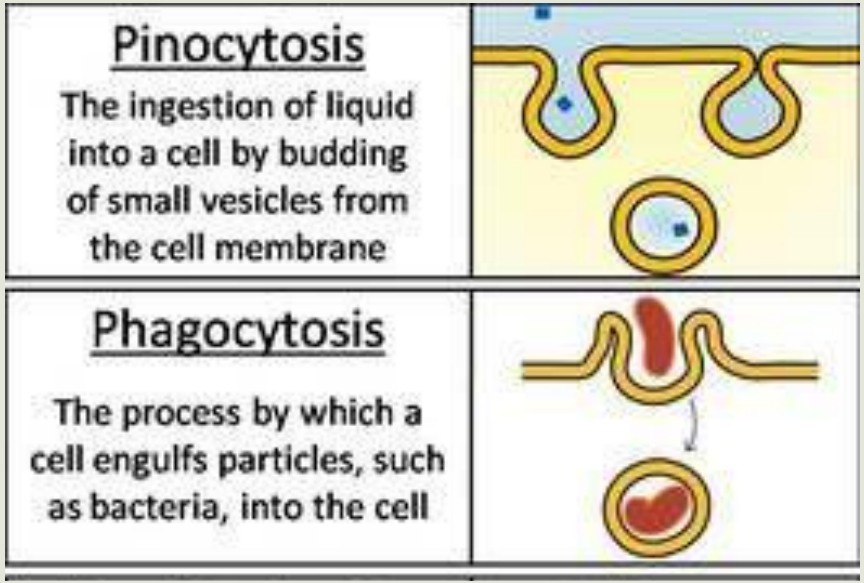
Active = energy used

o Endocytosis – movement of large amounts of material into the cell by the folding in of the membrane

Pinocytosis – “cell drinking”

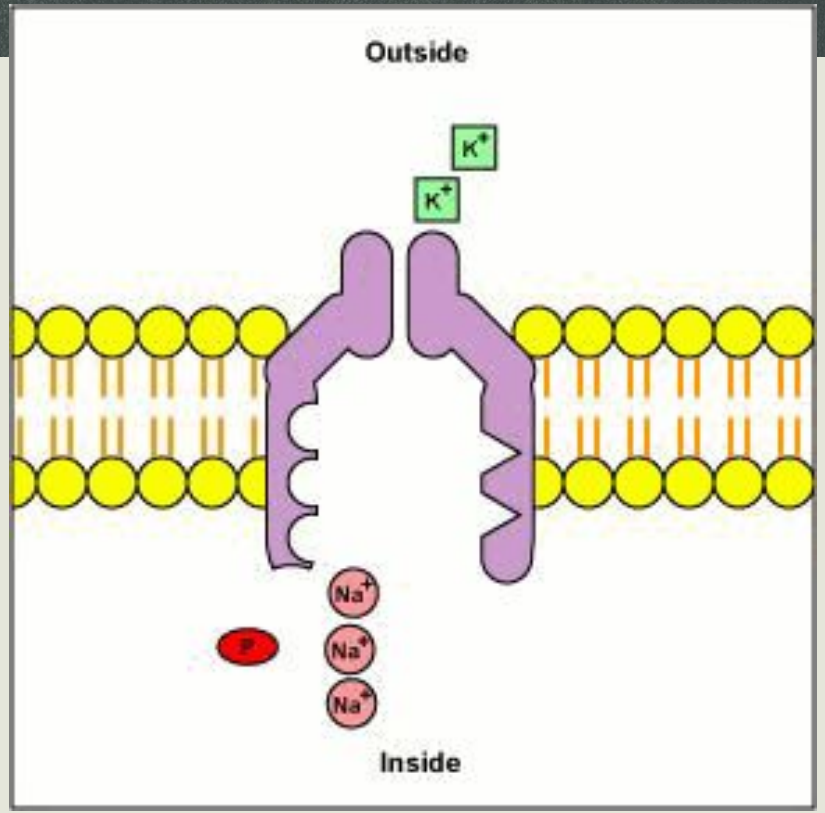
Phagocytosis – “cell eating”

o Exocytosis – release of material using vesicles fusing with membrane



Sodium Potassium Pump

A type of active transport that uses energy to move ions against its concentration gradient



4

Tonicity

Solution = Solvent + Solute

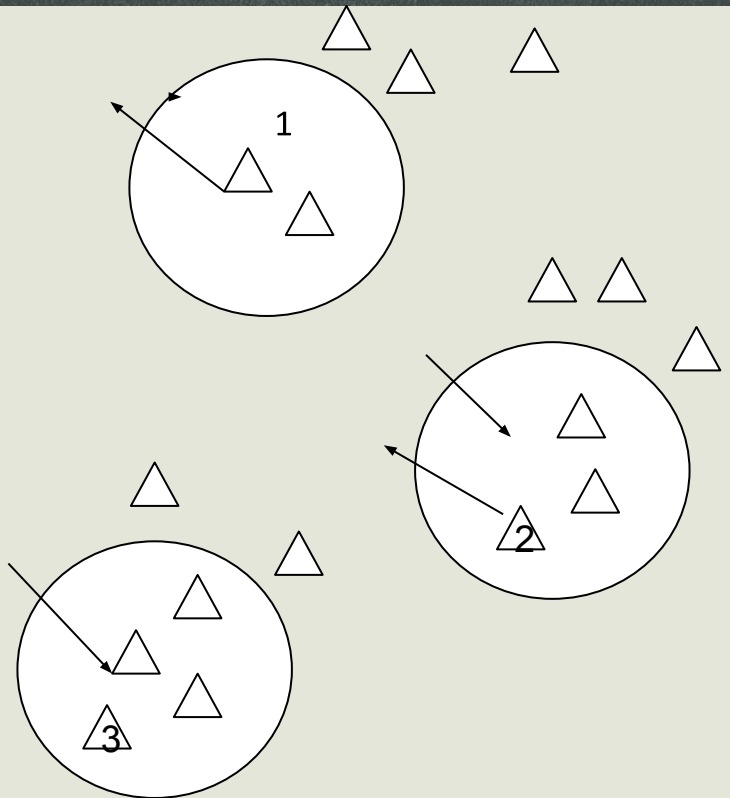
- Solvent: a substance that dissolves another substance
  - Or, the substance present in greater amount
- Solute: a substance which is dissolved by another substance
  - Or, the substance present in lesser amount

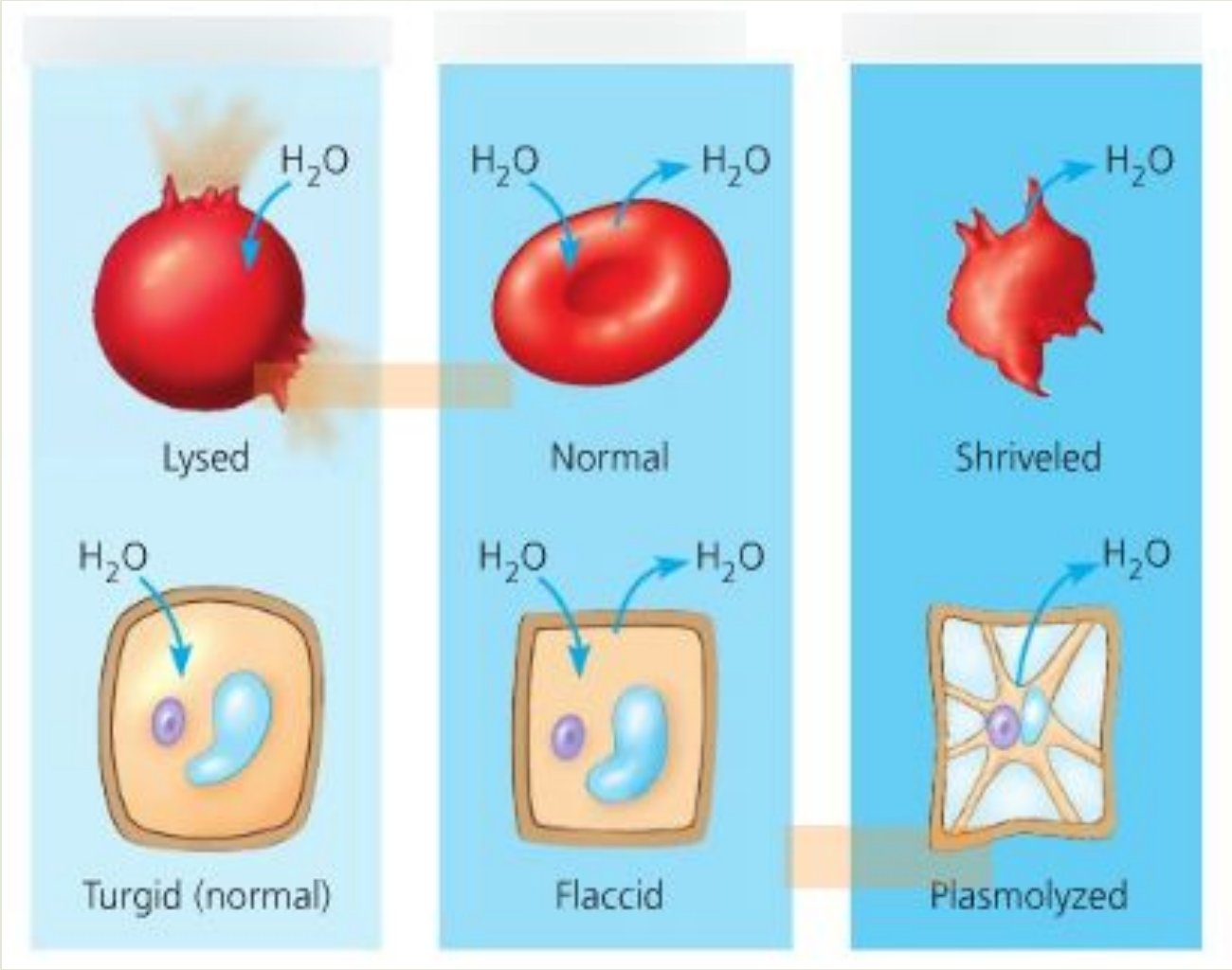
Tonicity (hypo-->hyper) (water always follows solute)

Hypertonic – solution with a higher solute concentration than the cell (water will move out of the cell)

Hypotonic – solution with a lower solute concentration than the cell (water will move into the cell)

Isotonic – solution with an equal solute concentration as the cell (no net movement of water)



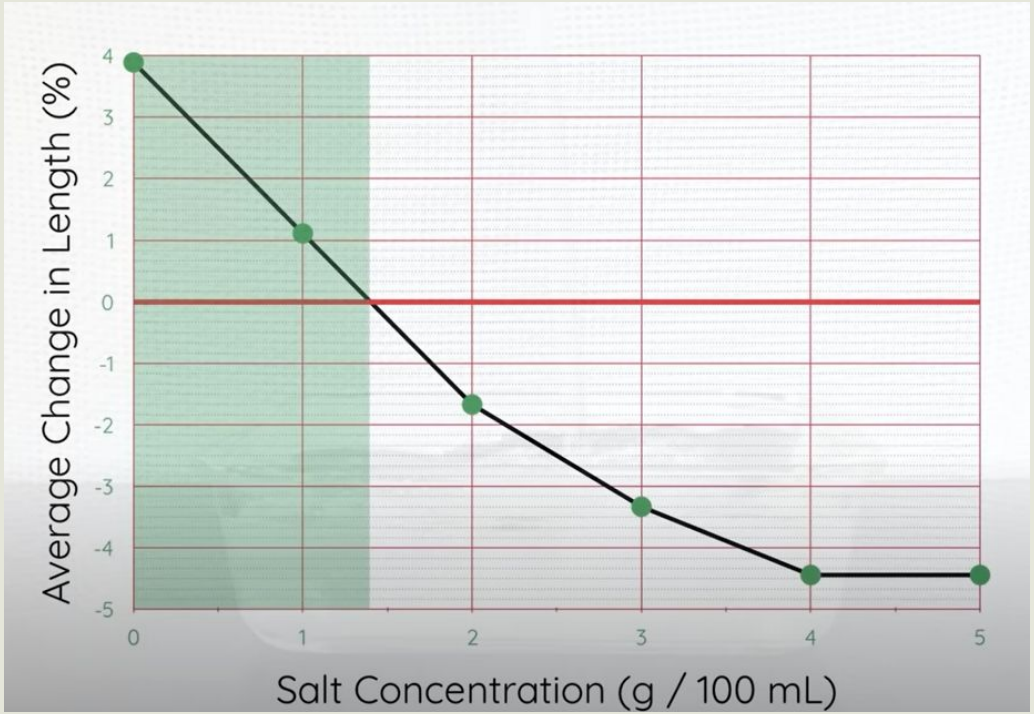

H_2O
Lysed
H_2O
H_2O
Normal
H_2O
Shriveled
H_2O
Turgid (normal)
H_2O
H_2O
Flaccid
H_2O
Plasmolyzed

4

Osmosis Potato Lab

Osmosis Data Tracker

	Before Mass	After Mass	Before Length	After Length	Percentage Difference
No Water	6.5 g	6.5 g	5 cm	5 cm	0%
Water	5.9 g	7 g	5 cm	5.2 cm	18.6%
Salt + Water	5.1 g	4.6 g	5 cm	4.5 cm	-9.8%


Average Change in Length (%)
4
3
2
1
0
-1
-2
-3
-4
-5
0
1
2
3
4
5
Salt Concentration (g / 100 mL)

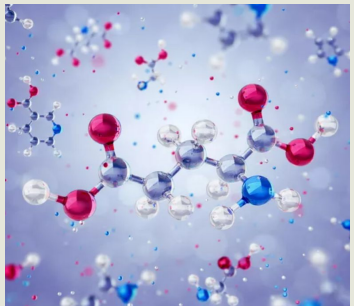
5

Intro to Macromolecules

Monomers vs Polymers

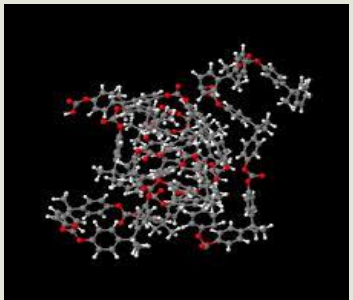
Monomers

- Small molecule
- Basic unit/ Building block of macromolecules;
- Ex: glucose, amino acids



Polymers

- Larger molecule
- Long chain composed of multiple similar or identical monomers.
- Ex: starch, insulin



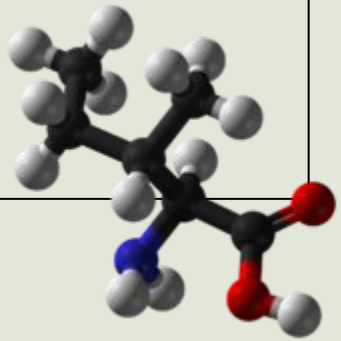
Organic Compounds

What is a functional group?

- where covalent bonds often form
- Indicate type of chemical reactions to occur

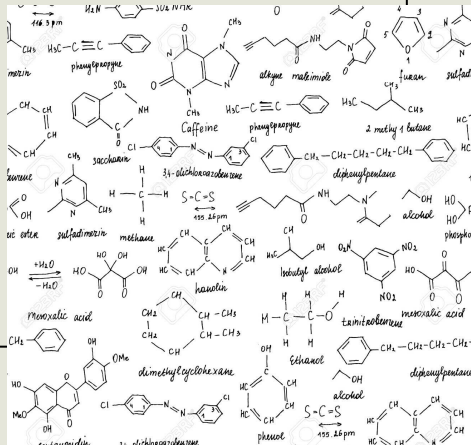
Why Carbon?

- 4 stable bonds



What is an organic compound?

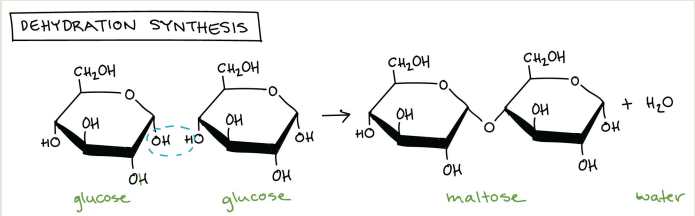
- Constitutes the forms of living organisms
- at least 5 carbon atoms
- Large
- CHONSP



Dehydration Synthesis and Hydrolysis

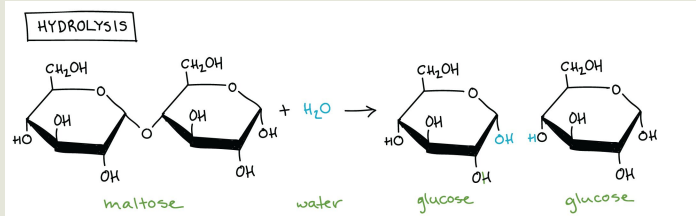
Dehydration Synthesis

- Monomers to polymer
- Stores Energy
- Creation of new covalent bond
- Creates larger molecules
- Gives off H2O as waste



Hydrolysis

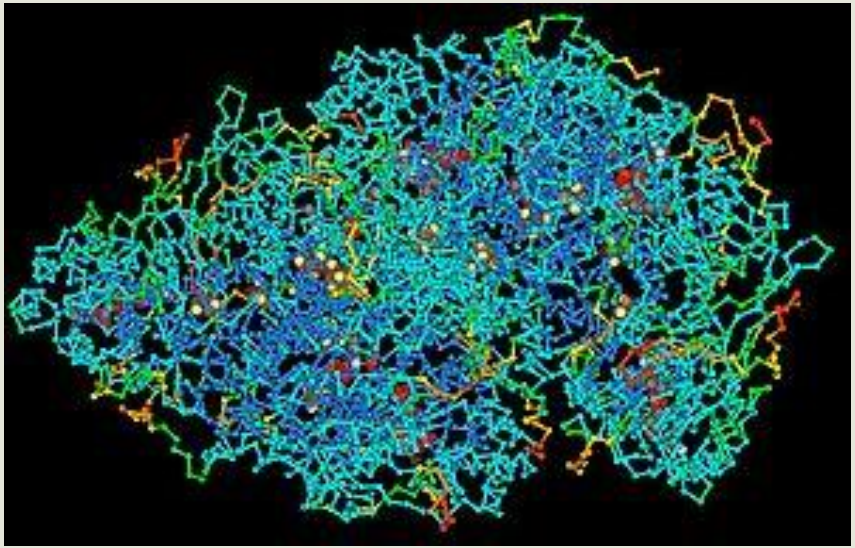
- Polymer to monomers
- Releases Energy
- Breakdown of covalent bond
- Creates smaller molecules
- Requires H20 to happen



What is a macromolecule?

Macromolecules are composed of many polymers that have a specific function.

They are formed when many monomers join together.



6

Carbohydrates

Basic Structure of Carbohydrates

Monomer

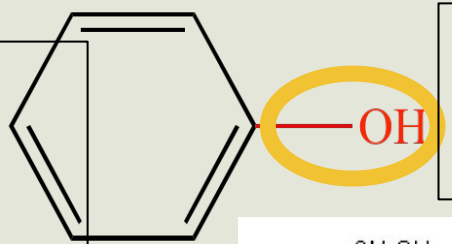
- Monosaccharides

Polymers

- Disaccharides: 2
- Oligosaccharides: 3 to 10
- Polysaccharides: 11 or more

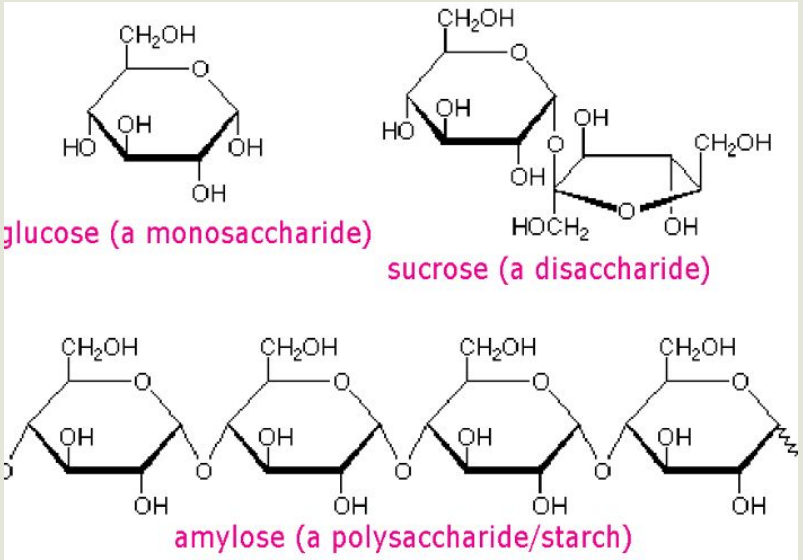
Structure and Composition

- Carbon, Hydrogen, and Oxygen



Functional Group

- Hydroxyl



Carbohydrate examples!

Function of Carbohydrates

Function of Carbohydrates

- Short term + Primary source of energy
- Regulation of blood glucose
- Biological recognition
- Flavor and sweeteners
- Dietary fiber

Storage

- In long polymers
- Structural support: chitin, cellulose  
- Energy storage: glycogen, starch

7

Lipids

Basic Structure of Lipids

Monomer

- Glycerol
- Fatty Acids

Polymers

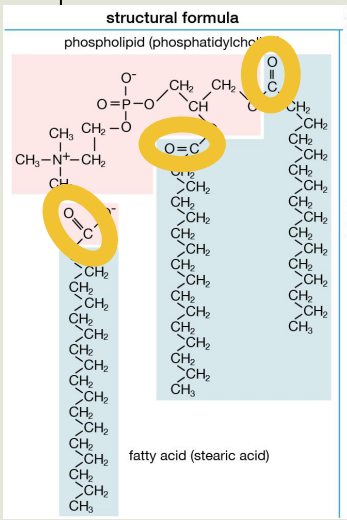
- Triglycerides
- Phospholipids
- Steroids

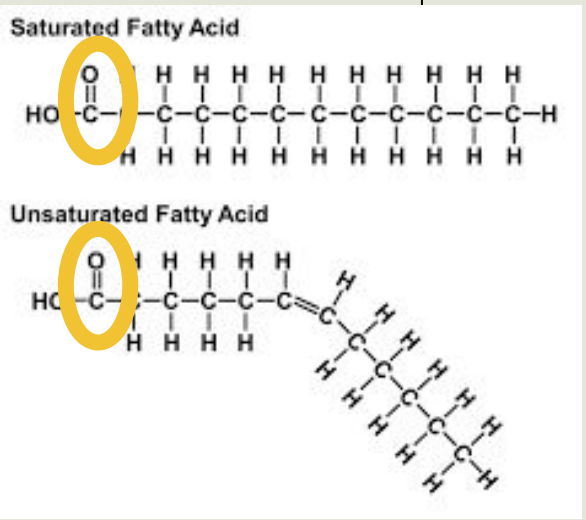
Structure and Composition

- Carbon, Hydrogen, and Oxygen

Functional Group

- Carbonyl





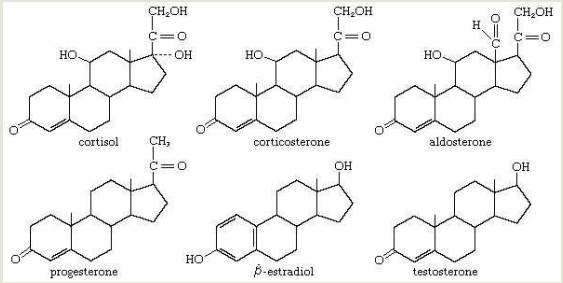
Function of Lipids

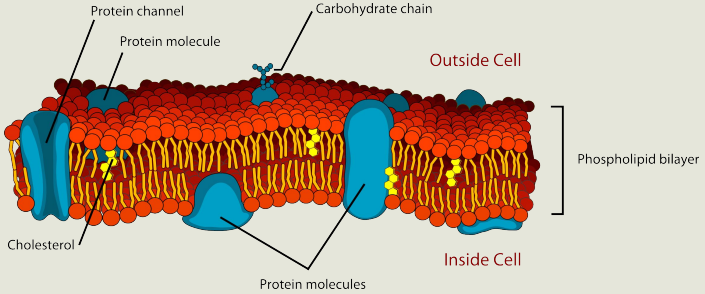
Function of Lipids

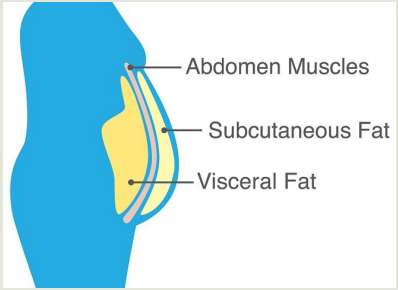
- Stores concentrated energy
- Cushioning for organs
- Insulation
- Compose cell membranes
- Steroids, Cholesterol, etc.

Storage

- Excess energy converted to triglycerides







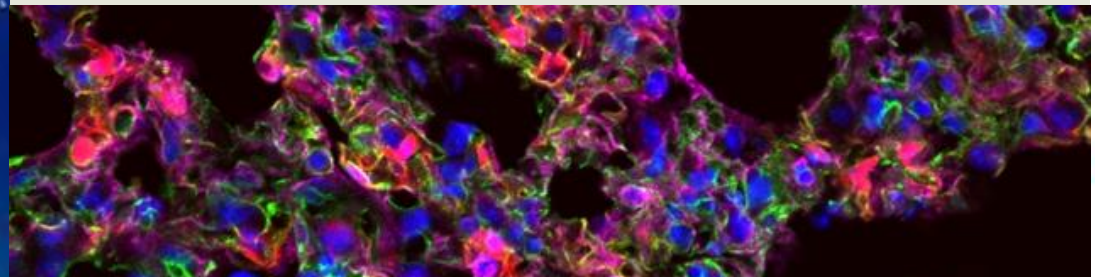
8

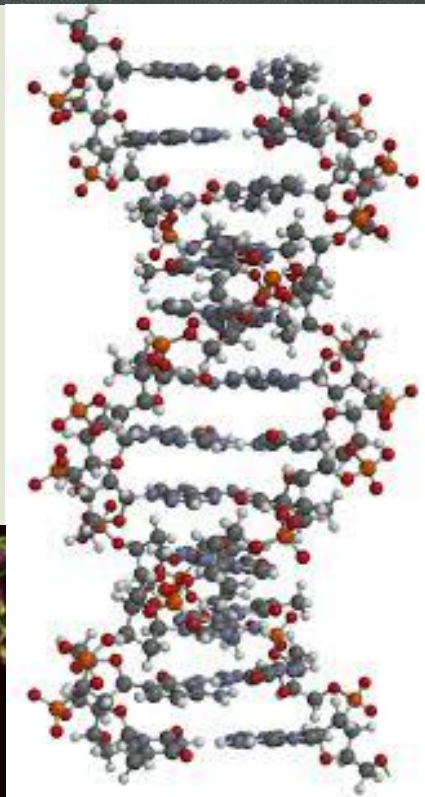
Nucleic Acids

Function of Nucleic Acids

Function of Nucleic Acids

- Stores hereditary information
- DNA = Instructions for making proteins
- RNA = Production of proteins





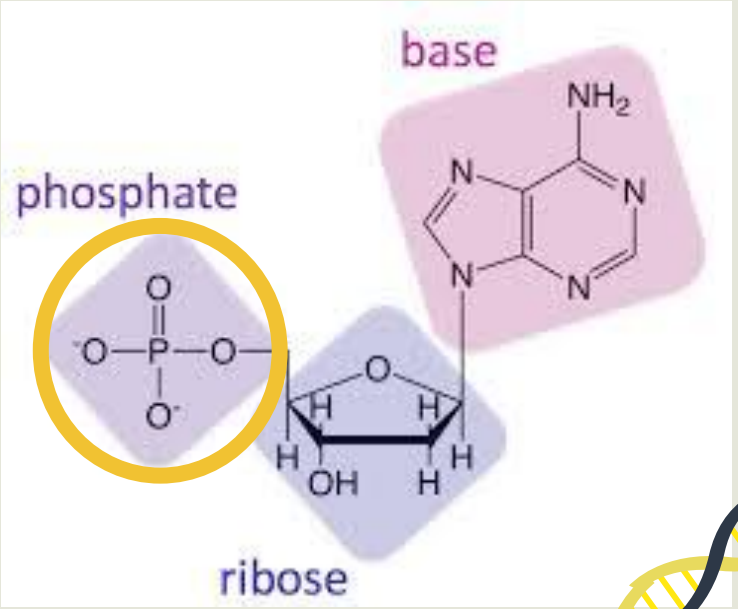
Basic Structure of Nucleic Acids

Monomer: Nucleotide

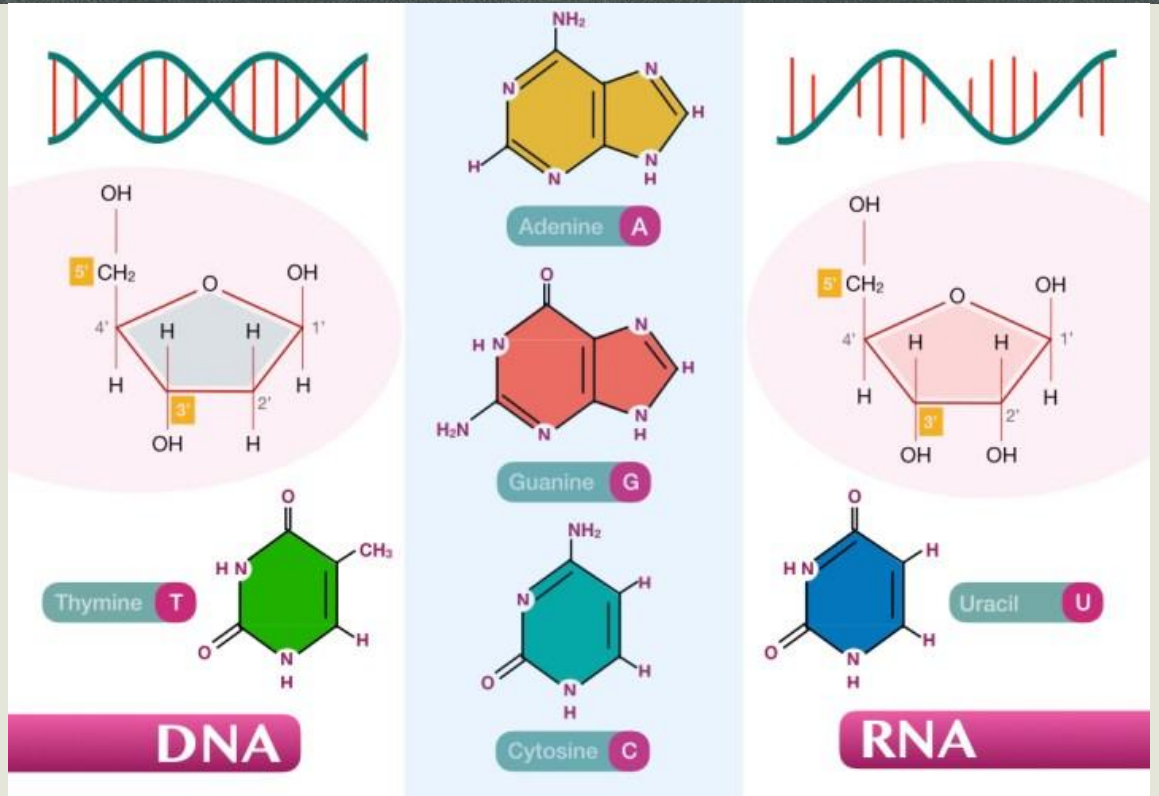
- Sugar- ribose or deoxyribose
- Phosphate group
- Nitrogenous base- Adenine, Guanine, Cytosine, Thymine, or Uracil

Functional Group

- Phosphate



DNA vs. RNA



Purines vs Pyrimidines

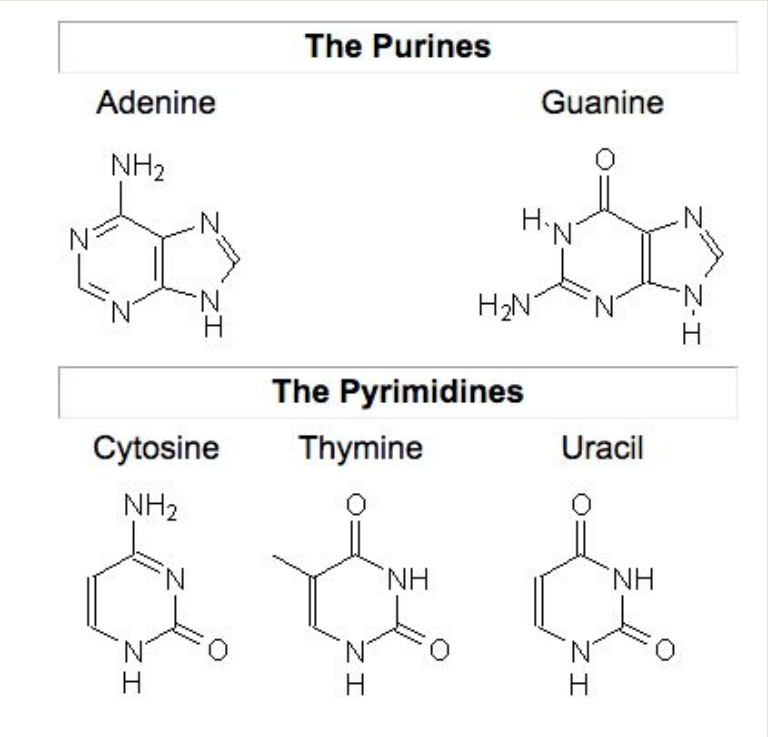
Purines

- Adenine and Guanine
- Two rings

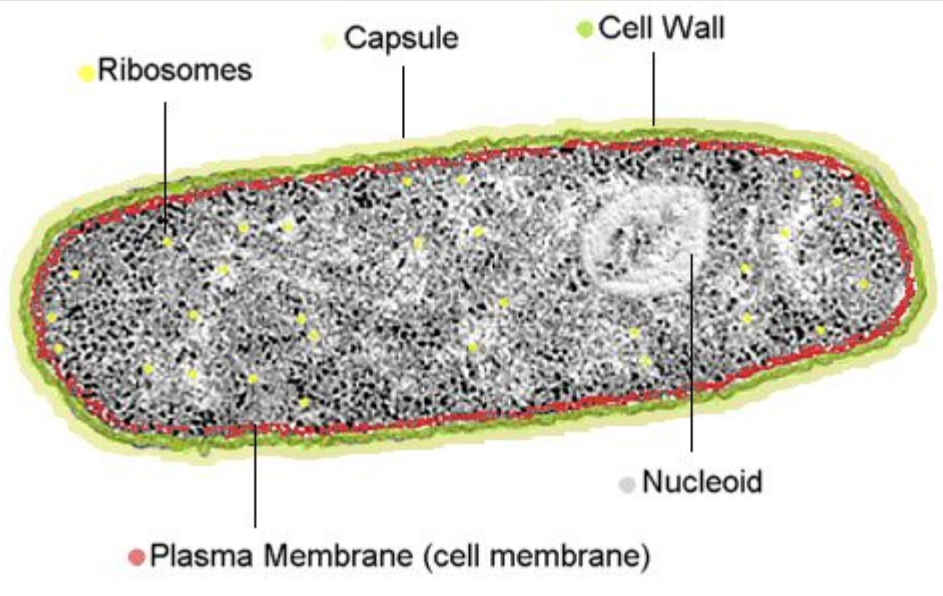
Pyrimidines

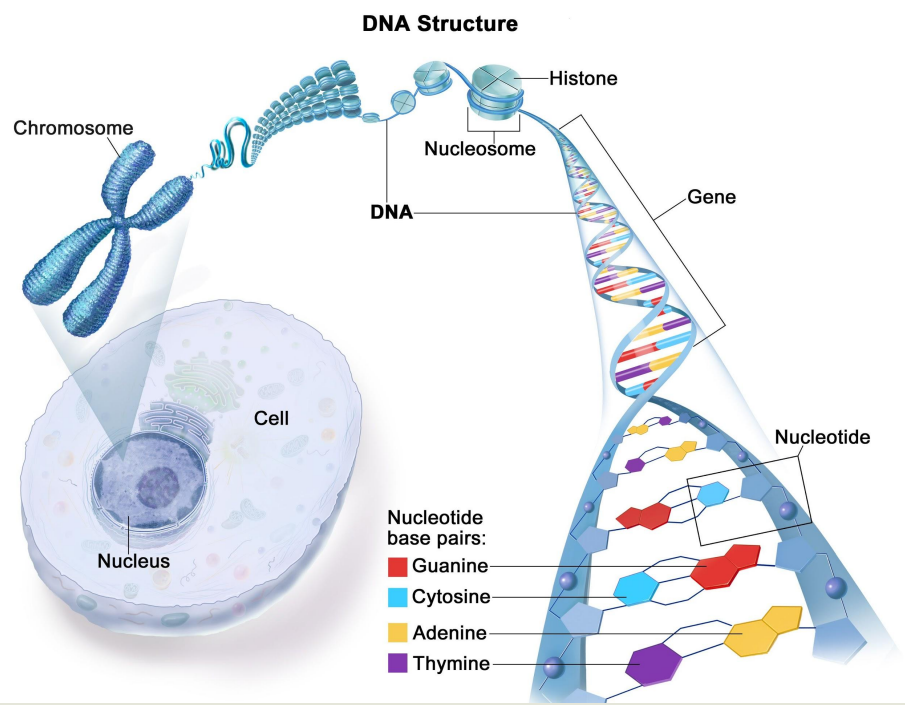
- Cytosine, Thymine, Uracil
- One ring

The bases together are always 3 rings across.



Storage of Nucleic Acids





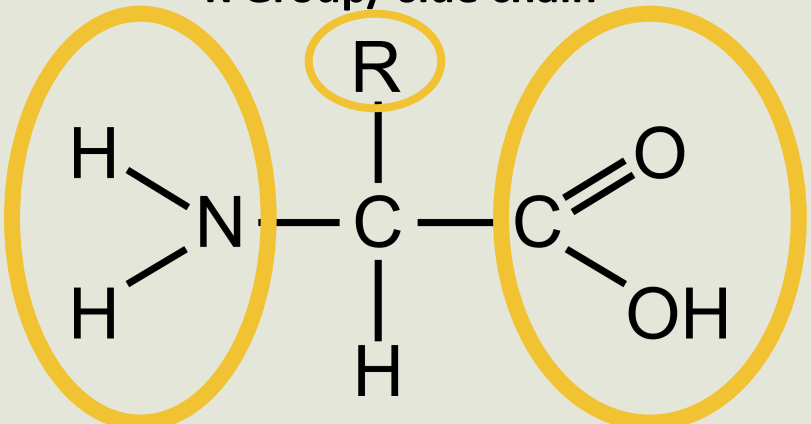
9

Proteins

Basic Structure of Proteins

- Atoms that make up proteins: **C**arbon, **H**ydrogen, **O**xygen, **N**itrogen, and **S**ulfur
- Monomer: Amino Acids → 20 different amino acids make up all proteins (all have same basic structure but different **R Groups**)

R Group/ side chain

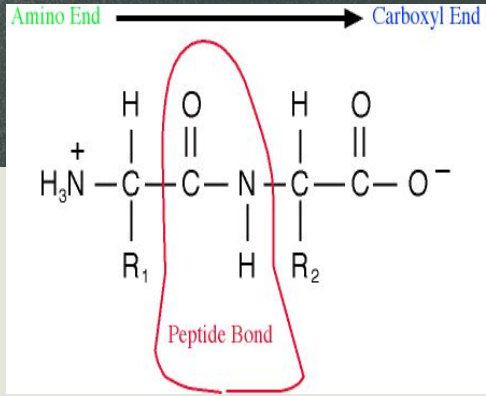


Amine Group

Carboxyl Group

The type of amino acid is dependent on the R-group!

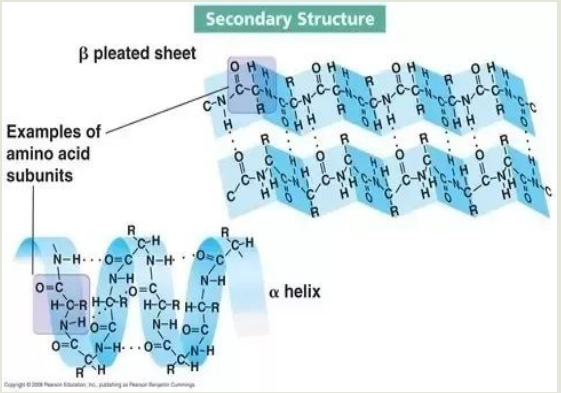
Protein Folding - Advanced Protein Structure



Primary Structure: a ribosome connects the amine group of one amino acid with the carboxyl group of a neighbouring amino acid (this occurs repeatedly until a unique polypeptide chain is formed)

Polymer

Secondary Structure: Carboxyls and amines that were distant from each other will now hydrogen bond



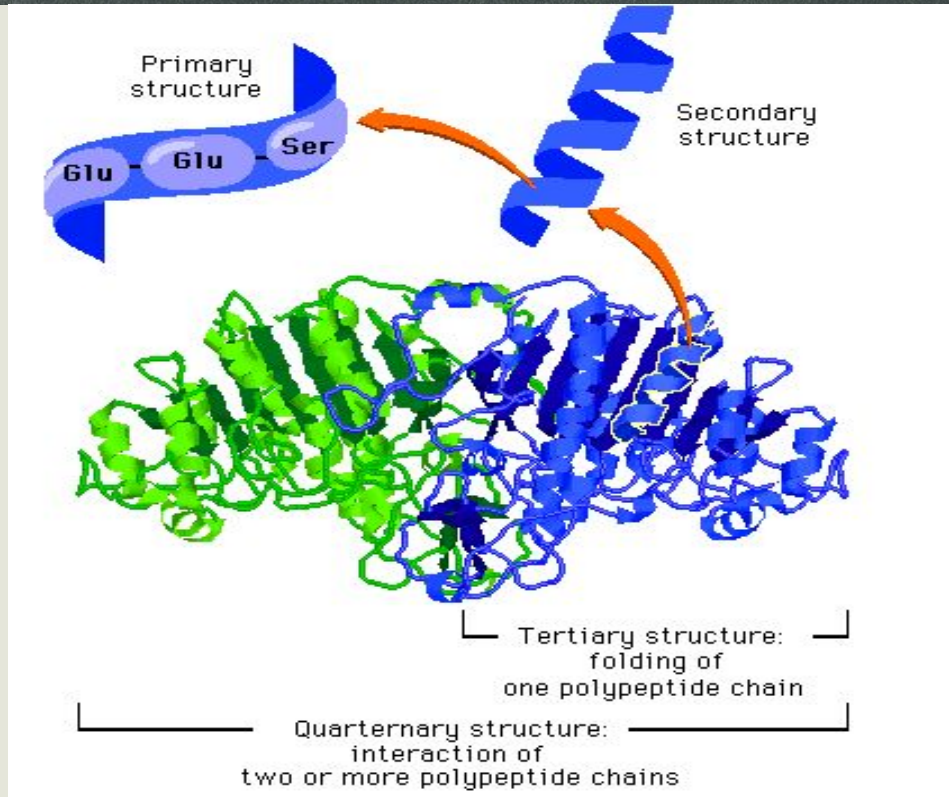
Tertiary Structure: The R Groups of different amino acids interact to form different types of bonds (hydrogen, Van der Waal, ionic, etc.)

*Secondary and Tertiary level folding occur simultaneously!

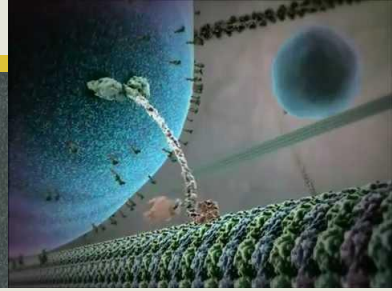
Protein Folding Continued

Quaternary Structure: A combination of initially separate polypeptide chains (same bonds that form in tertiary level can form here)

Purpose: creates domains within the 3-D structure of the protein where chemicals can bind



Functions of Proteins



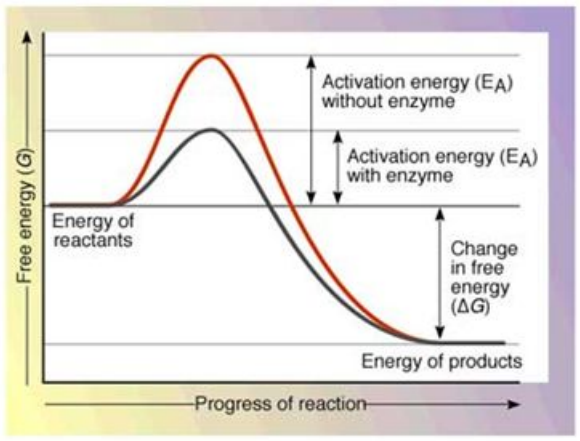
Type of Protein	Broad Function of this type of protein
Enzyme	Selective acceleration of chemical reactions (further discussed in next section)
Transport	Move substances through cell membranes
Motor	Move materials inside of the cell along a network called cytoskeleton
Transcription Factors	Bind to genes and can either suppress or induce gene transcription
Structural	Support; framework of bodily structures (ex; keratin)

10

Enzymes

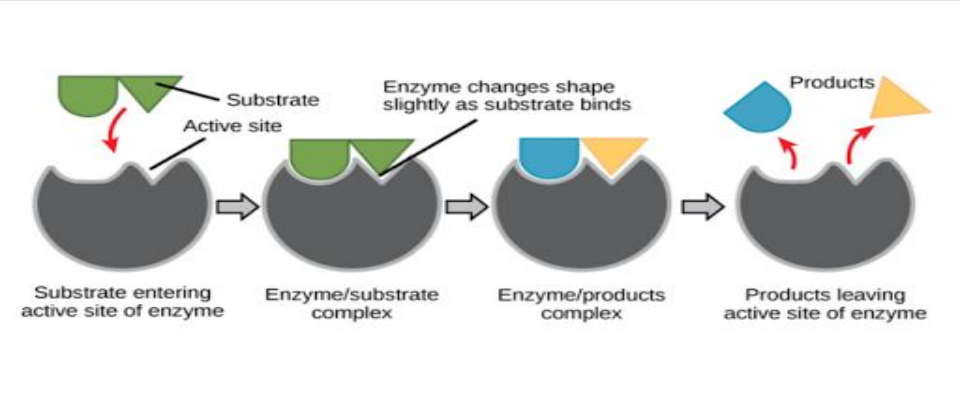
What is an Enzyme?

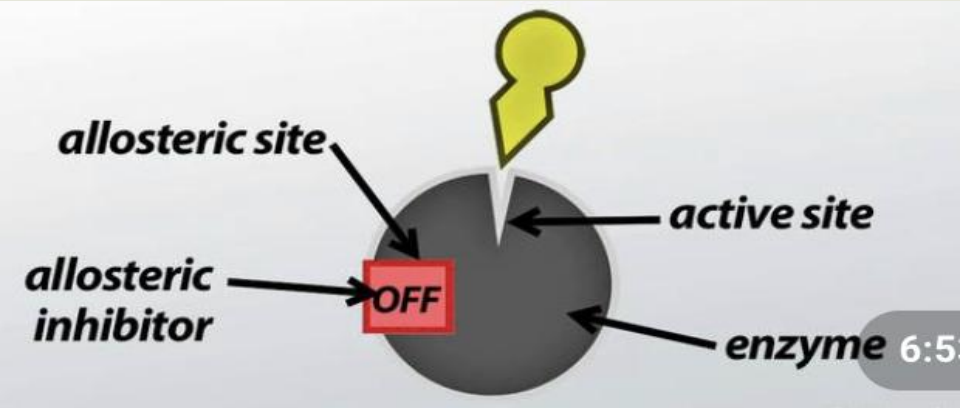
- An enzyme is a protein which increases the speed of a chemical reaction by lowering the activation energy
- Activation Energy: Energy required for molecules to interact/ chemically react with each other



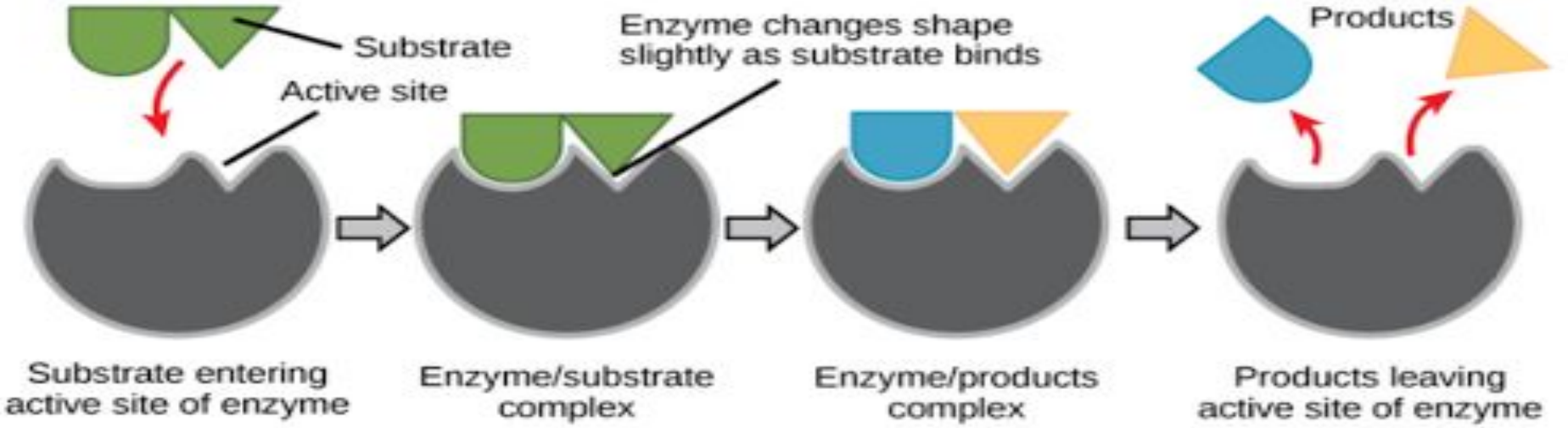
Structure

- Active Site: domain where substrates (molecules that are chemically reacting) bind
- Allosteric Site: domain where coenzymes (help reaction occur) or inhibitors (stop reactions) can bind
- **The enzyme's active site determines which substrates can bind**





Structure Continued



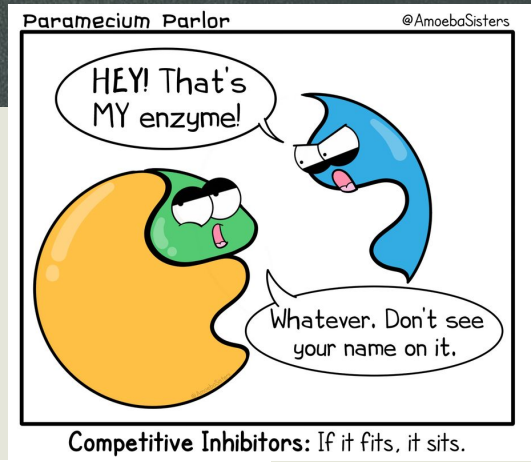
Competitive vs. Noncompetitive Inhibition

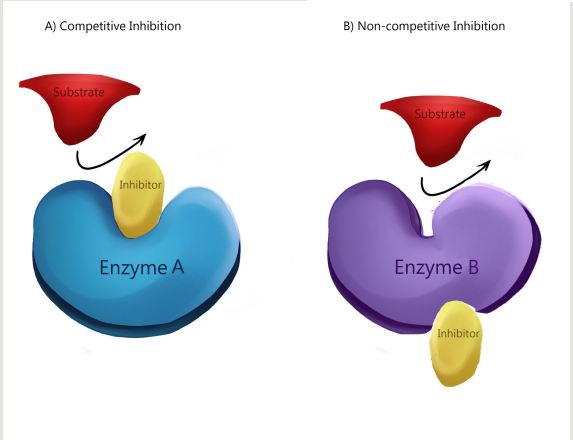
- **Competitive Inhibitor:** binds at the active site and blocks substrate

Ex; caffeine

- **Noncompetitive Inhibitor:** binds at an allosteric site which causes a change in the shape of the active site

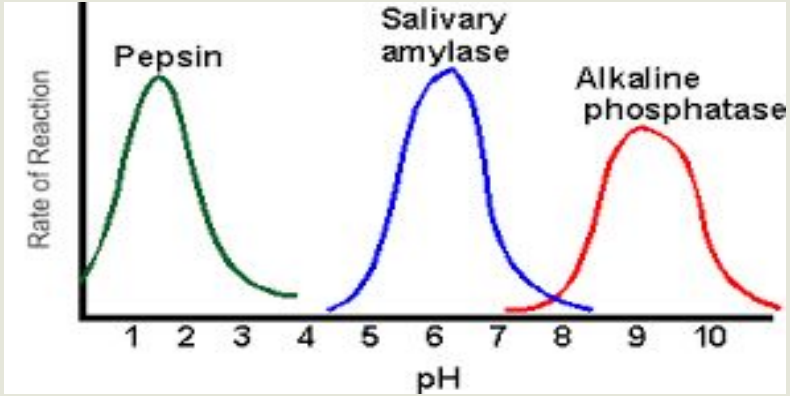
Ex; pesticides

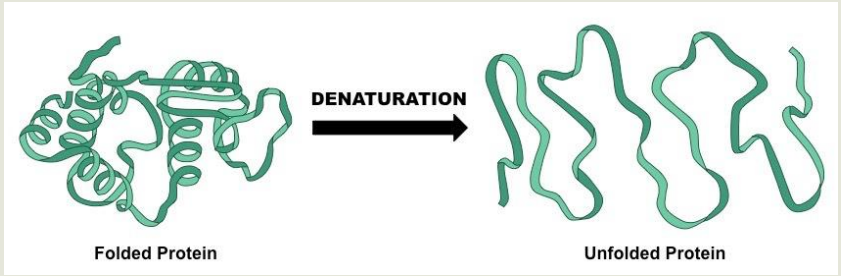




Effects of Temperature and pH

- Enzymes have an optimal pH and temperature at which they work best
- Increasing temperature and lowering or raising pH can cause **denaturation**
- **Denaturation:** when a protein loses its shape due to the breaking of chemical bonds



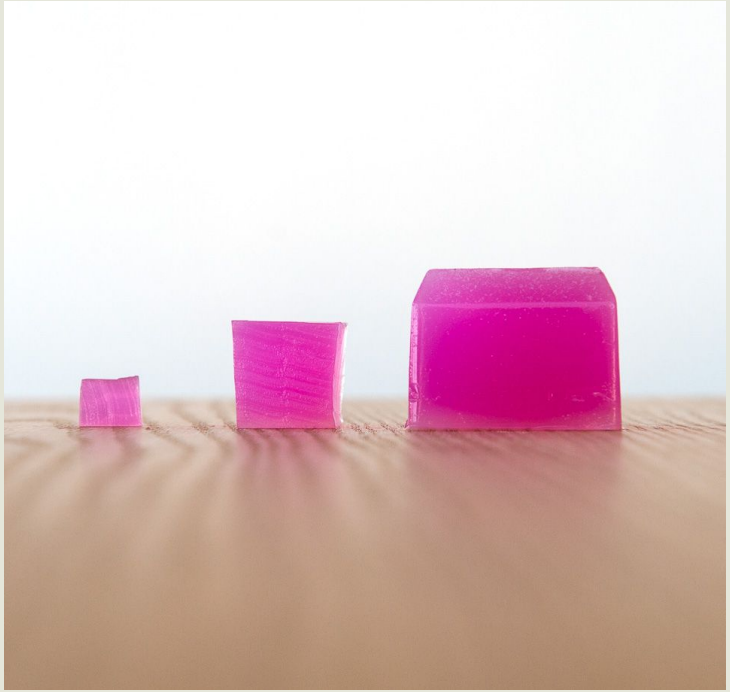


11

Cell Size

Essential Question

Look at the 3 agar cubes. If you were to place all of them in a clear liquid solution for the same amount of time, in which cube would the liquid diffuse the most (which cube would have the lowest ratio of pink to clear?)

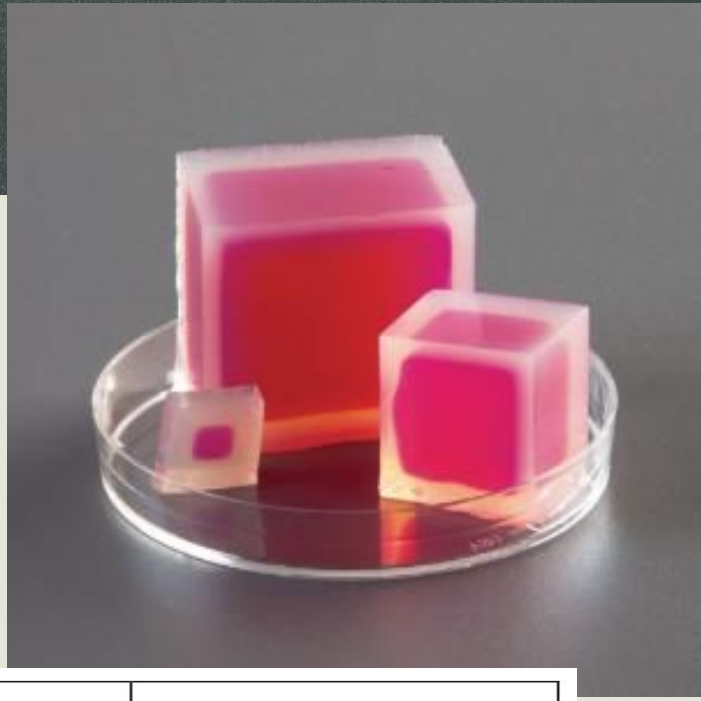


Essential Question Continued

The answer is the smallest cube! This is because the smallest cube has the largest surface area to volume ratio.

Greater surface area → More space for the liquid to enter from

Less Volume → Less time it takes for the liquid to move through the cube



Cube Side Length	Surface Area	Volume	Surface-area-to-volume ratio
1 cm	6 cm^2	1 cm^3	6 cm^{-1}
2 cm	24 cm^2	8 cm^3	3 cm^{-1}
3 cm	54 cm^2	27 cm^3	2 cm^{-1}

How does this connect to cells?

- Cells are small in size so that they can maintain a large surface area to volume ratio
- Multicellular organisms grow through cell division rather than cells getting bigger
- Cell Membrane = surface area
- Cytoplasm and Organelles = volume

Why must cells do this?

In order make cellular processes efficient, cells must be able to move materials in and out of their cells and within themselves quickly. If a cell is too large, it will take materials longer to move from one end of the cell to another.

Fun Fact

This is why plant roots have multiple tiny branches (more branches = more surface area for water and other nutrients to enter)!

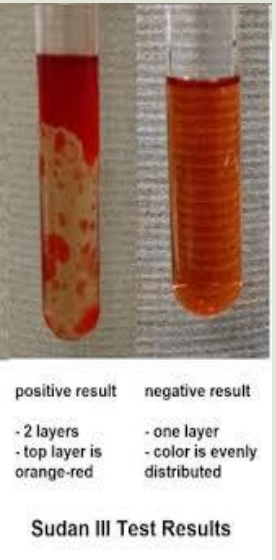
12

Macromolecule Tests

Test, Special Covalent Bond, and Facts about Lipids

Test:

- Sudan III
  - Positive: Red bubbles
  - Negative: Very light red



Special covalent bond:

- Ester Linkages

Other Facts:

- Essential to cell growth
- Hydrophobic
- Non-polar
- Common solvents: alcohol, acetone, ether
- Saturated fats have single carbon bonds, Unsaturated fats have double carbon bonds

Tests and Special Covalent Bond of Carbohydrates

Test:

- Benedicts for monosaccharides and disaccharides
  - Positive: Yellow-Orange
  - Negative: Translucent Blue
- Lugols for oligosaccharides and polysaccharides
  - Positive: Dark Purple
  - Negative: Amber/ Gold-Brown.

Special covalent bond:

- Glucoside Linkages

Left: Positive and Negative Lugol's’

Right: Positive and Negative Benedict's’

Test, Special Covalent Bond, and Facts about Lipids

Test:

- N/A
  - Every living organism has genetic material.

Special covalent bond:

- Phosphodiester Linkages