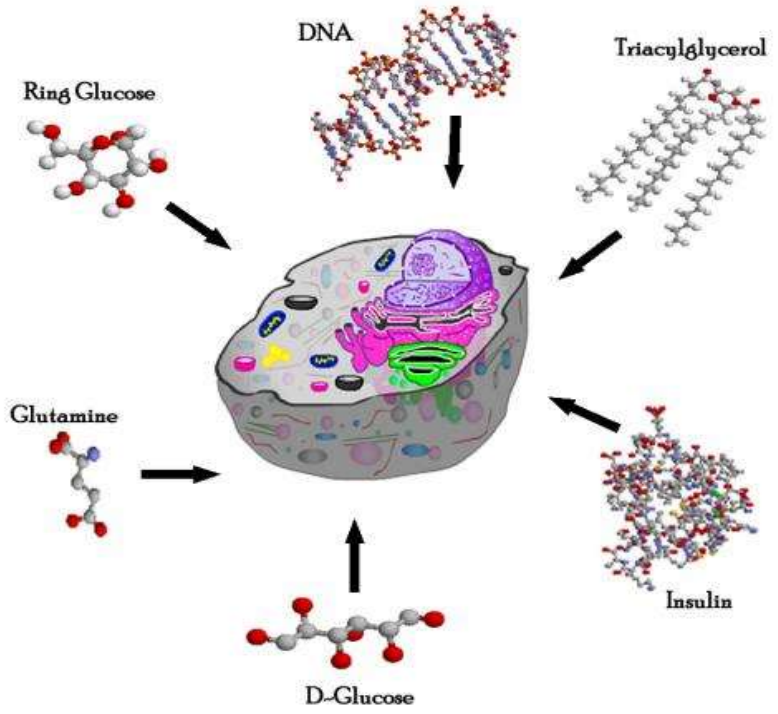
SBI4U
UNIT #1: BIOCHEMISTRY
LECTURE #3 (ENZYMES)



PROTEINS AND ENZYMES

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Proteins

Proteins: structural building blocks and functional molecules of cells.

Why Proteins are so important to living world?

- Proteins are the most diverse molecules in living organisms and among the most important.

- They act as structural building blocks, as functional molecules, and are involved in almost everything that a cell does.

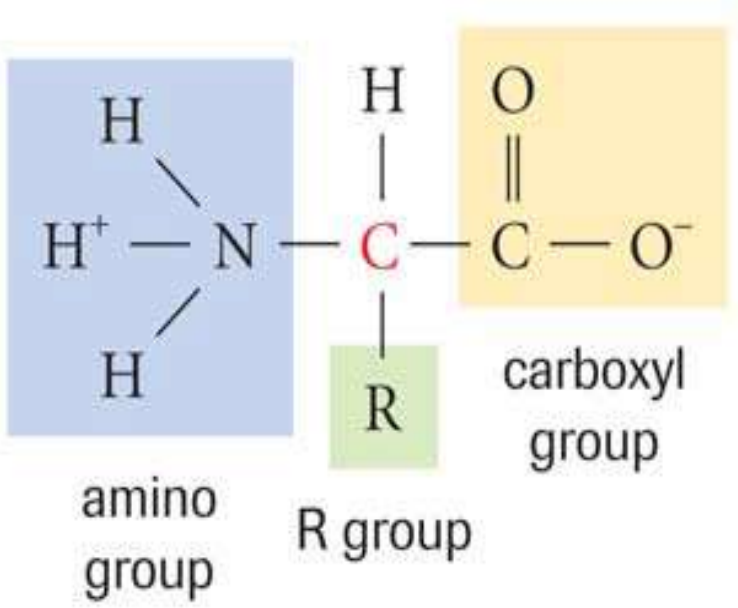
- More than 50% of the dry mass of cells is made up of proteins. All enzymes (biological catalysts) are proteins.

PROTEINS

Amino acids: Proteins are amino acid polymers folded into a specific 3D shape**.** There are 20 **amino acids and each is made up of a central carbon,**

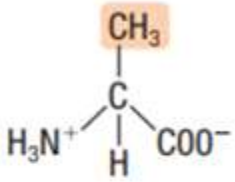
Amino acids composition:

- An amino group (-NH_2),
- A carboxyl group (-COOH),
- A hydrogen (H) atom
- One of 20 different “R” groups (also called side group). The “R” group represents the grouping that is unique to each amino acid.

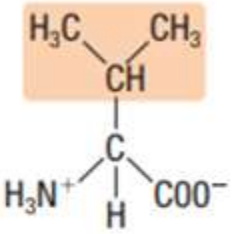


These R groups ranging from a single hydrogen atom to complex carbon chains or rings (except **Proline)

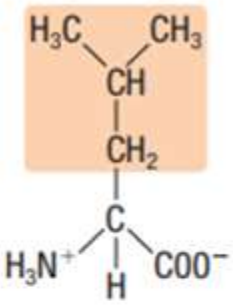
AMINO ACIDS



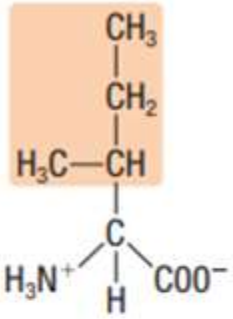
Alanine
Ala
A



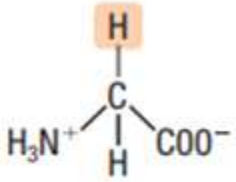
Valine*
Val
V



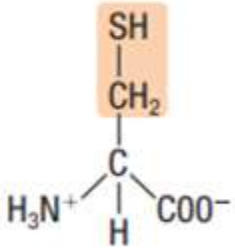
Leucine*
Leu
L



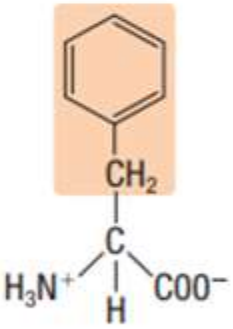
Isoleucine*
Ile
I



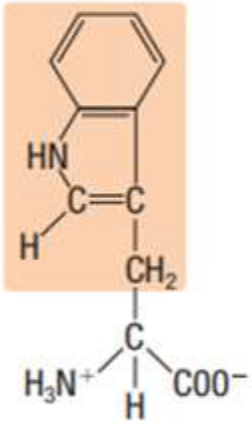
Glycine
Gly
G



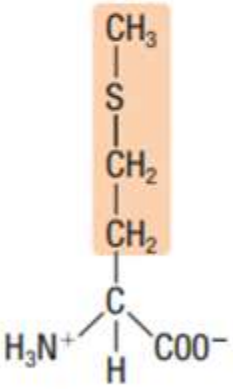
Cysteine
Cys
C



Phenylalanine*
Phe
F

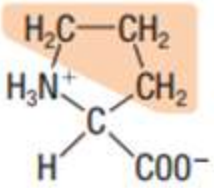


Tryptophan*
Trp
W



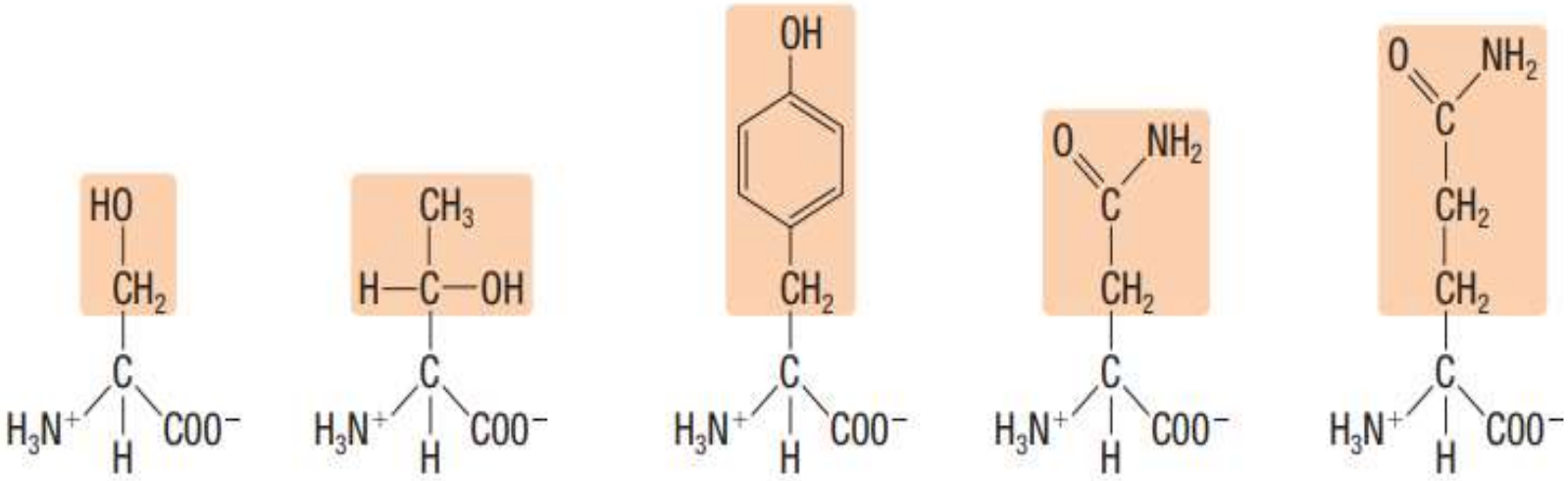
Methionine*
Met
M

non-polar amino acids



Proline
Pro
P

AMINO ACIDS



Serine
Ser
S

Threonine*
Thr
T

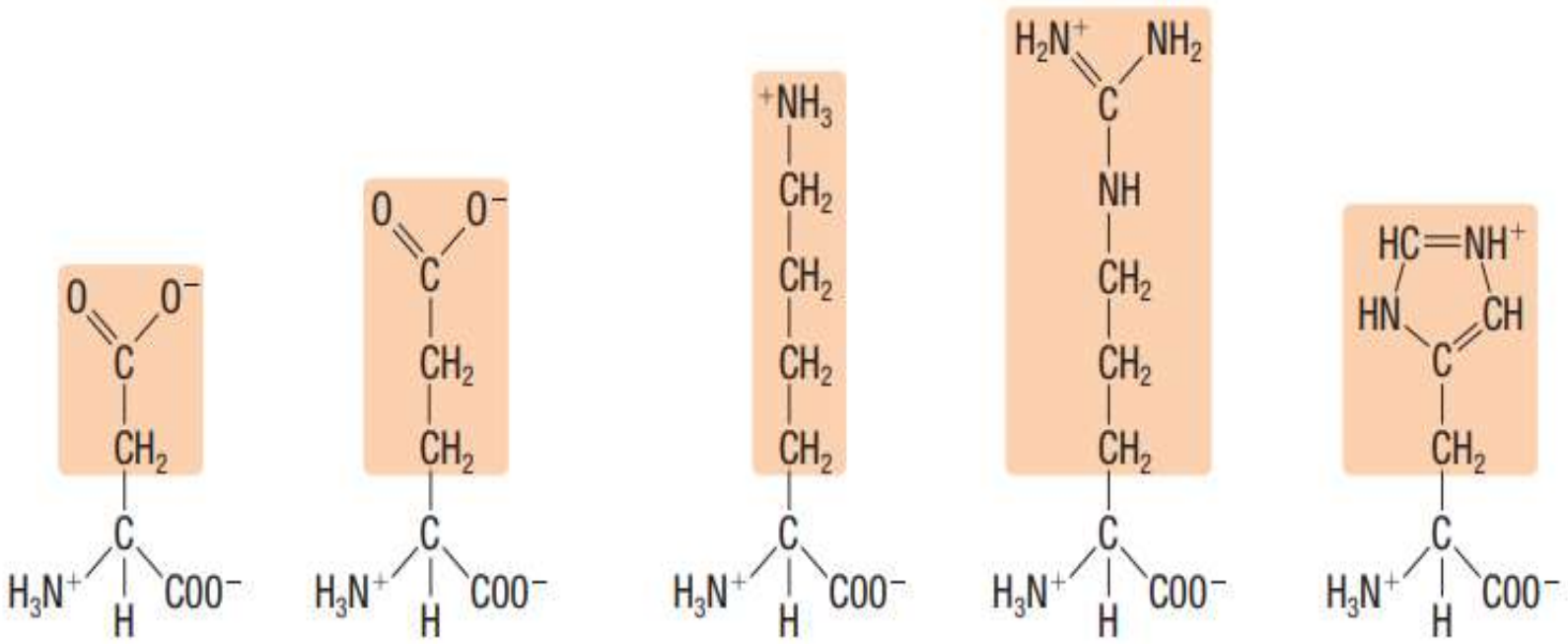
Tyrosine
Tyr
Y

Asparagine
Asn
N

Glutamine
Gln
Q

uncharged polar amino acids

AMINO ACIDS


Aspartic acid
Asp
D
Glutamic acid
Glu
E
Lysine*
Lys
K
Arginine
Arg
R
Histidine
His
H
negatively charged (acidic) polar amino acids
positively charged (basic) polar amino acids

AMINO MNEMONICS TRICKS!!!!

Non-polar side chains:

"Grandma Always Visits London In May For Winston's Party"

1. Glycine, Gly, ***G***
2. Alanine, Ala, ***A***
3. Valine, Val, ***V***
4. Leucine, Leu, ***L***
5. Isoleucine, Ile, ***I***
6. Methionine, Met, ***M***
7. Phenylalanine, Phe, ***F***
8. Tryptophan, Trp, ***W***
9. Proline, Pro, ***P***

AMINO MNEMONICS TRICKS!!!!

Polar side chains:

"**S**ome **T**imes **C**ats **T**ry **A** **G**rowl“

-***s****erine,* ***t****hreonine,* ***c****ysteine,* ***t****ryrosine* ***a****sparagine,* ***g****lutamine*

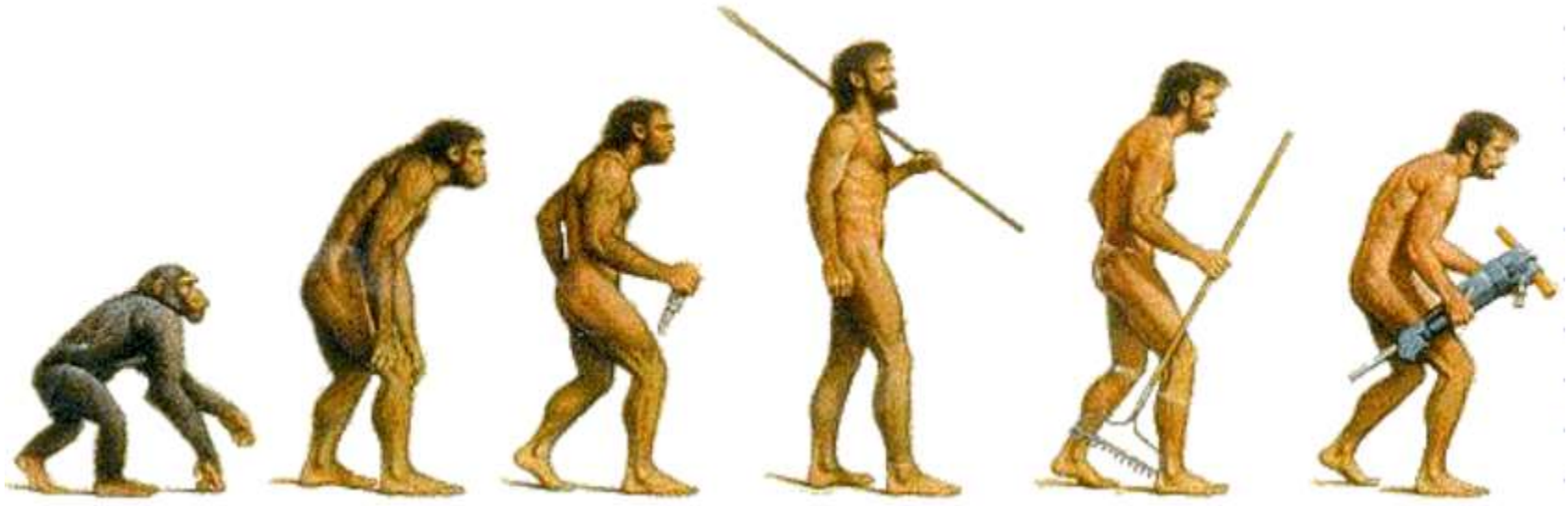
AMINO MNEMONICS TRICKS!!!!

Electrically charged side chains:

"**A** **G**ood **L**awyer **A**ims **H**igh"

-***A**spartate, **G**lutamate, **L**ysine, **A**rginine, **H**istidine*

10 ESSENTIAL AMINO ACIDS



These **T**en **V**aluable **A**mino **A**cids **H**ave **L**ong **P**reserved **L**ife **I**n **M**an

For the ten essential amino acids:

Threonine, **T**ryptophan, **Va**line, **A**rginine, **H**istidine, **L**ysine, **P**henylalanine, **L**eucine, **I**soleucine, **M**ethionine

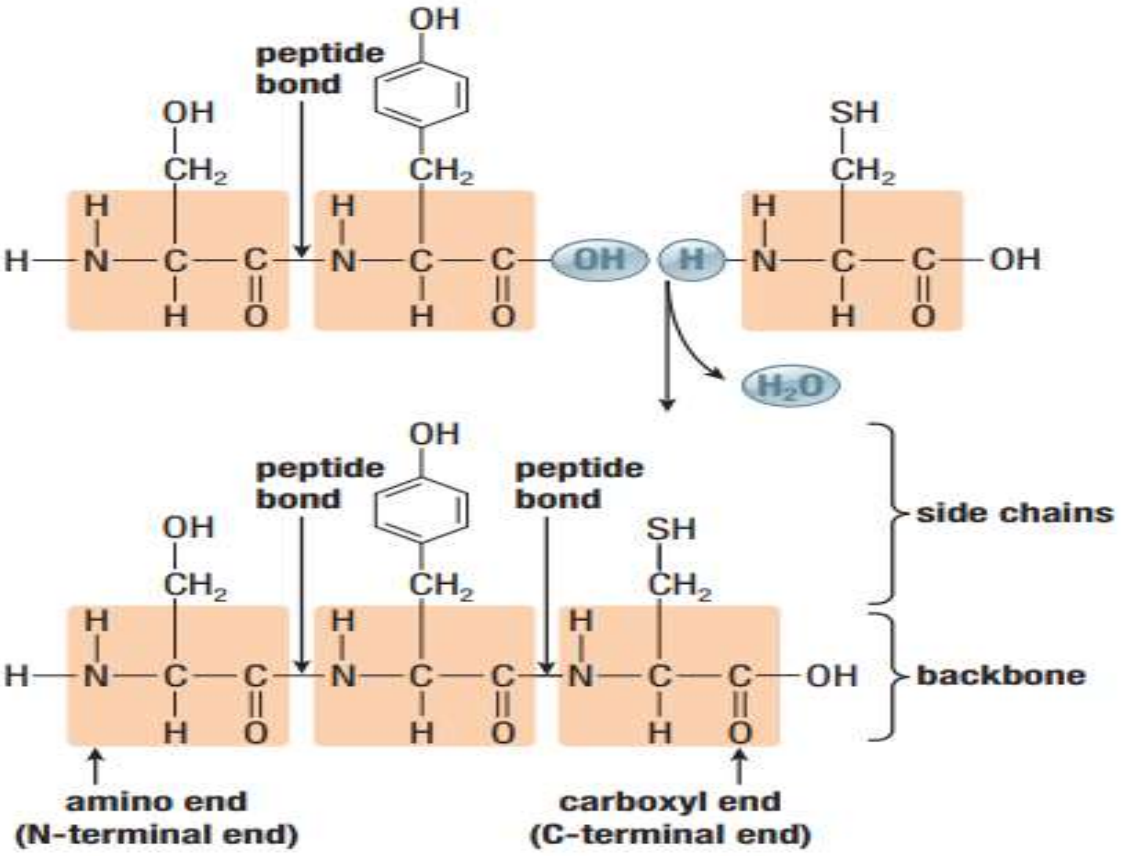
DIFFERENT TYPES OF PROTEINS

Table Different Types of Proteins and their Functions

Type of protein	Function	Example
structural	framework support	hair, tendons, and ligaments
defensive	infection fighters	antibodies
signal	messenger	hormones
carrier	transport of materials	hemoglobin
recognition and receptor	cellular markers	major histocompatibility complex
enzyme	catalyst	amylase
motile	movement	actin and myosin

PEPTIDES BONDS OF PROTEINS

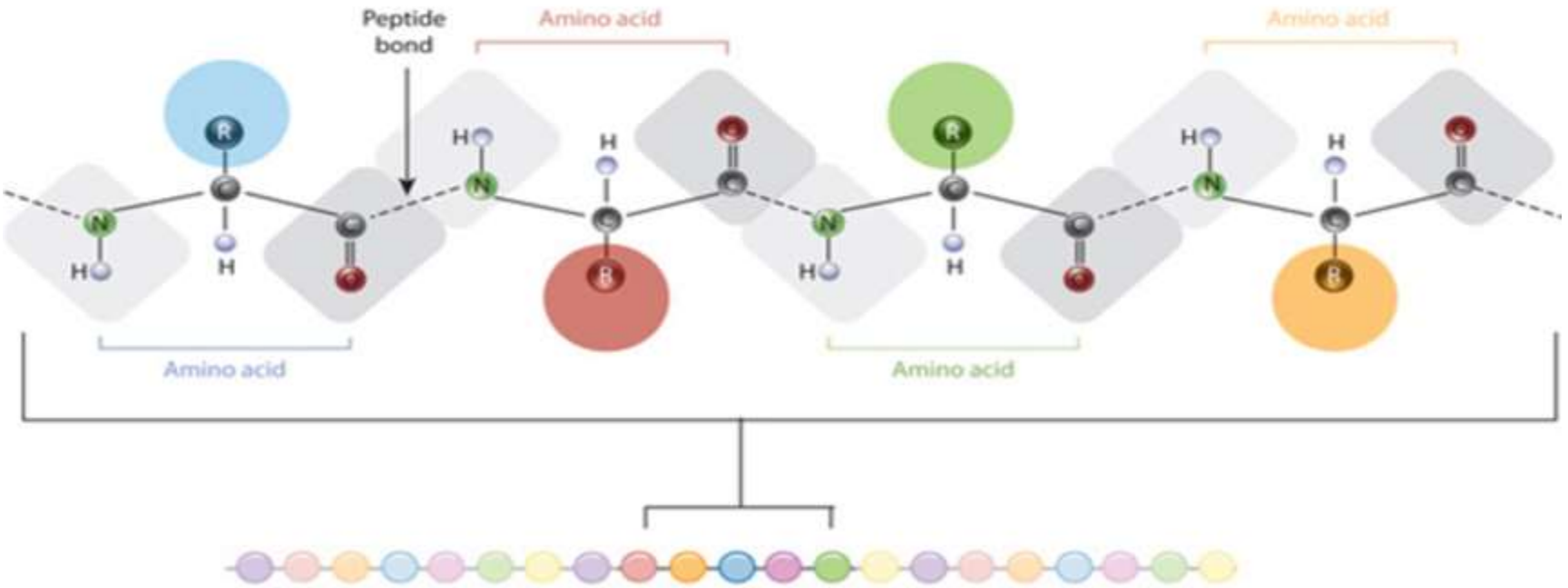
- **Peptide bond: a covalent bond** that links amino acids.
- **Peptide:** a chain of amino acids subunits that are connected by peptide bonds.
- **Polypeptide:** a peptide with more than **50 amino acid.**



2 MIN. BREAK!!!

PROTEIN STRUCTURE

I) **Primary structure: The linear sequence of amino acids within a protein is considered the primary structure of the protein**. Peptide bonds are formed by a biochemical reaction that extracts a water molecule as it joins the amino group of one amino acid to the carboxyl group of a neighboring amino acid.



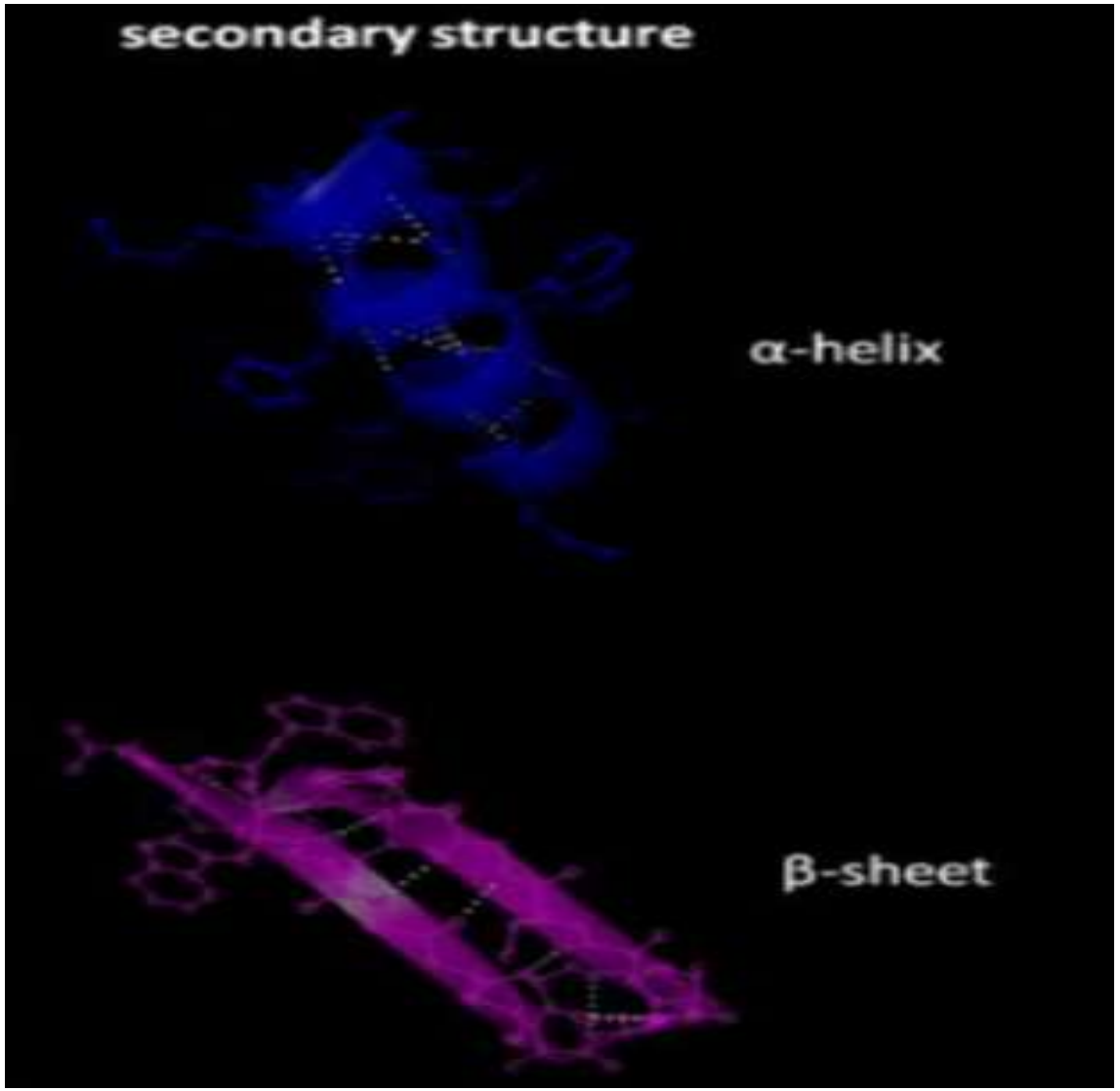
PROTEIN STRUCTURE

II) Secondary Structure: This refers to the coiling or folding of a polypeptide chain that gives the protein its 3-D shape. There are two types of secondary structures observed in proteins.

The alpha (α) helix structure. This structure resembles a coiled spring and is secured by hydrogen bonding in the polypeptide chain. E.g. hair protein

- **The beta (β) pleated sheet**. This structure appears to be folded or pleated and is held together by hydrogen bonding between polypeptide units of the folded chain that lie adjacent to one another. e.g. Silk protein

SECONDARY PROTEIN STRUCTURE



PROTEIN STRUCTURE

III) Tertiary Structure: This refers to the comprehensive 3-D structure of the polypeptide chain of a protein. There are several types of bonds and forces that hold a protein in its tertiary structure.

❑ **Hydrophobic interactions** greatly contribute to the folding and shaping of a protein. The "R" group of the amino acid is either hydrophobic or hydrophilic.

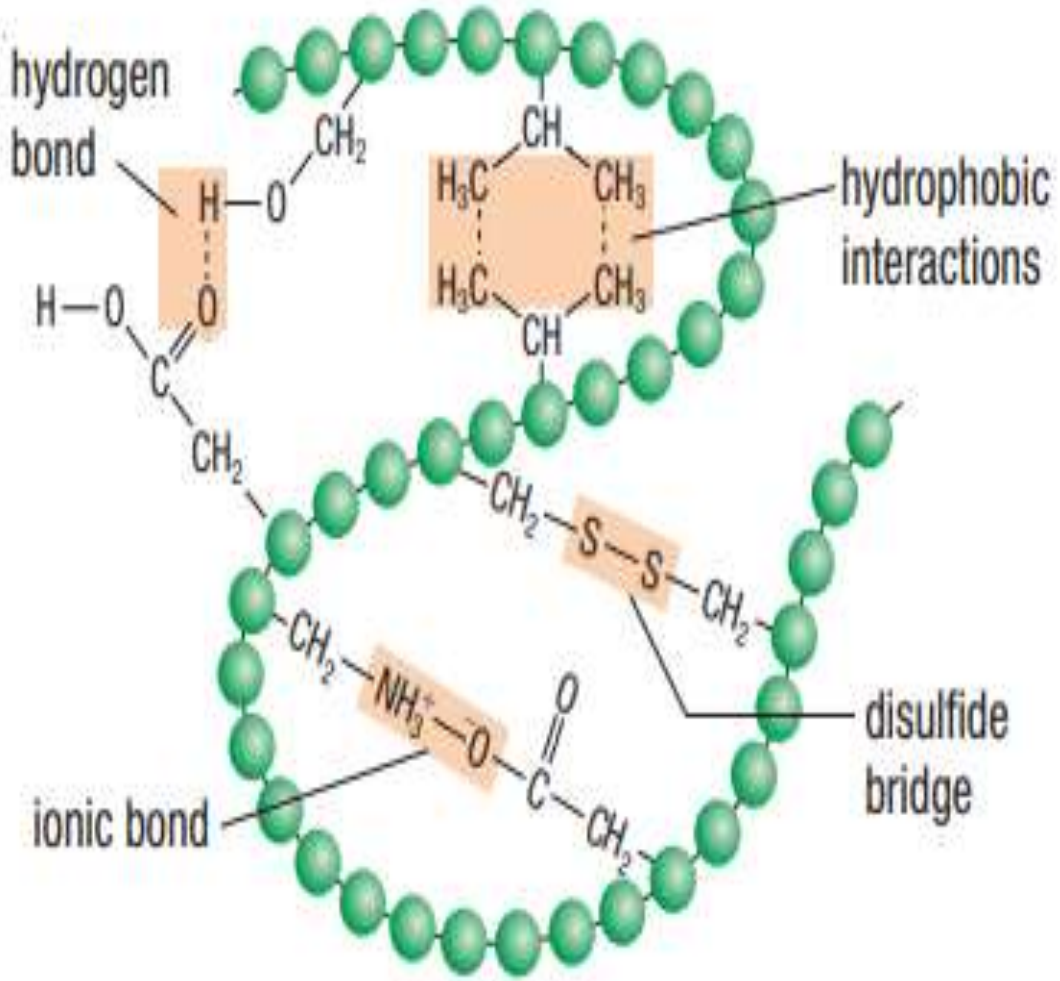
✓The amino acids with hydrophilic "R" groups: seek aquaous (water).
✓ The amino acids with hydrophobic "R" groups: seek to avoid water and position themselves towards the center of the protein.

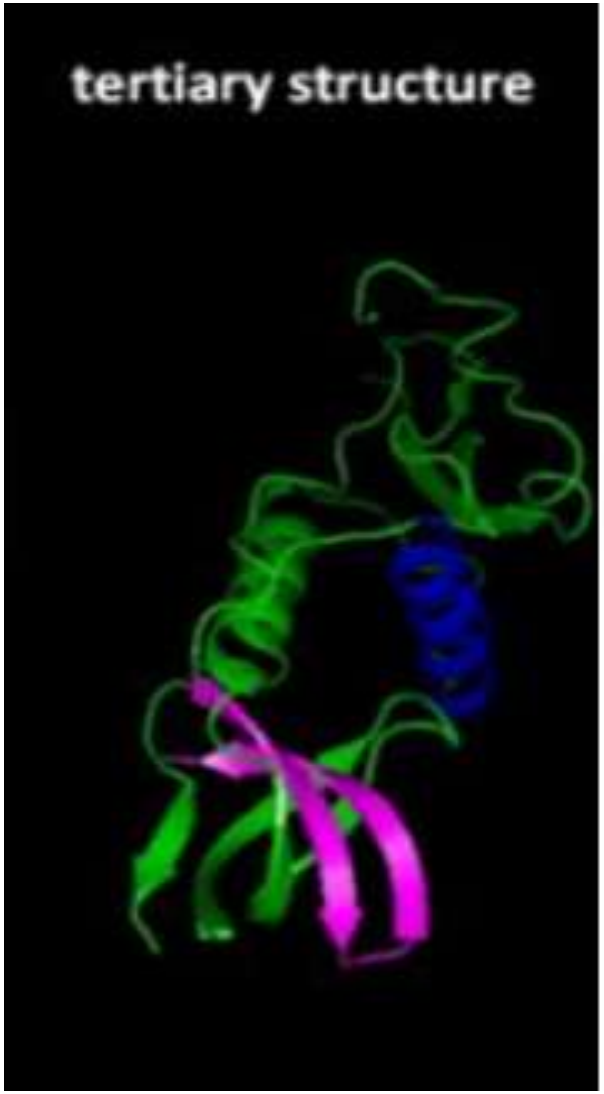
❑**Hydrogen bonding** in the polypeptide chain and between amino acid "R" groups helps to stabilize protein structure by holding the protein in the shape established by the hydrophobic interactions.

❑ **Ionic bonding:** occurs between the positively and negatively charged "R" groups that come in close contact with one another.

❑ **Disulfide bridge:** covalent bonding between the "R" groups of **cysteine** amino acids.

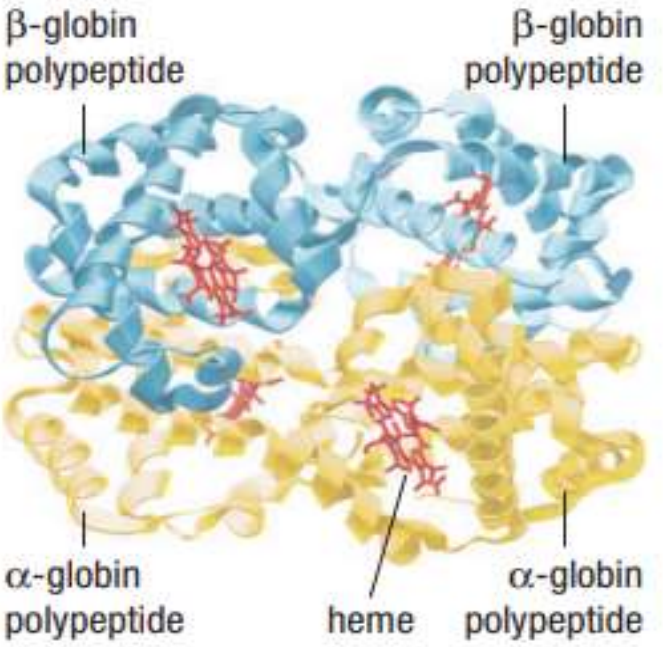
TERTIARY STRUCTURE

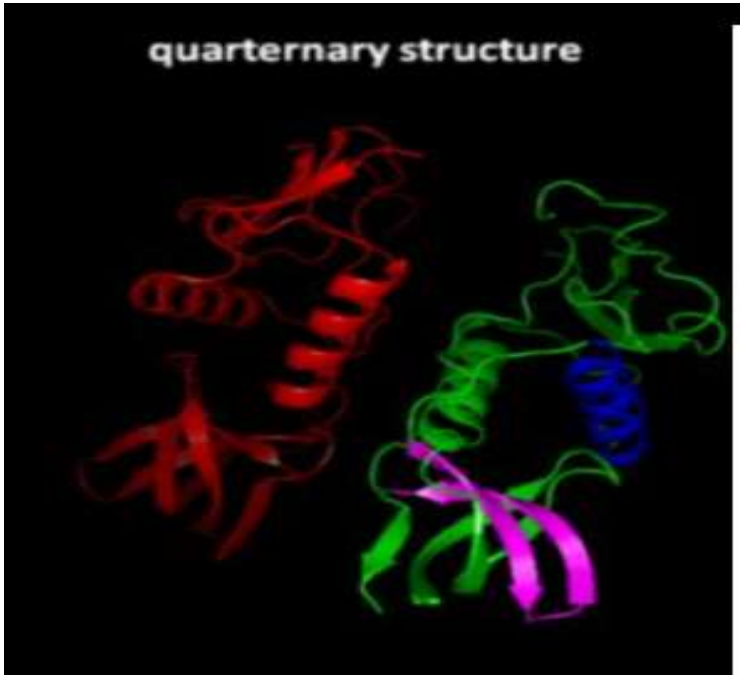




QUATERNARY STRUCTURE OF PROTEINS

IV) Quaternary Structure: This refers to the structure of a protein macromolecule formed by interactions between multiple polypeptide chains. E.g Hemoglobin. It found in the blood, is an iron-containing protein that binds oxygen molecules. It contains four subunits: two alpha subunits and two beta subunits.



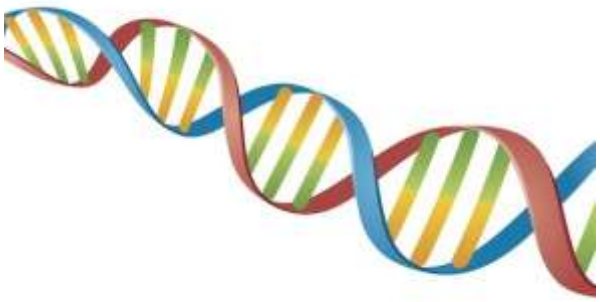


Protein prosthetic groups: Non-protein components in polypeptide chains. e.g. Fe^{2+}; Mg^{2+}

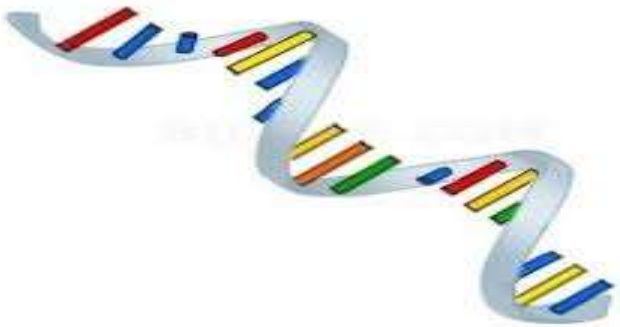
NUCLEIC ACIDS

Nucleic acids: They are used by all organisms to store the hereditary information that determines the structural and functional characteristics of an organism.

- **DNA (deoxyribonucleic acid).** E.g. Prokaryotes; eukaryote, and in many viruses.

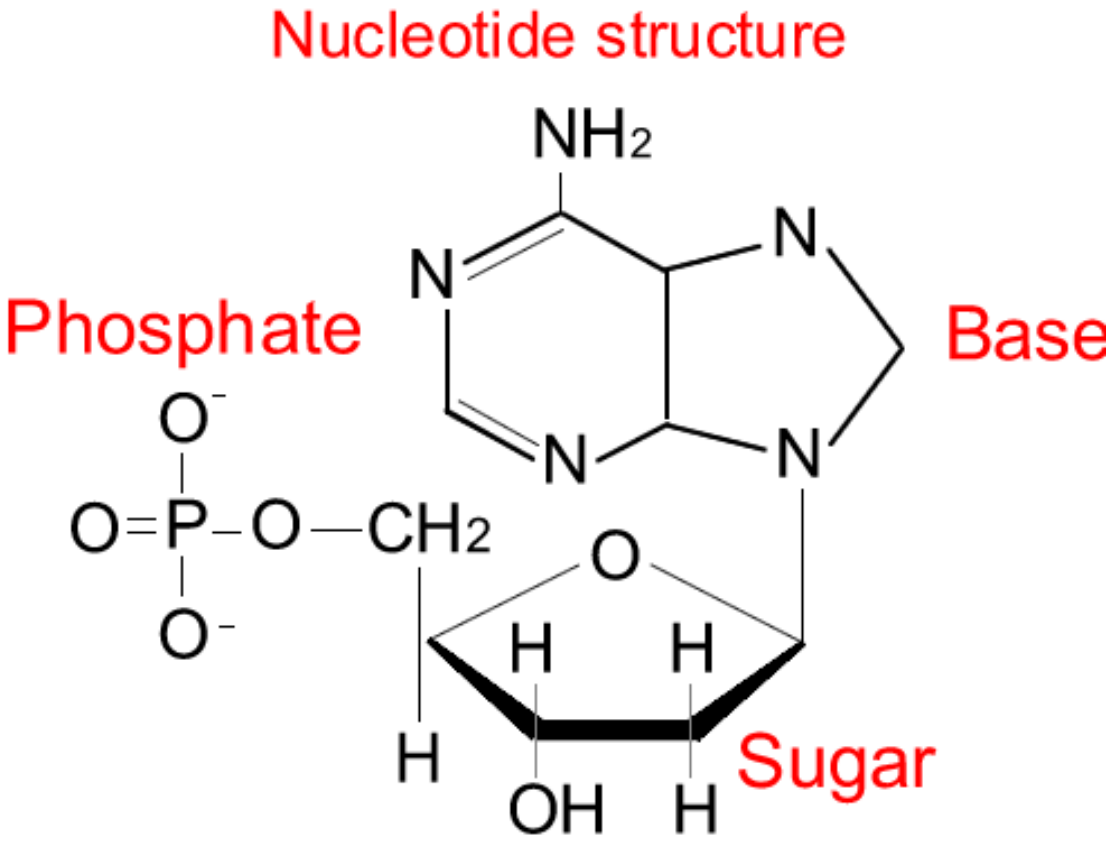


- **RNA (ribonucleic Acid).** E.g in some viruses (influenza virus, HIV virus)



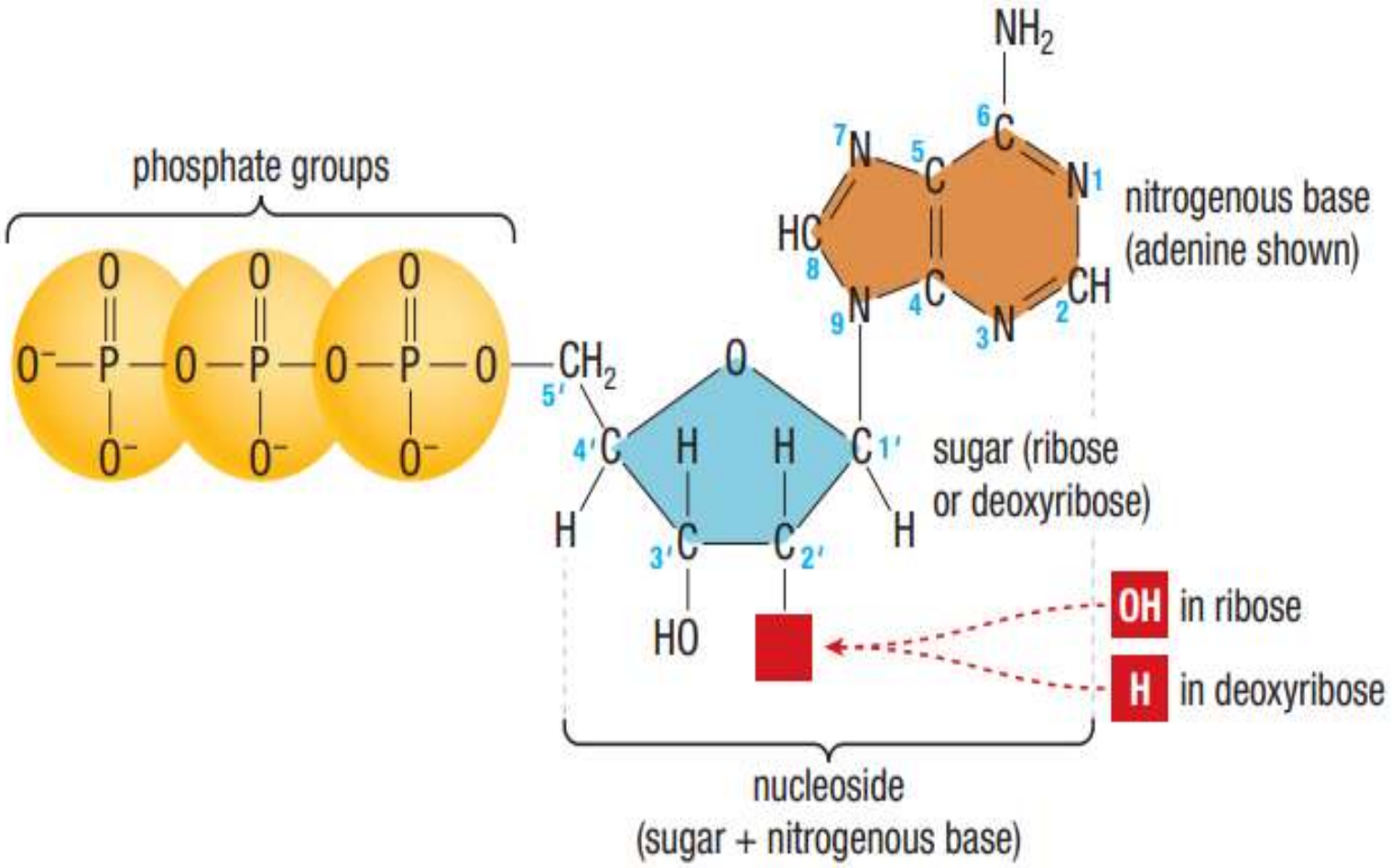
NUCLEOTIDES

Nucleotide: The building block of nucleic acids; consists of a 5-carbon sugar, a nitrogenous base, and one to three phosphate groups



NUCLEOTIDES

DNA VS. RNA SUGAR

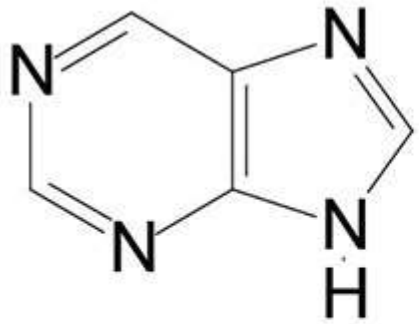


NUCLEOTIDES

TWO TYPES OF NUCLEIC BASES:

❑**Pyrimidines bases of nucleic acids:** The single organic ring of nucleic base. E.g Cytosine (C), Thymine (T), Uracil (U)

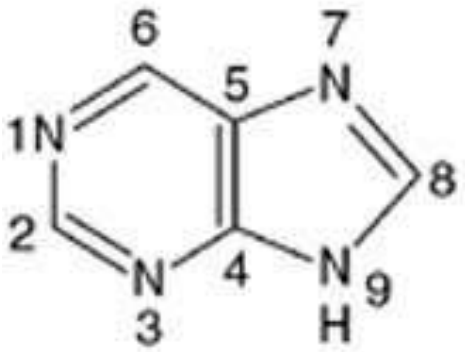
❑**Purine bases**: The double organic ring of nucleic base. E.g. Adenine (A) and Guanine (G)



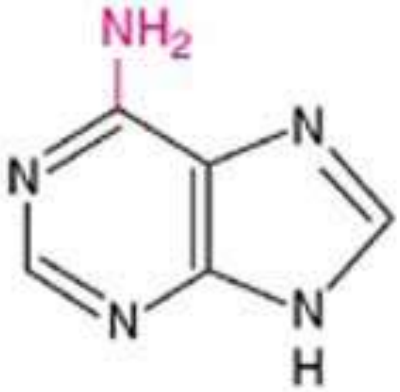
Purine

Pyrimidine

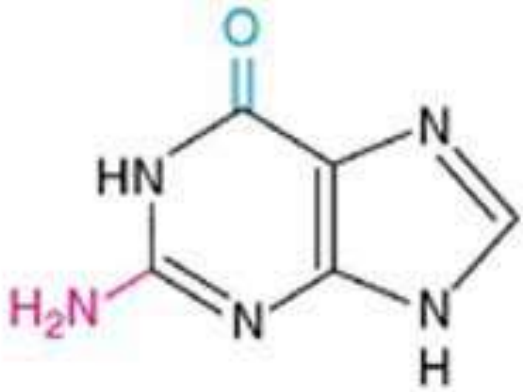
TYPES OF NUCLEIC ACID BASES



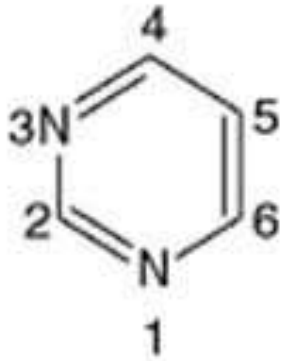
Purine



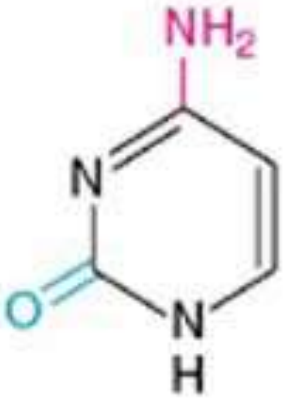
Adenine



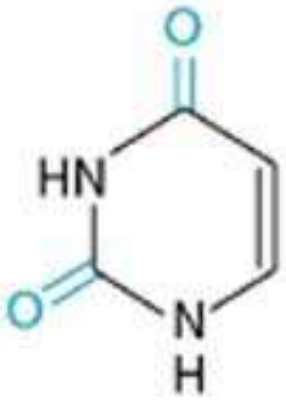
Guanine



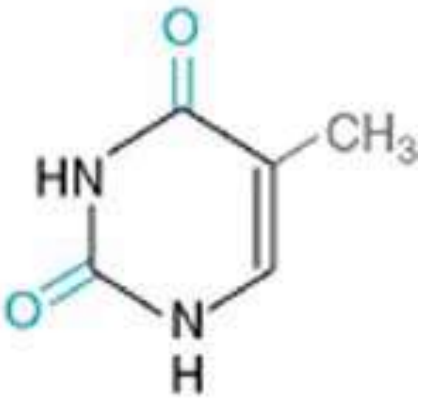
Pyrimidine



Cytosine



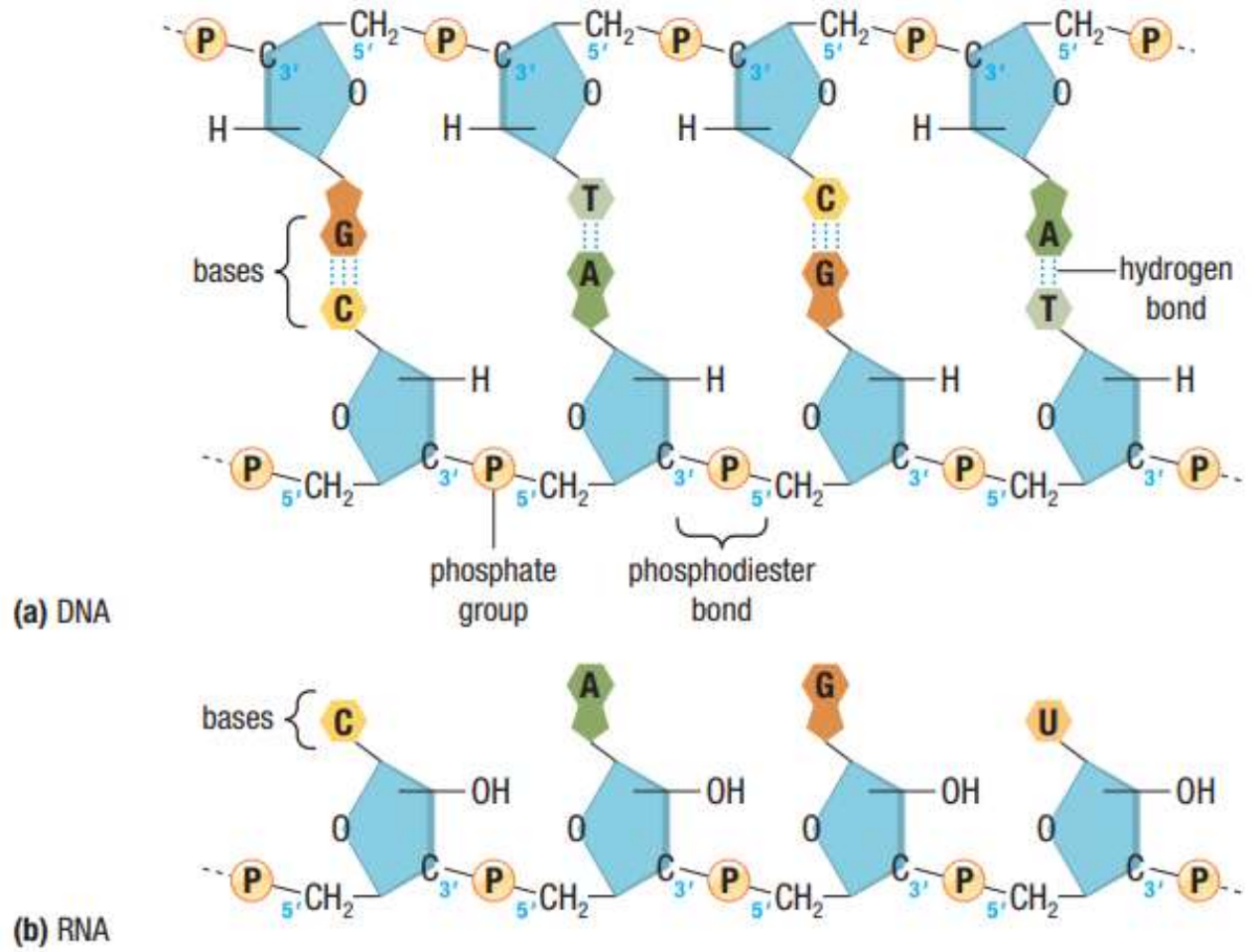
Uracil



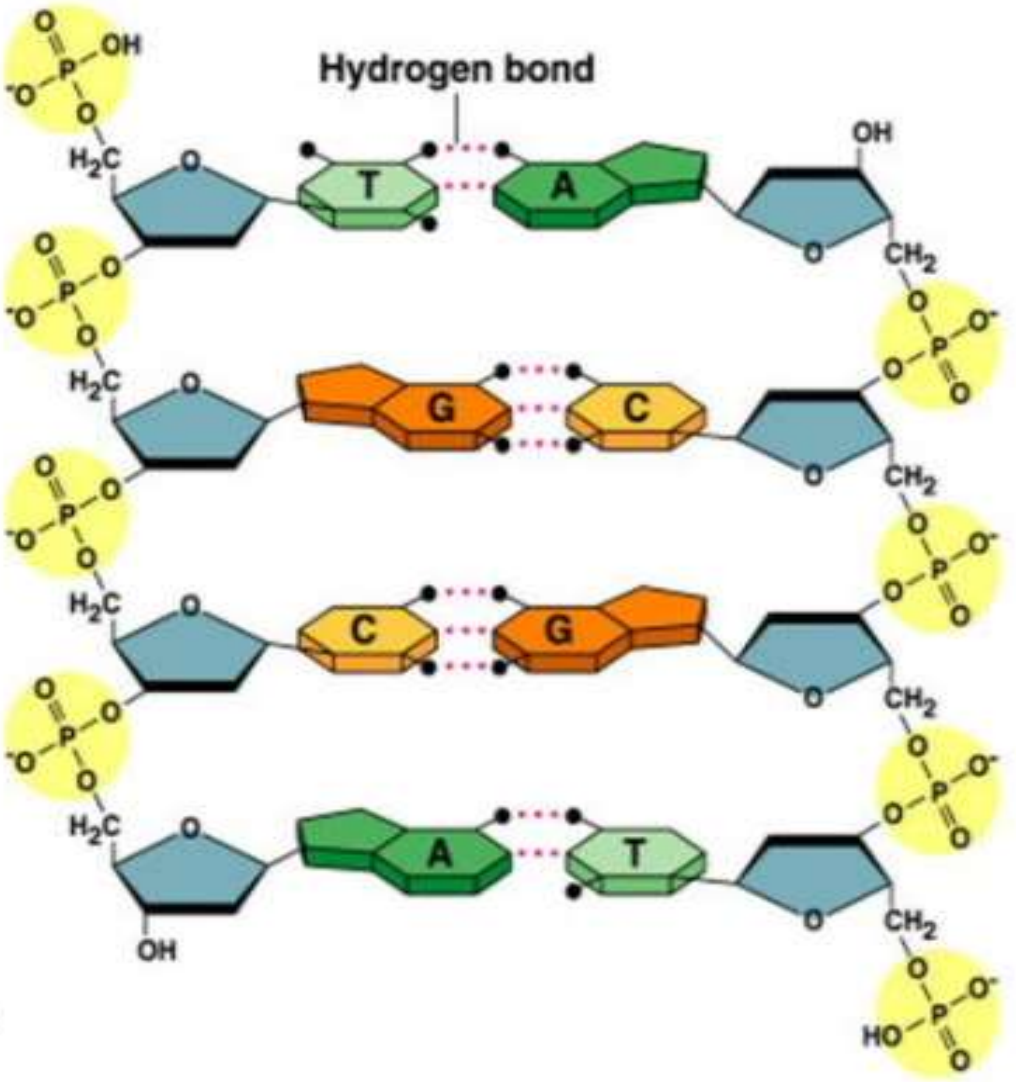
Thymine

DNA AND RNA: NUCLEOTIDE POLYMERS

Phosphodiester bond: A link that is formed between nucleotides by a phosphate bridge



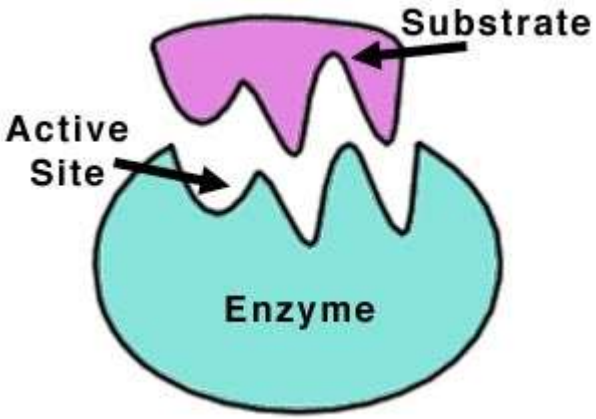
PHOSPHODIESTER BOND

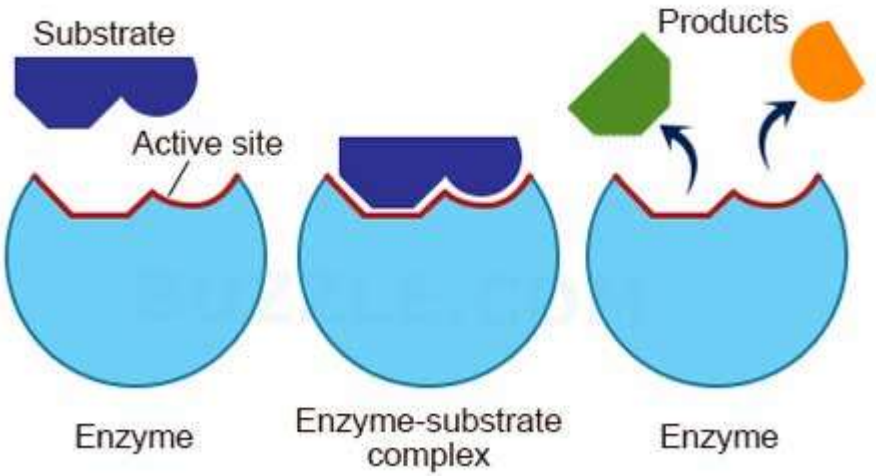


ENZYMES

Enzymes: a biological catalyst, usually a protein, than speeds up a chemical reaction.

- ❑ Substrate: a substance that is recognized by and binds to an enzyme.
- ❑Active site. A pocket or groove in an enzyme that its substrate.





Lock-and-key hypothesis of enzymatic action

ENZYMES HYPOTHESIS

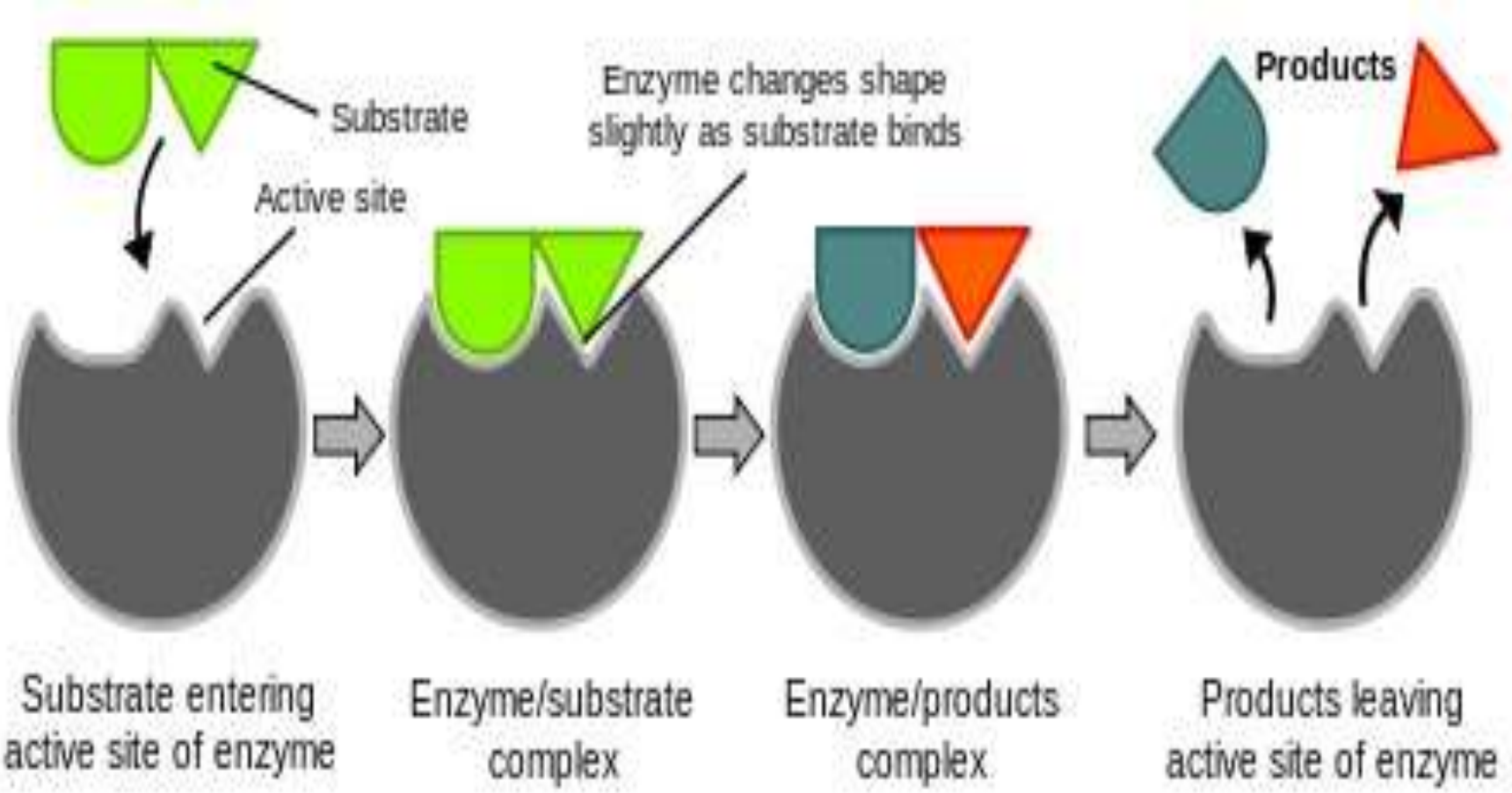


Figure: Induced-fit hypothesis

ENZYMES

- **Induced-fit model**: a model of enzyme activity that describes how an enzyme changes shape to better accommodation.

- **Cofactor:** a non-protein group that binds to an enzyme and is essential for catalytic activity. E.g. Fe, Cu, Zn, Mg.

- **Coenzyme:** an organic molecule that acts as a cofactor of an enzyme. E.g NAD^+ (Nicotinamide adenine dinucleotide) or vit. B3

FACTORS AFFECT ON ENZYME ACTIVITY

The six factors are:

(1) Concentration of Enzyme

(2) Concentration of Substrate

(3) Effect of Temperature

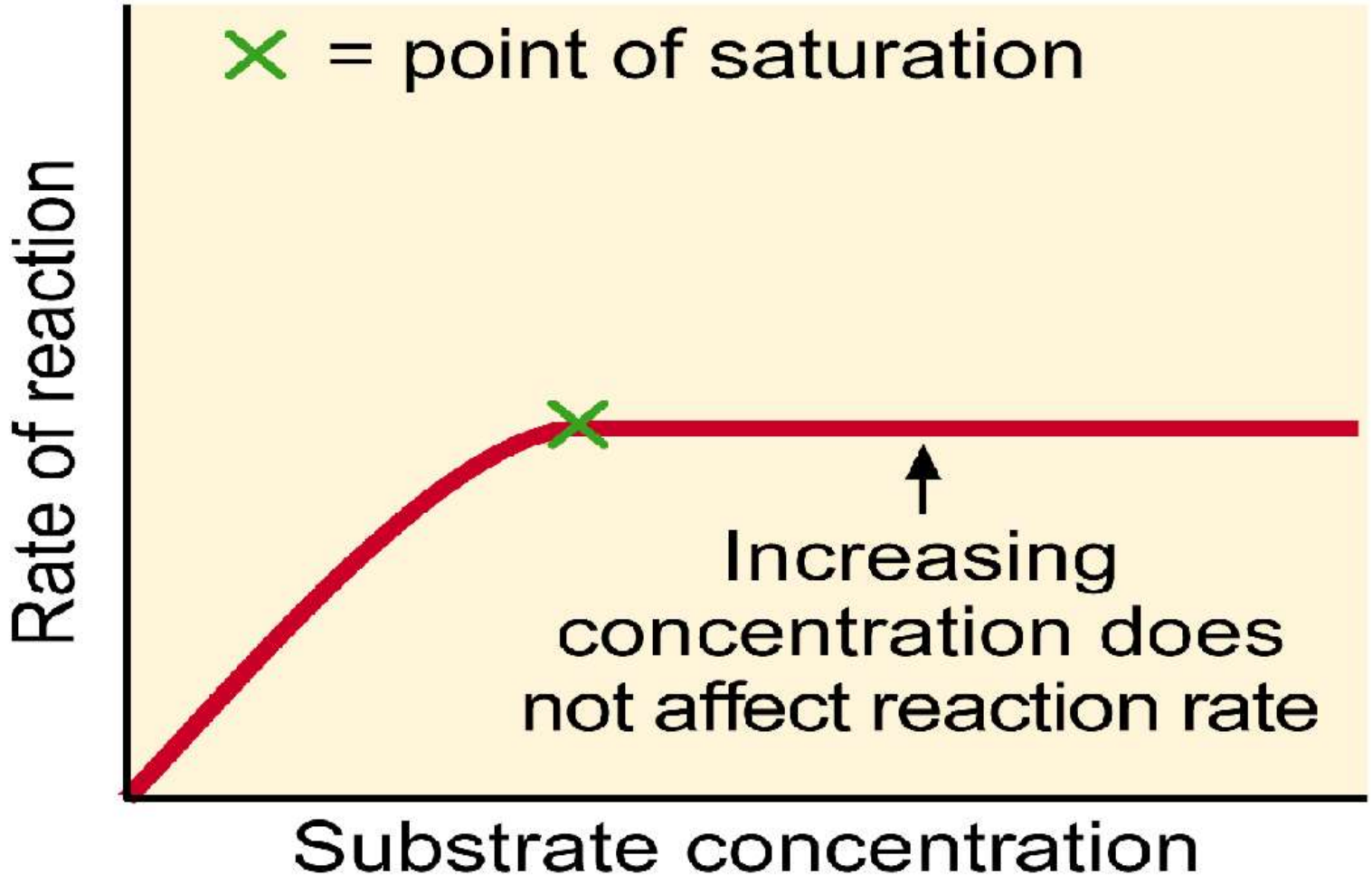
(4) Effect of pH

(5) Effect of Product Concentration and

(6) Effect of Activators.

CONDITIONS THAT AFFECT ENZYMES ACTIVITY

- **Enzyme and substrate concentration**:

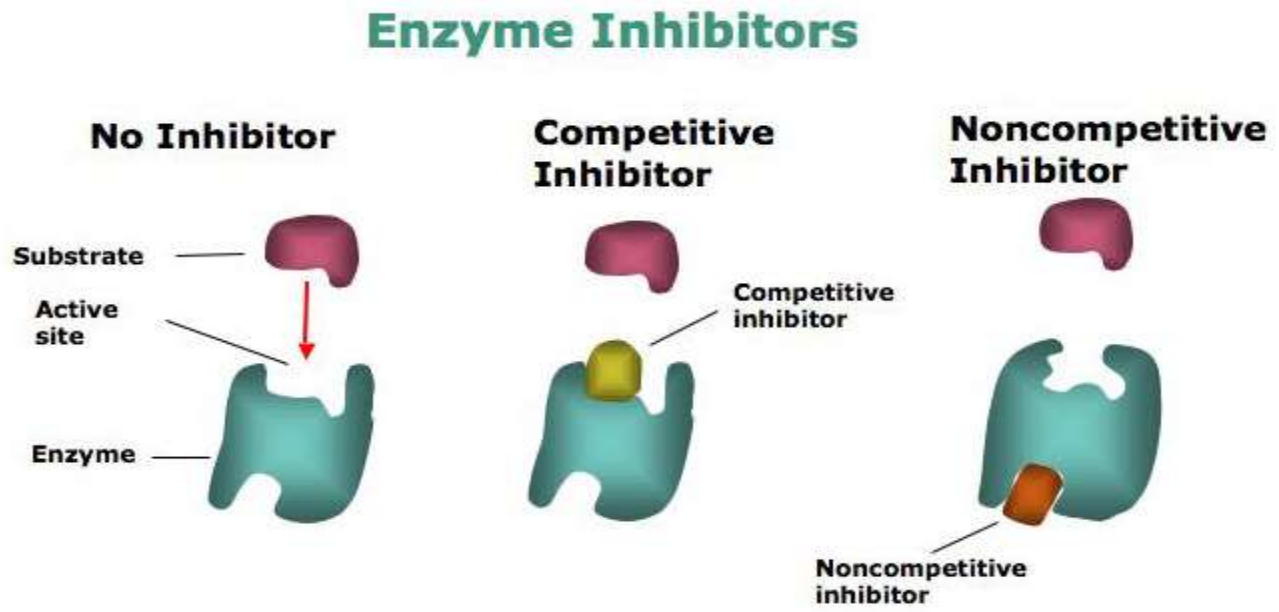


CONDITIONS THAT AFFECT ENZYMES ACTIVITY

Enzyme Inhibitors: They lower the rate at which an enzyme catalyzes a reaction.

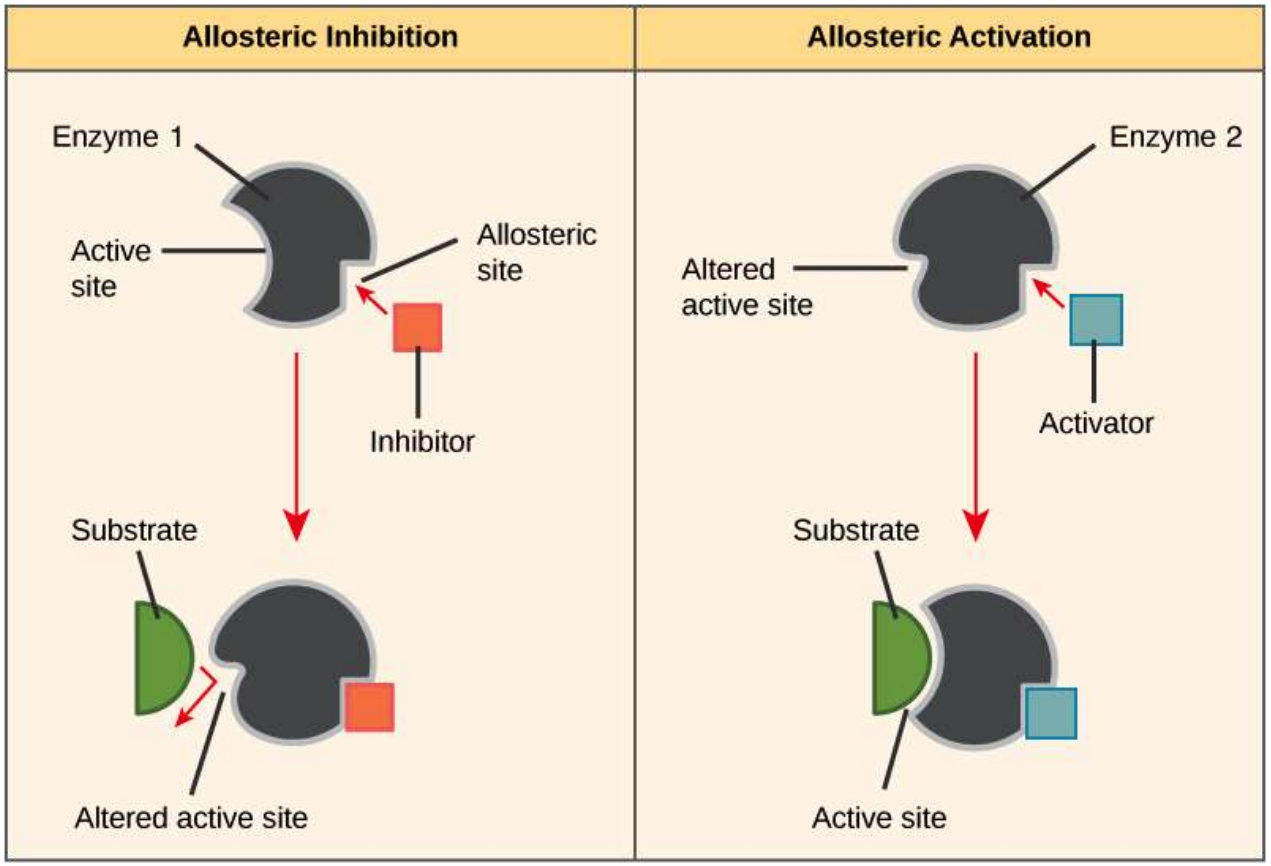
- **Competitive inhibition**: a situation in which a competitor substance binds to a normal substrate binding site to block enzyme activity.

- **Non-competitive inhibition**: a situation in which a competitor substance binds to an enzyme at a site that is not the active site, thus blocking enzymes activity.



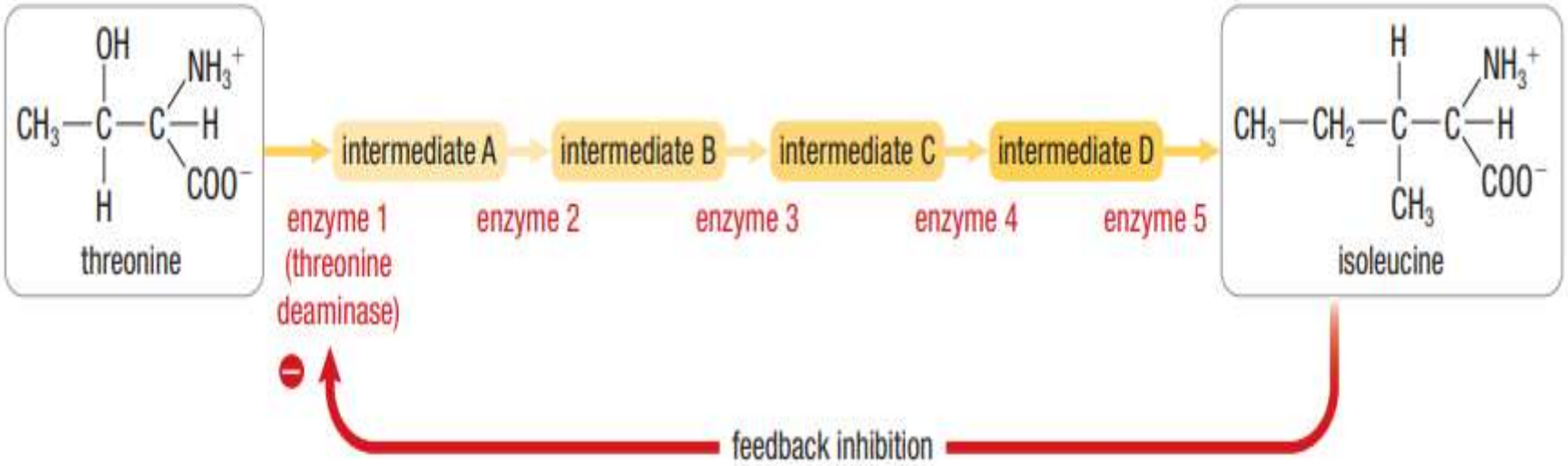
ALLOSTERIC CONTROL OF ENZYME ACTIVITY

Allosteric site: a binding site on an enzyme that binds regulatory molecules.
Allosteric regulation: the regulation of one site of a protein by binding to another site on the same protein.



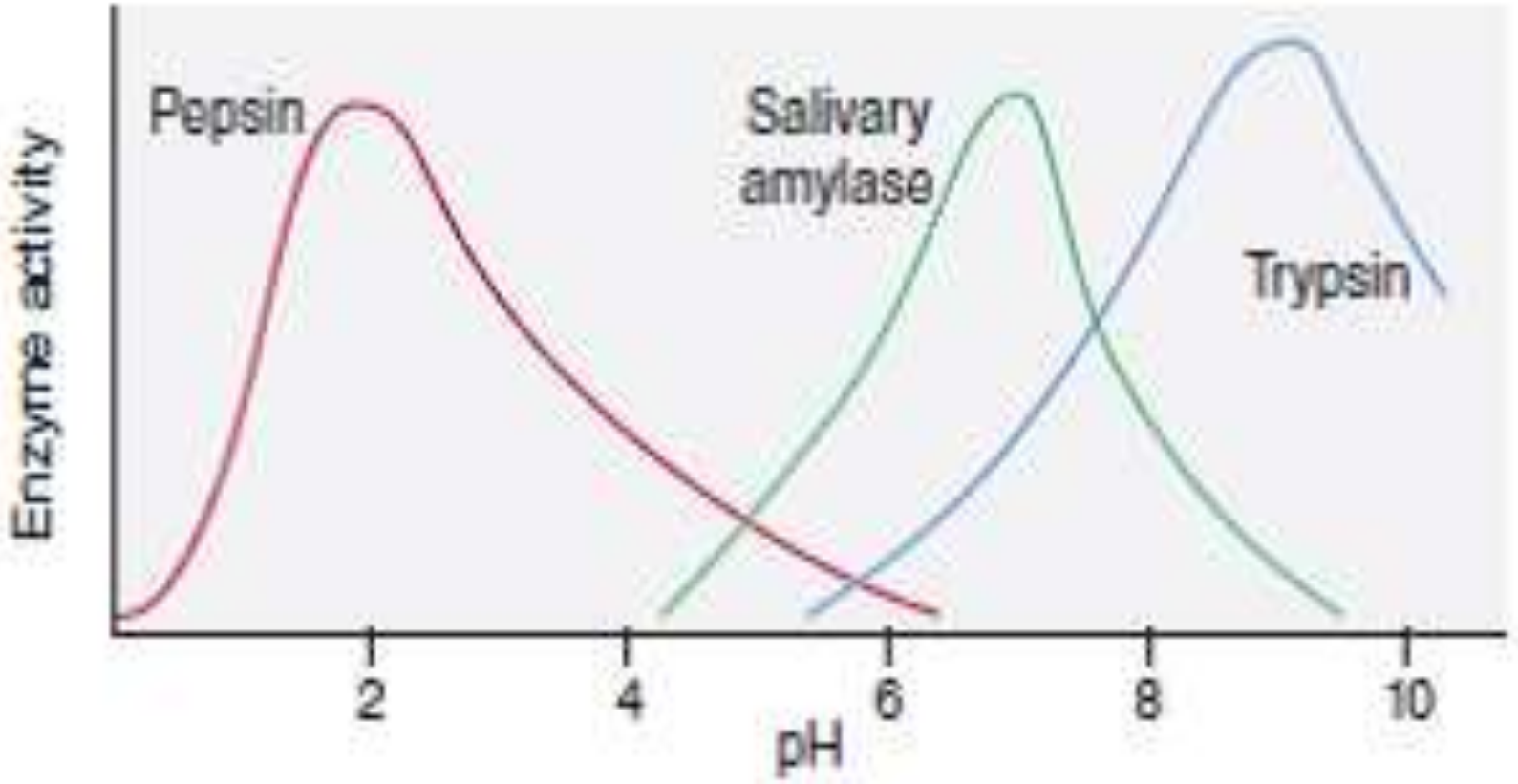
FEEDBACK INHIBITION

Feedback inhibition: the regulation of a pathway by one of the product of this pathway.



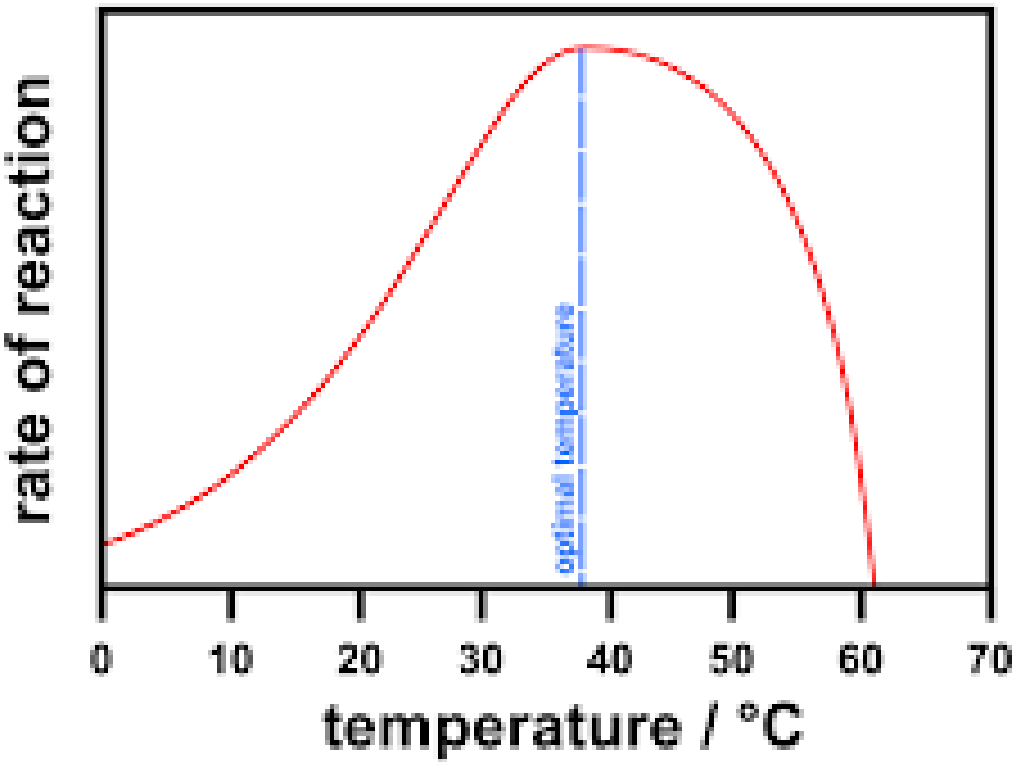
FACTORS AFFECT ON ENZYME ACTIVITY

Effect of pH:



FACTORS AFFECT ON ENZYME ACTIVITY

Effect of Temp.:



APPLICATION OF ENZYMES

Enzyme type	Enzyme	applications
Oxidoreductase	catalase	sterilization of milk
	glucose oxidase	removal of glucose from food
	lipoxidase	bleach in white bread
	peroxidase	paper manufacturing
Hydrolase	α and β amylase	brewing
	cellulase	wine making
	glucoamylase	starch processing
	penicillin amidase	antibiotics
	keratinase	leather manufacturing
Lyase	fumerate hydratase	malic acid
Isomerase	glucose isomerase	fructose syrup production

Table Additional Uses of Enzymes

Product or process	Effects of enzymes
animal feed	degradation of the components of feed to improve nutrient digestion and uses of the feed
brewing	faster maturation of beer; removal of carbohydrates in light beer
dairy	cheese making; removal or conversion of lactose in milk
detergent	breakdown of starch and fatty stains as an active biological component of powder and liquid detergents; colour brightening and softening of cotton garments
leather	unhairing, batting, and defatting; soaking to soften hides and skins
starch	production of glucose, dextrose, fructose, and special syrups for baking and soft-drink production
wine and juice	degradation of the protein pectin for clarification and increase in juice yield


THE END