# BIOCHEMISTRY (I)

## 2nd Stage Students Biology Department – College of Science

## 1st Semester 2017/2018

Dr. Saba Zuhair Hussein
Chemistry Department- College of Science

# Books

- **Principals of Biochemistry, 4th ed. by Horton *et.al*, 2006.**
- **Biochemistry,  2ed by P. Naik 2007 (JAYPEE).**

# Contents:

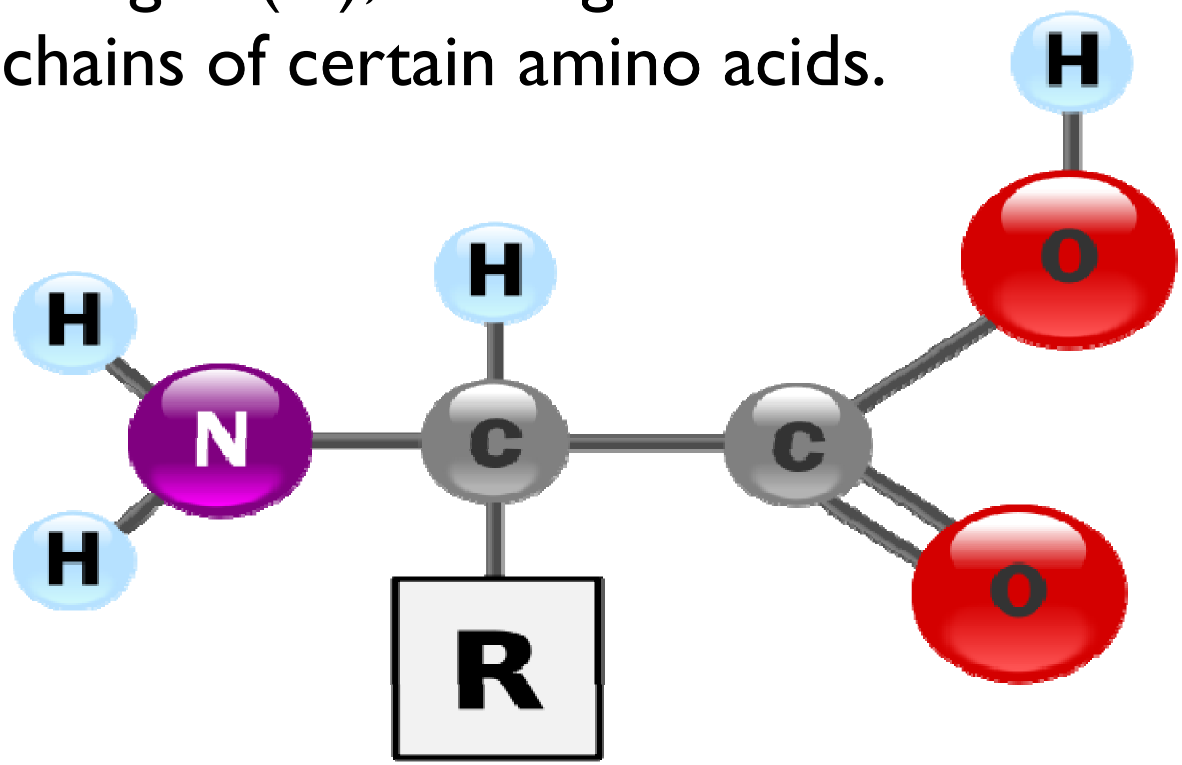
- **Amino Acid**
- **Peptides**
- **Nucleic acid**

# Lecture 1

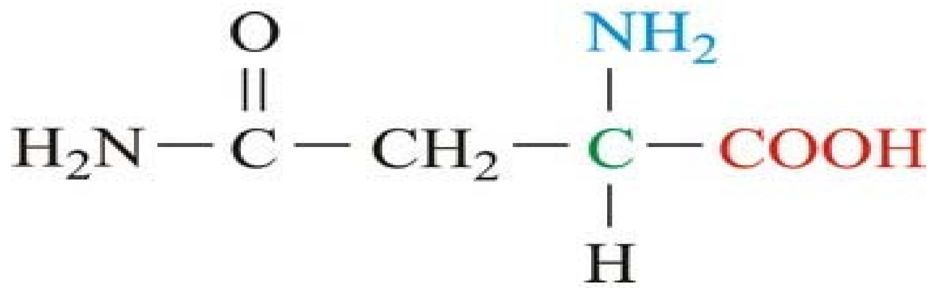
# Amino Acid

**Amino acids** are building blocks of peptides and proteins

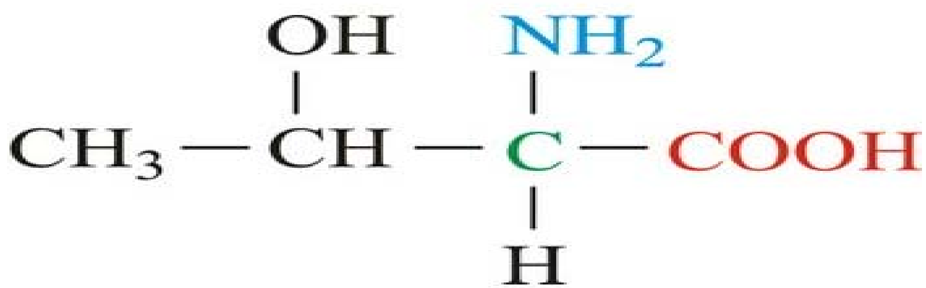
They are organic compounds containing amine (-NH2) and carboxyl (-COOH) functional groups, along with a side chain (R group) specific to each amino acid. The key elements of an amino acid are carbon (C), hydrogen (H), oxygen (O), and nitrogen (N), although other elements are found in the side chains of certain amino acids.



-The first to be discovered was **Asparagine (Asn),** in 1806, French chemists Louis-Nicolas Vauquelin and Pierre Jean Robiquet isolated a compound from asparagus (named asparagine)




-The last of the 20 common amino acids to be discovered was **Threonine (Thr)** in 1938 by William Cumming Rose .



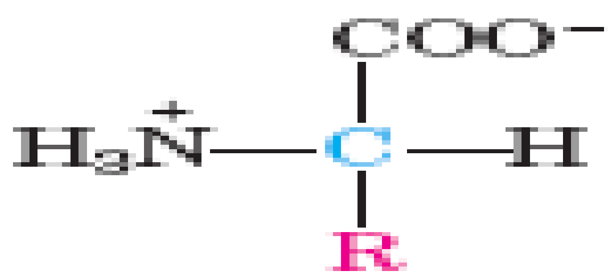
# Structure of the Amino Acids

Although over 200 amino acids have been shown to be present in the various plants and animals, only **20** of them (**L- isomers**) are commonly found in proteins, these 20 amino acids of proteins are often referred to as **standard, primary** or **normal amino acids,** to distinguish them from others.

They are called **proteogenic** amino acids.

The others which never occur in proteins are known as **non- proteogenic** amino acids.

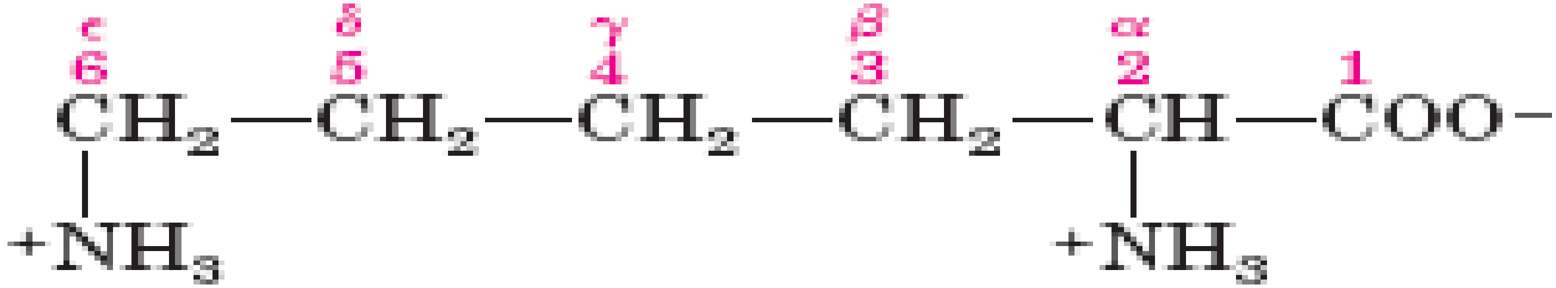
**L-form**



# Classification of Amino Acids

## 1. Classification based on the position of amino group

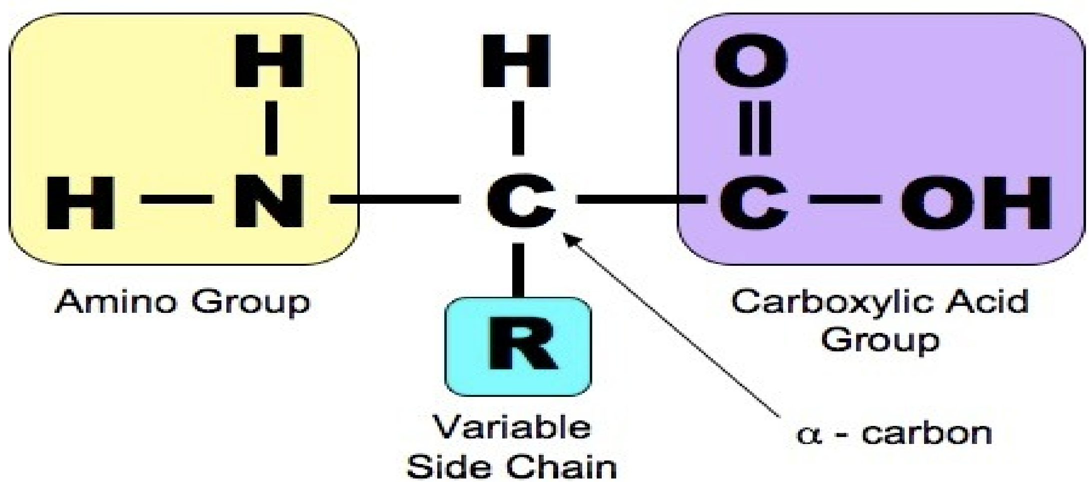
Amino acids may be classified as α, β or γ - amino acids according to the position of the amino group in the carbon chain




Lysine

**- All 20 of the common amino acids are**

***α*-amino acids**



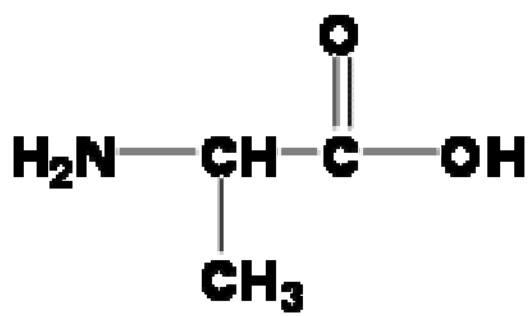
# Classification of Amino Acids

**2. Classification based on their acid-base properties**

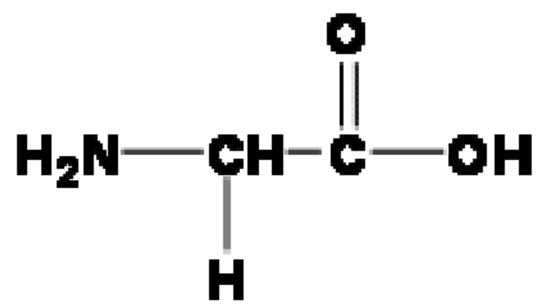
On the basis of the acid-base properties in solution, amino acids are classified into three types

**i) Neutral amino acids** : Most α-amino acids contain an amino group at one end and a carboxyl group at the other end. They do not contain any amino group or carboxyl group in the side chain (R). These are called neutral amino acids

**Examples**




alanine

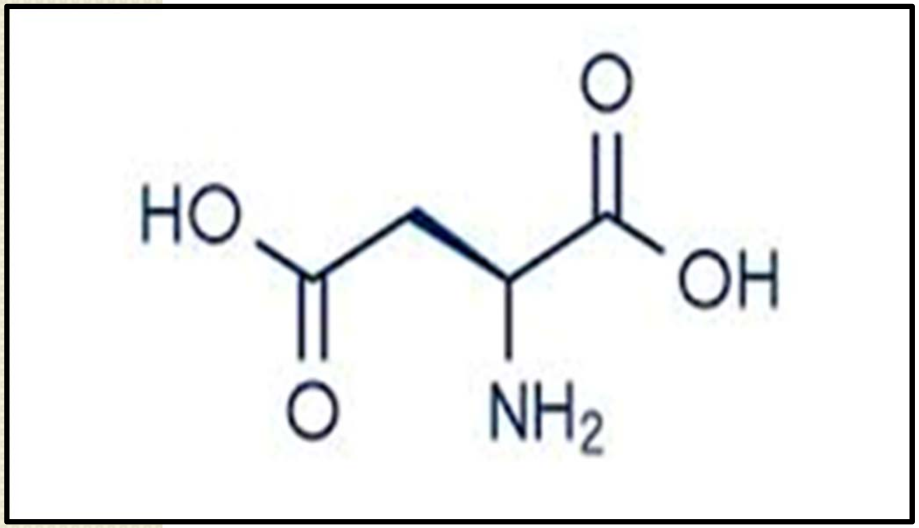



glycine

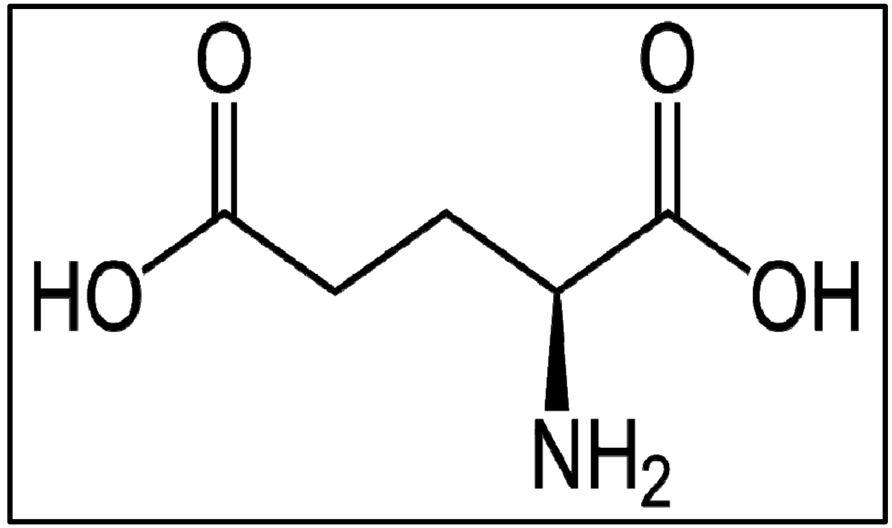
# Classification of Amino Acids

**ii) Acidic amino acids :** The amino acids containing an extra carboxyl group in the side chain are referred to as acidic acids

**Examples**




**Aspartic acid**

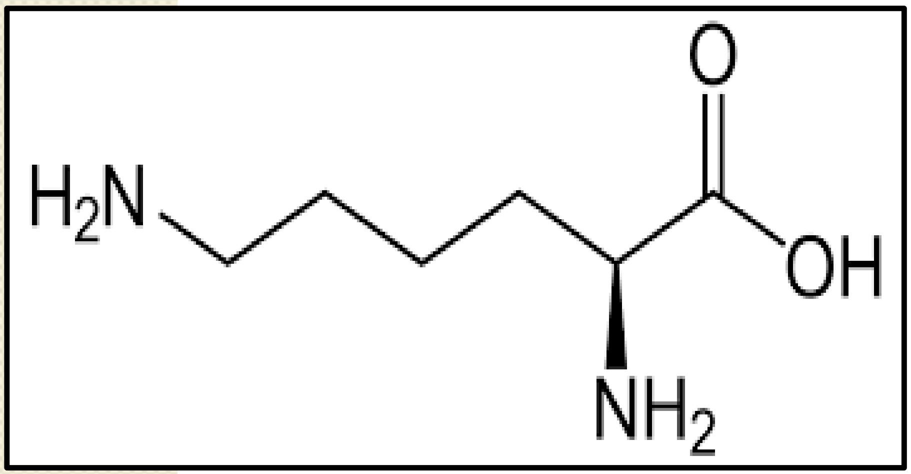



**Glutamic acid**

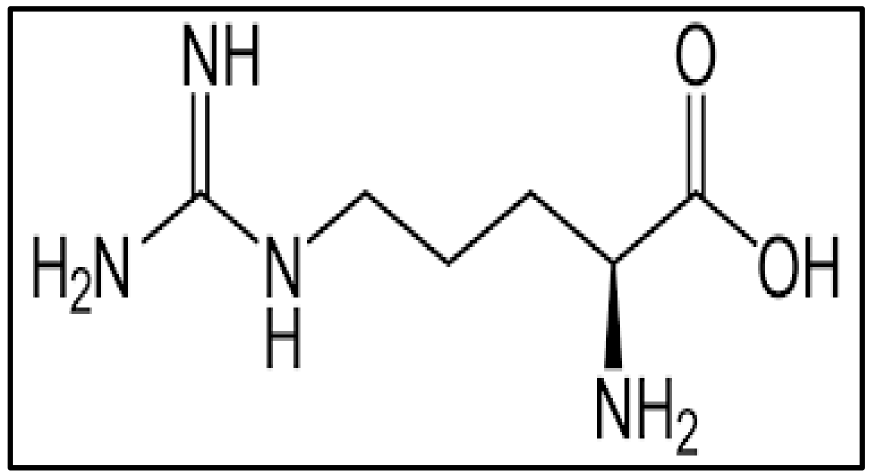
# Classification of Amino Acids

**iii) Basic amino acids** : The amino acids containing an extra amino group in the side chain are termed basic amino acids

**Examples**




**Lysine**




**Arginine**

# Nutritional Classification of Amino Acids

## 3. Classification based on their biological importance

### i) Essential or indispensable:

Amino acids are essential for the growth of body and its protection from diseases. Certain amino acids which are essential for the growth of body, **cannot** be synthesized by the body. Therefore, they must be included in the human diet.

Such amino acids are referred to as essential amino acids. They are also called indispensable amino acids.

| | | |
|---|---|---|
| **Val** | **Phe** | **Met** |
| **Leu** | **Trp** | **Lys** |
| **Ile** | **His** | |
| **Thr** | **Arg** | |

These are rich in cereals, soyabeans, egg, milk, cheese, meat, carrot leaves and tender coconut

# Nutritional Classification of Amino Acids

**ii) Non-Essential or dispensable:**

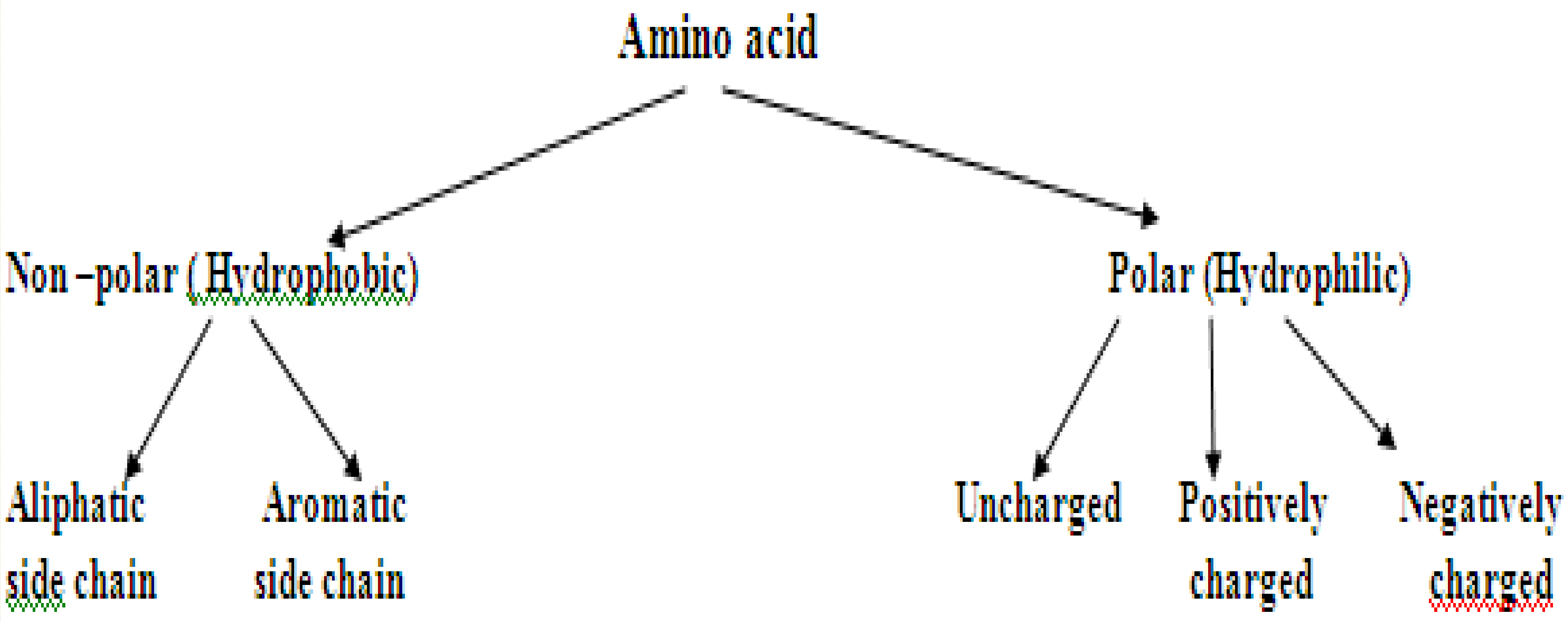
They **can** be produced from endogenous metabolites. Hence, they need not be included in the diet. These amino acids are termed nonessential amino acids

| | | |
|---|---|---|
| **Gly** | **Glu** | **Tyr** |
| **Ala** | **Gln** | **Pro** |
| **Ser** | **Asp** | |
| **Cys** | **Asn** | |

# Lecture 2

# Classification of Amino Acids

## 3. Classification based on their structure



# Classification of Amino Acids

## I- Nonpolar, Aliphatic R Groups (7 a.a)

They include amino acids with aliphatic side chains

| Name | Abr. | Sym. |
|---|---|---|
| Glycine | Gly | G |
| Alanine | Ala | A |
| Proline | Pro | P |
| Valine | Val | V |
| Leucine | Leu | L |
| Isoleucine | Ile | I |
| Methionine | Met | M |

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| Name | Abr. | Sym. |
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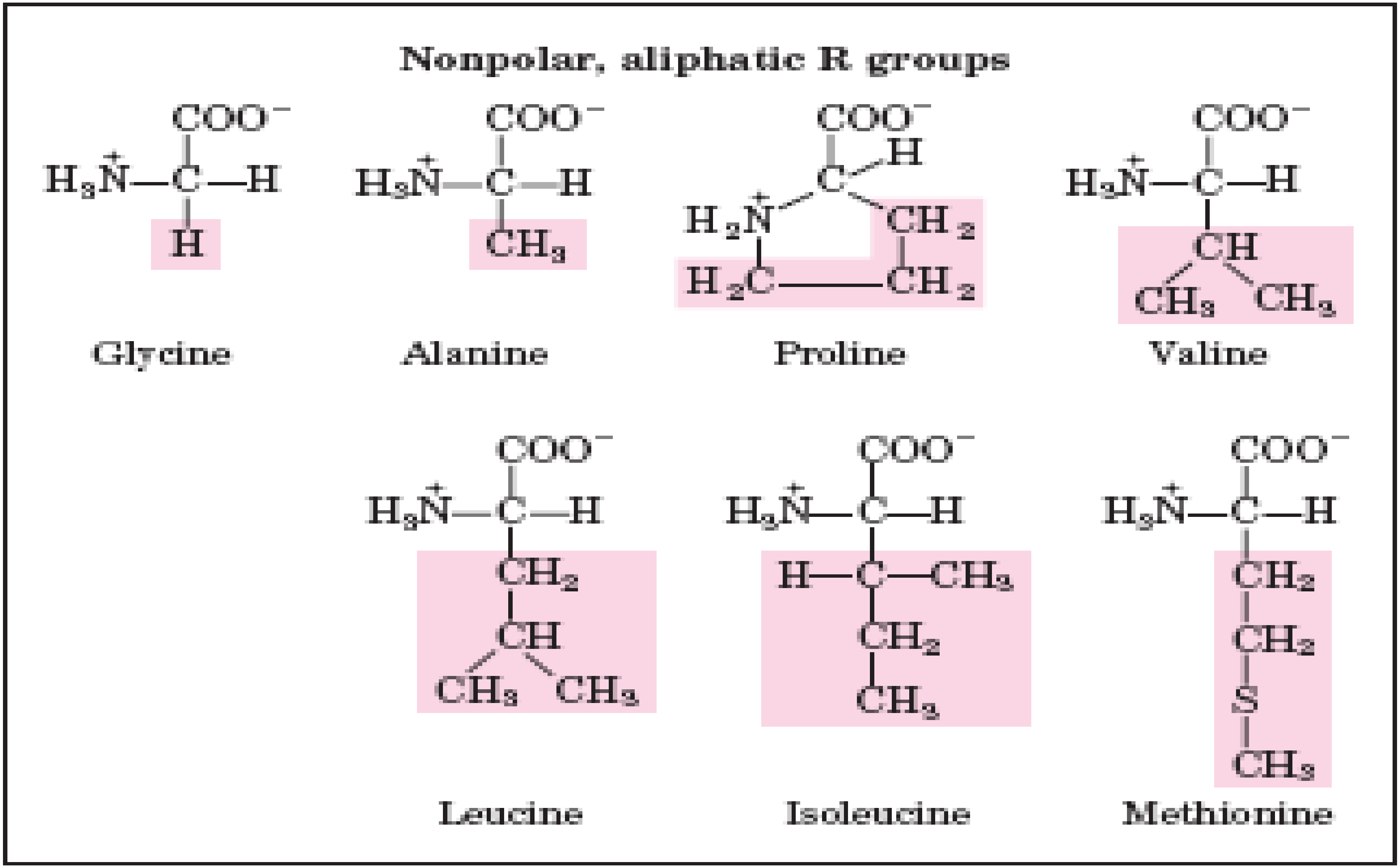
# Classification of Amino Acids

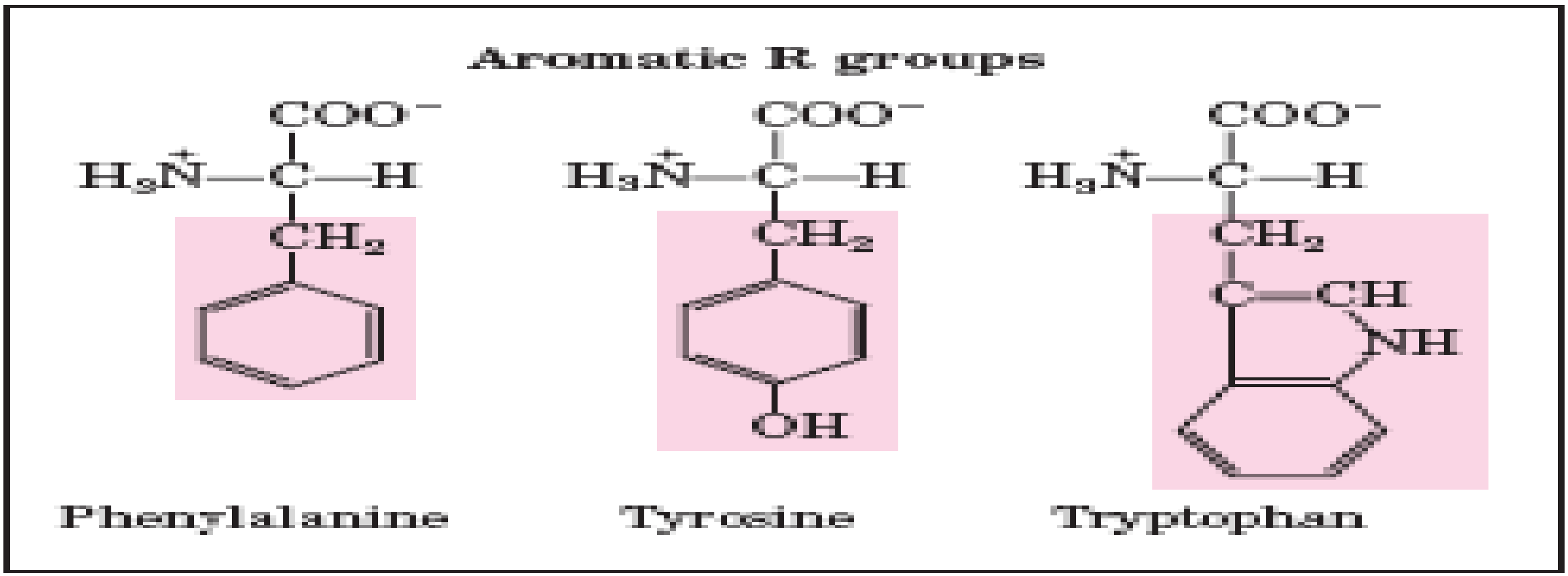



- **Met (Thioether group)** ⟶ **$-CH_2-S-CH_3$**

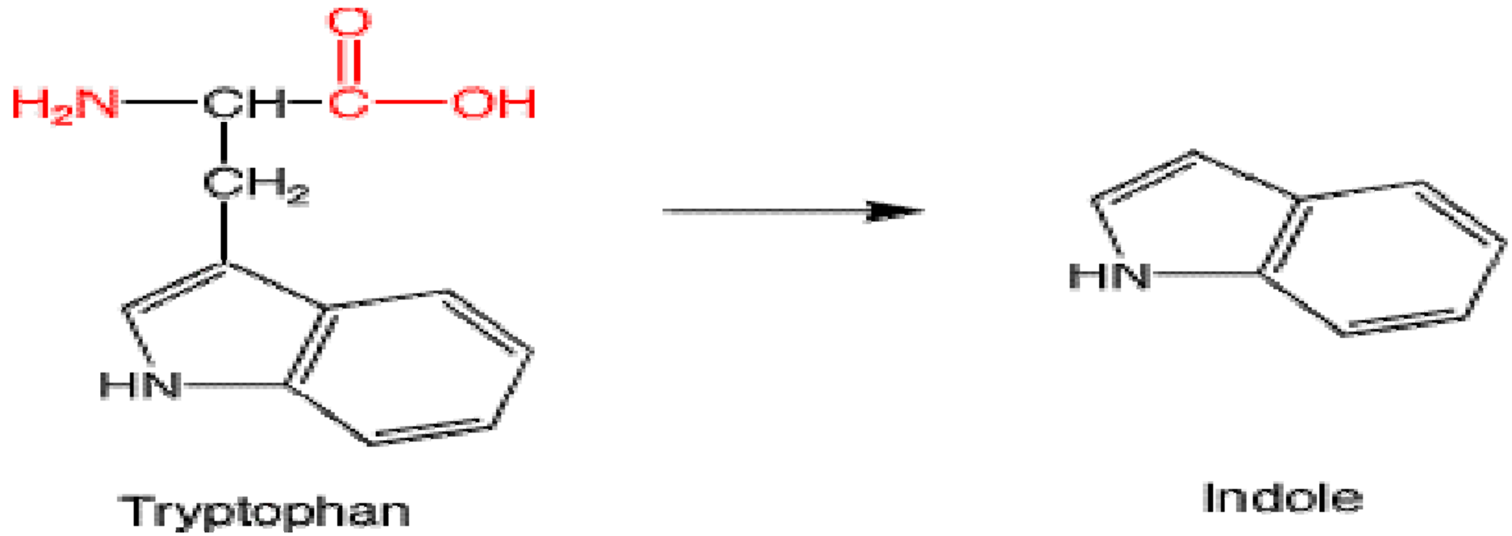
# 2- Aromatic R Groups (3a.a)

These are amino acids containing aromatic rings in the side chain

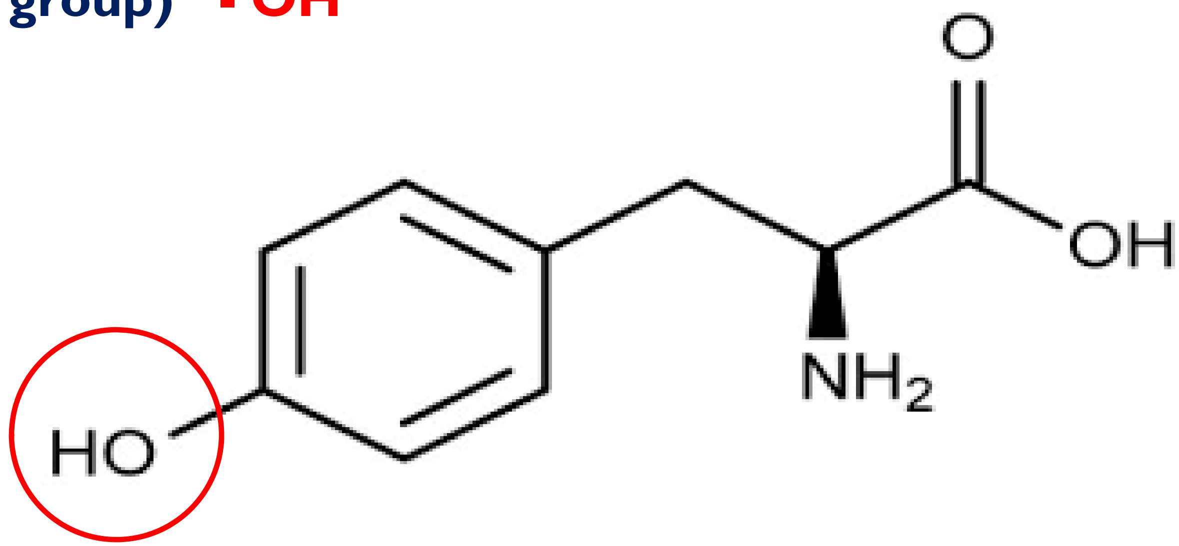
| Name | Abr. | Sym. |
|---|---|---|
| Phenylalanine | Phe | F |
| Tyrosine | Tyr | Y |
| Tryptophan | Trp | W |



❖ **Trp (Indole Ring)**

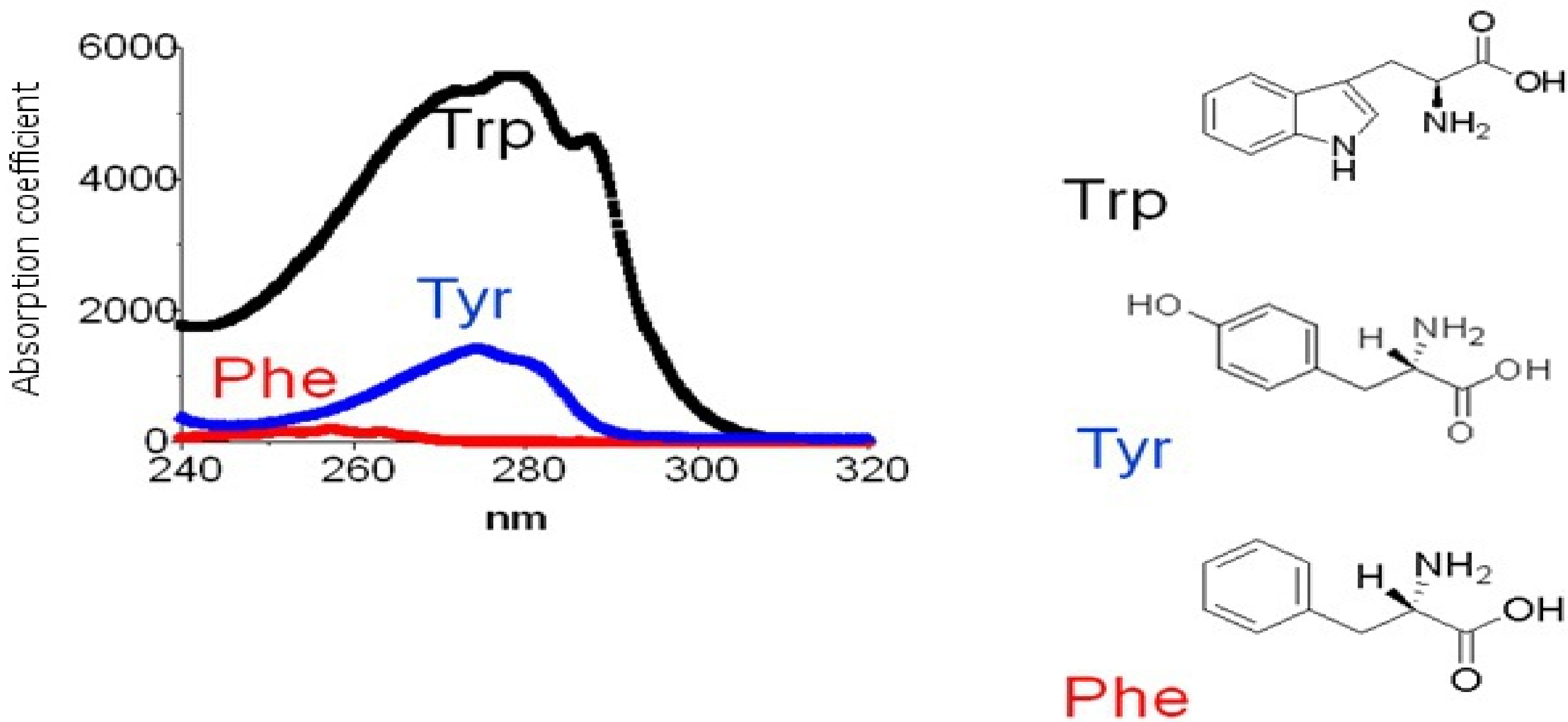



❖ **Tyr (Hydroxyl group)** **- OH**



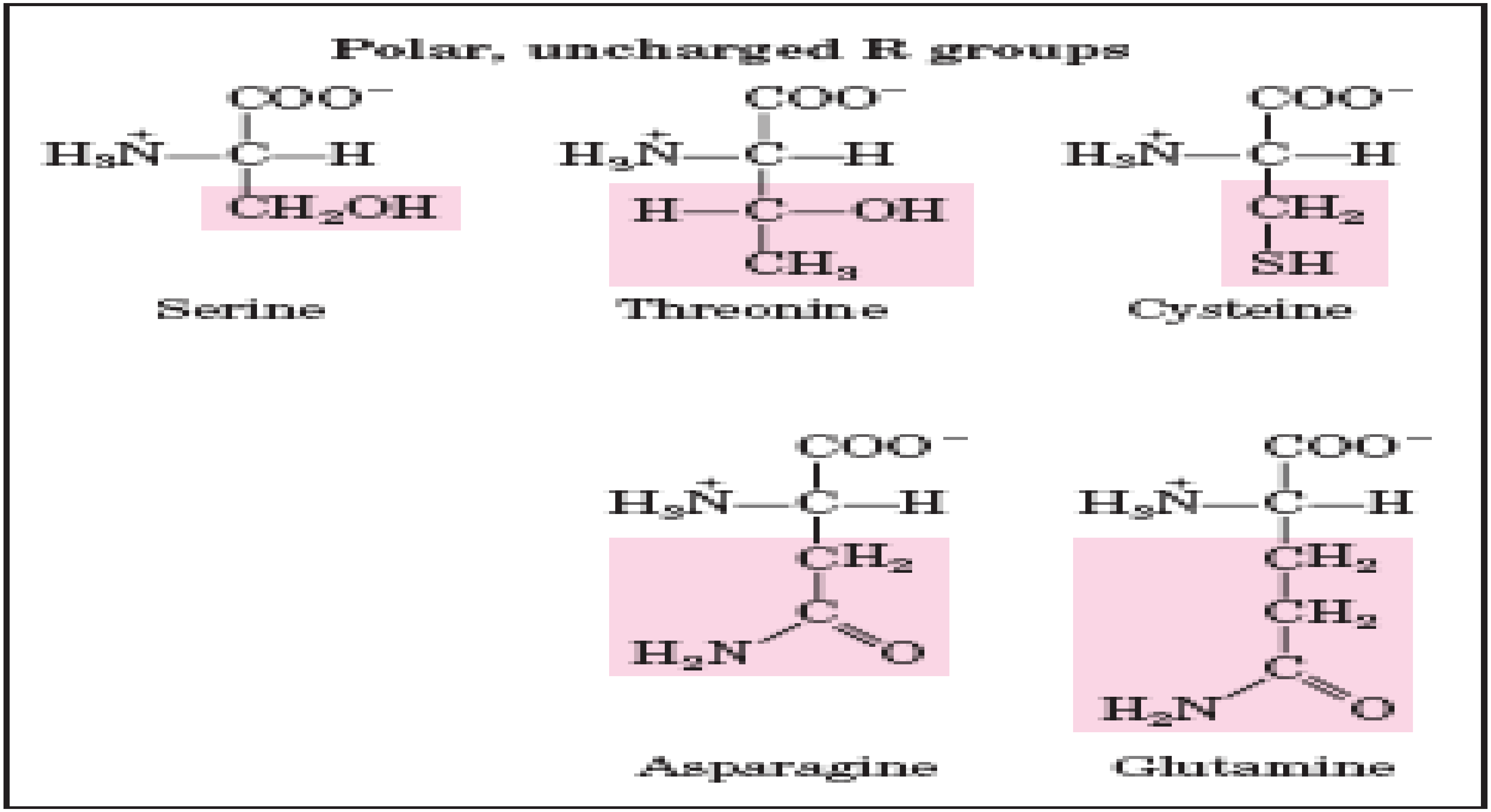
-**Tryptophan** and **Tyrosine,** and to a much lesser extent **Phenylalanine**, absorb ultraviolet light.

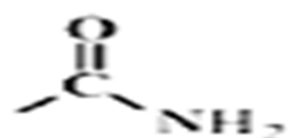
-This accounts for the characteristic strong absorbance of light by most proteins at a wavelength of 280 nm, a property exploited by researchers in the characterization of proteins.



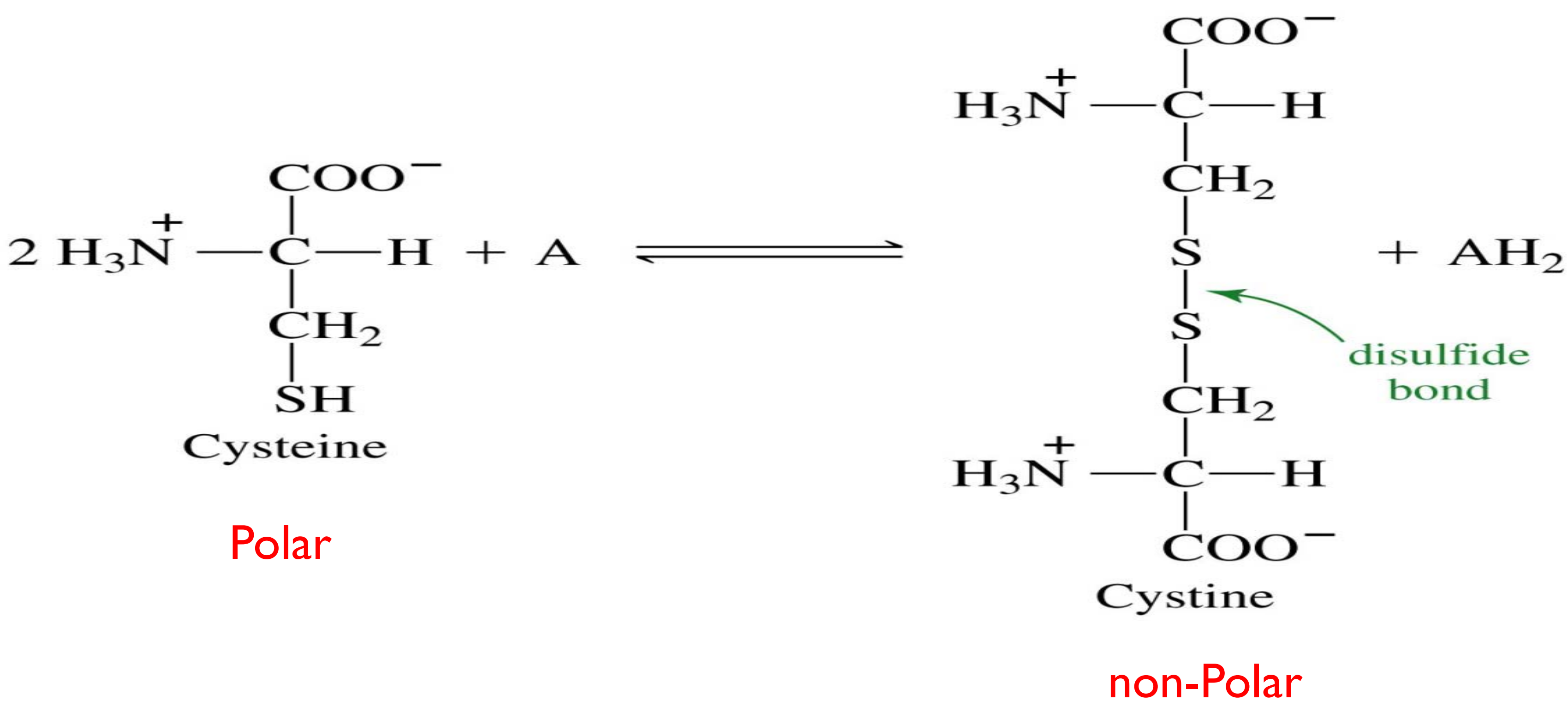
## 3- Polar Uncharged R Groups (5 a.a)

| Name | Abr. | Sym. |
|---|---|---|
| Serine | Ser | S |
| Threonine | Thr | T |
| Cysteine | Cys | C |
| Asparagine | Asn | N |
| Glutamine | Gln | Q |



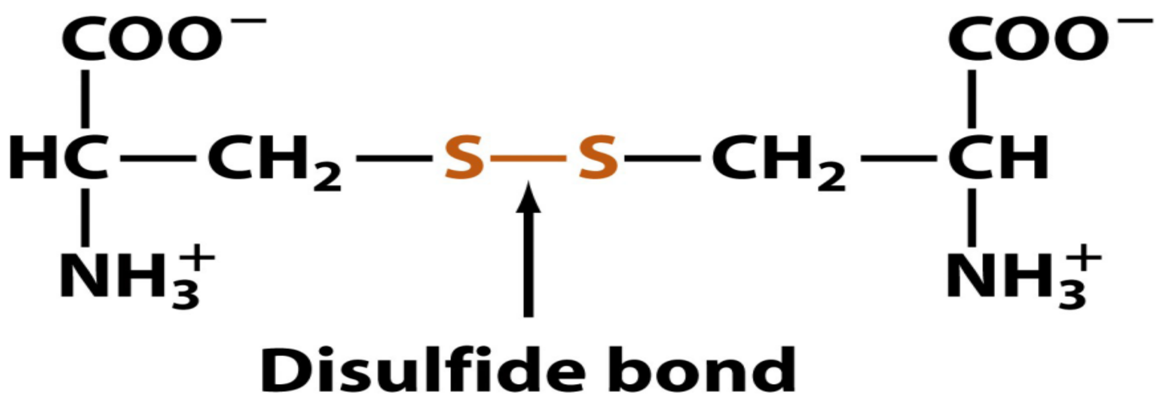

- Ser & Thr (Hydroxyl group) - OH
- Cys (Thiol group) -SH
- Asn & Gln (Amide group) 

**Cysteine** is readily oxidized to form a covalently linked dimeric amino acid called **Cystine**, in which two cysteine molecules or residues are joined by a **disulfide bond**. The disulfide-linked residues are strongly hydrophobic (nonpolar).



# Disulfide bonds

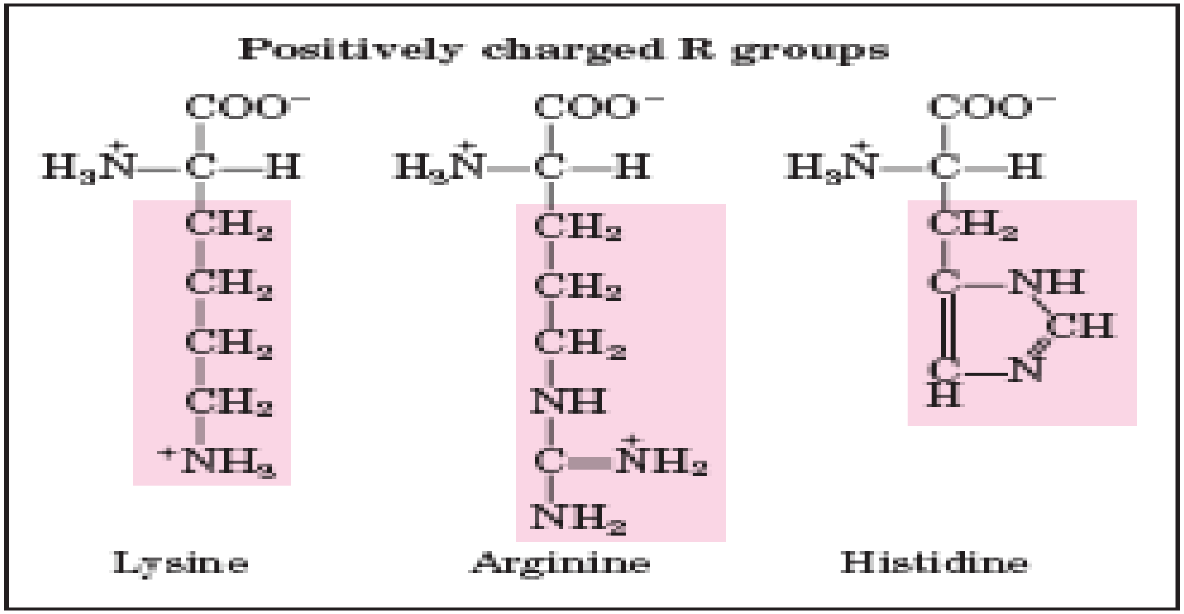
Disulfide bonds play a special role in the structures of many proteins by forming covalent links between parts of a protein molecule or between two different polypeptide chains



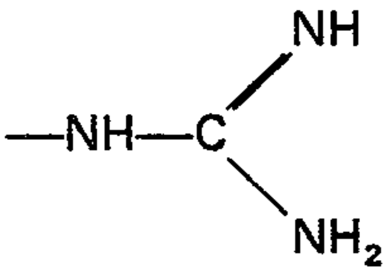
# 4- Positively charged R Groups (Basic) (3 a.a)

**Diamino acids** (Basic amino acids) : These amino acids contain two amino groups, one in the main an the other in the side chain

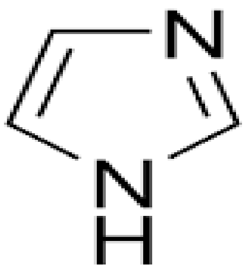
| Name | Abr. | Sym. |
|---|---|---|
| Lysine | Lys | K |
| Arginine | Arg | R |
| Histidine | His | H |



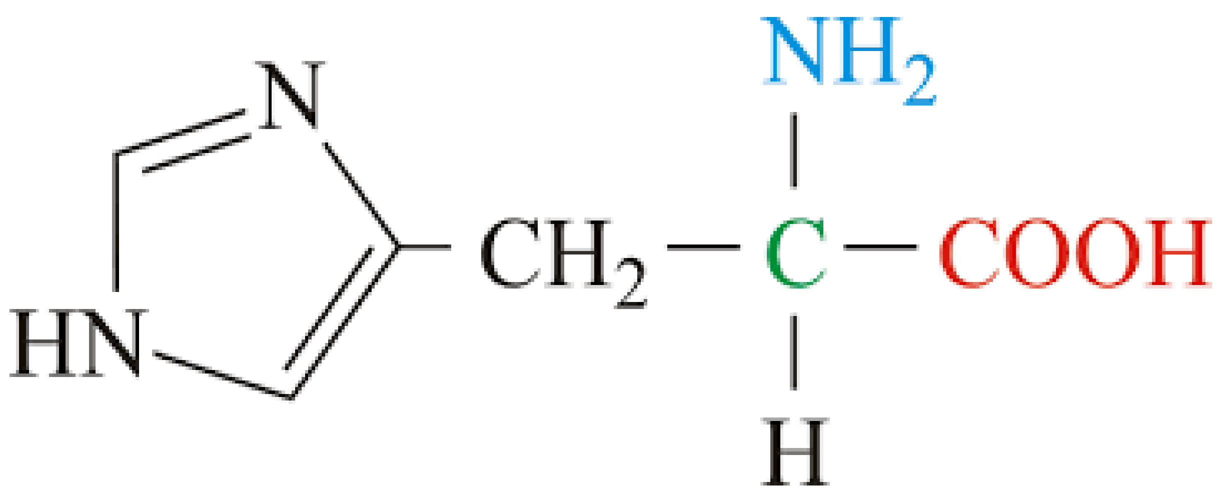

❖ Arg (Guanidino group)




❖His (Imidazole group)

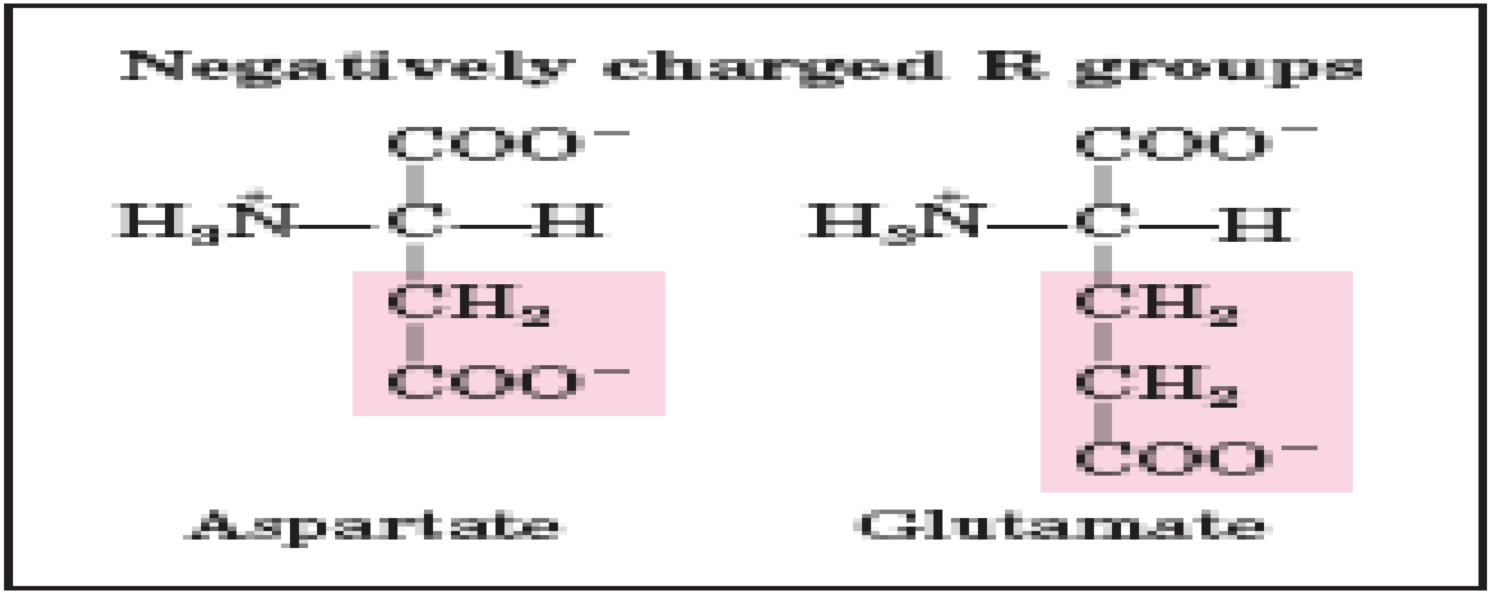


**Histidine** is the only common amino acid having an ionizable side chain with a p*K*a near neutrality. In many enzyme-catalyzed reactions, a His residue facilitates the reaction by serving as a proton donor/acceptor



# 5- Negatively charged R Groups (Acidic) (2 a.a)

| Name | Abr. | Sym. |
|---|---|---|
| Aspartate<br>Aspartic acid | Asp | D |
| Glutamate<br>Glutamic acid | Glu | E |



# Lecture 3

# Importance of Amino Acids

1. **Formation of proteins**: amino acids are joined to each other by **peptide bonds** to form proteins and peptides.
2. **Formation of glucose**: glucogenic amino acids are converted to glucose in the body.
3. **Enzyme activity**: the thiol group (-SH) of cysteine has an important role in certain enzyme activity.
4. **Transport and storage form of ammonia**: amino acid glutamine play an important role in transport and storage of amino nitrogen in the form of ammonia.

# Importance of Amino Acids

**5. As a buffer:** both free amino acids and some amino acids present in protein can potentially act as buffer , e.g. histidine can serve as the best buffer at physiological buffer ( pH= 7 ).

**6. Detoxification reactions:** Glycine , cysteine and methionine are involved in the detoxification of toxic substances.

**7. Formation of biologically important compounds:** specific amino acids can give rise to specific biologically important compounds in the body

# Importance of Amino Acids

## Biologically important compounds formed by amino acid

| Amino acid | Biologically important compound |
|---|---|
| Tyrosine | Hormone, e.g. adrenaline and thyroxine , Skin pigment,e.g. melanin |
| Tryptophane | Vitamin , e.g. niacin |
| Glycine ,arginine and methionine | Creatine |
| Glycine and , cysteine | Bile salts |
| Glycine | Haem |
| Aspartic and glutamic acids | Pyrimidine bases |
| Glycine, aspartic acid and glutamic acid | Purine bases |
| ß-Alanine | Coenzyme-A |

# Physical Properties of Amino Acids

- They are :

Colorless

Crystalline substances with different taste,

Generally soluble in water.

They have high melting points (above 200°C) and often result in decomposition.

## Optical activity

- **T**he **α -carbon** of amino acids is bonded to **four different groups**:

a **carboxyl group**,

an **amino group**,

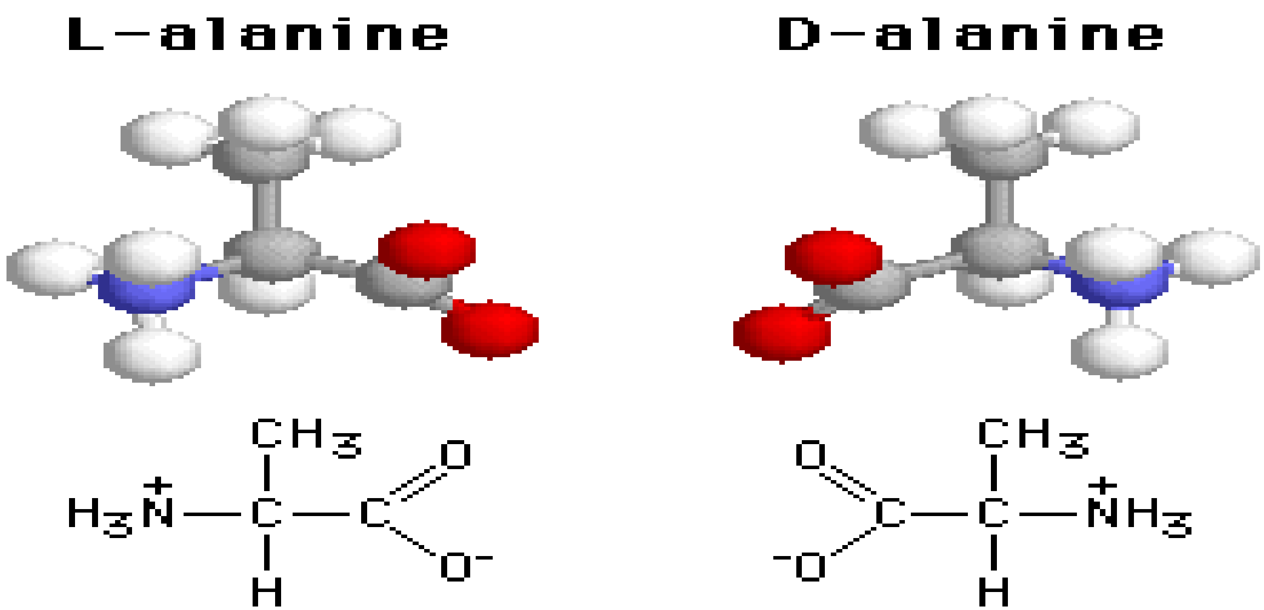
an **R group**, and

a **hydrogen atom** (except in **Glycine**, the R group is another hydrogen atom).

➢That led the α-carbon atom to be a **asymmetric - chiral center**.

Because of this asymmetry, all naturally occurring amino acids (of course except **Glycine**- is optically **inactive-**) exist in **two optically active forms** :

those having **–$NH_2$ group** to the **right** are designed as **D-form** and those having **–$NH_2$ group** to the **left** are designed as **L-form**



# Physical Properties of Amino Acids

- However the **two** amino acids, **Threonine** and **Isoleucine** have **two asymmetric carbon atoms each** and thus have **( $2^n = 2^2 = 4$ )** optical isomers.

- At pH=7 both carboxyl and amino groups are ionized.

- **All the amino acids found in proteins** are **exclusively of the L-configuration** (L Stereoisomers).

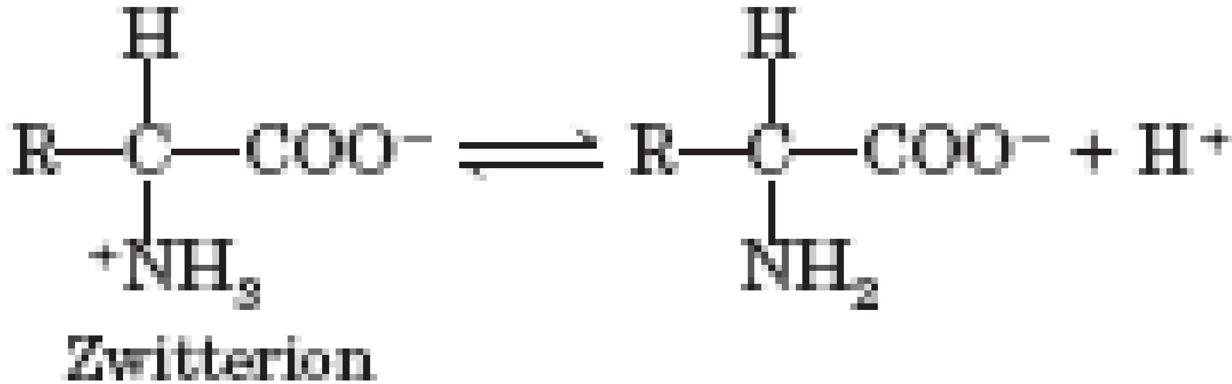
- However, D- amino acids are found in some antibiotics produced by microorganisms and in bacterial cell walls

# Amino Acids Can Act as Acids and Bases

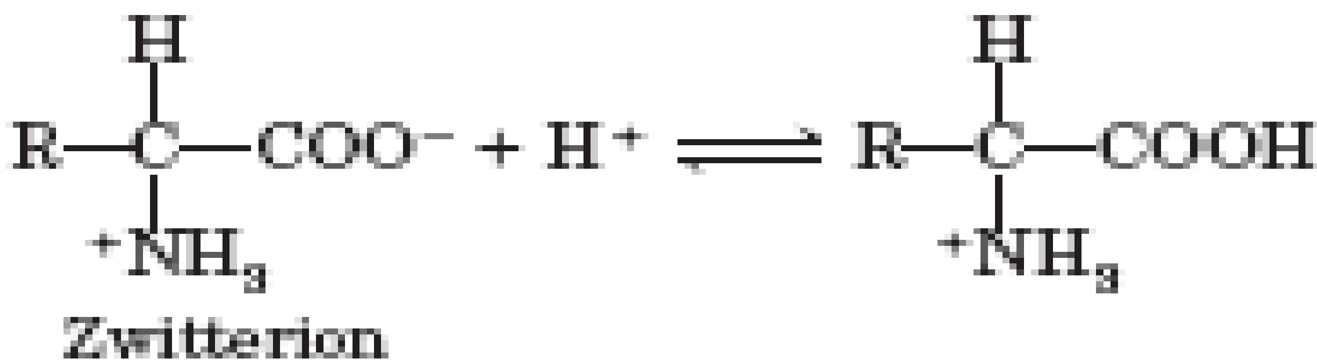
When an amino acid (monoamino monocarboxylic acid) is dissolved in water, it exists in solution as the **dipolar ion**, or **Zwitterion**, which means that they have both positive and negative charges on the same amino acids
(the **acidic α-COOH** group is ionized and becomes negatively charged anion $–COO^-$ **&** the **basic α-$NH_2$** group is protonated to form positively charged cation $–NH^{3+}$ )

Thus, the overall molecule **is electrically neutral**. Substances having this dual nature are **Amphoteric** and are often called **Ampholytes.**

# A zwitter ion can act as either



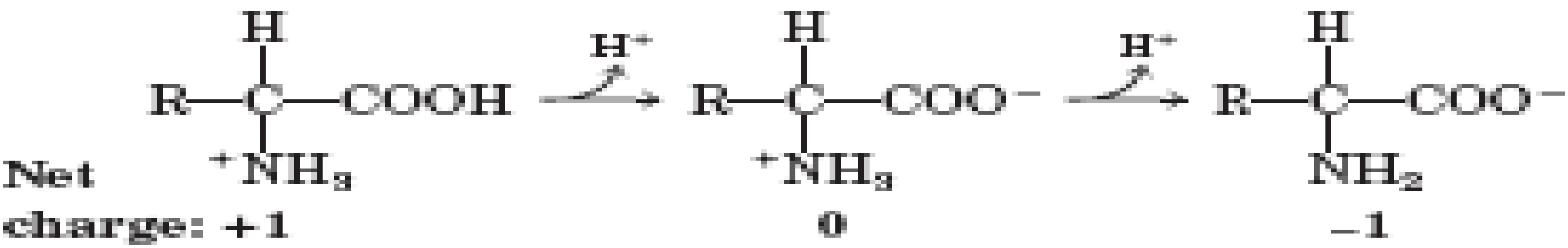

**an acid (proton donor)**




**or a base (proton acceptor)**

**Amino Acids May Have Positive, Negative or Zero Net Charge.**

The **net charge** of an amino acid depends upon the **pH of the medium**, therefore by changing the pH we can alter the charge on amino acids or proteins, which facilitates the physical separation of amino acids or proteins:



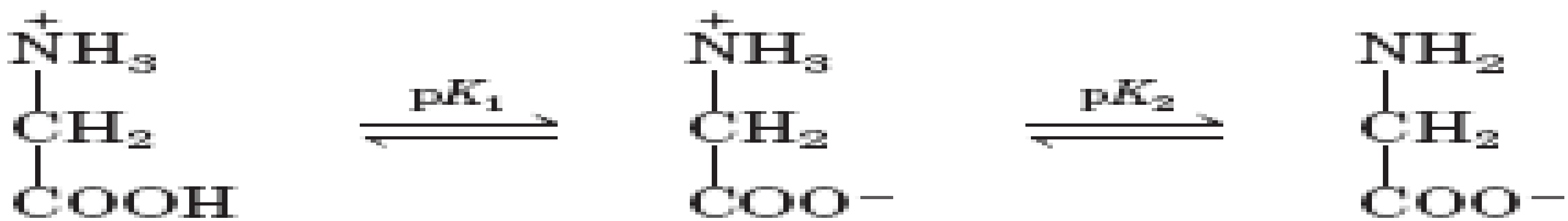

| | | |
|---|---|---|
| Acidic pH (pH<PI)<br>Cation | Isoelectric pH (pH=PI)<br>Zwitter ion (neutral) | Basic pH (pH>PI)<br>Anion |
| Amino acid is soluble | Amino acid is precipitate | Amino acid is soluble |

- At **acidic pH** (high concentration of $H^+$ ions), ionized $-COO^-$ group lose sits proton and becomes uncharged (-COOH), so the overall charge on molecule is **positive** **(the net charge=+ve)**.
- At **alkaline pH** (low concentration of $H^+$ ions), the $-NH^{3+}$ group accept a proton and becomes uncharged ($-NH_2$), so the overall charge on molecule is **negative** **(the net charge=-ve)**.
- The pH at which amino acid beers no net charge **(the net charge=0)** and therefore <u>does not move in an electric field</u> **is called isoelectric pH (pI** , i.e. **pH=pI),** an amino acid <u>precipitate out of the solution **in its pI**</u>.
- The pH at which amino acid beers the maximum total number of charge **(the charge= the maximum total number) is known as ($pH_m$)**

# Lecture 4

# Amino Acids Have Characteristic Titration Curves

**Gly**

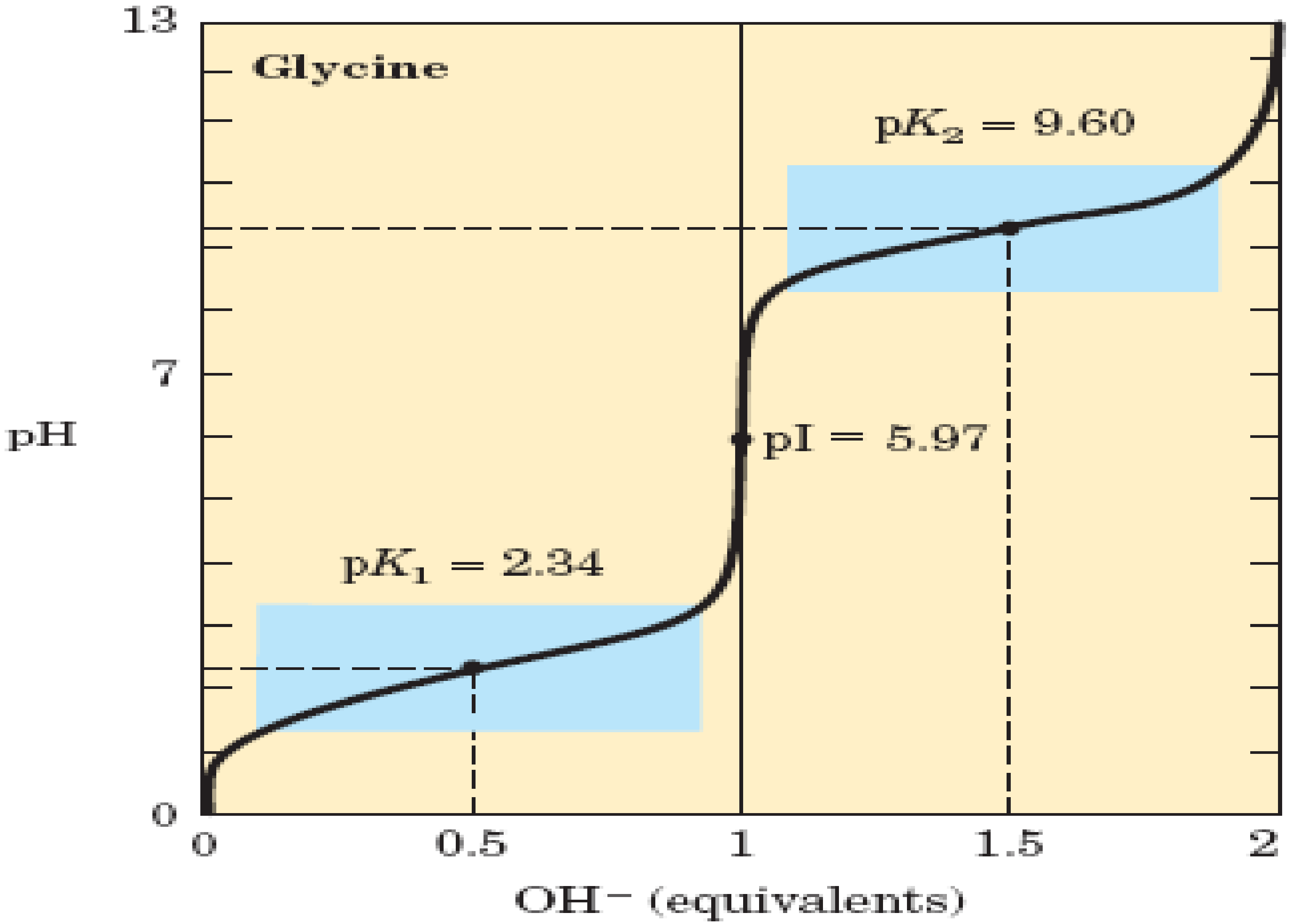



| Acidic pH | Neutral | Basic pH |
|---|---|---|
| (pH<PI) | (pH=PI) | (pH>PI) |
| Cation | Zwitter ion | Anion |

$$PI = PK_1 + PK_2 / 2$$

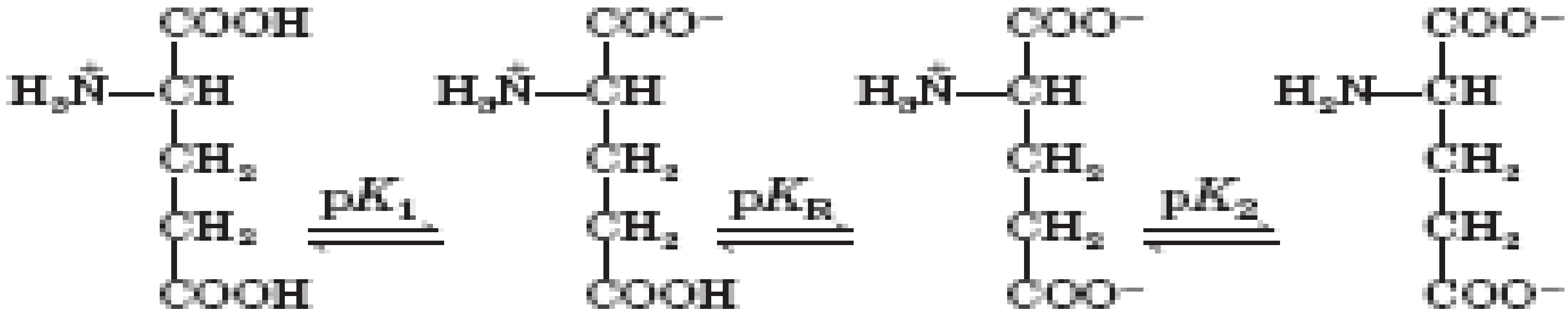
| | | |
|---|---|---|
| Gly | Leu | Phe |
| Ala | Ile | Trp |
| Val | Ser | Asn |
| Pro | Thr | Gln |
| | Met | |

# Amino Acids Have Characteristic Titration Curves



# Amino Acids Have Characteristic Titration Curves

**Glu**

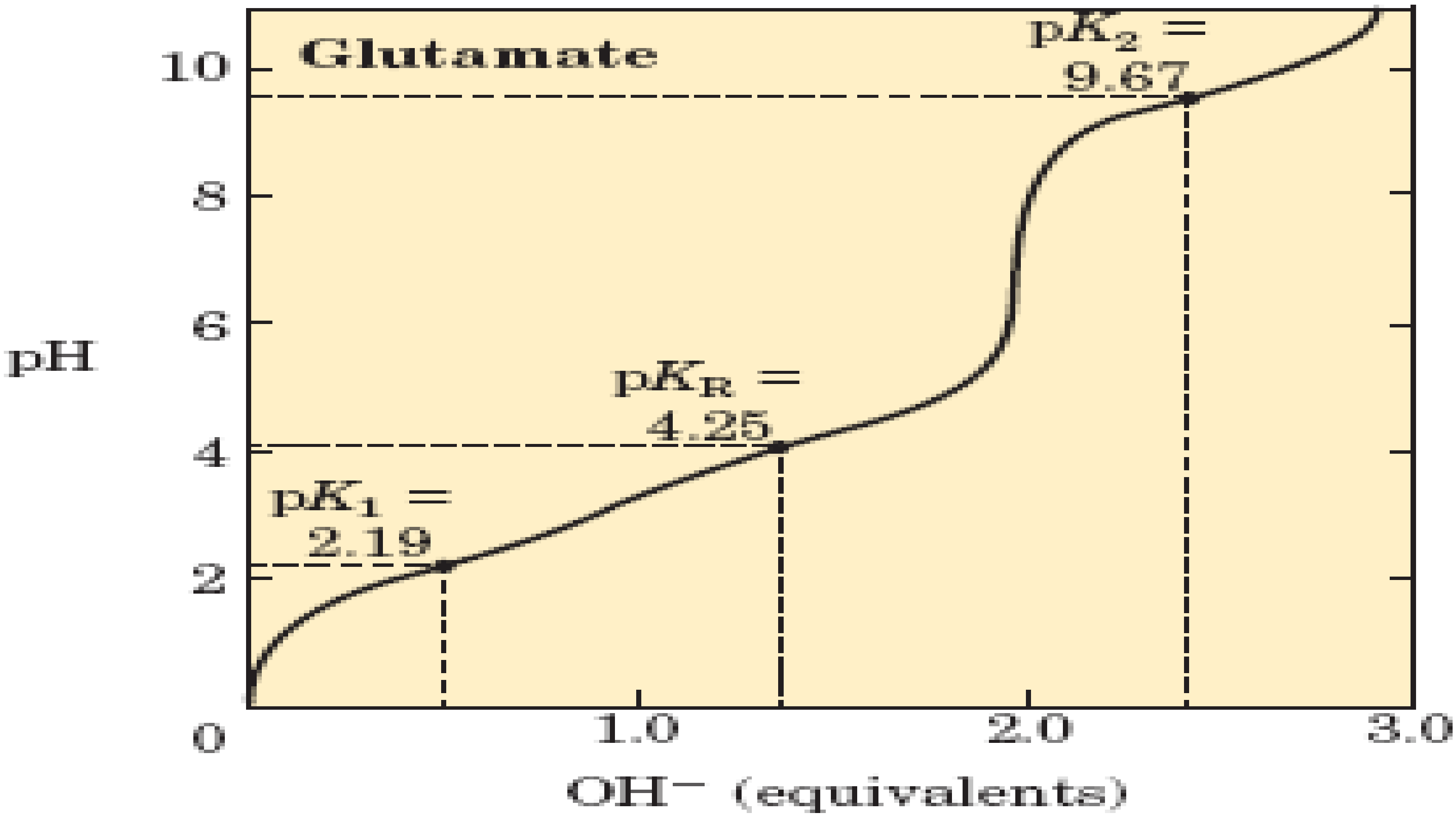



| Acidic pH (pH<PI) Cation (+1) | Neutral (pH=PI) Zwitter ion (0) | Basic pH (pH>PI) Anion (-1) | Basic pH (pH>PI) Anion (-2) |
|---|---|---|---|

$PI = PK_1 + PK_2 / 2$

| | |
|---|---|
| Asp | Cys |
| Glu | Tyr |

# Amino Acids Have Characteristic Titration Curves

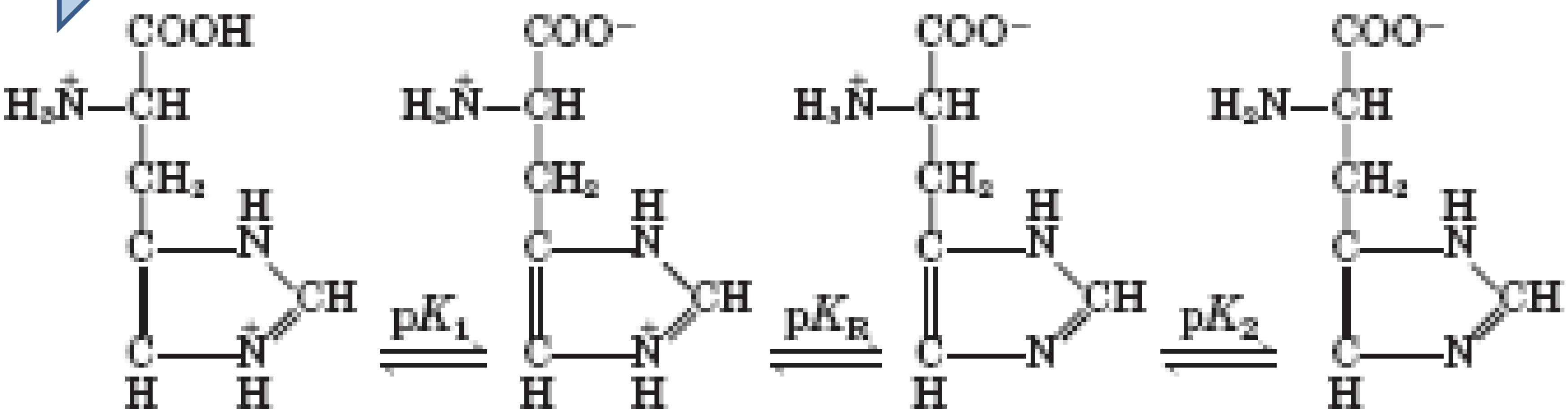



**Asp , Glu , Cys** [$PK_R$=$PK_2$]

**Tyr** [$PK_R$=$PK_3$]

# Amino Acids Have Characteristic Titration Curves

His




**Acidic pH (pH<PI) Cation (+2)**

**Acidic pH (pH<PI) Cation (+1)**

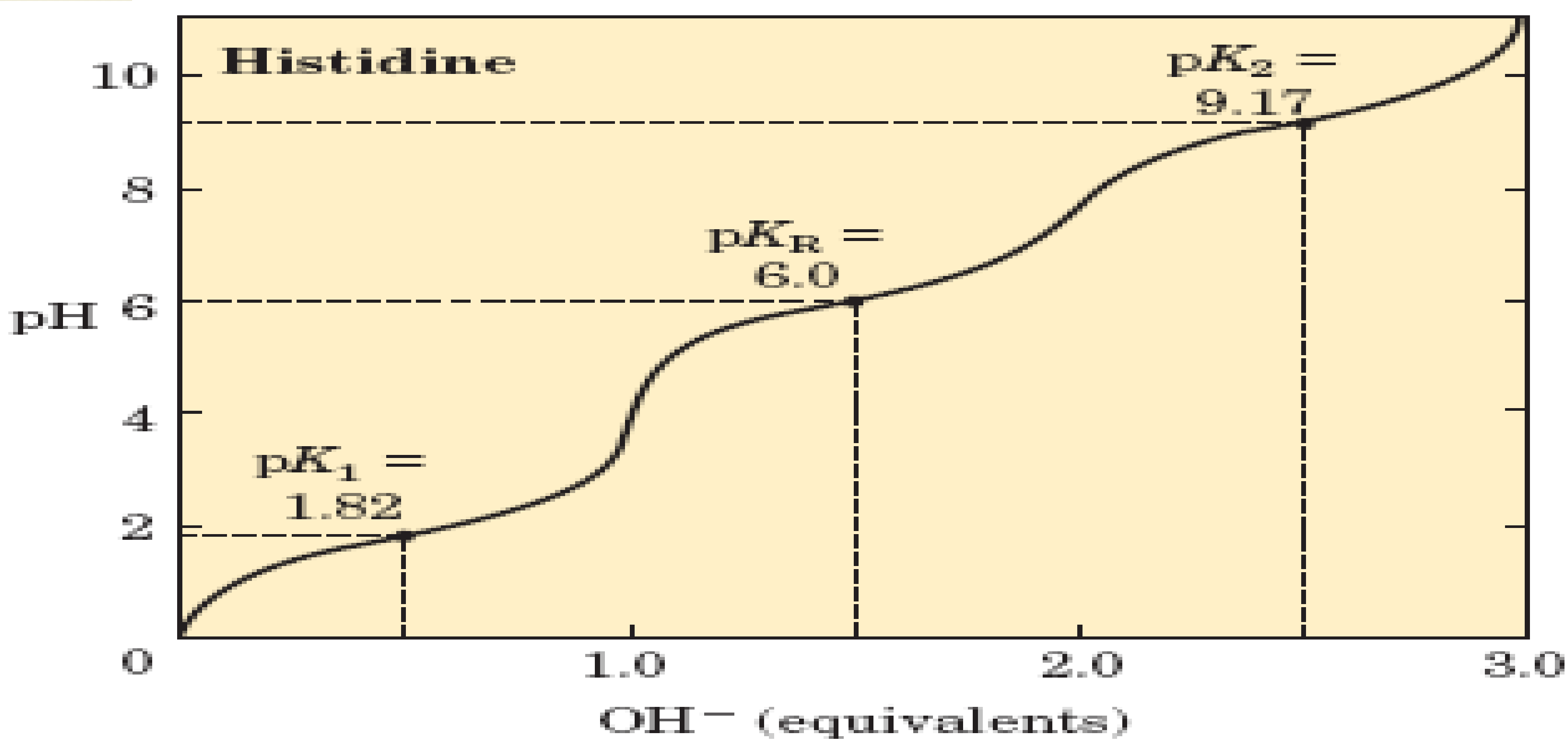
**Neutral (pH=PI) Zwitter ion (0)**

**Basic pH (pH>PI) Anion (-1)**

**$PI = PK_2 + PK_3 / 2$**

**Lys**
**Arg**
**His**

# Amino Acids Have Characteristic Titration Curves




**Lys ,Arg**

**[$PK_R = PK_3$]**

**His**

**[$PK_R = PK_2$]**

# Lecture 5

# Peptides

# Peptides

## <u>Peptides Are Chains of Amino Acids</u>

The amino acid units can be covalently joined through a substituted amide linkage, termed a **peptide bond**, **acid amide bond**

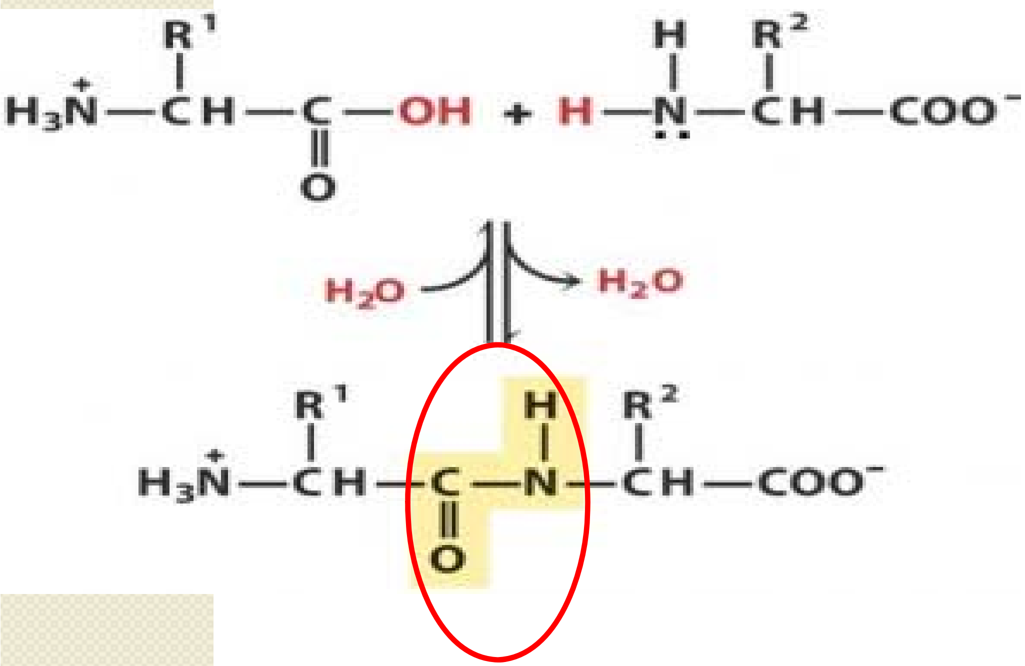
—CO—NH—


Each two amino acids can be joined by one peptide bonds to form;

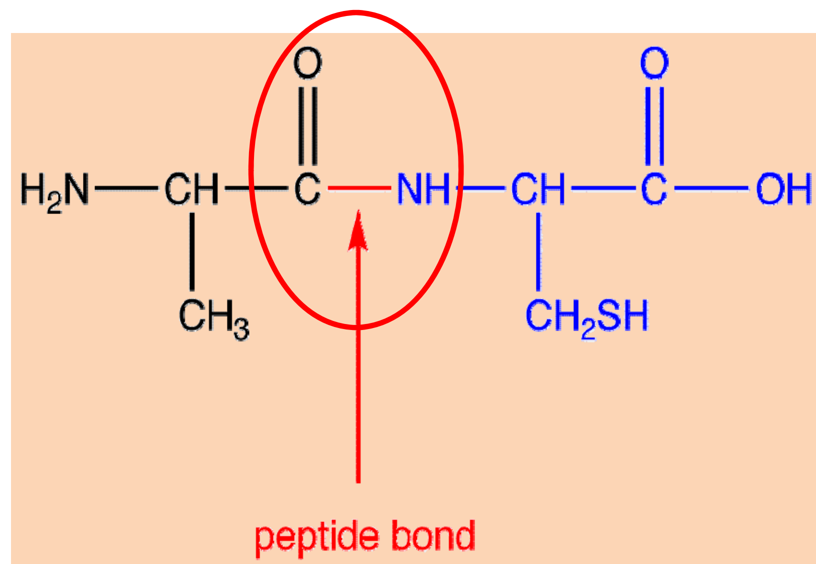
The part left over after losing a hydrogen atom from its amino group and the hydroxyl moiety from its carboxyl group

# Peptides

Peptide bonds can be hydrolyzed by **proteolytic enzymes** called **proteases** or **peptidases**. Proteolytic enzymes are found in all cells and tissues




**Ala-Cys**



Depending on the number of amino acids molecules composing a chain, the peptide may be termed as a:

**Dipeptide** (containing 2 amino acids units),

**Gly-Phe**

**Tripeptide** (containing 3 amino acids units),

**Pro-Met-Asp** and so on

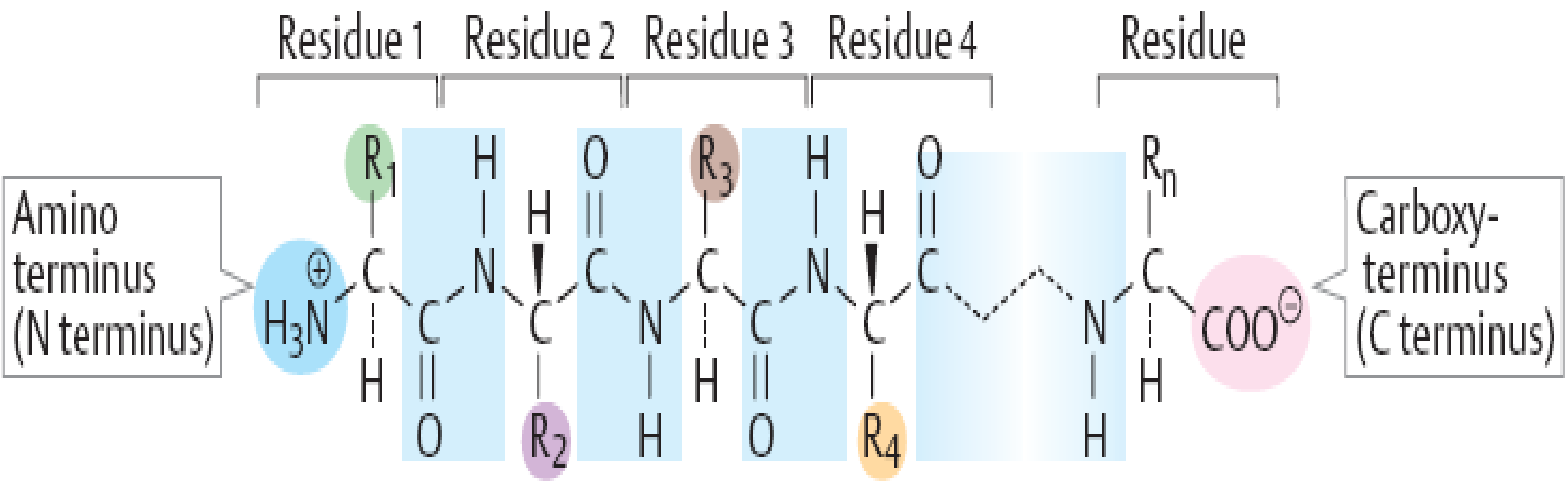
**Tetrapeptides (4 a.a)**,

**pentapeptides (5 a.a),**

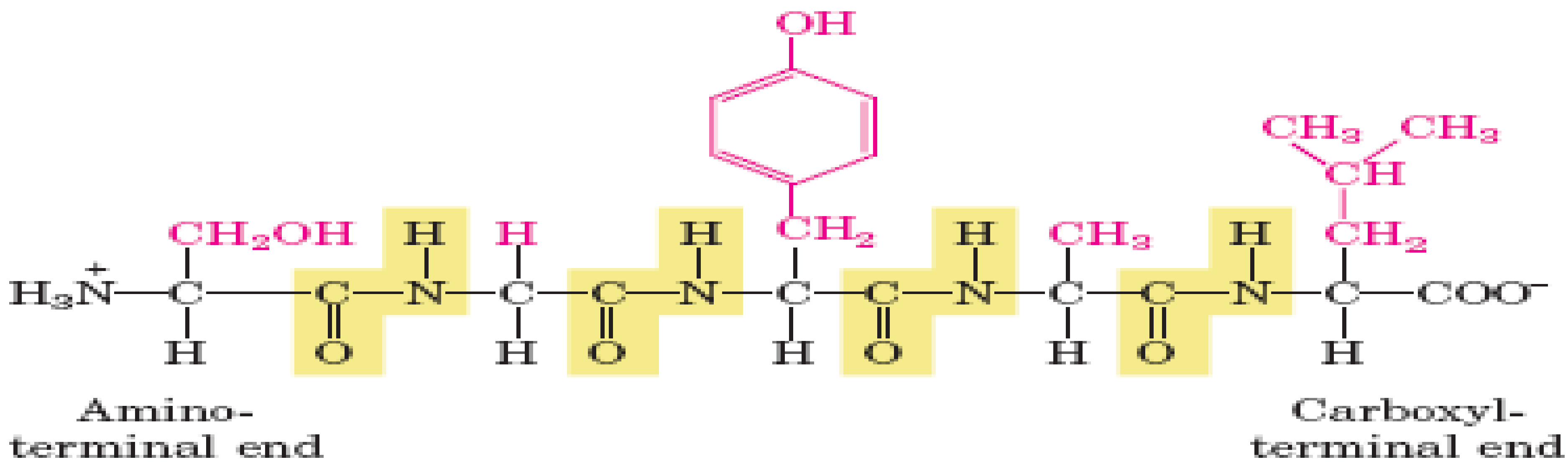
**Hexapeptides (6 a.a) …**

In a peptide,
the amino acid residue at the end with a free *α*-amino group is the **amino-terminal** (or ***N*-terminal**) residue;

The residue at the other end, which has a free carboxyl group, is the **carboxyl-terminal** (or **C-terminal**) residue.



**Peptides are named** beginning with the ***N*-terminal residue (at the left of the structure)**, then moving from left to right, the names of all amino acid residues (**except** the last one, i.e. the C-terminal residue) are written by adding the suffix ***–yl*** because all these are the **acyl groups**




**Ser–Gly–Tyr–Ala–Leu** ⇨ pentapeptide

**[serylglycyltyrosylalanylleucine]**

**Peptides**

**Oligopeptide**

**not** more than 10 amino acids units

**Polypeptide**

more than 10 amino acids units

polypeptides generally have molecular weights below 10,000

↓

**Protein**

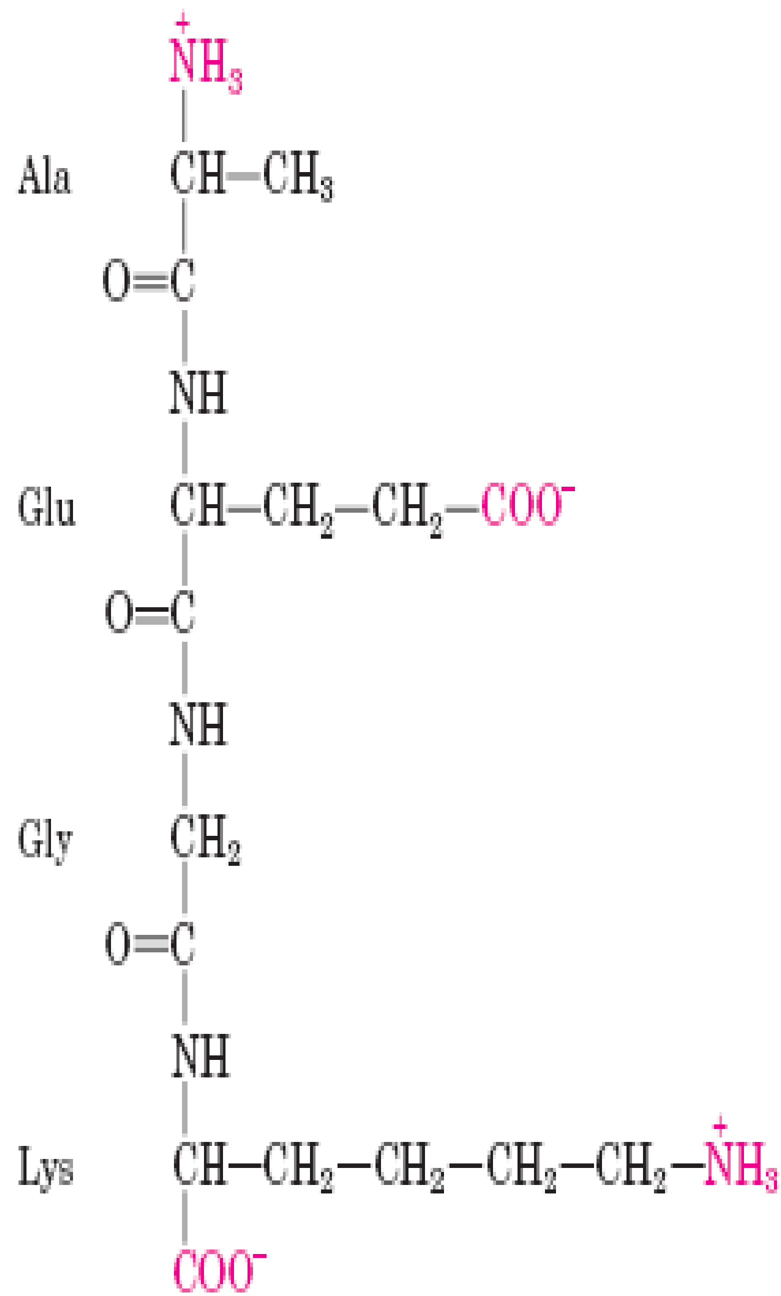
have higher molecular weights

# Ionization Behavior of Peptides

Peptides contain only one free α-amino group and one free α-carboxyl group, at opposite ends of the chain.

These groups ionize as they do in free amino acids, although the ionization constants are different because an oppositely charged group is no longer linked to the α-carbon.

The α-amino and α-carboxyl groups of all non-terminal amino acids are covalently joined in the peptide bonds, which do not ionize and thus do not contribute to the total acid-base behavior of peptides. However the R groups of some amino acids can ionize, and in a peptide these contribute to the overall acid-base properties of the molecule .



# Biologically Active Peptides

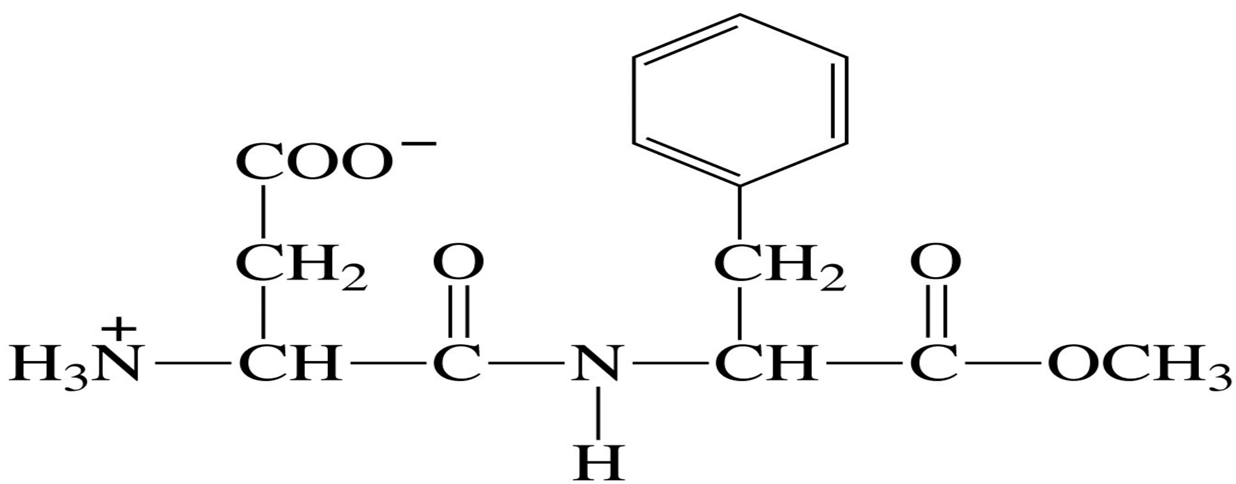
Naturally occurring peptides range in length from two to many thousands of amino acid residues.

Even the smallest peptides can have biologically important effects.

Consider the commercially synthesized **Dipeptide**

**L-aspartyl-L-phenylalanine methyl ester,**

the artificial sweetener better known as **Aspartame** or **NutraSweet**.

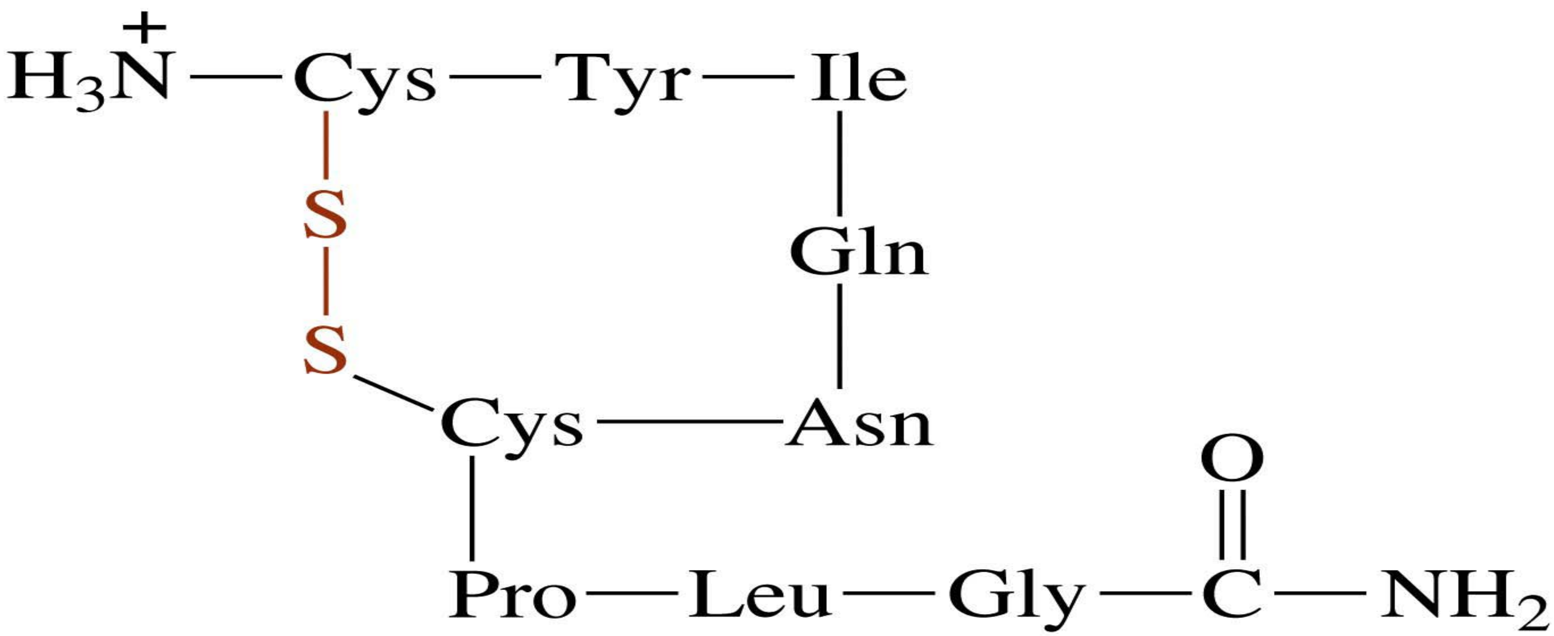



L-Aspartyl-L-phenylalanine methyl ester
(aspartame)

# Biologically Active Peptides

Many small peptides exert their effects at very low concentrations. For example, a number of vertebrate hormones are small peptides, these include

❖ **Oxytocin:** (a **9** amino acid residues)




Oxytocin

# Biologically Active Peptides

❖**Gastrin:** it is a local peptide hormone produced by stomach (the gastric mucosa), its secretion is stimulated by entry of dietary protein into the stomach, it stimulate the gastric juice.

❖**Enkephalins:** is a pentapeptide (**5** amino acid residues)

Tyr—Gly—Gly—Phe—Leu

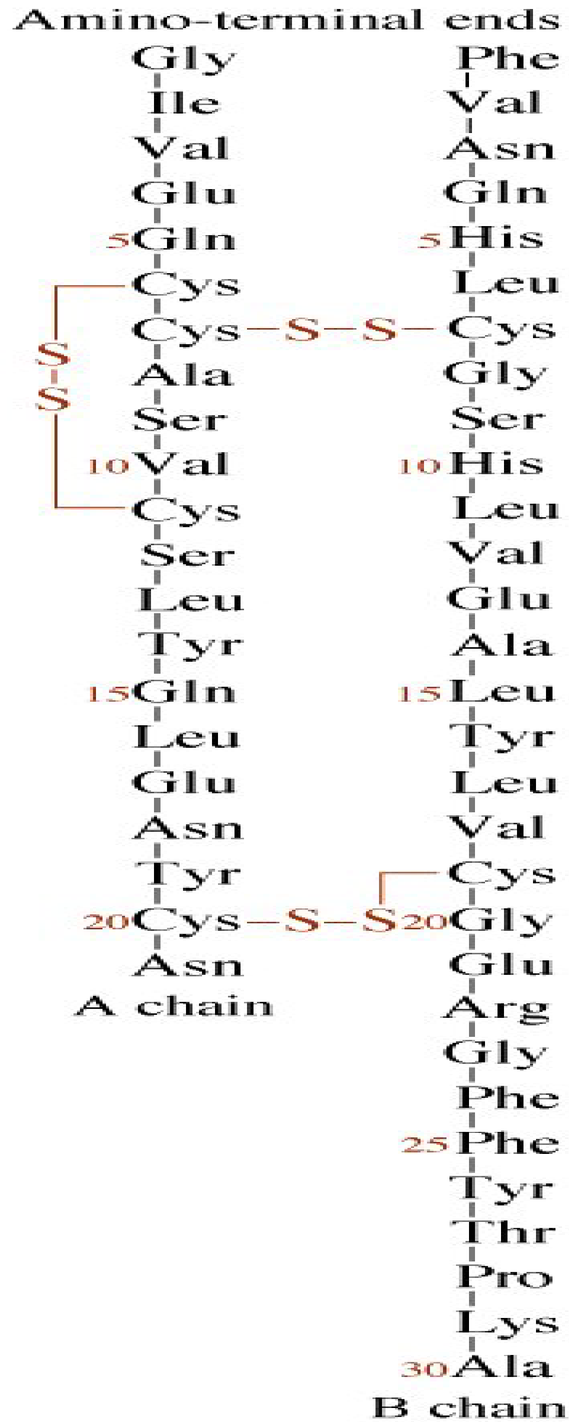
Leucine enkephalin

Tyr—Gly—Gly—Phe—Met

Methionine enkephalin

# Biologically Active Peptides

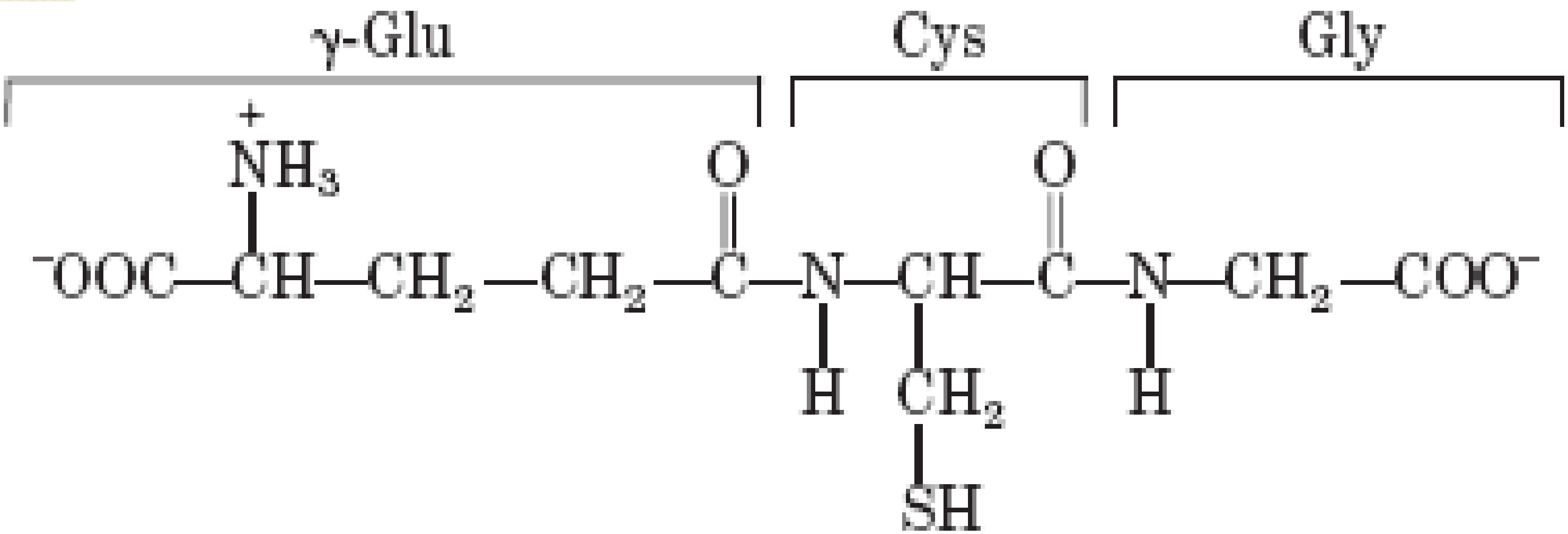
❖**Insulin**: the pancreatic peptide hormone, which contains two polypeptide chains, one having 30 amino acid residues and the other 21, which are linked together by disulfide bonds.



# Biologically Active Peptides

**Glutathione (GSH):** It is a tripeptide (**3** amino acid residues), which derived from **glycine**, **glutamate**,and **cysteine**.

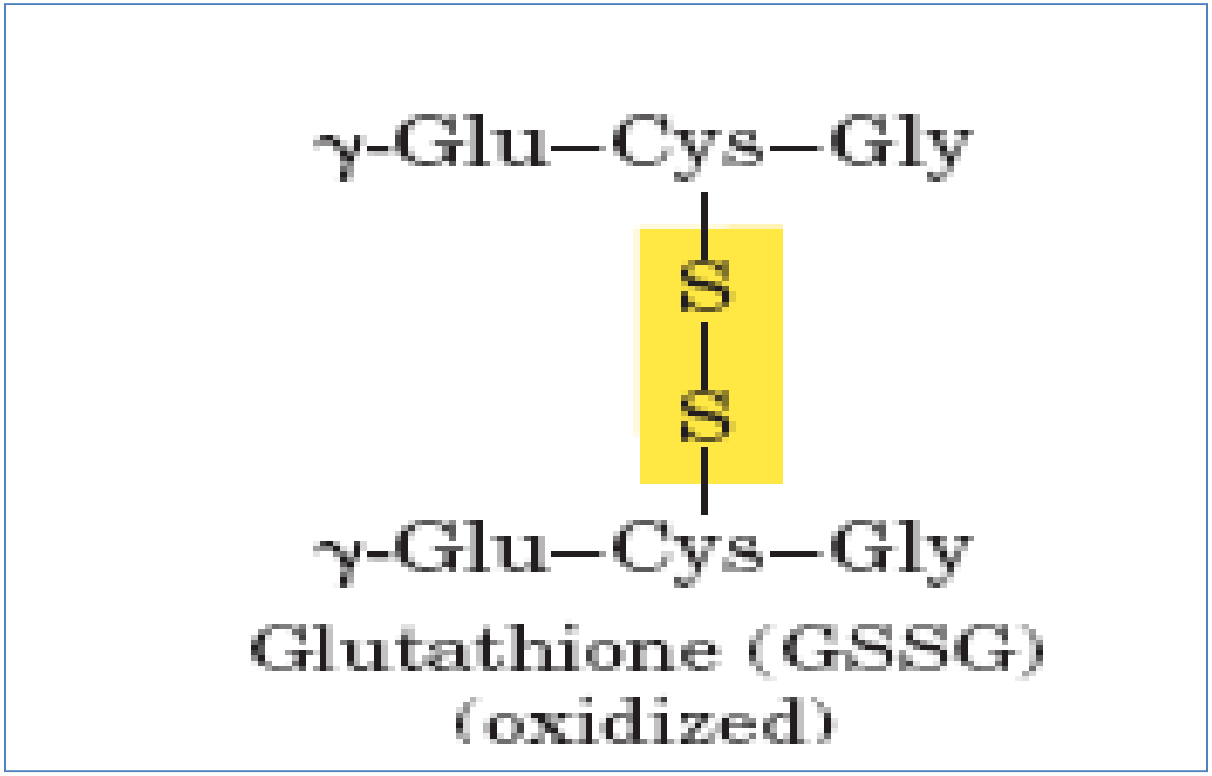
**GSH** characterized by its **γ-peptide** bond (between glutamate, and cysteine) , which is not attacked by peptidase), present in plants, animals, and some bacteria, often at high levels, it is found in all mammalian cell except the neurons.



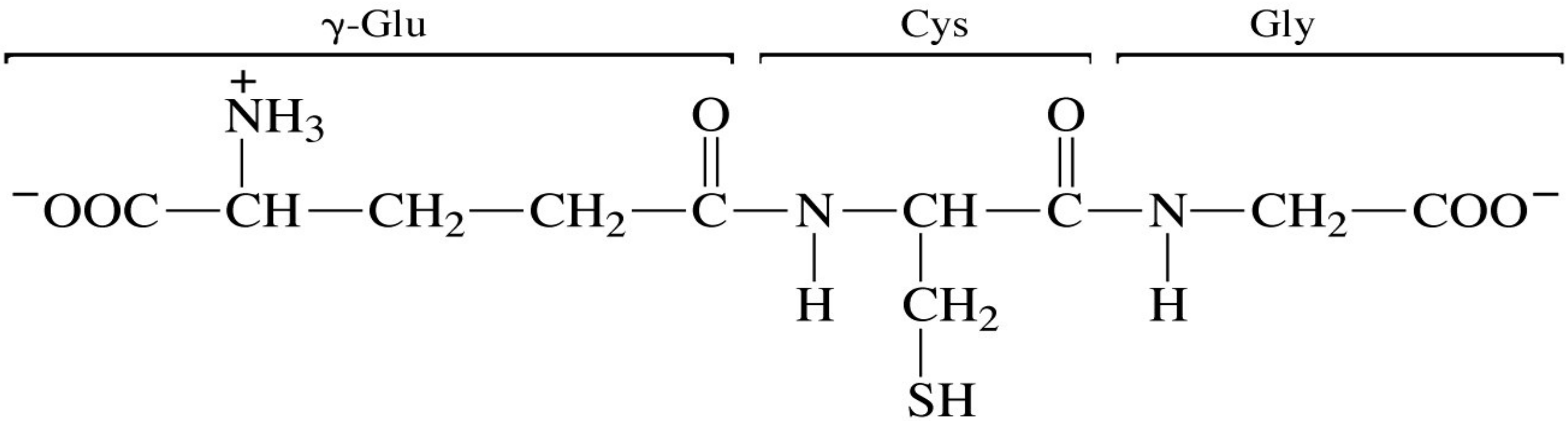

Glutathione (GSH)
(reduced)

# Biologically Active Peptides

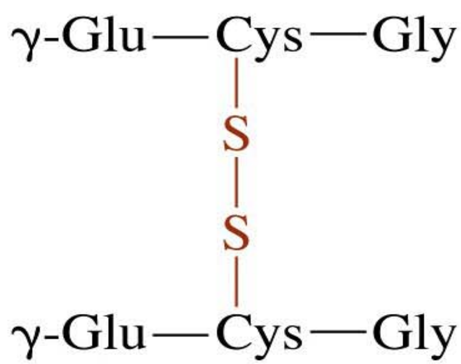
The oxidized form of glutathione (**GSSG**), produced in the course of its redox activities, contains two glutathione molecules linked by a disulfide bond



# Biologically Active Peptides




Glutathione (GSH)
(reduced)

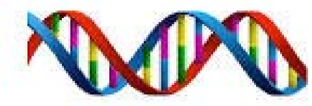



Glutathione (GSSG)
(oxidized)

# Lecture 6

# Nucleic Acid

# Nucleic Acid



**Nucleic acids** are macromolecules that store, transmit and express the genetic information of a cell, which present in all living cells in combination with proteins to form nucleoproteins.

Nucleic acids are polymers of a specific sequence of subunits or monomers called **nucleotides**. They are therefore called **polynucleotides**

# Nucleic Acid

Two types of nucleic acid are found

a- Deoxyribonucleic acid (DNA)

DNA is found in the nuclei with small amounts in mitochondria and chloroplasts

b- Ribonucleic acid (RNA)

RNA is found in cell cytoplasm (90%) and the nucleolus (10%)

## Components of Nucleic acids

Nucleic acids are made up of three chemical units:

i) Nitrogenous base [purines or pyrimidines]

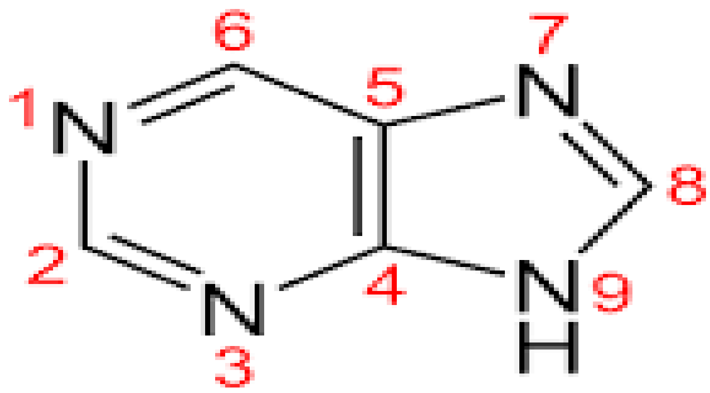
ii) Pentose sugar [ribose or deoxyribose]

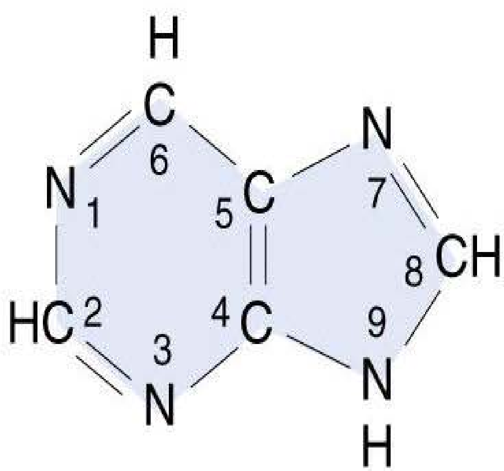
iii) Phosphoric acid

# Nitrogenous Bases

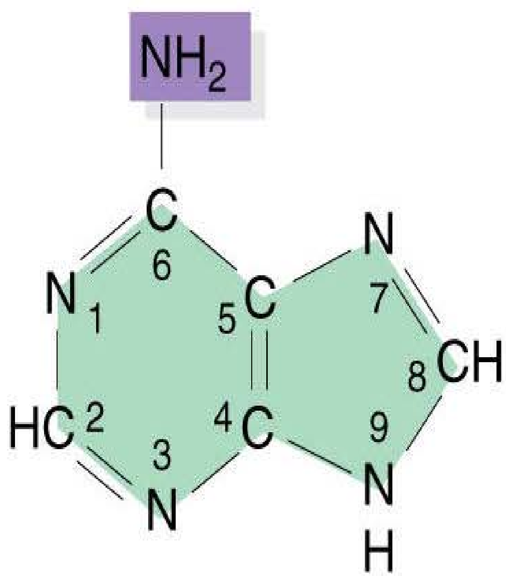
# Purines

**Purine ring**

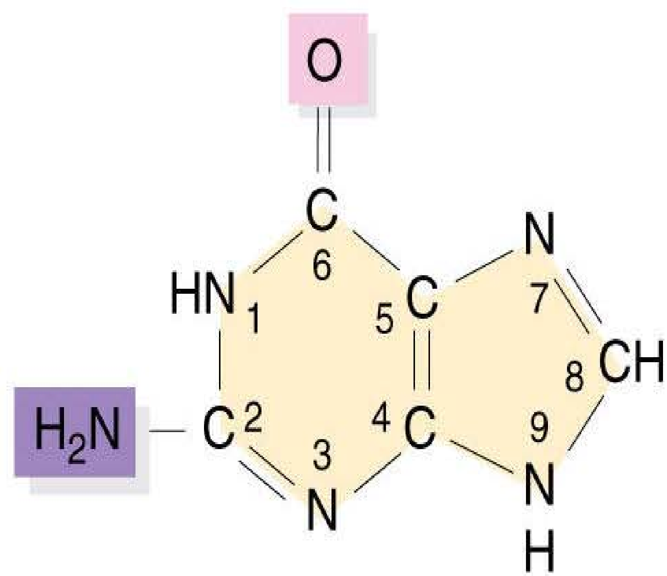



Purine




Adenine (A)

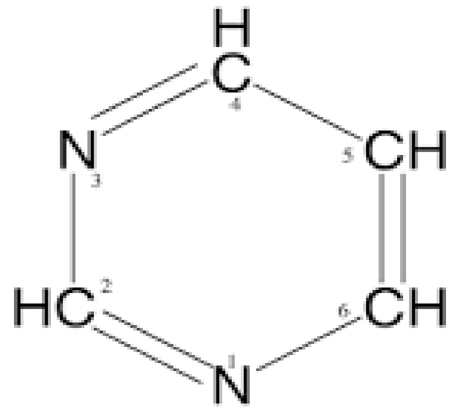


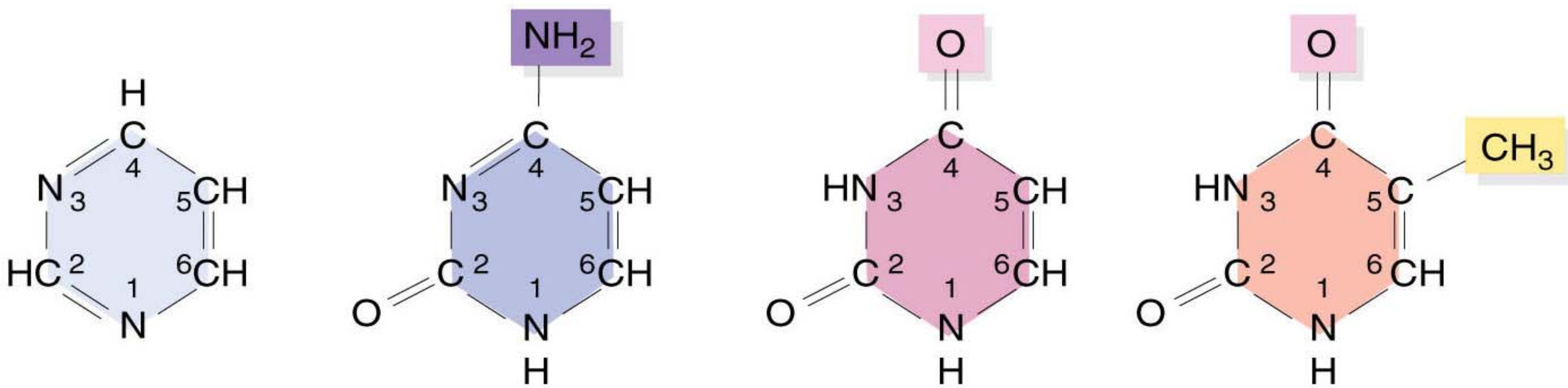

Guanine (G)

## Nitrogen Bases

# Pyrimidines

**Pyrimidine ring**




**Pyrimidine**

**Cytosine (C)**

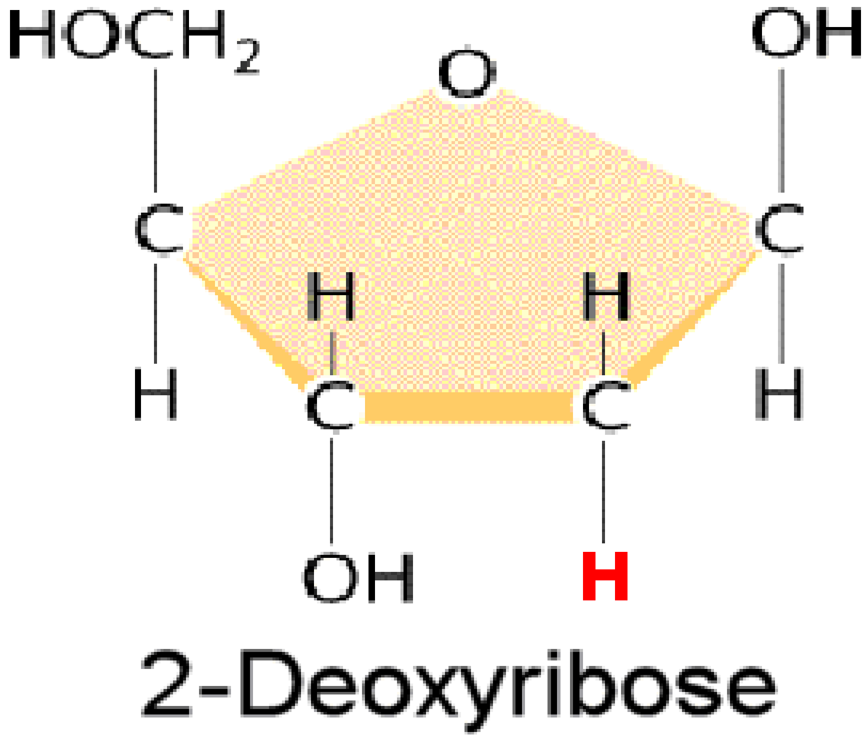
**Uracil (U)**
**(found in RNA)**

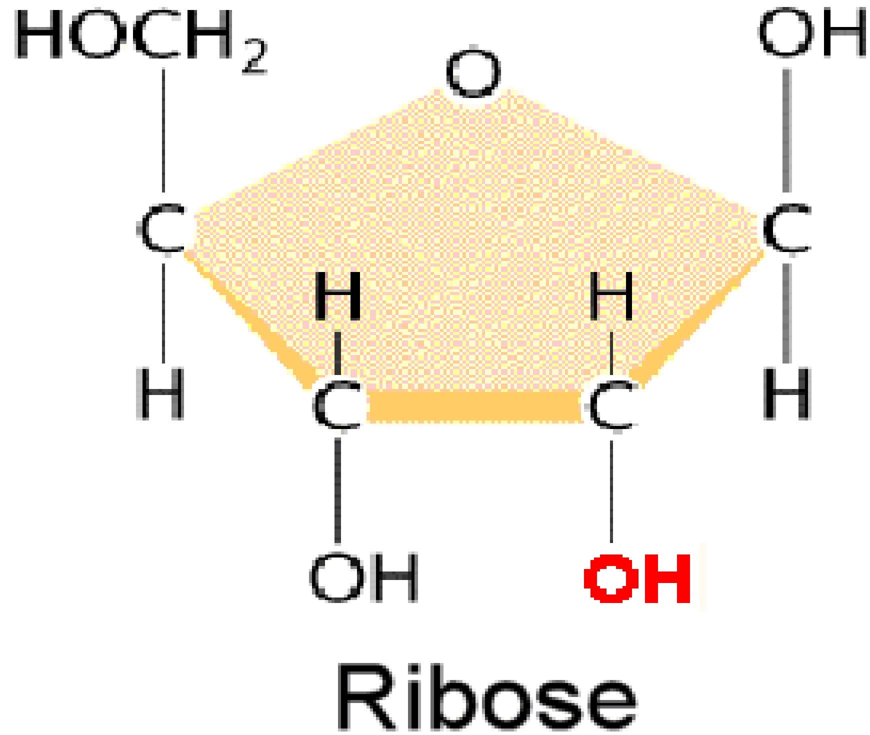
**Thymine (T)**
**(found in DNA)**

**DNA contain**
**A, G, C, T**

**RNA contain**
**A, G, C, U**

# SUGARS



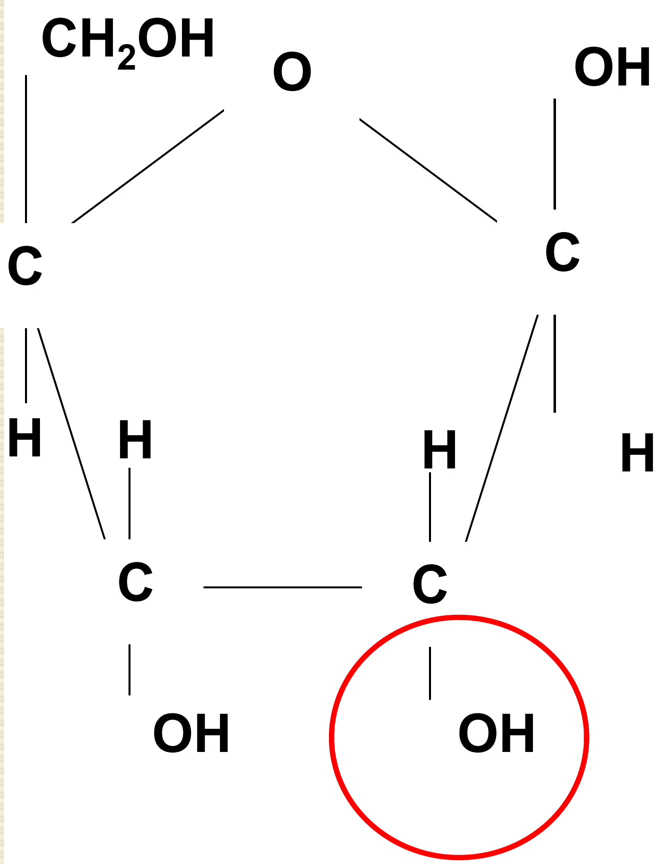

**DNA contain β-D-2-Deoxyribose**

**RNA contain β-D-Ribose**

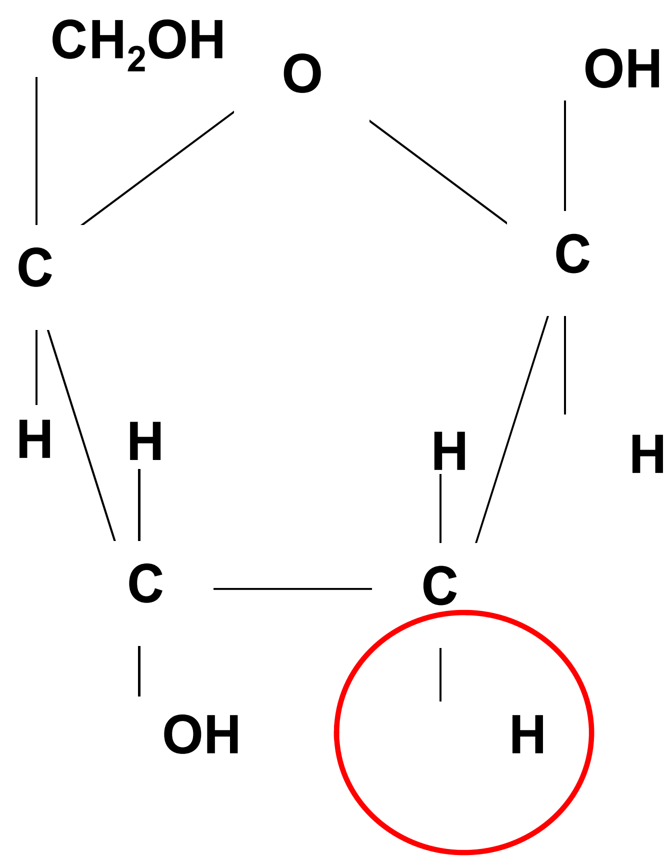
# SUGARS

## Spot the difference

**RIBOSE**



**DEOXYRIBOSE**



# Nucleic Acid

## Nucleosides consist of:

1. Nitrogen base purine or pyrimidine
2. Sugar (β-D-Ribose and β-D-2-deoxyribose )

**Nucleotides are phosphorylated Nucleosides**

- **Nucleosides: Nitrogen bases + Sugar**
- **Nucleotides: Nitrogen bases + Sugar + Phosphate group**

# Nucleoside Structure

**SUGAR**

Ribose or
Deoxyribose

| BASE | |
|---|---|
| PURINES | PYRIMIDINES |
| Adenine (A)<br>Guanine(G) | Cytocine (C)<br>Thymine (T)<br>Uracil (U) |

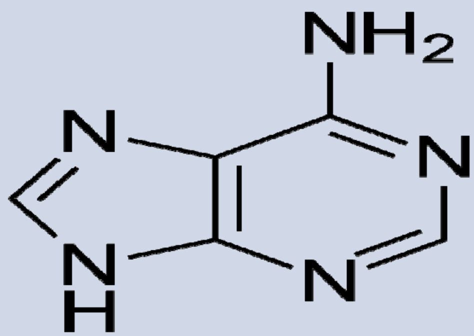
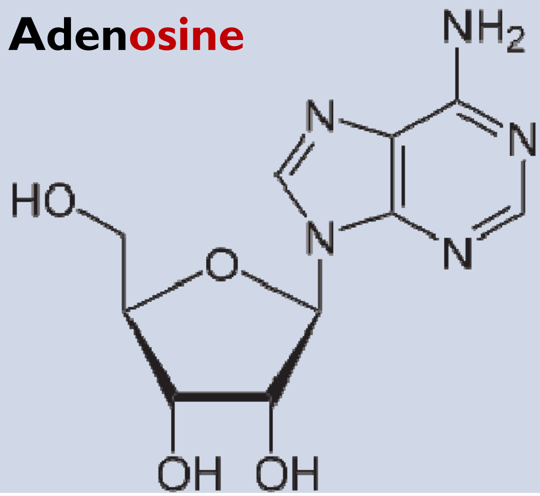
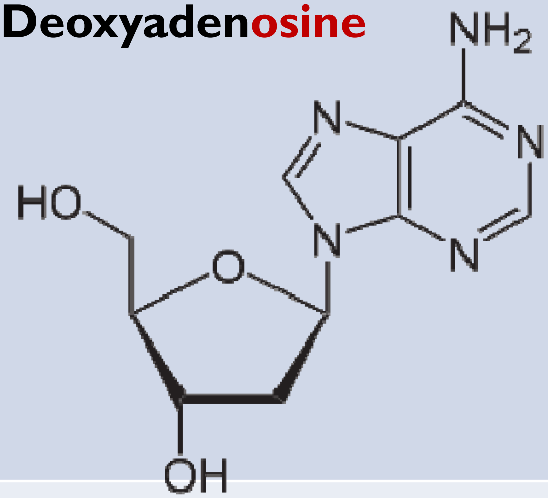
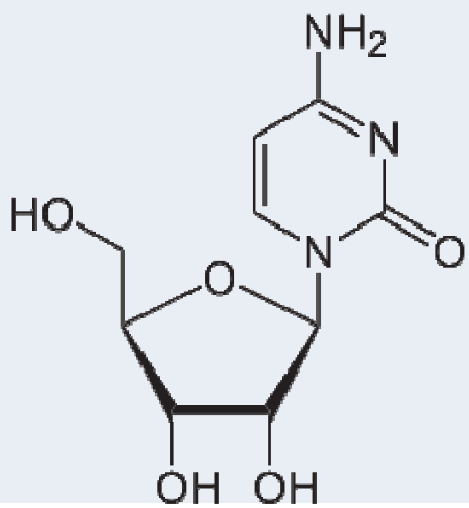
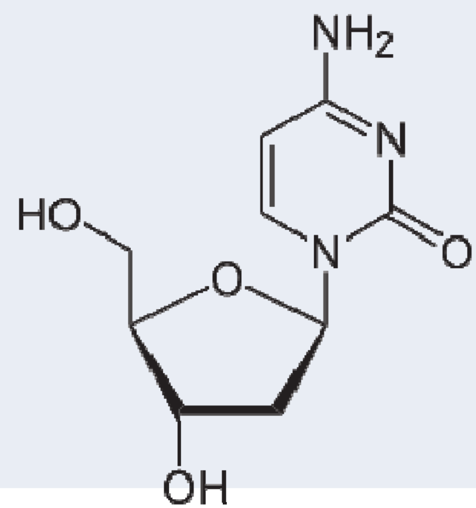
**NUCLEOSIDE**

**β-N-glycosidic bond**

# Nucleoside

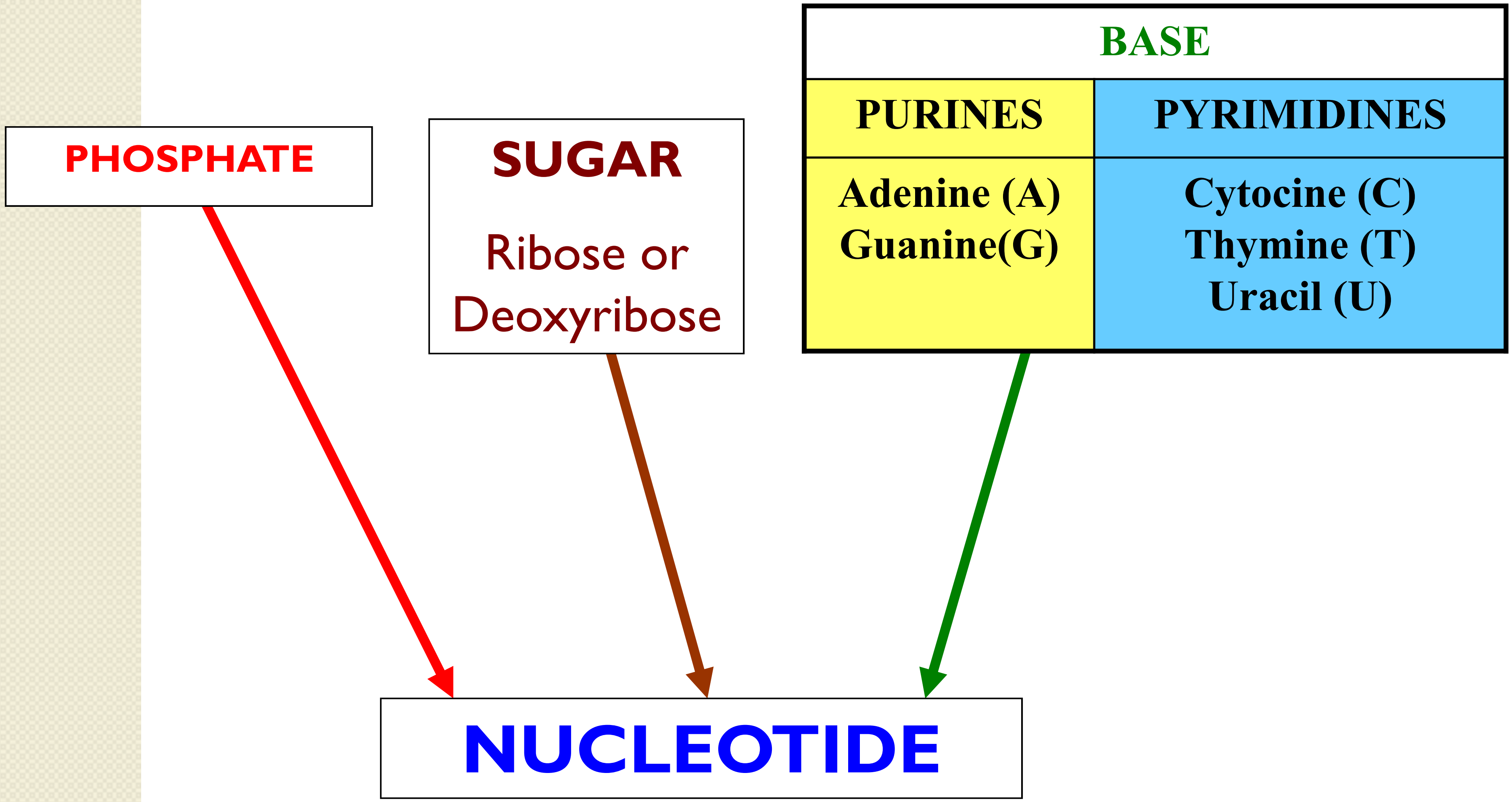
| Base | Ribonucleoside | Deoxyribonucleoside |
|---|---|---|
| Adenine (A) | Adenosine | Deoxyadenosine |
| Guanine (G) | Guanosine | Deoxyguanosine |
| Uracil (U) | Uridine | Deoxyuridine |
| Cytosine (C) | Cytidine | Deoxycytidine |
| Thymine (T) | Thymidine | Deoxythymidine |

# Nucleoside Structure

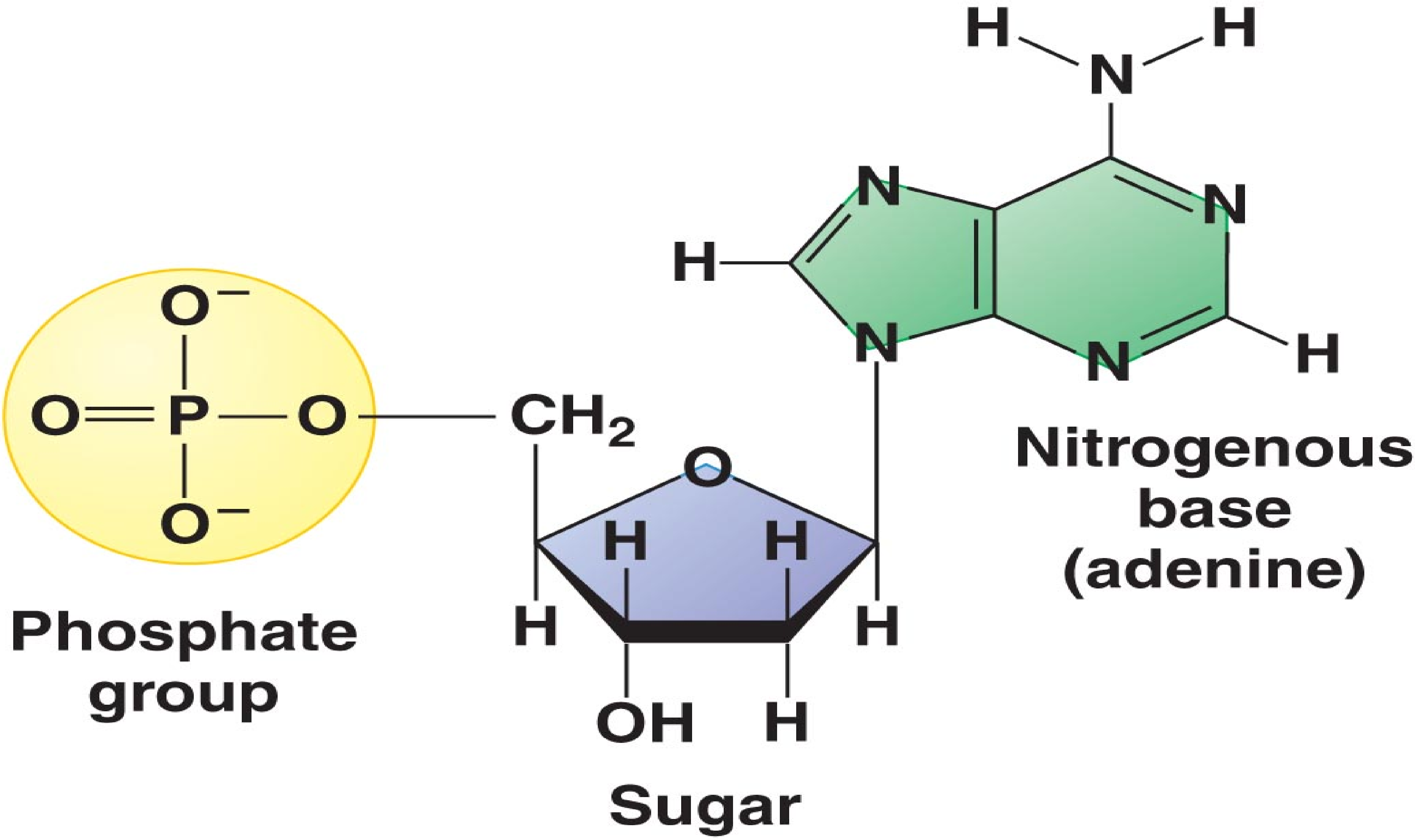
| Nitrogenous base | Ribonucleoside | Deoxyribonucleoside |
| --- | --- | --- |
| **Adenine (A)**  | **Adenosine**  | **Deoxyadenosine**  |
| **Cytosine (C)**  | **Cytidine**  | **Deoxycytidine**  |

# Lecture 7

# Nucleotide Structure

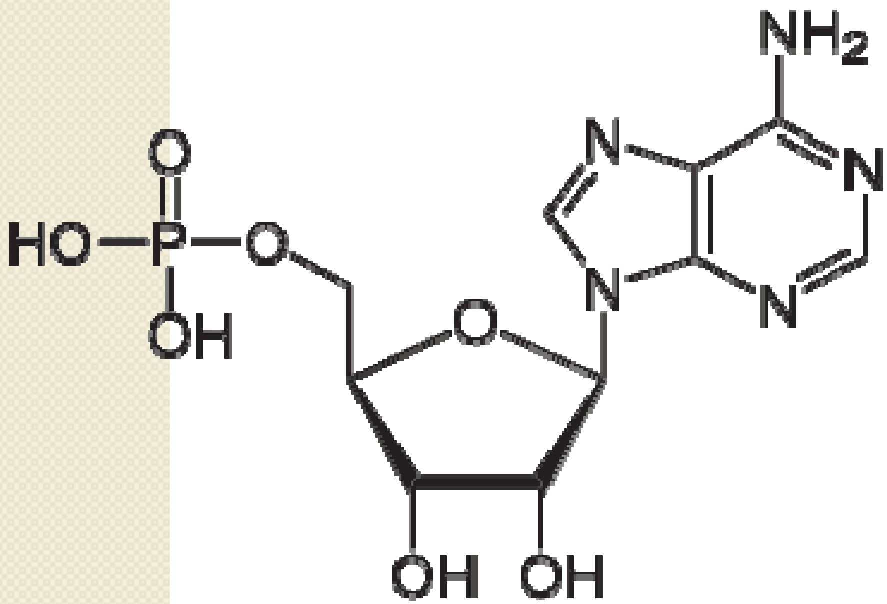


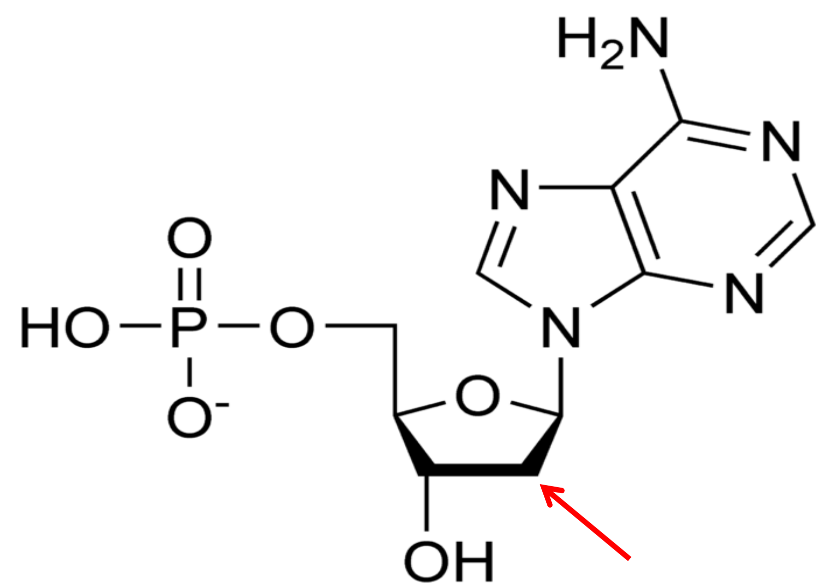
# NUCLEOTIDE



H
N
H
N
N
H
N
N
H
O⁻
O
P
O
O⁻
CH2
O
H
H
H
H
OH
H
Phosphate group
Sugar
Nitrogenous base (adenine)

# Nucleotide Structure

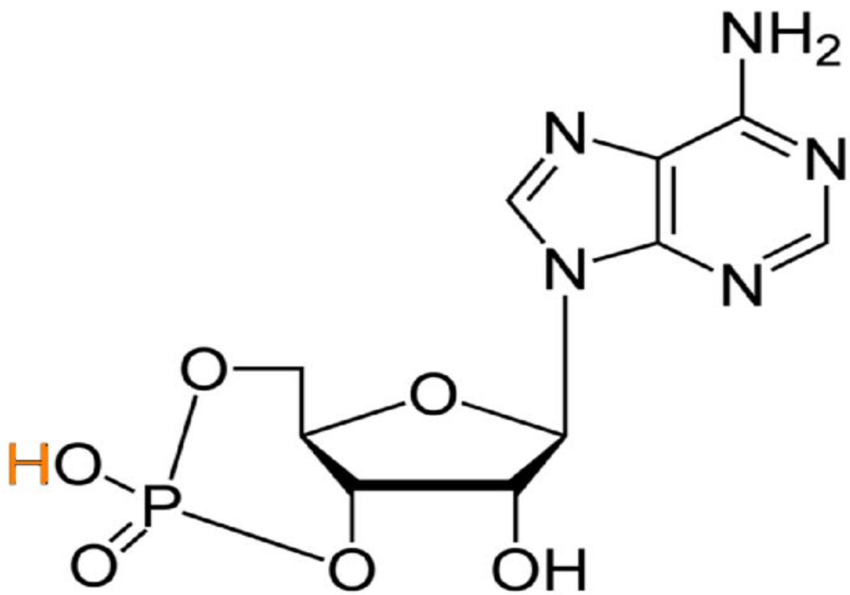


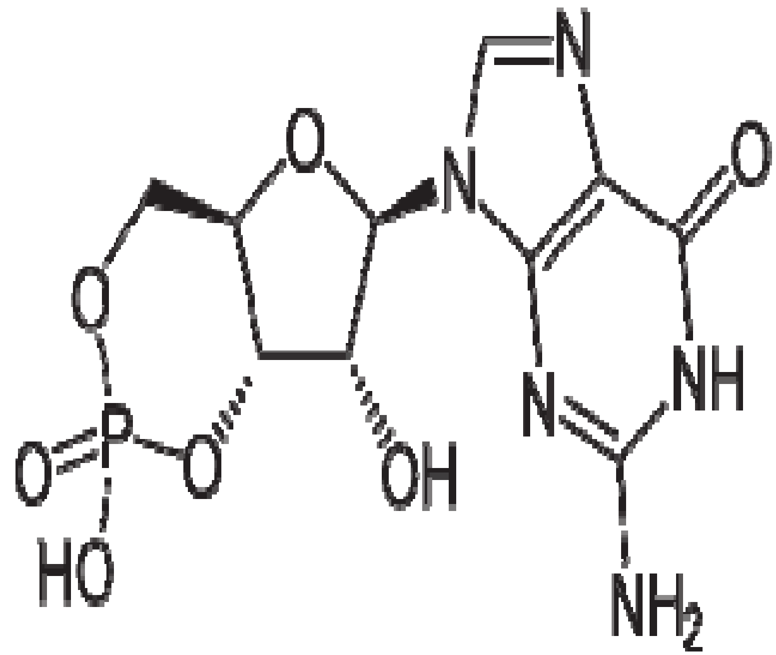




**Adenosine Monophosphate (AMP)**

**Deoxyadenosine Monophosphate (dAMP)**

# Cyclic AMP or GMP



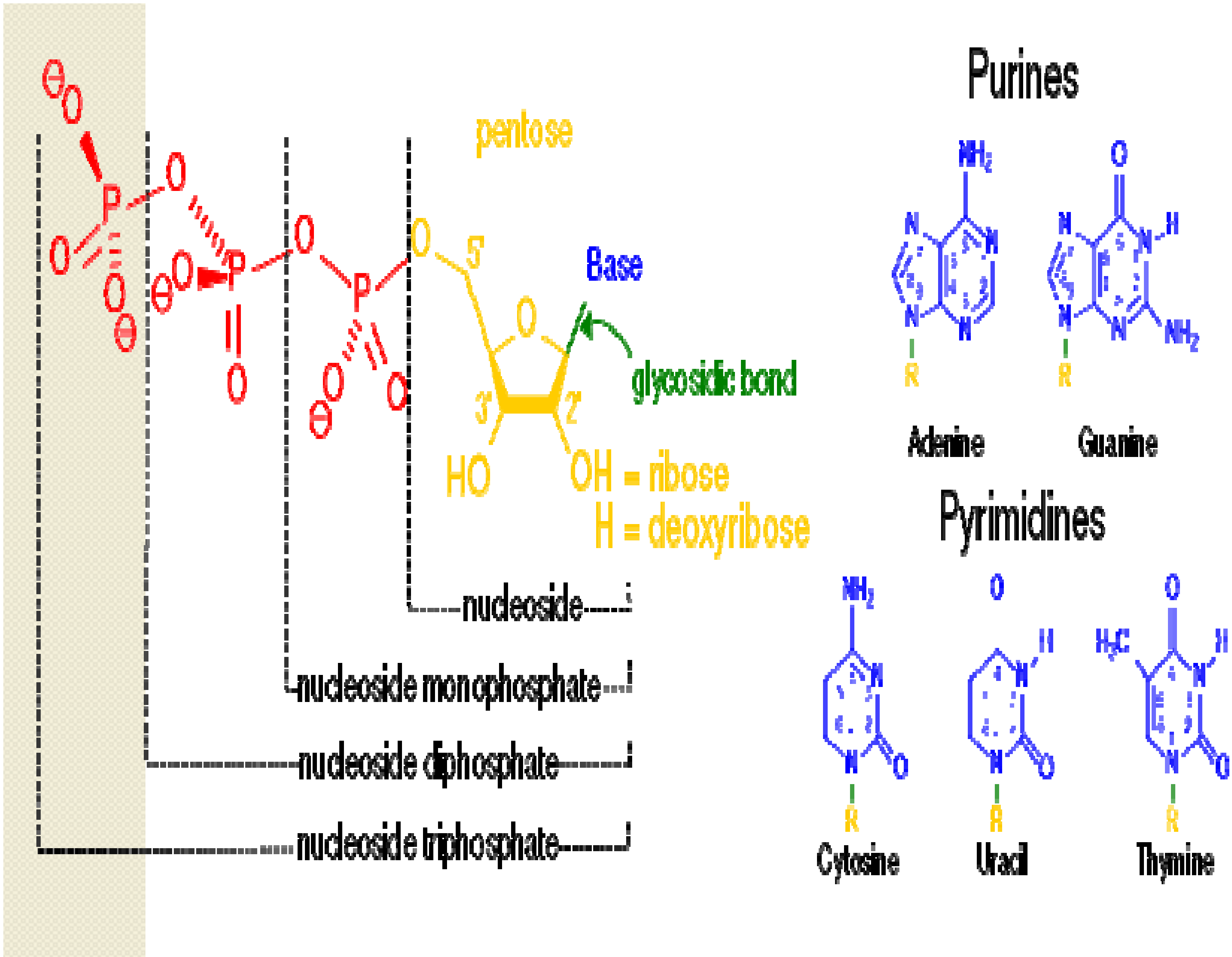




**c-AMP**

**c-GMP**

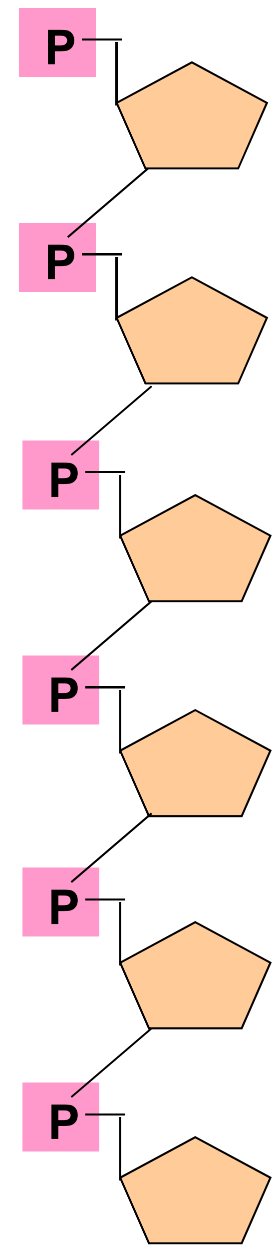
**$NAD^+$ = Nicotinamide Adenine Dinucleotide**

**$FAD^+$ = Flavin Adenine Dinucleotide**


pentose
5'
Base
glycosidic bond
3'
2'
HO
OH = ribose
H = deoxyribose
nucleoside
nucleoside monophosphate
nucleoside diphosphate
nucleoside triphosphate
Purines
Adenine
Guanine
Pyrimidines
Cytosine
Uracil
Thymine

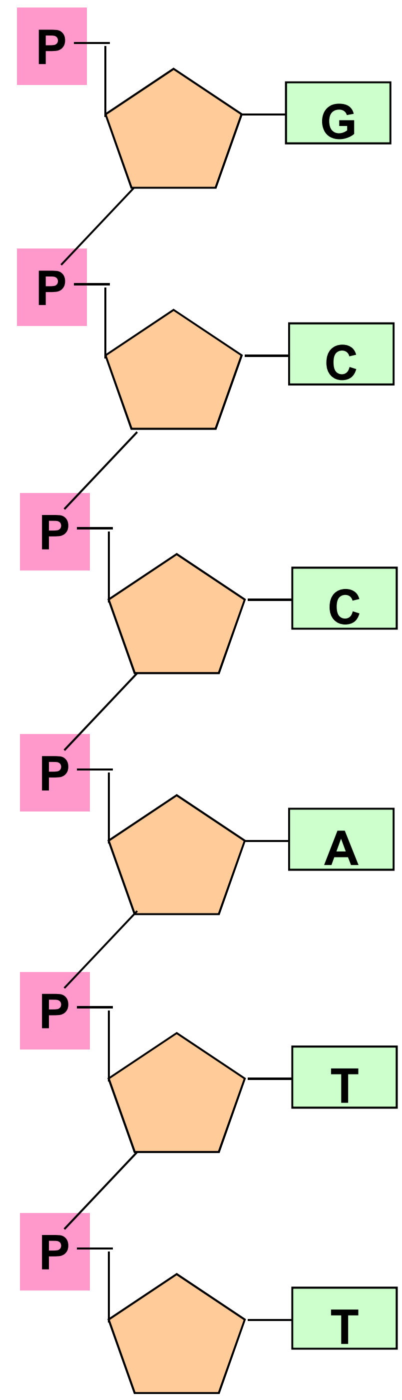
# THE SUGAR-PHOSPHATE BACKBONE

- The nucleotides are all orientated in the same direction
- The phosphate group joins the 3rd Carbon of one sugar to the 5th Carbon of the next in line.



# ADDING IN THE BASES

- The bases are attached to the 1st Carbon
- Their order is important
  It determines the genetic information of the molecule



# DNA Structure and Function

**DNA**, abbreviation of **deoxyribonucleic acid**, organic chemical of complex molecular structure that is found in all prokaryotic and eukaryotic cells and in many viruses.

DNA codes genetic information for the transmission of inherited traits.

**DNA** serves as the genetic material for cells both prokaryotes and eukaryotes.

# DNA Structure and Function

- DNA is located in the nucleus separated from cytoplasm by the nuclear membrane
- DNA present also in mitochondria (less than 0.1% of the total DNA)
- in chloroplasts of plants

# Lecture 8

# Primary Structure of DNA

Nucleotides are joined together through the phosphate group of one nucleotide connecting in an ester linkage to the OH group on the third carbon atom of the sugar unit of a second nucleotide, linked covalently by **3',5' phosphodiester bond**.

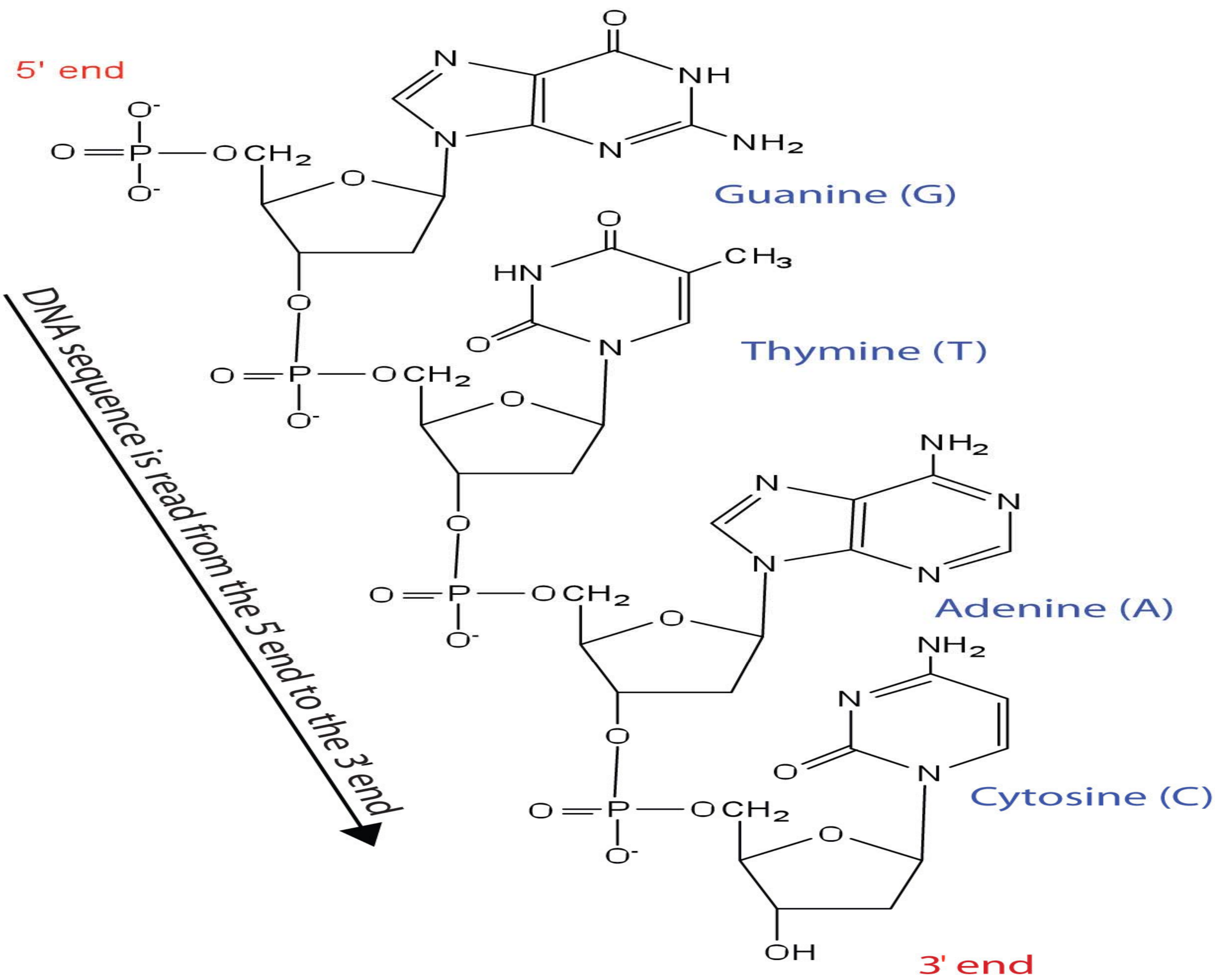
This unit joins to a third nucleotide, and the process is repeated to produce a long nucleic acid chain "Structure of a Segment of DNA".

## Primary Structure of DNA

The final nucleotide has a free OH group on the 3′ carbon atom and is called the *3′ end*. The sequence of nucleotides in the DNA segment would be written 5′-dG-dT-dA-dC-3′, which is often further abbreviated to dGTAC or just GTAC.

**DNA is negatively charged macromolecule**

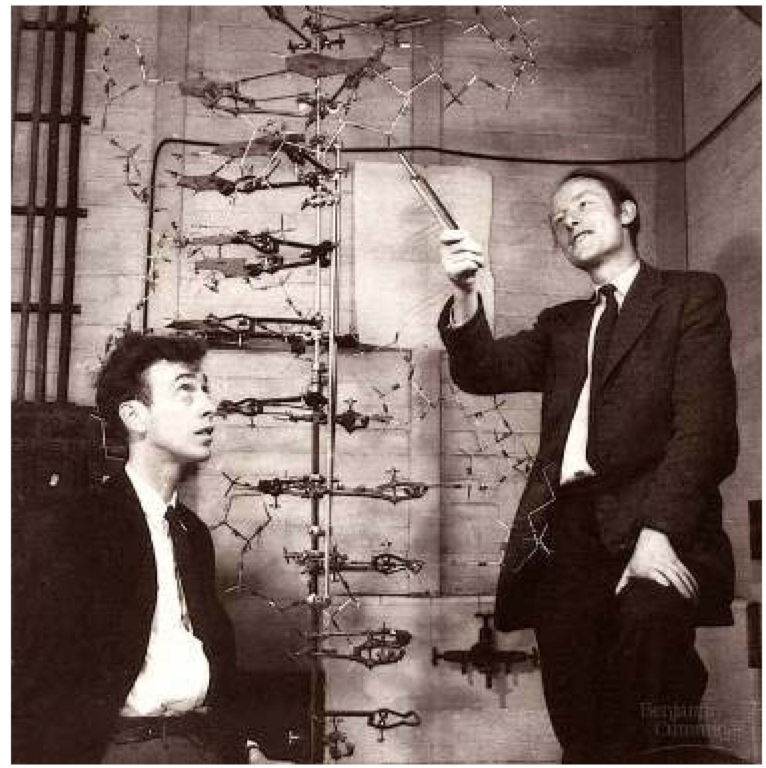
# Primary Structure of DNA



## Secondary Structure of DNA

# The Double Helix (1953)

**Watson and Crick model**



# Secondary Structure of DNA

- The sister strands of the DNA molecule run in opposite directions (**antiparallel**)
- They are joined by the bases
- Each base is paired with a specific partner:

**A** is always paired with **T**

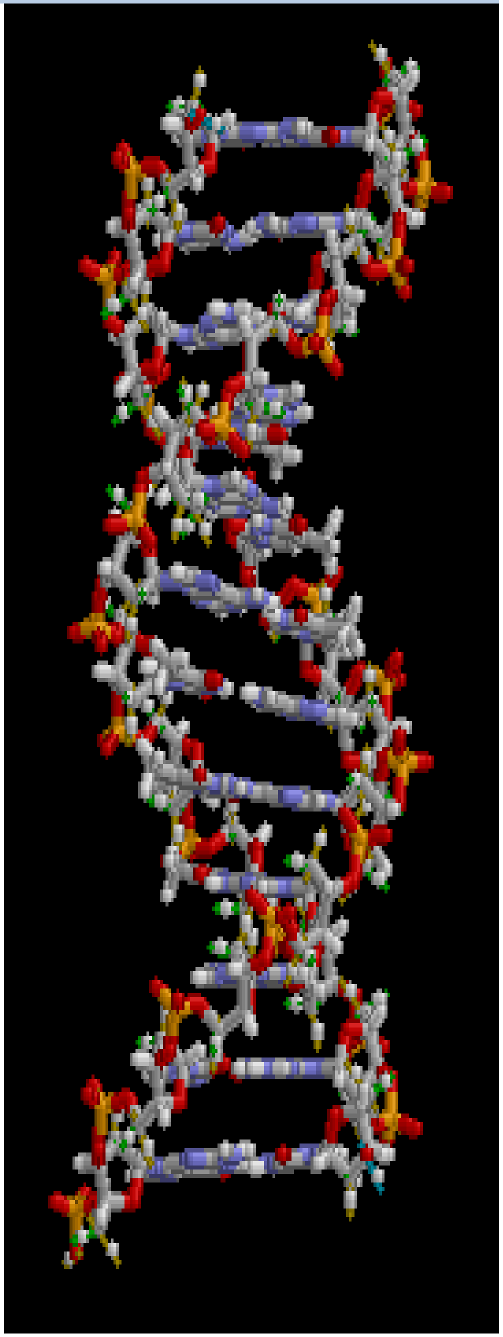
**(two hydrogen bonds)**

**G** is always paired with **C**

**(three hydrogen bonds)**

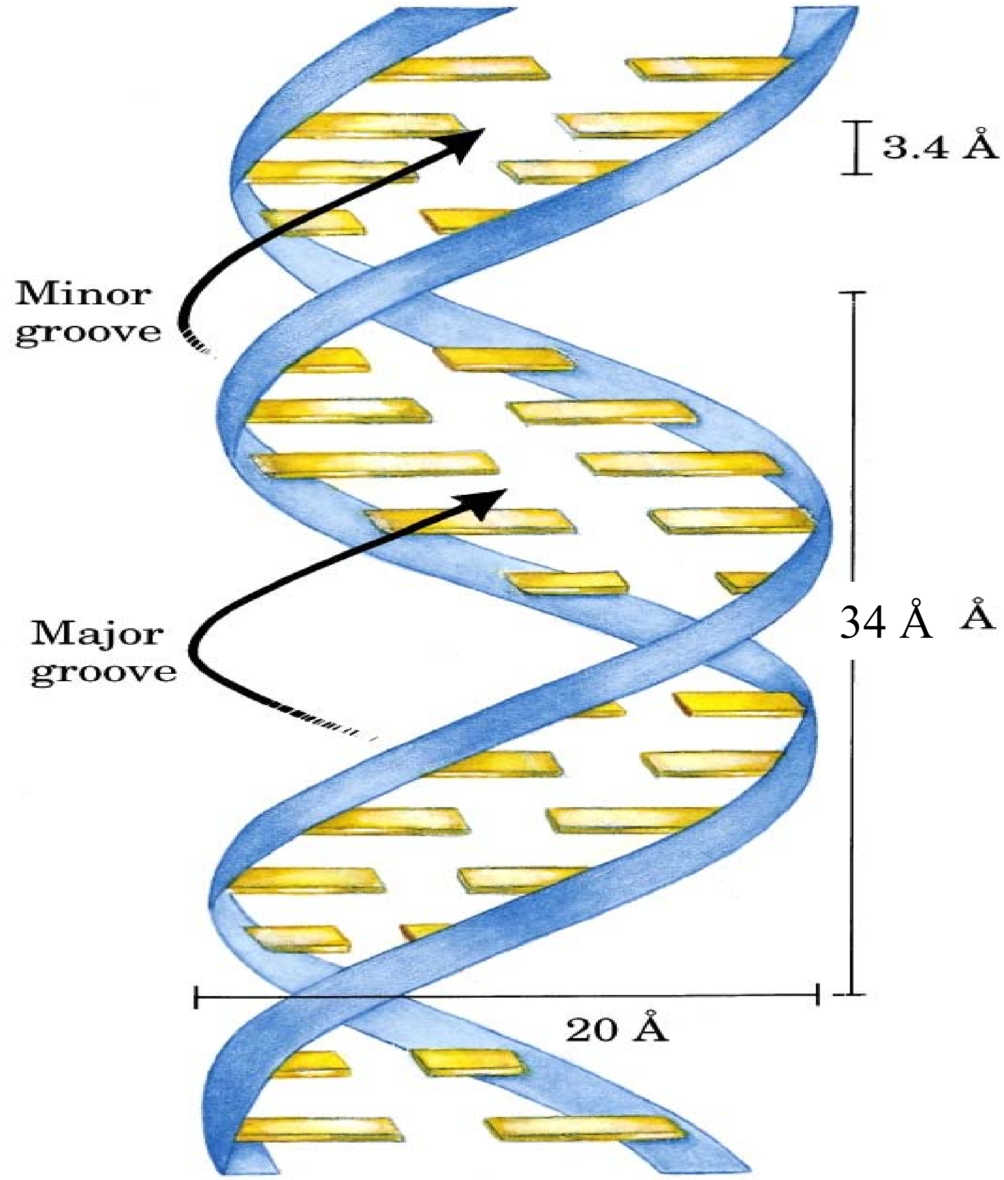
**Purine with Pyrimidine**

- Thus the double strands are **complementary** but **not** identical
- The diameter of the helix is 20A$^o$



# Watson-Crick model for the structure of DNA…

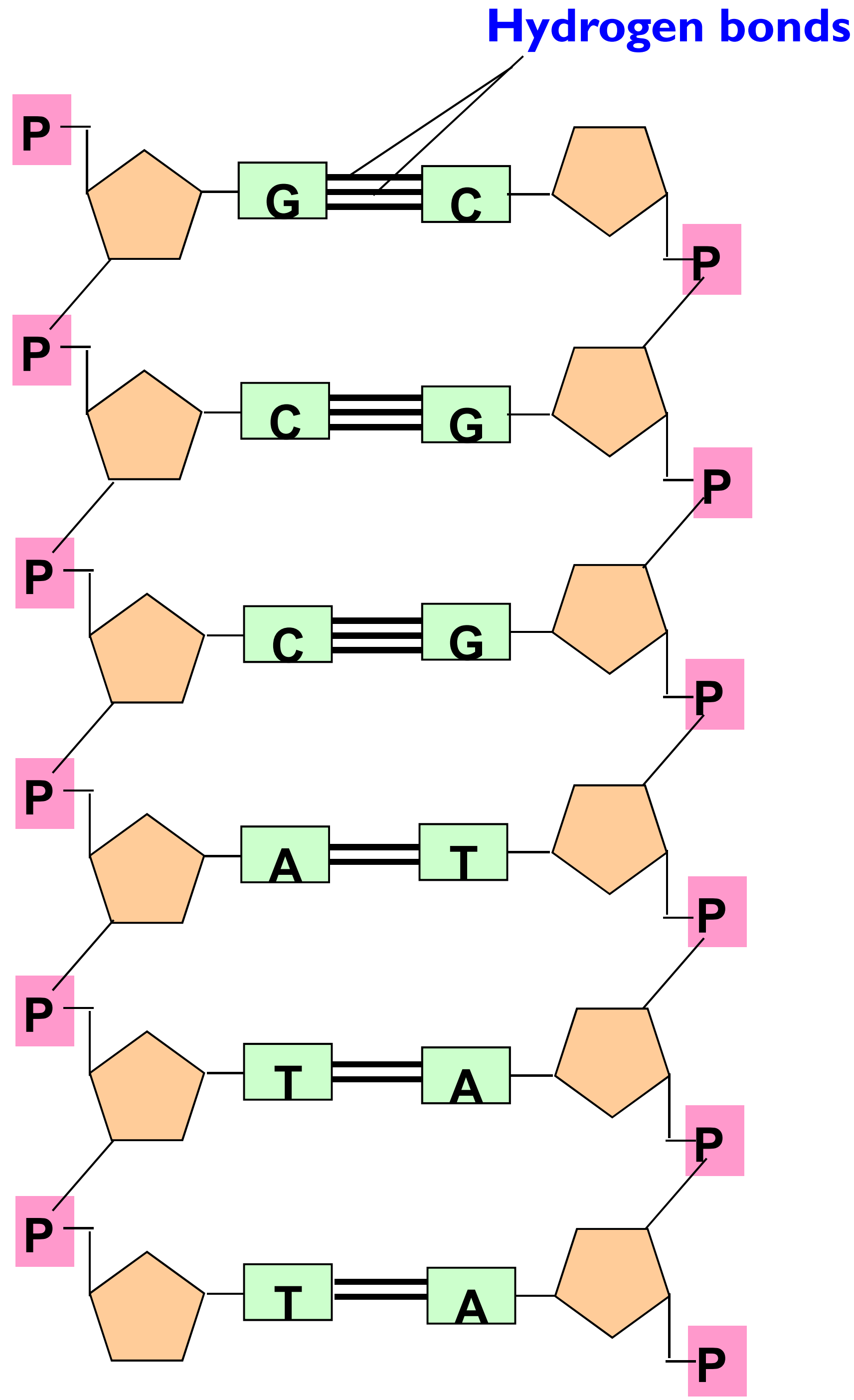
- The diameter of the helix is 20Å
- Adjacent bases are separated by 3.4 Å along the helix axis and the helical structure repeats after ten residues on each chain , that is
- At intervals of 34 Å



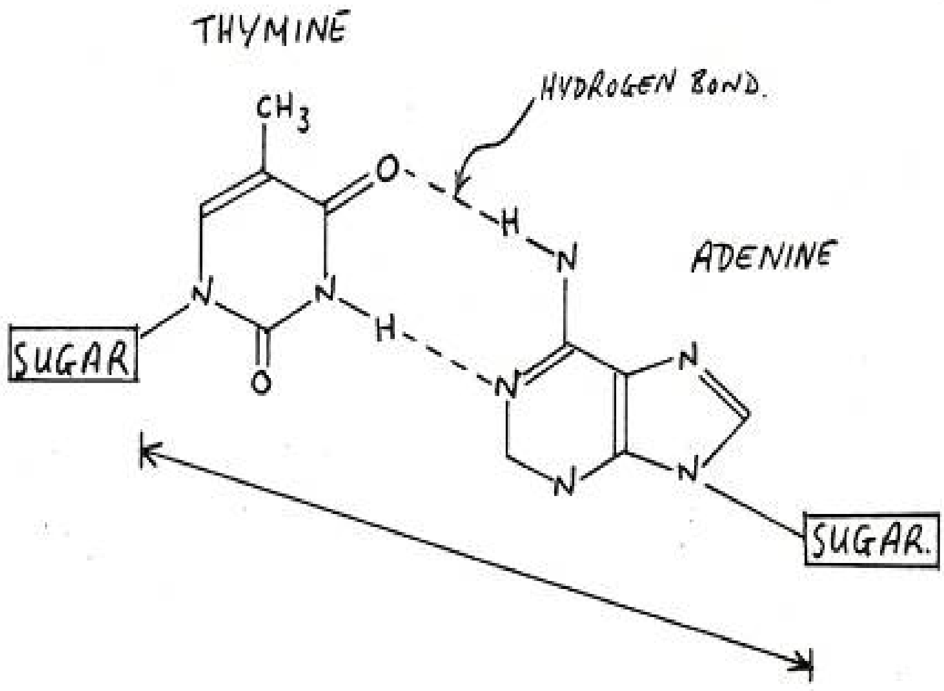
(a)

# DNA IS MADE OF TWO STRANDS OF POLYNUCLEOTIDE

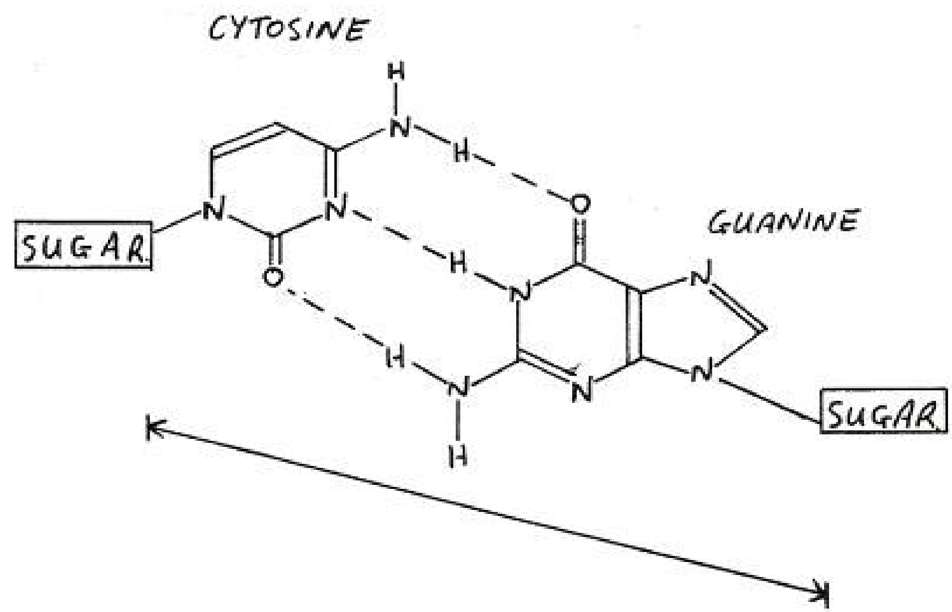
- The ratio of purine to pyrimidine bases in the DNA is always around one (1)
- G+A :T+C = 1
- G+A / T+C = 1
- G+A = C+T



# Watson & Crick Base pairing




**T ═ A**




**C ≡ G**

# Tertiary Structure of DNA

- **Tertiary structure**: Is the supercoiling of DNA double helix which is winding, bending and twisting to form more compact shape.

- DNA molecules are either **linear** or **circular**

- **In circular DNA,** the ends of the DNA are joined to create a closed circle with no free 3′ and 5′ hydroxyl and phosphoryl groups .

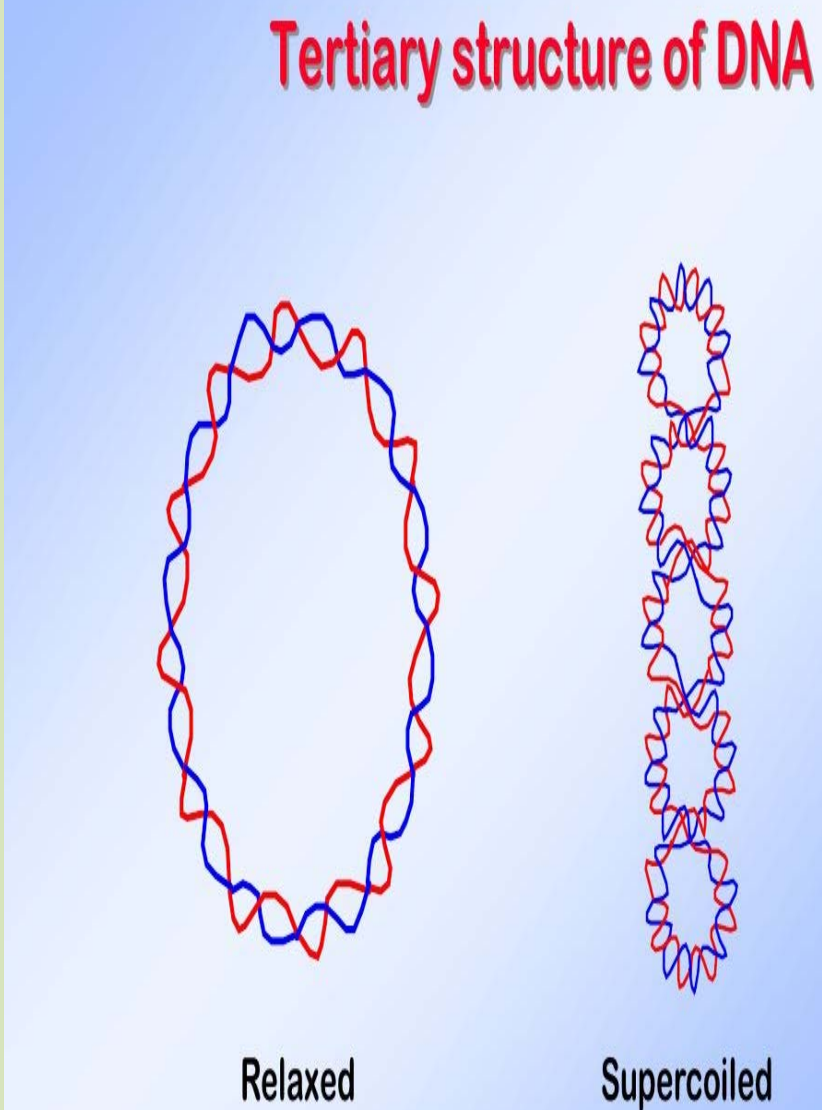
- The DNA in human chromosomes are **linear**

# Tertiary Structure of DNA

- A DNA molecule without any super helical turns is known as a **relaxed molecule**

- **Supercoiling** is biologically important because:

A supercoil DNA molecule has more compact shape than does it in relaxed state



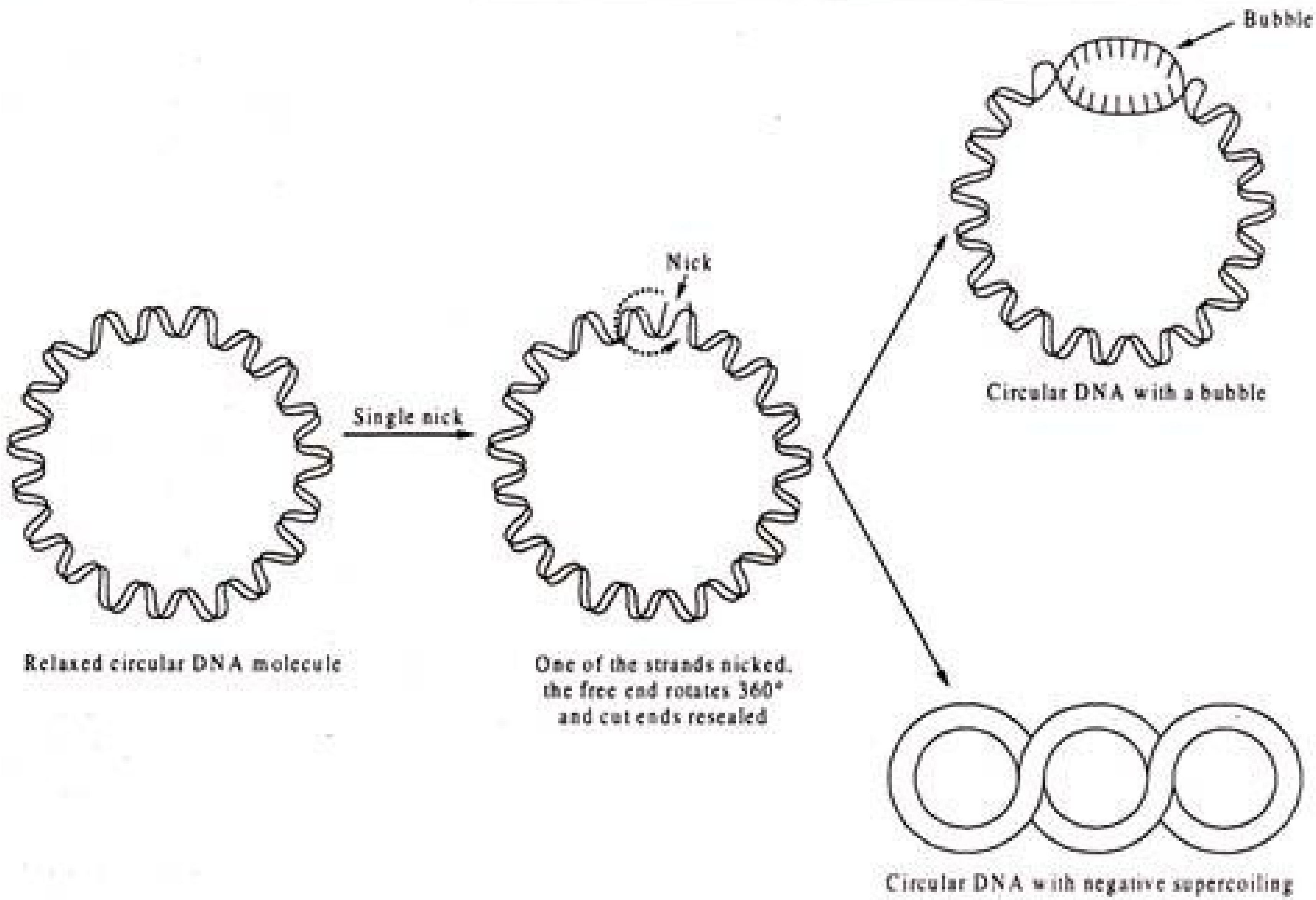



**Fig. 9.9 :** Different states of circular DNA. A nick in a DNA strand and rotation through 360° relaxes the pressure of the helix and leads to formation of either a bubble or a negative supercoiling

# Lecture 9

# Functions of DNA

i) DNA is the genetic material capable of storing and transmitting genetic information (heredity character) from parents to their off springs.

ii) All cellular functions are under the control of DNA

iii) DNA acts as a template for the synthesis of mRNA by a process called transcription. The mRNA thus produced helps protein synthesis in the cytoplasm by translation in combination with tRNA

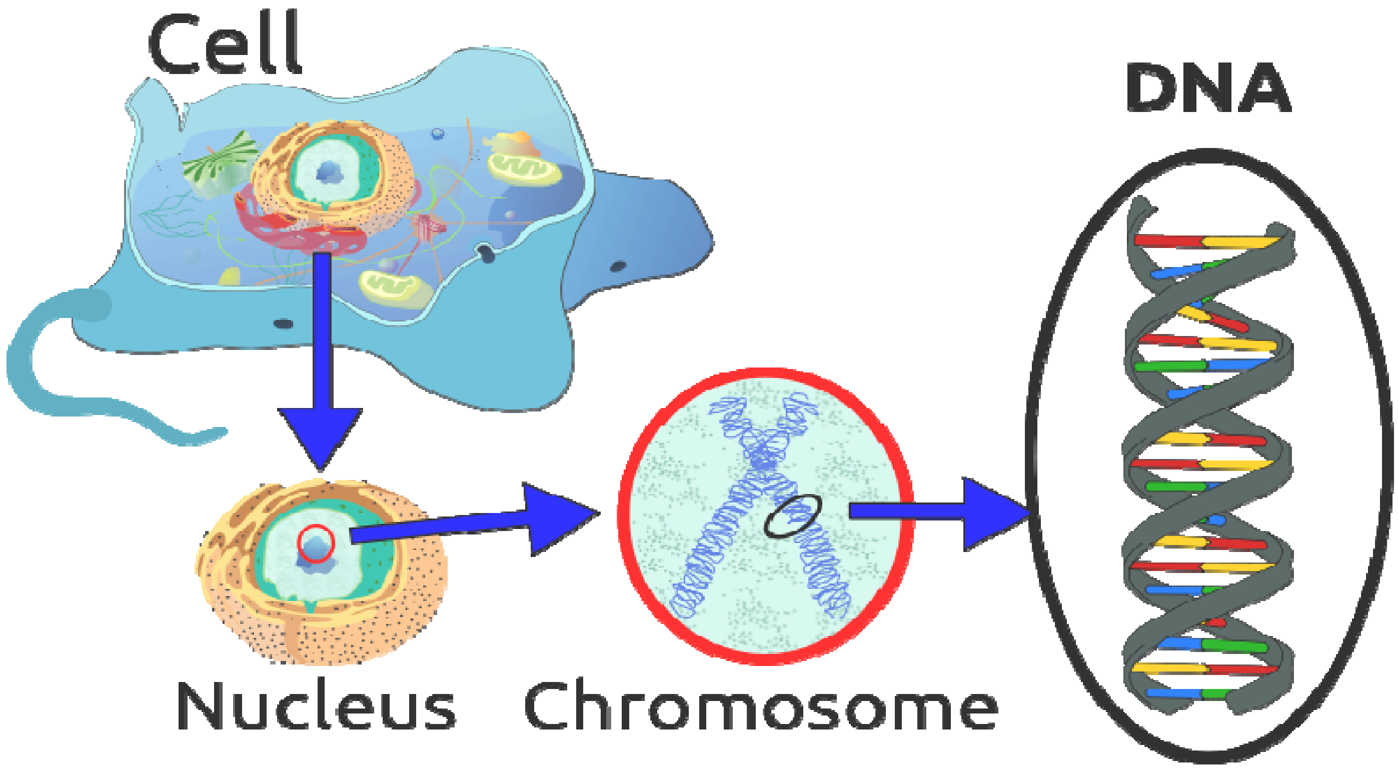
$$\text{DNA} \xrightarrow{\text{transcription}} \text{mRNA} \xrightarrow{\text{translation}} \text{Protein}$$

iv) DNA acts as a cofactor in the synthesis of ATP which in turn is necessary for the production of RNA and protein in the nucleus.

v) DNA produces mutations resulting in new characters

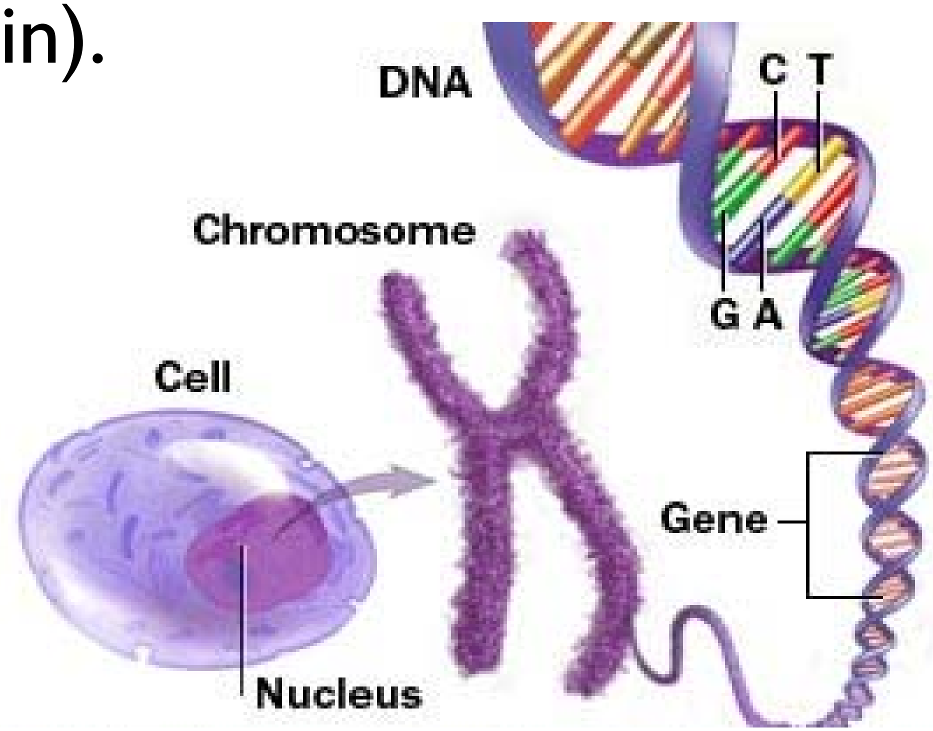
# Nucleic acid

- **Chromosome**: is a large single double helix DNA molecule containing many genes and functioning to store and transmit genetic information.



# Nucleic acid

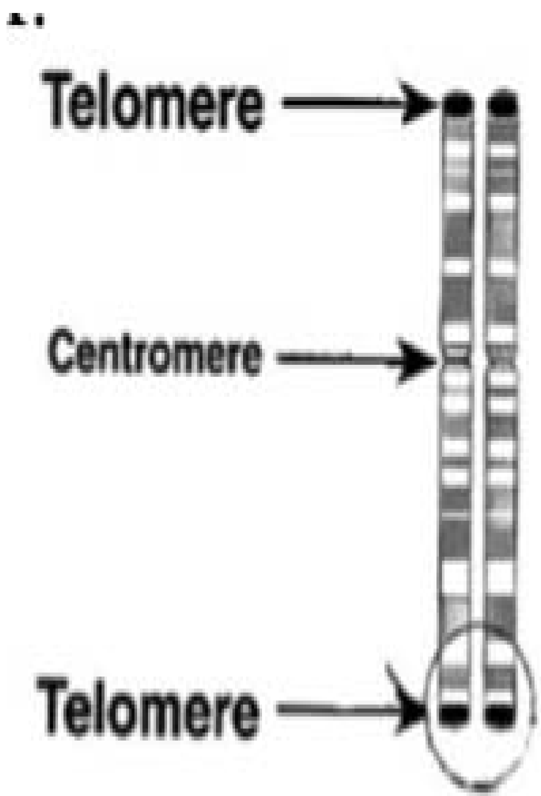
- **Gene:** is a sequence (segment) of a chromosome which codes for a molecule that has a function (polypeptide or protein).

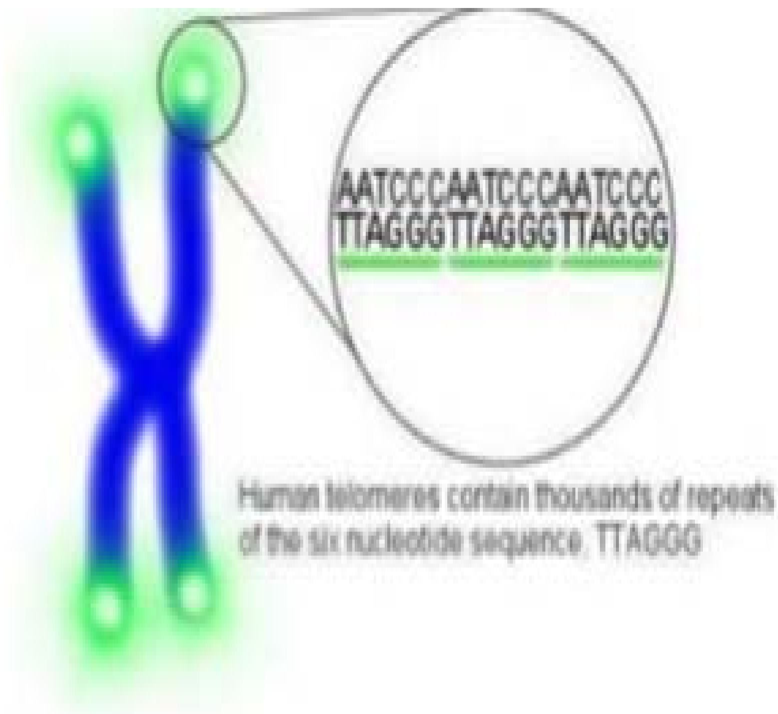



- **Genome:** is the **genetic material** of an organism.

# Nucleic acid

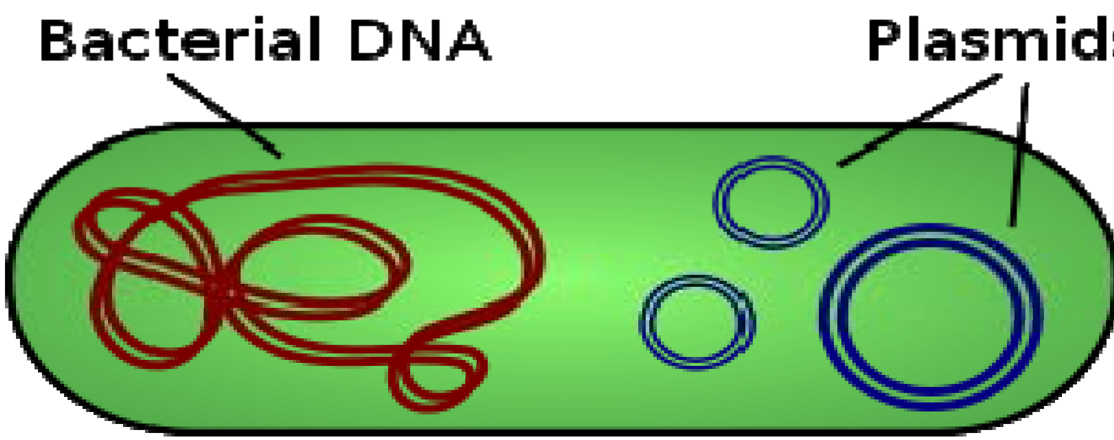
- **Satellite DNA:** are DNA segments of highly repeated sequence of about 10 b.p. (consists of a single sequence repeated many times over)



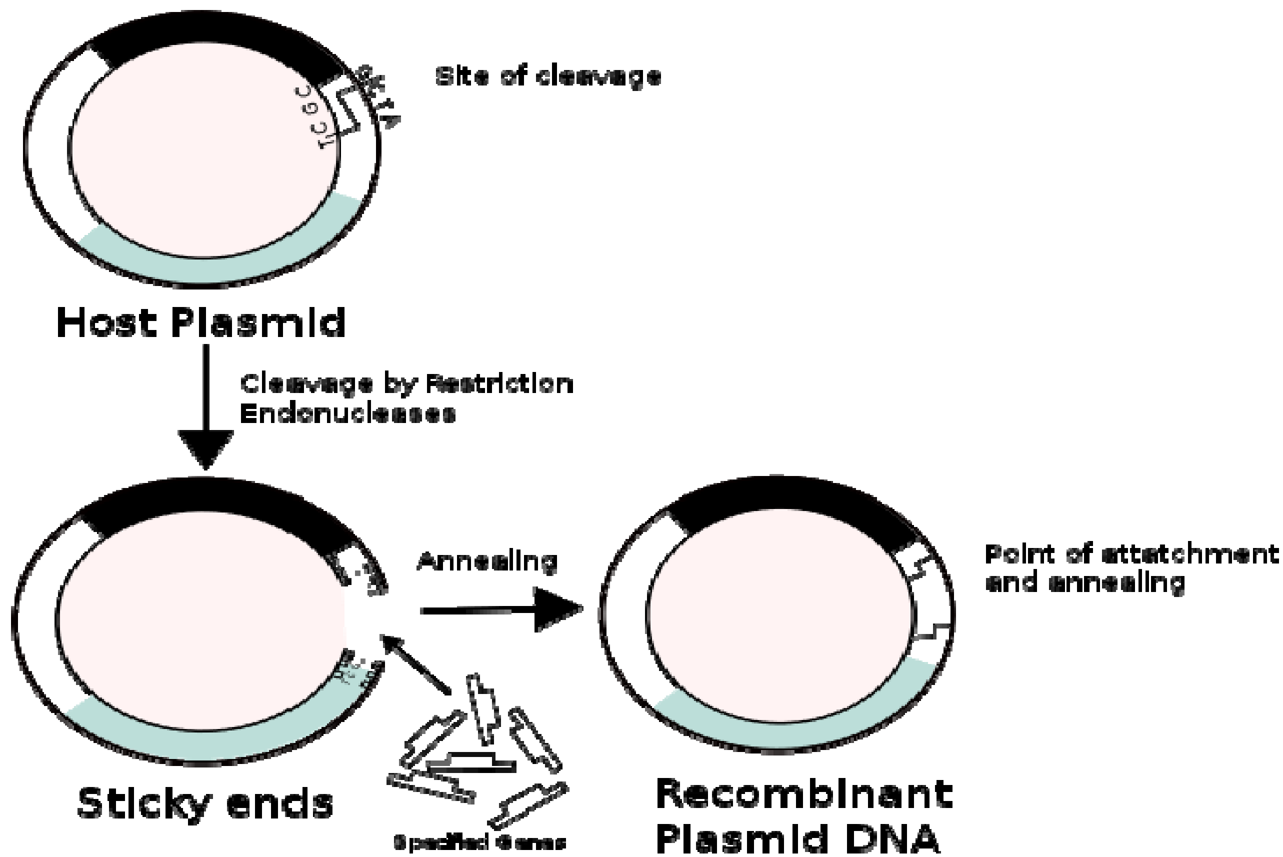
# Nucleic acid

- **Plasmids:** is a small DNA molecule within a cell that is physically separated from a chromosomal DNA and can replicate independently.
- They are most commonly found as small circular, double-stranded DNA molecules in bacteria; however, plasmids are sometimes present in archae and eukaryotic organisms. In nature, plasmids often carry genes that may benefit the survival of the organism, for example antibiotic resistance



# Nucleic acid

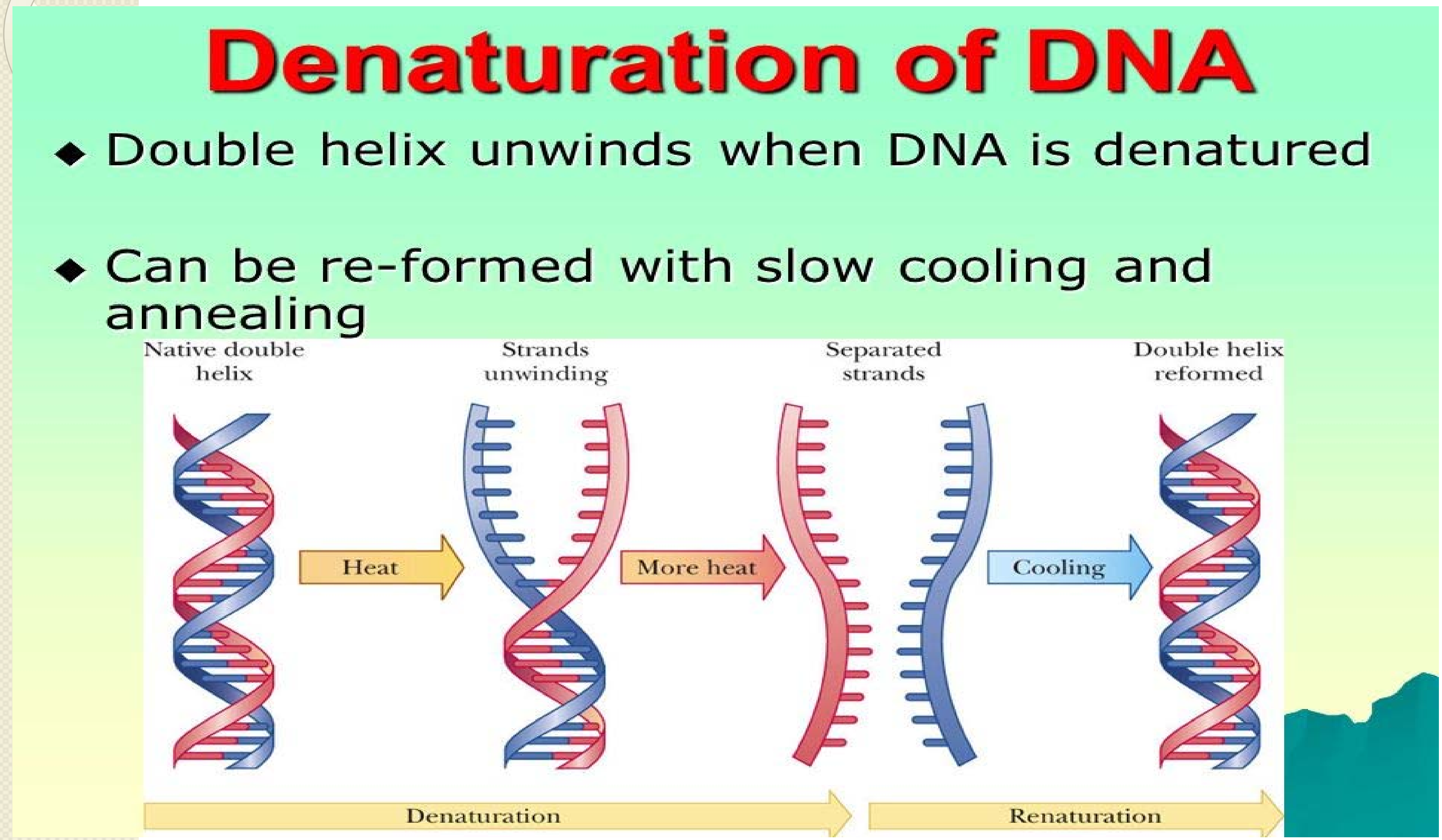
- **Recombinant DNA:** joining together of DNA molecules from two different species that are inserted into a host organism to produce new genetic combinations that are of value to science, medicine, agriculture, and industry. Since the focus of all genetics is the gene, the fundamental goal of laboratory geneticists is to isolate, characterize, and manipulate genes.



# Physical Properties of DNA

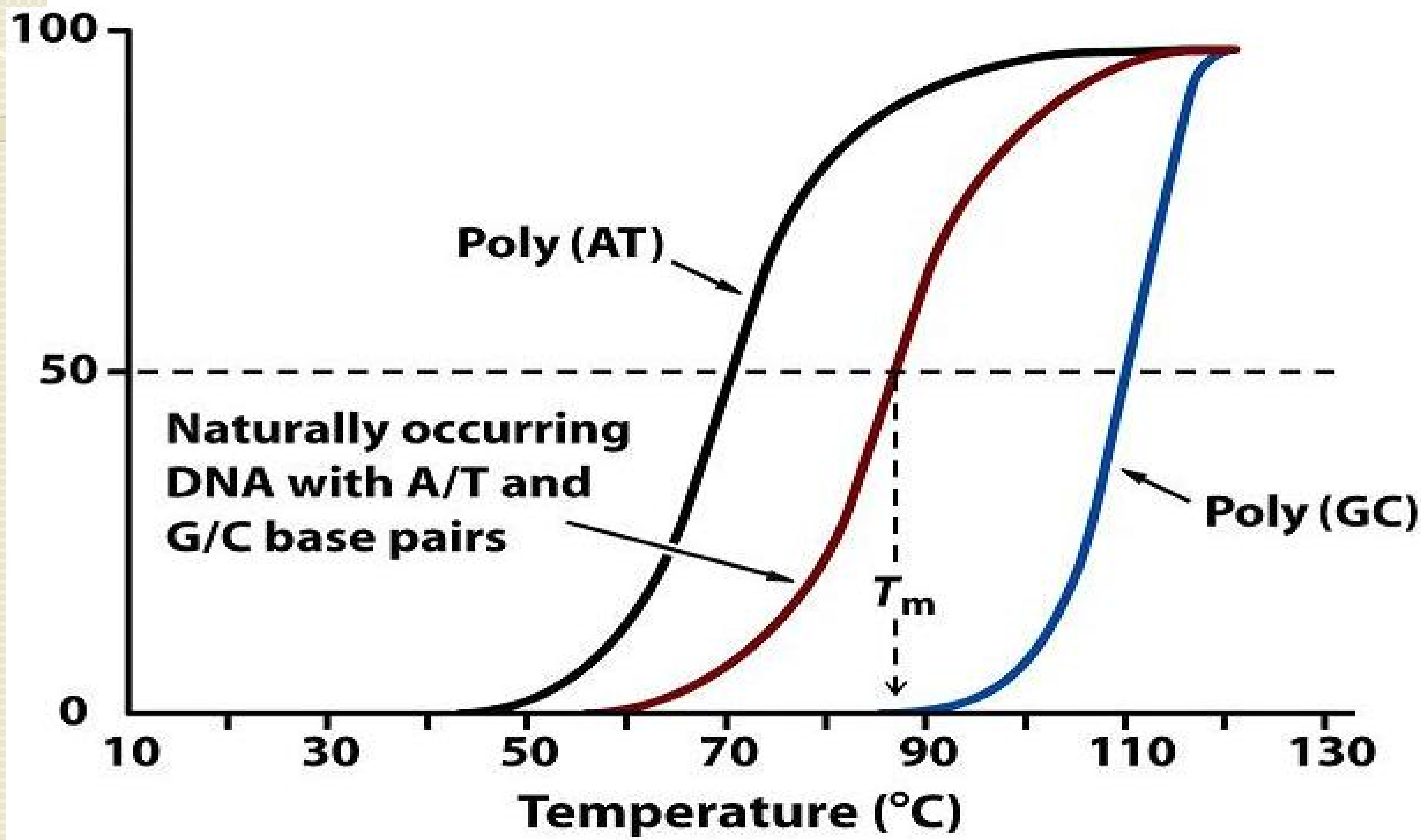
**1- Denaturation of DNA**:

**2- Renaturation (Annealing):**



# Physical Properties of DNA

## 3- Melting Temp (Tm):



# Physical Properties of DNA

**4- Mutation**:

a. Exposure to U.V. light, X –rays or γ –rays causes alteration such as adjacent T=T dimerization.

b. Deamination of nitrogen bases by exposure to nitrous compounds as $HNO_3$ and $NaNO_2$ converting:

Cytosine ⟶ Uracil + NH3

Adenine ⟶ Hypoxanthine + $NH_3$

c. Xenobiotics (nitrogen base analogues) such as : Caffeine may replace Thymine (T)

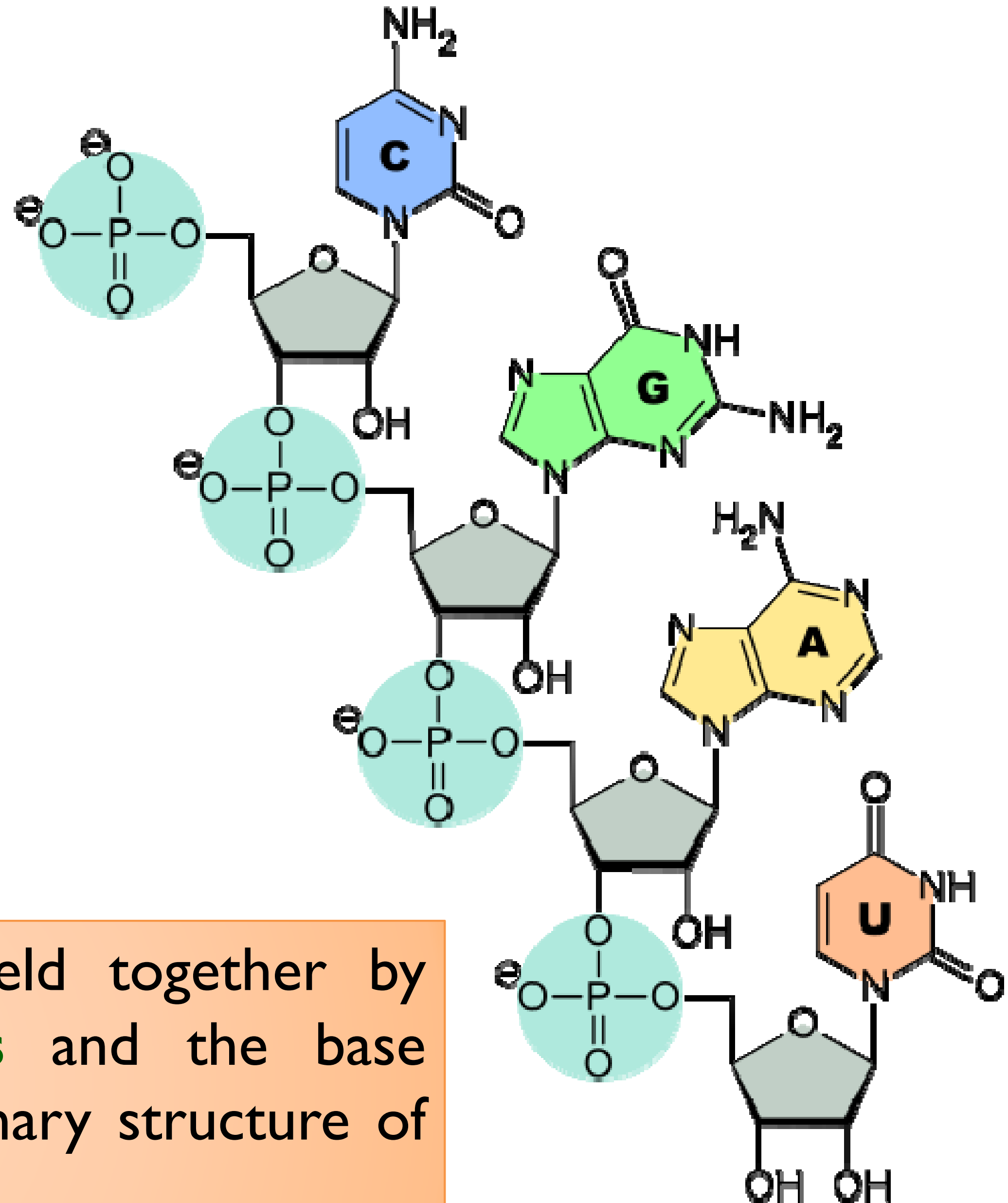
d. Alkylating agents: agents that can add R- groups such as $–CH_3$, -$C_2H5$, to the nitrogen bases altering their molecular structure.

# Lecture 10

# RNA Structure and Function

## 1. Primary structure

- **RNA** is a polymer of ribonucleotides. Thus, it is polyribonucleotide. It contains four types of ribonucleotides viz
- Adenosine monophosphate
- Guanosine monophosphate
- Uridine monophosphate
- Cytidine monophosphate

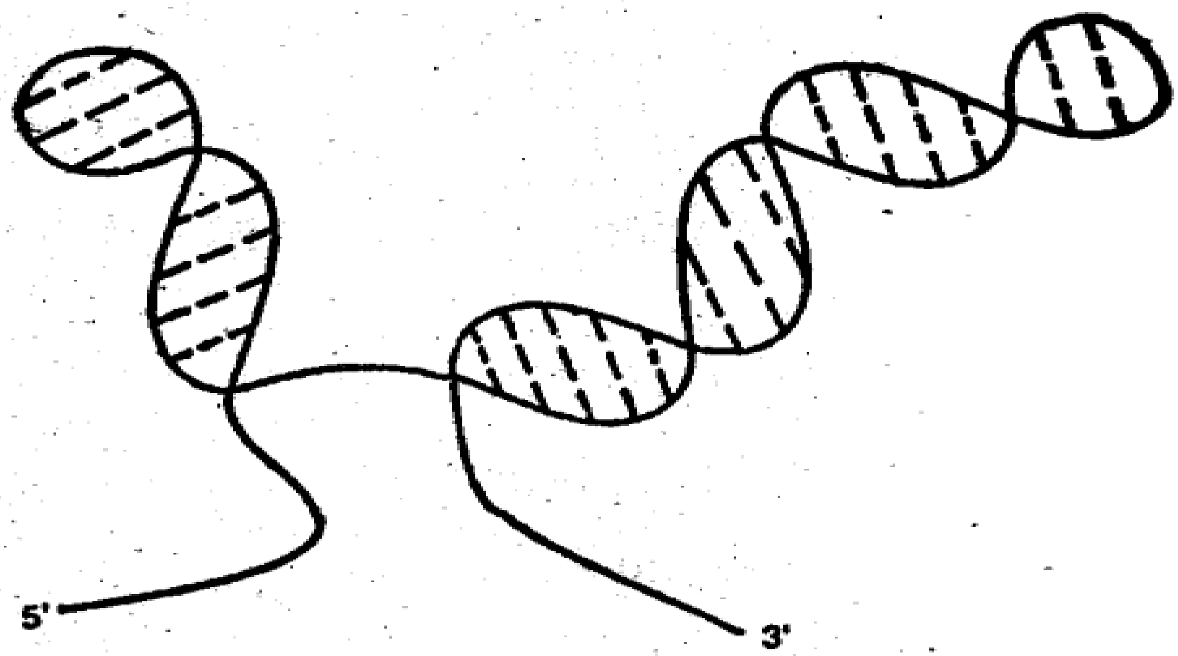



The mononucleotides are held together by **3',5'phosphodiester bonds** and the base sequence constitutes the primary structure of the polynucleotide

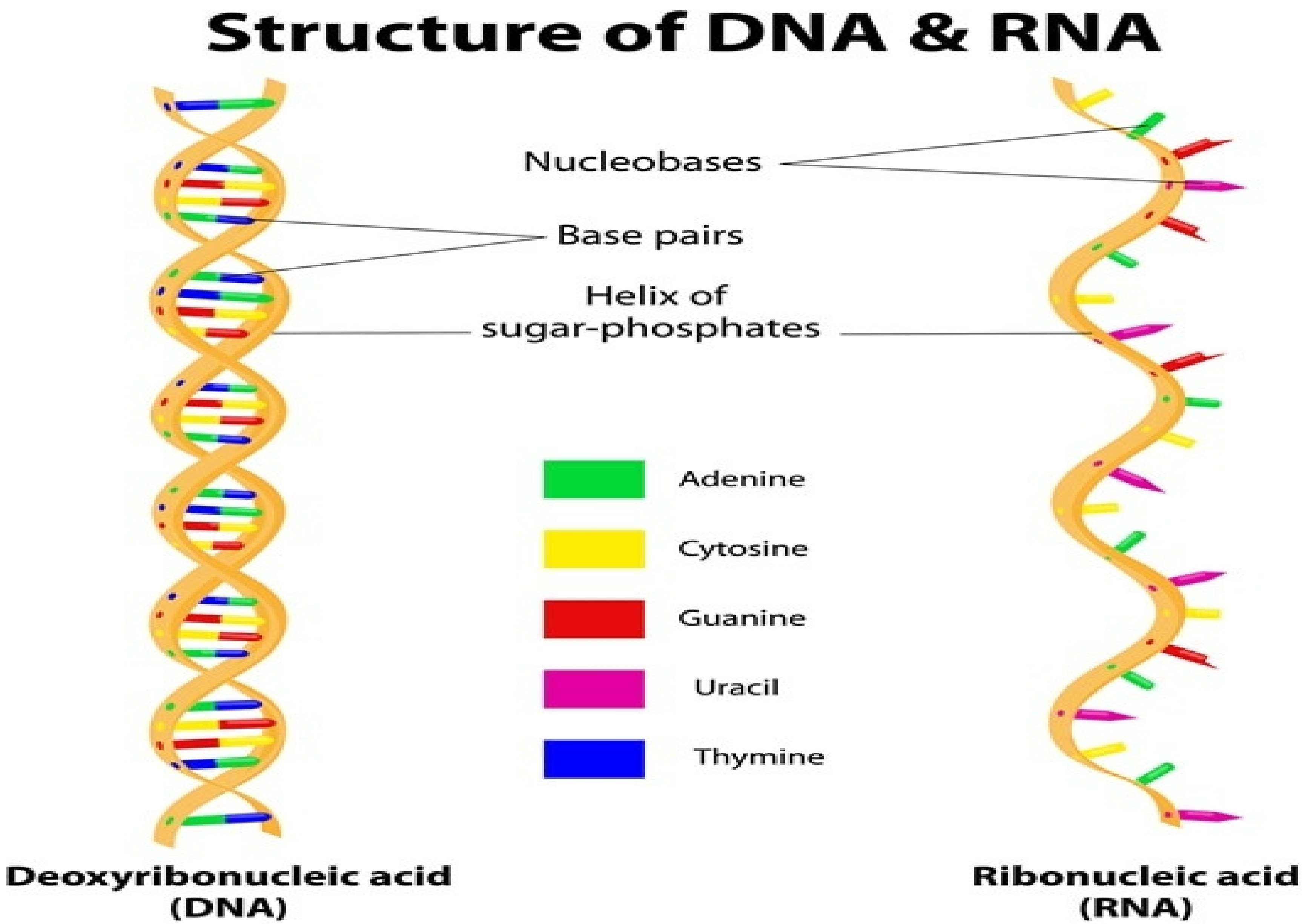
# RNA Structure and Function

## I. Secondary structure

- **RNA** occurs as a single strand molecule. There is internal hydrogen bonding within the chain to keep it in a coiled or helical form.
- The coiled strand folds back on itself and thus acquires double-stranded characteristics



# Difference between RNA and DNA



# Difference between RNA and DNA

| DNA | RNA |
|---|---|
| General genetic material present predominantly in nucleus | Genetic material of some viruses present in cytoplasm |
| The sugar moiety is deoxyribose | The Sugan moiety is ribose |
| Exists as double strand helix | Exists as single strand helix |
| Consists of adenine, guanine, cytosine and thymine | Consists of adenine guanine, cytosine and uracil |
| There is only one type of DNA | There are three types of RNA |
| Denatured on heating | |
| Denatured on heating | Stable towards heat |
| Consists of larger number of nucleotides upto 4.3 million | Consists of a fewer number of nucleotide upto 12,000 |

# RNA Structure and Function

## Three Types of RNA

1- Messenger RNA (mRNA)

2- Transfer RNA (tRNA)

3- Ribosomal RNA (rRNA)

- ***Messenger RNA*** - mRNA is a copy of the genetic information that was transcribed from the cell's original blueprint, DNA.

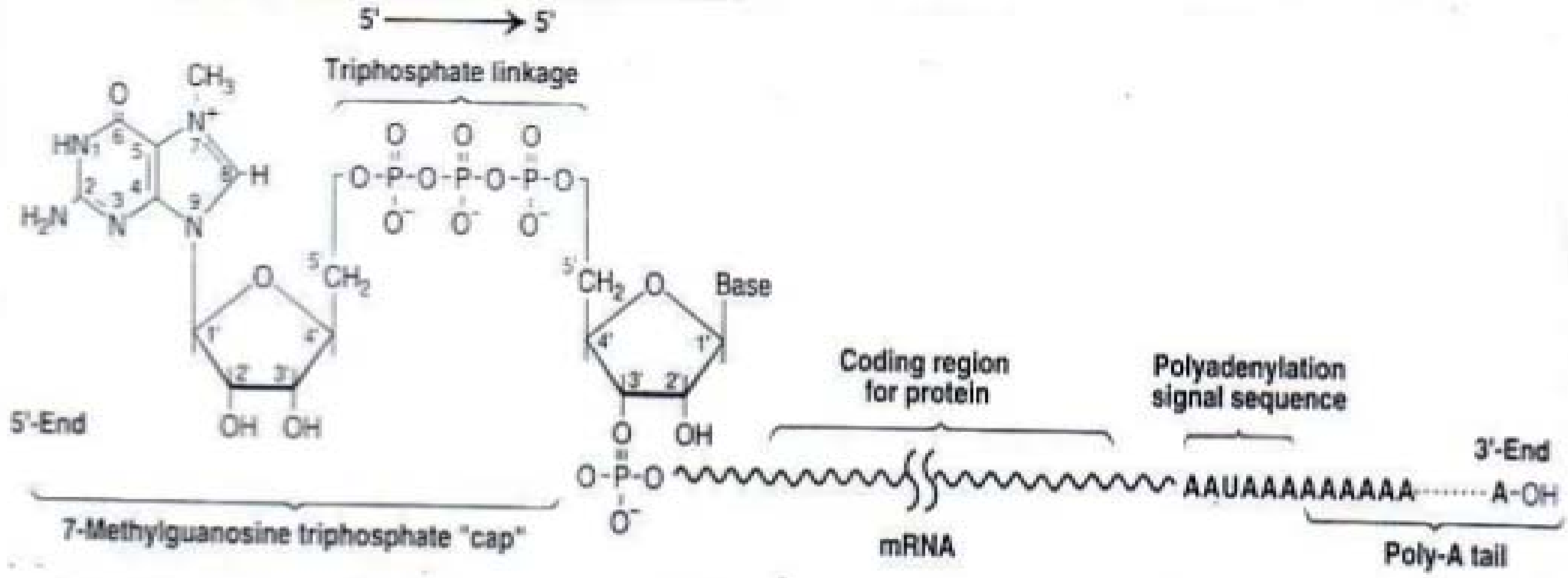
- This is so named because it is the type of RNA which carries message for protein synthesis from DNA (gene) to the sites of protein formation (ribosomes).

- Only about 5% of total cellular content of RNA is mRNA.

- mRNA is formed from DNA by transcription in the nucleus and then migrated into the cytoplasm and attached itself to a number of ribosomes

- ***Messenger RNA*** The **5′** end of mRNA is "capped" by a 7-methyl-guanosine triphosphate (m7 GPT).

- A poly(A) "tail" attached to the other **3′** end of mRNA. This tail consist of series of adenylate residues 200-250 nucleotides in length joined by **3′,5′ phosphodiester bonds**




## Function

mRNA serves as a messenger by carrying genetic information from DNA to the sites of protein synthesis (ribosomes).

- ***Transfer RNA*** - Transfer RNA constitutes about 10-15% of total RNA of the cell
- The Amino Acid Suppliers: tRNA is also part of the process of building proteins. Like a little truck, tRNA brings the amino acid to the ribosome. Which amino acid it brings depends on which was coded for in the mRNA instructions. At the ribosome, these amino acids are joined together to form proteins.

Transfer RNA is the smallest of the RNA species containing approximately 75 nucleotides with a molecular weight of 25,000. It has a cloverleaf structure with four attachement sites or arms.

## Function

The rRNA molecules serve as adapters for the translation of the information in the mRNA into specific amino acids for protein synthesis

**tRNA structure**

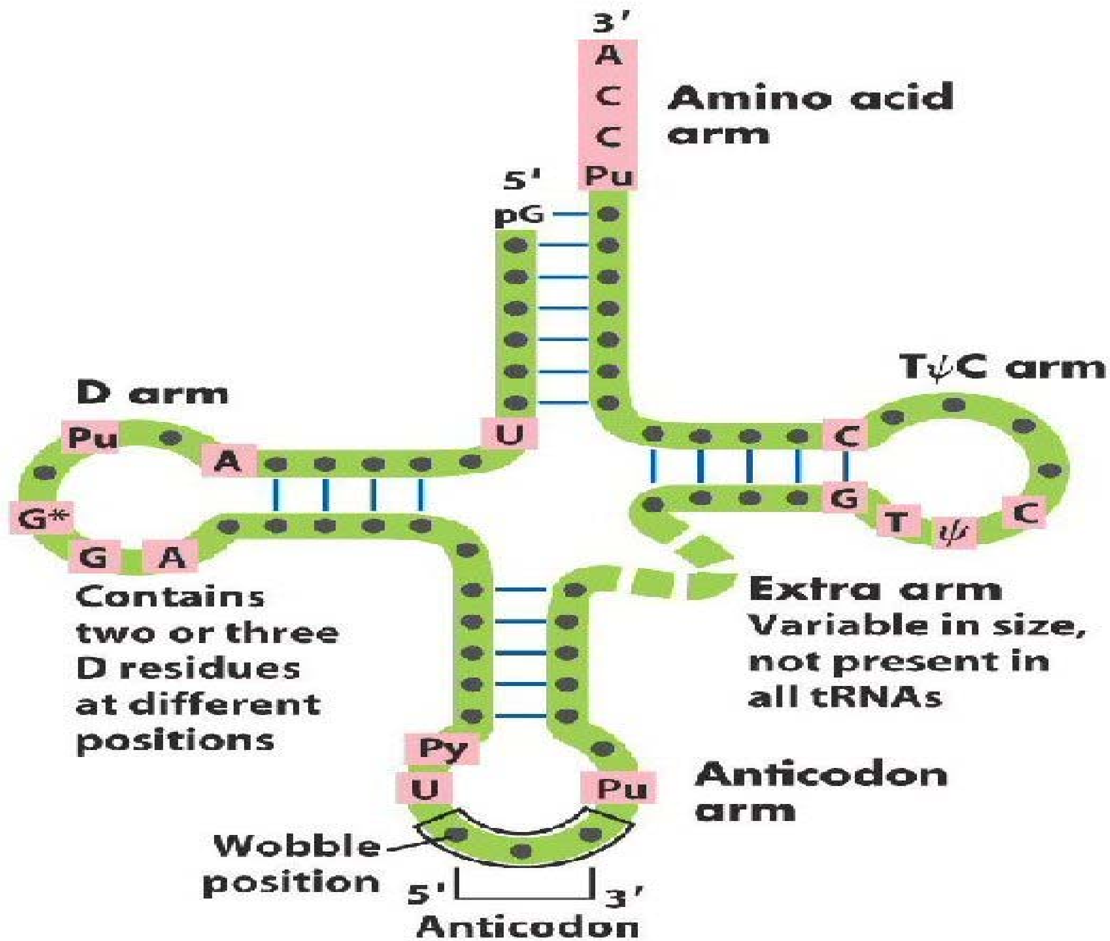
1- The acceptor arm

2- The D arm

3- The anticodon arm

4- The T ψ C arm

5- The extra arm



- ***Ribosomal RNA*** -The Protein Factories: Most of the RNA in cells is part of the structure of small cellular organelles known as ribosomes, the protein factories of the cells.

Ribosomal RNA constitutes about 80% of the total RNA of the cell. It occurs as nucleoprotein in the minute round particles called ribosomes located in cytoplasm

## Functions

i) rRNA plays a prominent role in binding m-RNA to ribosomes and its translation to tRNA.

ii) An rRNA component is found to perform the peptidyl transferase activity. Thus it acts as an enzyme called ribozyme.

مع تمنياتي بالموفقية والنجاح

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