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Doctor 2022 - medicine - MU

biochemistry sheet

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Amino Acid Structure

we will focus on the structure part of the chemical properties and the stereochemistry of the 20 standard amino acid.

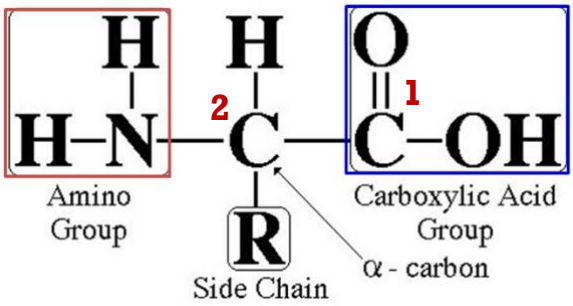
stereochemistry : the arrangement of the atoms in the space

الأحماض الأمينية ومشتقاتها يفوق عددها 300 مركب ولكن المعيارية (20)

-Amino acids are biologically important organic molecules that contain both carboxylic acid (-COOH) as well as amine (-NH2) groups

-The side-chain also called "R" group is specific to each amino acid

- we can differentiate between 20 standard amino acids from the nature of the side chain (R group)
- R group could be (aromatic, cyclic, sulfer…etc)



Amino group is attached to α- carbon (C2)

- The secret of the amino acid in the α -carbon which is the carbon no.2, α-carbon is the carbon which is the next neighbor to carboxylic group
- The reference point in the functional group (carboxylic group)
- The 20 standard amino acid called (α-amino acid)whyyy??
  → because the amino group as attached to (α-carbon)

C, N, O and H are the key elements of amino acids

Biological significance of Amino Acids

1-Amino acids are N-containing molecules important for survival of animals for cells life

2-The basic structural building unit (monomers) of proteins it is building blocks of proteins

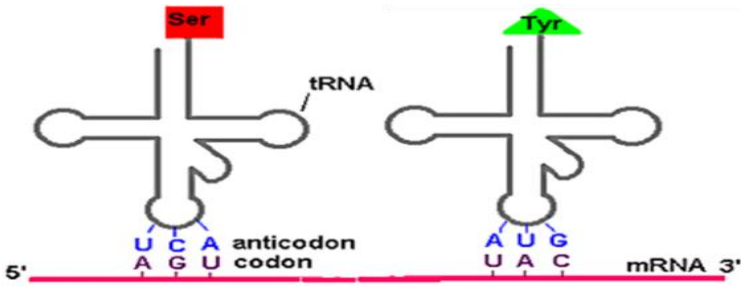
3-Precursors of many biomolecules like Neurotransmitters (non-protein role)

4-They are also utilized as an energy source they're also utilized as an energy source (during metabolism process)

*** There are 20 standard (canonical) amino acids which are encoded directly by triplet codons in the universal genetic code during in vivo protein synthesis process (mRNA translation)**

Genetic code table

-The 20 standard amino acids are known as proteinogenic or natural amino acids



2nd base in codon

1st base in codon	U	C	A	G	3rd base in codon
U	Phe Phe Leu Leu	Ser Ser Ser Ser	Tyr Tyr STOP STOP	Cys Cys STOP Trp	U C A G
C	Leu Leu Leu Leu	Pro Pro Pro Pro	His His Gln Gln	Arg Arg Arg Arg	U C A G
A	Ile Ile Ile Met	Thr Thr Thr Thr	Asn Asn Lys Lys	Ser Ser Arg Arg	U C A G
G	Val Val Val Val	Ala Ala Ala Ala	Asp Asp Glu Glu	Gly Gly Gly Gly	U C A G

- **Proteinogenic → added or incorporated to polypeptide chain during the mRna translation process**
- **Natural → automatically happened in the body**
- **Standard → found in the genetic code table**

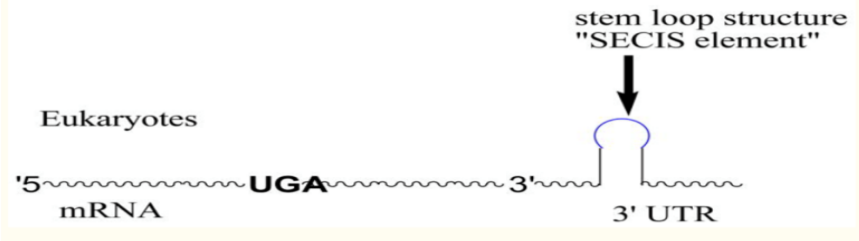
In vitro→ outside the body

In vivo → inside the body

Standard Amino Acids

Histidine	Arginine	Alanine
Isoleucine	Asparagine	Asparatate
Leucine	Glutamine	Cysteine
Methionine	Glycine	Glutamate
Phenylalanine	Proline	
Threonine	Serine	
Tryptophan	Tyrosine	
Valine		
Lysine		

1-They are proteinogenic and natural amino acid (the other proteinogenic amino acids N-formyl methionine, pyrrolysine and selenocysteine are called non-standard or non-canonical amino acids) **there are 3 amino acids that are non-standard (not found in the genetic code table) but they are proteinogenic, added during the mRna process by a unique mechanism : 1- N-formyl methionine 2- pyrrolysine 3- selenocysteine**

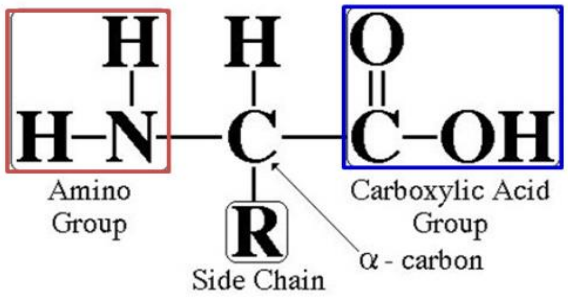


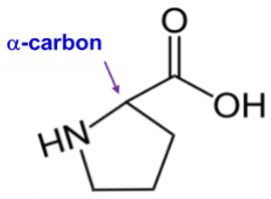
Incorporation of selenocysteine in protein structure by unique mechanism

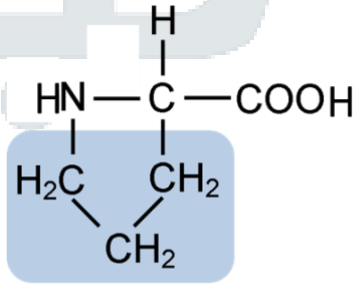
2. Known as 2-, alpha- or α- amino acids as the primary amino group (-NH2) is attached to α-carbon (the carbon next to –COOH group). Proline is an exception which has a secondary amino group (-NH-) In all the standard amino acids there is primary amino group attached to α-carbon EXCEPT → proline (2nd amino group)

Q:All these characteristics refer to proline except :

a) Standard b) beta amino acid c) has 2nd amino group d) α- aminoacid
Answer : b





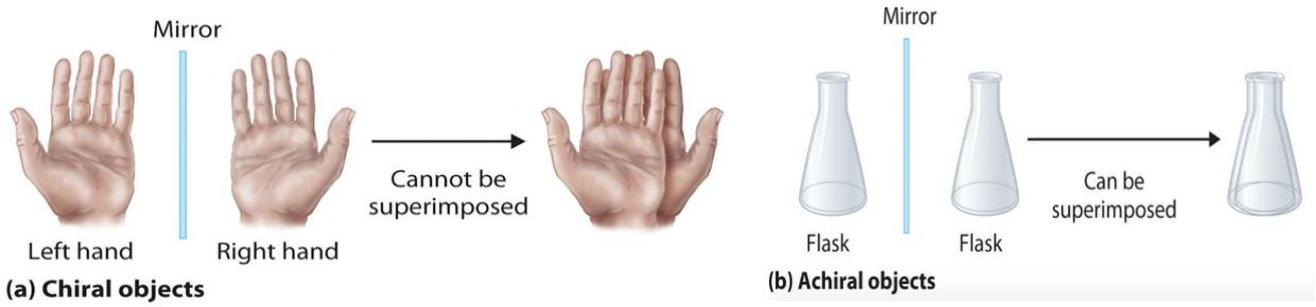


proline

3-They are all chiral molecules (except glycine which has achiral C) with L-stereochemical configuration (left-handed isomers)

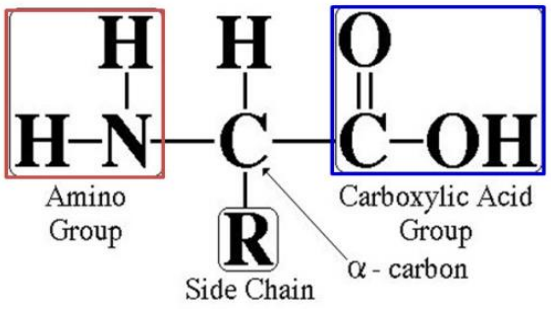
Chirality → means our hands (hands are a great example for chiral objects)

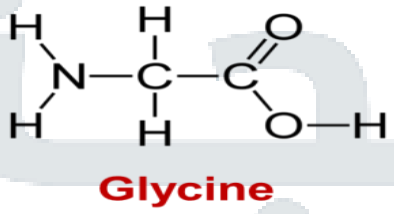
(left hand is mirror image to the right hand but they're not superimposable)



***Chiral molecules should contain at least one chiral center (usually a carbon atom)**

***Chiral carbon: asymmetric carbon atom attached to 4 different groups of atoms**





Isomerization

***Isomers: are molecules with same molecular formula but different chemical structures**

1-Constitutional (structural) isomers: atoms and functional groups bind together in different ways

Constitutional → molecules with the same molecular formula but the major difference is in their chemical structure (difference in functional group)

Example : glucose and fructose are Aldehyde and ketone respectively

2-Stereoisomers (spatial isomers): differ in the configuration of atoms rather than the order of atomic connectivity

Stereoisomers → differ in the arrangement of the atoms in the space (left, right, up and down) but have the same functional group

D/L Amino Acids

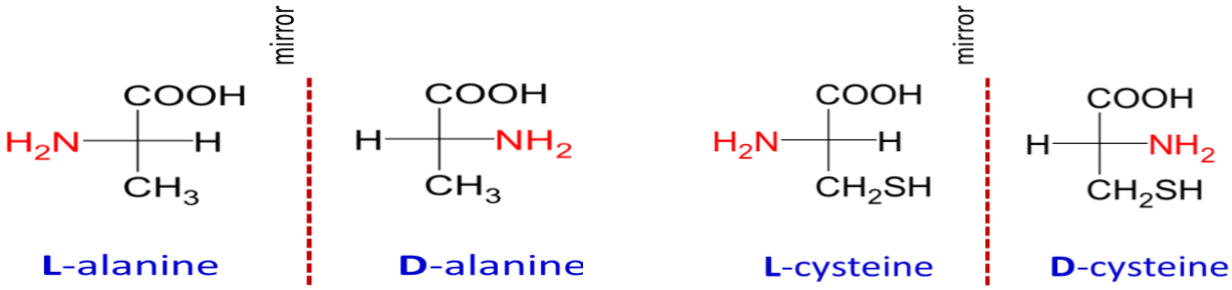
***Enantiomers: are two stereoisomers that are mirror images to each other but not superimposable**

***D-** (dexter)/**L-** (laevus) **Nomenclature system: commonly used to assign the configurations in sugars (carbohydrates) and amino acids**

***As a rule of thumb: if the amino group is on the right-hand side of α-carbon at Fisher projection, the configuration is D. If it is on the left-hand side, the configuration is assigned as L.**

- **Which one is active in our body, L- amino acid or D- amino acid? answer: L-amino acid**
- **Which one is active in our body, L-carbohydrate or D-carbohydrate? answer: D-carbohydrate**
- **We should know that enzymes in our bodies are sterioactive, depend on the spatial of the molecule (amino acid or carbs... etc.)**
- **Note: assign/called/named as/ designated as → all have the same meaning**

Fischer Projections of Amino Acids



Fisher Projection:is one way commonly used to represent the structure of chiral molecules like carbohydrates and amino acids

D/L Amino Acids

Most naturally occurring sugars are D-isomers while most naturally occurring amino acids are L-isomers (amino acids of protein)

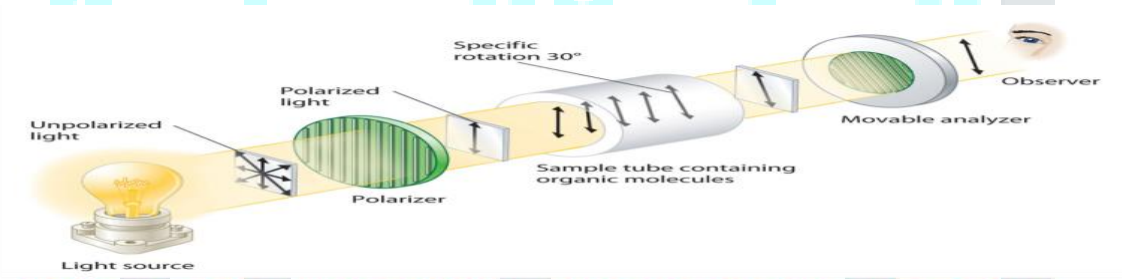
D-amino acids polypeptides (right-handed isomers) are components of bacterial cell walls to resist digestion by other organisms

Optical Activity

Enantiomers are optically active and can rotate the polarized light plane either clockwise or counterclockwise

We can't put glycine into the polarimeter why?

➔ **Because glycine is achiral/doesn't have optical activity**



Polarimeter is used to measure optical rotation

***(+)/(-) nomenclature system: if one enantiomer rotates the light clockwise, it is labeled (+) or (d) (dextrorotatory). The second mirror image enantiomer is labeled (-) or (l) laevorotatory**

Q- what does (+)L-Tyrosine mean

Answer: the amino group located on the left, and the amino acid rotates to the right

***D/L system should not be confused with +/- or d/l system. For example, D-isomer might be levorotatory**

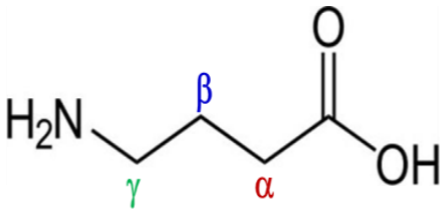
***9 of 19 L-amino acids commonly found in proteins are dextrorotatory**

***Racemic mixture contains equal amounts of each enantiomer (net rotation is zero**

Classification of Amino Acids

>300 amino acids classified in many ways:

1-Proteinogenic and non-proteinogenic amino acids (either have non-protein role like GABA and carnitine or formed by post translational modification of protein like hydroxyproline)

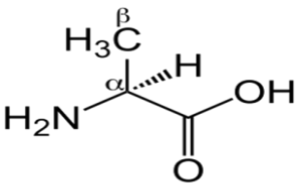


γ-aminobutyric acid (GABA)

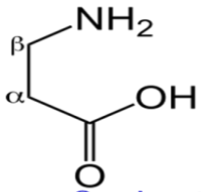
The number of proteinogenic is 23 amino acid (20standard and 3 non-standard)

2-Standard and non-standard amino acids

3-α, β, γ and δ amino acids



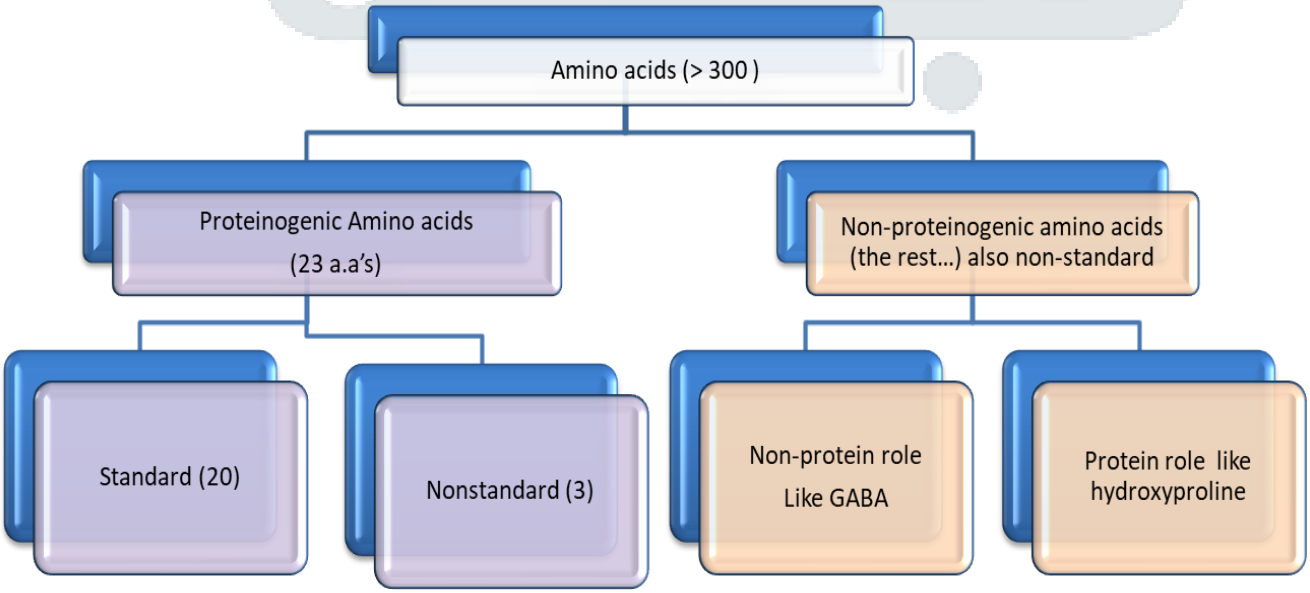
α-alanine



β-alanine

***β-amino acids are non-proteinogenic with β-alanine is the only common naturally occurring β-amino acid. β-alanine is used in plants and microorganisms in the synthesis of pantothenic acid (vitamin B5)**

***Unlike α-peptides, The β-peptides are artificial peptides used in some antibiotics to counter resistance as they are more stable against proteolytic degradation**



Categories of Standard Amino Acids

The 20 standard amino acids are classified into 3 major categories according to the polarities of their "R" groups:

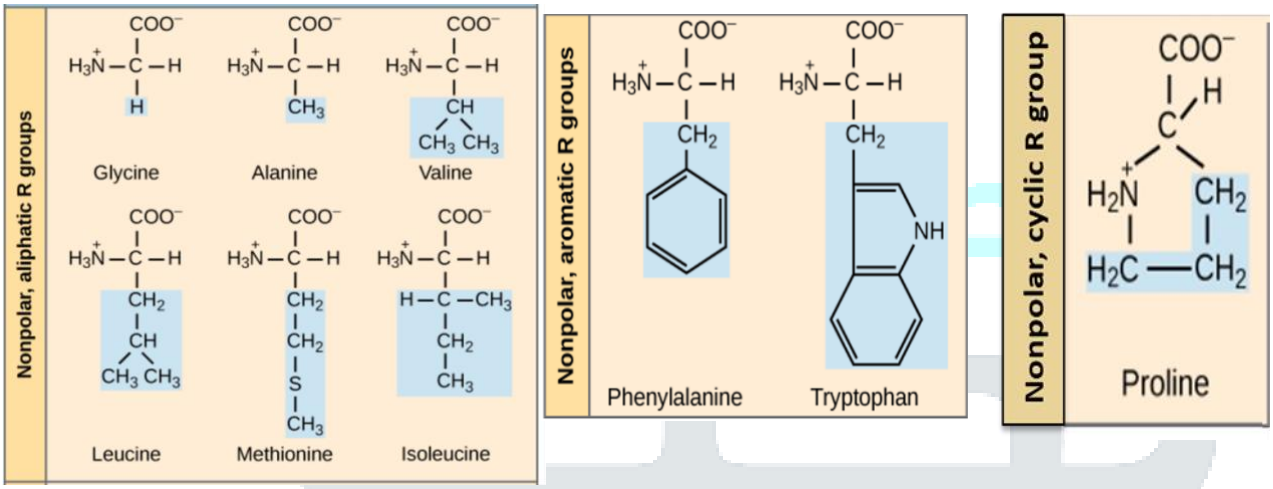
1-Amino acids with non-polar R groups

2-Amino acids with charged polar R groups

3-Amino acids with uncharged polar R groups

Amino acids with non-polar R groups

6 amino acids with aliphatic, 2 with aromatic and one with cyclic side chains



***Glycine has the simplest side chain: H atom**

***Alanine, valine, leucine and isoleucine have aliphatic hydrocarbon side chains**

***Methionine has a thioether side chain (sulfur atom)**

***Proline has a cyclic pyrrolidine side chain**

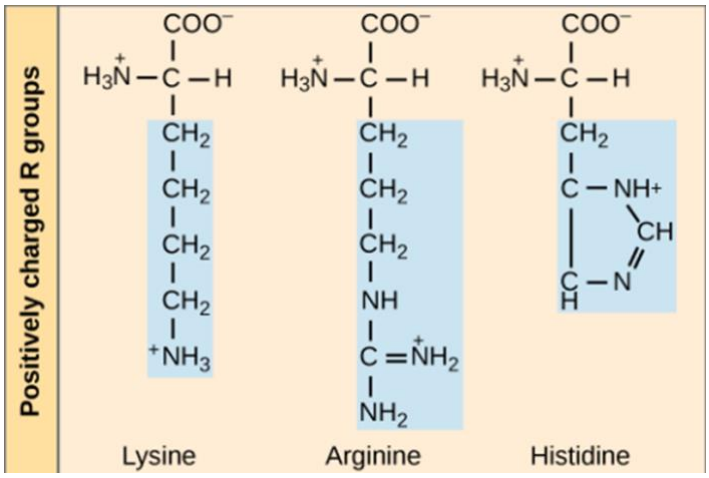
***Phenylalanine has a phenyl moiety**

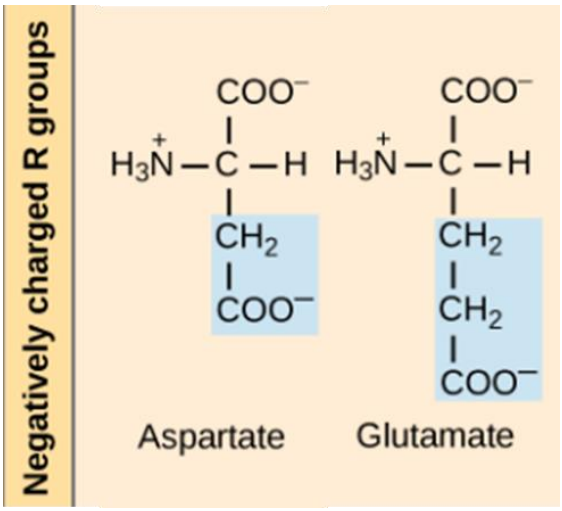
***Tryptophan has an indole group**

Amino acids with charged polar R groups

3 amino acids are positively charged (basic)

and 2 amino acids are negatively charged (acidic)





***Arginine has a guanidine group**

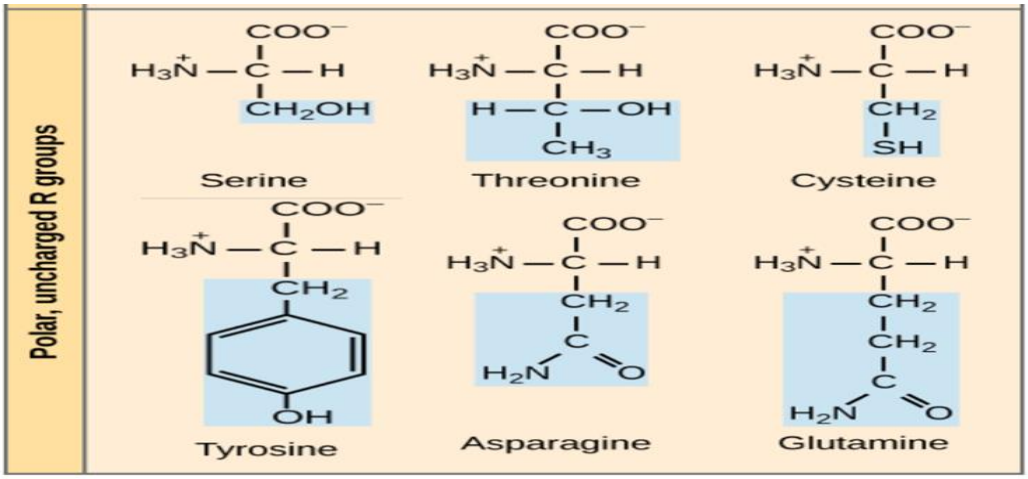
***Lysine has a butyl ammonium side chain**

***Histidine has imidazole group**

***Aspartic and glutamic acids in their ionized state are called aspartate and glutamate, respectively**

Amino acids with uncharged polar R groups

6 amino acids with hydroxyl, amide or thiol groups



*Serine and threonine bear hydroxyl (-OH) R group

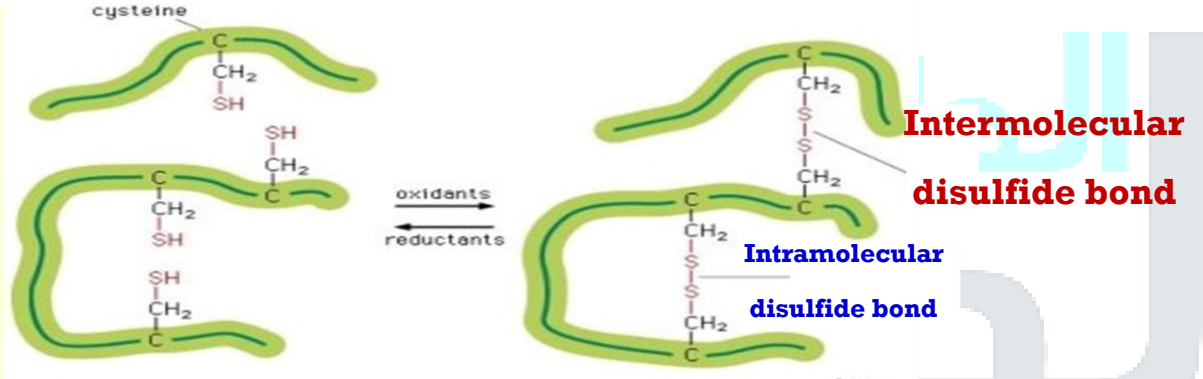
*Asparagine and glutamine have amide bearing side chains. They are the amide derivatives of aspartic and glutamic acids

*Tyrosine is aromatic and has a phenolic group

*Cysteine has a thiol group that can form a disulfide bond (-S-S-) with another cysteine through the oxidation of 2 thiol groups (cystine is the oxidized dimeric form). The disulfide bridge in proteins contributes to the stability and overall shape of a protein

Amino acids with uncharged polar R groups

- Disulfide bond is a covalent linkage formed between the sulfhydryl groups (SH) of two cysteine residues (after oxidation) to produce a cystine residue



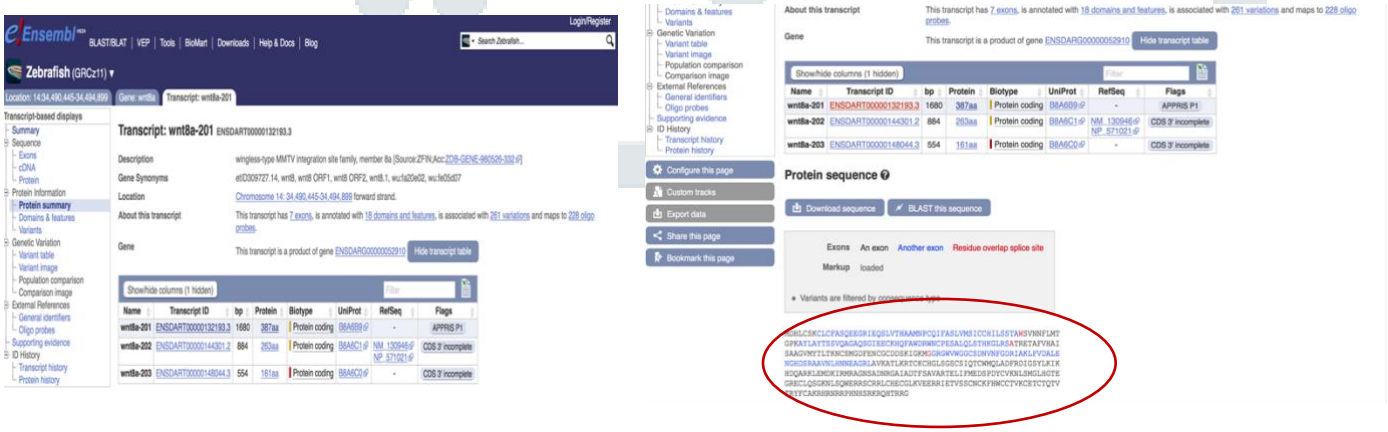
*Cysteine residues may be separated from each other by many amino acids in the primary sequence of a polypeptide or may even be located on two different polypeptides. The folding of the polypeptide chain(s) brings the cysteine residues into proximity and permits covalent bonding of their side chains.

*Disulfide bond could be intramolecular (2 cysteine residues on the same polypeptide chain) or intermolecular (2 cysteine residues on two separate/ different polypeptide chains)

Amino Acids Abbreviations

3-letters	1-letter	Amino acid
Ala	A	Alanine
Arg	R	Arginine
Asn	N	Asparagine
Asp	D	Aspartic acid (Aspartate)
Cys	C	Cysteine
Gln	Q	Glutamine
Glu	E	Glutamic acid (Glutamate)
Gly	G	Glycine
His	H	Histidine
Ile	I	Isoleucine
Leu	L	Leucine
Lys	K	Lysine
Met	M	Methionine
Phe	F	Phenylalanine
Pro	P	Proline
Ser	S	Serine
Thr	T	Threonine
Trp	W	Tryptophan
Tyr	Y	Tyrosine
Val	V	Valine

Ensembl Genomic Browser



كل الدقائق التي تعبت بها اليوم تلقَاها غدًا، لا بد لكل شيءٍ أن يأخذ وقته، لا بُدّ للبذرة من سقاءٍ وماءٍ وغذاء، ولا بُدّ لمَن تاقَ الجمال أن يرى الظلام أولًا، ولمن تاقَ الارتِواء أن يَعبُرَ على نهر الظَمأ، ليست الحياة صورةً ورديّة، ولا الوصول لحظةٌ فوريّة، ولا النجاح قصّةٌ مَحكيّة، إنما هي لحظات، وأيام وسنوات، يعيش الواحد فيها ألف ألمٍ وأمَل، لو لم يعلم عنها أحد، كفاكَ أنَّ الله يراك.

لذلك = اجتهد ألف يوم، لاستحقاقِ يوم

«وما الحياة الدنيا إلا متاع الغرور»

انتبه لخطوتك، واضبط نيَّتك. 💗

- أ. قصي العسيلي.