

# Polypeptides and proteins

# Peptide bond

micro molecules → monomers → amino acid and the macro molecules is the poly peptide or protein. (polymers).

is a chemical bond that is formed between two amino acids when the carboxyl group of one molecule reacts with the amino group of the other molecule, releasing a molecule of water (H<sub>2</sub>O).

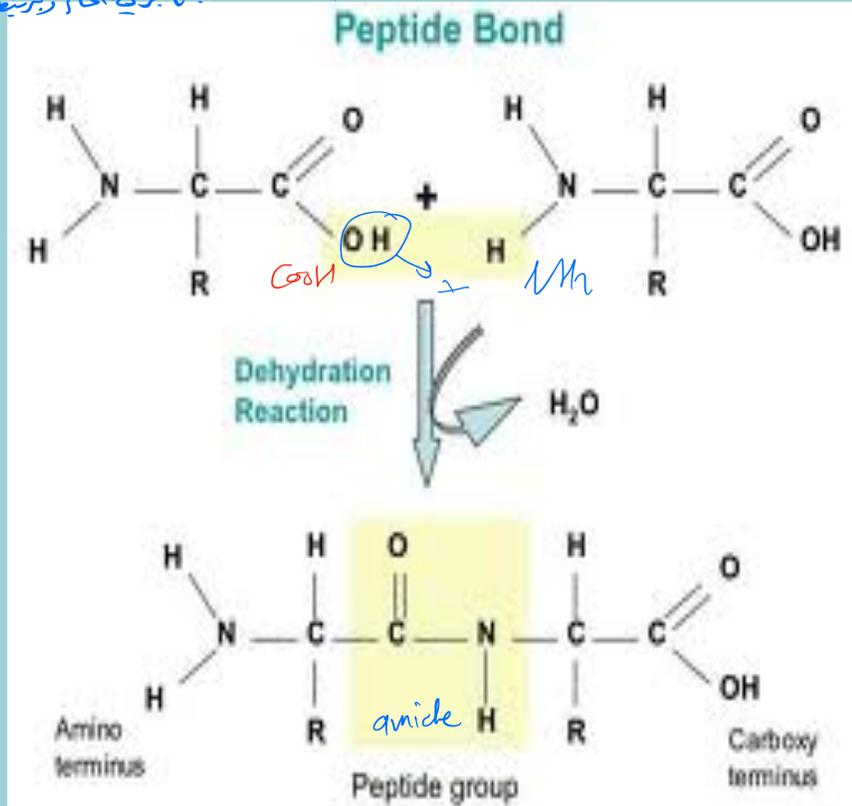
This is a dehydration synthesis reaction (also known as a condensation reaction), and usually occurs between amino acids

تفاعل بين جزيئين خردا جزئي ماء (واحد من amino acid والآخر بقية ذرة صغرى من peptide bond) يظهر جزيء الماء في الطرف الآخر

The resulting CO-NH bond is called a peptide bond, and the resulting molecule is an amide.

Di-peptides have two amino acids, tri-peptides have three amino acids, and a sequence of amino acids linked by peptide bonds is known as a polypeptide.

Polypeptides and proteins are chains of amino acids held together by peptide bonds



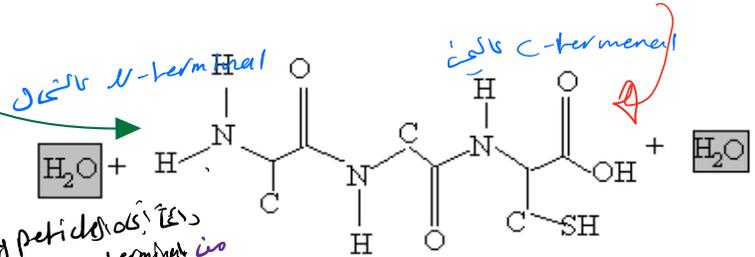
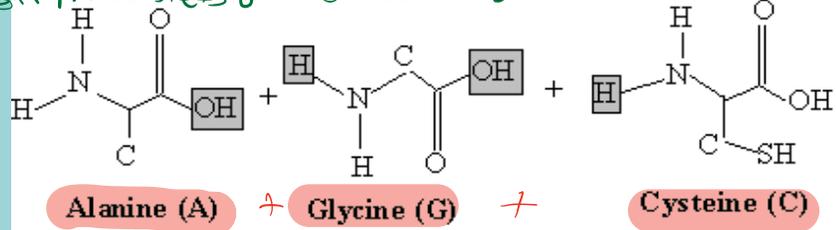
الرابطة التي تربط peptide bonds تسمى reaction between amino acid والذرة الصغيرة من amino group

# Direction of Polypeptide chain

one peptide bond يتكون من any two amino acid  
تفاعل one water molecule

Sequences of amino acids in a polypeptide are read from the amino terminal end to the carboxy-terminal end.

dehydration reaction تفاعل الجفاف  
peptide bond يتكون من ابي بالاسكن



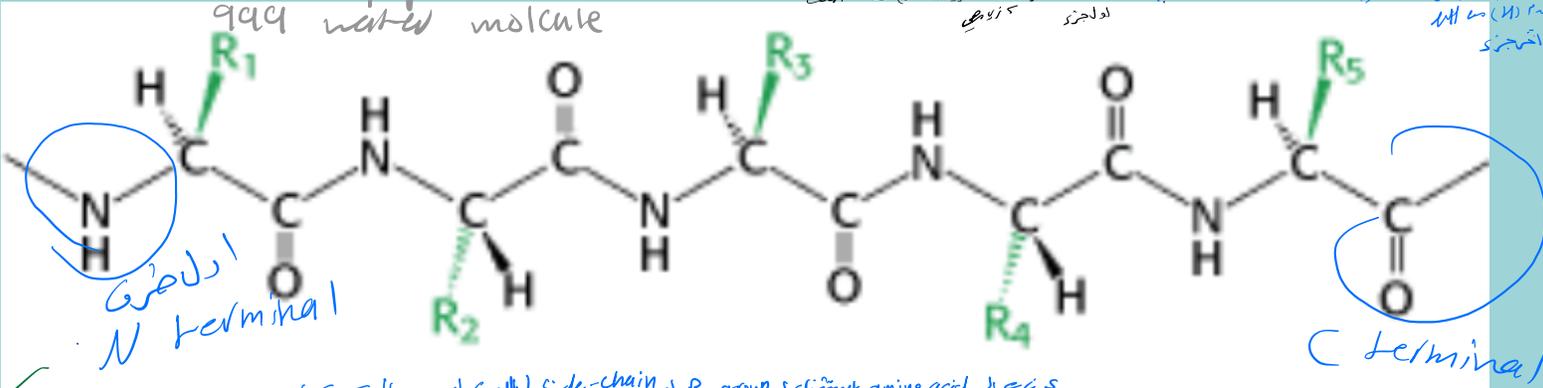
لوسالبي - كاسيني 1000 amino acid تفاعل واحد  
تفاعل واحد peptide bond  
water molecule?

Poly Peptide chain  
N-terminal C-terminal

Polypeptide Chain AGC plus 2 molecules of water

N-terminal amino acid  
C-terminal amino group  
amino acid تتفاعل مع amino group  
تفاعل واحد peptide bond  
amino acid (H) مع (OH) من  
السكر

1000-1 = 999 peptide bond  
999 water molecule



amino acid (R-group) Side-chain (باللون الاخضر او الورد بالاسم)

A polypeptide chain consists of a constant backbone (black) and variable side chains "R" (green).  
any polypeptide or any protein have a constant backbone  
بعض خولاي بغيري بمرتبته خنا بمرتبته

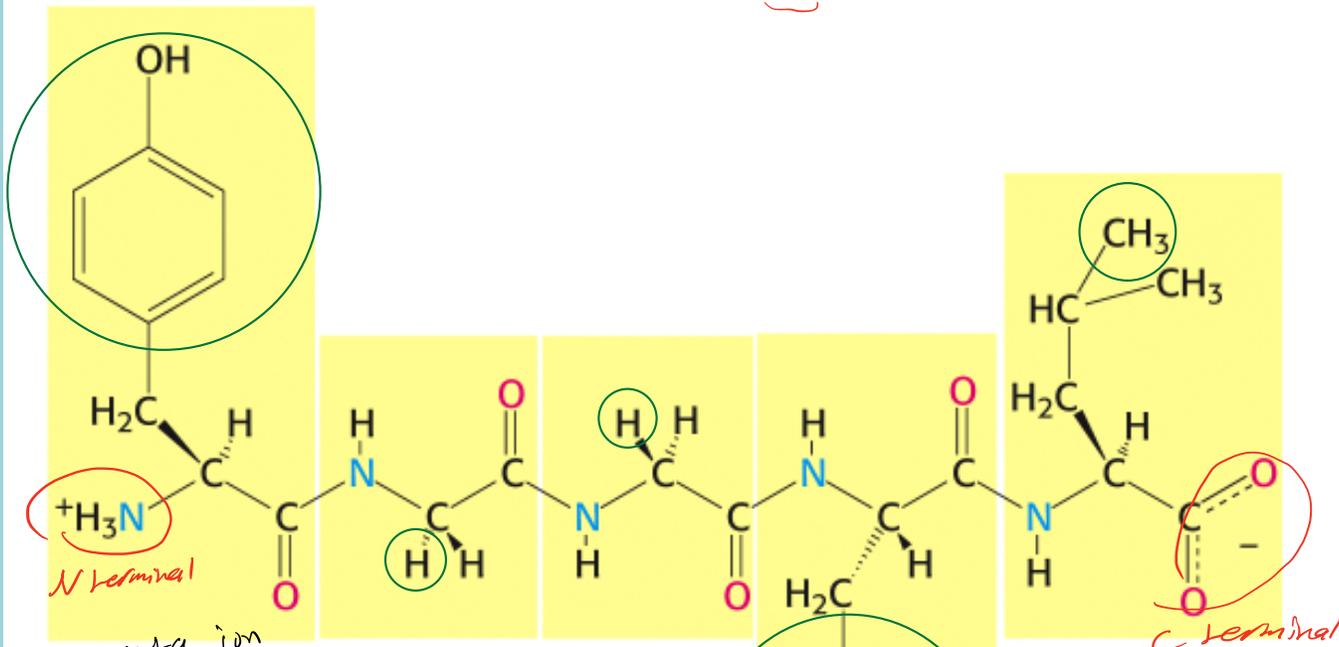
gene expression  
البروتين يتكون من RNA و DNA  
بعض البروتينات تتكون من RNA و DNA

# Polypeptide chain has direction

سلسلة بوليببتيد

Side chain of amino acid  
 عدد اقل من 20

طريق الايض في الخلية  
 احاطة في جسم الخلية  
 بعضه من نقل البروتين في نقله  
 الازوت في transcription  
 MRNA  
 RNA من translation  
 Sequence of amino acid



الذئبان الى على  
 Side chain  
 constant  
 back bone

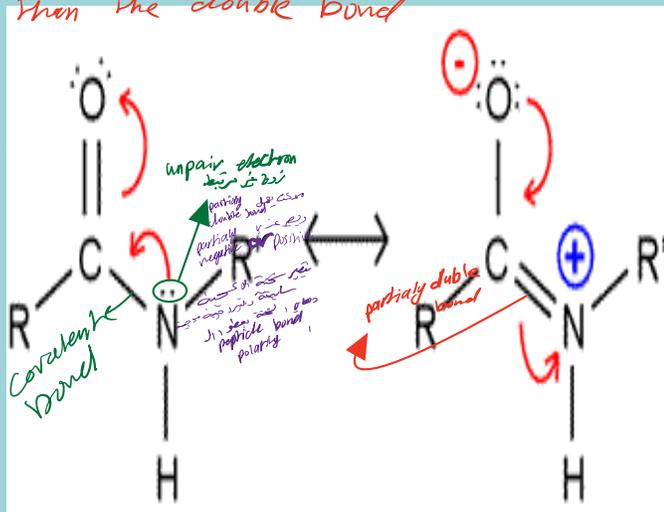
Tyr                      Gly                      Gly                      Phe                      Leu

Amino terminal residue                      Carboxyl terminal residue

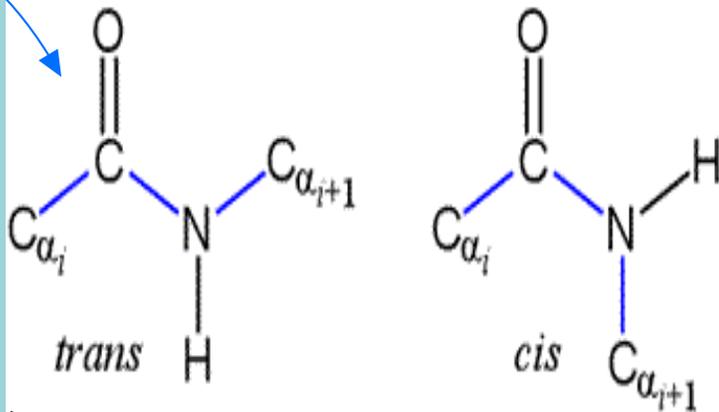
# Characteristics of the peptide bond:

1. It is a covalent bond.
2. Strong bond
3. Peptide bond is uncharged but polar
4. Lack of rotation around the bond: The peptide bond has a partial double-bond character- that is; it is shorter than a single bond and is therefore rigid and planar.

Single bond halter than the double bond



5. Trans configuration: The peptide bond is generally a trans bond (instead of cis).



لهذا الرابطة Trans هي الجواب

Trans form is strongly favoured because of steric clashes that occur in the cis form

دعنا لو كاننا نفضل اذكي يكون مع ال side chain كبرهنا ونازلة  
 ومانتة كبرهنا ال side chain  
 راجع ال clash  
 حنا يكون المراد ستر

الذات سوا حلها بطلو انك من ال single bond راكر بتوي من ال double bond  
 عنتين فلتسوا  
 كلام موجودين

partial

partially polar

covalent bond

unpair electron

partially double bond



# Proteins Biomedical Importance

- 1- They provide immune protection, antibodies search out foreign invaders.  
*الغزاة*
- 2- They function as catalysts: enzymes catalyse reactions that generate energy, synthesize and degrade biomolecules, replicate and transcribe genes, etc.  
*حفزات*
- 3- They transport and store other molecules such as Haemoglobin transports oxygen.
- 4- They provide mechanical support, the internal protein network "cytoskeleton", maintains cellular shape and physical integrity.
- 5- They generate movement, actin and myosin filaments form the contractile machinery of muscle.  
*على امتداد الخلية*  
*متجهين*
- 6- They work as receptors that enable cells to sense and respond to hormones and other environmental cues.



# Protein structure → one polypeptide or more than one بمجرد واحد أو أكثر

## Four levels of protein structure:

Primary structure (Amino acid sequence) → all the proteins and all the polypeptides have primary structure  
البنية الأولية  
جميع البروتينات وجميع الببتيدات لها بنية أولية

Secondary structure  $\alpha$ -helix,  $\beta$ -sheet, turns  
البنية الثانوية

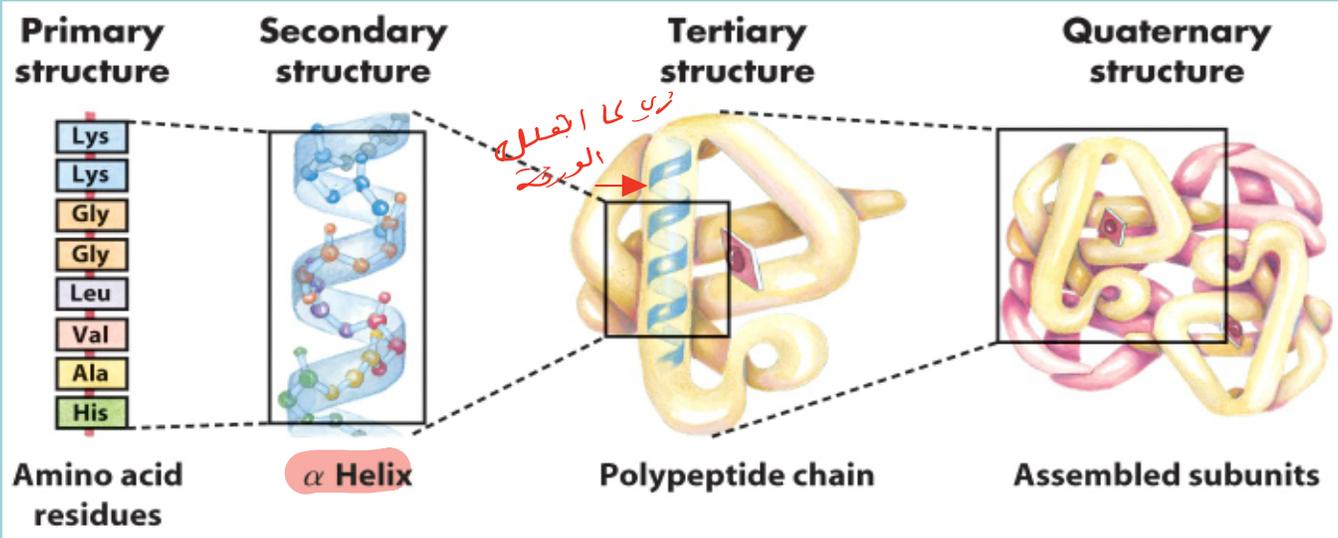
3D-structure ↓

Tertiary structure: Three-dimensional structure formed by assembly of secondary structures



Quaternary structure: formed by more than one polypeptide chains

البنية الرباعية  
تتكون من أكثر من سلسلة ببتيد



# 1- Primary structure of proteins

The primary structure is the **sequence of residues (amino acids)** in the polypeptide chain.

البنية الأولية للبروتين هي تسلسل الأحماض الأمينية في السلسلة الببتيدية

By convention, the primary structure of a protein is reported starting from the **amino-terminal (N) end** to the **carboxy-terminal (C) end**.

تبدأ تسلسل الأحماض الأمينية من الطرف الأميني (N) إلى الطرف الكربوكسيل (C)  
 كودون AUG هو كودون البداية  
 كودون UAG و UGA هما كودونات التوقف  
 AUG هو كودون البداية  
 UAG و UGA هما كودونات التوقف

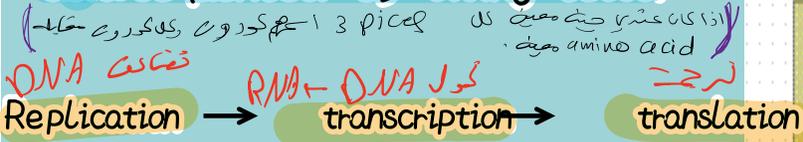
The sequence of amino acids in a protein is determined by the **genetic code** for the protein.

الشفرة الجينية  
 تسلسل الأحماض الأمينية  
 في البروتين

The genetic code is the set of rules by which information encoded in genetic material (DNA or mRNA sequences) is translated into proteins (amino acid sequences) by living cells.

الشفرة الجينية هي مجموعة القواعد التي تحدد كيفية ترجمة المعلومات المشفرة في المادة الجينية (سلسلة DNA أو mRNA) إلى بروتينات (سلسلة أحماض أمينية) بواسطة الخلايا الحية.

		Second letter			
		U	C	A	G
First letter	U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine
		UUC Phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine
	UUA Leucine	UCA Serine	<b>UAA Stop codon</b>	<b>UGA Stop codon</b>	
	UUG Leucine	UCG Serine	<b>UAG Stop codon</b>	UGG Tryptophan	
	C	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine
		CUC Leucine	CCC Proline	CAC Histidine	CGC Arginine
CUA Leucine		CCA Proline	CAA Glutamine	CGA Arginine	
CUG Leucine		CCG Proline	CAG Glutamine	CGG Arginine	
A	AUU Isoleucine	ACU Threonine	AAU Asparagine	AGU Serine	
	AUC Isoleucine	ACC Threonine	AAC Asparagine	AGC Serine	
	AUA Methionine; initiation codon	ACA Threonine	AAA Lysine	AGA Arginine	
	<b>AUG Methionine; initiation codon</b>	ACG Threonine	AAG Lysine	AGG Arginine	
G	GUU Valine	GCU Alanine	GAU Aspartic acid	GGU Glycine	
	GUC Valine	GCC Alanine	GAC Aspartic acid	GGC Glycine	
	GUA Valine	GCA Alanine	GAA Glutamic acid	GGA Glycine	
	GUG Valine	GCG Alanine	GAG Glutamic acid	GGG Glycine	



Sequence of amino acid





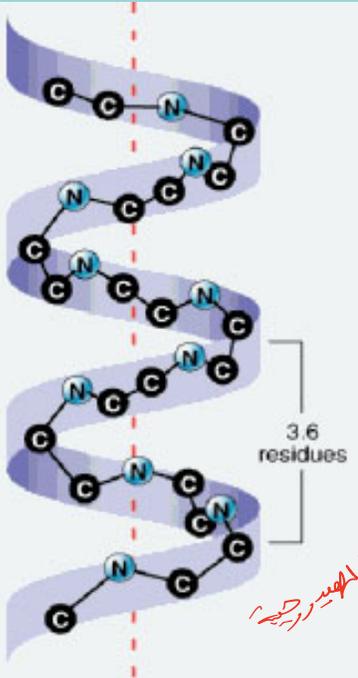
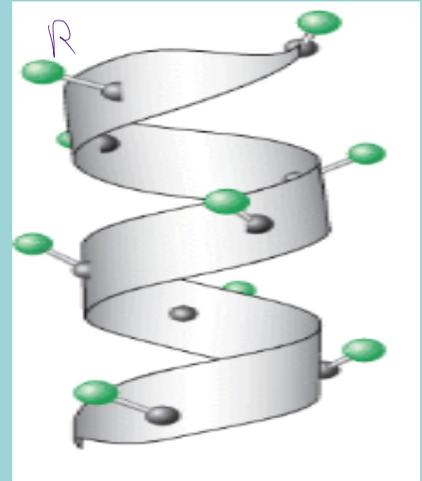
# α-helix

زنجیره تکرار شونده وجود رابطه  
صدا زنجیره ای بین آل backbone  
الذاتکة البرابطة وصل (یعنی فشار رابطه)

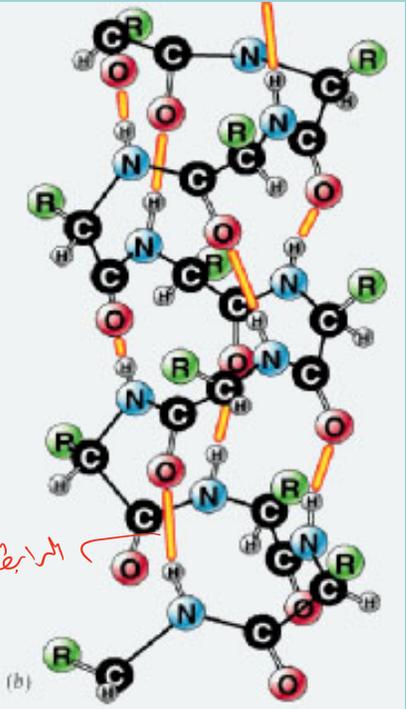
طغنون

In the alpha helix, the polypeptide chain is coiled tightly in the fashion of a spring.  
The "backbone" of the peptide forms the inner part of the coil while the side chains extend outward from the coil.

داخلي  
Backbone كجوا  
Side chain زنجيرا



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الرابطة الهيدروجينية

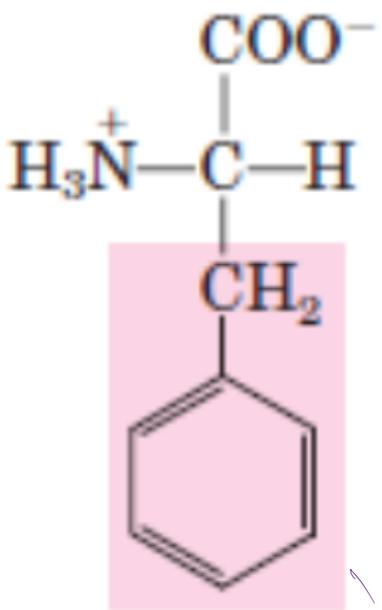
The helix is stabilized by hydrogen bonds between the N-H of one amino acid and the C=O of the 4th amino acid away from it. One "turn" of the coil requires 3.6 amino acid units.

بكل لفه  
كاسم يتسلف مع باقي  
بعدما وصل الى آخر

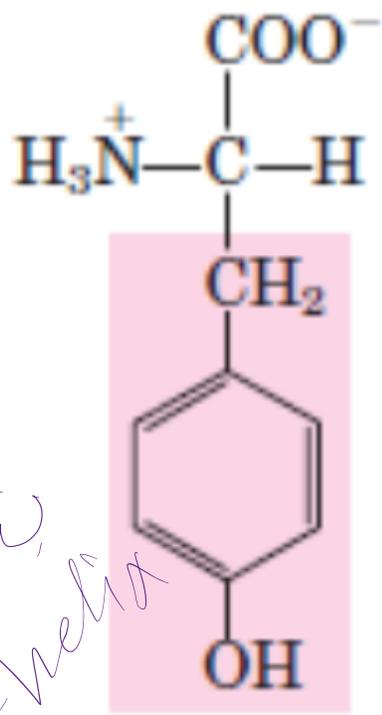


ذاتیہ لہریکے لئے سے  $\alpha$ -helix ہو وجود ندارد بصورتی چیتے سے ال  $\alpha$ -helix کو جو amino acid back bone

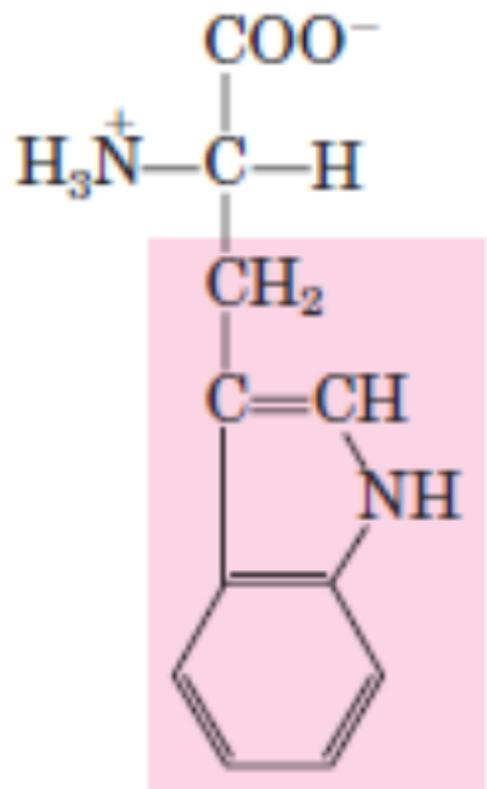
## Aromatic R groups



Phenylalanine



Tyrosine



Tryptophan

*Handwritten note:*  $\alpha$ -helix

# $\beta$ -sheet

→ رتبه و جود روابط هیدروژنی  
بسیار با هم  
backbone

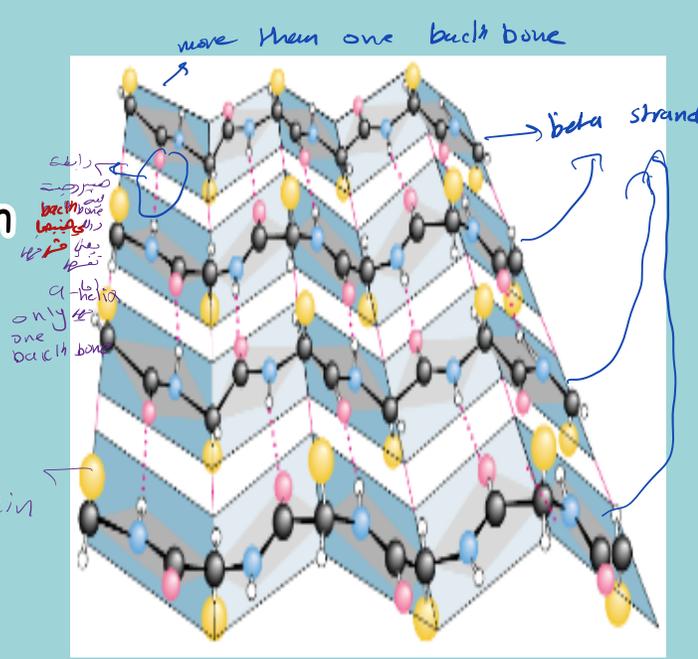
The  $\beta$  sheet (also  $\beta$ -pleated sheet) is less common than the  $\alpha$ -helix.

Beta sheets consist of beta strands connected laterally by at least two or three backbone hydrogen bonds, forming a generally twisted, pleated sheet.

A beta strand is a stretch of polypeptide chain typically 3 to 10 amino acids long with backbone in an almost fully extended conformation.

The majority of  $\beta$  strands are arranged adjacent to other strands and form an extensive hydrogen bond network with their neighbors in which the N-H groups in the backbone of one strand establish hydrogen bonds with the C=O groups in the backbone of the adjacent strands.

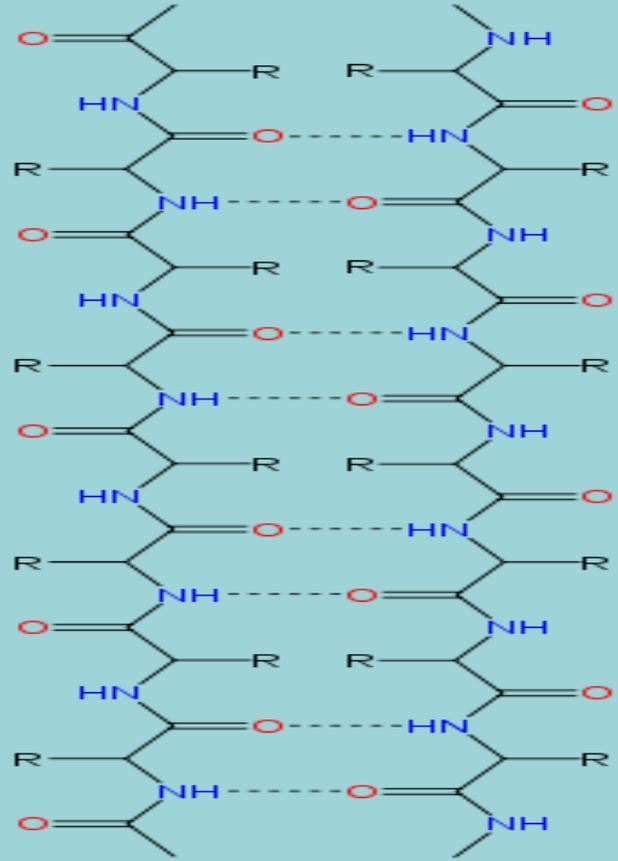
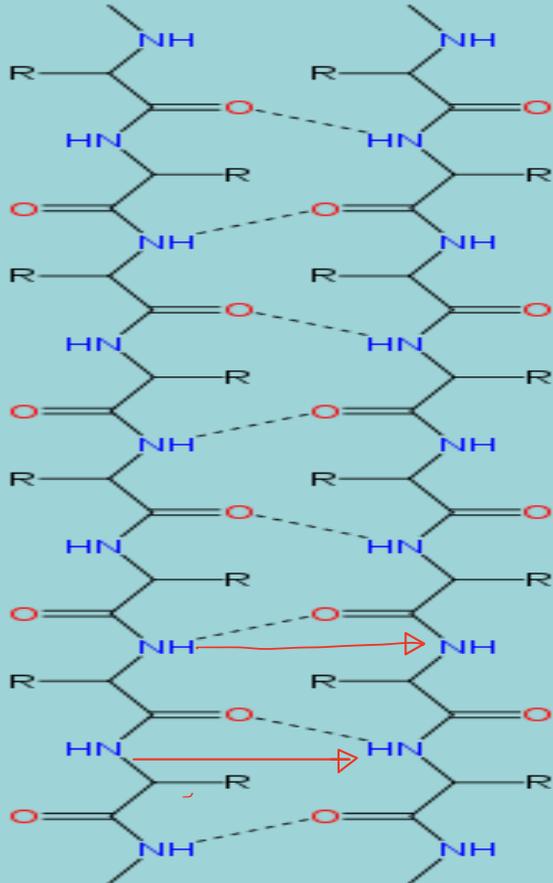
In the fully extended  $\beta$  strand, successive side chains point straight up, then straight down, then straight up, etc.



که یکی از آن a-helix زیاده که 4 تا 5 رتبه  
قریبی به 3 تا 4 رتبه  $\beta$ -sheet  
جذب به هم رتبه 3 تا 4

ashes  
a-helix  $\rightarrow$  one chain  
 $\beta$ -sheet  $\rightarrow$  more than one chain

# Parallel and antiparallel $\beta$ -sheets



الكربوكسيلية موازية الكربونيل

**Parallel:** Adjacent polypeptide chains running in the same direction

**Antiparallel:** when the adjacent polypeptide chains run in opposite direction

# Turns (loops)

α-helix  
β-sheet  
α-helix  
β-sheet

A turn is an element of secondary structure in proteins where the polypeptide chain reverses its overall direction

→ polypeptide amino acid sequence  
سلسلة الأحماض الأمينية (سلسلة) ←

A turn is a structural motif where the C<sup>α</sup> atoms of two residues separated by few (usually 1 to 5) peptide bonds are in close approach (< 7 Å), while the corresponding residues do not form a regular secondary structure element such as an alpha helix or beta sheet.

## Tight turns

are classified according to the separation between the two end residues:

A- In an **Alpha-turn** the end residues are separated by **four peptide bonds**

B- In a **Beta-turn** or **Beta-bend** (the most common form) by **three bonds**

C- In a **Gamma-turn**, by **two bonds**

D- In a **Delta-turn**, by **one bond**

E- In a **π-turn**, by **five bonds**

amino acid sequence 3 bonds for tight turn  
← four →  
n-1

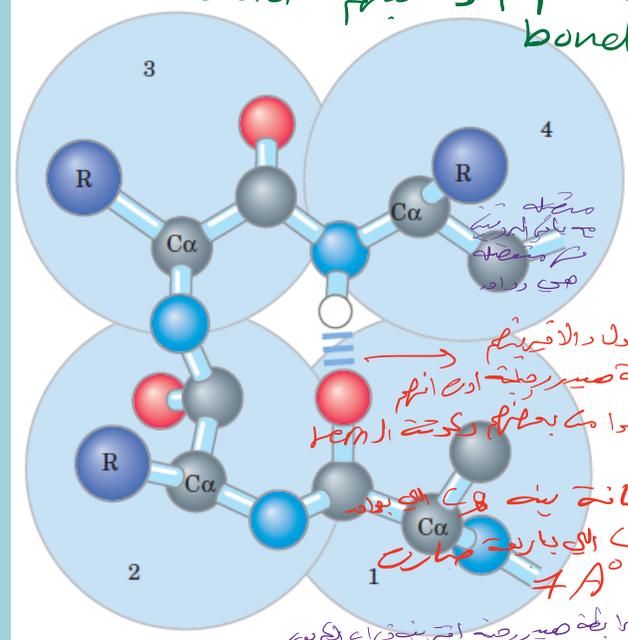
# β-Bends

Often found at sites where the peptide chain changes direction.

β-Bends are stabilized by the formation of hydrogen <sup>bond</sup> and by having a distance of less than 7Å between the Cα atoms of residues one and four

β-bends are generally composed of four amino acids, one of which may be proline that causes a "kink" in the polypeptide chain.

4 amino acid } peptide bond



1) الذرة والاقرب لهم  
رابطة هيدروجينية اذ انهم  
يقتربان مع بعضهما وكذا ال H-bond  
2) المسافة بينه وبين Cα التي ياربها  
اقل من 7 Å  
3) المسافة بين الذرة والاقرب لهم  
بين الذرة والاقرب لهم  
مسافة اقل من 7 Å

المسافة بين الذرة والاقرب لهم  
المسافة اقل من 7 Å

طبيعة هذه موجودة في ال turn كما اننا نلاحظ في ال biologically active ال كبريت

Glycine, the amino acid with the smallest R-group, is also frequently found in β-bends.

3D structure  
Secondary structure  
turn  
المسافة اقل من 7 Å

# Super secondary structures (also called motifs)

بنية مستوية  
Secondary structure

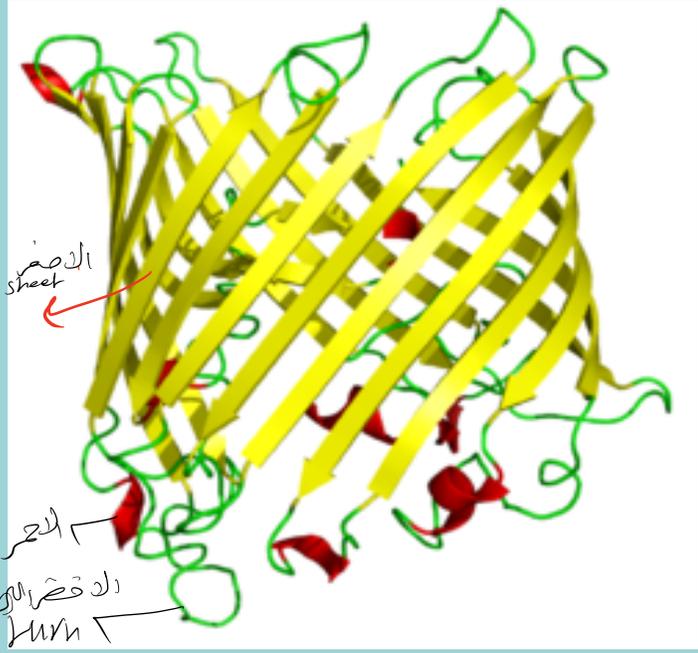
Super secondary structures are combinations of alpha-helices and beta-structures connected through loops.

رابط

These folding patterns are stabilized through the same kind of linkages than the tertiary level. Sometimes the term "motif" is used to describe these super secondary structures.

بنية  $\beta$ -sheet و  $\alpha$ -helix  
بنية مستوية و بنية حلزونية  
بنية مستوية و بنية حلزونية

These structures can be relatively simple, as alpha-alpha (two alpha helices linked by a loop), Beta-Beta (two beta-strands linked by a loop), Beta-alpha-Beta (Beta-strand linked to an alpha helix that is also linked to other beta strand, by loops) or more complex structures, like the beta-barrel.



الاصفر  
 $\beta$ -sheet  
الحلزون  
 $\alpha$ -helix  
الدقيرة  
turn

Beta-barrel motif