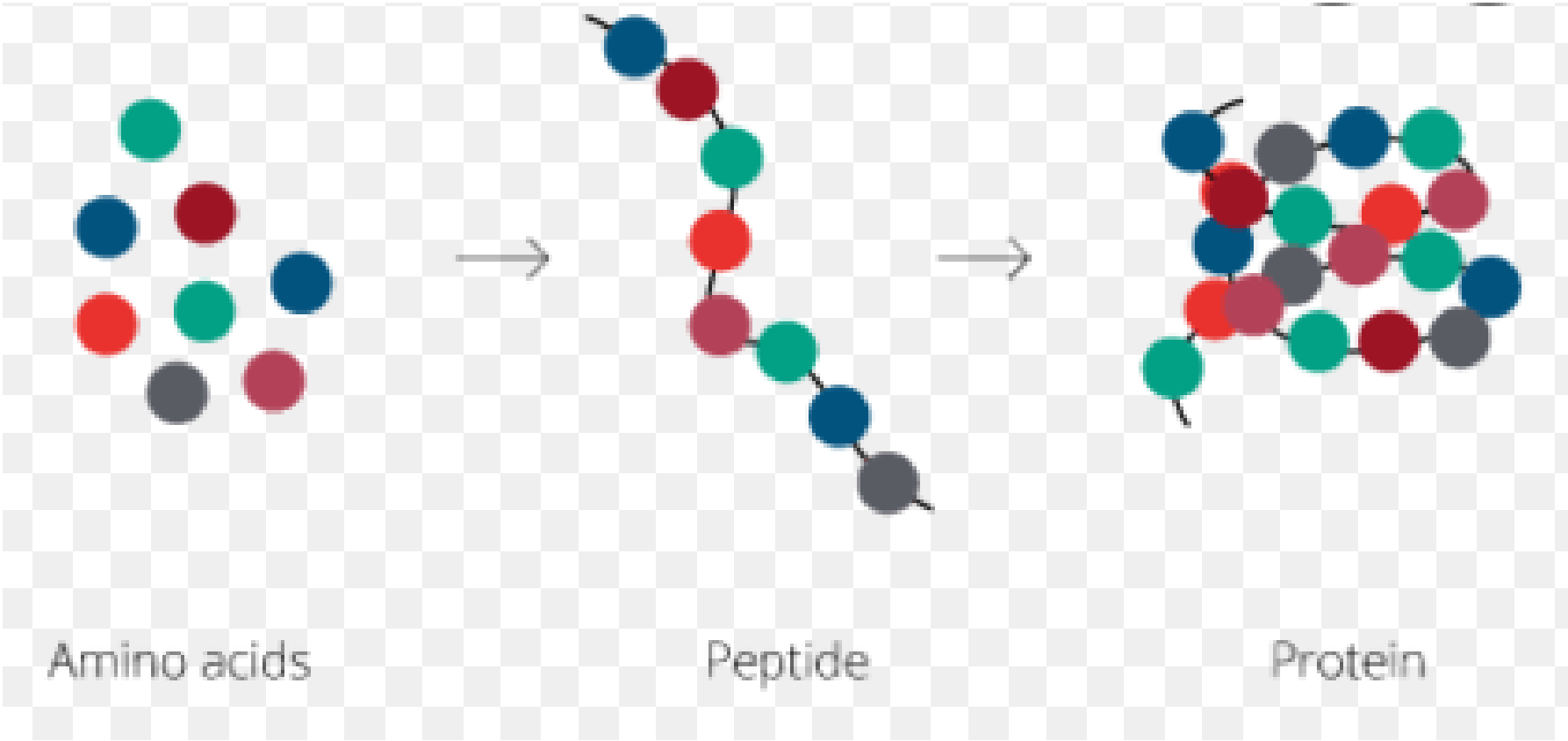
Peptide and polypeptide formation and properties



PEPTIDE/POLYPEPTIDES

-Peptides are polymers of amino acids.

- Peptides are small condensation products of amino acids

-Their structure and functions depend upon
- Nature of amino acids present in them,
-Sequence of amino acids,
-Spatial relationship of amino acids.

-Many peptides are formed from breakdown of proteins

Peptide- Peptides are relatively small polymers, 2-10 amino acid unit. If 2 amino acids were involved then called Dipeptide viz, tripeptide for 3 amino acid unit and Decapeptide for 10 unit.

Oligopeptide :a few amino acids

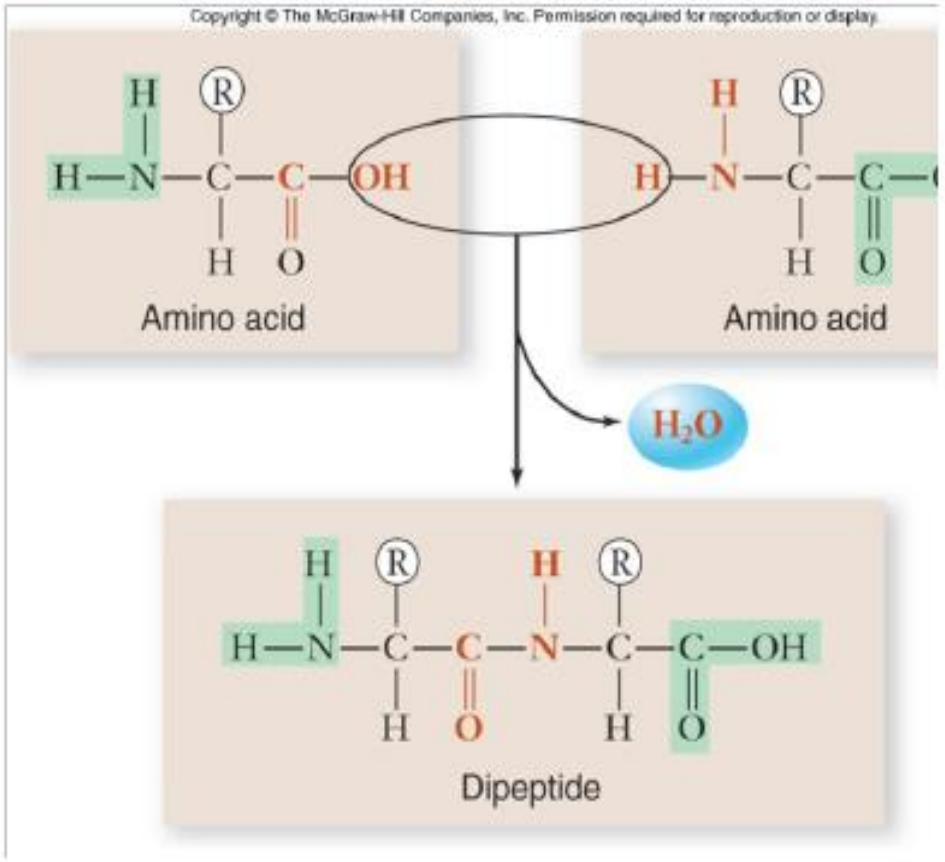
Polypeptide- big peptides are called polypeptides more than 50 amino acids

Polypeptide : many amino acids

Peptide bonds occur between amino acids

- The COOH group of 1 amino acid binds to the NH2 group of another amino acid

- Forms a peptide bond!

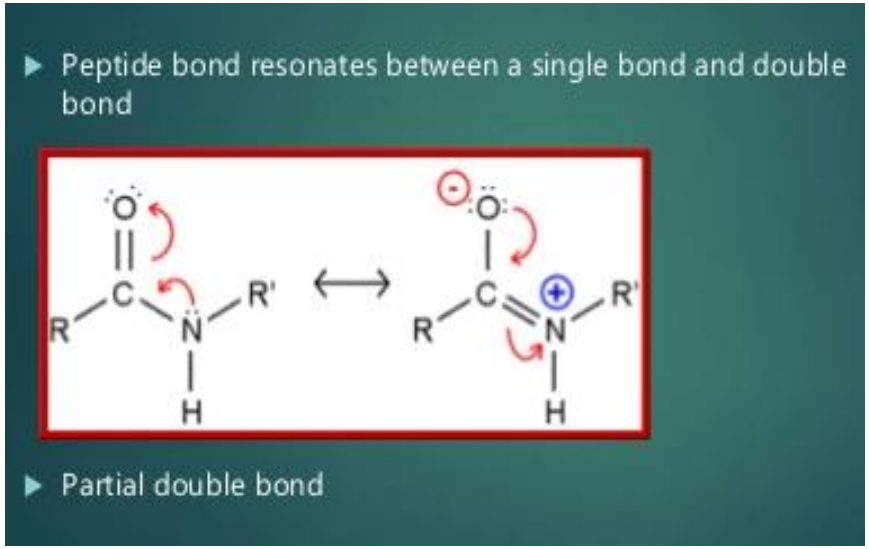


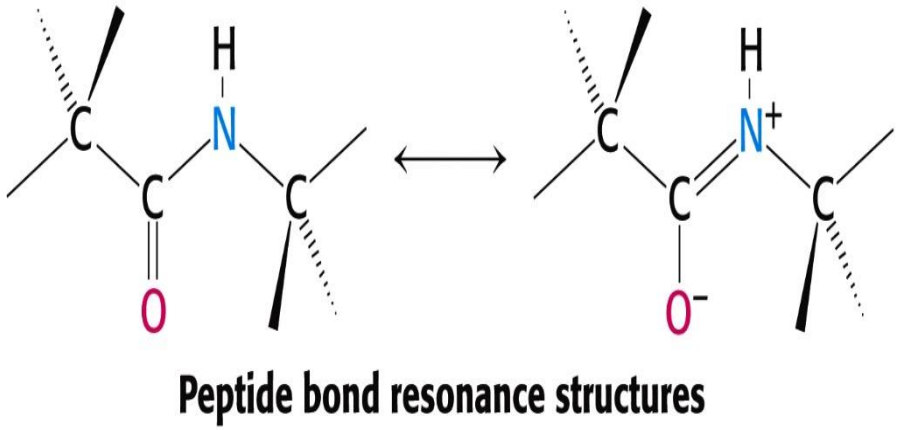
Features of peptide bond

- Peptide bond is an amide linkage formed **between carboxyl group and amino group** by removal of water molecule. The reaction is called **condensation** reaction.
- **Covalent bonding** interactions leading to the stability of protein structure.
- The peptide bond is rigid and planar and the atoms in the peptide bond are **Cα-C-N-Cα.**
- The peptide bond is coplanar, this indicates a resonance or partial sharing of two pairs of electrons between the carbonyl oxygen and the amide nitrogen.
- The 4 atoms of the peptide group (C, H, O, and N) lie in a single plane, in such a way that the oxygen atom of the carbonyl group and the hydrogen atom of the amide nitrogen are **trans** to each other.
- Peptide bond **has a partial double bond character** and shows **the resonance feature** which makes the **peptide bond strong and rigid and limits the rotation about this bond.**

Peptide bond resonance

- Peptide bonds have *partial* double bond character due to resonance that limits rotation about this bond:

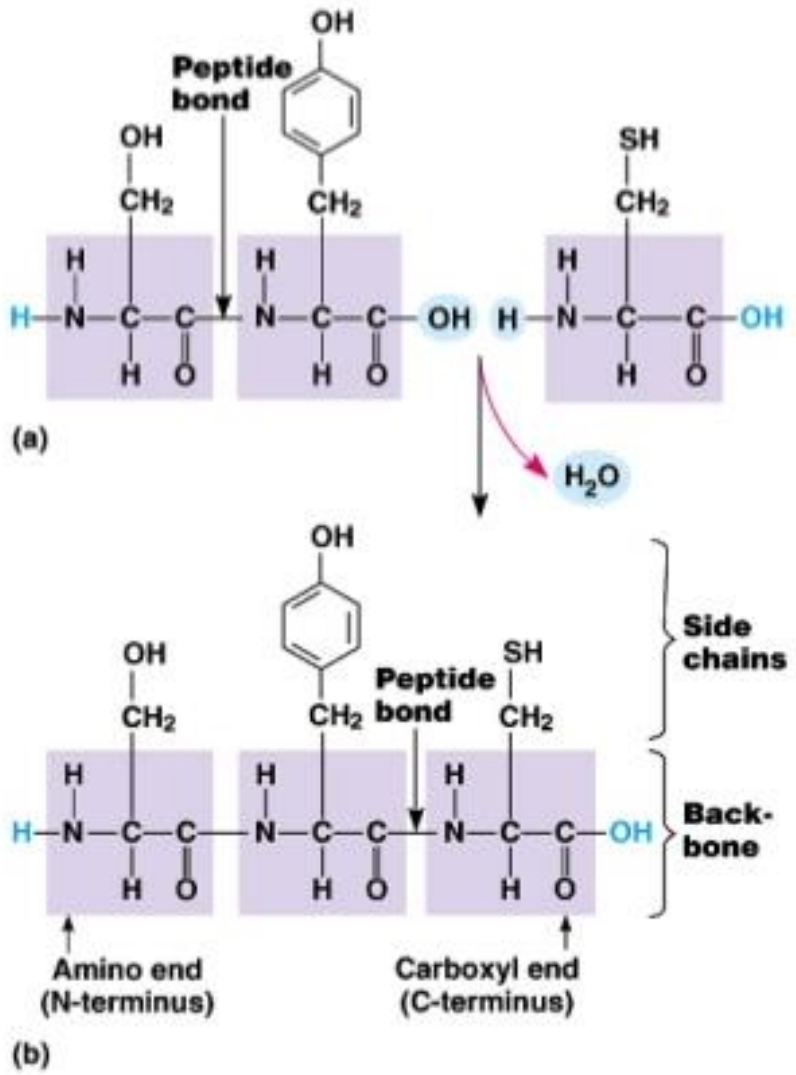




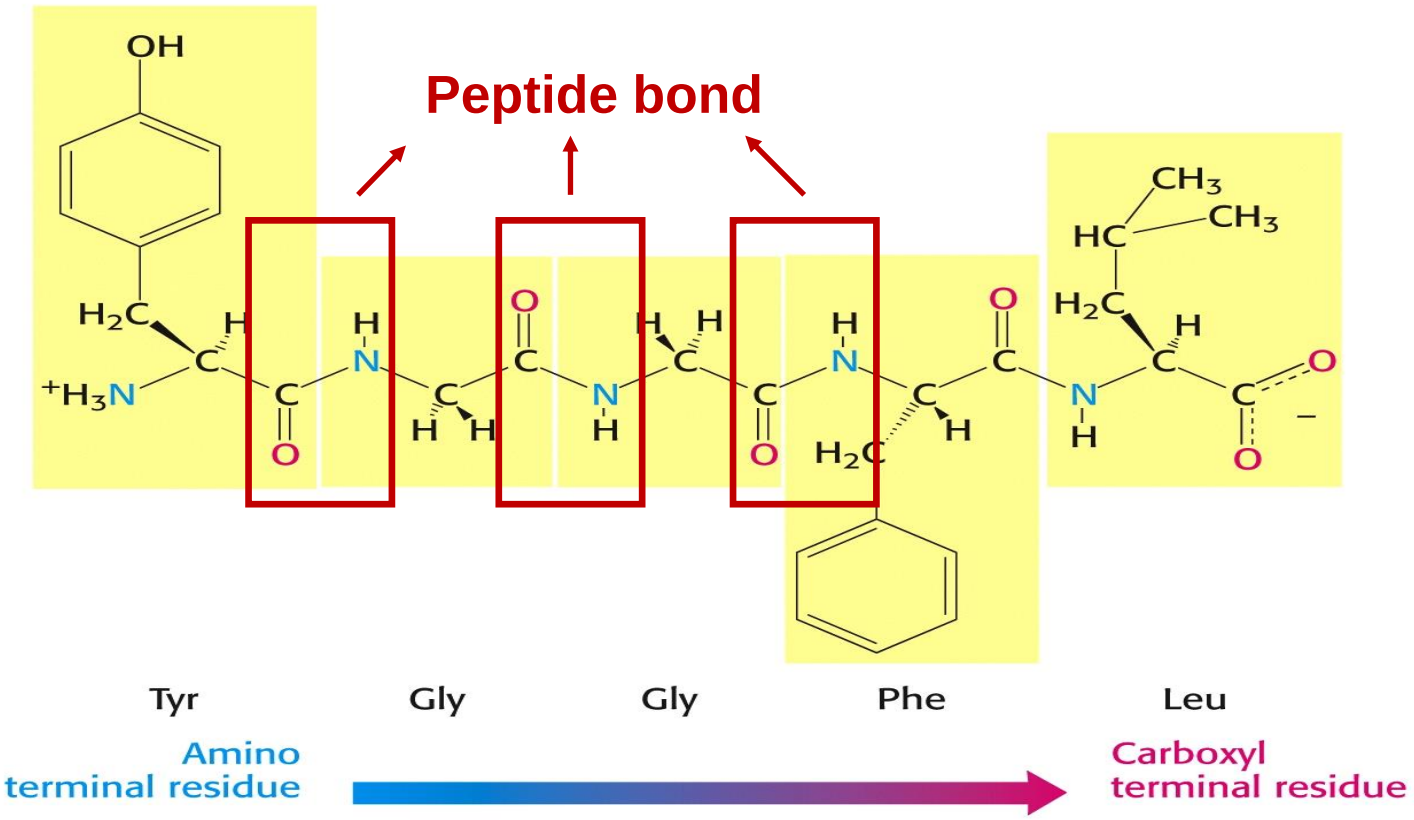
- **Resonating structures are formed due to delocalization of electrons in atoms**

Polypeptide formation

- Condensation reaction to join 2 amino acid
- Requires:
  - Carboxyl group
  - Amine
- **Peptide** bond: links between amino acids



Polypeptide chain



Naming of peptides

- The amino acid suffixes –ine (glycine), -an (tryptophan), -ate (glutamate) are changed to –yl with the exception of C-terminal amino acid
- **E.g, Glutamyl-cysteinyl-glycine**

$+H_3N$ –glutamate - cysteine - glycine - COO^- Amino acids in a peptide

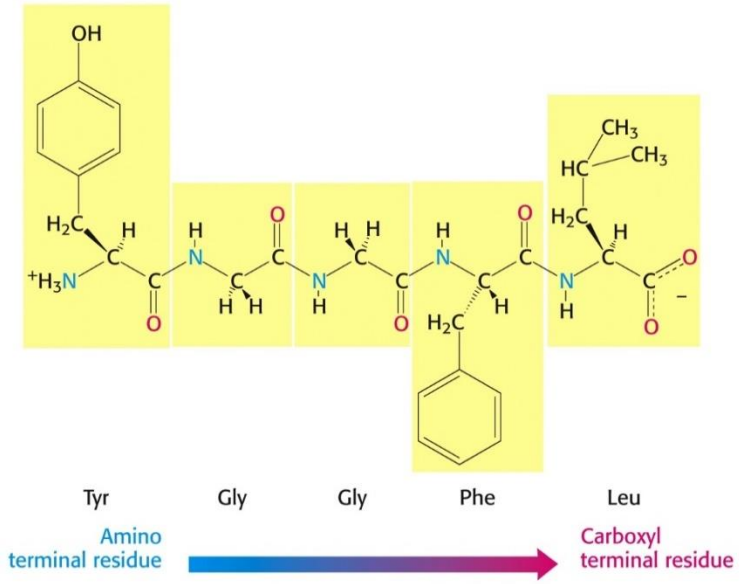
E - C - G One letter symbols

Glu - Cys - Gly Three letter symbols

Glutamyl - cysteinyl - glycine Peptide name

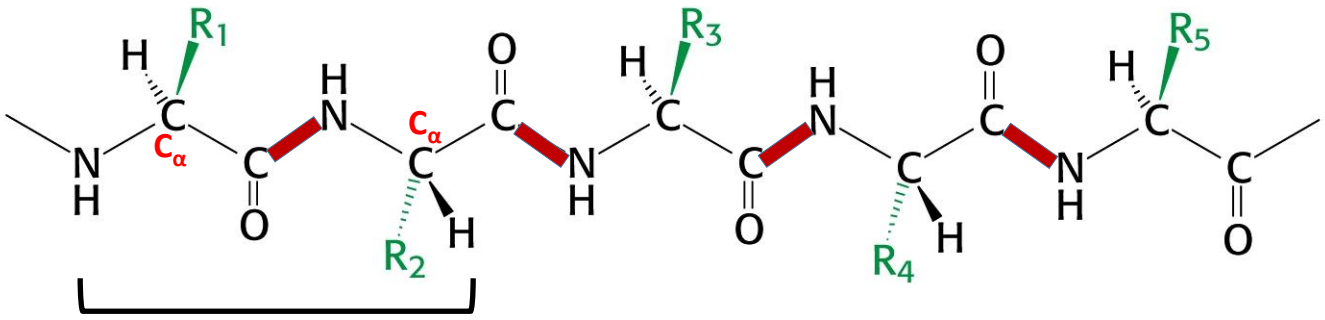
Features of polypeptide chain

- **Polarity**: Because of different ends- **amino end** (-NH_3^+) and a **carboxyl** end (-COO^-), polypeptide chain shows polarity.
- **Amino end** is the beginning of a polypeptide chain**.**
- Repeating part is the **main chain or backbone, whereas the** variable part **is the side chain.**
- **Hydrogen bonding potential of the backbone.** Carboxyl group is a good hydrogen bond acceptor.
- **Polypeptides containing** more than 50 residues are called proteins.
- Pentapeptide means 5 amino acids linked by 4 peptide bonds. Similarly, tripeptide (3 aa + 2 peptide bond), tetrapeptide (4 aa + 3 peptide bond) etc.



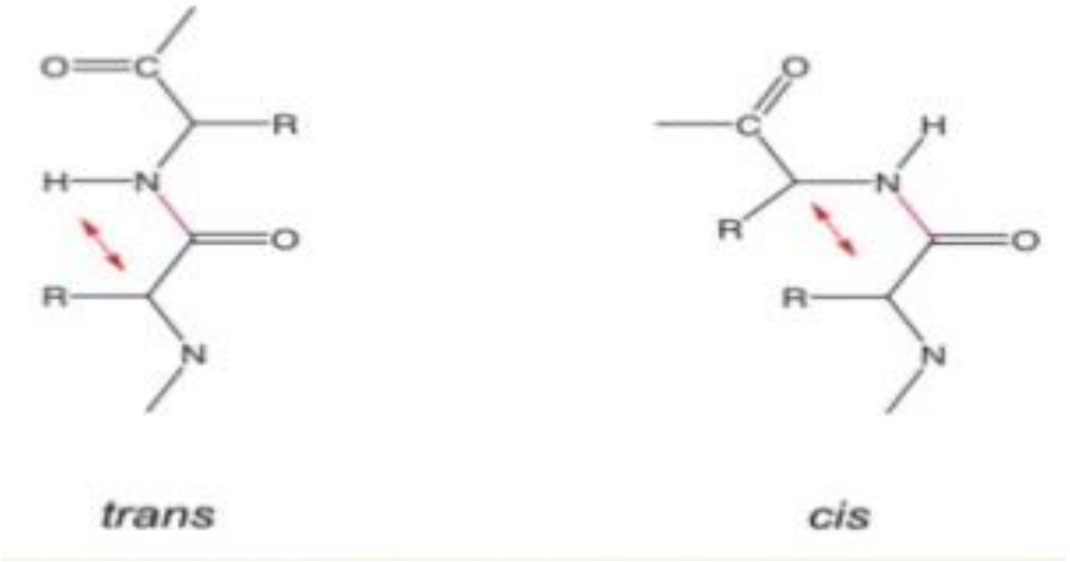
What is *trans* and *cis* configuration in a polypeptide chain?

- ***trans*** configuration: the two Cα- carbon atoms are on opposite side of a peptide bond.



***trans*- configuration**

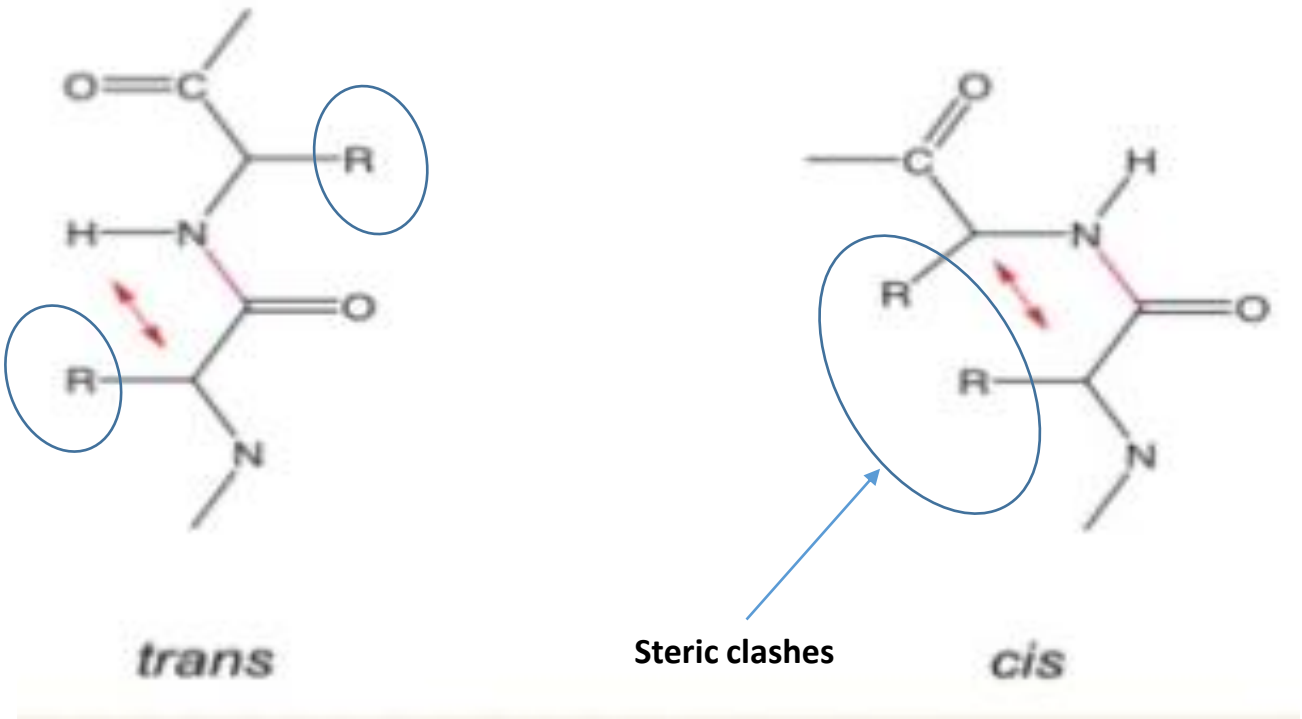
- ***cis*** configuration: the two Cα- carbon atoms are on the same side of a peptide bond.



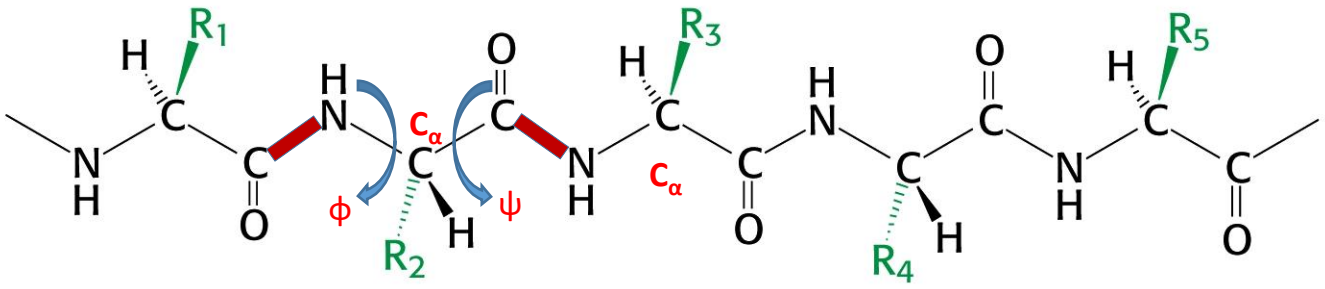
TRANS IS GENERALLY FAVORED OVER CIS:

- **Because *trans* configuration of peptides experience minimum steric interaction from the R groups.**

- ***Cis* –peptides are energetically extremely unfavourable because of steric clashes between the R groups attached to C-alpha carbon atoms**

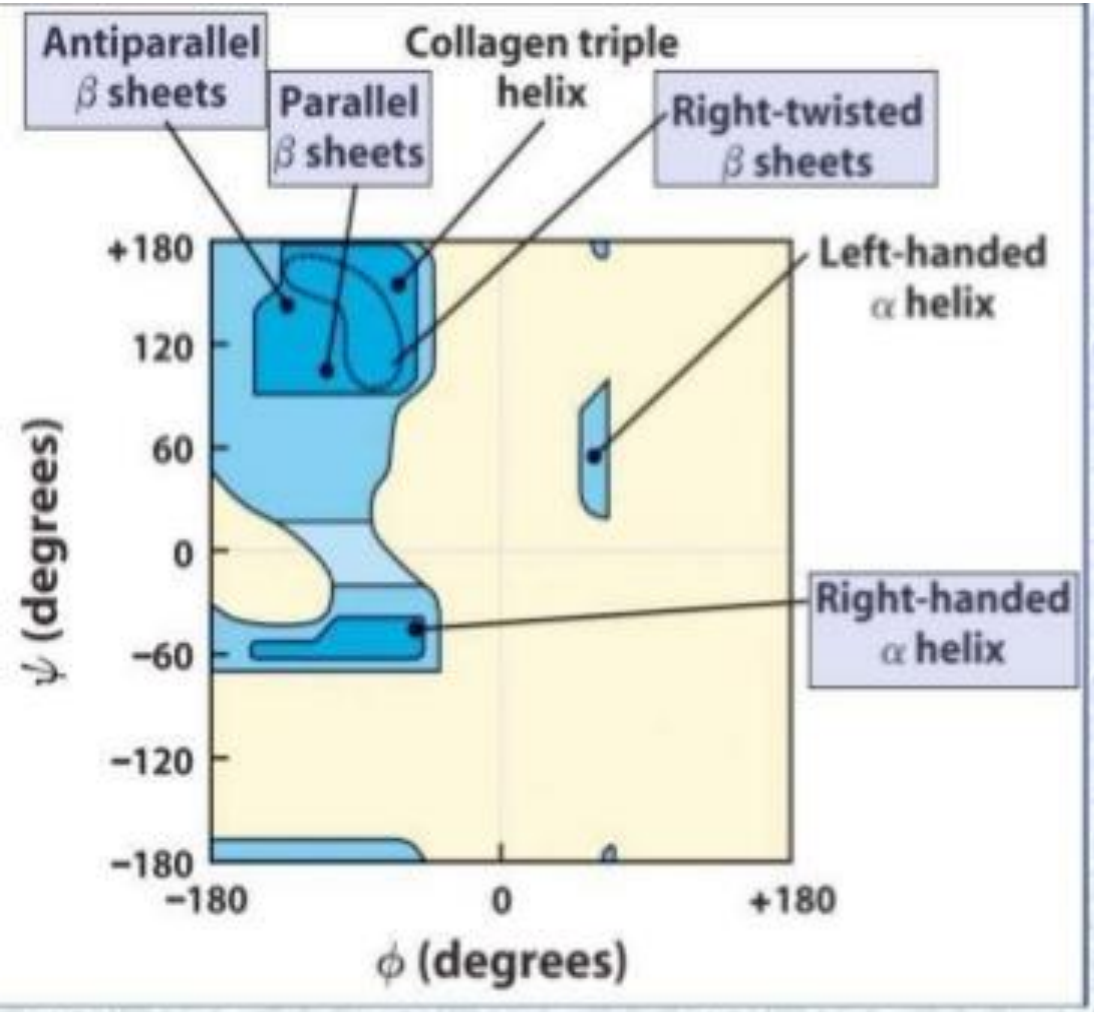


Rotation about bonds in a polypeptide chain



- The structure of each amino acid in a polypeptide can be adjusted by rotation around two single bonds.
  - **The two torsion angles of the polypeptide chain, describe the rotations of the polypeptide backbone around the bonds between N-Cα (called Phi, ϕ) and Cα-C (called Psi, ψ)**
- Phi and Psi angles determine the path of polypeptide chain. This freedom of rotation of amino acids allows proteins to fold in many ways.
- Phi and Psi angles are also called as **rotation angles or torsional angles or dihedral** angles. The angle lies between -180 and +180.

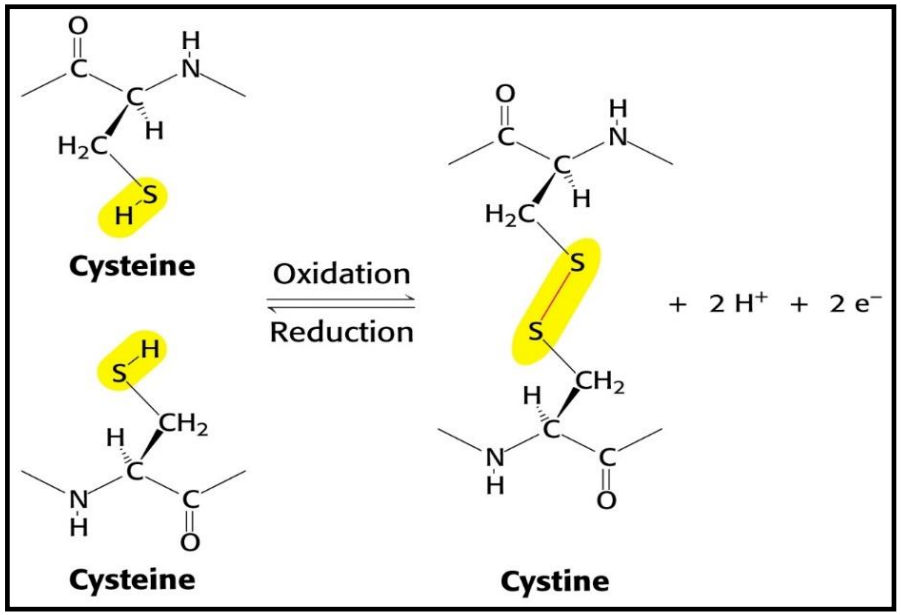
Ramachandran plot



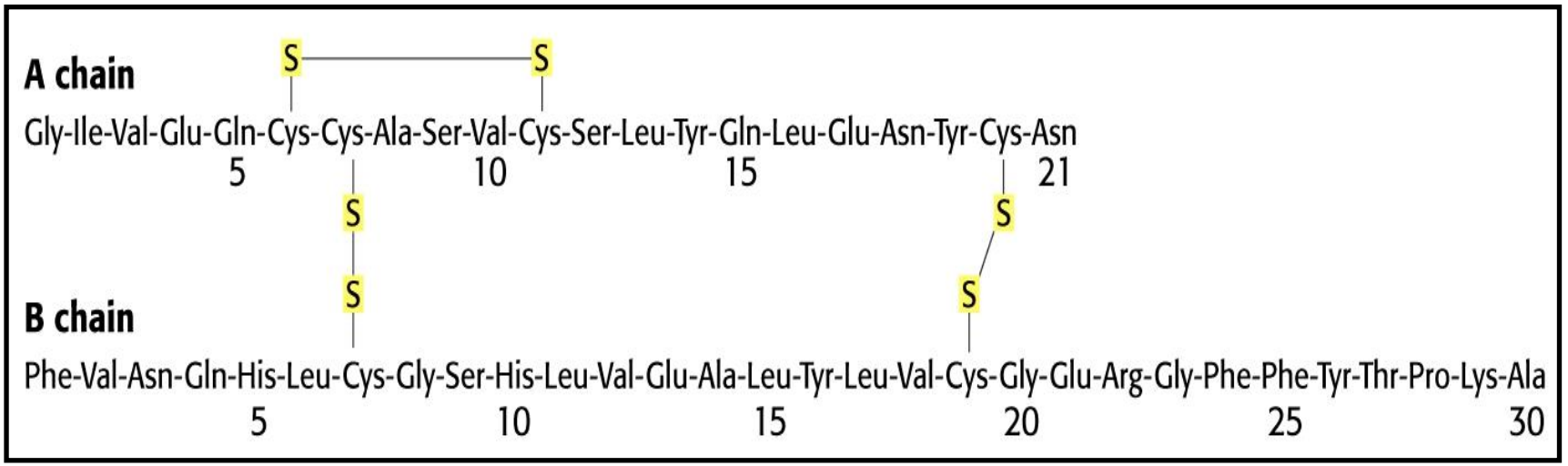
- A Ramachandran plot is a way to visualize backbone dihedral angles ψ against φ of amino acid residues in protein structure.
- A Ramachandran plot can be used to show which values, or conformations, of the ψ and φ angles are possible for an amino-acid residue in a protein and to show the empirical distribution of datapoints observed in a single structure.
- The darkest areas correspond to the "core" regions representing the most favorable combinations of phi-psi values.

- **Glycine and proline not included in Ramachandran plot**

Disulphide bonds between cysteine residues



- Pairs of sulphydryl groups may come together to form disulphide bonds.
- Disulphide bonds plays important role in Stabilizing proteins.
- Tertiary structure of a protein is stabilized by disulphide bond.



Amino acid sequence of a **bovine insulin**

Functions or Role of peptides

- Hormones and pheromones
  - insulin (sugar uptake)
  - oxytocin (childbirth)
  - sex-peptide (fruit fly mating)
- Neuropeptides
  - substance P (pain mediator)
- Antibiotics:
  - polymyxin B (for Gram - bacteria)
  - bacitracin (for Gram + bacteria)
- Protection, e.g. toxins
  - amanitin (mushrooms)
  - conotoxin (cone snails)
  - chlorotoxin (scorpions)

Biologically important peptides

Glutathione
Thyrotropin releasing hormone (TRH)
Oxytocin
Vasopressin
Angiotenins
Bradykinin
Methionine enkephalin

Sample questions

1. Amino acids are

a) building blocks of carbohydrates
b) building blocks of nucleic acids
c) building blocks of lipids
d) building blocks of proteins

2. Amino acids has

a) both amino group and carboxyl group
b) both amino group and keto group
c) amino group only
d) carboxyl group only

3. Which of the following is an α-imino acid

a) Serine
b) Threonine
c) Valine
d) Proline

4. The naturally occurring form of amino acid in proteins

a) L-amino acids only
b) D-amino acids only
c) both L and D amino acids
d) none of these

5. Sulphur containing amino acids are

a) Cysteine and methionine
b) Methionine and threonine
c) Cysteine and threonine
d) Cysteine and serine

6. Aromatic amino acids include

a) Phenylalanine, tyrosine and tryptophan
b) Phenylalanine, serine and tryptophan
c) Threonine, tyrosine and tryptophan
d) Asparagine, tyrosine and tryptophan

7. Which of the following is not the classified form of conjugated proteins?

a) Lipoproteins
b) Glycoproteins
c) Metalloproteins
d) Complete proteins

8. Which part of the amino acid gives it uniqueness?

a) Amino group
b) Carboxyl group
c) Side chain
d) None of the mentioned

9. Amino acids are

a) Amphipathic
b) Amphiprotic/amphoteric

10. Which amino acid absorbs UV light?

a) Tryptophan
b) Valine
c) Isoleucine
d) Serine

11. Which amino acid has phenol group in its side chain?

a) Tryptophan
b) Phenylalanine
c) Tyrosine
d) Serine

12. Peptide bond is a _____

a) Covalent bond
b) Ionic bond
c) Metallic bond
d) Hydrogen bond

13. A tripeptide has _____

a) 3 amino acids and 1 peptide bond
b) 3 amino acids and 2 peptide bonds
c) 3 amino acids and 3 peptide bonds
d) 3 amino acids and 4 peptide bonds

14.How many respective amino acids are present in a below given amino acid sequence?

H_2N…A-G-K-Y-K-F-Y-L-M-Y-T-H-K-D-H-I-C-C-E-N-A-A-Q-R…COOH

Tyrosine ?

Lysine ?

Phenylalanine ?

Glutamine ?

Aspartate ?

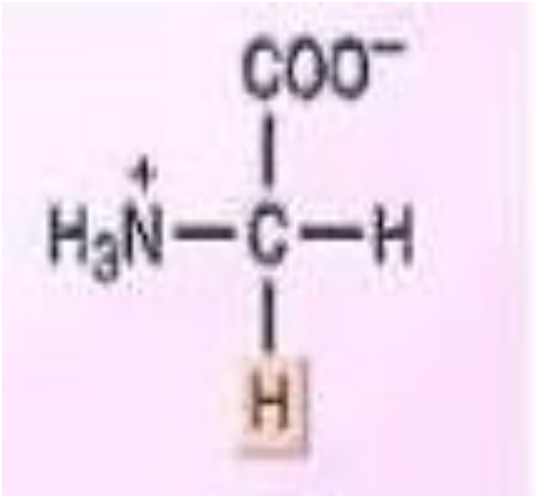
Glutamate ?

Asparangine ?

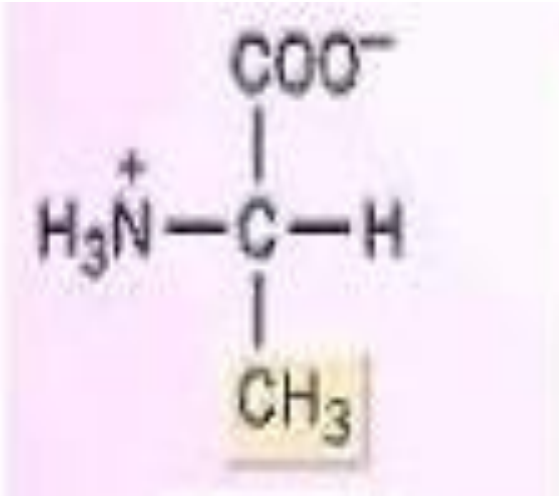
Arginine ?

Tryptophan ?

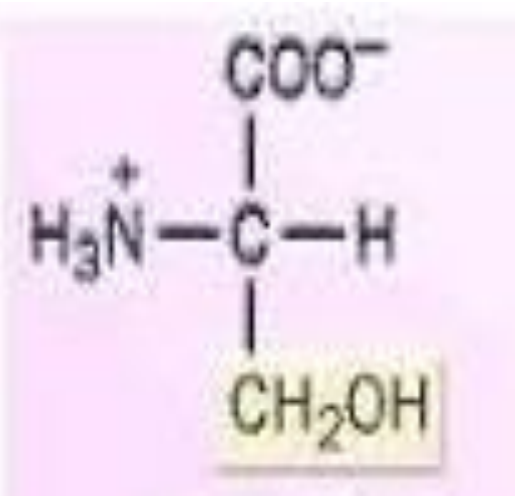
15) Below given is three amino structures. Determine which amino acid do not have chiral carbon, C-alpha? What are the names of the amino acids.



A



B



C

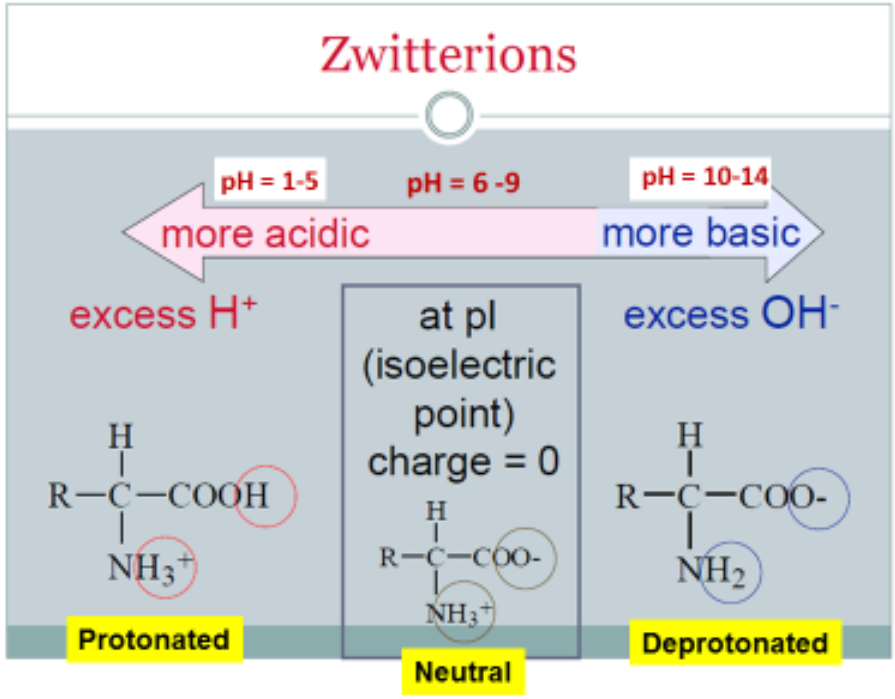
16. The following questions refer to the structures A-E below:

a) Which is a “zwitterion”?

b) Which represents the structure of an amino acid at very high pH?

c) Which represents the structure of an amino acid at very low pH?

d) Which structure is not possible



At cellular pH 7.4 , all amino acids exist as “Zwitterions”.