Ministry of Higher Education and Scientific Research
AL-Mustaqbal University College of Science
Department of medical biotechnology

Biochemistry

Lecture 2

Amino Acid and Peptides

By
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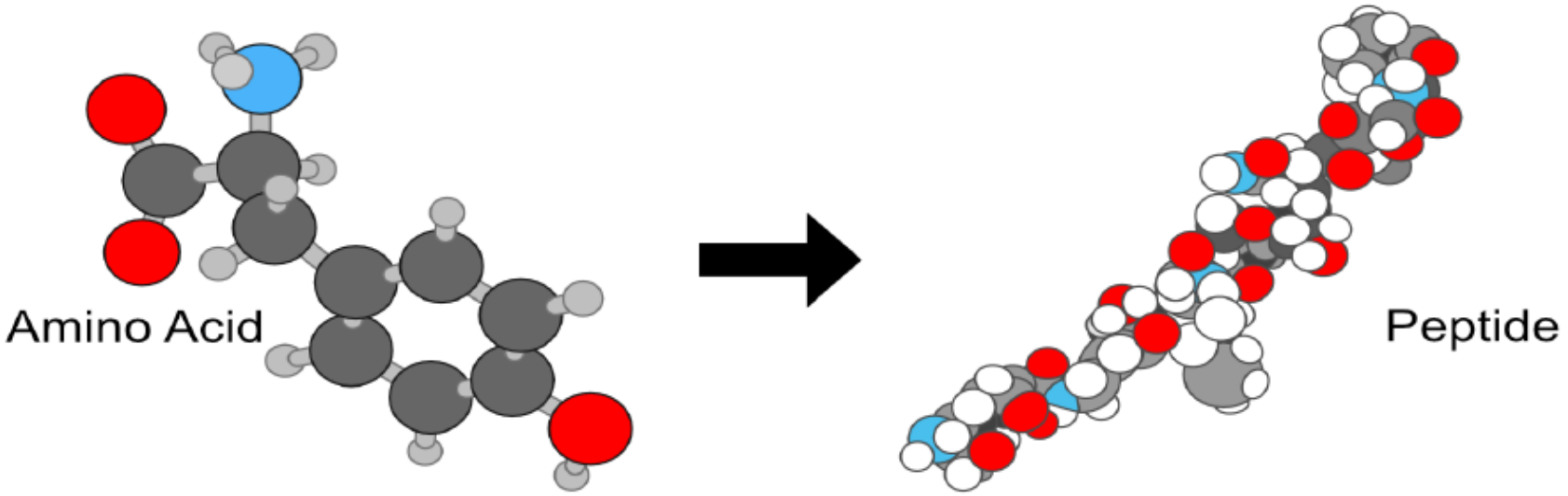
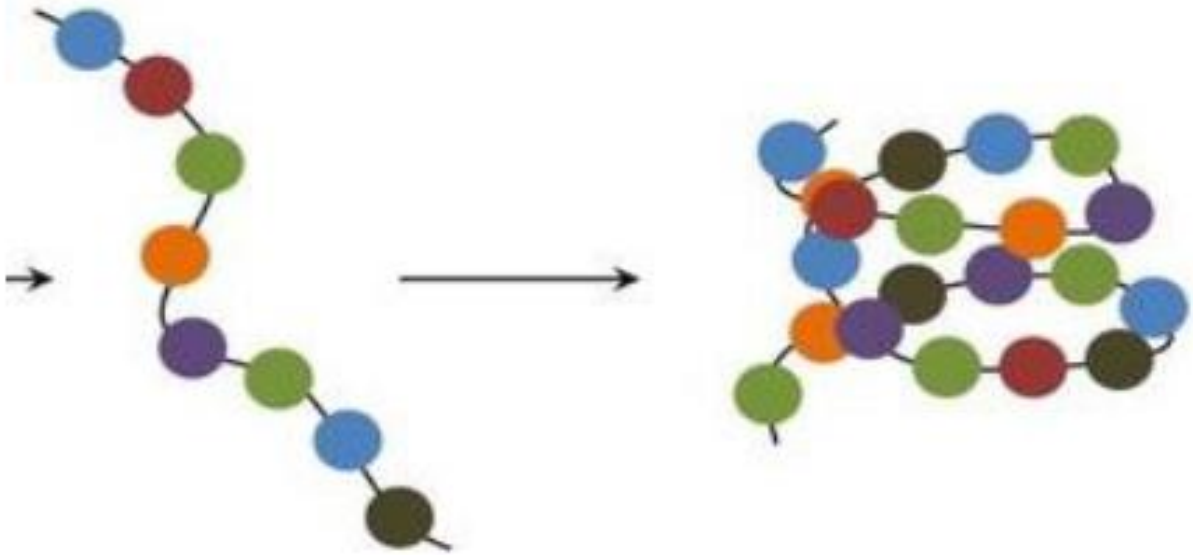
Amino acids, peptides And polypeptides





peptide

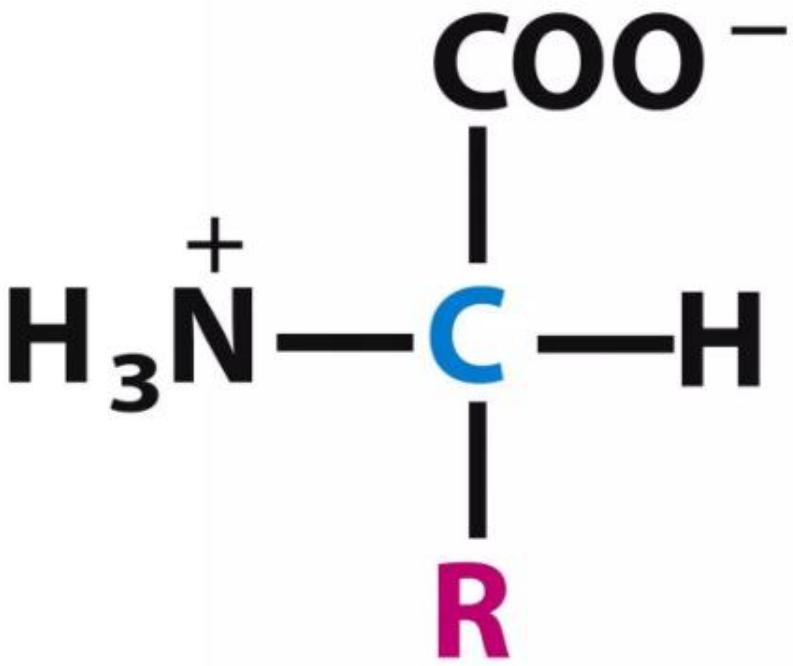
protein

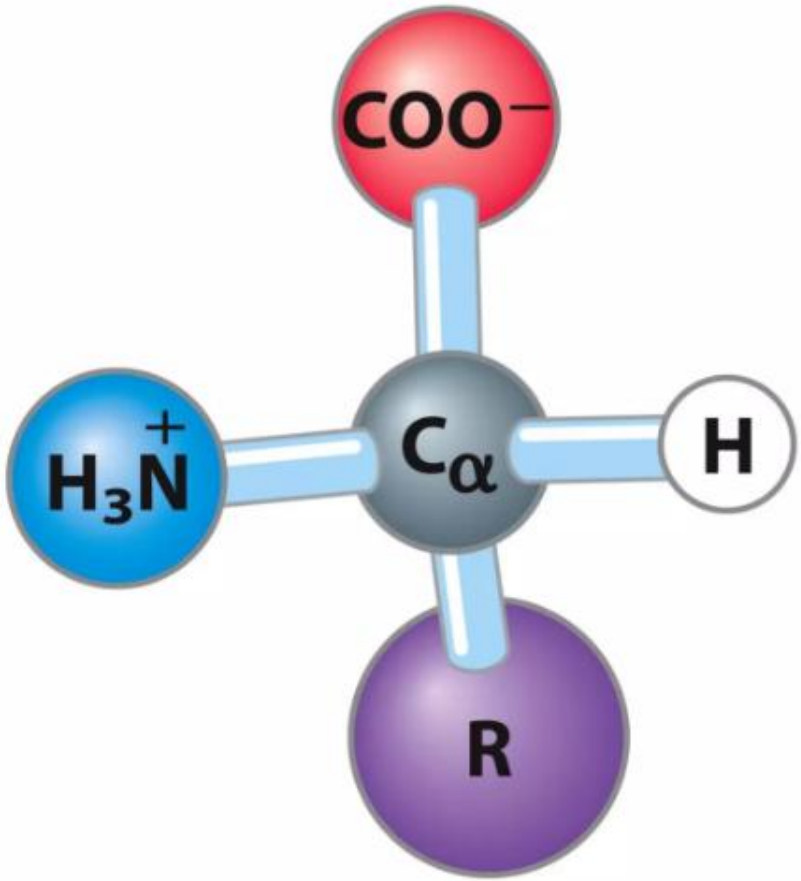
Amino acids:

- ✓ Amino acids are organic molecules that, when linked together with other amino acids, form a protein.
- ✓ Amino acids are essential to life because the proteins they form are involved in virtually all cell functions. General structural formula for α-amino acids.
- ✓ There are 20 different R groups in the commonly occurring amino acids.
- ✓ Generally, amino acids have the following structural properties:

1. A carbon (the alpha carbon).
2. A hydrogen atom (H).
3. A Carboxyl group (-COOH).
4. An Amin group (-NH2).
5. A "variable" group or "R" group.

Amino acids share many features, differing only at the R substituent

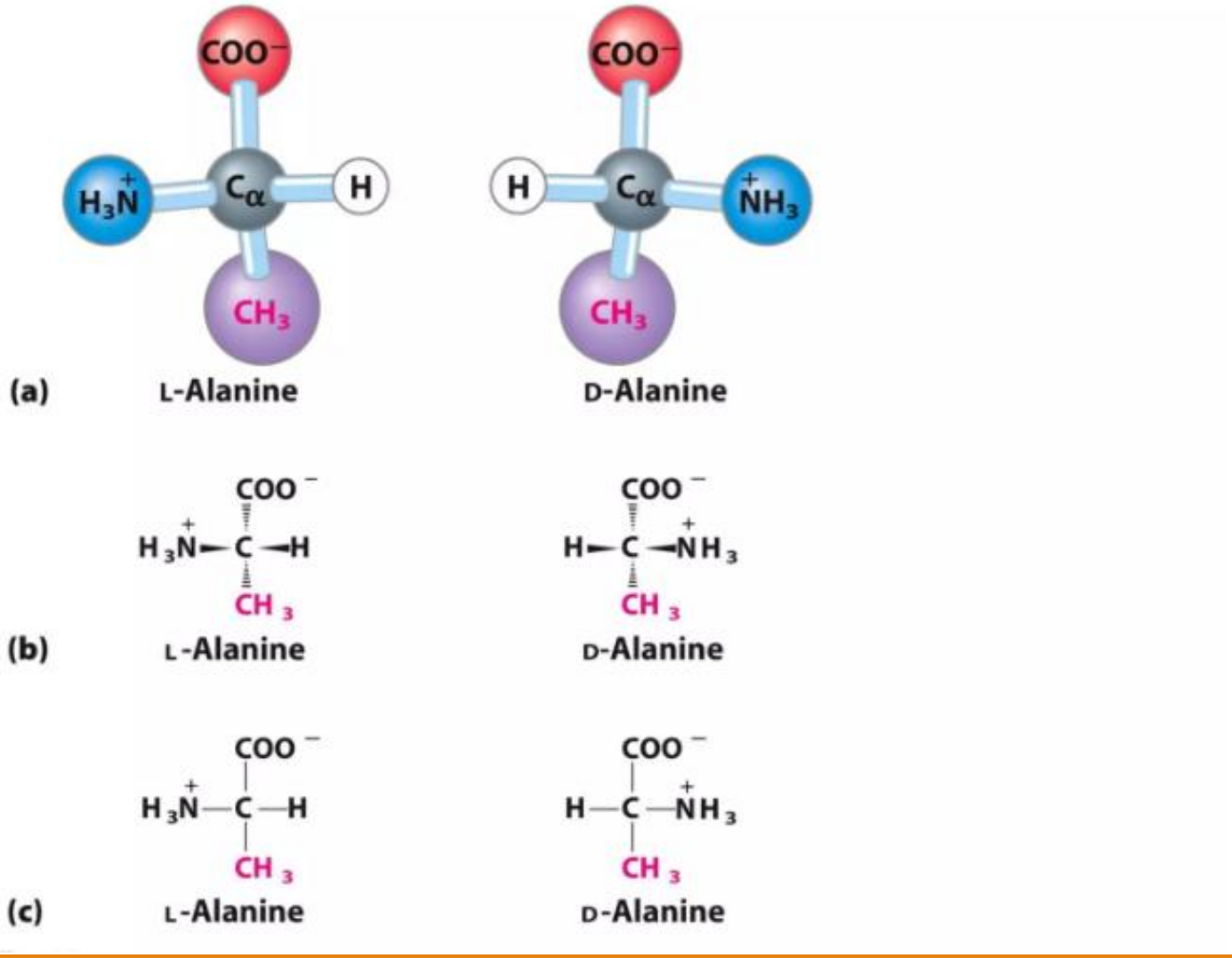




Most α-Amino Acids are Chiral

- The α-carbon has always four substituents and is tetrahedral
- All (except proline) have an acidic carboxyl group, a basic amino group, and an alpha hydrogen connected to the α-carbon
- Each amino acid has an unique fourth substituent R
- In glycine, the fourth substituent is also hydrogen

Proteins only contain L amino acids



Amino Acid Groups:

- ✓ Amino acids can be classified into four general groups based on the properties of the "R" group in each amino acid .
- ✓ Amino acids can be polar, nonpolar, positively charged, or negatively charged. Polar amino acids have "R" groups that are hydrophilic, meaning that they seek contact with aqueous solutions .
- ✓ Nonpolar amino acids are the opposite (hydrophobic) in that they avoid contact with liquid. These interactions play a major role in protein folding and give proteins their 3-D structure.
- ✓ Below is a listing of the 20 amino acids grouped by their "R" group properties .
- ✓ The nonpolar amino acids are hydrophobic, while the remaining groups are hydrophilic.

Nonpolar Amino Acids:

Ala: Alanine	Gly: Glycine	Ile: Isoleucine
Leu: Leucine	Met: Methionine	Trp: Tryptophan
Phe: Phenylalanine	Pro: Proline	Val: Valine

Polar Amino Acids:

Cys: Cysteine	Ser: Serine	Thr: Threonine
Tyr: Tyrosine	Asn: Asparagine	Gln: Glutamine

1. Polar Basic Amino Acids (Positively Charged)

His: Histidine Lys: Lysine Arg: Arginine

2. Polar Acidic Amino Acids (Negatively Charged)

Asp: Aspartate Glu: Glutamate

Classification of amino acids:

While amino acids are necessary for life, not all of them can be produced naturally in the body These:

1. Nonessential amino acids:

- ✓ (11 amino acids can be produced naturally) are alanine, arginine, asparagine, aspartate, cysteine, glutamate, glutamine, glycine, proline, serine, and tyrosine.
- ✓ With the exception of tyrosine, nonessential amino acids are synthesized from products or intermediates of crucial metabolic pathways. For example: alanine and aspartate are derived from substances produced during cellular respiration.
- ✓ Alanine is synthesized from pyruvate, a product of glycolysis. Aspartate is synthesized from oxaloacetate, an intermediate of the citric acid cycle.
- ✓ Six of the nonessential amino acids (arginine, cysteine, glutamine, glycine, proline, and tyrosine) are considered conditionally essential as dietary supplementation may be required during the course of an illness or in children.

2.Essential amino acids :

- ✓ Amino acids that cannot be produced naturally.
- ✓ They are histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine.
- ✓ Essential amino acids must be acquired through diet .
- ✓ Common food sources for these amino acids include eggs, soy protein, and whitefish.

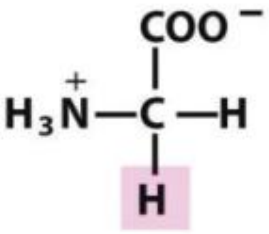
Unlike humans, plants are capable of synthesizing all 20 amino acids.

Amino Acids: Classification

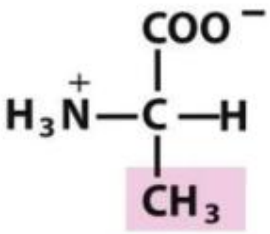
Common amino acids can be placed in five basic groups depending on their R substituents:

- Nonpolar, aliphatic (7)
- Aromatic (3)
- Positively charged (3)
- Negatively charged (2)
- Polar, uncharged (5)

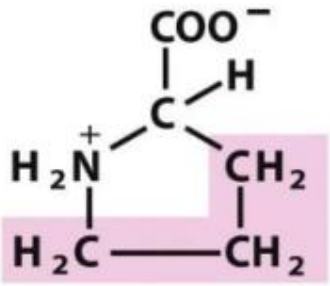
Nonpolar, aliphatic R groups



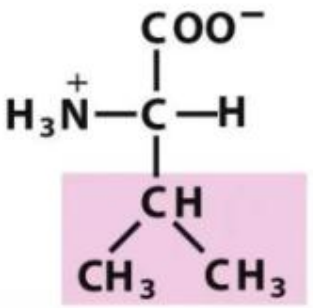
Glycine



Alanine

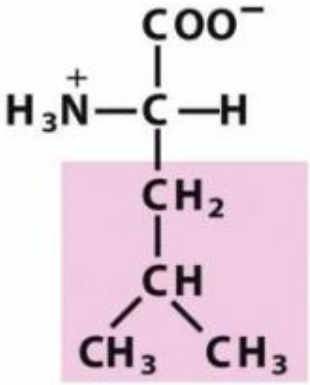


Proline

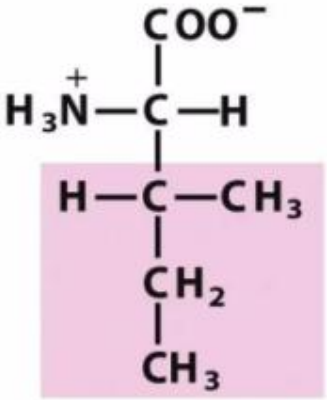


Valine

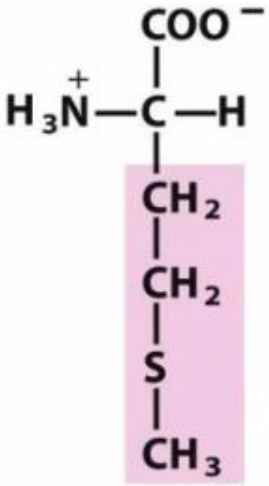
These amino acid side chains are ***hydrophobic***



Leucine

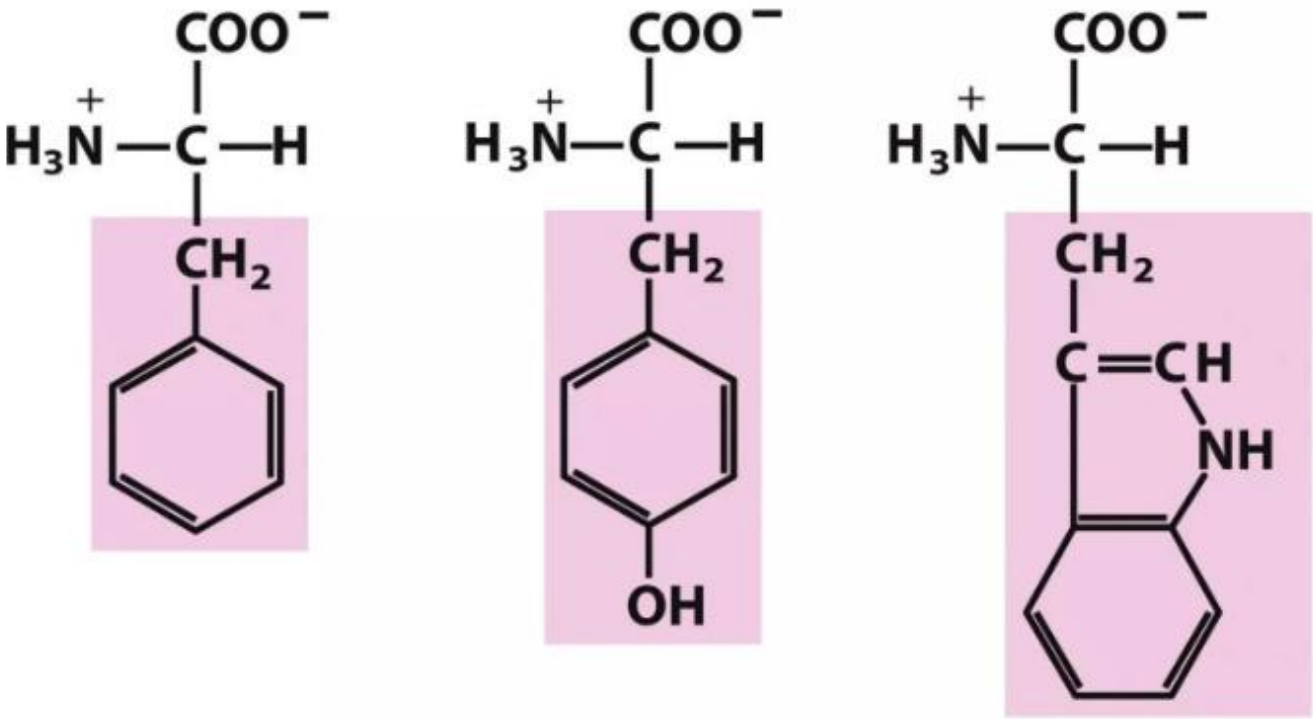


Isoleucine



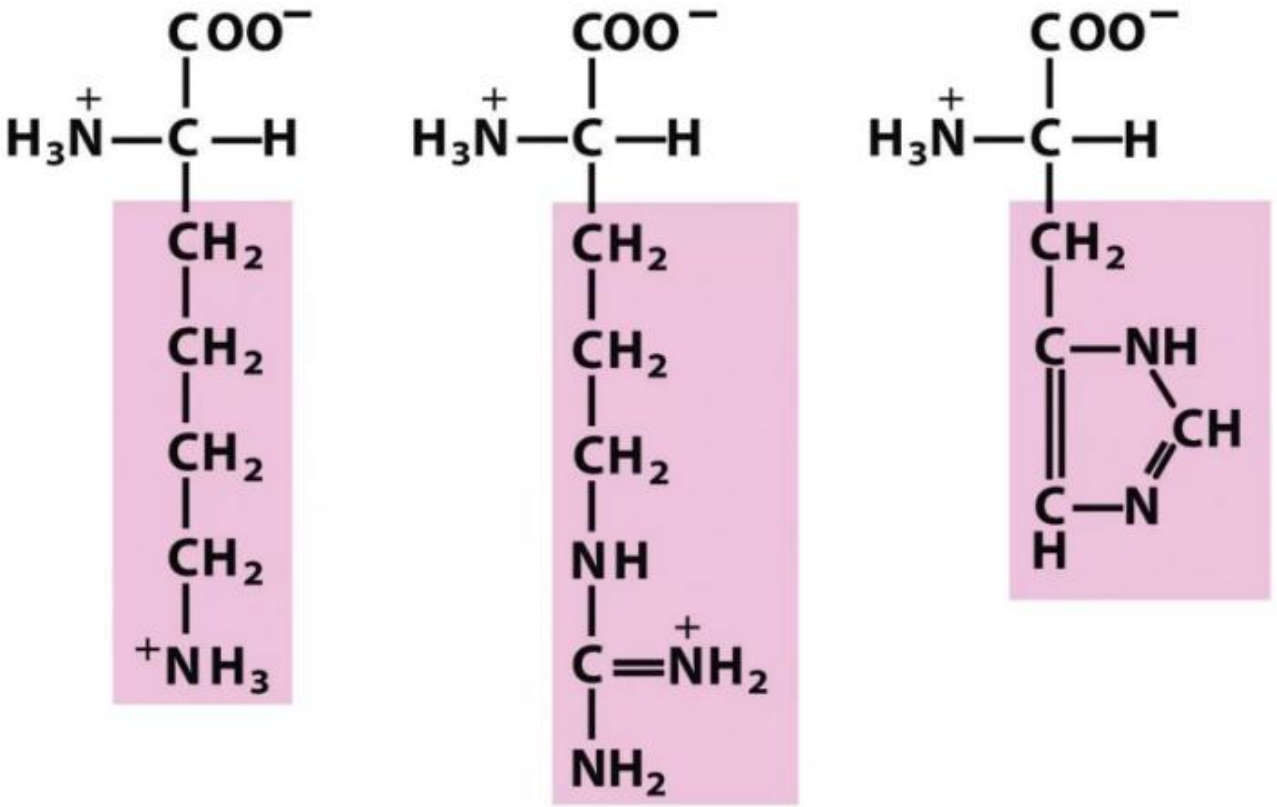
Methionine

Aromatic R groups

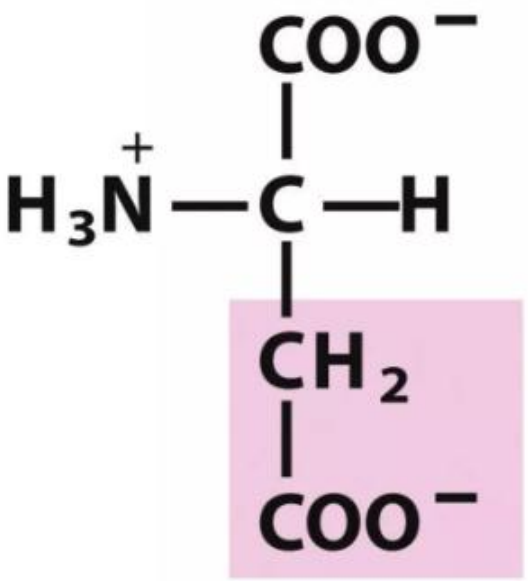


Phenylalanine Tyrosine Tryptophan

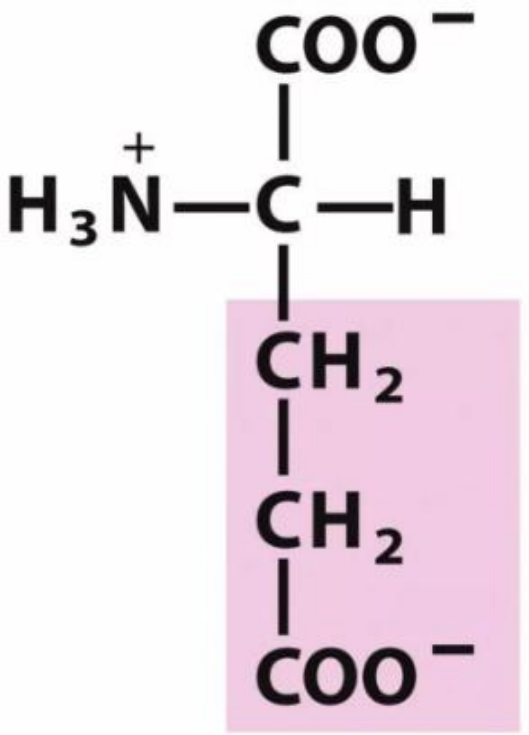
Positively charged R groups



Negatively charged R groups

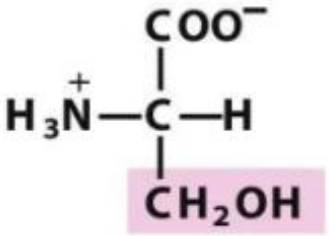


Aspartate

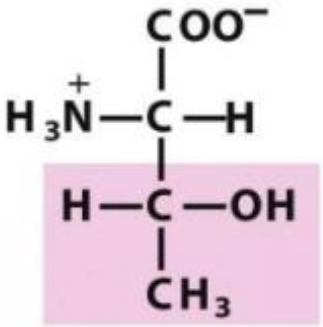


Glutamate

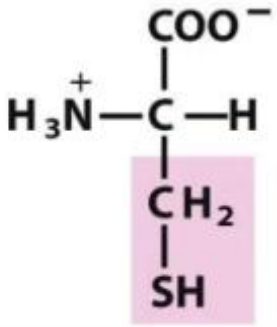
Polar, uncharged R groups



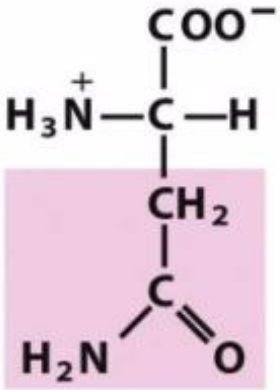
Serine



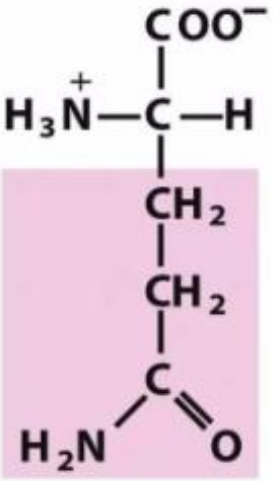
Threonine



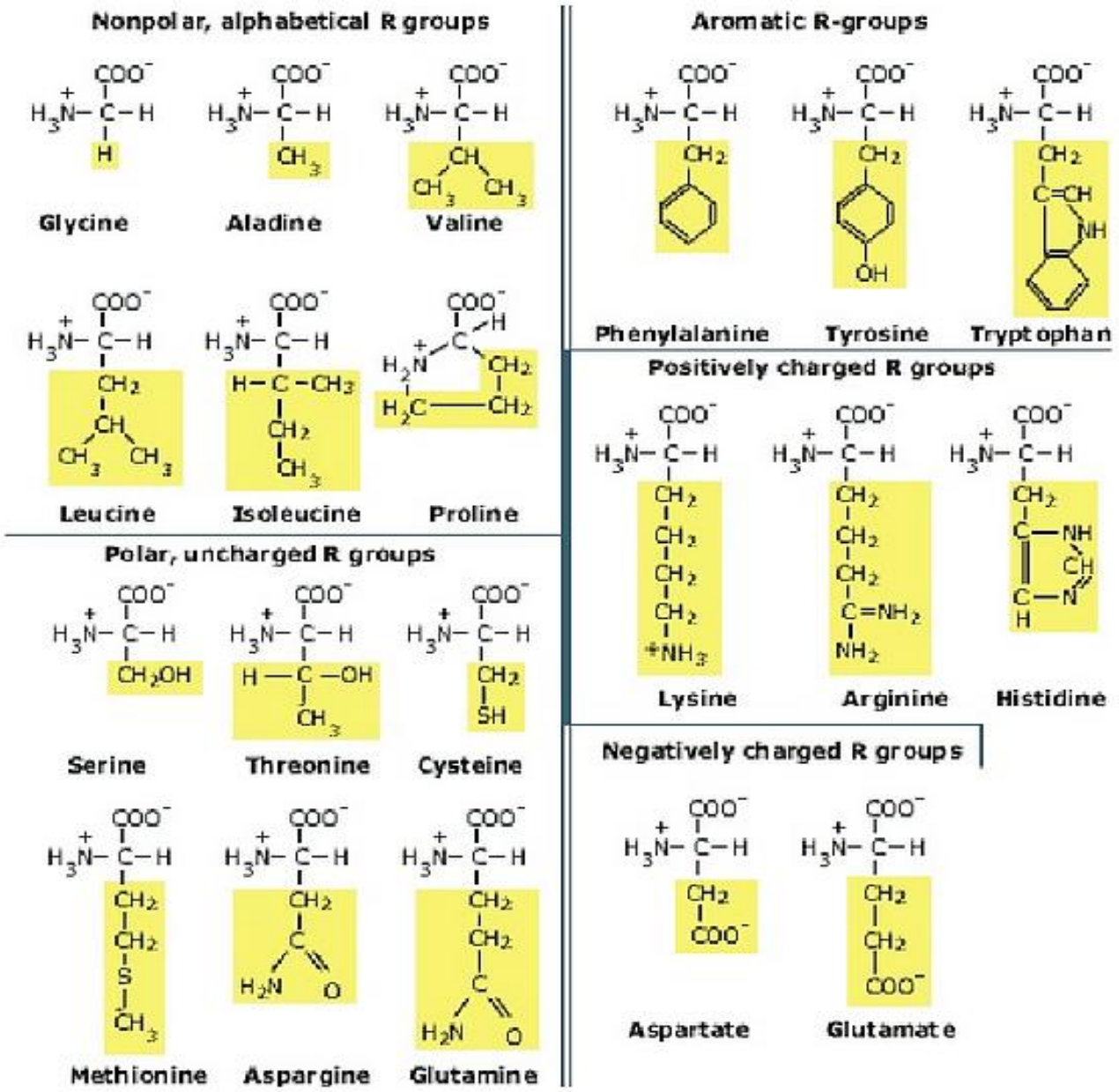
Cysteine



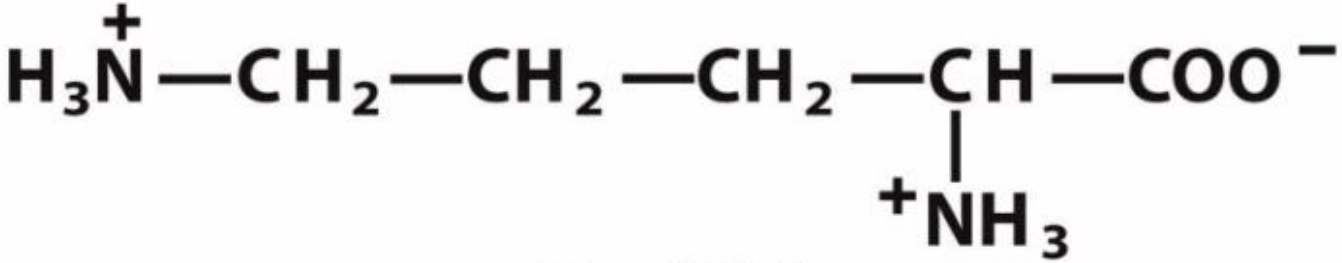
Asparagine



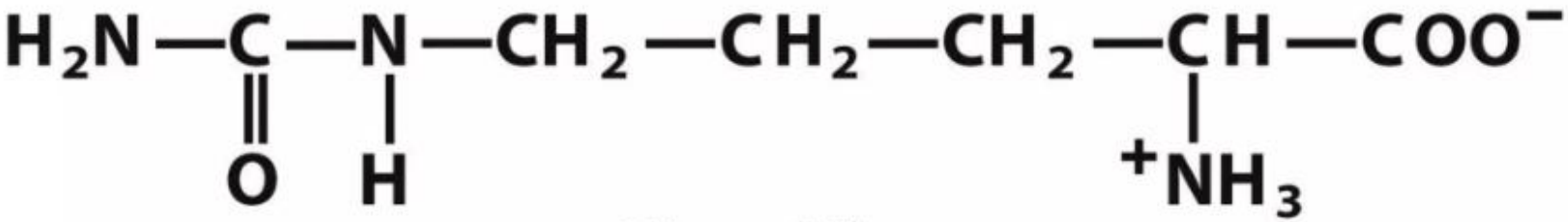
Glutamine


Nonpolar, alphabetical R groups
Glycine
Aladine
Valine
Leucine
Isoleucine
Proline
Polar, uncharged R groups
Serine
Threonine
Cysteine
Methionine
Aspargine
Glutamine
Aromatic R-groups
Phenylalanine
Tyrosine
Tryptophan
Positively charged R groups
Lysine
Arginine
Histidine
Negatively charged R groups
Aspartate
Glutamate

Important Amino Acids in Urea Metabolism

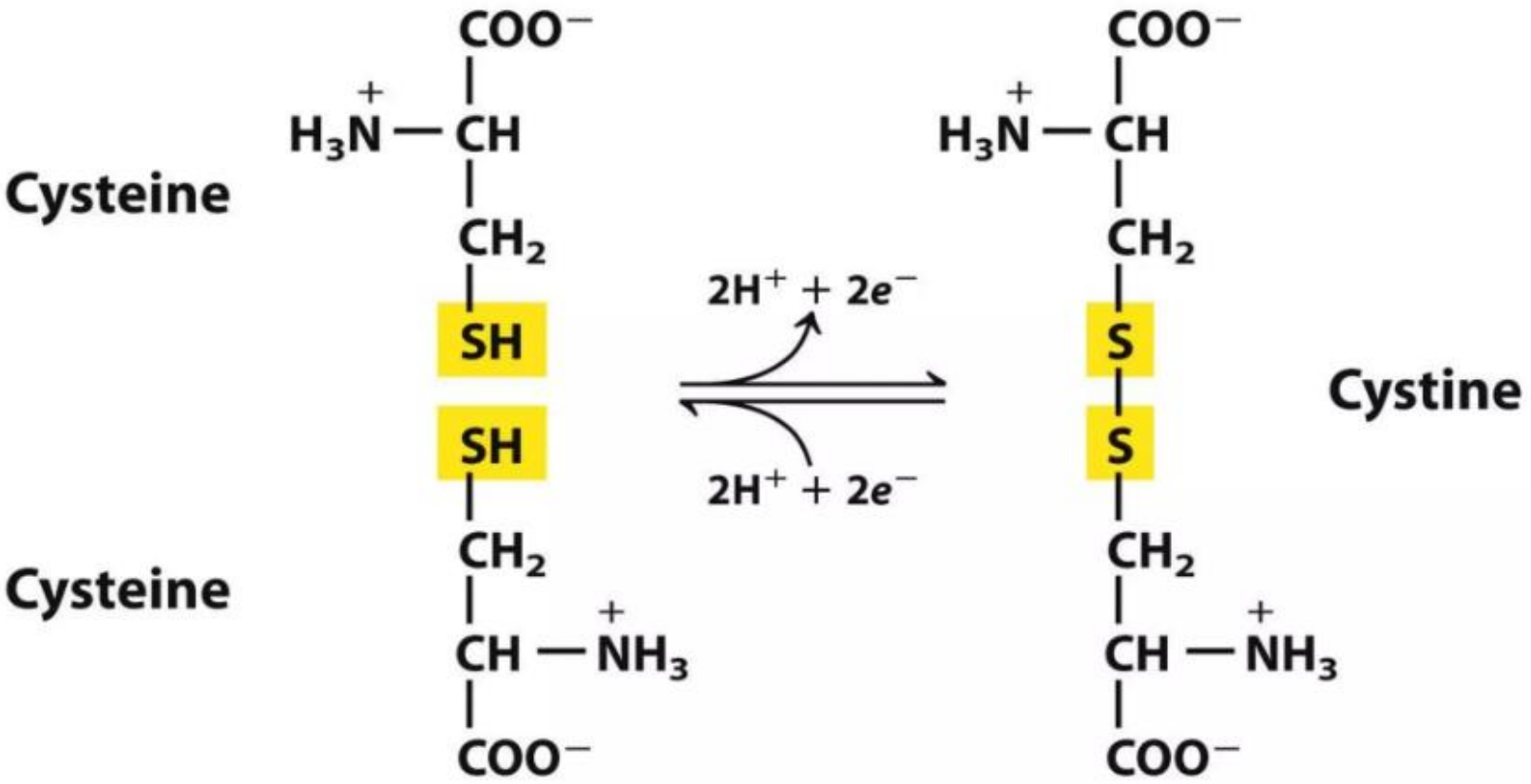


Ornithine

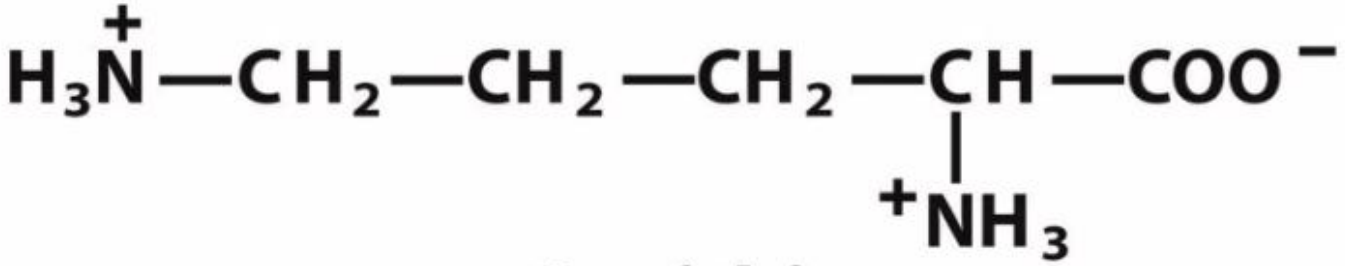


Citrulline

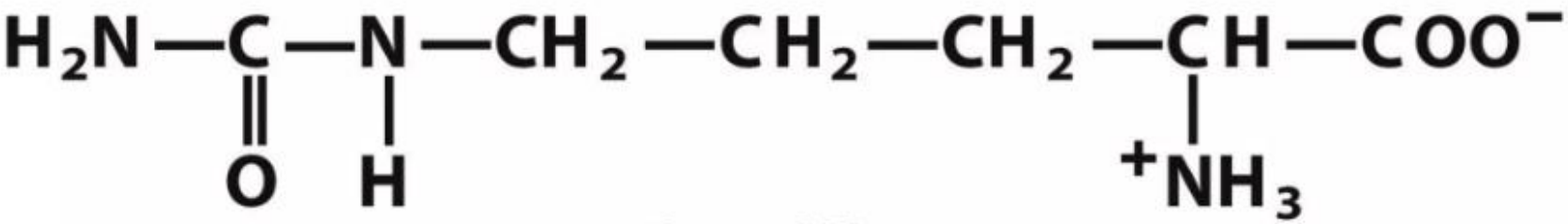
Reversible formation of a disulfide bond by the oxidation of two molecules of cysteine. Disulfide bonds between Cys residues stabilize the structures of many proteins.



Important Amino Acids in Urea Metabolism



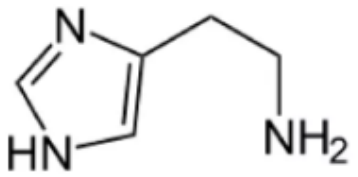
Ornithine



Citrulline

A Derivative of amino acids

• **Histamine** is an organic nitrogen compound involved in local immune responses as well as regulating physiological function in the gut and acting as a neurotransmitter.



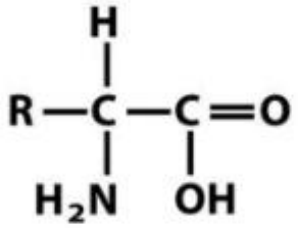
• Histamine triggers the inflammatory response

• Histamine increases the permeability of the capillaries to white blood cells and some proteins, to allow them to engage pathogens in the infected tissues

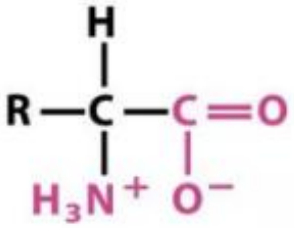
• Histamine is derived from the decarboxylation of the amino acid histidine, a reaction catalyzed by the enzyme *L-histidine decarboxylase*

Ionization of Amino Acids

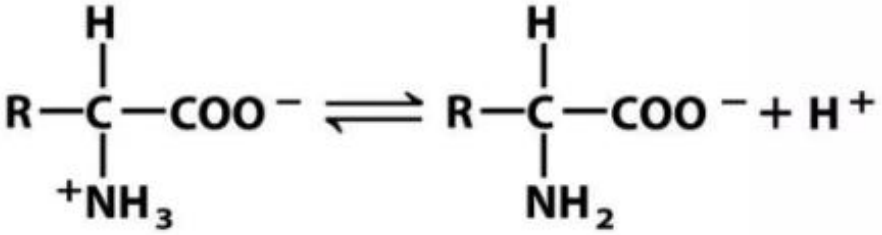
- At acidic pH, the carboxyl group is protonated and the amino acid is in the cationic form
- At neutral pH, the carboxyl group is deprotonated but the amino group is protonated. The net charge is zero; such ions are called Zwitterions
- At alkaline pH, the amino group is neutral $-NH_2$ and the amino acid is in the anionic form.



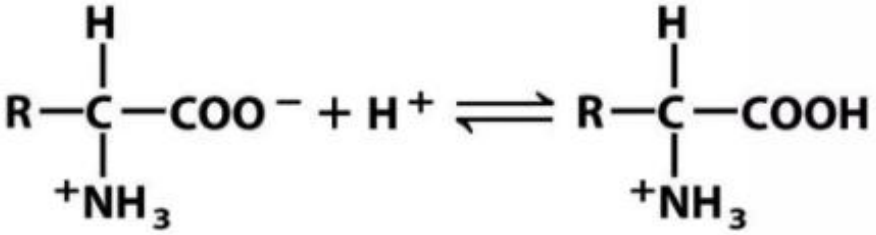
Nonionic form



Zwitterionic form

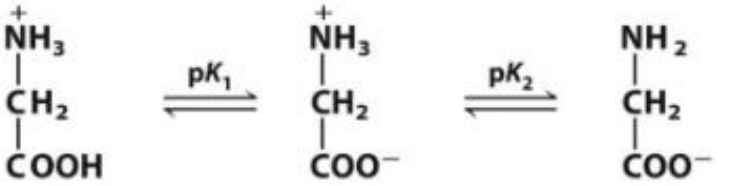


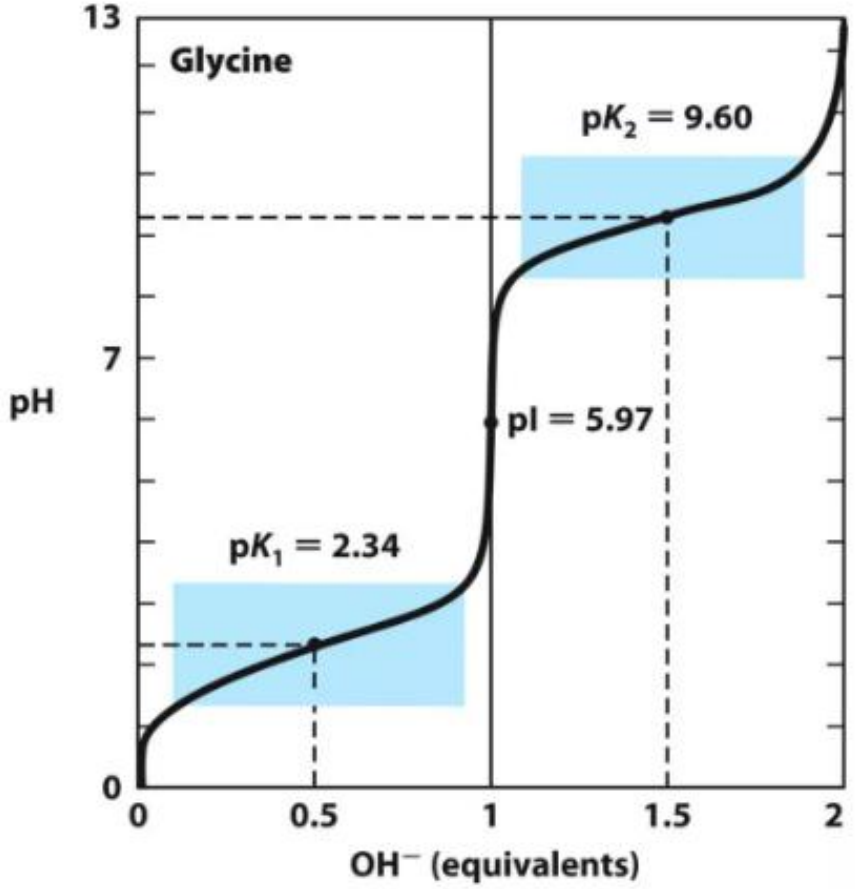
Zwitterion as acid



Zwitterion as base

Cation → Zwitterion → Anion





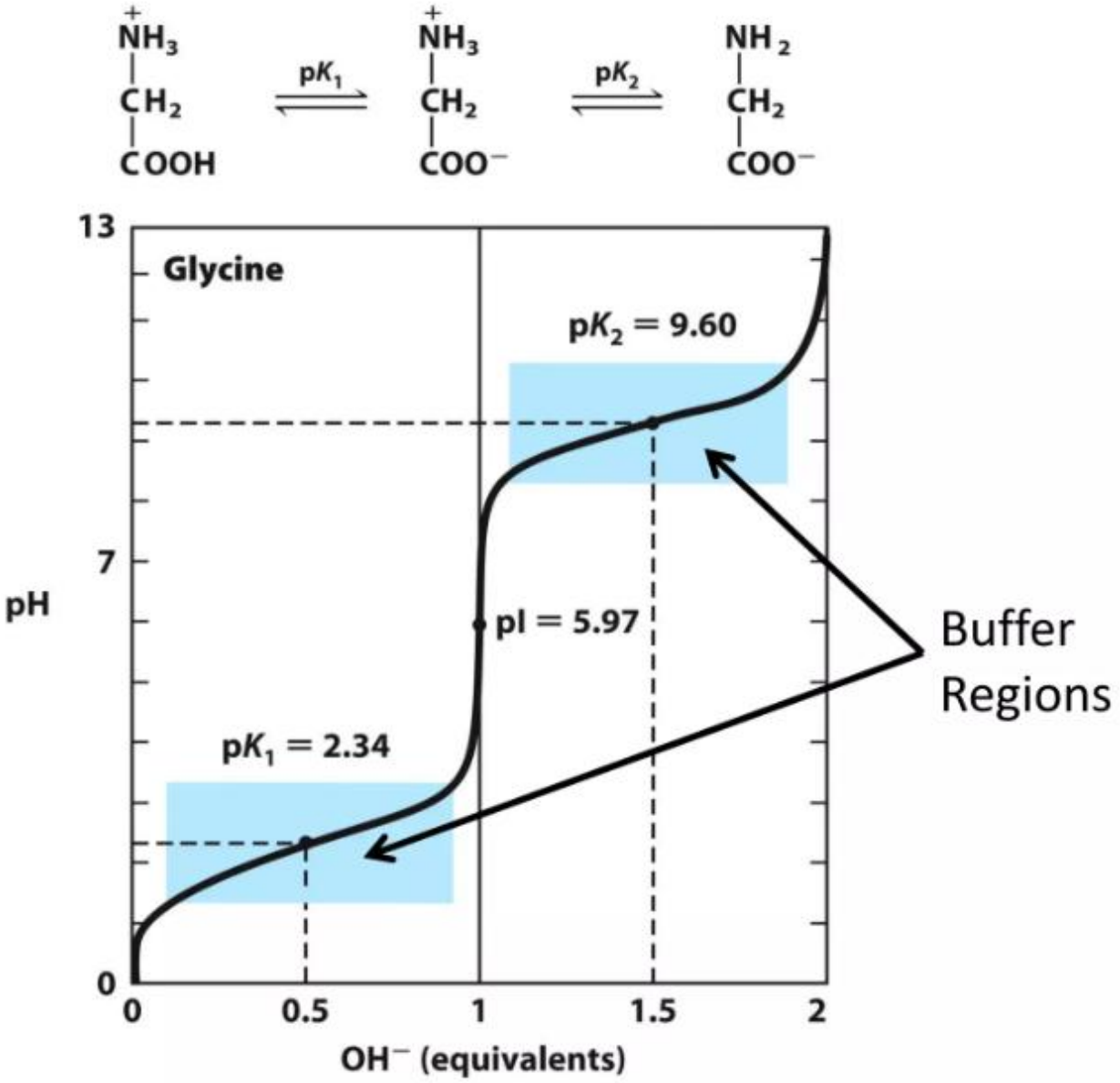
Amino acids can act as buffers

Amino acids with uncharged side chains, such as glycine, have two pK_a values:

The pK_a of the α-carboxyl group is 2.34

The pK_a of the α-amino group is 9.6

It can act as a buffer in two pH regimes.


NH3+
CH2
COOH
pK1
NH3+
CH2
COO−
pK2
NH2
CH2
COO−
13
7
0
pH
Glycine
pK2 = 9.60
pI = 5.97
pK1 = 2.34
Buffer Regions
0
0.5
1
1.5
2
OH− (equivalents)

Amino acids carry a net charge of zero at a specific pH (the pI)

- Zwitterions predominate at pH values between the pK_a values of the amino and carboxyl groups
- For amino acids without ionizable side chains, the Isoelectric Point (equivalence point, pI) is

$$pI = \frac{pK_1 + pK_2}{2}$$

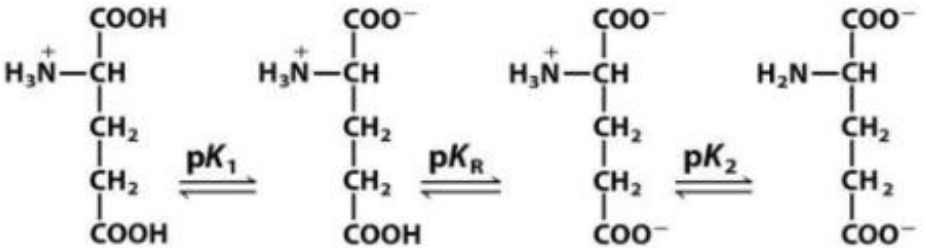
- At this point, the net charge is zero
  - AA is least soluble in water
  - AA does not migrate in electric field

How to Calculate the pI When the Side Chain is Ionizable

- At the pI, *the net charge of the molecule is zero*
- Identify species that carries a net zero charge
- Identify the species on either side of the neutral form (0 charge)
- Take average the two pK_a values

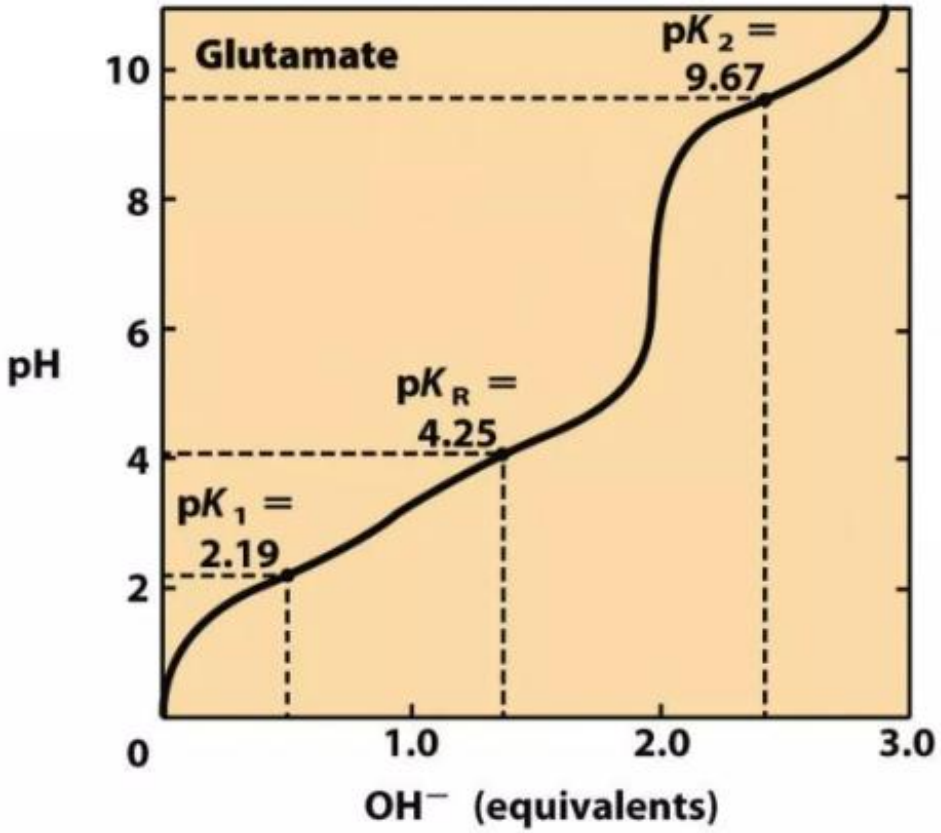
What is the pI of histidine?

- $(pK_R + pK_2)/2 = pI$
- $(6 + 9.17)/2 = 7.58$



Net charge: +1 0 −1 −2

What is the pI of glutamate?



Types of Peptides:

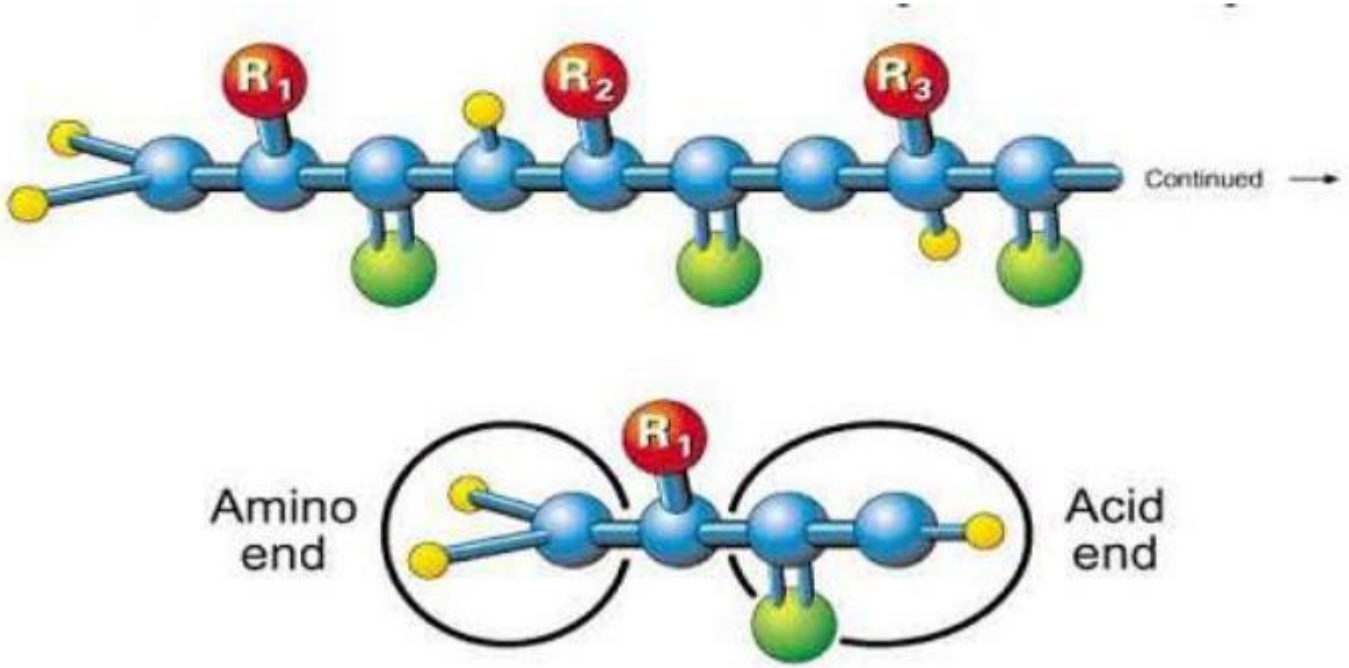
A peptide is a short-chain made up of amino acid which, together with other peptides, types of peptide:

1. Dipeptide: two amino acids
2. Oligopeptide: 5-10 amino acids
3. Polypeptide: molecular mass below5000g/mol

Protein: Molecular mass between 6000 -40,000,000g. in a protein, upward of a hundred amino acids are so joined to form a polypeptide chain.

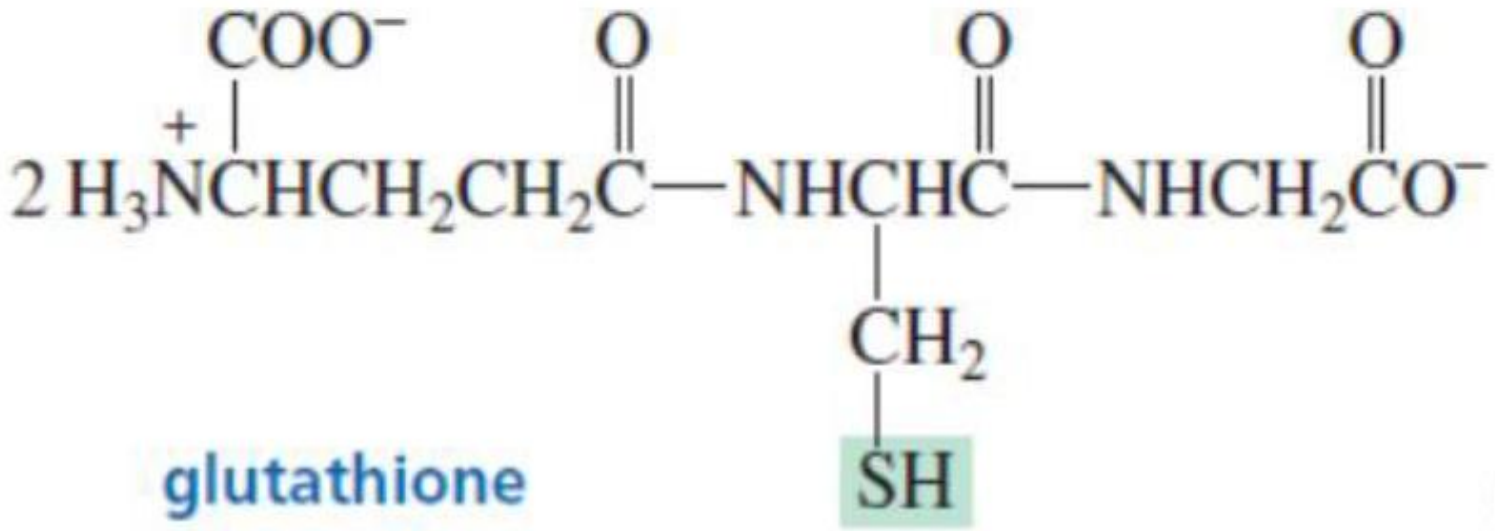
Polypeptides:

- ✓ Polypeptides are chains of amino acids .
- ✓ Proteins are made up of one or more polypeptide molecules.
- ✓ The amino acids are linked covalently by peptide bonds .
- ✓ One end of every polypeptide, called the amino terminal or N-terminal, has a free amino group. The other end, with its free carboxyl group, is called the carboxyl terminal or C-terminal.



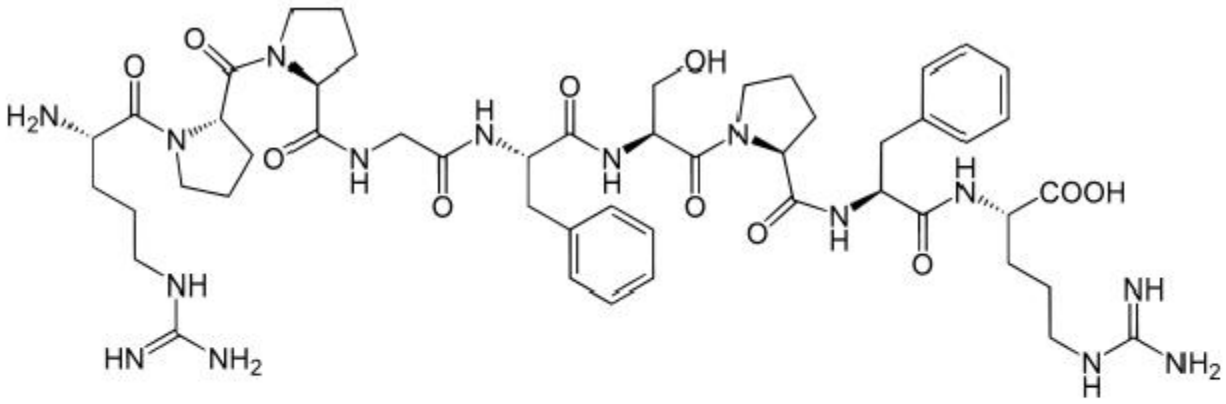
Some Biologically important peptides:

1. **Glutathione:** is a substance made from the amino acids glycine, cysteine, and glutamic acid .It is produced by the liver and involved in many body processes.



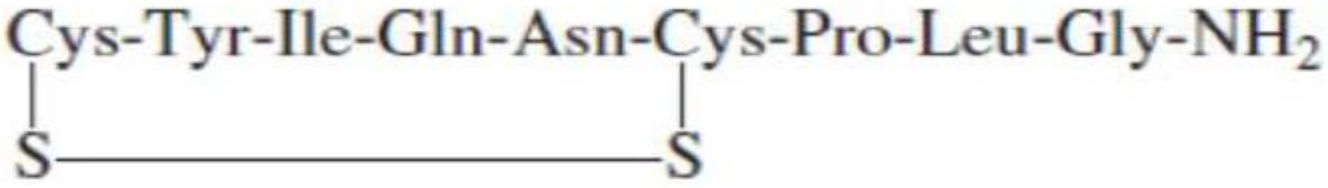
glutathione

1. **Bradykinin:** is a peptide that promote inflammation.

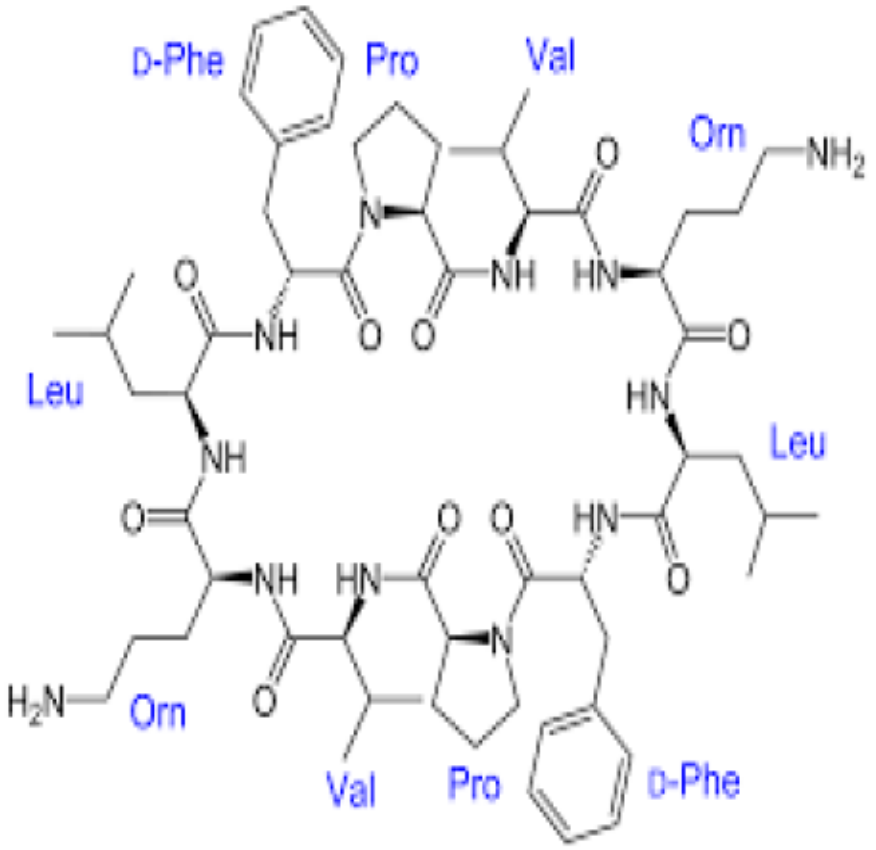


Arg-Pro-Pro-Gly-Phe-Ser-Pro-Phe-Arg

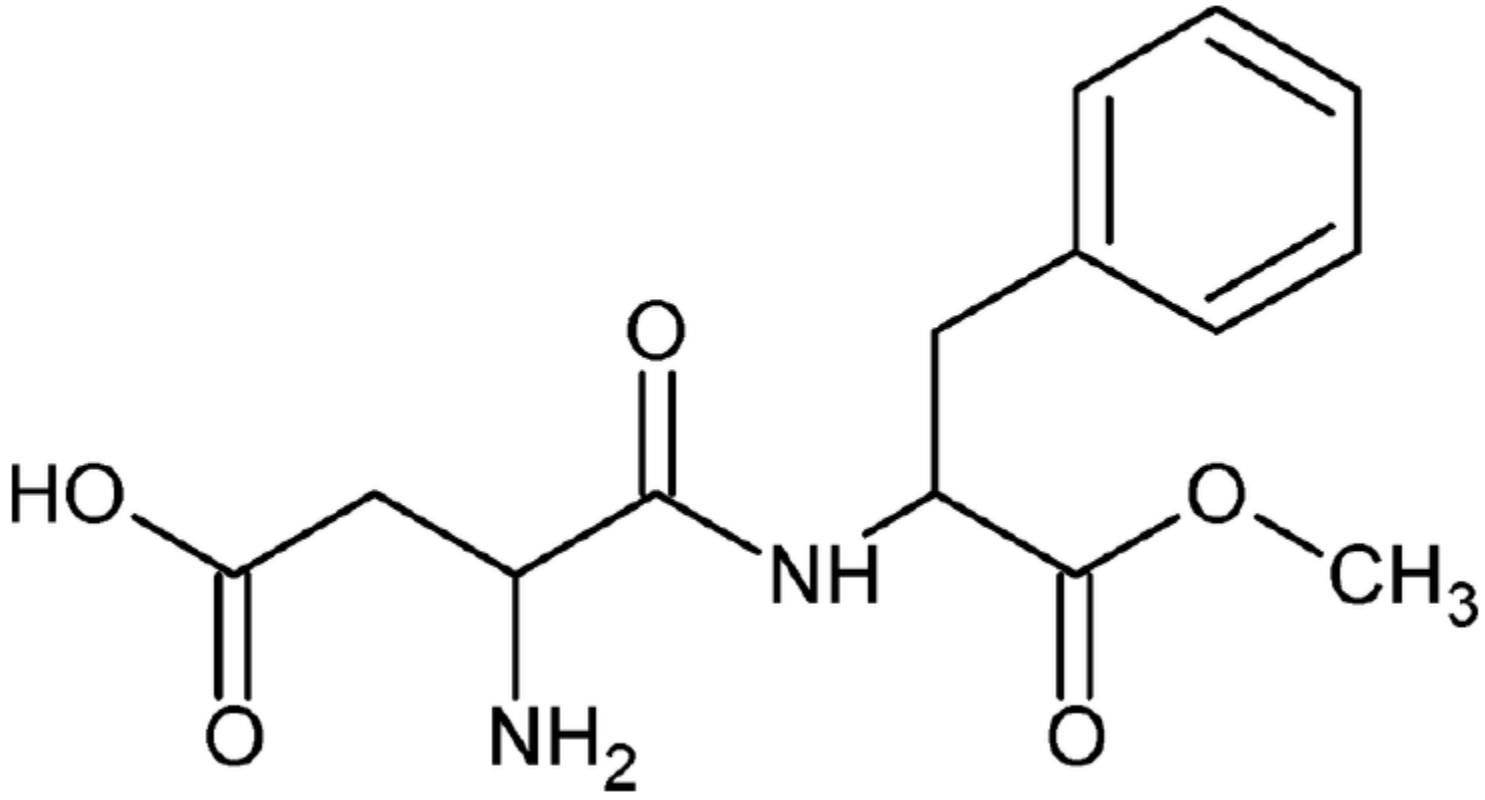
2. **Vasopressin:** A cyclic hormone consisting of nine amino acids, secreted by the posterior lobe of the pituitary glad. controls blood pressure by regulating the contraction of smooth muscle. It is also an antidiuretic..



3.Gramicidin S: A cyclic peptide consisting of ten amino acids. Produced by fungi ,it acts as an antibiotics it acts as an antibiotics.



4. <u>Aspartame</u>: it is the methyl ester of a dipeptide of L-aspartate and L-phenylalanine. and is commonly used as a sugar substitute in foods and beverages.



Thank you

Quiz 1

Q1 / define:

- Biochemistry
- pH
- Acid
- Base
- Electrolytes

Q2/ Explain the buffer solution and the number of its types, including an example of each type.