Amino Acid & Protein Chemistry

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surat

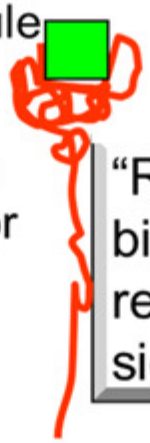
- More than 300 A.A. in nature
- Commonly found in proteins = 20 only.
- Each amino acids are expressed by DNA-Genetic codon

- 21st = ?????
- 22nd = ?????

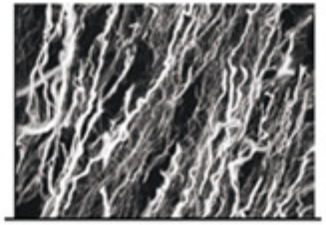
Proteins Shape Dictates Function

Signal molecule

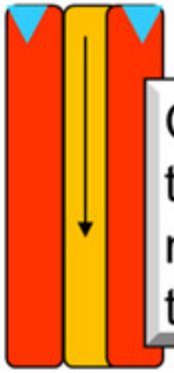
Protein receptor



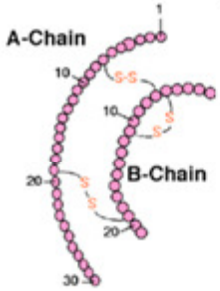
"Receptors" with binding sites that recognize chemical signals



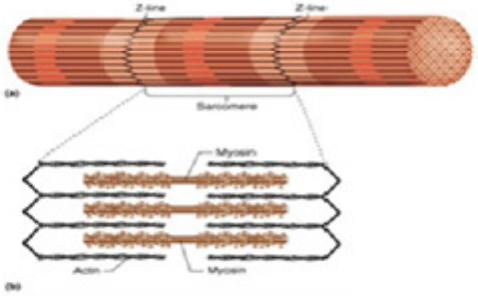
Collagen fibers

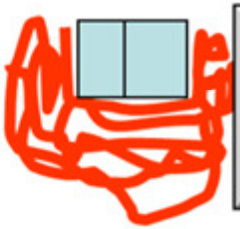


Cylindrical tubes to transport large molecules across the cell membrane

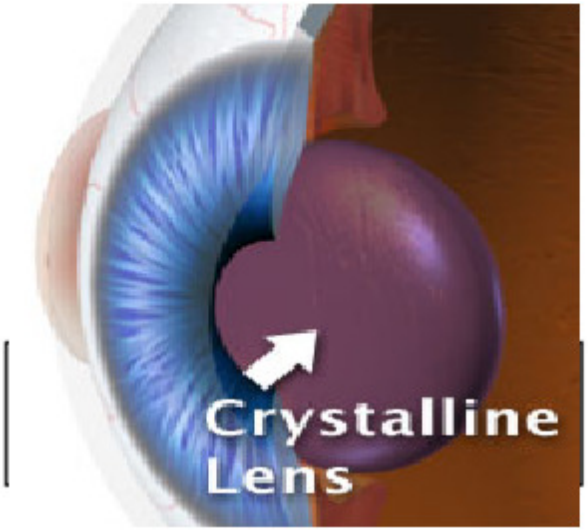


Peptide hormones (insulin)





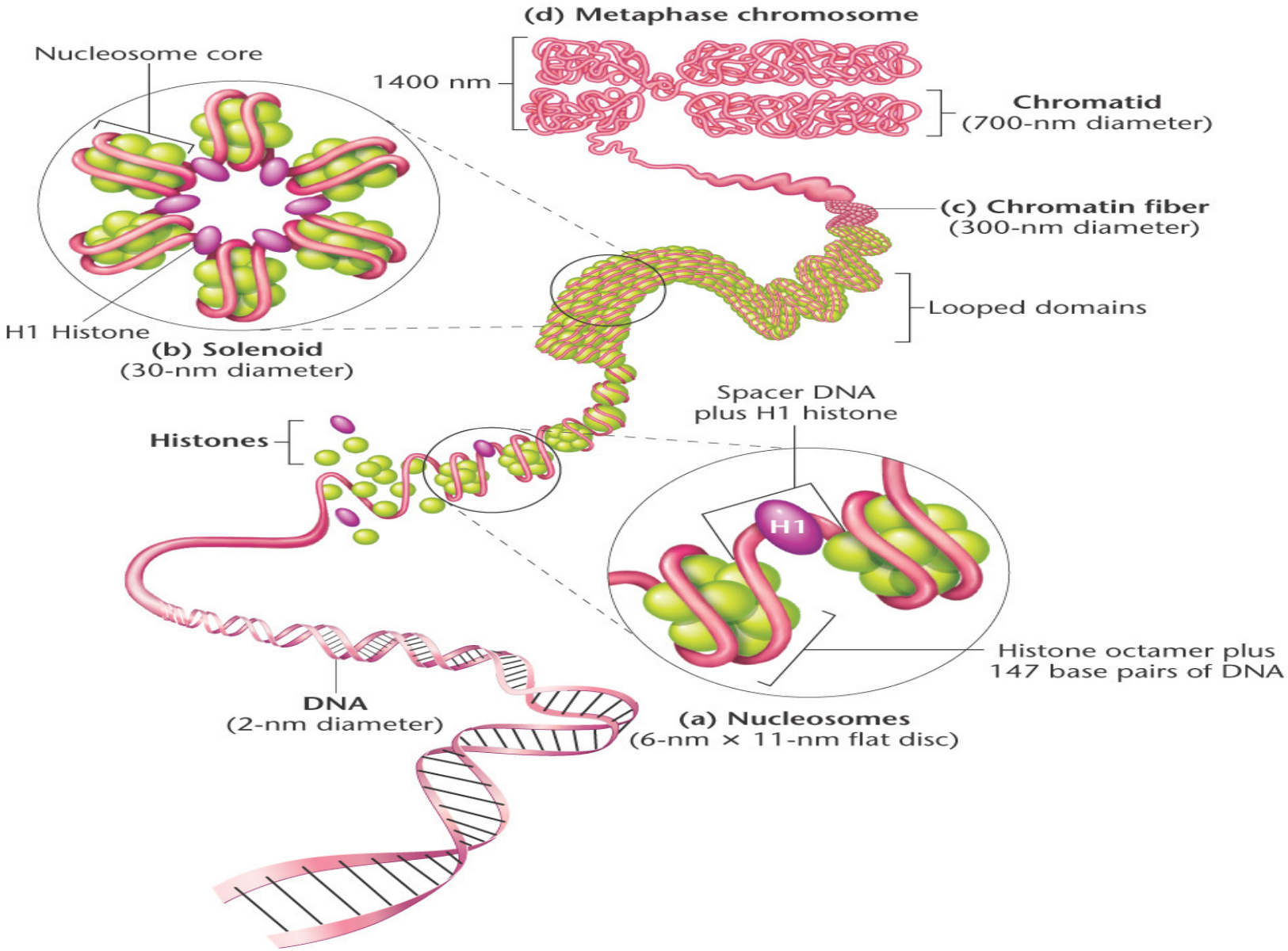
Enzymes that join or split other molecules



Hemoglobin to transport oxygen

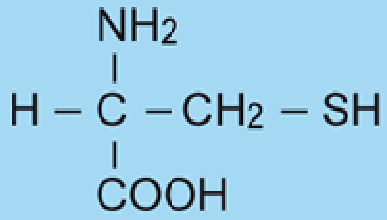
Antibodies - chains bound with binding sites for antigens

Is there any protein in this?

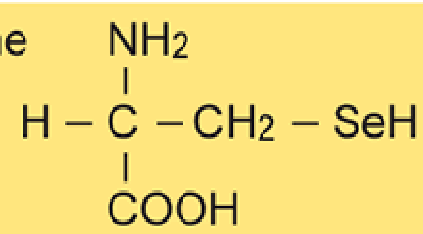


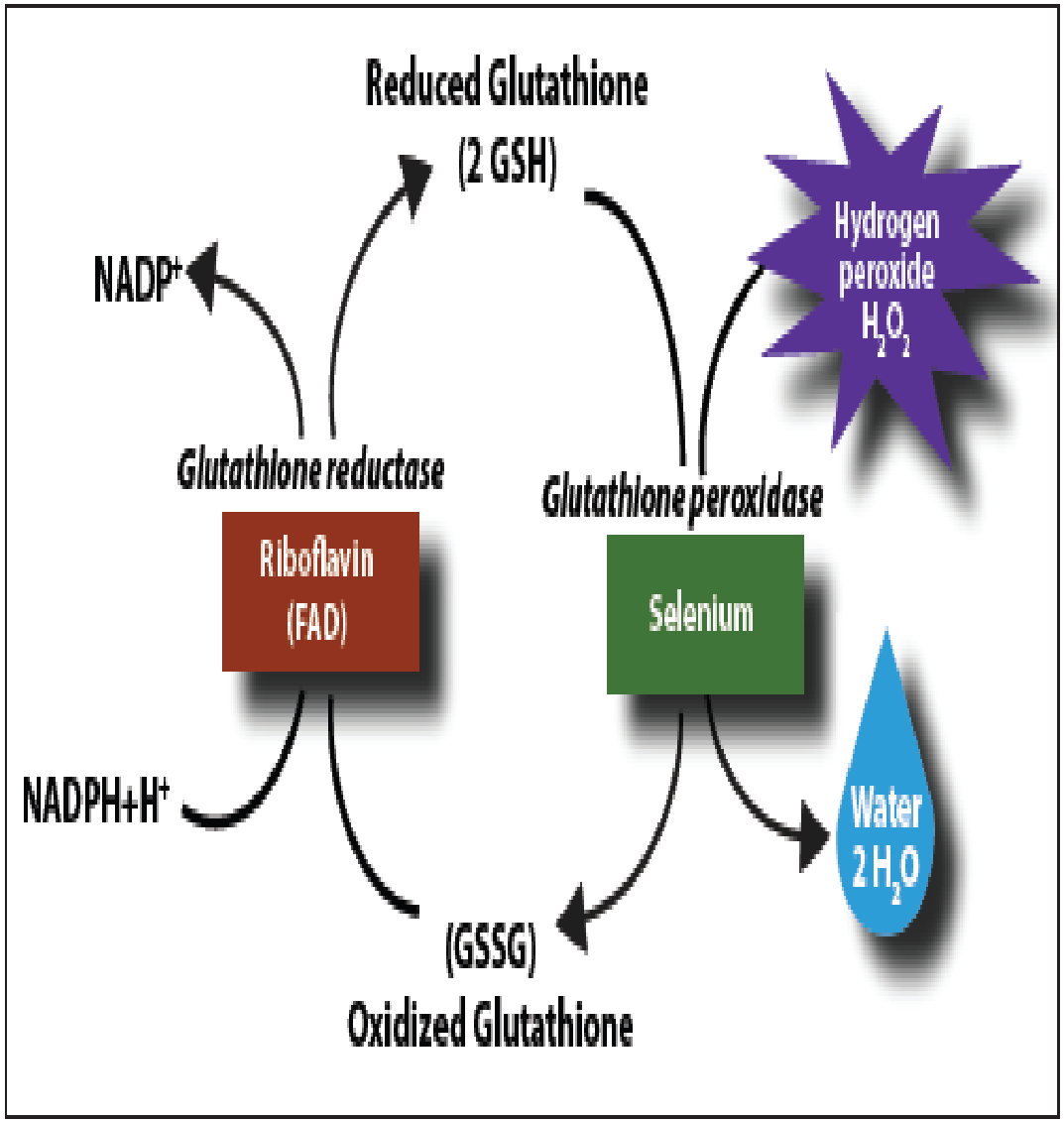
21st Amino Acid = Code By UGA

Cysteine

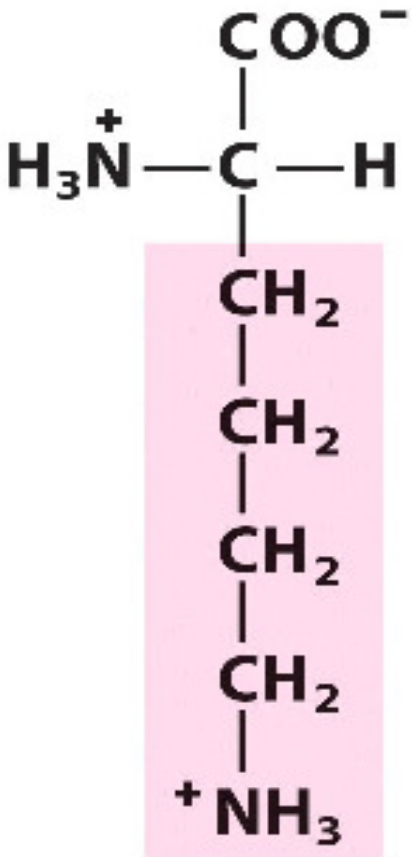


Selenocysteine

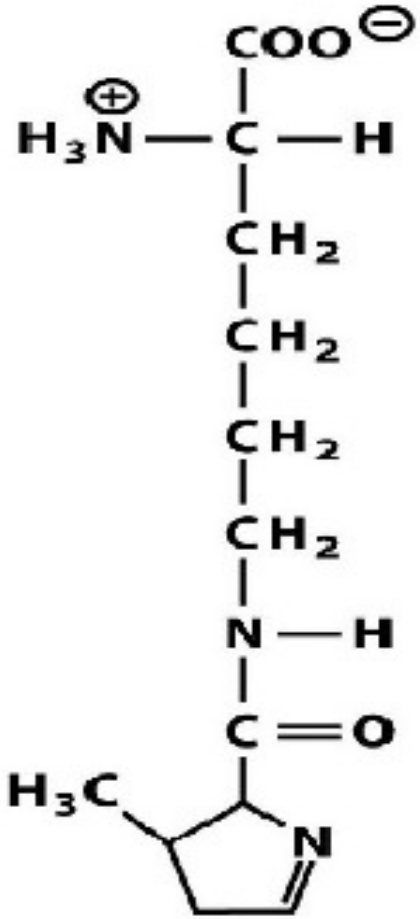




22nd Amino acid = Code by UAG



Lysine



Pyrrolysine

What is the role of Amino acid other than “Unit of Protein”?

Amino acid Significant

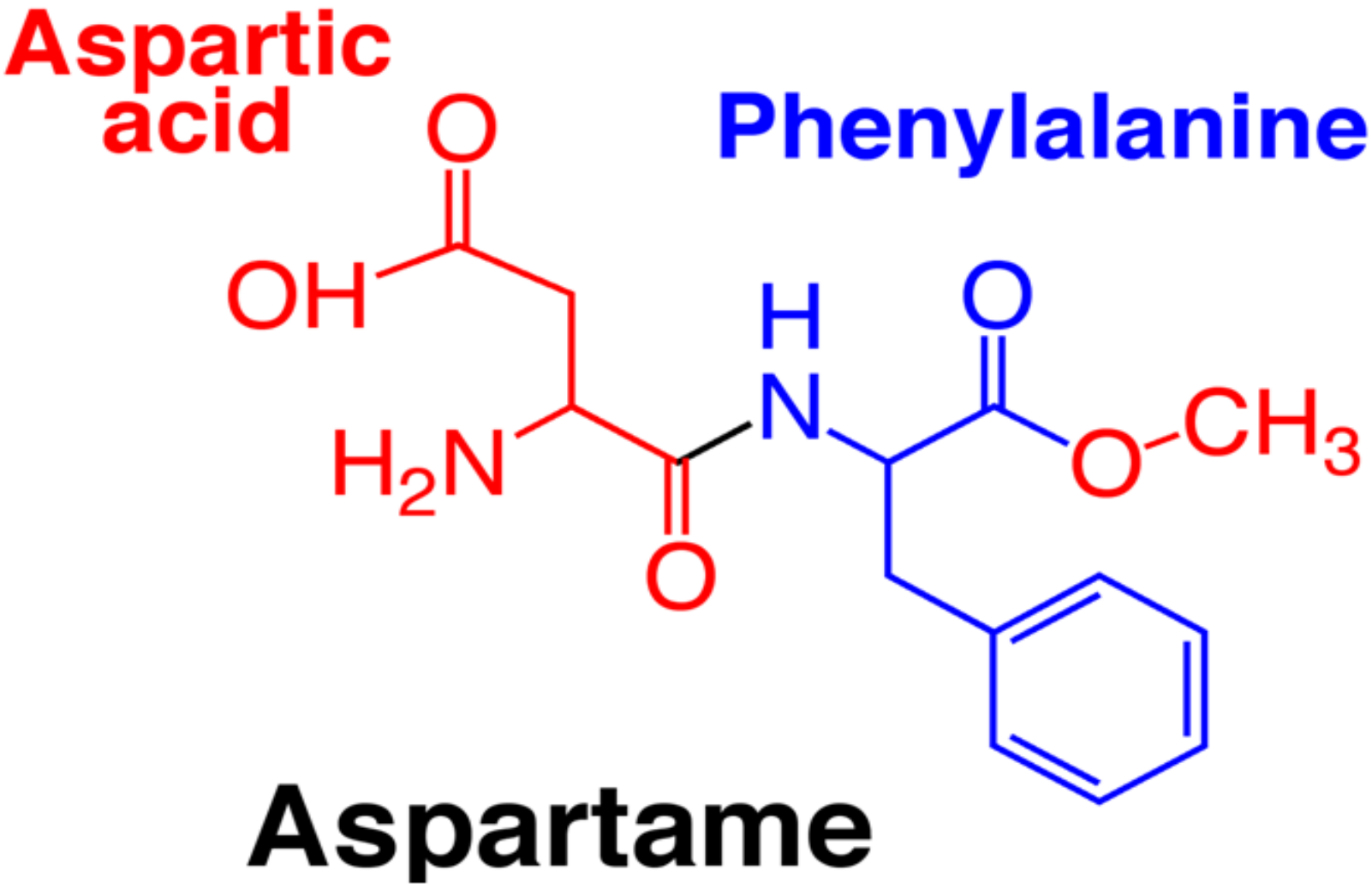
- Neurotransmitters
- Pigment
- Creatinine
- Conjugation
- Detoxification
- Supplement
- Derived Amino acid

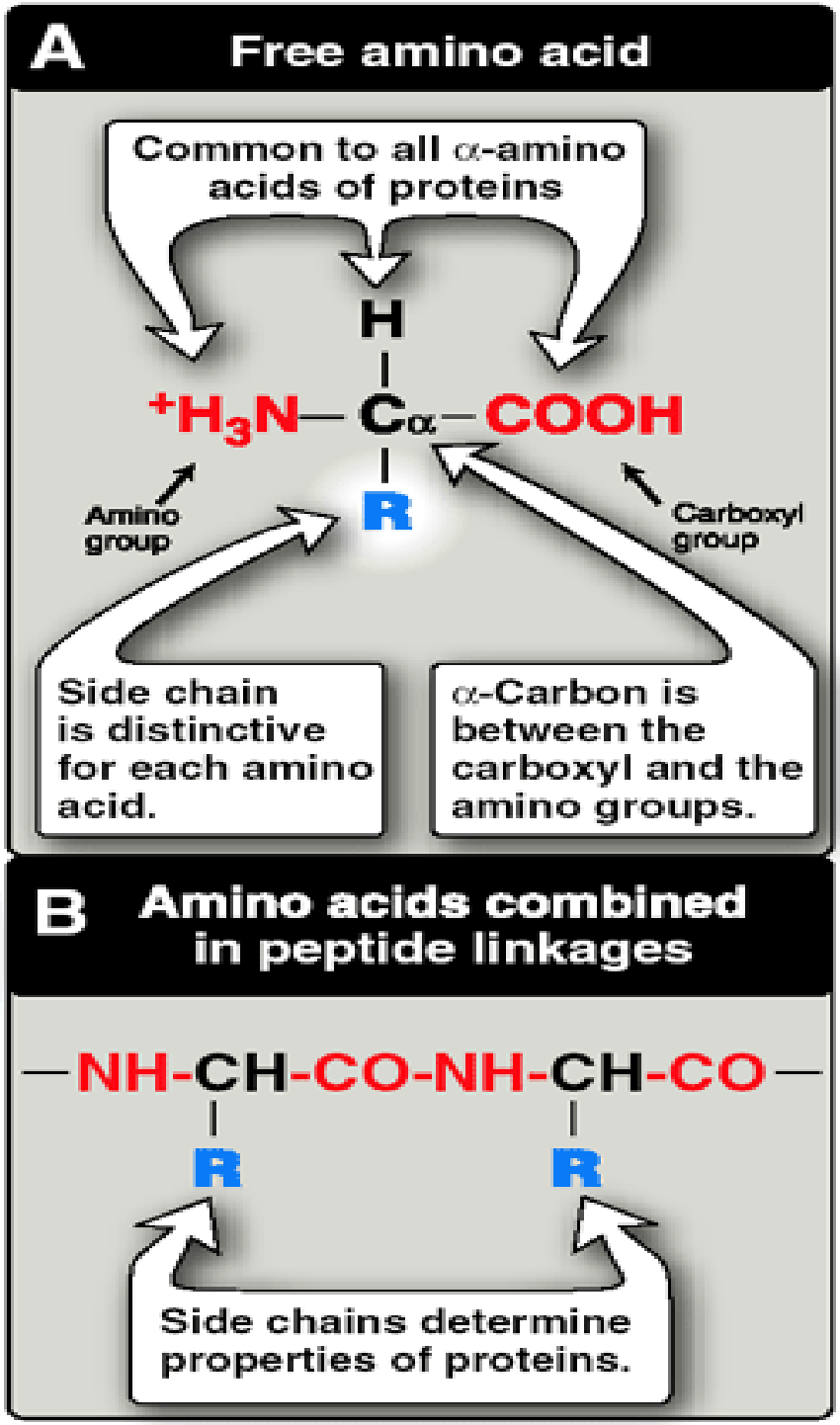
Neurotransmitter

- Dopamine
- Epinepherine
- Nor Epinepherine
- Histamine
- Metatonine
- Seretonine


FREE
10% Extra
300 Pellets +
30 Pellets Free
Sugar Free
~Gold~
Low calorie sugar substitute
India's No. 1 sweetener
New
Sugar Free
~Gold~
Low Calorie Sugar Substitute

Aspartame



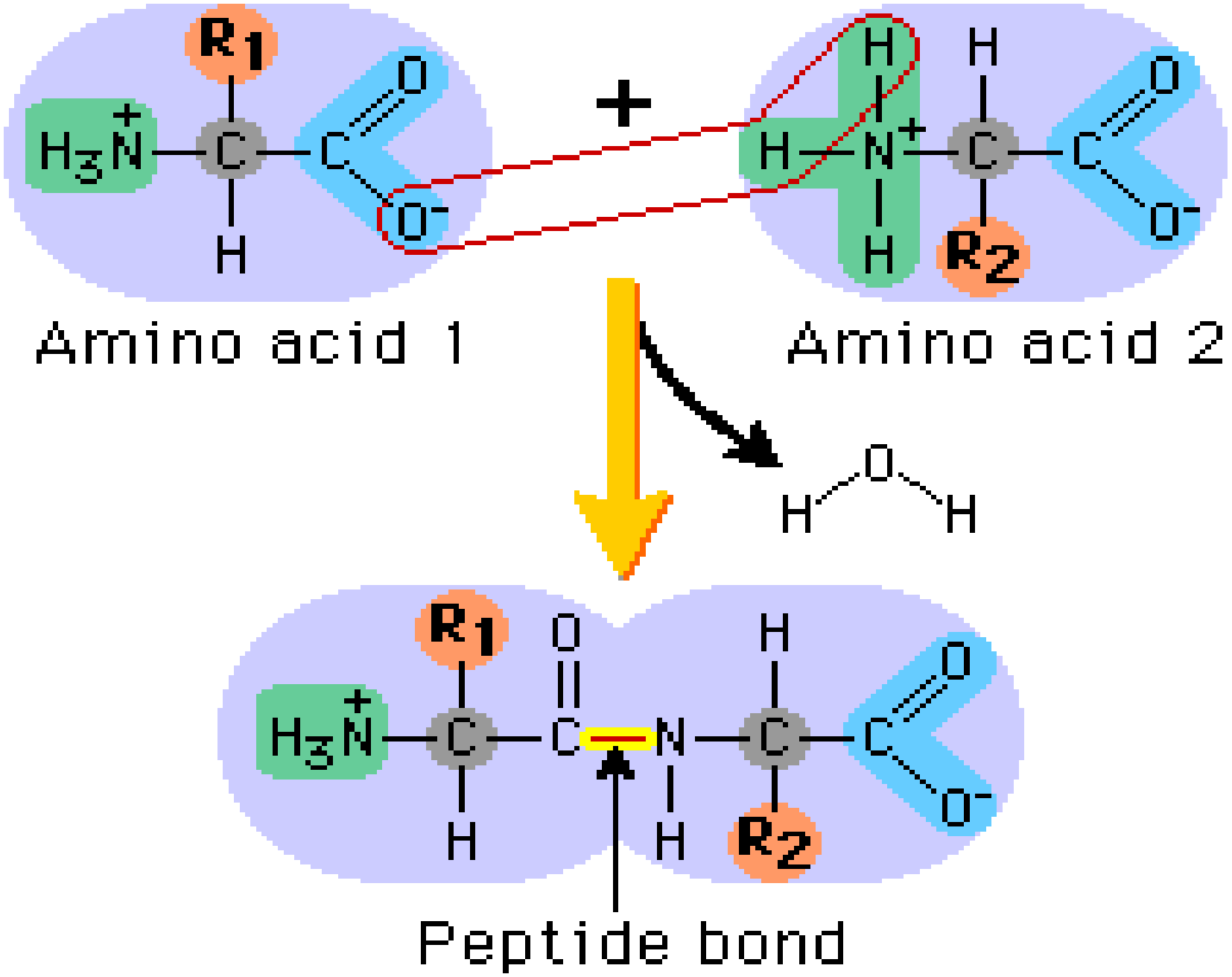

A
Free amino acid
Common to all α-amino acids of proteins
H
+H3N— Cα —COOH
R
Amino group
Carboxyl group
Side chain is distinctive for each amino acid.
α-Carbon is between the carboxyl and the amino groups.
B
Amino acids combined in peptide linkages
—NH-CH-CO-NH-CH-CO—
R
R
Side chains determine properties of proteins.

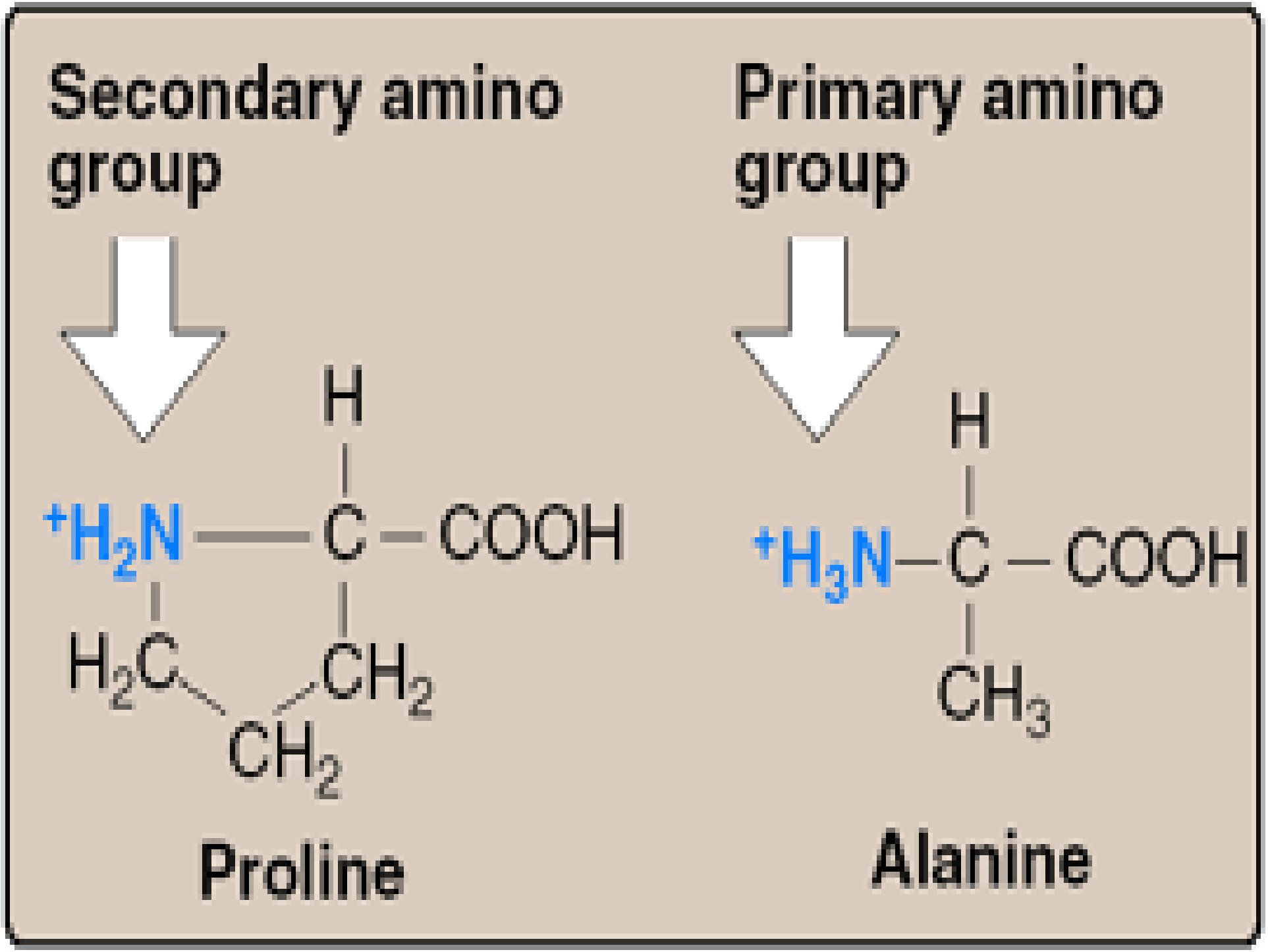
- Each amino acid
  - ✓**Primary Amino group**
  - ✓**Carboxyl group**
  - ✓**Side chain ("R-group)**

- Most of the aminoacids (except proline) are Alpha A.A.

- At physiologic pH,
  - ✓Carboxyl group = negative = $–COO^-$
  - ✓Amino group = positive = $–NH_3^+$

- Group are involve in peptide bond
- Protein properties depends on A.A. side chains.


R1
H3N+
C
C
O
O-
H
+
H
H
H
N+
C
C
O
O-
R2
H
Amino acid 1
Amino acid 2
O
H
H
R1
O
H
H3N+
C
C
N
C
C
O
O-
H
H
R2
Peptide bond


Secondary amino group
Primary amino group
H
+H2N — C — COOH
H2C
CH2
CH2
Proline
H
+H3N — C — COOH
CH3
Alanine

Proline

- Secondary amino group
- Unique geometry
- Contributes for formation of fibrous structure of collagen

- Interrupts the α-helices found in globular proteins.

CLASSIFICATION OF AMINOACID

1. Based on structure
2. Based on side chain (polarity)
3. Based on metabolic fates
4. Based on nutritional requirement

Amino acid Classification Based on Structure

A. Aliphatic amino acids:

1. **Monoamino monocarboxylic**
   - **Simple a.a.**
   - **Branched a.a.**
   - **Hydroxyl a.a.**
   - **Sulphur containing a.a.**
   - **Amide group containing a.a.**
2. **Monoamino dicarboxylic**
3. **Diamino monocarboxylic**

B. Aromatic amino acids:

C. Heterocyclic amino acids:

D. Imino acid :

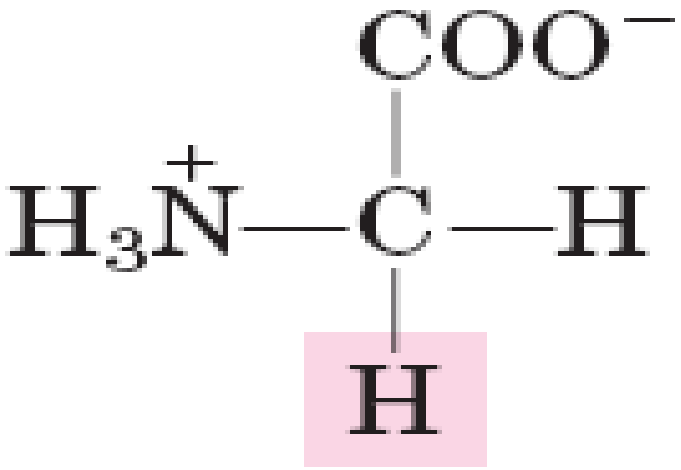
E. Derived amino acids:

A. Aliphatic amino acids

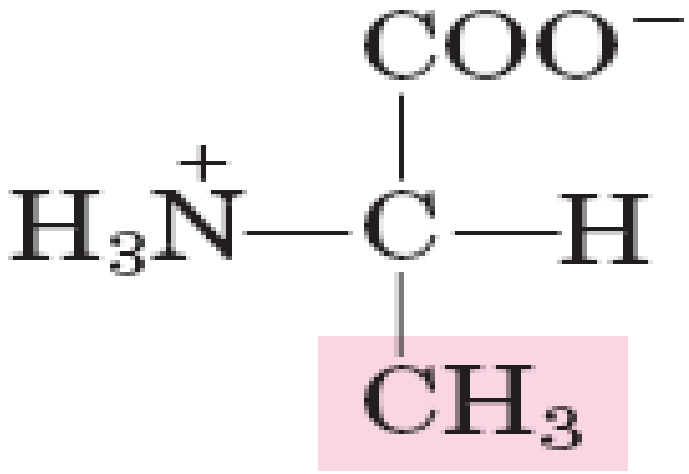
1. Mono amino mono carboxylic acids

- **Simple amino acids:**
  - Glycine
  - Alanine
- **Branched chain amino acids:**
  - Valine
  - Leucine
  - Isoleucine
- **Hydroxy amino acids:**
  - Serine
  - Threonine
- **Sulphur containing aminoacids:**
  - Cysteine
  - Methionine
- **Amide group containing amino acids:**
  - Aspargine
  - Glutamine

Simple Amino Acids

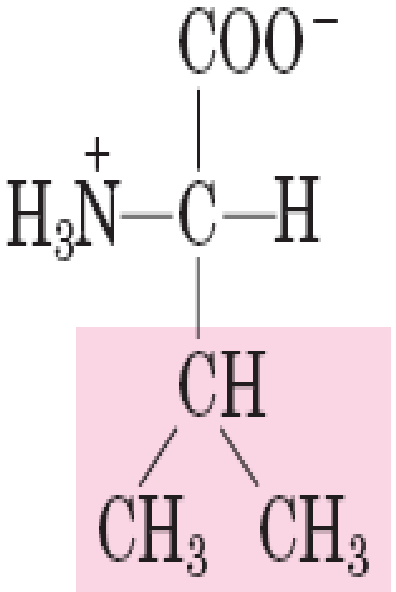


Glycine

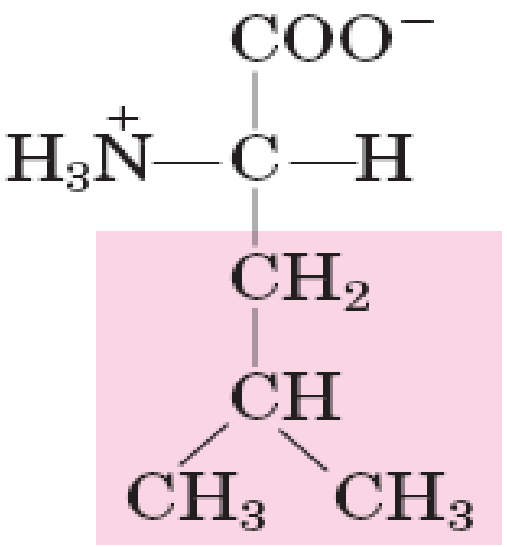


Alanine

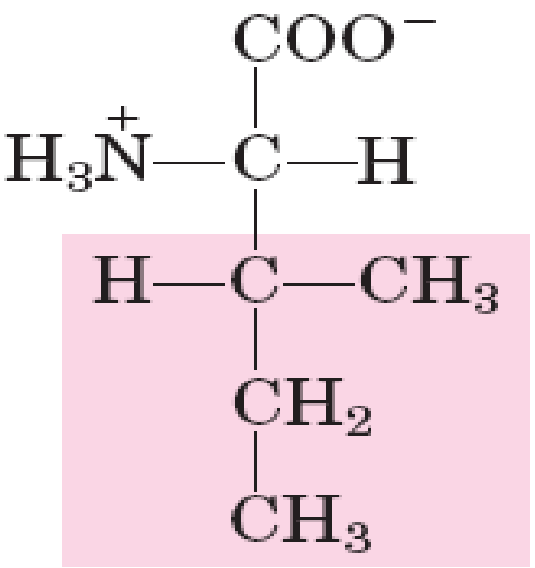
Branched chain Amino Acids



Valine

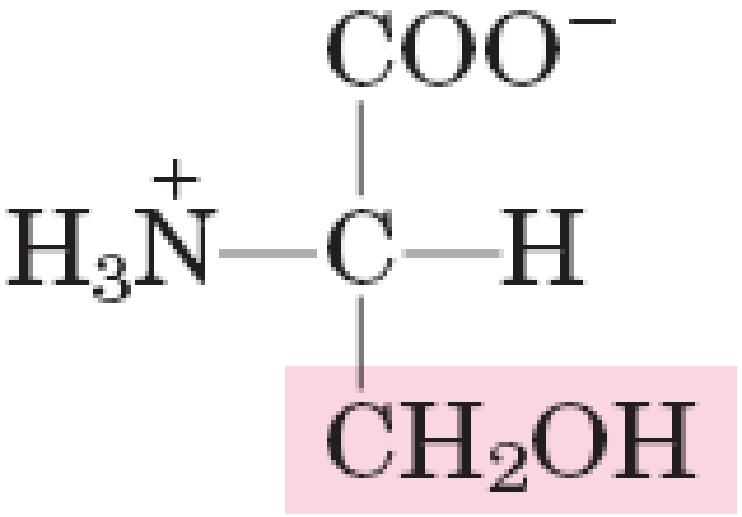


Leucine

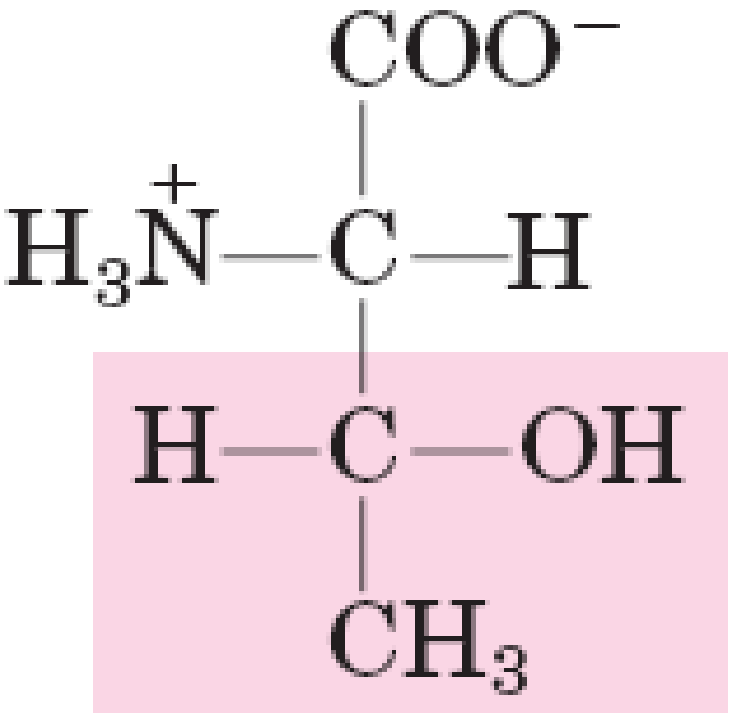


Isoleucine

Hydroxy Amino Acids

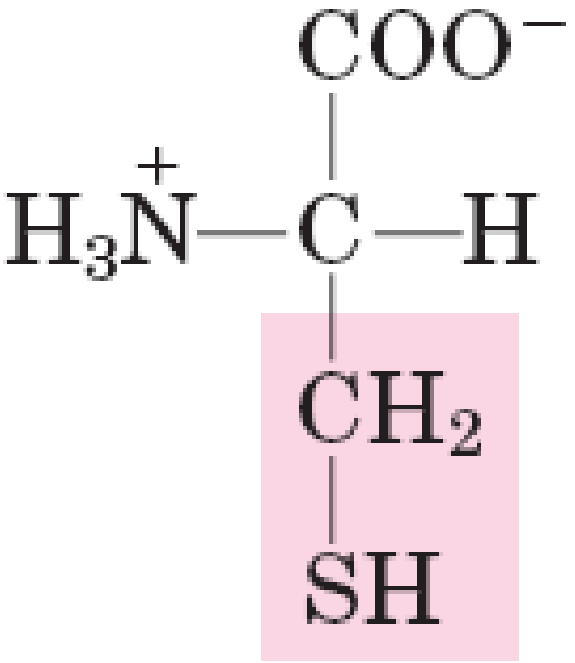


Serine

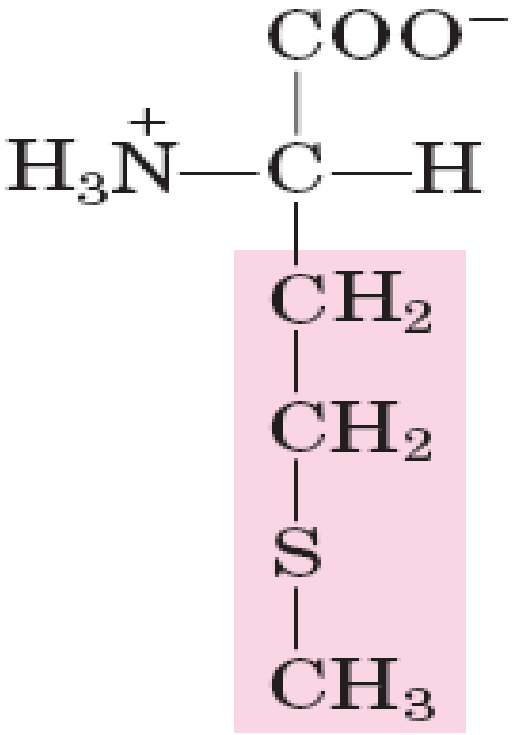


Threonine

Sulphur Containing Amino Acids

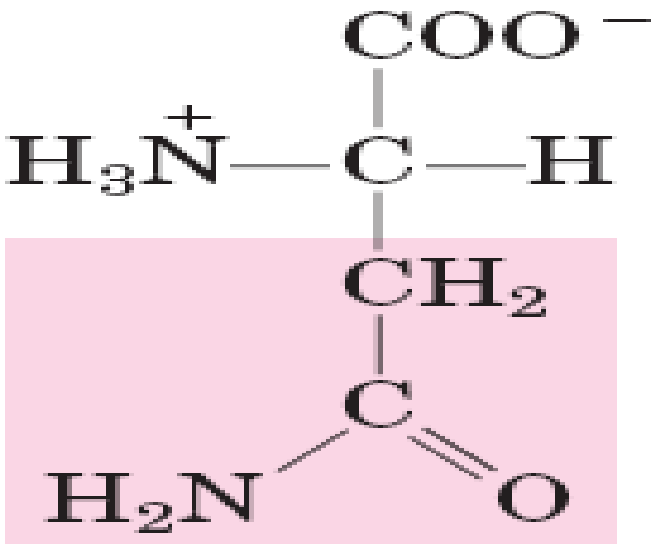


Cysteine

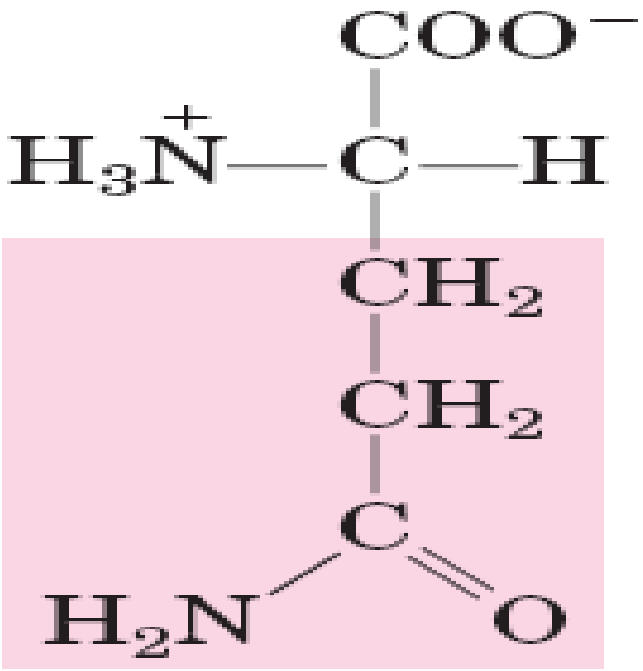


Methionine

Amide Containing Amino Acids



Asparagine



Glutamine

2. Mono amino dicarboxylic acids

Aspartic acid

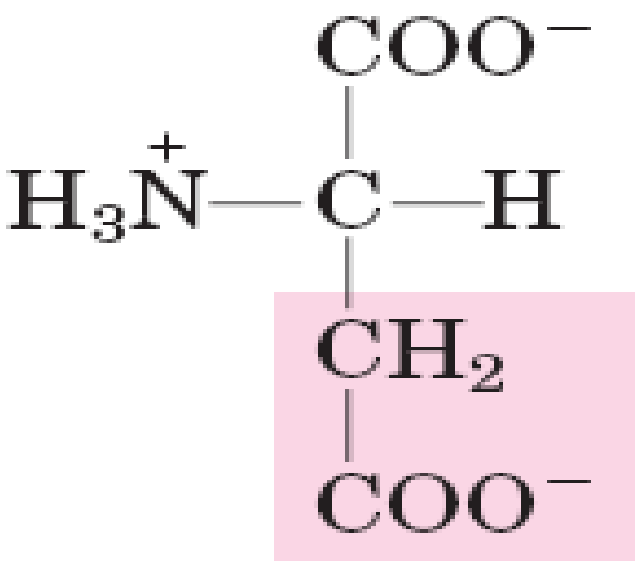
Glutamic acid

3. Di basic mono carboxylic acids

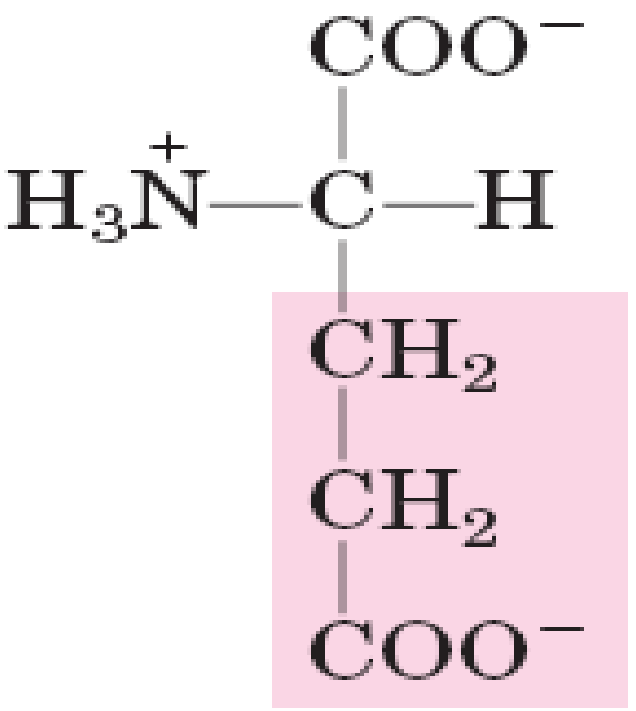
Lysine

Arginine

Mono-amino Di-carboxylic Amino Acids

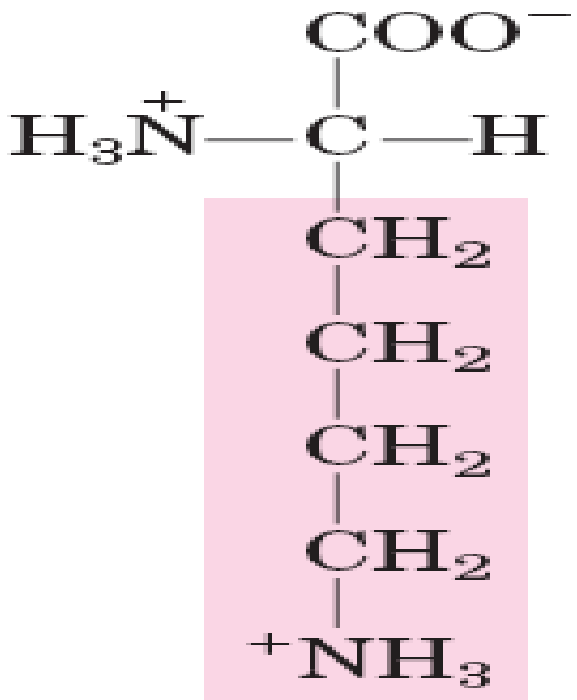


Aspartate

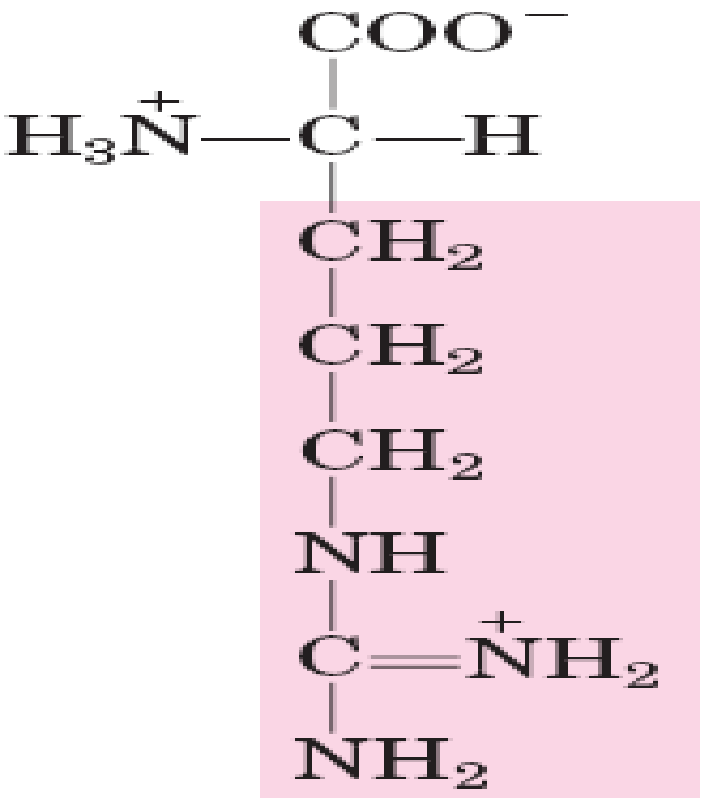


Glutamate

Di-basic Mono-carboxylic Amino Acids



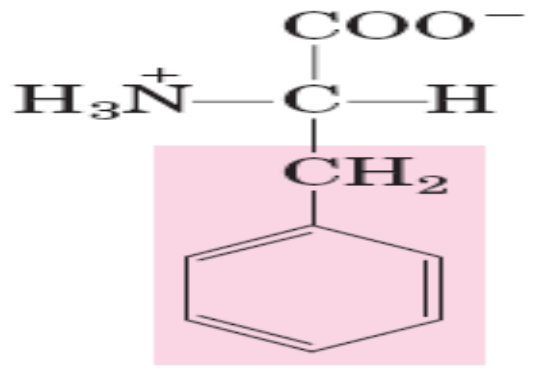
Lysine



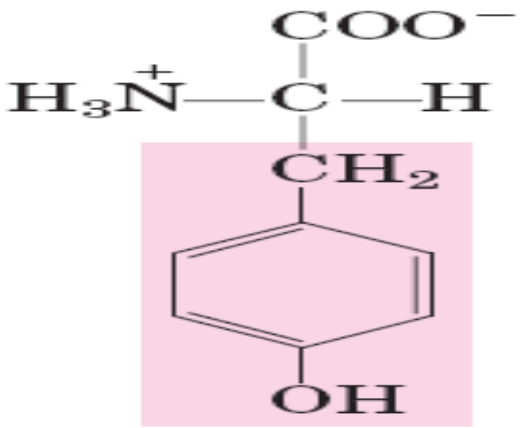
Arginine

B.Aromatic amino acids:

- Phenylalanine
- Tyrosine



Phenylalanine

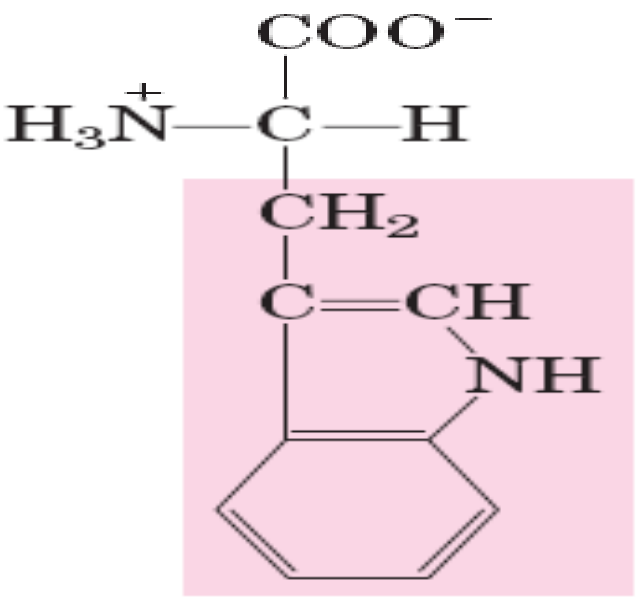


Tyrosine

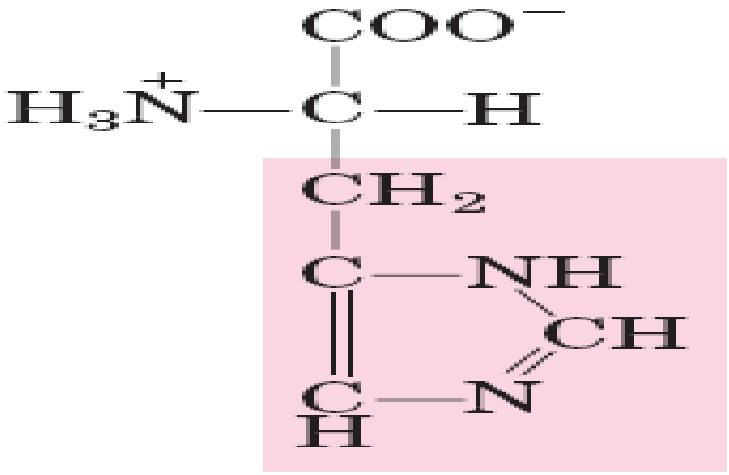
Importance ????

C.Heterocyclic amino acids:

- Tryptophan
- Histidine

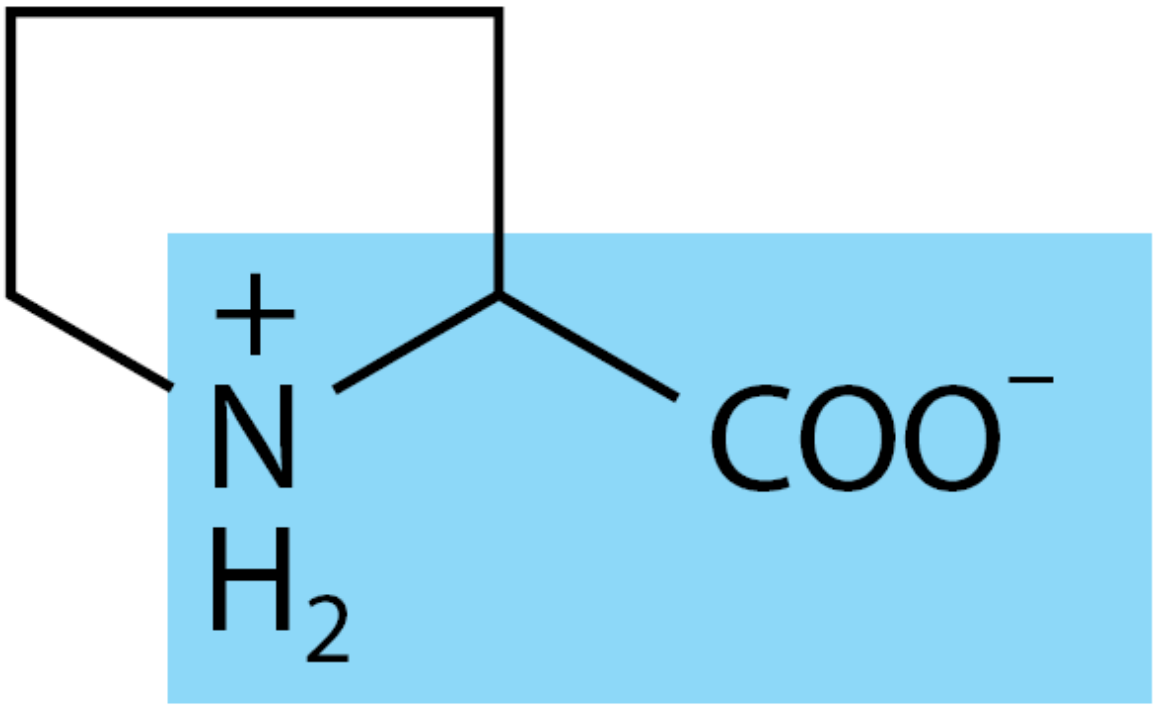


Tryptophan



Histidine

- **D.Imino acid:**
- Proline



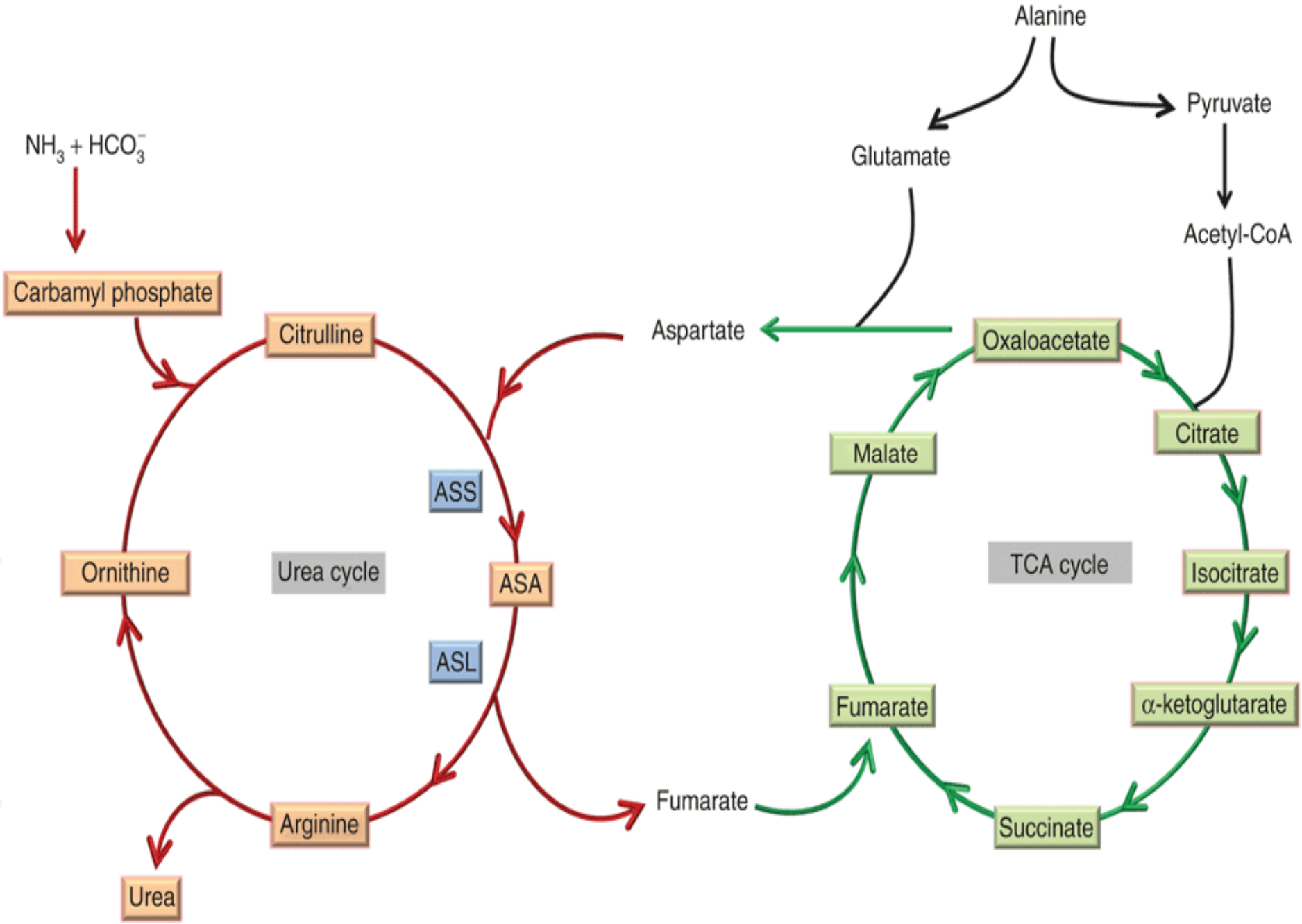
E.Derived amino acids:

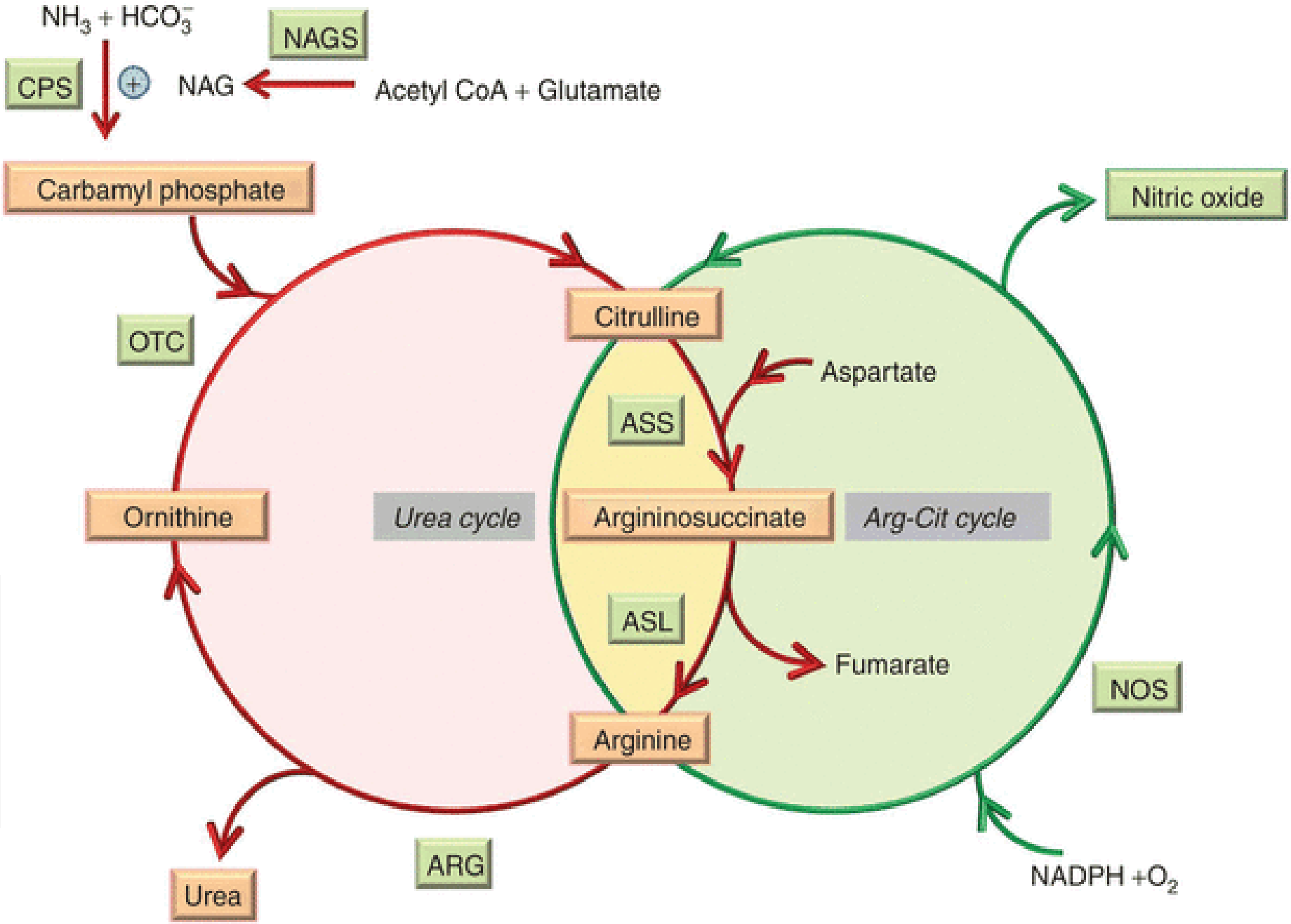
Found in proteins:

- Hydroxy lysine & Hydroxy proline = Collagen.
- Gamma carboxylation of glutamic acid residues of clotting factor.

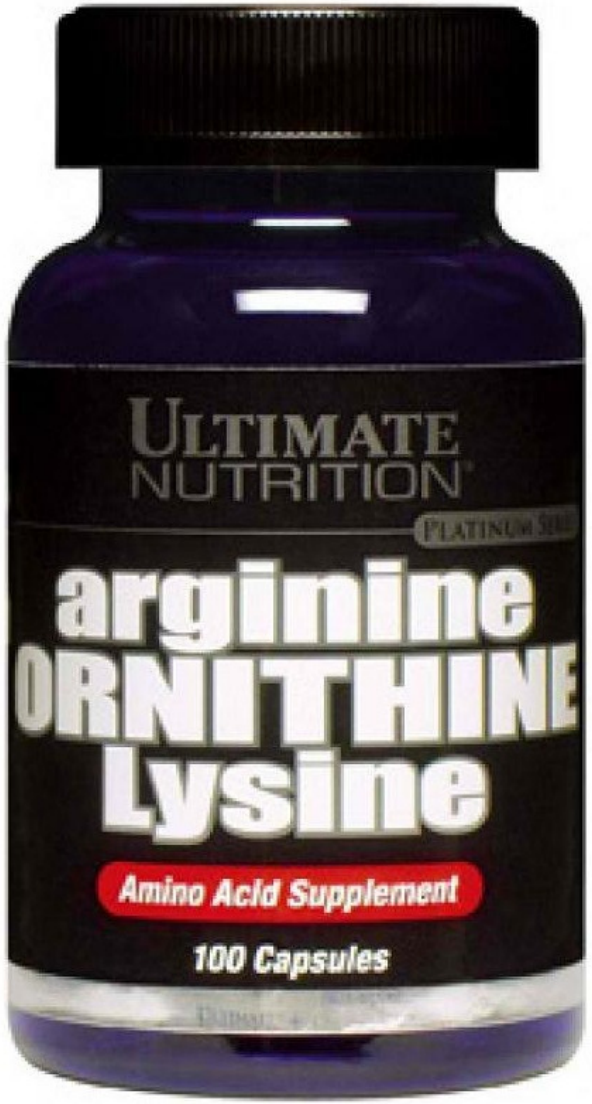
Not found in proteins:(non protein amino acids):

- Ornithine = ????
- Citruline = ????
- Homocysteine = Methionine Metabolism

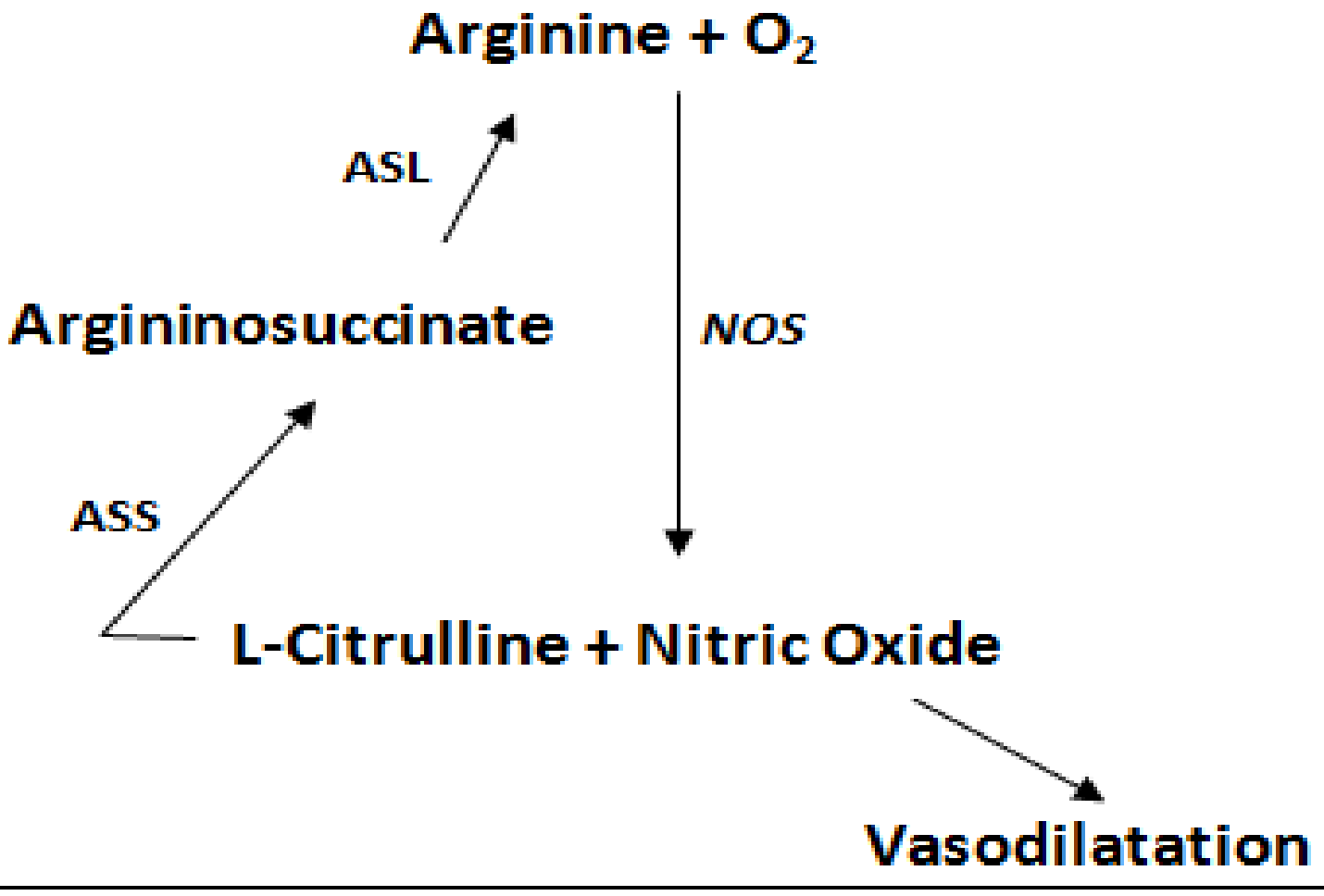

Alanine
Pyruvate
Glutamate
Acetyl-CoA
$NH_3 + HCO_3^-$
Carbamyl phosphate
Citrulline
Aspartate
Oxaloacetate
Citrate
Malate
ASS
Ornithine
Urea cycle
ASA
TCA cycle
Isocitrate
ASL
Fumarate
α-ketoglutarate
Fumarate
Arginine
Succinate
Urea


$NH_3 + HCO_3^-$
NAGS
CPS
NAG
Acetyl CoA + Glutamate
Carbamyl phosphate
Nitric oxide
OTC
Citrulline
Aspartate
ASS
Ornithine
Urea cycle
Argininosuccinate
Arg-Cit cycle
ASL
Fumarate
NOS
Arginine
ARG
Urea
NADPH +O_2

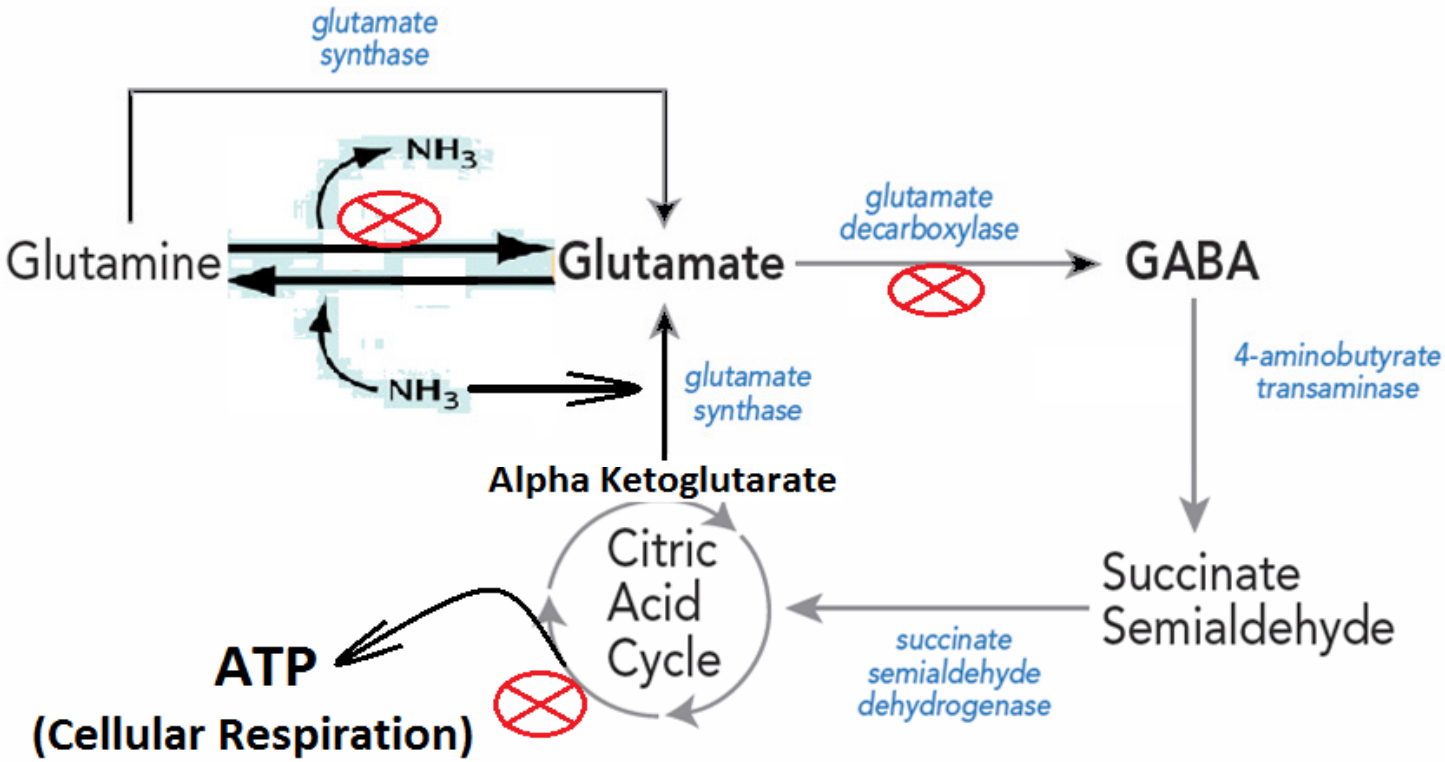
What can be use of this product?



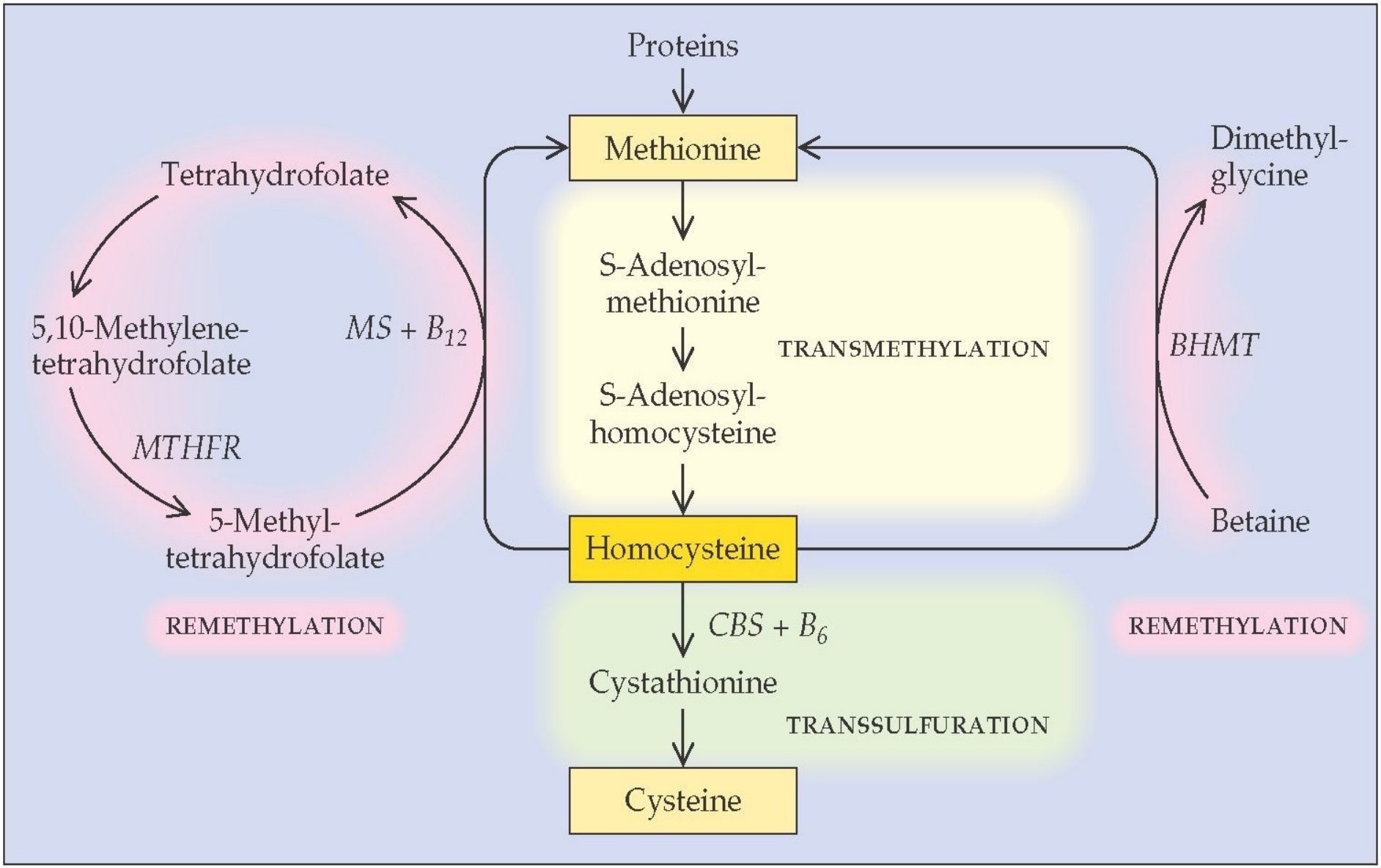
Citrulline – NO Cycle



What can be effect of high NH3 ?



What can prevent & decrease hyper-homocysteinemia?



E.Derived amino acids:

Non –alpha amino acids:

- Gamma amino butyric acid(GABA)
- Beta alanine
  - Constituent of pantothenic acid & Co-enzyme A.

Amino acid Classification Based on side chain (Polarity)

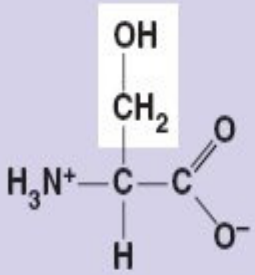
a) Non-polar side chains

b) Polar Un-charged side chain

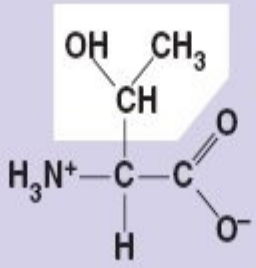
c) Polar charged side chain

- Acidic
- Basic

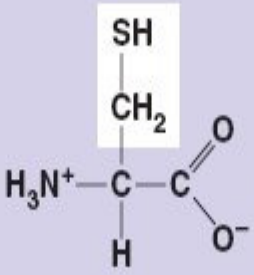
Polar



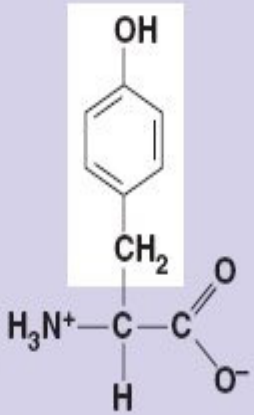
Serine (Ser)



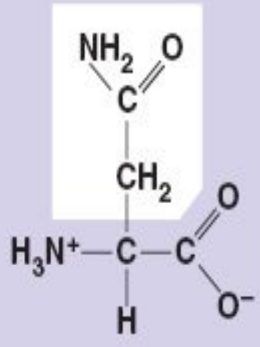
Threonine (Thr)



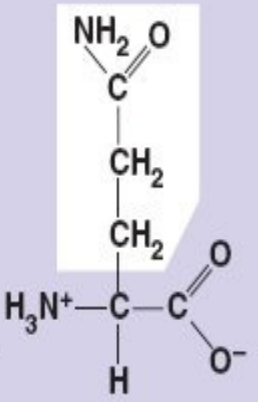
Cysteine (Cys)



Tyrosine (Tyr)



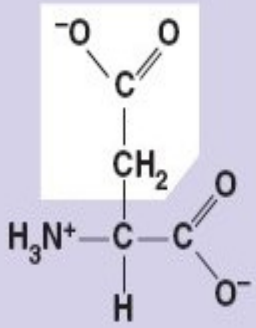
Asparagine (Asn)



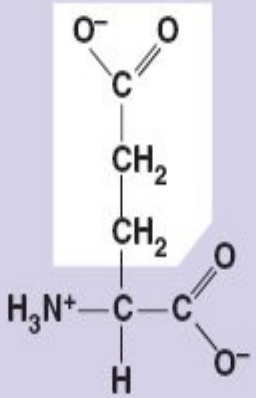
Glutamine (Gln)

Electrically charged

Acidic

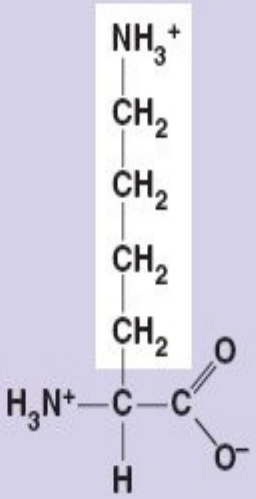


Aspartic acid (Asp)

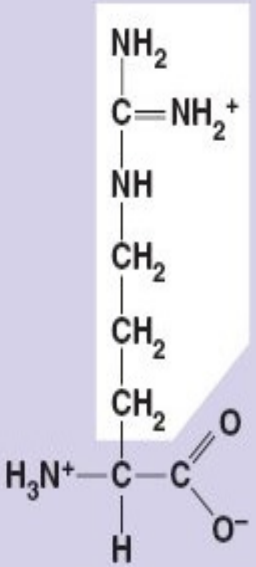


Glutamic acid (Glu)

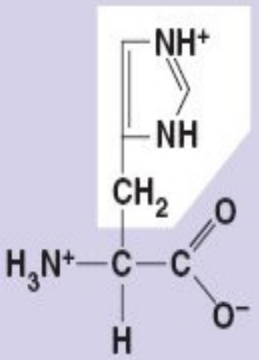
Basic



Lysine (Lys)



Arginine (Arg)



Histidine (His)

Amino acids with nonpolar

- Does not make bond
- Does not participate in hydrogen or ionic bonds
- Does not give off protons. Lipid - like a property
- Promotes hydrophobic interactions
- **In Water & In Polar environment**
  - Cluster together in the interior of the protein
  - Aggragate like droplets of oil in water.
- **In Hydrophobic environment, E.g. membrane**
  - Found on outer side of the protein
  - Interacting with the lipid environment.

Amino acids with Polar - Acidic

- Aspartic and Glutamic acid
- Proton donors
- At physiologic pH
- Fully ionized
- Negatively charged ($–COO^-$)

Amino acids with Polar - Basic

- Lysine & Arginine
- Accept protons
- At physiologic pH
- Fully ionized
- Positively charged. (NH_3^+)

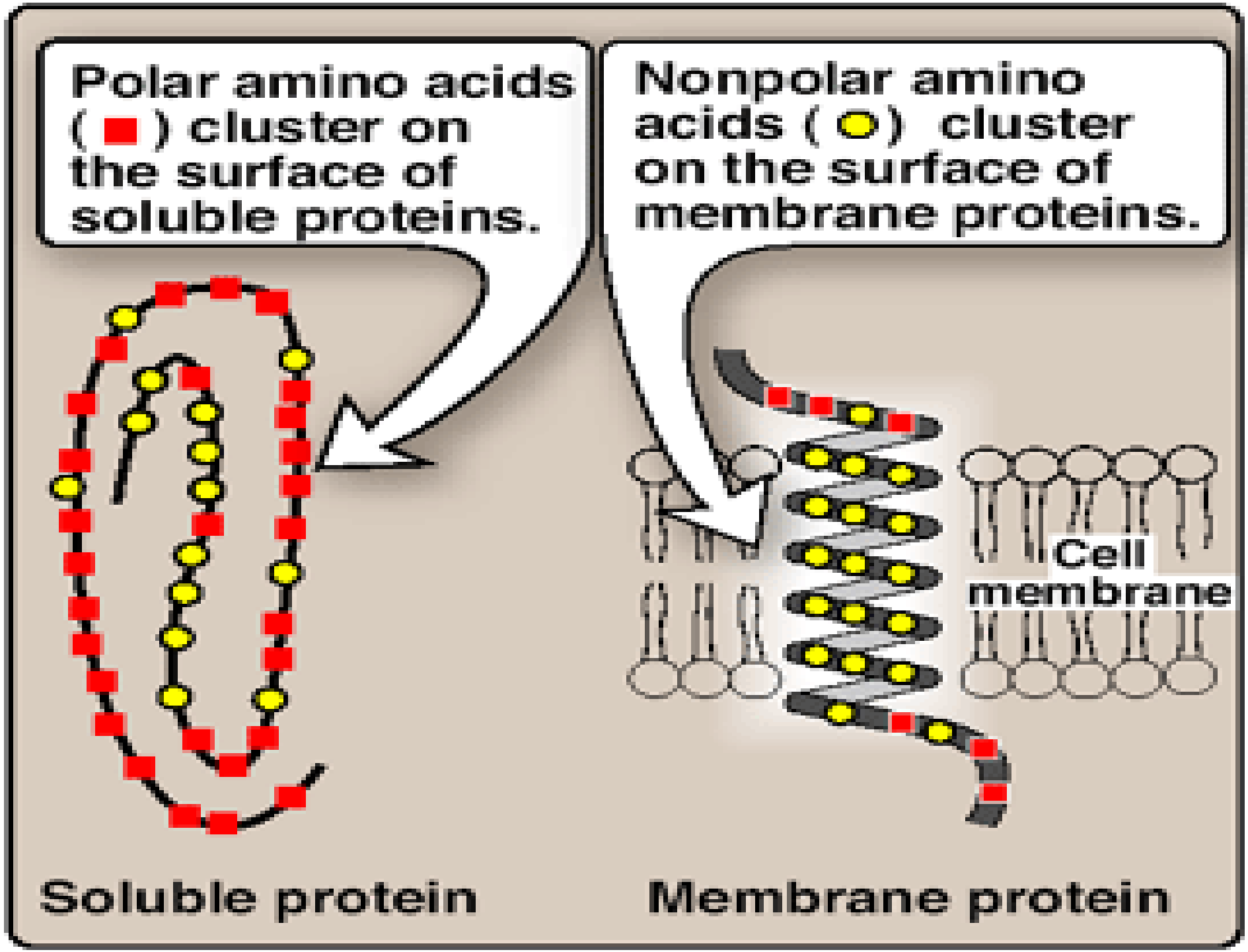
- In Histidine, at physiological pH
- Free amino acid = largely uncharged
- Into a protein, either positively charged or neutral
- Plays important in the functioning of Hemoglobin.

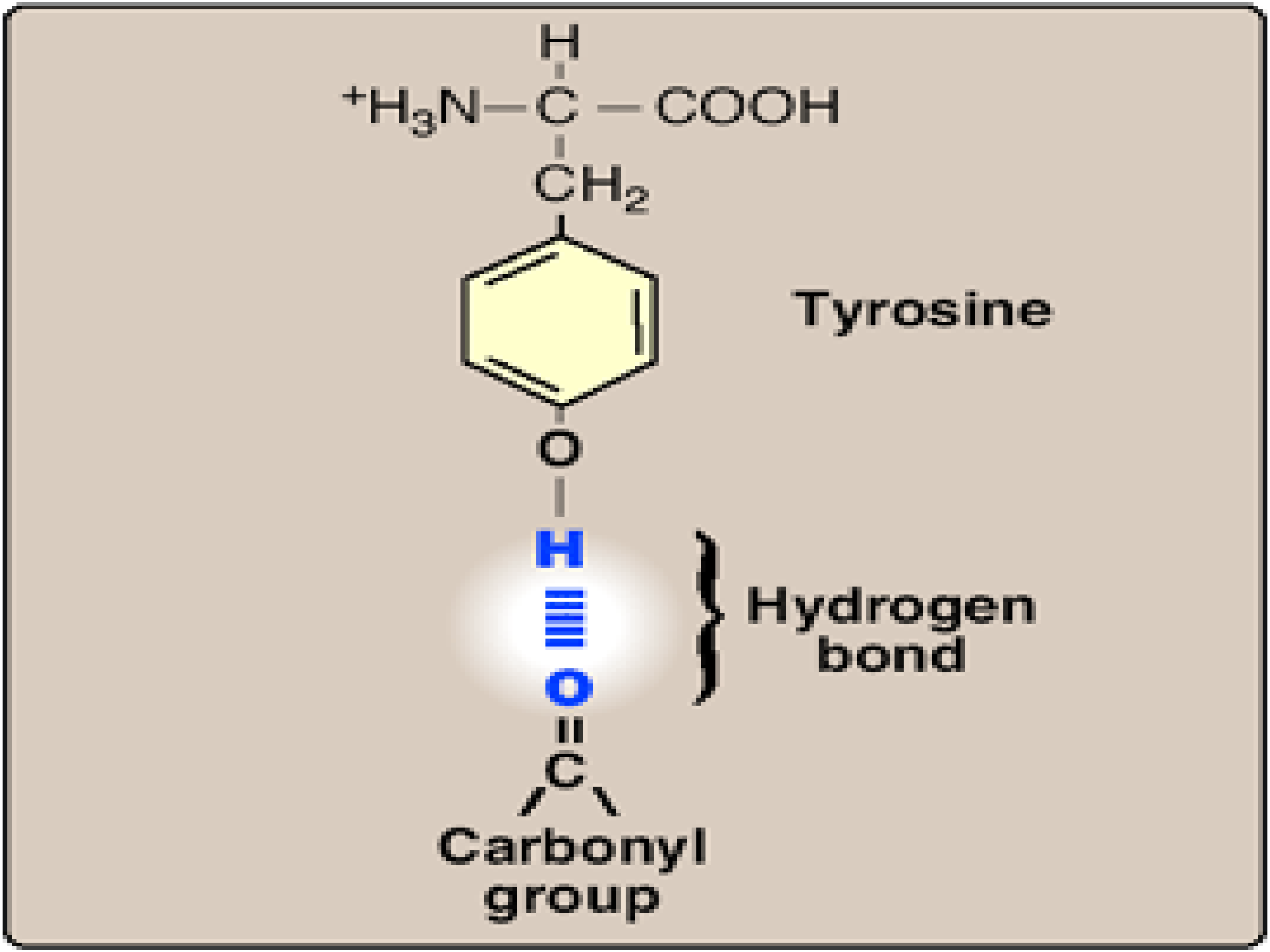
Amino acids with polar uncharged

- Zero net charge at neutral pH

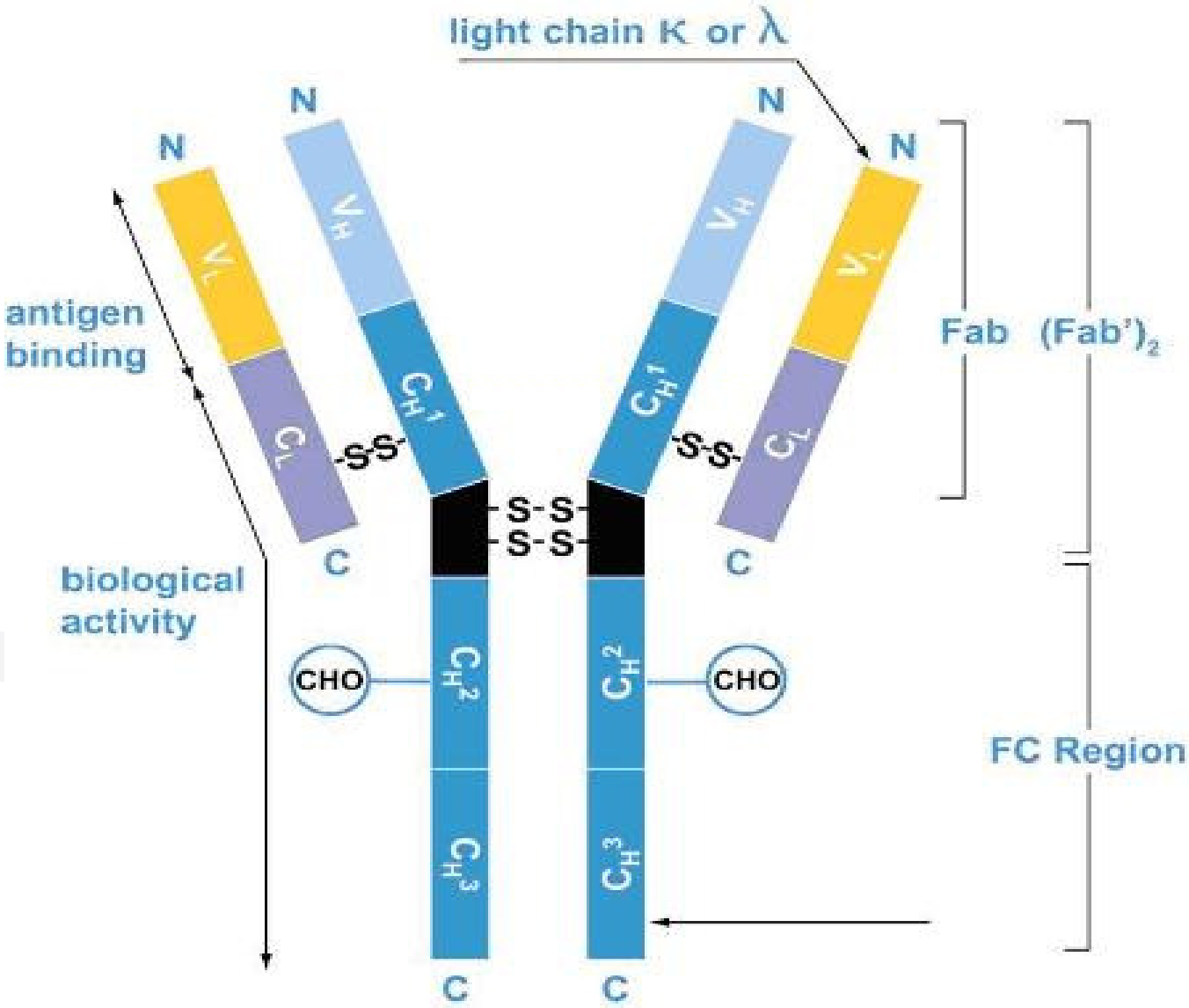
Side chains of Following

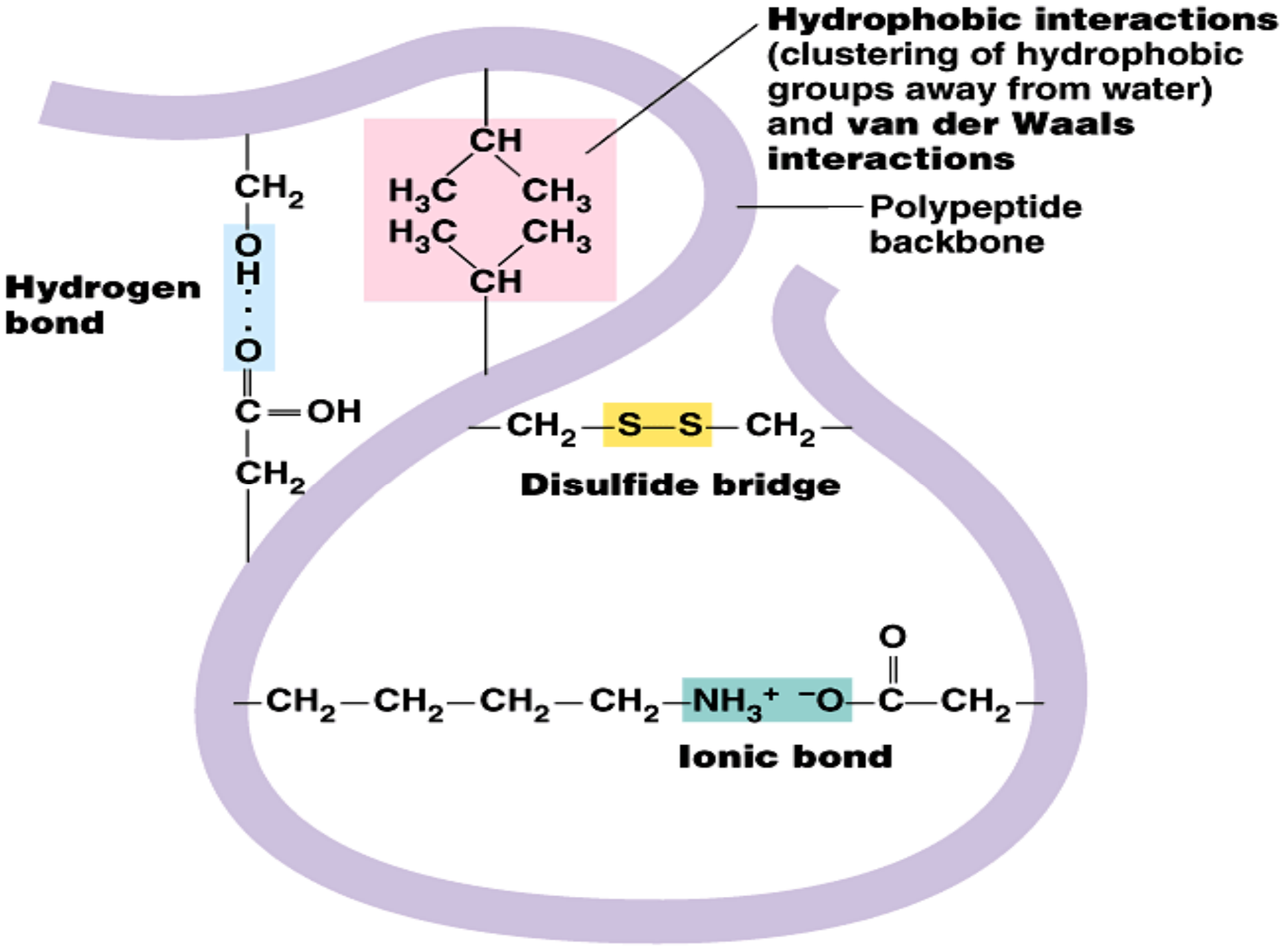
- Cysteine & Tyrosine can lose a proton at an alkaline pH.
- Serine, Threonine & Tyrosine
  - -OH group participate in hydrogen bond
- Asparagine & Glutamine
  - Carbonyl group & Amide group = participate in -OH bonds.


Polar amino acids (■) cluster on the surface of soluble proteins.
Nonpolar amino acids (●) cluster on the surface of membrane proteins.
Cell membrane
Soluble protein
Membrane protein


H
+H3N—C—COOH
CH2
Tyrosine
O
H
O
Hydrogen bond
C
Carbonyl group

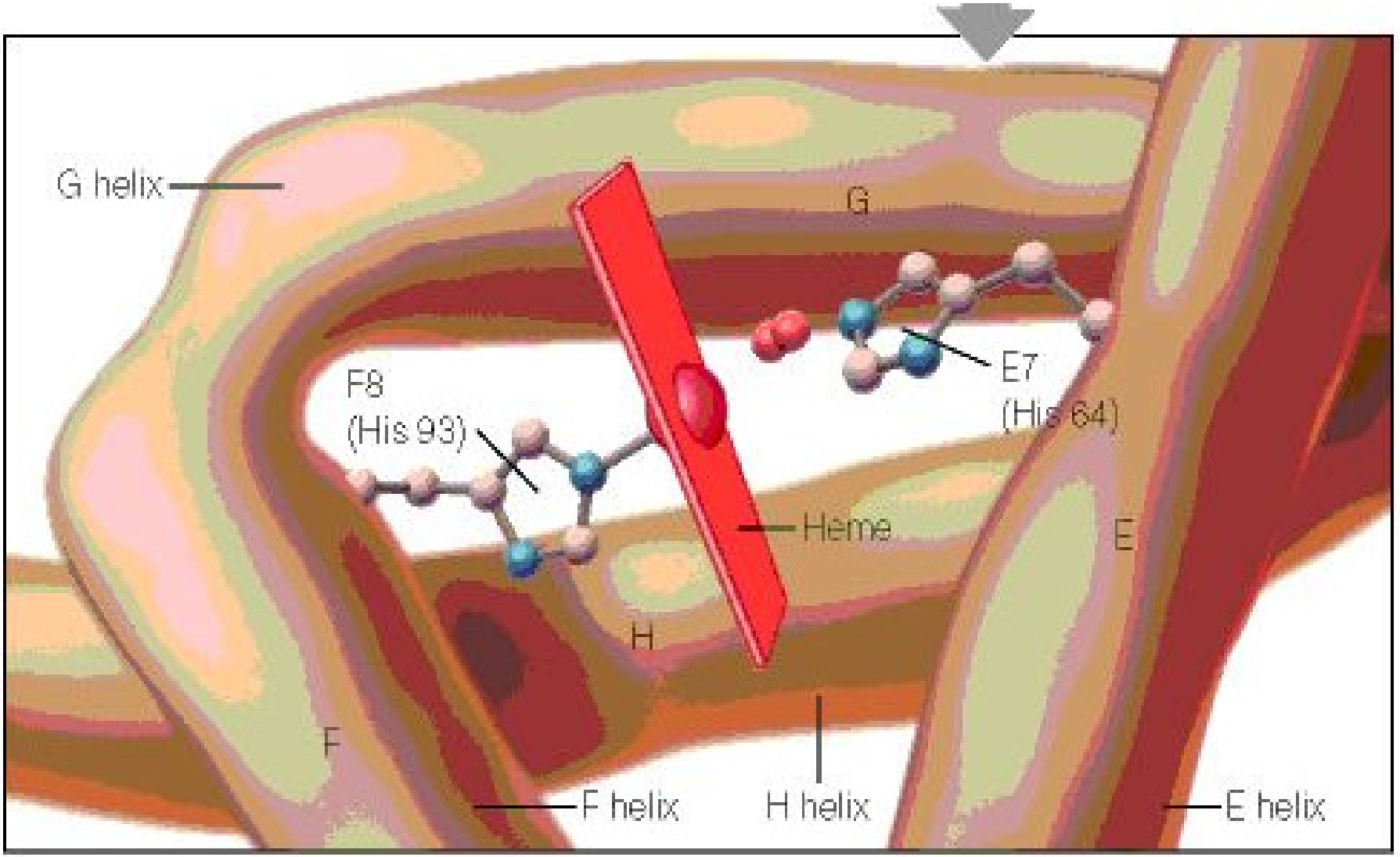
What is there in protein to providing stability and strength?

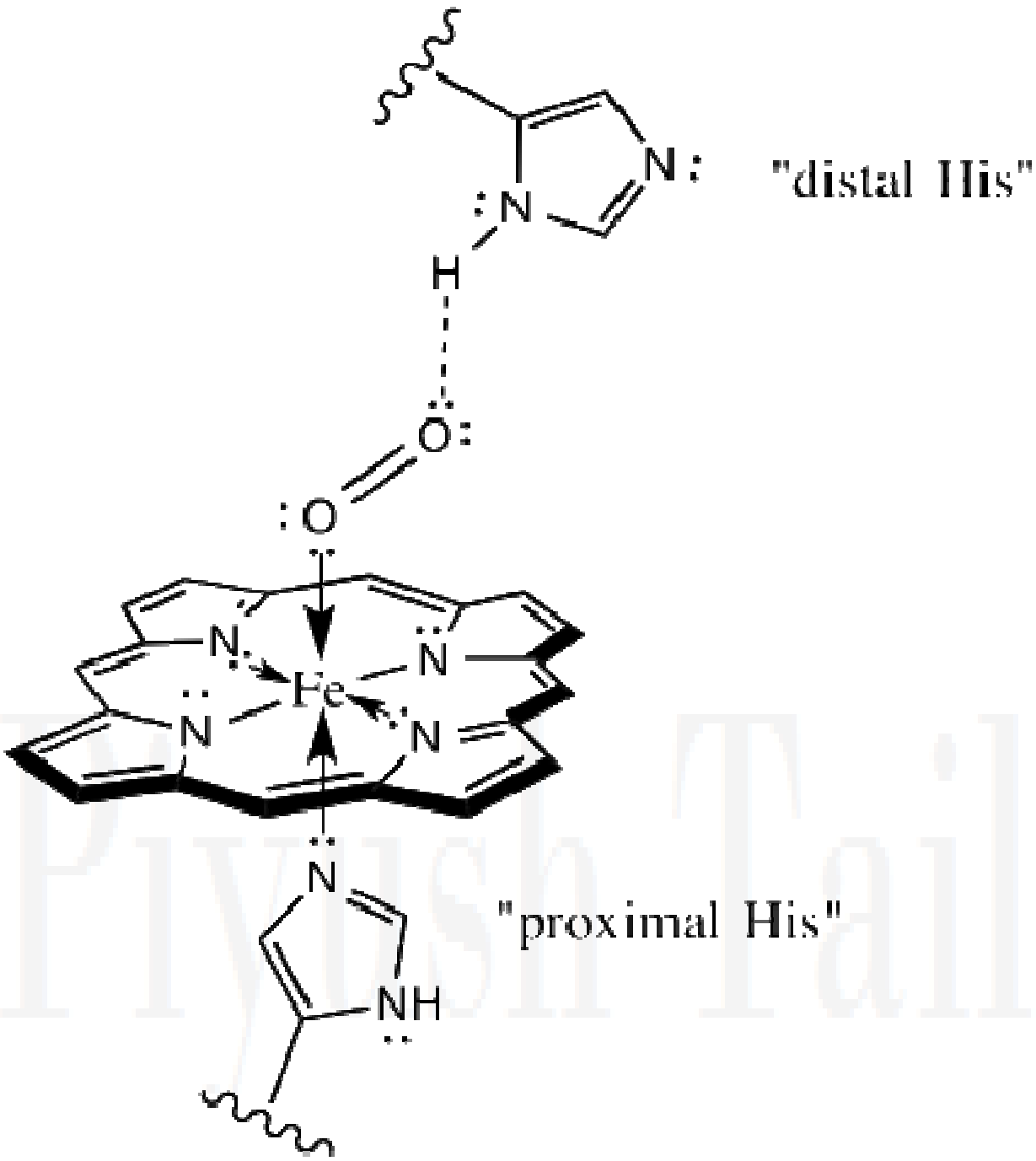


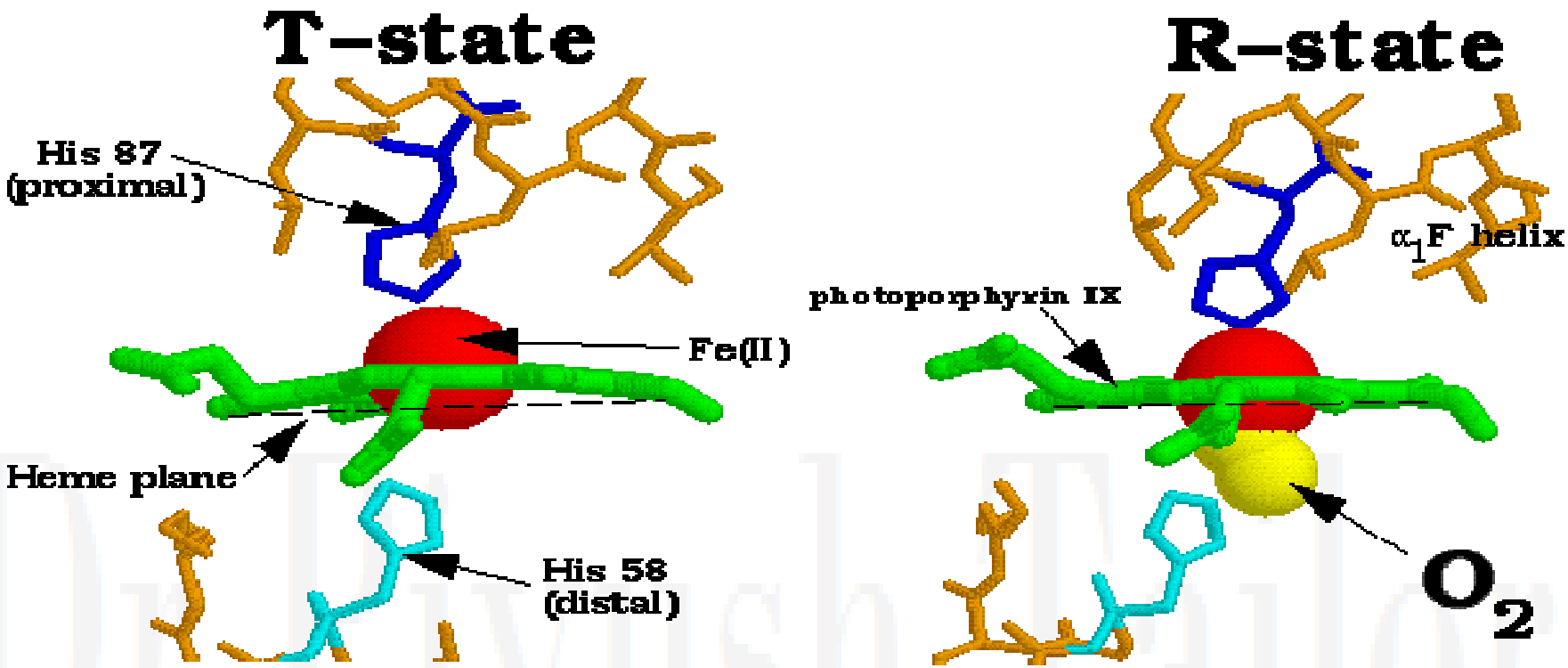


Disulfide bond

- Sulfhydryl group (–SH)
- component of the active site of many enzymes.
- –SH groups of two cysteines = oxidized = Dimer = Cystine
- -OH = can attachment with phosphate group.
- -NH3 = can attach with oligosaccharide of glycoproteins.


G helix
G
E7
(His 64)
F8
(His 93)
Heme
E
H
F
F helix
H helix
E helix




T-state
His 87
(proximal)
Fe(II)
Heme plane
His 58
(distal)
R-state
α1F helix
photoporphyrin IX
O2

1 Unique first letter:

Cysteine	=	Cys	=	**C**
Histidine	=	His	=	**H**
Iso**l**eucine	=	Ile	=	**I**
Methionine	=	Met	=	**M**
Serine	=	Ser	=	**S**
Valine	=	Val	=	**V**

2 Most commonly occurring amino acids have priority:

Alanine	=	Ala	=	**A**
Glycine	=	Gly	=	**G**
Leucine	=	Leu	=	**L**
Proline	=	Pro	=	**P**
Threonine	=	Thr	=	**T**

3 Similar sounding names:

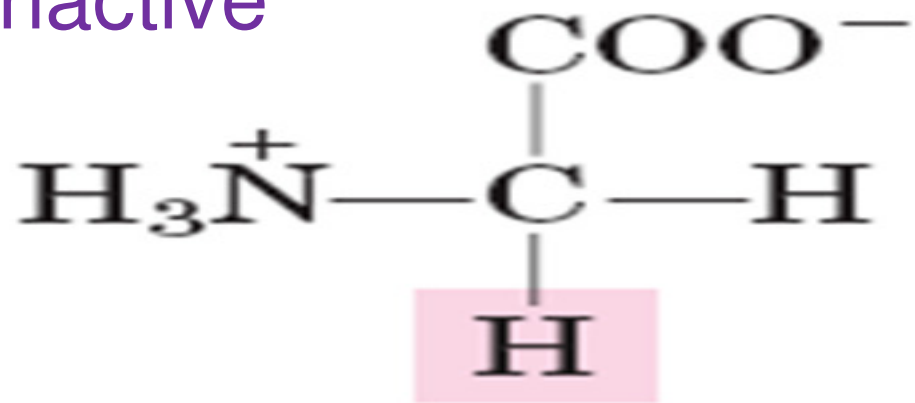
Arginine	=	Arg	=	**R** ("a**R**ginine")
Asparagi**n**e	=	Asn	=	**N** (contains N)
Aspartate	=	Asp	=	**D** ("aspar**D**ic")
Glutamate	=	Glu	=	**E** ("glut**E**mate")
Glutami**n**e	=	Gln	=	**Q** ("**Q**-tamine")
Phenylalanine	=	Phe	=	**F** ("**F**enylalanine")
Tyrosine	=	Tyr	=	**Y** ("t**Y**rosine")
Tryptophan	=	Trp	=	**W** (double ring in the molecule)

4 Letter close to initial letter:

Aspartate or asparagine	=	Asx	=	**B** (near A)
Glutamate or glutamine	=	Glx	=	**Z**
Lysine	=	Lys	=	**K** (near L)
Undetermined amino acid	=			**X**

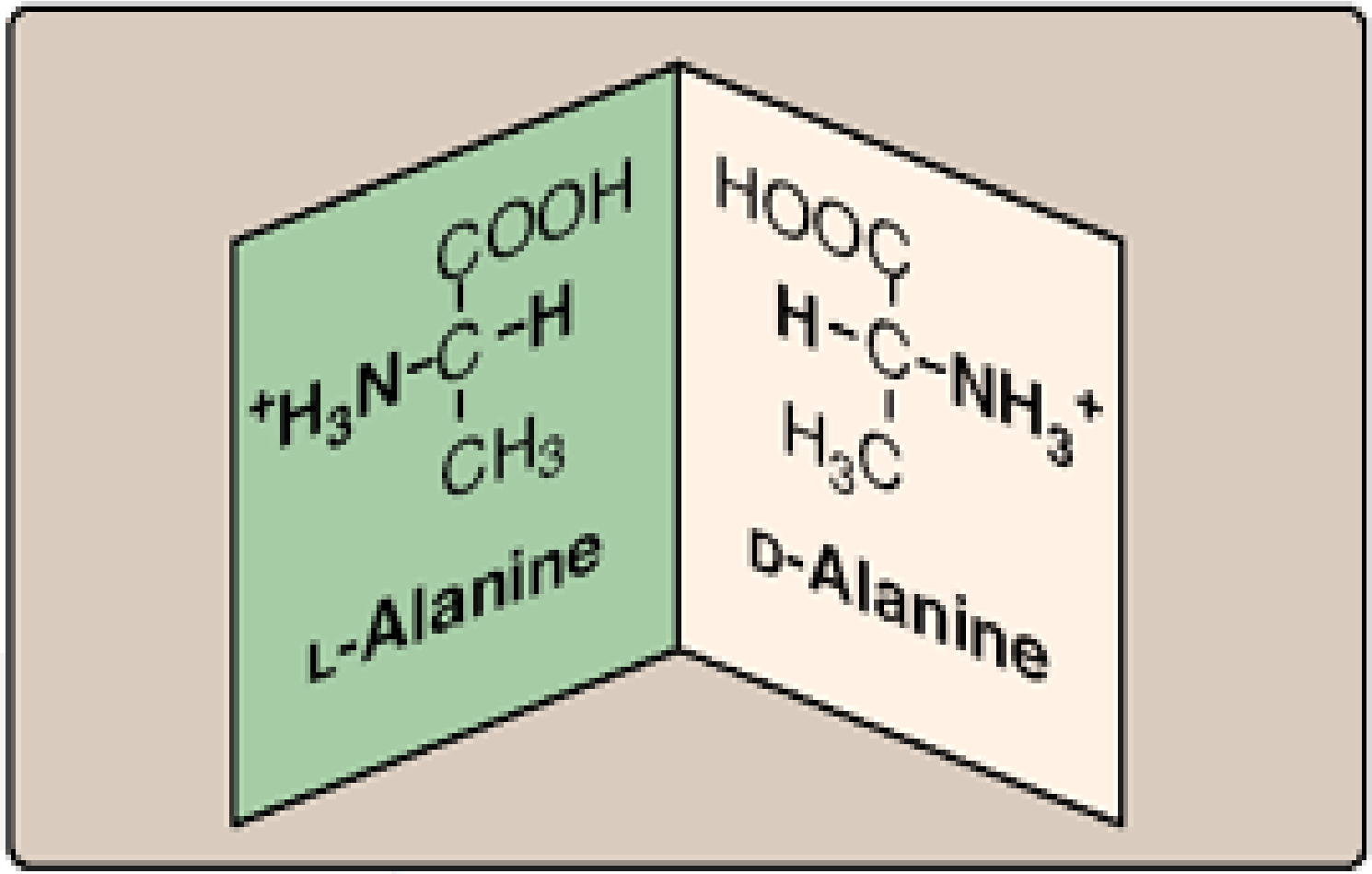
Optical properties of amino acids

- α-carbon = Four different group
- D and L form
- Stereoisomers,
- Glycine is the exception
- “Glycine is optically inactive”



Glycine

Stereoisomer



- **D-amino acids**
  - Micro-organisms
  - Constituents of certain antibiotics like Actinomycin-D, Polymyxin & Valinomycin
  - Bacterial cell wall peptidoglycans.

Acidic and Basic Properties of Amino Acids

- Amino acids in aqueous solution
  - Weakly acidic α-carboxyl groups
  - Weakly basic α-amino groups.
  - Ionizable group in its side chain.
- Can act as buffers.
- pH = log $1/[H^+]$
- pH = - log $[H^+]$

Henderson-Hasselbalch equation

- Relationship between
  - pH of the solution
  - Conc. of a weak acid (HA) and its conjugate base (A^-)

$$\underset{\text{weak acid}}{HA} \rightleftarrows \underset{\text{proton}}{H^+} + \underset{\text{salt form or conjugate base}}{A^-}$$

$$K_a = \frac{[H^+][A^-]}{[HA]}$$

Henderson-Hasselbalch equation

- .

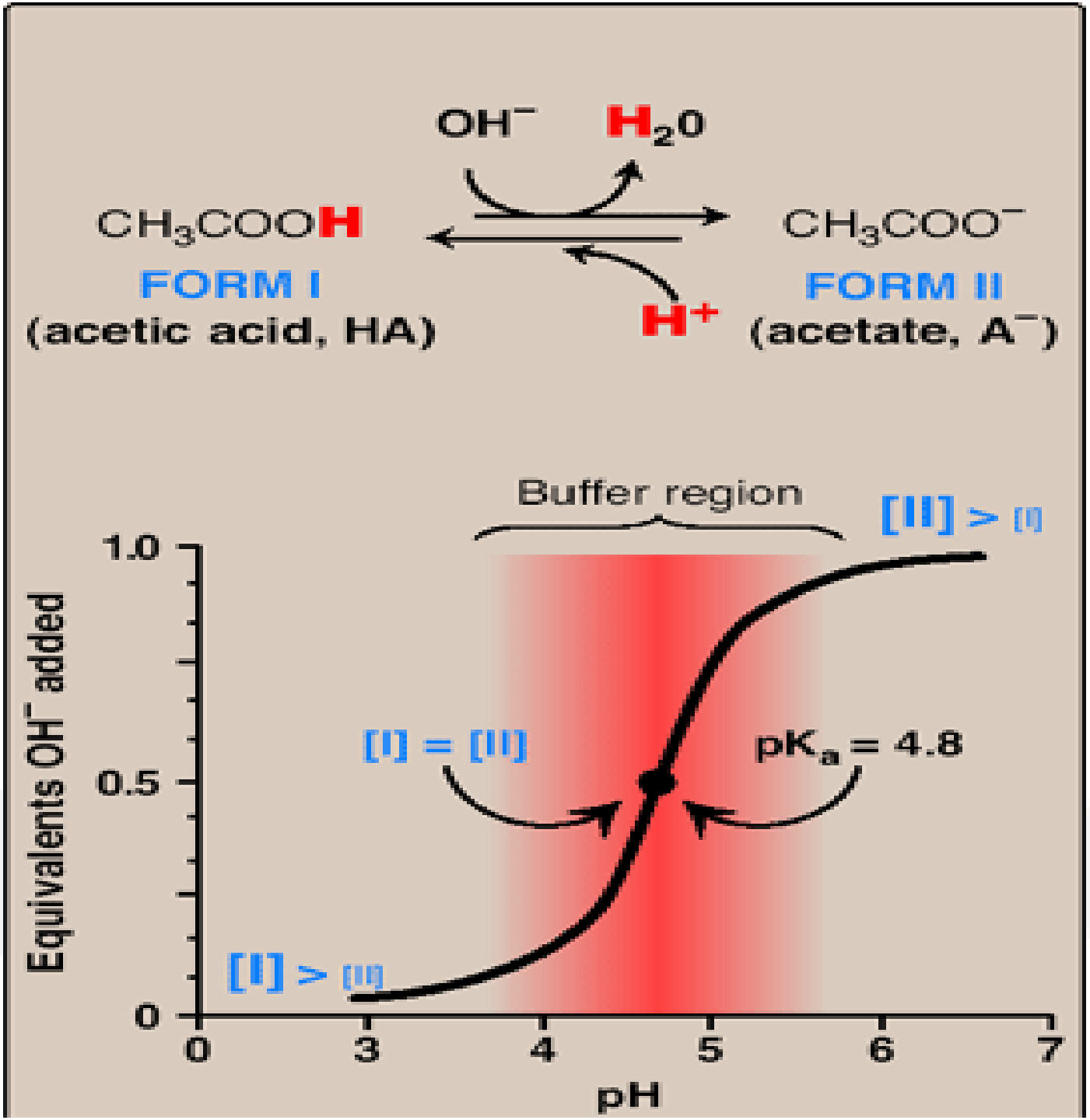
$$K_a = \frac{[H^+][A^-]}{[HA]}$$

$$\log K_a = \log [H^+] + \log \frac{[A^-]}{[HA]}$$

$$-\log [H^+] = -\log K_a + \log \frac{[A^-]}{[HA]}$$

We then use the definitions of pH and pK_a:

$$pH = pK_a + \log \frac{[A^-]}{[HA]}$$

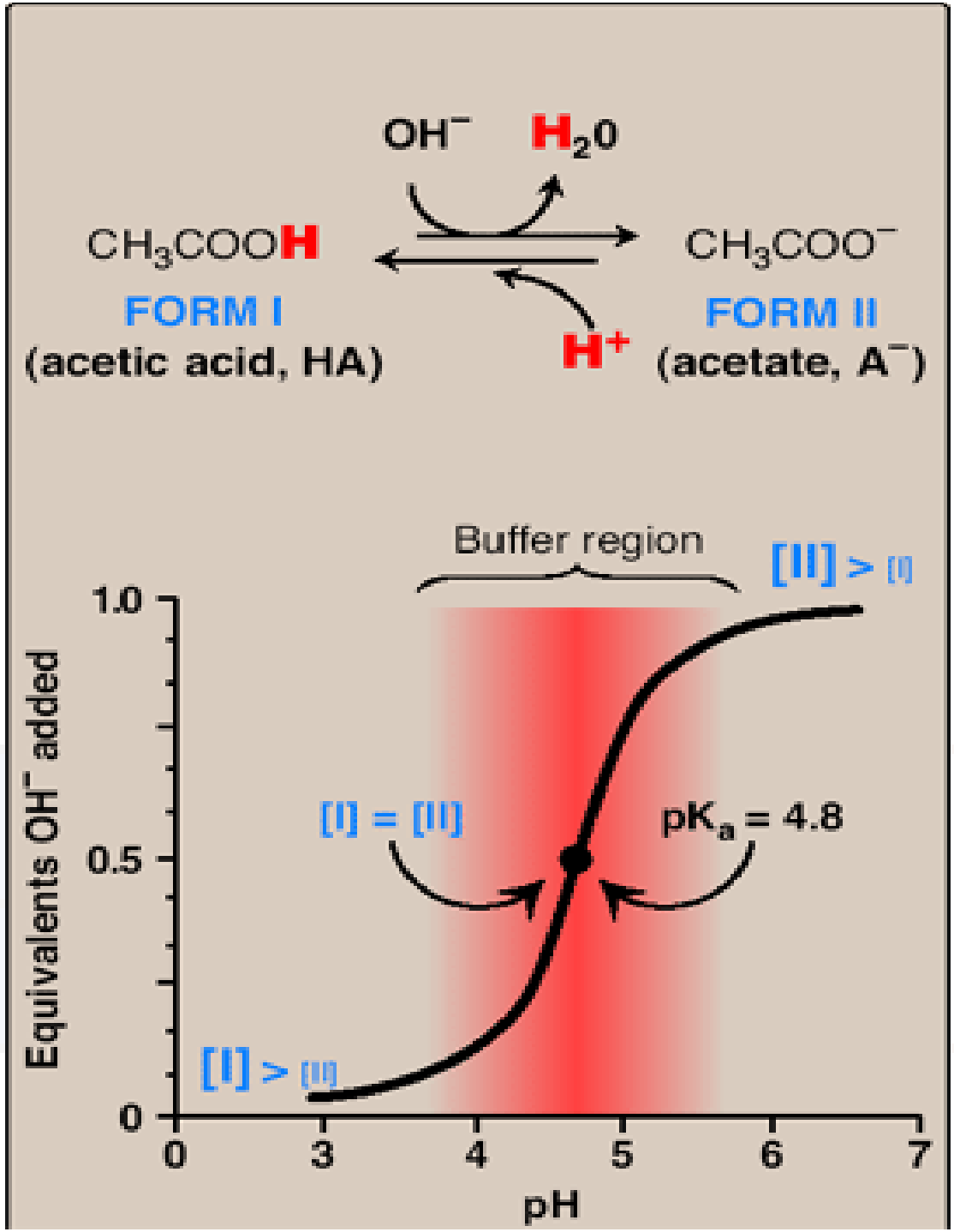

OH⁻
H₂0
CH₃COOH
CH₃COO⁻
FORM I
(acetic acid, HA)
H⁺
FORM II
(acetate, A⁻)
Buffer region
[II] > [I]
Equivalents OH⁻ added
1.0
0.5
0
[I] = [II]
pKa = 4.8
[I] > [II]
0
3
4
5
6
7
pH

Buffers

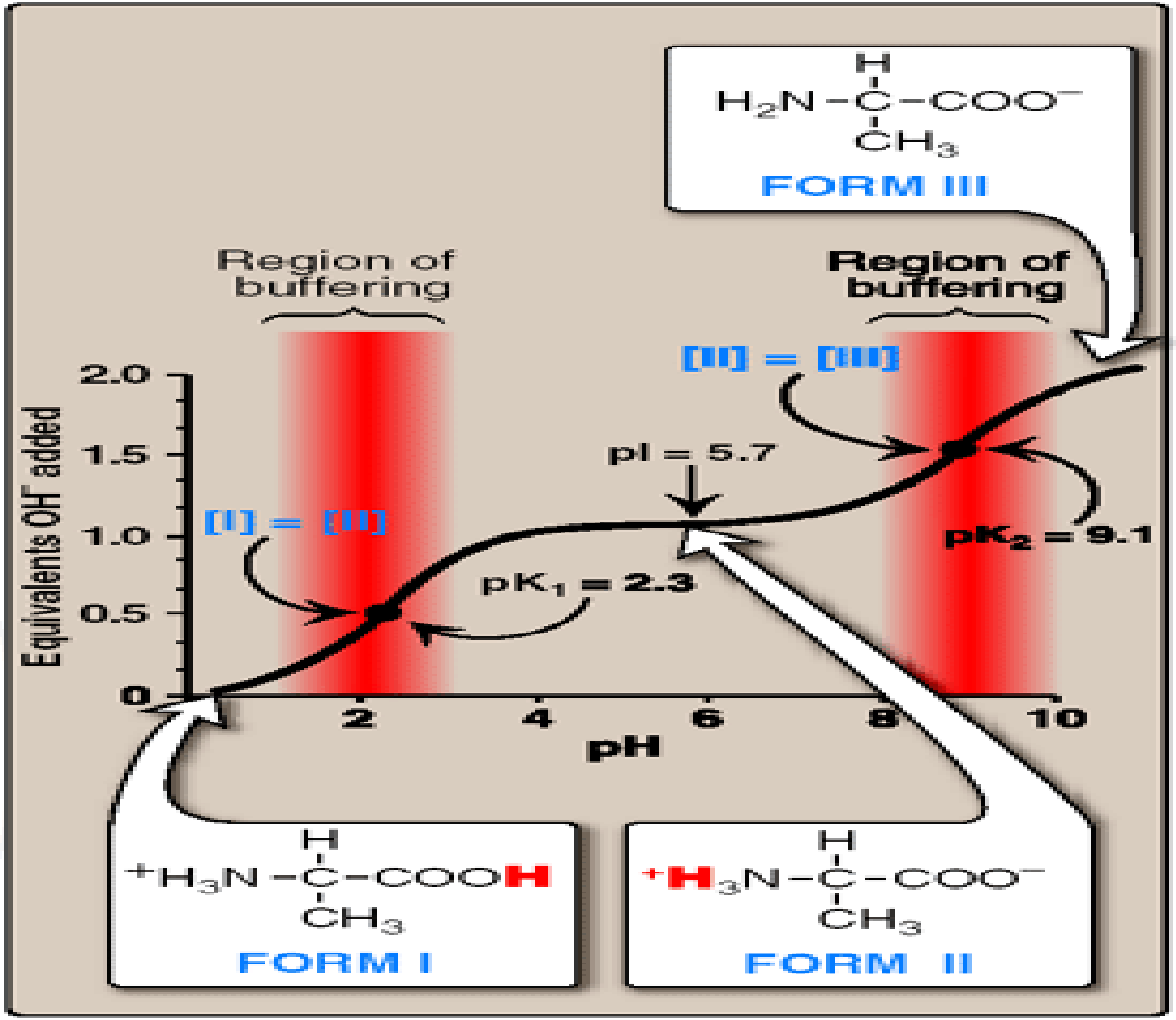
- Resists change in pH following the addition of an acid or base.
- Mixing of weak acid (HA) & its conjugate base (A^-).

- When HCl + **A^-** = **HA.**
- When HCO3- + **HA** = H2CO3 + **A^-**.

- [HA] = [A^-] , at that pH = pK_a
- So, Maximum buffering at a pH = pK_a,
- But still serve as an effective in ±1 pH of pK_a.
- .

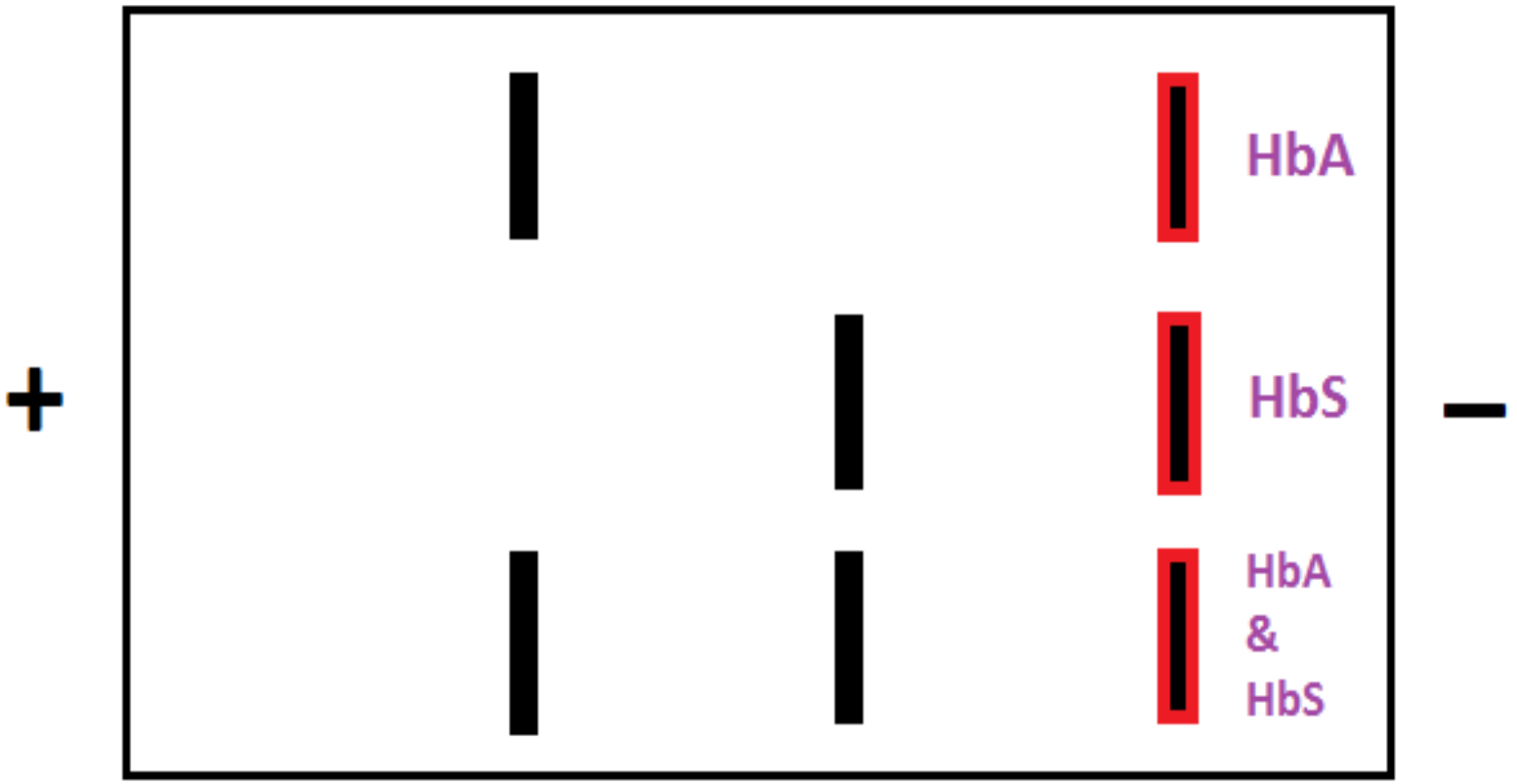

OH⁻
H20
CH3COOH
CH3COO⁻
FORM I
(acetic acid, HA)
H+
FORM II
(acetate, A⁻)
Buffer region
[II] > [I]
1.0
0.5
0
Equivalents OH⁻ added
[I] = [II]
pKa = 4.8
[I] > [II]
0
3
4
5
6
7
pH

- (HA)= CH_3–COOH
- (A^-) = CH_3–COO^-
- pK_a of this 4.8
- Maximum buffering at pH 4.8.
- Buffer capacity between pH 3.8 to 5.8
- At pH < pK_a
  - Protonated acid form (CH_3–COOH)
- At pH > pK_a
  - Deprotonated base form (CH_3–COO^-)


FORM III
Region of buffering
Region of buffering
[II] = [III]
pI = 5.7
[I] = [II]
pK2 = 9.1
pK1 = 2.3
Equivalents OH⁻ added
2.0
1.5
1.0
0.5
0
2
4
6
8
10
pH
FORM I
FORM II

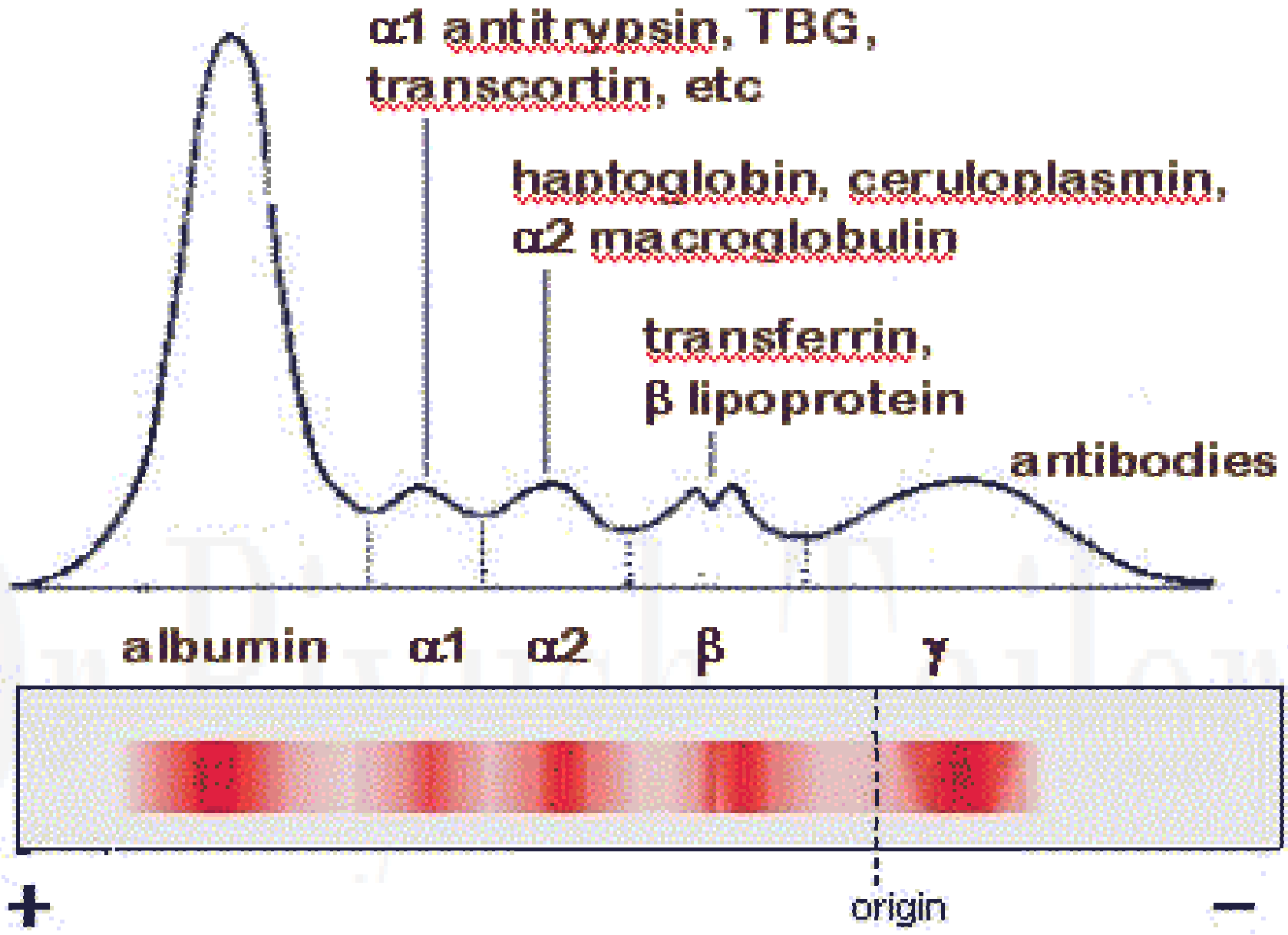
What will be effect of charges, on movement of protein ,in electrical field?

- Separation of plasma proteins is done by it's charges.
- Separation is easier at pH > pI .
- Thus, the charge on the proteins is negative.

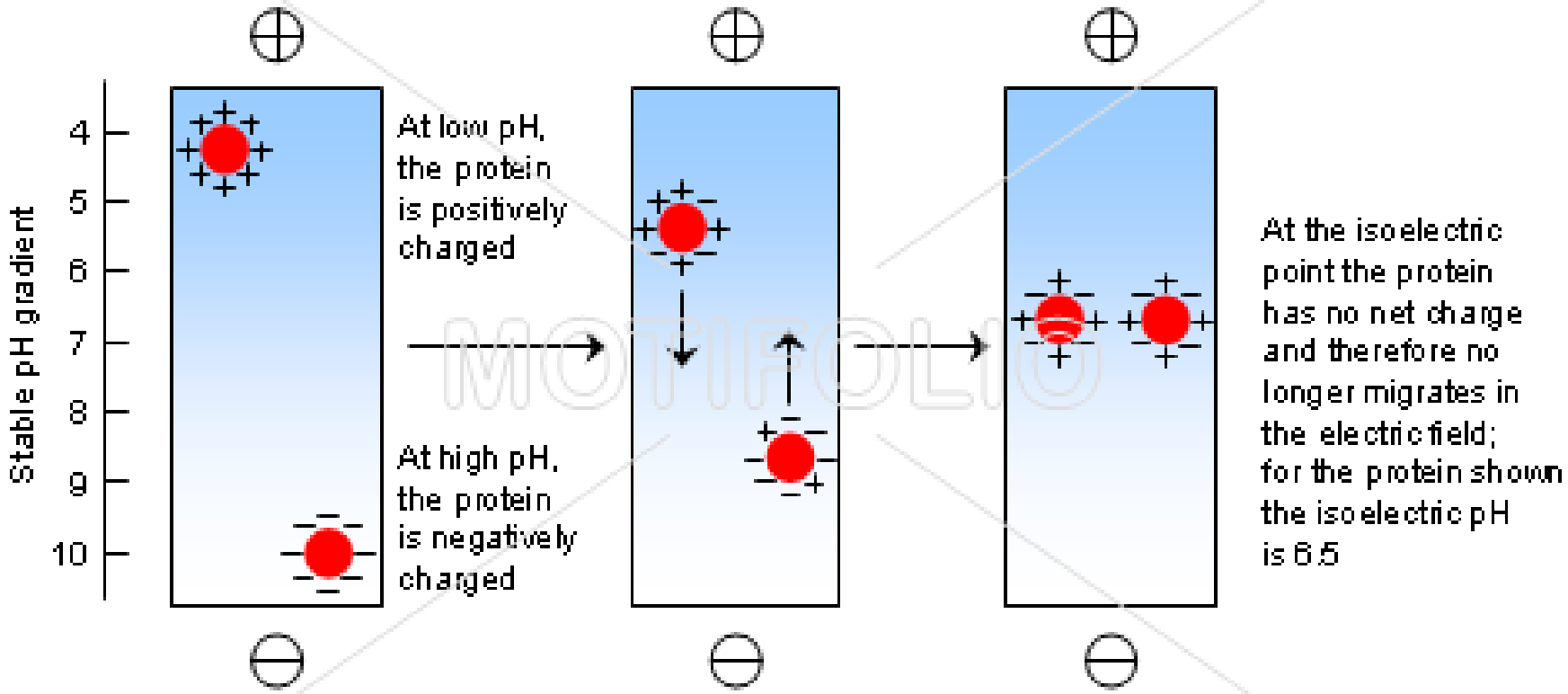


Haemoglobin Electrophoresis

Plasma Protein



Separation of protein molecules by isoelectric focusing



6111185

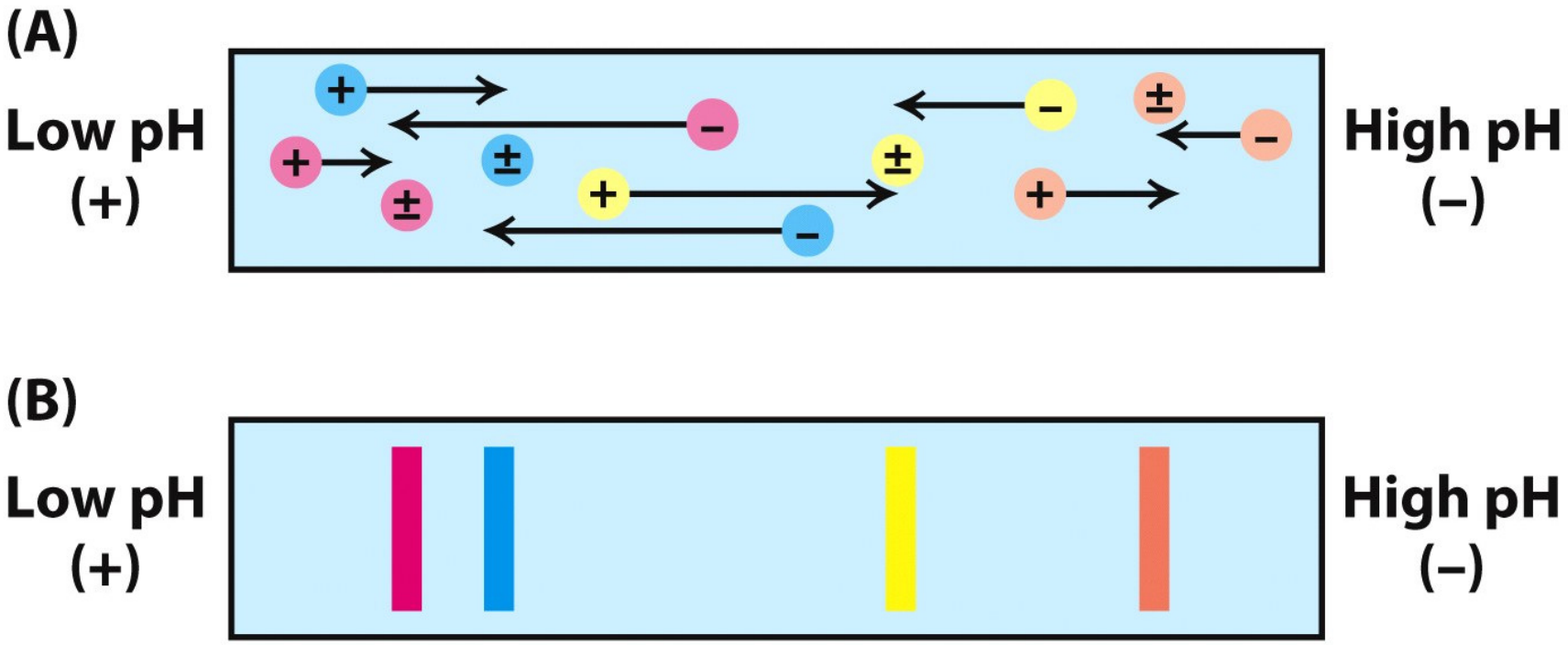
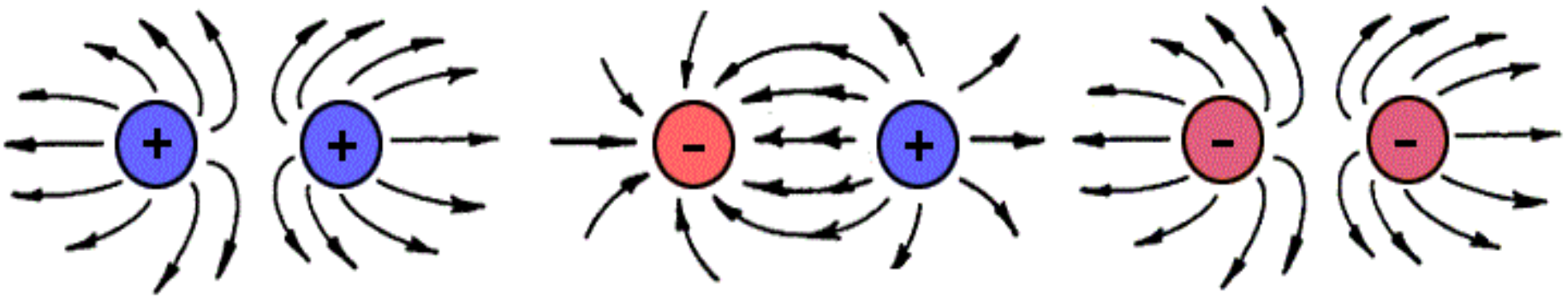
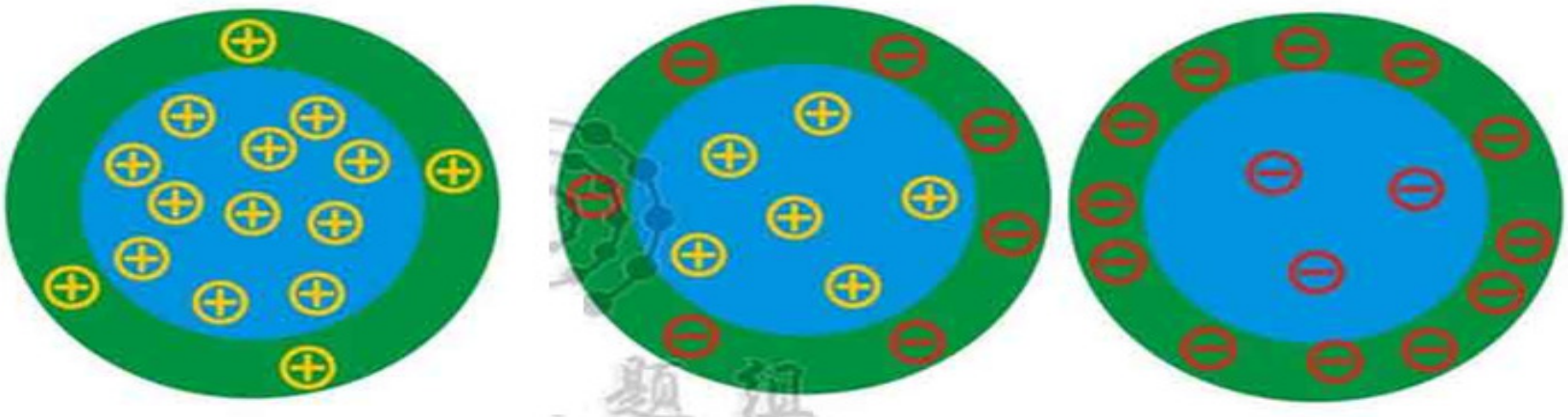


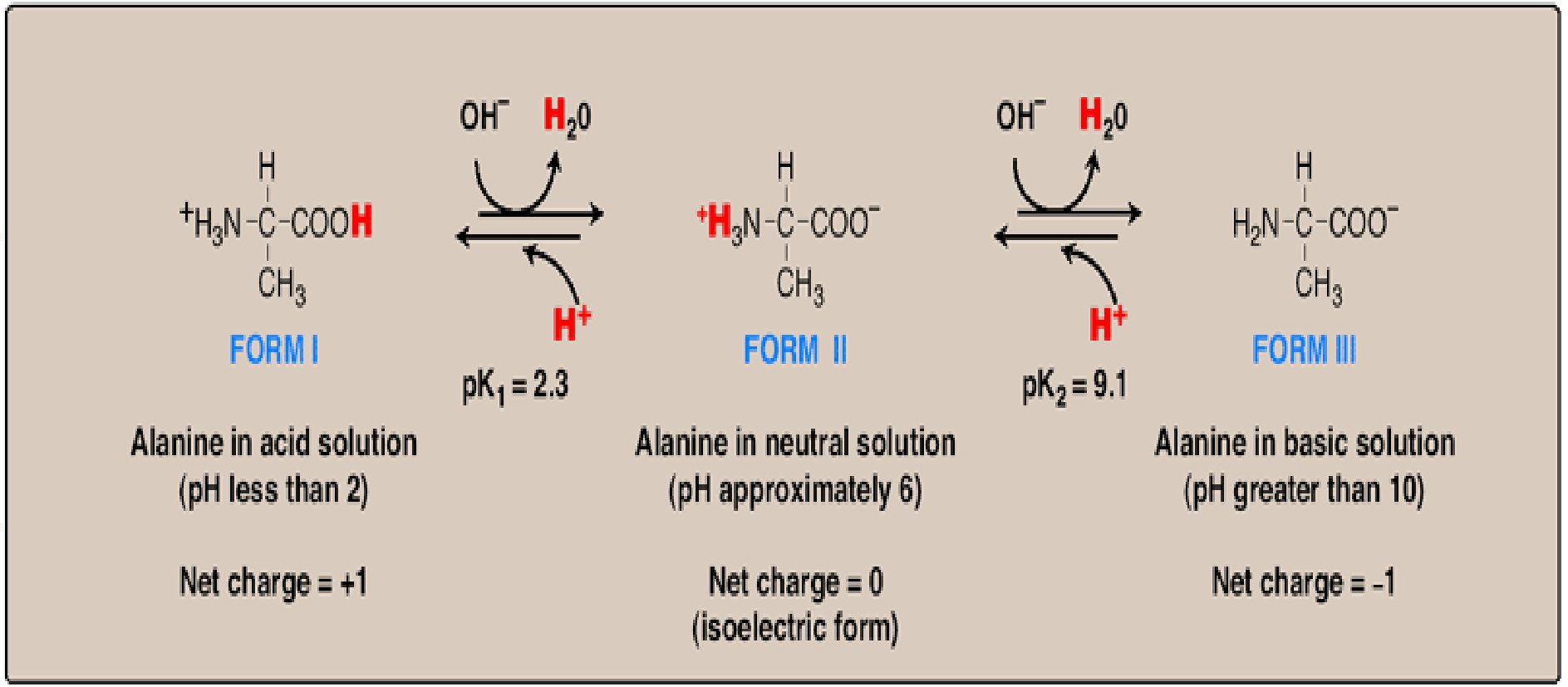
Figure 3.11
***Biochemistry*, Seventh Edition**

At What pH
This ion molecule has least solubility?





pH<5 pH=7 pH>10


OH⁻ H20
H
+H3N-C-COOH
CH3
FORM I
H+
pK1 = 2.3
H
+H3N-C-COO⁻
CH3
FORM II
OH⁻ H20
H+
pK2 = 9.1
H
H2N-C-COO⁻
CH3
FORM III
Alanine in acid solution
(pH less than 2)
Net charge = +1
Alanine in neutral solution
(pH approximately 6)
Net charge = 0
(isoelectric form)
Alanine in basic solution
(pH greater than 10)
Net charge = -1

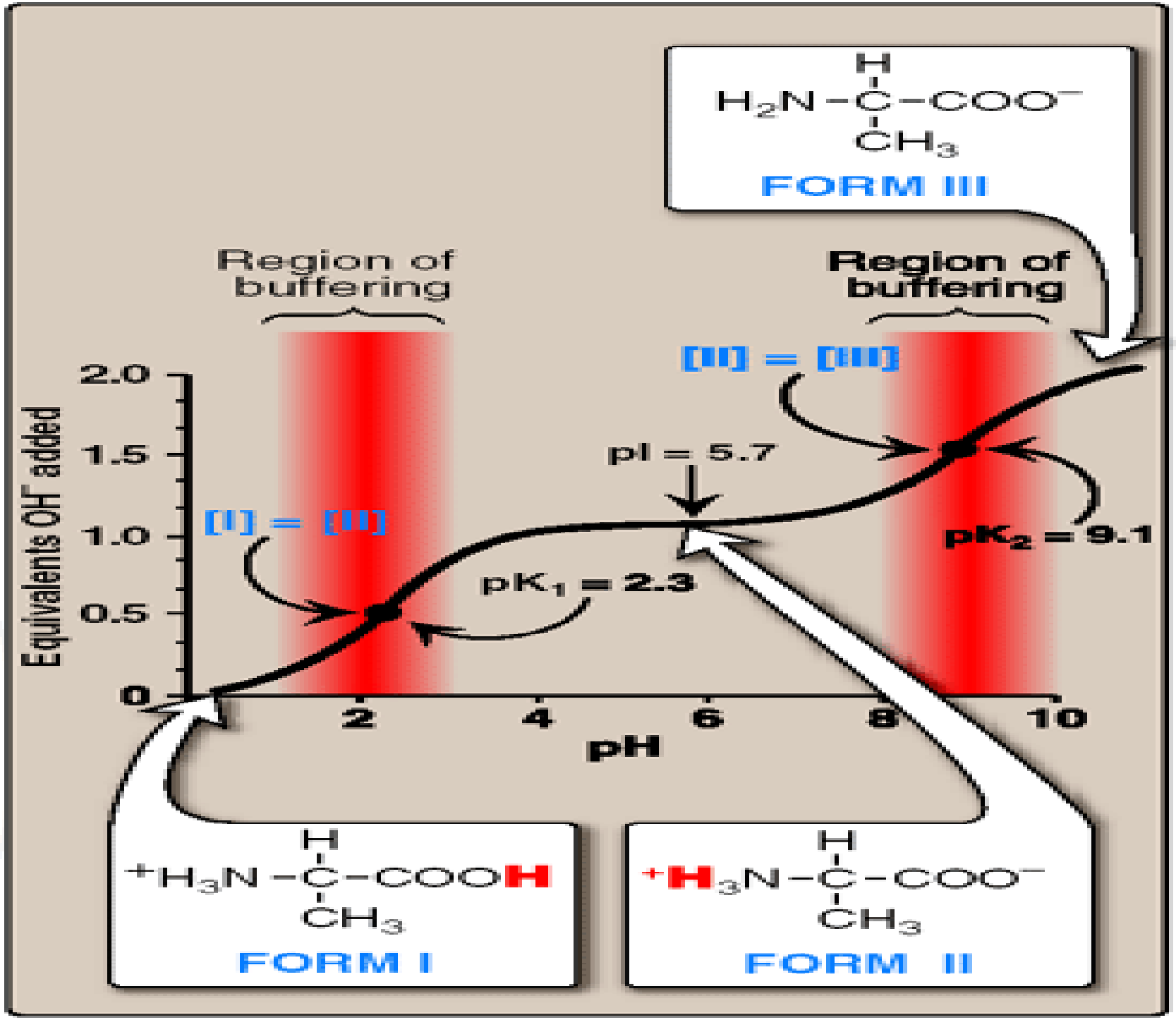
Zwitterion

- E.g. In Alanine,
- At a low (acidic) pH,
    - groups are positive charged ($NH3^{+}$).
- At a high (basic) pH,
    - groups are negative charged(COO^{-}).
- While at one pH = it is dipolar.
- Overall charge is zero.
- pH = pI (Iso-electric pH)

- At physiologic pH, All amino acids have a
  - Negatively charged group ($–COO^-$)
  - Positively charged group ($–NH_3^+$)

Ampholyte Amino Acid

- Glutamate, Aspartate, Histidine, Arginine, and Lysine have additional potentially charged groups in their side chains.
- Act either as an Acid as well as Base


FORM III
Region of buffering
Region of buffering
[II] = [III]
pI = 5.7
[I] = [II]
pK2 = 9.1
pK1 = 2.3
Equivalents OH⁻ added
2.0
1.5
1.0
0.5
0
2
4
6
8
10
pH
FORM I
FORM II

Application of Henderson-Hasselbalch equation

$$K_1 = \frac{[H^+]\,[II]}{[I]}$$

$$pH = pK_1 + \log \frac{[II]}{[I]}$$

Buffer pairs:

- **COO^- /COOH** pair can serve as a buffer at around pK_1
- **NH_3^+/–NH_2** pair can serve as buffer at around pK_2.

- **Bicarbonate Buffer**
- **HCO--/ H2CO3** = (Strong base / Weak acid)

- **When the pH is equal to pK_1 (2.3),**
  - Equal amounts of Forms I and II of alanine.
- **When the pH is equal to pK_2 (9.1),**
  - Equal amounts of Forms II and III of alanine.

Henderson & Hesselbatch
In Bicarbonate (Blood) Buffer

$$pH = pK_{a\ H_2CO_3} + \log\left(\frac{[HCO_3^-]}{[H_2CO_3]}\right)$$

$$\text{pH} = \text{pK} + \log \frac{[HCO_3^-]}{[PCO_2 \times 0.03]}$$

$$= 6.1 + \log \frac{24\ \text{mEq/L}}{(40 \times 0.03)}$$

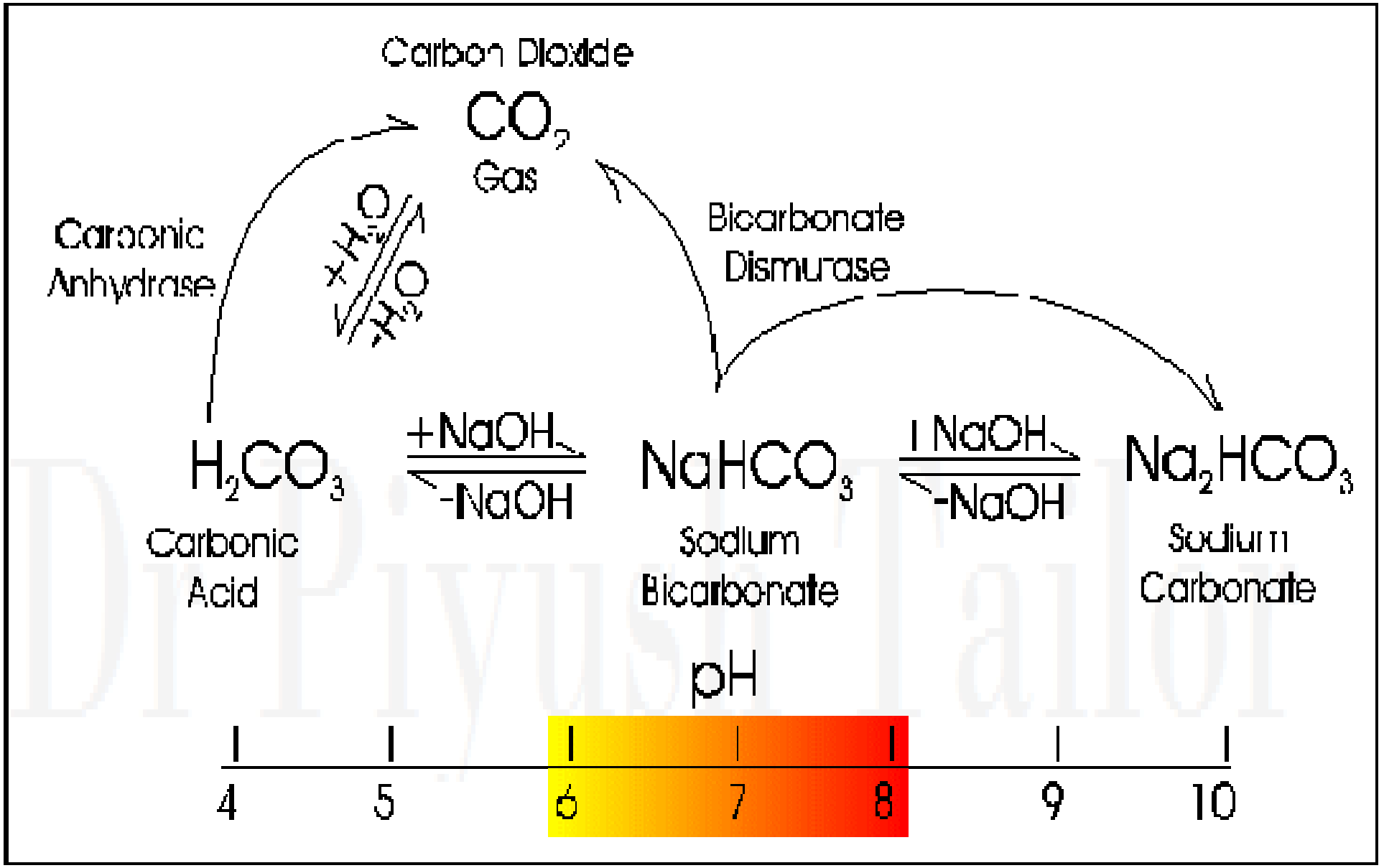
$$= 6.1 + \log \frac{24\ \text{mEq/L}}{(1.2\ \text{mEq/L})}$$

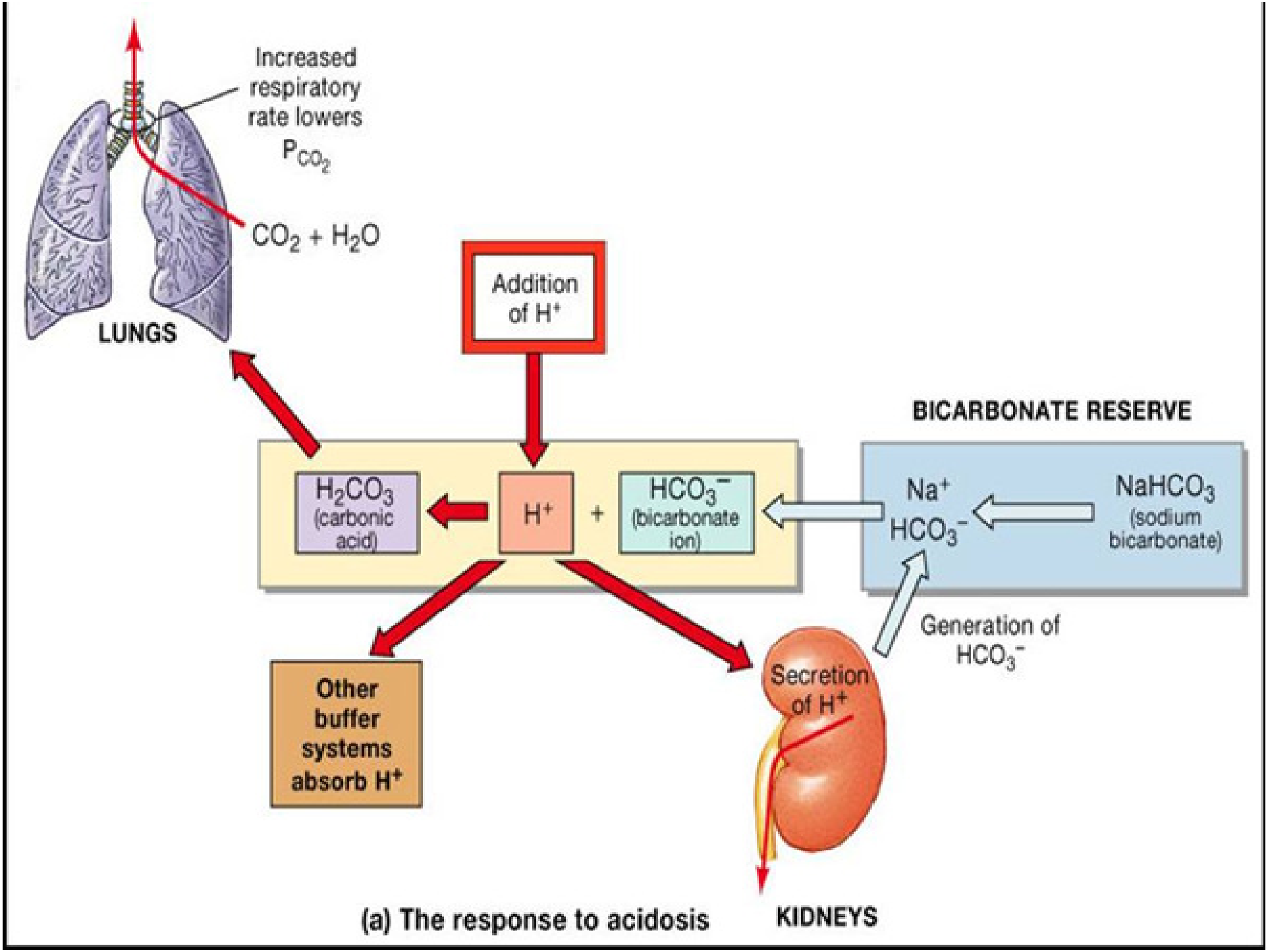
$$= 6.1 + \log \frac{20}{1} \quad (20{:}1\ \text{ratio})$$

$$= 6.1 + 1.3$$

$$= 7.4$$

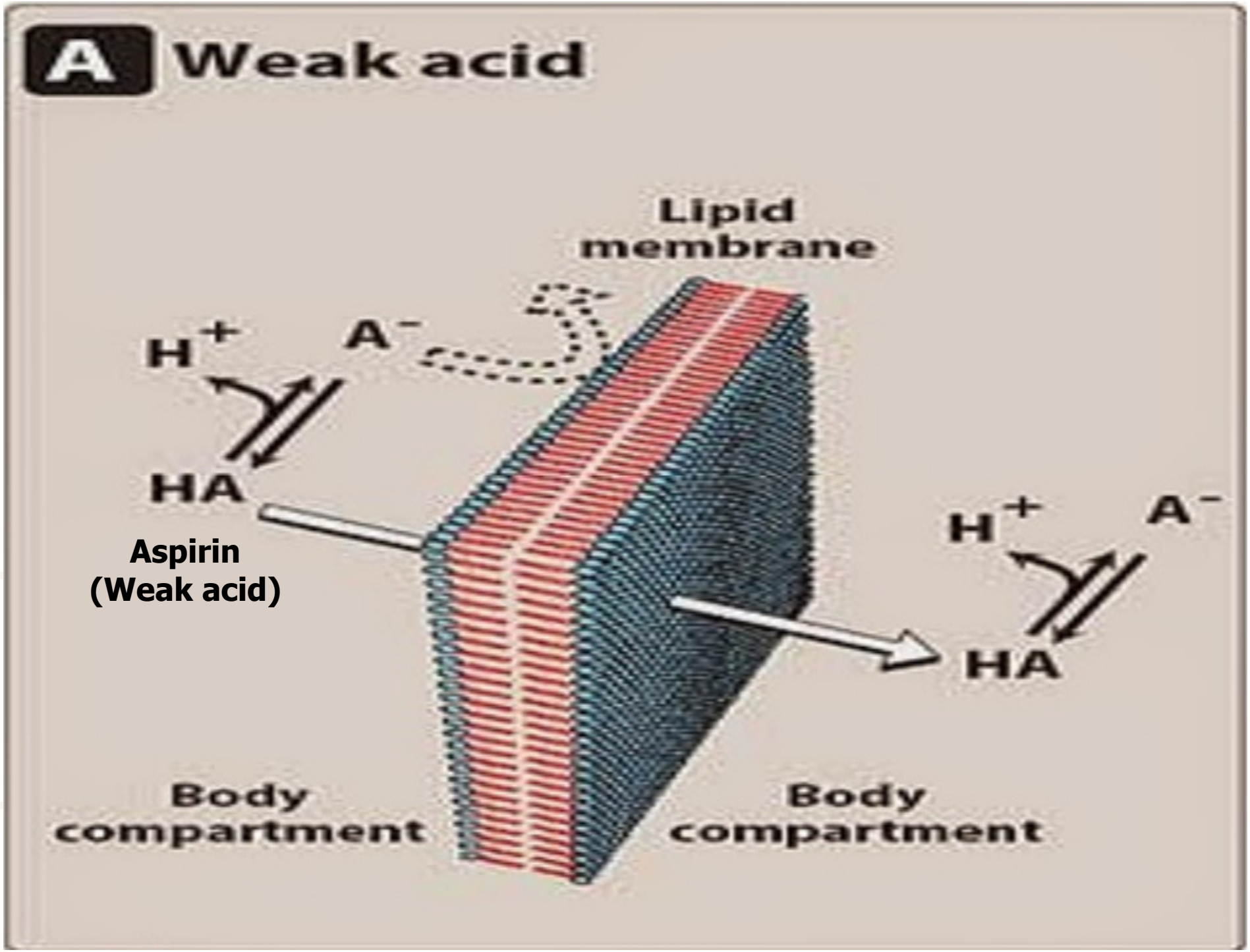
How is it work?

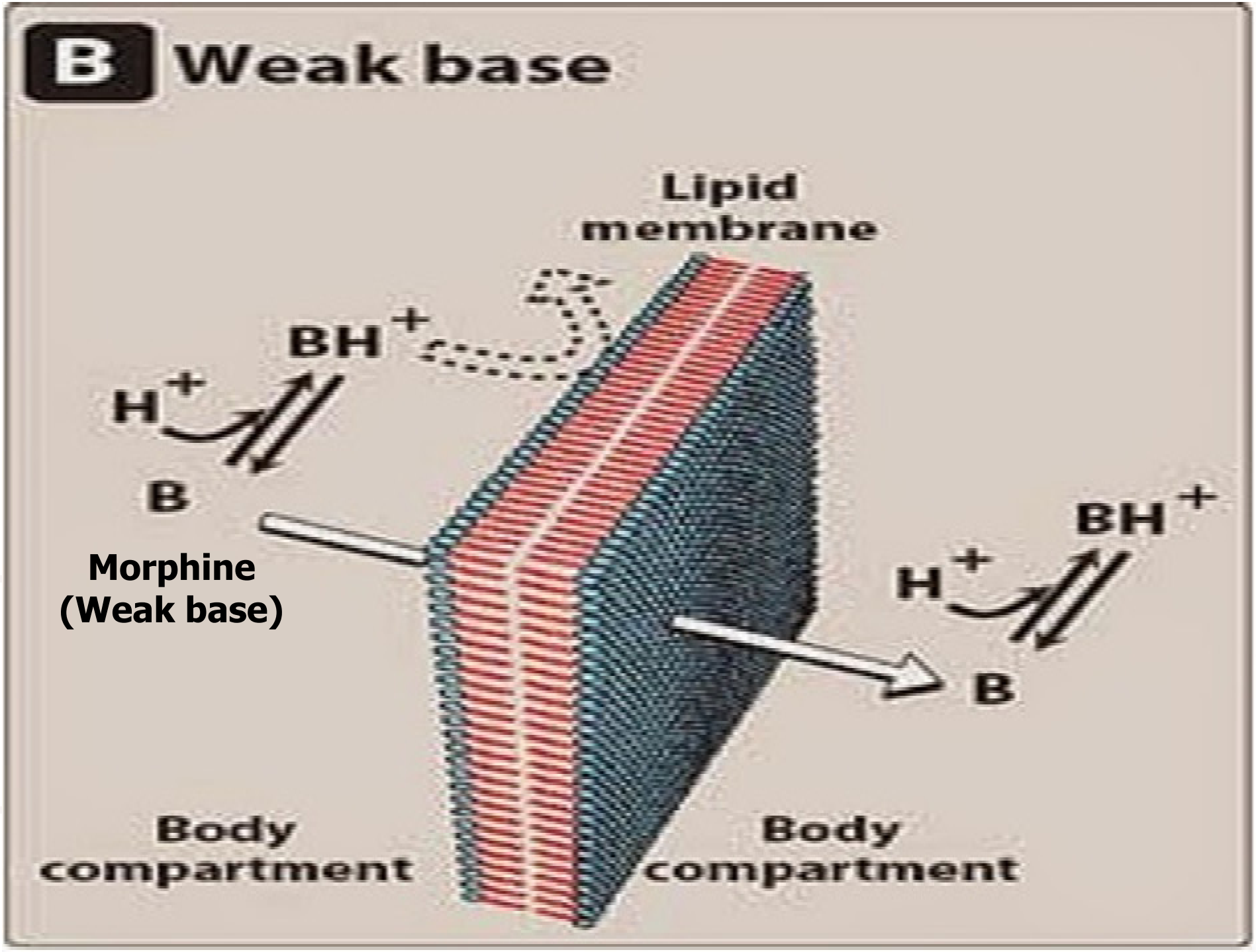




(a) The response to acidosis

- ✓ **Most drugs are either weak acids or weak bases**
- ✓ **Drug passes through membranes if it is uncharged.**
- ✓ **Absorption of drug depend on**
  - ✓ **Ratio of conc. Of charged and uncharged forms.**
- ✓ **Ratio depend on**
  - ✓ **pH at the site of absorption**
  - ✓ **Strength of the weak acid or base,**
  - ✓ **pK_a of ionizable group of drug.**
- ✓ Henderson-Hasselbalch equation useful
  - ✓ How much will be drug ratio (charge: uncharge drug) at that differ in pH.
  - ✓ For example, Stomach (pH 1.0–1.5) & blood (pH 7.4)


A Weak acid
Lipid membrane
H+
A−
HA
Aspirin
(Weak acid)
H+
A−
HA
Body compartment
Body compartment


B Weak base
Lipid membrane
BH+
H+
B
Morphine (Weak base)
BH+
H+
B
Body compartment
Body compartment

A BICARBONATE AS A BUFFER

- $pH = pK + \log \frac{[HCO_3^-]}{[H_2CO_3]}$
- An increase in HCO_3^- causes the pH to rise.
- Pulmonary obstruction causes an increase in carbon dioxide and causes the pH to fall, resulting in respiratory acidosis.

LUNG ALVEOLI

$$CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

3.Based on metabolism fate:

Purely ketogenic:

- Leucine is purely ketogenic.it is converted to ketone bodies.

ketogenic and glucogenic:

- Lysine,isoleucine,phenylalanine,tyrosine and tryptophan are partially ketogenic and partially glucogenic.

Purely glucogenic:

- All the remaining 14 amino acids are purely glucogenic as they enter only into the glucogenic pathway.

4. Based on nutritional requirements:

***Essential or indispensable*:**

- Isoleucine
- Leucine
- Lysine
- Tryptophan
- Threonine
- Phenylalanine
- Methionine and
- Valine are essential amino acids.

- Their carbon skeleton cannot be synthesized by human beings and so preformed amino acids are to be taken in food for normal growth.

***Semi-essential*:**

- Histidine and Arginine
- Growing children require them in food. But they are not essential for the adult requirement.

Non-essential or Dispensable:

- The remaining 10 amino acids are non-essential.
- Their carbon skeleton can be synthesized by the body.

Properties of amino acids

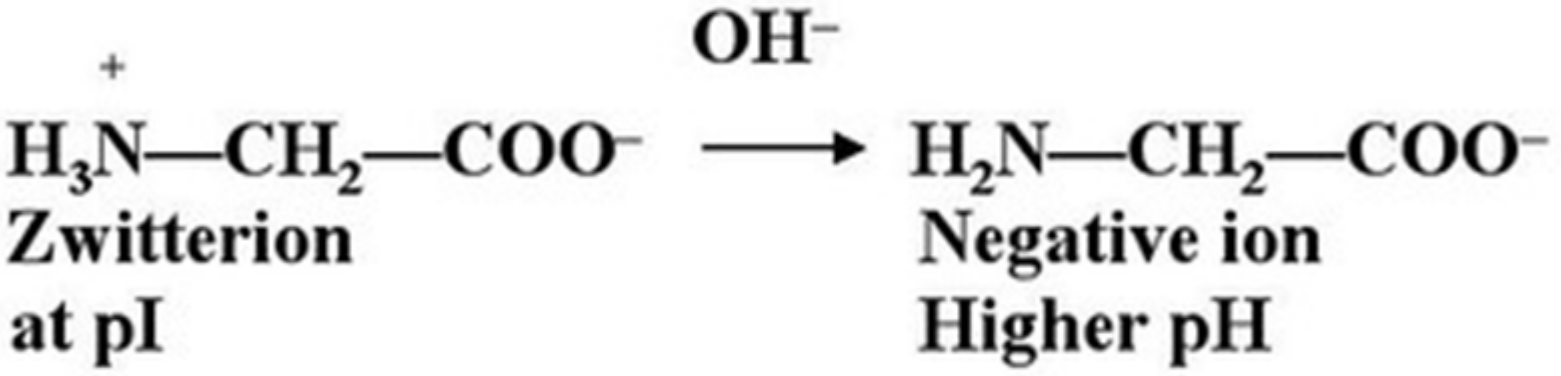
- Sweet in taste
  - Glycine
  - Alanine
  - Valine
  - Serine
  - Tryptophan
  - Histidine
  - Proline
- Leucine is tasteless
- Bitter
  - Isoleucine
  - Arginine
- Flavouring agent
  - Sodium glutamate
- Artificial sweetener
  - Aspartame (aspartic acid & phenylalanine)

Ampholyte and Iso-electric point Zwitterion

- Amino acids can exist as ampholytes or zwitterions in solution, depending on the pH of the medium.
- The pH at which the molecule carries no net charge is known as iso-electric point or iso-electric pH (pI).
- In acidic solution = Cationic in form
- In alkaline solution = Anions in form.

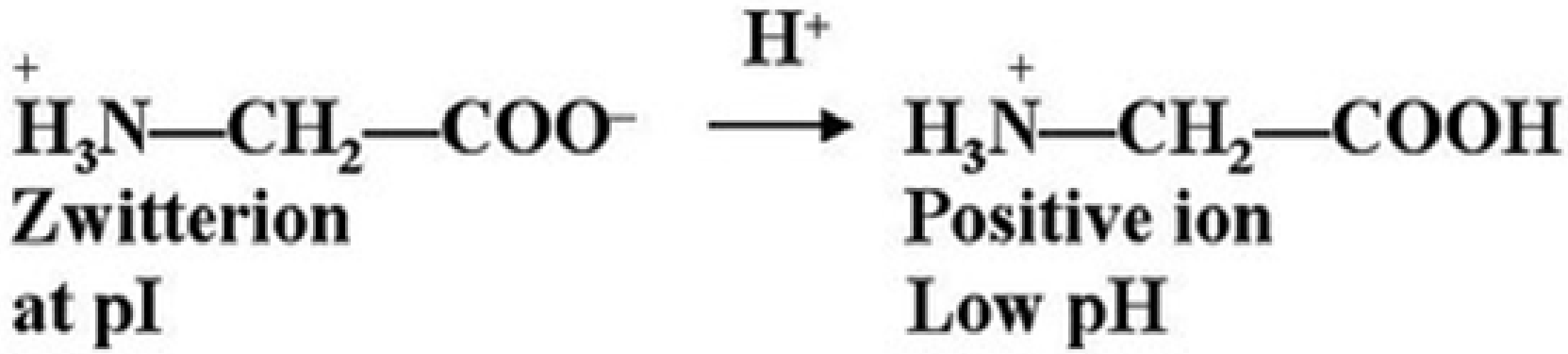
Amino acid in Basic solution

- **Amino acid donate H^+ to solution**
- **So A.A. remains negative charged in basic solution**



Amino acid in Acidic solution

Amino acid accept H+ from solution
So A.A. remains positive charged in basic solution



At iso-electric pH the amino acid

- ✓ **All groups are ionized**
- ✓ **But net charge is "Zero"**

So at iso-electric pH, there is

- ✓ **Least mobility in an electrical field.**
- ✓ **Least Solubility**
- ✓ **Minimum buffering capacity**

- To such a solution if we add HCl drop by drop, at a particular pH,
  - 50% molecules are in cation form
  - 50% in zwitterion form.
- This pH = pK1 (with regard to COOH).
- If more HCL is added,
  - more molecules become cationic

- If titrate solution with NaOH, molecules acquire the anionic form.
  - 50% of molecules are anions
  - 50% in zwitterion form
- This pH = pK2 (with regard to NH2).

- The iso-electric pH (pI) for mono amino mono carboxylic amino acids can be calculated as :

$$pI = \frac{pK1 + pK2}{2}$$

- Buffering action is maximum in and around pK1 or at pK2
- Buffering minimum at pI.
- In the case of amino acids having more than two ionizable groups, correspondingly there will be more pK values.

- At physiological pH of 7.4, both carboxyl and amino groups of amino acids are completely ionized.

- The pK value of imidazolium group of Histidine is 6.1, and so effective as a buffer at the physiological pH of 7.4.
- The buffering capacity of plasma proteins and hemoglobin is mainly due to histidine residue.

Decarboxylation:

Histidine $\rightarrow$ Histamine + CO_2

Tyrosine $\rightarrow$ Tyramine + CO_2

Tryptophan $\rightarrow$ Tryptamine + CO_2

Amide Formation:

Aspartic acid + NH_3 $\rightarrow$ Aspargine

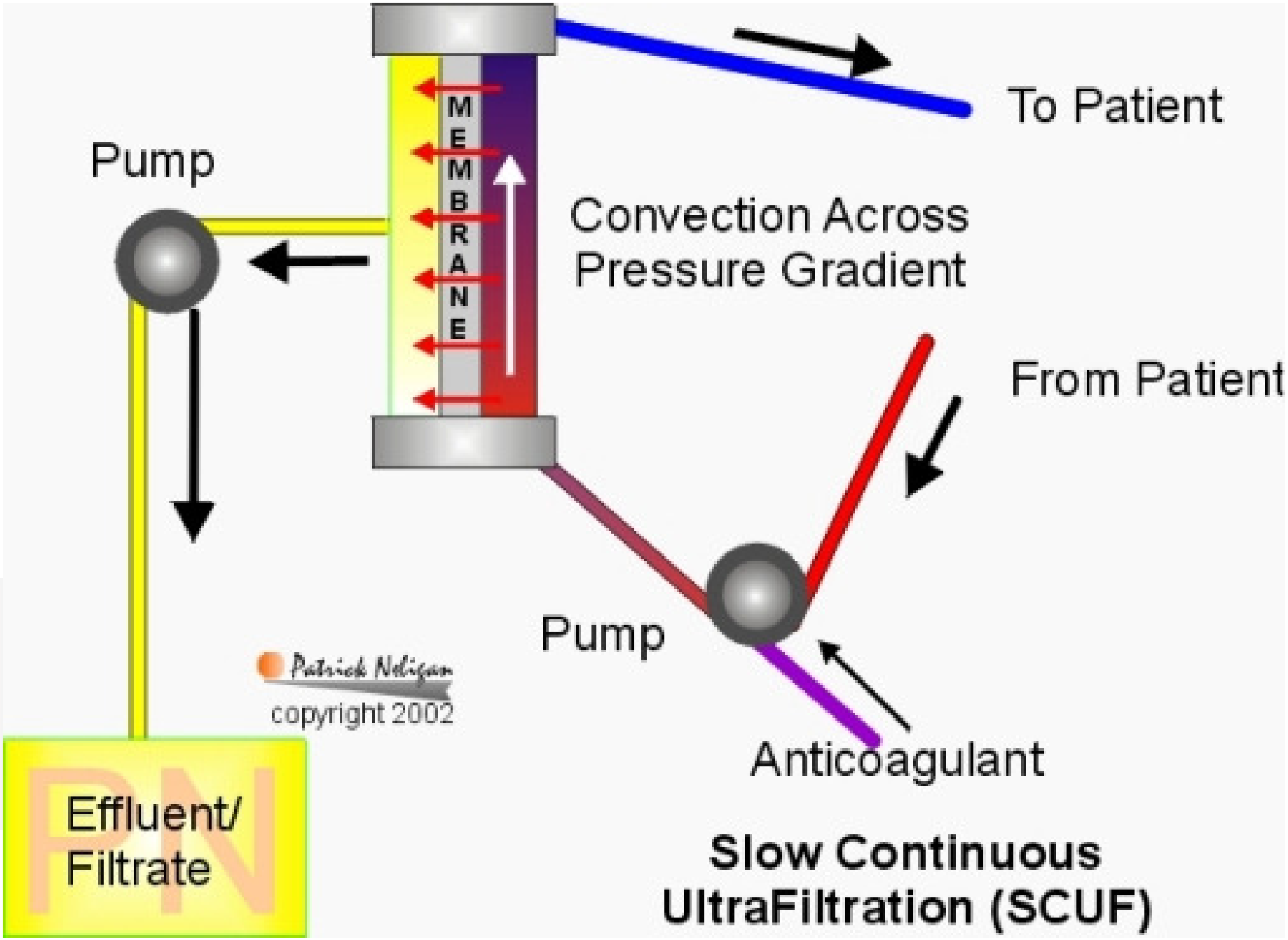
Glutamic acid + NH_3 $\rightarrow$ Glutamine

Story continue……..

Cycloserine = anti-tuberculous drug.

Azaserine = anticancer drug.

……..Never End


To Patient
Pump
MEMBRANE
Convection Across
Pressure Gradient
From Patient
Pump
Patrick Neligan
copyright 2002
Anticoagulant
Effluent/
Filtrate
Slow Continuous
UltraFiltration (SCUF)

- Pellagra can occur in Carcinoid syndrome.
- Vitamin C deficiecy causes Scurevy.
- Increase ammonia causes brain toxicity.
- Aspartate & Ornithine is use in hepatotoxicity
- Arginine & Ornithine is useful for athletes.

1 To find a woman you need Time and Money therefore:

$$\text{Woman} = \text{Time} \times \text{Money}$$

2 "Time is money" so

$$\text{Time} = \text{Money}$$

3 Therefore

$$\text{Woman} = \text{Money} \times \text{Money}$$

$$\text{Woman} = (\text{Money})^2$$

4 "Money is the root of all problems"

$$\text{Money} = \sqrt{\text{Problems}}$$

5 Therefore

$$\text{Woman} = (\sqrt{\text{Problems}})^2$$

$$\text{Woman} = \text{Problems}$$

A+

Amino acids
(fully protonated)

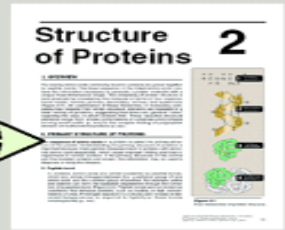
are composed of

- **α-Carboxyl group (–COOH)** *is* → deprotonated (COO^-) at physiologic pH
- **α-Amino group ($–NH_3^+$)** *is* → protonated (NH_3^+) at physiologic pH
- **Side chains of 20 different types** *composed of*
  - **Nonpolar side chains** — Alanine, Glycine, Isoleucine, Leucine, Methionine, Phenylalanine, Proline, Tryptophan, Valine → *found* → in the interior of proteins that function in an aqueous environment and on the surface of proteins (such as membrane proteins) that interact with lipids
  - **Uncharged polar side chains** — Asparagine, Cysteine, Glutamine, Serine, Threonine, Tyrosine → *found* → on the outside of proteins that function in an aqueous environment and in the interior of membrane-associated proteins
  - **Acidic side chains** — Aspartic acid, Glutamic acid → *characterized by* → Side chain dissociates to $–COO^-$ at physiologic pH → *found* → on the outside of proteins that function in an aqueous environment and in the interior of membrane-associated proteins
  - **Basic side chains** — Arginine, Histidine, Lysine → *characterized by* → Side chain is protonated and generally has a positive charge at physiologic pH → *found* → on the outside of proteins that function in an aqueous environment and in the interior of membrane-associated proteins

can

- **Release H^+** *and act as*
- **Weak acids** *described by*
- **Henderson-Hasselbalch equation:** $pH = pK_a + \log \frac{[A^-]}{[HA]}$ *predicts*
- **Buffering capacity** *predicts*
- **Buffering occurs ±1 pH unit of pK_a** *predicts*
- **Maximal buffer when $pH = pK_a$** *predicts*
- **$pH = pK_a$ when $[HA] = [A^-]$**

In proteins, most α-COO^- and α-NH_3^+ of amino acids are combined in peptide bonds. → Therefore, these groups are not available for chemical reaction. → Thus, the chemical nature of the side chain determines the role that the amino acid plays in a protein, particularly . . . → . . . how the protein folds into its native conformation.



Thank You