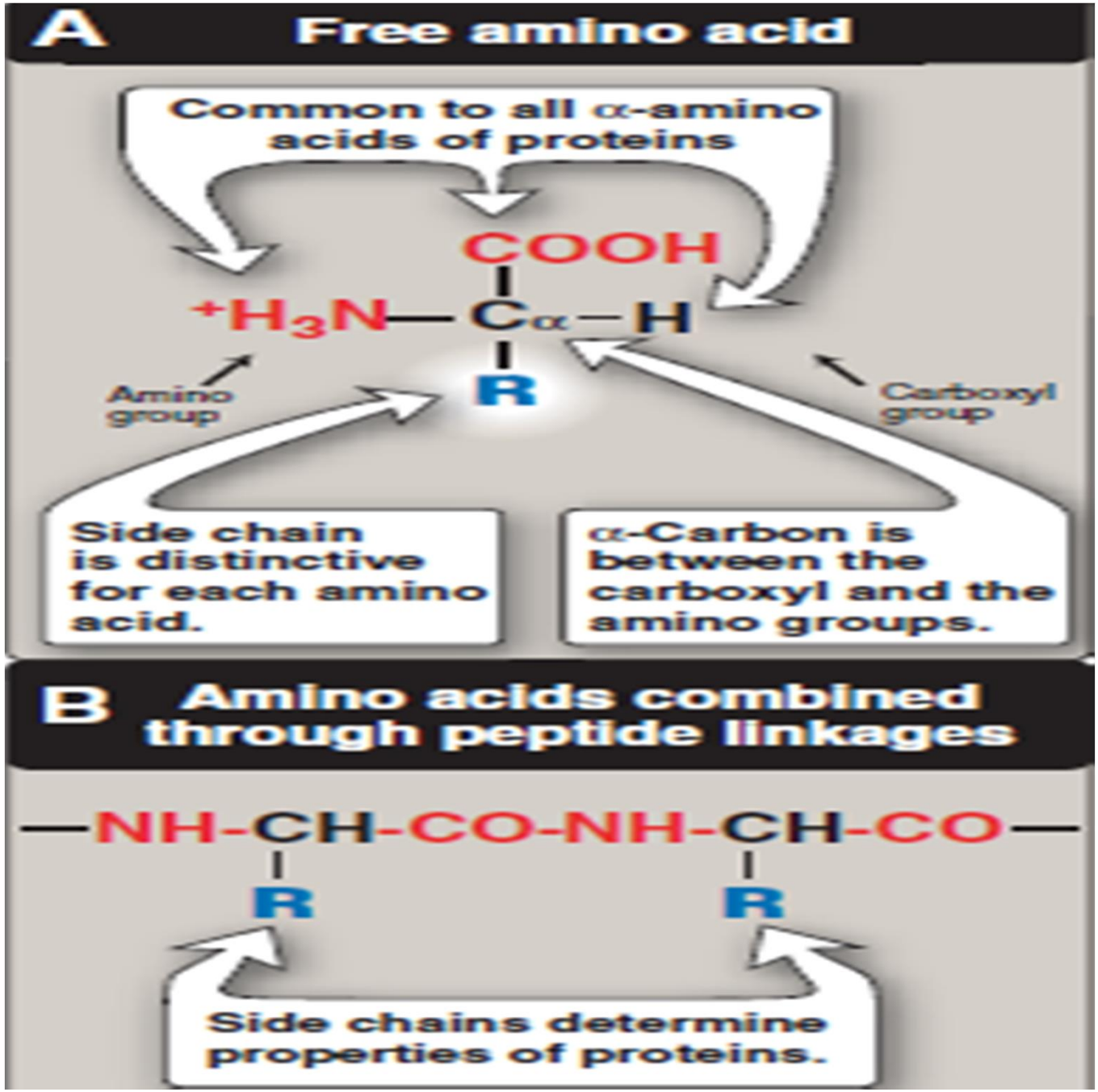

A
Free amino acid
Common to all α-amino acids of proteins
COOH
+H3N—Cα—H
R
Amino group
Carboxyl group
Side chain is distinctive for each amino acid.
α-Carbon is between the carboxyl and the amino groups.
B
Amino acids combined through peptide linkages
—NH-CH-CO-NH-CH-CO—
R
R
Side chains determine properties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

Each amino acid has an α**-carboxyl group** and a primary α**-aminogrou**p (except for proline, which has a **secondary amino group**).

At physiologic pH, the α-carboxyl group is dissociated, forming the negatively charged carboxylate ion (–COO–), and the α-amino group is protonated (–NH3+).

Each amino acid also contains one of 20 distinctive

Classify amino acids with examples.

Based on nature of side chain

Non-polar amino acids: Alanine, Phenylalanine, Valine ('al' is common to them).
Uncharged (neutral), polar amino acids: Serine, Threonine, Tyrosine (OH containing).
Acidic amino acids: Aspartic acid, Glutamic acid.
Basic amino acids: Arginine, Lysine, Histidine.

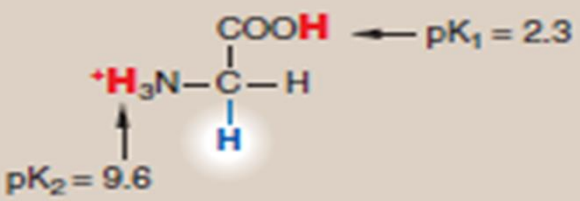
Based on nutritional requirement

Essential amino acids: **M**ethionine, **A**rginine, **T**hreonine, **T**ryptophan, **V**aline, **I**soleucine, **L**eucine, **P**henylalanine, **H**istidine, **L**ysine [MN: MATT VIL PHLy].
Non-essential amino acids: **G**lutamic acid, **A**spartic acid, **G**lutamine, **A**sparagine, **G**lycine, **A**lanine [MN: GA GA GA].

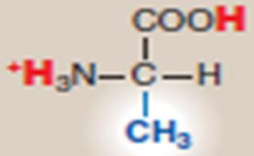
Based on metabolic fate

Glucogenic amino acids: **G**lutamic acid, **A**spartic acid, **G**lutamine, **A**sparagine, **G**lycine, **A**lanine [MN: GA GA GA].
Ketogenic amino acids: Leucine. *Both glucogenic and ketogenic:* **P**henylalanine, **L**ysine, **I**soleucine, **T**yrosine and **T**ryptophan [MN: SPLITT].

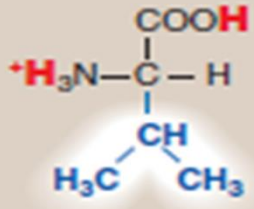
NONPOLAR SIDE CHAINS



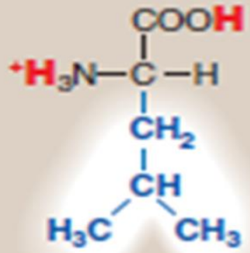
Glycine



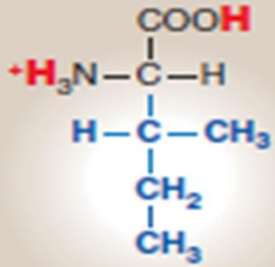
Alanine



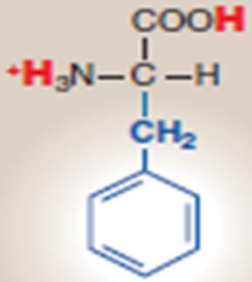
Valine



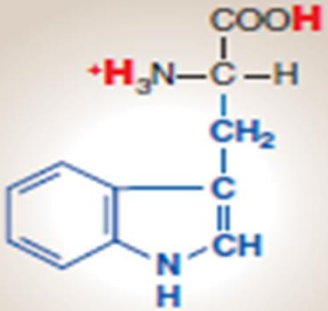
Leucine



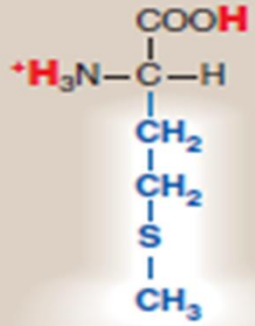
Isoleucine



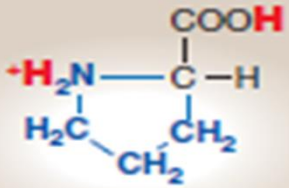
Phenylalanine



Tryptophan

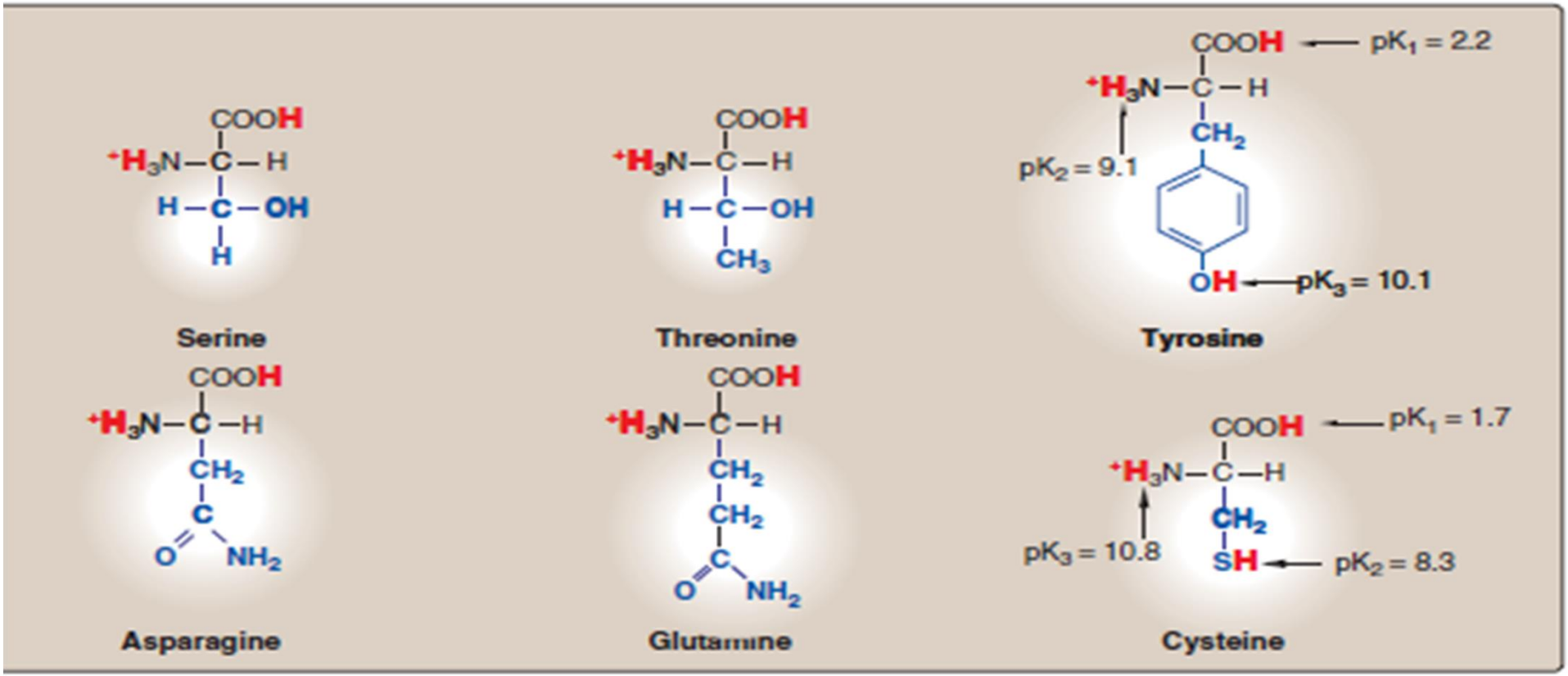


Methionine

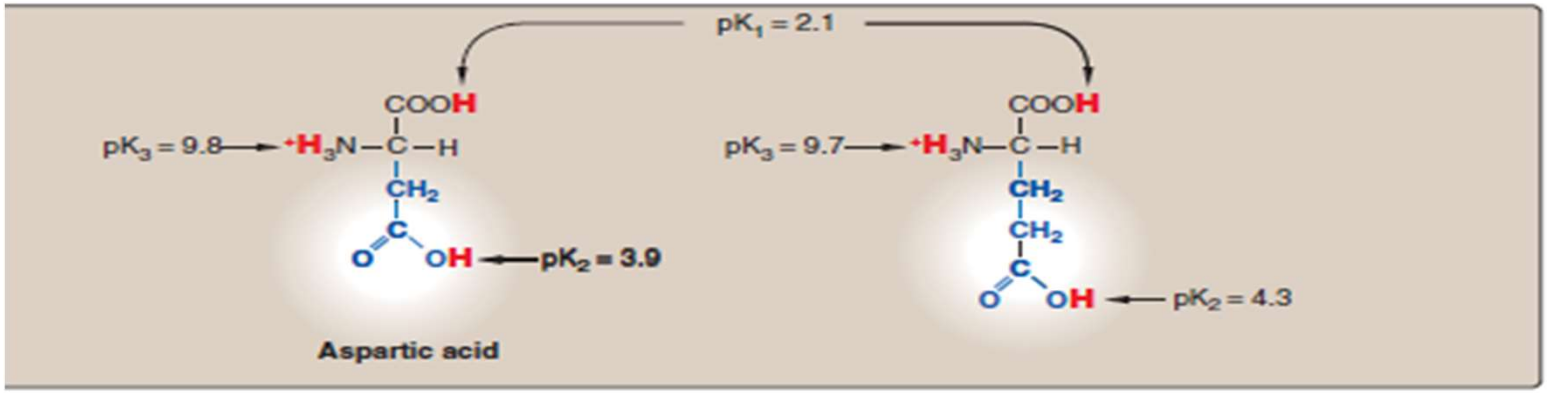


Proline

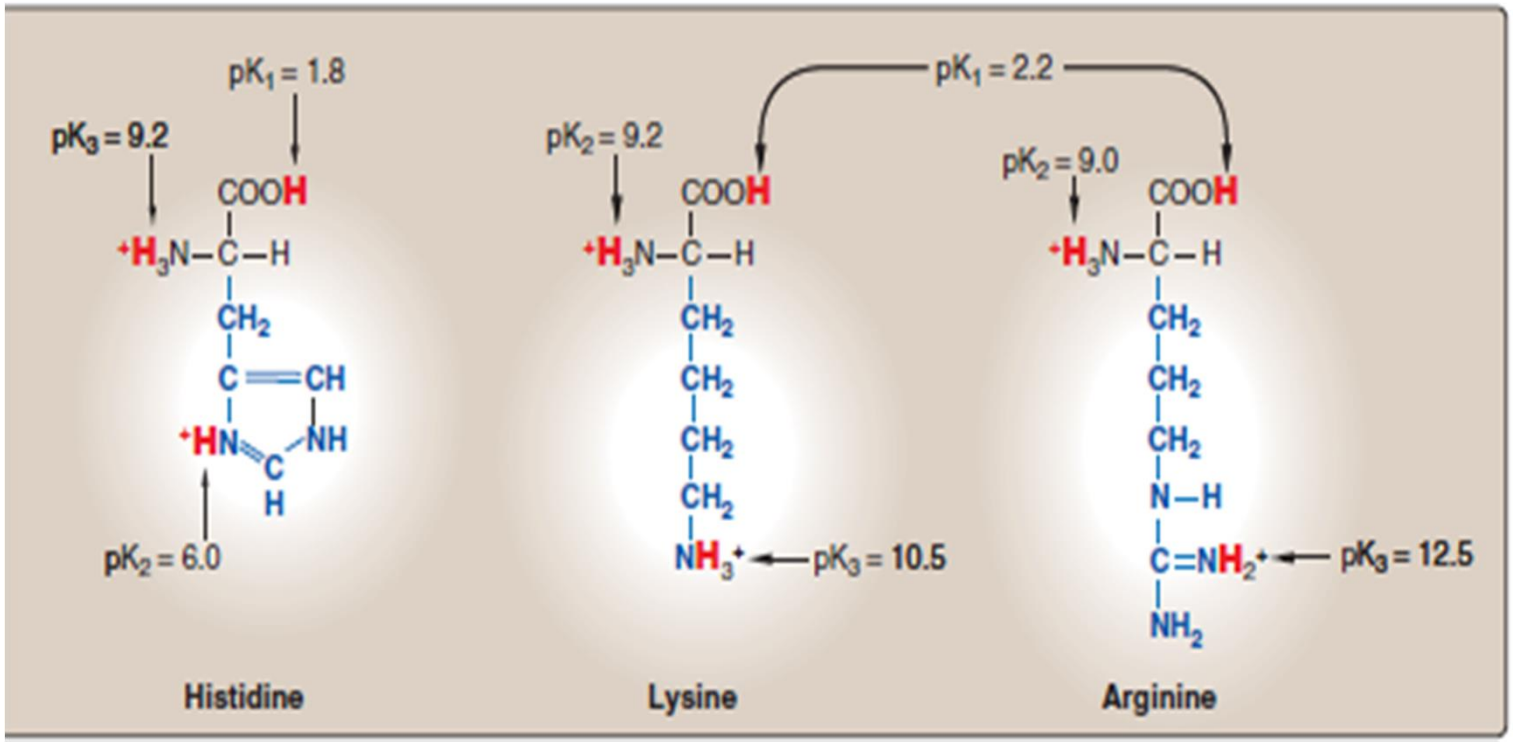
UNCHARGED POLAR SIDE CHAINS



ACIDIC SIDE CHAINS



BASIC SIDE CHAINS



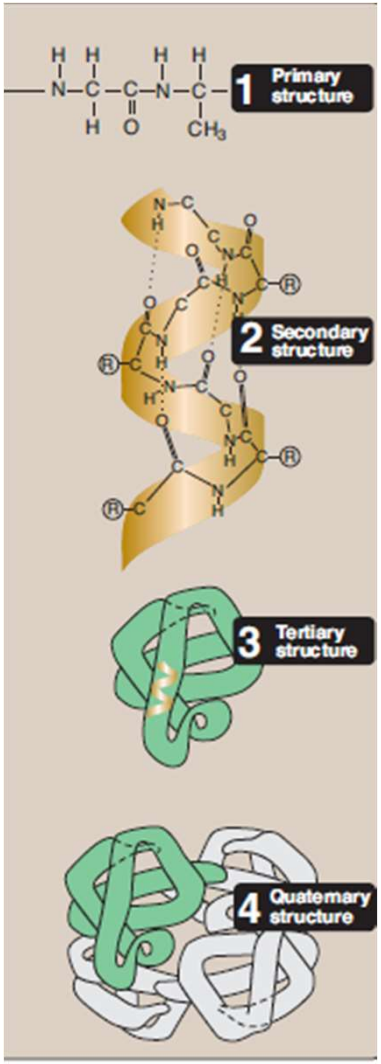
Protein

Primary structure: It is defined as the number and sequence of amino acids in a protein. It also includes the position of disulfide bonds.

Secondary structure: Local folding (regular/irregular) of short segments of polypeptides results in secondary structure. For example, α-helices, β-pleated sheets and random coils.

Tertiary structure: It is the folding and linking between secondary structural elements of a protein to give it a three-dimensional structure. For example, β-barrel in pyruvate kinase, four-helix bundle in cytochromes.

Quaternary structure: It refers to the regular association of two or more polypeptide chains to form a complex. It is stabilized by weak interactions. Each polypeptide is called subunit.
For example, hemoglobin and immunoglobulin.



Explain various bonds seen in protein structure.

Six kinds of bonds are seen in a protein structure. They are peptide bonds, hydrogen bonds, van der Waals interactions, hydrophobic interactions, ionic interactions and disulfide linkages.

Hydrogen bonds: It is formed by sharing of hydrogen between two electron donors. H is donated by: -OH, -NH, -NH2; H-acceptors: COO-, C = O, -S-S-.

Electrostatic (ionic) bonds: It is formed by attraction between two oppositely charged amino acids. Positively charged amino acids—lysine, arginine. Negatively charged amino acids—aspartic acid and glutamic acid.

Hydrophobic bonds: It is formed by interaction between the side chains of non-polar amino acids. They are seen in the core of proteins.

van der Waals forces: These are attraction-repulsion forces between all atoms due to oscillating dipoles.

Disulfide bonds: These are covalent linkages that may form when the thiol groups of two cysteine residues are oxidized to a disulfide: 2 R-SH → R-S-S-R.

Peptide bonds: It is a covalent bond formed between α-carboxyl group of one amino acid with α-amino group of the succeeding amino acid.

What is isoelectric pH? Mention its significance.

Definition: The pH at which a protein possesses equal number of positive and negative charges (net charge is zero) is called isoelectric pH with respect to that protein (Table 7.1).

Significance: At this pH, proteins have least solubility and they precipitate in solution

Proteins	Isoelectric pH
Pepsin	1.1
Casein	4.6
Albumin	4.7

What is denaturation of proteins?

Definition: Denaturation of proteins is an irreversible disruption of secondary, tertiary and quaternary structure of proteins leading to loss of their physical, chemical and biological properties.

Denaturing agents

- *Physical agents:* Heat, vigorous mixing, X-rays, ultraviolet (UV) radiation, etc.

- *Chemical agents:* Acids, alkali, organic solvents, salts of heavy metals, high concentration
of urea, etc.

Name some biologically important peptides giving their significance.

Definition: Peptides with few amino acids (4–10) are generally termed as oligopeptides (Table 7.2).

Name	Property
Carnosine (β-alanyl-L-histidine) Anserine (N-methyl-carnosine)	These two peptides are found in muscle. They activate myosin adenosine triphosphatase (ATPase) activity
Glutathione (GSH tripeptide: γ-glutamyl-cysteinyl-glycine)	It is an important component of cellular antioxidant defense system. It participates as a cofactor in many reactions
	Two molecules of GSH can donate a pair of hydrogen to reduce a substrate $H_2O_2 + 2GSH \xrightarrow{\textit{Glutathione peroxidase}} 2H_2O + GS\text{-}SG$
Thyrotropin-releasing hormone (TRH) (contain 3 amino acids)	Secreted by hypothalamus. It stimulates the release of thyroid-stimulating hormone (TSH) from anterior pituitary
Vasopressin (antidiuretic hormone: contains 9 amino acids)	Secreted by posterior pituitary gland. It regulates water excretion by kidney
Enkephalin (pentapeptide)	Peptide found in brain, which inhibits the sense of pain
Angiotensin II	A peptide with 8 amino acids, which stimulates release of aldosterone from adrenal cortex
Bradykinin (contains 9 amino acids)	Vasodilator peptide

Enumerate different functions of proteins with suitable examples.

Functions	Examples
Structural proteins	Keratin of hair and nails, collagen (bones, cartilage and connective tissue)
Contractile proteins	Actin, myosin
Transport proteins	Hemoglobin, serum albumin, transferrin
Regulatory proteins	Hormones (insulin, glucagon, growth hormone)
Enzymes	Pepsin, trypsin, hexokinase
Defense proteins	Immunoglobulin, fibrinogen
Storage proteins	Ferritin, hemosiderin

DIGESTION OF DIETARY PROTEINS

A. Digestion of proteins by gastric secretion

The digestion of proteins begins in the stomach, which secretes gastric juice—a unique solution containing hydrochloric acid and the proenzyme, pepsinogen.

1. Hydrochloric acid:

2. Pepsin

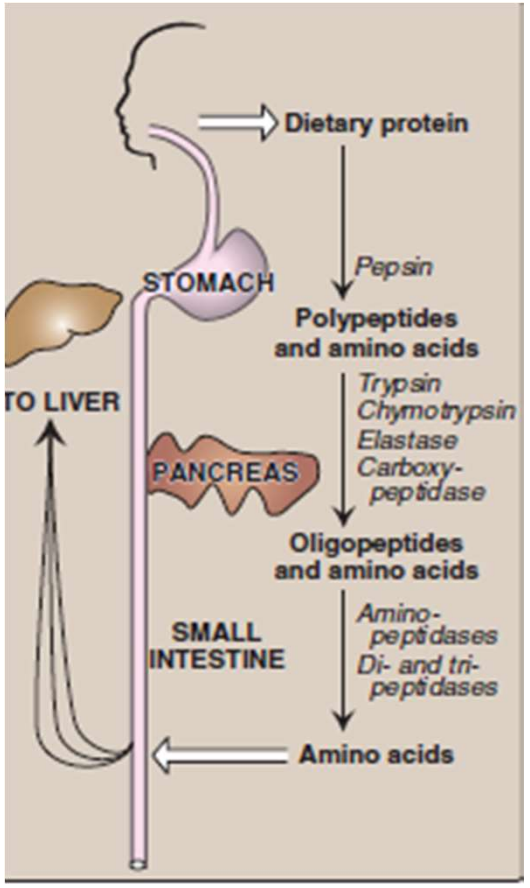
B. Digestion of proteins by pancreatic enzymes

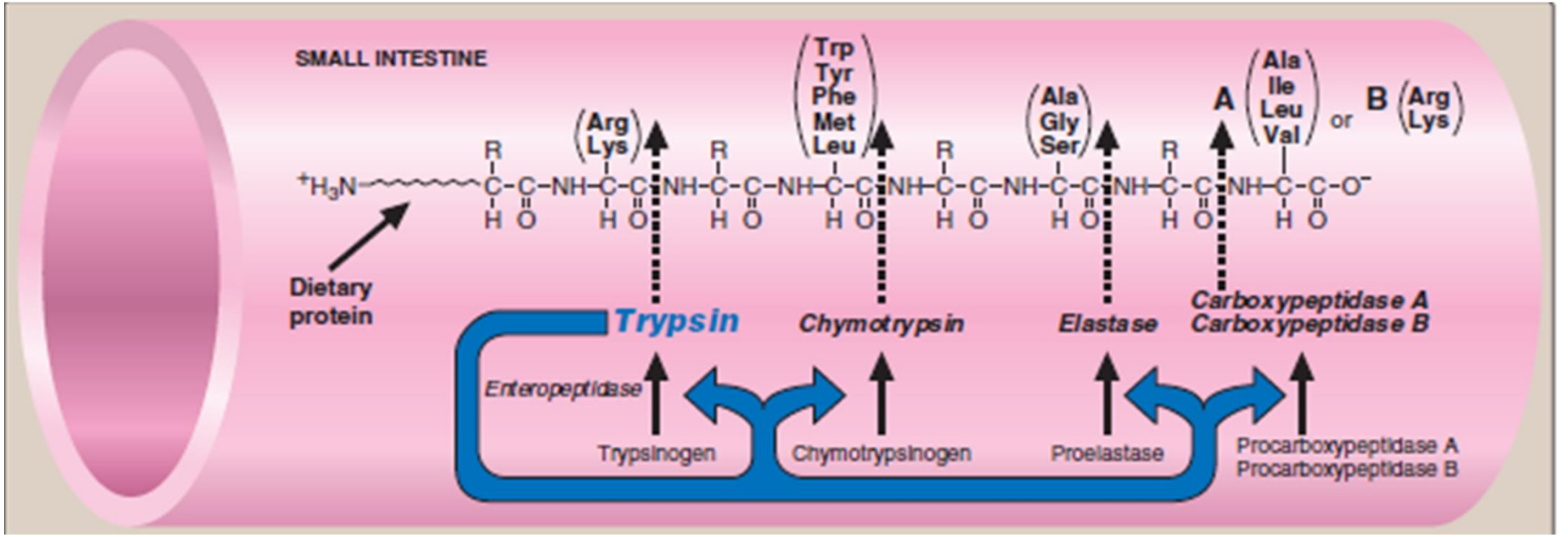
1. Specificity

2. Release of zymogens

3. Activation of zymogens

4. Abnormalities in protein digestion




SMALL INTESTINE
Arg
Lys
Trp
Tyr
Phe
Met
Leu
Ala
Gly
Ser
A
Ala
Ile
Leu
Val
or
B
Arg
Lys
Dietary protein
Trypsin
Chymotrypsin
Elastase
Carboxypeptidase A
Carboxypeptidase B
Enteropeptidase
Trypsinogen
Chymotrypsinogen
Proelastase
Procarboxypeptidase A
Procarboxypeptidase B

1. Enzyme and enzyme precursors
2. Structural proteins:
a. **Keratin: found in epidermal structures,**
e.g. hair, nails, surface layers of the skin
b. **Collagen: main protein of connective tissues present in bone and dentine**
c. Elastin: present in elastic fibres of connective tissue, especially in arterial walls
d. **Fibrin: protein of blood clots formed from soluble precursor, fibrinogen**
e. **Silk fibroin: constituent of silk fibres**
3. Transport proteins:
a. **Oxygen-carrying: haemoglobin**
b. **Hydrogen-carrying: flavoproteins**
c. **Electron-transporting: cytochromes**
d. **Fatty acid-transporting: serum albumin**
e. **Metal-carrying serum proteins: transferrins (iron), caeruloplasmin (copper)**
4. Receptor proteins
5. Hormones:
a. **Protein hormones: insulin, growth hormone, follicle-stimulating hormone**
b. **Polypeptide hormones: gastrin, vasopressin, oxytocin, calcitonin, glucagon, adrenocorticotropic hormone**
6. Contractile proteins: actomyosin of muscle
7. Lubricants: glycoproteins present in saliva and dental plaque and generally in secretions of the gastrointestinal, respiratory and urinary tracts
8. Storage proteins:
a. **Myoglobin: 0 2 storage in red muscle**
b. **Ferritin: iron reserves in liver and spleen**