Ingestion, Digestion & Absorption of Dietary Proteins

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Class1: 17-10-2018 (8:00 to 9:00 AM)

Learning Objectives

- Ingestion of Dietary Proteins
- Digestion of Dietary Proteins
- Absorption of Amino Acids
- Transport of Amino acids

Introduction

Dietary Protein

- Consists of long chains of amino acids (aa)

- In the digestive process, enzymes in stomach and small intestine break down complex protein into polypeptides and further into individual aa

- aa are absorbed through wall of small intestine, pass into blood and further to liver through portal vein

Importance of Dietary Proteins

- Role of proteins in diet is important for structural component of cells and tissues.
- Without adequate protein in diet, body cells and tissues not able to function.
- Proteins are large, complex molecules made up of smaller aa compounds.

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- Some aa are made by body and are nonessential, but others are essential, so we need to get them from diet.

- Therefore, consume protein-rich foods each day, since body does not have a way to store protein.

Cont--

- **Essential aa**: Cannot be synthesize in the body so "essential" to eat them from dietary food.

- **Non-essential**: Body can synthesize them from other proteins so not essential to eat them

TABLE 27-1 Amino Acid Requirements of Humans

Nutritionally Essential	Nutritionally Nonessential
Arginine[a]	Alanine
Histidine	Asparagine
Isoleucine	Aspartate
Leucine	Cysteine
Lysine	Glutamate
Methionine	Glutamine
Phenylalanine	Glycine
Threonine	Hydroxyproline[b]
Tryptophan	Hydroxylysine[b]
Valine	Proline
	Serine
	Tyrosine

Table 27.1. Harper's Illustrated Biochemistry 30th Edition

Ingestion of Dietary Proteins

- Ingested dietary proteins is hydrolysed to aa, which are source of essential aa in blood

- Absorbed from intestine and utilization of these aa for synthesis of body proteins ex. Structural proteins, plasma proteins, enzymes, milk proteins, hormones

- Also synthesis of necessary non-protein nitrogen compounds includes urea, uric acid, creatine, creatinine, aa, polypeptides.

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- **Recommended Dietary allowance (RDA) for both men and women:** 0.8 g of protein/kg body weight/day

- **Dietary proteins**: Dietary proteins in our diet are either from animal source or vegetable source

- **Animal sources**: Milk and dairy products, meat, fish, eggs

- **Vegetable sources**: Cereals, pulses, peas, beans and nuts

Overview of the Digestion of Dietary Proteins

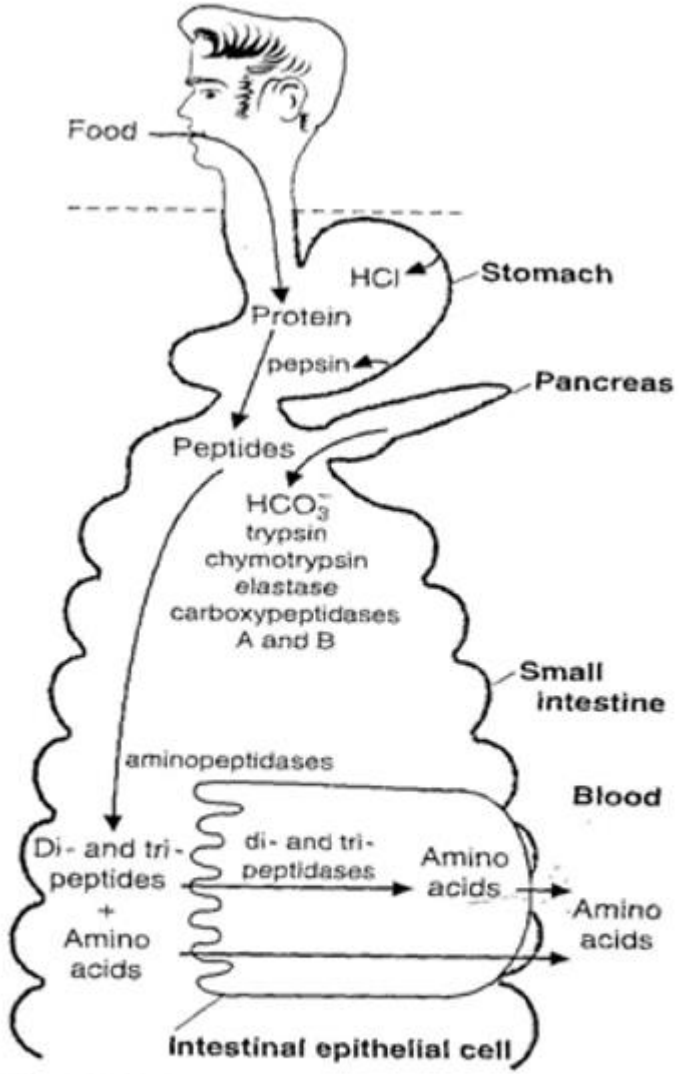


Fig. 37.3. Digestion of proteins. The proteolytic enzymes, pepsin, trypsin, chymotrypsin, elastase, and the carboxypeptidases, are produced as zymogens that are activated by cleavage after they enter the gastrointestinal lumen (see Fig. 37.4). Marks, Marks and Smith, Medical Biochemistry

Digestion of Dietary Proteins

- Proteins are too large to be absorbed by the intestine, therefore, hydrolysed into di- and tripeptides as well as individual aa, which can be absorbed

- Proteolytic enzymes responsible for degrading proteins are produced by three different organs: **stomach, pancreas, and small intestine**

Activation of Gastric and Pancreatic zymogens

- Pepsinogen catalyzes its own cleavage at the pH of the stomach
- Trypsinogen is cleaved by enteropeptidase
- Active form of the enzyme trypsin plays a key role by catalysing the cleavage of other pancreatic zymogens

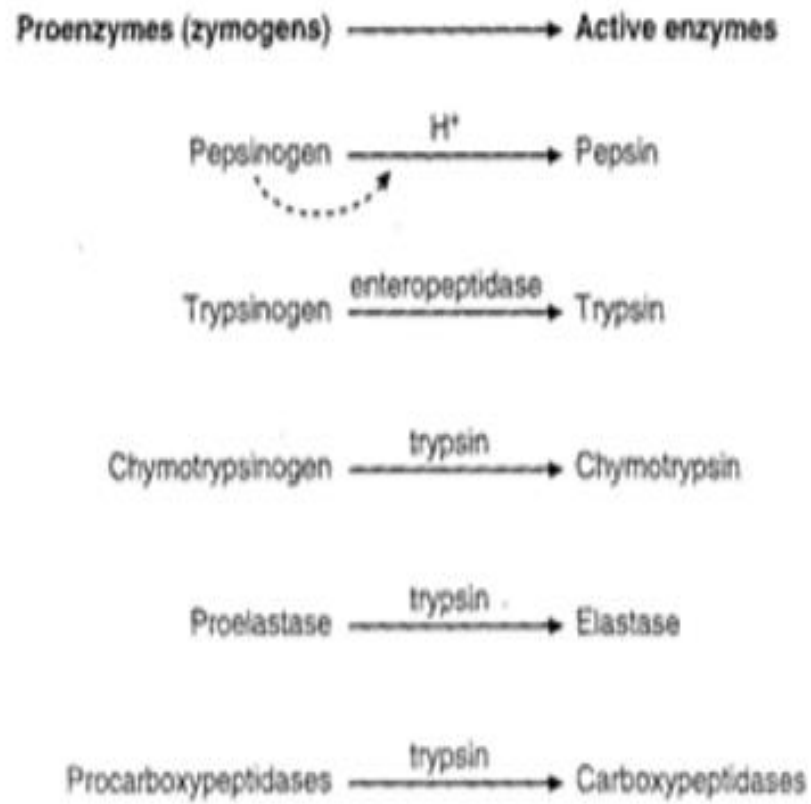


Fig. 37.4. Activation of the gastric and pancreatic zymogens. Pepsinogen catalyzes its own cleavage at the pH of the stomach. Trypsinogen is cleaved by enteropeptidase. The active form of the enzyme trypsin plays a key role by catalyzing the cleavage of the other pancreatic zymogens.

Marks, Marks and Smith, Medical Biochemistry

Cont--

Digestion by gastric secretion: Digestion of proteins begins in the stomach, which secretes gastric juice, a unique solution containing hydrochloric acid (HCl) and the proteolytic enzyme

- Pepsin is a potent proteolytic enzyme and is present in gastric juices

- It is secreted as inactive zymogen form, pepsinogen.

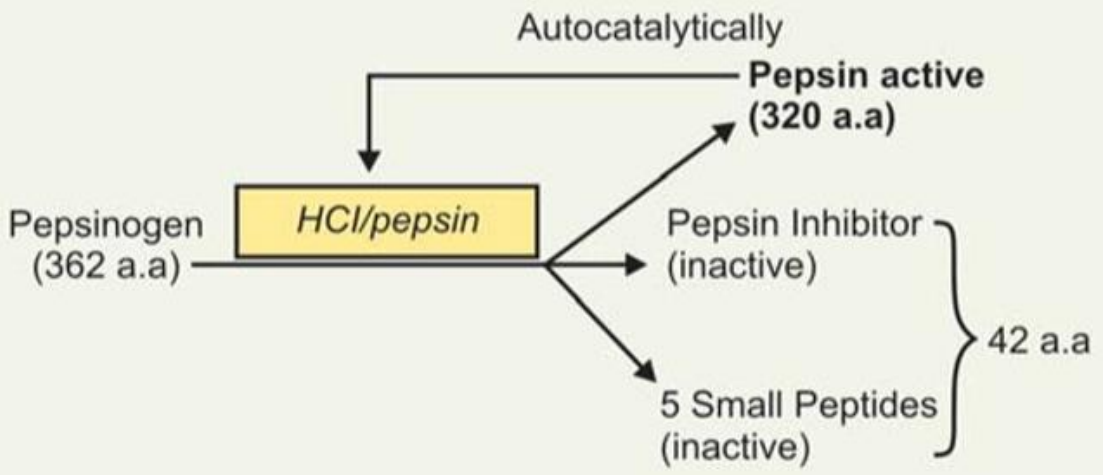
Cont--

- It is synthesised in “chief cells” of stomach
- HCl maintains gastric pH at about 1 to 2 and ensures maximum pepsin activity
- Optimum pH for pepsin is 1.6 to 2.5 and pepsin gets denatured if the pH is greater than 5.

Cont--

- Pepsinogen is hydrolysed in stomach with help of HCl or pepsin itself (autocatalytically) to form the “active” pepsin

- In process of activation (i) An inactive peptide called as “pepsin inhibitor and (ii) 5 smaller peptides are liberated.



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- Pepsin is a proteinase, a non-specific endopeptidase, and it hydrolyses peptide bonds inside protein molecule and produces proteoses and peptones

- It is particularly active on a peptide bond, which connects the -COOH group of an aromatic aa like Phe, Tyr, and Tryp with amino group of either a dicarboxylic acid or an aromatic a.a

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Pepsin also hydrolyse the peptide bonds of:

COOH group of methionine and leucine

Leucine and glutamic acid

Glutamic acid and asparagine

Leucine-valine

Valine and cysteine

- Pepsin cannot act on proteins like keratins, Silkfibroins, mucoproteins, mucoids and protamines

Digestion by pancreatic secretion

- Optimum pH for activity of pancreatic enzymes (pH 8) provided by alkaline bile and pancreatic juice.

- Secretion of pancreatic juice is stimulated by peptide hormones, Cholecystokinin

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- **On entering the small intestine**, large polypeptides produced in stomach by action of pepsin are cleaved to oligopeptides and amino acids

- Catalyzed by a group of pancreatic proteases that include both endopeptidases (Trypsin, Chymotrypsin, Elastase) and exopeptidases (metalloenzyme, contains zinc).

Digestion by proteolytic enzymes in intestinal juice

Amino-peptidases: Luminal surface of intestinal epithelial cells contains aminopeptidase, an exopeptidase repeatedly cleaves N-terminal residue from oligopeptides to produce smaller peptides and free aa.

- Requires Zn++, Mn++ and Mg++ as a cofactor which help in formation of a metal-enz-substrate coordination complex for catalysis

Cont--

- Can hydrolyse a terminal peptide bond connected to an end a.a bearing a free-α NH_2 group and splits off the end a.a. from N-terminal end of a peptide, changing latter to a “tripeptide”

Tri and Di-peptidases: hydrolyse the peptides at either of two places

- In microvillus membrane of intestinal epithelial cells, or inside epithelial cells after peptides absorbed inside cell

Cont--

- **Tri-peptidase** acts on a tri-peptide and produces a di-peptide and free a.a

- **Di-peptidase** hydrolyses a di-peptide to produce two molecules of aa

- They require Mn++, Co++ or Zn++ as cofactors for their activity.

Cleavage of dietary protein in small intestine by pancreatic proteases

- Peptide bonds susceptible to hydrolysis for each of the five major pancreatic proteases
- First three are serine endopeptidases, whereas last two are exopeptidases
- Each is produced from an inactive zymogen

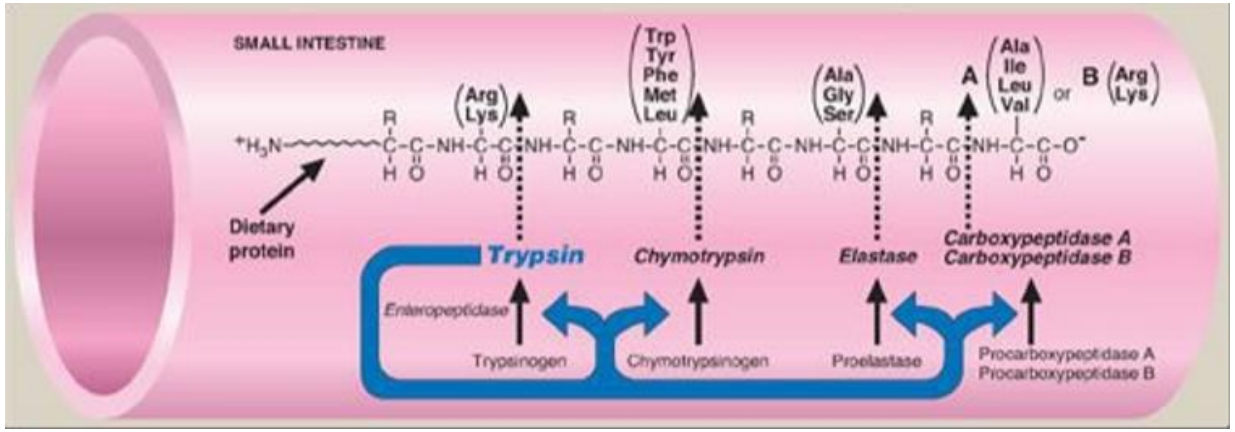


Fig 19.5. Lippincott's Illustrated Reviews, Biochemistry, 6th Ed

Absorption of Amino Acids

- Free aa are taken into enterocytes by a sodium-linked secondary transport system of apical membrane.
- Di- and tripeptides, are taken up by a proton-linked transport system.
- Peptides are hydrolyzed in cytosol to aa that are released into portal system by facilitated diffusion.

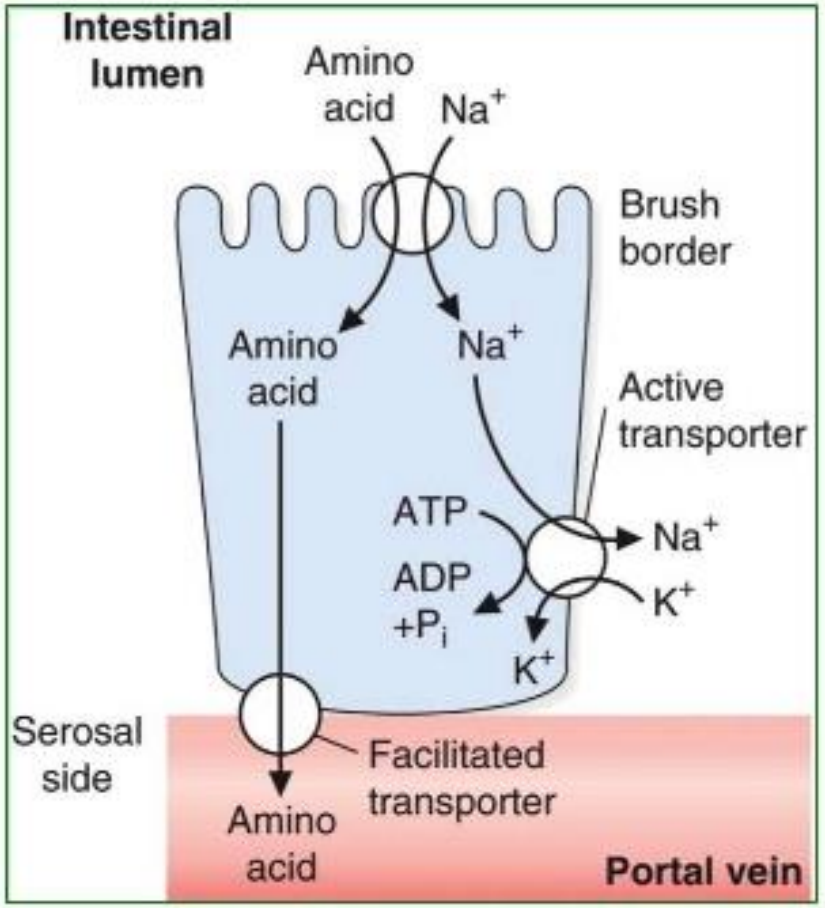
Cont--

- Therefore, only free aa are found in portal vein after a meal containing protein

- These aa are either metabolized by liver or released into general circulation

Absorption of products of protein digestion by carrier protein transport system

- AA are absorbed into epithelial cells by Na^+-linked secondary transport via symporter
- Various aa are transported by carriers specific for them
- AA exit cell at basal membrane via various passive carriers by facilitated transporter
- AA enter the blood by simple diffusion



Marks, Marks and Smith, Medical Biochemistry

Interaction with students

- Distributed subtopics of class to students for participate in group discussion in next class.

Reference Books

1) Text Book of Medical Biochemistry by Chatterjee & Rana Shinde, 8th Ed
2) Biochemistry, Lippincott's Illustrated Reviews, 6th Ed
3) Harper's Illustrated Biochemistry-30th edition
4) Lehninger Principles of Biochemistry
5) Marks, Marks and Smith, Medical Biochemistry

Thank you