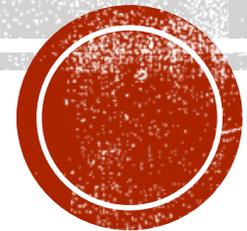


Protein Digestion & Absorption



Students Learning Outcomes

❖ By the end of this lecture, the students should be able to:

1. Describe how proteins are **digested**
2. Explain how the products of protein digestion are **absorbed** into the blood
3. Illustrate the source and **fate of amino acid pools**



Content

I. Digestion of proteins

A. In the stomach

B. In the intestine

II. Absorption of amino acids



Introduction

- ❖ **Definition of the protein:** It is a complex organic nitrogenous compounds formed of **amino acids**.
- ❖ **Bonds in protein:** Several bonds are present in the protein, but the primary bond is the **peptide bond**.
- ❖ **Protein digestive enzymes (peptidases = proteolytic enzyme) :** The peptide bond is the target of the action of the proteolytic enzymes that digest the protein by attacking this bond.
- ❖ **There are 7 peptidases:** present in the stomach and intestines (pepsin, trypsin, chymotrypsin, carboxypeptidase, aminopeptidase, tripeptidase and dipeptidase)
- ❖ **End-product of protein digestion:** **amino acids**

Protein digestion

I. Digestion in the Mouth

II. Digestion in the stomach

- a) HCL**
- b) Pepsin**

III. Digestion in the small intestine

- a) Pancreatic juice**
- b) Intestinal juice**

I. Digestion in the mouth

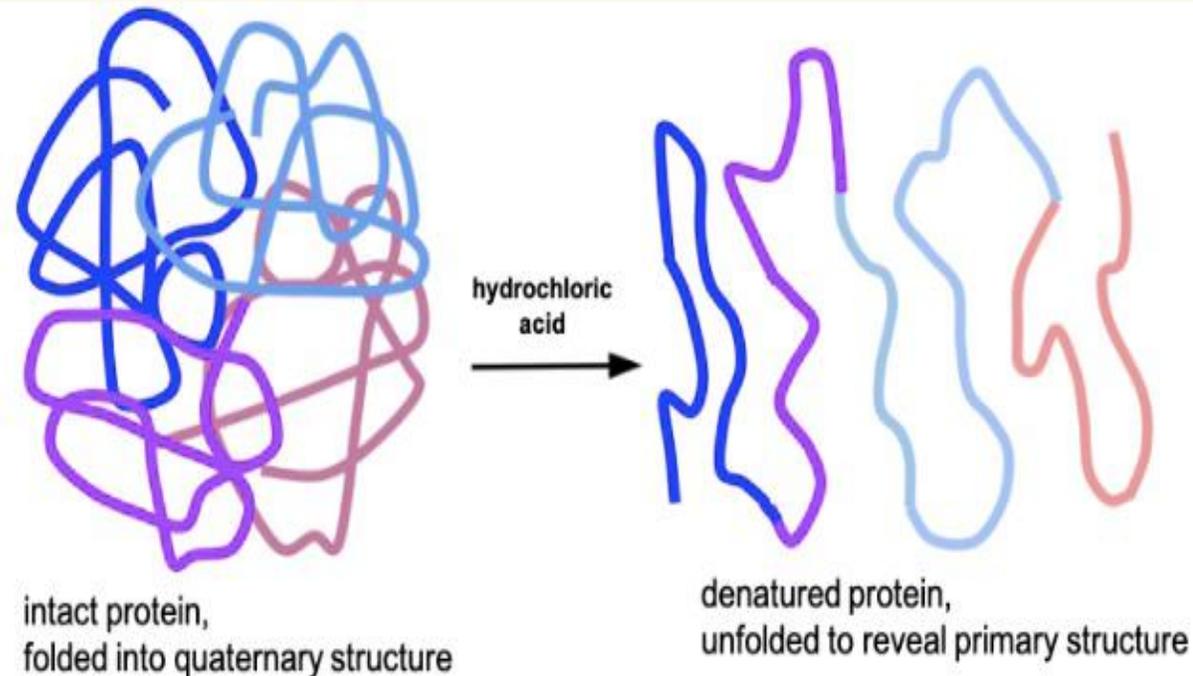
- ❖ **No** protein digestion in the mouth
- ❖ Protein digestion **starts on the stomach**

II. Digestion in the stomach

- ❖ Digestion of proteins starts in the stomach.
- ❖ The end products of protein digestion in the stomach are:
 - Proteoses** (Large peptides)
 - Peptones** (smaller peptides)
- ❖ Digestion in the stomach occurs under effect of gastric juice that contains both **HCl** and **pepsin enzyme**

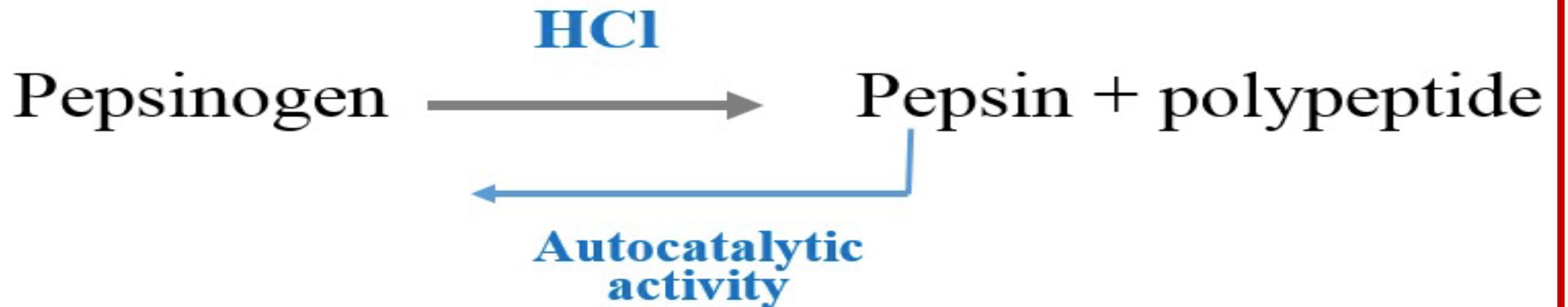
■ 1. Gastric HCL:

- ✓ It causes **denaturation** of proteins
- ✓ It **activates pepsinogen** to pepsin
- ✓ It **makes PH** of stomach suitable for the action of pepsin



2. Pepsin:

- ✓ It is secreted in an **inactive** form called **pepsinogen** from the stomach.
- ✓ It is activated by **HCL** then by **autoactivation**.
- ✓ Its optimum PH: **1.5-2.2** (highly acidic).
- ✓ It is an **endopeptidase**, which acts on the **central** peptide bond in which the **amino** groups belong to **aromatic** amino acids.
- ✓ It convert the protein to : **proteoses and peptones**.



III. Digestion in the Intestine

- ❖ The protein digestion is completed in the intestine.
- ❖ The end products of protein digestion in the intestine are **amino acids**
- ❖ Digestion in the intestine occurs under effect of proteolytic enzymes in:
 - A. **Pancreatic juice**
 - B. **Intestinal juice**

A. Pancreatic Juice enzymes

1. Trypsin

2. Chymotrypsin

3. Carboxypeptidase



I. Trypsin

- ✓ It is secreted in an **inactive** form called **trypsinogen** from the pancreatic juice.
- ✓ It is activated by **enterokinase to trypsin** then by **autoactivation**.
- ✓ Its optimum PH: **7-8** (alkaline).
- ✓ It is an **endopeptidase**, which acts on the **central** peptide bond in which the **amino** groups belong to **basic** amino acids.

2. Chymotrypsin

- ✓ It is secreted in an **inactive** form called **chymotrypsinogen** from the pancreatic juice.
- ✓ It is activated by **trypsin** to **chymotrypsin**.
- ✓ **No autoactivation.**
- ✓ Its optimum PH: **7-8** (alkaline).
- ✓ It is an **endopeptidase**, which acts on the **central** peptide bond in which the **carboxy** groups belong to **aromatic** amino acids.
- ✓ NB: both trypsin & chymotrypsin acts on **proteoses** and **peptones** converting them to **large polypeptides**.

3. Carboxypeptidase

- ✓ It is secreted from the pancreatic juice.
- ✓ Its optimum PH: **7-8** (alkaline).
- ✓ It is an **exo**peptidase, which acts on the **terminal** carboxylic group of the peptide chain



B. Intestinal Juice enzymes

1. Aminopeptidase

2. Tripeptidase

3. Dipeptidase



1- Aminopeptidase

- ✓ It is an **exopeptidase**, which acts on the **terminal** amino group of the peptide chain
- ✓ Optimum PH is 7-8,
- ✓ Both amino and carboxypeptidase acts on **large polypeptide** converting it to **tripeptides** and releasing amino acids.

2- Tripeptidase

- ✓ Acts on tripeptides → releasing 1 amino acid → converting it to dipeptides.

3- Dipeptidase Breaks the dipeptides to 2 amino acids

So end products of protein digestion is: amino acids

Absorption of amino acids

- 1- Carrier proteins transport system**
- 2- Glutathione transport system
(gamma-Glutamyl cycle)**

Absorption of amino acids

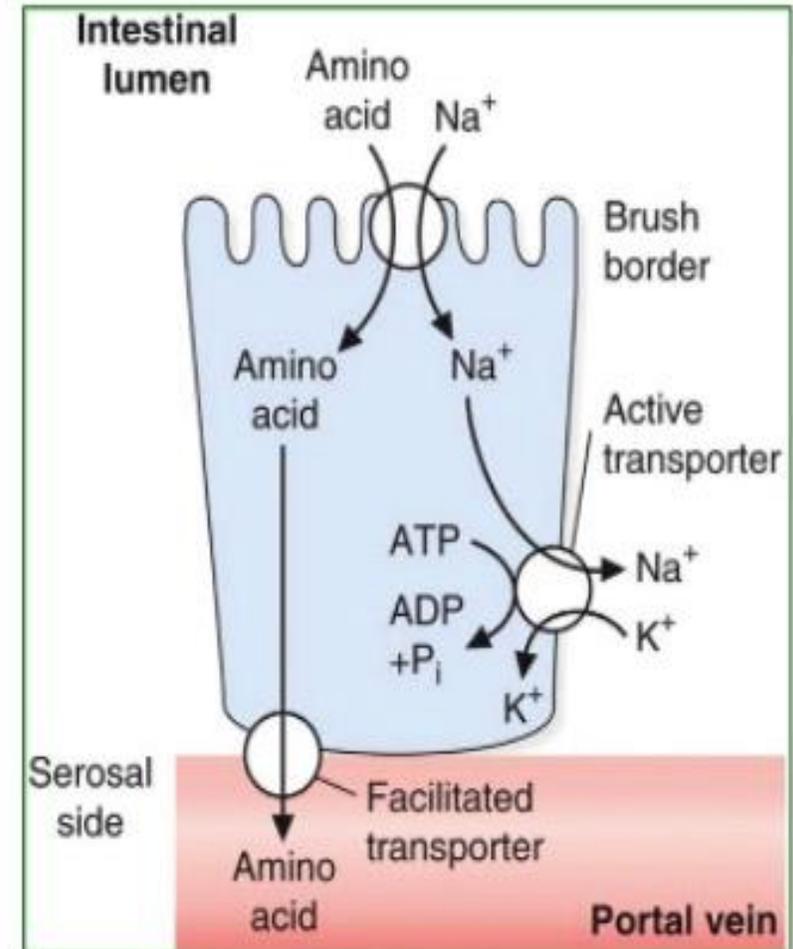
❖ It is an **active process** that need energy derived from **ATP**.

❖ It occurs in **small intestine**.

❖ **Two Mechanisms for amino acids absorption:**

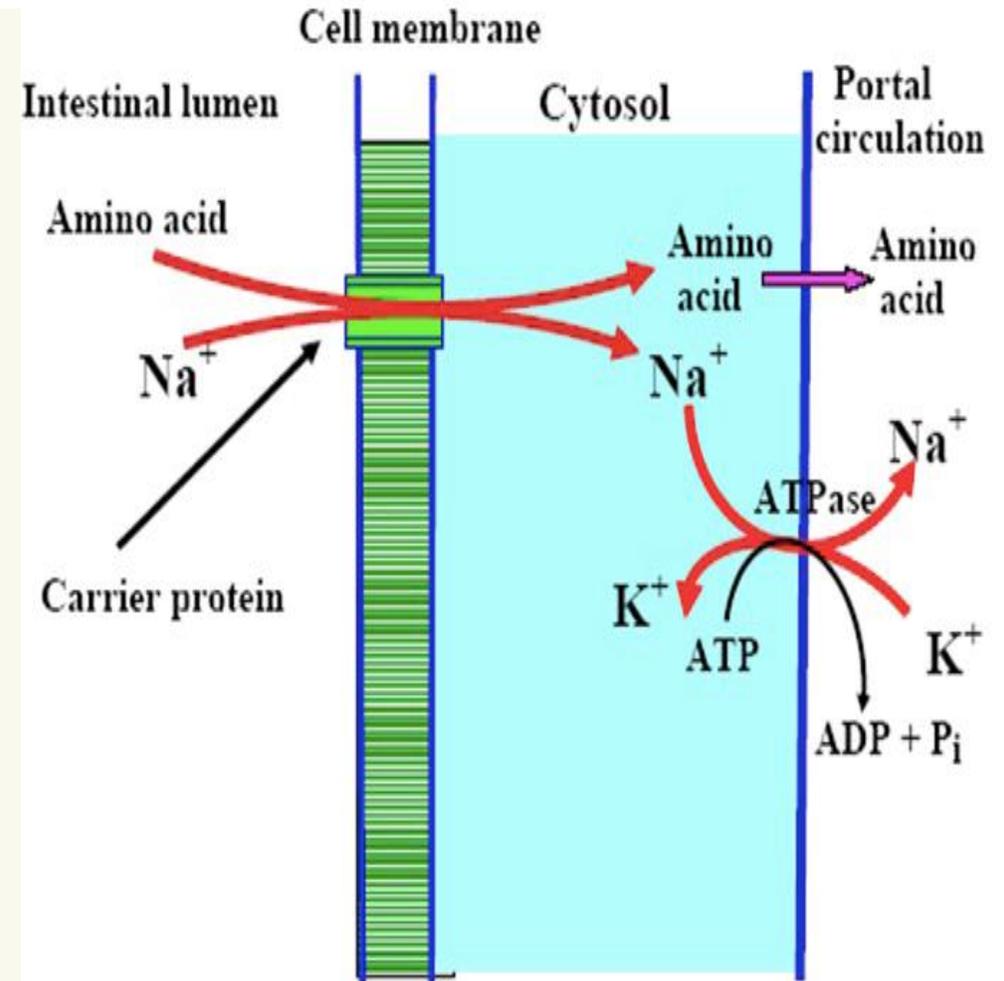
1. Carrier proteins transport system
2. Glutathione transport system (γ -Glutamyl. cycle).

Active transport
of Amino acids



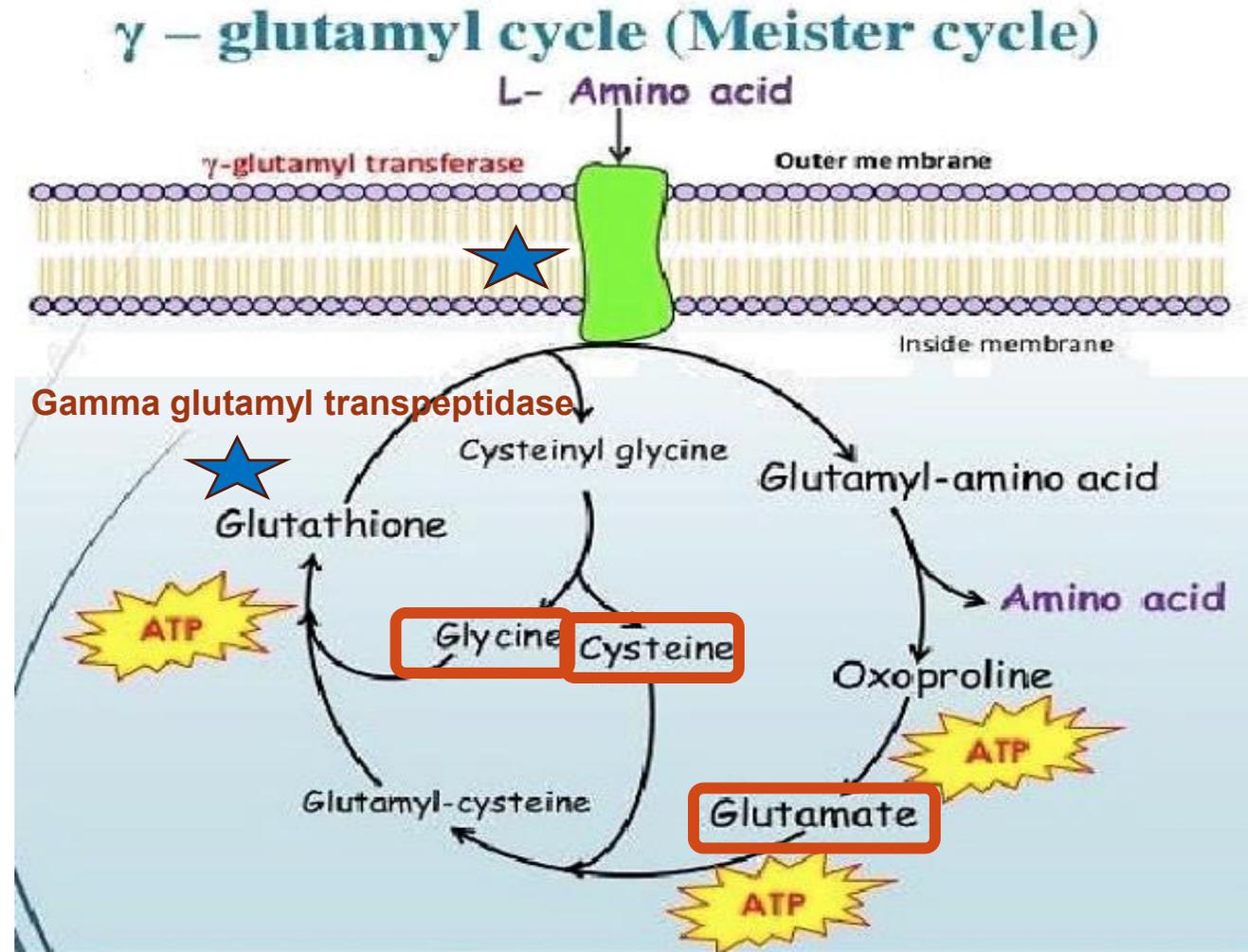
I. Carrier proteins transport system:

- ❖ The **main system** for amino acid absorption.
- ❖ An active process needs energy derived from ATP.
- ❖ Absorption of **one** amino acid needs **one** ATP molecule – and **sodium**-dependent.
- ❖ Need **7 carrier protein transporters**, one for each group of amino acids.
- ❖ Each carrier protein has two sites one for **amino acid** and one for **Na⁺**.
- ❖ The absorbed amino acid passes to the portal circulation, while Na⁺ is extruded out of the cell in exchange with K⁺ by Na/K ATPase pump.



II. Glutathione transport system (Gamma-Glutamyl cycle)

- ❖ **Glutathione** is used to transport amino acids from intestinal lumen to cytosol of intestinal mucosa cells.
- ❖ It is an **active process** that needs energy derived from **ATP**.
- ❖ Absorption of **one** amino acid molecule needs **3 ATP** molecules.
- ❖ Glutathione reacts with amino acid in the presence of gamma **glutamyl transpeptidase** to form gamma glutamyl amino acid.
- ❖ Gamma glutamyl amino acid releases amino acid in the cytosol of intestinal mucosa cells with formation of **5-oxoproline** that is used for **regeneration of glutathione** to begin another turn of the cycle.



Two Mechanisms for amino acids absorption:

	Carrier protein transport system	γ -Glutamyl cycle
Importance	The <u>1st</u> mechanism for amino acid absorption	The <u>2nd</u> mechanism for amino acid absorption
Enzymes	One enzyme (Na^+ - K^+ ATPase)	Three enzymes
ATP	One ATP required	Three ATP molecules
Requires	Different carrier protein transporters , one for each group of amino acids	Glutathione (composed of 3 amino acids)



Life
isn't about
finding yourself.

...

Life
is about
creating yourself.



References

