



Protein Digestion and absorbance

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At the end of this lesson student should be able to define:

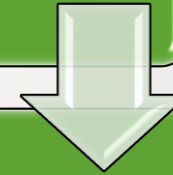
- Protein structure and dietary sources
- The different sites of protein digestion
- Classification of enzymes involved in proteins digestion
- How amino acids and digested proteins are absorbed?
- The clinical significance of proteins digestion and absorbance.

A large, black-bordered frame is centered on the right side of the slide. Inside the frame, the word "Aim" is written in a bold, black, serif font, centered on a light gray background.

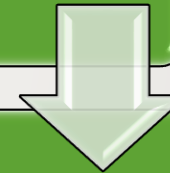
Aim

Protein Digestion

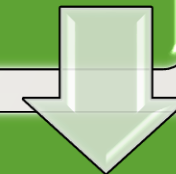
By Gastric secretion



By Small intestine



Genetic errors in amino acids transportation



Abnormalities in protein digestion

Role of gut hormones in digestion

Pancreatic enzymes and their activities



Protein Digestion

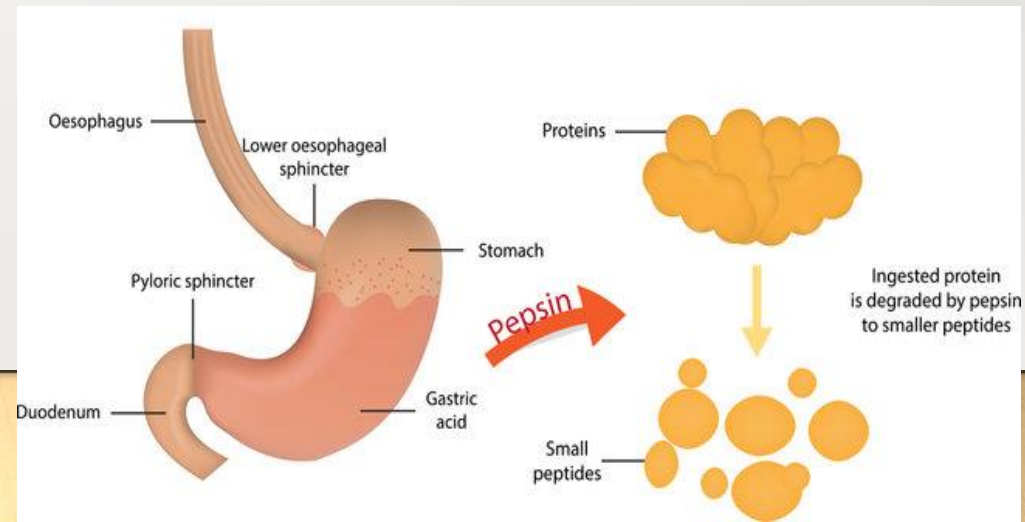
- Dietary proteins 70-100 g/day.
- Proteins are generally **too large** to be absorbed by the intestine.
- They must be **hydrolyzed to their constituent amino acids**, which can be absorbed.

-The Proteolytic Enzymes Responsible for Degrading Dietary Proteins can be found:

- The stomach
- The pancreas
- The small intestine

Protein Digestion

- The mechanical cutting and mixing with saliva take place in the mouth however, no digestion occur in the mouth.
- Then it goes to the stomach as a bolus.
- After protein denaturation, enzymes can act on it easily because there is an increase in the surface area
- Pepsin and HCL helps in protein denaturation.
- Only amino acids and di and tri peptides can be absorbed

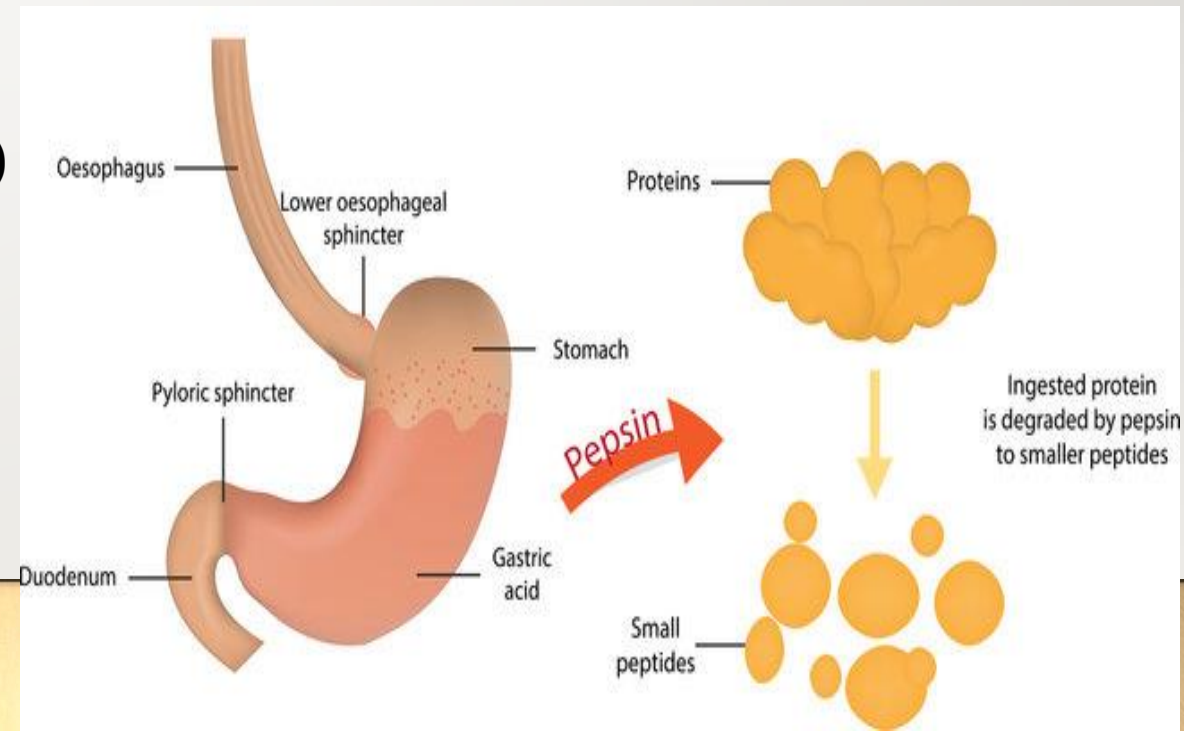


Digestion of proteins in stomach(gastric secretion):

- The **gastric juice** contains two important compound for protein digestion:

1) **Hydrochloric acid (HCL)**

2) **Pepsin** (pepsinogen form in autocatalysis manner)





HCL

- **A strong acid**
- **Denatures proteins therefore they are more susceptible to hydrolysis by proteases.**
Protease is any enzyme that performs proteolysis; protein catabolism by hydrolysis of peptide bonds

Apart from the that HCL kills some bacteria.

- **Strong alkaline media can also denature protein**

Pepsin

- Secreted as inactive zymogen (pepsinogen)
- Acid-stable
- Endopeptidase (Cuts the bond which is present in the middle of the peptide)

Pepsinogen is activated by:

1) Hydrochloric acid

2) Pepsin (autocatalysis)

- The end product of Protein digestion by stomach is (Polypeptides + few free amino acids)

Digestion of proteins in small intestine

- The digestion in small intestine **is controlled by hormones**

1. Digestion by **pancreatic enzymes** Cholecystokinin (CCK) and Secretin



Two small peptide hormones are released from cells of the upper part of small intestine
(proteases)

2. Digestion by **intestinal aminopeptidase**.

Cholecystokinin(CCK)

- **It's secretion is stimulated by:**

presence of partially digested proteins (& lipids) in the upper small intestine

It has effect on:

- the release of pancreatic digestive enzymes
- Triggers the contraction of the gall bladder & release of bile
- Reduces gastric motility slower release of gastric contents into the small intestine
- Stimulate the release of proteases

Secretin

- **Its secretion is stimulated by:**

Low pH of the chyme entering the intestine

It has effect on:

- Pancreas release of a watery solution rich in bicarbonate to neutralize the pH of the intestinal contents (to reach the optimum pH for digestive activity by pancreatic enzymes)

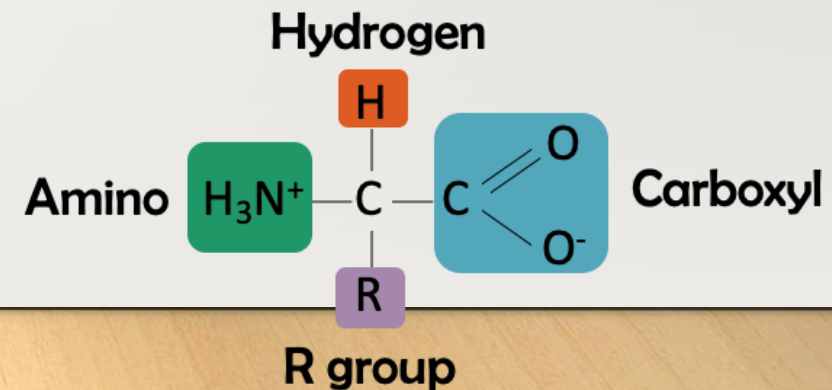
Digestion by pancreatic enzymes:

- The pancreatic juice contains a **group of pancreatic proteases (enzymes)**
- Each of which has different **specificity for the cleavage sites**
- These proteases are synthesized and secreted as **inactive zymogens (inactive form)**

Of note:

- The protein structure contains two terminals:
- 1)N-terminals: containing amino acids.
- 2)C-terminals: containing carboxyl group.

The Carboxypeptidases is acting on the C-terminals (Breaking)



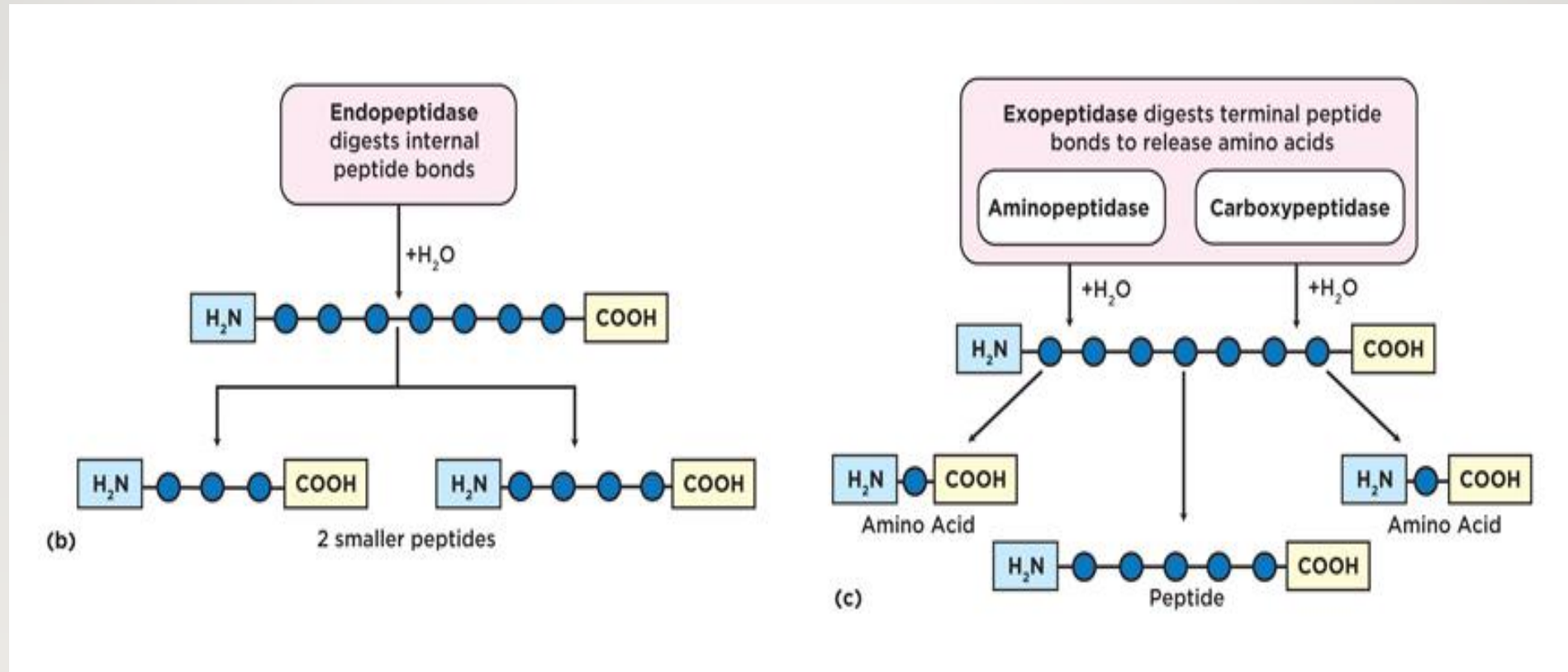
Pancreatic enzymes:

Zymogen	Active enzyme	Activating enzyme
Trypsinogen	Trypsin (endopeptidase)	1) Enteropeptidase 2) Trypsin (autocatalysis)
Chymotrypsinogen	Chymotrypsin (endopeptidase)	Trypsin
Proelastase	Elastase (endopeptidase)	Trypsin
Procarboxypeptidases	Carboxypeptidases (exo-peptidases)* Two types A & B	Trypsin

#Trypsin starts a cascades of reaction because it can activate all other pancreatic enzymes

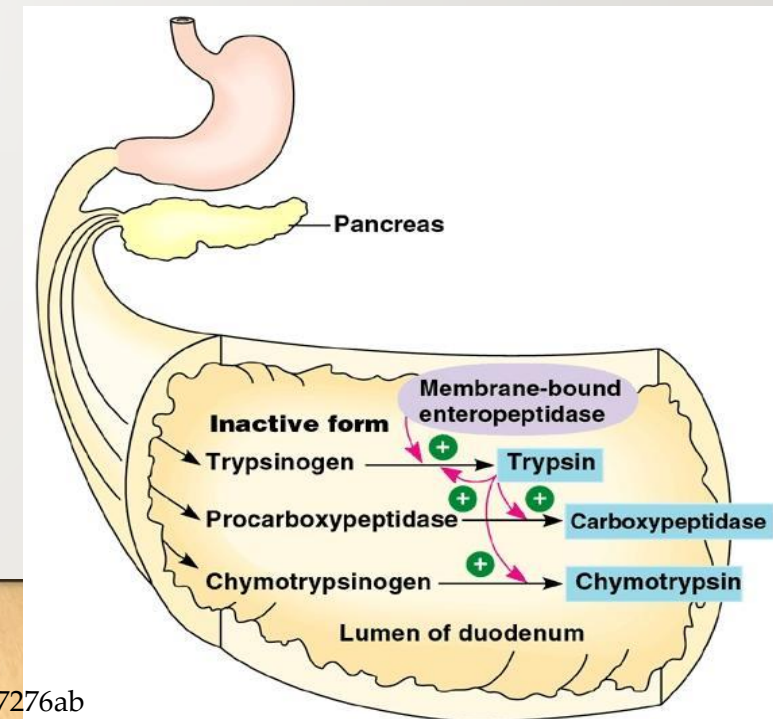
#polypeptides are their substrates and their products are oligopeptides and amino acids.

Endopeptidase and Exopeptidase



Pancreatic Enzymes Activation

- Converts trypsinogen to trypsin is initiated by a Enteropeptidase (the conversion is initiated by this enzyme)
- **Trypsin** then activates all the other pancreatic zymogens (including itself)
- **Enteropeptidase** is an enzyme synthesized by and present on the luminal surface of intestinal mucosal cells of the brush border membrane, and converts trypsinogen into its active form trypsin.

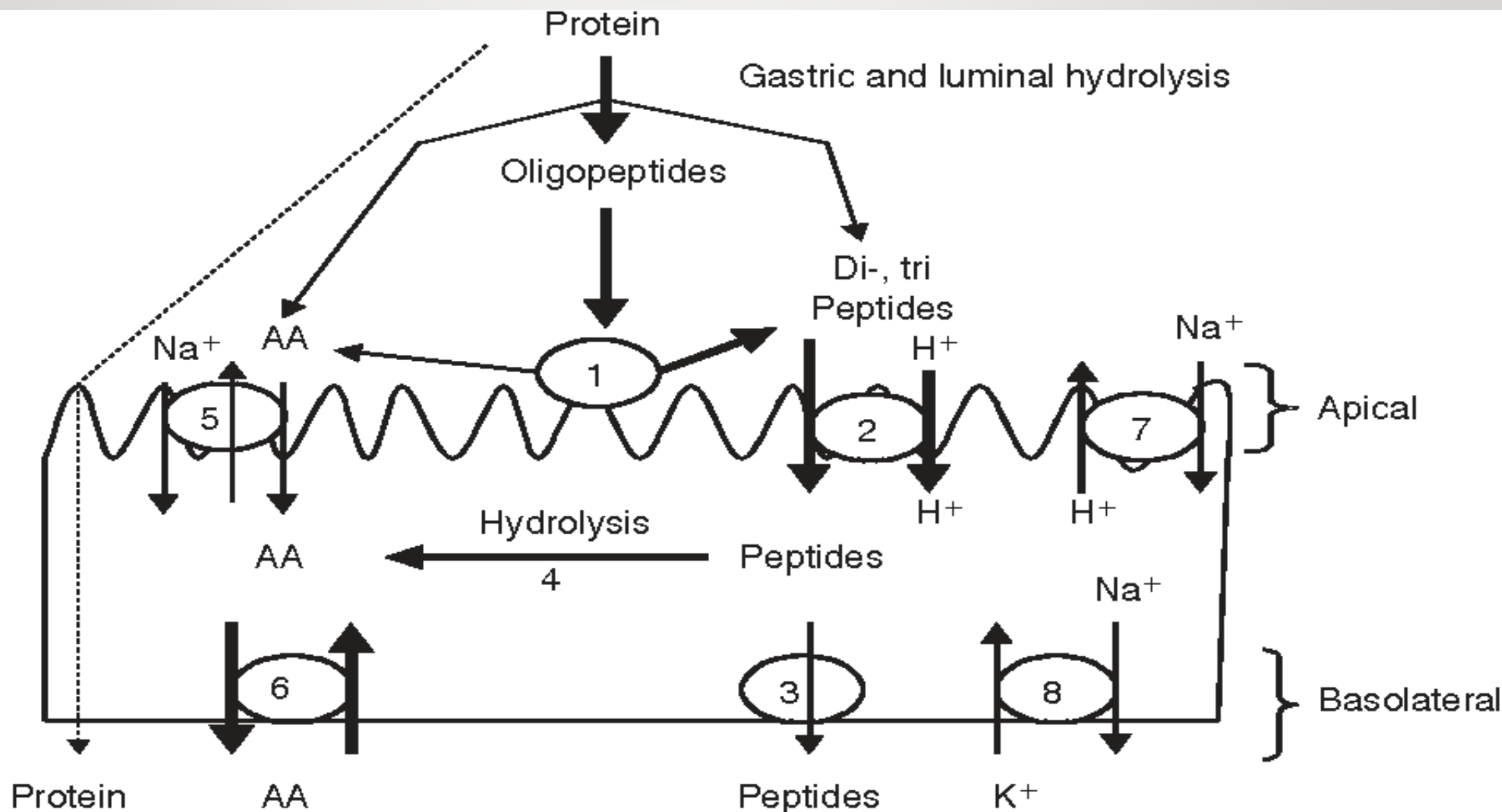


Digestion by intestinal aminopeptidase

- **Intestinal aminopeptidase is and** exopeptidase **on the luminal surface of the intestine**
- It cleaves the oligopeptides that were the end products of pancreatic proteases action and turn them into **free amino acids and smaller peptides** (di- & tri-peptides)
- Break the N-terminals of proteins > giving a lot of amino acids.



LUMEN



BLOOD

Genetic disorder in amino acid transport

- **Cystinuria** (COLA amino acids appear in the urine)
 - Is one of the most common genetic disorder of amino acid transport
 - Inherited
 - Problems in the transport of Cystine and dibasic amino acids
 - It effects small intestine and the kidney function
 - Results in kidney stones formation because they're not absorbed
 - Oral hydration (drinking lots of water) is an important part of treatment (to prevent kidney stones formation)

*COLA (Cystinuria ,Ornithine, Lysine., Arginine)



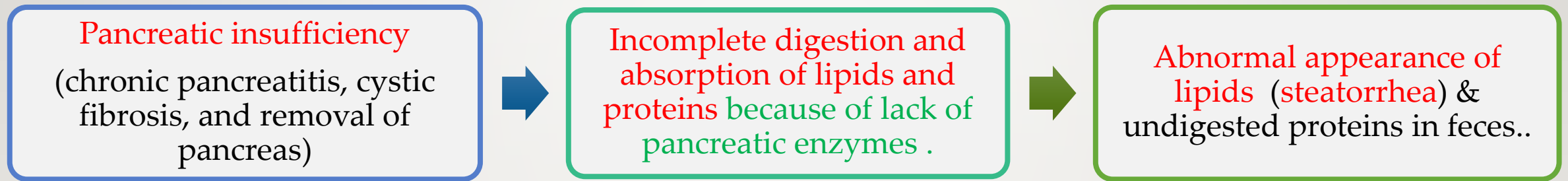
Celiac disease (Celiac sprue)

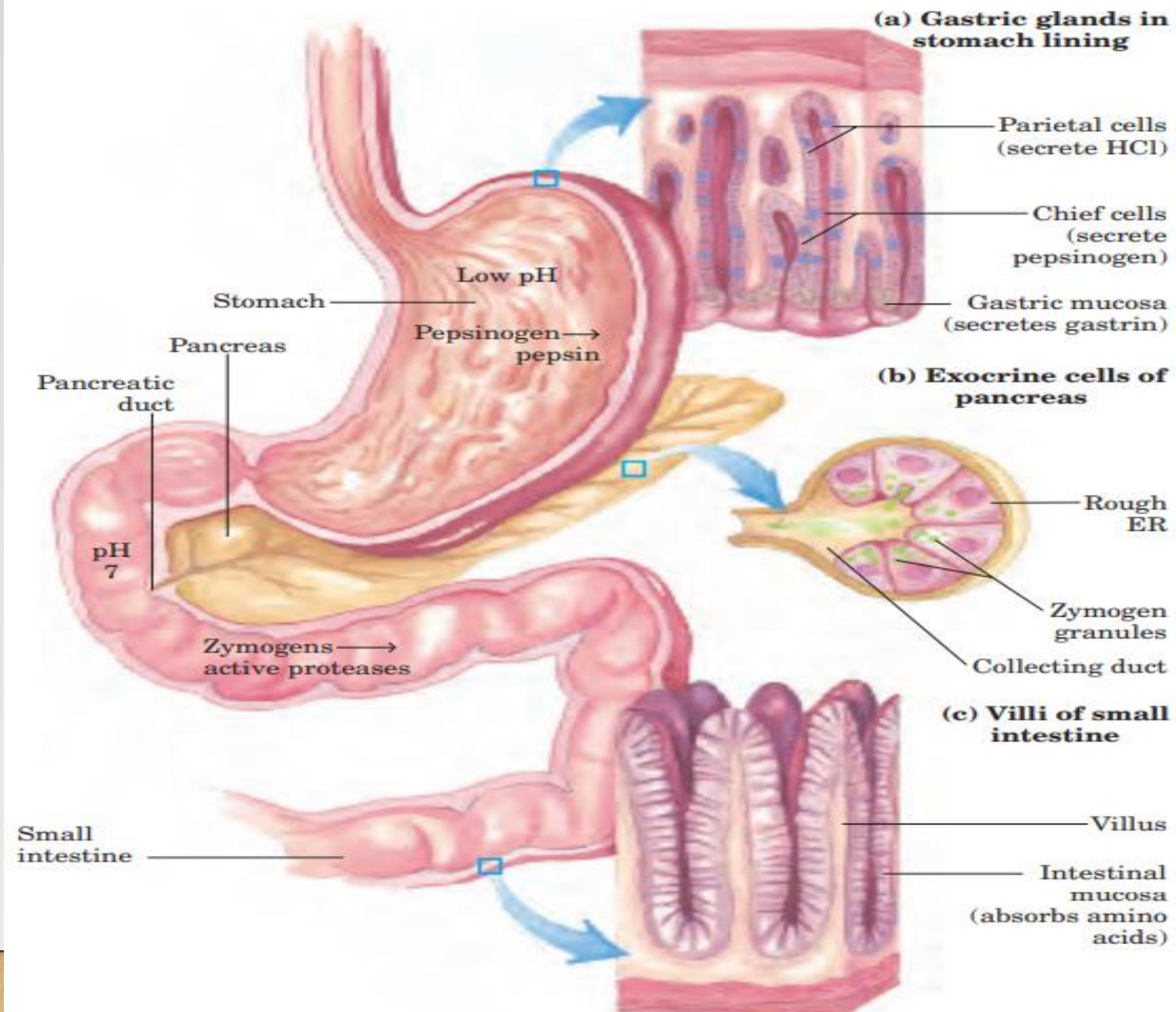
- It is a disease of malabsorption resulting from immune-mediated damage to the villi of the small intestine in response to ingestion of gluten.
- Symptoms are frequent diarrhea, abdominal pain, decrease in weight.
- Gluten is a protein found in wheat, rye, and barley.
- Auto immune disease , gluten is metabolized to gliadin which will be attacked by **anti-gliadin antibodies** which will lead to inflammation, damage to enterocytes and malabsorption.
- Diagnosis is made by looking for anti-gliadin antibodies levels

Take home message:

- ✓ The intestinal digestion of proteins occurs in the small intestine's lumen, on the luminal surface of the small intestine, and is completed intracellularly to produce free amino acids.
- ✓ In pancreatic insufficiency, the digestion and absorption of fat & protein is incomplete → steatorrhea & appearance of undigested proteins in the feces.
- ✓ Proteolytic enzymes responsible for digestion of dietary proteins are produced by the stomach, the pancreas & the small intestine.
- ✓ The digestion of proteins in the stomach is the result of the action of HCl and pepsin.
- ✓ Pancreatic proteases are, like pepsin, synthesized and secreted as inactive zymogens.

Take home message:







- **The different sites of protein digestion**
- **Describe different enzymes involved in proteins digestion**
- **Describe the site of secretion and action of enzymes involved in protein digestion**
- **Describe how amino acids, Di peptide and tripeptide are absorbed**
- **The clinical significance of malfunction of proteins digestion and absorbance**

Learning objectives

Incomplete transport & digestion of Fat and Proteins is a sign of ?

- A- Pancreatic Insufficiency
- B- Stomach Insufficiency
- C- Adrenal Insufficiency
- D- Cardiovascular Disease

Trypsin activates all pancreatic enzymes including its precursor ?

- A- True
- B- False
- C. Under certain conditions is true

Amino acid absorptions is tightly depending on:

- A- Ca channels
- B- Na transporters
- C. Sufficient amounts of Fe
- D. All the above

Which of the hormones below control the digestion of proteins in small intestine?

- A. Cholecystokinin (CCK)
- B. Cortisol
- C. Secretin
- D. A and C