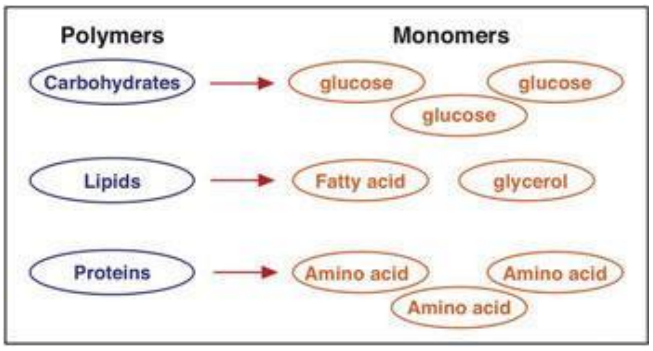
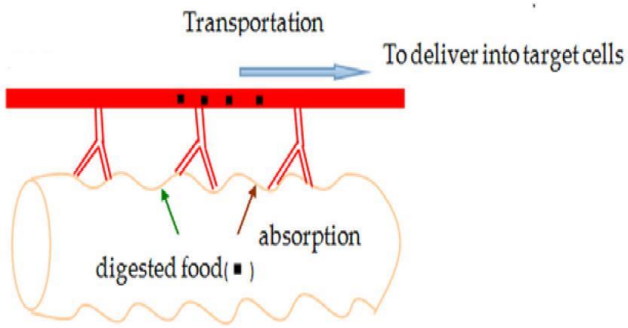
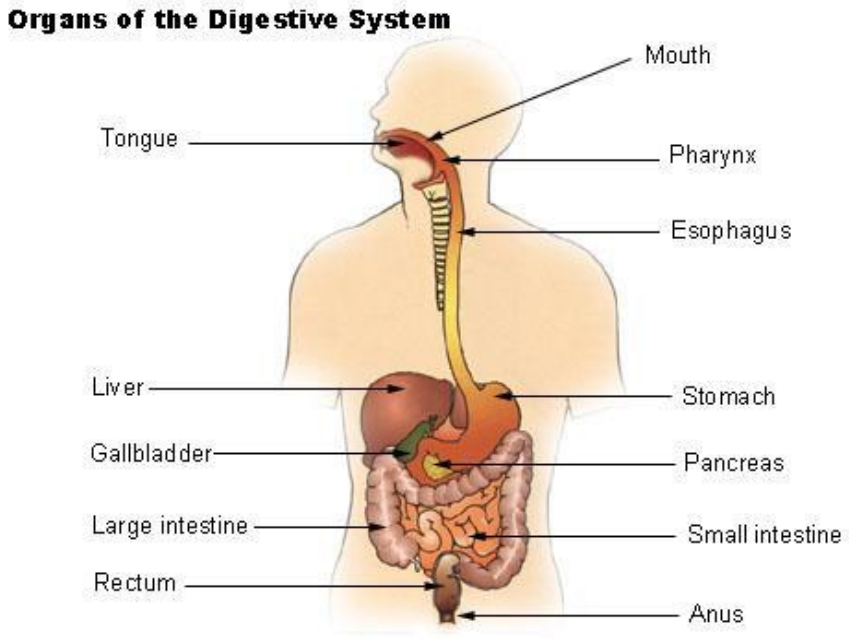
Biochemical Composition & Effects of GIT Secretions

Introduction:

- ***Carbohydrates, lipids and proteins*** *that make up the bulk of our diet are large complex molecules.*
- *They must be hydrolyzed to* ***monosaccharides, fatty acids and amino acids,*** *respectively, before their absorption and utilization.*

Digestion	Absorption
• ***Mechanical and chemical processes*** *taking place in GIT by which complex food is broken down into* ***simpler and absorbable forms.***	• *Passage of digested nutrients from* ***GIT*** *into the* ***blood stream*** *to be transported within the body.*
	



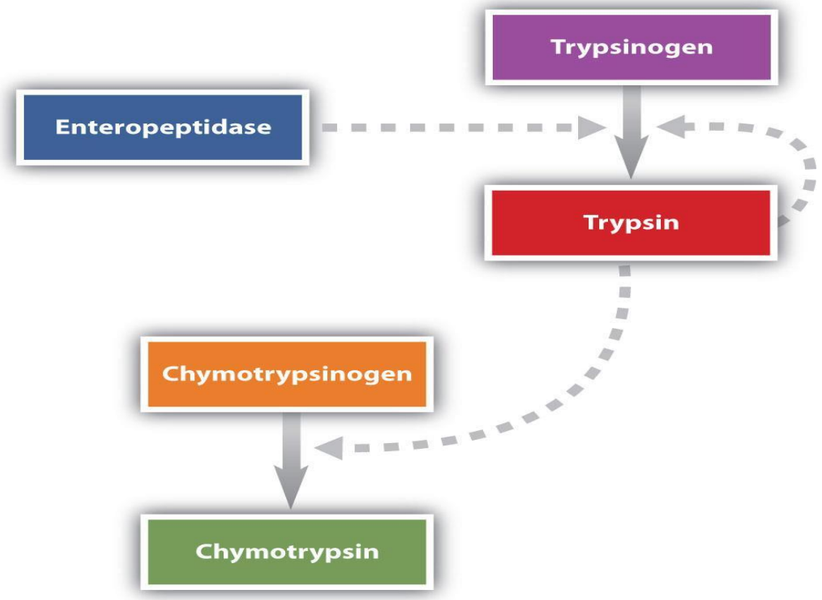
	Salivary Secretions	Gastric Secretions	Bile Secretions	Pancreatic Secretions	Intestinal Secretions
pH	6.2 - 7.6	1 - 3	7.5 - 8.8	7.1 - 8.2	7 - 8
Organic Component	1. Salivary enzymes (salivary amylase, lingual lipase). 2. Mucus.	1. Gastric enzymes (lipase, pepsin, gelatinase, renin). 2. Mucus. 3. Intrinsic factor.	1. Bile salts & pigments. 2. Cholesterol. 3. Phospholipid as lecithin 4. Fatty acids.	1. Pancreatic enzymes (amylase, lipase, colipase, trypsin & other protein digesting enzymes) 2. Trypsin inhibitor.	1. Enzymes. 2. Mucin.
Inorganic Component	• Na • Ca • K • Cl • Mg	• **Mainly** HCl	• Na • Cl • K • HCO3 • Ca • Mg	• Mainly NaHCO3	• Na • Cl • K • HCO3
Effects on CHO	• Starts Digestion of CHO • **Salivary amylase (Ptyalin):** ➢ **Partially digests** cooked starch & glycogen to dextrin & few maltose. ➢ Its action stops in stomach **when pH falls.**	• **No** carbohydrate digesting **enzymes** available. • Only, **HCl** can partially hydrolyze the disaccharides and polysaccharides.		• **Pancreatic amylase:** ➢ **Completely digests** starch, glycogen, & dextrin into maltose & few glucose. ➢ It acts on **cooked & uncooked starch.**	• **Maltase, lactase and sucrase** hydrolyze the corresponding disaccharides to produce **glucose, fructose and galactose.**

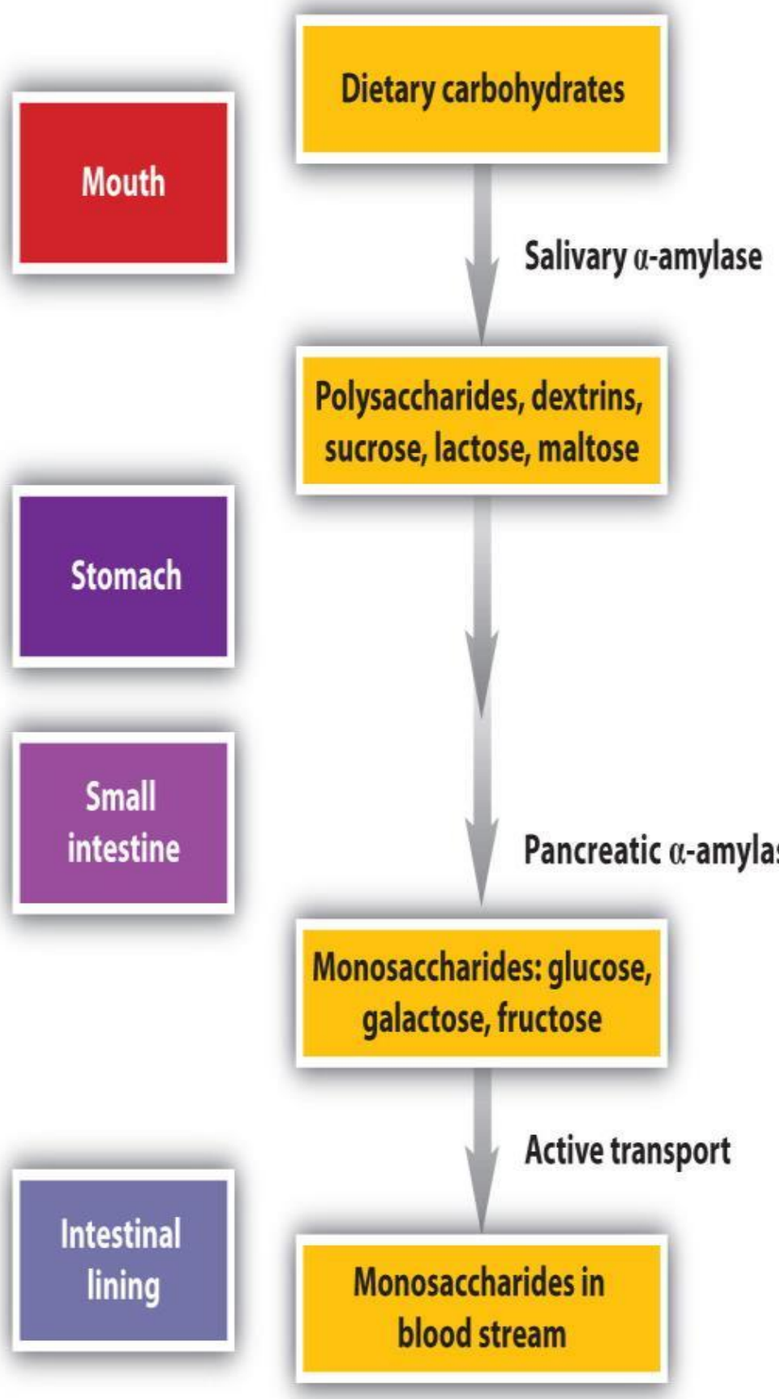
	Salivary	Gastric	Bile	Pancreatic	Intestinal
Effects on Fat	• *Starts digestion of fat.* • ***Lingual lipase:*** ➢ *secreted by the **Ebner's glands** at dorsum of tongue.* ➢ *Helps fat digestion in **newborn** (pancreatic lipase is still **not developed**)*	• *triglycerides Digestion* • ***Gastric lipase:*** ➢ *pH **3-6*** ➢ *Hydrolyzes TG containing short, medium and unsaturated long chain fatty acids at third ester bond to forms **free fatty acid (FFA) and α, β (1,2) diglycerides.***	• *Bile salts assist **emulsification** of fat by lowering **surface tension** & exposing **large area** of TG to action of pancreatic lipase.* • *Bile salts are required for activity of **pancreatic phospholipase A2 and cholesterol esterase.*** • *Bile salts together with lipids form **water soluble micelles** → help absorption of lipids & fat soluble vitamins.*	**A. Digestion of triglycerides :** • ***Pancreatic lipase (the most active lipase) and colipase:*** ➢ *Hydrolyzes the 1st and 3rd ester bonds producing **2 FFA and β (2) monoglyceride** (The major digestion products of TG) which may be converted to **α (1) mono-glyceride** by **isomerase** (slow ineffective process).* ➢ ***Colipase** is protein coenzyme required for optimal enzyme activity of pancreatic lipase.* **B. Digestion of phospholipids:** • ***Phospholipase A2:*** ➢ ***Activated by** trypsin, bile salts and Ca* ➢ ***Hydrolyzes** glycerol phospholipids by removing FA in position 2 (β) to form **lyso-phospholipids.*** **C. Digestion of cholesterol esters:** • ***Pancreatic cholesterol esterase (cholesterol ester hydrolase):*** ➢ *Hydrolyzes cholesterol ester into **FA & free cholesterol.*** ➢ ***Requires** bile salts for its activity*	• ***Intestinal lipase:*** ➢ *Act **within** intestinal mucosal cells where it hydrolyzes the absorbed α (1) monoglyceride → **glycerol & FFA*** • ***Intestinal phospholipase:*** ➢ *Complete the hydrolysis of lysophospholipids to **glycerol, FA, phosphoric acid & nitrogenous base.***

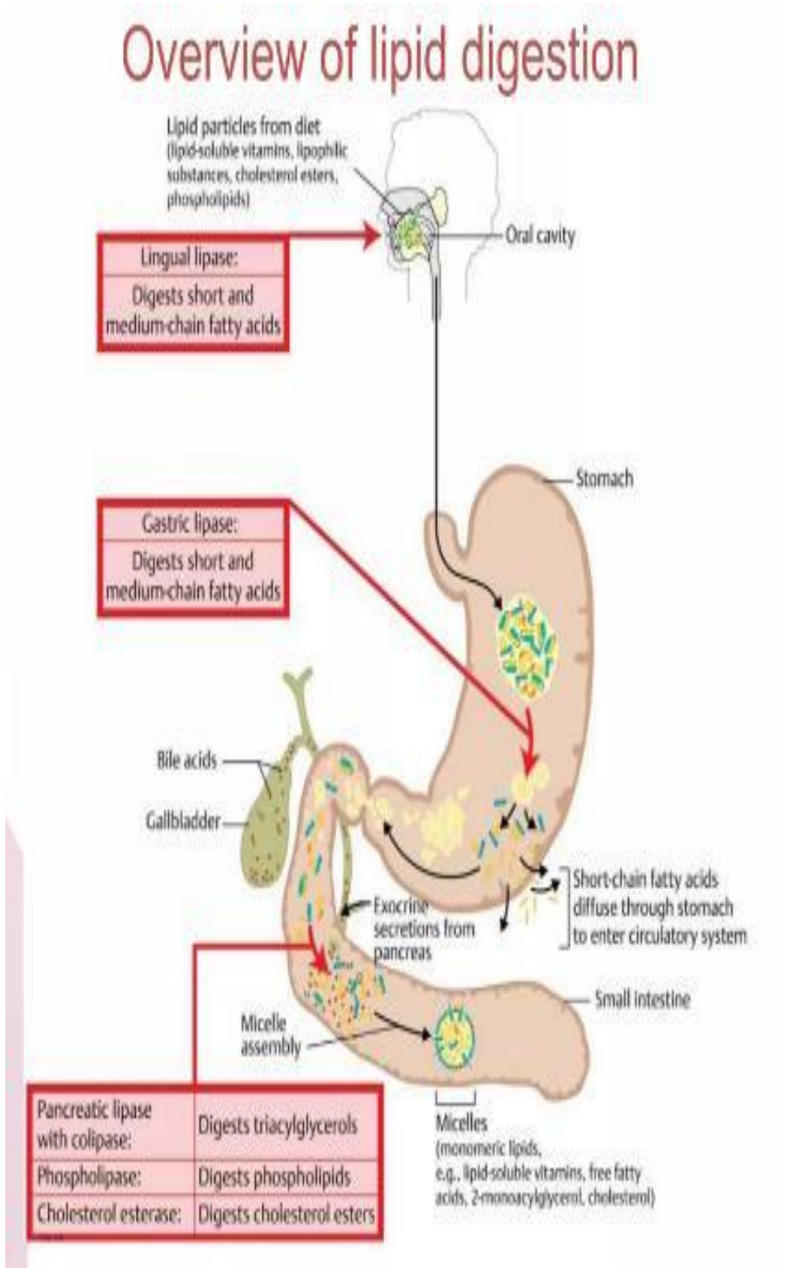
	Salivary	Gastric Secretions	Bile	Pancreatic	Intestinal Secretions
Effects on proteins		• *Protein digestion **begins** in the stomach.* **A. Gastric HCL:** *1) It causes **protein denaturation** to the easily digested metaproteins.* *2) It activates **pepsinogen** to pepsin.* *3) It makes **pH** in the stomach suitable for the action of pepsin.* **B. Pepsin:** *1) pH: **1.5-2.2*** *2) An **endo-peptidase** acting on central peptide bond in which NH2 belongs to aromatic amino acids.* *3) Secreted as **inactive pepsinogen.*** *4) Activated by **HCL then by autoactivation.*** **C. Rennin:** *1) pH **4*** *2) A **milk-clotting enzyme** in the stomach of infants and young animals.* *3) prevents rapid passage of milk from stomach → gives sense of fullness.* *4) Acts on **casein (main milk protein)** converting it to **soluble paracasein**, which binds calcium ions forming **insoluble calcium paracaseinate** (milk clot).* *5) Calcium paracaseinate is then digested by **pepsin.*** **D. Gelatinase:** ➢ *liquefies **gelatin***			• ***Aminopeptidase:*** ➢ *It is **an exopeptidase** acts on the terminal peptide bond at the NH2 terminus of the polypeptide chain, releasing **a single amino acid.*** • ***Tri-peptidase:*** ➢ *Acts on tripeptides to release **a single amino acid and a dipeptide.*** • ***Di-peptidase:*** ➢ *Acts on dipeptides to release **2 amino acids.*** *So, the end products of protein digestion in the small intestine are **amino acids.***

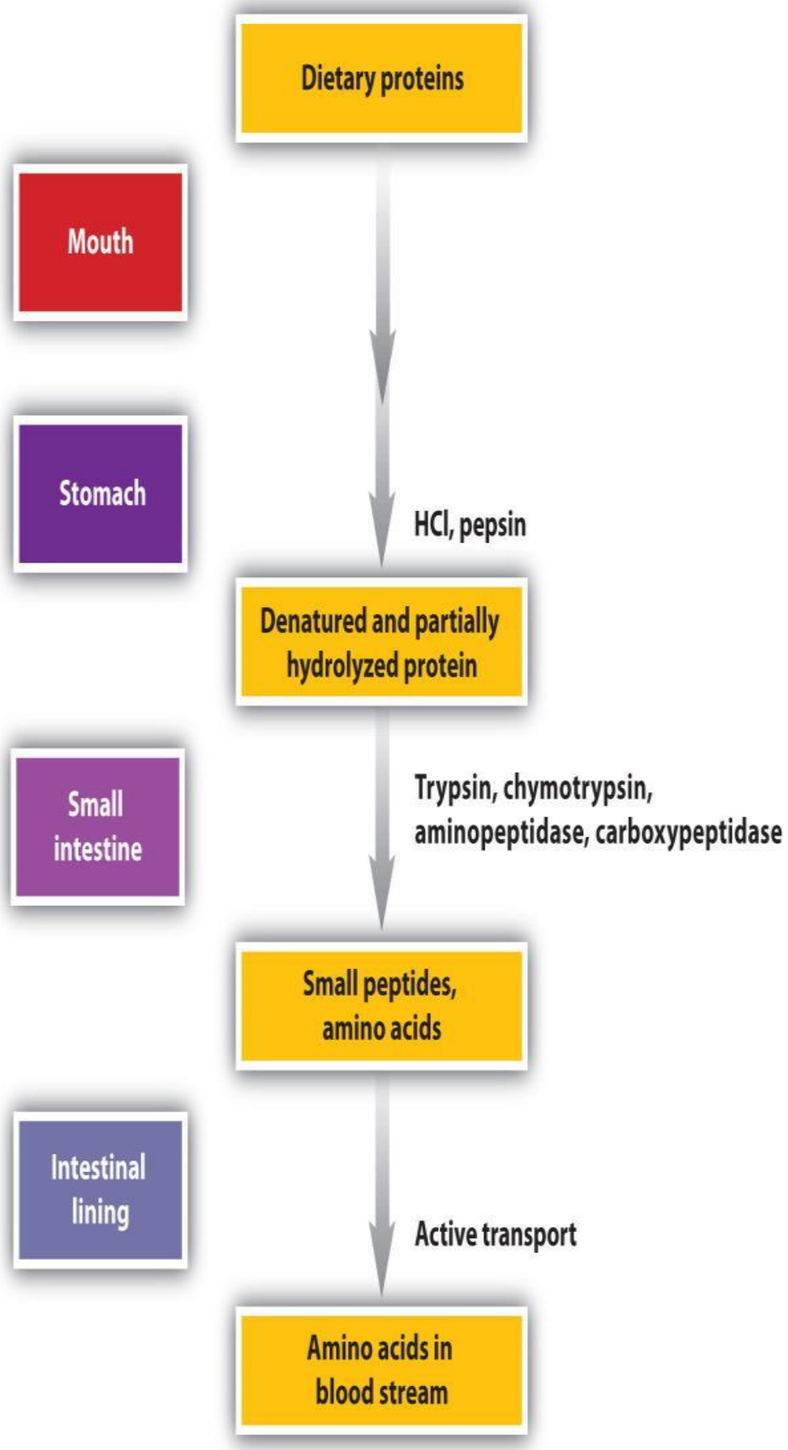
Pancreatic enzymes

Enzyme	pH	Secreted in inactive form	Activated by	Type	Action
Trypsin	**8**	Trypsinogen	**Enterokinase** & autoactivation	Endopeptidase	• Hydrolyzes central peptide bond in which the COOH belongs to **basic amino acids** e.g. arginine, lysine and histidine.
Chymotrypsin	**8**	Chymotrypsinogen	Trypsin.	Endopeptidase	• hydrolyzes central peptide bond in which the COOH belongs to **aromatic amino acids**.
Elastase	**8**	Pro-elastase	Trypsin.	Endopeptidase	• acts on peptide bonds formed by **glycine, alanine and serine.** • It digests elastin and collagen
Carboxypeptidase	**7.4**	Pro-carboxypeptidase	Trypsin.	**Exo**peptidase	• Hydrolyzes **terminal (peripheral) peptide bond** at the COOH end of the polypeptide chain.




Mouth
Dietary carbohydrates
Salivary α-amylase
Polysaccharides, dextrins, sucrose, lactose, maltose
Stomach
Small intestine
Pancreatic α-amylase
Monosaccharides: glucose, galactose, fructose
Intestinal lining
Active transport
Monosaccharides in blood stream


Overview of lipid digestion
Lipid particles from diet (lipid-soluble vitamins, lipophilic substances, cholesterol esters, phospholipids)
Oral cavity
Lingual lipase: Digests short and medium-chain fatty acids
Stomach
Gastric lipase: Digests short and medium-chain fatty acids
Bile acids
Gallbladder
Short-chain fatty acids diffuse through stomach to enter circulatory system
Exocrine secretions from pancreas
Small intestine
Micelle assembly
Micelles (monomeric lipids, e.g., lipid-soluble vitamins, free fatty acids, 2-monoacylglycerol, cholesterol)
Pancreatic lipase with colipase: Digests triacylglycerols
Phospholipase: Digests phospholipids
Cholesterol esterase: Digests cholesterol esters


Dietary proteins
Mouth
Stomach
HCl, pepsin
Denatured and partially hydrolyzed protein
Small intestine
Trypsin, chymotrypsin, aminopeptidase, carboxypeptidase
Small peptides, amino acids
Intestinal lining
Active transport
Amino acids in blood stream

- ***Emulsification:***

Def:	• ***Breakdown*** *of large fat globules into smaller ones.*
Site:	• *In the mouth* ***(chewing)*** • *In the stomach* ***(peristaltic contractions)*** • *In intestine* ***(peristaltic movement, bile salts & by lyso-phospholipids).***

Absorption of carbohydrates, lipids and proteins

1- Absorption of carbohydrates

- *The end products of carbohydrate digestion are* ***monosaccharide****s (glucose, galactose and fructose).*
- *They are absorbed from the jejunum to portal veins to the* ***liver*** *where galactose and fructose are converted to* ***glucose.***
- ***Mechanisms responsible for absorption of monosaccharides:***

1) Passive transport (facilitated diffusion):	*2) Active transport:*
• ***With*** *conc. Gradient*	• ***Against*** *conc. Gradient*
• *It occurs by facilitative transporter* ***(GLUT5),***	• *Using carrier protein* ***(SGLUT1)***
• *Needs* ***no*** *energy.*	• *Needs energy*
• *Ex.* ***Fructose and pentoses absorption.***	• *Ex.* ***Glucose absorption.***

2- Absorption of lipids

- *The end products of lipid digestion are **monoglycerides, FAs, glycerol, cholesterol and lysophospholipids.***
- *They are absorbed from the **jejunum and ileum.***
- *Short chain FAs and glycerol are **H2O soluble** → absorbed to liver.*
- *Long chain FAs, cholesterol, monoglycerides and lysophospholipids are **H2O insoluble** → absorbed as **micelles** using bile salts → mucosal cells.*
- *Bile salts are reabsorbed to liver **(enterohepatic circulation).***
- *In mucosal cells, TG and other lipids are **resynthesized** → bind to protein, forming **chylomicrons** which then enter circulation.*

3- Absorption of proteins

- *The end products of protein digestion are **amino acids.***
- *They are absorbed from the **jejunum and ileum** → portal circulation.*
- ***Mechanisms responsible for absorption of amino acids:***

1) Passive transport:	*2) Active transport:*
By simple diffusion	• ***Two mechanisms are involved:*** *a) Carrier protein transport system.* *b) Glutathione transport system.*
*Needs **no** energy*	*Needs energy*