



Summary of

DIGESTION AND ABSORPTION

Physiology

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Digestion

Site	Carbohydrates	Proteins	Lipids
Mouth	Ptyalin (Salivary alpha-amylase) starts carbohydrate digestion, converting starches to smaller glucose polymers and alpha limit dextrans.	_____	_____
Stomach	Ptyalin continues digestion in the center of the food mass only which are not exposed to the acid and where the pH is still above 4.	Pepsin hydrolyzes 20% of proteins into peptones and smaller polypeptides.	Little to no digestion or absorption of fat due to absence of bile salts.
Small intestines	<p>-Pancreatic amylase (alpha amylase that digest 1-4 linkage), digests 50%-80% of starch which gives: maltose, maltotriose and alpha limit dextrans.</p> <p>-Brush border enzymes (Lactase, Sucrase, Maltase, α-Dextrinase) finalize hydrolysis into glucose, fructose, and galactose.</p>	<p>-Proteolytic enzymes of pancreas like: endopeptidases (trypsin, chymotrypsin) and exopeptidases (carboxypeptidases, aminopeptidases) hydrolyze proteins.</p> <p>-Brush border (peptidases) convert small peptides into oligopeptides and amino acids.</p> <p>-Peptidases inside the cytosol of the enterocytes hydrolyze small peptides into amino acids</p>	<p>1.Lipids emulsified into small droplets (0.5-1micron) by bile salts. 2.Pancreatic lipases and co-lipases act on the water/oil interface to hydrolyze the 1st +3rd ester linkages of triglycerides which gives 2 free fatty acids +2 monoglycerides. 2.mentioned Productsincluding + phospholipids +cholesterol +bile salts, form micelles (5nm diameter). 3.Micelles contact the gut wall, and their components diffuse across the brush border into the epithelial cell (no border enzymes, transport appears as simple diffusion) 4.Emptied micelles are reloaded, shuttling more lipids to enterocytes, repeating as the meal progresses. In the terminal ileum, bile salts are actively absorbed.</p>

Absorption

Macromolecule	Process
Carbohydrates	<p>-By secondary active co-transport, Na⁺-linked carrier at membrane of epithelial cells transports glucose with Na⁺ into enterocytes (epi cells), then Na⁺ is pumped out at basolateral membrane and glucose removed at the basolateral membrane by facilitated diffusion into capillaries of the villus then Na⁺ is pumped out at basolateral membrane. (Galactose follows the same path while fructose enters by facilitated diffusion using different carrier that is not linked to Na and at basal membrane it diffuses passively.</p> <p>-Absorption can also occur with solvent drag through tight junctions. Increased glucose concentration in chym leads to increased absorption by increasing osmotic pressure in the paracellular space ->increased fluid flow through the tight junction ->carries anything dissolved in fluids.</p>
Proteins	<p>-Small peptides are transported into the enterocyte by a carrier mediated transport system (secondary active co-transport) it depends on Na⁺ pump to maintain a chemical gradient across luminal membrane.</p> <p>-Amino acids are transported by membrane bound carriers:</p> <ul style="list-style-type: none">* Na⁺ dependent carriers:<ol style="list-style-type: none">1. For neutral amino acids.2. Proline and hydroxyproline.3. Phenylalanine and methionine.*Na⁺ independent carriers: for basic and neutral aminoacids.
Lipids	<p>Absorption across the luminal membrane of intestinal epithelial cell by passive diffusion.</p> <p>1.Once inside the epithelium, FFA + monoglycerides reform Triglycerides again. (needs ATP and Co-A). Triglycerides (80-90%) + cholesterol (3%) + phospholipids (10%) + B- lipoprotein (5%) = chylomicrons (60-750nm diameter).</p> <p>2.chylomicrons are expelled from epithelial cells by exocytosis then diffuses through the extracellular space and is removed from the villus by lacteals (terminal lymphatic vessel) and lymphatic circulation then enters the circulation at thoracic duct.</p> <p>-Some glycerol molecules (aren't esterified into triglyceride) and short chain fatty acids pass directly through epithelial cells and removed from the villus by diffusion into blood capillaries.</p>

Absorption

Substance	Process
Water	Driven by active Na ⁺ absorption, Na ⁺ transport at basolateral membrane causes water influx through epithelial cells and tight junctions. Rapid removal of water through capillaries maintains the gradient.
Na ⁺	Actively absorbed in small intestine and colon. -Passive diffusion at luminal membrane, active at basolateral membrane. -Co transport system with amino acids and monosaccharides. -Aldosterone enhances Na ⁺ absorption when there's need for it and water due to dehydration crucial in the colon).
Cl ⁻	Mainly absorbed in upper small intestine (duodenum, jejunum). - Passive diffusion when electrical gradient established by Na ⁺ absorption.
K ⁺	Absorbed passively in small intestine. - In colon, usually secreted in exchange for Na ⁺ .
Ca ⁺⁺	Actively absorbed throughout intestine. -Binds to protein at brush border membrane, possibly a carrier then inside, binds to calbindin which transports it across cell. -Ca ⁺⁺ transported out at basolateral membrane. -Vitamin D and parathyroid hormone increase Ca ⁺⁺ absorption.

Absorption

Substance	Process
Fe⁺⁺	<p>Main absorption in upper small intestine (duodenum, adjacent jejunum). - Promoted by acidic stomach pH and vitamin C. - Fe⁺⁺ more soluble than Fe⁺⁺⁺. - Vitamin C enhances absorption by reducing ferric iron to ferrous iron. - Various inhibitors include phosphates, oxalates, phytic acid, and pancreatic juice.</p> <p>-exact mechanism still unsettled, 2 theories:</p> <ol style="list-style-type: none">1.active transport at the luminal membrane.2.secreting a globular protein from the epithelial cells known as apoferritin, this protein binds to Fe⁺⁺ →ferritin, this complex of protein and iron transported into the cell by receptor mediated endocytosis. <p>- Then iron stored in the epithelial cell in form of ferritin, then transported into the blood where it binds transferrin as needed</p>
Vitamins	<p>Most absorbed in upper small intestine</p> <ul style="list-style-type: none">-Vit. B12 in the ileum.-Water-soluble vitamins usually passively absorbed except C, B1, B12.-Vit. B12 absorption requires intrinsic factors secreted from oxyntic cells of stomach.-Lipid-soluble vitamins (A, D, E, K) follow the route of lipids, solubilized in micelles and chylomicrons.