

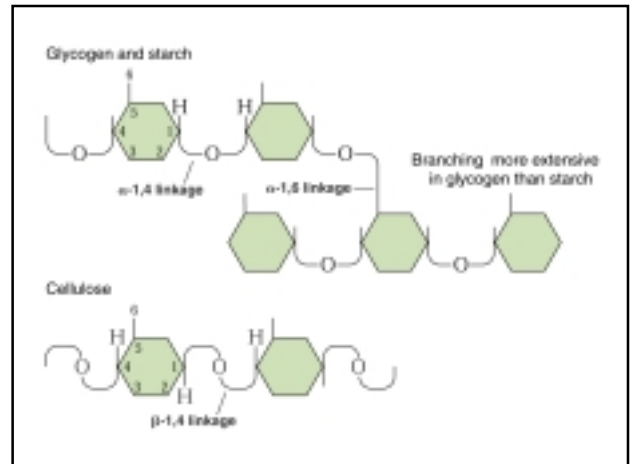
Region	Secretion	Daily amount (L)	pH	Composition*	
Duodenum	Salivary glands	1+	6.5	Amylase, lipase	
Esophagus	Stomach	Gastric juice	1-2	1.5	Pepsinogen, HCl, mucus, intrinsic factor
	Pancreas	Pancreatic juice	1	7-8	Trypsinogen, chymotrypsinogen, carboxy and aminopeptidases, lipase, amylase, maltase, nucleases, bicarbonate
Gut-Bladder	Bile	1	7-8	Fats and fatty acids, bile salts and pigments, cholesterol	
	Duodenum	Secretions enteric	1	7-8	Esterolases, carboxy- and aminopeptidases, maltase, lipase, sucrase, lipase, nucleases
Jejunum	Stomach				
	Small intestine				
	Colon				
Rectum					

\*Including mucus and water, which together make up some 85% of the actual secretion.

**Table 13-1 Action of the major enzymes secreted in the mouth, stomach, pancreas, and small intestine**

Enzyme	Site of action	Substrate	Products of action
<b>Mouth</b>			
Salivary $\alpha$ -amylase	Mouth	Starch	Disaccharides (low)
<b>Stomach</b>			
Pepsinogen/pepsin	Stomach	Proteins	Large peptides
<b>Pancreas</b>			
Pancreatic $\alpha$ -amylase	Small intestine	Starch	Disaccharides
Trypsinogen/trypsin	Small intestine	Proteins	Large peptides
Chymotrypsin	Small intestine	Proteins	Large peptides
Elastase	Small intestine	Elastin	Large peptides
Carboxypeptidase	Small intestine	Large peptides	Small peptides (oligopeptides)
Aminopeptidase	Small intestine	Large peptides	Oligopeptides
Lipase	Small intestine	Triglycerides	Monoglycerides, fatty acids, glycerol
Nuclease	Small intestine	Nucleic acids	Nucleotides
<b>Small intestine</b>			
Enterokinase	Small intestine	Trypsinogen	Trypsin
Disaccharidase	Small intestine*	Disaccharides	Monosaccharides
Peptidase	Small intestine*	Oligopeptides	Amino acids
Nucleotidase	Small intestine*	Nucleotides	Nucleotides, phosphate acid
Nucleosidase	Small intestine*	Nucleosides	Sugars, phosphate, purines

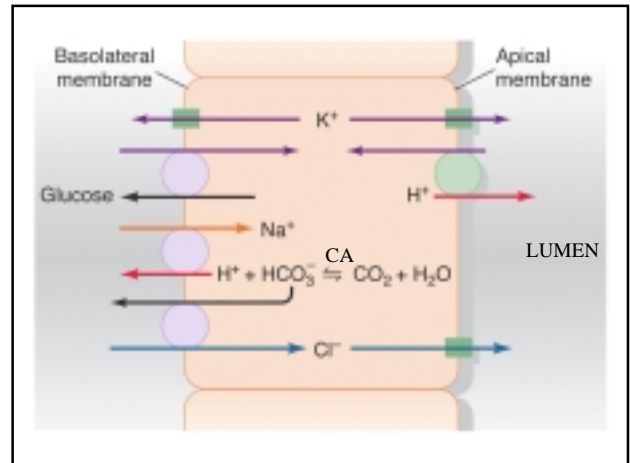
\*Invariable



**Table 13-2 The major gastrointestinal peptide hormones**

Hormone	Tissue of origin	Target tissue	Primary action	Stimulus to secretion
Gastrin	Stomach fundus	Intrinsic cells and mucosa of stomach	HCl production and secretion, stimulation of gastric motility	Vagovagal activity, peptides and gastrin in stomach
Cholecystokinin (CCK)	Upper small intestine	Gallbladder	Contraction of gallbladder	Fatty acids and amino acids in duodenum
Secretin	Duodenum	Pancreas, gastric cells, and mucosa of stomach	Pancreatic juice secretion; Water and $\text{NaHCO}_3$ secretion; Inhibition of gastric motility	Food and strong acid in stomach and small intestine
Gastric inhibitory peptide (GIP)	Upper small intestine	Gastric mucosa and parietal cells	Inhibition of gastric secretion and motility	Monosaccharides and fat in duodenum
Inhibitory peptide (IP)	Upper small intestine	Stomach	Inhibition of gastric secretion and motility	Acid in duodenum
Vasoactive intestinal peptide (VIP)	Duodenum	Stomach intestine	Increase of blood flow; secretion of thin gastric fluid; inhibition of gastric secretion	Fat in duodenum
Enteroglucagon	Duodenum	Jejunum, pancreas	Inhibition of motility and secretion	Carbohydrates in duodenum
Kalypalin	Small intestine	Stomach, pancreas, intestine	Stimulation of HCl secretion; inhibition of pancreatic enzyme secretion and/or fluid secretion	Basic conditions in stomach and intestine
Secretastatin	Small intestine	Stomach, pancreas, intestine, spleen, air circulation	Inhibition of HCl secretion; pancreatic secretion; fluid secretion; and intestinal flow	Acid in lumen of stomach

\*These peptides are also known to control secretion of other hormones. Additional related secretory peptides identified in both humans and pig have include substance Y, bombesin, bombesin-like peptide, ghrelin, ghrelin, and GHRP.



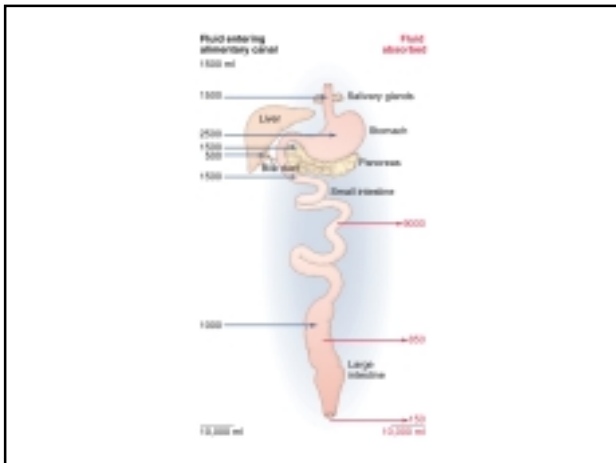
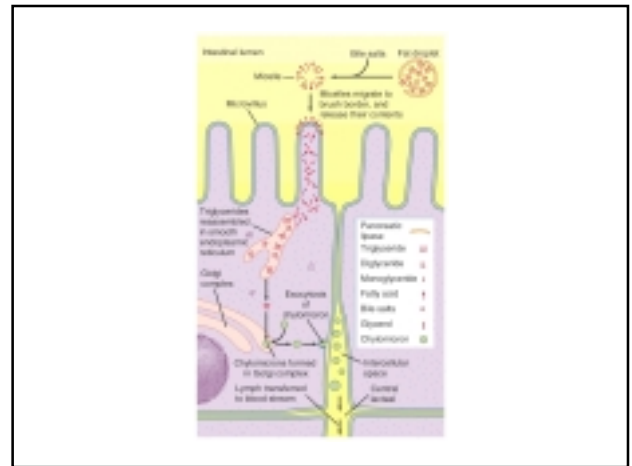
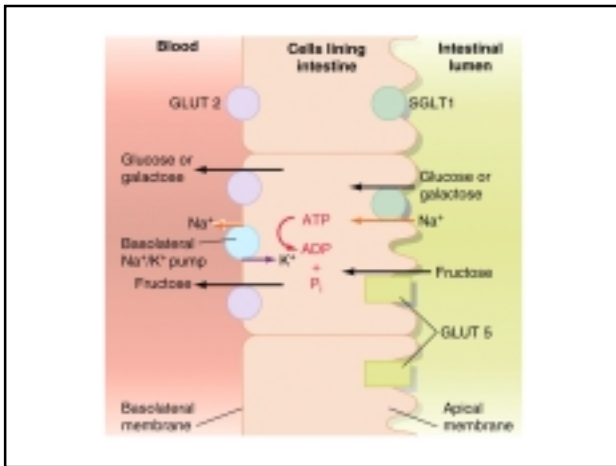
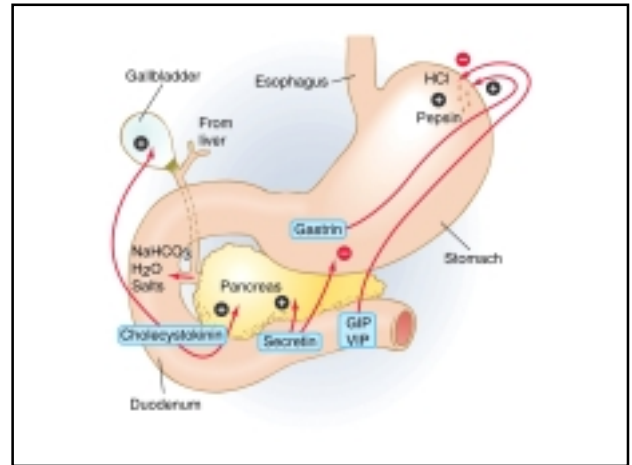
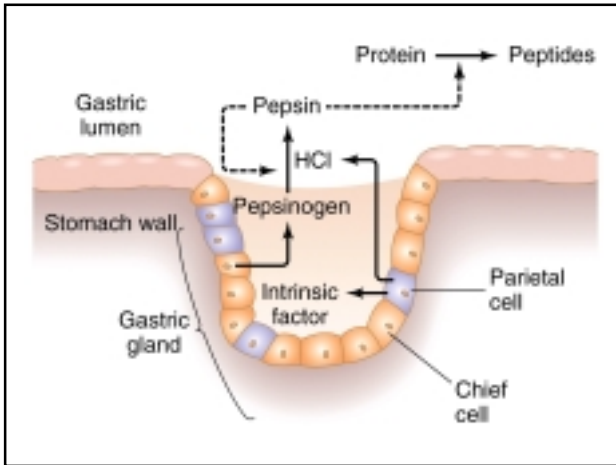


Table 13-3: Major nutrients absorbed

Nutrient	Major dietary sources (availability)	Typical average	Factors to consider?	Deficiency symptoms
Carbohydrate (CHO)	Cereals, fruits, vegetables	Marked loss due to malabsorption	Fluid losses due to diarrhea; malabsorption of CHO and fat can cause dehydration, muscle pain, weakness	Energy failure, weakness, muscle pain, weakness
Protein	Meat, dairy, eggs, legumes, nuts, grains	Marked loss due to malabsorption	Protein deficiency can cause edema, muscle wasting, weakness	Protein deficiency, edema, muscle wasting, weakness
Fat and fat-soluble vitamins (A, D, E, K)	Meat, dairy, eggs, nuts, grains, oils	Marked loss due to malabsorption	Malabsorption of fat-soluble vitamins can cause deficiency	Fatigue, weakness, muscle pain, weakness
Water	Drinks, food	Marked loss due to malabsorption	Excessive water loss can cause dehydration	Dehydration, weakness, muscle pain, weakness
Electrolytes (Na <sup>+</sup> , K <sup>+</sup> , Ca <sup>2+</sup> , Mg <sup>2+</sup> )	Meat, dairy, eggs, nuts, grains, fruits, vegetables	Marked loss due to malabsorption	Excessive loss of electrolytes can cause dehydration, muscle pain, weakness	Dehydration, weakness, muscle pain, weakness
Minerals (Fe, Zn, Cu, Se, I)	Meat, dairy, eggs, nuts, grains, fruits, vegetables	Marked loss due to malabsorption	Excessive loss of minerals can cause deficiency	Weakness, muscle pain, weakness
Vitamins (B1, B2, B6, B12, C, E)	Meat, dairy, eggs, nuts, grains, fruits, vegetables	Marked loss due to malabsorption	Excessive loss of vitamins can cause deficiency	Weakness, muscle pain, weakness

Abbreviations: CHO = carbohydrate; Na<sup>+</sup> = sodium; K<sup>+</sup> = potassium; Ca<sup>2+</sup> = calcium; Mg<sup>2+</sup> = magnesium; Fe = iron; Zn = zinc; Cu = copper; Se = selenium; I = iodine.