

The Digestive System 3

Learning Outcomes

- Identify the organs of the digestive system and their basic functions.
- Describe the four layers that form the wall of the gastrointestinal tract.
- Identify the locations of the salivary glands, and describe the functions of their secretions.
- Describe the location, structure, and functions of the pharynx and esophagus.
- Describe the location, structure, and functions of the stomach.
- Describe the location, structure, and functions of the pancreas.
- Describe the location, structure, and functions of the liver and gallbladder.

Learning Outcomes

- Describe the location, structure, and functions of the small intestine.
- Describe the location, structure, and functions of the large intestine.
- Describe the three phases of digestion.
- Describe the major hormones that regulate digestive activities

Small Intestine

- Length
 - 5-7 metres in living person
 - Extends from pylorus of stomach to cecum of large intestine
 - Ends in ileocecal sphincter (in RLQ)
- Three major regions: duodenum, jejunum, ileum
- Functions
 - Site of most of digestion
 - Essentially all nutrient absorption occurs here

Small Intestine

SMALL
INTESTINE:

DUODENUM

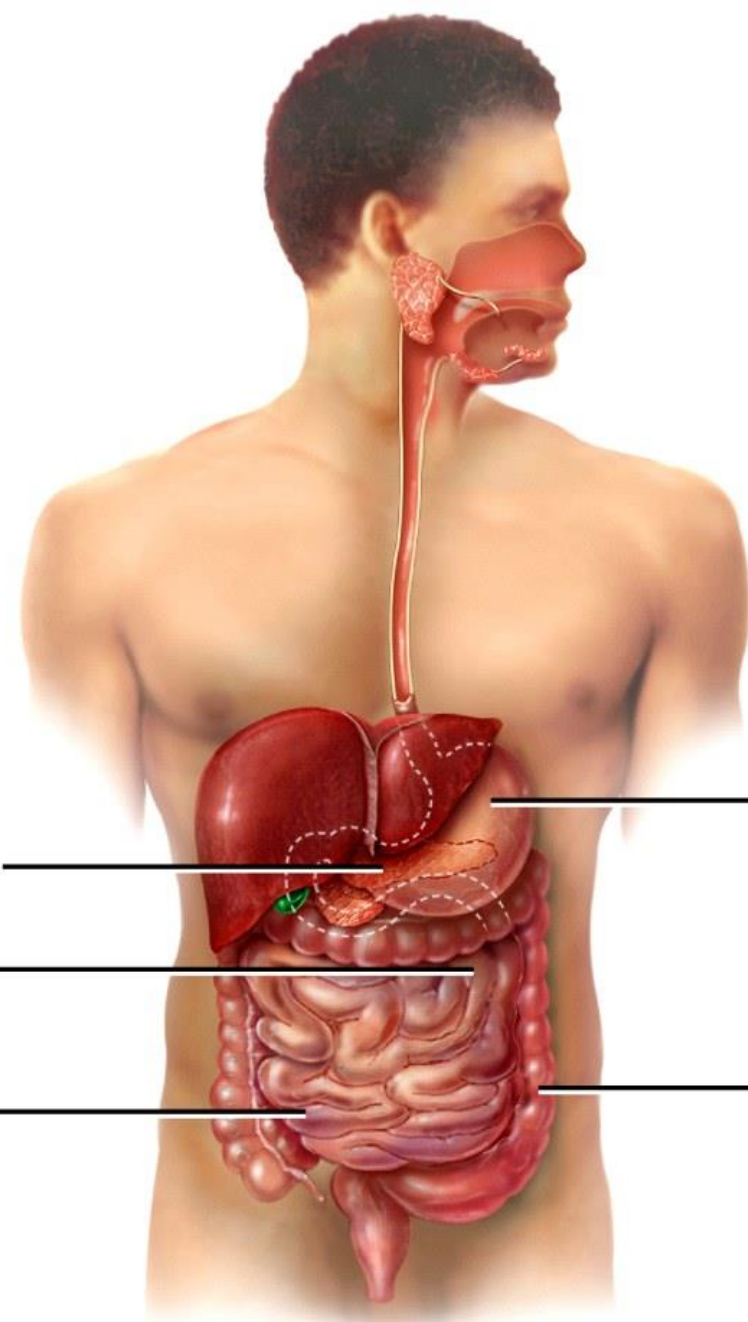
JEJUNUM

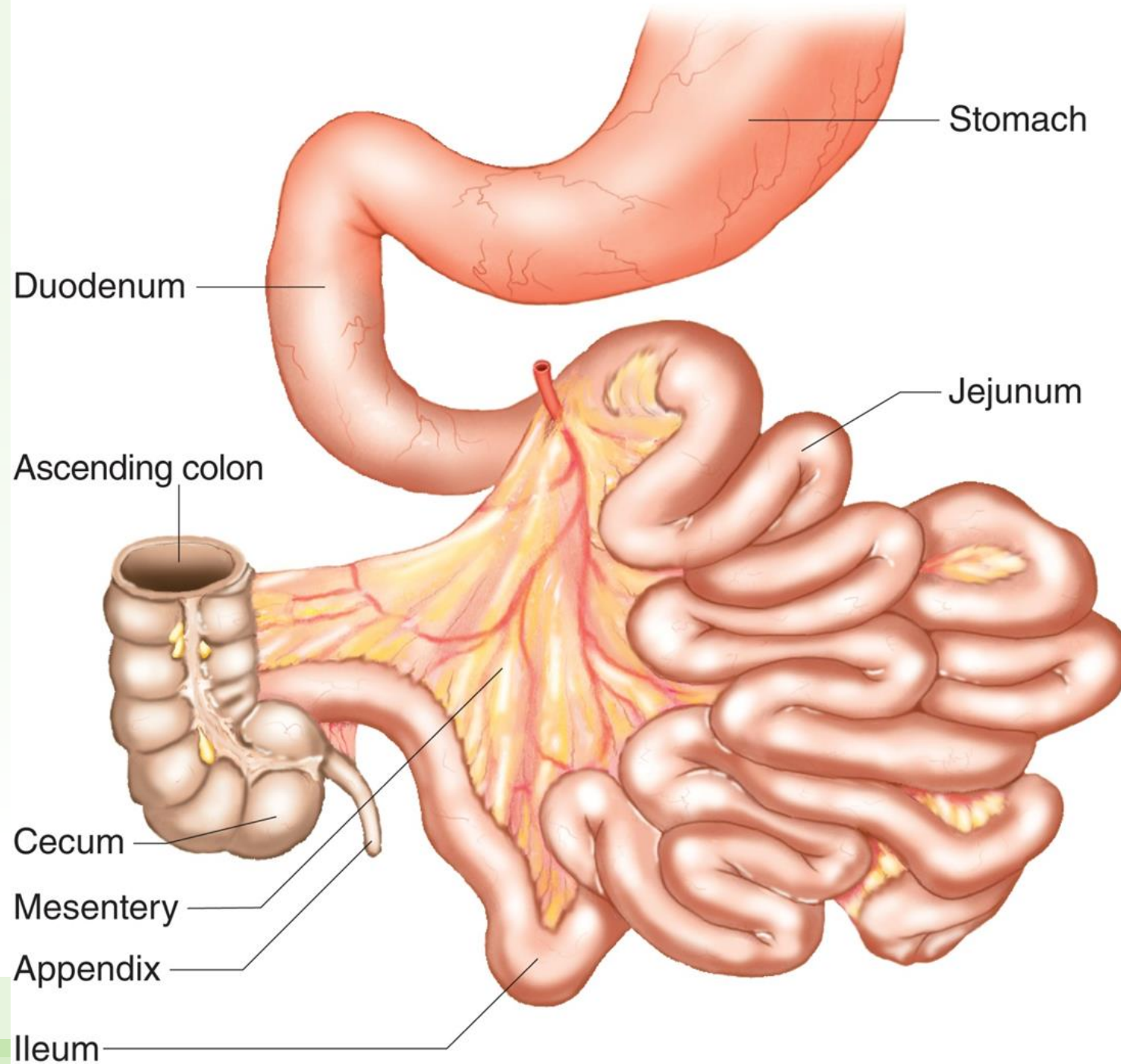
ILEUM

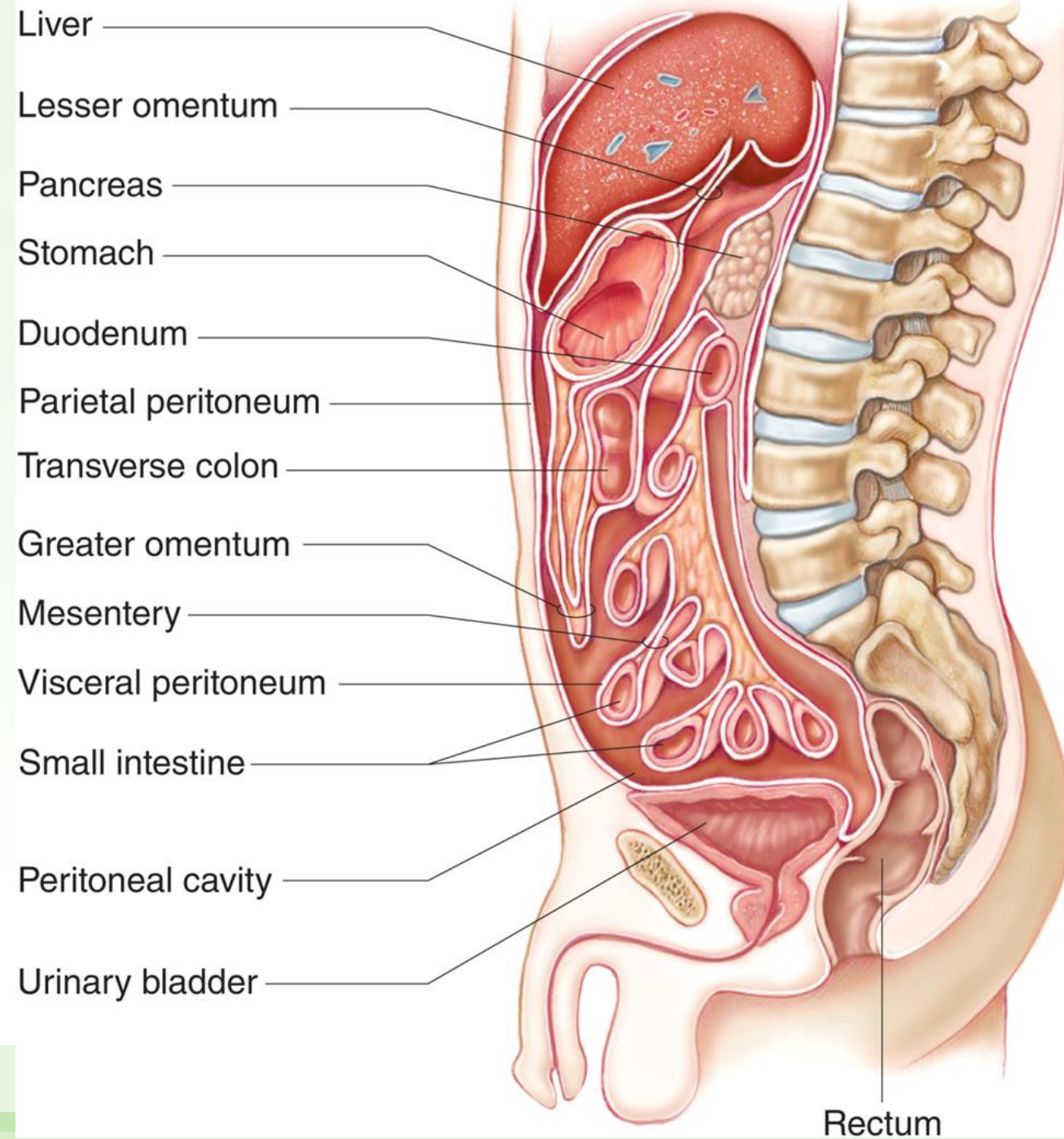
Stomach

Large
intestine

Anterior view of external anatomy







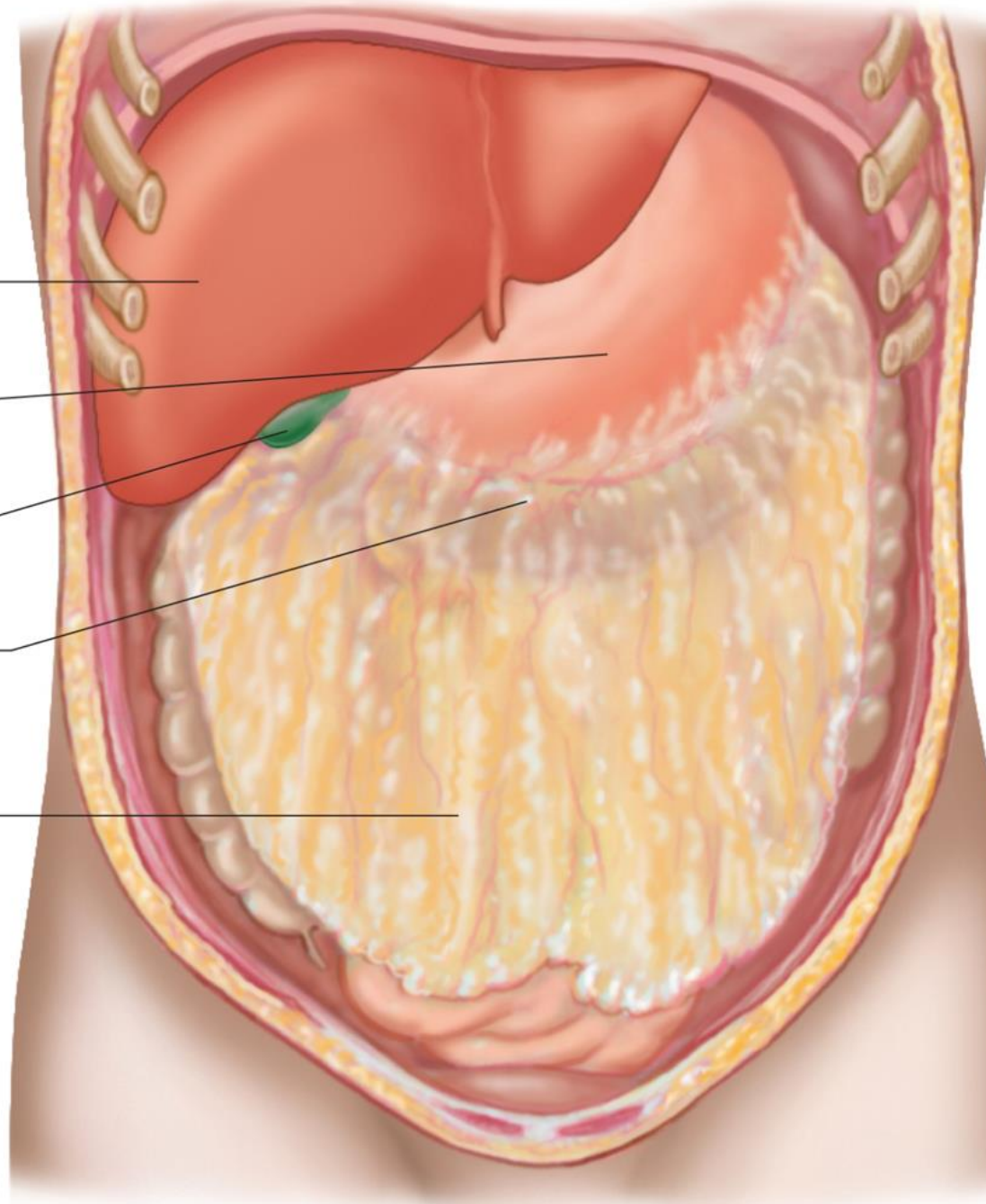
Liver

Stomach

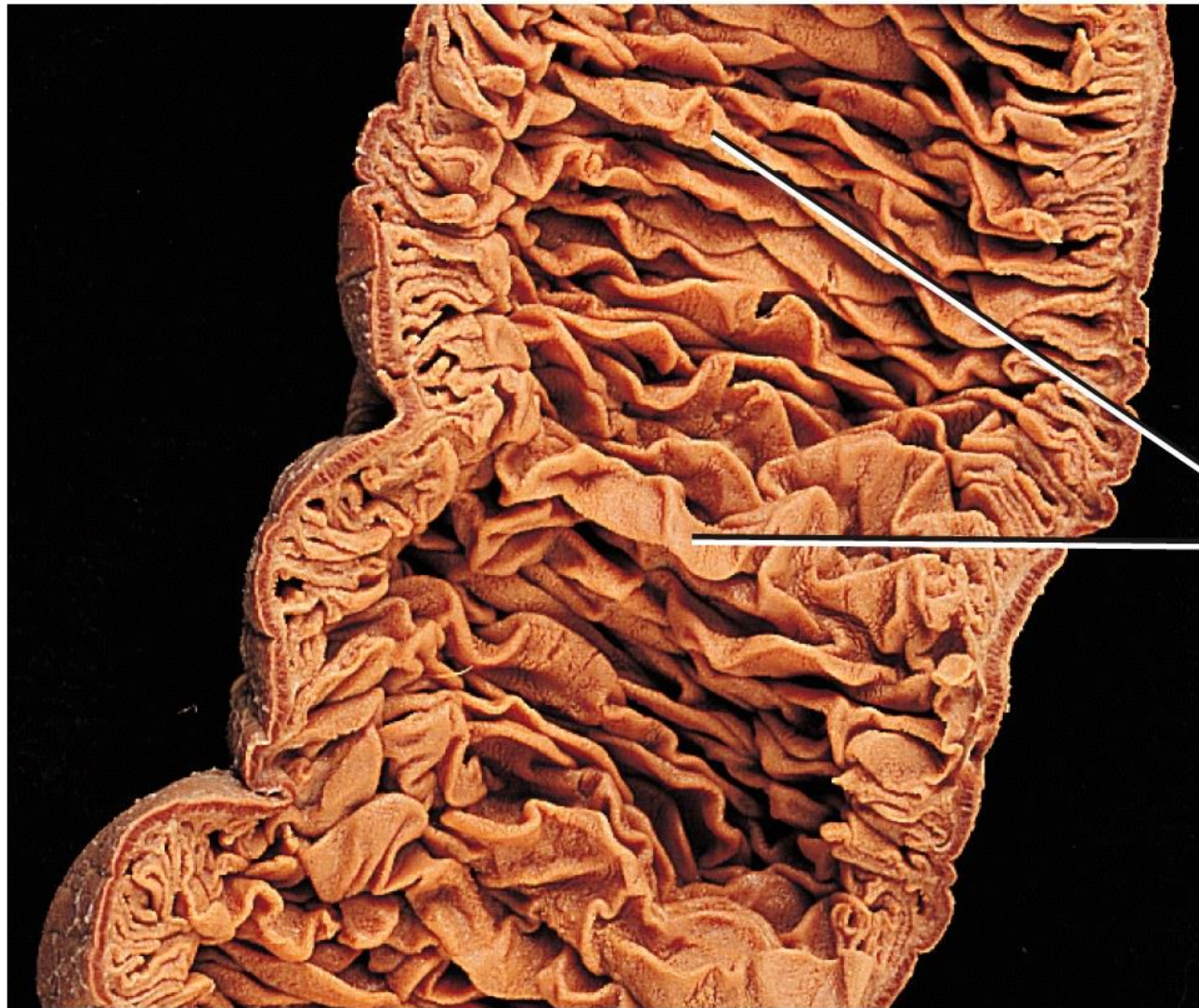
Gallbladder

Transverse colon
underneath

Greater
omentum



Small Intestine



Circular folds

Internal anatomy of the jejunum

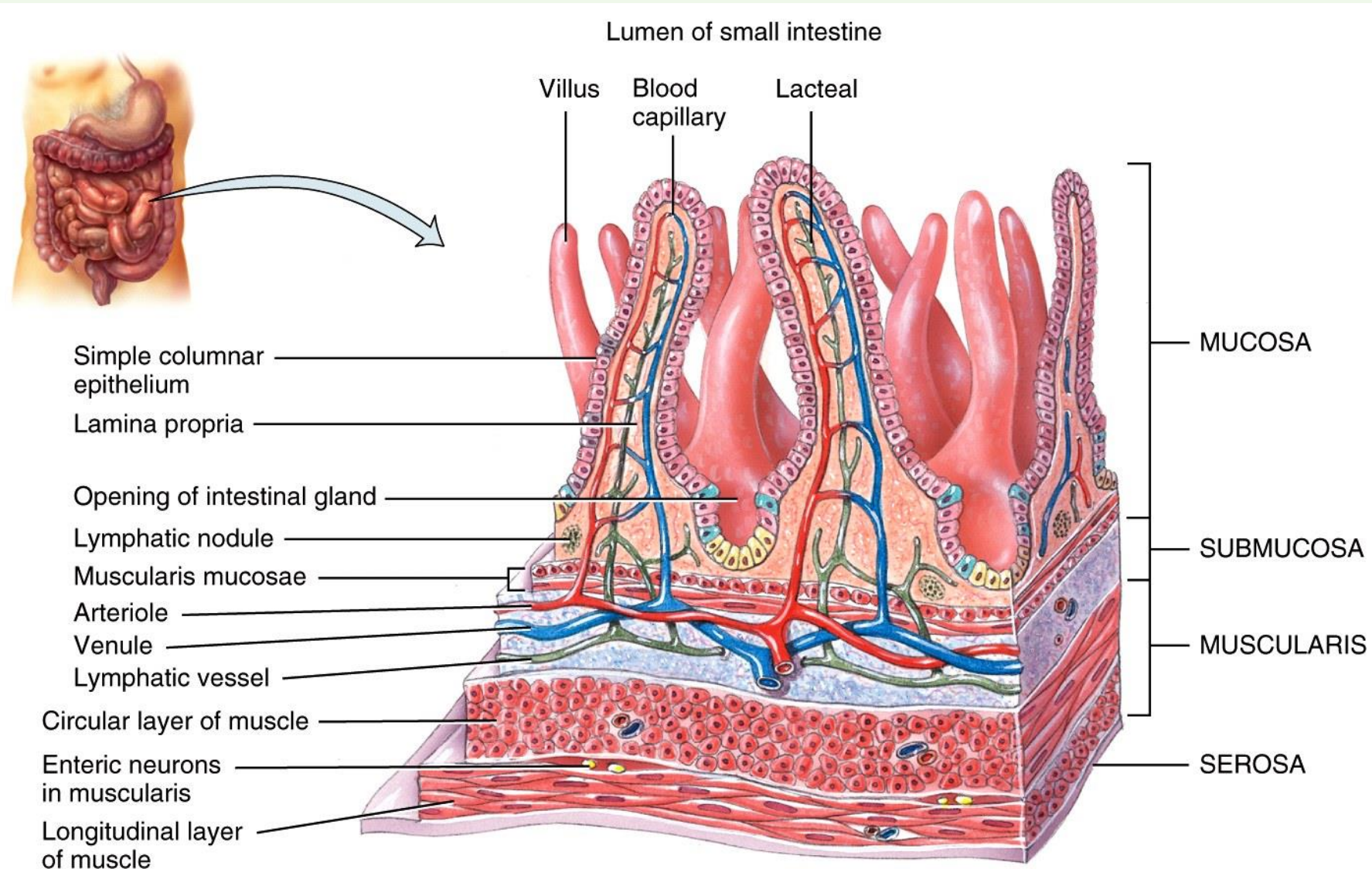
Small Intestinal Wall Structure

- Same 4 layers but with modifications
- Mucosa
 - Epithelium in mucosa: simple columnar
 - Absorptive cells with microvilli
 - Intestinal glands
 - Secrete enzymes that complete digestion
 - Secrete hormones secretin, cholecystokinin (CCK), glucose-dependent insulinotropic peptide (GIP)
 - Goblet cells : secrete alkaline mucus to neutralize acidic chyme
 - Lymphatic tissue (Peyer's patches) within wall
 - Lymphatic nodule in mucosa
 - Defense against pathogen

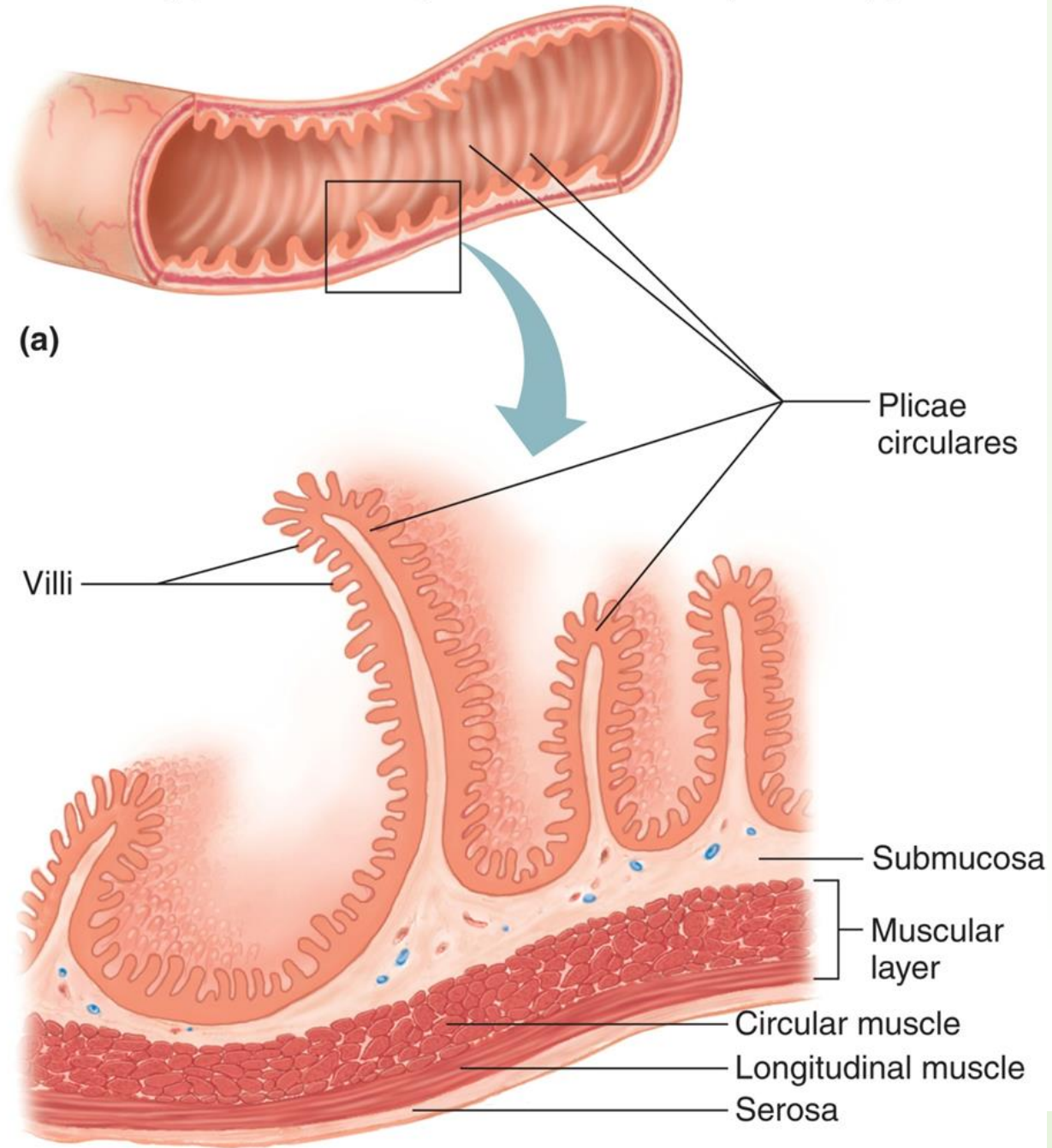
Small Intestinal Wall Structure

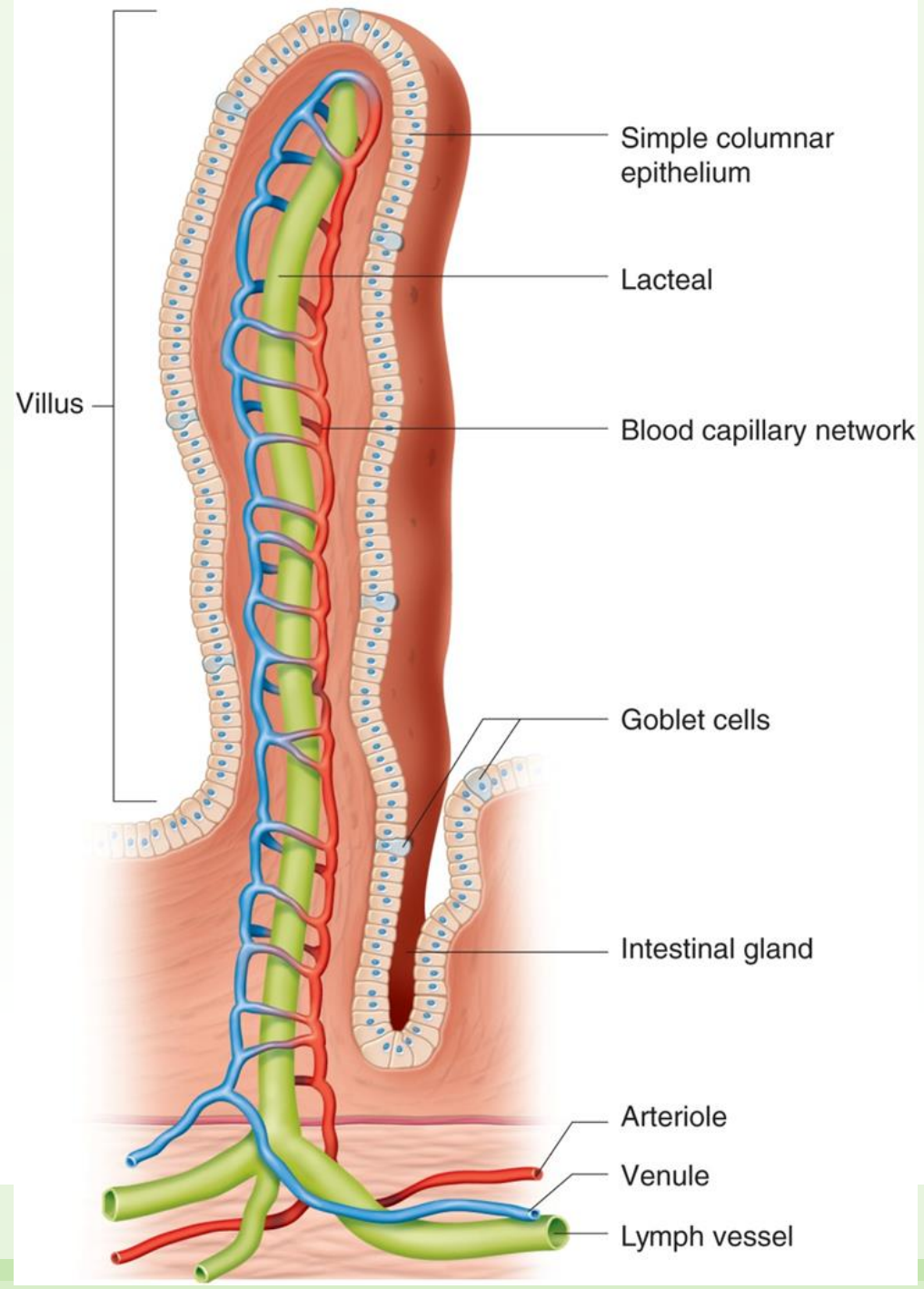
- Circular folds
 - Plicae circulares
 - to increase surface area for efficient digestion & absorption
- Villi: fingerlike projections of mucosa
 - Increase surface area for nutrient absorption
 - Contain vessels that absorb nutrients:
 - Blood capillary
 - Lacteal (lymph capillary) for long chain fatty acid absorption

Intestinal Wall Structure



Three-dimensional view of layers of the small intestine showing villi





- Submucosa
- Serosa

Digestion in Small Intestine

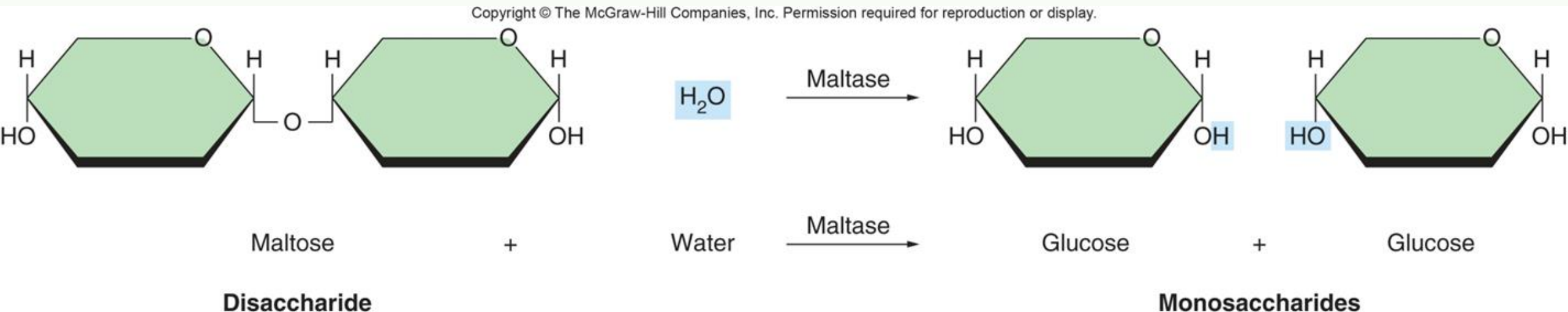
- Mechanical digestion
 - Segmentation activity: for mixing
 - Peristalsis for movement of intestinal contents after most absorption completed: slow waves
- Chemical digestion: 2 L/d of secretions
 - Alkaline chyme due to bicarbonate
 - From pancreas and alkaline mucus from small intestine
 - Enzymes produced by cells on villi
 - Peptidases: breaks small peptides
 - Disaccharidases: sucrase, lactase, and galactase

Absorption in Small Intestine

- Chyme enters small intestine carrying partially digested carbohydrates and proteins
- Intestinal juice (composed of bile, pancreatic juice, intestinal juice) completes digestion
- 90% of absorption of products of digestion occurs in the small intestine
 - Monosaccharides and amino acids
 - Fatty acids and monoglycerides
 - Phosphate sugar, and bases of DNA, RNA

Summary: Carbohydrate Digestion

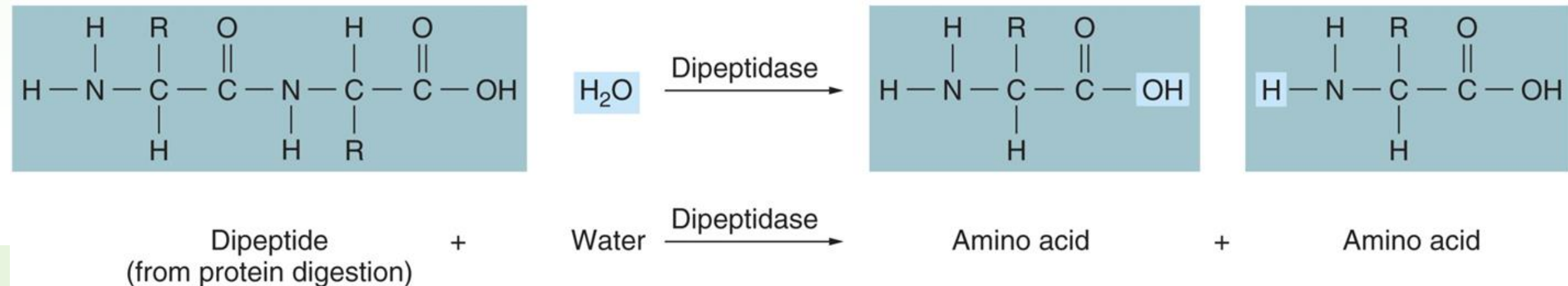
- Amylases (salivary and pancreatic):
 - Starch and dextrin → maltose
- Disaccharidases (from small intestine):
 - Maltase: maltose → glucose + glucose
 - Lactase: lactose → glucose + galactose
 - Sucrase: sucrose → glucose + fructose



Protein Digestion

- Pepsin, trypsin, chymotrypsin, and carboxypeptidase
 - Proteins → small peptides
- Peptidases at surface:
 - Peptides → amino acids, dipeptides, and tri-peptides

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Fat Digestion

- Lipase (pancreatic)
 - Triglycerides \rightarrow fatty acids + monoglycerides

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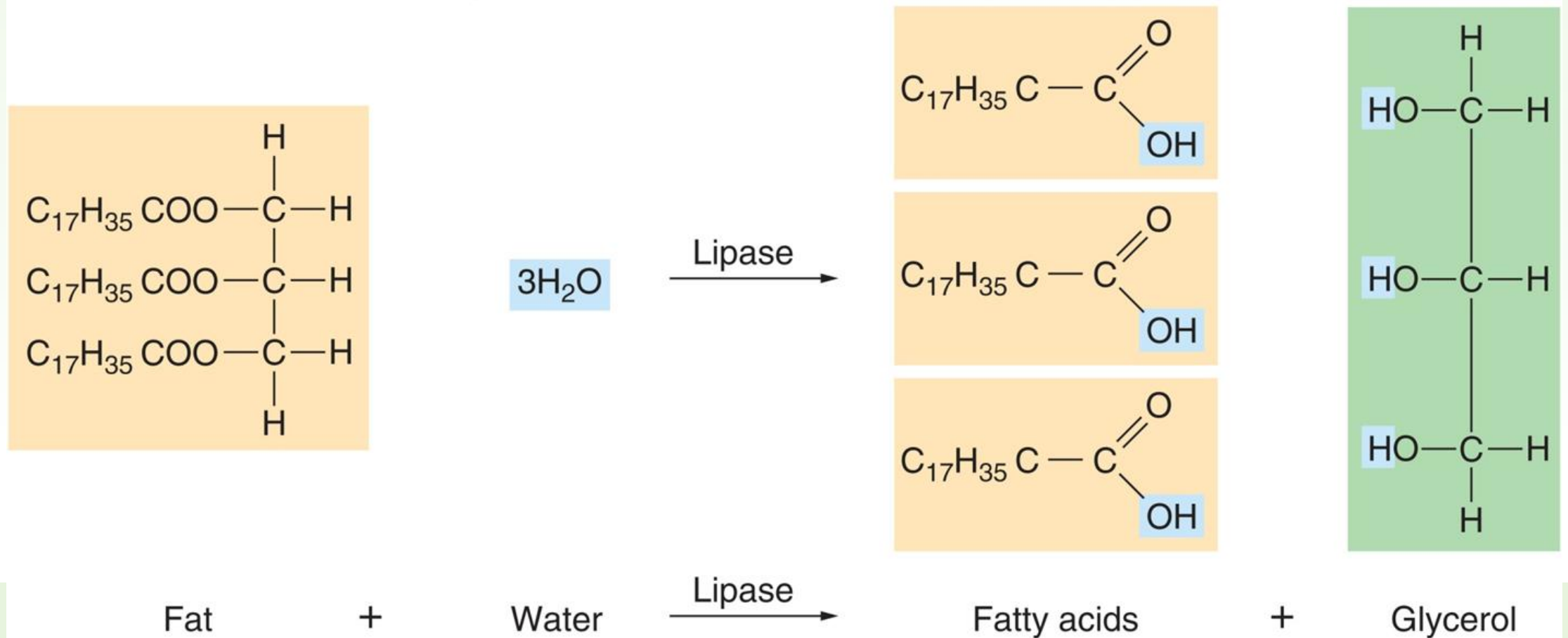
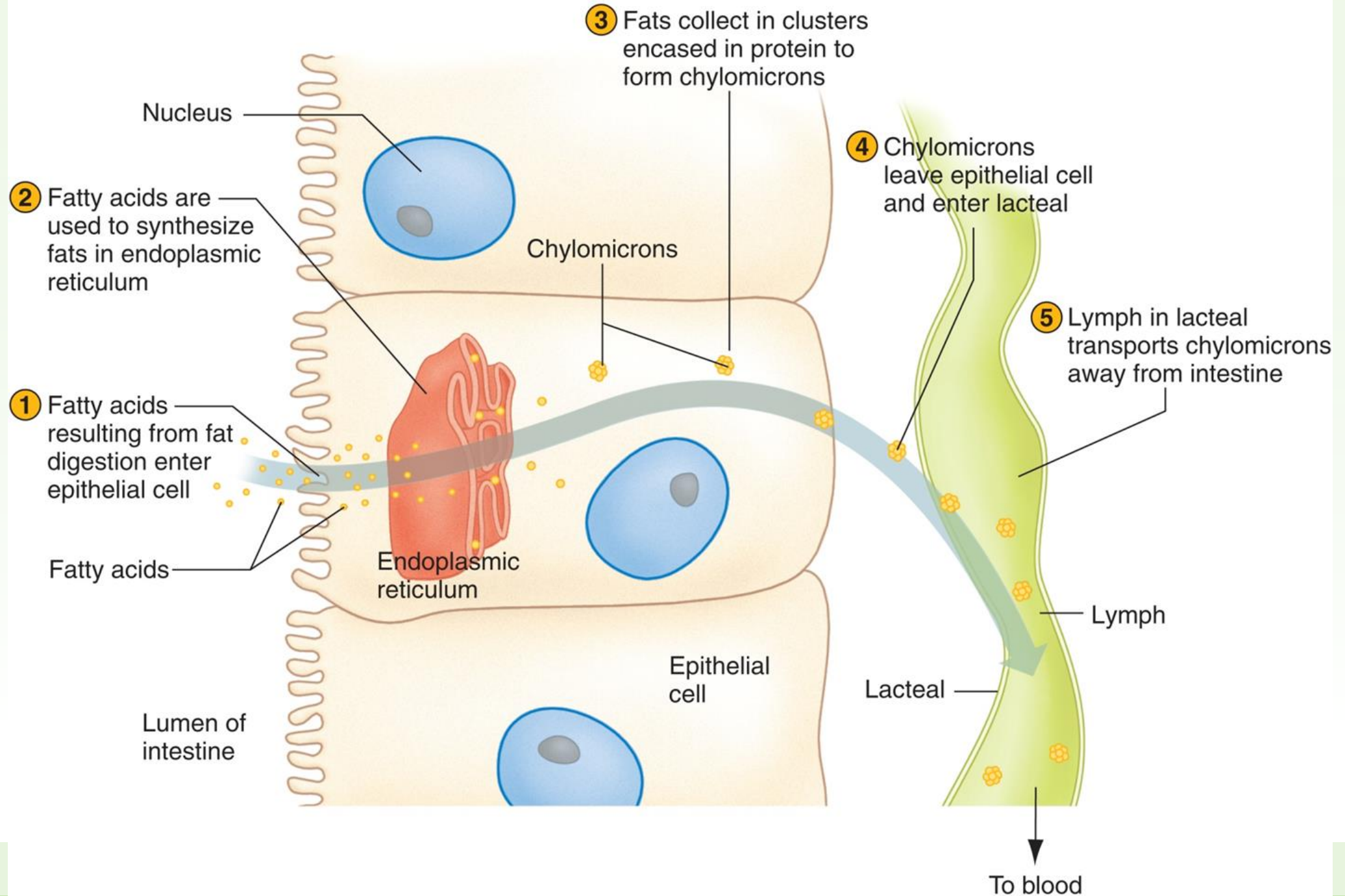


TABLE 17.9 | Summary of the Major Digestive Enzymes **AP|R**

Enzyme	Source	Digestive Action
Salivary Enzyme		
Salivary amylase	Salivary glands	Begins carbohydrate digestion by breaking down starch and glycogen to disaccharides
Gastric Enzymes		
Pepsin	Gastric glands	Begins protein digestion
Gastric lipase	Gastric glands	Begins butterfat digestion
Pancreatic Enzymes		
Pancreatic amylase	Pancreas	Breaks down starch and glycogen into disaccharides
Pancreatic lipase	Pancreas	Breaks down fats into fatty acids and glycerol
Trypsin, chymotrypsin	Pancreas	Breaks down proteins or partially digested proteins into peptides
Carboxypeptidase	Pancreas	Breaks down peptides into amino acids
Nucleases	Pancreas	Breaks down nucleic acids into nucleotides
Intestinal Enzymes		
Peptidase	Mucosal cells	Breaks down peptides into amino acids
Sucrase, maltase, lactase	Mucosal cells	Breaks down disaccharides into monosaccharides
Intestinal lipase	Mucosal cells	Breaks down fats into fatty acids and glycerol
Enterokinase	Mucosal cells	Converts trypsinogen into trypsin

Absorption of Products of Digestion

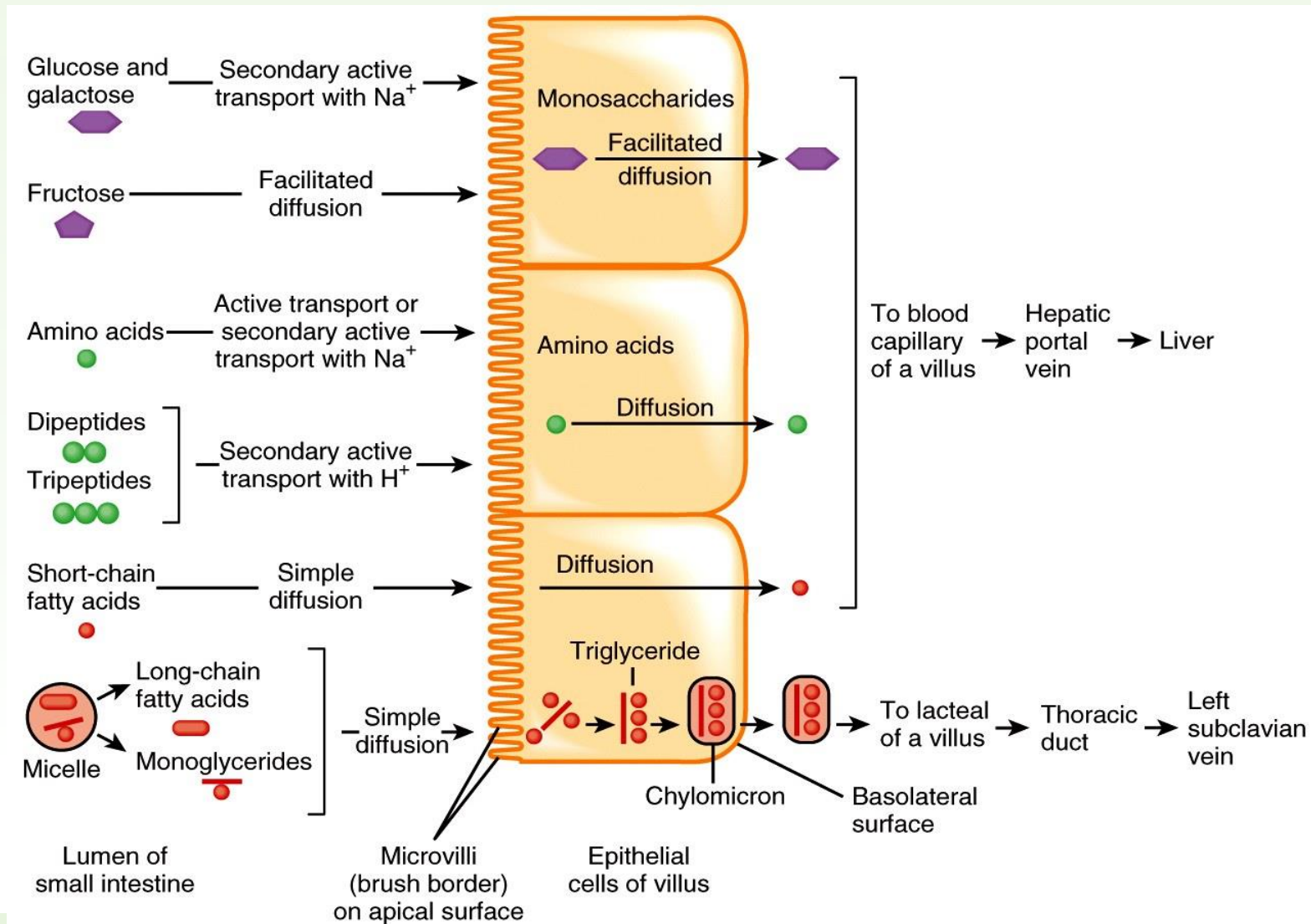
- By diffusion, facilitated diffusion, osmosis and active transport
- Carbohydrates → monosaccharides
 - Via portal system (blood) to liver
- Proteins (jejunum + ileum) → amino acids
 - Via portal system (blood) to liver
- Lipids →
 - Short-chained fatty acids or monoglycerides or → blood in villi
 - Larger lipids coated by proteins in chylomicrons → lacteals → lymphatics (lymph) → then blood



Absorption of Products of Digestion

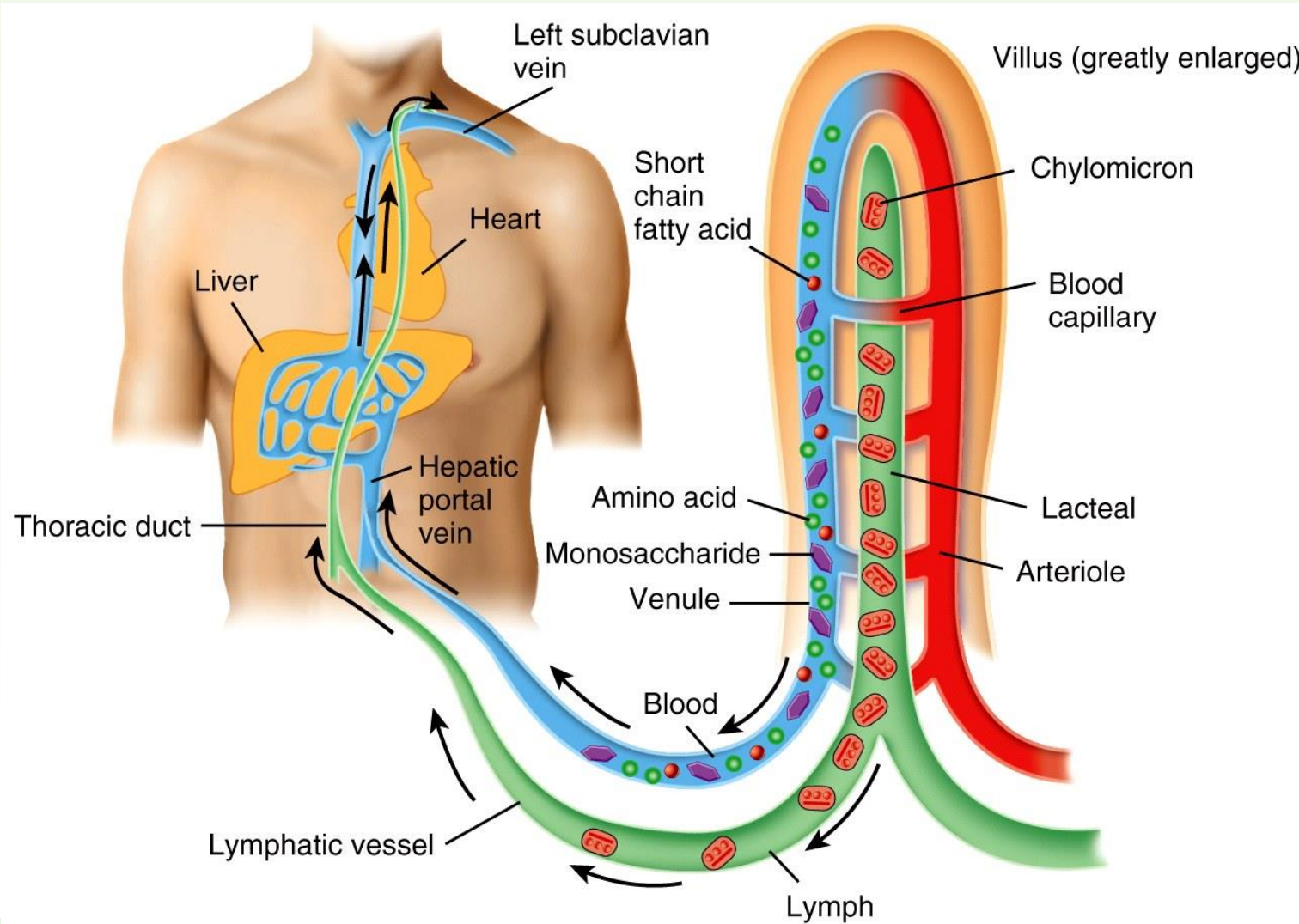
- Water and salt
 - Primarily osmotic movement that accompanies other nutrients
- Vitamins
 - Fat-soluble (A, D, E, K) absorbed with fat
 - Water-soluble (B's, C) with simple diffusion
 - B₁₂
 - Combines with intrinsic factor for transport through duodenum and jejunum
 - Finally can be absorbed by active transport in ileum

Absorption of Products of Digestion



Mechanisms for movement of nutrients through absorptive epithelial cells of the villi

Absorption of Products of Digestion



Movement of absorbed nutrients into the blood and lymph

TABLE 17.10 | Intestinal Absorption of Nutrients

Nutrient	Absorption Mechanism	Means of Transport
Monosaccharides	Facilitated diffusion and active transport	Blood in capillaries
Amino acids	Active transport	Blood in capillaries
Fatty acids and glycerol	Facilitated diffusion of glycerol; diffusion of fatty acids into cells	
	(a) Most fatty acids are resynthesized into fats and incorporated in chylomicrons for transport.	Lymph in lacteals
	(b) Some fatty acids with relatively short carbon chains are transported without being changed back into fats.	Blood in capillaries
Electrolytes	Diffusion and active transport	Blood in capillaries
Water	Osmosis	Blood in capillaries

Control: Phases of Digestion

- Rule: activate forward and inhibit behind
- Three phases: cephalic, gastric, intestinal
 1. Cephalic: smell, sight, thought of food →
 - Cranial nerves VII + IX stimulate salivary glands
 - Cranial nerve X (vagus) stimulates gastric glands
 2. Gastric: stretching, pH of stomach →
 - Gastrin activates stomach and relaxes pyloric sphincter
 3. Intestinal phase: intestinal hormones play key roles

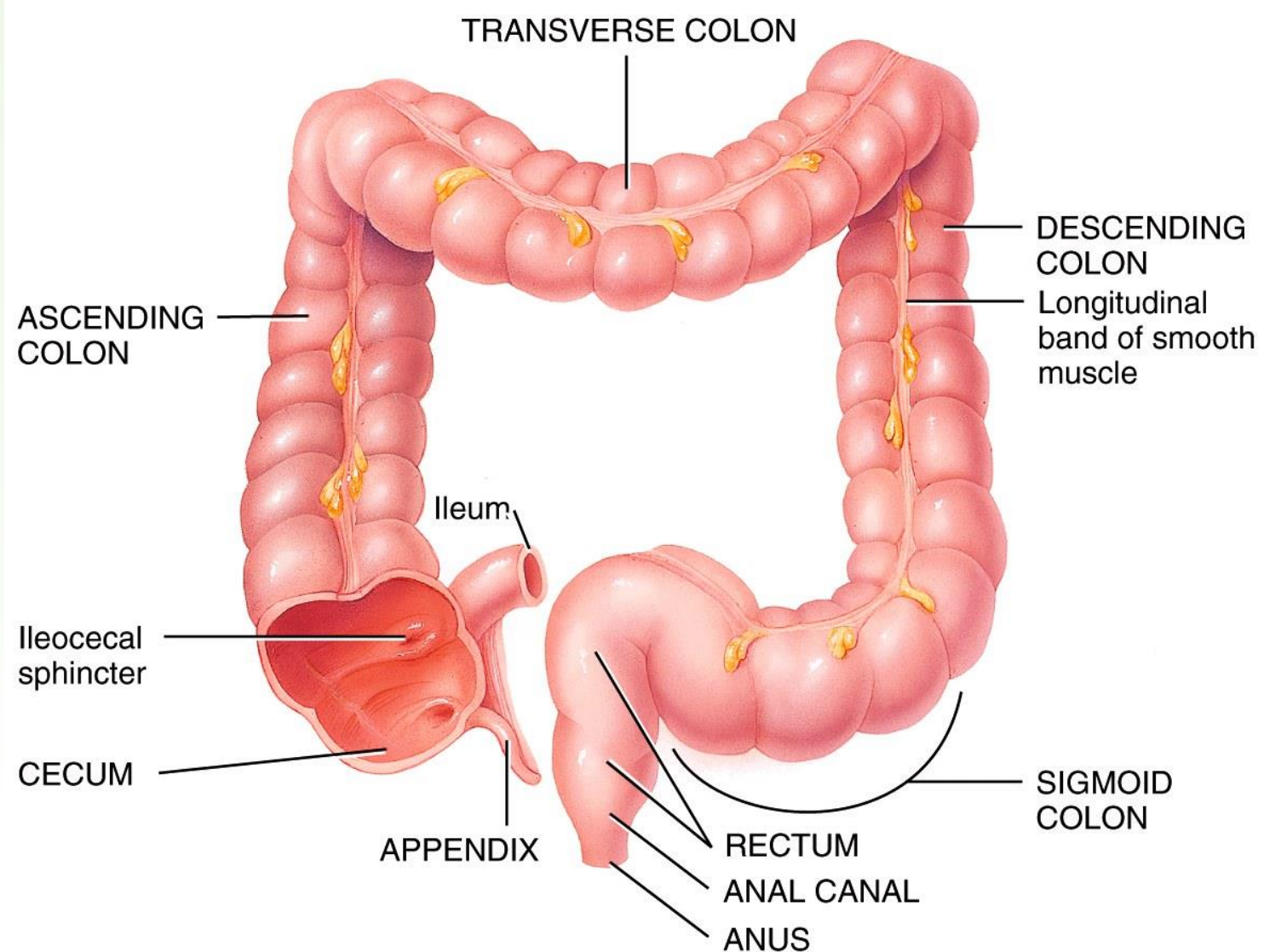
Control: Phases of Digestion: intestinal phase

- Secretin
 - Released when acidic chyme enters intestine
 - Stimulates release of pancreatic juice high in bicarbonate to buffer acidic chyme from stomach
- Cholecystokinin (CCK)
 - Released when chyme rich in amino acids and fatty acids enters intestine
 - Stimulates release of pancreatic juice high in digestive enzymes
 - Decreases gastric motility and secretion
 - Stimulate gallbladder to contract and release bile

Large Intestine

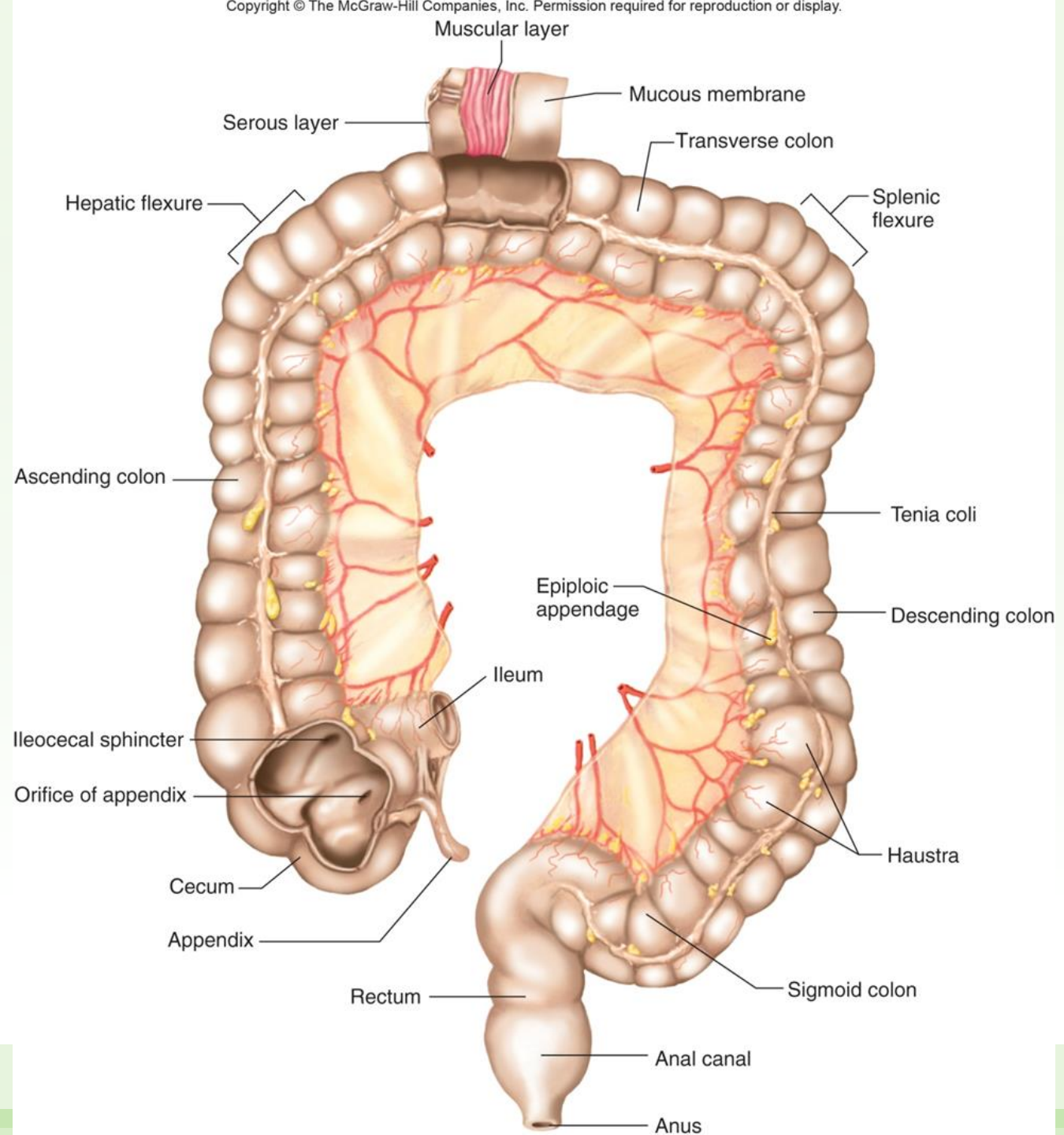
- Structure: 4 regions
 - Cecum
 - Ileocecal sphincter
 - Appendix attached
 - Colon: ascending, transverse, descending and sigmoid
 - Rectum
 - Anal canal with sphincters
- Wall: standard 4 layers
 - Mucosa: goblet cells secrete mucus
 - Muscularis: incomplete longitudinal layer

Large Intestine

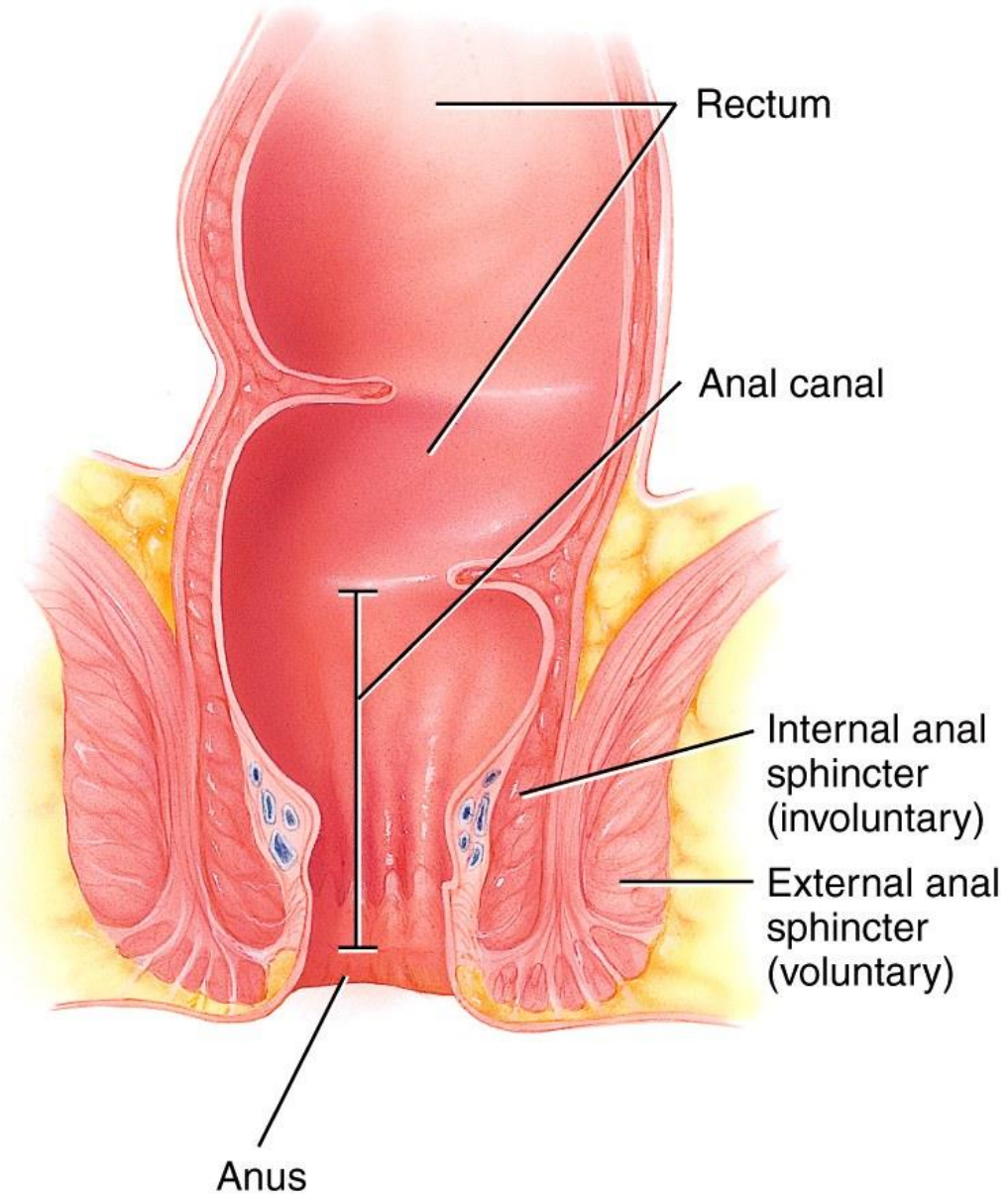


Anterior view of large intestine showing major regions

Large Intestine

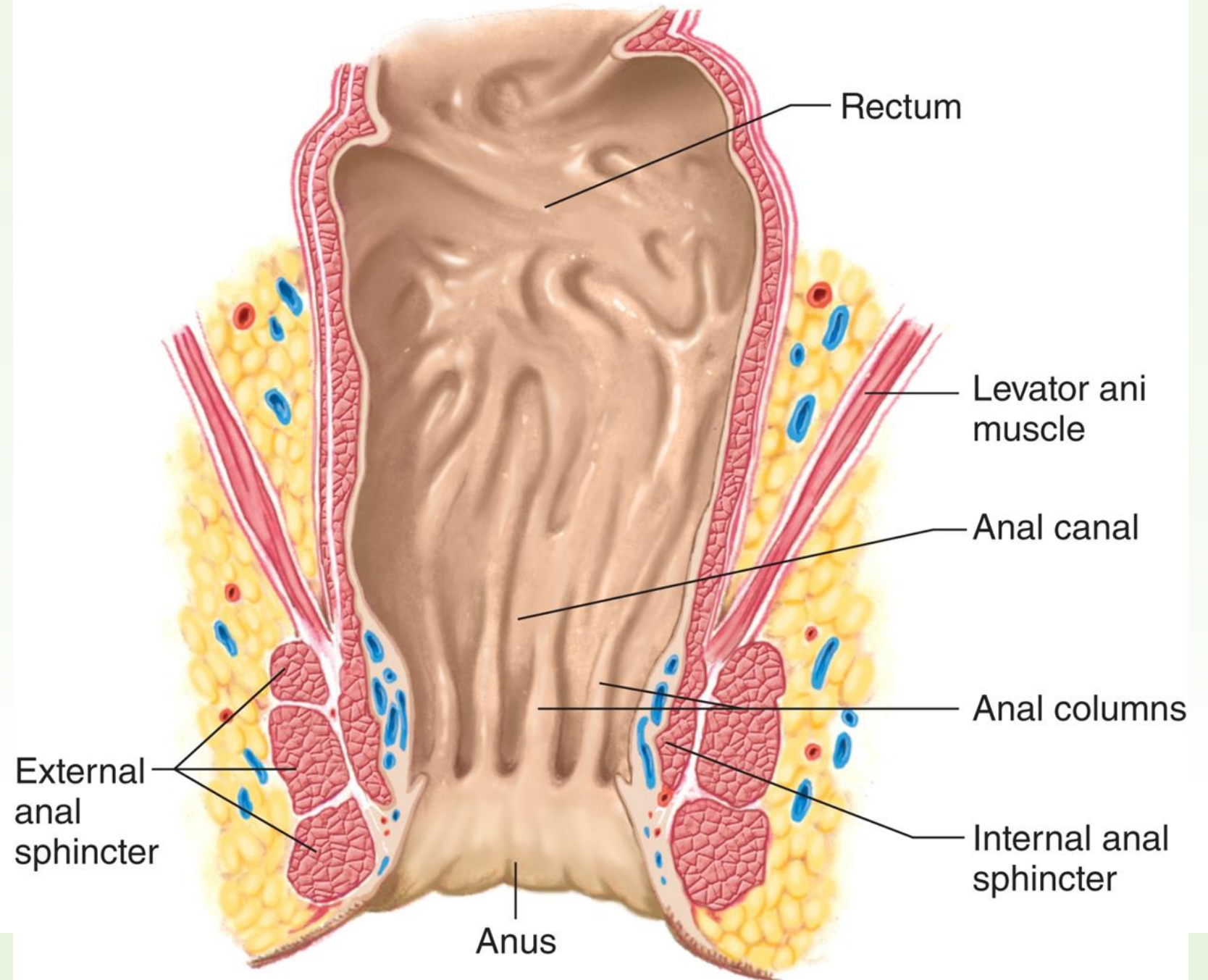


Large Intestine

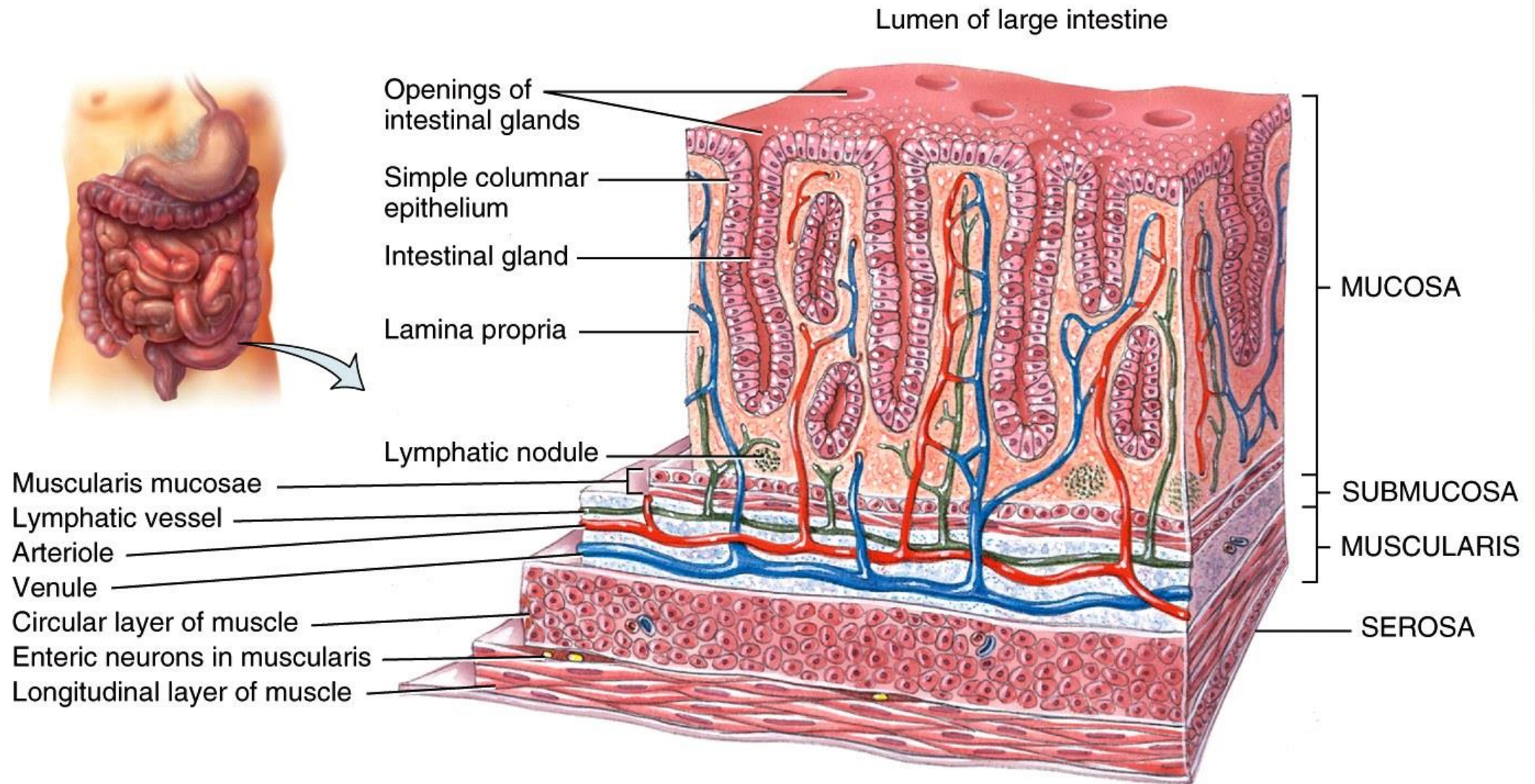


Frontal section of anal canal

Large Intestine



Large Intestine



Three-dimensional view of layers of the large intestine

Digestion and Absorption

- Ileocecal sphincter limits rate of emptying of ileum
- Slow peristalsis
- Mass peristalsis
 - Triggered by presence of food in stomach
 - Wastes move from mid-colon → rectum
- Bacterial digestion
 - Produce some B-vitamins + vitamin K
 - Produce gases: flatus
 - Colon absorbs salt + water

Defecation Reflex

- Stretch of rectum wall → neural reflex
→ contraction of longitudinal muscle
- Combined pressure + parasympathetic activity → relaxes internal anal sphincter
- External anal sphincter is voluntary
- Contraction of diaphragm and abdominal muscles aid defecation

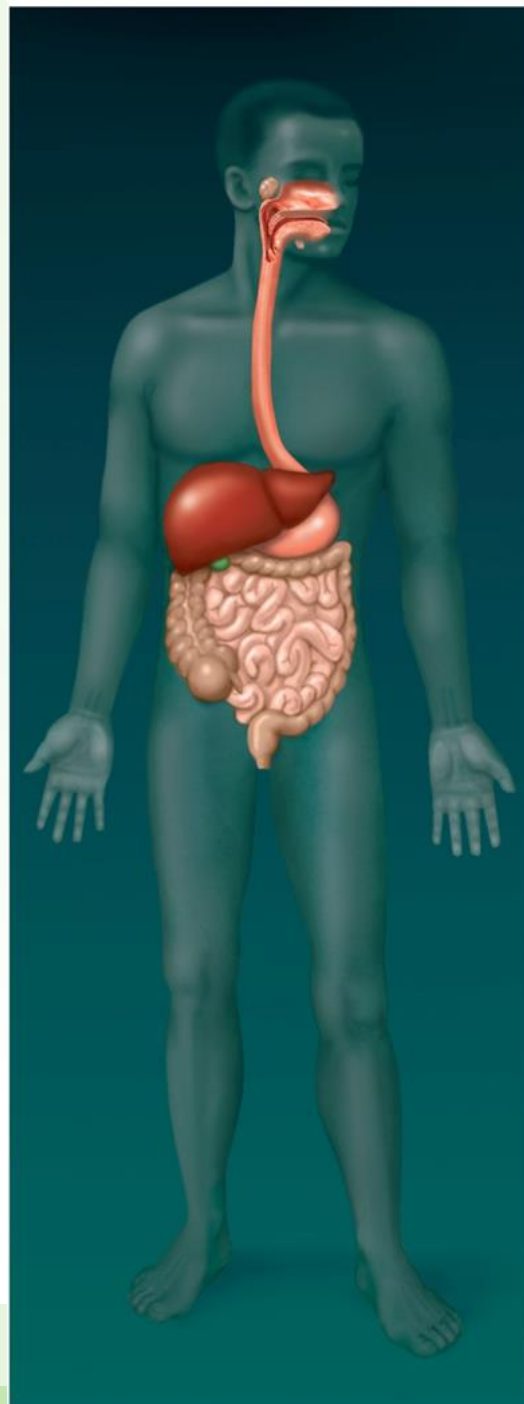
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TABLE 17A | **Diagnostic Tests for Colorectal Cancer**

Diagnostic Test	Description
Digital rectal exam	Physician palpates large intestine and rectum
Double-contrast barium enema	X-ray exam following ingestion of contrast agent highlights blockages in large intestine
Fecal occult blood test	Blood detected in feces sample
Colorectal cancer gene test (experimental)	Mutations associated with colorectal cancer detected in DNA of cells shed with feces
Sigmoidoscopy	Endoscope views rectum and lower colon
Colonoscopy	Endoscope views rectum and entire colon

Aging

- Decreased GI secretion, motility, strength of responses
- Loss of taste, increased risk for periodontal disease, difficulty swallowing, hiatal hernia, gastritis, peptic ulcer disease
- Increased risk for gallbladder problems, cirrhosis of liver, pancreatitis, constipation, hemorrhoids, diverticulitis



Integumentary System



Vitamin D activated in the skin plays a role in absorption of calcium from the digestive tract.

Cardiovascular System



The bloodstream carries absorbed nutrients to all body cells.

Skeletal System



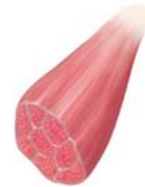
Bones are important in mastication. Calcium absorption is necessary to maintain bone matrix.

Lymphatic System



The lymphatic system plays a major role in the absorption of fats.

Muscular System



Muscles are important in mastication, swallowing, and the mixing and moving of digestion products through the gastrointestinal tract.

Respiratory System



The digestive system and the respiratory system share common anatomical structures.

Nervous System



The nervous system can influence digestive system activity.

Urinary System



The kidneys and liver work together to activate vitamin D.

Endocrine System



Hormones can influence digestive system activity.

Reproductive System



In a woman, nutrition is essential for conception and normal development of an embryo and fetus.