

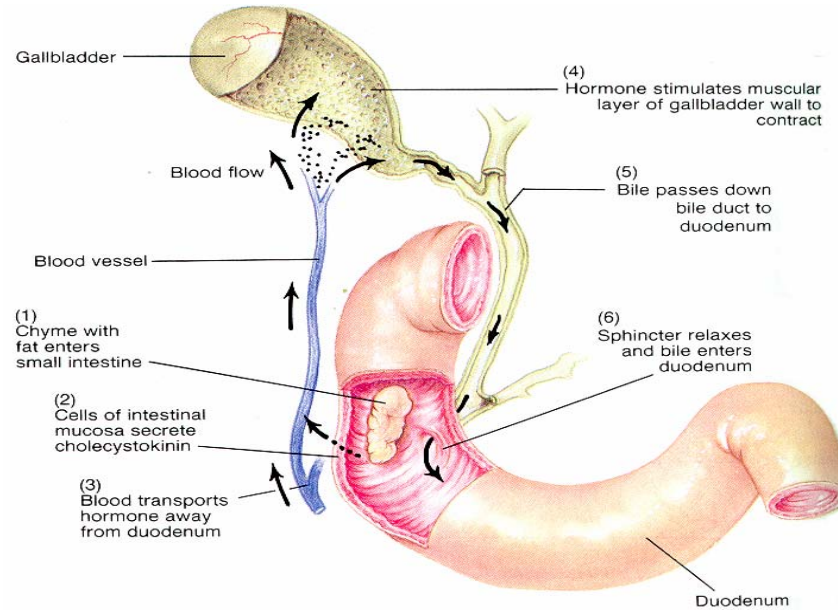
Small Intestine

- Most digestion occurs here, therefore, it is specifically designed for absorption.
 - Long length provide a large surface area
 - modification of the wall further increases surface area (plicae [circulare folds] , villi, and microvilli).
- Average dimension is 1 inch in diameter and 21 feet in length (in cadaver and 10 ft in living person).

Gross Anatomy

The small intestine is divided into three parts: one immobile and two mobile.

- Duodenum-
 - the first portion and the shortest part of the SI, about 10 inches long.
 - It has a “C” shaped curve that begins at the pyloric sphincter of the stomach and merges with the jejunum.
 - It lies behind the parietal peritoneum and is the most fixed portion of the SI.

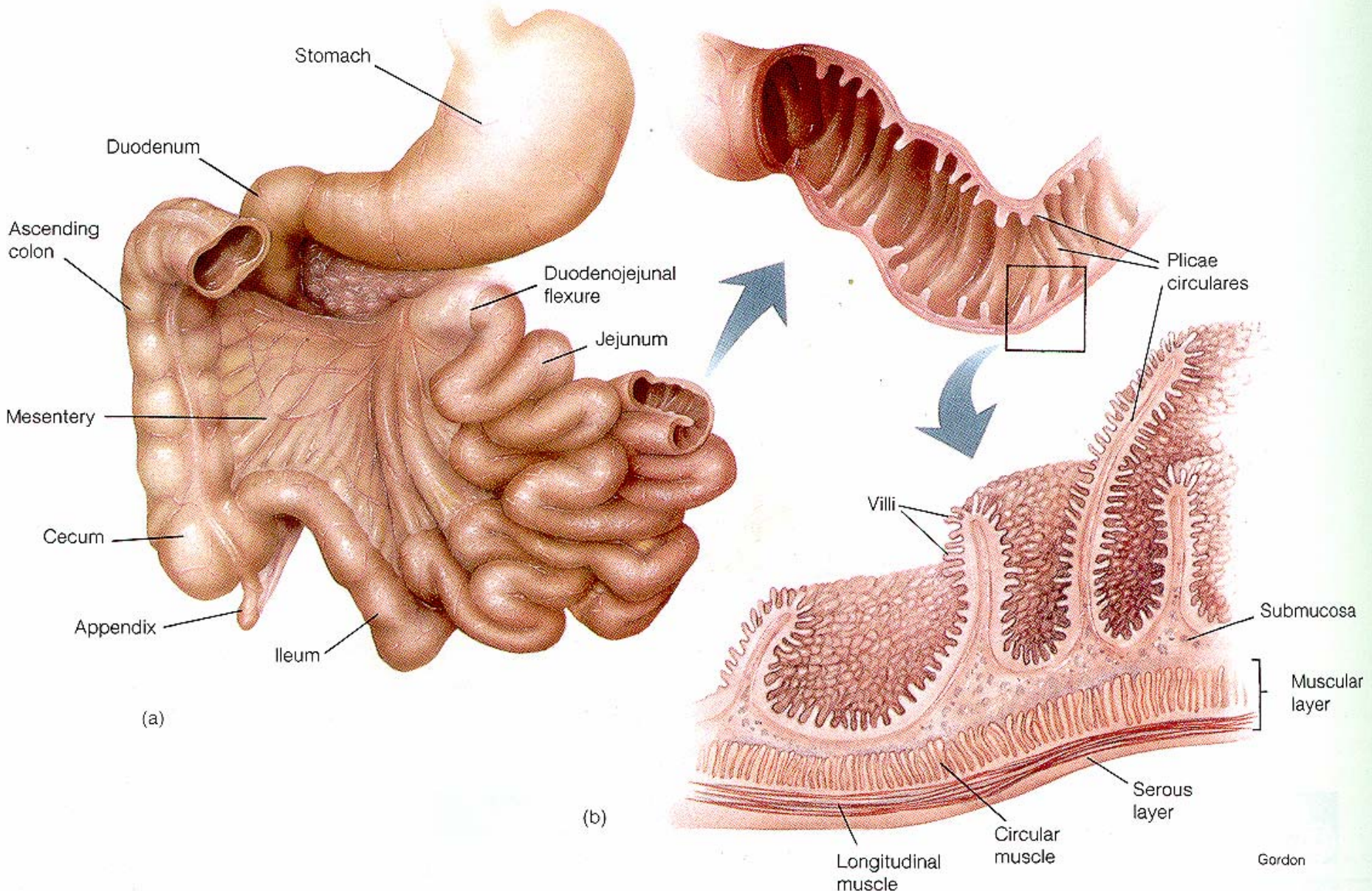


Gross Anatomy(cont.)

- The jejunum and ileum are the remaining mobile portions of the SI that are suspended from the posterior abdominal wall by a double-layered fold of peritoneum, called **mesentery**. This supporting tissue contain the blood vessels, nerves, and lymphatic vessels that supply the intestinal wall.
- **Jejunum**- approximately $\frac{2}{5}$ (3 ft.) of the remainder of the SI.
- **Ileum**- makes up the remaining 6-7 ft. of the SI. The terminal portion of the ileum empties into the medial side of the cecum (first portion of the large intestine) through the ileocecal valve.

Micro Anatomy

- The wall of the SI is composed of the same 4 layers that make up most of the GI tract.
- There are special features for its digestive and absorptive functions: villi and microvilli.
 - villi- finger like fold of the mucosa that are more numerous in the duodenum and proximal part of the jejunum.
 - they are 1mm long and give the intestine its velvety appearance.
 - Villi vastly increase the surface area of the epithelium available for absorption and digestion.
 - Each villi has a connective tissue network containing blood vessels, nerves, and a **lacteal** (a lymphatic vessel that absorbs fat)



Gordon

Circular folds (plicae)- permanent ridge in the mucosa that also tend to increase the surface area and causes the chyme to move slower through the SI.

Micro Anatomy(cont.)

- Surface epithelium- consist of simple columnar epithelium containg
 - absorptive cells
 - goblet cells- mucus producing
 - hormone producing cells
 - paneth cells.
- Microvilli
 - these are the cytoplasmic extensions on the surface of the columnar epithelium that line the SI that allow for an even greater surface area for absorption.

Micro Anatomy(cont.)

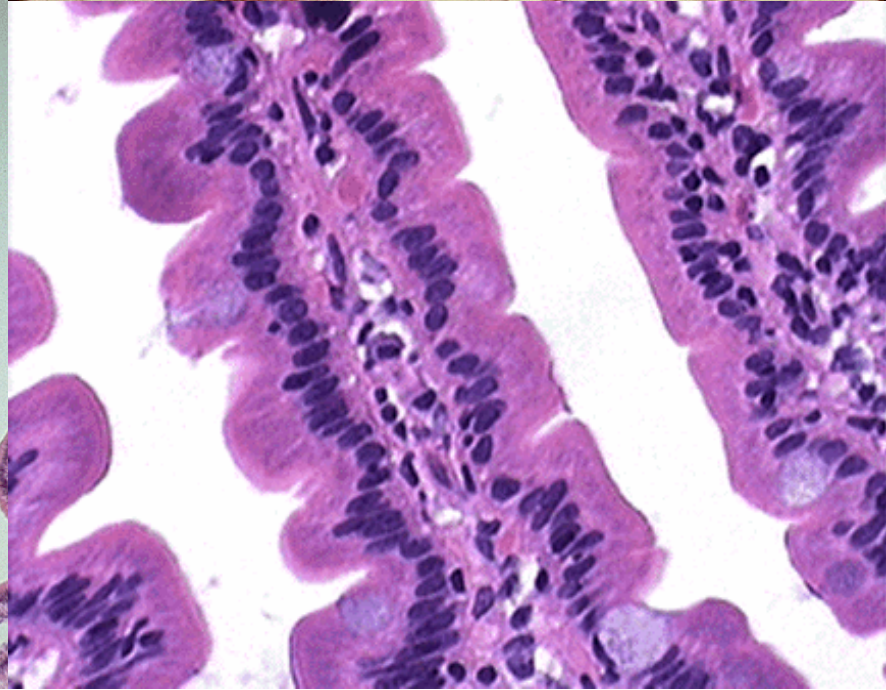
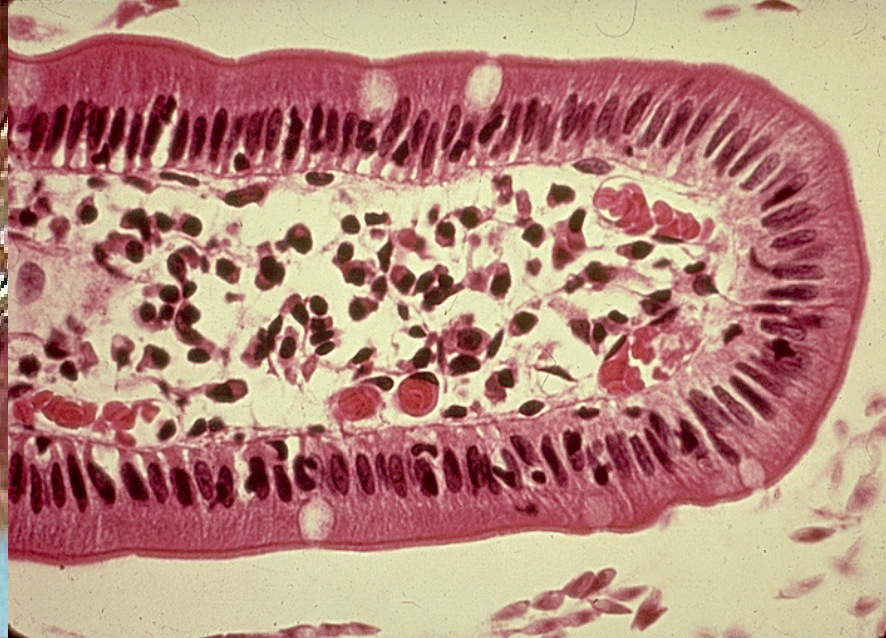
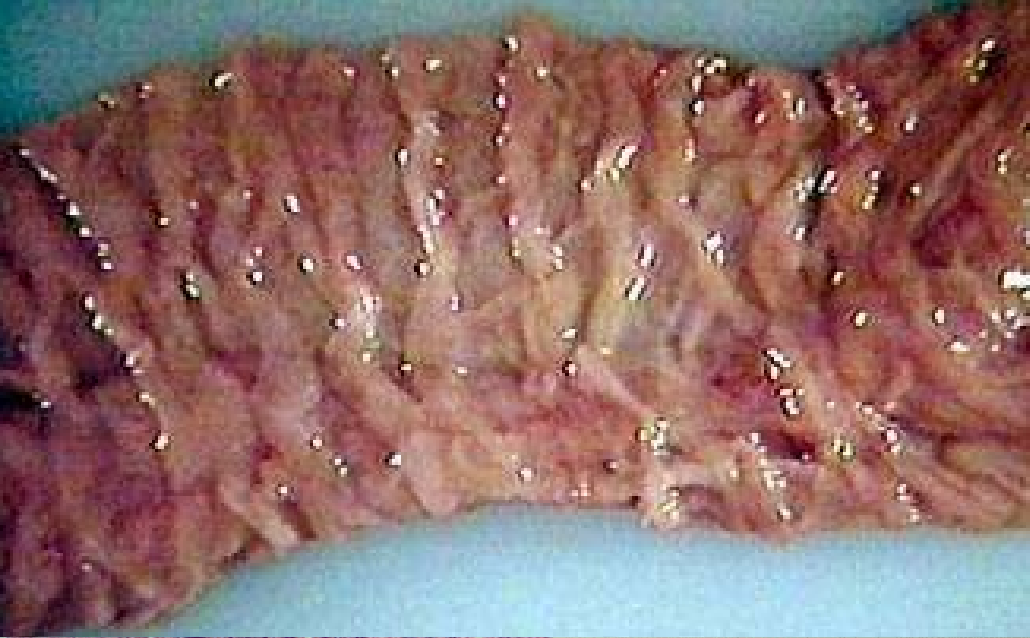
- **intestinal glands**- produce and secrete intestinal juices.
- **Paneth cells**- found in the deep part of the intestinal gland.
 - Secrete **lysozyme**- enzyme that kills bacteria
 - helps to regulate the bacteria population
 - can be phagocytic
- **Hormone producing cells**- also found in the deep parts of the gland and secretes
 - **secretin**
 - **cholecystokinin**
 - **gastric inhibitory peptide**

Ileum, villi and goblet cells





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Paneth Cells

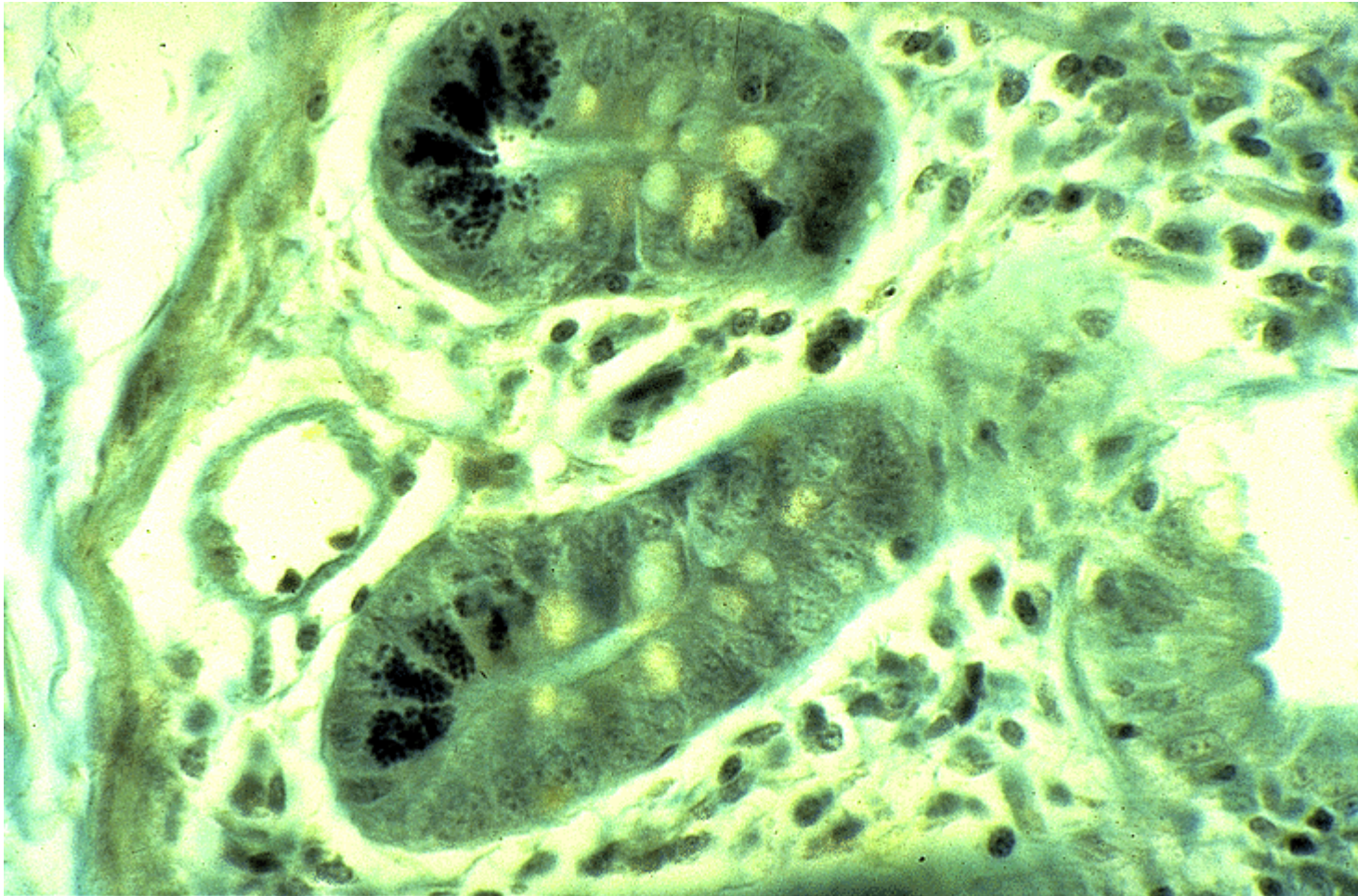


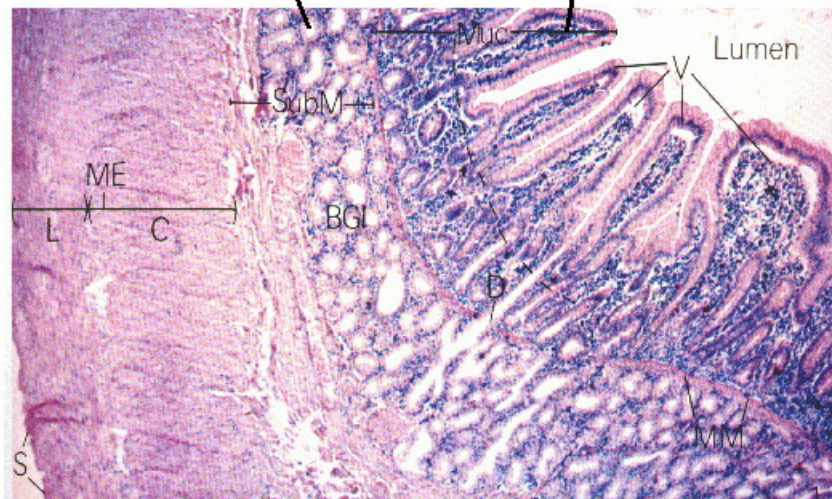
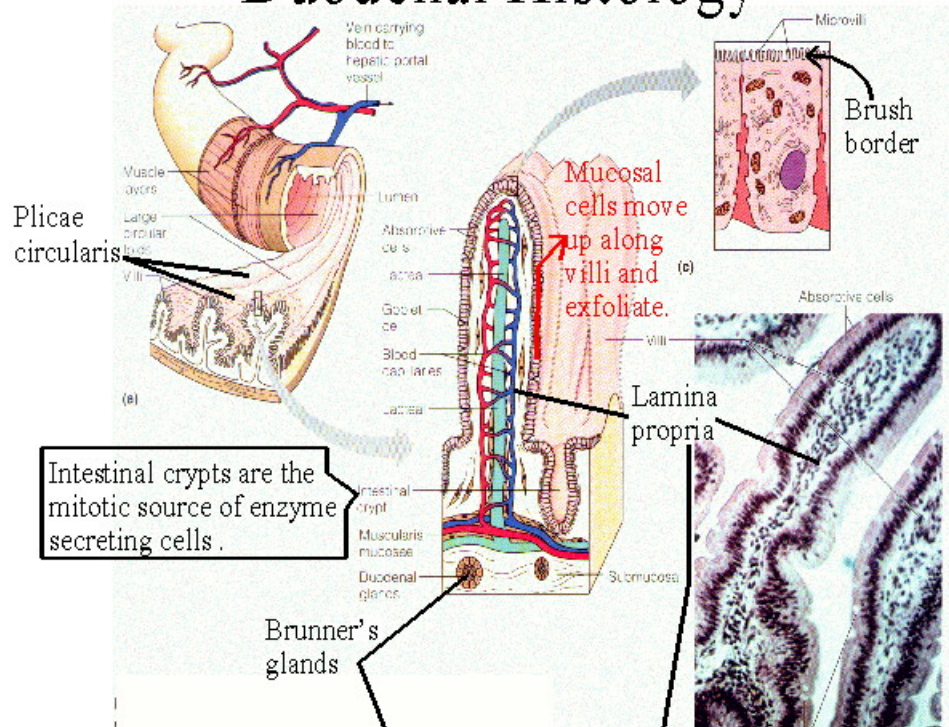
Exhibit 19.1 Hormonal Control of Gastric Secretion, Pancreatic Secretion, and Secretion and Release of Bile

HORMONE	WHERE PRODUCED	STIMULANT	ACTION
Gastrin	Pyloric mucosa	Stretching of stomach, partially digested proteins and caffeine in stomach, and high pH of stomach chyme	Stimulates secretion of gastric juice, increases movement of GI tract, and relaxes pyloric sphincter and ileocecal sphincter.
Gastric inhibitory peptide (GIP)	Intestinal mucosa	Fatty acids and glucose in small intestine	Stimulates release of insulin by pancreas, inhibits gastric secretion, and slows gastric emptying.
Secretin	Intestinal mucosa	Acid chyme that enters the small intestine	Inhibits secretion of gastric juice and stimulates secretion of pancreatic juice rich in bicarbonate ions.
Cholecystokinin (CCK)	Intestinal mucosa	Partially digested proteins (amino acids) and triglycerides (fatty acids)	Inhibits gastric emptying, stimulates the secretion of pancreatic juice rich in digestive enzymes, causes ejection of bile from the gallbladder, and induces a feeling of satiety (feeling full to satisfaction).

Other Special Structures and Glands

- Solitary lymphatic nodules
 - **Peyer's patches**- groups of lymphatic nodules- most numerous in the ileum.
- **Duodenal glands**- secrete alkaline mucus that helps neutralize gastric acid in the chyme.

Duodenal Histology



ME = muscularis externa, L = longitudinal layer, C = circular layer, SubM = submucosa, BG = Brunner's glands, D = duct of Brunner's gland, MM = muscularis mucosae, V = villi, Muc = mucosa.

Ileum and Peyer's Patches



Duodenum, Brunner's Glands



Mechanical Digestion in the Small Intestine

- Has two types of movement
 - **Segmentation**- the major mode of movement that involves localized segmental contraction in areas containing chyme, creating a sloshing effect.
 - Parasympathetic dependent
 - **Peristalsis**- propels the chyme through the digestive tract

Chemical Digestion in the Small Intestine

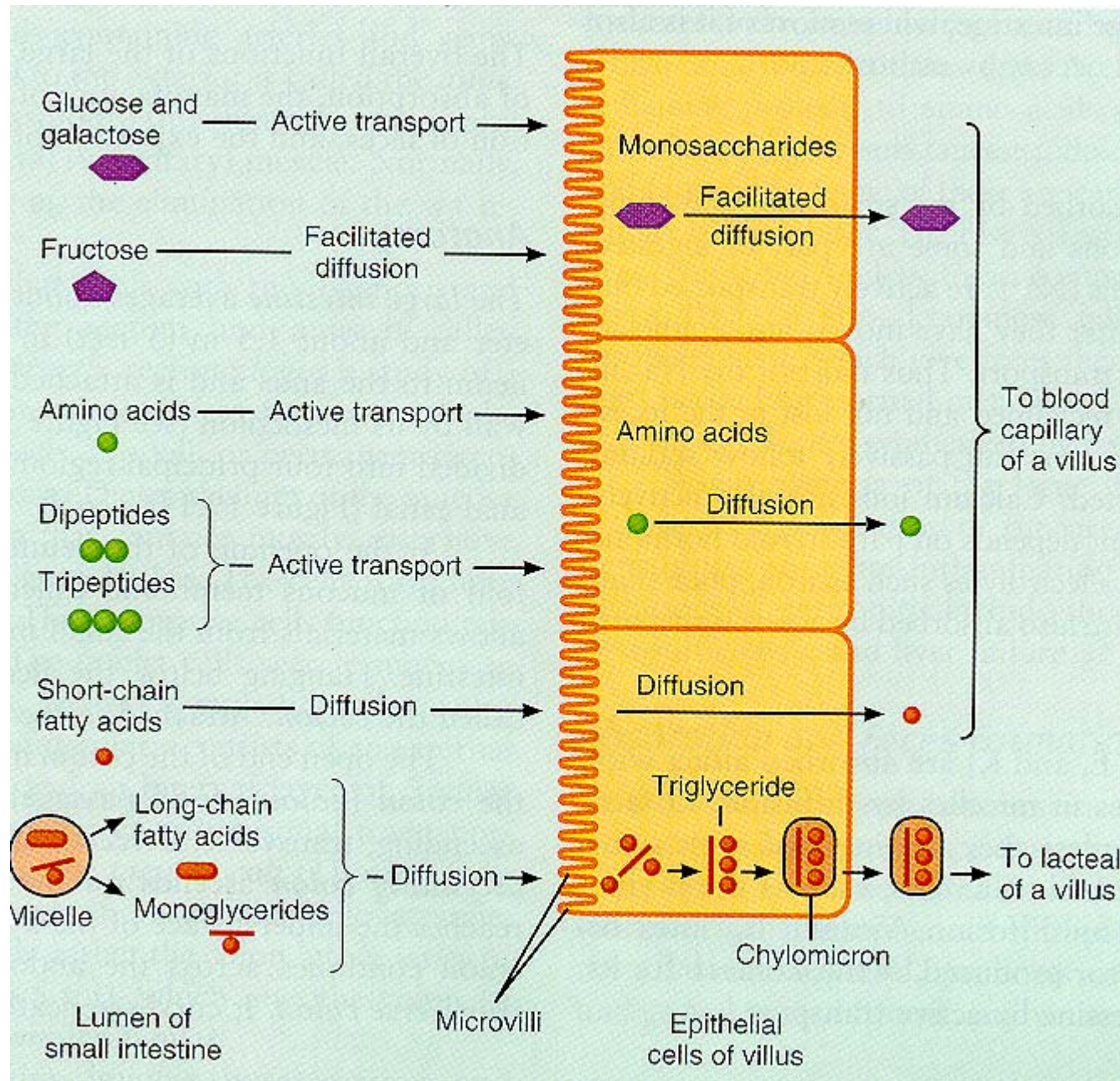
ENZYME	SOURCE	SUBSTRATE	PRODUCT
Carbohydrate-digesting			
Salivary amylase	Salivary glands	Starches (polysaccharides)	Maltose (disaccharide)
Pancreatic amylase	Pancreas	Starches (polysaccharides)	Maltose (disaccharide)
Maltase	Small intestine	Maltose	Glucose
Sucrase	Small intestine	Sucrose	Glucose and fructose
Lactase	Small intestine	Lactose	Glucose and galactose
Protein-digesting			
Pepsin (activated from pepsinogen by hydrochloric acid)	Stomach (peptic cells)	Proteins	Peptides
Trypsin (activated from trypsinogen by enterokinase)	Pancreas	Proteins	Peptides
Chymotrypsin (activated from chymotrypsinogen by trypsin)	Pancreas	Proteins	Peptides
Carboxypeptidase (activated from procarboxypeptidase by trypsin)	Pancreas	Terminal amino acid at carboxyl (acid) end of peptides	Peptides and amino acids
Peptidases	Small intestine	Terminal amino acids at amino end of peptides and dipeptides	Amino acids
Lipid-digesting			
Pancreatic lipase	Pancreas	Triglycerides (fats) that have been emulsified by bile salts	Fatty acids and monoglycerides
Nucleases			
Ribonuclease	Pancreas and small intestine	Ribonucleic acid nucleotides	Pentoses and nitrogenous bases
Deoxyribonuclease	Pancreas and small intestine	Deoxyribonucleic acid nucleotides	Pentoses and nitrogenous bases

Regulation of Intestinal Secretion and Motility

- The most important regulator of motility and secretion is local reflexes in response to chyme.
 - Intestinal stretching initiates nerve impulses to the CNS where returning parasympatetic impulses increase motility.
 - Sympathetic impulses decrease motility.

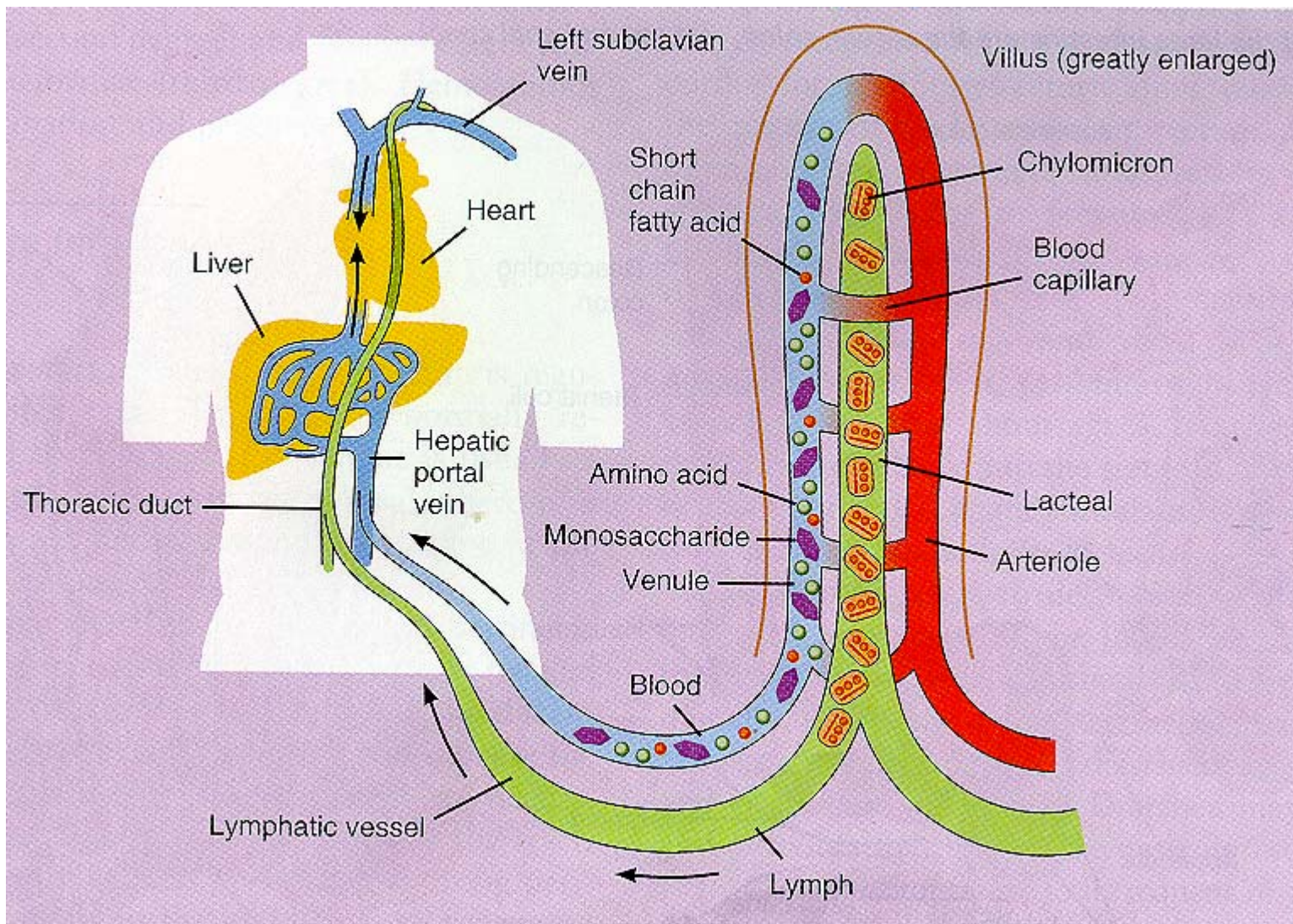
Absorption

- The passage of digested nutrients from the GI tract to the blood or lymph.
 - Occurs by simple diffusion, facilitated diffusion, osmosis, and active transport.
- 90% of all absorption takes place in the small intestine.
 - The other 10% is in the stomach and large intestine.



Lipid Absorption (cont)

- plasma lipids are insoluble in water,so they must be combined with protein transporters to make them soluble
- **Lipoprotein-** the combination of lipid and protein.
 - **LDL-** rich in cholesterol and some phospholipid
 - functions to transport cholesterol from adipose and muscle tissue to other parts of the body.
 - High LDL associated with atherosclerosis because cholesterol can be deposited in the arteries.
 - **HDL-** rich in cholesterol and phospholipids
 - functions to transport cholesterol from body tissues to the liver where it is broken down to become a component of bile salts.
 - High levels are associated with a decreased risk of cardiovascular disease because they may remove cholesterol from arterial walls.
- American Heart Association recommends a total blood cholesterol level less than 200 mg/dl.



Left subclavian vein

Villus (greatly enlarged)

Heart

Short chain fatty acid

Chylomicron

Liver

Blood capillary

Thoracic duct

Hepatic portal vein

Amino acid

Lacteal

Monosaccharide

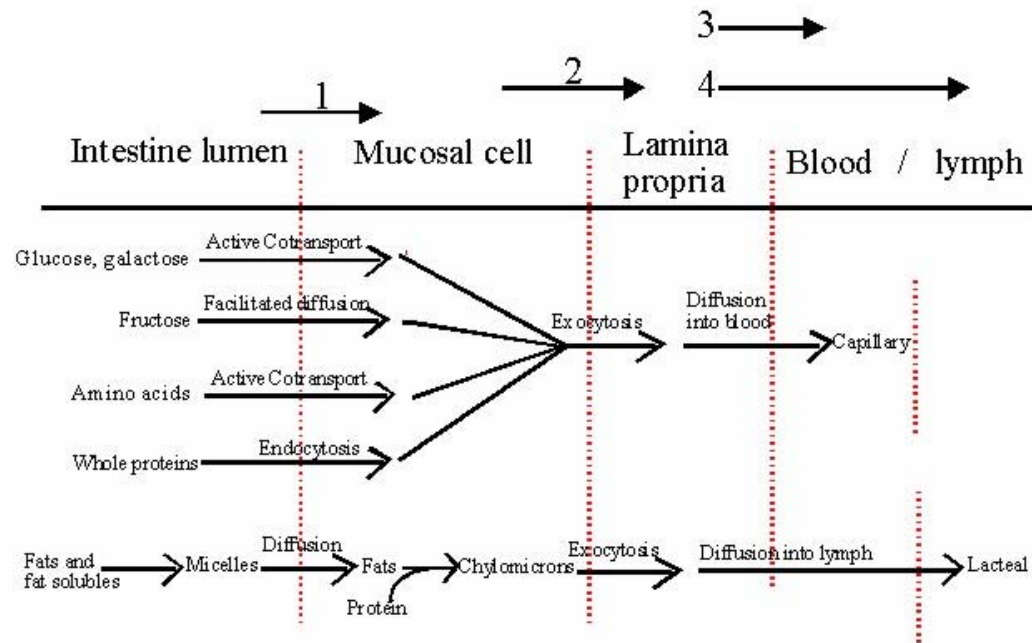
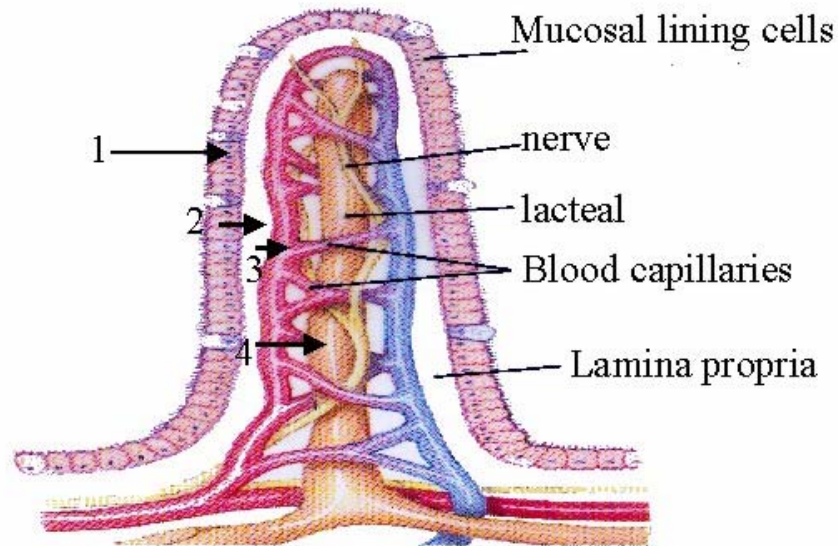
Arteriole

Venule

Blood

Lymphatic vessel

Lymph



Water Absorption

- Most all of the water entering the SI is absorbed (98%) and the remainder is a passed on and absorbed in the LI.
- Water is absorbed by osmosis.

Electrolyte Absorption

- Electrolytes come from GI secretions and ingested foods
- Most of the sodium is reclaimed through active transport as well as chlorine, Iodine, and nitrate
- Calcium's movement depends on parathyroid hormone and vitamin D.
- Other ions, such as iron, potassium, magnesium, and phosphate are absorbed by active transport.

Vitamin Absorption

- Fat-soluble vitamins (A, D, E, and K) are absorbed with triglycerides in micelles by diffusion.
- Most water soluble vitamins (B, C) are absorbed by diffusion
- Vitamin B12 must combine with intrinsic factor produced by the stomach for its absorption in the small intestine by active transport.