

Biology 224

Human Anatomy and Physiology - II

Week 6; Lecture 1; Monday

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Gut Tube: Development, Structure, Function

METBOLISM AND NUTRITION

**(DIGESTIVE STRUCTURES AND
THEIR FUNCTIONAL ROLES)**

Basic Terms:

Nutrients:

1. Provide energy
2. Form new body components
3. Assist in various physiological functions/processes

Six classes of nutrients:

1. Carbohydrates
2. Lipids
3. Proteins
4. Minerals
5. Vitamins
6. Water

Basic Terms:

Metabolism: all chemical reactions that occur in the body.

Anabolism: combining smaller molecules into larger ones.

Catabolism: breaking large molecules into smaller ones with release of energy.

Enzymes: proteins that act as catalysss to sdpeed up chemical reactions.

CARBOHYDRATES (Carbon, hydrogen, oxygen)

- Sugars, primary one used by body is **glucose**.
- Stored in body as long chains (polysaccharides) called glycogen in liver and muscle cells.
- Monosaccharides** (short) – from fruits and sugar cane.
- Polysaccharides** – from grains and vegetables.
- Glucose preferred form of sugar for body.
- Surplus glucose converted to glycogen.
- Surplus glycogen converted to triglycerides and stored in adipose (fat) tissue.

LIPIDS (many hydrogen bonds, so lots of stored energy)

- Used for long-term storage
- **Triglycerides** – storage
- **Phospholipids** – cell membranes, myelin sheaths
- **Steroids** (e.g. cholesterol) – modified to become hormones and bile secretions (from liver).
- Excess stored in adipose tissue.

PROTEINS

- Many functions: structural, transport, cell movement, enzymes, specialized functions such as hemoglobin)
- Made up of amino acids (20 types)
- During digestion, broken down to individual amino acids
- Can be later rebuilt.
- Liver can convert excess amino acids to triglycerides.
- Large excess of amino acids lost in urine.

MINERALS

Inorganic nutrients required in small amounts

- About 4% of total body weight (mostly in skeleton).
- Macrominerals (needed at levels of over 100 milligrams a day): Calcium, Phosphorus, Sulfur, Sodium, Potassium, Chlorine, Magnesium
- Microminerals (needed in only trace amounts): Iron, Iodine, Copper, Zinc, Fluorine, Manganese, Cobalt, Chromium, Selenium

VITAMINS

Organic nutrients required in small amounts

- Do not provide energy or building materials, but act as co-enzymes (necessary for enzyme functions)

- **Fat Soluble** (absorbed with lipids in small intestine; can be stored in cells): A, D, E, K

- **Water Soluble** (absorbed with water in large intestine; excess excreted in urine, not stored): B, C, Pantothenic acid, Folic acid, Biotin

METABOLISM: sum role of all cellular activities that maintain the body.

DIGESTION: mechanical and chemical processes involved in breaking larger food particles down into smaller ones.

ABSORPTION: process by which these (resulting) molecules pass from the gut tube to the bloodstream and lymphatic circulation.

MOUTH:

Initial mechanical and chemical digestion.

Recall differences between nasal pharynx and oral pharynx as separated by hard and soft components of the palate. Separation allows breathing while chewing.

Mechanical Digestion: chewing (teeth), manipulation of food by muscles of mastication (V_3), buccinator (VII), and tongue (XII).

Chemical Digestion: salivary amylase (initial carbohydrate breakdown) – starch breakdown.

Absorption: little or none (except for alcohol!)

DETAIL ON TEETH:

In maxilla or dentary:

Incisors (4): tearing and nipping.

Canines (2): slashing, tearing, shearing, biting.

Premolars (4): larger, complexly surfaced, for chewing and grinding.

Molars (6): even larger grinding teeth.

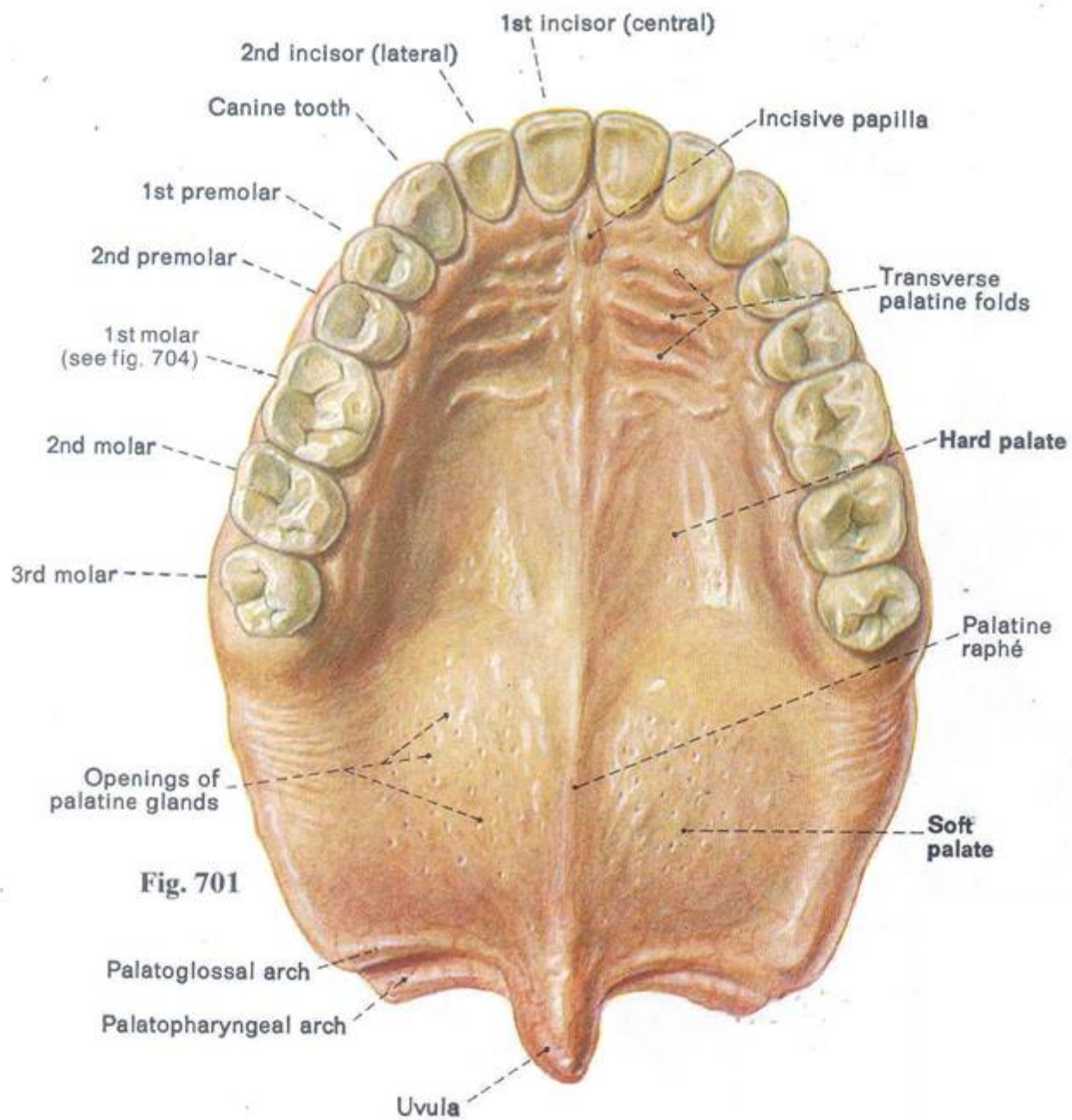


Fig. 701

ESOPHAGUS:

Lined by striated muscle (not smooth). Important for passage of food, but...

No chemical or mechanical digestion.

First part of body in which **PERISTALSIS** takes place.

Peristalsis – wave of muscular action that propels bolus of food down gut tube.

Empties into stomach at **CARDIAC SPHINCTER**.

STOMACH:

Main functions:

- 1.Storage
- 2.Preparation of food before it moves to small intestine
- 3.Testing area in case of “poisonous ingestion”.
- 4.Not an absorptive structure.

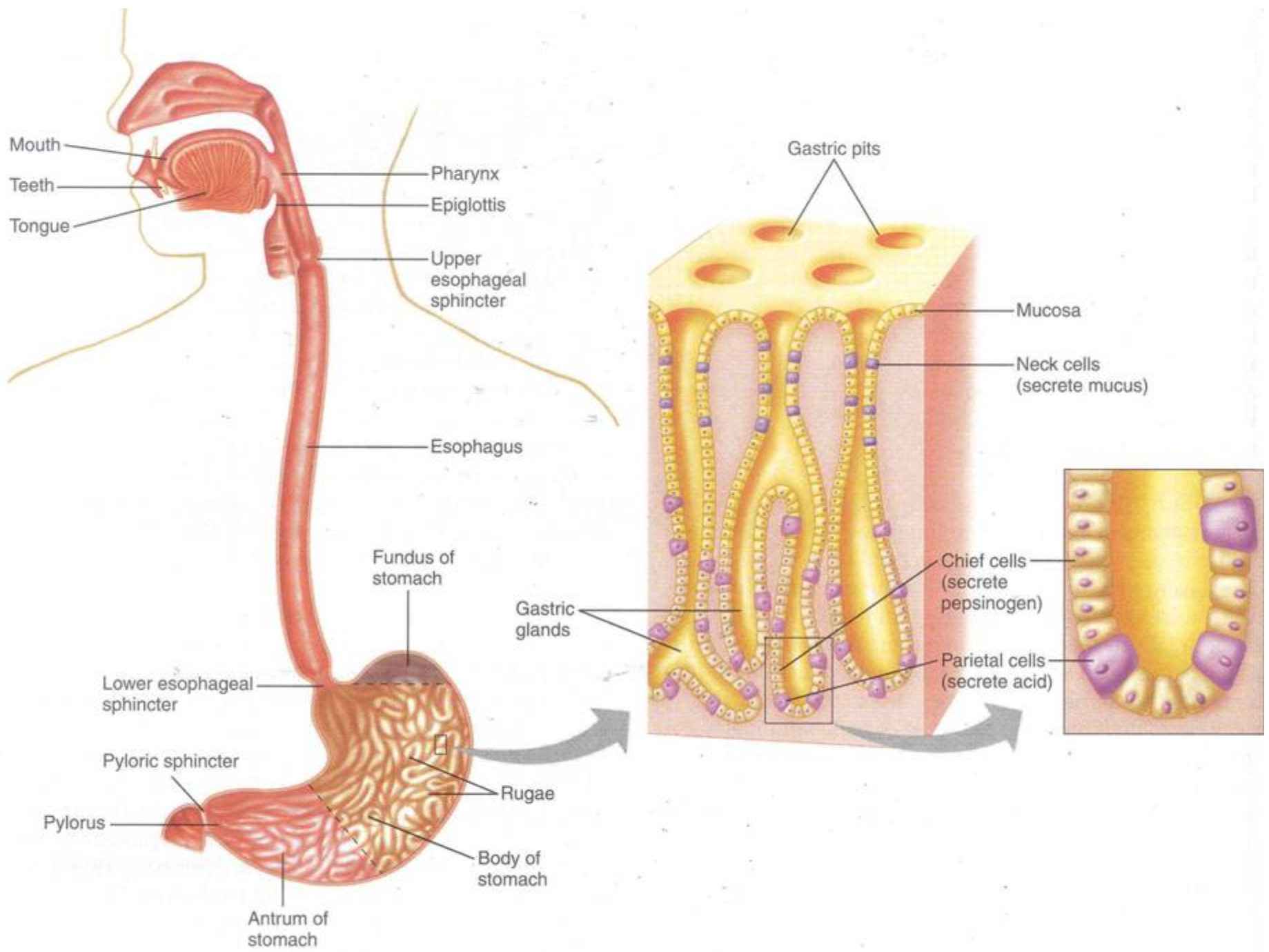
Stomach: Mechanical Digestion

Inner surface derived from endoderm. Three layers of smooth muscle (derived from mesoderm) to churn/mix food. Breaks food down and mixes with gastric secretions.

Rugae – folds on internal surface of stomach

1. Increase surface area
2. Allow distention.
3. When not completely distended, allows food to be pushed up against ridges for further mechanical digestion.

Movements – associated with parasympathetic autonomics – **Vagus nerve (X)**!



Stomach: Gastric Secretions

Remember, inner lining derived from endoderm.

Primary gastric secretion: **HYDROCHLORIC ACID** (HCl) from **Parietal Cells**.

Other gastric secretions:

1. **Mucous** – lubricates food, protects stomach lining from HCl.
2. **Zymogenic Cells** (Chief Cells) – **PEPSINOGEN**. HCl cleaves pepsinogen into **PEPSIN**, which chemically digests proteins.
3. **Entroendocrine Cells** – secrete hormones that regulate stomach functions such as peristalsis, other secretions, etc.
4. **Gastrin** – stimulates secretion of HCl.
 - Gastrin secretion controlled by Vagus nerve. Can be stimulated by smell, taste, chewing, swallowing.

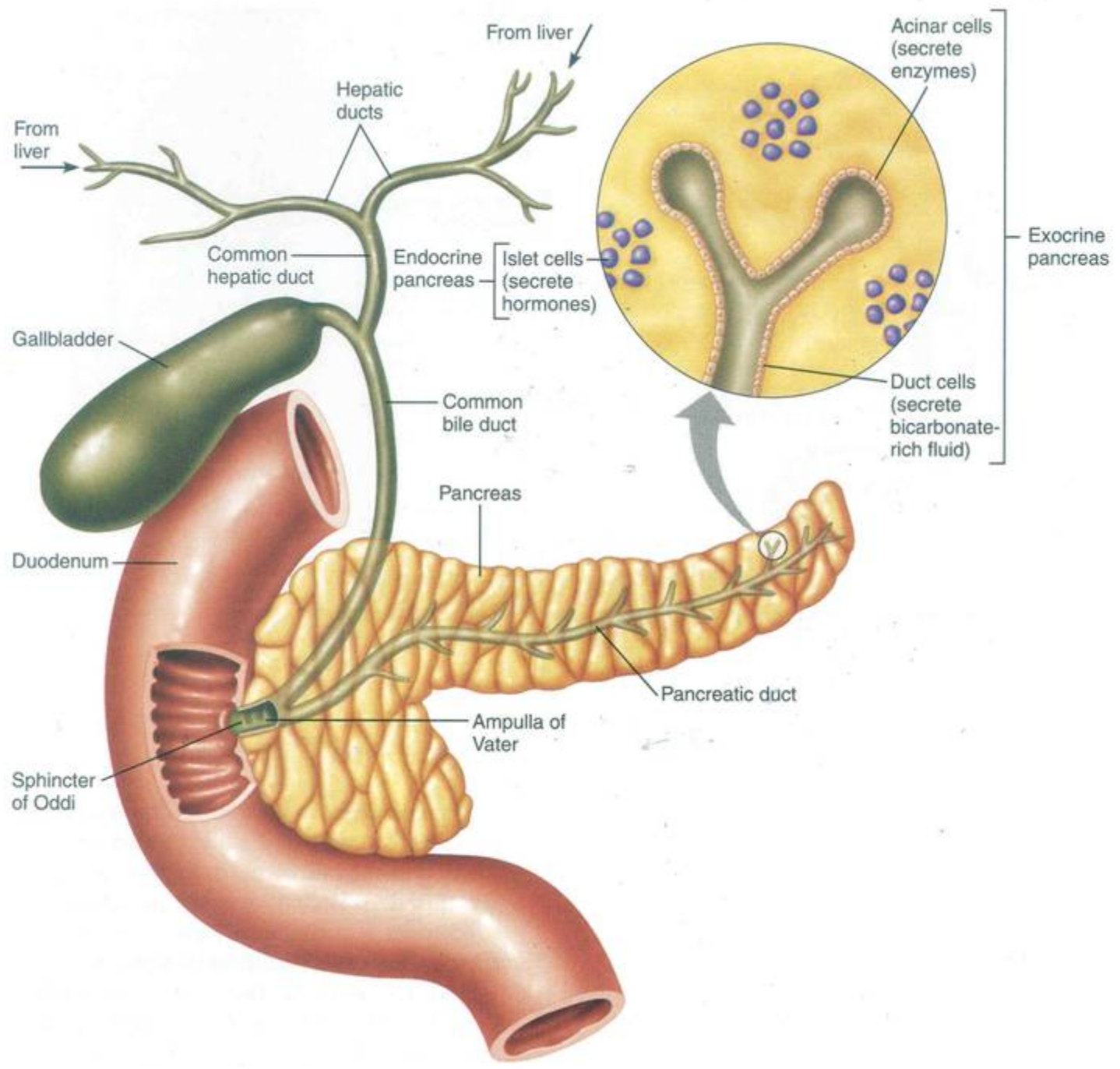
SMALL INTESTINE:

1. Most of the absorption of nutrients and water.
2. Complete/finish chemical digestion of proteins, carbohydrates, and fats.
3. Duodenum, Jejunum, Ileum

SMALL INTESTINE; DUODENUM

Glands dumping into duodenum
via common bile duct:

1. Liver via **bile duct**.
2. Products stored in gall bladder
via **cystic duct**.
3. Pancreas (usually directly into
duodenum via **pancreatic duct**).



(FOREGUT) PANCREAS:

Both endocrine and exocrine organ.

Exocrine Secretion: Vagal stimulation promotes secretion of three pancreatic enzymes:

1. **Pancreatic Lipase** – splits large fats into smaller
2. **Pancreatic amylase** – breaks down polysaccharides into monosaccharides and disaccharides.
3. **Pancreatic Protyolytic Enzymes** – inactive forms of the following secreted into duodenum:
 - **Trypsin**
 - **Chymotrypsin**
 - **Carboxypeptidase**

Enterokinase activates the trypsin. Trypsin activates the others.

(FOREGUT) LIVER:

Detoxification

Glycogen storage.

1. **Bile Secretion** – bile is extremely alkaline.
2. Neutralizes acidic material passed from stomach to duodenum
3. Aids in fat breakdown.

(FOREGUT) GALL BLADDER:

1. Although bile generated by the liver constantly it isn't needed at all times – only when food passes.
2. Gall bladder acts as storage awaiting food passage.
3. Passes bile to common bile duct via **cystic duct**.

MIDGUT: JEJUNUM AND ILEUM

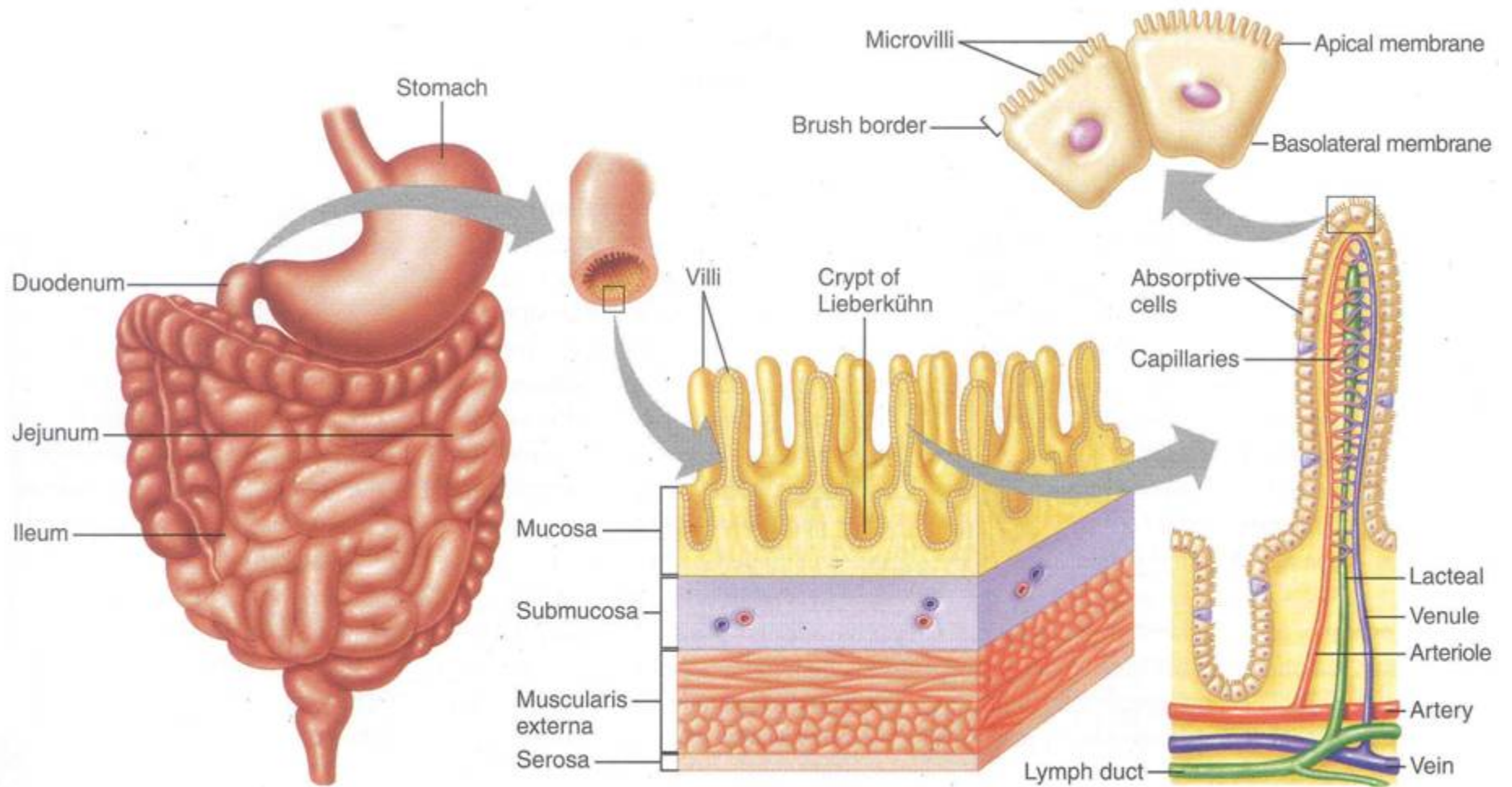
Morphology Review:

1. Jejunum – about 2.5 meters (8 feet)
2. Ileum – about 3.5 meters (11-12 feet)
3. Great length increases absorptive surface area, and passage through it increases time for absorption.

Plicae Circulares – internal folds of small intestine.

Villi – tall, pillar-like bumps arise from internal surface to increase surface area. Inside each one: arterial branch, venous branch, nerve, lacteal.

Intestinal glands – clefts between villi (old name = “Crypts of Lieberkühn”).



MIDGUT: JEJUNUM AND ILEUM

Remaining Mechanical Digestion:

1. Peristaltic Contractions – propel mashed-up foodstuff

2. **Segmenting Contractions** – circularly arranged bands of smooth muscle can constrict small intestine to point of occlusion. Functions to break up chyme, keeping it loose and mushy.

MIDGUT: JEJUNUM AND ILEUM

Chemical Digestion: Digestive enzymes secreted from cells covering villi (secretions most heavily from spaces between microvilli).

- 1. EMULSIFICATION** – physical breakdown of lipid particles (usually to glycerol and free fatty acids) – primarily a function of the bile.
- 2. PROTEIN DIGESTION** – Trypsin and other finish breaking proteins to shorter polypeptides. AMINOPEPTIDASE breaks them down further into individual amino acids.
- 3. CARBOHYDRATE DIGESTION** – “Disaccharidases” (many kinds) break complex sugars into smaller 2-ring sugars, and (mostly) glucose

MIDGUT: JEJUNUM AND ILEUM

Absorption in the Small Intestine:

1. **WATER** – 80-90% of water entering gut tube absorbed in small intestine.
2. **CARBOHYDRATES** – primarily through microvilli of villi.
3. **PROTEINS** – through columnar-shaped absorptive cells on the villi
4. **LIPIDS** – glycerol and free fatty acids combine with bile secretions to form a **MICELLE** (hydrophilic outer surface; lipids internally) allowing them to be absorbed across villi

MIDGUT: JEJUNUM AND ILEUM

Lipid Processing:

1. **MICELLE** absorbed across villi.
2. Once inside cells, housed in endoplasmic reticulum.
3. Lipids packed into protein coated droplets called **CHYLOMICRONS**.
4. Sent to lacteal of villus.

MIDGUT: JEJUNUM AND ILEUM

VITAMIN AND MINERAL ABSORPTION:

1. FAT SOLUBLE VITAMINS

- A – maintain epithelia
- D – facilitate absorption and use of calcium
- E – DNA, RNA, RBC formation
- K – needed for clotting

2. WATER SOLUBLE VITAMINS absorbed with water.

3. B-12 requires specialized protein carrier (in ileum).

LARGE INTESTINE:

1. Absorption: remainder of **water** to be absorbed (primarily in ascending and transverse regions) and careful water balance achieved here. Also some salts, certain vitamins.
2. **MICROORGANISMS**: *Escheria coli* (*E. coli*) – a bacterium – aid in final conversion of liquid waste into semisolid feces. Also synthesize vitamins K and B12.
3. **DESCENDING COLON**: intestinal glands secrete **mucous** – facilitates movement of drier material, neutralizes acids of remaining bacteria.

FECES AND DEFECATION:

Much of mass of feces is unusable material (cellulose or “roughage”) and dead bacteria.

DEFECATION (ELIMINATION) - process of expelling feces from terminal end of gut tube. Controlled by “**defecation reflex**”.

1. Internal anal sphincter relaxes.
2. Coelom pressurized (lateral and abdominal hypaxial muscles).
3. Peristaltic waves pass through sigmoid colon.
4. External anal sphincter relaxes (and feces exits body).