Physiology (code)-year 2

Lecture 2 (Digestive system)

By Dr. Rafida Al-Amiri

Basic Science Department

college of dentistry

University of Basrah

Objectives:

1.Describe the Small and Large Intestine , list their regions and secretion.

2.Describe the liver and Pancreas , Functions of the liver and regulation of pancreatic secretion.

3. Control of GIT motility.

1.Small Intestine

Major regions of Small intestine:

1:Duodenum: (25–38 cm)

- Shortest region of small intestine
- Chyme and bile mix completing digestion.

2:Jejunum: (about 2.5 m)

- Middle section
- Serves as primary site of nutrient absorption.

3:Ileum: (about 2–4 m long)

- Final section of small intestine
- Empties into large intestine
- Completes nutrient absorption.

Layers of Small intestine

1)Mucosa Absorb nutrients from chyme.

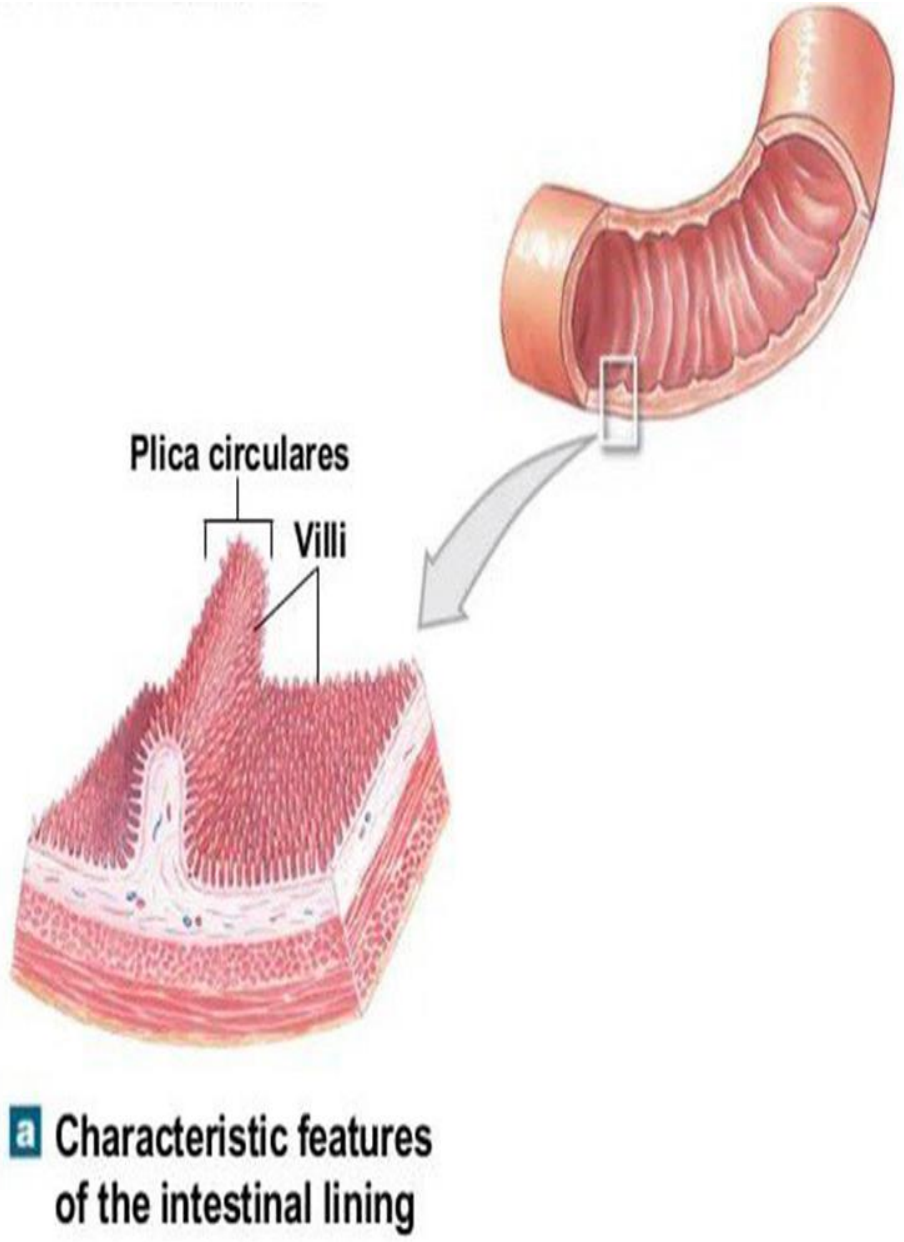
2)Submucosa Provides blood vessels ,lymphatic vessels and nerves to support mucosa on the surface.

3)Muscularis layer Contracts and moves the small intestine.

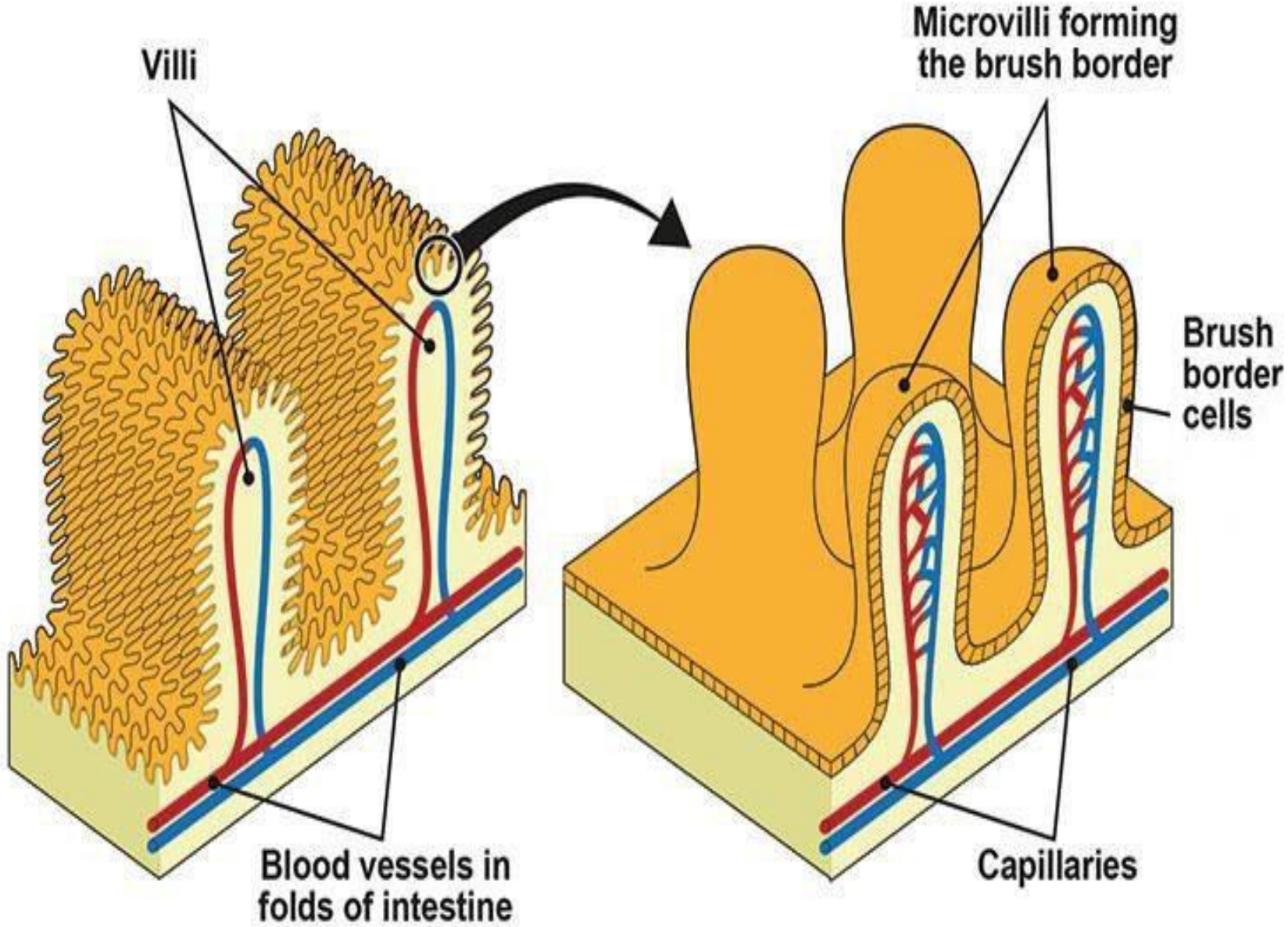
4)Serosa Continuous throughout and surrounds the intestine.

- The interior walls of the small intestine are tightly wrinkled into projections called (***circular folds*** or ***plicae circulares)***

that greatly increase their surface area.



- Microscopic examination of the mucosa reveals that the mucosal cells are organized into finger-like projections known as ***villi***, which further increase the surface area. Many villi are present on the surface of intestine.
- The cells on the surface of the mucosa also contain finger-like projections of their cell membranes known as ***microvilli***, which further increase the surface area of the small intestine.
- Each villus has multiple microvilli emerging from the epithelial cells forming a border.
- Purpose: All of these wrinkles and projections help to greatly increase the amount of contact between the cells of the mucosa and chyme to maximize the absorption of vital nutrients.
- Each square inch of mucosa contains around 20,000 villi.


Villi
Microvilli forming
the brush border
Brush
border
cells
Blood vessels in
folds of intestine
Capillaries

Secretions

There are many sources of digestive secretions into the small intestine and these secretions are controlled by nerves, including the vagus, and hormones.

The most effective stimuli for secretion are local mechanical or chemical stimulations of the intestinal mucous membrane such as chyme and food particles.

In general, the secretion of the small intestine is a thin, colourless or slightly straw-coloured fluid, containing flecks of mucus, water, inorganic salts, and organic material.

The inorganic salts are those commonly present in other body fluids, with the bicarbonate concentration higher than it is in blood.

Aside from mucus, the organic matter consists of cellular debris and enzymes, such as a pepsinlike protease (from the duodenum only), an amylase, a lipase, sucrase, maltase, enterokinase (enzyme changes the inactive pancreatic secretion trypsinogen into trypsin, one of the enzymes that digest proteins produced by the glands of Brunner in the membrane lining of the duodenum) and alkaline phosphatase.

Large intestine

Posterior section of the intestine , consisting typically of four regions: the cecum, colon, rectum, and anus. The term *colon* is sometimes used to refer to the entire large intestine.

The large intestine is wider and shorter than the small intestine (approximately 1.5 meters in length), and has a smooth inner wall.

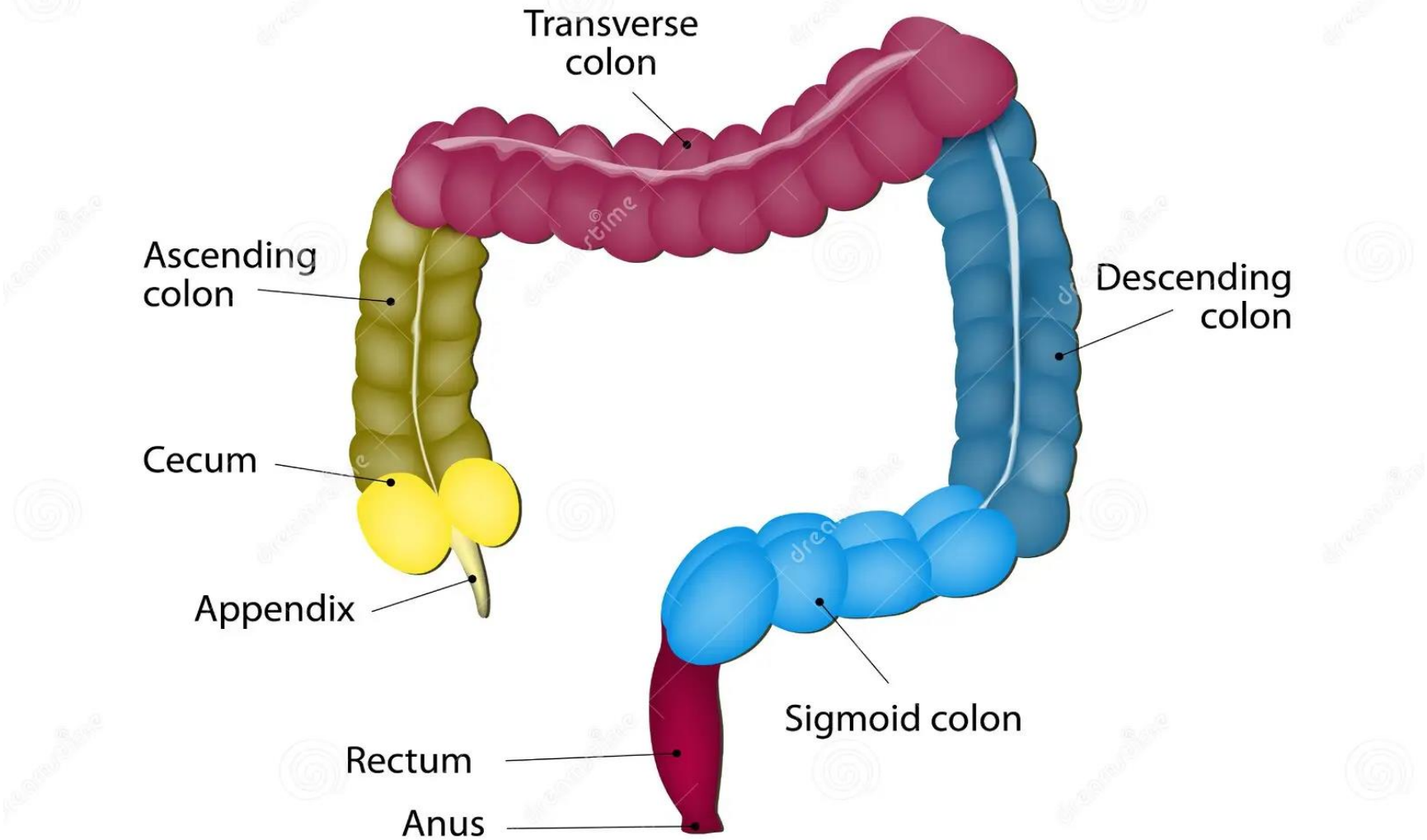
In the proximal, or upper, half of the large intestine, enzymes from the small intestine complete the digestive process , and bacteria produce B vitamins (B_{12}, thiamin, and riboflavin) as well as vitamin K .

The primary function of the large intestine, however, is absorption of water and electrolytes from digestive residues (a process that usually takes 24 to 30 hours) and storage of fecal matter until it can be expelled.

Churning movements of the large intestine gradually expose digestive residue to the absorbing walls.

A progressive and more vigorous type of movement known as the ***gastrocolic reflex***, which occurs only two or three times daily, propels the material toward the anus.

ANATOMY OF THE LARGE INTESTINE



Control of GIT functions:

1. Nervous control (control motility and secretion):

a. Intrinsic control (local) specific for GIT, it is called *enteric nervous system* (ENS) which has neurons, nerve fibers, receptors and chemical transmitters.

•The enteric nervous system is composed of two layers of neurons and connecting fibers, the outer layer called the **myenteric (Auerbach,s) plexus** which controls mainly the GIT movement. The inner layer called the **submucous (Meissner's) plexus**, which is important in controlling secretion and blood flow and also subserves many sensory functions, receiving signals from the gut epithelium and from stretch receptors in the gut wall. All these plexuses are connected to each other in some way, and the plexus in the upper GIT are continuous with neurons plexus in lower GIT.

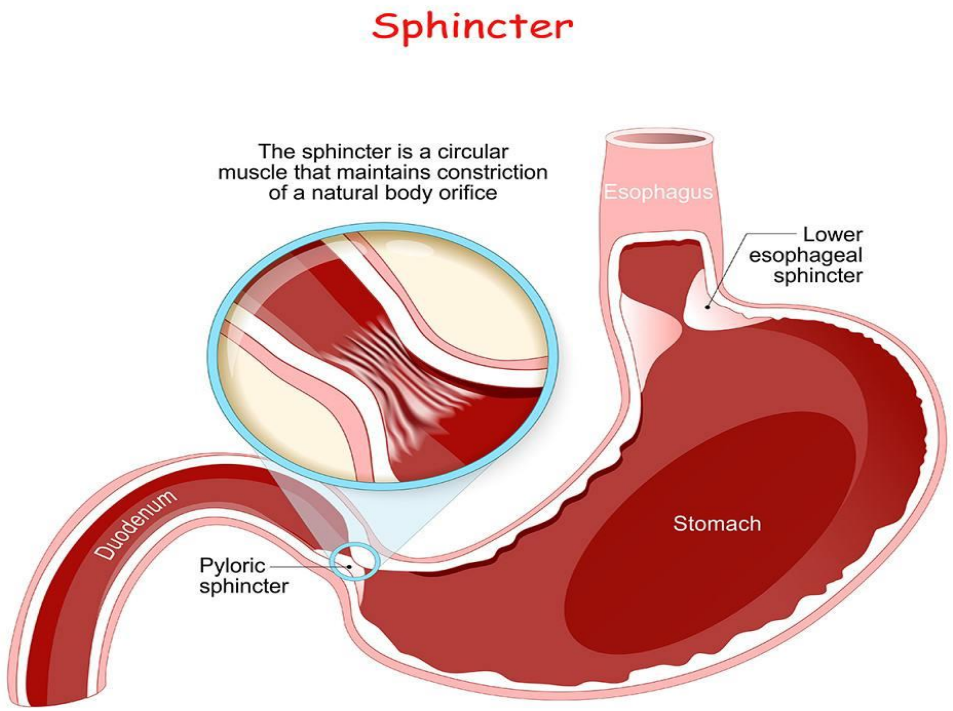
- The Meissner’s plexus are usually attached to receptors in mucosa, these receptors are of 2 types (chemoreceptors :stimulated by chemical nature of food, and mechanoreceptors :stimulated by mechanical stimuli e.g. stretch and pressure) .
- **Chemical transmitters of GIT**: The usual chemical transmitter is ***acetylcholine*** but, in some neurons, there are other transmitters (peptide in nature)→***Glucagon***, ***substance P (pain),*** and ***VIP*** **(*vasoactive intestinal polypeptide*)**.
- If we remove all neurons from GIT except enteric nervous system, all parts of GIT with work normally

b. Extrinsic control related to autonomic nervous system:

1. Parasympathetic : supply to the gut is divided into cranial and sacral divisions. The cranial division is mediated almost entirely through the *vagus*. Vagus nerves innervate esophagus, stomach, little innervations to small intestine, pancreas, and first half of the large intestine. The sacral fibers originate in S2, S3 S4 sacral segments of the spinal cord, and supply the distal part of the large intestine.

- Stimulation of the fibers (parasympathetic) release acetylcholine and cause a general increase in the activity of the entire enteric nervous system which in turn enhances the activity of most GIT functions, and causing sphincters to relax, so they are stimulatory to GIT.

2. Sympathetic : The fibers originate in the spinal cord between the segmentsT8 and L2. Stimulation of the sympathetic nervous system inhibits activity in the GIT, causing sphincters to contract, they inhibit the secretion of acetylcholine, inhibit the motility and secretion, so they are inhibitory the GIT.



Humoral control (hormonal control):

This is done through gastro intestinal hormones secreted from GIT mucosa including:

1.Gastrin hormone: It is polypeptide, released from antrum of the stomach by cells called **G-cells**. The main stimulus for its release is the presence of food in the stomach. Food in the stomach → stretch the stomach → stimulate mechanoreceptor and chemical materials in the food →stimulate chemoreceptors → gastrin secretion

Action of gastrin:

1. Increases gastric motility and secretion.
2. Closing the lower **esophageal sphincter** (between esophagus and stomach).
3. Increases small intestinal motility
4. Increases large intestinal motility
5. Relaxes **pyloric sphincter.**

2.Cholecystokinin-pancreazymin (CCK-PZ):

Released by mucosa of upper part of small intestine, mainly the duodenum.

Main stimulus for its release is the presence of fat in the duodenum.

Actions:

1. Decreases the secretion and motility of stomach, so delays digestion of food (delays the feeling of hunger).
2. Contract the gall bladder and causes release of bile.
3. Stimulates the pancreatic exocrine secretion (secretion of digestive enzymes).

3.Secretin:

•Released from mucosa of upper small intestine, mainly the duodenum.

•Stimulus for secretion: acid in duodenum.

Actions:

1. ↓ Gastric secretion and emptying.

2. ↑ Pancreatic exocrine secretion (HCO3 -).

4.Gastric inhibitory peptide (GIP) :

•Released from duodenum.

•Stimulus for secretion: acid and fat in duodenum.

•**Actions:** Inhibits gastric secretion and emptying .

The movement of GIT (GIT motility): There are 2 types of movements in GIT:

1. **Mixing movement**: local mix the food with secretion in GIT, done by visceral smooth muscle of the organ.
2. **Propulsive movement**: push the food from one part of GIT to the other. It is also called ***peristalsis.*** It is due to contraction of the smooth muscle and it's not unique for GIT it is also occurs in other organs like ureters.

• Peristalsis has one direction of movement called **oral to caudal** direction (**oral to rectal**) while in abnormal conditions e.g. vomiting, the direction will be reversed (opposite).

• The stimulus for peristalsis is distention of lumen of GIT by food (or other material even a foreign body). This distention is going to stimulate the mechanoreceptor which will send impulse to Myenteric nerve plexus which will initiates peristalsis.

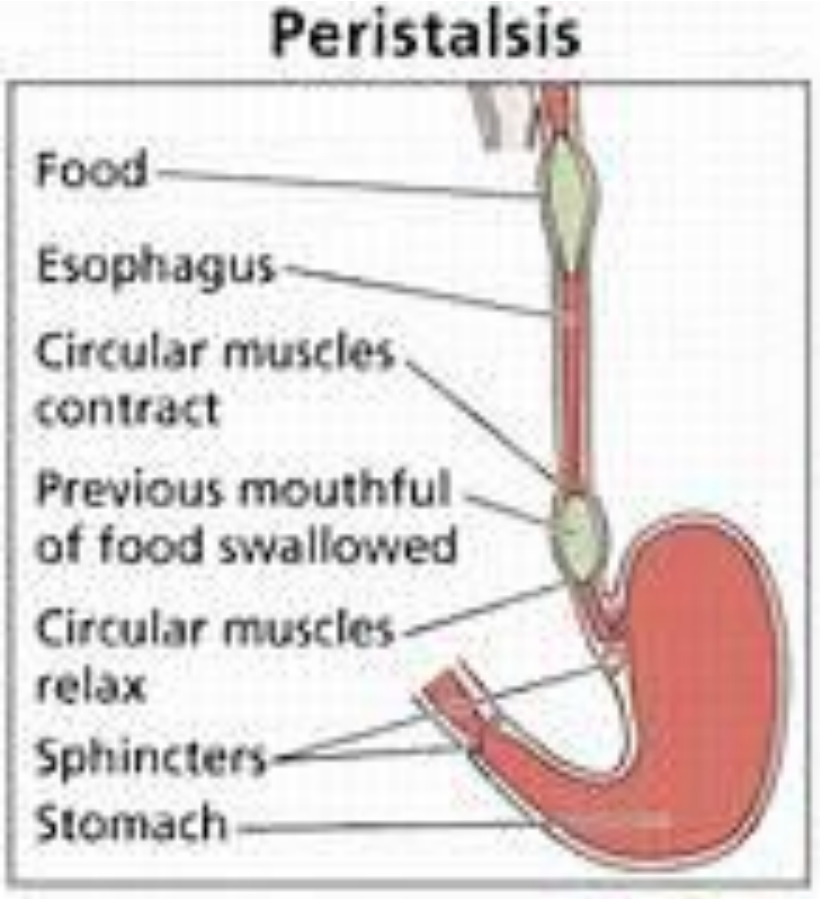
If any part of GIT is removed then re-sutured in opposite side → no peristalsis.

• Peristalsis is due to local Myenteric nerve plexus and it is controlled by extrinsic nerve system (sympathetic → inhibitory, parasympathetic → stimulatory).

• In vomiting the peristalsis is reversed and this is done by extrinsic nervous system.

The area behind the distention will contract due to release of acetylcholine and substance P while the area after (in front of) the distention will relax due to the release of vaso-active intestinal polypeptide (VIP). This is called the **law of gut**.

The area in front of distention is going to do receptor relaxation so food will move from oral to caudal end, and food will move to the relaxed area.



Liver

The liver is one of the largest lymphoid organs in the human body and plays a predominant role in several pivotal functions to maintain normal physiological activities.

Functions of liver :

1) Its major functions include bile production — consisting of bile salts, cholesterol, bilirubin, and electrolytes.
2) Blood sugar and ammonia level control.
3) Synthesis of various hormones and enzymes, and detoxification of endogenous and exogenous substances .
4) Water absorbing and metabolizing bilirubin, Fat and carbohydrates .
5) Supporting blood clots.
6) Vitamin and mineral storage that helps metabolizing proteins for digestion,
7) Filtering the blood and removing compounds from the body, being involved in the immune activity .
8) Production of albumin.

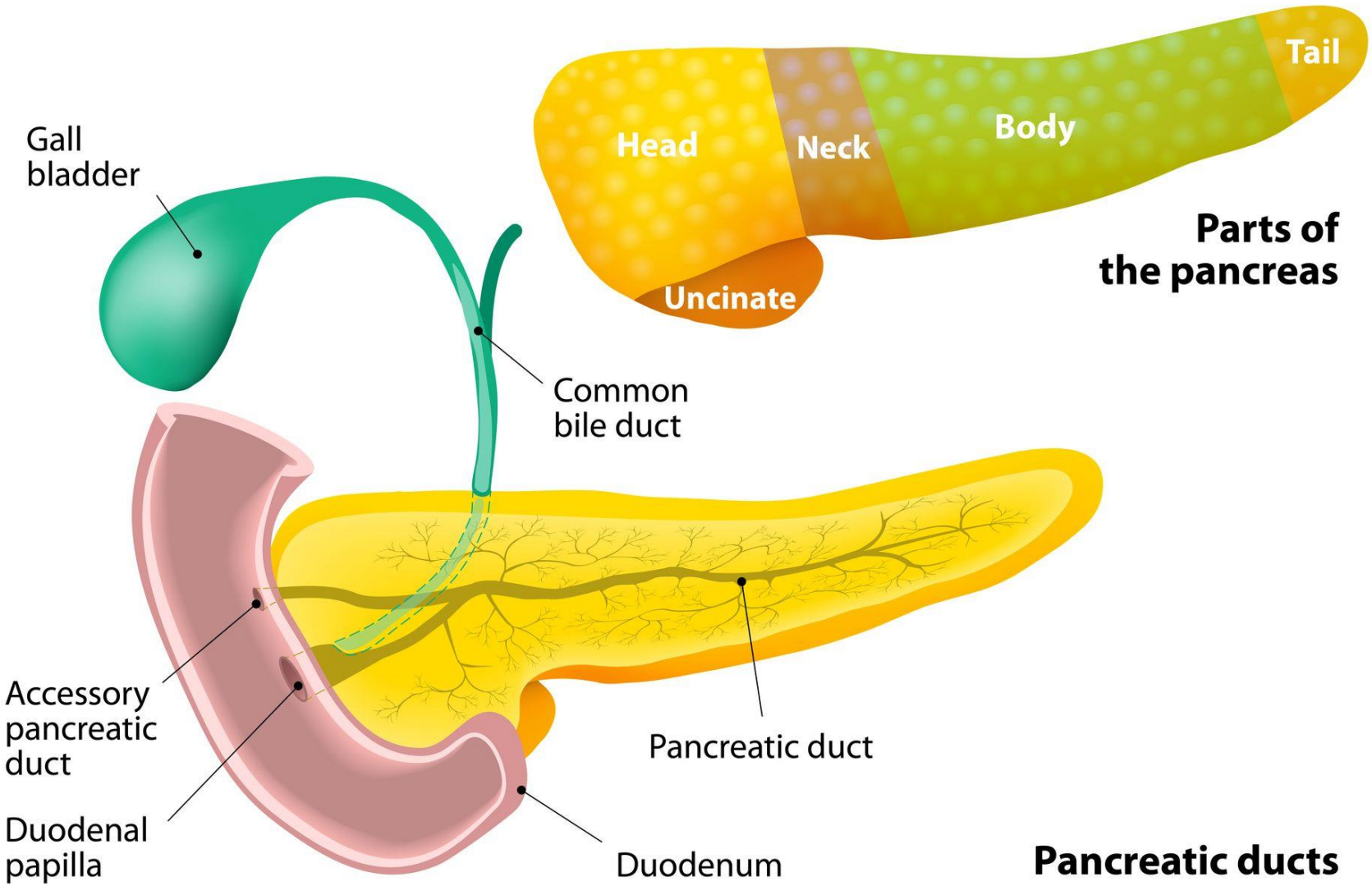
Pancreas

One of the major sources of digestive secretion, a large gland that produces both digestive enzymes and hormones. This gland discharges digestive enzymes into the gut and secretes the hormones insulin and glucagon, and vital in carbohydrate metabolism.

The pancreas empties its secretions into the duodenum through the major pancreatic duct (duct of Wirsung) in the duodenal papilla and the accessory pancreatic duct a few centimeters away from it. Pancreatic juice contains enzymes (protases ,lipase and amylase) that digest proteins, fats, and carbohydrates.

Secretions of the liver are delivered to the duodenum by the common bile duct via the gallbladder and are also received through the duodenal papilla.

ANATOMY OF THE PANCREAS



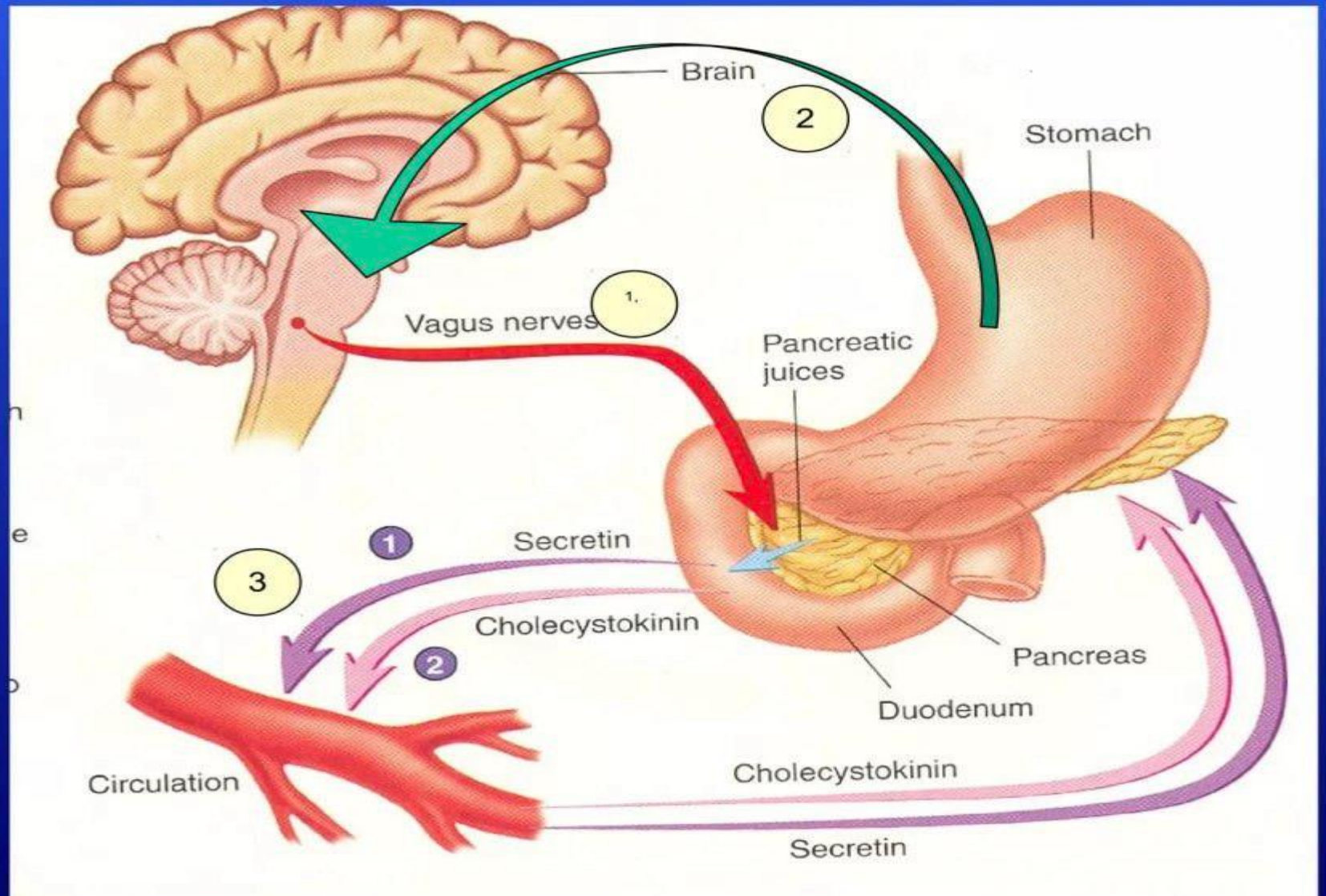
Pancreatic Secretion

Phases of Pancreatic juice (Enzymes) secretion

1. **Cephalic** Phase (20%)

2. Gastric Phase (10%)

3. Intestinal Phase (70%)



Cephalic Phase of Pancreatic Secretion

- The same nervous signals from the brain that cause secretion in the stomach also cause acetylcholine release by the vagal nerve endings in the pancreas.
- 20 per cent of the total secretion of pancreatic enzymes
- But little of the secretion flows immediately through the pancreatic ducts into the intestine because only small amounts of water and electrolytes are secreted along with the enzymes.

Gastric Phase of Pancreatic Secretion

- Nervous stimulation of enzyme secretion continues
- Another 5 to 10 per cent of pancreatic enzymes
- But, again, only small amounts reach the duodenum because of continued lack of significant fluid secretion.

Intestinal Phase of Pancreatic Secretion

- Chyme enters the small intestine, pancreatic secretion becomes copious, mainly in response to the hormones

1. **Cholecystokinin:** Digestive Enzyme Secretion

   65 to 80 per cent

1. **Secretin:** Secretion of Copious Quantities of Bicarbonate Ions—Neutralization of Acidic Stomach

Digestion in GIT:

•***Digestion of carbohydrates*:** Because the food remains only for a short time in the mouth, only 3-5% of all starches that have been eaten will have become digested, enzyme ά-amylase hydrolyzes starches into disaccharide, maltose and other small polymers of glucose. The action of the enzyme can continue for up to an hour after the food has entered the stomach, then the action is blocked by the acid of the gastric secretions, about 30-40% of the starches will be hydrolyzed mainly to maltose.

Pancreatic secretion in the small intestine contains a large quantities of amylase that continue splitting starches into maltose and other small polymers of glucose.

The epithelial cells lining the small intestine contain enzymes lactase, sucrase and maltase, which are capable of splitting the disaccharides lactose, sucrose and maltose into their constituent monosaccharides.

•***Digestion of fat:*** The first step in fat digestion is to break the fat globules into small size so that the water-soluble digestive enzymes can act on the globule surfaces, this process is called **emulsification** of the fat and it is achieved under the influence of bile salts. Digestion of fats by pancreatic enzymes (lipases, cholesterol esterase and phospholipase A2), however, the epithelial cells of the small intestine also contain a minute quantity of lipase known as **enteric lipase**.

Digestion of proteins: *Pepsin* is capable of digesting essentially all different types of proteins in the diet, pepsin digestion represents 10-30% of total protein digestion. Most protein digestion occurs principally in the small intestine under the influence of the *proteolytic enzymes* of the pancreatic secretions. *Trypsin* and *chymotrypsin* can split protein molecules into small polypeptides. The brush border of the small intestine contains several different enzymes aids in the digestion of proteins.

Absorption in GIT:

***Absorption in stomach*:**

•Although gastric enzymes begin breaking down proteins, the stomach wall is not well adapted to absorb digestive products. However, the stomach absorb small quantities of water, glucose, certain salts, alcohol, and some lipid soluble drugs.

•Most nutrients are absorbed in the small intestine. Alcohol, which is not a nutrient, is absorbed in the stomach. This is why? The intoxication effects of alcohol are felt soon after consuming alcoholic beverages.

Absorption in the small intestine: The villi and microvilli greatly increase the surface area of the intestinal mucosa.


Thank You!