The Gastrointestinal Tract (GIT)
• **Definition**
• The GIT is a tube that starts by the mouth and ends by the anus.
• Oral cavity, pharynx, esophagus, stomach, small intestine, large intestine, rectum, and anal canal.
associated glands

- Connected to this tube certain exocrine glands that pour their secretions in this tube
  - salivary glands
  - the pancreas
  - the liver
General structure
Histology
from outside to inside:
- serosa
- longitudinal smooth muscle
- myenteric or auerbachs nerve plexus
- circular smooth muscle layer
- submucous or meissners nerve plexus
- submucosa
- mucosa
Innervation of the GIT

By
• Intrinsic innervation:
  Enteric nervous system (ENS).
• Extrinsic innervation:
  Autonomic nervous system (ANS).
  Somatic nervous system.
Enteric nervous system

- Regarded as displaced part of CNS
- Formed of around 100 million neurons
- Made of **two** nerve plexuses
  1. Myenteric or Auerbachs nerve plexus: controls motility
  2. Submucous or Meissners nerve plexus: controls secretions
• The enteric nervous system is connected with the autonomic nervous system.
• Through this connection, the parasympathetic increases motility and secretion whereas the sympathetic decreases motility and secretion.
• This connection is not essential for the function of the ENS.
Neurotransmitters of the enteric nervous system

- The main neurotransmitter is the acetylcholine.
- NE is also secreted.
- Others: NO, VIP.
Autonomic fibers

parasympathetic fibers to GIT

• Vagus nerve supplies upper GIT up to the transverse colon

• The remainder by sacral

• Sympathetic fibers: thoracolumbar
Regulation of the GIT function

- It is regulated by both neural and hormonal mechanisms mainly locally.
• The *neural* control through
• Intrinsic nervous system (ENS)
• Extrinsic nervous system (ANS, and somatic nervous system).
• The *hormonal* control by:
• Peptide hormones released by endocrine cells scattered throughout the GIT.
These hormones include gastrin, secretin, cholycystokinin, pancreozymin (CCK-PZ), vasoactive intestinal peptide (VIP), somatostatin and other hormones.
The mouth

- Also known as oral cavity.
- Functions:
  - 1-Orifice for food and water intake.
  - 2-mastication.
  - 3-mixes food with saliva.
  - 4-initiate swallowing.
The oral cavity

It is bounded by muscles and bones:
Anteriorly: by the lips.
Posteriorly: continuous with the oropharynx.
Laterally: by the muscles of the cheeks.
Superiorly: by the bony hard palate and muscular soft palate.
Inferiorly: by the tongue and soft tissues of the floor of the mouth.
• contains

**Saliva** from the salivary glands

**The tongue**

• contains taste buds

• moves food and mixes it with saliva
Teeth

• grind food by the mastication process

• The grinding cycle starts voluntary then continues automatically by the contact of food with the gums and teeth leading to reflex mouth opening followed by closure
Functions of chewing - mastication

• It breaks large solid food particles into smaller ones - aids digestive enzymes.
• Stimulates salivary secretion
• Mix saliva with the food particles to produce a bolus that can be swallowed
Saliva

- Saliva is an alkaline secretion pH less than 7 but approach 8 during active secretion.
- Amount is 1.5 liters/day
- Osmolarity: hypotonic
- Secreted by SALIVARY GLANDS
Salivary glands

- The parotids ——20% : purely serous gland
- Submandibular——70% : mixed gland
- Sublingual-------5% : mixed gland but mainly mucous
- The remaining 5% are secreted by small salivary glands in the oral cavity and the tongue
Salivary glands

- Exocrine glands with acini and ducts
- **Acini** have one or two types of cells:
  - Serous cells: secrete water, electrolytes, and enzymes
  - Mucous cells: secrete mucous
- **Ducts**:
  - Intercalated, striated, and excretory ducts.
Composition of saliva

Proteins:
1-enzymes:
   - salivary alpha amylase
   - lingual lipase
2-mucus in the form of mucins
3-immunoglobulin A
bacteriocidal and bacterostatic agents.
4- lysozyme
5- lactoferrin
6-proline rich compounds
7-ABO blood group substances
Electrolytes:

- Saliva secreted in acini is isotonic but modified in ducts.
- Ducts impermeable to water but Na, and Cl absorbed and K and HCo3 secreted.
- (more potassium and bicarbonate and low sodium and chloride).
- High flow rate (close to plasma).
- Low flow rate (hypotonic).
FUNCTIONS OF SALIVA

• **Digestive functions:**
• **Protective functions:**

Lubricant that facilitates chewing, taste, speech, and swallowing.

Moisture for the mouth

Protection for the mouth and specially for the teeth enamel (lactoferrin, lysosomes, prline rich protein)

Neutralization of hyper acidity

IgA
Regulation of salivary secretion

- regulated through neural mechanisms
- Parasympathetic stimulates salivary secretion (large amount)
- Sympathetic stimulates salivary secretion (small amount)
- Stimuli are:
  - presence of food in the mouth: non-conditioned reflex
  - sight, smell, thought of food: conditioned reflex
CLINICAL ABNORMALITIES

- **XEROSTOMIA**(dry mouth):
  - Result in difficulty in speech, swallowing, halitosis, dental caries, increased susceptibility to oral infections.
  - Caused by: Dehydration, sjogren’s syndrome, radiation, and drugs (anticholinergic)
• **Ptyallism:**
• Drolling of saliva to outside the mouth due to increased production or decreased swallowing.
The pharynx

- Lies immediately posterior to the mouth and nasal cavity.
- Common route for air and food.
- Involved in vocalization and swallowing reflex.
• Divide into 3 parts:
• Oropharynx,
• nasopharynx,
• and laryngeopharynx.
Swallowing -- deglutition

• **SWALLOWING** is a reflex response that is triggered by impulses in the trigeminal glossopharyngeal and the vagus nerves
• impulses are integrated in the nucleus of tractus solitarius and nucleus ambiguus
• The efferent impulses travel in the trigeminal facial and hypoglossal nerves
• Deglutition starts voluntary but continues involuntary
• It has three phases:
  • oral,
  • pharyngeal
  • and oesophageal.
oral phase:

- It starts by collecting food and pushing it to the back of the mouth.
- The tongue moves upwards and backwards to propel the bolus into the pharynx.
- The mouth should be closed.
pharyngeal phase:

as soon as the bolus touches the pharynx, there are certain receptors that sense food arrival and sends impulses to the swallowing center which initiate many actions:

• The nasal cavity is closed by elevation of the soft palate.
• The muscles of the pharynx contract medially.
• The vocal cords proximate to each other
• Epiglottis close the larynx
• The larynx is elevated upwards so an acute angle is formed between the larynx and pharynx.
• Respiration is inhibited
• Pharyngeal wall proceed a certain movement called perstalsis
• When reach upper oesophageal sphincter it opens
Esophageal phase

starts when food enters the esophagus

• This will initiate a peristaltic wave that pushes food downwards to the lower esophageal sphincter which will be relaxed and food enter the stomach
peristalsis

- It is a ring of contraction proximally preceded by a ring of relaxation that travel in an oro-caudal direction at different speeds.
- Its main function is propulsion of food.
- Coordinated and regulated by a wave of excitation called the basic electrical rhythm that is initiated in pacemaker cells.
- Peristalsis can be primary or secondary.
Clinical abnormalities

- **Dysphagea** is difficulty of swallowing
- **Achalasia** is failure of relaxation of the lower esophageal sphincter due to degeneration of the neurons that secrete nitric oxide and VIP
The stomach

- Anatomy
- The stomach has the following parts
- The cardia
- The fundus
- The body
- The antrum
- The pylorus
• **Histology**
• The gastric mucosa is made of the surface epithelium at which a group of gastric glands open in a common opening called the gastric pit
Types of cells in a gastric gland:

- The cells that make the gastric glands are
- *chief cells* or zymogen cells (secrete pepsin)
- *parietal cells* (secrete HCL, intrinsic factor)
- *Mucous cells* (secrete mucous)
Functions of the stomach

- Storage of food (4hrs)
- Digestion of proteins and lipids (pepsin and gastric lipase enzyme)
- Protection (HCL, vomiting)
- Synthesis (IF)
- Facilitates Iron absorption
- Absorption (water, alcohol, some drugs)
- Endocrine functions (gastrin, glucagon, somatostatin)
The gastric juice

- a mount is 2.5 liters per day
- highly acidic - pH 2-4
- Its composition is as follows
  - Water
  - Electrolytes (H+, K+, HCO3-, Na+)
- **Intrinsic factor**
- secreted by parietal cells
- **Enzymes**
- pepsinogen
- Gastric lipase
- **Mucus** in the form of mucins
Mechanism of acid secretion

• hydrogen ions are secreted by active transport from the parietal cells to the lumen of the gastric glands through the hydrogen –potassium ATPase

• hydrogen comes from the dissociation of the carbonic acid
carbonic acid is formed by the hydration of carbon dioxide with water in the presence of the enzyme carbonic anhydrase
bicarbonate formed diffuses to the interstitium in exchange with chloride and then to the blood (post-prandial alkaline tide)
The parietal cells have three types of receptors:
- $M_3$ receptors for acetylcholine
- $H^2$ receptors for histamine
- $G$ receptors for the hormone gastrin
Regulation of gastric secretion

• Gastric secretion is regulated in three phases:
  • cephalic phase
  • gastric phase
  • intestinal phase
cephalic phase

- The stimuli are presence of food in the mouth (non conditioned)
- sight, smell and thought about food (conditioned)
- efferent fibers through the vagus nerve
- It mainly neural partially hormonal
- Accounts for about 40% from total secretion.
Gastric phase

- The stimulus is the presence of food in the stomach
- Accounts for 50%
- Regulation through local neural and hormonal mechanisms
• **Neural mechanism:**
• Distension of stomach stimulate gastric secretion by:
  • Intramural reflexes
  • Vagovagal reflex
• **Hormonal mechanism:**
  • Food in stomach (distention, amino acids) stimulate release of gastrin which stimulate acid secretion.
  • Accounts for 50%
The intestinal phase

- It is mainly inhibitory
- Activated when chyme reaches the intestine.
- Accounts for only 10%
- Mainly through hormonal factors from the small intestine enterogastocrine, CCK, secretin & GIP
gastric barrier

• The gastric barrier prevents the acid from eroding the gastric wall
• It is made of
  • mucus that contains glycoproteins and peptides
  • presence of a bicarbonate under the mucus
• Secretion of acid in finger like channels at pumps areas
Gastric motility and emptying

- The stomach shows the following types of movements
  - Receptive relaxation
  - Gastric peristalsis
  - Hunger contractions
Receptive relaxation

- Proximal part of the stomach relaxed to accommodate the arrived food with minimal increase in pressure.
- Mediated by vagus nerve
Gastric peristalsis

- Sweeps down towards the lower part of the stomach to allow chyme to pass through the pylorus.
- 3-4 times/min
- When reach lower part of the stomach causes sequential contraction of antrum followed by pylorus and then duodenum.
Hunger contractions

- Migrating motor complex (MMC)
- Peristaltic waves occurs every 90 min between meals.
- Remove remnants food.
Gastric emptying

- Factors determine emptying:
- Stomach (antral) contraction
- Pyloric sphincter
- Deudenal contraction
• Gastric motility and emptying depends on type of food:
  • carbohydrates leave the stomach rapidly followed by proteins then lipids
• osmolality of food:
  • hyper osmolar food leaves the stomach very slowly
• **PH:** (alkaline more rapid than acidic)

• **Hormones:**

  - (secretin, CCK, and GIP) - inhibition

  - Gastrin (increases both gastric and intestinal motility)
CLINICAL CORRELATES

- **Peptic ulceration:**
- Defect in mucosa of stomach or intestine caused by gastric secretion
• **Causes:**
  • Infection with helicobacter pylori bacteria
  • Non steroidal anti inflammatory drugs (like aspirin)
  • Zollinger ellison syndrome
- Treatment:
- Proton pump inhibitors
- H2 blockers
- Muscarinic blockers
- Prostaglandins analogue
- Antiacid
- Surgical treatment (vagotomía)
The exocrine pancreas

- Accounts for 98% of the pancreatic mass
- It has a head body and tail
- Consist of lobules
- Each lobule consist of acini and ducts
The main pancreatic duct joins the common bile duct to form the ampulla of Vater which opens in the duodenum at the duodenal papilla the orifice of which is governed by the sphincter of Oddi.
The pancreatic juice

- Amount 1.5 liters/ day
- Alkaline (8)
- **Contents:**
  - 1-Water
  - 2-Electrolytes (Contains high bicarbonate) secreted by ductular and centroacinar cells.
• 3-Contains the following enzymes
• Essential for digestion.
• **1-Protein digestive enzymes:**
• Secreted in inactive form
• **Trypsinogen****-trypsin**
• **Chymotrypsinogen****-chymotrypsin**
• **Procarboxyypeptidase ***-carboxyypeptidase**
• **Proelastase********-elastase**
• They are activated in the lumen of the small intestine by the enzymes enterokinases or enteropeptidases which is secreted by the intestinal epithelium.

• These activate trypsinogen to trypsin then trypsin activates the others including itself.
Points to be considered

- Most of the protein in food is digested by Pancreatic proteases
- There is trypsin inhibitor as a safe guard
- Trypsinogen is an inactive form of trypsin activated only in the intestinal lumen so that it does not hurt pancreatic tissue
- Pancreatic Juice is alkaline:
  - 1-neutralize the acids of the stomach
  - 2-To provide optimal medium for enzymes
• **3-lipids digestive Enzymes:**
  • Pancreatic lipase
  • colipase
  • Cholestrol estrase
  • Phospholipase A2
• A major component of dietary fat is triglyceride, or neutral lipid.

• It must first be digested into a 2-monoglyceride and two free fatty acids.

• Sufficient quantities of bile salts must also be present in the lumen of the intestine.

• Normal digestion and absorption of dietary fat is critically dependent on secretions from both the pancreas and liver.
Triglyceride $\xrightarrow{\text{Pancreatic Lipase}}$ Monoglyceride $\rightarrow$ Free fatty acids
2—Carbohydrates digestive Enzyme:

- 2-Pancreatic alpha amylase
- The major dietary carbohydrate for many species is starch, a storage form of glucose in plants
- alpha-amylase is the enzyme that hydrolyses starch to maltose as well as the trisaccharide maltotriose and small branchpoints fragments called limit dextrins. The major source of amylase in all species is pancreatic secretions, although amylase is also present in saliva of some animals, including humans
4-Enzymes for nucleic acid digestion:
- Ribonuclease: for RNA digestion
- deoxyribonuclease: for DNA digestion
Regulation of pancreatic secretion

- It is regulated mainly hormonally by
- The hormone cholecystokinin pancreozymin (CCK-PZ) stimulates pancreatic juice rich in enzymes
The hormone secretin stimulates a watery pancreatic secretion rich in bicarbonates.

The hormone gastrin and Vagal stimulation similar to cck.
control of pancreatic secretion

- **1-Cephalic phase:**
- Food in mouth (non-conditioned)
- Seeing, smelling, thinking of food (conditioned)
- Both act through vagus nerve
- Vagus → acinar cells → enzyme secretion (directly)
- vagus → G cells → gastrin → enzyme secretion (indirectly)
2-gaseric phase:

- When food reaches stomach
- **Neural** and **hormonal** mechanisms stimulate pancreatic secretion rich in enzymes.
• **Neural:**

• stomach distension → vagovagal reflex → stimulate pancreatic secretion.

• **Hormonal:**

• Gastric distension or amino acids → gastrin → stimulate pancreatic secretion
3-intestinal phase:

- Main phase of pancreatic secretion
- Through **hormonal** mechanisms:
  - Hormones released when chyme reaches the small intestine
  - Secretin
  - CCK
• **Secretin**
• It is a polypeptide of 27 amino acids.
• It is secreted by cells in the duodenum when they are exposed to the acidic contents of the emptying stomach.
• It stimulates the **exocrine** portion of the **pancreas** and the bile ducts cells to release fluid rich in **bicarbonate** into the **pancreatic fluid** (thus neutralizing the acidity of the intestinal contents).
Cholecystokinin (CCK)

• A mixture of peptides, of which an octapeptide (8 amino acids) is the most active.
• It is secreted by cells in the duodenum and jejunum when they are exposed to food.
• It acts
  – on the **gall bladder** stimulating it to contract and force its contents of **bile** into the intestine
  – on the **pancreas** stimulating the release of **pancreatic digestive enzymes** into the pancreatic fluid.

• CCK also acts on **vagal neurons** leading back to the **medulla oblongata** which give a **satiety signal** (i.e., "that's enough")
Clinical correlates

- **Acute pancreatitis:**
- Activation of pancreatic enzymes within the duct.
- To guard against it by secretion of inactive protein digestive enzymes and the presence of trypsin inhibitor in the pancreas.
Chronic pancreatitis:

- Result in release of low amount of pancreatic enzymes in the duodenum leading to maldigestion and malabsorption of proteins and fat (fatty stool or steatorrhoea)
The liver

- One of the largest glands in the body
- It weighs 1.5 Kg in a normal adult
- Has four lobes
Histology of the liver

• The anatomic unit is the hepatic lobule
• It contains the central vein in the center and the portal canals at the peripheries
• Rows of hepatocytes are extending from the peripheries to the center
• In between these are large capillary like vessels called hepatic sinusoids
• Between these cellular columns are bile canaliculi
• These sinusoids have large gaps between their endothelial cells
• There are tissue macrophages in their walls called kupffer cells
• The portal canals have the following structures
  • A branch from the hepatic artery
  • A branch from the portal vein
  • A bile canaliculus
• Blood flows from the peripheries to the center while bile flows in the opposite direction
• A lymphatic
Functions of the liver

- Synthesis and Secretion of bile
- Metabolic functions for carbohydrates, proteins, and lipids
- Filtration of the blood from invading organisms
- Storage of glycogen, iron, and vitamins
- Excretion of end products of metabolism (through bile)
• Detoxification of poisons and ammonia
• Synthesis of plasma proteins except gamma globulins
• Hematopoiesis during intrauterine life
• Reservoir for blood
Bile

- Bile is a greenish golden alkaline juice
- The amount that enters the small intestine per day is 0.5 liter
• Bile from the gall bladder differs from that of the liver it is more concentrated and has less Ph
• Water forms 96—98% in liver bile pH 8.3
• While it forms 89% in bile from the gall bladder Ph 7.3
Composition of bile

- Bile is composed of
- Water
- Bile salts
- Bile pigments
- Phospholipids
- Cholesterol
- Electrolytes
Bile salts

• This is the important ingredient of bile
• These are the sodium and potassium salts of bile acids conjugated to glycine or taurine
• **primary** Bile acids are:
  • Cholic acid
  • Chenodeoxy cholic acid
• **Secondary**:
  • Deoxycholic
  • Lithocholic
Function of bile salts

- They facilitate fat digestion by emulsification.
- This is the breaking of a large lipid droplet into smaller ones.
• Fat absorption by **micelles** formation

• **Micelles** are cylindrical structures that contain the end product of fat digestion in their cores while their membranes are made of phospholipids and bile salts
By this micelles which are water soluble transport water insoluble substances like cholesterol fatty acids 2monoacyl glycerols to the brush border to be absorbed
• The total amount of bile salts in the body is 3—5 gms
• This pool should recirculate twice after a normal meal
• The amount synthesized by the liver per day is 200---400mg
• This means that bile salts have **entero hepatic circulation**

• Most of the bile salts are absorbed at the terminal ileum and return to the liver to be reused again
Bile pigments

• These are the end product of Hb catabolism
• They are responsible for bile color
• Unconjugated bilirubin is transported in the blood bound to albumin
• In the hepatocytes it is converted to water soluble conjugated bilirubin
• It is conjugated to glucuronic acid by the enzyme glucuronyl transferase
• Conjugated bilirubin is bilirubin diglucuronide
• Normal serum level of bilirubin is 0.5—1 mg/dl
• It is also the cause of the normal brown color of the stools
Regulation of bile secretion

- It is controlled by
- Hormonal mechanisms through
- **Choleretics:**
  - factors that increase secretion of bile from the liver and its flow within bile ducts.
  - Include secretin, vagus, gastrin.
• **Cholagauges:**
  • which causes contraction of the gall bladder and relaxation of the sphincter of Oddi
  • They include hormone CCK and vagus nerve.
Clinical correlates

• Jaundice
• Yellowish coloration of the sclerae skin mucous membranes nails

Types:
• Pre hepatic (hemolytic)
• Hepatic
• Post hepatic (obstructive)
• **Gallstones:**
  - Eg. Cholestrol stones, calcium stones
  - May obstruct pancreatic or common bile duct result in pancreatitis or obstructive jaundice
  - Surgically removed
- **Cholycystectomy:**
- Surgical removal of gall bladder.
- Not eat diet with high fat
Small Intestine

- Objectives:
  - Function of the small intestine
  - Mechanism of digestion of proteins, starches, lipids
  - Mechanisms of absorption of glucose, amino acids, fatty acids
  - Motility of the small intestine
Small Intestine

- Is the main site for digestion
  and absorption
The small intestine

- It is made of
- Duodenum.....25cm
- Jejunum and ileum ...260cm
• Jejunum is the upper ..........40%
• Ileum is the lower .............60%
• Starts from the pyloric sphincter and ends with ileocecal valve
• Its surface is increased 600 folds by the followings
  • Mucosal folds
  • Villi
  • and microvilli.
Histology of the small intestine

- The glands of the small intestine are the **crypts of Lieberkuhn** in which are the following types of cells are found
  - The **enterocytes** that contain the digestive enzymes
  - **Enterochromafin** cells that secrete GIT hormones, secreten, CCK
  - **Goblet** cells that secrete mucus
• In the duodenum there are special mucus secreting glands called
  Brunners glands (Submucosal), secrete alkaline fluid
• Lymphatics called peyer’s patches
• Secretion of the intestinal juice (succus entericus)
Succus Entericus

- is one liter per day
- Isotonic alkaline, turbid, fishy odour
- enzymes come from brush border
- life span of the enterocytes is 2—5 days
The enzymes are:
- disacharidases
- Peptidases
- Enterokinases (entropeptidases)
- nucleases
Control of intestinal secretion

- It is controlled mainly locally through neuroendocrine mechanisms.
- The presence of food is main stimulus.
- VIP (neurotransmitter) causes vasodilation, increases bicarbonate and water secretion.
- Parasympathetic stimulation and irritation increases mucus secretion.
Carbohydrates Digestion

Starts in the mouth by salivary alpha amylase
Slightly continues in the stomach
Main site is the small intestine lumen
The amylases digest polysaccharides amylopectin amylose and glycogen to glucose maltose maltotriose and alpha Limit dextrins
• Digestion is completed at the brush border by the dextrinases maltase sucrase lactase
• The end products are
  • Glucose
  • Galactose
  • fructose
• Deficiency of lactase leads to lactose malabsorption, flatulence and diarrhea due to intestinal bacteria.
• Common in Africa and Asia.
• After meal no rise of blood glucos.
Digestion of Proteins

• Starts in the stomach by pepsin
• Main site is the small intestinal lumen because of the presence of the powerful pancreatic enzymes
• Further digestion takes place in the brush border & the cytoplasm of the enterocytes
• End products are amino acids of different types
Lipid Digestion

• Starts in the mouth due to the presence of lingual lipase
• The lipases attach bonds no. 1&3 so their end products are
  • Fatty acids
  • 2 monoacylglycerols
  • Free cholesterol due to the action of cholesterol esters hydrolases
Absorption of Aminoacids

• Di-tripeptides can be absorbed readily
• Amino acids are absorbed according to their apical isomerism
• D-amino acids are absorbed passively
• L-aminoacids are absorbed by several active transport mechanisms which is Na dependent
• Amioacids in the enterocytes pass passively to the portal vein
Carbohydrates Absorption

- Glucose and Galactose absorbed actively by SGLUT1 brush border.
- Fructose absorbed by facilitated diffusion.
- Pentose sugars from digestion of nucleic acids are passively absorbed.
- Basolateral facilitated transport GLUT2.
Lipid Absorption

• Formation of micelles
• water soluble enter the unstirred water layer
• make contact with the brush border
• Monoglycerides, long chain fatty acids and cholesterol
• Enter the enterocytes by passive diffusion esterified
• To triglycerides and esterified cholesterol
• Esterified fatty acids surrounded by a layer of lipoprotein, phospholipids and cholesterol to form chylomicrons
• Enter the lymphatics to the systemic circulation through the thoracic duct
• Short chain triglycerides absorbed by 2ry active Na dependent transport
Small Intestine Movement

• basal electric rhythms (BER)

• Spontaneous cyclic waves of depolarization and repolarization

• Responsible for coordination of intestinal movements
• MMC (Interdigestive period)
• Segmentation contraction
  Number of ring like contraction
• Peristalsis
The colon (the large intestine)

- **Histology**
- The outer longitudinal layer is arranged in three bundles called teniae coli and the outpouchings between them are called haustra.
• There are no villi on the mucosa
• The colonic glands are short inward projections that secrete mucus
Motility of small intestine

- Peristalsis
- Segmentation
- Tonic contraction
Motility of the colon

• The colon shows the following types of motility
  • Peristalsis
  • Segmentation
  • Mass action contractions
  • The gastroileal reflex
Segmentation

- ring-like contractions that appear at fairly regular intervals along the gut and then disappear and are replaced by another set of ring contractions in the segments between the previous contractions
Mass action contractions

- in which there is simultaneous contraction of the smooth muscle over large confluent areas.
- These contractions move material from one portion of the colon to another.
- They also move material into the rectum, and rectal distention initiates the defecation reflex.
The gastroileal reflex

• When food leaves the stomach, the cecum relaxes and the passage of chyme through the ileocecal valve increases.
• This is presumably a vagal reflex
gastrocolic reflex

- Distention of the stomach by food initiates contractions of the rectum and, frequently, a desire to defecate.
The functions of the colon

- Absorption of sodium & water
- This leads to formation of the stool
- The absorptive capacity of the colon make rectal instillation a practical route for drug administration especially in children
- Secretion of K & HCO3 in addition to large amount of mucus
- It contains the intestinal bacteria
- The dietary fiber is concentrated
The intestinal bacteria

- The microorganisms present in the colon
Role of intestinal bacteria

- It utilizes important substances like B12, ascorbic acid & choline
- It synthesizes vitamin K, a number of the B complex & folic acid
- It produces very short chain fatty acids
- It causes the brown color of the stool through its action on bile pigments
• Formation of amines and gases
• Deconjugation of bile acids and bile pigments
The dietary fiber

- Cellulose hemicellulose & lignin in the diet are the important components of the dietary fiber.
- It is all types of ingested food that reach the colon in an essentially unchanged state.
Functions of the dietary fiber

- It forms the bulk of the stool and this increases the motility of the colon which guards against constipation
- Has a tropic effect on the mucosa of the large intestine
- It reduces the incidence of cancer of the colon, diabetes mellitus, & the coronary artery disease
Defecation is a reflex response stimulated by rectal distention.

The urge to defecate occurs when the pressure in the rectum reaches 18mm Hg while the maximum pressure that can tolerated is 55mmHg.
Control of defecation

- The parasympathetic to the internal sphincter is inhibitory while the sympathetic is excitatory.
- It relaxes when the rectum is distended.
- The nerve supply to the external sphincter skeletal muscle comes from the pudendal nerve.
Figure 26–32. Sagittal view of the anorectal area at rest (above) and during straining (below). Note the reduction of the anorectal angle and lowering of the pelvic floor during straining. (Modified and reproduced with permission from Lembo A, Camilleri, M: Chronic constipation. N Engl J Med 2003;349:1360)
• The central integrating station are the sacral segments S2-S3-S4
• The response is rectal contraction with relaxation of the internal anal sphincter (involuntary)
• Whether to relax the external anal sphincter (voluntary) or not this depends on the situation
The stool (feces)

- The stool contains inorganic material, undigested plant fiber, bacteria, and water.
- It is relatively unaffected by the type of food.
- **Water** 75% normally 200ml
- **Solids** 25%
- Percentage of the total solids
- Cellulose & others: variable
- Bacteria: 30%
- Inorganic matter (calcium phosphates): 15%
- Fats: 5%
The GIT hormones

- These are of two families
- The *gastrin family* – gastrin and cholecystokinin-pancreozymin CCK-PZ
- The *secretin family* – secretin – vasoactive intestinal peptide peptide VIP`- gastric inhibitory peptide GIP and others
• The hormone gastrin
• Secreted by the G cells in the antral mucosa
• Some G cells are present in the pancreas
• **Functions:**
  • Stimulates acid secretion by the parietal cells
  • Stimulates pancreatic secretion rich in enzymes
  • Has a tropic effect on the mucosa of the stomach and the intestine
The hormone CCK

• Secreted by the I cells in the upper small intestine

• Actions:
  • Stimulates pancreatic secretion rich in enzymes
  • Causes contraction of the gall bladder-(cholagugue) and relaxation the sphincter of Oddi
• Has a tropic effect on the mucosa of the pancreas
• Inhibits gastric secretion and motility
• In high doses causes contraction of the pyloric sphincter and the lower esophageal one
• Augments the action of secretin
The hormone secretin

- It is the first hormone discovered in 1902
- Secreted by S cells in the intestine
- **Functions:**
  - Stimulates pancreatic secretion rich in bicarbonate
  - Stimulates bile synthesis and flow
  - Inhibits gastric secretion and emptying
  - Stimulates insulin secretion
  - In high doses causes contraction of the pyloric and the lower esophageal sphincters
GIP & VIP

- Gastric inhibitory peptide (GIP) is secreted by K cells
- Its main action is stimulation of insulin secretion so it is called glucose dependant insulinotropic polypeptide
- Vasoactive intestinal peptide (VIP)
- Its main action is smooth muscle relaxant
DIGESTION AND ABSORPTION
Carbohydrates Digestion and absorption

• Types of CHO in diet:
• Monosaccharides:
• glucose
• fructose, and
• galactose)
• **Disaccharides:**
  - Maltose (2 glucose)
  - Sucrose (glucose + fructose)
  - Lactose (glucose + galactose)
• Polysaccharides:
  • Starch
  • Derivatives of starch (amylose, amylopectin)
  • glycogen
Carbohydrates Digestion

- Starts in the mouth by salivary alpha amylase
- Slightly continues in the stomach
- Main site is the small intestine lumen
The amylases digest polysaccharides (amylopectin, amylose) and glycogen to:

- glucose,
- maltose,
- Maltotriose and
- alpha dextrins
• Digestion is completed at the brush border by the dextrinases, maltase, sucrase, lactase.
• The end products are
  • Glucose
  • Galactose
  • Fructose
Carbohydrates absorption

- 100% absorbed
- Only for monosaccharides.
• glucose is absorbed by secondary active transport sodium dependant
• In the apical membranes by SGLT1&2
• In the basolateral membranes by GLUT2
• Galactose consume the same mechanism as glucose
• Fructose absorption is sodium independent by facilitated diffusion
Protein digestion

• Starts in the **stomach** by pepsin, renin.
• Main site is the **small intestinal** lumen because of the presence of the powerful pancreatic enzymes
• Endopeptidases (trypsin, chymotrypsin, and elastase)
• Exopeptidase (caboxypeptidase A, B)
• Further digestion takes place in the brush border & the cytoplasm of the enterocytes by
• Aminoptidase, caroxyptidase, endoptidase, and dipeptidase
• End products are amino acids of different types
Protein absorption

- 95-98% absorbed
- Amino acids (cotransported with Na)
- Di, and tripeptidase (by a mechanism involving a H ion)
- Complete proteins (endocytosis)
Lipid digestion

- Starts in the mouth due to the presence of lingual lipase
- Stomach (gastric lipase)
- The main site is the small intestine lumen:
• From pancreas:
• lipase,
• co-lipase
• Cholestrol ester hydrolase
• Bile salt activated lipase
• From the liver:
• Bile salts, which cause emulsification and micelle formation
• The end products are:
• Fatty acids
• 2 monoacylglycerols
• Free cholesterol
Fat absorption

- This depends on the type of fatty acid
- **Short chain** fatty acids containing less than 10—12 carbon atoms cross both the apical and the basolateral membranes by simple diffusion enter the blood directly and circulate as free fatty acids
**Long chain** fatty acids containing more than 10—12 carbon atoms are reesterified in the cytoplasm of the enterocytes with 2 monoacylglycerols to form triglycerides to which cholesterol esters is added and it is covered by a layer of protein and phospholipids to form chylomicrons.
• **Chylomicrons** leave the cells through the process of exocytosis and enter the lymphatics because these are large molecules.

• Enter the blood indirectly through the thoracic duct.