Chapter 24: The Digestive System

Chapter Objectives

OVERVIEW OF THE DIGESTIVE SYSTEM
1. Identify the organs of the gastrointestinal tract and the accessory organs of digestion.
2. List and define the six primary processes of digestion performed by the gastrointestinal tract.

LAYERS OF THE GI TRACT
3. Name the four basic tissue layers of the GI tract that are commonly found from the stomach to the anus.
4. Discuss the characteristic structure and duties of the epithelial, lamina propria, and muscularis mucosae layers of the mucosa.
5. Describe the structures of the submucosal layer.
6. Describe the muscle changes and layers through the extent of the GI tract.
7. Describe the serosa as a part of the peritoneum.

NEURAL INNERVATION OF THE GI TRACT
8. Describe the enteric nervous system in terms of plexuses and innervation of the various organs.
9. Describe the role that ENS and ANS neurons play in the GI tract functions.

PERITONEUM
10. List the components of the peritoneal serosal membrane and the structures that the peritoneum forms in the abdominal cavity.

MOUTH
11. Discuss the function of the parts of the mouth.
12. Examine the general construction of the tongue.
13. Specify the properties of each layer of the tooth structure.
14. Describe tooth shapes and functions and the number of teeth that are found in the two dentitions.
15. Describe the secretory output of the salivary glands.
16. Discuss the chemical and enzymatic constituents of saliva and their actions on ingested food.
17. Discuss the factors that control salivation.

PHARYNX
18. Describe the location, the regions and the function of the pharynx.
19. List the three stages of swallowing (deglutition).
ESOPHAGUS
20. Describe the location of the esophagus.
21. Describe the tissue composition for changes in the epithelium, submucosa, muscularis, and serosa from the top of the esophagus to the merger with the stomach.
22. Describe peristalsis.

STOMACH
23. List the cells of gastric glands and the products secreted from each cell type.
24. Describe the functions of gastrin.
25. Describe the progressive mixing movements, which are produced by the stomach muscularis, which prepare and eject chyme through the pyloric sphincter.
26. Explain the function of the acid and enzymes of the stomach in the initial breakdown of proteins and lipids during digestion.
27. Name some substances that are absorbed into the blood from the stomach.

PHASES OF DIGESTION
28. Discuss how the perception of food results in production of particular gastric secretions and motility (Cephalic phase).
29. Illustrate the operation of each neural and hormonal component in the negative feedback regulation of gastric secretion (Gastric phase).
30. Discuss the reasons for the responses and actions of each enteric hormone and the enterogastric reflex in control of acid and enzyme secretion and mixing movements of the stomach (Intestinal phase).
31. Discuss the other small intestine hormones and their roles in the digestive system.

PANCREAS
32. Describe the form and secretions of the exocrine and endocrine cell clusters within the pancreas.
33. Discuss the chemical components and list the enzymes present in pancreatic juice.
34. Describe why pancreatic enzymes are secreted in an inactive form and how they are activated.
35. Discuss the types of nutrients that are digested by the pancreatic enzymes and the pH environment that is necessary for their function.
36. List the hormones that regulate pancreatic juice secretion.

LIVER AND GALLBLADDER
37. Describe the anatomy of the liver and gall bladder.
38. Describe the cellular, vascular, and duct arrangements and duties of the liver lobule.
39. Describe the network of arteries and portal veins that contribute to the blood flow into the sinusoids and then merge into the central and hepatic veins.

40. Describe the components of bile, its general function, and the hormones that control its secretion.

41. Discuss the functions of the liver in carbohydrate, lipid and protein metabolism and the liver’s other functions.

**SMALL INTESTINE**

42. Describe the three structures that increase the total surface area of the small intestine.

43. Discuss the mechanical actions of smooth muscle in production of segmentation and peristaltic movements that mix and propel the food within the small intestine.

44. List the enzymes responsible for chemical digestion in the small intestine and what they will digest. Indicate if the enzyme is a pancreatic enzyme or a brush border enzyme.

45. Describe the end products of chemical digestion of carbohydrates, proteins, and lipids.

46. Discuss the transport mechanisms that are responsible for movement of different monosaccharides from the intestinal lumen into the epithelial cell and then into capillaries.

47. Explain the ways the transport of different amino acids is related to active processes.

48. Discuss the sequence of processes that perform absorption of fatty materials, from the interacations with lipase enzymes and bile to form micelles to the construction of chylomicrons and transport in the lacteal capillaries.

49. Discuss the regulated active and passive means by which ions are transported into the blood from the intestines.

50. Explain how vitamins move into the blood via methods that are related to their water or lipid soluble nature.

51. Describe the locations and volumes of water entry into the GI tract, and then the reabsorption by osmosis established by nutrient and electrolyte movements.

**LARGE INTESTINE**

52. List the cell types in the large intestine and their functions.

53. Describe the mechanical movements that occur in the large intestine.

54. Explain the role of bacteria in the final degradation of food substances, and the absorption of the last substrates and particular vitamins.

55. Discuss the processes involved in the absorption of the remaining water and electrolytes and the formation of feces.
56. Establish the interactions between the stretch receptors of the rectum and reflexive responses of the internal and external anal sphincters that promote expulsion of feces at a consciously selected time.

**Chapter Lecture Notes**

**Overview of Digestive System Organs**

**Gastrointestinal tract (Fig 24.1)**

- Mouth
- Pharynx and esophagus
- Stomach
- Small intestine
- Large intestine
- Rectum and anus

**Accessory structures**

- Teeth
- Tongue
- Salivary glands
- Liver
- Gallbladder
- Pancreas

**Digestion**

Digestion includes six basic processes

- **Ingestion** - taking food into the mouth (eating)
- **Secretion** - release of water, acid, buffers, and enzymes into the lumen of the tract by cells within the walls of the GI tract and accessory organs
- **Mixing and propulsion** - alternating contraction and relaxation of the smooth muscles within the walls of the GI tract
Digestion

Mechanical digestion - movements of the GI tract that aid chemical digestion

Chemical digestion – a series of catabolic (hydrolysis) reactions that break down large carbohydrate, lipid, and protein food molecules into smaller molecules that are usable by body cells

Absorption - the passage of end products of digestion from the GI tract into blood or lymph for distribution to cells

Defecation - emptying of the rectum, eliminating indigestible substances from the GI tract

Layers of the GI Tract

The basic arrangement of layers in the gastrointestinal tract from the inside outward (Fig. 24.2)

1. Mucosal layer
2. Submucosal layer
3. Muscularis layer
4. Serosa layer

Mucosal Layer

Epithelium

Nonkeratinized stratified squamous (in mouth, esophagus & anus) = tough simple columnar in the rest

secretes enzymes and absorbs nutrients

specialized cells (goblet) secrete mucus onto cell surfaces

enteroendocrine cells - secrete hormones controlling organ function

Lamina propria

thin layer of areolar connective tissue

contains blood vessels and mucosa associated lymphatic tissue

Muscularis mucosae - thin layer of smooth muscle

causes folds to form in mucosal layer
increases local movements increasing absorption with exposure to “new” nutrients

Submucosa

Aerolar connective tissue
contains blood vessels, glands and lymphatic tissue

Meissner’s (submucosal) plexus
parasympathetic
vasoconstriction
local movement by muscularis mucosae smooth muscle
innervates secretory cells of mucosal glands

Muscularis externa

Skeletal muscle = voluntary control
in mouth, pharynx, upper esophagus and anus
control over swallowing and defecation

Smooth muscle = involuntary control
inner circular fibers & outer longitudinal fibers
mixes, crushes & propels food along by peristalsis

Auerbach’s plexus (myenteric)
both parasympathetic & sympathetic innervation of circular and longitudinal smooth muscle layers

Serosa
The visceral layer of the peritoneum, a serous membrane
Consists of areolar connective tissue covered with simple squamous epithelium
Secretes slippery fluid

Enteric Nervous System

ENS - neurons that extend from the esophagus to the gut (Fig 24.3)
has motor neurons, interneurons, and sensory neurons
myenteric plexus and the submucosal plexus are part of ENS

myenteric neurons control motility (mixing and propulsion)

submucosal neurons control secretion

Can function independently of the CNS

**Autonomic Nervous System Control of GI Tract**

Parasympathetic (Vagus nerve (X)) - synapse with neurons in the ENS and increase their action

Sympathetic - inhibits the ENS neurons

**Peritoneum**

**Peritoneum**

- visceral layer covers organs - serosa
- parietal layer lines the walls of body cavity

**Peritoneal cavity**

- potential space containing a bit of serous fluid

**Parts of the Peritoneum** (Fig 24.4)

- Greater omentum – drapes over the large and small intestine
- Falciform ligament – divides right and left lobes of the liver
- Lesser omentum – between stomach and liver

**Peritoneum**

- Mesentery – binds small intestine to the abdominal wall
- Mesocolon – binds parts of the large intestine to the abdominal wall

**Digestion in the Mouth** (Table 24.1)

**Mouth**

- site of ingestion
- mechanical digestion by chewing with teeth
- site of beginning of chemical digestion of carbohydrates

**Tongue** (Fig 24.5)
Skeletal muscle covered with mucous membrane

Muscles permit the tongue to be moved to participate in food manipulation for chewing and swallowing and in speech

The upper surface and sides of the tongue are covered with papillae. Some papillae contain taste buds.

Under the tongue are glands that secrete lingual lipase begins breakdown of triglycerides into fatty acids and glycerol

Teeth (Fig 24.7)

The teeth are adapted for mechanical digestion mastication or chewing - breaks food into pieces

Parts of teeth

crown
neck
roots
pulp cavity

Types of teeth and their function

incisors for biting
canines or cuspids for tearing
premolars & molars for crushing and grinding food

Composition of teeth

Enamel
hardest substance in body
calcium phosphate or carbonate

Dentin
calcified connective tissue

Cementum
There are two dentitions, or sets of teeth (Fig 24.8)

Deciduous (primary) or baby teeth
- 20 teeth that start erupting at 6 months
- 1 new pair of teeth per month

Permanent (secondary) teeth
- 32 teeth that erupt between 6 and 12 years of age

Salivary glands (Fig 24.6)
- Lie outside the mouth and pour their contents into ducts that empty into the oral cavity
- Mumps is an inflammation and enlargement of the parotid salivary glands

Saliva – secreted by salivary glands
- Salivation is entirely under nervous control
  - Parasympathetic – increases salivation
    - sight, smell, sounds, memory of food, tongue stimulation
    - cerebral cortex signals the salivatory nuclei in brainstem - (CN 7 & 9)
  - Sympathetic – decreases salivation
    - dry mouth when you are afraid

Composition
- 99.5% water
- 0.5% solutes such as salts, dissolved gases, various organic substances, and enzymes

Functions of saliva
- Wet food for easier swallowing
  - Mixes with chewed food to form bolus
- Dissolves food for tasting
- Protects mouth from infection with its rinsing action - 1 to 1 and 1/2qts/day
Enzyme (lysozyme) - helps destroy bacteria

Bicarbonate ions buffer acidic foods

Chemical digestion of starch begins with the enzyme, salivary amylase

  begins starch digestion at pH of 6.5 or 7.0 found in mouth

  when bolus & enzyme hit the pH 2.5 gastric juices hydrolysis ceases

    Pharynx and Esophagus (Table 24.2)

Pharynx

  Funnel-shaped tube extending from internal nares to the esophagus (posteriorly) and larynx

    (anteriorly)

  Skeletal muscle lined by mucous membrane

  The nasopharynx functions in respiration only, whereas the oropharynx and laryngopharynx have digestive as well as respiratory functions

Esophagus

  Collapsed muscular tube that connects the pharynx to the stomach

  Pierces the diaphragm at hiatus

    hiatal hernia or diaphragmatic hernia – leads to gastric reflux or heartburn

  The role of the esophagus is to secrete mucus and transport food to the stomach

Histology of the esophagus (Fig 24.9)

  Mucosa – nonkeratinized stratified squamous epithelium

  Submucosa – aerolar connective tissue with large mucous glands

  Muscularis - upper 1/3 is skeletal, middle is mixed, lower 1/3 is smooth

    upper & lower esophageal sphincters are prominent circular muscle

    Adventitia - connective tissue blending with surrounding connective tissue - no serosa

Deglutition or swallowing is facilitated by saliva and mucus (Fig 24.10)

  voluntary stage – movement of bolus to oropharynx by the movement of the tongue

  pharyngeal stage (involuntary)
nasopharynx closed by uvula and soft palate
epiglottis closes opening to larynx
bolus moves through oropharynx and laryngopharynx
upper esophageal sphincter relaxes

esophageal stage
Peristalsis pushes food down
circular fibers behind bolus contract pushing it down
longitudinal fibers in front of bolus contract and shorten the distance of travel
peristalsis is the method that pushes food through all of the digestive tract not just the esophagus

Digestion in the Stomach
begins the digestion of proteins  (Fig 24.11)
continues the digestion of triglycerides
serves as a mixing and holding area for food
converts a bolus to a liquid called chyme
absorbs some substances

Gastric gland secretion
Mucous neck cells (Fig 24.12)
secretes mucus - protects lining of stomach from being digested by acid and pepsin

Chief or zymogenic cells
secretes pepsinogen – inactive form of pepsin, a protease (an enzyme that digests proteins)
secretes gastric lipase – an enzyme that breaks down triglycerides into glycerol and fatty acids

Parietal cells (Fig 24.13 & 24.14)
secretes HCl – helps breakdown food by nonspecific acid attack
secretes intrinsic factor - promotes absorption of vitamin B12 for RBC production

G cells

secrete gastrin, a hormone, into the bloodstream, not the stomach lumen

“get it out of here”

release more gastric juice (HCl and pepsinogen)

increase gastric motility

relax pyloric sphincter

constrict lower esophageal sphincter preventing entry to stomach

Mechanical digestion - peristaltic movements called mixing waves

Gentle mixing waves

every 15 to 25 seconds

mixes bolus with 2 quarts/day of gastric juice to turn it into chyme (a thin liquid)

More vigorous waves

travel from body of stomach to pyloric region

Intense waves near the pylorus

open it and squirt out 1-2 teaspoons full with each wave

Chemical Digestion (Table 24.3)

conversion of proteins into peptides by pepsin

most effective in the very acidic environment (pH = 2) of the stomach

milk triglycerides converted into fatty acids and monoglycerides

has a limited role in the adult stomach

HCl kills microbes in food

Absorption in the stomach

impermeable to most substances

limited absorption of

water
electrolytes
certain drugs (especially aspirin)
alcohol

Regulation of Gastric Secretion and Motility

Cephalic phase - prepares the mouth and stomach for food that is about to be eaten

Initiated by sensory receptors in the head

Cerebral cortex - sight, smell, taste & thought of food

Stimulate parasympathetic nervous system

The facial and glossopharyngeal nerves stimulate the salivary glands to produce saliva

Vagus nerve increases stomach muscle and glandular activity

Gastric Phase - “Stomach Working”

Nervous control (Fig 24.24)

stretch receptors & chemoreceptors provide sensory information

ENS stimulates continued vigorous peristalsis and gastric glandular secretions

at end, chyme is released into the duodenum

Hormonal control

distention and presence of caffeine or protein cause G cells secretion of gastrin into bloodstream

gastrin increases stomach glandular secretion of pepsin and HCl

gastrin increases stomach churning

gastrin relaxes the pyloric sphincter

Intestinal phase

Begins when food enters the small intestine

Nervous control

stretch receptors, fatty acids or sugar signals medulla

sympathetic nerves slow stomach activity & increase intestinal activity
enterogastric reflex inhibits gastric motility and increases the contraction of the pyloric sphincter to decrease gastric emptying

Hormonal control – hormones from small intestine (Table 24.8)

secretin
  stimulates the flow of pancreatic juice rich in bicarbonate
  inhibits the secretion of gastric juice
cholecystokinin (CCK)
  decreases stomach emptying
  stimulates the secretion of pancreatic juice rich in digestive enzymes
  increases the flow of bile
gastric inhibitory peptide (GIP)
  decreases stomach secretions, motility & emptying

Pancreas

Pancreas – has both endocrine function and digestive function (exocrine) (Fig 24.14)

Islets of Langerhans (pancreatic islets) - endocrine
  1% of gland
  pale staining cells
  produce hormones – insulin and glucagon
pancreatic acini – exocrine
  99% of gland
  dark cell clusters
  produce pancreatic juice

Pancreatic juice
  water
  sodium bicarbonate
  converts the acidic stomach contents to a slightly alkaline pH (7.1-8.2)
halts stomach pepsin activity
promotes activity of pancreatic enzymes

pancreatic enzymes (Table 24.5)

pancreatic amylase – continues breakdown of starch (carbohydrate) into glucose
pancreatic lipase – breakdown of triglycerides into fatty acids and glycerol
ribonuclease and deoxyribonuclease – digest RNA and DNA (nucleic acids)
proteases – breakdown of proteins

secreted in inactive form so that they don’t digest the pancreas

trypsinogen – active form, trypsin

activated by enterokinase (a brush border (small intestine) enzyme)

trypsin inhibitor - combines with any trypsin produced inside pancreas to limit
damage to pancreas

digests most proteins

chymotrypsinogen – active form, chymotrypsin

activated by trypsin
digests on most proteins

procarboxypeptidase – active form, carboxypeptidase

activated by trypsin
digests amino acids from one end, carboxy end, of a protein

Proelastase – active form, elastase

activated by trypsin
digests elastic fibers in connective tissue

Regulation of pancreatic secretions

Gastric inhibitory peptide (GIP)
fatty acids & sugar in small intestine causes increased insulin release

Secretin
acidity in duodenum causes increased sodium bicarbonate release

Cholecystokinin (CCK)

fats and proteins in duodenum causes increased digestive pancreatic enzyme release

Liver and Gallbladder

Liver – large organ inferior to diaphragm that has many functions in digestion and metabolism

Gallbladder – a sac located in a depression on the posterior surface of the liver

storage facility for bile

Histology of the Liver (Fig 24.15)

Hepatocytes (liver cells) are arranged around a central vein in lobules

Sinusoids (blood-filled spaces) are in between hepatocytes

Kupffer cells (Stellate reticuloendothelial cells) – fixed macrophage located in sinusoids

phagocytize microbes & foreign matter

Hepatocytes make bile which passes into bile canaliculi to bile ducts

From bile ducts, bile passes to the right and left hepatic ducts which unite to form the common hepatic duct

Common hepatic duct joins the cystic duct from the gallbladder to form the common bile duct which enters the hepatopancreatic ampulla (ampulla of Vater) (Fig 24.14)

Blood supply to liver (Fig 24.16)

Blood coming to the liver

hepatic artery – branch of abdominal aorta

hepatic portal vein – nutrient rich blood from stomach, spleen & intestines

Blood leaving the liver

hepatic vein – joins inferior vena cava

Liver Functions

Bile – produced by hepatocytes

yellow-green in color
pH 7.6 to 8.6

components

  water

  cholesterol

  bile salts - Na & K salts of bile acids

  bile pigments - bilirubin from hemoglobin breakdown

bile function - emulsification of triglycerides

  separating triglyceride groups into smaller particles

bile secretion is regulated by the parasympathetic nervous system, secretin and CCK

Carbohydrate Metabolism

  can turn proteins into glucose

  can turn triglycerides into glucose

  can turn excess glucose into glycogen & store in the liver

  can turn stored glycogen back into glucose as needed

Lipid Metabolism

  can synthesize cholesterol

  can synthesize lipoproteins - HDL and LDL (used to transport fatty acids in bloodstream)

  can stores some fat

  can break down some fatty acids

Protein Metabolism

  can convert one amino acid into another

  can deaminate amino acids - removes NH2 (amine group) from amino acids so can use what is left as energy source

  can convert toxic ammonia (NH3) produced by deamination into urea for excretion by the kidney

  can synthesizes plasma proteins utilized in the clotting mechanism and immune system
Other Liver Functions

Detoxifies the blood by removing or altering drugs & hormones (thyroid & estrogen)
Stores fat soluble vitamins - A, B12, D, E, K
Stores iron and copper
Phagocytizes worn out blood cells & bacteria
Activates vitamin D (the skin can also do this with 1 hr of sunlight a week)

Small Intestine

Location of the majority of the absorption of the digestive system

Internal anatomy has a large surface area for absorption (Fig 24.17 & Fig 24.18 & 24.19)

plica circularis
permanent folds that contain part of submucosal layer
not found in lower ileum

villi
Core is lamina propria of mucosal layer
Contains vascular capillaries and lacteals (lymphatic capillaries)

microvilli
cell surface feature known as brush border

Mechanical Digestion in the Small Intestine

Weak peristalsis in comparison to the stomach - chyme remains for 3 to 5 hours
Segmentation - local mixing of chyme with intestinal juices - sloshing back & forth

Chemical Digestion in the Small Intestine (Table 24.4)

Carbohydrates are broken down into monosaccharides for absorption
pancreatic amylase - break down starches into maltose, maltotriose, and alpha-dextrins
brush border enzymes
alphadestrinase - alpha-dextrins into glucose
maltase - maltose to glucose
sucrase - sucrose to glucose and fructose
lactase - lactose to glucose and galactose

Proteins are broken down into amino acids for absorption
pancreatic peptidases - split peptide bonds between different amino acids
brush border enzymes
aminopeptidase - break peptide bonds that attach terminal amino acids to amino ends of peptides
dipeptidase - split dipeptides to amino acids

Most lipid digestion, in an adult, occurs in the small intestine
emulsification by bile of globules of triglycerides
pancreatic lipase - splits triglycerides into monoglycerides, fatty acids & glycerol

Nucleic acids are broken down into nucleotides and nucleotide parts for absorption
Pancreatic nucleases digest DNA and RNA to nucleotides
brush border enzymes
nucleosidease – breaks apart nucleotides into pentose, phosphate & nitrogenous bases
phosphatase – removes phosphate group from nucleotide

Absorption in the Small Intestine (Fig 24.20)

Carbohydrate absorption - absorbed into blood capillaries as monosaccharides
Absorption into epithelial cell
  glucose & galactose – sodium symporter (active transport)
  Fructose - facilitated diffusion
Movement out of epithelial cell into bloodstream is by facilitated diffusion
Protein absorption - absorbed into the blood capillaries as amino acids
Absorption into epithelial cell by active transport with Na+ or H+ ions (symporters)
Movement out of epithelial cell into blood by facilitated diffusion

Absorption of Lipids
Small fatty acids enter cells & then blood by simple diffusion
Larger lipids exist only within bile salts coated micelles
Lipids enter cells by simple diffusion leaving bile salts behind in gut
Bile salts reabsorbed into blood & reformed into bile in the liver
Fat-soluble vitamins enter cells since were within micelles
Inside epithelial cells, fats are combined with proteins to form chylomicrons
Chylomicrons leave intestinal cells by exocytosis into a lacteal
  travel in lymphatic system to reach veins near the heart
  removed from the blood by the liver and fat tissue
In the liver, the lipids are combined with protein transporters called lipoproteins to make
  them soluble so that they can be transported in blood and utilized by body cells
Absorption of Electrolytes
  some from digested foods and liquids and some from gastrointestinal secretions
Enter epithelial cells by diffusion & secondary active transport
  sodium & potassium - \( \text{Na}^+/\text{K}^+ \) pumps (active transport)
  chloride, iodide and nitrate - passively follow
  iron, magnesium & phosphate ions - active transport
  Intestinal \( \text{Ca}^{2+} \) absorption requires vitamin D & parathyroid hormone
Absorption of Vitamins
  Fat-soluble vitamins (A, D, E, and K) are absorbed along with ingested dietary lipids
    travel in micelles & are absorbed by simple diffusion
  Water-soluble vitamins (B and C)
    absorbed by diffusion
  \( \text{B}_{12} \) combines with intrinsic factor before it is transported into the cells
    receptor mediated endocytosis
Water absorption - osmosis from the lumen of the intestines through epithelial cells and into blood capillaries (Fig 24.21)

absorption of water depends on the absorption of electrolytes and nutrients to maintain an osmotic balance with the blood

Large Intestine

Large Intestine (Fig 24.22)

the mucosa has no villi or permanent circular folds

epithelium is a simple columnar epithelium

absorptive cells - absorb mostly water

goblet cells - secrete mucus

Mechanical Digestion in Large Intestine

Mechanical movements in Large intestine

Peristaltic waves – 3-12 contraction per minute

haustral churning - relaxed pouches are filled from below by muscular contractions (elevator)

mass peristalsis – strong peristalsis wave that contents of large intestine into the rectum

Digestive reflexes

gastroilial reflex - when stomach is full, gastrin relaxes ileocecal sphincter so small intestine will empty into large intestine making room in the small intestine for new material from the stomach

gastrocolic reflex - when stomach fills, a strong mass peristaltic wave moves contents of transverse colon into rectum

Chemical Digestion in Large Intestine

No enzymes are secreted only mucous

Bacteria ferment

undigested carbohydrates into carbon dioxide & methane gas

undigested proteins into simpler substances (indoles) – odor
turn bilirubin into simpler substances that produce color

Bacteria produce vitamin K and some B vitamins in colon

Absorption and Feces Formation in the Large Intestine

Absorbs water, electrolytes, and some vitamins (Table 24.6)

Feces - water, inorganic salts, sloughed-off epithelial cells, bacteria, products of bacterial decomposition, and undigested parts of food

Although most water absorption occurs in the small intestine, the large intestine absorbs enough to make it an important organ in maintaining the body’s water balance

Defecation Reflex

Defecation - elimination of feces from the rectum (Fig 24.22)

Gastrocolic reflex moves feces into rectum

Stretch receptors signal sacral spinal cord

Parasympathetic nerves contract muscles of rectum & relax internal anal sphincter

External sphincter is voluntarily controlled to allow or postpone defecation

Aided by voluntary contractions of the diaphragm and abdominal muscles