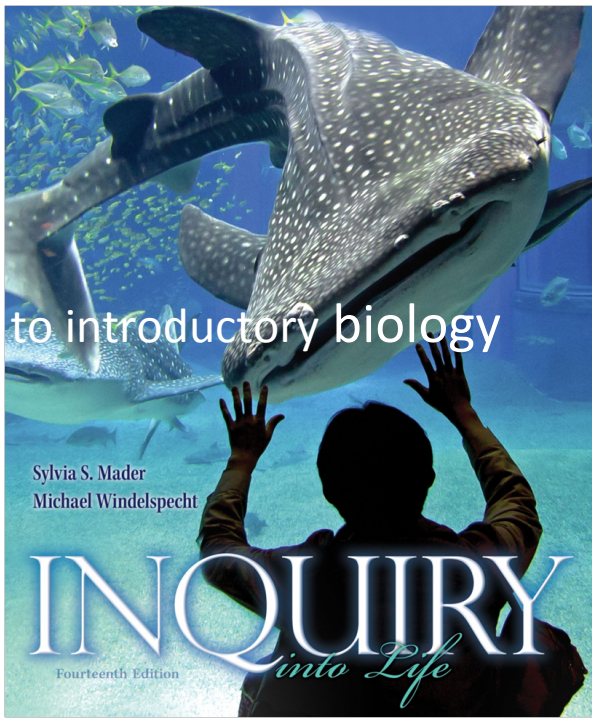
Fundamental Biology
BI 1101

an interdisciplinary approach to introductory biology



Anggraini Barlian,
Iriawati
Tjandra Anggraeni
SITH-ITB

Five Levels of Organization

Molecular

Cellular

Organismal

Population

Ecological System

Learning outcomes

After this lecture, you should be able to:

- Describe systematically the digestive tract and the process in each part.
- Explain the function of digestive glands
- Explain the correlation between disorder or diseases in digestive tract with the concept of structure and function of each part of digestive tract and digestive glands

ANIMAL STRUCTURE & FUNCTION

DIGESTIVE SYSTEM AND NUTRITION

Introduction: *Getting Their Fill of Krill*

- A 72-ton humpback whale eats small fishes and crustaceans called krill
- A whale's digestive system may process up to 2 tons of krill a day

Introduction: *Getting Their Fill of Krill*

- Humpback whales strain krill from seawater using large plates, called baleen
  - Whales take a large gulp of water into their throat
  - As they force water out, it is strained through baleen plates that hang from the upper jaw
- Humpback whales create a net of bubbles to concentrate the krill

OBTAINING AND PROCESSING FOOD

Animals ingest their food in a variety of ways

- Most animals have one of three kinds of diets
  - **Herbivores**, plant-eaters—cattle, snails, sea urchins
  - **Carnivores**, meat-eaters—lions, hawks, spiders
  - **Omnivores**, eating both plants and other animals—humans, roaches, raccoons, crows

Animals ingest their food in a variety of ways

Animals obtain and ingest their food in different ways

- Suspension feeding
- Substrate feeding
- Fluid feeding
- Bulk feeding

Introduction

- All animals must eat to provide
  - energy and
  - the building blocks used to assemble new molecules.
- Animals also need essential
  - vitamins and
  - minerals.

THE HUMAN DIGESTIVE SYSTEM

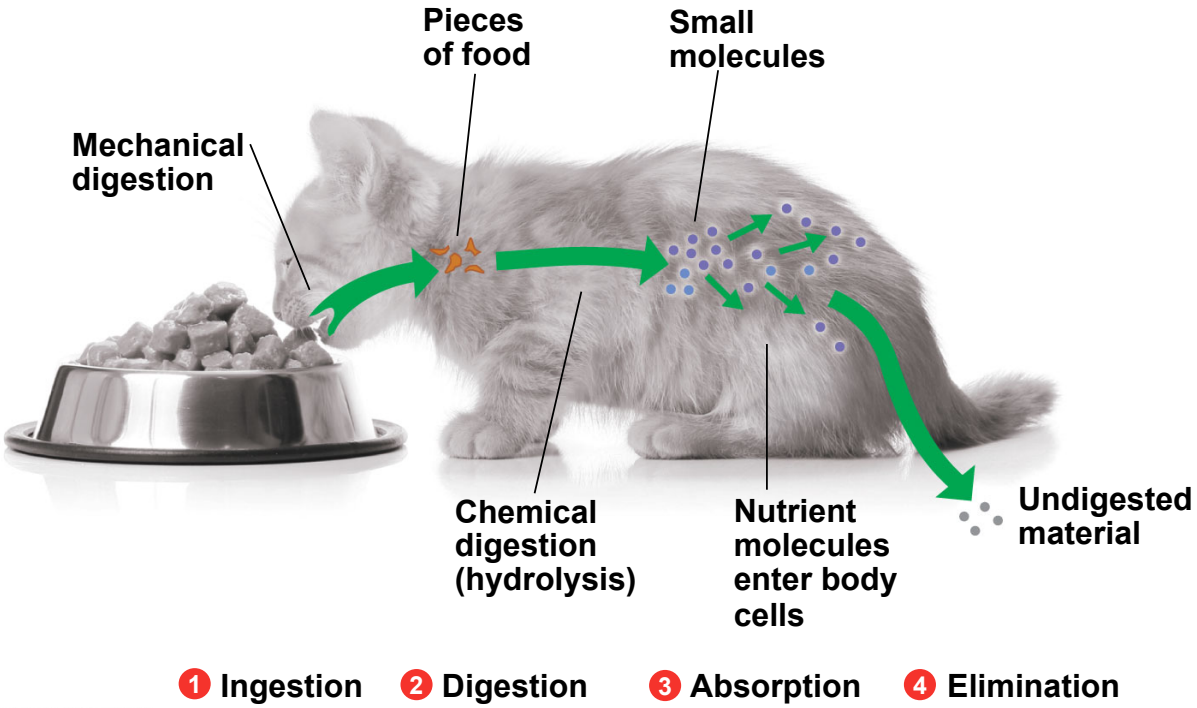
Food processing occurs in four stages

- Food is processed in four stages.
  1. **Ingestion** is the act of eating.
  2. **Digestion** is the breaking down of food into molecules **small** enough for the body to absorb.
     - *Remember*: biomolecule → subunits by hydrolysis
  3. **Absorption** is the take-up of the products of digestion, usually by the cells lining the digestive tract.
  4. **Elimination** is the removal of undigested materials out of the digestive tract.

Mechanical digestion = mechanical breakdown of large → small food particles

•Just a physical change in material!!

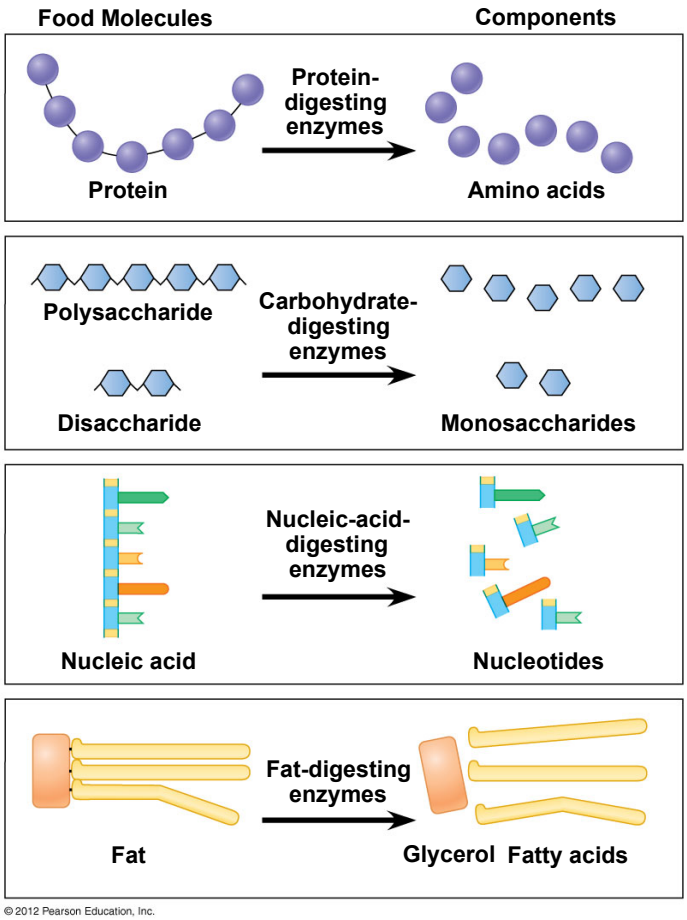
•Increases ***surface area*** of food particles for chemical digestion



Chemical digestion

•***Hydrolysis*** of covalent bonds within molecules

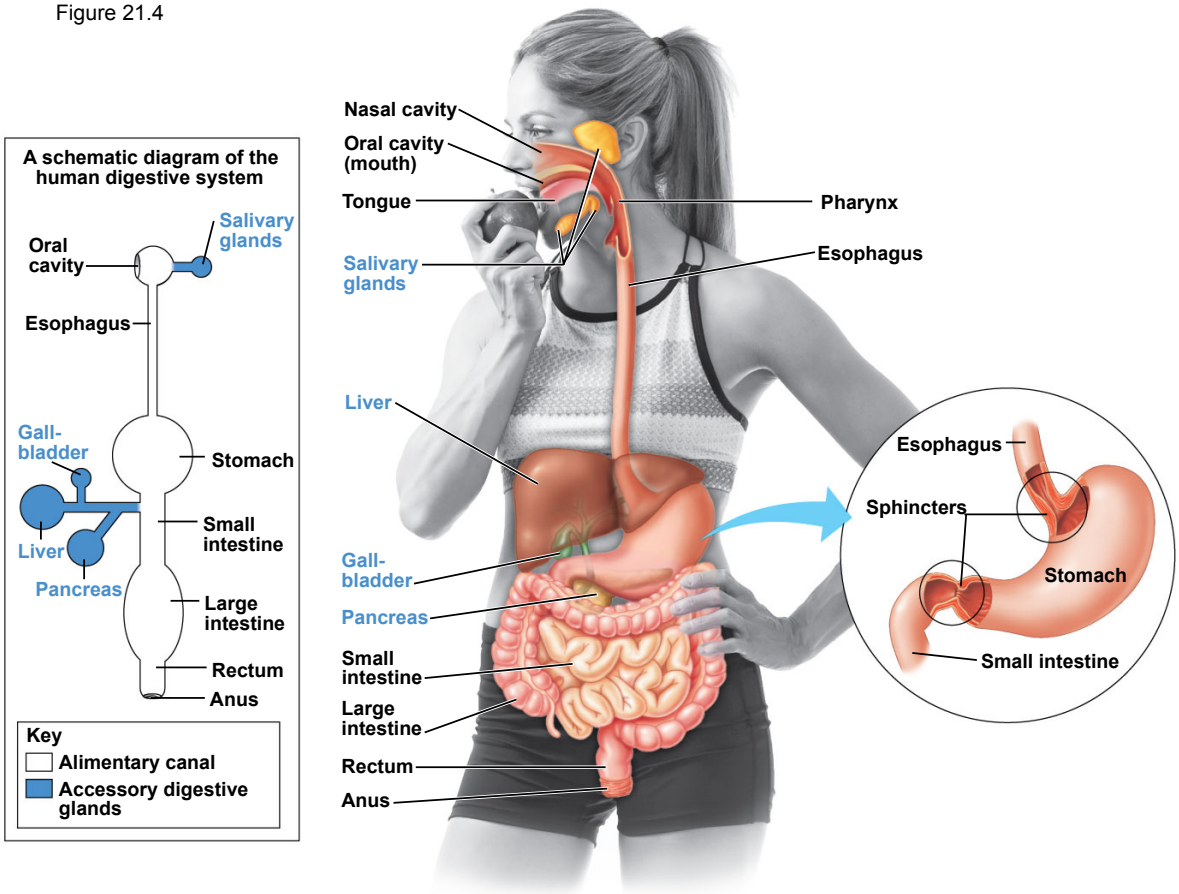
•Requires enzyme to catalyze these events



The Digestive Tract

- Digestion involves two processes.
  - **Mechanical digestion**
    - Begins with the chewing of food in the mouth
    - Continues with the churning and mixing of food in the stomach
  - **Chemical digestion**
    - Enzymes break down macromolecules into smaller molecules that can be absorbed

Figure 21.4



The Digestive Tract

- Organs of the human digestive tract

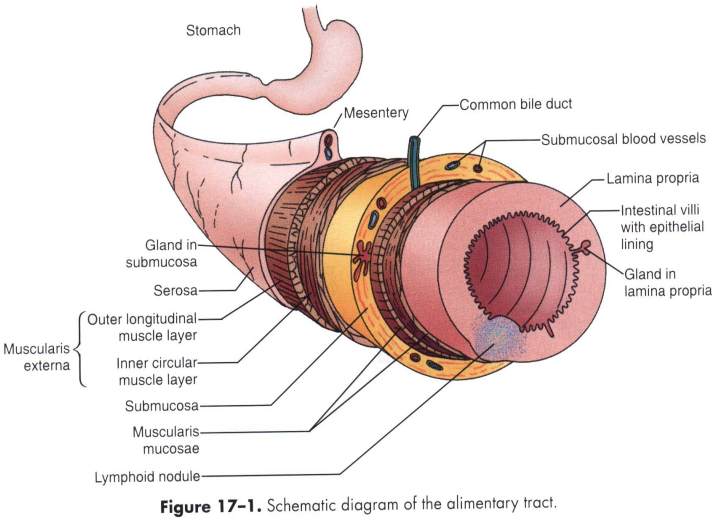


Figure 17–1. Schematic diagram of the alimentary tract.

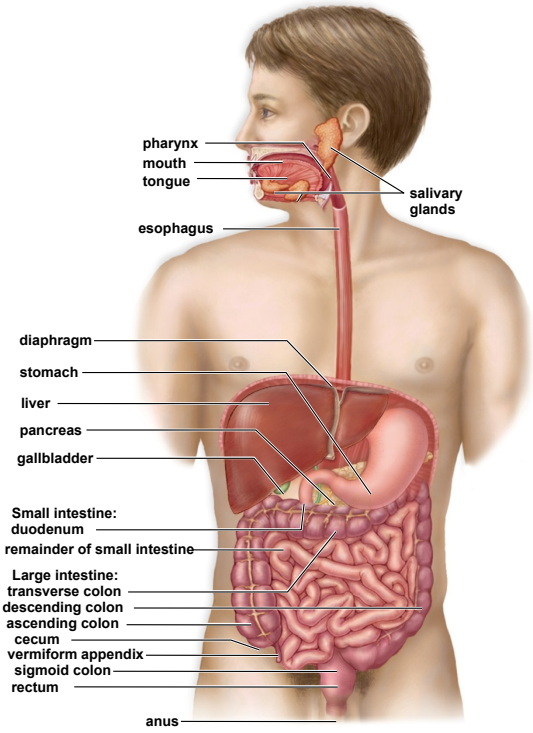


Figure 14.1

Mouth

- pH = 7
- Mechanical digestion
  - Chewing cuts, smashes, and grinds food, making it easier to swallow.
- Chemical digestion
  - Saliva releases ***salivary amylase***
    - Polysaccharides + H_2O → mono and disaccharides

The Mouth

- The mouth, which ingests food, is bounded externally by the lips and cheeks.
  - **The tongue**
    - Comprised of skeletal muscles to change shape of the tongue
    - Taste buds are sensory receptors that allow people to enjoy eating by taste and texture

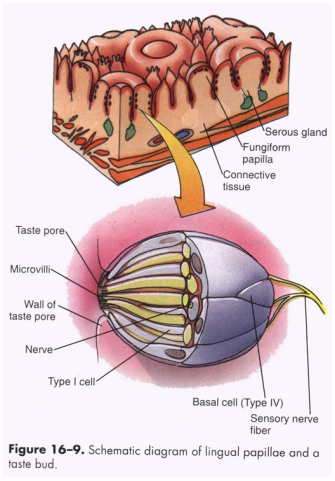
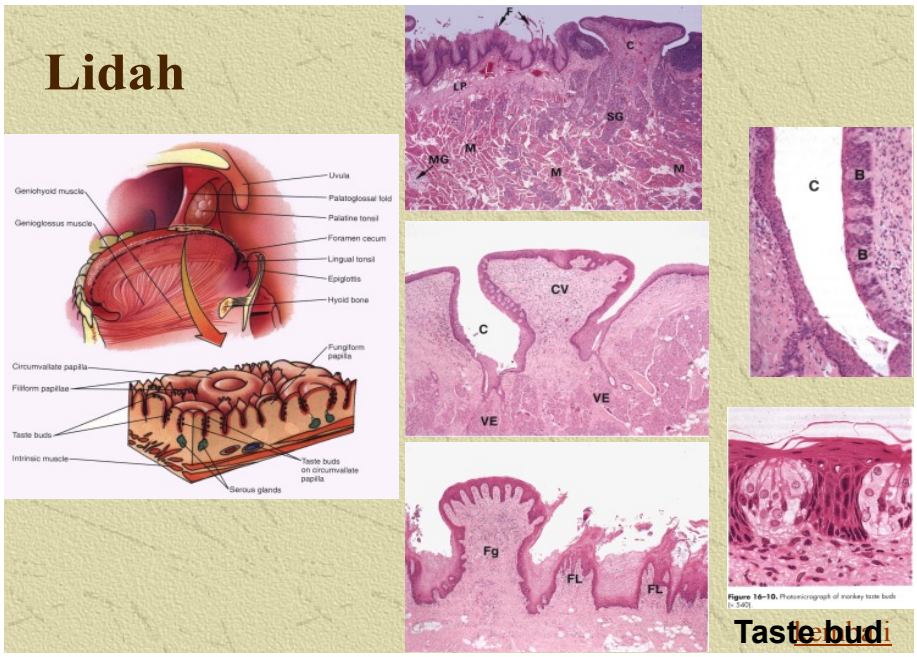


Figure 16–9. Schematic diagram of lingual papillae and a taste bud.



LIDAH: wilayah: badan lidah (2/3 bagian) dan akar lidah. Diantaranya : sulcus terminalis (ada kel sirkumvalata)

Adanya papila-papila: p. filiformis, p. fungiformis, p. sirkumvalata

ARTIFICIAL TOUNGE

Wine tasting notes are famous for their verbal flourishes—for example, "kirsch, dried beef and baker's chocolate,"—but the liquid is ultimately just a collection of molecules, some sour, some bitter, some dry. And we're getting better at quantifying taste. A newly developed **artificial tongue** uses the very proteins from our mouthes to measure the dryness of wine.

The Mouth

- The roof of the mouth separates the nasal cavity from the mouth.
  - Prevents ingested food from entering the nasal cavity
  - Divided into two parts
    - **Hard palate** (anterior)
      - Contains several bones
    - **Soft palate** (posterior)
      - Made of muscle
      - Uvula: finger-shaped projection at back of the mouth
      - Tonsils: Help protect the body from infections

The Mouth

- Salivary glands produce saliva.
  - Three different glands are located in the mouth.
    - One pair lies on either side of the face
    - One pair lies beneath the tongue
    - One pair lies beneath the floor of the mouth
  - Saliva keeps the mouth moist.
  - Saliva contains the enzyme salivary amylase.
    - Begins process of digesting starch

MULUT :Terdiri dari mukosa (ep. Berlapis banyak); jar. Ikat (lamina propria)

KELENJAR LUDAH: parotid, submandibular, sublingual

***Parotid: serous (bercab. Majemuk) . Enzim :ptialin**

*** Submandibula & sublingual: seromukus (tubuloasiner) → MUCIN DAN ZIMOGEN**

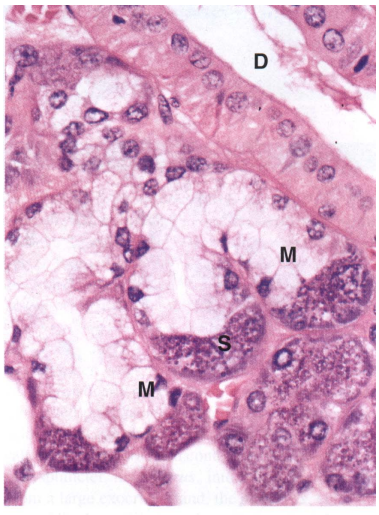


Fig. 13.17 Submandibular gland H & E × 450

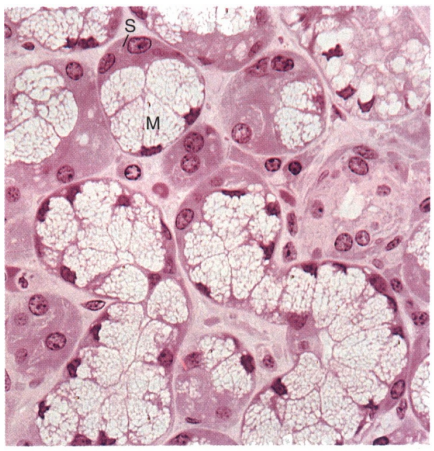


Figure 18–2. Photomicrograph of the monkey sublingual gland, displaying mucous acini (M) with serous demilunes (S) (× 540).

The Teeth

- Teeth are used to chew food into pieces suitable for swallowing.
- Adults have 32 teeth.
- Each tooth has two main divisions.
  - A crown
  - A root

  Dentistion:
  - Biphiodon (manusia)
  - Poliphiodon (hiu)

The Teeth

- 20 baby teeth
- 32 adult teeth
- Tooth divided into
  - **Crown**
    - Enamel
    - Dentin
    - Pulp
  - **Root**
    - Dentin
    - Pulp
  - **Gingiva** (gums)

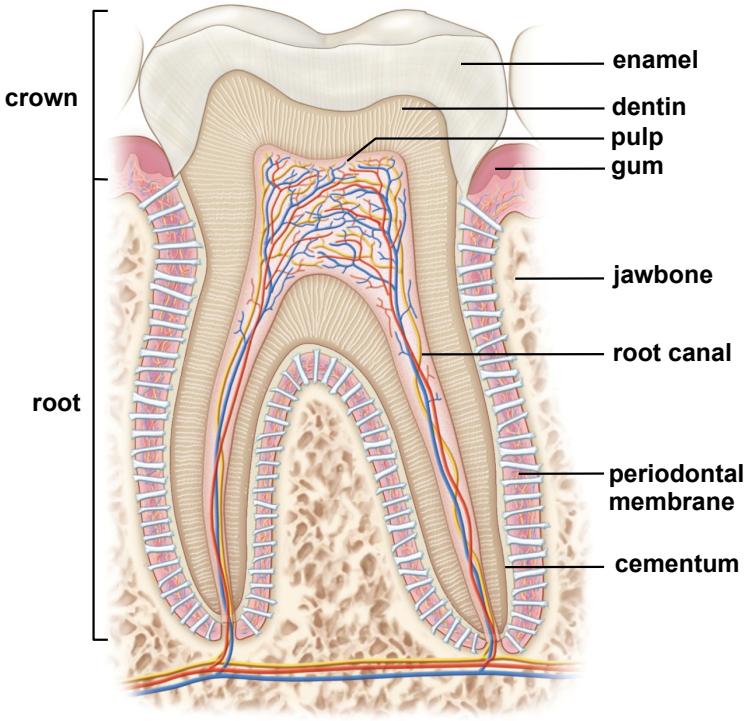


Figure 14.2b

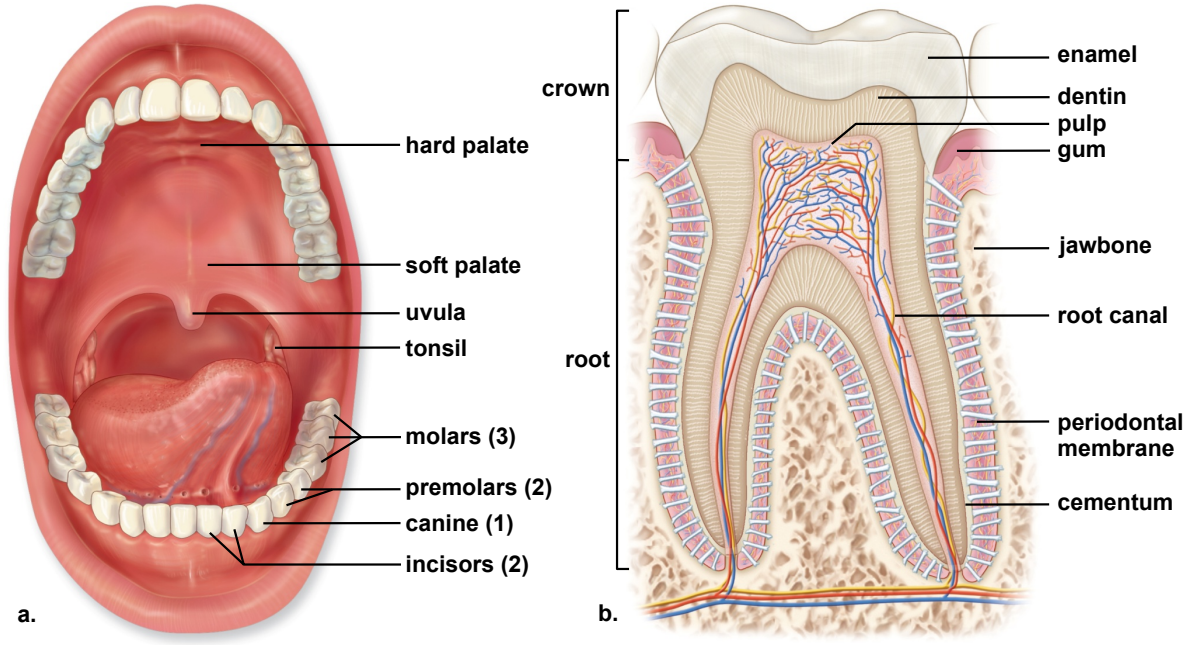


Figure 14.2

The Teeth

- Bacteria that adhere to teeth metabolize sugar and release acids, which erode enamel.
- **Dental caries** (cavities) result from eroded enamel, a slow process.
  - Once the dentin layer is reached, the damage spreads more rapidly
- **Gingivitis** is inflammation of the gums.
- **Periodontitis** is inflammation of the periodontal membrane, characterized by bone loss.

The Pharynx

- Passageway that receives air from the nasal cavities and food from the mouth
- Swallowing
  - Reflex action – performed automatically
  - Soft palate closes off the nasopharynx
  - Trachea moves up causing the epiglottis to cover the **glottis**
  - As a result, food can enter esophagus only

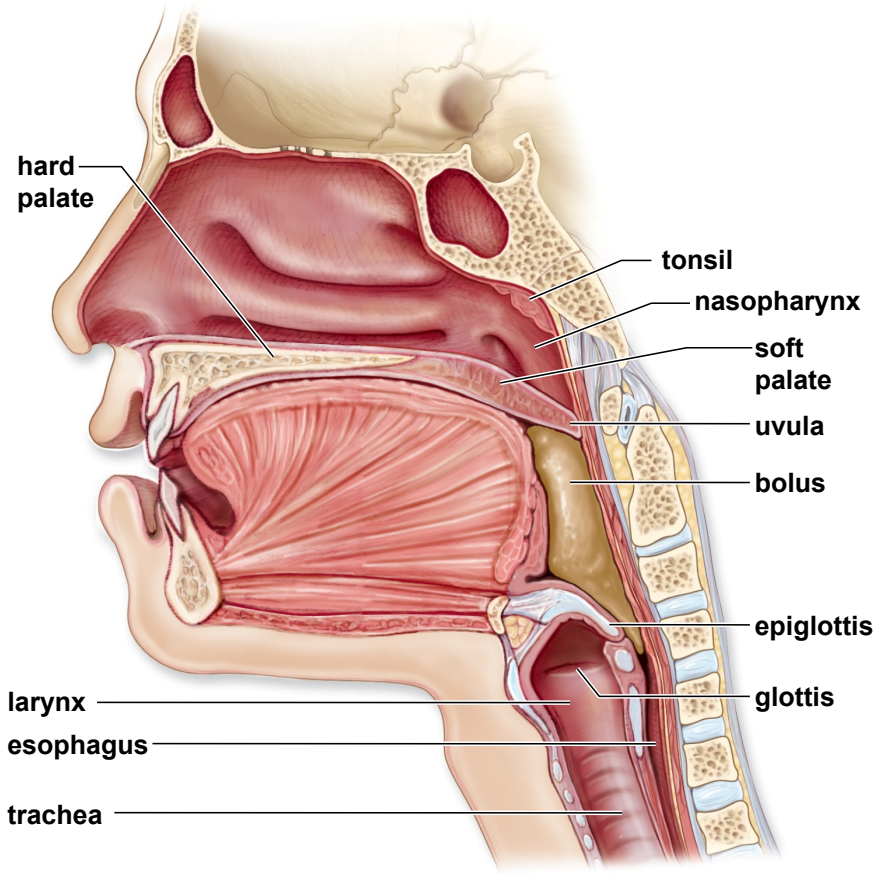
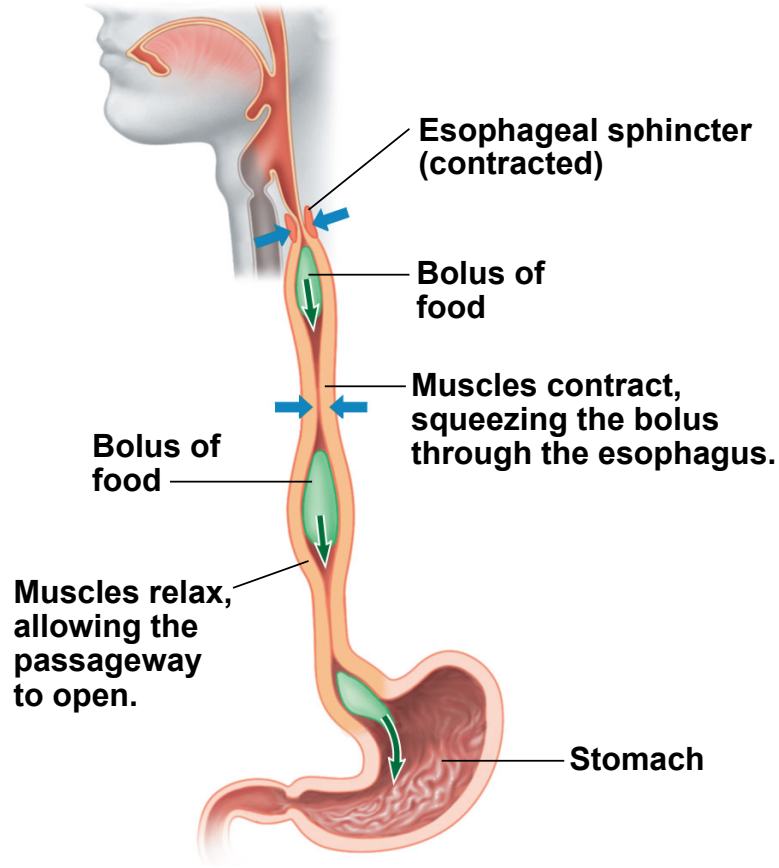


Figure 14.3

The Esophagus

- **Esophagus**
  - The esophagus is a muscular tube that extends from the pharynx to stomach.
    - Usually collapsed except during swallowing
  - **Peristalsis**, rhythmic muscular contractions, pushes food along the digestive tract.
  - The sphincter muscle closes the esophagus from the stomach
    - Relaxation of the sphincter allows food to enter the stomach
    - If contents of the stomach escape into the esophagus, this causes **heartburn**



Peristalsis:

Smooth muscle contractions that move food through digestive tract

The Wall of the Digestive Tract

- Four layers of the Digestive Tract
  1. **Mucosa**
     - Epithelium supported by connective tissue
     - Smooth muscle lines lumen (central cavity)
     - Glandular epithelial cells secrete enzymes
     - Goblet cells secrete mucus
  2. **Submucosa**
     - Loose connective tissue that contains blood vessels
     - Peyer's patches - lymph nodules →Help protect us from disease
  3. **Muscularis**
     - Two layers of smooth muscle
     - Circular, inner layer encircles tube
     - Longitudinal, outer layer runs perpendicular
  4. **Serosa**
     - Very thin outermost layer of squamous epithelium
     - Secretes serous fluid to moisten surface
     - Organs slide against one another

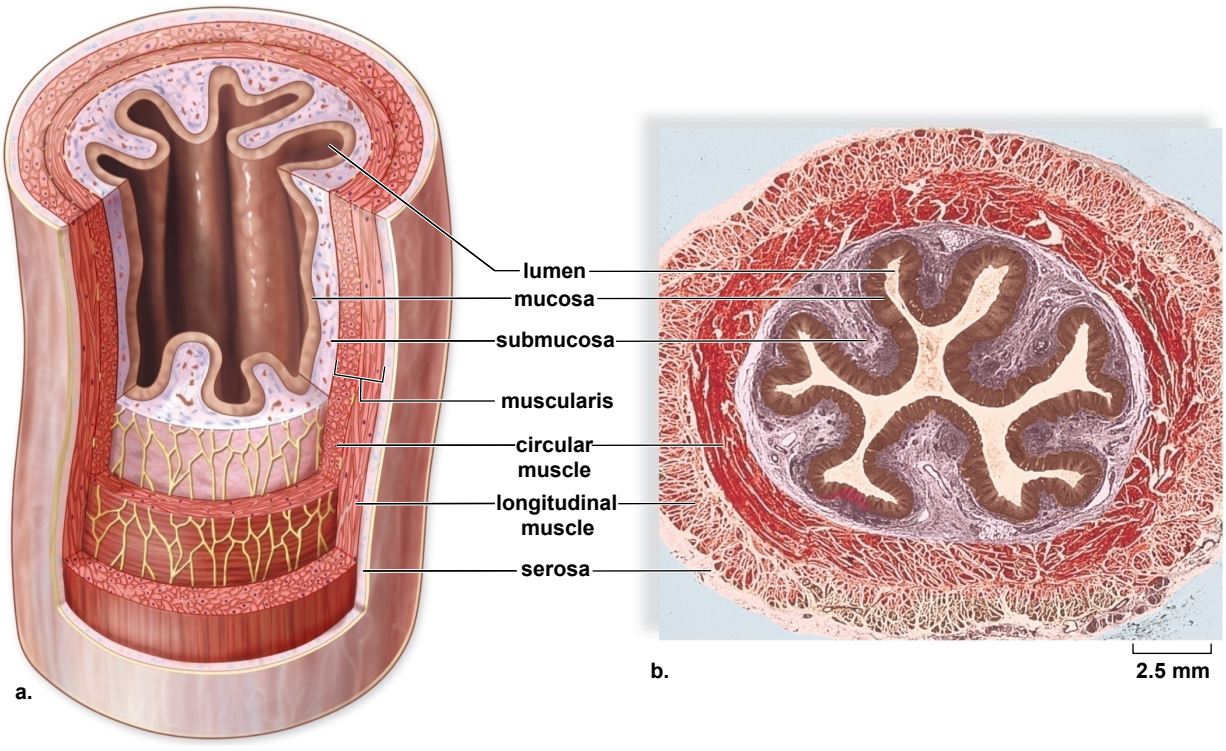


Figure 14.4

Stomach

- pH = 2
- Mechanical digestion
  - Churning of stomach
  - Low pH denatures proteins
- Chemical digestion
  - **Pepsin**
    - Proteins + H2O → amino acids
- Secretes **gastric juice**, made up of
  - Mucus (protects stomach lining from HCl)
  - Pepsinogen (*inactive* form of pepsin)
    - Pepsinogen (inactive) → pepsin (active) in presence of acid
  - HCl
    - kills ingested bacteria,
    - breaks apart cells in food, and
    - denatures proteins.

Gastric juice secreted by gastric glands in response to GASTRIN hormone.

The Stomach

- **Stomach**
  - Thick-walled, J-shaped organ
  - Continuous with esophagus and duodenum of small intestine
  - Receives food from the esophagus
  - Starts digestion of proteins
  - Moves food into the small intestine
  - Expands to hold about four liters when full.
    - Rugae or folds allows for expansion

The Stomach

- The columnar epithelium lines the stomach.
  - Contains gastric pits which lead into gastric glands
  - Gastric glands produce gastric juice
    - Pepsinogen (becomes pepsin)
    - Hydrochloric acid (HCl)
    - Mucus

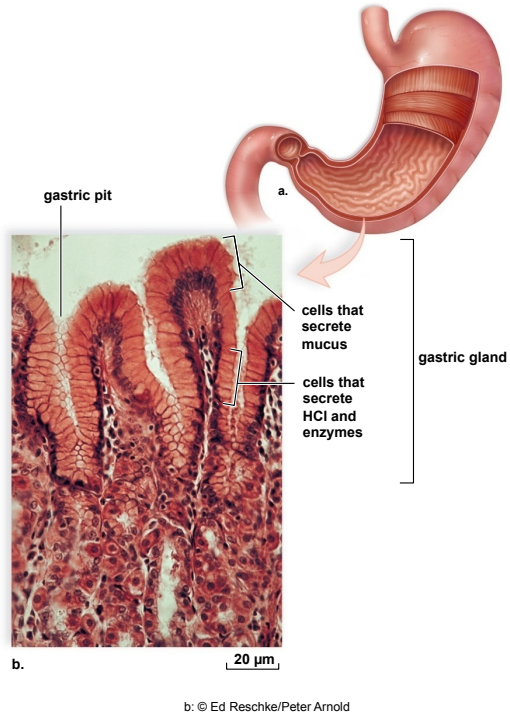
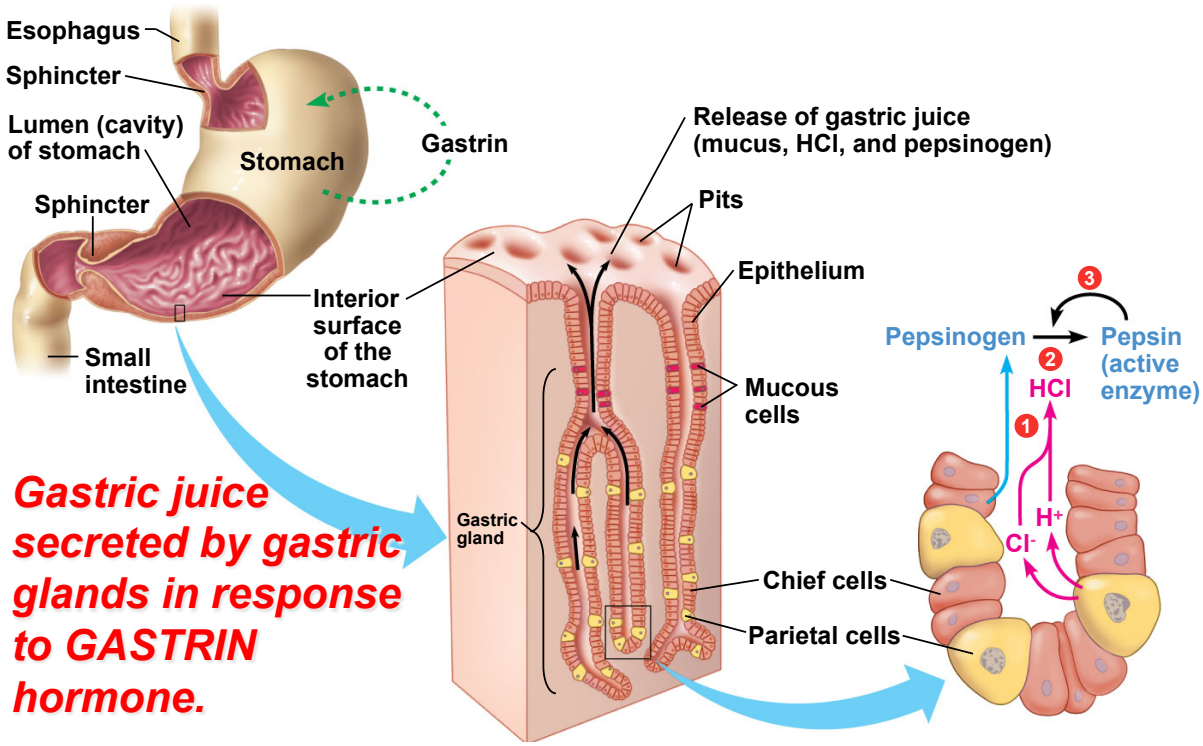


Figure 14.5

The Stomach

- The stomach acts both mechanically and chemically on food.
- The wall has three layers of muscles.
  - Circular, longitudinal, and oblique
  - Churns the food, mixing it with gastric juices
- Most food is not absorbed by the stomach.
  - Alcohol and other liquids are absorbed in the stomach
- The stomach normally empties in two to six hours.
  - **Chyme** – food leaving stomach
  - Enters small intestine through pyloric sphincter

Figure 21.8

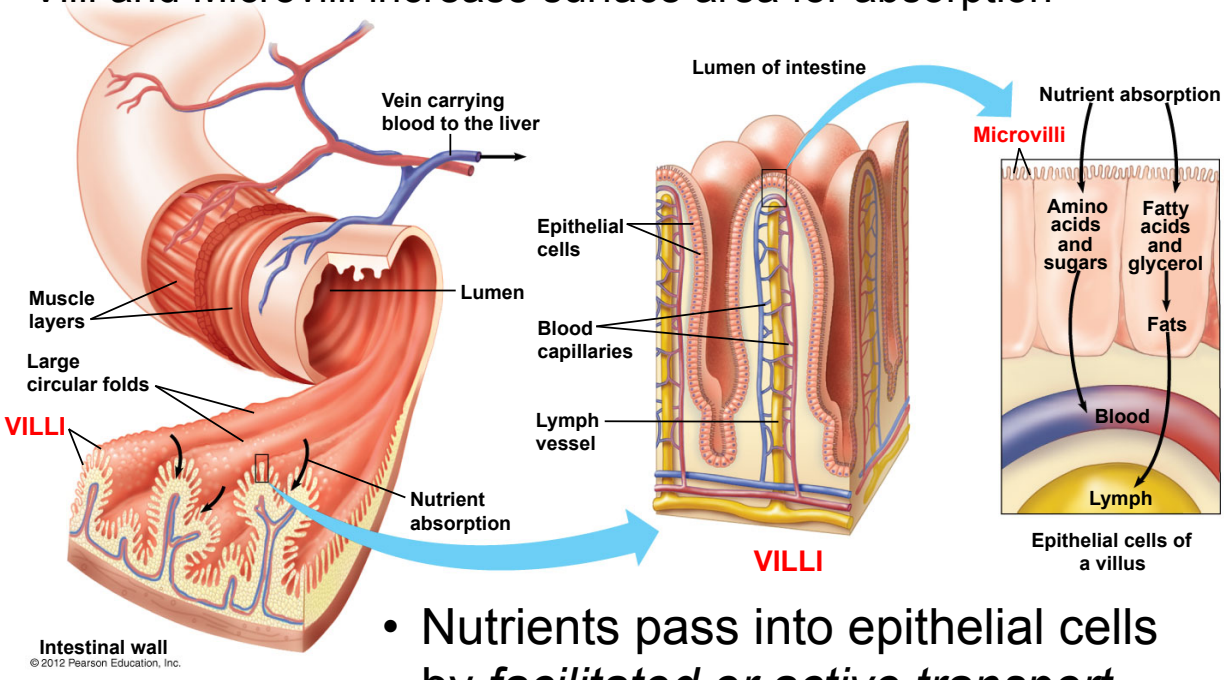


Small Intestine

- ***Major organ of chemical digestion and nutrient absorption***
- pH = 8 due to Na-bicarb released by pancreas
- Releases the hormone SECRETIN in response to food entering small intestine
- *Final chemical digestion* of macromolecules:
  - Pancreatic amylase
    - Poly and disaccrharides + H2O → monosaccharides
  - Trypsinogen → trypsin (active) at basic pH
    - Proteins + H2O → amino acids
  - Chymotrypsinogen → chymotrypsin (active) at basic pH
    - Proteins + H2O → amino acids
  - Lipase (with assistance of bile)
    - Triglycerides + H2O → glycerol + fatty acids

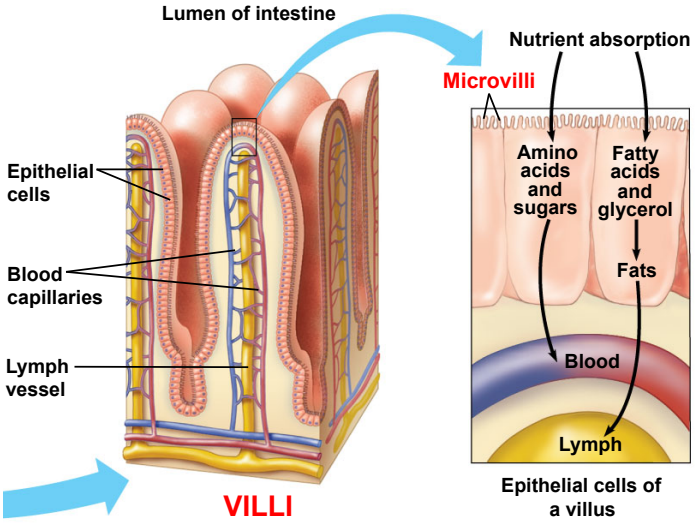
Small intestine is site of absorption!!

Villi and Microvilli increase surface area for absorption



- Nutrients pass into epithelial cells by *facilitated or active transport*

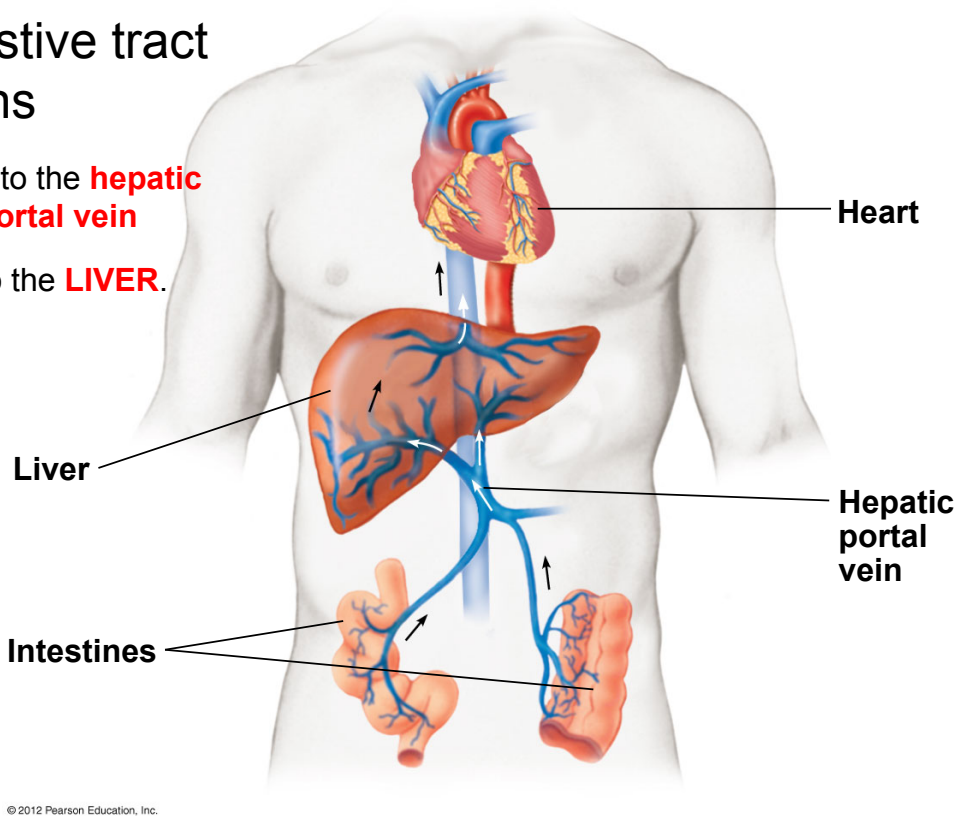
Small intestine is site of absorption!!



- Amino acids and sugars pass
  - out of the intestinal into blood

- Fatty acids and glycerol are
  - recombined into fats,
  - coated with proteins, and
  - transported into lymph vessels.

- Blood from the digestive tract drains
  - into the **hepatic portal vein**
  - to the **LIVER**.



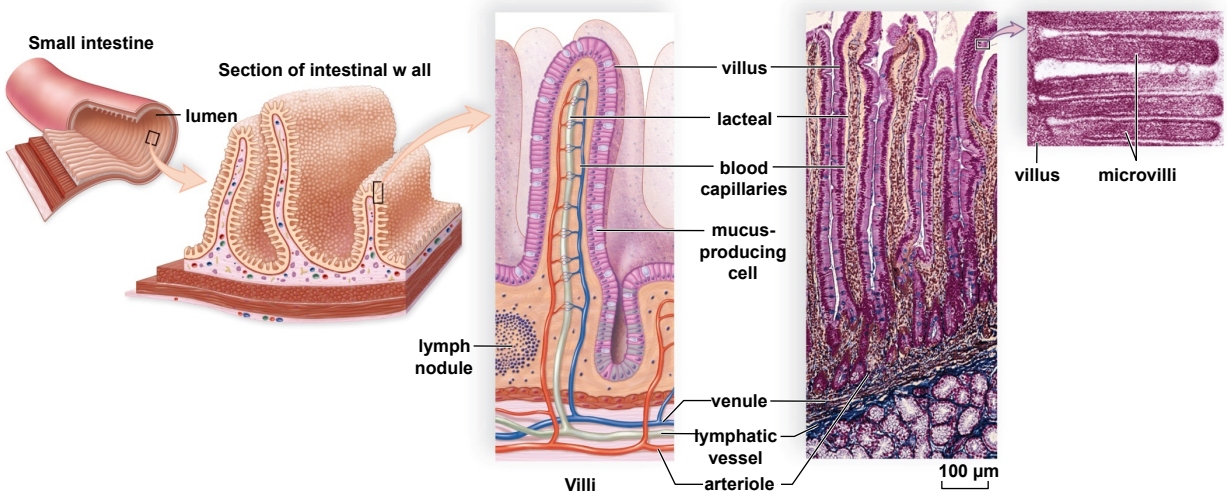
The Small Intestine

- **Small Intestine**
  - Approximately six meters long
    - Smaller in diameter compared to the large intestine
  - **Duodenum**
    - The first 25 centimeters of the small intestine
    - Receives bile from the liver
      - Bile emulsifies fat
    - Receives pancreatic juice from the pancreas
      - Many enzymes for digestion of nutrients
      - Bicarbonate to neutralize acidic pH of chyme

- The Small Intestine
  - **Jejunum**
    - Middle section
  - **Ileum**
    - Remainder leading to large intestine
    - Contains **Peyer's patches** – immune response to intestinal pathogens

The Small Intestine

- The small intestine has large surface area.
  - **Villi** – fingerlike projections
    - Blood capillaries for nutrient absorption
      - Carries sugars and amino acids
    - **Lacteals** (lymph/blood capillaries)
      - Part of lymphatic system
      - Carries digested fats
  - **Microvilli** – microscopic extensions on surface of epithelial cells of villi



(villi): © Manfred Kage/Peter Arnold; (microvilli): Photo published in Medical Cell Biology, Charles Flickinger, photo by Susumu Ito, Copyright Elsevier, 1979.

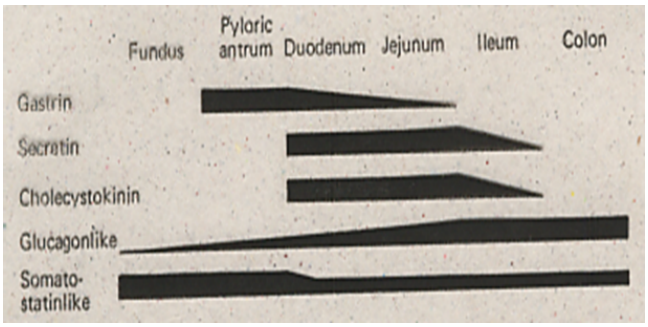
Figure 14.6

Regulation of Digestive Secretions

- Digestive secretions are regulated by the nervous system and by hormones.
  - **Hormone** – substance produced by a group of cells that affects a different group of cells (target cells)
    - Hormone released into the blood for transport
    - Ex: **Gastrin** released by stomach after protein rich meal
      - Stomach churns, gastric gland activity increased
    - Ex: **GIP** (gastric inhibitory peptide) produced by duodenal wall
      - Inhibits gastric gland secretion

Regulation of Digestive Secretions

- Two other hormones that regulate digestion
  - Secretin - produced by duodenal wall
    - Release stimulated by entrance of HCl in chyme
  - CCK (cholecystokinin) - produced by duodenal wall
    - Release stimulated by proteins and fat in chyme
  - Together, secretin and CCK act on three organs.
    - Pancreas to increase pancreatic juice output
    - Liver to increase bile output
    - Gallbladder to contract to release bile



Secretin and CCK together stimulate actions of three organs.

- Pancreas
- Liver
- Gallbladder

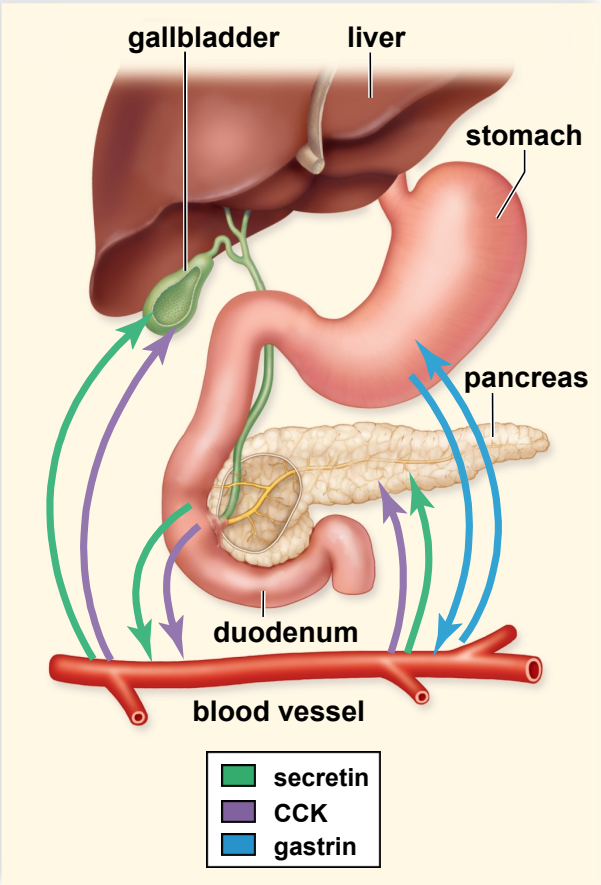
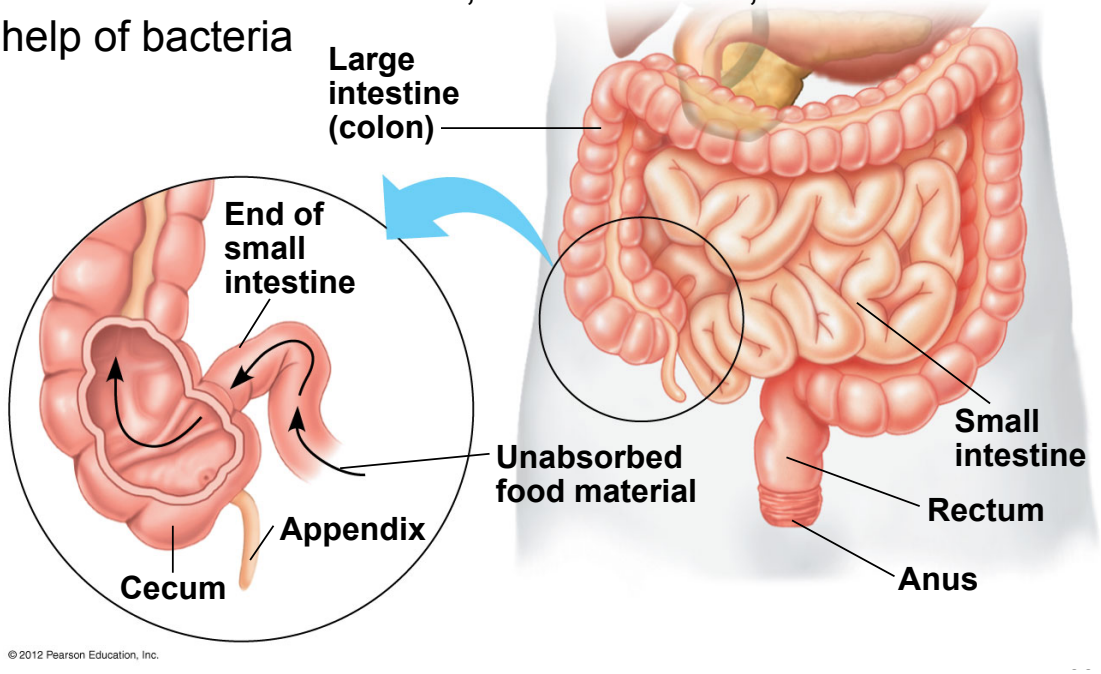


Figure 14.7

Large Intestine

- Excretes solid wastes
- Reabsorption of water
- Synthesis of several vitamins, like Vitamin K, with help of bacteria



The Large Intestine

- **Large Intestine**
  - Includes cecum, colon, rectum and anal canal
  - Larger in diameter, but shorter length compared to the small intestine

- Functions:
  - Absorbs water, salts, and some vitamins
  - Stores indigestible materials until eliminated as feces

The Large Intestine

- **Cecum**
  - Lies below junction with small intestine
  - Small pouch (6 cm long) that forms first part of the large intestine
  - Human cecum has projection called **appendix or veriform appendix**
    - Like tonsils, may play a role in fighting infection
    - Subject to inflammation, appendicitis
    - If inflamed it should be removed before rupturing

- Cecum
  - Lies below junction with small intestine
  - Human cecum has vermiform appendix
    - Role in fighting infection

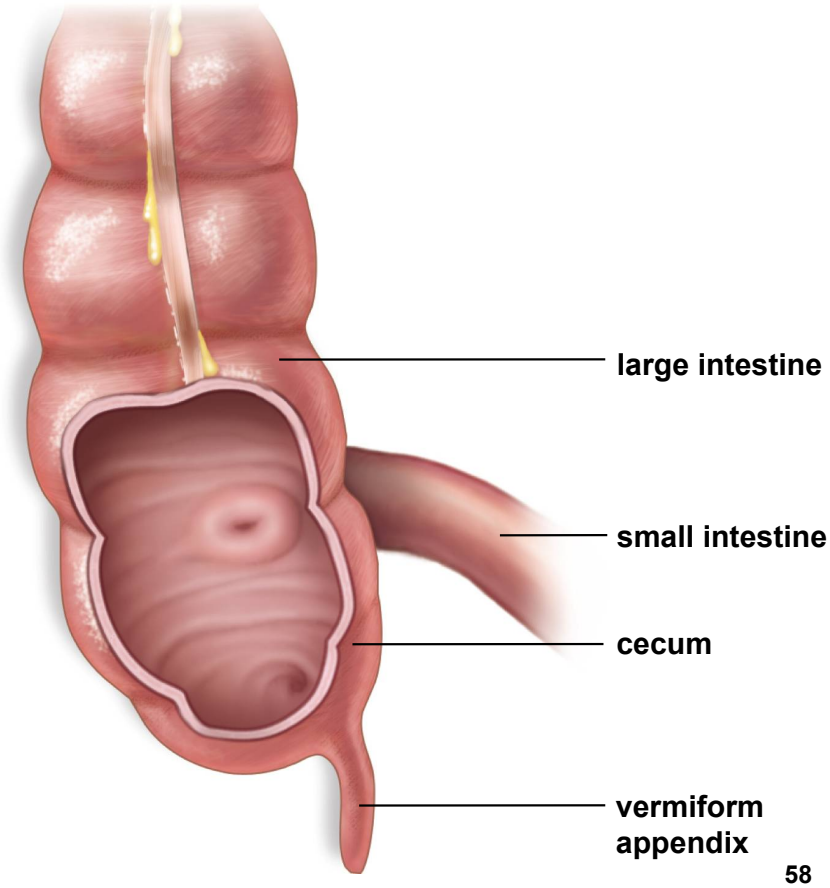


Figure 14.8

The Large Intestine

- **Colon**
  - Ascending, transverse, descending, and sigmoid
- **Rectum**
  - Last 20 cm of large intestine
  - Opens to anus
- **Anus**
  - Where **defecation** (expulsion of feces) occurs
  - Reflex triggered as feces are forced into rectum

- **Defecation** occurs after the stretching of the rectal wall initiates nerve impulse to the spinal cord
- As a result, rectal muscles contract and anal sphincters relax

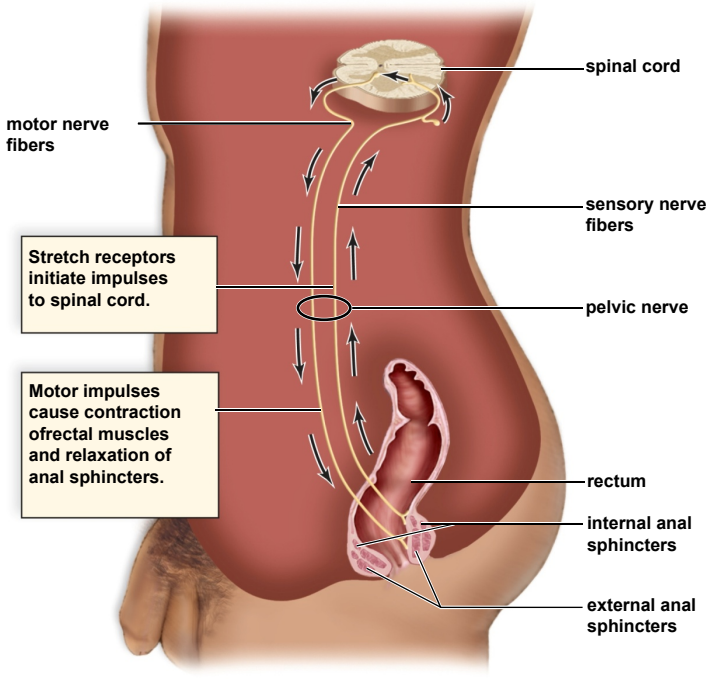


Figure 14.9

The Large Intestine

- Feces are typically ¾ water and ¼ solids
  - Bacteria, plant fiber and indigestible materials are in the solid portion.
  - Bacterial breakdown of indigestible materials account for the odor also for the presence of gas.
  - Metabolism of bilirubin and oxidized iron account for the brown color.

Accessory Organs/ glands of Digestion

- Accessory organs/ glands of digestion
  - Pancreas
  - Liver
  - Gallbladder
  - Three salivary gland types

Accessory Organs of Digestion

- Pancreas
- Liver
- Gallbladder

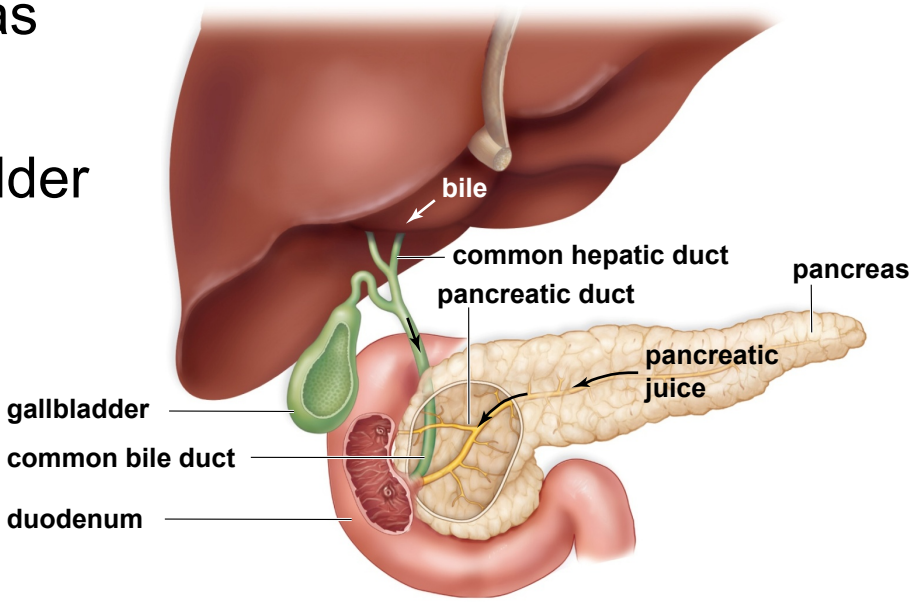


Figure 14.10a

Accessory Organs of Digestion

Pancreas

- Endocrine function
  - Insulin and glucagon
  - blood glucose regulation
- Exocrine function – pancreatic juice
  - Sodium bicarbonate: neutralizes the stomach acid
  - Pancreatic amylase: digests starch
  - Trypsin: digests protein
  - Lipase: digests fat

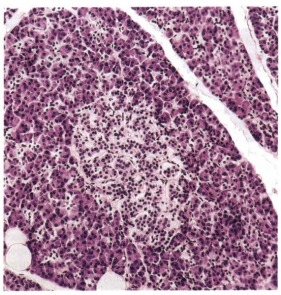
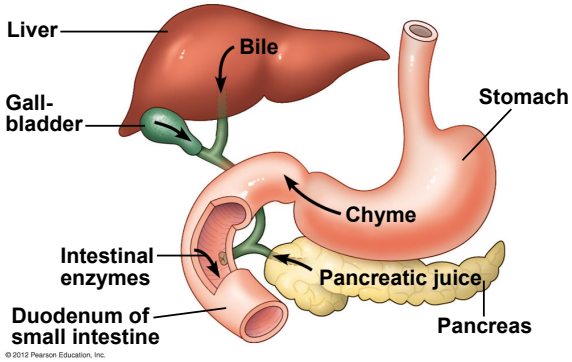


Figure 18–6. Photomicrograph of the human pancreas, displaying secretory acini and an islet of Langerhans (I) (× 132).



Accessory Organs of Digestion

- **Liver**
  - Largest gland in the body
  - Lobules are structural and functional units
  - Three structures located between lobules
    - A bile duct takes bile away.
    - A branch of the hepatic artery brings O_2 rich blood.
    - A branch of the hepatic portal vein transports nutrients from intestines.
    - Each lobule has a central vein that enters a hepatic vein.

Hepatic Portal System

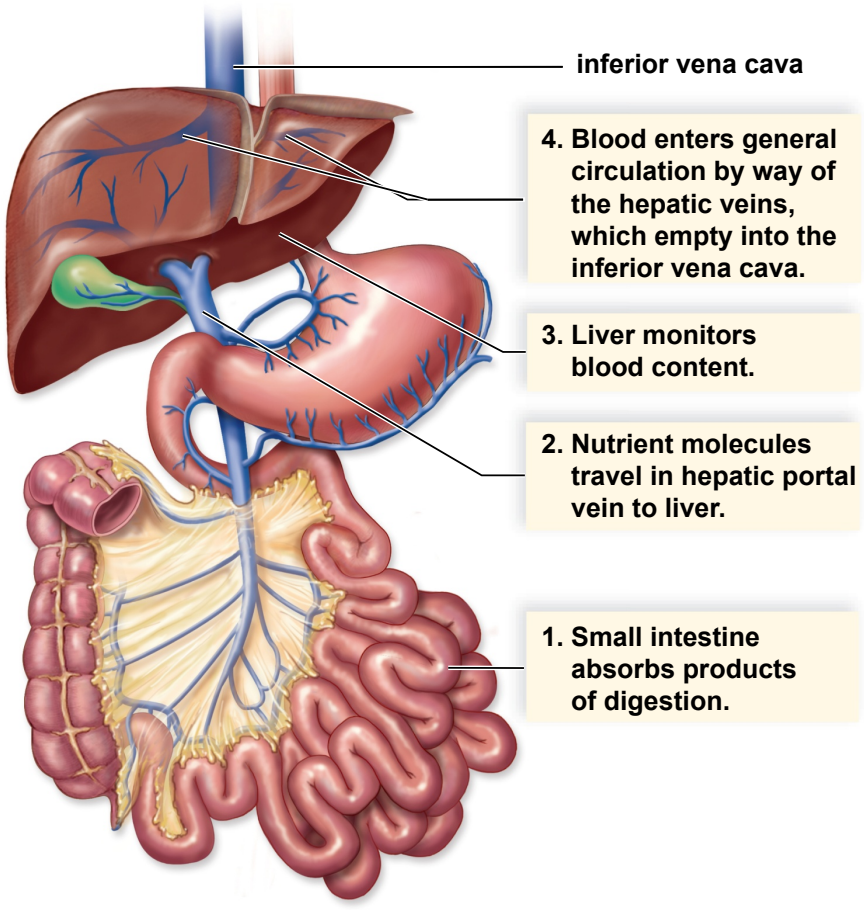
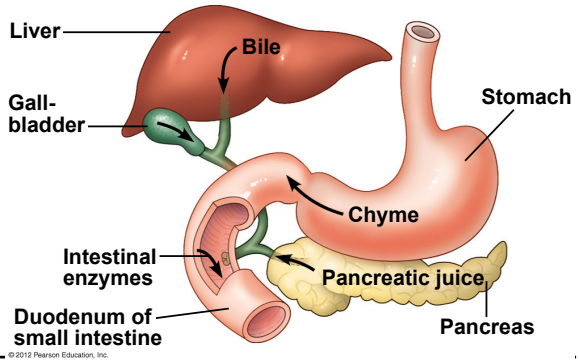


Figure 14.11

Liver

- Produces bile
- converts glucose in blood to glycogen,
- stores glycogen and releases sugars back into the blood as needed,
- Detoxifies substances absorbed from digestive tract
- Processes amino acids and produces urea



The Liver

- Acts as gatekeeper for the blood
  - Detoxifies and removes poisonous substances
  - Removes and stores iron and vitamins A, D, E, K, and B_{12}
  - Makes plasma proteins
  - Regulates cholesterol
  - Regulates blood glucose – stores as glycogen
  - Produces **bile**
    - Bilirubin – hemoglobin breakdown product
    - Bile salts – emulsify fat

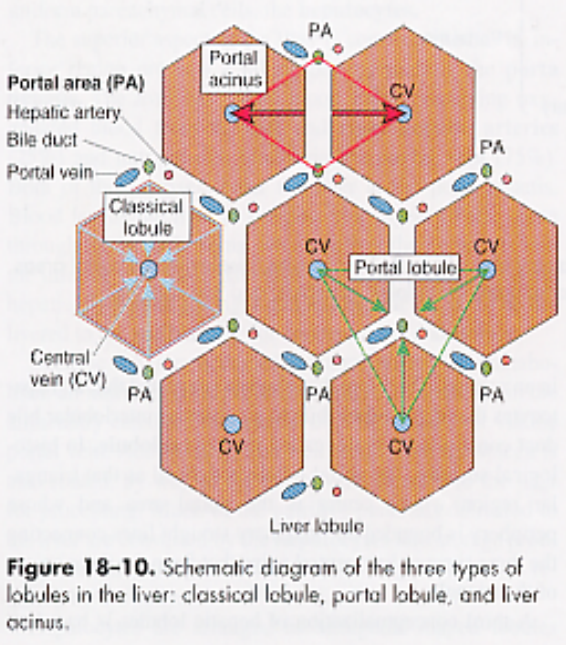
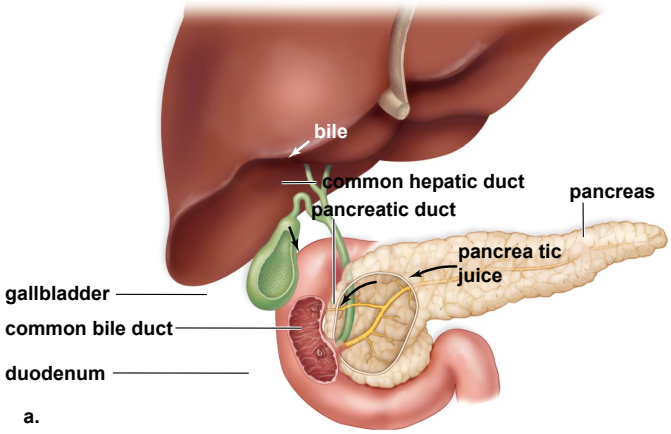
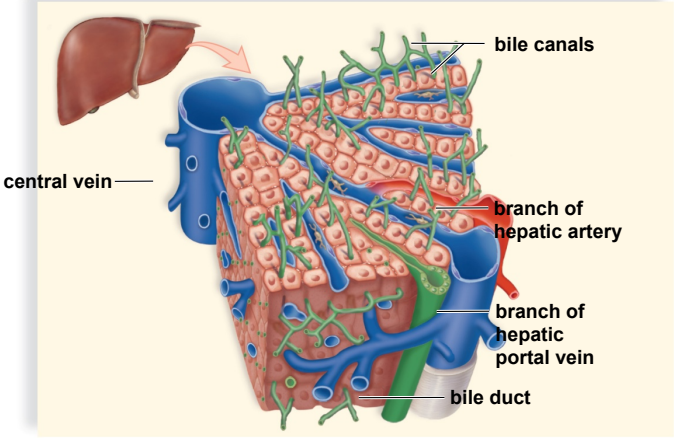


Figure 18–10. Schematic diagram of the three types of lobules in the liver: classical lobule, portal lobule, and liver acinus.

Dalam setiap portal lobule, dibagi menjadi 3 zona. Breakdown glikogen menjadi glukosa di setiap zona berlangsung sekitar 6 jam.





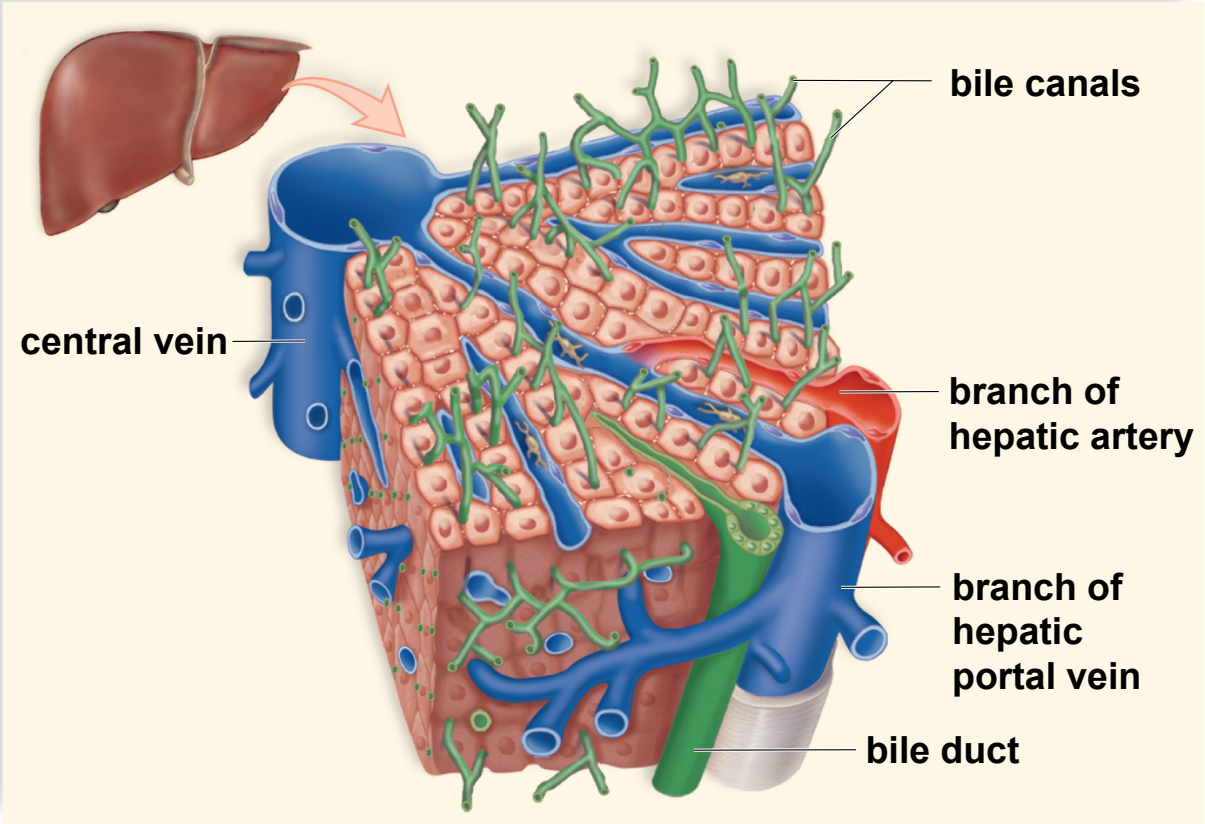
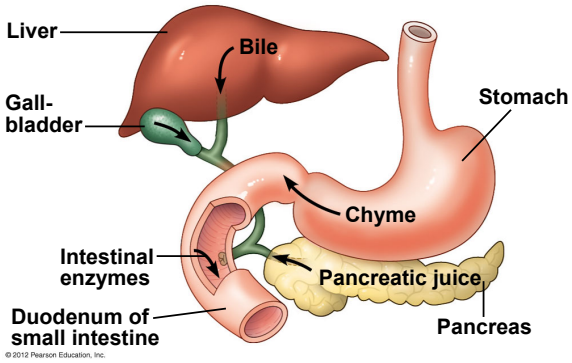


Figure 14.10b

Gallbladder

- Stores bile produced by liver
  - Bile released to small intestine in response to hormone **SECRETIN**
- Bile
  - Synthesized from cholesterol, aids in physical digestion of lipids
    - ***Emulsify*** – disperse oil into water
    - Increases efficiency of chemical digestion of lipids by lipase

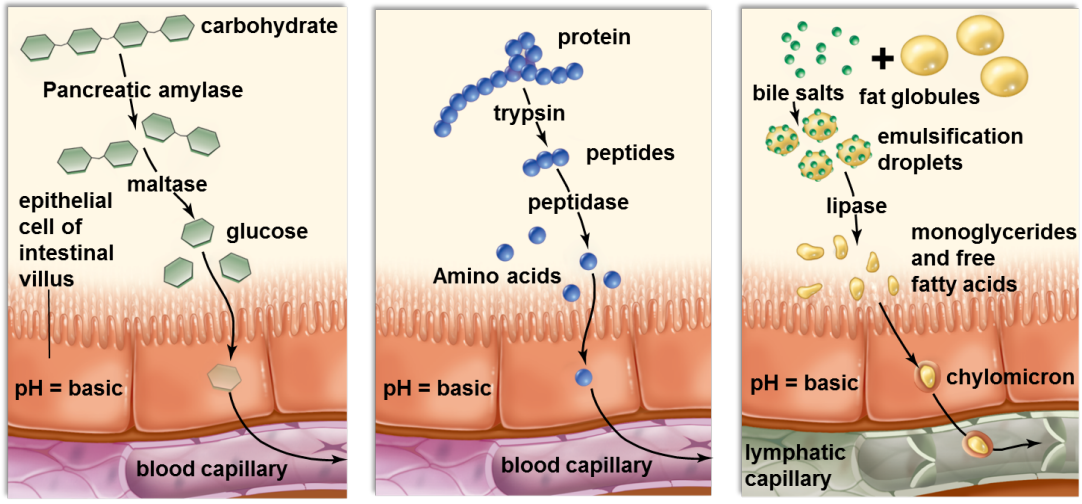


The Gallbladder

- **Gallbladder**
  - The liver produces 400-800 ml of bile each day.
  - The gallbladder stores excess bile.
  - Water is reabsorbed so that bile is thickened.
  - Bile is secreted through the common bile duct into the duodenum.

TABLE 14.3 Major Digestive Enzymes

Enzyme	Produced By	Site of Action	Optimum pH	Digestion
Salivary amylase	Salivary glands	Mouth	Neutral	Starch + H_2O ⟶ maltose
Pancreatic amylase	Pancreas	Small intestine	Basic	Starch + H_2O ⟶ maltose
Maltase	Small intestine	Small intestine	Basic	Maltose + H_2O ⟶ glucose + glucose
Pepsin	Gastric glands	Stomach	Acidic	Protein + H_2O ⟶ peptides
Trypsin	Pancreas	Small intestine	Basic	Protein + H_2O ⟶ peptides
Peptidases	Small intestine	Small intestine	Basic	Peptide + H_2O ⟶ amino acids
Nuclease	Pancreas	Small intestine	Basic	RNA and DNA + H_2O ⟶ nucleotides
Nucleosidases	Small intestine	Small intestine	Basic	Nucleotide + H_2O ⟶ base + sugar + phosphate
Lipase	Pancreas	Small intestine	Basic	Fat droplet + H_2O ⟶ glycerol + fatty acids



a. carbohydrate digestion b. protein digestion c. fat digestion

Obesity

- Today, obesity is defined as having a body mass index (BMI) of 30 or greater.
- Your BMI can be determined based on your height and a standard graph.
- It does not account for certain factors.
  - Fitness
  - Gender
  - Bone structure

Obesity

- Likely caused by a combination of behavioral, genetic, metabolic, and social factors
- Related factors contributing to obesity
  - Sedentary life style
  - Processed foods
  - Higher number of fat cells in obese individuals
  - Reduced levels of leptin which regulates appetite

Obesity

- Obesity is associated with certain illnesses.
  - Type 2 diabetes
  - Hypertension
  - Cardiovascular disease
  - Respiratory dysfunction
  - Osteoarthritis
- Treatment depends on the degree of obesity.

Major Classes of Nutrients-
Carbohydrates

- Carbohydrates are present in food as complex polysaccharides like starch and fiber and simple sugars like glucose.
  - Glucose is the most readily available energy source.
  - Excess glucose is stored by liver and muscles as glycogen in quantities of up to 600g.
  - Additional glucose is converted into fat and stored in adipose tissue.
    - Between meals the liver keeps blood glucose constant by breakdown of glycogen.
    - Glucose is maintained at 50 – 80 mg/100ml blood.

Carbohydrates

- The typical American diet obtains one-sixth of daily calories from simple sugars.
  - Foods like candy and cookies, foods with high fructose corn syrup, starch in white bread have a **high glycemic index.**
  - They cause blood glucose levels to rise rapidly.
  - This in turn causes an overload of insulin.
  - A chronically high insulin level may have harmful effects.

Carbohydrates

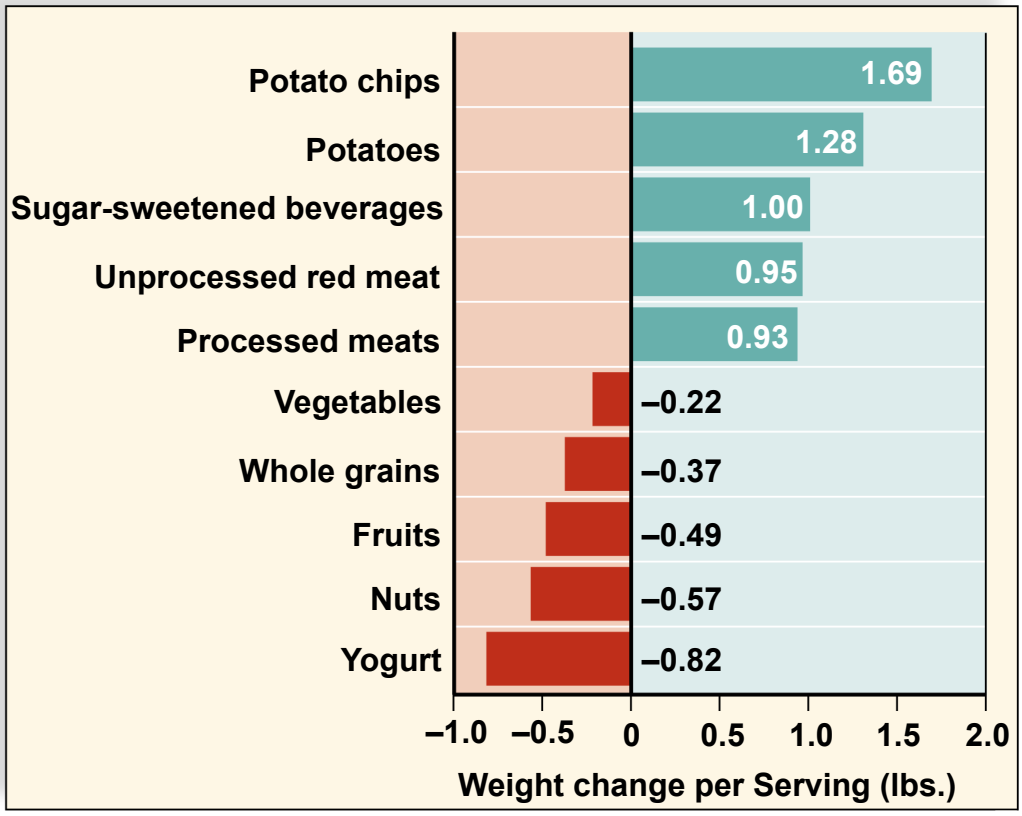
- Studies have shown that reducing intake of foods with high-glycemic-index carbohydrates can reduce weight gain.
- After adjusting for lifestyle factors such as physical activity, alcohol use, and smoking, dietary factors that had the greatest effect on body weight over time were identified
- The biggest cause of weight gain was potatoes.

TABLE 14.4 Reducing High-Glycemic Index Carbohydrates

To reduce dietary sugar:
1. Eat fewer sweets, such as candy, soft drinks, ice cream, and pastry.
2. Eat fresh fruits or fruits canned without heavy syrup.
3. Use less sugar—white, brown, or raw—and less honey and syrups.
4. Avoid sweetened breakfast cereals.
5. Eat less jelly, jam, and preserves.
6. Avoid potatoes and processed foods made from refined carbohydrates, such as white bread, rice, and pasta.

Carbohydrates

- Complex carbohydrates are recommended.
  - Slowly digested to sugars
  - Also contain **fiber**
    - Insoluble fiber: undigestible plant material
      - Acts as laxative
      - May protect against colon cancer
    - Soluble fiber
      - Combines with bile acids and cholesterol to prevent their absorption
  - Fiber derived from peas, beans, nuts, fruits, vegetables
    - Too much fiber can be detrimental as it prevents absorption of iron, zinc, or calcium



Proteins

- Dietary proteins are digested to amino acids which cells use to synthesize a variety of proteins.
- Foods rich in proteins include red meat, fish, poultry, dairy products, and legumes.
- Amino acids are usually not used as an energy source.
- Most amino acids are used to make structural proteins (muscle, hair, skin, nails).
- Others are used to synthesyze proteins such as hemoglobin, plasma proteins, enzymes, and hormones.

Proteins

- Adequate protein formation requires twenty amino acids.
- **Essential amino acids** include eight required from the diet because the body cannot produce them sufficiently.
- Complete protein sources such as milk, meat, eggs provide all twenty amino acids.
- Other dietary protein sources may contain insufficient amounts of at least one essential amino acid.
- Vegetarians are advised to combine plants from two or more incomplete protein groups.

Proteins

- Amino acids are not stored in cells, so a regular supply is required.
- Two servings per day are sufficient.
- The body is harmed if the amount of protein in the diet is limited.
- Excess protein requires deamination of amino acids which leads to urea formation.
- Water is lost as kidneys excrete urea.

Lipids

- Lipids include fats, oils, and cholesterol
  - **Saturated fats**
    - Solid at room temperature
    - Usually of animal origin
      - Exceptions: palm oil, coconut oil
    - Associated with cardiovascular disease

Lipids

- **Unsaturated fats**
  - Oils have two kinds of **unsaturated fatty acids.**
    - Monounsaturated
    - Polyunsaturated
      - Polyunsaturated oils contain **essential fatty acids** that can be obtained only through the diet
        - » Linoleic acid
        - » Linolenic acid
      - Corn and safflower oils are high in polyunsaturated fatty acids

Lipids

- Olive and canola oil have a larger percentage of monounsaturated fatty acids compared to other cooking oils.
- Omega-3 fatty acids are especially protective against heart disease.
  - Found in cold-water fish, flax seed oil

Lipids

- Saturated fats – **trans fats**
  - **Trans fatty acids** are the worst type of saturated fat.
    - Formed by hydrogenation of unsaturated fatty acids to produce a solid fat in certain foods
    - Found largely in commercial food products such as cookies and crackers
    - May reduce ability to clear cholesterol from bloodstream

Lipids

- Fats That Cause Disease
  - Plaques form in and block arteries
    - Contain cholesterol and saturated fats
  - Cholesterol
    - Carried in blood by low density lipoprotein (LDL) and high density lipoprotein (HDL)
    - LDL (“bad” cholesterol) - transports cholesterol from the liver to cells
    - HDL- (“good” cholesterol) - transports cholesterol to the liver to make bile salts

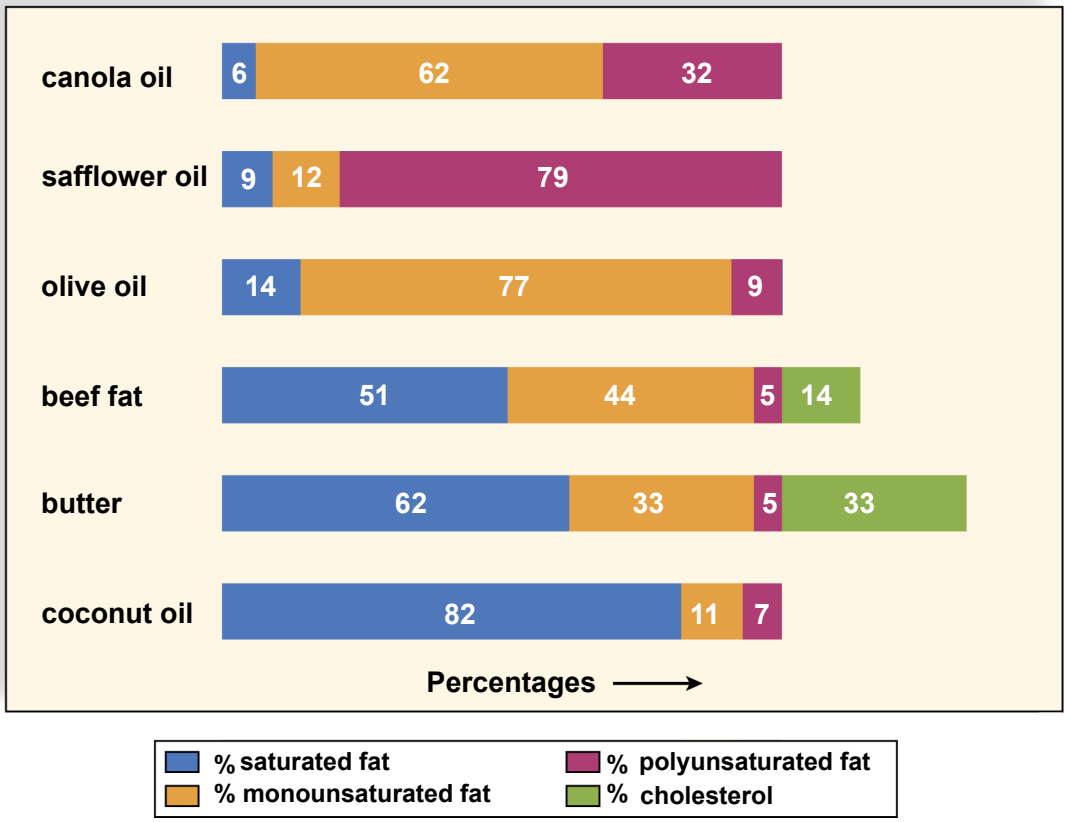


TABLE 14.5 Reducing Certain Lipids

To reduce saturated fats and trans fats in the diet:
1. Choose poultry, fish, or dry beans and peas as a protein source.
2. Remove skin from poultry and trim fat from red meats before cooking.
3. Broil, boil, or bake rather than fry.
4. Limit your intake of butter, cream, trans-fats, shortenings, and tropical oils (coconut and palm oils).*
5. Use herbs and spices to season foods instead of butter or margarine.
6. Drink skim milk instead of whole milk, and use skim milk in cooking and baking.
To reduce dietary cholesterol:
1. Limit cheese, liver, and certain shellfish (shrimp and lobster). Preferably, eat white fish and poultry.
2. Substitute egg whites for egg yolks in both cooking and eating.
3. Include soluble fiber in the diet. Good sources are oat bran, oatmeal, beans, corn, and fruits, such as apples, citrus fruits, and cranberries.

*Although coconut and palm oils are from plant sources, they are mostly saturated fats.

Vitamins

- **Vitamins**
  - Organic compounds the body needs for metabolic purposes but is unable to produce
    - Many are coenzymes – enzyme helpers
    - Deficiencies produce specific symptoms
    - Not all vitamins are coenzymes, for example vitamin A is a precursor for a visual pigment
  - Thirteen vitamins in total
    - Fat soluble - vitamins A,D,E,K
    - Water soluble - remaining nine

Vitamins

- Antioxidants-defend against free radicals
  - Cellular metabolism generates free radicals
    - Most common are superoxide (O_2^-) and hydroxide (OH^-)
    - Cause cell damage leading to disorders and even cancer
  - Vitamins C,E, and A believed to defend the body
  - Especially abundant in fruits and vegetables

Vitamins

- Vitamin D (calcitrol)
  - Skin cells contain a precursor cholesterol molecule that is converted to vitamin D after UV exposure
  - Further modification occurs in kidneys and liver.
    - Becomes calcitrol
    - Promotes calcium absorption from intestines
  - Deficiency causes rickets in children.

Illnesses Due to Vitamin Deficiency

a. rickets

b. pellagra

c. scurvy

Bleeding of gums is a symptom of scurvy, a vitamin C deficiency

Rickets due to vitamin D deficiency

Pellagra dermatitis due to niacin deficiency

Figure 14.17

TABLE 14.6 Fat-Soluble Vitamins

Vitamin	Functions	Food Sources	Conditions With	
			Too Little	*Too Much*
Vitamin A	Antioxidant synthesized from beta-carotene; needed for healthy eyes, skin, hair, and mucous membranes, and for proper bone growth	Deep yellow/orange and dark, leafy green vegetables, fruits, cheese, whole milk, butter, eggs	Night blindness, impaired growth of bones and teeth	Headache, dizziness, nausea, hair loss, abnormal development of fetus
Vitamin D	A group of steroids needed for development and maintenance of bones and teeth	Milk fortified with vitamin D, fish liver oil; also made in the skin when exposed to sunlight	Rickets, bone decalcification and weakening	Calcification of soft tissues, diarrhea, possible renal damage
Vitamin E	Antioxidant that prevents oxidation of vitamin A and polyunsaturated fatty acids	Leafy green vegetables, fruits, vegetable oils, nuts, whole-grain breads and cereals	Unknown	Diarrhea, nausea, headaches, fatigue, muscle weakness
Vitamin K	Needed for synthesis of substances active in clotting of blood	Leafy green vegetables, cabbage, cauliflower	Easy bruising and bleeding	Can interfere with anticoagulant medication

TABLE 14.7 Water-Soluble Vitamins

Vitamin	Functions	Food Sources	Conditions With	
			Too Little	*Too Much*
Vitamin C	Antioxidant; needed for forming collagen; helps maintain capillaries, bones, and teeth	Citrus fruits, leafy green vegetables, tomatoes, potatoes, cabbage	Scurvy, delayed wound healing, infections	Gout, kidney stones, diarrhea, decreased copper
Thiamine (vitamin B_1)	Part of coenzyme needed for cellular respiration; also promotes activity of the nervous system	Whole-grain cereals, dried beans and peas, sunflower seeds, nuts	Beriberi, muscular weakness, enlarged heart	Can interfere with absorption of other vitamins
Riboflavin (vitamin B_2)	Part of coenzymes, such as FAD; aids cellular respiration, including oxidation of protein and fat	Nuts, dairy products, whole-grain cereals, poultry, leafy green vegetables	Dermatitis, blurred vision, growth failure	Unknown
Niacin (nicotinic acid)	Part of coenzymes NAD and NADP; needed for cellular respiration, including oxidation of protein and fat	Peanuts, poultry, whole-grain cereals, leafy green vegetables, beans	Pellagra, diarrhea, mental disorders	High blood sugar and uric acid, vasodilation, etc.
Folacin (folic acid)	Coenzyme needed for production of hemoglobin and formation of DNA	Dark, leafy green vegetables, nuts, beans, whole-grain cereals	Megaloblastic anemia, spina bifida	May mask B_{12} deficiency
Vitamin B_6	Coenzyme needed for synthesis of hormones and hemoglobin; CNS control	Whole-grain cereals, bananas, beans, poultry, nuts, leafy green vegetables	Rarely, convulsions, vomiting, seborrhea, muscular weakness	Insomnia, neuropathy
Pantothenic acid	Part of coenzyme A needed for oxidation of carbohydrates and fats; aids in the formation of hormones and certain neurotransmitters	Nuts, beans, dark, leafy green vegetables, poultry, fruits, milk	Rarely, loss of appetite, mental depression, numbness	Unknown
Vitamin B_{12}	Complex, cobalt-containing compound; part of the coenzyme needed for synthesis of nucleic acids and myelin	Dairy products, fish, poultry, eggs, fortified cereals	Pernicious anemia	Unknown
Biotin	Coenzyme needed for metabolism of amino acids and fatty acids	Generally in foods, especially eggs	Skin rash, nausea, fatigue	Unknown

Minerals

- Minerals are inorganic chemical elements also required by the body.
  - Major Minerals
    - Body contains more than 5 grams
    - Constituents of cells and body fluids
    - Structural components (Ca^{+2} in bones)
  - Trace Minerals
    - Body contains less than 5 grams
    - Components of larger molecules (Fe^{+} in hemoglobin)

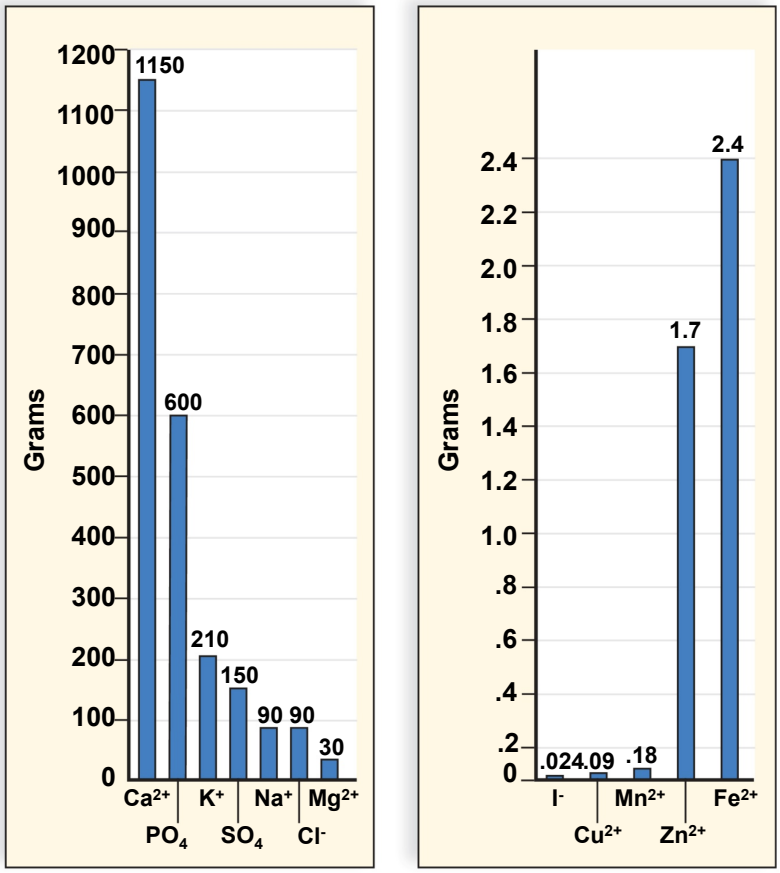


Figure 14.18

a. Major minerals

b. Trace minerals

Diet and Osteoporosis

- Many people take Ca^{+2} supplements to counteract osteoporosis, a bone degenerative disease.
- Disease develops due to osteoclasts being more active than osteoblasts.
- Bones become more porous and break more easily.
- Ca^{+2} intake 1,000 mg/day for men or premenopausal women
- Ca^{+2} intake 1,300 to 1,500 mg/day for women who are premenopausal
- Vitamin D is also used to promote Ca^{+2} absorption

Sodium and Hypertension

- Recommended daily amount of sodium intake is less than 2,400 mg; the average American takes in 4,000 to 4,700 mg.
- High sodium intake is linked to hypertension.
- Sources of sodium:
  - One-third is naturally in foods
  - One-third added by commercial processing
  - One-third added during home cooking

TABLE 14.9 Reducing Dietary Sodium

To reduce dietary sodium:
1. Use spices instead of salt to flavor foods.
2. Add little or no salt to foods at the table, and add only small amounts of salt when you cook.
3. Eat unsalted crackers, pretzels, potato chips, nuts, and popcorn.
4. Avoid hot dogs, ham, bacon, luncheon meats, smoked salmon, sardines, and anchovies.
5. Avoid processed cheese and canned or dehydrated soups.
6. Avoid brine-soaked foods, such as pickles or olives.
7. Read labels to avoid high-salt products.

Dietary Supplements

- Dietary supplements are nutrients or plant products used to enhance health.
- They are not required to undergo safety and effectiveness testing as are prescription drugs.
- Therefore, many supplements have not been tested scientifically to determine their benefits.
- They can be useful to correct deficiencies, but ingesting too much of any particular nutrient can be harmful.
- Protein or amino acid supplements are not recommended by most nutritionists.

Food Additives

- Food additives are substances added to food as preservatives, or to enhance flavor or appearance.
- Food dyes are the most controversial since color is an important psychological part of tasting food.
- Nine synthetic dyes are currently approved by the FDA for food use.
- The effect of food coloring on health is less certain than the psychological effect.
- Studies have been done, but links to illnesses were not conclusive.

Eating Disorders

- People with eating disorders have attitudes and behaviors towards food which cause serious disturbances in their diet.
- Eating disorders can develop in anyone regardless of ethnicity, socioeconomic status or intelligence.
- Eating disorders are usually treated with a combination of medication and psychological counseling.
  - Disorders include anorexia nervosa, bulimia nervosa, and eating disorders not otherwise specified

Anorexia Nervosa

- **Anorexia nervosa**
  - Irrational fear of getting fat - no matter how thin they become, they think they're overweight
  - Preoccupation with a perceived body defect
  - 90% of sufferers are women
  - Behavioral symptoms include
    - Self-imposed starvation
    - Purging episodes by self-induced vomiting
    - Laxative abuse
    - Extreme physical activity

Anorexia Nervosa

- Physical symptoms
  - Symptoms of starvation
    - Low blood pressure
    - Irregular heartbeat
    - Constipation
    - Constantly feeling cold
  - Decreased bone density
  - Many organs cease optimal function
  - Dried skin

Bulimia Nervosa

- **Bulimia nervosa**
  - Pattern of binge eating and purging to avoid gaining weight
  - As in anorexia, preoccupation with body shape and weight
  - Restrictive diet brings desire to binge, usually on high-calorie foods
  - Resulting sense of guilt usually leads to the next phase, purging

Bulimia Nervosa

- Can coexist with obesity or anorexia nervosa
- Physical symptoms
  - Abnormal heart rhythm
  - Damage to kidneys
  - Inflammation of pharynx and esophagus
  - Possible rupturing of stomach and esophagus
  - Erosion of teeth

Persons with bulimia nervosa have

- **recurrent episodes of binge eating: consuming a large amount of food in a short period and experiencing feelings of lack of control during the episode.**
- **obsession about body shape and weight.**
- **increase in fine body hair, halitosis, and gingivitis.**

Body weight is regulated by

- **a restrictive diet, excessive exercise.**
- **purging (self-induced vomiting or misuse of laxatives).**

© Donna Day/Stone/Getty Images

Persons with anorexia nervosa have

- **a morbid fear of gaining weight; body weight no more than 85% normal.**
- **a distorted body image so that person feels fat even when emaciated.**
- **in females, an absence of a menstrual cycle for at least three months.**

Body weight is kept too low by

- **a restrictive diet, often with excessive exercise.**
- **binge eating/purging (person engages in binge eating and then self-induces vomiting or misuses laxatives).**

© Ted Foxx/Alamy RF

Eating Disorders Not Otherwise Specified- Binge Eating Disorder

- Individuals with disorder often eat large amounts of food while feeling a loss of control over eating.
- Sufferers isually do not purge afterward, therefore are not as likely to have immediate medical problems.
- People with the disorder are often overweight.
- The cause is unknown, but many with this disorder claim they suffer a variety of emotional issues.

Pica

- Pica is the repeated ingestion of nonfood items, such as ash, charcoal, cotton, soap, soil or wool.
- Pica usually affects young children and stops before adolescence.
- Pica is often associated with intellectual disability, lack of proper parental care, and neglect.
- Children are at greater risk for poisoning.

Disorders of the Digestive System
Disorder of the Digestive Tract

- **Stomach Ulcers**
  - A thick layer of mucus normally protects wall of stomach.
  - A breakdown in mucus layer causes the stomach wall to be to be damaged by the acidic pH resulting in a **stomach ulcer.**
  - Most are caused by bacteroa *Helicobacter pylori*.
    - Treatment involves antibiotic therapy
  - They can also occur in duodenum due to acidic chyme.

Intestinal Disorders

- **Diarrhea**
  - The most common problem of the small and large intestines
  - Can be acute or chronic
    - Acute cases usually due to infections of the lower intestinal tract
      - Food poisoning can be mild or life-threatening
    - Chronic diarrhea
      - **Crohn's disease** – persistent inflammation of intestine

Intestinal Disorders

- **Constipation**
  - Dry, hard feces
  - May be due to ignoring the urge to defecate
  - Chronic constipation can lead to hemorrhoids
  - Can be treated with increased fluid and fiber intake
  - Laxatives and enemas should be used infrequently

Polyps and Colon Cancer

- **Polyps** are small growths arising from the epithelial lining in the colon.
  - May be benign or cancerous
  - Detected by a colonoscopy
  - May be due to high fat diet which increases bile secretion
  - Fiber may inhibit polyp development by promoting bile excretion

Disorders of the Accessory Organs-
Disorders of the Pancreas

- **Pancreatitis**
  - Inflammation of the pancreas due to alcohol, gallstones, or unknown factors
  - Pancreatic enzymes damage the organ
  - Can eventually lead to diabetes
- **Pancreatic Cancer**
  - Almost always fatal
  - Pancreas has essential functions, resistance to treatment, and spread of cancerous cells

Disorders of the Liver and Gallbladder

- **Jaundice** - abnormally large amount of bilirubin in blood
  - A common side effect of liver disorders
- **Hepatitis** – inflammation of liver
  - Usually caused by one of several viruses
- **Cirrhosis**
  - Often due to alcoholism where the liver develops fibrous scar tissue
- **Gallstones** - crystallized cholesterol blocks the common bile duct, causing obstructive jaundice
  - Often requires removal of gall bladder