The Digestive System and Body Metabolism

14

THE DIGESTIVE SYSTEM FUNCTIONS

Ingestion — taking in food

Digestion — breaking food down both physically and chemically

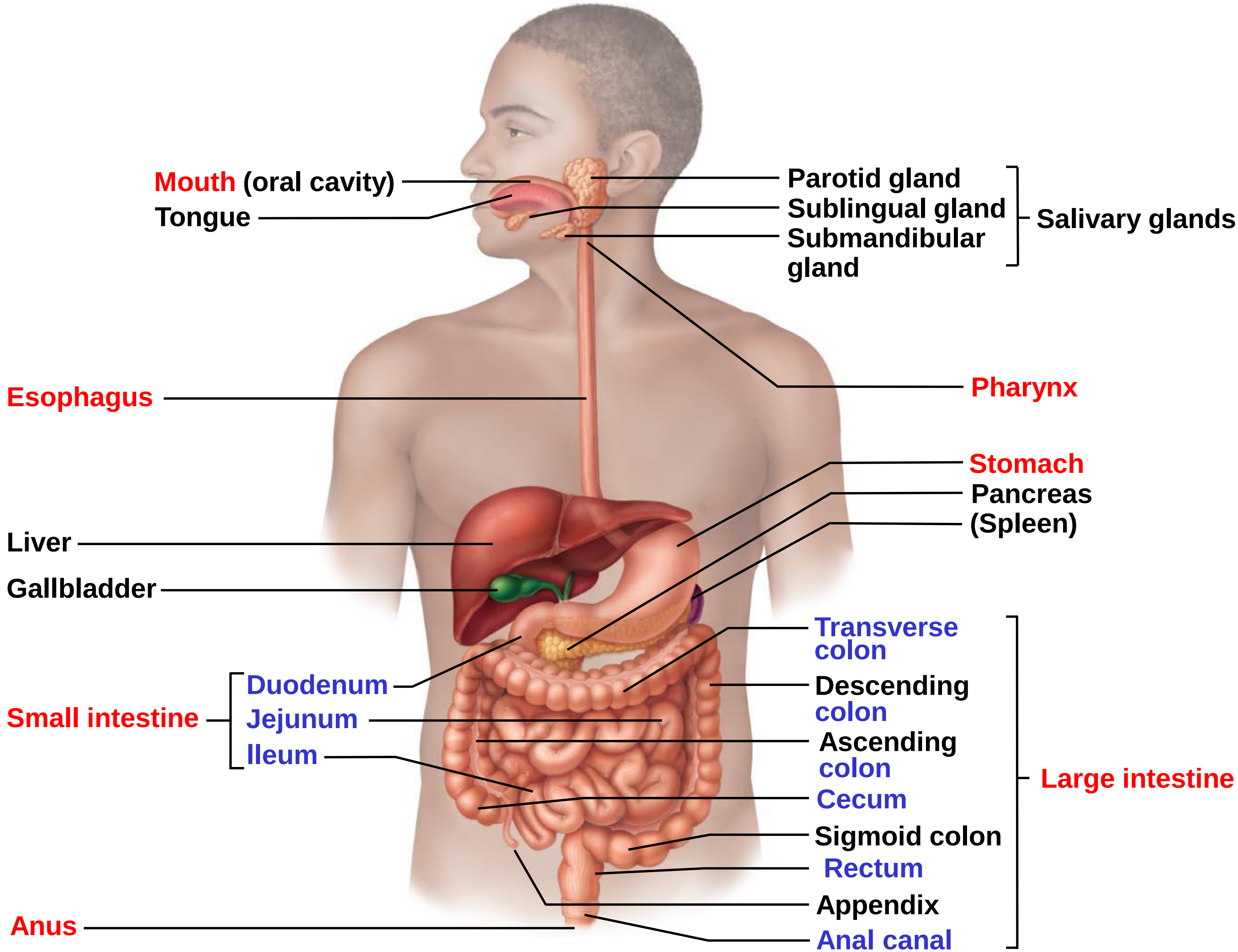
Absorption — movement of nutrients into the bloodstream

Defecation — rids the body of indigestible waste

ORGANS OF THE DIGESTIVE SYSTEM

Two main groups of organs

- Alimentary canal (gastrointestinal or GI tract) — continuous coiled hollow tube
  - These organs ingest, digest, absorb, defecate
- Accessory digestive organs
  - Includes teeth, tongue, and other large digestive organs



Mouth (oral cavity)
Tongue
Parotid gland
Sublingual gland
Submandibular gland
Salivary glands
Esophagus
Pharynx
Stomach
Pancreas
(Spleen)
Liver
Gallbladder
Transverse colon
Duodenum
Descending colon
Small intestine
Jejunum
Ascending colon
Ileum
Large intestine
Cecum
Sigmoid colon
Rectum
Appendix
Anus
Anal canal

Figure 14.1

ORGANS OF THE ALIMENTARY CANAL

Mouth: mechanical (mastication) breakdown; chemical digestion begins; taste

Pharynx: no digestive function / passageway

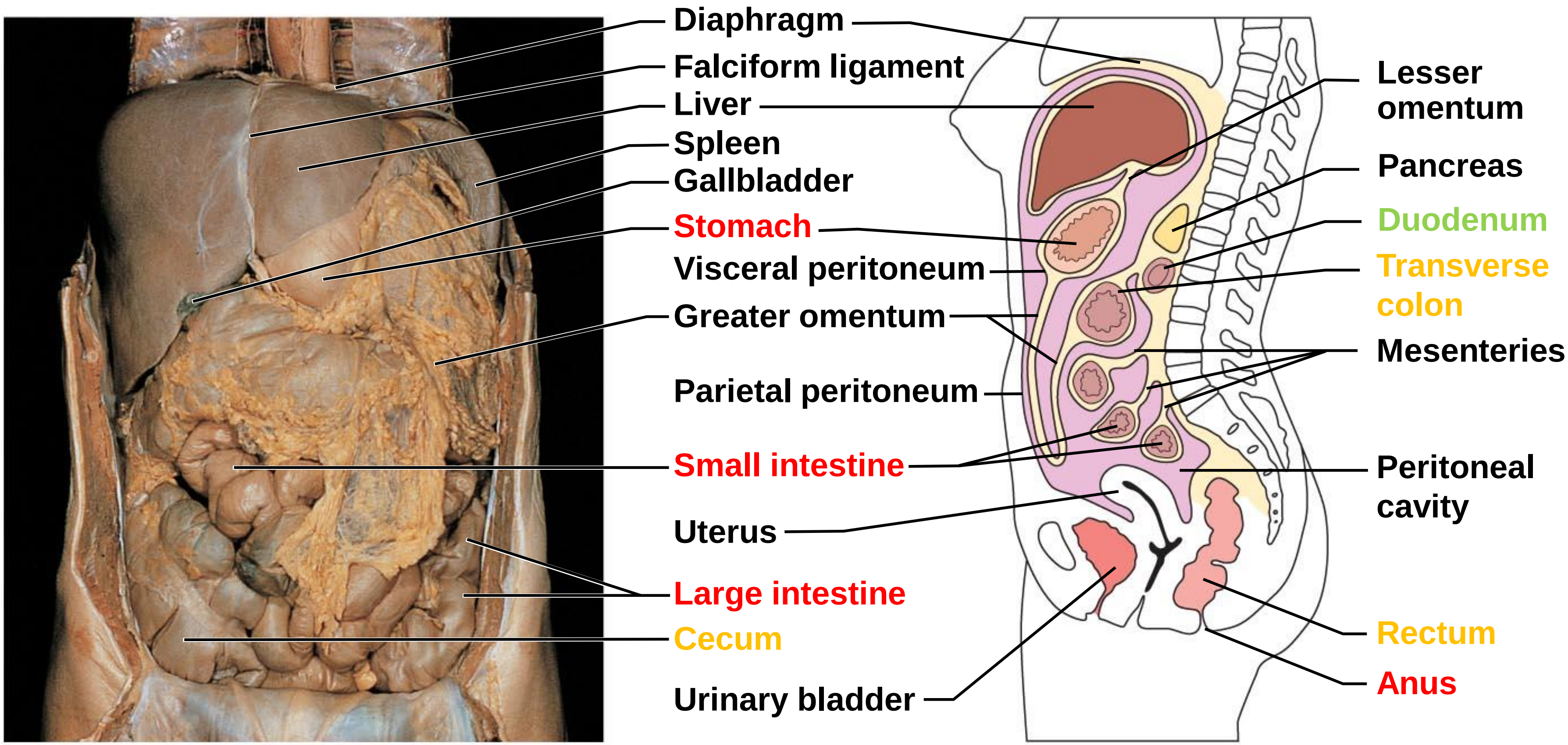
Esophagus: no digestive function; passageway / conducts food & air

Stomach: cardiac, fundus, body, pylorus, rugae / storage, chemical breakdown (chyme)

Small intestine: nutrient absorption / duodenum, jejunum, ileum / pancreatic enzymes & bile /microvilli, brush border, villi

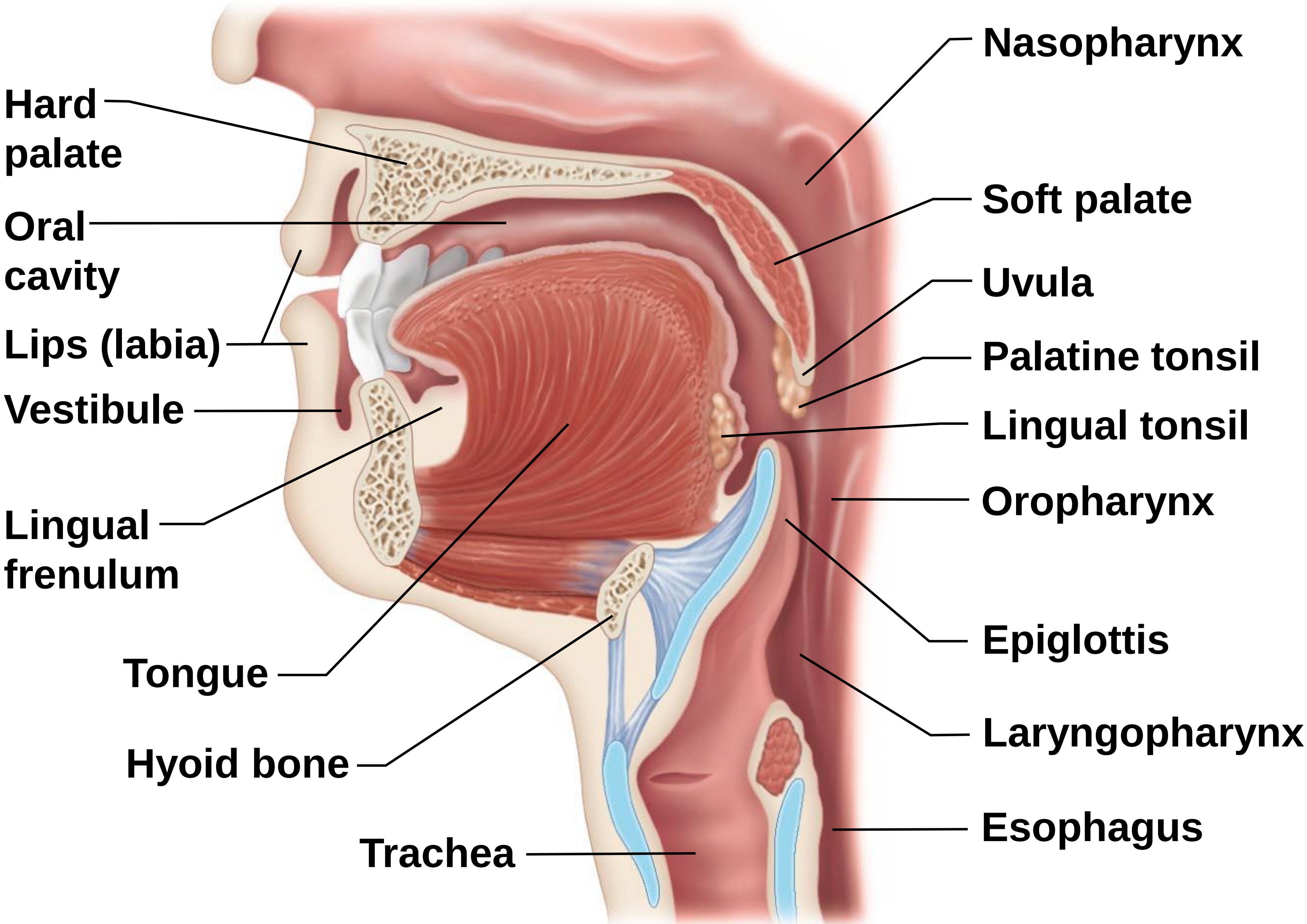
Large intestine: Cecum, Appendix, Colon, Rectum, Anal canal

Anus: opening to the environment



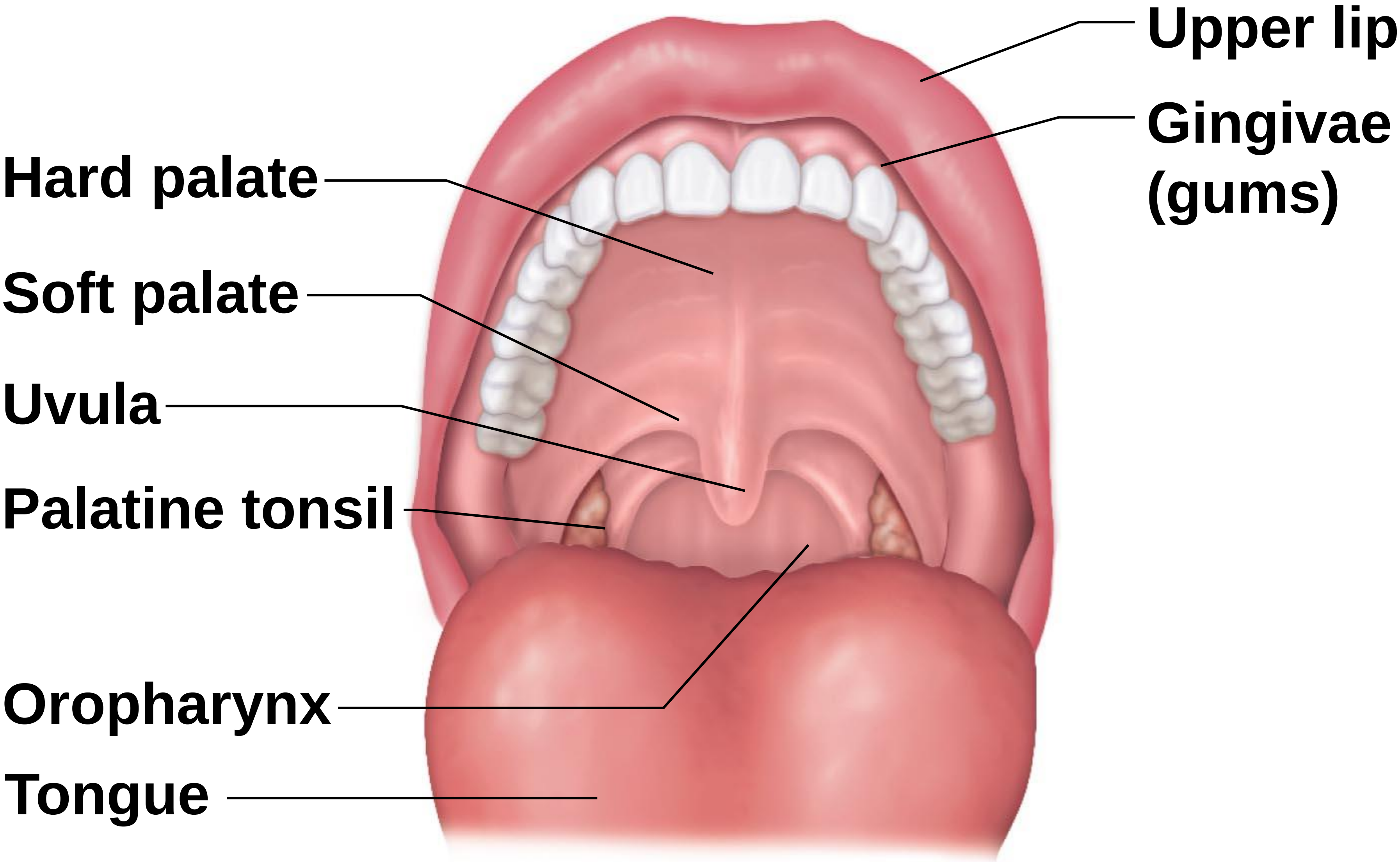
(a) (b)

Figure 14.5



(a)

Figure 14.2a



(b) courage detector

Figure 14.2b

LAYERS OF TISSUE IN THE ALIMENTARY CANAL ORGANS

Four layers from deep to superficial:

- **Mucosa:** innermost, lines the cavity
- **Submucosa:** blood vessels, nerve endings, mucosa-associated lymphoid tissue, and lymphatics
- **Muscularis externa:** Inner circular layer; outer longitudinal layer
- **Serosa:** outermost layer of the wall contains fluid-producing cells

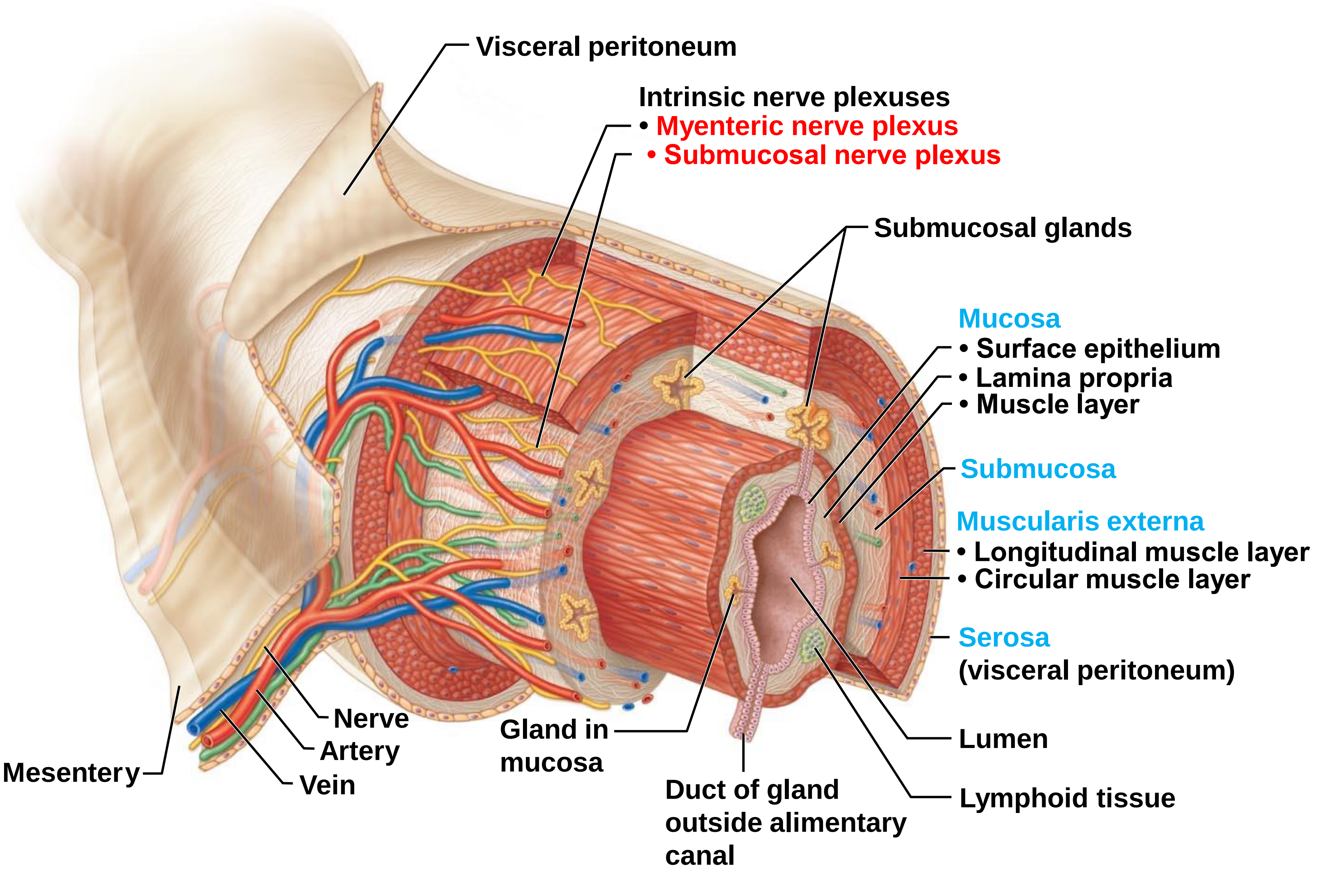

Visceral peritoneum
Intrinsic nerve plexuses
• Myenteric nerve plexus
• Submucosal nerve plexus
Submucosal glands
Mucosa
• Surface epithelium
• Lamina propria
• Muscle layer
Submucosa
Muscularis externa
• Longitudinal muscle layer
• Circular muscle layer
Serosa
(visceral peritoneum)
Lumen
Lymphoid tissue
Duct of gland outside alimentary canal
Gland in mucosa
Nerve
Artery
Vein
Mesentery

Figure 14.3

ALIMENTARY CANAL NERVE PLEXUSES

Two important nerve plexuses serve the alimentary canal

Both are part of the ***autonomic*** nervous system

- Submucosal nerve plexus
- Myenteric nerve plexus

Function is to regulate mobility and secretory activity of the GI tract organs

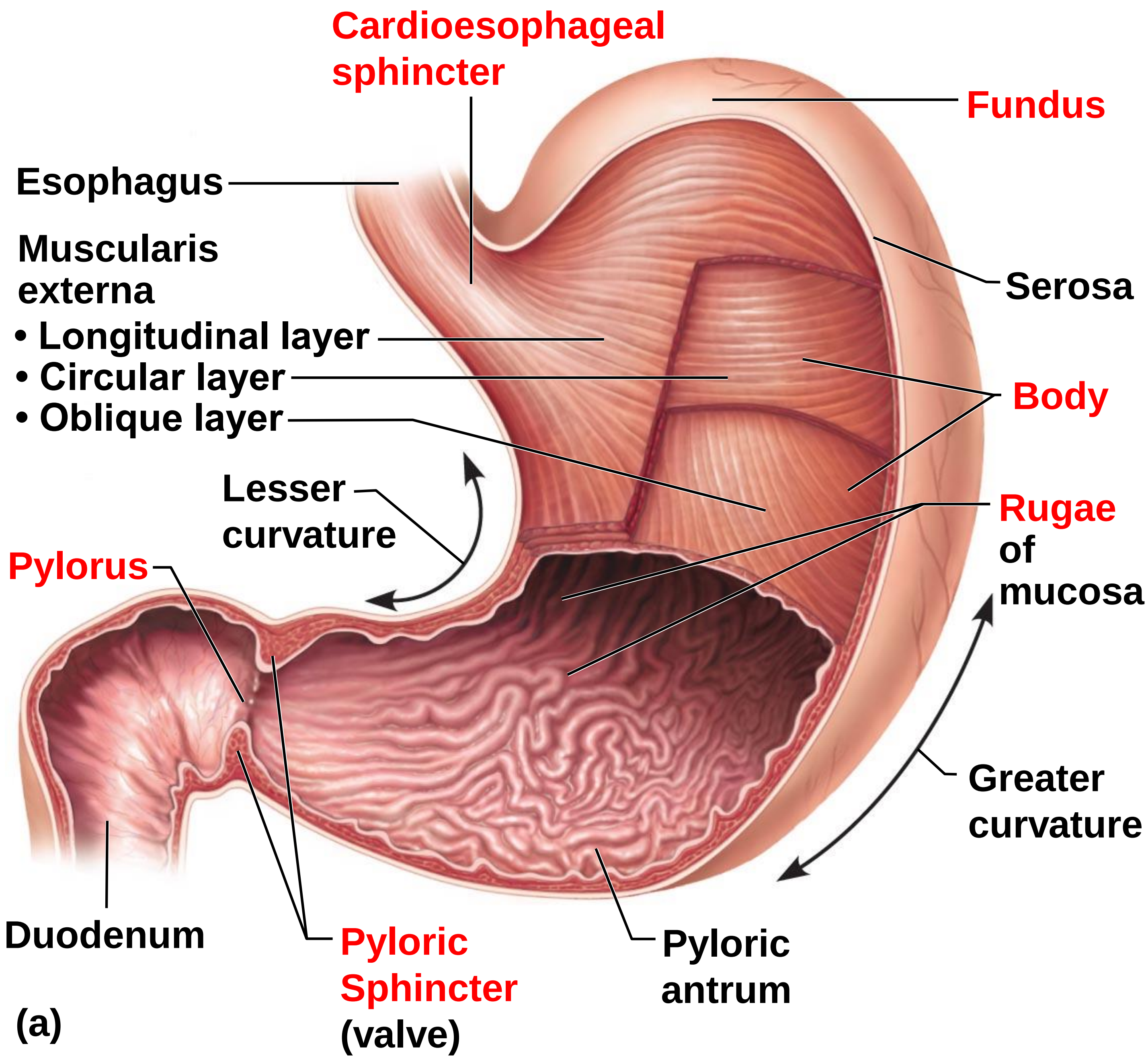
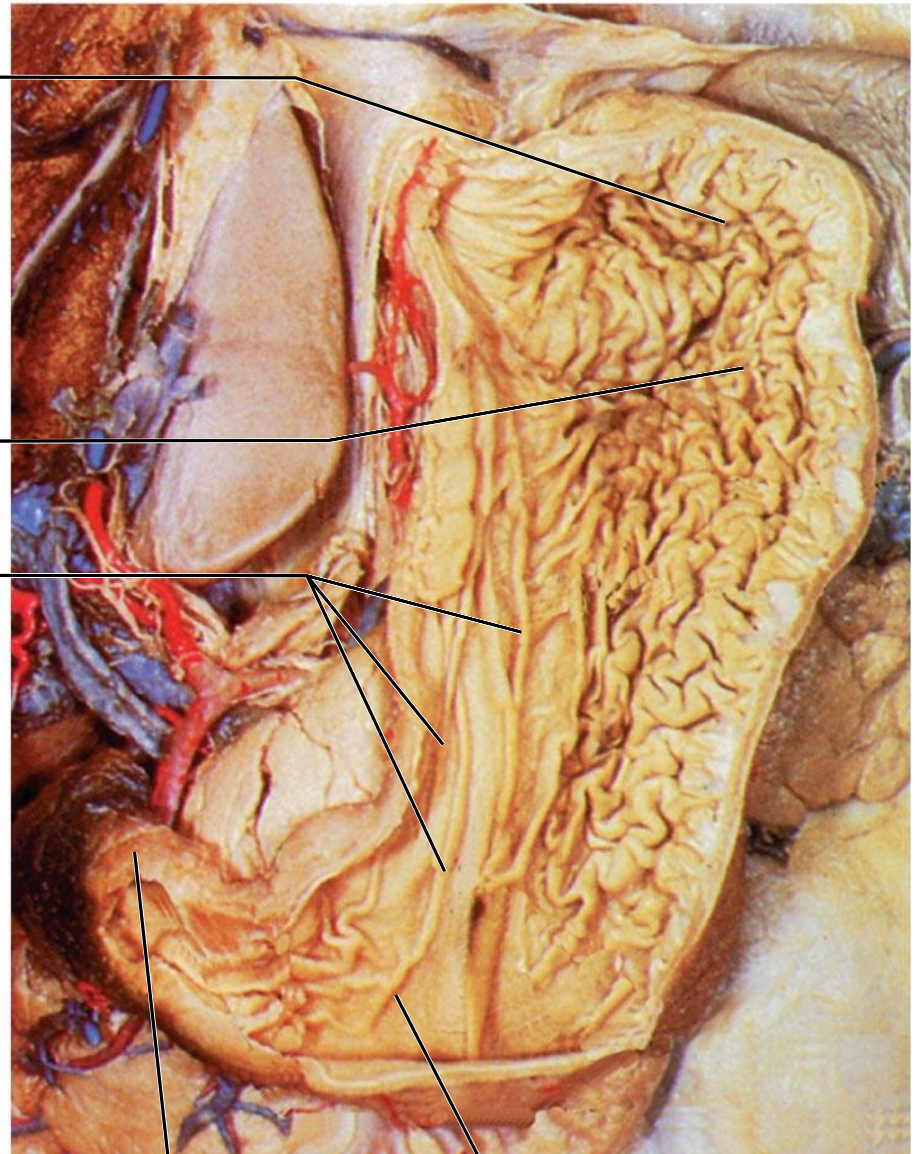

Cardioesophageal sphincter
Fundus
Esophagus
Muscularis externa
• Longitudinal layer
• Circular layer
• Oblique layer
Serosa
Body
Lesser curvature
Rugae of mucosa
Pylorus
Greater curvature
Duodenum
Pyloric Sphincter (valve)
Pyloric antrum
(a)

Figure 14.4a



(b)

Figure 14.4b

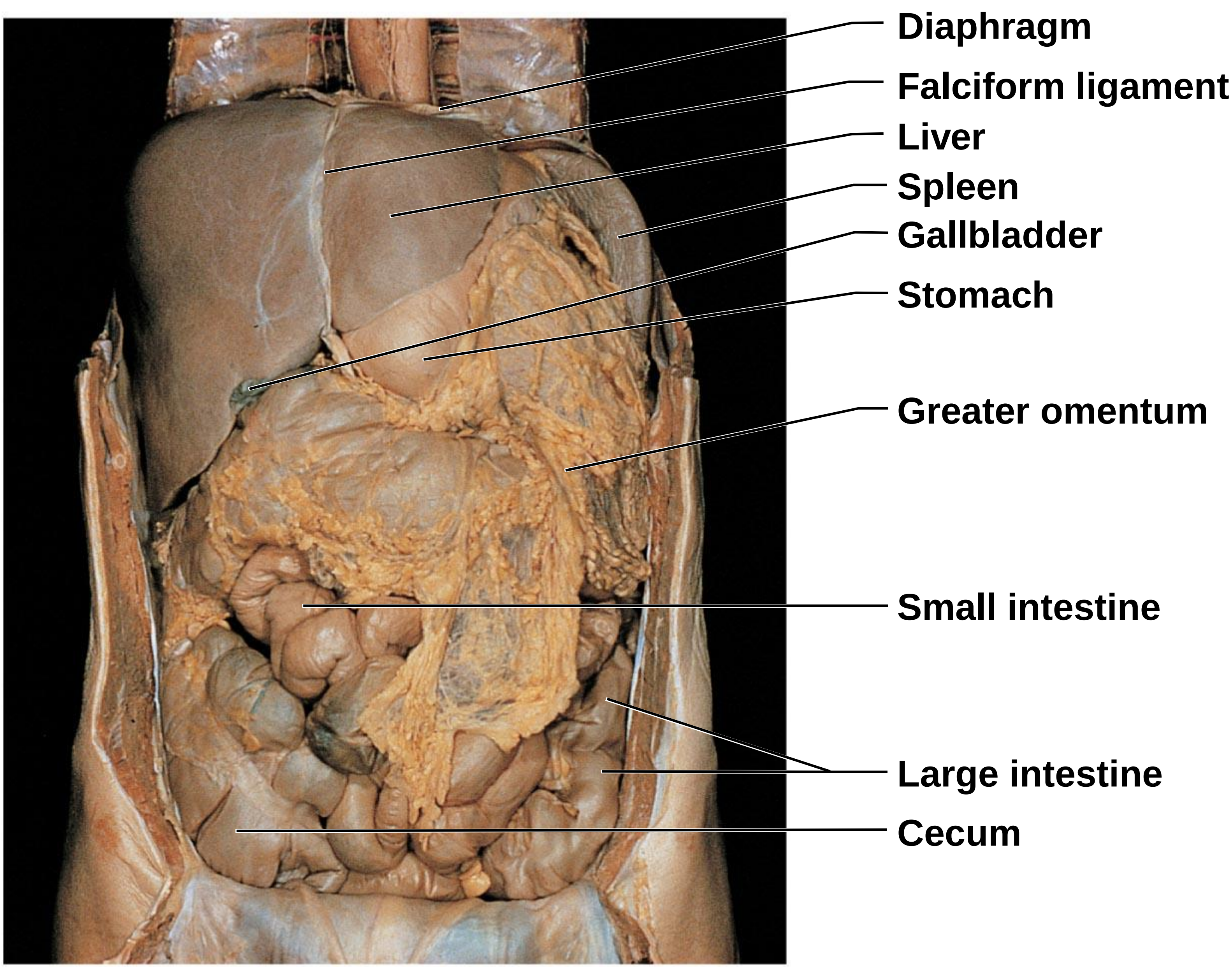
Digestive System

https://www.youtube.com/watch?v=nM5kMSjBrmw&list=PLCC2DB523BA8BCB53&index=2

Stomach

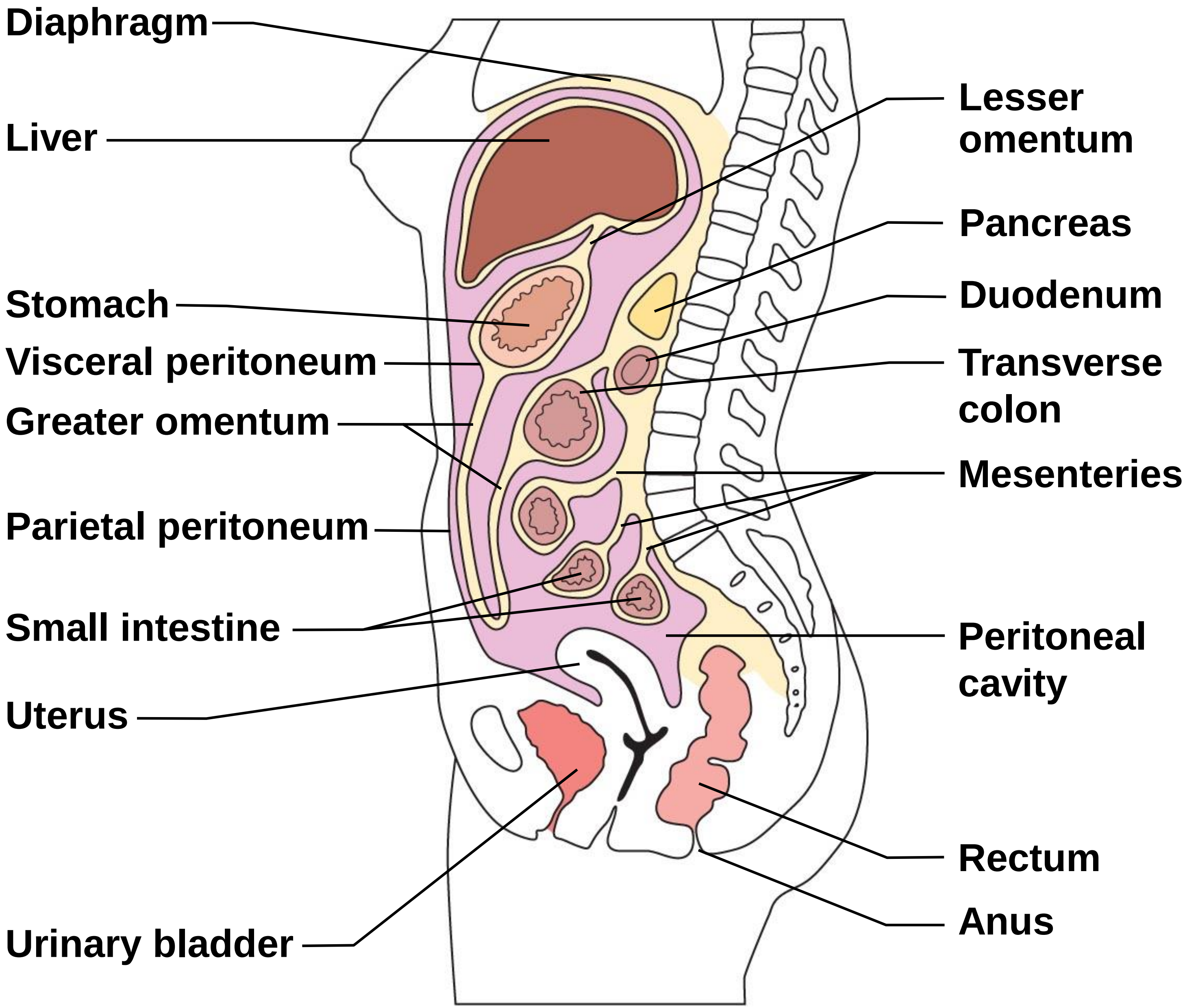
intestines

https://www.youtube.com/watch?v=qy_mlEnnlF4



(a)

Figure 14.5a



(b)

Figure 14.5b

STRUCTURE OF THE STOMACH MUCOSA

Mucosa is simple columnar epithelium

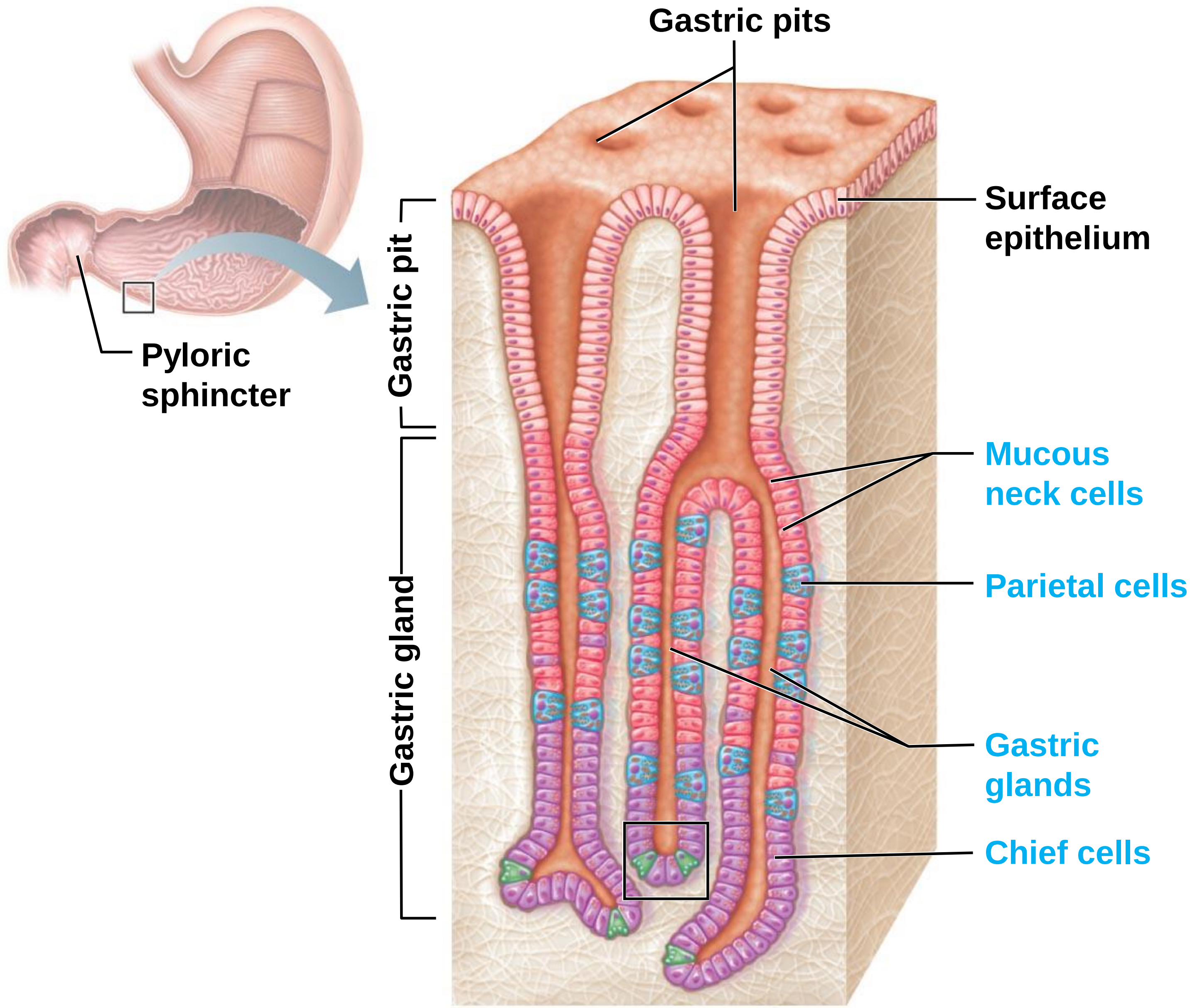
Mucous neck cells — produce a sticky alkaline mucus

Gastric glands — situated in gastric pits and secrete gastric juice

Chief cells — produce protein-digesting enzymes (pepsinogens)

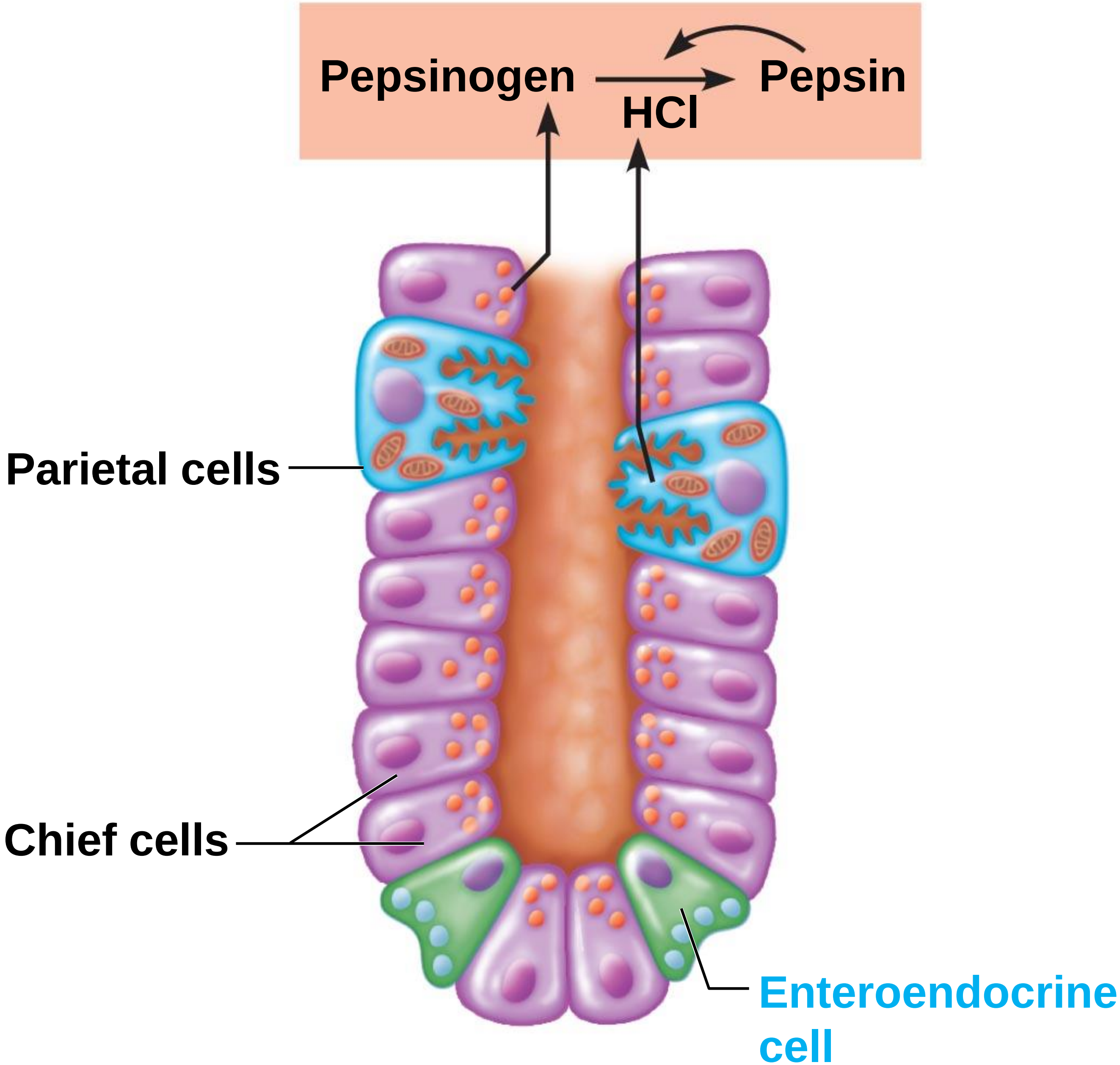
Parietal cells — produce hydrochloric acid

Enteroendocrine cells — produce gastrin



(c)

Figure 14.4c



(d)

Figure 14.4d

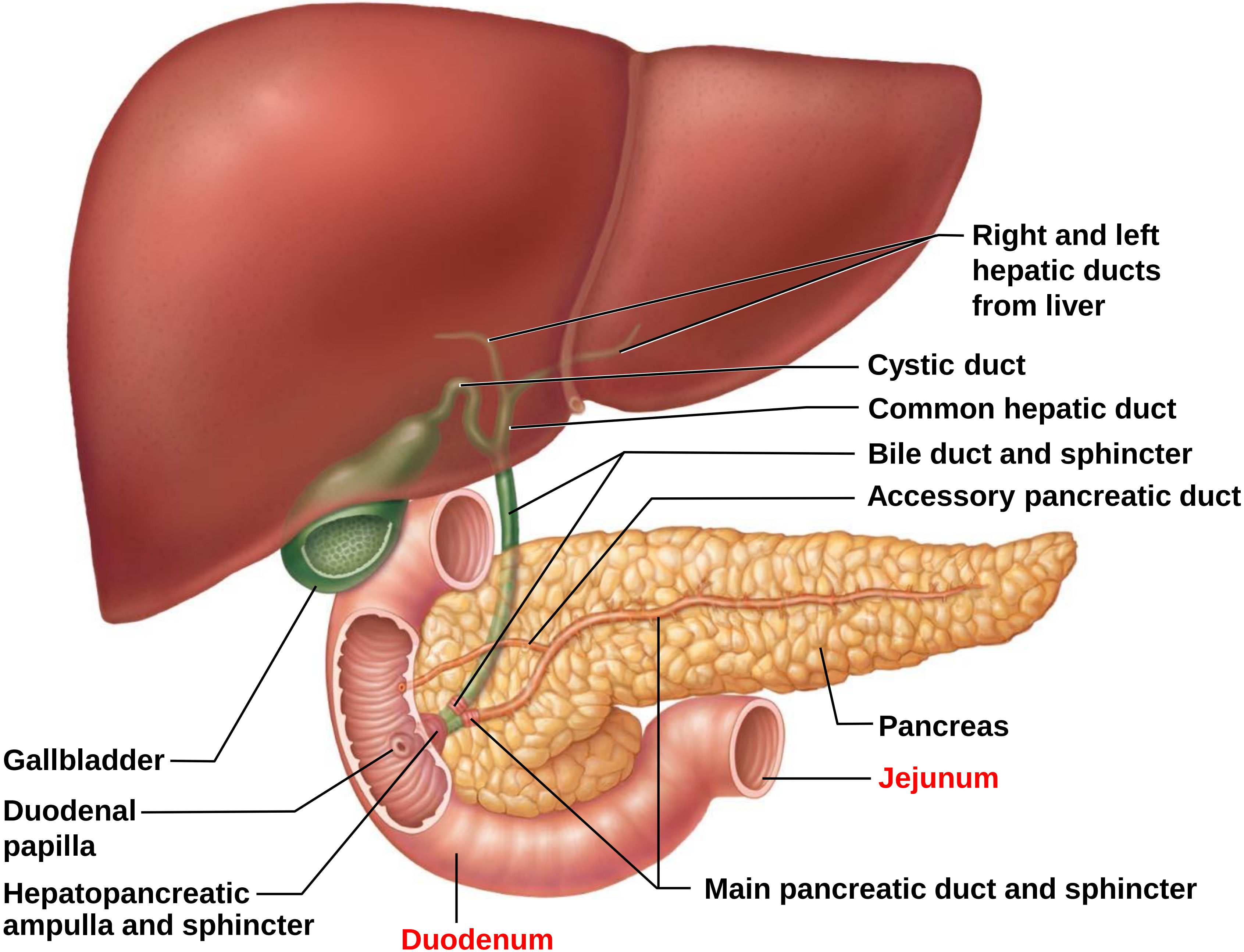
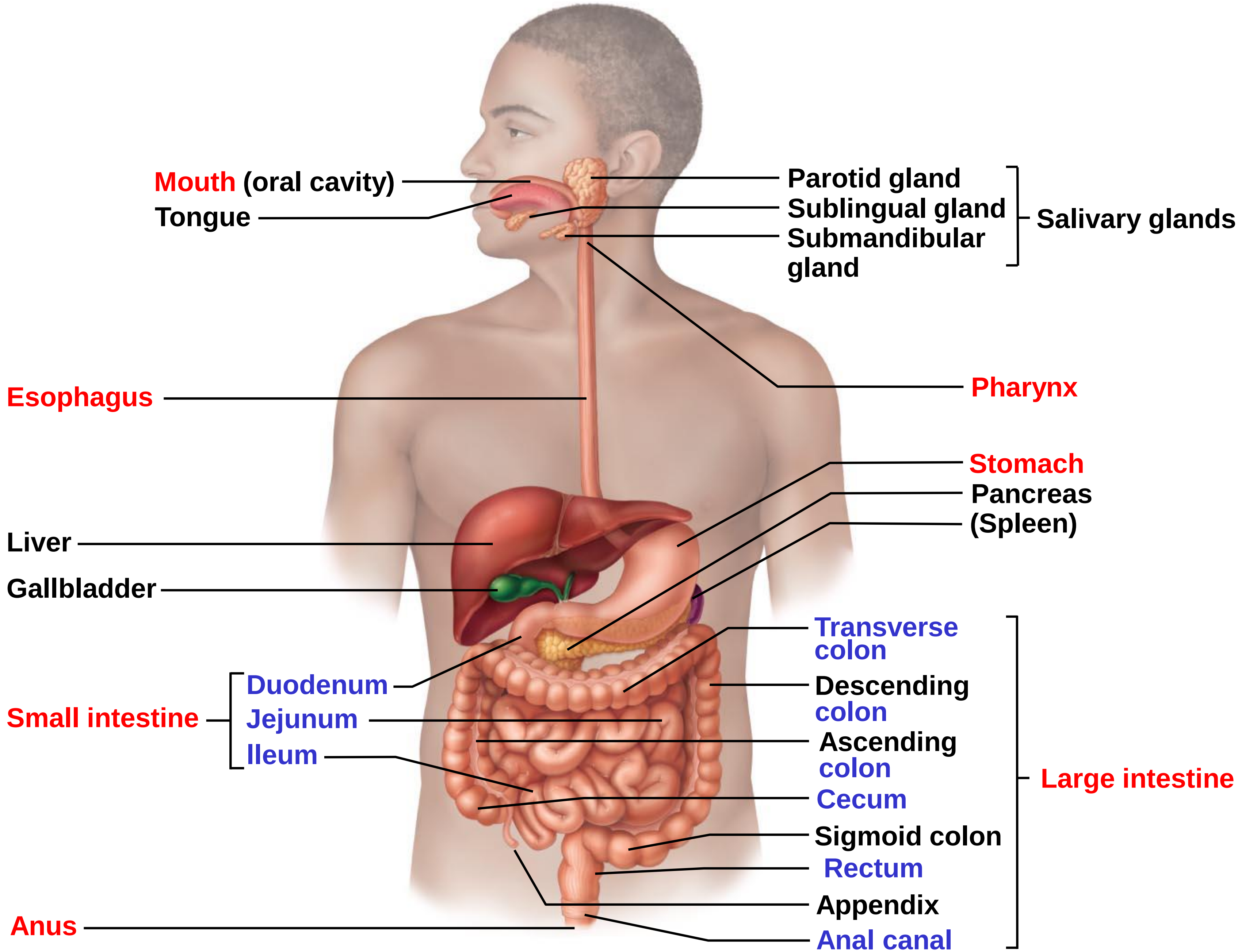

Right and left hepatic ducts from liver
Cystic duct
Common hepatic duct
Bile duct and sphincter
Accessory pancreatic duct
Pancreas
Jejunum
Main pancreatic duct and sphincter
Gallbladder
Duodenal papilla
Hepatopancreatic ampulla and sphincter
Duodenum

Figure 14.6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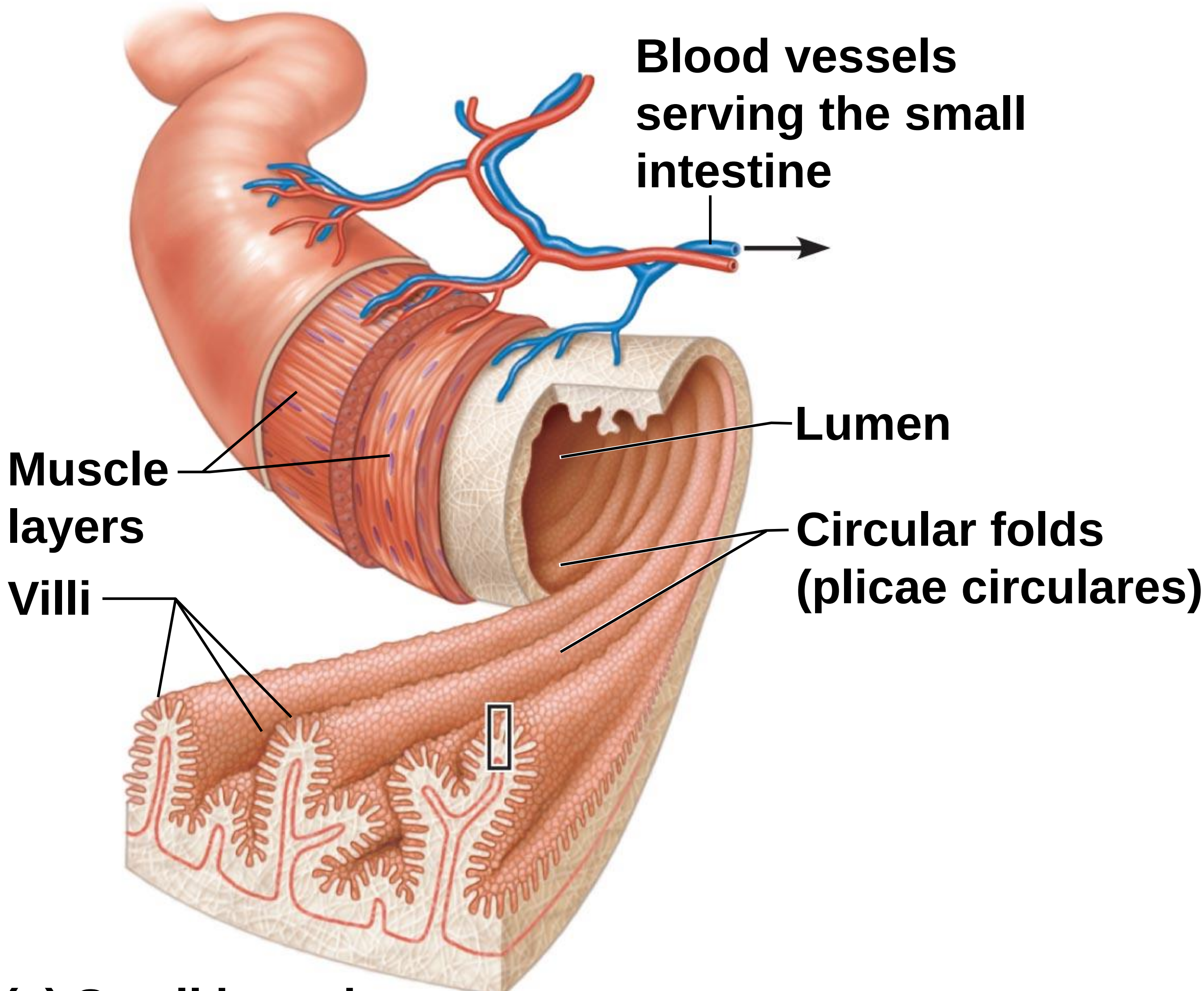
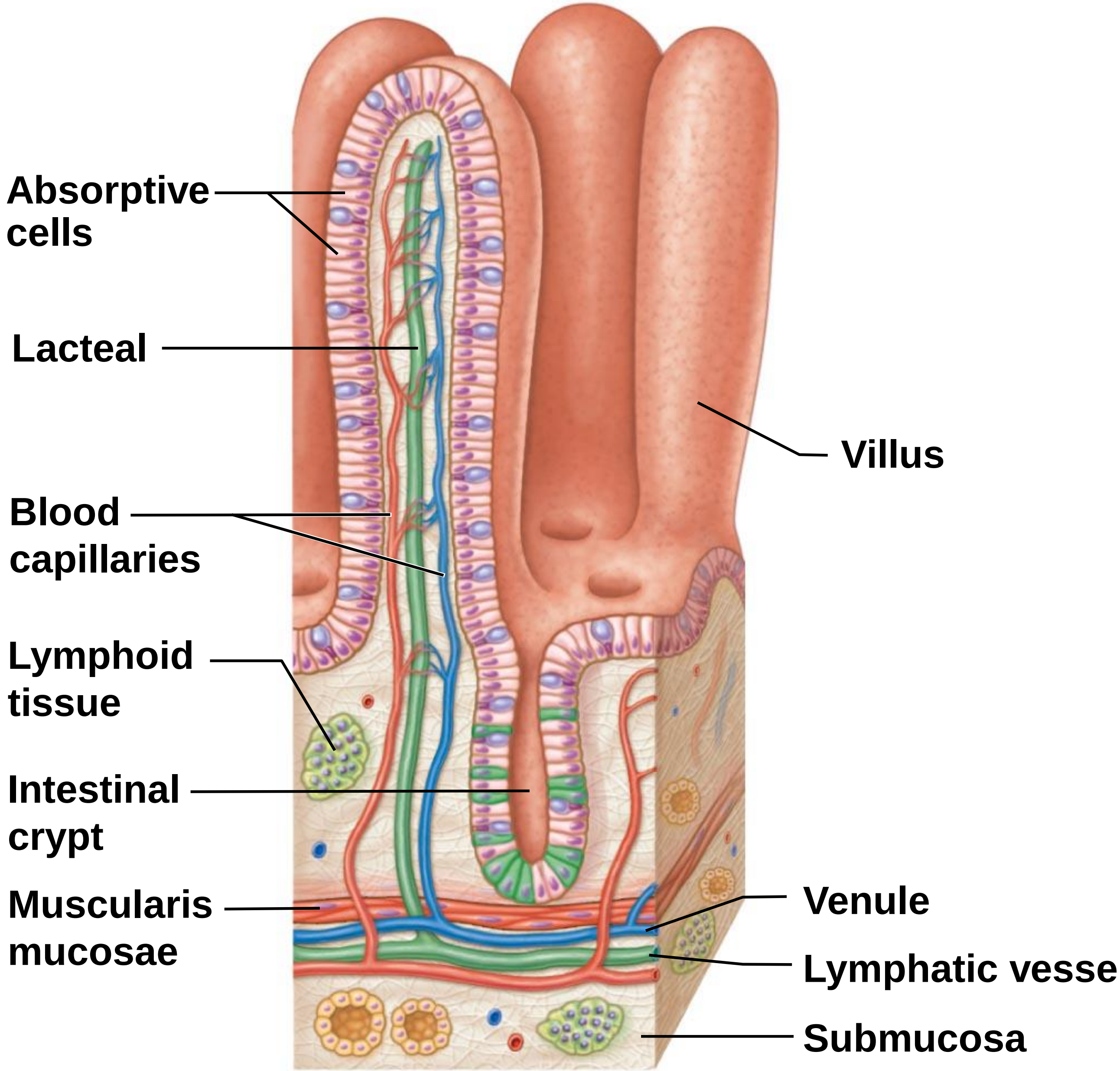
Small intestine
Jejunum
Ileum
Descending colon
Ascending colon
Cecum
Large intestine
Sigmoid colon
Rectum
Appendix
Anus
Anal canal

Figure 14.1



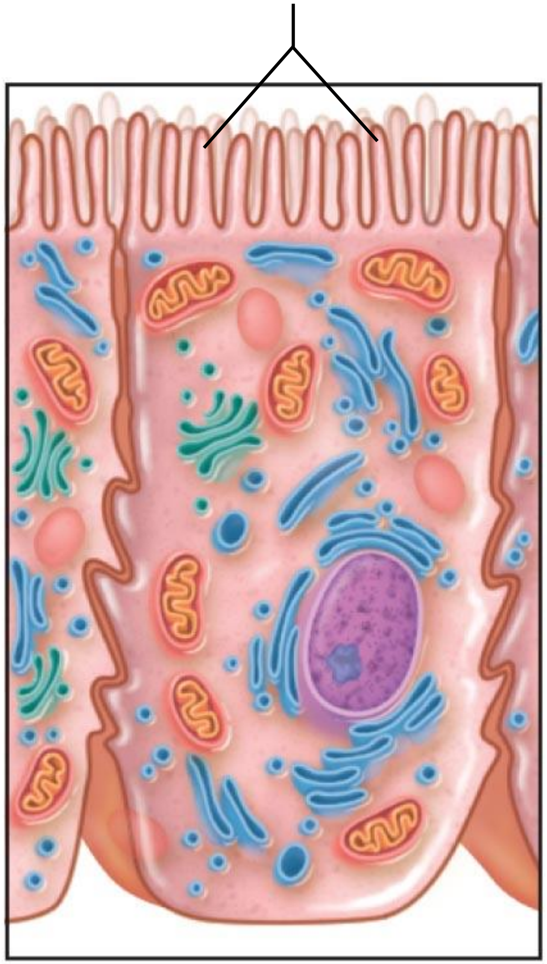
(a) Small intestine

Figure 14.7a



(b) Villi

Figure 14.7b



(c) Absorptive cells

Figure 14.7c

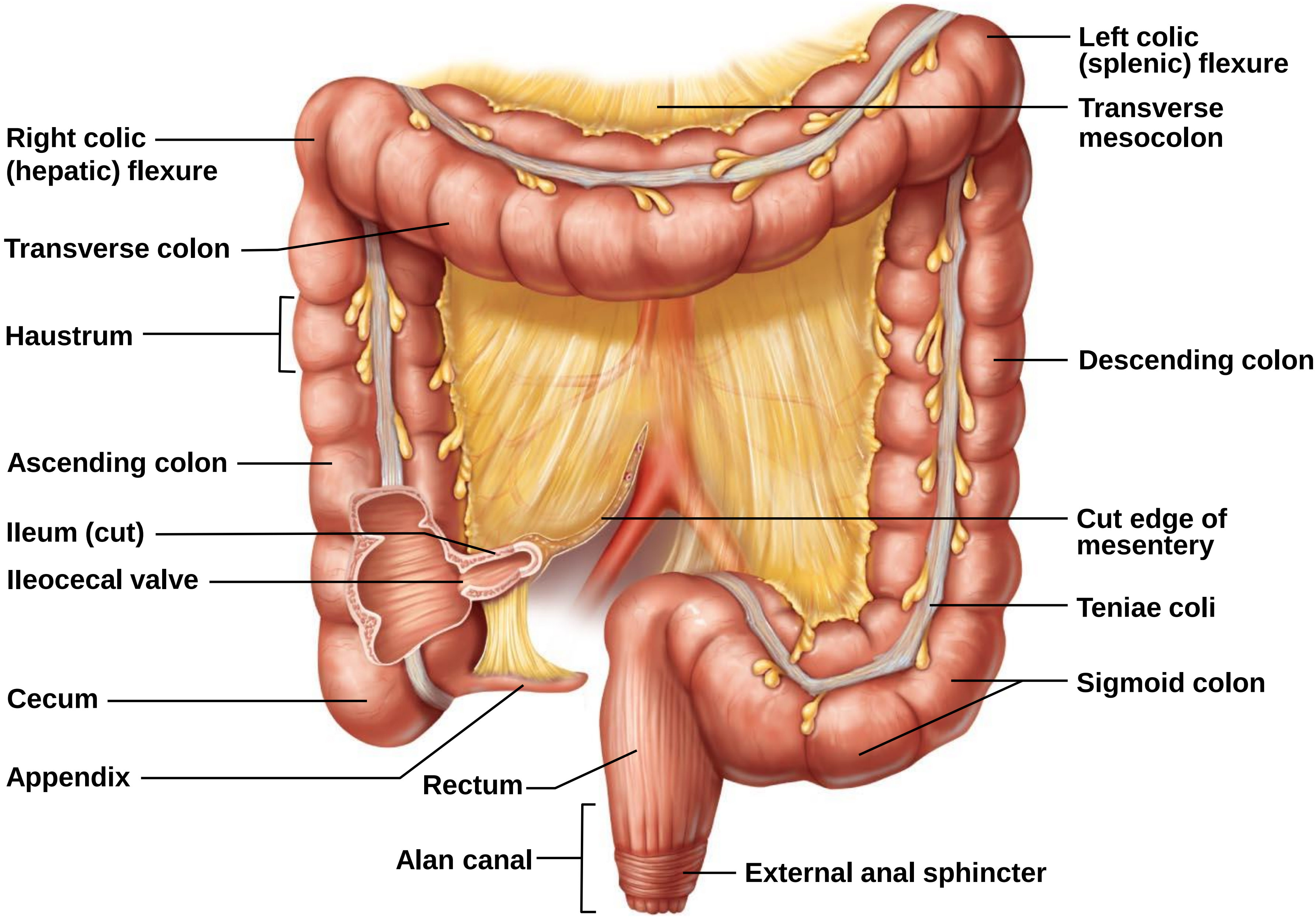

Left colic
(splenic) flexure
Transverse
mesocolon
Right colic
(hepatic) flexure
Transverse colon
Haustrum
Descending colon
Ascending colon
Cut edge of
mesentery
Ileum (cut)
Ileocecal valve
Teniae coli
Sigmoid colon
Cecum
Appendix
Rectum
Alan canal
External anal sphincter

Figure 14.8

ACCESSORY DIGESTIVE ORGANS

Teeth

Salivary glands

Pancreas

Liver

Gallbladder

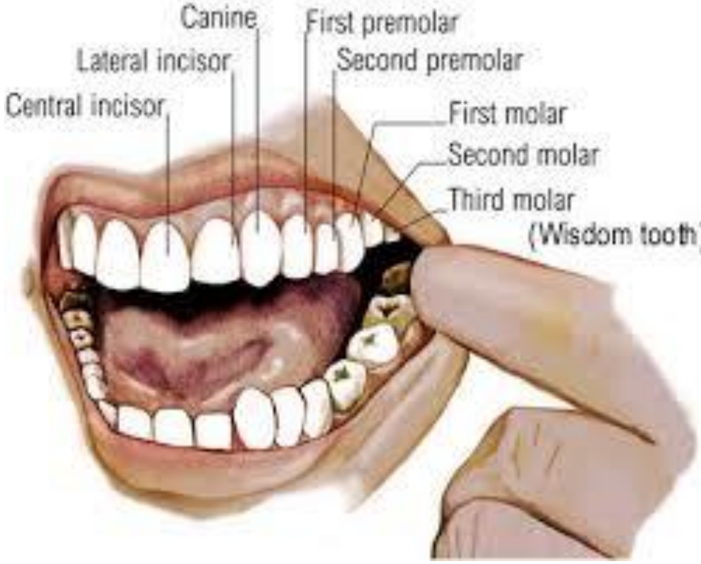
CLASSIFICATION OF TEETH

Incisors — cutting

Canines (eyeteeth) — tearing or piercing

Premolars (bicuspids) — grinding

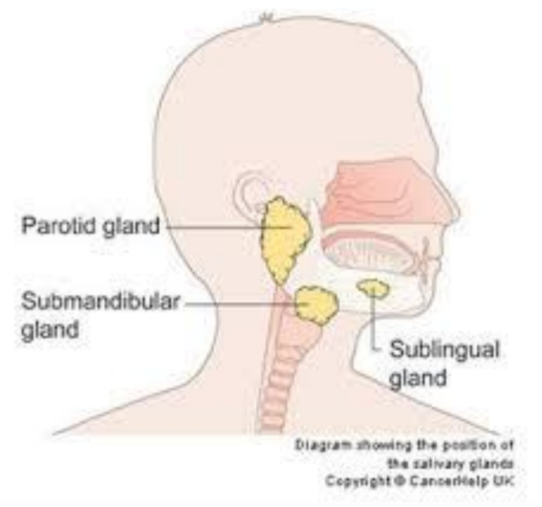
Molars — grinding



SALIVARY GLANDS

Three pairs of salivary glands empty secretions into the mouth

- **Parotid glands**
  - Found anterior to the ears
- **Submandibular glands**
- **Sublingual glands**
  - Both submandibular and sublingual glands empty saliva into the floor of the mouth through small ducts



SALIVA

Mixture of mucus and serous fluids

Helps to form a food bolus

Contains salivary amylase to begin starch digestion

Dissolves chemicals so they can be tasted

PANCREAS

Produces a wide spectrum of digestive enzymes that break down all categories of food

Enzymes are secreted into the duodenum

Alkaline fluid introduced with enzymes neutralizes acidic chyme coming from stomach

Hormones produced by the pancreas

- Insulin
- Glucagon

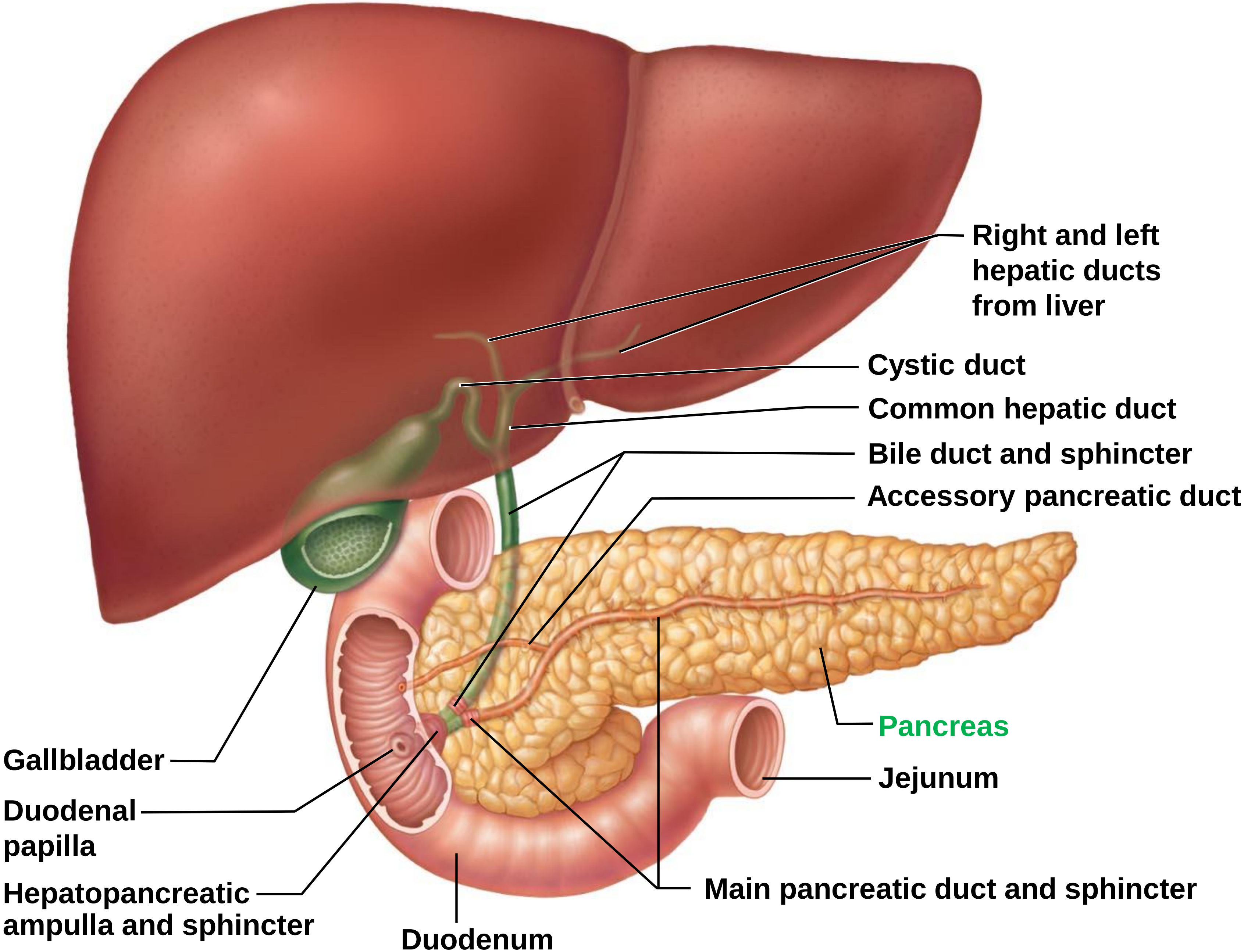

Right and left
hepatic ducts
from liver
Cystic duct
Common hepatic duct
Bile duct and sphincter
Accessory pancreatic duct
Pancreas
Jejunum
Gallbladder
Duodenal
papilla
Hepatopancreatic
ampulla and sphincter
Duodenum
Main pancreatic duct and sphincter

Figure 14.6

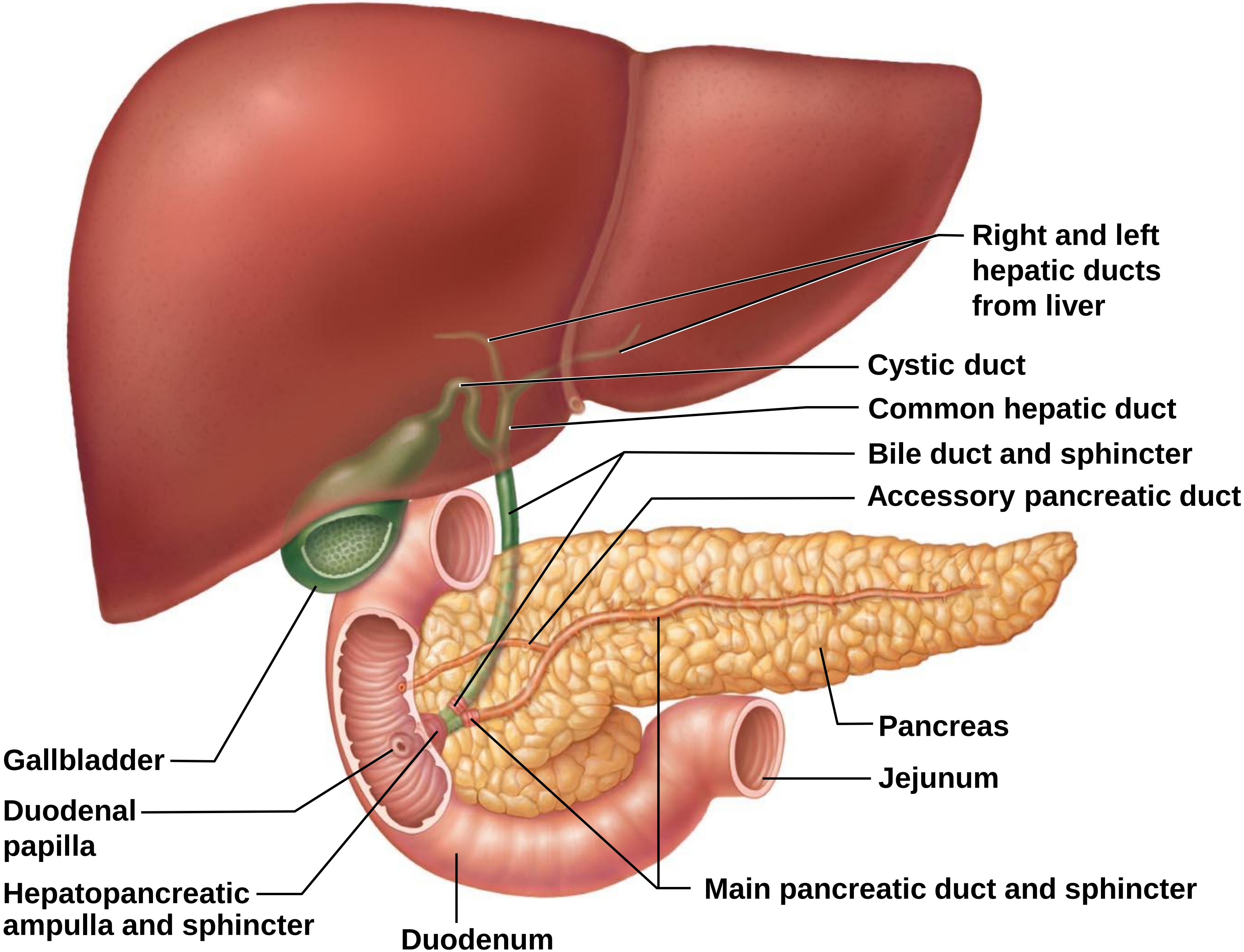
LIVER

Largest gland in the body

Located on the right side of the body under the diaphragm

Consists of four lobes suspended from the diaphragm and abdominal wall by the falciform ligament

Connected to the gallbladder via the common hepatic duct


Right and left
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Bile duct and sphincter
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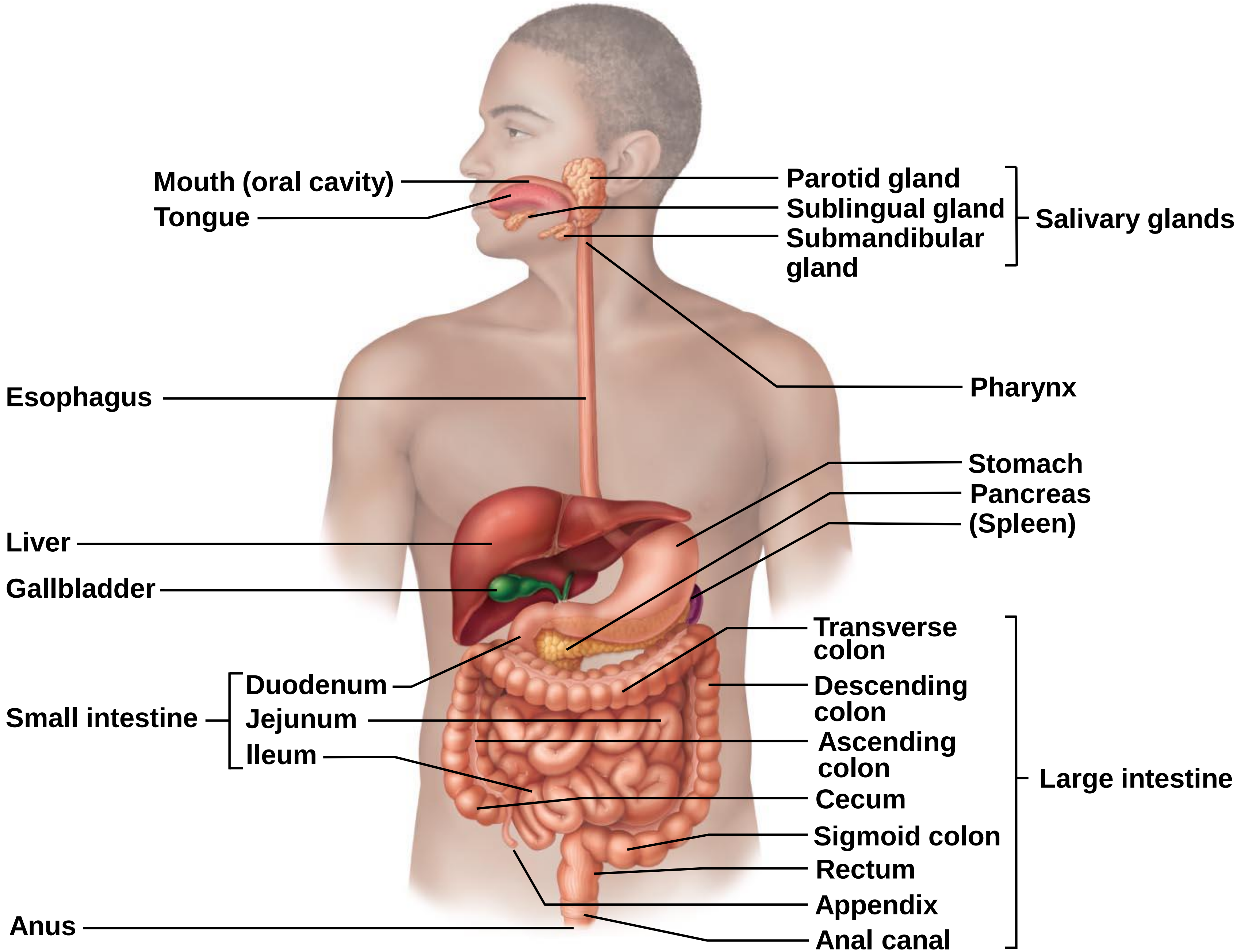
Duodenal
papilla
Hepatopancreatic
ampulla and sphincter
Duodenum
Main pancreatic duct and sphincter

Figure 14.6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Sublingual gland
Submandibular gland
Salivary glands
Pharynx
Stomach
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Transverse colon
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Ascending colon
Cecum
Sigmoid colon
Rectum
Appendix
Anal canal
Large intestine

Figure 14.1

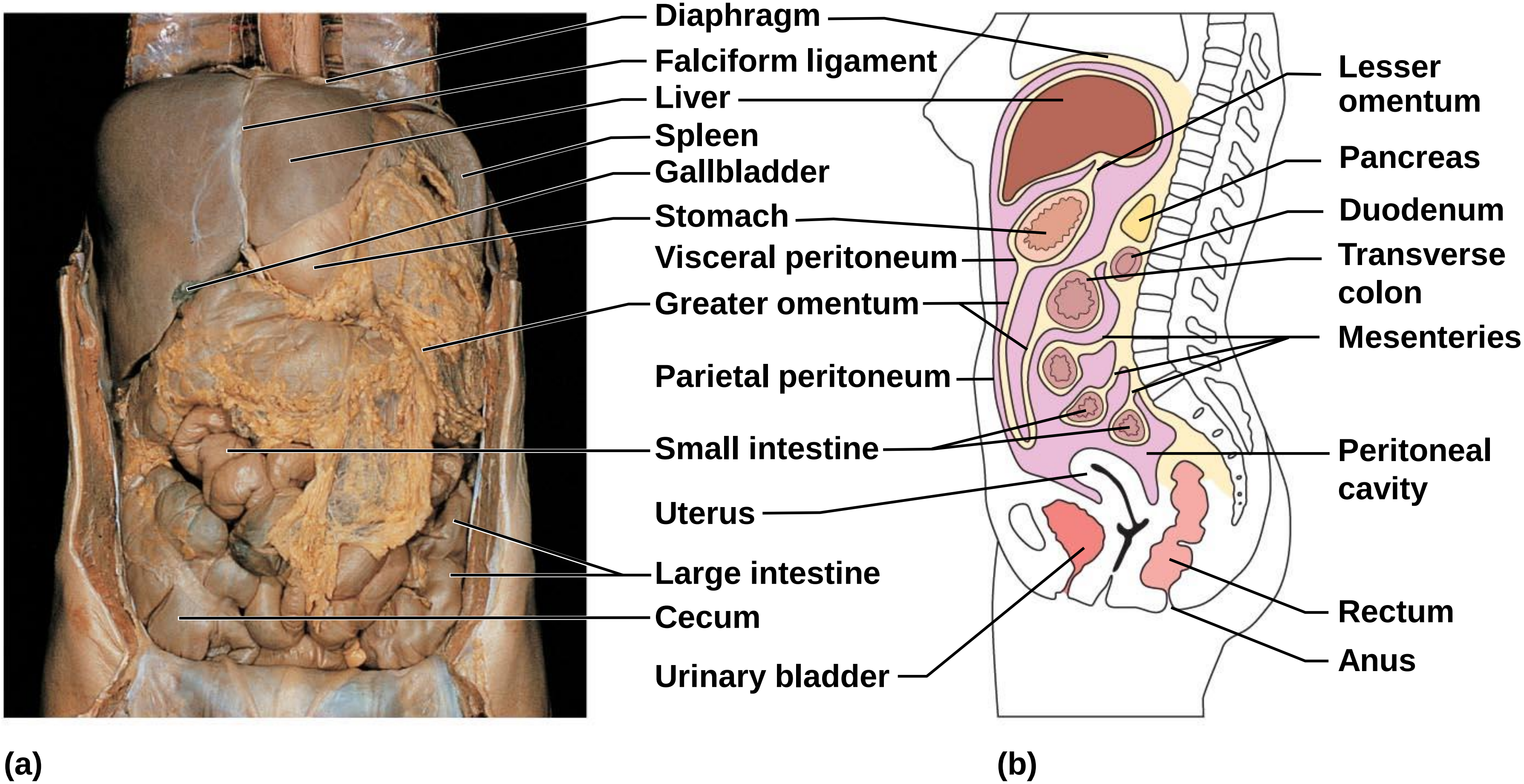

Figure 14.5a-b

BILE

Produced by cells in the liver

Function — emulsify fats by physically breaking large fat globules into smaller ones

Bile leaves the liver through the common hepatic duct

Composition is

- Bile salts
- Bile pigments (mostly bilirubin from the breakdown of hemoglobin)
- Cholesterol
- Phospholipids
- Electrolytes

GALLBLADDER

Sac found in hollow fossa of liver

When no digestion is occurring, bile backs up the cystic duct for storage in the gallbladder

When digestion of fatty food is occurring, bile is introduced into the duodenum from the gallbladder

Gallstones are crystallized cholesterol which can cause blockages

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FUNCTIONS OF THE DIGESTIVE SYSTEM

Ingestion — placing food into the mouth

Propulsion — moving foods from one region of the digestive system to another

- **Peristalsis** — alternating waves of contraction and relaxation that squeezes food along the GI tract
- **Segmentation** — moving materials back and forth to aid with mixing in the small intestine

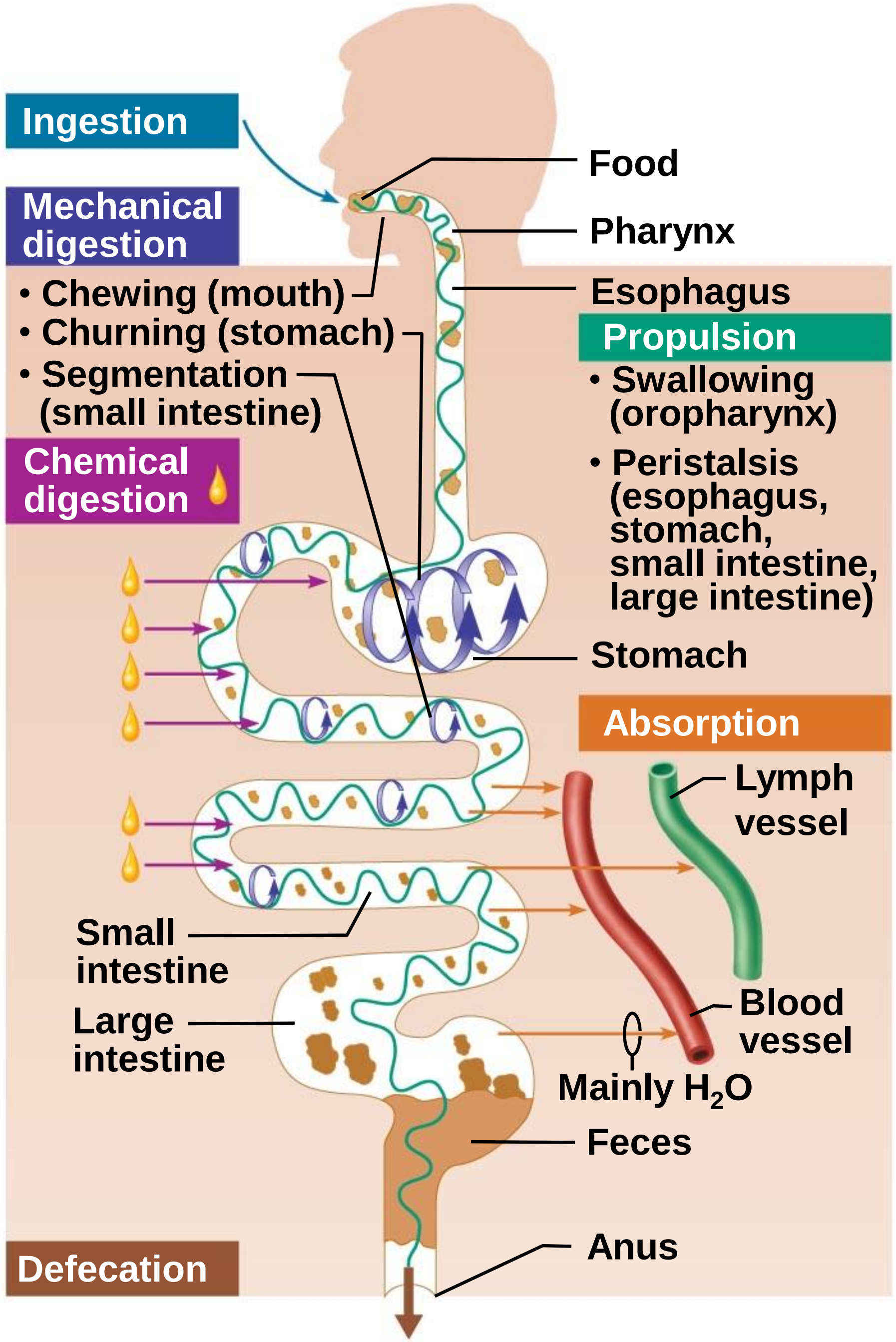

Ingestion
Food
Pharynx
Mechanical digestion
• Chewing (mouth)
• Churning (stomach)
• Segmentation (small intestine)
Esophagus
Propulsion
• Swallowing (oropharynx)
• Peristalsis (esophagus, stomach, small intestine, large intestine)
Chemical digestion
Stomach
Absorption
Lymph vessel
Small intestine
Blood vessel
Large intestine
Mainly H_2O
Feces
Anus
Defecation

Figure 14.11

FUNCTIONS OF THE DIGESTIVE SYSTEM

Food breakdown as ***mechanical*** digestion

- Examples:
  - Mixing food in the mouth by the tongue
  - Churning food in the stomach
  - Segmentation in the small intestine

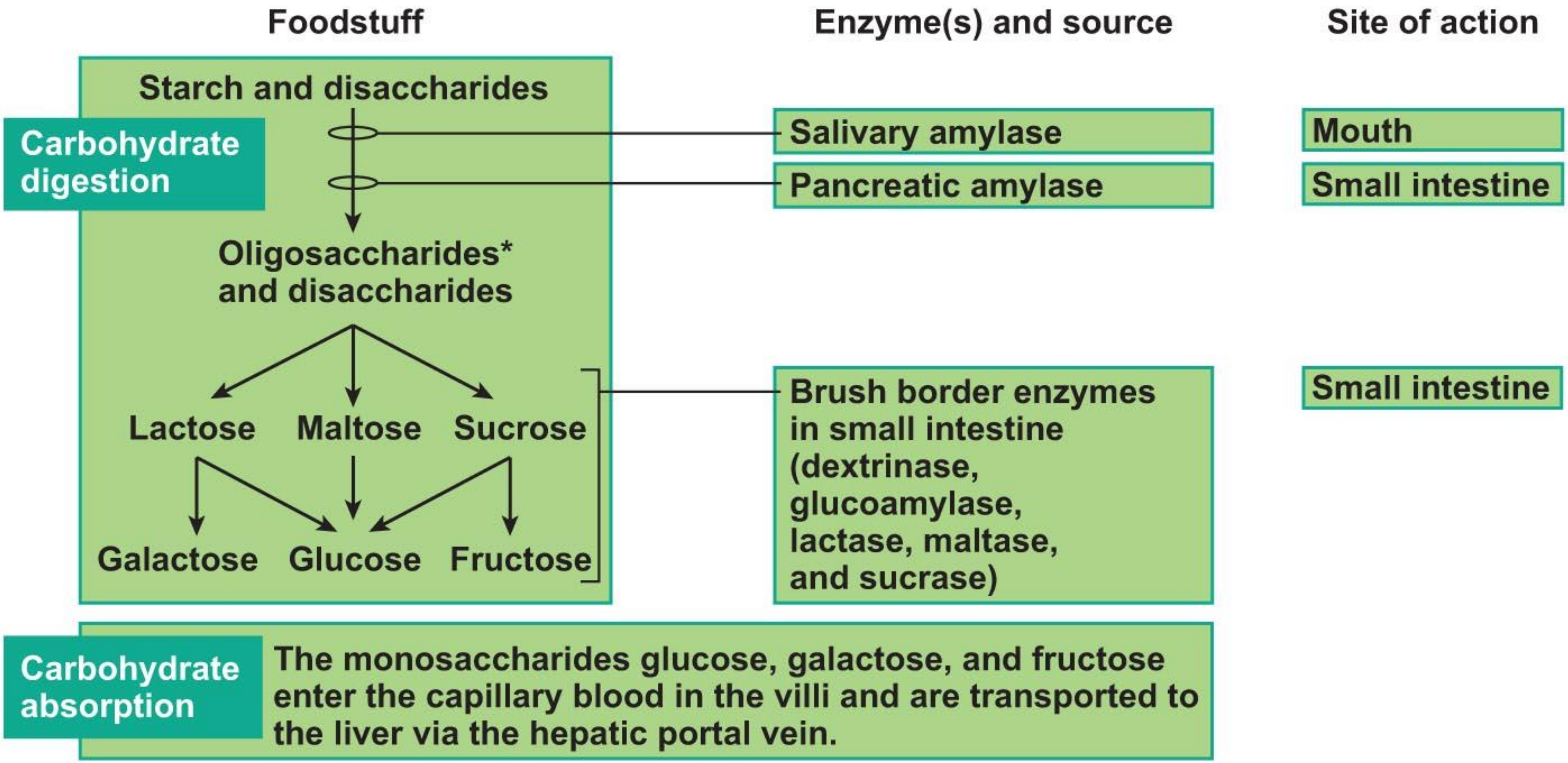
- Mechanical digestion prepares food for further degradation by enzymes

FUNCTIONS OF THE DIGESTIVE SYSTEM

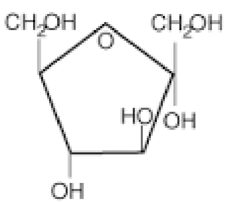
Food breakdown as ***chemical*** digestion

- Enzymes break down food molecules into their building blocks

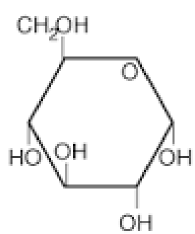
- Each major food group uses different enzymes
  - *Carbohydrates* are broken to *simple sugars*
  - *Proteins* are broken to *amino acids*
  - *Fats* are broken to fatty *acids and alcohols*



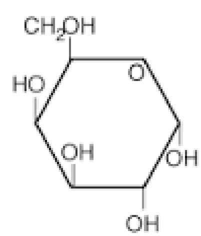
*Oligosaccharides consist of a few linked monosaccharides.



Fructose



Glucose



Galactose

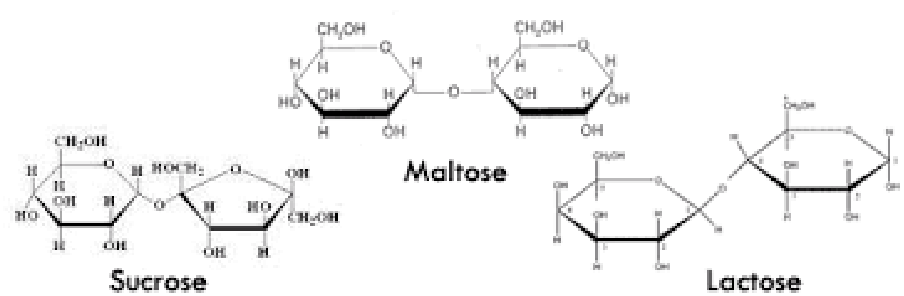


Figure 2. Disaccharide

Figure 14.13 (1 of 3)

Protein digestion

Foodstuff	Enzyme(s) and source	Site of action
Protein → Large polypeptides	Pepsin (stomach glands) in the presence of HCl	Stomach
Large polypeptides → Small polypeptides, small peptides	Pancreatic enzymes (trypsin, chymotrypsin, carboxypeptidase)	Small intestine
Small polypeptides, small peptides → Amino acids (some dipeptides and tripeptides)	Brush border enzymes (aminopeptidase, carboxypeptidase, and dipeptidase)	Small intestine

Protein absorption

Amino acids enter the capillary blood in the villi and are transported to the liver via the hepatic portal vein.

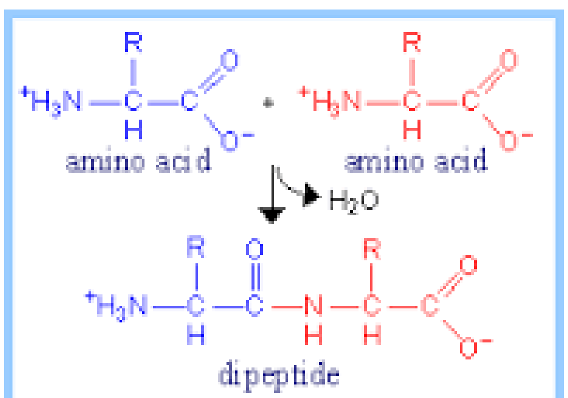
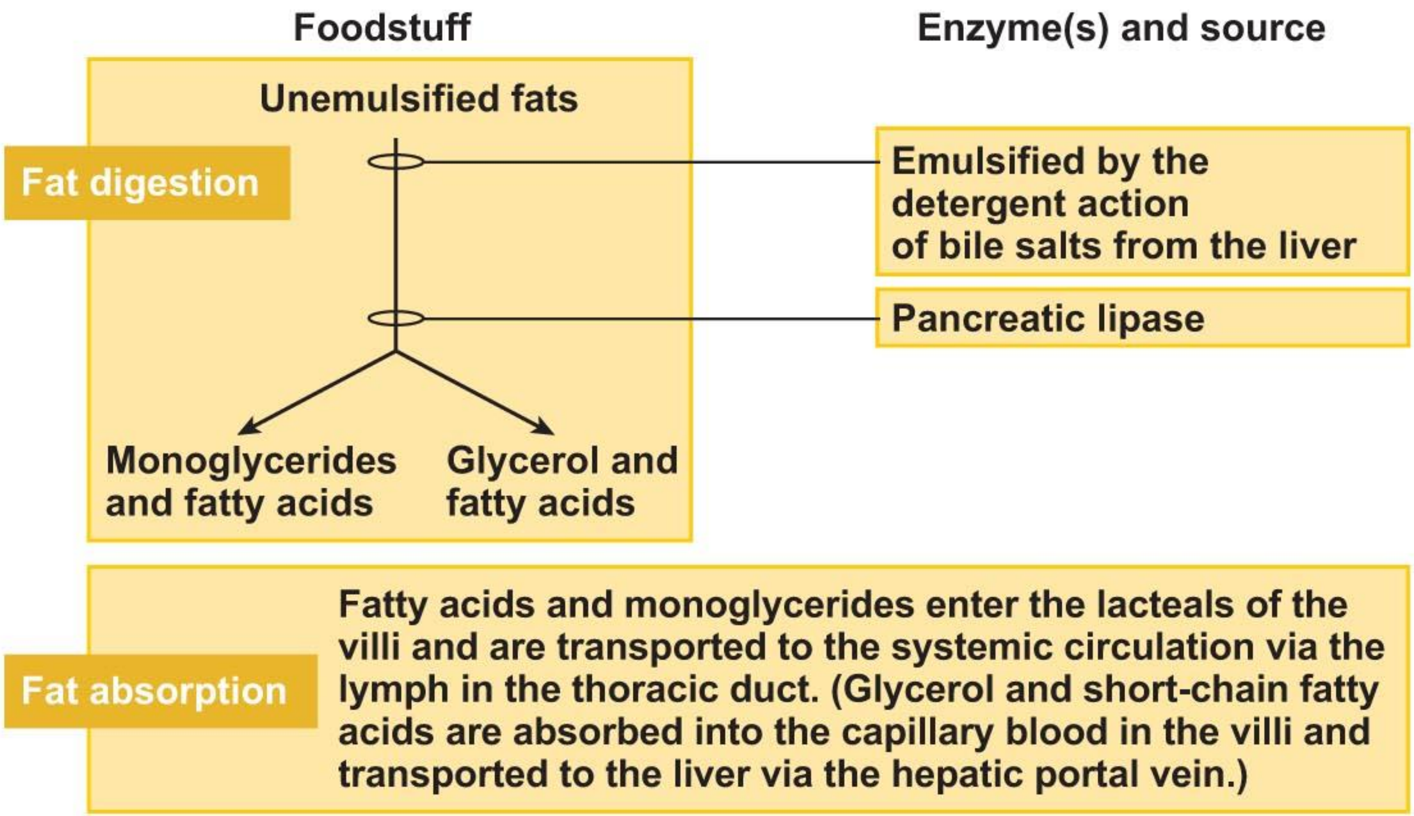


Figure 14.13 (2 of 3)



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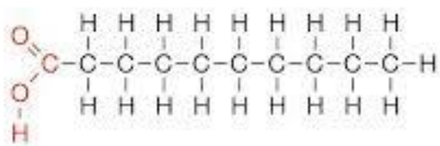


Unsaturated

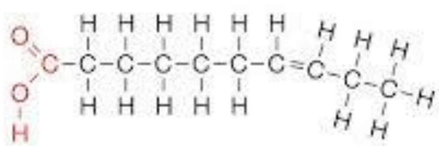


Figure 14.13 (3 of 3)

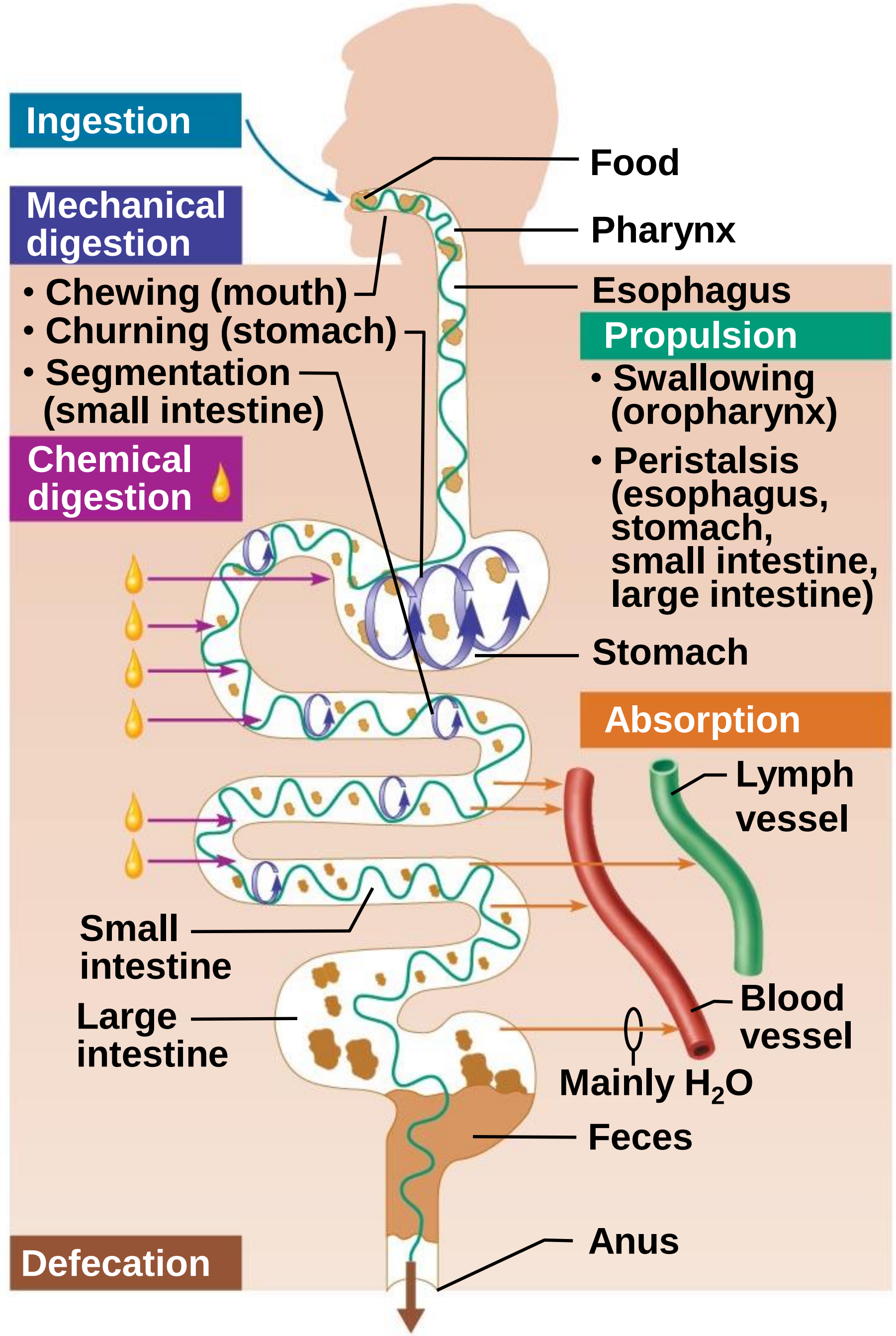
FUNCTIONS OF THE DIGESTIVE SYSTEM

Absorption

- End products of digestion are absorbed in the blood or lymph
- Food must enter mucosal cells and then into blood or lymph capillaries

Defecation

- Elimination of indigestible substances from the GI tract in the form of feces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• Swallowing (oropharynx)
• Peristalsis (esophagus, stomach, small intestine, large intestine)
Chemical digestion
Stomach
Absorption
Lymph vessel
Small intestine
Large intestine
Blood vessel
Mainly H_2O
Feces
Anus
Defecation

Figure 14.11

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CONTROL OF DIGESTIVE ACTIVITY

Mostly controlled by reflexes via the ***parasympathetic*** division

Chemical and mechanical receptors are located in organ walls that trigger reflexes

FOOD BREAKDOWN IN THE STOMACH

Gastric juice is regulated by neural and hormonal factors

Presence of food or rising pH causes the release of the hormone gastrin

Gastrin causes stomach glands to produce

- Protein-digesting enzymes
- Mucus
- Hydrochloric acid which makes the stomach very acidic

Acidic pH

- Activates pepsinogen to pepsin for protein digestion
- Provides a hostile environment for microorganisms

DIGESTION AND ABSORPTION IN THE STOMACH

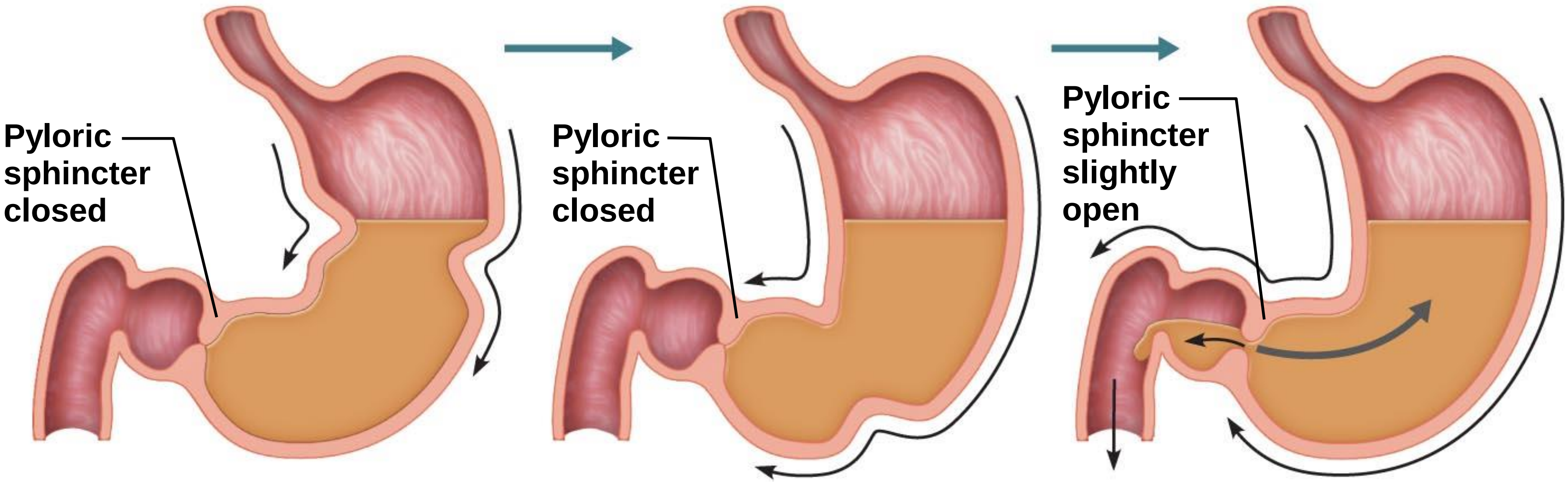
Protein digestion enzymes

- Pepsin — an active protein-digesting enzyme
- Rennin — works on digesting milk protein in infants, not adults

Alcohol and aspirin are the only items absorbed in the stomach

The pylorus meters out chyme into the small intestine (3 mL at a time)

The stomach empties in 4–6 hours



1 **Propulsion: Peristaltic waves move from the fundus to the pylorus.**

2 **Grinding: The most vigorous peristalsis and mixing action occur close to the pylorus.**

3 **Retropulsion: The pyloric end of the stomach pumps small amounts of chyme into the duodenum, while simultaneously forcing most of its contents backward into the stomach.**

[Digestion in Stomach]

[Ramen Noodles]

Figure 14.15

DIGESTION IN THE SMALL INTESTINE

Enzymes from the brush border function to

- Break double sugars into simple sugars
- Complete some protein digestion

Pancreatic enzymes play the major digestive function

- Help complete digestion of starch (pancreatic amylase)
- Carry out about half of all protein digestion
- Digest fats using lipases from the pancreas
- Digest nucleic acids using nucleases
- Alkaline content neutralizes acidic chyme

REGULATION OF PANCREATIC JUICE SECRETION

Release of pancreatic juice into the duodenum is stimulated by

- **Vagus nerve**

- Local hormones
  - **Secretin:** Secretin causes the liver to increase bile output
  - **cholecystokinin (CCK):** CCK causes the gallbladder to release stored bile
    - **Bile** is necessary for fat absorption and absorption of fat-soluble vitamins (**K, D, A**)

Hormones travel the blood to stimulate the pancreas to release enzyme- and bicarbonate-rich product

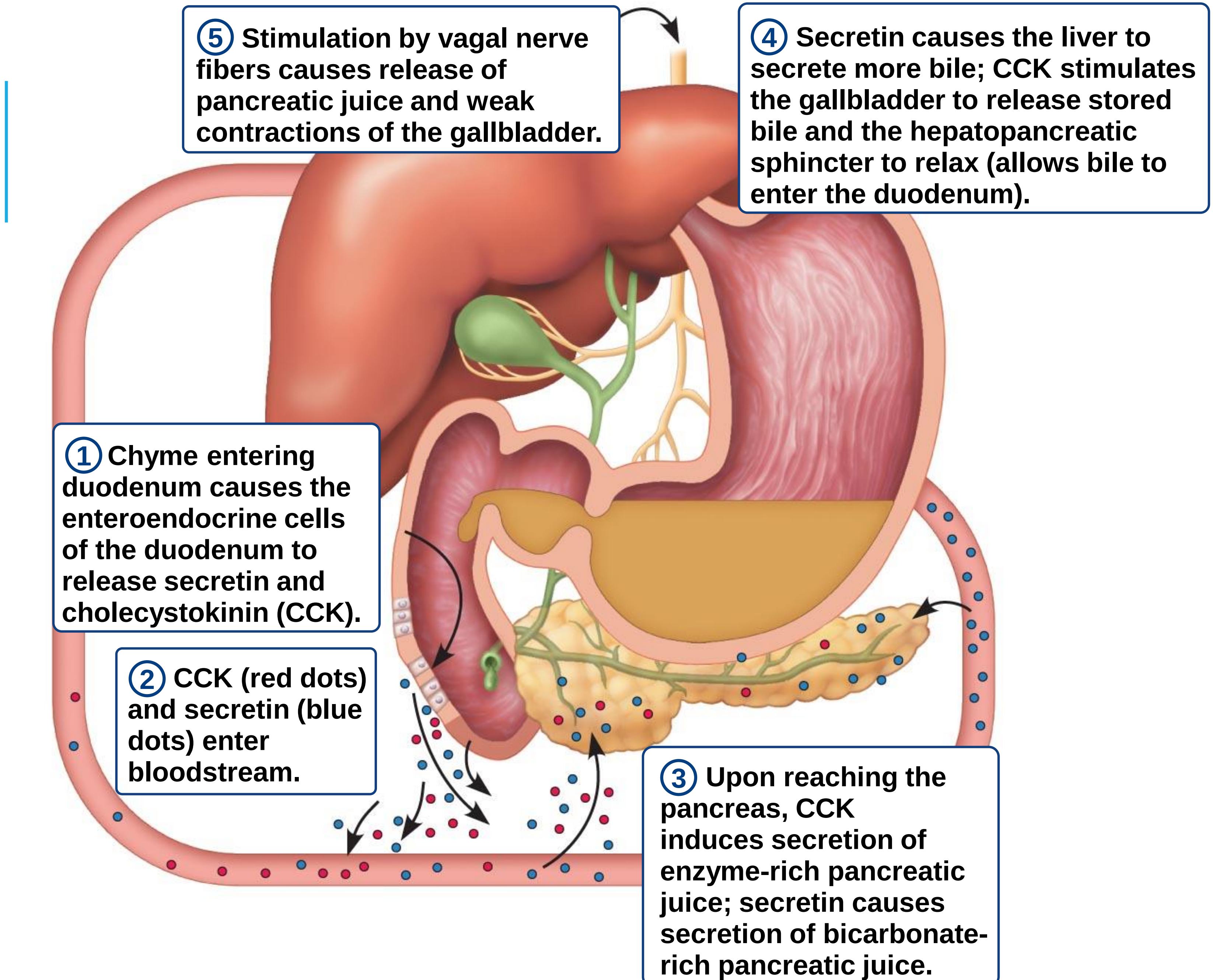

5 Stimulation by vagal nerve fibers causes release of pancreatic juice and weak contractions of the gallbladder.
4 Secretin causes the liver to secrete more bile; CCK stimulates the gallbladder to release stored bile and the hepatopancreatic sphincter to relax (allows bile to enter the duodenum).
1 Chyme entering duodenum causes the enteroendocrine cells of the duodenum to release secretin and cholecystokinin (CCK).
2 CCK (red dots) and secretin (blue dots) enter bloodstream.
3 Upon reaching the pancreas, CCK induces secretion of enzyme-rich pancreatic juice; secretin causes secretion of bicarbonate-rich pancreatic juice.

Figure 14.16

ABSORPTION IN THE SMALL INTESTINE

Water is absorbed along the length of the small intestine

End products of digestion

- Most substances are absorbed by active transport through cell membranes
- Lipids are absorbed by diffusion

Substances are transported to the liver by the hepatic portal vein or lymph

FOOD BREAKDOWN AND ABSORPTION IN THE LARGE INTESTINE

No digestive enzymes are produced

Resident bacteria digest remaining nutrients

- Produce some vitamin K and B
- Release gases

Water and vitamins K and B are absorbed

Remaining materials are eliminated via feces

- Feces contains
  - Undigested food residues, blood residue, mucus, bacteria, water

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NUTRITION

Nutrient — substance used by the body for growth, maintenance, and repair

Major nutrients

- Carbohydrates
- Lipids
- Proteins
- Water

Minor nutrients

- Vitamins
- Minerals

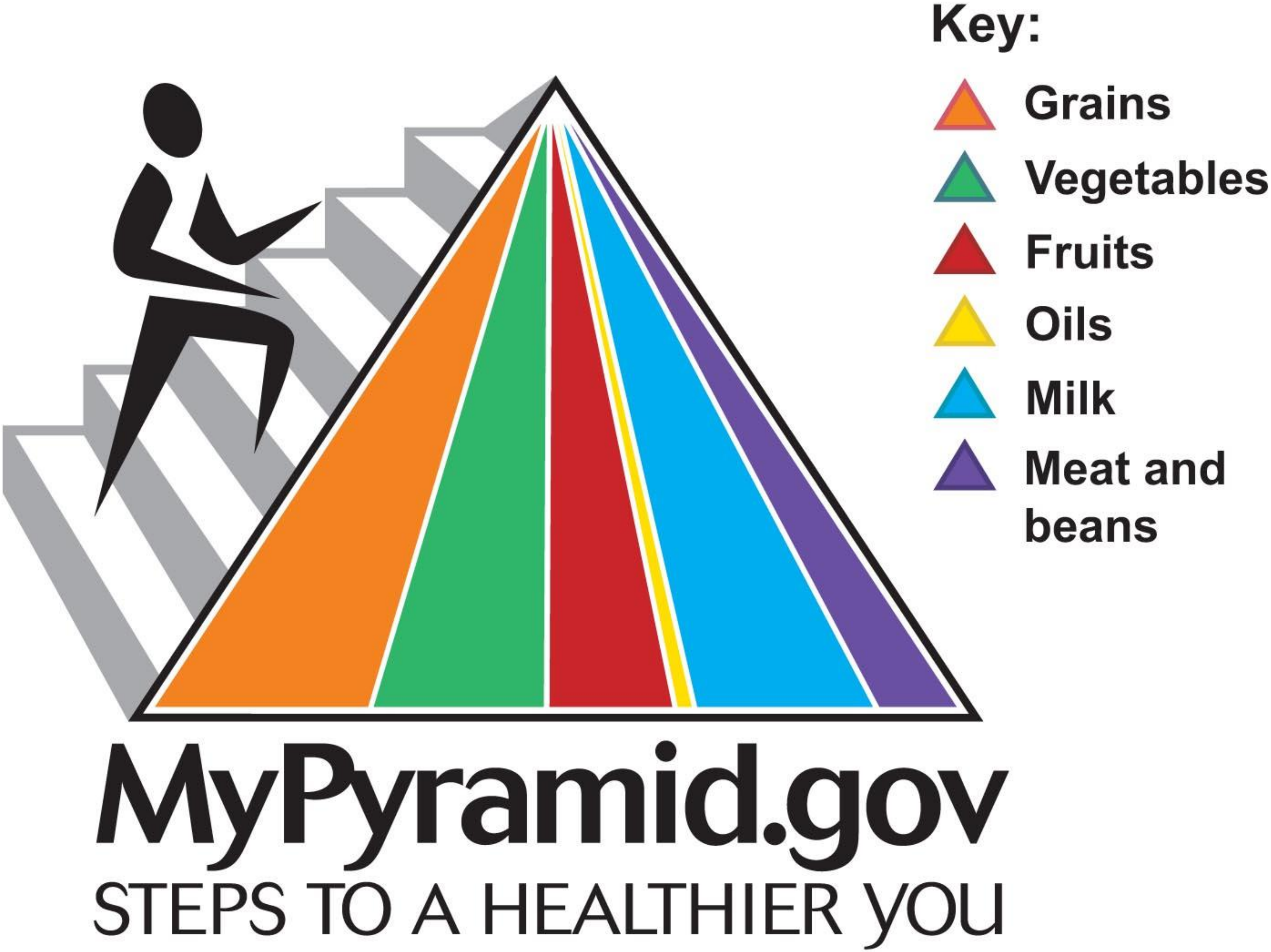
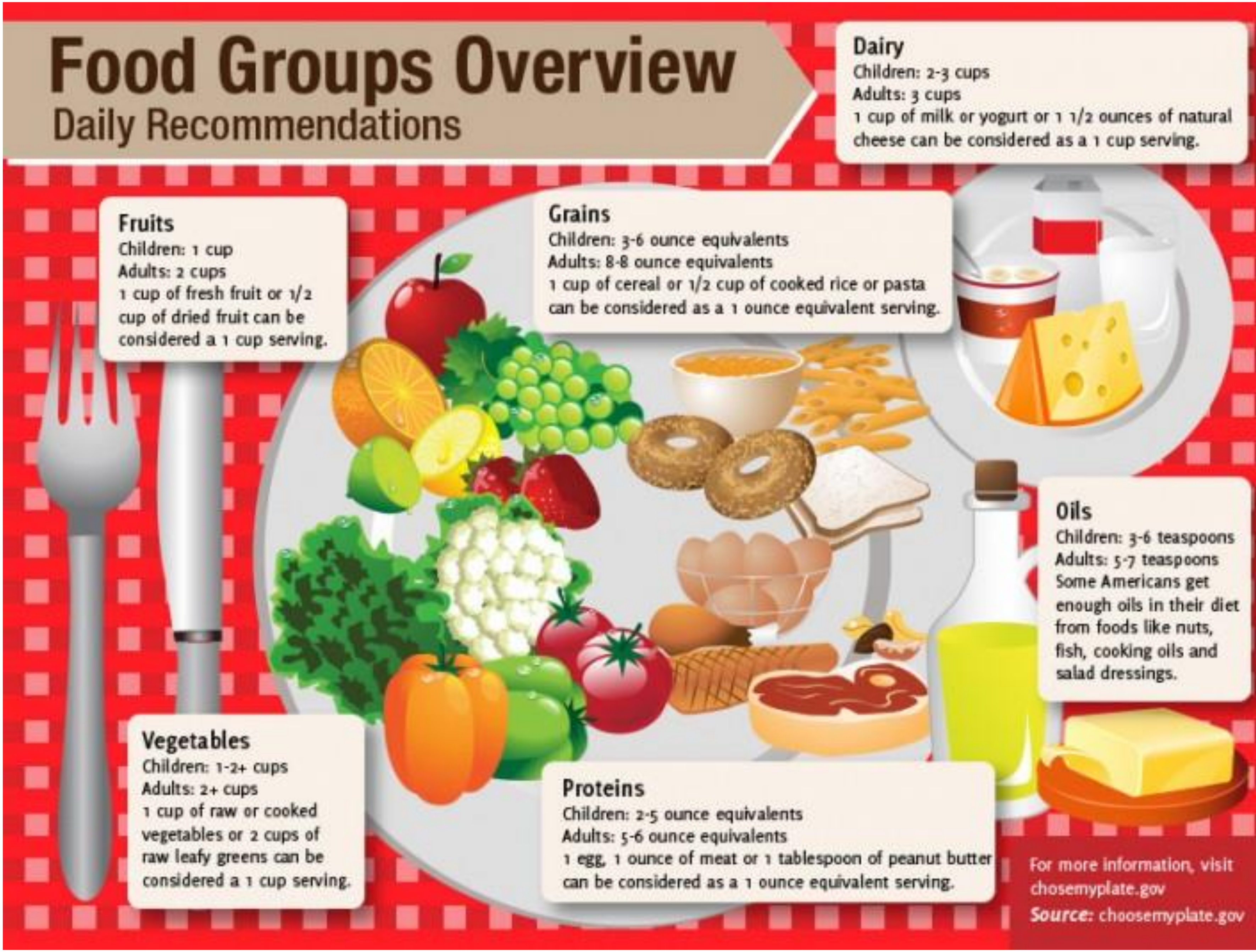

Key:
Grains
Vegetables
Fruits
Oils
Milk
Meat and beans
MyPyramid.gov
STEPS TO A HEALTHIER YOU

Figure 14.17



Food Groups Overview
Daily Recommendations
Dairy
Children: 2-3 cups
Adults: 3 cups
1 cup of milk or yogurt or 1 1/2 ounces of natural cheese can be considered as a 1 cup serving.
Fruits
Children: 1 cup
Adults: 2 cups
1 cup of fresh fruit or 1/2 cup of dried fruit can be considered a 1 cup serving.
Grains
Children: 3-6 ounce equivalents
Adults: 8-8 ounce equivalents
1 cup of cereal or 1/2 cup of cooked rice or pasta can be considered as a 1 ounce equivalent serving.
Oils
Children: 3-6 teaspoons
Adults: 5-7 teaspoons
Some Americans get enough oils in their diet from foods like nuts, fish, cooking oils and salad dressings.
Vegetables
Children: 1-2+ cups
Adults: 2+ cups
1 cup of raw or cooked vegetables or 2 cups of raw leafy greens can be considered a 1 cup serving.
Proteins
Children: 2-5 ounce equivalents
Adults: 5-6 ounce equivalents
1 egg, 1 ounce of meat or 1 tablespoon of peanut butter can be considered as a 1 ounce equivalent serving.
For more information, visit chosemyplate.gov
Source: choosemyplate.gov

DIETARY SOURCES OF MAJOR NUTRIENTS

Carbohydrates

- Most are derived from plants
- Exceptions: lactose from milk and small amounts of glycogens from meats

Lipids

- Saturated fats from animal products
- Unsaturated fats from nuts, seeds, and vegetable oils
- Cholesterol from egg yolk, meats, and milk products

DIETARY SOURCES OF MAJOR NUTRIENTS

Proteins

- Complete proteins — contain all essential amino acids
  - Most are from animal products
  - Essential amino acids are ones that our bodies cannot make
  - We must obtain essential amino acids through our diet

- Legumes and beans also have proteins, but are incomplete

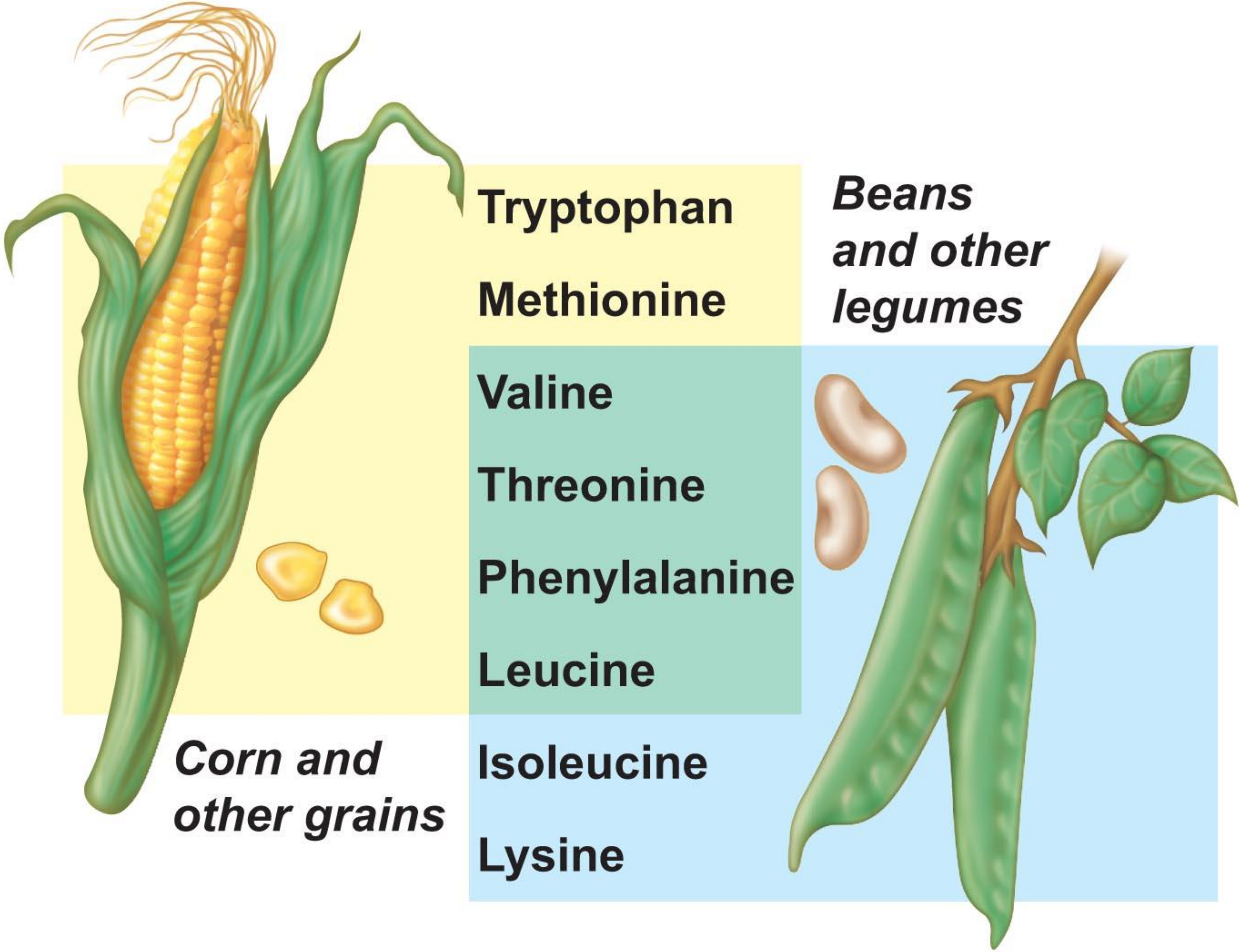

Tryptophan
Methionine
Valine
Threonine
Phenylalanine
Leucine
Isoleucine
Lysine
Beans and other legumes
Corn and other grains

Figure 14.18

DIETARY SOURCES OF MAJOR NUTRIENTS

Vitamins

- Most vitamins are used as coenzymes
- Found in all major food groups

Minerals

- Play many roles in the body
- Most mineral-rich foods are vegetables, legumes, milk, and some meats

WORKBOOK PAGE 288 #20 & 21

METABOLISM

Chemical reactions necessary to maintain life

- **Catabolism**
  - substances are broken down to simpler substances; energy is released
  - hydrolysis reactions: add water

- **Anabolism**
  - larger molecules are built from smaller ones
  - dehydration reactions: remove water

CARBOHYDRATE METABOLISM

Carbohydrates are the body's preferred source to produce cellular energy (ATP)

Glucose (blood sugar)

- Major breakdown product of carbohydrate digestion
- Fuel used to make ATP

CELLULAR RESPIRATION

[YOU SHOULD ALREADY KNOW THIS . . . IF NOT, REVIEW LAST YEAR'S NOTES ON YOUR OWN TIME] [SLIDES 66 – 70]

Aerobic respiration:

- Oxygen-using events take place within the cell to create ATP from ADP

Carbon leaves cells as carbon dioxide (CO_2)

Hydrogen atoms are combined with oxygen to form water

Energy produced by these reactions adds a phosphorus to ADP to produce ATP

ATP can be broken down to release energy for cellular use

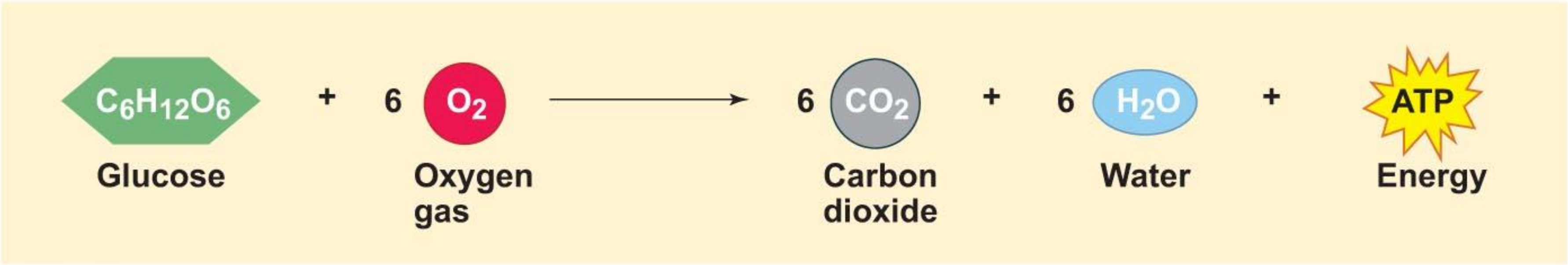

$C_6H_{12}O_6$
Glucose
+
6
O_2
Oxygen gas
6
CO_2
Carbon dioxide
+
6
H_2O
Water
+
ATP
Energy

Figure 14.19

METABOLIC PATHWAYS INVOLVED IN CELLULAR RESPIRATION

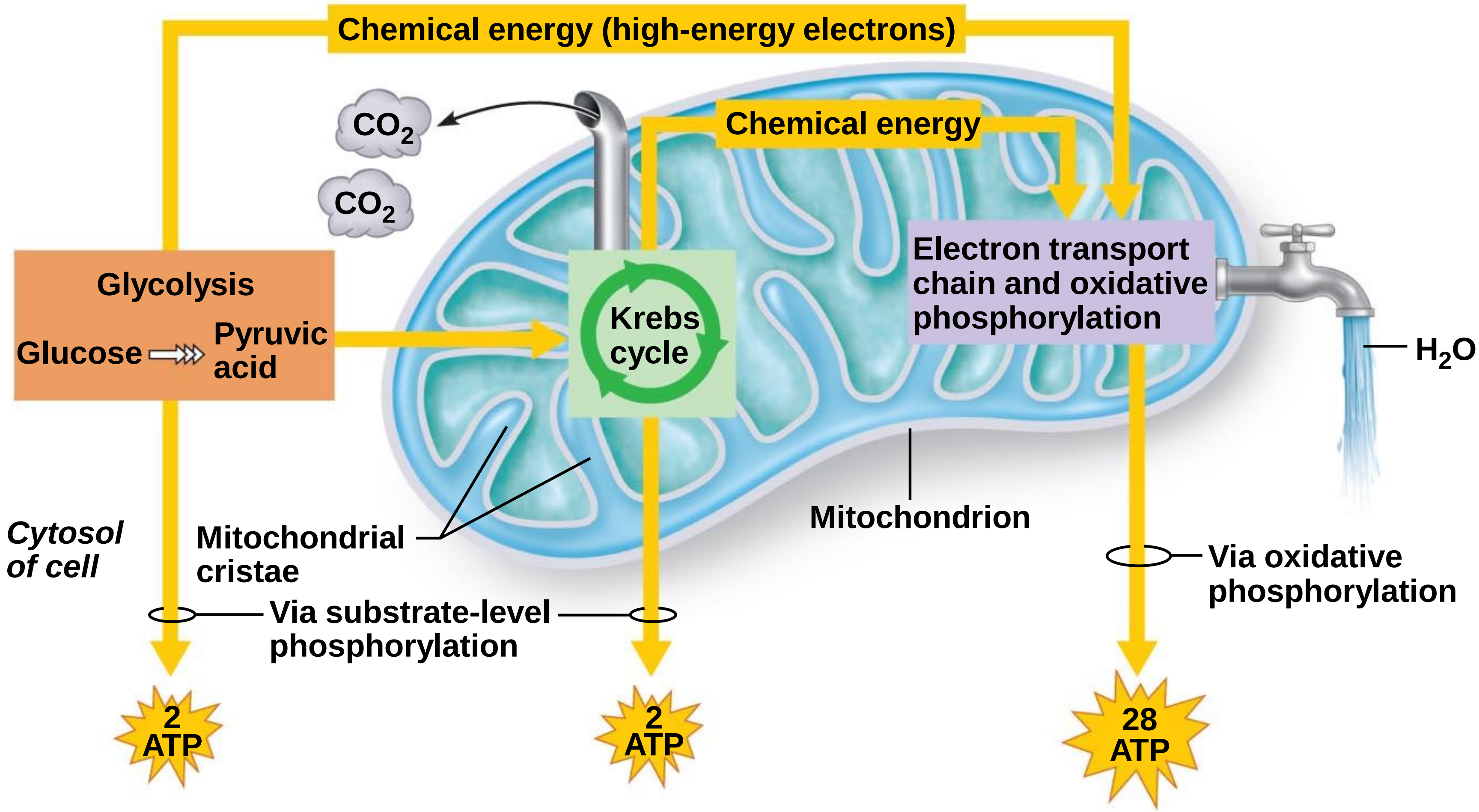
Glycolysis — energizes a glucose molecule so it can be split into two pyruvic acid molecules and yield ATP

Krebs cycle

- Produces virtually all the carbon dioxide and water resulting from cell respiration
- Yields a small amount of ATP

Electron transport chain

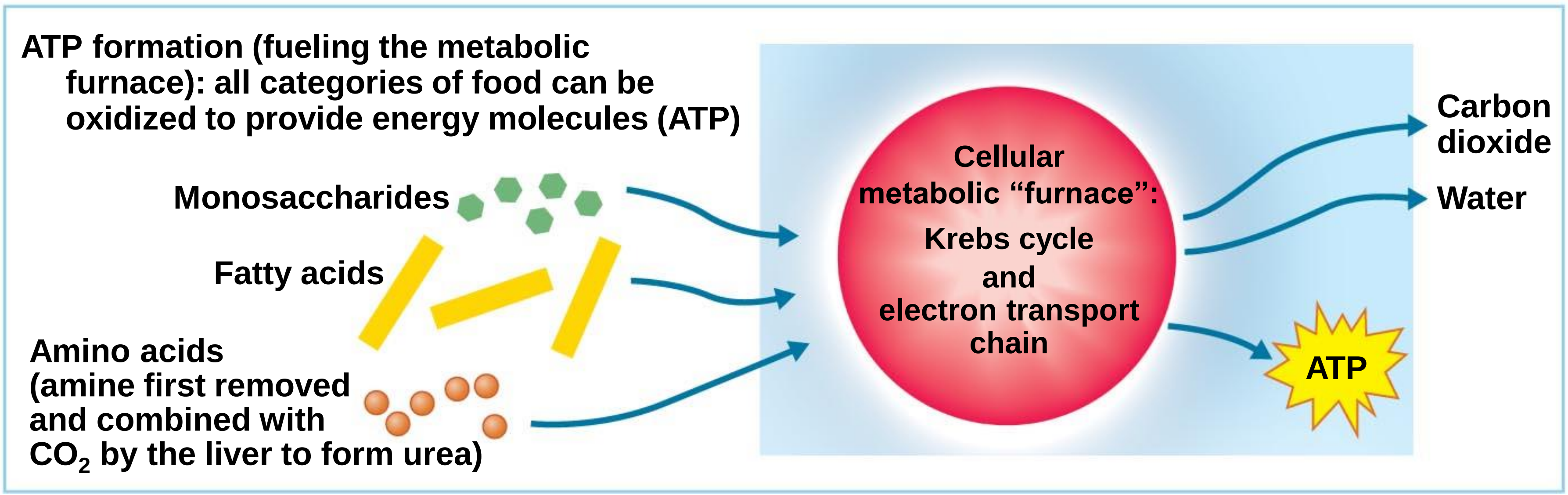
- Hydrogen atoms removed during glycolysis and the Krebs cycle are delivered to protein carriers
- Hydrogen is split into hydrogen ions and electrons in the mitochondria
- Electrons give off energy in a series of steps to enable the production of ATP



1 During glycolysis, each glucose molecule is broken down into two molecules of pyruvic acid as hydrogen atoms containing high-energy electrons are removed.

2 The pyruvic acid enters the mitochondrion where Krebs cycle enzymes remove more hydrogen atoms and decompose it to CO_2. During glycolysis and the Krebs cycle, small amounts of ATP are formed.

3 Energy-rich electrons picked up by coenzymes are transferred to the electron transport chain, built into the cristae membrane. The electron transport chain carries out oxidative phosphorylation, which accounts for most of the ATP generated by cellular respiration, and finally unites the removed hydrogen with oxygen to form water.


ATP formation (fueling the metabolic furnace): all categories of food can be oxidized to provide energy molecules (ATP)
Monosaccharides
Fatty acids
Amino acids (amine first removed and combined with CO_2 by the liver to form urea)
Cellular metabolic “furnace”:
Krebs cycle
and
electron transport chain
Carbon dioxide
Water
ATP

WORKBOOK PAGE 289 # 22

METABOLISM OF CARBOHYDRATES

Hyperglycemia — excessively high levels of glucose in the blood

- Excess glucose is stored in body cells as glycogen
- If blood glucose levels are still too high, excesses are converted to fat

Hypoglycemia — low levels of glucose in the blood

- Liver breaks down stored glycogen and releases glucose into the blood

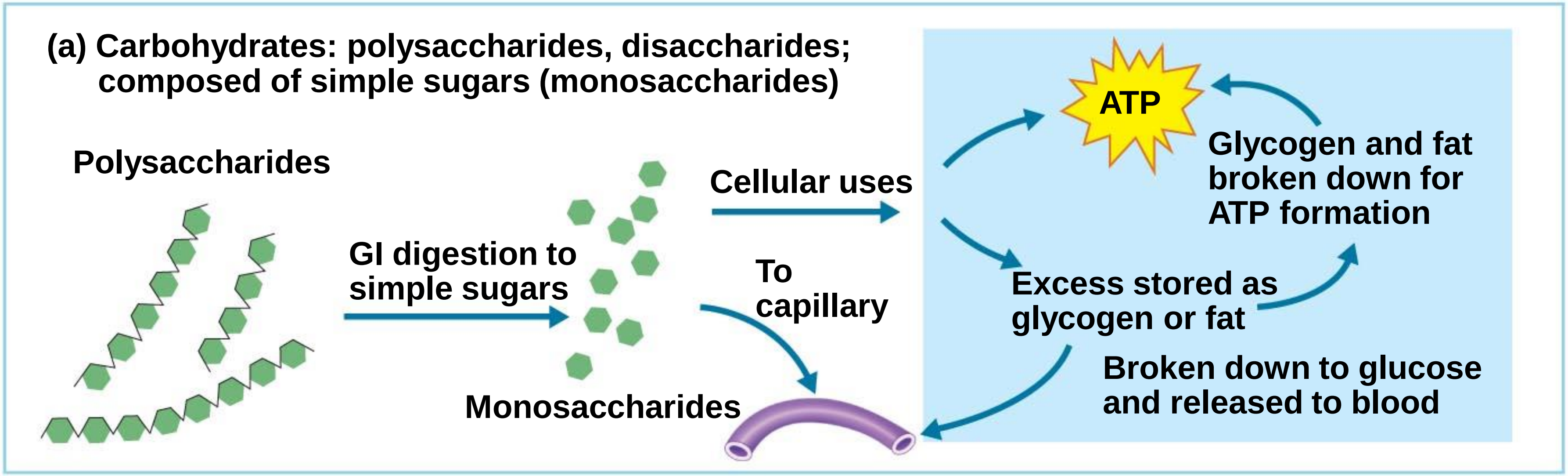


Figure 14.22a

FAT METABOLISM

Handled mostly by the liver

- Uses some fats to make ATP
- Synthesizes lipoproteins, thromboplastin, and cholesterol
- Releases breakdown products to the blood

Body cells remove fat and cholesterol to build membranes and steroid hormones

Fats must first be broken down to acetic acid

Within mitochondria, acetic acid is completely oxidized to produce water, carbon dioxide, and ATP

FAT METABOLISM

Acidosis (ketoacidosis) results from incomplete fat oxidation in which acetoacetic acid and acetone accumulate in the blood

- Breath has a fruity odor

- Common with
  - “No carbohydrate” diets
  - Uncontrolled diabetes mellitus
  - Starvation

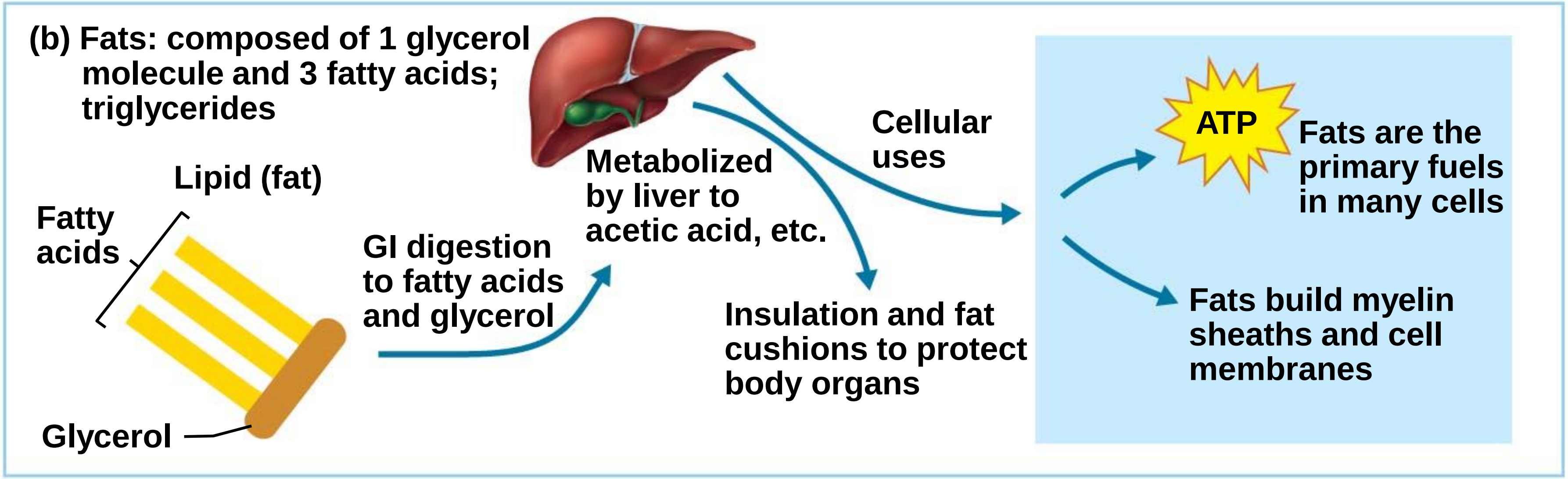


Figure 14.22b

PROTEIN METABOLISM

Proteins are conserved by body cells because they are used for most cellular structures

- Ingested proteins are broken down to amino acids

Cells remove amino acids to build proteins

- Synthesized proteins are actively transported across cell membranes
- Amino acids are used to make ATP only when proteins are overabundant or there is a shortage of other sources

To produce ATP

- a portion of the protein molecule enters the Krebs cycle in mitochondria (but only in extreme cases)

Liver converts amines → ammonia → urea

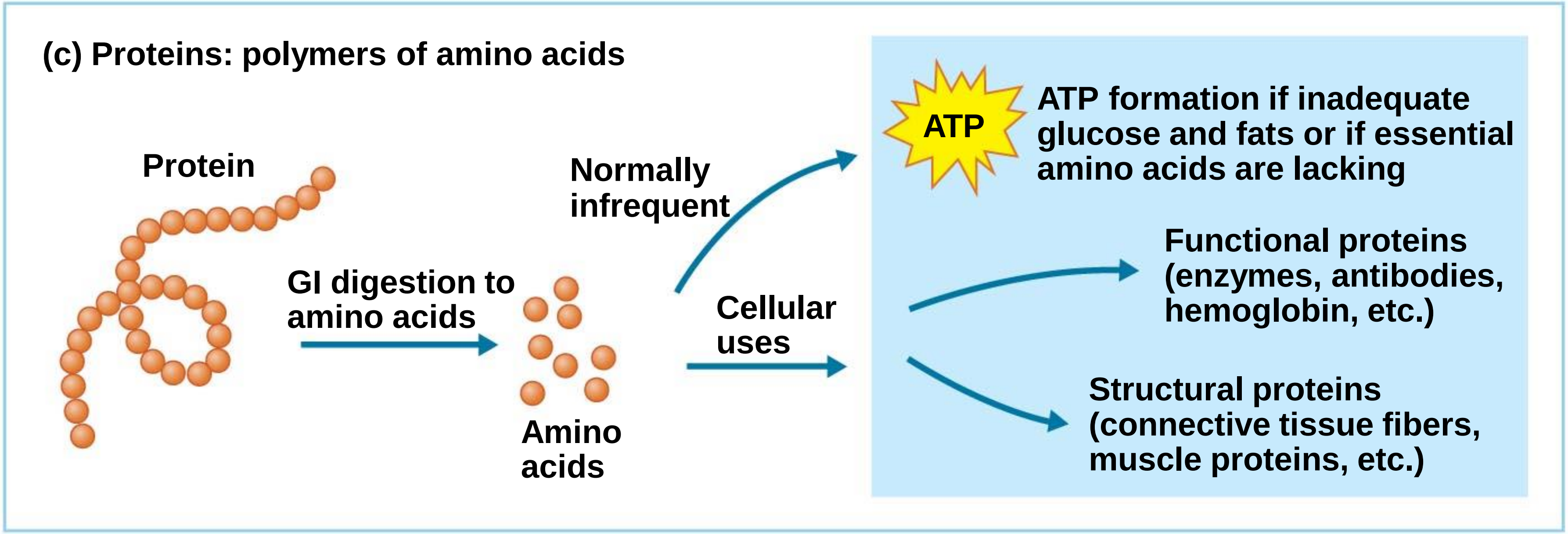


Figure 14.22c

ROLE OF THE LIVER IN METABOLISM

Several roles in digestion

- Manufactures bile
- Detoxifies drugs and alcohol
- Degrades hormones
- Produces cholesterol, blood proteins (albumin and clotting proteins)
- Plays a central role in metabolism

[Can regenerate if part of it is damaged or removed]

METABOLIC FUNCTIONS OF THE LIVER

Glycogenesis — "glycogen formation"

- Glucose molecules are converted to glycogen
- Glycogen molecules are stored in the liver

Glycogenolysis — "glucose splitting"

- Glucose is released from the liver after conversion from glycogen

Gluconeogenesis — "formation of new sugar"

- Glucose is produced from fats and proteins

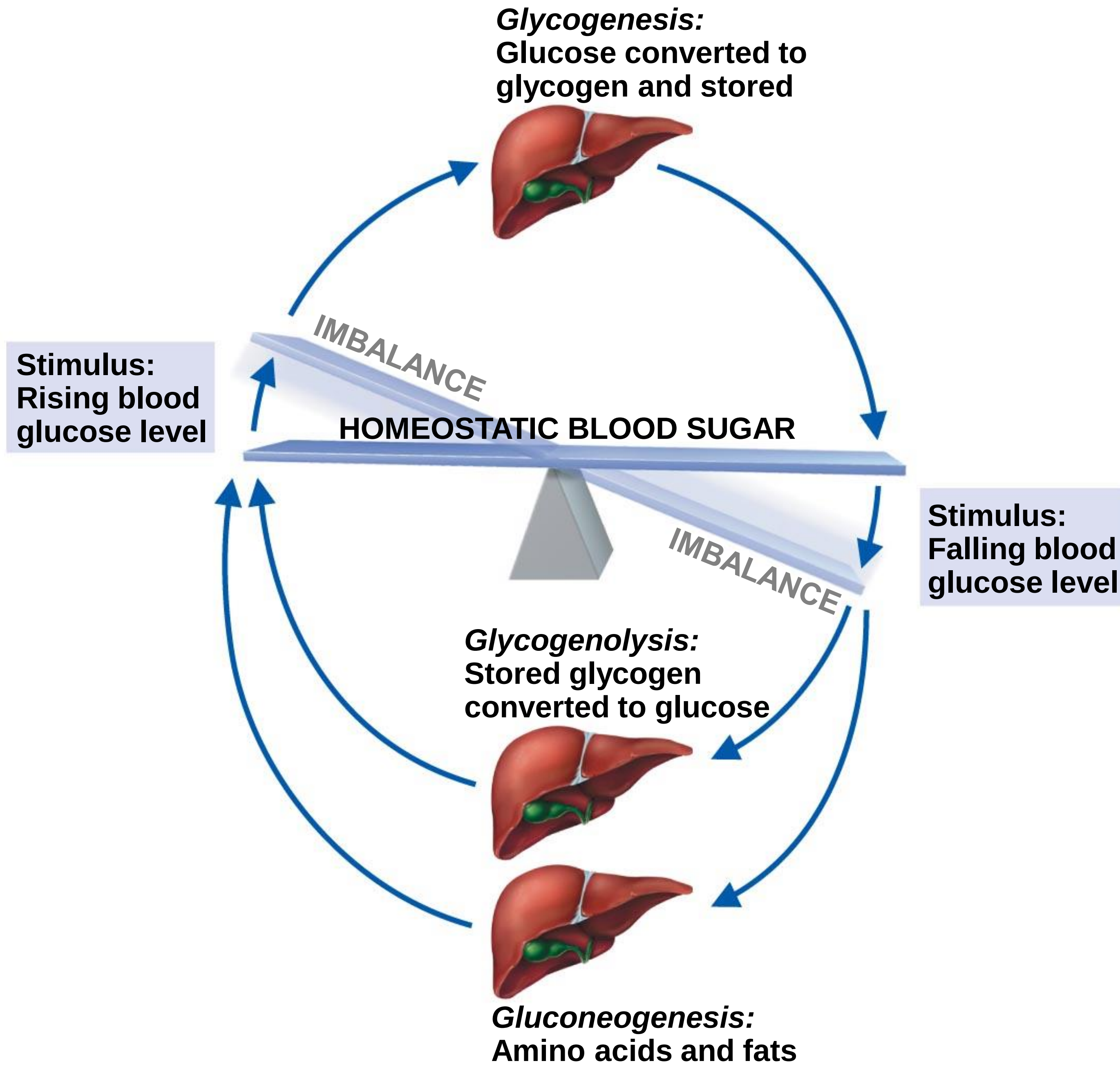

Glycogenesis:
Glucose converted to glycogen and stored
IMBALANCE
Stimulus: Rising blood glucose level
HOMEOSTATIC BLOOD SUGAR
Stimulus: Falling blood glucose level
IMBALANCE
Glycogenolysis:
Stored glycogen converted to glucose
Gluconeogenesis:
Amino acids and fats converted to glucose

Figure 14.23

METABOLIC FUNCTIONS OF THE LIVER

Fats and fatty acids are picked up by the liver

- Some are oxidized to provide energy for liver cells
- The rest are broken down into simpler compounds and released into the blood

CHOLESTEROL METABOLISM

Cholesterol is not used to make ATP

Functions of cholesterol

- Serves as a structural basis of steroid hormones and vitamin D
- Is a major building block of plasma membranes

Most cholesterol is produced in the liver
(85 percent) and is not from diet (15 percent)

CHOLESTEROL TRANSPORT

Cholesterol and fatty acids cannot freely circulate in the bloodstream

They are transported by lipoproteins (lipid-protein complexes)

- Low-density lipoproteins (LDLs):
  - transport to body cells
  - Rated “bad lipoproteins” since they can lead to artherosclerosis

- High-density lipoproteins (HDLs):
  - transport from body cells to the liver

BODY ENERGY BALANCE

Energy intake = total energy output

(heat + work + energy storage)

- Energy intake is the energy liberated during food oxidation
  - Energy produced during glycolysis, Krebs cycle and the electron transport chain
- Energy output
  - Energy we lose as heat (60 percent)
  - Energy stored as fat or glycogen

REGULATION OF FOOD INTAKE

Body weight is usually relatively stable

- Energy intake and output remain about equal

Mechanisms that may regulate food intake

- Levels of nutrients in the blood
- Hormones
- Body temperature
- Psychological factors

METABOLIC RATE AND BODY HEAT PRODUCTION

Basic metabolic rate (BMR) — amount of heat produced by the body per unit of time at rest

Average BMR is about 60 to 72 kcal/hour

Kilocalorie (kcal):

- unit of measure for the energy value of foods and the amount of energy used by the body

METABOLIC RATE AND BODY HEAT PRODUCTION

Factors that influence BMR

- **Surface area —** a small body usually has a higher BMR
- **Gender —** males tend to have higher BMRs
- **Age —** children and adolescents have higher BMRs
- **Thyroxine production** - the most important control factor
  - More thyroxine means a higher metabolic rate

TOTAL METABOLIC RATE (TMR)

TMR = Total amount of kilocalories the body must consume to fuel ongoing activities

TMR increases with an increase in body activity

TMR must equal calories consumed to maintain homeostasis and maintain a constant weight

BODY TEMPERATURE REGULATION

Most energy is released as foods are oxidized

Most energy escapes as heat

BODY TEMPERATURE REGULATION

The body has a narrow range of homeostatic temperature

- Must remain between 35.6°C to 37.8°C (96°F to 100°F)
- The body's thermostat is in the hypothalamus
  - Initiates heat-loss or heat-promoting mechanisms

BODY TEMPERATURE REGULATION

Heat-promoting mechanisms

- *Vasoconstriction* of blood vessels
  - blood is rerouted to deeper, more vital body organs

- *Shivering*
  - contraction of muscles produces heat

BODY TEMPERATURE REGULATION

Heat-loss mechanisms

- Heat loss from the skin via *radiation* and *evaporation*
  - Skin blood vessels and capillaries are flushed with warm blood
  - Evaporation of perspiration cools the skin

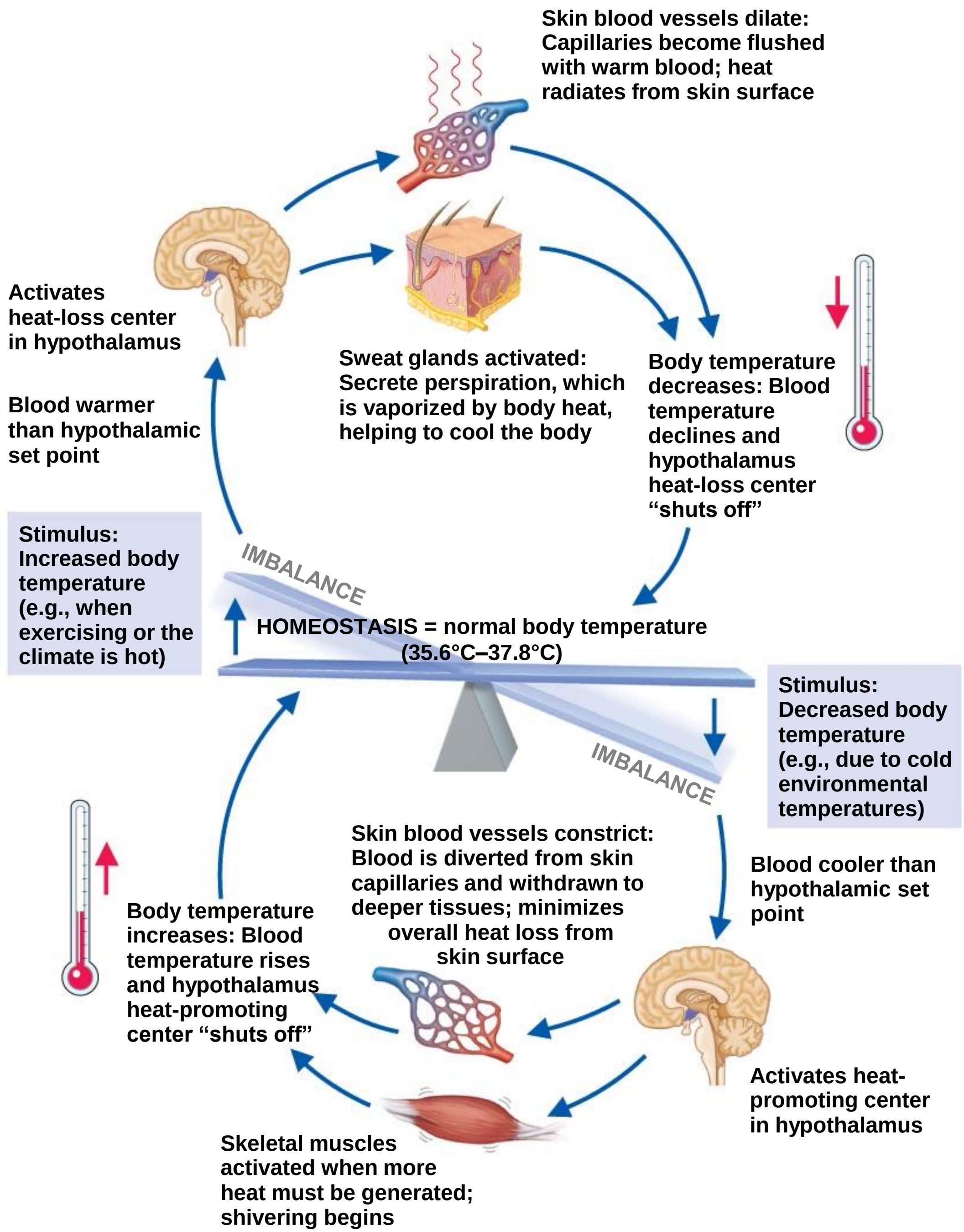

Skin blood vessels dilate: Capillaries become flushed with warm blood; heat radiates from skin surface
Activates heat-loss center in hypothalamus
Sweat glands activated: Secrete perspiration, which is vaporized by body heat, helping to cool the body
Body temperature decreases: Blood temperature declines and hypothalamus heat-loss center "shuts off"
Blood warmer than hypothalamic set point
Stimulus: Increased body temperature (e.g., when exercising or the climate is hot)
IMBALANCE
HOMEOSTASIS = normal body temperature (35.6°C–37.8°C)
IMBALANCE
Stimulus: Decreased body temperature (e.g., due to cold environmental temperatures)
Skin blood vessels constrict: Blood is diverted from skin capillaries and withdrawn to deeper tissues; minimizes overall heat loss from skin surface
Blood cooler than hypothalamic set point
Body temperature increases: Blood temperature rises and hypothalamus heat-promoting center "shuts off"
Activates heat-promoting center in hypothalamus
Skeletal muscles activated when more heat must be generated; shivering begins

Figure 14.24

BODY TEMPERATURE REGULATION

Fever — controlled hyperthermia

- Results from infection, cancer, allergic reactions, CNS injuries
- If the body thermostat is set too high, body proteins may be denatured and permanent brain damage may occur

DEVELOPMENTAL ASPECTS OF THE DIGESTIVE SYSTEM

The alimentary canal is a continuous tube by the fifth week of development

Digestive glands bud from the mucosa of the alimentary tube

The developing fetus receives all nutrients through the placenta

In newborns, feeding must be frequent, peristalsis is inefficient, and vomiting is common

DEVELOPMENTAL ASPECTS OF THE DIGESTIVE SYSTEM

Newborn reflexes

- Rooting reflex helps the infant find the nipple
- Sucking reflex helps the infant hold on to the nipple and swallow

Teething begins around age six months

DEVELOPMENTAL ASPECTS OF THE DIGESTIVE SYSTEM

Problems of the digestive system

- Gastroenteritis — inflammation of the gastrointestinal tract
- Appendicitis — inflammation of the appendix

Metabolism decreases with old age

Middle-age digestive problems

- Ulcers
- Gallbladder problems

DEVELOPMENTAL ASPECTS OF THE DIGESTIVE SYSTEM

Activity of the digestive tract in old age

- Fewer digestive juices
- Peristalsis slows
- Diverticulosis and cancer are more common