

Chapter 3

3.1 Organization of the Body

Atoms – the smallest units of matter

- Atoms bond to each other to form molecules

Molecules – groups of atoms bonded in specific configurations

- Examples
 - Water is H_2O
 - Carbon dioxide is CO_2
- Carbohydrates, proteins, fats, and vitamins are usually very large molecules
- The goal of digestion:
 - Break these large molecules down into smaller molecules
 - Absorb the smaller molecules into the cells of the body

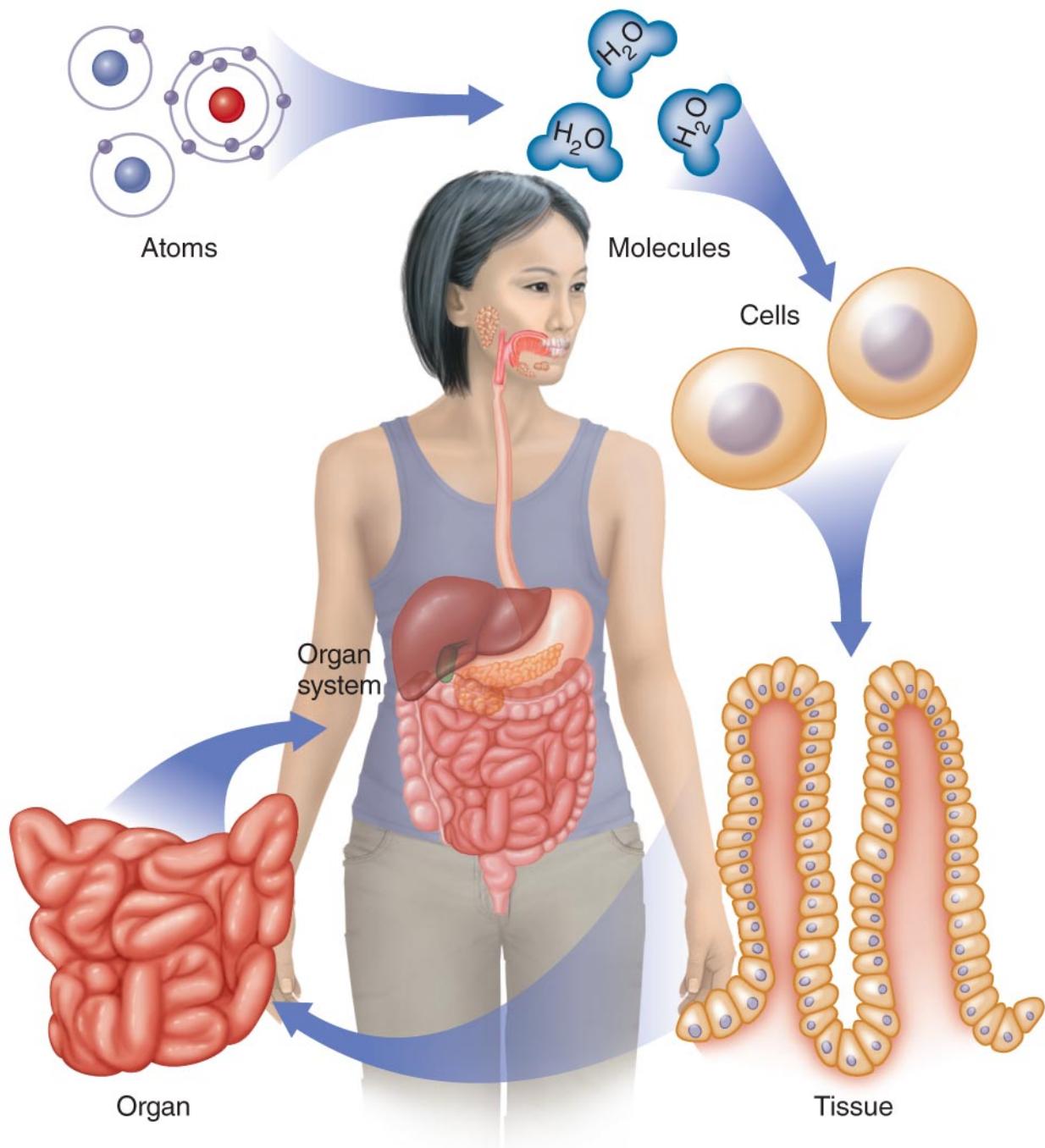


Figure 3.1

- Molecules are the building blocks of cells
- **Cells** – the smallest unit of life
- Molecules that result from the digestion of food are used to build the cells of the body
- **Cell membrane** – outer layer enclosing each cell of the body

- Composed of two layers of phospholipids
 - Long lipid “tails” face each other toward the interior of the membrane
 - Phosphate “heads” line the interior and exterior surfaces of the membrane
 - Cholesterol and proteins are embedded in the membrane
- The cell membrane is **selectively permeable**, allowing it to control the passage of materials into and out of the cell
 - The cell membrane encloses the
 - **Cytoplasm** – the liquid within the cell
 - **Organelles** – tiny structures that perform many different cellular functions
 - Examples
 - * Nucleus
 - * Mitochondria

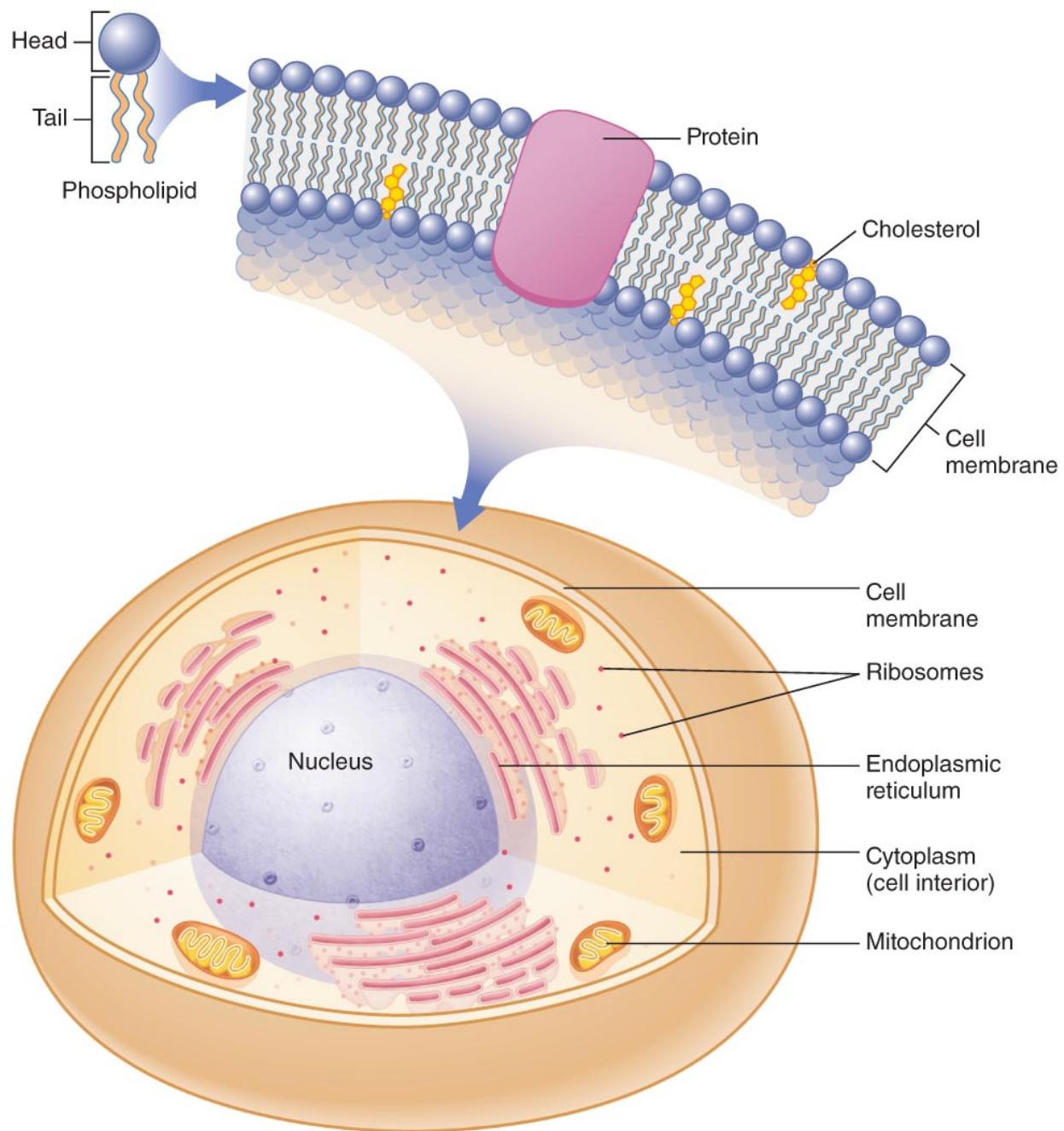


Figure 3.2: Representative Enterocyte

- Cells join together to form tissues
- **Tissue** – group of cells acting together to perform a common function
 - Examples
 - * Muscle tissue
 - * Nervous tissue

- Different tissues combine to form organs
- **Organ** – a sophisticated organization of tissues that performs a specific function
 - Examples
 - * Stomach
 - * Heart
 - * Brain
- **Organ systems** – groups of organs working together for a particular function
 - Example
 - * Gastrointestinal system

3.2 Types of Organ Systems (11)

- Nervous
- Cardiovascular (circulatory)
- Respiratory
- Renal
- Digestive
- Endocrine
- Integumentary & Exocrine
- Immune & Lymphatic
- Muscular
- Skeletal
- Reproductive

3.3 Why Do We Want to Eat?

Appetite – a desire to eat that is stimulated by

- Sight
- Smell
- Thought of food

Hunger – a physiologic drive to eat that occurs when our body senses that we need food

- The **hypothalamus** region of the brain contains a cluster of nerve cells known as the feeding center and another cluster of cells known as the satiety center
 - Nerve cells in the stomach and small intestine sense food and send message to hypothalamus
 - Hormones relay messages to the hypothalamus
 - Amount and type of food consumed influence satiety

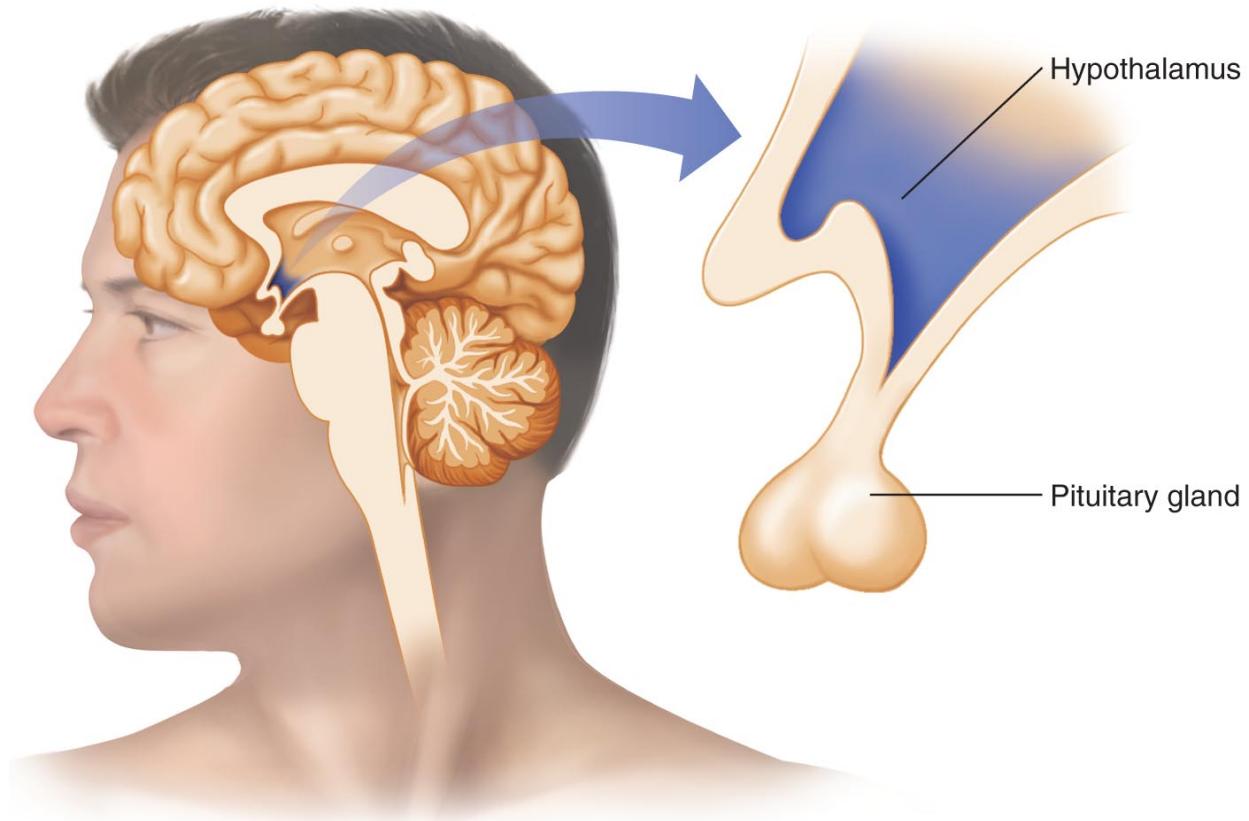


Figure 3.3: The Hypothalamus Triggers Hunger

- The signals that prompt us to eat include
 - Nerve receptors in the stomach, which send signals to the hypothalamus to indicate if the stomach is full or empty
 - Blood fuel (glucose, ketones) levels, which trigger the release of hormones
 - * insulin and glucagon
- **Hormones** – chemicals produced in specialized glands that travel in the bloodstream to target organs in other parts of the body
 - Some hormones stimulate hunger

- * Ghrelin
- Some hormones produce a feeling of satiety
 - * Cholecystokinin (CCK)
 - * Leptin
- Foods have different effects on our feelings of hunger and satiety
 - Proteins have the highest satiety value
 - Carbohydrates have a lower satiety value than fats
 - Bulky foods provided a sense of satiety
 - Solid foods are more filling than semisolid foods or liquids

3.4 What Happens to the Food We Eat?

- **Gastrointestinal (GI) tract** – series of organs arranged as a long tube through which the food passes
- The GI tract includes
 - Organs such as the stomach and intestines
 - **Sphincters** – muscles that control the passage of material from one organ to the next

The digestive system consists of the organs of the gastrointestinal (GI) tract and associated accessory organs. The processing of food in the GI tract involves ingestion, mechanical digestion, chemical digestion, propulsion, absorption, and elimination.

ORGANS OF THE GI TRACT

MOUTH

Ingestion Food enters the GI tract via the mouth.

Mechanical digestion Mastication tears, shreds, and mixes food with saliva.

Chemical digestion Salivary amylase begins carbohydrate breakdown.

PHARYNX AND ESOPHAGUS

Propulsion Swallowing and peristalsis move food from mouth to stomach.

STOMACH

Mechanical digestion Mixes and churns food with gastric juice into a liquid called chyme.

Chemical digestion Pepsin begins digestion of proteins, and gastric lipase begins to break lipids apart.

Absorption A few fat-soluble substances are absorbed through the stomach wall.

SMALL INTESTINE

Mechanical Digestion and Propulsion Segmentation mixes chyme with digestive juices; peristaltic waves move it along tract.

Chemical digestion Digestive enzymes from pancreas and brush border digest most classes of nutrients.

Absorption Nutrients are absorbed into blood and lymph through enterocytes.

LARGE INTESTINE

Chemical digestion Some remaining food residues are digested by bacteria.

Absorption Reabsorbs salts, water, and vitamins.

Propulsion Compacts waste into feces and propels it toward the rectum.

RECTUM

Elimination Temporarily stores feces before voluntary release through the anus.

ACCESSORY ORGANS

SALIVARY GLANDS

Produce saliva, a mixture of water, mucus, enzymes, and other chemicals.

LIVER

Produces bile to emulsify fats.

GALLBLADDER

Stores bile before release into the small intestine through the bile duct.

PANCREAS

Produces digestive enzymes and bicarbonate, which are released into the small intestine via the pancreatic duct.

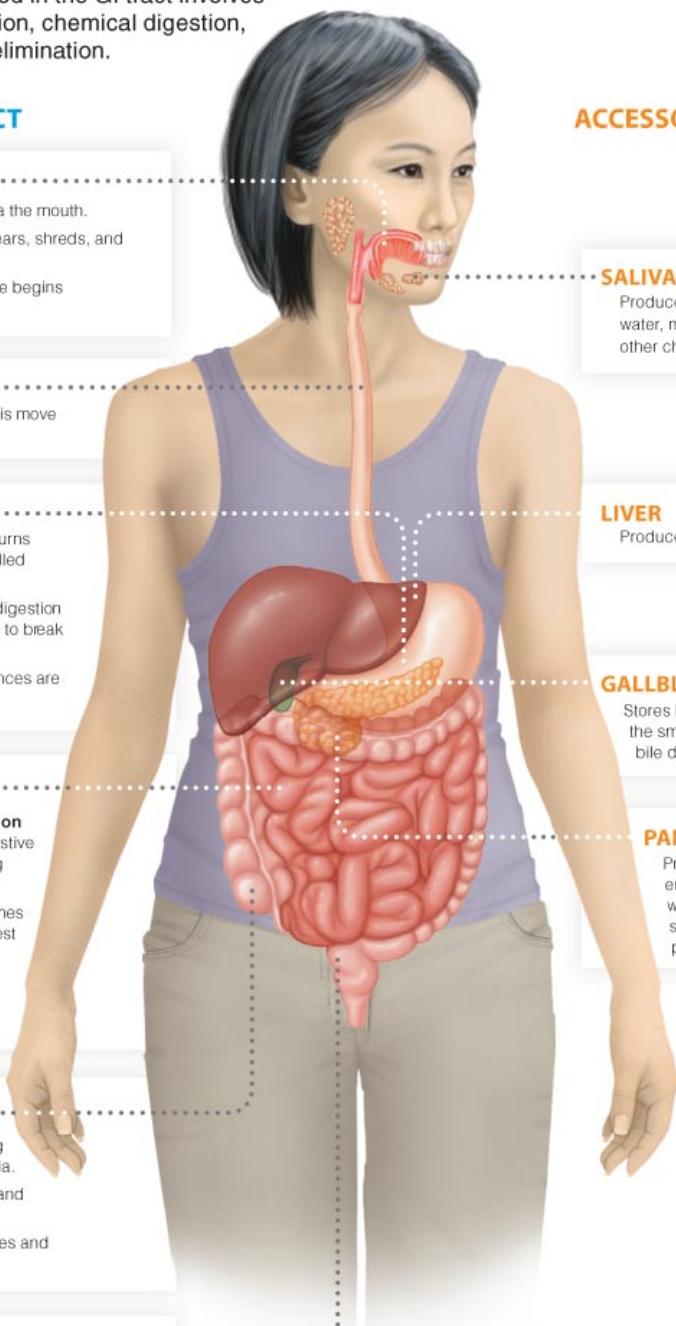


Figure 3.4: Digestive System

3.5 Digestion

3.5.1 The Mouth

- Digestion begins in the mouth
 - Chewing is the mechanical digestion that breaks food into smaller pieces
 - Some chemical digestion takes place in the mouth
 - * **Salivary amylase** – an **enzyme** produced by the **salivary glands** that begins the chemical digestion of carbohydrates

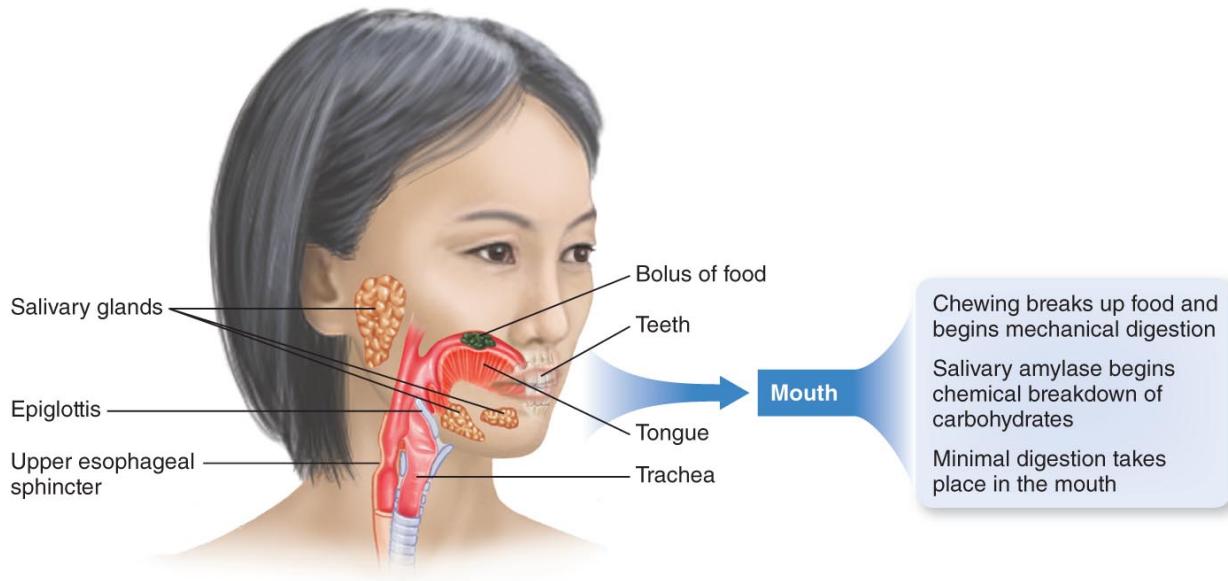


Figure 3.5

- The esophagus propels food into the stomach
 - The **epiglottis** covers the opening to the trachea during swallowing
 - Food travels from the mouth to the stomach through the **esophagus**
 - **Peristalsis** is the muscular contractions moving food through the GI tract
 - The **gastroesophageal sphincter** separates the esophagus from the stomach

3.5.2 Stomach

- The stomach mixes, digests, and stores food
- Digestion in the stomach includes
 - Extensive mechanical digestion to mix food with gastric juice
 - Chemical digestion of proteins and fats

- **Gastric juice** contains
 - **Hydrochloric acid (HCl)** – to denature proteins and activate pepsin
 - **Intrinsic factor** – a protein critical to the absorption of vitamin B₁₂
 - **Pepsin** – an enzyme to digest protein
 - **Gastric lipase** – an enzyme to digest fat
- **Chyme** – semisolid product of mechanical and chemical digestion in the stomach

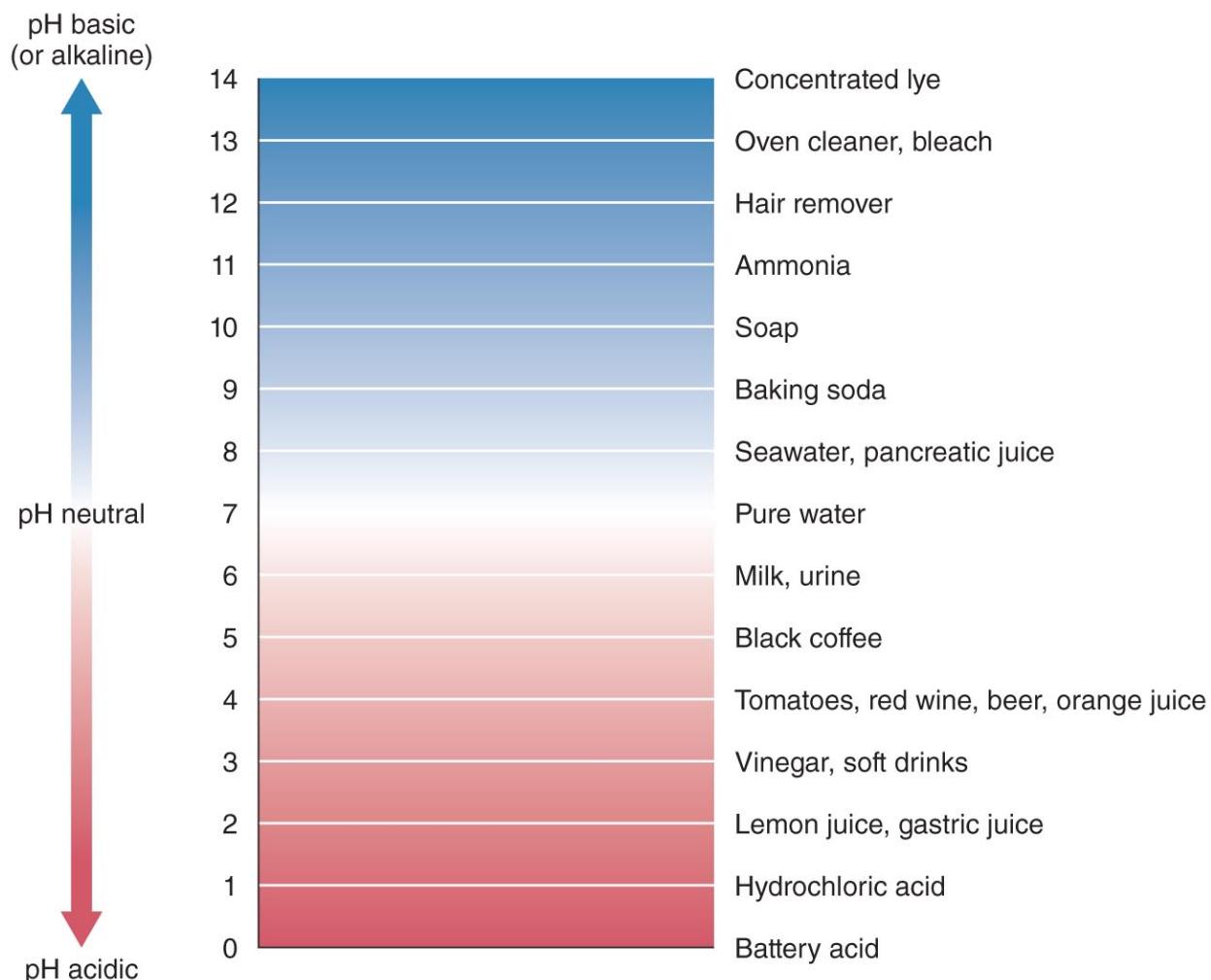


Figure 3.6: Hydrochloric Acid (HCl) on the pH Scale

3.5.3 Small Intestine

- From the stomach, chyme is slowly released through the pyloric sphincter to the small intestine
- Chemical digestion continues in the small intestine using pancreatic enzymes and bile

3.5.4 Large Intestine

- Undigested food components move through a sphincter called the **ileocecal valve** to the large intestine
- In the large intestine
 - Very little digestion takes place
 - Material is stored 12–24 hours prior to elimination
 - Water and some nutrients are absorbed

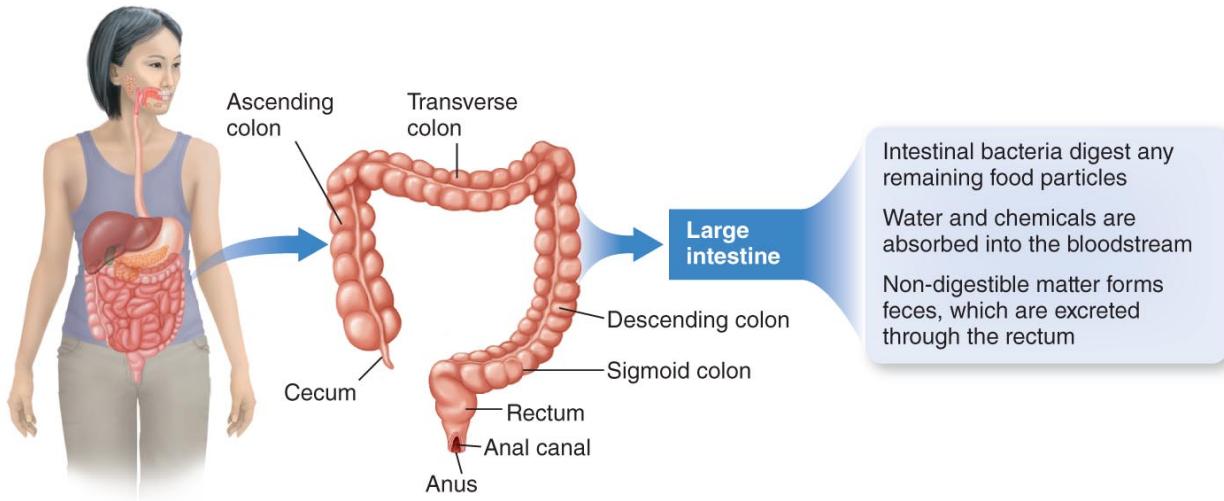


Figure 3.7: Elimination

3.5.5 Accessory Organs

- Surrounding the GI tract are several **accessory organs**
 - Salivary glands
 - Liver** – produces bile, which emulsifies fats
 - Pancreas**
 - * Produces many digestive enzymes
 - * Produces bicarbonate to neutralize chyme
 - Gallbladder** – stores bile

3.6 Absorption

- Absorption** – the process of taking molecules across a cell membrane and into cells of the body

- A small amount of absorption occurs in the stomach
- Most absorption of nutrients occurs in the three sections of the small intestine
 - Duodenum
 - Jejunum
 - Ileum
- The lining of the GI tract has special structures to facilitate absorption
 - **Villi** – folds in the lining that are in close contact with nutrient molecules
 - **Brush border** – composed of microvilli that greatly increase the surface area
- Water-soluble nutrients (carbohydrates, protein, minerals, and some vitamins) enter the **portal vein**
 - The portal vein transports these nutrients to the liver
- Fat-soluble nutrients (lipids and some vitamins) enter the lymphatic vessels
 - Lymphatic vessels transport these nutrients directly to the bloodstream
- Nutrients are absorbed across the mucosal membrane and into the blood stream or lymph by:
 - Passive diffusion
 - Facilitated diffusion
 - Active transport
 - Endocytosis

3.7 The Role of the Neuromuscular System

- Two components of the neuromuscular system regulate the activities of the GI tract
 - The muscles of the GI tract mix and move food
 - * Both voluntary and involuntary muscles
 - Nerves control the contractions and secretions of the GI tract
 - * The **enteric nervous system (ENS)**
 - * Other branches of the autonomic nervous system
 - * The central nervous system (CNS)

3.8 GI Tract Disorders

- The lining of the stomach is designed to cope with hydrochloric acid, but other regions of the GI tract are not
- Heartburn** – caused by hydrochloric acid in the esophagus
- Gastroesophageal reflux disease (GERD)** – a chronic disease for which painful, persistent heartburn is the most common symptom
- Peptic ulcers** – regions of the GI tract that have been eroded by HCl and pepsin
- The bacterium *Helicobacter pylori* contributes to the production of both gastric and duodenal ulcers
- Vomiting often accompanies a gastrointestinal infection such as the norovirus
- Cyclic vomiting syndrome (CVS)** – a chronic condition involving severe nausea and vomiting that can last for hours or days
- Diarrhea can be caused by
 - * Food intolerances
 - * Infection of the GI tract
 - * Stress
 - * Bowel disorders
 - Can lead to severe dehydration
 - Is more dangerous for children and the elderly
- Constipation** – no stool passed for two or more days

Table 3.1: Signs and Symptoms of Dehydration

Symptoms in Adults	Symptoms in Children
Thirst	Dry mouth and tongue
Light-headedness	No tears when crying
Less frequent urination	No wet diapers for 3 hours or more
Dark-colored urine	High fever
Fatigue	Sunken abdomen, eyes, or cheeks
Dry skin	Irritable or listless
	Skin does not rebound when pinches or released

Data adapted from: *Diarrhea*, National Digestive Diseases Information Clearinghouse, www.niddk.nih.gov.

- Irritable Bowel Syndrome (IBS)** – a disorder that interferes with normal colon function

- Symptoms of IBS include
 - Abdominal cramps and bloating
 - Either diarrhea or constipation
- IBS is more common in women than in men
- Cancer can develop in any region of the GI tract
- The most common forms are
 - Oral cancer
 - Pancreatic cancer
 - Colorectal cancer

3.9 In Depth: Disorders Related to Foods

- **Food intolerance** – a particular food causes numerous unpleasant symptoms, including
 - Gas
 - Pain
 - Diarrhea
 - *The immune system is not involved*
- **Food allergy** – hypersensitivity reaction of the immune system to a component in a food
- **Celiac disease** – an autoimmune disease that is also considered a genetic disorder
 - Complete intolerance for gluten, a protein found in wheat, rye, barley, and triticale
 - Can damage the small intestine, leading to poor absorption of nutrients
 - Requires a diet lacking wheat, rye, barley, and triticale

3.10 Non-Celiac Gluten Sensitivity

- Some individuals may have a negative GI reaction when consuming gluten, but do not have Celiac Disease
 - Bloating
 - Abdominal pain
 - Diarrhea
 - Possible joint pain
- Symptoms improve by following a gluten free diet