The Digestive System
DIGESTION – the process by which food is broken down into smaller particles suitable for absorption. Involves several processes:

1. Ingestion: taking food in
2. Propulsion: swallowing, peristalsis
3. Mechanical digestion: chewing, churning, segmentation
4. Chemical digestion: catabolism, breaking down food
5. Secretion: most acids, enzymes, and buffers required are provided by accessory organs.
6. Absorption: digested products from lumen of GI tract to blood
7. Defecation: the dehydration and compaction of indigestible substances
The digestive tract and the accessory organs of digestion make up the digestive system.

The **DIGESTIVE TRACT** is a hollow tube extending from the mouth to the anus.

It is also called the **ALIMENTARY CANAL** or the **GASTROINTESTINAL (GI) TRACT**.
The Digestive Tract...

- Structures of the digestive tract:
  - Mouth
  - Pharynx (throat)
  - Esophagus
  - Stomach
  - Small intestine
  - Large intestine
  - Rectum
  - Anus
The Accessory Organs...

- The accessory organs include:
  - Salivary glands
  - Teeth
  - Tongue
  - Liver
  - Gallbladder
  - Pancreas
Layers of the digestive tract...

- Although modified for specific functions in different organs, the wall of the digestive tract has similar structure throughout its length.

- The wall of the digestive tract has 4 layers:
  - Mucosa
  - Submucosa
  - Muscle layer
  - Serosa
Mucosa...

- Innermost layer
- Composed of a mucous membrane
- Has glands that secrete mucous, digestive enzymes, and hormones
Submucosa... 

- A thick layer of loose connective tissue
- Contains blood vessels, nerves, glands, and lymphatic tissue
Muscle layer...

- 2 layers of smooth muscle:
  - Inner circular layer
  - Outer longitudinal layer

- Responsible for several types of movements in the digestive tract
MIXING MOVEMENTS

- Stomach muscles mechanically digest the food and mix the particles with digestive juices

- PERISTALSIS – a rhythmic alternating contraction and relaxation of the muscles

- Peristalsis pushes the food through the digestive tract from one segment to the next – somewhat like the movement of toothpaste as it is squeezed through the tube
Peristaltic waves squeeze food from behind and push it forward.

They are stimulated by the presence of food.

Muscle activity is also responsible for:
- Deglutition – swallowing
- Defecation – elimination of waste
Serosa...

- Outermost lining
- Secretes serous fluid into the abdominal cavity, not into the digestive tract
- The serous fluid lubricates the digestive tract so that the organs do not rub against each other
The digestive tract begins with the **MOUTH**, also known as the **ORAL CAVITY** or **BUCCAL CAVITY**.
Mouth

- The mouth contains structures that assist in the digestive process:
  - Teeth
  - Tongue
  - Salivary glands
  - Hard palate
  - Soft palate
  - Uvula
  - Vestibule
Teeth

- MASTICATION – the process of chewing

- Teeth rip and grind food
During a lifetime, a person will have 2 sets of teeth

- **DECIDUOUS TEETH** – baby teeth, milk teeth
  - 20 deciduous teeth
  - Appear around 6 months of age
  - Finish appearing at about 2 ½ years
  - Between the ages of 6 -12, these teeth are pushed out and replaced

- **PERMANENT TEETH**
  - 32 teeth
- Names of teeth: incisors, cuspids, premolars, molars
- The shape and location of each tooth determines its function
- **INCISORS** tear and grasp food
- **MOLARS**, grind food
**TONGUE** – a muscular organ that occupies the floor of the mouth
- Mixes food with saliva (bolus)
- Pushes the food toward the pharynx
- Taste buds allow us to enjoy food
- Speech forming consonants
- Lingual frenulum: fold of membrane that secures tongue to floor of mouth
Tongue-tied: distorted speech due to shortened frenulum
Salivary Glands

- 3 pairs of **SALIVARY GLANDS** secrete their contents into the mouth
- **AMYLASE** enzyme to begin breakdown of starch
- Cleanses mouth
- Antibodies to inhibit bacteria
Salivary glands

- Mumps: inflammation of parotid glands caused by a myxovirus
- Risk in males of infecting testes that can lead to sterility (endocrine glands)
Halitosis: bad breath due to inhibited saliva secretion
The tongue pushes the food from the mouth into the PHARYNX (throat)

The pharynx is involved in swallowing
Pharynx

- Palatine & lingual tonsils: paired masses of lymphatic tissue
ESOPHAGUS – a long tube that carries food from the pharynx to the stomach
The act of swallowing pushes the **BOLUS** of food into the esophagus.

The presence of food in the esophagus stimulates peristaltic activity and causes food to move into the stomach.

Glands within the mucosa of the esophagus secrete mucus, which lubricates the bolus of food and facilitates its passage along the esophagus.
- There are 2 esophageal sphincters (thickening of smooth muscle)

- Pharyngoesophageal sphincter located at the top of the esophagus

- Cardioesophageal sphincter prevents reflux, or regurgitation, of stomach contents back into the esophagus
Esophagus

- Heartburn: gastric juice regurgitates into esophagus
  - Excess food
  - Obesity
  - Pregnancy
  - Running
Stomach

- **Stomach**: C-shaped organ
- Lies in the abdominal cavity, just under the diaphragm
1. digestion of food
2. secretion of gastric (stomach) juice, which includes digestive enzymes, and hydrochloric acid as its most important substances
3. secretion of gastric hormones and intrinsic factor
4. regulation of the rate at which the partially digested food is delivered to the small intestine
5. absorption of small quantities of water and dissolved substances
Regions of the stomach...

- **FUNDUS**
- **BODY**
- **PYLORUS**

- The **PYLORIC SPHINCTER** helps regulate the rate at which gastric contents are delivered to the small intestine.
There are thick folds called **RUGEAE** that allow the stomach to stretch

Can hold 1 gallon of food
Stomach muscles...

- Stomach has 3 muscle layers that lie in 3 directions:
  - Longitudinal
  - Oblique
  - Circular

- This arrangement allows the stomach to churn and mix the food with gastric juice to create a thick paste-like mixture called **CHYME**
Glands of the stomach...

- Stomach glands contain 3 types of secretory cells:
  - **Mucus cells** – secrete mucus
  - **Chief cells** – secrete digestive enzymes
  - **Parietal cells** – secrete hydrochloric acid (HCl) and intrinsic factor

- Together these secretions form the **GASTRIC JUICE**
Stomach

- Emesis: vomiting/reverse peristalsis
Gastric ulcers: erosion of the stomach wall
- Too much HCl
- Too little mucus
- Heliobacter pylori: bacteria destroys protective layer
Small intestine

- Chyme enters in small amounts due to pyloric sphincter
- 3 parts
  - Duodenum: first 10 inches
    - bile from liver enters via bile duct
    - Enzymes from pancreas enter via pancreatic duct
Small intestine

- Jejunum: next 8 feet
- Ileum: last 12 feet
- Most food is absorbed in small intestine
- High surface area
Small intestine

- Microvilli: brush border
- Villi: fingerlike projections
  - Blood capillaries within
  - Lacteal: lymphatic capillary
Peyer’s patches: lymphatic tissue patches keep bacteria from entering blood stream

Enzymes
- Pancreas
  - amylase to breakdown carbohydrates
  - Trypsin to breakdown protein
  - Lipase to breakdown lipid
Liver: bile to emulsify fats (break into smaller parts)
Fats absorbed into lacteal
Large Intestine

- Larger diameter, shorter in length
- Dries out food by absorbing water
- Eliminates food residue (feces)
- Cecum
- Appendix
- Ascending colon
- Transverse colon
- Descending colon
- Sigmoid colon
- Rectum
- Anal canal
- Anus
Large Intestine

- Synthesis of certain vitamins by the intestinal bacteria (vitamin K and certain B vitamins)
- 2 anal sphincters: voluntary & involuntary
- Goblet cells make mucus to ease passage of feces
- Constipation: slow movement; lack of fiber, improper bowel habits, lack of exercise, emotional upset, laxative abuse
Large Intestine

- Diarrhea: food moves too fast; not enough water absorption
Large Intestine

- Flatulence: gas produced by bacteria through digestion of food
Large Intestine

- Diverticulosis: small herniations of mucosa through the colon walls
Large Intestine

- Polyps: benign mass of normal cells
  - precancerous
Colon cancer
- 2nd leading cause of cancer deaths in males in US
- High fat diet, beef consumption, lack of calcium
Liver

- Liver: large, reddish-brown organ located in the upper abdominal cavity
- All blood from digestive system enters liver first
- HEPATIC refers to liver
Liver

- Produces bile to break up (emulsify) fat
- No bile or lipase, no fat absorption
- Detoxification of drugs
- Metabolism of carbohydrates, proteins, fats
Liver

- Hepatitis: inflammation of the liver
  - Caused by a virus (one of six)

Risk factors:
- people who share needles
- health workers who are exposed to infected blood

Possible symptoms:
- pain in the upper right quadrant of abdomen
- nausea and vomiting
- loss of appetite
- jaundice
- fatigue
- itching
Gallbladder

- Located underneath liver
- Stores bile
- Gallstones: crystallized bile
Gallbladder

Gallbladder

- Cirrhosis: chronic inflammation. Severe damage to liver
  - alcoholism
Both endocrine and exocrine secretions

The exocrine secretions include digestive enzymes

Most important of all digestive enzymes
Enzymes

- Amylase: carbohydrate breakdown
- Lipase: fat breakdown
- Trypsin, chymotrypsin, peptidases: protein breakdown
- Nucleases: nucleic acid breakdown
Hormones

- Insulin: brings glucose into cells
- Glucagon: releases glycogen from liver
Nutrition & Metabolism

“You are what you eat …” Is this a true statement?
Food

- Some converted into cellular molecules and structures
- Fuel to make energy for our cells, or ATP (measured in kilocalories)
Nutrients

- Substance in food that is used for growth, maintenance & repair
  - Carbohydrate
  - Lipid
  - Protein
  - Vitamins
  - Minerals
  - Water
Carbohydrates

- Plants
  - Cells favorite food
  - Sugar
  - Starch
  - Cellulose (fiber)
  - Simple vs. complex carbs
    - Complex take longer to digest; stabilizes blood sugar levels
Protein

- Complete (animal products): contain all 20 amino acids
- Incomplete (plant): missing one or more essential amino acids
  - Need to combine vegetables to complete protein
Triglycerides

- **Saturated**: animal fat; avoid
- **Unsaturated**: plant fat; liquid form
  - Trans fat: plant fat made solid; avoid
Lipids

- Cholesterol
  - Egg yolks
  - Meat
  - Animal products
  - Needed for cell membranes & making sex hormones
Vitamins

- Needed in small amounts
- A, C, E anticancer, anti-aging effects
  - Broccoli, cabbage, brussel sprouts
Minerals

- Small amounts
- Fe, I, Mg, Mn, K, Na
Energy Balance

- Energy intake = total energy output
- Stable body weight when energy in = energy out
- Energy values in foods
  - Carbs & protein 4 kcal/g
  - Fat 9 kcal/g
Basal Metabolic Rate (BMR)

- Amount of heat produced by the body per unit of time when it is at rest
  - Large surface to volume ratio (thin, small): increased
  - Small surface to volume ratio (large, heavy): decreased
  - Higher in males than females
  - Increased thyroid activity increases BMR
  - Decreases with age
  - Increases with emotion or infection
Total Metabolic Rate (TMR)

- Considers muscular work
Excessive triglyceride storage

Body fat 18% in males, 22% in females

BMI (body mass index)
- Weight (lbs) x 705 ÷ height (in)²
- Overweight 25-30
- Obese greater than 30
Obesity

- Most common health problem in US (1 in 3)
- Increased obesity in kids
- Decline in cardiovascular fitness
- Social stigma
  - Discrimination
  - Higher insurance premiums
Set point theory
- “clean your plate club” behavior formed during childhood
- More cells, more fat storage
- Feedback hormones response slow due to faster eating habits
- Fat cells may stimulate overeating
Feedback
Theories

- Fuel efficiency theory
  - Obese people better at storing fat
  - More fuel efficient
  - Product of evolution
Theories

- Genetic theory
  - 2 known obesity genes
  - Less than 5% of the population
False cures

- Water pills/laxatives
- Diet pills
  - Tolerance
  - dependency
- Fad diets
- Surgery
- No miracles
  - Move more, eat less