Digestive system (Chapters 23 and 24) **Page 1**

Nutrients

The molecules in foods that are needed for health and proper growth

- The macromolecule monomers:
  - √ Amino acids are the monomers of proteins
  - √ Monosaccharides are the monomers of carbohydrates
  - √ Fatty acids and glycerol are the monomers of lipids
- Vitamins
- Minerals (Atomic ions such as Ca^{2+}, Mg^{2+}, Fe^{3+}, etc.)

Chyme

Food after it has been swallowed

Digestion

Breaking down the macromolecules in chyme into smaller molecules

- The digestive system breaks macromolecules in chyme down into their monomer molecules
- The digestive system won't allow macromolecules in chyme to pass directly into the body (The macromolecules must first be digested into their monomers to be absorbed into the body)

Fig 23.6

Digestive system

The organ system responsible for (a) food intake, (b) digesting the macromolecules in chyme down into their monomer molecules, (c) absorbing nutrients (monomers, vitamins, minerals) and water into the body, and (d) eliminating the undigested wastes from the body

• Food is broken down by mechanical digestion (physically tearing) and chemical digestion (digestive enzymes, acids, and other chemicals)

√ Digestive enzymes = Proteins that break macromolecules into smaller molecules (usually monomers)

• Most digestive system organs are in abdominal cavity

• Gastrointestinal (GI) tract (also called the alimentary canal) = The continuous tube, from mouth to anus, that the chyme passes through

√ Major GI tract organs = Stomach, small and large intestines

• Accessory organs = Digestive system organs that are not part of the GI tract, but which supply digestive juices to the GI tract

√ Major accessory organs = Pancreas, gall bladder, liver

Figs 23.2 and 23.6

General structure of the GI tract organs

- Lumen (hollow interior) surrounded by a four-tissue wall

- Mucosa = innermost tissue layer: simple columnar epithelial cells
  - √ Cells secrete digestive juices and protective mucus; cells also absorb nutrients and water into the blood

  - √ Often arranged in pits or folds

- Submucosa = connective tissue layer outside mucosa
  - √ Loose connective and irregular dense connective tissue

  - √ Physically supports mucosa; contains blood vessels and neurons

- Muscularis externa = two layers of smooth muscle tissue
  - √ Circular muscle layer = inner muscle layer, cells point around canal

  - √ Longitudinal muscle layer = outer muscle layer; cells point up and down canal

  - √ Muscles layers are used for peristalsis (slow involuntary waves of contraction that propel chyme through the GI tract)

  - √ Muscles layers also used for segmentation contractions (churn and break apart the chyme into smaller pieces)

- Peritoneum = a fluid filled double membrane (serosa) that surrounds and cushions the GI tract organs
  - √ Visceral peritoneum = inner membrane; attached to muscle layer

  - √ Parietal peritoneum = outer membrane; attached to abdominal cavity wall

Figs 23.3, 23.4, 23.5, and 23.20

Oral cavity (mouth)

- Food is taken in and masticated (chewed)

  √ This is the first mechanical digestion of the food

- Salivary glands add a digestive enzyme

  √ This is the first chemical digestion of the food

Figs 23.2 and 23.12; Table 23.3

Pharynx

The upper region of the throat, behind the nasal cavity and the oral cavity.

- Conducts air, food, and water downward from oral cavity

Figs 23.2 and 23.12; Table 23.3

Esophagus (gullet)

Tube that conducts chyme (swallowed food and water) from pharynx to stomach

Figs 23.2 and 23.12; Table 23.3

Stomach

GI tract organ specializing in digestion of chyme (but essentially no absorption)

- Rugae = Large folds of the stomach's mucosa layer
- Gastric pits = Microscopic crevices in the stomach's mucosa layer
  - √ At the bottom of each gastric pit is a gastric gland (a stomach gland that secretes digestive juices)
  - √ Parietal cells = Gastric gland cells that secrete hydrochloric acid
  - √ Chief cells = Gastric gland cells that secrete digestive enzyme
- The stomach's muscularis externa has three muscle layers
  - √ The extra third layer is for better mechanical digestion

Figs 23.2, 23.15, and 23.16; Table 23.3

The esophageal and pyloric sphincters

Rings of smooth muscle that control passage of chyme into and out of the stomach

Fig 23.15

Small intestine

The GI tract organ where most chyme digestion and most nutrient (and water) absorption occur

- Subdivided into three sections:
  - √ Duodenum = region where chyme enters from stomach and digestive juices enter from accessory organs
  - √ Jejunum = region of most digestion and absorption
  - √ Ileum = final section of small intestine
- Inner surface is highly folded to increase absorption surface area
  - √ Villi = finger-shaped outward folds of the small intestine's mucosa
  - √ Microvilli = Microscopic finger-shaped outward folds of the cell membranes of the small intestine's epithelial cells
- Nutrients and water are absorbed into blood vessels inside the villi
  - √ Blood vessels in villi transport nutrients to liver
- Ileocecal valve = sphincter at end of small intestine

Figs 23.2, 23.18, and 23.19; Table 23.3

Large intestine (colon)

The GI tract organ for final water and ion (mineral) absorption from feces (the undigested chyme)

- Intestinal crypts = Microscopic inward folds of the large intestine's mucosa
- The large intestine is subdivided into four major regions (colons):
  - √ The ascending colon, transverse colon, descending colon, and sigmoid colon
- Bacteria in large intestine feed on undigested chyme
- Appendix = A fingerlike pouch at the start of the colon
  - √ Plays minor role in fighting infection
- Rectum = Feces storage area until expulsion
- Anus = sphincter where feces exits body

Figs 23.2, 23.21, and 23.22; Table 23.3

Accessory organs

Digestive system organs that are not part of the GI tract, but which supply digestive juices to the GI tract

- The pancreas, gall bladder, and liver
- All three organs secrete their digestive juices into the duodenum
- Their secretions are controlled by hormones from alimentary canal and nervous system

Figs 23.2 and 23.24; Table 23.3

Pancreas

An accessory organ that produces digestive juices and secretes them into duodenum

- Secretes many digestive enzymes and a buffer (to neutralize stomach acid)

Figs 17.18, 23.2, and 23.26; Table 23.3

Gall bladder

A small accessory organ near the liver that stores bile and secretes it into duodenum

- Bile = A detergent-like substance that helps digestion of fat by breaking down large fat globules into smaller ones

Figs 23.2 and 23.27; Table 23.3

Liver

A large accessory organ with several functions

- Manufactures bile and stores it in gall bladder
- Receives nutrients directly from the GI tract via the hepatic portal vein
- The liver stores carbohydrates and regulates their distribution

Figs 20.43 and 23.2; Tables 23.3 and 23.10

Metabolism

All the chemical reactions that take place in the body

- All metabolic reactions (including digestion of chyme in GI tract) are carried out by enzyme proteins

Digestive enzymes

Enzymes made by the digestive system to break down macromolecules in chyme into smaller molecules.

- Only the monomers from the foods are allowed to pass into the bloodstream. The lining of the GI tract does not allow intact macromolecules to pass through.

- Enzymatic digestion of macromolecules is usually a two-step process: Large polymers are first digested into smaller polymers, then the smaller polymers are digested into monomers

Protein	->	peptides	->	amino acids
Polysaccharide	->	disaccharides	->	monosaccharides
Fat globules	->	triglycerides	->	glycerol and fatty acids

- Most of the digestive enzymes are made by the pancreas and the small intestine; a few are made by the stomach and the salivary glands

Figs 23.29 and 23.31; Tables 28.8 and 23.9

Carbohydrate metabolism:

- Carbohydrate polymers (such as starch) are digested to glucose monomers in the GI tract.

  √ Cellulose (bran/fiber) = An indigestible plant polysaccharide

- Glucose is the major monosaccharide found in blood ("blood sugar")

  √ This is because cells use glucose as their major energy source

- The liver is the organ responsible for maintaining blood sugar homeostasis:

  √ The liver stores excess glucose as the polysaccharide glycogen when blood sugar is high (hyperglycemia)

  √ The liver secretes glucose by glycogenolysis (breaking down its stored glycogen into glucose monomers) when blood sugar is low (hypoglycemia)

Figs 17.19, 23.29, and 24.21; Table 23.10

Control of blood sugar levels

The pancreas contains small endocrine glands called pancreatic islets (the islets of Langerhans). The islets secrete the hormones insulin (which decreases blood sugar) and glucagon (which increases blood sugar)

- High blood glucose (hyperglycemia) causes insulin secretion from the pancreas
  - √ Insulin lowers blood sugar by causing cells to take in glucose
  - √ Most cells use the glucose for energy and growth; the liver stores glucose as glycogen
- Low blood sugar (hypoglycemia) causes glucagon secretion from the pancreas
  - √ Glucagon causes glycogenolysis (breaking down stored glycogen into glucose) in the liver; the liver secretes the glucose into the blood for use by other cells

Figs 17.18, 17.19, 24.21, and 24.22; Tables 17.7, 24.1, and 24.2

Diabetes mellitus

A disorder caused by the insulin system not functioning

- The body's cells can't take in glucose
  - √ The cells use fatty acids, ketone bodies, and amino acids as fuel sources
- Major symptom = Hyperglycemia (especially after a carbohydrate-rich meal)
- The urine's glucose and water content increase
- Glucose imbalance affects brain function and can lead to coma or death

Table 17.7 (and boxed Diabetes section next to table 17.7)

Triglyceride (fats and oils) metabolism

- Triglyceride molecules are digested into fatty acids and glycerol molecules in GI tract then absorbed into bloodstream

  - √ Animal lipids tend to have more saturated fatty acids and cholesterol (unhealthy)

  - √ Plant lipids tend to have more unsaturated fatty acids and don't have cholesterol (healthy)

- Cells use fatty acids for energy through aerobic respiration

- Fatty acids also are used as the building blocks for the cell's fats and phospholipids

- The liver uses fatty acids to make cholesterol

- Low density lipoprotein (LDL) = a protein + lipid globule that the liver secretes into the bloodstream to transport cholesterol and fats to other tissues

  - √ High LDL levels are associated with atherosclerosis

- High density lipoprotein (HDL) = a protein + lipid globule that cells secrete into the bloodstream to transport cholesterol to the liver for disposal (as bile)

  - √ High HDL levels are associated with lower cholesterol and healthy arteries

Metabolic rate

The amount of calories our body uses per hour

- Basal metabolic rate (BMR) = calories per hour when resting
  - √ Thyroxine = hormone from thyroid that sets BMR
  - √ BMR is also affected by size, gender, age
- Total metabolic rate (TMR) = calories used per hour when doing activities
  - √ Always above BMR
  - √ TMR depends on activities

Energy balance

When total calories (energy) gained from food exactly equals calories expended by body

- Energy balance results in no significant change in weight
- If more calories are taken in than are used, body weight increases
- If more calories are used than are taken in, body weight decreases