Chapter 11
The Digestive System

Biology 2201
All organisms need food, and *all foods contain nutrients*. Nutrients are the substances that provide the energy and the materials needed for growth, repair, regulation, and maintenance of the cells.

Therefore, food is what the organism consumes, and nutrients are substances within food that are needed by the cells to sustain life.
The 6 Essential Nutrients

1. **Carbohydrates**
   - Source
     - Plants
   - Function: Major source of energy in the body
     - Ie: sugar from candy bars or fruits and vegetables

2. **Lipids (Fats)**
   - Sources
     - Ingestion of animal and plant fats conversion of carbohydrates into fats
   - Functions
     - Storage of energy, component of cell membranes, cushion for delicate organs, carriers for certain vitamins, raw materials for important chemicals
3. Protein

- **Sources**
  - Meat, Fish, Poultry, milk, cheese, legumes, eggs, whole grains

- **Function**
  - Broken down into amino acids which are used in the construction of human proteins
  - Proteins are essential for the building, repair, and maintenance of cell structure.
  - The predominant part of muscles, nerves, skin, and hair is protein.
  - Things such as enzymes and antibodies are specialized proteins.
The 6 Essential Nutrients

4. Vitamins

- Sources
  - Various foods contain different types of vitamins
  - See page 358 – Table 11.1

- Functions
  - Required in small amounts for various metabolic functions including enzymatic activity
  - Some are fat soluble and stored in the body, while others are water soluble and need to be replenished on a daily basis
The 6 Essential Nutrients

5. Minerals

- **Sources**
  - Various foods we eat contain different minerals
    - Ie. Milk contains calcium, salt contains sodium, cereals often contain iron, bananas contain potassium

- **Function**
  - Used throughout the body for many functions
    - Calcium – tooth and bone formation
    - Iron – hemoglobin
    - Sodium / potassium – nervous system

See P 370-37/Charts Vitamin + Minerals
The 6 Essential Nutrients

6. **Water**

- **Sources**
  - Various foods and drink – ie. The tap
- **Function**
  - Used mostly as a solvent throughout the body, but also responsible for maintaining cell structure

- Carbohydrates, lipids, and proteins *require digestion.*
- Vitamins, water, and minerals *do not require digestion*
Section 11.2

The Human Digestive System

Foods taken into the body consist of large complex organic compounds.

- **Digestion** must occur in order to release the nutrients contained within the food.

- Digestion will break down the large complex organic compounds into smaller, simpler units that can be absorbed and used by the cells of the organism.
Two Types of Digestion

1. Mechanical Digestion
   1. Physical breaking up of food into smaller pieces by the teeth.
   2. The tongue manipulates the food into a mass called the bolus.
   3. The squishing action in the esophagus and intestines further break up the food mass (peristalsis).
   4. The Churning action of the stomach muscles contracting to mix food with the digestive juices in the stomach.
Two Type of Digestion

2. Chemical Digestion

- Separation of food into its **molecular components** using chemicals like stomach acid and digestive **enzymes**
  - Begins in the mouth with **salivary amylase** which breaks down sugars into simpler sugars – maltose
  - Majority takes place in the stomach with the help of hydrochloric acid and in the small intestine with the help of various digestive enzymes
The Digestive Tract - Mouth

- **Equipped with a number of teeth** lined up on upper and lower jaws. **Surface area**

- **Three sets of salivary glands** produce saliva which moistens food entering the mouth making it easy to swallow
  - Saliva production is stimulated by smell, hunger and taste of food
  - Contains salivary amylase - breaks starch into maltose

- Tongue covered in papillae that contain taste buds - pushes and churn food

- **Uvula** – prevents food from going up into the pharynx when we swallow
Pharynx - back of throat - passageway for food.

Made up of muscular walls containing:

- **Trachea** – tube going to the lungs
  - When you swallow the **epiglottis** closed over the **glottis** preventing food from entering the trachea

- **Esophagus** – Muscular tube going to the stomach
  - Muscles expand and contract pushing food down to the stomach – **Peristalsis**
  - No chemical digestion takes place here - only mechanical
Esophagus

- Made up of circular and longitudinal muscles which expand and contract to move food to the stomach by **peristalsis**

**Peristalsis:**
Wave-like muscle contractions that move food along the alimentary canal.

Occurs in the esophagus, small intestine and Colon. AKA Large intestine.
Stomach

- J-shaped sac in the middle of the digestive tract
- Has two **sphincters**:
  1. **Cardiac sphincter** – allows food into the stomach and keeps acid from entering the esophagus
  2. **Pyloric sphincter** – regulates and releases the amount of food entering the small intestine
* Stomach has highly folded (folds are called **rugae**) to increase surface area for digestion.
Stomach - Mechanical Digestion

- After eating the stomach walls begin to **contract** to **mix** and **churn** food with gastric juices
  - This mixture is called **chyme**
  - GROSS! This is the stuff that comes up when you get sick

- Food may remain in the stomach for 2 to 6 hours after eating (longer if you eat before going to bed)

- May stretch to hold up to 2 litres of food or liquid
Stomach – Chemical Digestion

- **Gastric glands** found in the wall of the stomach release **gastric juices**

- Production is stimulated by:
  - Thought, sight or smell of food
  - Food entering the stomach
  - Stretching of stomach wall

- With a pH of about 2, these juices are able to efficiently break down food --- Protein digestion begins here.
Gastric Juice Contains…

A. Hydrochloric acid (HCl)
   - Lowers the pH to about 2, which is necessary for the digestion of proteins.
   - Activates enzyme pepsin.
   - Kills bacteria.
   - Breaks down cellulose.

B. Pepsinogen (an inactive protein)
   - Enters the stomach and comes into contact with HCl and is converted to pepsin (active enzyme).
   - Pepsin breaks protein into polypeptides (chunks of protein).

C. Water

D. Gastrin - a hormone that controls the release of gastric juices.
Digestion in the Stomach

1. A bolus enters the stomach via the cardiac sphincter.

2. The food is further broken down by the movement of muscles in the stomach called **churning**.

3. Gastric glands secrete gastric juice containing HCl and pepsinogen that aid in the digestion of proteins.

   \[
   \text{HCl} + \text{pepsinogen} \rightarrow \text{pepsin}
   \]

4. When digestion in the stomach is finished, an acidic soupy liquid remains called **chyme**.

5. Exit through pyloric sphincter.

- Functions of HCl in gastric juice:
  - The HCl gives a pH of 1-2 which
    - kill harmful bacteria,
    - breaks down cellulose and cell membranes in food.
  - changes pepsinogen (an inactive enzyme) into Pepsin (an active enzyme).

- Pepsin changes proteins into long polypeptides.
Small Intestine

Subdivided into three parts:
1. **Duodenum** – First 25 cm after the stomach
2. **Jejunum** – The next 2 metres
3. **Ileum** – the last 5 metres

- This is the site of most digestion, along with **nutrient absorption**
- The lines of the small intestine highly folded and has finger-like projections called **villi**, along with their **microvilli** drastically increase the surface area inside the small intestine increasing the amount of nutrient absorption that can take place.
lacteal in microvilli absorb fat.
Villi and Microvilli

- All six essential nutrients are absorbed into the capillaries located in the microvilli

See Page 361 in your textbook
3 Parts to SI

A. Duodenum - 25 cm.
Chyme is immediately mixed with *Bile* from the liver/gallbladder and *pancreatic juices* and *bicarbonate ions* from the pancreas (neutralization)

B. Jejunum
Function:
Finish breakdown of carbohydrates and proteins so they can be absorbed by the villi.

2 m
- fats emulsified

C. Ileum
Function:
1. Absorb nutrients.
2. Push remaining undigested materials into the large intestine.
Anatomy of Small Intestine

- Stomach
- Duodenum
- Jejunum
- appendix
- Ileum
The Pancreas

- Produces **pancreatic juices** which are secreted into the **pancreatic duct** and to the **common bile duct** and into the duodenum.

- See Table 11.2 pg 365 and know the following enzymes:
  - Salivary amylase, pepsin, lipase, pancreatic amylase, maltase, sucrase, lactase

- Produces enzymes like:
  - Pancreatic amylase – converts starch to maltose
  - Lipase – converts fats to fatty acids and glycerol
  - And several others (see chart)
Pancreas - Chemically digests - Enzymes:

1. Protease - (trypsin + chymotrypsin) further breaks down polypeptides to smaller.

2. Pancreas - trypsin - breaks down simple polypeptides into a.a.

F. B. Lipase - breaks down fats into fatty acids + glycerol (now can be absorbed).

4. Pancreatic amylase - breaks down starch into maltose.
Intestinal glands - Enzyme action

1. Peptidase - break simple polypeptides into a.a.

2. Lipase - break down fats into fatty acids + glycerol \(\rightarrow\) absorbed

3. Maltase - breaks maltose into simple sugars \(\rightarrow\) can be absorbed

4. Sucrase - breaks sucrose into simple sugars \(\rightarrow\) can be absorbed

5. Lactase - breaks lactose into simple sugars \(\rightarrow\) absorbed
Small Intestine – Mechanical Digestion

- **Peristalsis**
  - **Rhythmical segmentation** is a form of peristalsis that mixes and pushes partially digested food through the small intestines.

- **Emulsification**
  - Fats are broken down into smaller droplets (not chemically changed) by **bile**.
  - **Bile** is produced in the liver and stored in the gall bladder, it enters the **duodenum** via the **common bile duct**.
  - Bile activates the **lipases** that will later chemically break down fats.
Small intestine - Other secretions

1. bile - emulsifies (break down) lipids + neutralizes chyme

2. sodium bicarbonate - neutralizes chyme

3. mucus - lubricates & protects enzymes
End products of digestion

Carbohydrates (Polysaccharide)
Sugars and Starches

Protein (Polypeptide)

Lipids (triglycerides)

Enzymes:
- Salivary amylase
- Maltase
- Sucrase
- Lactase
- Pancreatic Amylase
- Pepsin
- Trypsin
- Chymotrypsin
- Erepsins
- Lipase

End products:
- Monosaccharides
- Amino Acids
- Fatty Acids and Glycerol

Small enough to absorb

Digestion sheet #2
Small Intestine – Chemical Digestion

- Two major glands involved in digestion in the small intestine:
  1. The Pancreas
  2. The Intestinal glands

http://www.youtube.com/watch?v=8sDMVgw9d-c
Digestion Song
The Large Intestine

- Consists of the caecum, colon, rectum and anal canal
- Caecum
  - Blind end of the large intestine
- Appendix
  - Plays no role in digestion but may help fight infections
- Colon
  - Divided into 3 sections
    - Ascending (up)
    - Transverse (across)
    - Descending (down)
From Colon to Anus

- In the colon, water and dissolved minerals are absorbed into the blood from undigested food.
- Bacteria help release more nutrients by further breaking down food.
- The mass of indigestible material left behind is called feces.
- Feces passes into the rectum and anal canal.
- The anal sphincter allows limited control over the elimination of waste material from the body via the anus.
What IS Chemical Digestion?

The chemical break down of food by a process called hydrolysis

- Hydro = water  lysis = break
- Hydrolysis = break with water
- Water is used to break compounds at specific points in the molecules
- While hydrolysis normally is very slow, the three groups of enzymes make the process very fast
Enzymes Activity

- The effect of enzymes are greatly affected by:
  1. Temperature (warm = fast, cold = slow)
  2. Concentration (more = fast, less = slow)
  3. pH
    - (suitable pH levels vary, but most work best under neutral or basic pH conditions)

Some may also require specific metal ions to be present
Since the stomach is very acidic, it must be protected from the acidic environment.

- **Pyloric glands** — secrete a thick layer of mucus that coats and protects the lining of the stomach from digesting itself.

Ulcers form when the mucous layer begins to erode, leaving the stomach lining unprotected.

- Caused by bacteria that stop mucous production.

May also be caused by:
- Stress
- Smoking
- Alcohol consumption
Where ever the bacterium attaches in the stomach – mucus production stops, directly exposing the stomach wall to acid.

**Treatment:**

1. taking medication that reduces stomach acid production or strengthen the mucus layer.
2. antibiotics
3. making lifestyle adjustments (diet, quit smoking, drinking, reduce stress, diet change.)
4. Surgery

[Video – Ulcer / Bleeding ulcers](http://www.youtube.com/watch?v=SWMWsOXlBwE)
[http://www.youtube.com/watch?v=9-aVA8mz4e4](http://www.youtube.com/watch?v=9-aVA8mz4e4)
Small, hard masses form in the gallbladder, caused by the formation of crystals in the bile (cholesterol).

Contributing factors:
- Smoking, excessive alcohol use, obesity, and heredity

Treatments:
- Ultrasound waves break up stone so they may be passed out in the urine
- Surgically remove gallbladder
- Reduce cholesterol in diet
Inflammatory Bowel Diseases (IBD)

Crohn’s Disease
- **Inflammation** of the ileum lining (**Ileitis**)
- Causes pain and diarrhea, fever and rectal bleeding
- Decreased appetite and weight loss
- Difficult to diagnose since symptoms are similar to other disorders like irritable bowel syndrome

Colitis
- **Ulceration** and inflammation of the colon
- Symptoms include:
  - Loose, bloody stool, cramps
  - May have skin lesions and joint pain
- If meds do not work, person may have the entire bowel and rectum removed with an external opening for waste removal created
  - **Ileostomy**

[https://www.youtube.com/watch?v=eKLqFnAmK6c](https://www.youtube.com/watch?v=eKLqFnAmK6c)
Ileitis

Colitis

Crohn’s disease of the ileum showing narrowing of the lumen, bowel wall thickening, serosal-extension of mesenteric fat (‘creeping fat’), and linear ulceration of the mucosal surface.
Health & Digestive System

- Good nutrition is important for two reasons:
  - Provides energy to our bodies for metabolic activities to take place
  - Provides essential raw materials that our bodies need as building blocks but are unable to manufacture on their own

- Maintaining a healthy lifestyle means eating good nutritious foods.

- Following Canada’s Food Guide can help to ensure you eat the right foods to get the 6 essential nutrients
Canada’s Food Guide

Enjoy a variety of foods from each group every day.
Choose lower-fat foods more often.

Grain Products
Choose whole grain and enriched products more often.

Vegetables and Fruit
Choose dark green and orange vegetables and orange fruit more often.

Milk Products
Choose lower-fat milk products more often.

Meat and Alternatives
Choose leaner meats, poultry and fish, as well as dried peas, beans and lentils more often.
F. Y. I – Vitamins and Minerals

- For pages ... tables, but you should be familiar with the things that are in them.

- (Know Vitamins – ADEK (fat soluble – if have extra they are stored as fat cells))

- You will not explicitly be asked questions, but questions may contain information from these tables.

Nutrient wkst P. 388 / 10,11,12,15
Seatwork/Homework

- Nutrient Worksheet
- P. 373 #5,6,8,9
- P. 388 # 10,11,12,15