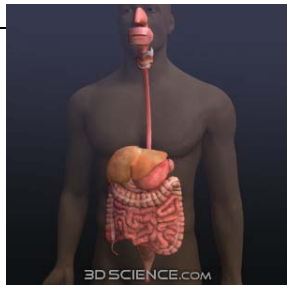
Chapter 11
The Digestive System

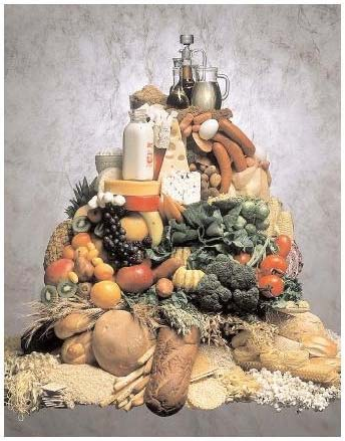
Biology 2201

April 2008



Section 11.1
The chemical Foundation of Digestion

- 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

The 6 Essential Nutrients

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 – haemoglobin**
      - **Sodium / potassium – nervous system**

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

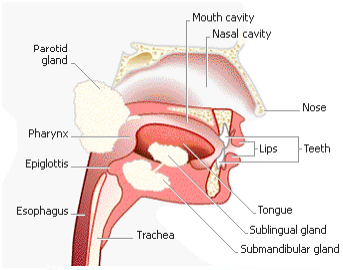
1. Mechanical Digestion
   - Physical breaking up of food into smaller pieces by the teeth.
   - The tongue manipulates the food into a mass called the **bolus**
   - The **squishing** action in the esophagus and intestines further break up the food mass
   - The **Churning** action of the stomach muscles contracting to mix food with the digestive juices in the stomache

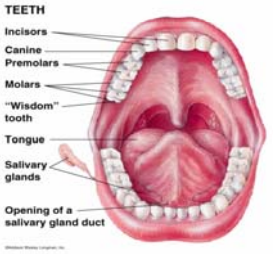
Two Type of Digestion

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
     - 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.
- 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
- Tongue covered in **papillae** that contain taste buds
- **Uvula** – prevents food from going up into the pharynx when we swallow



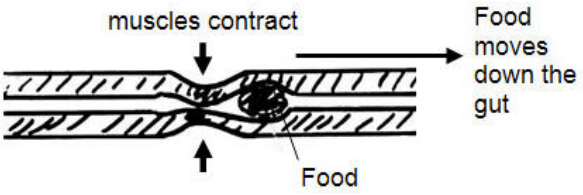


Pharynx

- 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

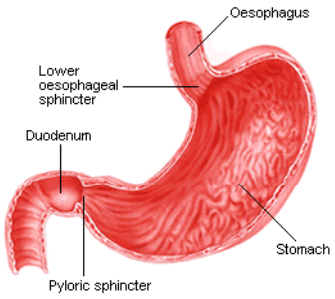
Esophagus

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



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 enter the esophagus
  2. **Pyloric sphincter** – regulates and releases the amount of food entering the small intestine



Stomach - Mechanical Digestion

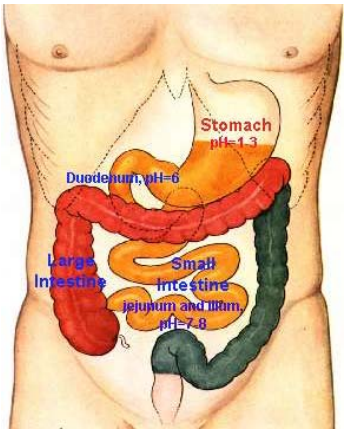
- After eating the stomach walls begin to contract to mix and churn food with gastric juices
  - This mixture is called **chyme**
    - GROSS! This is the stuff that comes up when you get sick
- Food may remain in the stomach for 2 to 6 hours after eating (longer if you eat before going to bed)
- May 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

Gastric Juice Contains…

- **Hydochloric acid (HCl)**
  - Lowers the pH to about 2, which is necessary for the digestion of proteins
- **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).

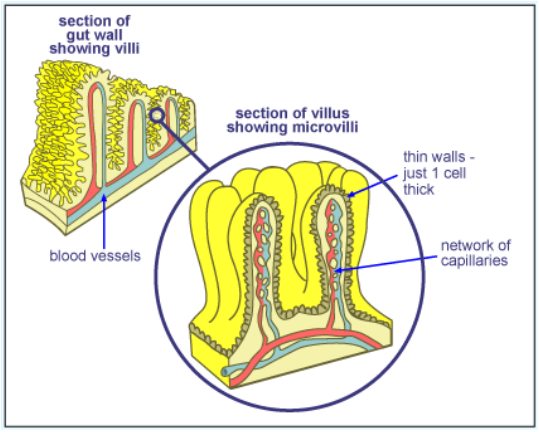


Small Intestine

- 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.

Villi and Microvilli

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



See Page 361 in your textbook

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 – Chemical Digestion

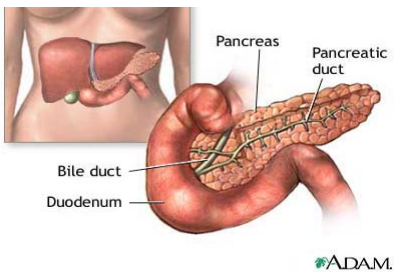
- Two major glands involved in digestion in the small intestine:
  1. The Pancreas
  2. The Intestinal glands

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



Three Major Types of Enzymes

1. Lipase **See figure 11.10 page 364**
   - Breaks down lipids into fatty acids and glycerol
2. Carbohydrase
   - Breaks down complex sugars into simple sugar molecules like glucose for use in our cells
3. Protease
   - Breaks down proteins into amino acids

Intestinal Glands

- Found in the walls of the small intestine
- They produce the following enzymes
  - Peptidases – converts simple amino acids into polypeptides
  - Lipase – converts fats into fatty acids and glycerol
  - Three enzymes that convert larger sugars into glucose
    - **Maltase & Sucrase & Lactase**

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 sphicter** 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

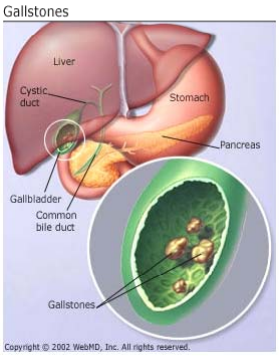
- The effect of enzymes are greatly affected by:
  - Temperature (warm = fast, cold = slow)
  - Concentration (more = fast, less = slow)
  - pH
    - (suitable pH levels vary, but most work best under neutral or basic pH conditions
  - Some may also require specific metal ions to be present

Digestive Disorders - Ulcers

- Since the stomach is very acidic, it must be protected from the acidic environment
  - **Pyloric glands** – secrete a thick layer mucous 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

Gallstones

- Small, hard masses form in the gallbladder, caused by the formation of crystals in the bile
- Contributing factors:
  - Smoking, excessive alcohol use, obesity, and heridity
- Treatments
  - Ultrasound waves break up stone so they may be passed out in the urine
  - Surgically remove gallbladder
  - Reduce cholesterol in diet



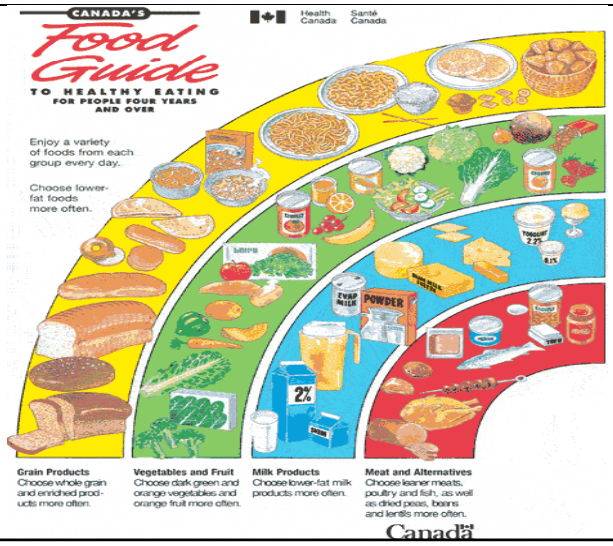
Inflammatory Bowel Diseases (IBD)

- **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 and external open for waste removal created
    - **Ileostomy**

Health & Digestive System

- Good nutrition is important for two reasons:
  1. Provides energy to our bodies for metabolic activities to take place
  2. 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



F. Y. I

- For pages 370 to 371 you do not need to memorize the tables, but you should be familiar with the things that are in them
- You will not explicitly be asked questions, but questions may contain information from these tables

Eating Disorders - Anorexia nervosa

- Characterized by a morbid fear of gaining weight, causing a person to go on a very restrictive diet.
- People are less than 85% of their normal body mass, and have a distorted self-image, seeing themselves as fat even when they clearly are not
- Symptoms include:
  - Severe weight loss, low blood pressure, irregular heartbeat, constipation
  - As the disorder progresses, the body shuts down, skin dries out and the digestive system stops working
  - Death may result
- Psychological therapy and hospitalization are required to recover from this disorder

Eating Disorders – Bulimia nervosa

- Characterized by binge eating followed by purging, usually done by vomiting or taking laxatives
- May be associated with both obesity and anorexia
- People are overly concerned about body shape and mass, so they diet, eventually lose control and binge on “forbidden foods”
- Blood composition is changed – damaging heart and kidneys, possibly leading to death
- Vomiting damages the esophagus, pharynx and acid decays the teeth from behind
- Psychological therapy and meds can be used to return the person to a more healthy lifestyle

CHAPTER REVIEW QUESTIONS

- PAGE 387
  - QUESTIONS 1 to 15

- You do not need to hand these questions in, but they are good review for this section of the chapter