Biology 2201 Ch 5: Fueling Life – The Digestive System

5.1 – Homeostasis in the Human Body (pp. 218-220)

Systems of the Human Body

- The human body contains numerous interconnected systems that have specific jobs which all work to keep humans alive, such as:
  - Digestive system
  - Respiratory system
  - Circulatory system
  - Excretory system
  - Nervous system
  - Endocrine system
  - integumentary system
  - skeletal system
  - muscular system
  - lymphatic and immune systems
  - reproductive system
- See Fig 5.1 p. 218 body systems

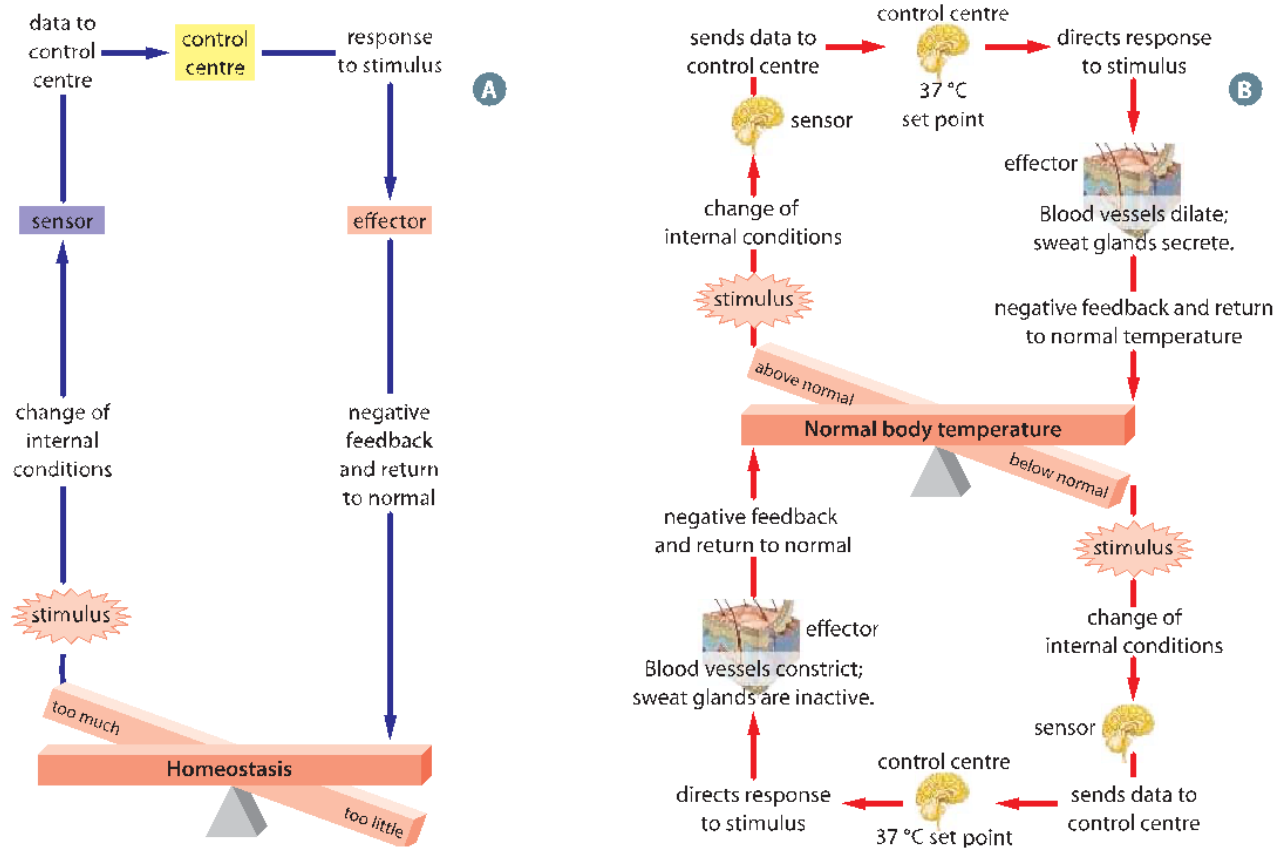
Homeostasis and Feedback Mechanisms

- homeostasis - the tendency of a body to maintain a relatively constant internal environment
- Regardless of external conditions, the internal environment of your body remains stable or relatively constant. If it fails to do so, you may become ill or worse.
- The body regulates the internal environment through two types of mechanisms:
  - Negative feedback
  - Positive feedback

Negative Feedback

- negative feedback mechanism - a feedback system that results in a variable being brought back to normal levels
- Most feedback systems in the body operate in this fashion.
- Body systems maintain homeostasis through a mechanism that has three components: a *sensor*, which detects a change in the internal environment; an *effector*, which brings internal conditions back into a normal range; and a *control centre*, which activates the effector based on information received from the sensor.
- Ex. Body temperature
  - If you are cold, you have receptors that indicate that. A signal is sent to your brain, and the brain sends messages out to the body to take appropriate actions such as shivering (muscles move to generate heat) and reducing blood flow to the skin (reduces release of heat)

Negative Feedback



Positive Feedback

- Positive feedback mechanisms also regulate homeostasis. With positive feedback, a variable's level is continually increased.
- Ex. Blood clotting
  - Substances released by the injured blood vessel wall begin the process of blood clotting. Platelets in the blood start to cling to the injured site and release chemicals that attract additional platelets. As the platelets continue to amass, more of the chemicals are released and more platelets are attracted to the site of the clot. The positive feedback accelerates the process of clotting until the clot is large enough to stop the bleeding.
- contractions of the uterus during childbirth are maintained by positive feedback mechanisms.

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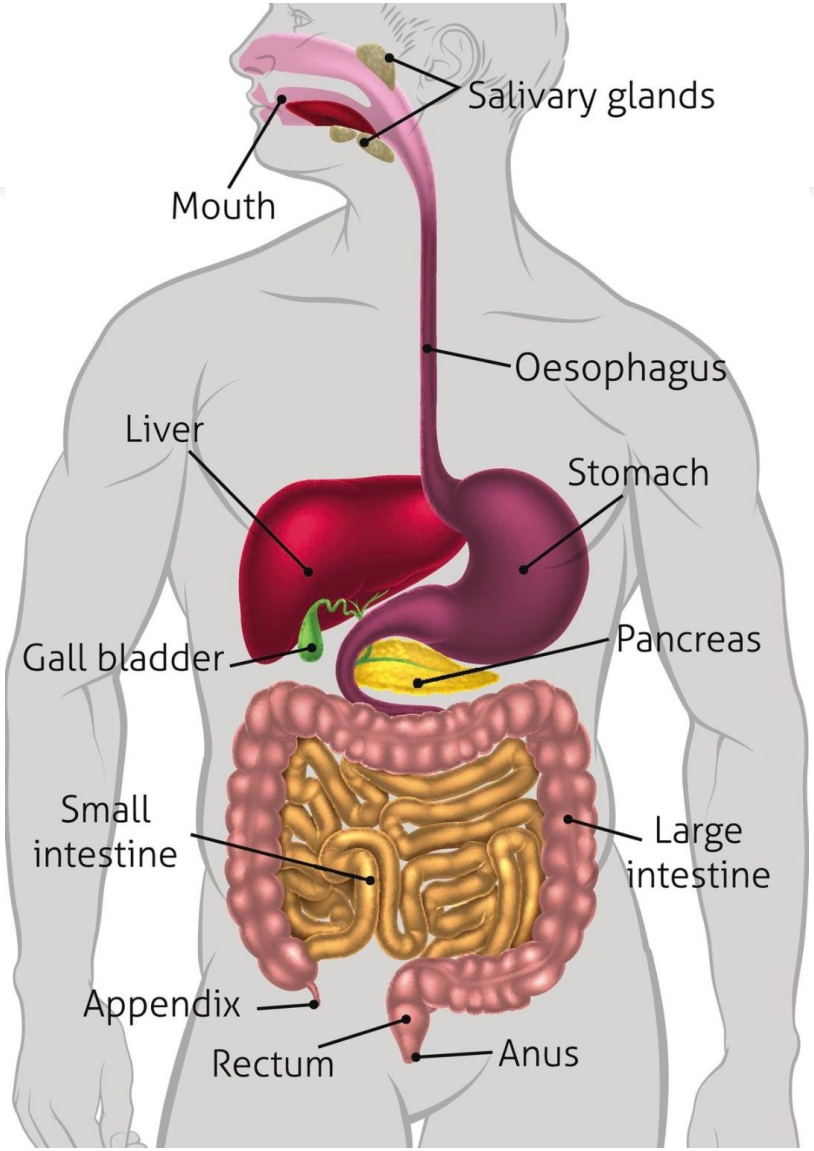
5.2 – The Human Digestive System (pp. 221-235)

The Human Digestive System

- digestive system - system into which food is taken and broken down. Humans have a one-way digestive tract (food goes in one opening, waste exits a separate opening)
- The digestive tract is approximately 8 m long and consists of the mouth, esophagus, stomach, small intestine, large intestine, rectum and anus
- Accessory glands also aid in digestion and include the pancreas, liver, gall bladder, salivary glands. They are not a part of the 8 m tube but produce/release enzymes or other substances into the digestive tract
- The digestive tract is also referred to as the gastrointestinal tract (GI tract) or alimentary canal.

Digestive System Diagram (see p. 221)



Types of Digestion

- Food is broken down in two ways
  - chemical digestion - chemical breakdown of food by enzymes and other digestive juices.
  - mechanical digestion - breakdown of food through chewing or churning
- Some organs may perform both types of digestion or simply one of them

Parts of the Digestive System - Mouth

- Mouth - part of the digestive system where ingestion (taking food in) occurs
  - The idea, smell, or taste of food triggers three pairs of salivary glands near the mouth to secrete a watery fluid, called saliva. Saliva lubricates food and contains salivary amylase
  - amylase an enzyme in saliva that breaks down starch into simpler sugars
  - Mechanical digestion also occurs as teeth grind up food and your tongue rolls your food into a ball called a bolus
  - To prevent food from going into your windpipe, a flap of tissue called the epiglottis covers the trachea

Parts of the Digestive System - Esophagus

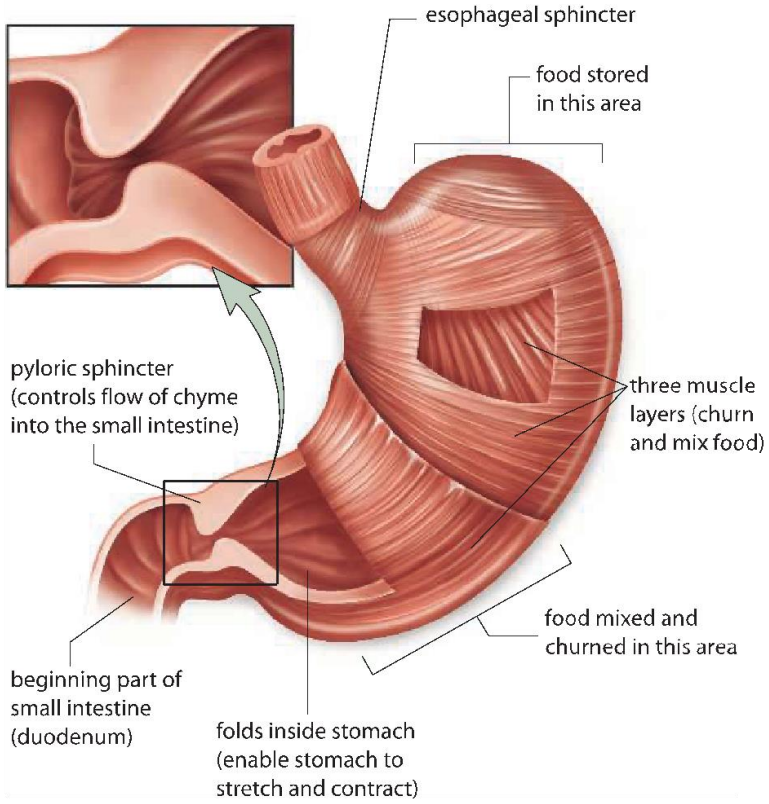
- Esophagus - muscular portion of the digestive tract that directs food from the mouth to the stomach
- No chemical or mechanical digestion occurs here
- The bolus moves through the esophagus partly by gravity, but mainly through a wavelike series of muscular contractions and relaxations called peristalsis
  - peristalsis - wavelike series of muscular contractions and relaxations that moves food through the digestive system (see Fig 5.4 , 223)
- Entry to the stomach is controlled by a ring- like muscular structure, called the esophageal sphincter. Relaxation of the esophageal sphincter allows the bolus to pass into the stomach. Contraction of this sphincter usually prevents the acidic contents of the stomach from backing up into the esophagus.
  - esophageal sphincter muscular ring that controls the entry of food into the stomach

Parts of the Digestive System - Stomach

- stomach - J-shaped sac whose muscles and secretions break down food and push it into the small intestine
- Mechanical and chemical digestion occur here
- Peristalsis causes the stomach to churn and this helps break food into smaller pieces. As well, stomach acid (HCl) has a low pH (1-3) helps to soften and break down proteins. The combination of broken down food and gastric juice (water, acid, salts, mucus and enzymes) is called chyme
- The stomach protects itself from self-digestion in a number of ways:
  - the stomach secretes little gastric juice until food is present.
  - some stomach cells secrete mucus, which prevents gastric juice from harming the cells of the stomach lining.
  - the stomach produces its protein-digesting enzyme, pepsin, in a form that remains inactive until hydrochloric acid is present.

Parts of the Digestive System – Stomach cont…

- absorption - process by which nutrients move into cell through diffusion or active transport
- Very few substances are absorbed in the stomach because most substances in the chyme have not yet been broken down sufficiently.
- The stomach does absorb some water and salts as well as certain anti-inflamatory medications, such as Aspirin™, and alcohol.
- pyloric sphincter - muscular ring that acts as a valve between the stomach and the small intestine



Parts of the Digestive System – Small Intestine

- small intestine - length of the digestive tract between the stomach and the large intestine
- The small intestine is named such for its diameter, not its length. It is actually quite long at 6 m long.
- Both mechanical and chemical digestion occur here, as well as the vast majority of absorption.
  - segmentation - a process by which some mechanical digestion occurs in the small intestine
- The lining of the small intestine is folded greatly in structures called villi and microvilli (see Fig 5.6 p. 226)
  - villus (villi) - finger-like projection along the ridges of the small intestine; increases surface area to aid in the absorption of nutrients
  - microvillus (microvilli) - microscopic projection found along exposed cell surfaces that greatly increases the surface area of the cell

Parts of the Digestive System – Small Intestine cont…

- The small intestine is divided into 3 sections:
  - Duodenum
  - Jejunum
  - Ileum
- The first 25 cm of the small intestine is called the *duodenum*. The duodenum is generally U-shaped and is the shortest and widest of the three regions. Ducts (channels) from the liver and pancreas join to form one duct that enters the duodenum. Thus, the duodenum is an important site for the chemical digestion of the chyme received from the stomach.
- The jejunum, which is about 2.5 m long, contains more folds and secretory glands than the duodenum. It continues to break down food so that the end products can be absorbed.
- The ileum, which is about 3 m long, contains fewer and smaller villi. Its function is to absorb nutrients and to push the remaining undigested material into the large intestine.

Parts of the Digestive System – Accessory Glands

- There are several glands/organs that help in digestion which are not directly a part of the digestive tract. Instead, they produce chemicals which aid in digestion and get released into the digestive tract.
- Examples of accessory organs
  - Pancreas
  - Liver
  - Gall bladder

Parts of the Digestive System – Pancreas

- pancreas - small gland in the abdomen that secretes digestive enzymes into the small intestine (duodenum)
- Pancreatic fluid contains a multitude of enzymes, including the following:
  - trypsin and chymotrypsin, which are peptidases that digest proteins
  - pancreatic amylase, which is a carbohydrase that digests starch in the small intestine
  - lipase, which digests fat
- Pancreatic fluid also contains bicarbonate, which neutralizes the chyme from the stomach. This brings the pH up to around 8.

Parts of the Digestive System – Liver

- liver - organ found in the abdomen that performs hundreds of functions as an accessory organ of the digestive system, including the secretion of bile to digest fats
- Bile salts play a crucial role in the digestion of fats. Bile salts assist lipases in accessing fats because they are partly soluble in water and partly soluble in fats. Bile salts work like a detergent, dispersing large fat droplets into a fine suspension of smaller droplets in the chyme. This emulsification process produces a greater surface area of fats on which the lipases can act. As a result, the digestion of fats can occur more quickly.

Parts of the Digestive System – Gall Bladder

- gall bladder - organ that stores bile produced by the liver
- The arrival of fat-containing chyme in the duodenum stimulates the gall bladder to contract. This causes bile to be transported through a duct (shared by both the gall bladder and the liver) and injected into the duodenum.

Digestion and Absorption in the Small Intestine

- Most of the chemical digestion in the small intestine occurs in the duodenum and acts on all four categories of macromolecules and their components.
  - carbohydrase - enzyme that catalyzes the hydrolysis of carbohydrates
  - lipase - enzyme that catalyzes the hydrolysis of triglycerides into glycerol and fatty acids
  - peptidase - enzyme that hydrolyzes the peptide bonds that link amino acids in proteins and peptides
  - See Table 5.2 p. 229
- The absorption of the nutrients occurs along the jejunum and ileum and end up into the bloodstream
  - Carbohydrate levels are regulated by the liver in the form of glucose
  - Amino acids are sent to the liver as well, to be distributed to body cells for protein manufacture
  - Lipids end up in the bloodstream as free fatty acids and glycerol for use by body cells

Maintaining Homeostasis in the Digestive Tract

- See Table 5.3 p. 234
- The activities of the digestive tract are coordinated by the nervous system and the endocrine system.
  - The nervous system stimulates salivary and gastric secretions in response to the sight, smell, and consumption of food. When food arrives in the stomach, proteins in the food stimulate the secretion of a stomach hormone called *gastrin*. Gastrin then stimulates the secretion of hydrochloric acid and the inactive precursor molecule of pepsin from glands in the stomach. The secreted hydrochloric acid lowers the pH of the gastric juice, which acts to inhibit further secretion of gastrin (a negative feedback loop)
  - The passage of chyme from the stomach into the duodenum inhibits the contractions of the stomach, so that no additional chyme can enter the duodenum until the previous amount has been processed. This inhibition of stomach contractions is guided, in part, by hormones that are secreted into the bloodstream by the duodenum .These hormones include *secretin, CCK* (cholecystokinin), and *GIP* (gastric inhibitory peptide). Chyme with a high fat content is the strongest stimulus for the secretion of CCK and GIP. Chyme with a high acidity is the strongest stimulus for the release of secretin.
  - CCK and secretin also have other regulatory functions in digestion. CCK stimulates increased pancreatic secretions of digestive enzymes and gall bladder contractions. Gall bladder contractions inject more bile into the duodenum, which enhances the emulsifying and digestion of fats. Secretin also stimulates the pancreas to release more bicarbonate to neutralize acidic chyme.

Parts of the Digestive System – Large Intestine

- large intestine - final portion of the digestive system; main function is to concentrate and eliminate waste materials
- The large intestine has a larger diameter but is only 1.5 m long
- No digestion here
- Its main functions are reabsorption of water and salts and the elimination of waste.
- Bacteria in the large intestine also produce vitamins such as B_{12} and K
- At the end of this process, any remaining indigestible materials, along with the colon bacteria, form the feces. The feces pass into the rectum and anal canal, which comprise the last 20 cm of the large intestine.

Parts of the Digestive System – Rectum and Anus

- The function of the rectum is to store the feces until they are eliminated. The rectum has three folds that enable it to retain the feces while passing gas.
- The opening to the anus is usually controlled by two sets of sphincters. You are able to control contraction and relaxation of one of these sets of sphincters. The other set is under the control of the nervous system. When the rectum is full, receptor cells trigger a reflex that moves the feces out of the body by peristalsis.

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5.3 – Health and the Digestive System (pp. 236-241)

The Importance of Good Nutrition

- Maintaining a healthy body mass and feeling energized and healthy results from eating a well-balanced diet, getting regular rest and exercise, and adopting positive, self-enriching attitudes. Deficiencies in any of these areas can severely affect our ability to function.
- What we eat is influenced by our lifestyles and attitudes. All individuals are unique, and it is impossible for everyone to fit an “ideal” body image that tends to be projected by aspects of our society.

Vitamins and Minerals

- vitamin – organic compounds needed in small quantities in order to sustain life
- Minerals – inorganic compounds needed in small quantities in order to sustain life
- The body cannot manufacture either of these so they need to be injested
- See Table 5.4 p. 237

Digestive Disorders

- Most disorders of the digestive system affect either the nutritional state of the body or its salt and water content. Examples
  - ulcers
  - inflammatory bowel disease
  - hepatitis
  - cirrhosis
  - gallstones.

Ulcers

- ulcer - digestive system disorder that forms when the thick layer of mucus that protects the lining of the stomach from the acids in the digestive juices is eroded
- Research has shown that most ulcers are caused by acid-resistant bacteria, *Helicobacter pylori*, which attach to the stomach wall. The sites of attachment stop producing the protective mucus, and the stomach acid eats away at the stomach wall.
- Other factors, such as smoking, caffeine and alcohol intake, and stress, can contribute to the formation of ulcers.
- Treatments for ulcers include medications that reduce the amount of acid in the stomach or strengthen the layer of mucus, antibiotics, and sometimes lifestyle adjustments. If these treatments do not work, surgery to block nerve signals or even to remove part of the stomach is possible.

Inflammatory Bowel Disease – Crohn's

- inflammatory bowel disease - general name for diseases that cause inflammation in the intestines
- IBS includes conditions such as Crohn's disease and colitis
- Crohn's disease
  - also called ileitis or enteritisis
  - a serious inflammatory bowel disease that usually affects the ileum of the small intestine, but it can affect any part of the digestive tract from the mouth to the anus.
  - The inflammation extends deep into the lining of the affected organ, causing the intestines to empty frequently. This results in diarrhea and sometimes rectal bleeding.
  - can be difficult to diagnose because its symptoms are similar to the symptoms of other intestinal disorders, such as irritable bowel syndrome and ulcerative colitis.
  - it may be an autoimmune disorder, in which the body recognizes part of its own digestive tract as a foreign substance and attacks it.
  - Crohn's disease is chronic and may be inherited.
  - There is no cure, so treatments focus on medications to reduce pain, suppress the inflammation, reduce the immune response, and allow time for the tissue to heal. If medications do not control the symptoms, surgery is sometimes performed to remove the diseased portions of the digestive tract.

Inflammatory Bowel Disease – Colitis

- colitis is restricted to the innermost lining of the colon, causing inflammation and ulceration.
- The symptoms are similar to Crohn's disease and include loose and bloody stool, cramps, and abdominal pain. There may be skin lesions, joint pain, and (in children) a failure to grow properly.
- Treatments include medications that are similar to those given for Crohn's disease. Surgery is a final option. The entire bowel and rectum are removed, and an external opening is created for waste.

Hepatitis

- hepatitis - inflammation of the liver tissue; the three most common types are hepatitis A, B, and C (there are six different viruses but these are the three dominant ones, accounting for 90% of all cases)
  - A – drinking contaminated water
  - B – sexual contact
  - C – contact with infected blood
- Typical symptoms of acute hepatitis are:
  - Fever;
  - Appetite loss;
  - Nausea;
  - Abdominal pain;
  - Jaundice (yellowish colour on the skin and eyeballs).
- There are vaccines for A and B, but not C

Cirrhosis

- cirrhosis - a disorder of the liver in which scar tissue replaces healthy liver tissue and prevents the liver from functioning properly
- Chronic alcoholism and hepatitis C are the most common causes of cirrhosis of the liver.
- There are few symptoms in the early stages of the disease. Blood tests, however, can determine if the liver is becoming fatty— an early warning sign that cirrhosis is developing.
- The liver is amazing in its ability to heal itself, but, in many cases, there is not enough regeneration to avoid liver failure.
- A liver transplant is the primary treatment for liver failure. There is active research on a bioartifical liver, which uses pig cells to perform the functions that are normally carried out by the human liver.

Gallstones

- gallstone - small, hard mass that forms in the gall bladder when cholesterol precipitates out of the bile and forms crystals that grow in size
- Three factors that are related to the formation of gallstones are obesity, alcohol intake, and heredity.
- Gallstones are usually treated with medications or with ultrasound shock waves to disintegrate the stones..
- Since gallstones often reoccur, it is important to reduce the causal factors. Cholesterol in the gall bladder can be lowered by losing weight, increasing the intake of the omega-3 fatty acids that are present in fish, and decreasing the size of meals.
- If the gallstone problem is serious, the entire gall bladder may need to be surgically removed.

Obesity

- obesity - a condition in which body mass is 20 percent or more above what is considered to be an ideal body mass for a person's height
- In Canada, more than half of Canadians are classified as overweight or obese.
- Obesity is most likely caused by a combination of hormonal, genetic, lifestyle, and social factors. Research scientists have shown that people who are obese have more fat cells than people who are not obese. When weight is lost, the fat cells simply get smaller; they do not disappear.
- Lifestyle choices, such as the consistent eating of fatty foods, sedentary activities, and inadequate aerobic exercise, contribute to the development of excess body fat. Healthy lifestyle choices that involve a commitment to making more balanced and moderate dietary choices and to increasing physical activity can result in weight loss.