CHAPTER VII

The Digestive System: Have A Snack

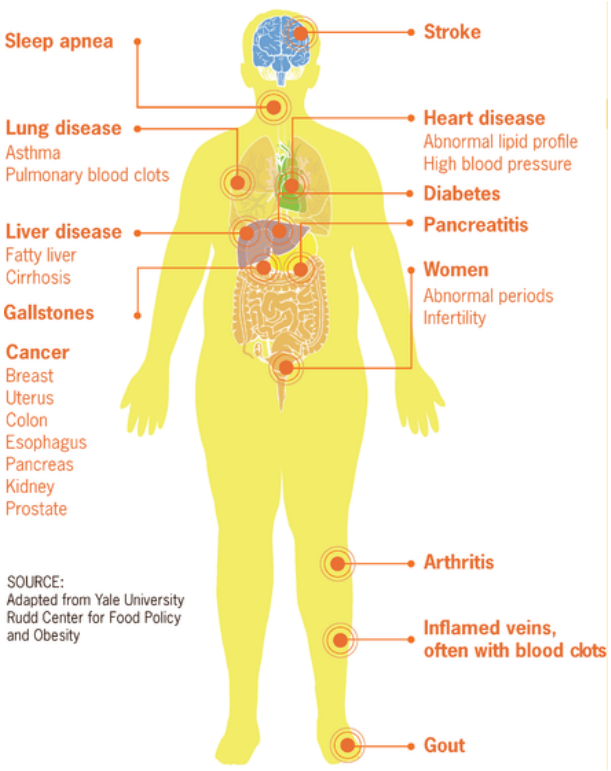
LEARNING OBJECTIVES

By the end of this class you should be able to:

- List the functions of the digestive system and explain which organ is primarily involved in them
- Summarize diseases and conditions associated to the digestive tract
- Identify the different structures of the oral cavity and list how they contribute to the digestion process.
- Explain how the structures of the esophagus and stomach relate to their functions
- Describe the similarities and differences of the small and large intestines and their respective roles in digestion
- Describe the functions of the pancreas, liver and gallbladder and explain why they are called "accessory organs"
- Define nutrition and essential nutrients, dietary fiber, vitamins and minerals.
- Explain how digestive enzymes such as amylase work to breakdown food

Introduction

With **obesity** at high rates in the United States, there is a public health focus on reducing obesity and associated health risks, which include diabetes, colon and breast cancer, and cardiovascular disease. How does the food consumed contribute to obesity? Fatty foods are calorie-dense, meaning that they have more calories per unit mass than carbohydrates or proteins. One gram of carbohydrates has four calories, one gram of protein has four calories, and one gram of fat has nine calories. Greater amounts of food energy taken in than the body's requirements will result in storage of the excess in fat deposits. Excess carbohydrate is used by the liver to synthesize glycogen. When glycogen stores are full, additional glucose is converted into fatty acids. These fatty acids are stored in adipose tissue cells—the fat cells in our body whose primary role is to store fat for later use. To combat childhood obesity, which is rapidly rising, and to ensure that children get a healthy start in life, in 2010 First Lady Michelle Obama launched the **Let's Move!** campaign. The goal of this campaign is to educate parents and caregivers on providing healthy nutrition and encouraging active lifestyles in future generations. This program aims to involve the entire community, including parents, teachers, and healthcare providers to ensure that children have access to healthy foods—more fruits, vegetables, and whole grains—and consume fewer calories from processed foods. Another goal is to ensure that children get physical activity. With the increase in television viewing and stationary pursuits such as video games, sedentary lifestyles have become the norm (visit www.letsmove.gov to learn more).



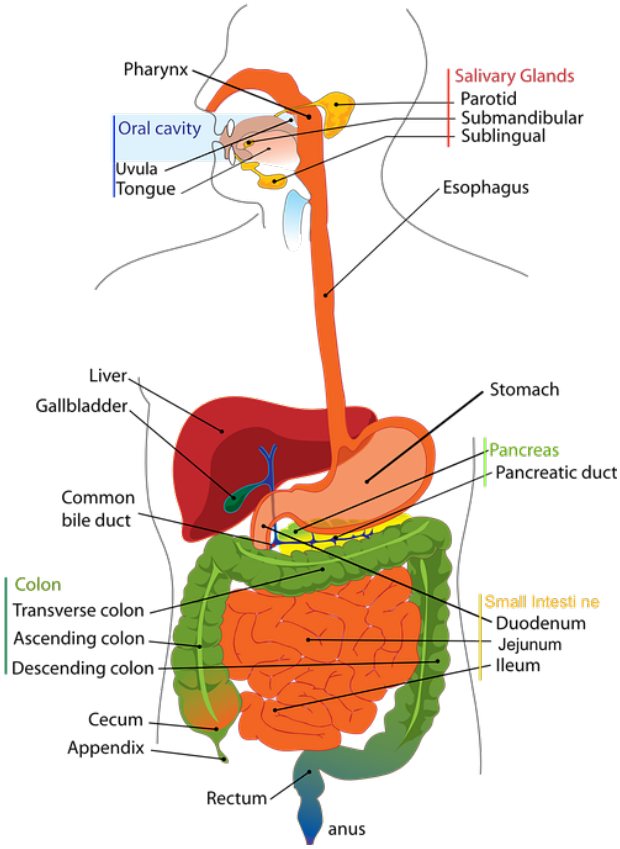
Medical Complications of Obesity. (credit: Center for Disease Control, Public Domain)

Activity 1. Critical Thinking & Discussion

Discuss why obesity is described as a "growing epidemic". Why is the US government involved in campaigns to curb it?

The Components Of Our Digestive System

The conversion of the food consumed to the nutrients required is a multistep process involving **digestion** and **absorption**. During digestion, food particles are broken down to smaller components, which are later absorbed by the body. This happens by both physical means, such as chewing, and by chemical means. One of the challenges in human nutrition is maintaining a balance between food intake, storage, and energy expenditure. Taking in more food energy than is used in activity leads to storage of the excess in the form of fat deposits. The rise in obesity and the resulting diseases like type 2 diabetes makes understanding the role of diet and nutrition in maintaining good health all the more important. The process of digestion begins in the **mouth,** or oral cavity, with the intake of food. The **teeth** play an important role in masticating (chewing) or physically breaking food into smaller particles. The **enzymes** present in **saliva** also begin to chemically break down food. The food is then swallowed and enters the **esophagus**—a long tube that connects the mouth to the **stomach**. Using **peristalsis**, or wave-like smooth-muscle contractions, the muscles of the esophagus push the food toward the stomach. The stomach contents are extremely acidic, with a pH between 1.5 and 2.5. This acidity kills microorganisms, breaks down food tissues, and activates digestive enzymes. Further breakdown of food takes place in the **small intestine** where bile produced by the **liver**, and enzymes produced by the small intestine and the **pancreas**, continue the process of digestion. The smaller molecules are absorbed into the blood stream through the epithelial cells lining the walls of the small intestine. The waste material travels on to the **large intestine** where water is absorbed and the drier waste material is compacted into **feces**; it is stored until it is excreted through the anus.



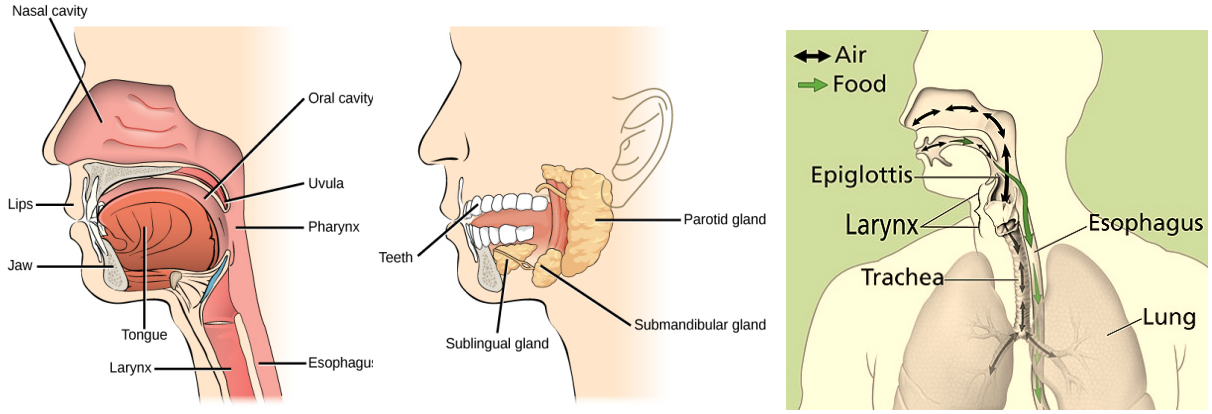
The Human Digestive System (credit: Public Domain)

Activity 2a. Functions And Diseases Of The Digestive System
As you read through, notice which parts of the digestive system help protect the body against disease. Pay also attention to the different diseases and issues linked to this organ system.

The Oral Cavity

The oral cavity is the space in the mouth containing the **teeth** and **tongue**. It is roofed by a bony **hard palate** which extends dorsally to become the **soft palate**. The hard and soft palates of mammals separate the mouth cavity from the air passages above. This allows chewing a mouthful of food and breathing at the same time. Both physical and chemical digestion begin in the mouth or oral cavity, which is the point of entry of food into the digestive system. The food is broken into smaller particles by **mastication**, the chewing action of the teeth. All mammals have teeth and can chew their food to begin the process of physically breaking it down into smaller particles. The chemical process of digestion begins during chewing as food mixes with **saliva**, produced by the different sets of **salivary glands**. Saliva contains mucus that moistens food and buffers the pH of the food. Saliva also contains **lysozyme**, which has antibacterial action. It also contains an enzyme called **salivary amylase** that begins the process of converting starches in the food into a smaller sugar called maltose. Another enzyme called **lipase** is produced by cells in the tongue to break down fats. The chewing and wetting action provided by the teeth and saliva prepare the food into a mass called the **bolus** for swallowing. The tongue helps in swallowing—moving the bolus from the mouth into the pharynx (throat). The pharynx opens to two passageways: the **esophagus** and the **trachea**. The esophagus leads to the

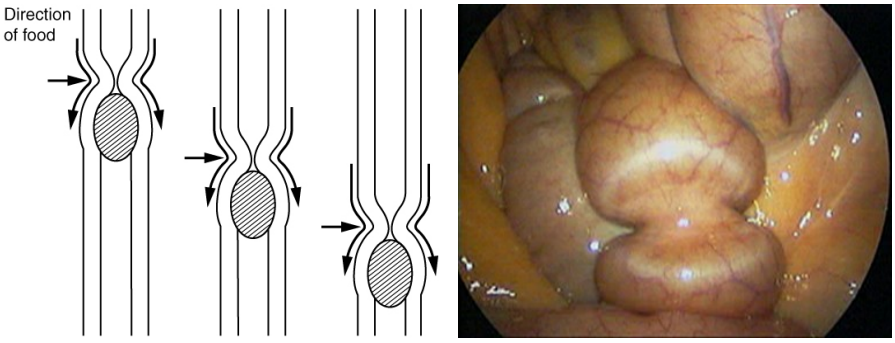
stomach and the trachea leads to the lungs. The epiglottis is a flap of tissue that covers the tracheal opening, called **glottis**, during swallowing to prevent food from entering the trachea, and thus, the lungs.



The Oral Cavity. Digestion of food begins in the oral cavity. Food is masticated by teeth and moistened by saliva secreted from the salivary glands. Enzymes in the saliva begin to digest starches and fats. With the help of the tongue, the resulting bolus is moved into the esophagus by swallowing. The epiglottis prevents the bolus from entering the airways (trachea) (credit: left and center, CNX OpenStax CC BY 4.0; right: Alan Hoofring, National Cancer Institute Public Domain).

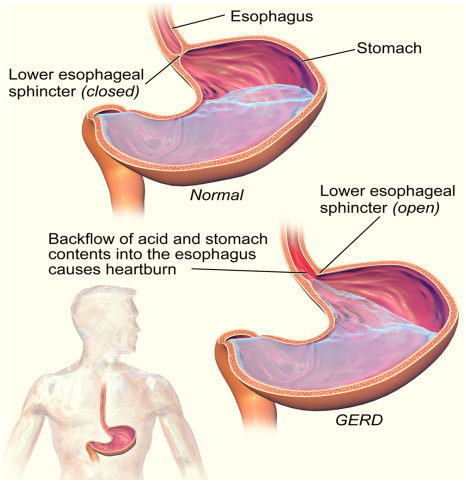
The Esophagus

The esophagus is a tubular organ that connects the mouth to the stomach. The chewed and softened food passes through the esophagus after being swallowed. The smooth muscles of the esophagus undergo **peristalsis** (wave-like contractions) that pushes the food toward the stomach. The peristaltic wave is unidirectional—it moves food from the mouth the stomach, and reverse movement is not possible, except in the case of the vomit reflex. The peristaltic movement of the esophagus is an involuntary reflex; it takes place in response to the act of swallowing.



Peristalsis Of The Esophagus. Left: the esophagus transfers food from the mouth to the stomach through alternating waves of muscle contraction and relaxation called peristaltic movements (credit: OpenStax College, CC BY 3.0). Right: Peristalsis taking place in the intestine of a horse. Viewed during laparoscopic surgery. (credit: Malcom Morley, CC BY-SA 3.0).

Ring-like muscles called **sphincters** form valves in the digestive system. The gastro-esophageal sphincter (or cardiac sphincter) is located at the stomach end of the esophagus. In response to swallowing and the pressure exerted by the bolus of food, this sphincter opens, and the bolus enters the stomach. When there is no swallowing action, this sphincter is shut and prevents the contents of the stomach from traveling up the esophagus. Acid reflux or "heartburn" occurs when the acidic digestive juices escape into the esophagus. When this is long lasting and quite serious, it is called gastroesophageal reflux disease (GERD). Depending on the severity of the heartburn and other symptoms, treatment for GERD may include lifestyle changes, medicines, or surgery.

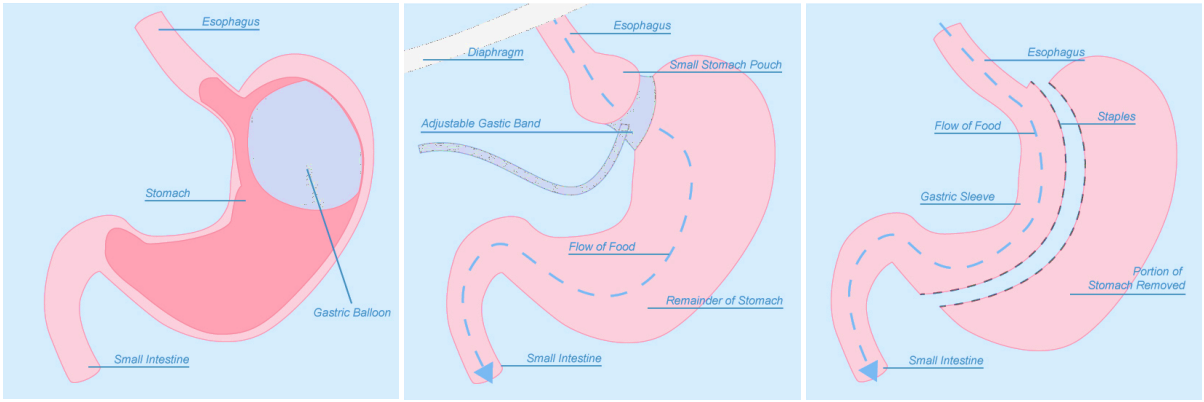


Gastroesophageal Reflux Disease (GERD) (credit: BruceBlaus, CC BY-SA 4.0)

The Stomach

A large part of protein digestion occurs in the stomach. It is a saclike organ that secretes **gastric digestive juices**. The pH in the stomach is between 1.5 and 2.5. This **highly acidic** environment is required for the chemical breakdown of food and the extraction of nutrients. When empty, the stomach is a rather small organ; however, it can expand to up to 20 times its resting size when filled with food. Popular culture tends to refer to the stomach as the location where all digestion takes place. Of course, this is not true. An important function of the stomach is to serve as a temporary holding chamber. You can ingest a meal far more quickly than it can be digested and absorbed by the small intestine. Thus, the stomach holds food and passes only small amounts into the small intestine at a time.

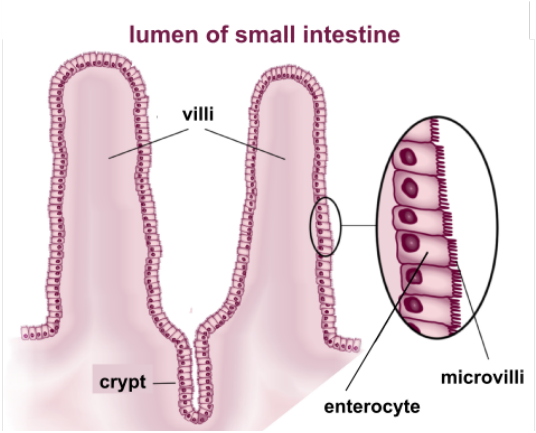
Protein digestion is carried out by an enzyme called **pepsin** in the stomach chamber. The highly acidic environment kills many microorganisms in the food and, combined with the action of the enzyme pepsin, results in the catabolism (break down) of protein in the food. Chemical digestion is facilitated by the churning action of the stomach caused by contraction and relaxation of smooth muscles. The partially digested food and gastric juice mixture is called **chyme**. Gastric emptying occurs within two to six hours after a meal. Only a small amount of chyme is released into the small intestine at a time. The movement of chyme from the stomach into the small intestine is regulated by hormones, stomach distension and muscular reflexes that influence the **pyloric sphincter**. The stomach lining is unaffected by pepsin and the acidity because pepsin is released in an inactive form and the stomach has a thick mucus lining that protects the underlying tissue. When this mucus lining is ruptured, **ulcers** can form in the stomach. Ulcers are open wounds in or on an organ caused by bacteria (*Helicobacter pylori*) when the mucus lining is ruptured and fails to reform. Severe obesity can be hard to treat with diet and exercise alone and **bariatric surgery** might be needed. Bariatric surgery is an operation that helps lose weight by making changes to the digestive system. Some types of bariatric surgeries make the patient's stomach smaller, allowing eating and drinking less at one time and making him/her feel full sooner.



Examples Of Bariatric Surgery. Left to right: Gastric balloon, gastric band and gastric sleeve (credit: Edward Roberts, CC BY 2.0)

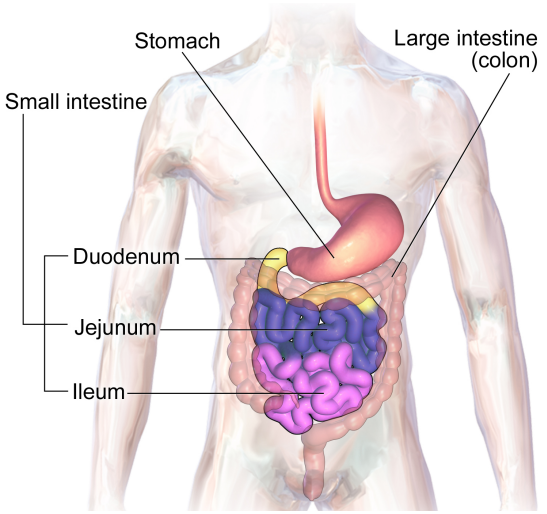
The Small Intestine

Chyme released from the stomach enters the small intestine, which is the primary digestive organ in the body. Not only is this where most digestion occurs, it is also where practically all **absorption** (transfer of the nutrients into the bloodstream) occurs. The small intestine is the longest part of our digestive system. It is about 3.05 meters (10 feet) long in a living person (but about twice as long in a cadaver due to the loss of muscle tone). Since this makes it about five times longer than the large intestine, one might wonder why it is called "small." In fact, its name derives from its relatively smaller diameter of only about 2.54 cm (1 in), compared with 7.62 cm (3 in) for the large intestine. The small intestine is a long tube-like organ with a highly folded surface containing finger-like projections called the **villi**. The top surface of each villus has many microscopic projections called **microvilli**. The epithelial cells of these structures absorb nutrients from the digested food and release them to the bloodstream on the other side. The villi and microvilli, with their many folds, increase the surface area of the small intestine and increase absorption efficiency of the nutrients.



Histology Of The Small Intestine. Villi, microvilli and crypts of the small intestine serve to increase the total absorption surface of the intestine. Enterocytes are the epithelial cells of the internal lining of the intestine (credit: BallenaBlanca, CC BY-SA 4.0)

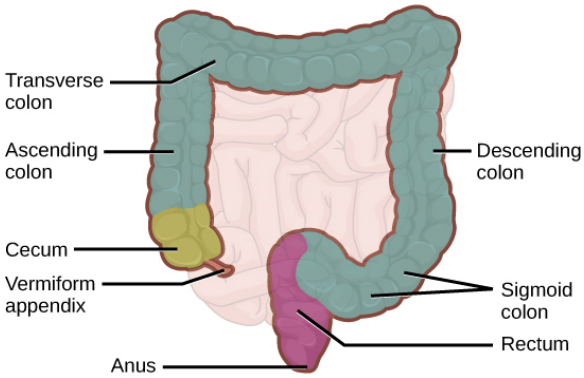
The small intestine is divided into three parts: the **duodenum**, the **jejunum** and the **ileum**. The duodenum is separated from the stomach by the pyloric sphincter. There, chyme is mixed with **pancreatic juices**, an alkaline solution rich in bicarbonate that neutralizes the acidity of chyme from the stomach. Pancreatic juices contain several digestive enzymes that break down starches, small sugars, proteins, and fats. **Bile** is produced in the liver and stored and concentrated in the gallbladder; it enters the duodenum through the bile duct. Bile contains bile salts, which make fats accessible to the water-soluble enzymes. These digestive juices breakdown the food particles in the chyme into glucose, triglycerides, and amino acids. Absorption of fatty acids also takes place in the duodenum. In the jejunum, breakdown of nutrients is continued while most of the carbohydrates and amino acids are absorbed through the intestinal lining. The bulk of chemical digestion and nutrient absorption occurs in the jejunum. In the ileum, the last part of the small intestine, bile salts and vitamins are absorbed into the bloodstream. The undigested food is sent to the colon from the ileum via peristaltic movements of the muscle. If you have **lactose intolerance**, also called milk intolerance, you have digestive symptoms—such as bloating, diarrhea, and gas—after you consume foods or drinks that contain lactose. Lactose intolerance may affect your health if it keeps you from getting enough nutrients, such as calcium and vitamin D. Lactose intolerance is caused by lactose malabsorption, a condition in which your small intestine makes low levels of lactase, the enzyme that breaks down lactose, and can't digest all the lactose you eat or drink. You can manage lactose intolerance symptoms by changing your diet to limit or avoid foods that contain lactose. Some people may only need to limit lactose, while others may need to avoid lactose altogether. Using lactase products can help some people manage their symptoms.



Anatomy Of The Small Intestine. (credit: BruceBlaus, CC BY 3.0)

The Large Intestine

The small intestine ileum ends and the large intestine begins at the ileocecal valve. The vermiform, "worm-like," **appendix** is located at the ileocecal valve situated near and above the right hip bone. The appendix functions in maintaining the gut microorganisms and is a component of the immune/lymphatic system. The large intestine **reabsorbs the water** from indigestible food material and processes the waste material. The human large intestine is much smaller in length compared to the small intestine but larger in diameter. It has three parts: the **cecum**, the **colon**, and the **rectum**. The cecum joins the ileum to the colon and is the receiving pouch for the waste matter. The colon is home to many bacteria or "intestinal flora" that aid in the digestive processes. The main functions of the colon are to extract the water and mineral salts from undigested food, and to store waste material. The rectum stores **feces** until **defecation**. The feces are propelled using peristaltic movements during **elimination**. The **anus** is an opening at the far-end of the digestive tract and is the exit point for the waste material. Two sphincters regulate elimination, the exit of feces, the inner sphincter is involuntary and the outer sphincter is voluntary.



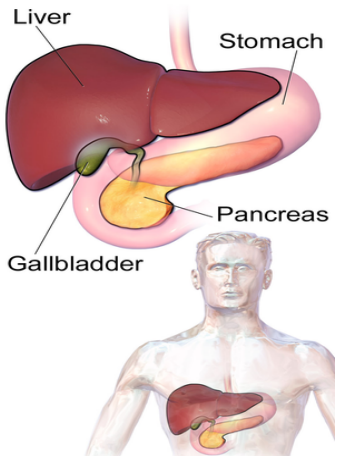
Anatomy Of The Large Intestine. The large intestine reabsorbs water from undigested food and stores waste material until it is eliminated. (credit: OpenStax College CC BY 3.0)

Each year, approximately 140,000 Americans are diagnosed with **colorectal cancer**, and another 49,000 die from it, making it one of the deadliest malignancies. People with a family history of colorectal cancer are at increased risk. Smoking, excessive alcohol consumption, and a diet high in animal fat and protein also increase the risk. Despite popular opinion to the contrary, studies support the conclusion that dietary fiber and calcium do not reduce the risk of colorectal cancer. Colorectal cancer may be signaled by constipation or diarrhea, cramping, abdominal pain, and rectal bleeding. Bleeding from the rectum may be either obvious or occult (hidden in feces). Since most colon cancers arise from benign mucosal growths called polyps, cancer prevention is focused on identifying these polyps. The **colonoscopy** is both diagnostic and therapeutic. Colonoscopy not only allows identification of precancerous polyps the procedure also enables them to be removed before they become malignant. Screening for fecal occult blood tests and colonoscopy is recommended for those over 50 years of age.

Accessory Organs

The organs discussed above are the organs of the digestive tract through which food passes. They form the **alimentary canal**. Accessory organs are organs that add secretions (enzymes) that breakdown food into nutrients. Food does not go through the accessory organs. Accessory organs include **salivary glands**, the **liver,** the **pancreas**, and the **gallbladder**. The liver, pancreas, and gallbladder are regulated by hormones in response to the food consumed.

- The liver is the largest internal organ in humans and it plays a very important role in digestion of fats and detoxifying blood. The liver produces **bile**, a digestive juice that is required for the mixing of fatty components of the food with enzymes in the duodenum. The liver also processes the vitamins and fats and synthesizes many plasma proteins.
- The pancreas is another important gland that secretes digestive juices. The chyme produced from the stomach is highly acidic in nature; the pancreatic juices contain high levels of bicarbonate, an alkali that neutralizes the acidic chyme. Additionally, the pancreatic juices contain a large variety of enzymes that are required for the digestion of protein and carbohydrates.
- The gallbladder is a small organ that aids the liver by storing bile and concentrating bile salts. When chyme containing fatty acids enters the duodenum, the bile is secreted from the gallbladder into the duodenum.

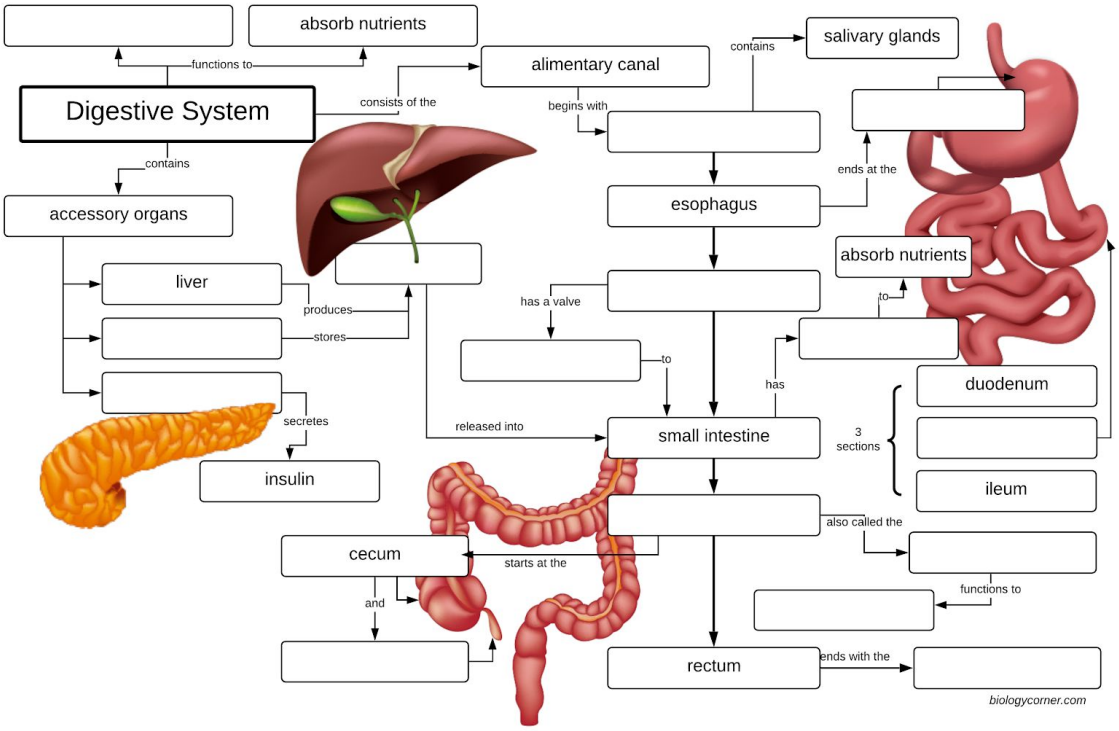


Accessory Organs in Digestion. The liver, pancreas, and gallbladder are considered accessory digestive organs, but their roles in the digestive system are vital. (credit: BruceBlaus CC BY-SA 4.0)

Activity 3. Overview Of The Digestive System

Complete the concept map below

Digestive System Concept Map Name:_____ Date:_____



Word Bank: | appendix | pyloric sphincter | villi | large intestine | mouth | gallbladder | cardiac sphincter | | breakdown food | jejunum | reabsorb water | pancreas | bile | colon | anus | stomach |

(credit: Biology Corner, CC BY-NC-SA 4.0)

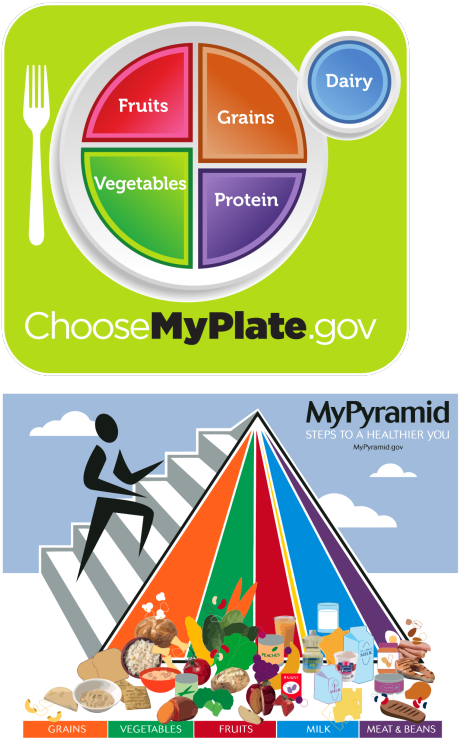
Activity 2b. Functions And Diseases Of The Digestive System

Organize the information from the text above in the table below:

Organ	Function(s)	Possible Associated Disease(s)
Oral cavity		
Esophagus		
Stomach		
Small intestine		
Large intestine		
Accessory organs		

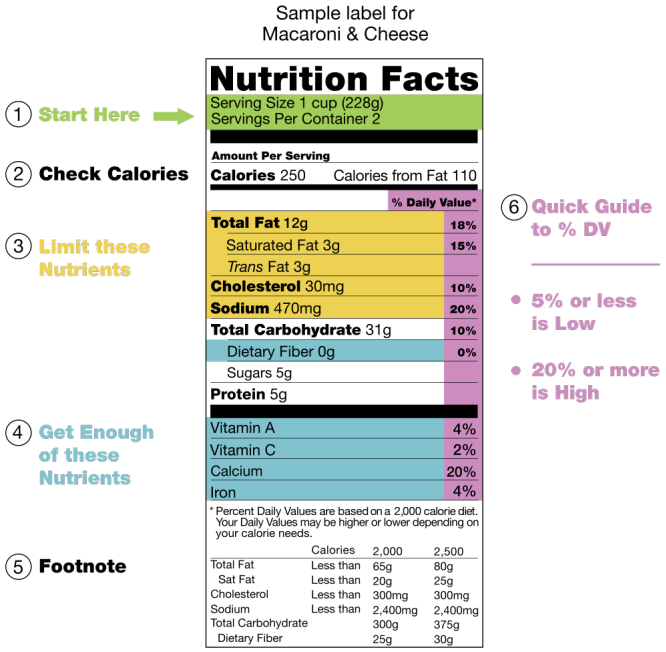
What Is Nutrition and Why Is It Important?

Nutrition is the science that interprets the interaction of nutrients and other substances in food in relation to maintenance, growth, reproduction, health and disease of an organism. It includes food intake, absorption, assimilation, biosynthesis, catabolism, and excretion. In humans, an unhealthy diet can cause **deficiency-related diseases** such as blindness, anemia, scurvy, preterm birth, stillbirth and cretinism, or **nutrient excess health-threatening conditions** such as obesity and metabolic syndrome; and such common chronic systemic diseases as cardiovascular disease, diabetes and osteoporosis. Thus, the human diet should be well balanced to provide nutrients required for bodily function and the minerals and vitamins required for maintaining structure and regulation necessary for good health and reproductive capability. The organic molecules required for building cellular material and tissues must come from food. **MyPlate** is the current nutrition guide published by the USDA (United States Department of Agriculture) Center for Nutrition Policy and Promotion, a food circle depicting a place setting with a plate and glass divided into five food groups. It replaced the USDA's MyPyramid guide on June 2, 2011, ending 19 years of USDA food pyramid diagrams. MyPlate is displayed on food packaging and used in nutrition education in the United States. It is divided into four sections of approximately 30 percent grains, 40 percent vegetables, 10 percent fruits and 20 percent protein, accompanied by a smaller circle representing dairy, such as a glass of milk or a yogurt cup. MyPlate is supplemented with additional recommendations, such as "Make half your plate fruits and vegetables", "Switch to 1% or skim milk", "Make at least half your grains whole", and "Vary your protein food choices. The guidelines also recommend portion control while still enjoying food, as well as reductions in sodium and sugar intakes.



Food Guides by the USDA. Since 2011, MyPlate has replaced the My Pyramid food guidance system (credit: USDA ChooseMyPlate.gov, Public Domain)

During digestion, digestible carbohydrates are ultimately broken down into glucose and used to provide energy within the cells of the body. Complex carbohydrates, including polysaccharides, can be broken down into glucose through biochemical modification; however, humans do not produce the enzyme necessary to digest cellulose (fiber). The intestinal flora in the human gut are able to extract some nutrition from these plant fibers. These plant fibers are known as **dietary fiber** and are an important component of the diet. The excess sugars in the body are converted into glycogen and stored for later use in the liver and muscle tissue. Glycogen stores are used to fuel prolonged exertions, such as long-distance running, and to provide energy during food shortage. Fats are stored under the skin of mammals for insulation and energy reserves. Proteins in food are broken down during digestion and the resulting amino acids are absorbed. All of the proteins in the body must be formed from these amino-acid constituents; no proteins are obtained directly from food. Fats add flavor to food and promote a sense of satiety or fullness. Fatty foods are also significant sources of energy, and fatty acids are required for the construction of lipid membranes. Fats are also required in the diet to aid the absorption of fat-soluble vitamins and the production of fat-soluble hormones. While the animal body can synthesize many of the molecules required for function from precursors, there are some nutrients that must be obtained from food. These nutrients are termed **essential nutrients**, meaning they must be eaten, because the body cannot produce them. The fatty acids omega-3 alpha-linolenic acid and omega-6 linoleic acid are essential fatty acids needed to make some membrane phospholipids. **Vitamins** are another class of essential organic molecules that are required in small quantities. Many of these assist enzymes in their function and, for this reason, are called coenzymes. Absence or low levels of vitamins can have a dramatic effect on health. **Minerals** are another set of inorganic essential nutrients that must be obtained from food. Minerals perform many functions, from muscle and nerve function, to acting as enzyme cofactors. Certain amino acids also must be procured from food and cannot be synthesized by the body. These amino acids are the "essential" amino acids. The human body can synthesize only 11 of the 20 required amino acids; the rest must be obtained from food.



How To Understand And Use The US Nutritional Fact Label. This U.S. Government Nutrition Facts panel illustrates which nutrients experts recommend you limit and which they recommend you consume in adequate amounts. DV stands for Daily Values. (credit: Trounce, Public Domain).

Activity 4. Effect Of Amylase On Starch

Starch is produced by most plants as their energy storage. It is thus not surprising that it is the most common carbohydrate in our diet. This exercise will examine the effects of amylase on starch. Remember amylase is the enzyme found in the mouth produced by the salivary glands (salivary amylase) and also by the pancreas (pancreatic amylase), and released in the duodenum, responsible for the digestion of starch. Once in contact with amylase, starch should be broken down into smaller chains of glucose, such as maltose for example. These smaller chains can then be broken down further by other enzymes, until glucose (sugar) molecules are obtained. Our cells then use glucose to produce energy.

Work in groups of 6 and follow your instructor's directions to carry the following experiment:

A - SETTING-UP DIFFERENT CONDITIONS

1. Collect 7 test tubes and add the following to each tube. Label the tubes. Use graduated cylinders to measure your solutions
   - Tube 1 ADD 1 ml of amylase + 5 ml of distilled water
   - Tube 2 ADD 5 ml of starch solution + 1 ml of distilled water
   - Tube 3 ADD 1 ml of amylase solution
   - Tube 4 ADD 1 ml of amylase solution
   - Tube 5 ADD 1 ml of amylase solution
   - Tube 6 ADD 1 ml of amylase solution

2. Incubate the following tubes as indicated
   - Tube 1 – 3 – incubate at 37 C
   - Tube 4 – leave at room temperature
   - Tube 5 – incubate on ice
   - Tube 6 – place in boiling water for 5 minutes. 500 ml beaker or larger, with 300 ml of water on a hotplate

3. After 5 minutes of incubating tubes 1 – 3 ADD 5 ml of starch to each one. DO NOT REMOVE THE TUBES FROM THE INCUBATING CONDITIONS. TRY TO ADD THE STARCH WHILE THEY ARE INCUBATING IN THE SET CONDITIONS

4. After adding the starch, continue incubating for 30 mins.

B – TESTING FOR STARCH AND SUGARS

1. Test for starch using iodine. The iodine molecule binds to starch, if present, and forms a blue-black color. In the absence of starch, a light brown color is observed.
   - After the incubation tine is us, place a drop of each of the tubes 1-6 on a piece of paraffin or a depression plate.
   - Add one drop of iodine to each one and record any color change.
   -
2. Test for simple sugars using Benedict's solution. When starch is broken down it will result in small sugars, maltose for example. When these simpler sugars are heated in the presence of Benedict's solution, a yellow to brick-red color change may occur. In the absence of these simple sugars the color will be unchanged after heating.
   - Add 1 ml from each test tube to be tested (tubes 1-6) in a clean test tube
   - Add 1 ml of Benedict's solution to each one
   - Incubate in boiling water bath for 3 minutes
   - Remove the tubes and record the colors

C – RESULTS

Complete the table with your observations (color change) and results (interpretation of your observations). Give the table a title.

	Test for Starch (iodine)		Test for Sugars (Benedict's)	
	observation	result	observation	result
Tube 1				
Tube 2				
Tube 3				
Tube 4				
Tube 5				
Tube 6				

D – CONCLUSIONS

What do these results reveal regarding the conditions needed for amylase to breakdown starch? How does it relate to digestion in your body?

Note: make sure to handle hot tubes carefully with clamps

(credit: AMitchell125, CC BY-SA 3.0)

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Review Questions

1. What prevents swallowed food from entering the airways
2. Explain the mechanism responsible for gastroesophageal reflux.
3. What is the role of the accessory organs in digestion?
4. Explain how the villi and microvilli aid in absorption.
5. Name two components of the digestive system that perform mechanical digestion. Describe how mechanical digestion contributes to acquiring nutrients from food.
6. Explain how the stomach is protected from self-digestion and why this is necessary.
7. Describe unique anatomical features that enable the stomach to perform digestive functions.
8. What are essential nutrients?
9. What is the role of minerals in maintaining good health?
10. Explain why some dietary lipid is a necessary part of a balanced diet.
11. The gut microbiome (the bacterial colonies in the intestines) have become a popular area of study in biomedical research. How could varying gut microbiomes impact a person's nutrition?
12. Many mammals become ill if they drink milk as adults even though they could consume it as babies. What causes this digestive issue?
13. Explain how the digestive system and nutrition help protect against diseases but can also be the root of health issues.

With text modified from OpenStax Biology 2e, Anatomy and Physiology, Concepts of Biology and National Institute of Health / National Institute of Diabetes and Digestive and Kidney Disease (NIH/NIDDK) Wikipedia "MyPlate"