SBI3U-C

UNIT
3

Animals: Structure and Function

Table of Contents

Introduction

The primary focus of this unit will be on human internal systems. The internal systems of organisms such as insects, fish, and amphibians will be mentioned for comparison purposes. You will investigate how three important systems—digestive, respiratory, and circulatory—are related, and what that means for managing human health.

Throughout this unit, you will analyze the relationships between changing societal needs (such as an aging population), technological advances (such as magnetic resonance imaging, or MRI), and our understanding of these human internal systems.

Overall Expectations

After completing this unit, you will be able to

- analyze the relationships between changing societal needs, technological advances, and our understanding of internal systems of humans
- investigate, through activities and computer simulation, the functional responses of the respiratory and circulatory systems of animals, and the relationships between their respiratory, circulatory, and digestive systems
- demonstrate an understanding of animal anatomy and physiology, and describe disorders of the respiratory, circulatory, and digestive systems

SBI3U-C

Lesson 9

The Human Digestive System

Introduction

Thirty years ago, Canadians asked the simple question "What's for dinner?" Today, they are now asking "What chemicals are in my food?" Everything is made from chemicals, including food. We eat food to get the chemicals we need to grow and stay healthy. Food may also contain other chemicals, including additives, toxins, contaminants, and agricultural compounds. Some of these substances occur naturally in food, while others are added. At high enough concentrations, some can cause illness.

The average person now eats more fresh fruits and vegetables than ten years ago—about twelve kilograms more per year. A typical produce section in a supermarket currently stocks over five times the number of items displayed a decade ago. The increased availability and variety of fresh fruits and vegetables is, in part, due to the extensive use of chemical fertilizers and pesticides. Yet residues of these agricultural chemicals can remain in our food.

Planning Your Study

You may find this time grid helpful in planning when and how you will work through this lesson.

Suggested Timing for This Lesson (hours)	
Nutrition	½
Activities	1
The Digestive System and Food Processing	3
Key Questions	½

What You Will Learn

After completing this lesson, you will be able to

- explain the anatomy of the digestive system and the importance of digestion in providing nutrients needed for energy and growth

Nutrition

Our bodies are machines that require a steady supply of nutrients to be used as an energy source, to make compounds for metabolic processes, and to be used as building blocks for maintenance, growth, and repair of tissues. Every cell in the body must have a constant supply of energy to remain alive. Carbohydrates, lipids, and proteins can all be used as energy sources.

Nutrients are categorized into two groups: macronutrients and micronutrients. Macronutrients are needed in large amounts every day; these include carbohydrates, lipids, and proteins. Micronutrients are needed in only small amounts every day; these include vitamins and minerals. Nutrients can also be classified as organic (produced by living organisms such as plants and animals) or inorganic (derived from non-living sources such as rocks and soil). Most of the nutrients you consume are of the organic type but, as you will learn, you do require some inorganic nutrients, including certain minerals, to maintain your health.

Polymers and Monomers

Macronutrients are often made by combining smaller molecules. Polymers are large molecules found in animals and plants that consist of long chains of smaller repeating molecules called monomers. Monomers bond together to form polymers through a process called anabolism, a chemical reaction in which simple molecules are built into larger, more complex ones. Examples of polymers include complex carbohydrates (composed of simple sugars), proteins (composed of amino acids), and lipids (composed of fatty acids).

Macronutrients

Macronutrients are required in relatively large amounts. The main function of macronutrients is to provide energy. Carbohydrates, lipids (fats), and protein are examples of macronutrients.

Macronutrient (1 gram)	Energy (kJ)
Carbohydrate	16.7
Fat	37.6
Protein	16.7

Table 9.1: Energy comparison of macronutrients

Carbohydrates

Carbohydrates are organic compounds that contain carbon, hydrogen, and oxygen. Carbohydrates are categorized into three groups:

Monosaccharides—single sugar units that are the basic unit of carbohydrates

Disaccharides—two monosaccharides bonded together

Polysaccharides—many monosaccharides bonded together

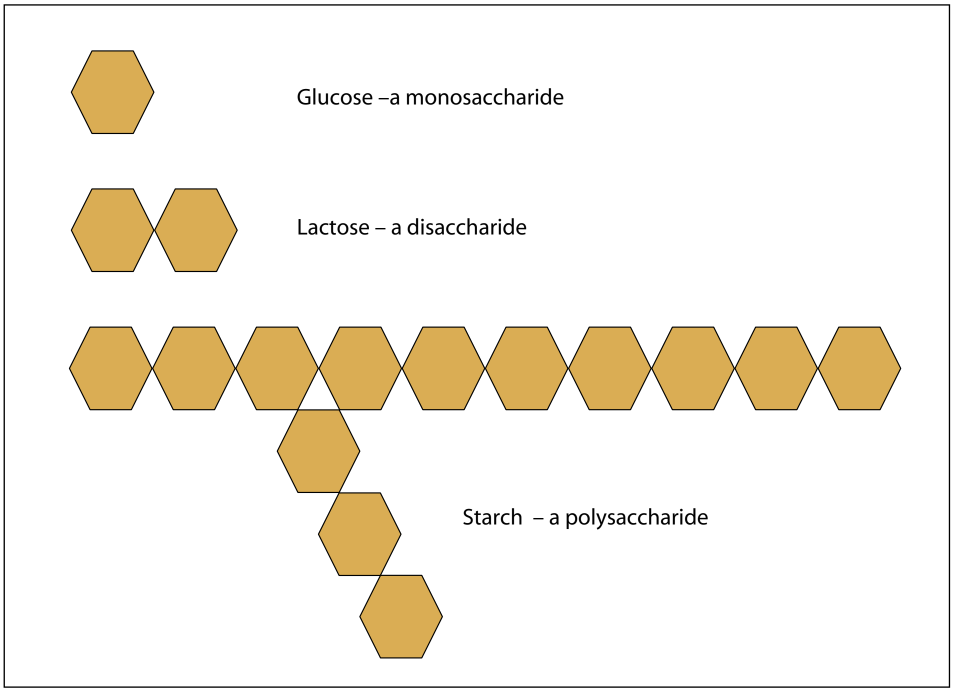


Figure 9.1: Image showing the differences between a monosaccharide, a disaccharide, and a polysaccharide

Carbohydrates are important short-term energy storage molecules. Glucose is the monomer, or building block, for biologically important polysaccharides such as starch (where energy is stored in plants) and cellulose (which is the basis for plant fibres). Cellular respiration takes place in the mitochondria of the cell; there, glucose is broken down to produce energy. After a meal, excess glucose is stored in the liver or muscle as glycogen, or it is converted into fat. Simple carbohydrates, the monosaccharides and disaccharides, are found in white and brown sugar, fructose, corn syrup, molasses, honey, white flour, white bread, candy, and alcohol. Complex carbohydrates, the polysaccharides, are found in whole grains, beans, and vegetables. Complex carbohydrates need more time to be broken down into monosaccharides, so they do not raise blood sugar levels as fast as simple carbohydrates.

Lipids

Lipids are organic compounds that contain carbon, hydrogen, and oxygen. Lipids consist of an assortment of molecules, including fats, phospholipids, and steroids. Fats store energy in their many bonds, and are used for long-term energy storage in human cells. Fats may contain saturated or unsaturated fatty acids. Saturated fats (such as the fat on a piece of steak) are solid at room temperature, and unsaturated fats (such as olive oil) are liquid at room temperature. Triglycerides, stored in fat cells, consist of three fatty acids bonded to glycerol. There is more energy in one gram of fat than in one gram of carbohydrate or protein (Table 9.1). Your body requires a certain amount of fat each day to function properly.

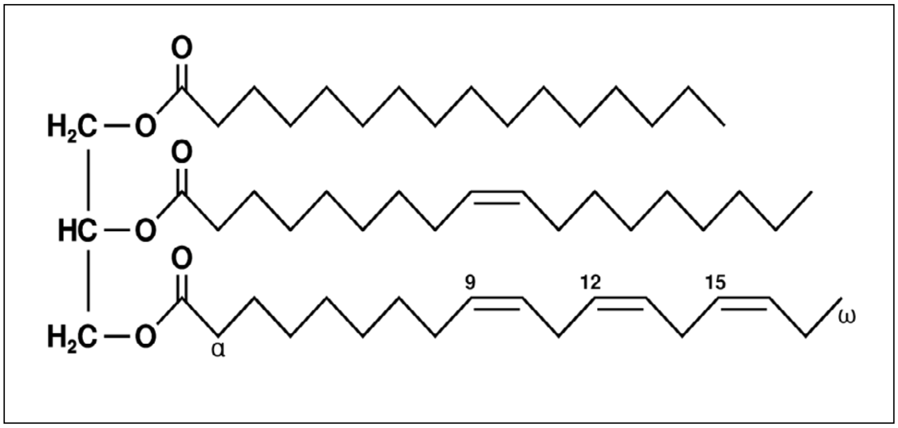


Figure 9.2: Diagram of a triglyceride with a glycerol backbone (left), with three long fatty acids attached

Protein

Proteins are organic compounds that contain carbon, hydrogen, oxygen, nitrogen, and sometimes sulphur. Amino acids are the monomers for proteins. There are 20 different amino acids. Peptide bonds join amino acids together in a long chain to make a polypeptide. The polypeptide then folds up to produce the final form of the protein (Figure 9.3). Fish, meat, eggs, cheese, lentils, and beans are all excellent sources of protein.

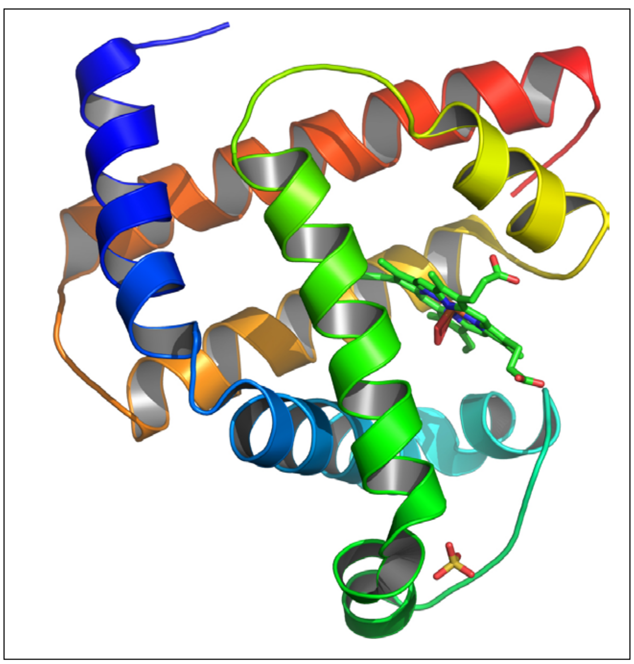


Figure 9.3: Image of a protein model

Eating too much of any of these macronutrients can result in weight gain, whereas eating too few—or an unbalanced diet—can lead to malnutrition and, in severe cases, death.

Micronutrients

Micronutrients are required in small amounts. Vitamins and minerals are examples of micronutrients.

Vitamins

Vitamins are organic compounds that contain carbon, hydrogen, oxygen, nitrogen, and small amounts of other elements. They are essential nutrients your body needs in small amounts for various functions. Vitamins cannot be used as an energy source.

Vitamins are divided into two groups: water-soluble (B-complex and C) and fat-soluble (A, D, E, and K). Water-soluble vitamins can dissolve in water and are often excreted from the body with urine. Fat-soluble vitamins are stored in the liver and fatty tissues. They take much longer to be eliminated. This means that we generally require a more consistent intake of water-soluble vitamins.

Vitamin C, a water-soluble vitamin, is an antioxidant that helps prevent cancer. Humans cannot produce it, so the majority of our vitamin C is obtained from fresh fruits and vegetables. Vitamin K, a fat-soluble vitamin, is necessary for blood clotting, enhancing bone health, and preventing osteoporosis. It is produced through a symbiotic relationship with bacteria in our large intestine.

A balanced diet will provide all the necessary vitamins.

Minerals

Minerals are inorganic compounds containing no carbon. Minerals cannot be used as an energy source.

Minerals are also divided into two groups: the major elements, such as calcium, phosphorus, magnesium, iron, iodine, and potassium, and the trace elements, such as copper, cobalt, manganese, fluorine, and zinc. All of these must be supplied in our diet, because the body is unable to manufacture its own, and can only maintain its mineral balance for short periods of time.

A balanced diet will provide all the necessary minerals. Plants are an excellent source of minerals.

Water

Water is not a nutrient, even though it is essential for life. Two-thirds of our body weight consists of water. Water is part of every living cell, and is the medium for all metabolic changes (digestion, absorption, and excretion). Water transports nutrients throughout the body, acts as a lubricant, and helps maintain our body temperature.

Eating a Balanced Diet

Eating a balanced diet means getting the right types and amounts of food (proteins, starches, fruits and vegetables, etc.) to supply nutrition and energy for maintaining body cells, tissues, and organs, and for supporting normal growth and development.

Vegetarians and Vegans

Vegetarians do not eat meat, including beef, chicken, pork, or fish. Some also choose not to eat other animal products such as eggs or milk. People who choose to avoid eating any products of animal origin are called vegans; they do not eat any meat, milk, cheese, eggs, honey, or gelatin. Because they eliminate certain foods from their diets, vegetarians and vegans must include other foods that will provide the nutrients ordinarily found in animal products. By eating a variety of foods including fruits, vegetables, and whole grains, vegetarians can get nutrients from non-meat sources. Vegans, however, need to pay special attention to getting enough iron, calcium, vitamin D, and vitamin B_{12} (Table 9.2).

Nutrient	Source
Iron	Seeds, soy-based foods, fortified breakfast cereals, and dark green leafy vegetables (spinach)
Calcium	Milk, yogurt, cheese, calcium-fortified soy products, orange juice, cereals, and cereal bars
Vitamin D	Fortified dairy products and soy milk
Vitamin B_{12}	Yeast flakes, fortified soy milk, and fortified cereals

Table 9.2: Sources of nutrients for vegans and vegetarians

Support Questions

Be sure to try the Support Questions on your own before looking at the suggested answers provided.

1. List three functions of nutrients. Suggested answer
2. What is the unit of energy? Suggested answer
3. What is cellular respiration and where does it take place? Suggested answer
4. Name three macronutrients required by humans and indicate a good source of each one. Suggested answer
5. A balanced diet means getting the right types of food. List four nutrients a vegan has to pay special attention to acquiring in their diet. Suggested answer

Activity: A Burning Comparison

Purpose

To determine which type of food has more energy. **Note:** If you are unable to do this activity, you can use the sample data provided in the Suggested Answers, below.

Hypothesis

If energy is related to the length of time a piece of food will burn, then food with more energy will burn longer.

Materials

- 2 paper clips
- 1 mini-marshmallow
- 1 almond
- matches or a lighter
- watch
- water to douse the burnt material

The mini-marshmallow and almond should have approximately the same mass.

Safety

Nut allergies: Do not perform this activity if you are allergic to nuts.

Fire: Be aware of your surroundings at all times with an open flame and be sure to douse all burnt objects with water before disposal.

Procedure

1. Straighten out both paper clips.
2. Pierce the marshmallow with one paper clip, and pierce the almond with the other paper clip.

You may need an assistant for steps 3 and 4.

3. Light the mini-marshmallow on fire and, using the watch, record the length of time the flame was present in the observation table, below. When the flame is out, run water over the burnt remains to make sure it won't flare up once it's in the garbage.
4. Light the almond on fire and, using the watch, record the length of time the flame was present in the observation table, below. When the flame is out, run water over the burnt remains to make sure it won't flare up once it's in the garbage.

Substance	Time in seconds
Mini-marshmallow	
Almond	

Table 9.3: Observations

When you have recorded your observations, answer the following three Support Questions.

Support Questions

6. Which food item burned the longest? Suggested answer

7. Why did the food item identified in the question above burn longer? Suggested answer

8. Why is it important to make sure that both food items have the same mass when doing this experiment? Suggested answer

Enzymes and Digestion

All reactions that take place within cells are referred to as metabolism. Hydrolysis is a type of reaction that uses water to break down large molecules into smaller molecules. In digestion, hydrolysis is accelerated using an enzyme to weaken the bond between two parts of a polymer, allowing for the insertion of a water molecule into the bond. This results in the production of monomers.

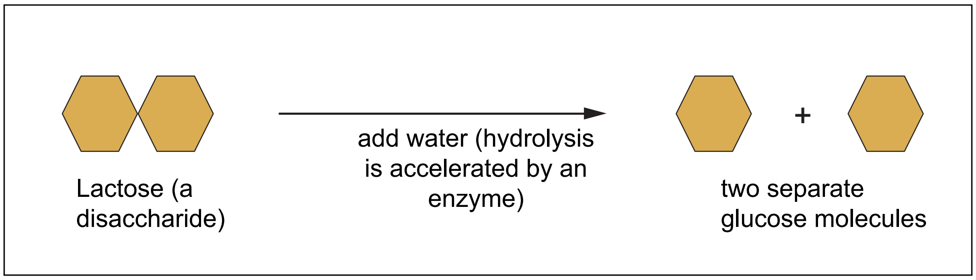


Figure 9.4: Diagram showing a lactose molecule separated by adding water

Enzymes are biological catalysts that control all the reactions carried out in the cell. They reduce the activation energy needed for reactions to take place, thereby increasing the rate of a reaction. Activation energy is the least amount of energy needed for a chemical reaction to take place. Striking a match on the side of a matchbox, for example, provides the activation energy (in the form of heat produced by friction) necessary for the chemicals in the match to ignite. Activation energy is usually expressed in terms of joules per mole (J/mol) of reactants.

Most cellular reactions occur about a million times faster with the help of an enzyme than they would without an enzyme. Most enzymes act specifically with only one reactant (called a substrate) to produce products. The enzyme locks onto the substrate, which causes the enzyme and substrate to change shape slightly. This lowers the activation energy needed for the reaction to take place. Once the reaction is complete, the products are released.

Enzymes are commonly named by adding the suffix "ase" to the root name of the substrate molecule the enzyme is acting upon. For example, lipase catalyzes the hydrolysis of a lipid triglyceride. Sucrase catalyzes the hydrolysis of sucrose into glucose and fructose. A few enzymes discovered before this naming system was devised are known by common names; for example, pepsin and trypsin.

Enzymes are classified by their function. In digestion, there are three main types:

- carbohydrases, which break down carbohydrates
- proteases, which break down proteins
- lipases, which break down lipids

All enzymes have an optimum pH and temperature at which they function most efficiently.

Support Questions

Be sure to try the Support Questions on your own before looking at the suggested answers provided.

9. List two factors that affect enzyme function. Suggested answer

The Digestive System and Food Processing

The digestive system is a group of organs responsible for the conversion of food into absorbable chemicals, which are then used to provide energy for growth and repair (Figure 9.5). The digestive system is also known by a number of other names, including the gut, the digestive tube, the alimentary canal, the gastrointestinal (GI) tract, the intestinal tract, and the intestinal tube.

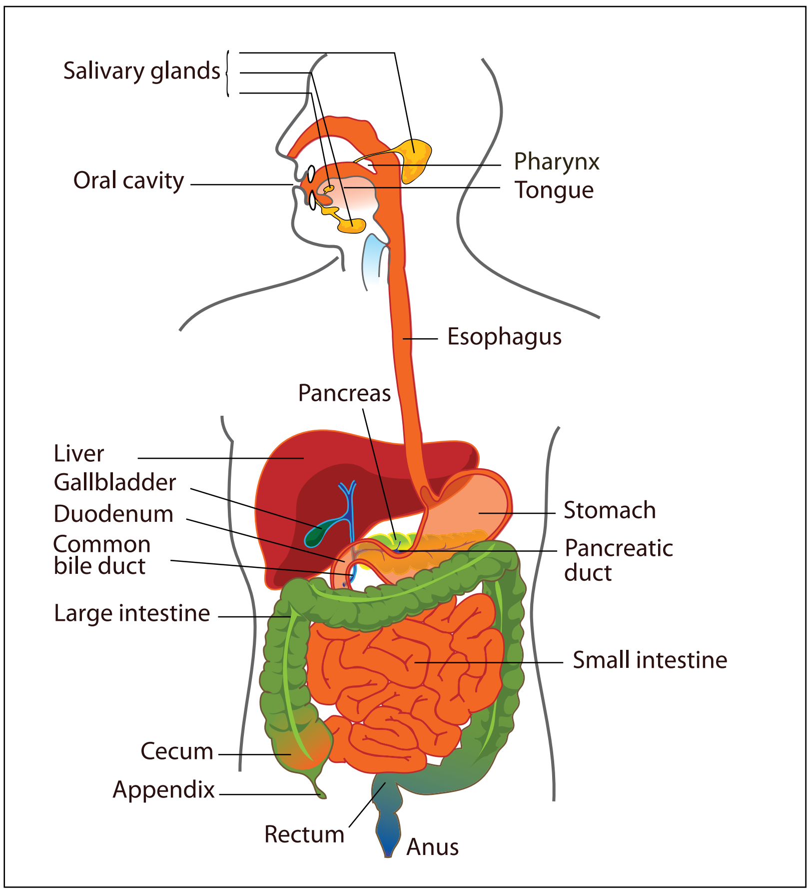


Figure 9.5: The human digestive system

Food processing has several steps: ingestion, digestion, absorption, and elimination.

Ingestion: A Tour of the Mouth

Ingestion involves taking food into the mouth, chewing it, and swallowing it. The mouth, pharynx, esophagus, and stomach are involved in ingestion.

The Mouth and Teeth

The mouth is specialized for ingestion and for beginning the digestive process. Mechanical digestion begins with the biting, grinding, and chewing (mastication) of food. The teeth in our mouths vary in size and function (Figure 9.6). The incisors are used for biting; the long, pointed canines are used for piercing and tearing, and the flattened surfaces of the premolars and molars are used for crushing and grinding. Teeth break food into smaller pieces to increase surface area for enzymes to act on our food.

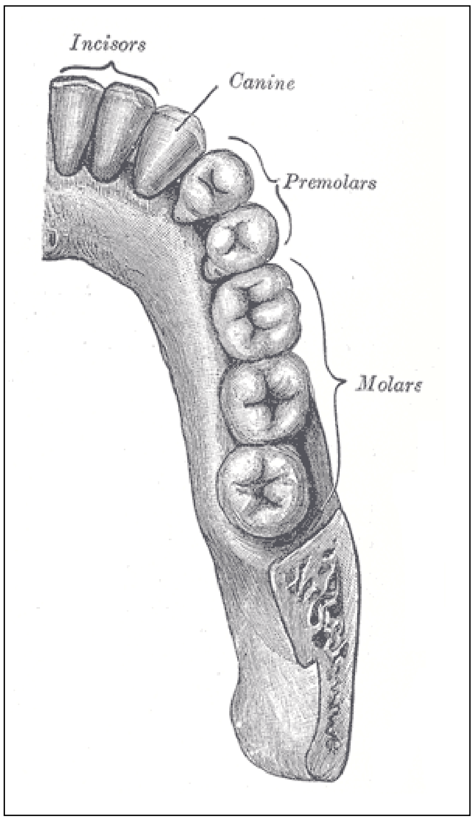


Figure 9.6: Types of human teeth

Source: Wikimedia Commons

The Tongue and Saliva

While food is being mechanically broken apart by the teeth, it is also moistened and lubricated by the saliva. Some of the food molecules dissolve, enabling the sense of taste. Three pairs of salivary glands secrete about one litre of saliva into the mouth cavity each day. Saliva contains salivary amylase, an enzyme that breaks down carbohydrates. The mechanical and chemical digestion of food results in a moistened ball-like mass called a bolus that is easier to swallow. The tongue manipulates food during the chewing process, pushing it back onto the molars, and lifting and flattening it on the roof of the mouth to aid in the mechanical breakdown, then pushing it to the back of the mouth to be swallowed. The tongue is also used to taste our food.

Activity: Locating Structures

In this activity you will locate your tongue, larynx, epiglottis, and uvula.

Materials

- mirror

Procedure

1. Make sure that your hands are clean. Use your fingertips to grip the tip of your tongue. Now swallow. Record your observations describing the sensation of trying to swallow while holding your tongue, in the observation table, below. What parts of your mouth and throat seem to be involved?
2. Locate your larynx (also known as your voice box). Looking into a mirror, locate your Adam's apple, which is the bulge in the front of your throat. This is your larynx. Your epiglottis is located at the back of your throat, above the larynx.
3. Locate your uvula. Looking into a mirror, open your mouth. The uvula is the dangling piece of tissue you see hanging over the back of your throat. It prevents food from accidentally entering the nasal passages as it moves through the pharynx.

Observations

Table 9.4: Observation table

4. Was it easy or difficult to swallow while holding your tongue? Most people find it very difficult.

Activity: How Does the Cracker Taste?

Introduction

Saliva makes it easier for you to chew and taste your food. Saliva also helps chemically break down your food before it even reaches your stomach, using an enzyme called amylase.

Most of our daily energy comes from carbohydrates known as polysaccharides. Starch is an example of a polysaccharide (many glucose molecules joined together); some examples of foods high in starch include cereal, potatoes, corn, and flour. Amylase is essential to digest the energy from these foods.

Amylase is an enzyme found in your saliva that helps split polysaccharides like starch into monosaccharides like glucose, a simple sugar with a sweet taste. Glucose is the source of metabolic energy used by plant and animal cells. Amylase works by cleaving the bonds between the subunits in the polysaccharide, adding a water molecule across the bond, in a process called hydrolysis. As you can imagine, being able to break down polysaccharides into simple sugars like glucose is essential for most organisms, including humans.

Materials

- 1 unsalted cracker

Procedure

Take the cracker, and start chewing it up like you normally would. However, instead of swallowing the cracker once it's chewed, keep on chewing. Chew for longer than you usually would without swallowing the cracker. Continue chewing for a long time until you notice that the taste of the cracker has changed. Then, answer Support Question 12, below.

Support Questions

10. Describe how the taste of the cracker changed as you chewed it. Why did this occur?

Suggested answer

The Pharynx

The pharynx is the region we call our throat. After a bite of food has been chewed and formed into a lump called the bolus then swallowed, it moves through the pharynx. Because the pharynx leads to both the trachea (windpipe) and the esophagus, it is important that it keep the food from going down into the lungs by mistake. Once in the pharynx, the food glides over the epiglottis and then passes into the esophagus (Figure 9.7). The epiglottis is a flap of tissue made of cartilage that prevents food from entering the trachea to prevent choking. Waves of muscular movements called peristaltic contractions move the bolus through the pharynx and esophagus towards the stomach.

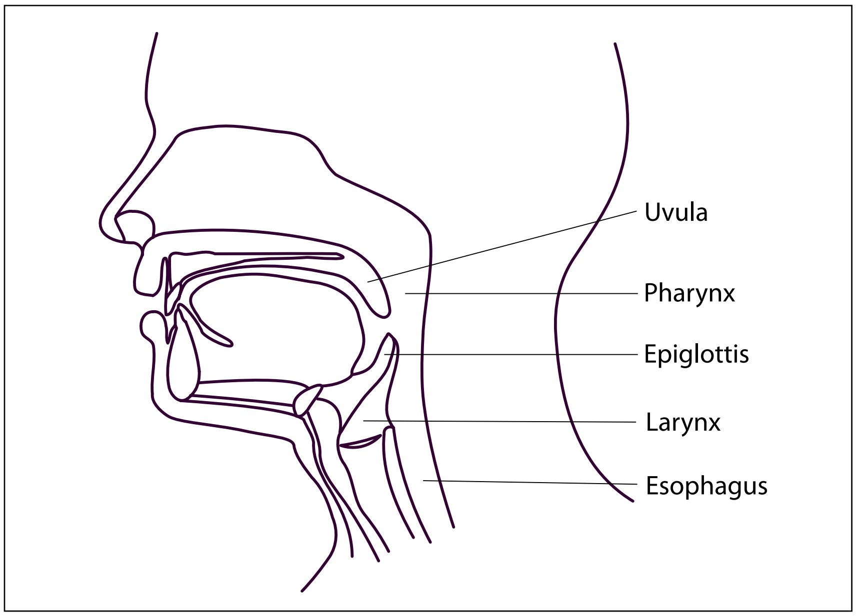


Figure 9.7: The structure of the oral cavity

Source: Wikimedia Commons

The Esophagus

The esophagus is a tube of muscle, approximately 25 centimetres (10 inches) long, that takes food down to the stomach. The top of the esophagus is attached to the pharynx. The bottom of the esophagus is attached to the stomach by a ring of smooth muscle called the cardiac sphincter. This sphincter tightens to prevent food from moving from the stomach back into the esophagus.

There are two major muscle layers lining the esophagus. The first is an outer muscle layer whose fibres run up and down the esophagus lengthwise. The inner layer of muscle contains circular fibres that form a series of rings around the esophagus. No digestion takes place in the esophagus.

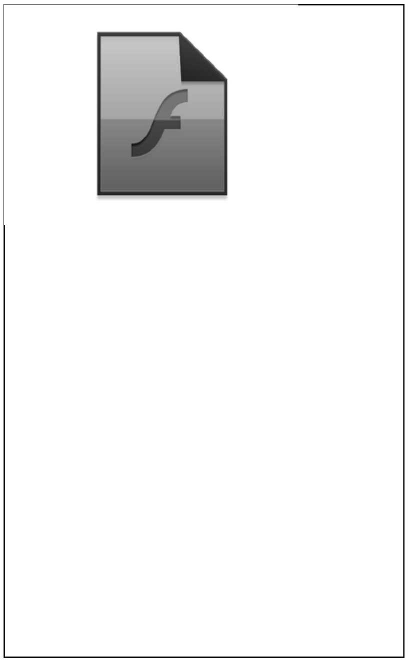


Figure 9.8: Animation showing peristalsis in the esophagus

Support Questions

11. What are three functions of the tongue? Suggested answer

12. What is the role of the epiglottis in swallowing? Suggested answer

13. What is mechanical digestion? Suggested answer

14. State two functions performed by saliva. Suggested answer

The Stomach

The stomach is a J-shaped organ that lies between the esophagus and the small intestine in the upper abdomen. The stomach has three main functions: to store the swallowed food and liquid; to mix up the food, liquid, and digestive juices produced by the stomach; and, to slowly empty its contents into the small intestine. Only a few substances, such as water, aspirin, and alcohol, can be absorbed into the blood directly from the wall of the stomach. Any other food substances must undergo the stomach's digestive processes. In the stomach, mechanical and chemical digestion occur at the same time. Mechanical digestion includes churning, while chemical digestion includes the use of enzymes such as pepsin to aid with protein digestion, and lipase to aid with lipid digestion. The digestive chemicals used in the stomach come from the gastric glands that line the stomach.

Gastric glands consist of the following:

- mucous cells, which secrete an alkaline mucus that protects the epithelium (tissue that lines the surface of the stomach) against shear stress and acid;
- parietal cells, which secrete hydrochloric acid (HCl);
- chief cells, which secrete pepsin, a protease enzyme; and
- G cells, which secrete gastrin, to increase the secretion of HCl.

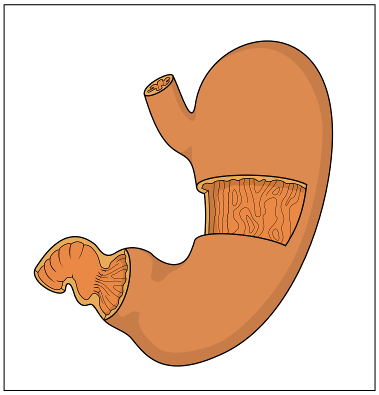


Figure 9.9: Diagram of the stomach and its folds

The openings of the gastric glands are called gastric pits (Figure 9.10).

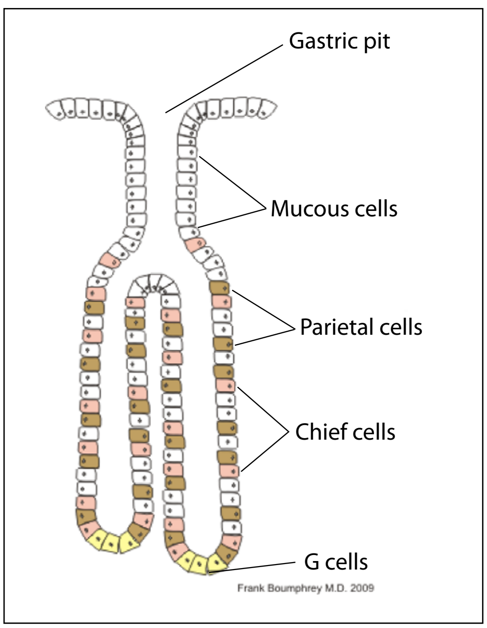


Figure 9.10: Anatomy of a gastric gland

Source: Wikimedia Commons

Gastric glands in the stomach produce hydrochloric acid (HCl). It is released to kill bacteria, provide the right conditions for enzymes, and to begin some hydrolysis reactions. The pH of the stomach is 2, which is acidic enough to dissolve iron nails. So how does the stomach not digest itself? Mucus is secreted by mucous cells within the gastric gland; this lines the stomach, forming a protective coating against the corrosive effects of the HCl.

Thick layers of smooth muscle and numerous folds enable the stomach to expand. The stomach's strong muscular walls mix and churn the food with acids and enzymes (gastric juice), breaking it into smaller pieces. About three litres of gastric juice are produced by glands in the stomach every day. The food is processed into a semi-liquid form called chyme. Chyme is held in the stomach by contraction of the pyloric valve. About four hours or so after eating a meal, the chyme is slowly released a little at a time through the pyloric sphincter, a thick muscular ring between the stomach and the first part of the small intestine called the duodenum.

Because the stomach absorbs water, water-soluble pesticides may enter the body at this point. Health experts routinely advise consumers to wash fruits and vegetables under clear drinking water before eating. In fact, many pesticides are water-soluble and can be washed off under running water. These efforts also remove dirt and bacteria. Although minuscule amounts of pesticide may remain even after washing, credible scientific evidence indicates they represent no risk.

Support Questions

15. List three functions of the hydrochloric acid in the stomach. Suggested answer

16. List three functions of the stomach. Suggested answer

17. **a)** What is the name of the enzyme that breaks down protein in the stomach?

b) What is the pH that it must operate under? Suggested answer

Digestion

Digestion is the second stage in the process of breaking down food into molecules small enough for the body to absorb. Digestion breaks macronutrients into their smaller components, which we can then use for growth, reproduction, maintenance, and repair of our tissues. For example, polysaccharides like starch are broken down into monosaccharides (simple sugars) like glucose, fats are digested into glycerol and fatty acids, and proteins are broken down into amino acids. Nucleic acids are even broken up into nucleotides. The pancreas, liver, gallbladder, and small intestine all play a role in digestion.

The Pancreas

The pancreas is a small organ located near the lower part of the stomach and the beginning of the small intestine. This organ has two main roles. It functions as an exocrine organ by producing digestive enzymes, and as an endocrine organ by producing hormones, with insulin being the most important. The pancreas secretes the digestive enzymes through a system of ducts into the digestive tract, while it secretes its variety of hormones directly into the bloodstream.

Pancreatic enzymes complete the job of breaking down protein, carbohydrates, and fats. Lipases work on lipids, carbohydrases work on sugars and starches, and proteases like trypsin break apart protein. The pancreas also helps neutralize chyme by producing bicarbonate. The bicarbonate ions help neutralize the hydrochloric acid and increase the pH in the duodenum to a pH of 9. If the pancreas is not working properly to neutralize chyme and break down proteins, fats and starch, starvation may occur.

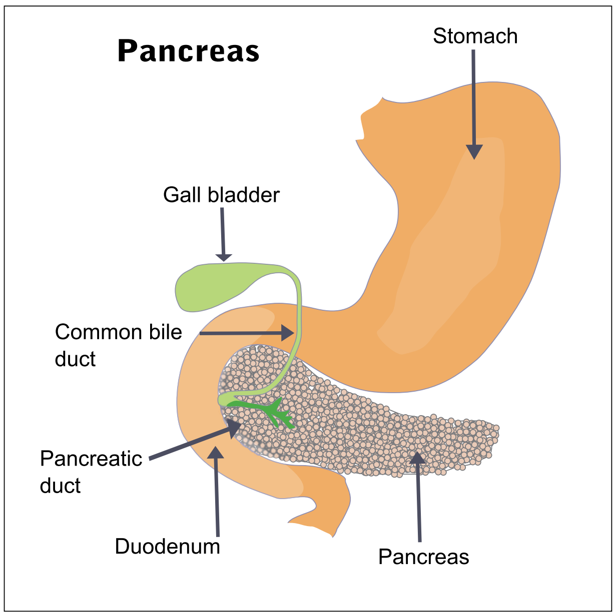


Figure 9.11: Diagram of the pancreas and surrounding organs

The Small Intestine

The small intestine is a narrow, twisting tube that occupies most of the lower abdomen between the stomach and the beginning of the large intestine. It extends about 20 feet in length. The small intestine consists of three parts: the duodenum (the C-shaped part), the jejunum (the coiled midsection), and the ileum (the last section—see Figure 9.12).

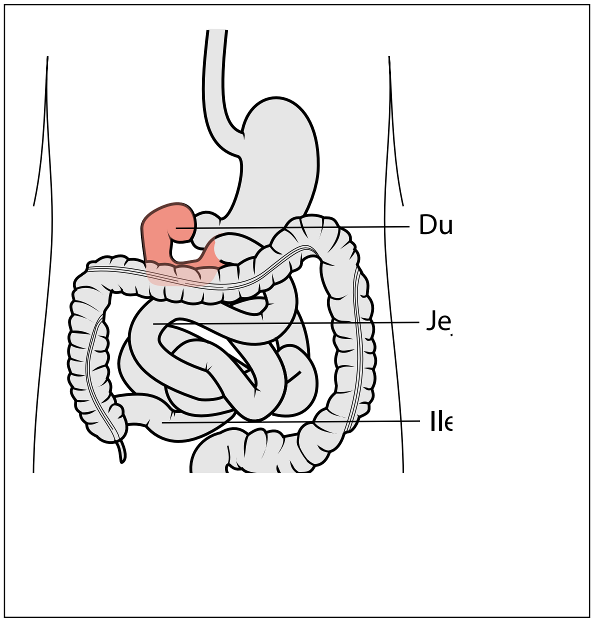


Figure 9.12: The small intestine
Source: Wikimedia Commons

Digestion in the Small Intestine

The small intestine has two important functions: digestion and absorption. The digestive process is completed here by enzymes made by intestinal cells, the pancreas, and the liver. Glands in the intestine walls secrete enzymes that break down starches and sugars. The pancreas secretes enzymes into the small intestine that help break down carbohydrates, fats, and proteins. For example, trypsin, which is made in the pancreas, is secreted into the duodenum, where it acts to hydrolyse proteins into their smaller monomers called amino acids. The liver produces bile, which is stored in the gallbladder. Bile helps to make fat molecules (which otherwise are not soluble in water) soluble, so they can be absorbed by the body.

Absorption in the Small Intestine

Absorption is the movement of molecules across the gastrointestinal tract (or GI) into the blood to be circulated throughout the body. Most of the end products of digestion, along with vitamins, minerals, and water, are absorbed in the small intestinal lumen (the inside of the small intestine).

The small intestine absorbs the nutrients from the digestive process. Nutrient absorption is efficient because the inside surface of the GI tract is folded to increase the amount of surface for absorption, and the surface is lined with villi (hairlike projections) and microvilli cells. The combination of villi and microvilli increase the surface area of the small intestine greatly, allowing rapid absorption of nutrients to occur.

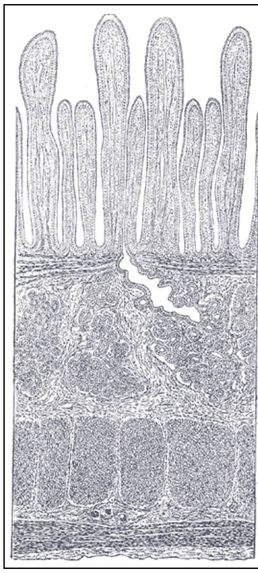


Figure 9.13: Cross-section of the intestinal wall with villi

Nutrients are not the only chemicals to be absorbed in the small intestine. Toxic metals like lead and thallium (used in insecticides), and the herbicide paraquat are three examples of toxins that are transported across the intestinal wall and into the blood. The slow movement of substances through the intestinal tract increases the length of time that a compound is available for absorption in the intestine—including, unfortunately, toxic substances.

Support Questions

18. Why are the villi and microvilli important in the process of digestion? Suggested answer

Hormonal Control of Digestion

Digestion is actually carried out by enzymes, but the secretion of these enzymes is controlled by the nervous system and endocrine system. There are four regulatory hormones that help ensure digestive secretions are present only when needed: gastrin, secretin, cholecystokinin (CCK), and enterogastrone.

Gastrin is released from the stomach lining in response to the presence of food. Gastrin stimulates the production of gastric juices.

The acidic pH of the chyme when it enters the duodenum stimulates the intestinal wall to release secretin. Secretin stimulates the pancreas to release bicarbonate, which neutralizes the acidic chyme.

The presence of amino acids or fats in the duodenum triggers the release of cholecystokinin (CCK) and enterogastrone. CCK is produced by the cells in the lining of the duodenum, and causes the gallbladder to contract and release bile into the small intestine. CCK also stimulates the release of pancreatic enzymes. Enterogastrone inhibits acid secretions by the stomach and also inhibits peristalsis, thereby slowing down the entry of food into the duodenum.

Support Questions

19. Match the hormone to the correct function. Suggested answer

Hormone	Function
1. Gastrin	A. stimulates the pancreas to release bicarbonate, which neutralizes the acidic chyme.
2. Secretin	B. causes the gallbladder to contract and release bile into the small intestine.
3. Cholecystokinin (CCK)	C. inhibits peristalsis and acid secretions by the stomach.
4. Enterogastrone	D. stimulates the production of gastric juices.

It takes food approximately five hours to pass through the human small intestine. Undigested material travels next to the large intestine.

Elimination

The Large Intestine

The main job of the large intestine is to reabsorb water and salts (electrolytes) from the undigested material and to form solid waste that can be excreted. The large intestine forms an upside down U over the coiled small intestine. It begins at the lower right side of the body and ends on the lower left side. The large intestine is about five to six feet long, and it can take twelve to twenty-four hours for material to travel the length of the large intestine. The large intestine has three main parts: the cecum, the colon (itself divided into ascending, transverse, descending, and sigmoid), and the rectum (Figure 9.14).

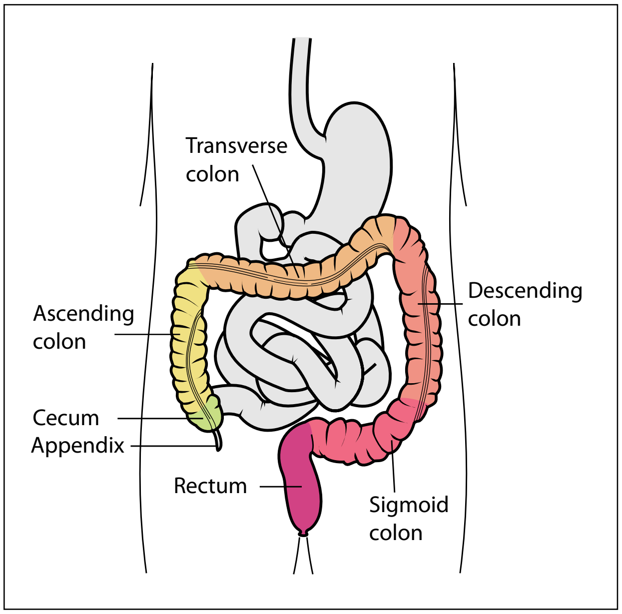


Figure 9.14: The large intestine
Source: Wikimedia Commons

Chyme enters the large intestine at a pouch called the cecum. This area allows food to pass from the small intestine to the large intestine. The colon is where fluids and salts are re-absorbed, and extends from the cecum to the rectum. Together, the small intestine and large intestine absorb 90% of the water that enters the digestive system. As the water is removed, feces (waste material) become more solid as they move along the colon via peristaltic waves. (When someone gets sick and has diarrhea, the time spent in the large intestine is reduced, leaving more water in the waste material.)

Feces also contain undigested polysaccharides known as cellulose fibre, which has no caloric value to humans, but which helps to move food along the digestive tract; this is why you need fibre in your diet. The undigested contents of the large intestine are moved toward the rectum, where they are stored until they leave the body through the anus as a bowel movement. Relatively little absorption of macronutrients takes place in the large intestine. As a general rule, if a macronutrient has not been absorbed after passing through the stomach or small intestine, very little further absorption of it will occur in the large intestine.

Living in the large intestine is a wide variety of bacteria, most of which are harmless. Some are even beneficial, because they help break down needed micronutrients or produce vitamins, like vitamin K, which then get absorbed into the body. Bacterial metabolism in the large intestine produces a mixture of gases (methane and hydrogen sulfide) called flatus. Intestinal bacteria live on organic material that would otherwise be eliminated with feces. For example, *Escherichia coli* are common bacteria found in the large intestine, and as a result are commonly found in feces.

Support Questions

20. What are two functions of the colon? Suggested answer

21. Draw the large intestine and label the following: cecum, ascending colon, transverse colon, descending colon, appendix, and rectum. Suggested answer

Accessory Organs of Digestion

In addition to the salivary glands and the pancreas, the liver and the gallbladder are also involved in digestion (Figure 9.15). During the digestive process, the accessory organs produce secretions that assist the organs of the alimentary canal.

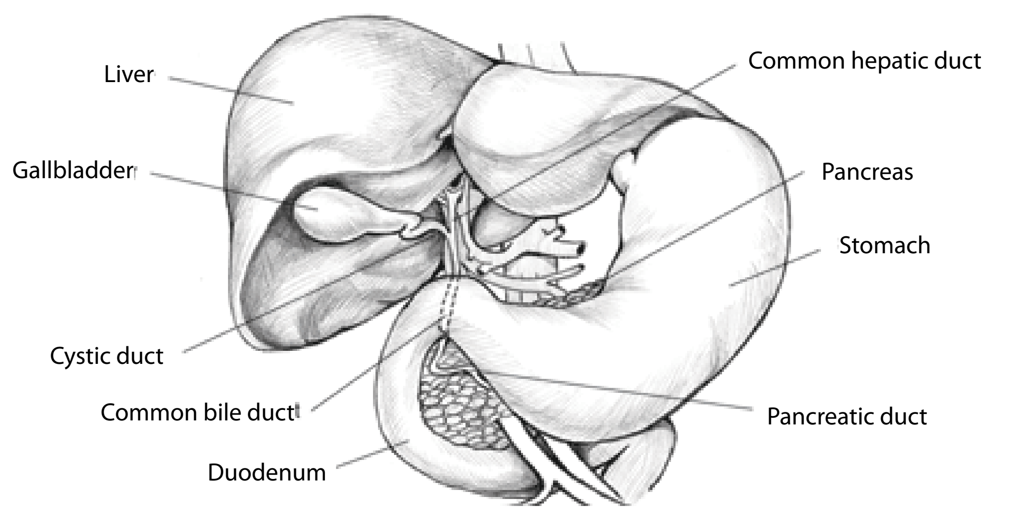


Figure 9.15: Accessory organs of digestion

Source: catalog.niddk.nih.gov

Liver

The liver is one of the most active organs in your body. It is located in the upper abdomen on the right side, and is divided into two lobes, as shown in Figure 9.15. The liver is the second largest organ in the human body after the skin.

The liver has many functions:

- it metabolizes carbohydrates, fats, and proteins;
- it forms and excretes bile salts;
- it stores blood, glycogen, vitamins A, D, and B_{12}, and iron;
- it detoxifies the end products of protein digestion, drugs, and poisons, such as alcohol; and
- it produces antibodies and essential elements of the blood-clotting mechanism.

Toxic substances enter our bodies daily from many sources. Some of the poisons that the liver deals with include pesticides in the air and on foods, alcohol, prescription and recreational drugs, smoke and other environmental toxins in the air we breathe. The liver keeps the body free of toxins by changing their chemical structure to make them water-soluble, so they can then be excreted out of the body through urine. The liver also produces bile, which absorbs harmful toxins and transports them out of the body.

Gallbladder

The gallbladder is a pear-shaped sac, usually stained dark green by the bile it contains. It is located in the hollow underside of the liver. Its duct, the cystic duct, joins the hepatic duct from the liver to form the common bile duct, which enters the duodenum, as shown in Figure 9.14. The gallbladder receives bile from the liver and then concentrates and stores it. It secretes bile when the small intestine is stimulated by the entrance of fats.

Support Questions

22. What are two functions of the liver? Suggested answer

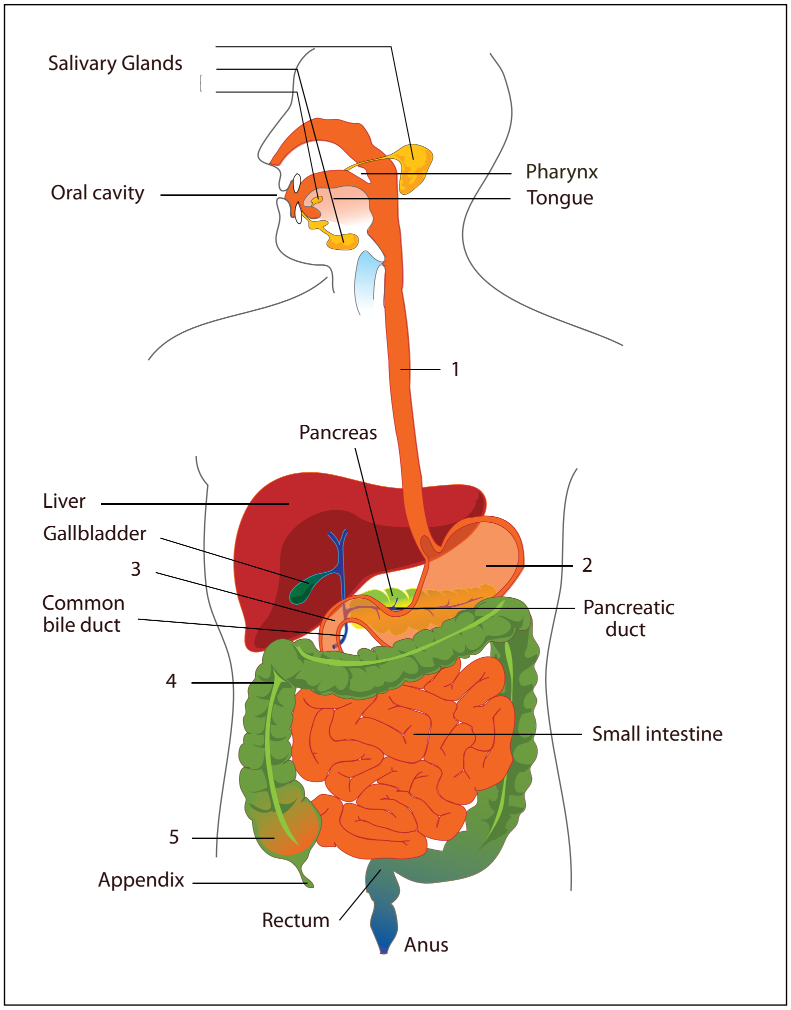
23. What is the function of the gallbladder? Suggested answer

Key Questions

Now work on your Key Questions in the online submission tool. You may continue to work at this task over several sessions, but be sure to save your work each time. When you have answered all the unit's Key Questions, submit your work to the ILC.

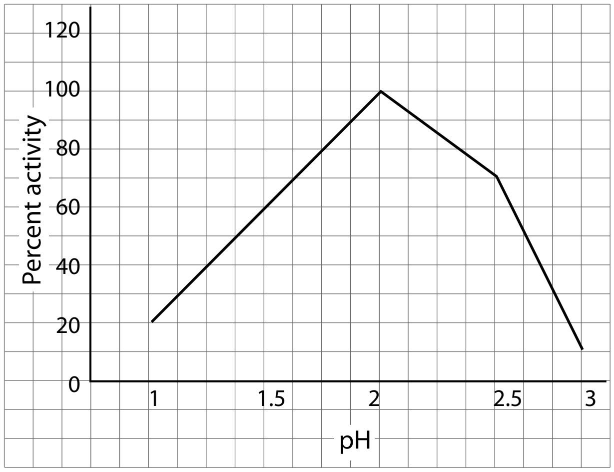
(16 marks)

26. a) Identify the five unlabelled structures in the following diagram, indicated by the numbers 1 to 5. **(5 marks: 1 mark each)**



b) Colon cancer patients often have surgery to remove all or part of the large intestine. Explain why it is important to have a functioning large intestine, and how your digestion would be affected if it were removed. **(2 marks: 1 mark for function, 1 mark for how digestion would change)**

27. The following graph relates the activity of a digestive enzyme to pH. (Note: the lower the pH, the more acidic the environment.)



a) Where in the digestive system would this type of environment be located? **(1 mark)**

b) What is the optimal pH of this enzyme? **(1 mark)**

c) What is the name of this enzyme and what macronutrient does it act upon? **(1 mark: ½ mark for each answer)**

28. a) Explain the purpose of chemical digestion, and list three locations where it takes place. **(2 marks: 1 mark for the explanation, 1 mark for the locations)**

b) One of your friends has decided he must lose some weight, while another has decided she is going to become a vegan. What advice would you give each of them about the foods they should eat, and how eating these foods would allow them to safely reach their dietary goals? **(4 marks: 2 marks for each friend)**

Now go on to Lesson 10. Send your answers to the Key Questions to the ILC when you have completed Unit 3 (Lessons 9 to 12).