Module 3
Human Biology 1

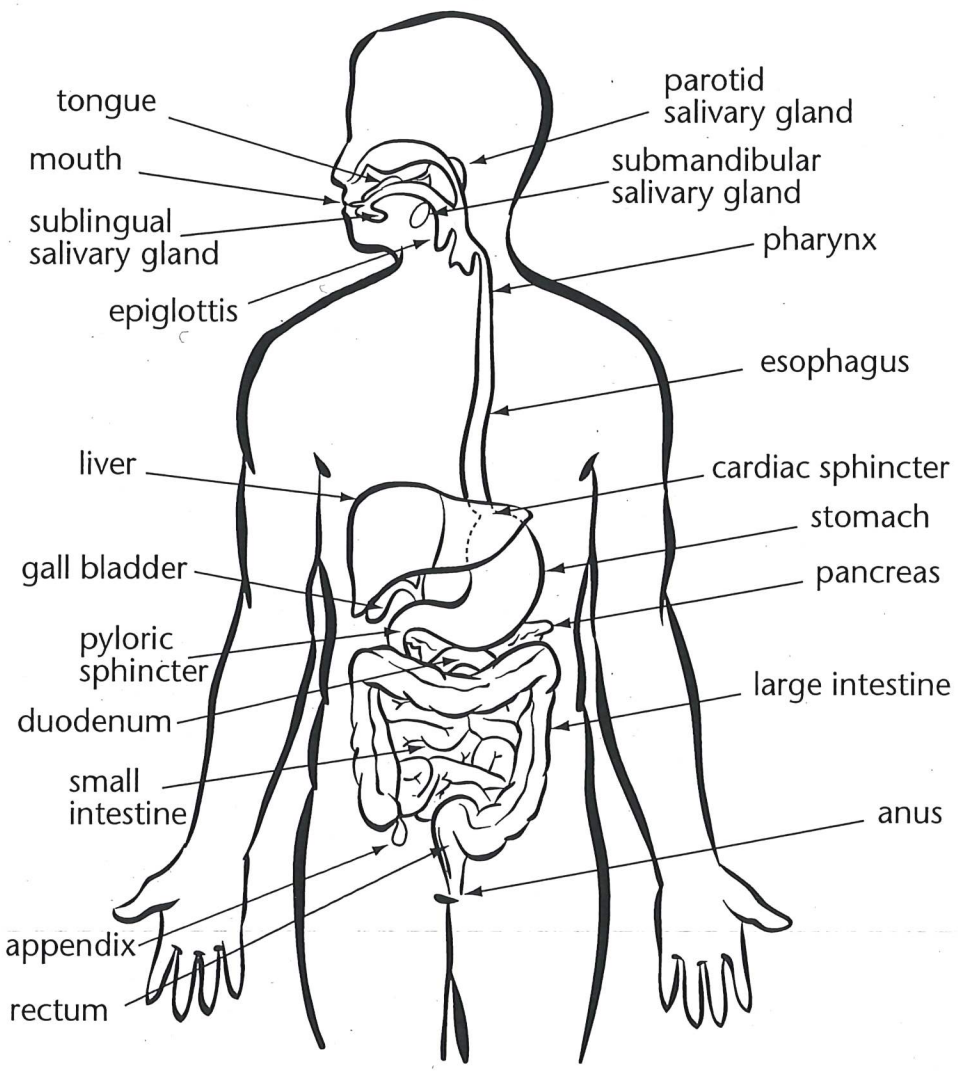
Overview

Module 3 begins to apply what you've learned at the micro-level of cell biology (in Modules 1 and 2) to the macro-level: tissue development, and organ systems. Organ systems such as the digestive, circulatory, and respiratory are explored in detail. You will need a good knowledge of the content within Module 3 (and Module 4). Don't hesitate to go back into the learning materials from Modules 1 and 2. It's highly unlikely you will remember all its content so going back to review it is a necessity. The Web sites listed throughout the course link to numerous interactive media sites. They can provide you with a broad perspective on a topic or some times a very narrow perspective. If you have Internet access, you are strongly encouraged to spend a little time exploring these sites. They just might be want the doctor ordered!

Section 3.1
Digestive System

Section Overview

While you are eating a meal, many cellular activities occur to digest it. The focus of this section is to explore these cellular activities and how they cooperate within the organs of the digestive system. So, the next time you growl down that burger, you'll know what's going on in the body to help digest it.



Lesson 3.1A
Human Digestive System Anatomy and General Functions

Overview

Food provides the molecules our bodies need for respiration, growth, and development. Food is eaten as complex molecules. Did you know that the average person eats approximately 500 kilograms of food per year?

Earlier in the course these molecules were also referred to as polymers. Examples are carbohydrates, proteins, lipids/fats, and nucleic acids. These polymers cannot be used by the body because they are too big to pass through membranes and into the bloodstream.

The digestive system breaks down food by mechanical and chemical means into smaller monomers that can be absorbed into the blood by the many villi of the **small intestine**. Glucose, amino acids, glycerol and fatty acids, and nucleotides are examples of small molecules that can be absorbed by the body.

If you have access to a computer and the *Biology 12 Media CD*, go to *Round the Clock Digestion* now.

Go to your:

Biology 12 Media CD > Module 3 > Round the Clock Digestion.

Resource List

- *Inquiry Into Life*
- *Biology 12 Provincial Exam Preparation package*
- *Biology 12 Web site*
  http://www.openschool.bc.ca/courses/biology/bi12/mod3.html
- *Biology 12 Media CD*

Human Digestion: Structures and Functions

This lesson introduces the organs of the digestive system and the basic functions that each organ has in the ingestion, digestion, absorption, or elimination of nutrients that enter the body. In the lesson you will study simplified descriptions of the functions of each organ. Each component of the digestive system will be covered in much more detail in the lessons that follow.

The **mouth** is responsible for the mechanical and chemical digestion of food. In the mouth, saliva mixes with food to form a food ball or bolus.

The **tongue** functions in taste as well as in moving, mixing, and positioning food for chewing and swallowing.

The **teeth** cut and crush food increasing surface area and mixing with saliva.

Every day the **salivary glands** produce about a litre of saliva. It contains salivary amylase, which begins the hydrolysis of starch into maltose.

The **pharynx** or throat is the passageway for both the food bolus to the esophagus and for air to enter the trachea. The process of swallowing takes place in the pharynx.

The **epiglottis** meets with the glottis when swallowing takes place. It covers the opening to the trachea and allows food to move into the esophagus.

The **esophagus** or food tube is about 25 centimetres long. Smooth muscle contractions of the esophagus, also referred to as peristalsis, move the food bolus to the stomach.

The **cardiac sphincter** is a ring of muscle located at the entrance to the stomach. It keeps digested food (acid chime) in the stomach, preventing reflux during digestion in the stomach.

The **stomach** is a muscular organ that mechanically and chemically digests food. It produces hydrochloric acid that lowers the pH in the stomach. The low pH activates the pepsinogen enzyme, which helps to digest proteins into peptides.

The **pyloric sphincter** controls the amount of acid chyme that enters the duodenum by releasing small quantities at regular intervals.

The **duodenum**, the first section of the small intestine, is important for the digestion and absorption of nutrients. It produces enzymes such as maltase and peptidases, and it also receives enzymes and bicarbonate from the pancreas and bile from the liver, via the gallbladder. The bicarbonate neutralizes the acid and the bile emulsifies fats. The absorption of nutrients is facilitated by numerous villi that line the inside of the duodenum.

The **liver** produces bile that is stored in the gall bladder. Bile is released into the small intestine to emulsify fats.

The **gall bladder** stores bile for the emulsification of fats/lipids.

The **pancreas** makes pancreatic juice that contains numerous digestive enzymes, as well as bicarbonate ions that neutralize acid chime entering the small intestine.

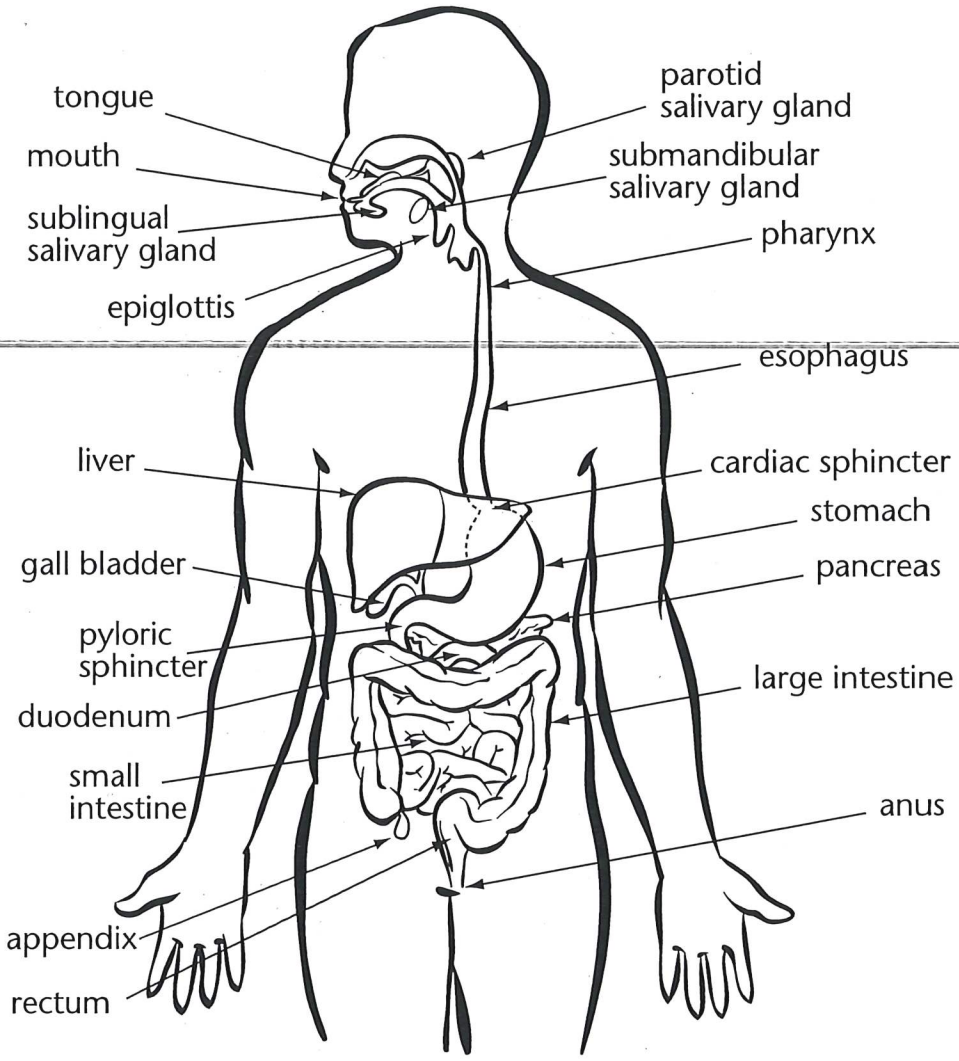
The **small intestine** is essential in the chemical digestion and absorption of nutrients.

The **appendix** is a projection of the cecum at the entrance to the large intestine. It may have a role in the immune function in humans.

The **large Intestine (colon)** is important for the absorption of water and production of vitamins.

The **rectum** functions in the storage of feces and defecation.

The **anus** is a sphincter involved in the defecation reflex.



Use the *Biology 12 Media CD* (if you purchased it) to complete the interactive activities in this lesson. It is also possible to complete the lesson using only the *Inquiry Into Life* textbook. Either way, list the main digestive function(s) and list them in detail within your notes.

If you have access to a computer and the *Biology 12 Media CD*, take a look at a student-produced video called *Digestive System* to become more familiar with the structures of the digestive system. Concentrate on identifying the names of the structures.

Go to your:

Biology 12 Media CD > Module 3 > Digestive System.

If you have access to a computer and the *Biology 12 Media CD*, go to the *Digestive System Structures and Functions* media piece now. Roll the mouse over the image to reinforce the structures and general functions of the digestive system. There is no need to take notes at this time. You will make those as part of the guided practice.

Go to your:

Biology 12 Media CD > Module 3 > Digestive System Structures and Functions.

Now work through two exercises that will help you learn the names of the digestive organs and how they fit together. The first exercise involves the matching of digestive structures with the appropriate name. The structures that are difficult to identify are the three **salivary glands**—sublingual (under the tongue), submandibular (under the jaw), and parotid (on top)—as well as the **cardiac sphincter** at the entrance to the **stomach** and the **pyloric sphincter** at the entrance to the **small intestine.**

The *Digestive System Matching Exercise* on the *Biology 12 Media CD* will help you master these identifications. Include the structures with the correct number in the guided practice assignment.

Go to your:

Biology 12 Media CD > Module 3 > Digestive System Matching Exercise.

To test yourself, try building a digestive system from the individual structures. The structures must be placed in the correct order, paying particular attention to the **pancreas**, **gallbladder**, and **appendix**. Go to the *Digestive System Building Exercise* now and try it out. If you have a stopwatch, you may want to time your first three trials. A decrease in the amount of time needed to complete the activity will be evidence that you're learning the material.

Go to your:

Biology 12 Media CD > Module 3 > Digestive System Building Exercise.

The structures you are responsible for on the Provincial Exam are listed in Guided Practice 3.1A 1.

If need be, use your *Inquiry Into Life* textbook to determine the main function(s), and list them in detail within your study cards and/or notes.

If you have access to the Internet, go to the *Biology 12 Web site* Lesson 3.1A Human Digestive System Anatomy and General Functions to see a good overview of the role cells play in tissue development and organ systems.

Guided Practice 3.1A 1
Study Flash Cards

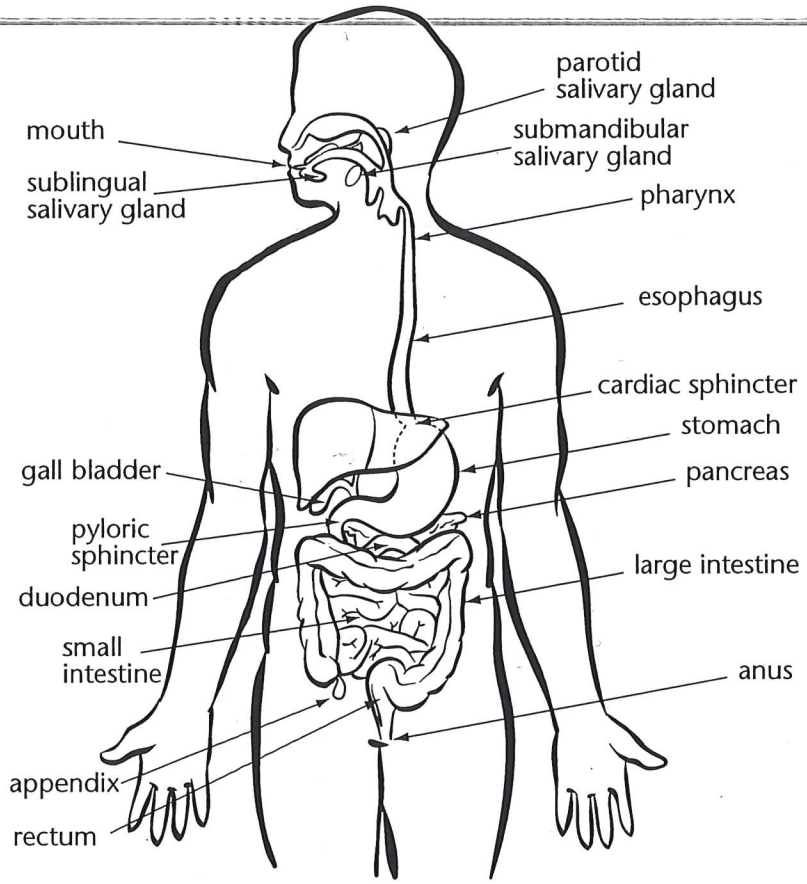
Using the information in your lessons, the *Inquiry Into Life* textbook, and the *Biology 12 PEP*, make a study flash card for each of the following vocabulary terms. Be sure the information is in your words, as that will be more meaningful to you.

Vocabulary terms to know for this lesson:

- anus
- appendix
- cardiac sphincter
- duodenum
- epiglottis
- esophagus
- gall bladder
- large intestine (colon)
- liver
- mouth
- pancreas
- pharynx
- pyloric sphincter
- rectum
- salivary glands
- small intestine
- stomach
- teeth
- tongue

Guided Practice 3.1A 2
Written Response

List the digestive organs in the order that they function in the digestive system. You may need to refer to your textbook for help.



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2.	11.
3.	12.
4.	13.
5.	14.
6.	15.
7.	16.
8.	17.
9.	

Summary

This lesson is intended as an overview of the section and the details for each topic follow in other lessons. There is no section assignment for this lesson.

Completing this lesson has helped you to:

- identify the digestive system structures in a diagram
- list a function for each digestive structure discussed in the lesson
- recognize that each digestive organ plays an important role in the proper functioning of the whole digestive system

Lesson 3.1B
From the Mouth to the Stomach

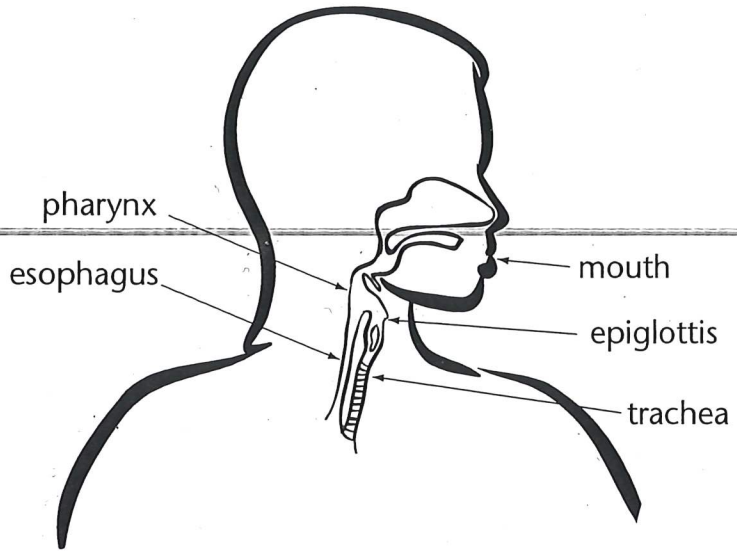
Overview

The digestive system uses mechanical and chemical means to break down food into smaller monomers that can be absorbed by the body. Glucose, amino acids, glycerol and fatty acids, and nucleotides are examples of small molecules that can be absorbed. This lesson will discuss the roles of the mouth, the pharynx (throat), the esophagus, and the stomach in this process.

Resource List

- *Inquiry Into Life*
- *Biology 12 Provincial Exam Preparation package*
- *Biology 12 Web site*
  http://www.openschool.bc.ca/courses/biology/bi12/mod3.html

The Mouth



The **mechanical digestion** and **chemical digestion** of food begins in the **mouth**. Mechanical digestion involves the cutting and crushing of food by the teeth. The tongue aids mechanical digestion by moving and positioning food for chewing and swallowing, and mixing food with saliva.

Saliva is released from salivary glands inside the mouth. Salivary glands produce about one litre of saliva each day. Saliva contains mainly water used to moisten food and aid hydrolysis, as well as salivary amylase, an enzyme protein responsible for the chemical digestion of starch, which is converted to maltose.

The mechanical and chemical processes that take place in the mouth produce a food ball or bolus that can then be swallowed.

The Pharynx

The pharynx or throat is a common passage for food to the esophagus and air to the trachea. The epiglottis meets with the glottis during swallowing to cover the opening to the trachea and send food into the esophagus.

Mechanical digestion of food (mouth, teeth, and tongue) and mixing it with saliva produces a food ball or bolus that can be swallowed. As the food moves from the mouth to the pharynx past the uvula (dangly thing at the back of the mouth and goaltender for our digestive system) our control of the process ends.

Swallowing is a reflex action that happens automatically. This reflex pushes the bolus into the esophagus. The trachea or windpipe lies in front of the esophagus and shares the pharynx as a passage for air. When swallowing occurs the soft palate of the mouth pushes down and the trachea pushes up (visible by movement of the Adam's apple), bringing the glottis and epiglottis together to close the trachea. The **epiglottis** covers the opening to the trachea to ensure food moves into the esophagus.

To view an animation showing the steps for swallowing, go to the *Biology 12 Web site* Lesson 3.1B From the Mouth to the Stomach.

The Esophagus

The esophagus, a food tube about 25 centimetres long, moves the food bolus to the stomach by peristalsis. Once the food ball enters the esophagus, it is pushed towards the cardiac sphincter by smooth muscle contractions called peristalsis. Food travels from the mouth to the stomach in about 4 to 8 seconds.

Peristalsis occurs throughout the length of the digestive tract and is responsible for keeping things moving and for the occasional strange sounds that arise. The digestive tract is surrounded by both circular and longitudinal smooth muscle that allows for rhythmic contractions or peristalsis. This movement is like squeezing the last little bit from the bottom of a tube of toothpaste.

The cardiac or gastroesophageal sphincter is a ring of muscle located at the entrance to the stomach that keeps the food and acid chyme in the stomach, preventing reflux during mechanical digestion. If reflux occurs and chyme moves back into the esophagus, a burning sensation in the throat is experienced. This irritation of the esophagus is commonly known as heartburn.

To view an animation of peristalsis, go to the *Biology 12 Web site* Lesson 3.1B From the Mouth to the Stomach.

The Stomach

The **stomach** is a muscular organ that mechanically and chemically digests food. The muscular walls of the stomach contract to mix the food with acid and enzymes, resulting in the production of acid chyme. Cells in the stomach lining produce hydrochloric acid, the **pepsinogen** enzyme, and mucus. The low pH caused by the production of hydrochloric acid kills bacteria and activates pepsinogen, which, as **pepsin**, digests proteins into peptides. Pepsin has optimal activity in the low pH of the stomach. The mucus protects the stomach from its acidic contents. The following chart summarizes the components and function of **gastric juice**.

Gastric Juice • produced in stomach • pH 2-3	water	a solvent for food aiding in production of chyme, acts in hydrolysis of bonds in food molecules
	enzyme pepsinogen	when activated, becomes pepsin and digests protein into shorter peptides
	hydrochloric acid (HCl)	activates pepsin; lowers pH and liquifies stomach contents, forming acid chyme
	mucus	protects the stomach from its acidic contents

The pyloric sphincter controls the amount of acid chyme that enters the duodenum by releasing small amounts at regular intervals.

The duodenum is important for the digestion and absorption of nutrients, and it makes enzymes like maltase and peptidases. From the pancreas it receives enzymes and bicarbonate that neutralize acid. From the liver, via the gall bladder, it receives bile that emulsifies fats. The function of the small intestine, accessory organs, and the large intestine are the topics of later lessons in this section.

Go to the *Biology 12 Web site* Lesson 3.1B From the Mouth to the Stomach and test your knowledge with an animated quiz called *Mouth to Stomach*.

Guided Practice 3.1B 1
Study Flash Cards

Using the information in your lessons, the *Inquiry Into Life* textbook, and the *Biology 12 PEP*, make a study flash card for each of the following vocabulary terms. Be sure the information is in your words, as that will be more meaningful to you.

Vocabulary terms to know for this lesson:

- chemical digestion
- digestive tract
- gastric juice
- hydrochloric acid
- hydroxide
- mucus
- pepsin
- pepsinogen
- peristalsis
- physical digestion
- salivary amylase
- swallowing

Guided Practice 3.1B 2
Written Response

1. Describe in your own words the mechanical and chemical processes in the mouth that result in the formation of a bolus.

2. Summarize the composition and functions of gastric juice. Include the pH, the components and the function of each component in your answer.

Summary

Now do Section Assignment 3.1 Part A.

Completing this lesson has helped you to:

- describe the role of the mouth in the digestion of food
- describe the role of the throat in the swallowing of a bolus
- understand the role of the esophagus in digestion and the process of peristalsis
- list the composition of gastric juice and the role of the stomach in digestion

Lesson 3.1C
The Pancreas: Structure and Function

Overview

The pancreas is both an exocrine and an endocrine gland that externally resembles masses of tiny grapes. Exocrine glands release their products into ducts while endocrine glands release their products directly into the bloodstream. The pancreas does both.

The cells of the exocrine tissue secrete pancreatic juice that flows down the pancreatic duct, into the bile duct, and then to the duodenum. The endocrine tissue consists of groups of cells known as the islets of Langerhans. Those cells primarily secrete the hormones insulin and glucagons, which will be discussed later.

Resource List

- *Inquiry Into Life*
- *Biology 12 Provincial Exam Preparation package*
- *Biology 12 Web site*
  http://www.openschool.bc.ca/courses/biology/bi12/mod3.html

The Pancreas: Structure and Function

Read the section in *Inquiry Into Life* textbook titled Three Accessory Organs. It discusses the pancreas, which is a gland that produces pancreatic juice that contains several digestive enzymes. This is an exocrine function of the pancreas and the enzymes produced help to digest food molecules in the small intestine.

~~All enzymes produced in the pancreas act in the small intestine.~~ Pancreatic juice is released into the duodenum through a duct in response to acid chyme from the stomach entering the small intestine. The sodium bicarbonate found in pancreatic juice maintains the pH in the duodenum at 7.5 to 8.5. Sodium bicarbonate neutralizes stomach acid and creates an optima pH for the enzymes that act in the small intestine.

The following chart summarizes the digestive enzymes produced by the pancreas and released into the small intestine.

Enzyme	Glandular Source	Site of Action and pH	Substrate or food acted upon	Product
pancreatic amylase	pancreas	small intestine basic (7.5)	starch	maltose
trypsin	pancreas	small intestine basic (7.5)	protein	peptides
lipase	pancreas	small intestine basic (7.5)	fat droplets	glycerol and fatty acids
nuclease	pancreas and small intestine	small intestine basic (7.5)	nucleic acids (DNA and RNA)	nucleotides

The following table summarizes the components and functions of pancreatic juice.

sodium bicarbonate	neutralizes acid chyme and brings the pH from 3 in the stomach to 7.5 in the small intestine
pancreatic amylase	continues the hydrolysis of starch into maltose started in the mouth by salivary amylase
trypsin	hydrolysis of proteins into peptides
lipase	hydrolysis of fats into glycerol and fatty acids
nuclease	hydrolysis of nucleic acids into nucleotides

The pancreas also has an endocrine function. The endocrine tissue of the pancreas produces the hormones insulin and glucagon. Both are protein hormones that maintain a constant blood sugar (glucose) level in the blood. Insulin and glucagon are secreted directly into the blood in response to changing blood sugar levels. Insulin responds to increases in blood sugar and glucagon responds to decreases in blood sugar. This is a homeostatic mechanism that keeps blood sugar levels in balance. A normal blood sugar level is approximately 100mg/100ml or 0.1%.

Insulin is a protein hormone produced by endocrine tissue in the pancreas called the Islets of Langerhans. It is released by the pancreas into the blood in response to increases in blood sugar levels following meals and snacks. Insulin makes cell membranes more permeable to glucose by acting on protein carriers and increasing the rate of facilitated diffusion of glucose into cells.

The movement of glucose into cells lowers blood sugar to normal levels. This is most important in liver, muscle, and fat cells. In the liver, glucose is stored by the synthesis of glycogen. Muscle cells store glucose as glycogen and they burn sugar to supply the energy needed for movement. Glucose provides glycerol for the formation of lipids in fat cells. All of these processes act to lower blood sugar.

Glucagon is another protein hormone produced by the Islets of Langerhans. It is released into the blood in response to decreases in blood sugar levels between meals or during extended periods without food. Glucagon acts mainly on liver and fat cells. Liver cells break down

glycogen into glucose and convert protein and fat into glucose (gluconeogenesis). Fat cells break down fat into glycerol and fatty acids that provide energy for the liver. These actions raise blood sugar levels.

Diabetes mellitus (Greek: diabetes = a passer through, and mellitus = sweet) was named for the excessive amounts of urine produced by an individual. The high glucose content of this urine attracted flies and other insects.

Type I diabetes, called juvenile or insulin dependent diabetes, is seen in young people and is caused by a lack of insulin production by the beta cells of the pancreas. Without insulin, blood sugar levels rise because glucose does not enter the cells. This lack of glucose to cells causes hunger. The high blood sugar level increases urination and causes thirst. These patients must take insulin daily to control blood sugar levels.

Type II diabetes is called adult or non-insulin dependent diabetes. These individuals do not require insulin therapy but must make lifestyle changes to control blood sugar levels. The major causes of Type II diabetes are obesity and inactivity. Patients must carefully monitor their diet and exercise regularly.

Go to the *Biology 12 Web site* Lesson 3.1C The Pancreas: Structure and Function to read the Mader online resources for digestion.

Guided Practice 3.1C 1
Study Flash Cards

Using the information in your lessons, the *Inquiry Into Life* textbook, and the *Biology 12 PEP*, make a study flash card for each of the following vocabulary terms. Be sure the information is in your words, as that will be more meaningful to you.

Vocabulary terms to know for this lesson:

- blood sugar
- insulin
- lipase
- nuclease
- pancreas
- pancreatic amylase
- pancreatic juice
- sodium bicarbonate
- trypsin

Guided Practice 3.1C 2
Written Response

1. Name three digestive enzymes, two hormones, and one other compound produced in the pancreas.
2. Describe how the two hormones produced in the pancreas act to regulate blood sugar levels.
3. Patients with Type I diabetes do not produce sufficient amounts of insulin. How does this affect an individual, what are the symptoms, and how is the disease treated?
4. Patients with Type I diabetes do not produce sufficient amounts of insulin. How does this affect an individual, what are the symptoms, and how is the disease treated?

Summary

Now do Section Assignment 3.1 Part B.

Completing this lesson has helped you to:

- understand the vital role of the pancreas as an accessory organ in the digestion of food
- list the components of pancreatic juice and the functions of each component in digestion
- describe the role of the pancreas in the control of blood sugar levels in the body

Lesson 3.1D
The Liver and Gall Bladder: Structure and Function

Overview

Interestingly, the liver can regenerate itself, and this fact may have been known centuries ago. In Greek mythology, the story of Prometheus tells of Zeus punishing Prometheus for giving humans the knowledge of fire. The eternal punishment involved chaining him to a rock and having his liver eaten by an eagle each day. Overnight the liver would grow back.

In this lesson we will discuss a few of the many functions of the liver.

Resource List

- *Inquiry Into Life*
- *Biology 12 Provincial Exam Preparation package*
- *Biology 12 Web site*
  http://www.openschool.bc.ca/courses/biology/bi12/mod3.html

The Liver and Gall Bladder

The liver and its functions are referred to as the hepatic system. The Greek word for liver is *hepar*. The hepatic artery and the hepatic portal vein from the intestines carry blood to the liver. The hepatic vein carries blood from the liver to the heart.

The liver is the largest internal organ in the human body. It is located in the upper right area of the abdominal cavity below the diaphragm. The liver consists of four lobes that are divided into thousands of tiny units called lobules. Within and between each cylindrical lobule is a complex array of blood vessels (of the portal and hepatic systems) and bile canaliculi (small canals). Bile ducts empty into the gall bladder, a bile storage area nestled under the right lobe of the liver. The bile duct continues from the gall bladder to the duodenum. The liver produces about 700 millilitres of bile every day.

To see a video that shows the size of a liver, go to the *Biology 12 Web site* Lesson 3.1D The Liver and Gall Bladder: Structure and Function.

Note: As you work through the following topic refer to Figure 14.10 on page 268 of your *Inquiry Into Life* textbook.

The Liver and Gall Bladder: Structure and Function

The liver has many functions. Generally, it helps maintain homeostasis within the blood by removing harmful or unwanted materials, and producing and adding useful materials to the blood.

The liver acts as the gatekeeper to the blood. Nutrients and some unwanted or poisonous substances (e.g., alcohol) entering the body through the small intestine are transported to the liver by the hepatic portal vein before entering circulatory system. The liver removes poisonous substances and detoxifies the blood.

Following a meal, glucose entering the liver via the hepatic portal vein is stored as glycogen. Between meals this glycogen is broken down by the liver and used to maintain a constant blood sugar level of about 0.1%. Recall that this process is controlled by the hormones, insulin and glucagon released by the pancreas.

The liver removes iron and fat-soluble vitamins (A, D, E, and K) from the blood and stores them.

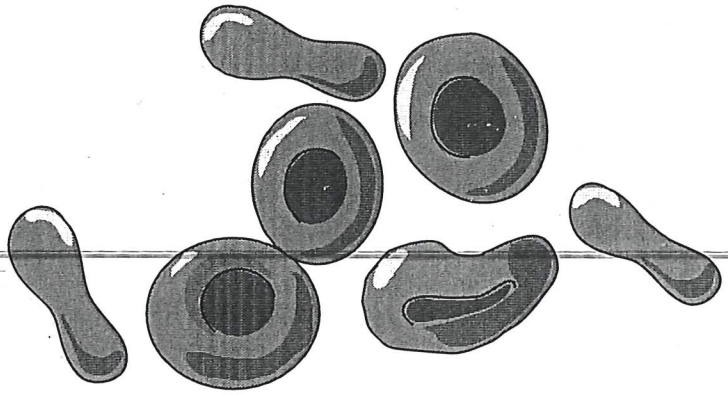
The liver uses amino acid monomers to build important blood proteins. These proteins are called plasma proteins because they are found in the plasma or liquid portion of blood. Examples of plasma proteins are albumin and fibrinogen. Albumin transports other large molecules in the blood and maintains blood pressure (an osmotic effect). Fibrinogen is needed for the formation of blood clots.

When the liver runs out of glycogen it is forced to produce glucose in other ways. The liver can convert amino acids from protein into glucose. This process is called **gluconeogenesis**. To make glucose this way, the liver must remove the amino groups found on the amino acids. This process produces ammonia, which is combined with carbon dioxide in the liver to make urea. Urea is a form of nitrogenous waste. In this form, the kidneys can remove it from the blood and excrete it in urine.

The liver recycles red blood cells, which only last a few months. When hemoglobin, the oxygen-carrying protein found in red blood cells, is broken down, bilirubin is produced. The liver removes bilirubin from the blood and excretes it as a component of bile. The bile pigments—bilirubin (red) and biliverdin (green)—give bile a yellow-green colour.

If the liver is not functioning properly (there are many possible reasons) bilirubin will build up in the tissues. This bilirubin build-up may cause the skin and whites of the eyes appear yellow—a condition called jaundice.

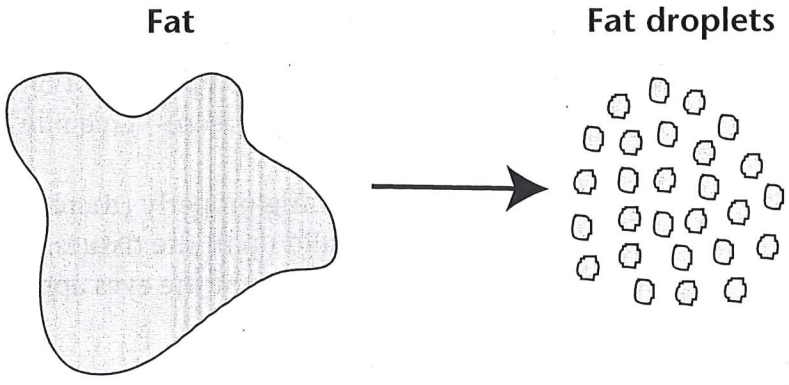
Red Blood Cells



Biconcave shape contain hemoglobin that carries oxygen produced in bone marrow

The liver helps to regulate the level of cholesterol in the blood by converting it into bile salts. These bile salts are responsible for emulsifying fats.

Bile produced by the liver is stored in the gallbladder. When food moves from the stomach to the small intestine, bile is released through the bile duct and mixes with the partially digested nutrients. Bile emulsifies fats by breaking them into small droplets and increasing the surface area exposed to digestive enzymes. Bile does not breakdown fat or lipid molecules. It is the lipase enzyme, produced in the pancreas, that breaks down fat into glycerol and fatty acids.



To review the Mader online resources, go to the *Biology 12 Web site* Lesson 3.1D The Liver and the Gall Bladder.

Guided Practice 3.1D 1
Study Flash Cards

Using the information in your lessons, the *Inquiry Into Life* textbook, and the *Biology 12 PEP*, make a study flash card for each of the following vocabulary terms. Be sure the information is in your words, as that will be more meaningful to you.

Vocabulary terms to know for this lesson:

- liver
- gall bladder
- bile
- emulsification
- fats

Guided Practice 3.1D 2
Written Response

1. What is the name of the blood vessel that connects the small intestine to the liver?
2. What is the function of the gall bladder?
3. What are the six functions of the liver?
4. What is the function of bile?

Summary

Now do Section Assignment 3.1 Part C.

Completing this lesson has helped you to:

- understand the role of the liver in the digestion of food
- list the many functions of the liver
- understand the role of the gallbladder in digestion
- describe how bile emulsifies fat to aid the action of the lipase enzyme

Lesson 3.1E
The Small Intestine: Structure and Function

Overview

The **small intestine**, which is approximately six metres long, is named for its narrow diameter. The small intestine receives small quantities of acid chyme from the stomach, released at intervals by the pyloric sphincter.

The first twenty-five centimetres of the small intestine is called the duodenum. In the duodenum, bile, and pancreatic juice enter the small intestine through a common duct. Bile, produced in the liver and stored in the gallbladder, emulsifies fats in the small intestine. Pancreatic juice adds sodium bicarbonate that neutralizes acid chime and makes the pH slightly basic and digestive enzymes (pancreatic amylase, trypsin, lipase, and nucleases). The cells of the small intestine also produce enzymes (maltase, peptidases, nucleosidases).

If you have access to a computer and the *Biology 12 Media CD*, review the media piece *Organelle Cooperation* from Module 1 now.

Go to your:

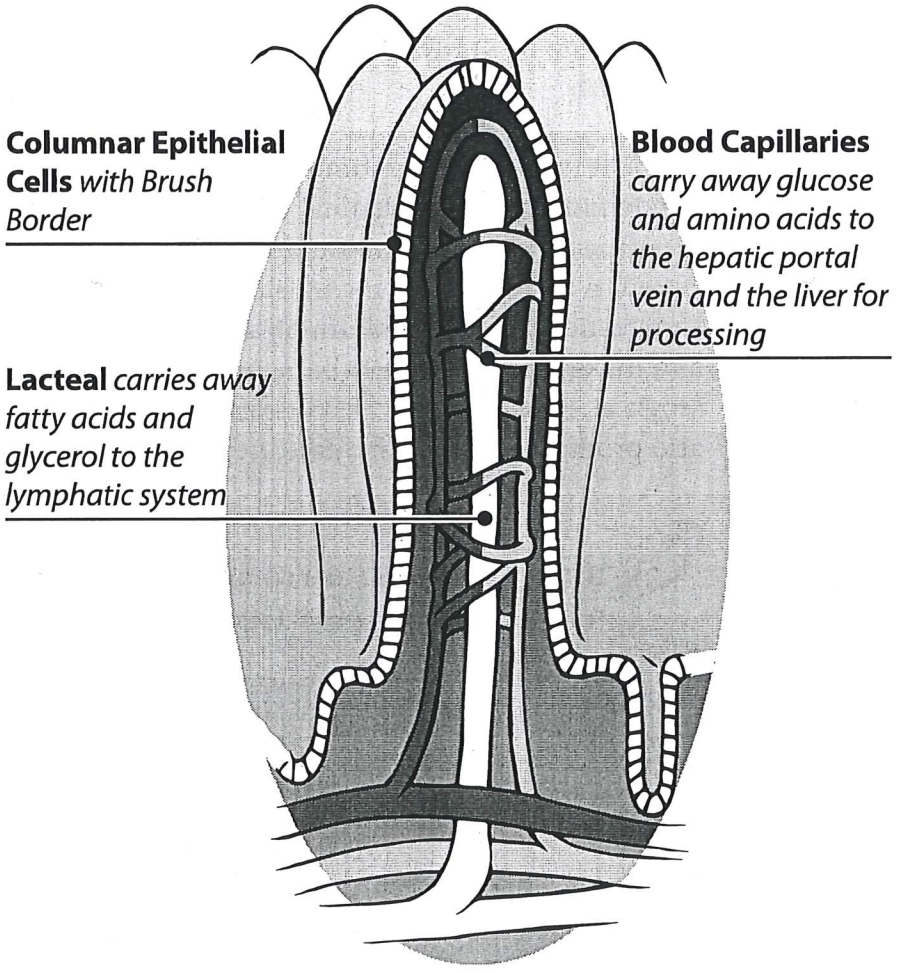
Biology 12 Media CD > Module 3 > Organelle Cooperation.

Resource List

- *Inquiry Into Life*
- *Biology 12 Provincial Exam Preparation package*
- *Biology 12 Web site*
  http://www.openschool.bc.ca/courses/biology/bi12/mod3.html
- *Biology 12 Media CD*

The Small Intestine: Structure and Function

In the small intestine, arguably the most important digestive organ, pancreatic juice, intestinal juice, and bile are responsible for the absorption of nutrients into the blood and lymph (tissue fluid) for use by the body. The walls of the small intestine are highly folded and covered with villi. Villi are finger-like extensions that increase the **surface area** available for absorption of nutrients.



Look at Figures 14.5 and 14.6 on pages 264–265 of your *Inquiry Into Life* textbook.

The outer cell layer of each villus is made up of columnar epithelial cells. These cells resemble columns packed tightly together and have nuclei near their bases. These cells absorb nutrients and transfer them to the blood capillaries and lacteals. This absorption involves active

transport and requires ATP energy. To increase absorption, the outer surfaces of these cells are covered with **microvilli** (called a brush border) that increase the surface area even more.

Each villus contains blood capillaries and small lymphatic vessels called **lacteals**. Glucose and amino acids move through the epithelial cells and into the blood capillaries, and travels via the hepatic portal vein to the liver for processing. Fatty acids and glycerol are packaged by epithelial cells and moved into lacteals. The lymphatic vessels later dump them into the bloodstream.

The cells of the small intestine produce the enzymes maltase, peptidases, and nucleosidases. These enzymes and their functions are summarized in the following table.

<table>
<tr><th>Intestinal Juice</th><th>Enzymes</th><th>Function</th></tr>
<tr><td rowspan="5">produced from intestinal cells and the contributions from accessory organs (the pancreas, the liver and the gall bladder)</td><td>maltase</td><td>hydrolysis of maltose to glucose</td></tr>
<tr><td>peptidases</td><td>hydrolysis of peptides to amino acids</td></tr>
<tr><td>nucleosidases</td><td>hydrolysis of nucleotides to sugars, phosphates, and nitrogenous bases</td></tr>
<tr><td colspan="2">Contributions from other organs</td></tr>
<tr><td>liver: bile</td><td>emulsification of fats for easier hydrolysis</td></tr>
<tr><td>pancreas: pancreatic juice</td><td>neutralize acid chemical digestion</td></tr>
</table>

To review the Mader online resources, go to the *Biology 12 Web site* Lesson 3.1E The Small Intestine: Structure and Function.

Guided Practice 3.1E 1
Study Flash Cards

Using the information in your lessons, the *Inquiry Into Life* textbook, and the *Biology 12 PEP*, make a study flash card for each of the following vocabulary terms. Be sure the information is in your words, as that will be more meaningful to you.

Vocabulary terms to know for this lesson:

- blood capillaries
- intestinal juice
- lacteal
- maltase
- microvilli
- nucleases
- peptidases
- small intestine
- villus

Guided Practice 3.1E 2
Written Response

1. Describe how fats are emulsified, digested, and absorbed in the small intestine.
2. Sketch and label a villus. Include an explanation of how the structure of the villus facilitates absorption of nutrients.
3. When nutrients are absorbed into the villus, which enter the bloodstream and which enter the lacteals?
4. Name three enzymes found in intestinal juice and describe their functions.

Go to the *Biology 12 Web site* Lesson 3.1E The Small Intestine: Structure and Function. Under Digestion, complete the online Small Intestine Digestion and Endoscopy animation quizzes.

Summary

Now do Section Assignment 3.1 Part D.

Completing this lesson has helped you to:

- understand the roles of the small intestine in the digestion of food
- describe the components of intestinal juice and their functions
- describe the function of a villus and how nutrients are absorbed and transported

Lesson 3.1F
The Large Intestine: Structure and Function

Overview

The **large intestine** is 1.5 metres long and contains 100 trillion bacteria. It is made up of the cecum, colon, rectum, and anus. It is called the large intestine because it has a larger diameter than the small intestine (6.5 centimetres vs. 2.5 centimetres). The large intestine is much shorter, though (1.5 metres vs. 6 metres).

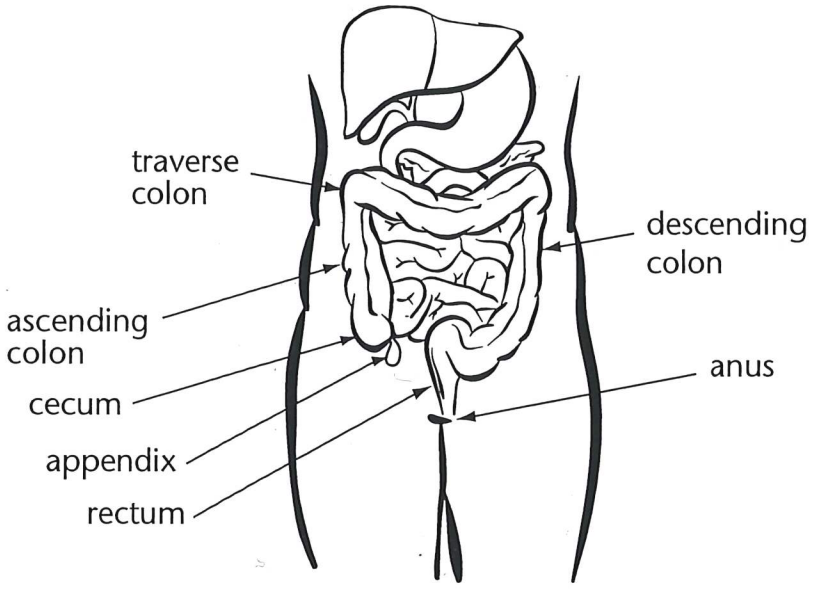
Resource List

- *Inquiry Into Life*
- *Biology 12 Provincial Exam Preparation package*
- *Biology 12 Web site*
  http://www.openschool.bc.ca/courses/biology/bi12/mod3.html

The Large Intestine: Structure and Function

The main functions of the **large intestine** are to reabsorb water and store indigestible materials, such as plant fibre (cellulose). When the rectum is full, nerves on the rectum wall initiate a defecation reflex and allow the passage of **feces** through the anus to the outside. Removal of this waste is a homeostatic mechanism within the body.

The Large Intestine



As the large intestine absorbs water from the liquid chyme, the undigested material hardens into feces. Feces are about 40% water. The solid portion of feces is made up of bacteria, fibre, and other indigestible solids. Oxidized iron and the products of bilirubin metabolism give feces its brown colour.

Bacteria in the large intestine use indigestible materials as food, which produces molecules that give feces and gas their unpleasant odour. The relationship between this bacterial flora and our bodies is mutually beneficial to both. The bacteria have nutrients and a stable environment within the large intestine. In return they produce vitamins and other molecules that are beneficial to the body.

Bacteria such as *Escherichia coli* (*E. coli*) also produce vitamins—mainly vitamin K and various B vitamins—that are absorbed by the body. These normal bacteria also inhibit the growth of disease-causing bacteria.

Recent studies show that up to 99% of these bacteria are obligate anaerobes that cannot survive in the presence of oxygen. These bacteria do not cause infections because they can't live in the oxygenated tissues of the body.

To review the Mader online resources, go to the *Biology 12 Web site* Lesson 3.1F The Large Intestine: Structure and Function.

Guided Practice 3.1F 1
Study Flash Cards

Using the information in your lessons, the *Inquiry Into Life* textbook, and the *Biology 12 PEP*, make a study flash card for each of the following vocabulary terms. Be sure the information is in your words, as that will be more meaningful to you.

Vocabulary terms to know for this lesson:

- anaerobic bacteria
- feces
- large intestine

Guided Practice 3.1F 2
Written Response

1. List the three functions of the large intestine. Why is the large intestine important for the regulation of water levels in the body?

2. Describe the composition of human feces.

3. Describe how the anaerobic bacteria normally found in the large intestine help to maintain good health.

Summary

Now do Section Assignment 3.1 Part E.

Completing this lesson has helped you to:

- describe the role of the large intestine in the digestion of food
- understand the contribution of normal intestinal bacteria to our bodies
- understand the role of the large intestine in water balance in the body
- list the composition of feces

Lesson 3.1G
Digestion and Enzyme Function Review

Overview

Digestive enzymes are proteins with unique tertiary structures. They are produced by the cells of glands that contain the machinery for protein production (lots of rough ER). Enzymes are exported in "juices" and act on specific food molecules or substrates in various locations in the digestive system. This lesson discusses the source glands for the various digestive enzymes and the hydrolysis reactions they catalyze. These **hydrolytic enzymes** form enzyme-substrate complexes with food molecules and lower the activation energy required to successful break (hydrolyze) chemical bonds. The enzymes are not consumed in the reactions, so are available to act over and over again.

Resource List

- *Inquiry Into Life*
- *Biology 12 Provincial Exam Preparation package*
- *Biology 12 Web site*
  http://www.openschool.bc.ca/courses/biology/bi12/mod3.html
- *Biology 12 Media CD*

Digestion and Enzyme Function Review

Enzymes were introduced in a previous lesson that discussed enzyme-producing glands. You will need to know all aspects of the hydrolytic reaction for each digestive enzyme. This table and the following exercises will help you master this material.

Digestive Enzymes Summary Table

Enzyme	Glandular Source	Site of action and pH	Substrate or food acted upon	Product
Salivary Amylase	salivary glands (mouth)	mouth neutral (7)	starch	maltose
Pepsin	gastric glands (stomach)	stomach acidic (3)	proteins	peptides
Pancreatic Amylase	pancreas	small intestine basic (8)	starch	maltose
Trypsin	pancreas	small intestine basic (8)	protein	peptides
Lipase	pancreas	small intestine basic (8)	fat droplets	glycerol and fatty acids
Nuclease	pancreas and small intestine	small intestine basic (8)	nucleic acids (DNA and RNA)	nucleotides
Peptidases	small intestine	small intestine basic (8)	peptides	amino acids
Maltase	small intestine	small intestine basic (8)	maltose	glucose
Nucleosidases	small intestine	small intestine basic (8)	nucleotides	base, sugar, phosphate

Pay attention to a few key points in this table. All enzymes end with -ase, except those that breakdown protein. The names of protein-digesting enzymes (proteases) end with -sin.

All enzymes produced in the pancreas act in the small intestine. Pancreatic juice is released into the duodenum through a duct and valve in response to acid chyme entering the small intestine from the stomach. The sodium bicarbonate found in pancreatic juice neutralizes stomach acid and creates a pH of 8 in the duodenum.

All enzymes act on specific substrates and produce specific products. Many of the polymers are digested in a two step fashion (e.g., starch to maltose to glucose). You will be familiar with these substrates and products from the lesson on biological molecules. If required, review your notes from that lesson.

If you have access to a computer and the *Biology 12 Media CD*, go to *What's That Enzyme?* now to watch an animation that summarizes the digestive process.

Go to your:

Biology 12 Media CD > Module 3 > *What's That Enzyme?*

If you have access to the Internet, go to the *Biology 12 Web site* Lesson 3.1G Digestion and Enzyme Function Review to review this material.

Guided Practice 3.1G 1
Study Flash Cards

Using the information in your lessons, the *Inquiry Into Life* textbook, and the *Biology 12 PEP*, make a study flash card for each of the following vocabulary terms. Be sure the information is in your words, as that will be more meaningful to you.

Vocabulary terms to know for this lesson:

- hydrolytic enzyme
- lipase
- maltase
- nuclease
- nucleosidases
- pancreatic amylase
- pepsin
- pepsinogen
- peptidases
- pH
- product
- salivary amylase
- site of action
- site of production
- substrate
- trypsin

Guided Practice 3.1G 2
Digestive Enzymes

1. Fill in the blanks in the following enzyme table.

Digestive Enzymes Summary Table

Enzyme	Glandular Source	Site of action and pH	Substrate or food acted upon	Product
Salivary Amylase				
Pepsin				
Pancreatic Amylase				
Trypsin				
Lipase				
Nuclease				
Peptidases				
Maltase				
Nucleosidases				

2. List the digestive enzymes produced by each gland. You should have a total of nine enzymes.

Salivary Gland	Gastric Gland	Pancreas	Intestinal Cells

Summary

Now do Section Assignment 3.1 Part F.

Completing this lesson has helped you to:

- understand the role hydrolytic enzymes in chemical digestion
- list the source glands for each digestive enzyme in the course
- list the enzyme, substrate, product, source gland, site of action, and pH for each digestive reaction