Digestive Enzymes at Work

Student Laboratory Kit

Introduction

People must eat to live but how does the body transform a pizza into the essential nutrients (peptides, amino acids, fatty acids, and glucose) it needs to carry out cell processes and cell growth? This activity explores the biochemistry of digestion.

Concepts

- Catalysts
- Digestion
- Enzymes
- Gastrointestinal tract

Background

The human body is composed of millions of cells that need oxygen, water, and nutrients to survive. The amazing transformation of food into the simpler molecules that can be absorbed by the body for use by the cells is called *digestion*. Digestion occurs in the *gastrointestinal (GI) tract*, which is also called the alimentary canal (see Figure 1). The GI tract is a mucous membrane-lined tube that extends from the mouth to the anus. While in the GI tract, food is first mechanically broken down and then chemically treated with acids, bases, and enzymes within the organs of the digestive system. Enzymes are biochemical catalysts. A *catalyst* is any substance that causes a chemical reaction to occur without being permanently altered in the process. A single molecule of catalyst can perform the same reaction thousands of times a second. Enzymes are globular, three-dimensional proteins with characteristic shapes that allow only a few specific substances called substrates, to temporarily bond with the enzyme. Because of the exclusive nature of enzyme/substrate binding, the human body contains thousands of different enzymes that are needed to catalyze all the different biochemical reactions that must occur.

Digestion begins in the mouth. The food mixes with saliva while the teeth grind the food. The tongue shapes the food and saliva mixture into a ball called a *bolus* (plural, boluses). *Saliva* provides the first chemical treatment of the food. Saliva is composed of a neutral pH mixture of water, mucus, proteins, mineral salts, and the enzyme amylase. *Amylase* begins the breakdown of starch, a carbohydrate, into glucose (see Figure 2 on page 2). Glucose is the sugar used during cellular respiration as a source of cellular energy.

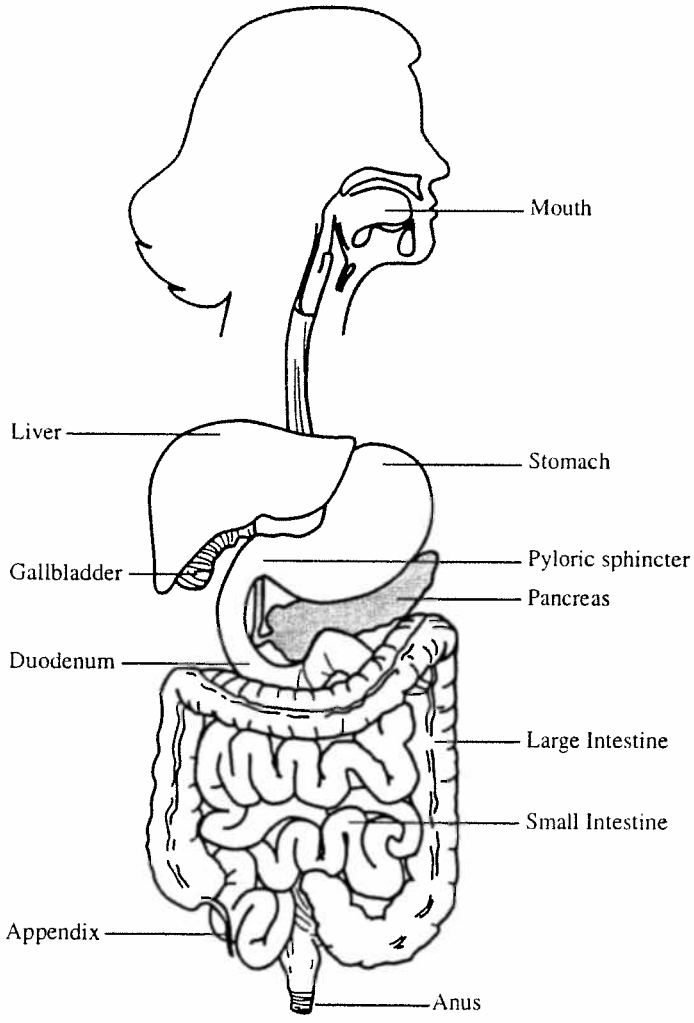

Figure 1.

The bolus is swallowed for further digestion in the stomach. Gastric juices in the stomach contain mucus, hydrochloric acid, pepsinogen, and small amounts of other enzymes. Hydrochloric acid acts to denature (uncoil) the proteins in food and activates pepsinogen, the inactive precursor of the enzyme *pepsin*. Since pepsin would digest the muscular walls of the stomach along with the food proteins, the inner layer of stomach cells secrete viscous alkaline mucus that coats the inside of the stomach. The mucus protects the stomach walls from the action of pepsin. The gastric juices are mixed with the bolus by movements of the stomach wall, producing a very thick liquid called *chyme*. The amount of time that chyme spends in the stomach depends upon the type of food present. Foods that are predominantly carbohydrates pass through the stomach quickly, followed by high-protein foods, and finally by high-fat foods, which may spend several hours in the stomach. Glucose, alcohol, fat-soluble drugs, some salts, and small amounts of water are absorbed through the walls of the stomach directly into the bloodstream for transport to the liver, where they are metabolized or sent on to other cells in the body. Movements by the stomach wall muscles, called *peristaltic waves*, push the chyme toward the bottom of the stomach where the stomach connects to the small intestine. Once the first section of the small intestine is full, the chyme combines with excretions from the pancreas, liver, and the small intestine. Pancreatic juice from the pancreas, bile salts from the liver, and excretions from the epithelial cells of the small intestine contain enzymes that are capable of completing the digestion of carbohydrates, proteins, nucleic acids, and fats.

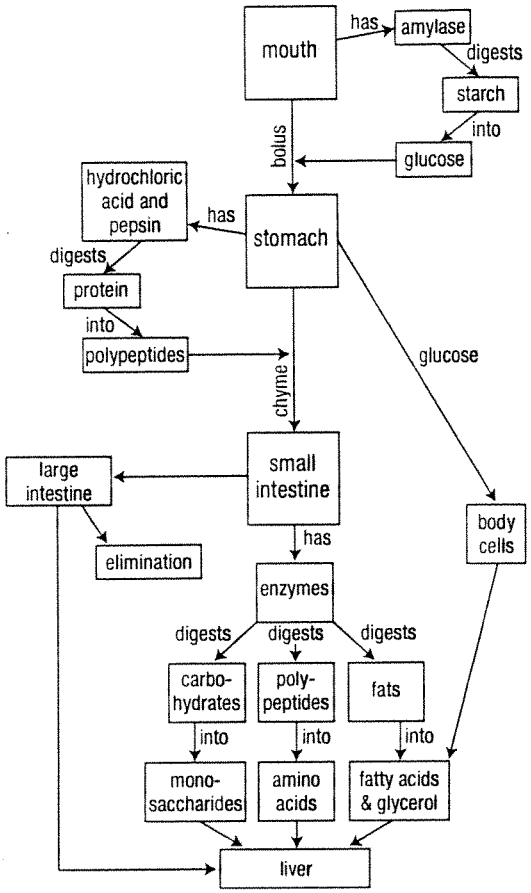

Figure 2.

The digestion of carbohydrates into glucose and other simple sugars is completed in the small intestine by the enzymes sucrase, maltase, lactase, and pancreatic amylase. The resulting sugars are absorbed through the mucous lining of the small intestine into the bloodstream for transport to the liver where they are converted to glucose, glycogen or fat. *Glycogen* is used for intermediate energy storage. The partially digested proteins from the stomach are still too large to be absorbed through the small intestine. Pancreatic juice contains three peptidases that complete the digestion of protein into amino acids for absorption into the bloodstream. Each peptidase in the pancreatic juice is very specific and splits the bonds only between particular combinations of amino acids. Chyme also contains the nucleic acids of the plant and animal cells that were ingested. Nucleases found in the pancreatic juice convert these nucleic acids into nucleotides, which are absorbed and transported to the liver.

Fats (lipids) are hydrolyzed into fatty acids and glycerol by intestinal and pancreatic lipase with help from bile salts secreted by the liver. Hepatic cells of the liver produce bile, which is stored in the gall bladder before being excreted into the small intestine. Bile salts help with the digestion of fat globules by acting like soap. The globules of fat are small clumps of lipids that stick together in the chyme. Bile salts break the globules into smaller drops, creating greater surface area for pancreatic lipase to break the lipids into fatty acids and glycerol.

Once the nutrients produced by the enzymes have been absorbed by the small intestine, they travel to the liver where they are metabolized, if necessary, before being transported by the blood and lymph to every cell in the body. The material remaining in the small intestine travels to the large intestine where more mucous is added and where water and electrolytes are absorbed before the "waste" is expelled from the body.

Experiment Overview

The purpose of this experiment is to visualize the products of enzyme digestion in the human gastrointestinal tract. Activity 1 highlights the digestion of protein in the stomach by the enzyme pepsin. Activity 2 illustrates the digestion of milk fat by intestinal lipase into fatty acids and the resulting change in pH. Activity 3 uses iodine and Benedict's reagent to visualize the digestion of starch to glucose by amylase in the mouth.

Name _____ Per. _____ Date _____

Chapter 16- Pre-Lab
Digestive Enzymes at Work (Flinn Scientific)

Using the attached handout about digestive enzymes, answer the following questions.

Background

1. The transformation of food into simpler molecules that can be absorbed by the body for use by the cells is called _____.

   a. Digestion occurs in the _____ _____.

2. _____ are biological catalysts.

   a. A catalyst is any substance that causes a _____ _____ to occur without being permanently _____ in the process.
   b. Enzymes have characteristic shapes which allow it to only bind to a specific _____.

3. Digestion begins in the _____.

   a. Food is physically broken down in the mouth by _____.
   b. Food is chemically broken down in the mouth by _____.
      i. The enzyme found in saliva that breaks down starches is called _____.
         a. Starch is broken down into _____, which will be used during _____ _____ as a source of cellular energy.
      ii. Food mixed with saliva is called _____.

4. Bolus is further digested in the _____.
   a. For each secretion of gastric juice, list their function.

Gastric Secretion	Function
1. Hydrochloric acid-	1.
2. Pepsin-	2.
3. Mucus-	3.

   b. Gastric juice mixed with bolus is called _____.
   c. List the types of food, in order, from the shortest time to be digested to the longest time to be digested.

Shortest time

Longest time

   d. _____ _____ push chyme to the bottom of the stomach and into the small intestine.

5. List 3 secretions that chyme encounters once inside the small intestine.

   a. The digestion of carbohydrates into glucose is completed by the enzymes

   b. Sugars that are digested are transported to the liver where they are stored as

   c. Pancreatic juice contain _____, which are enzymes that complete the digestion of proteins.
   d. Pancreatic juice contain _____, which are enzymes that break up nucleic acids into _____.
   e. Pancreatic juice contains _____ _____, which is an enzyme that digests fats into _____ _____ and _____.
   f. The liver secretes _____, which breaks fat globules into smaller droplets.

6. Once the nutrients have been absorbed by the small intestine, they travel to the liver where they are _____ before being transported by blood and lymph to the cells of the body.

7. The remaining material in the small intestine is passed to the _____ _____, where water and electrolytes are reabsorbed before the waste is expelled from the body.