

Biology 13A Lab #13: Nutrition and Digestion

Lab #13 Table of Contents:

• Expected Learning Outcomes	102
• Introduction	103
• Food Chemistry & Nutrition	104
• Activity 1: Testing for the Presence of Nutrients	104
• Activity 2: The Digestive System and Digestion	111

Expected Learning Outcomes

At the end of this lab, you will be able to

- list the essential nutrients found in food;
- describe the basic chemical composition of carbohydrates, proteins, fats, and vitamins;
- identify nutrient content in foods and test for nutrients in unknown samples;
- learn the parts of the digestive system;
- explain functions of major nutrients in the body.

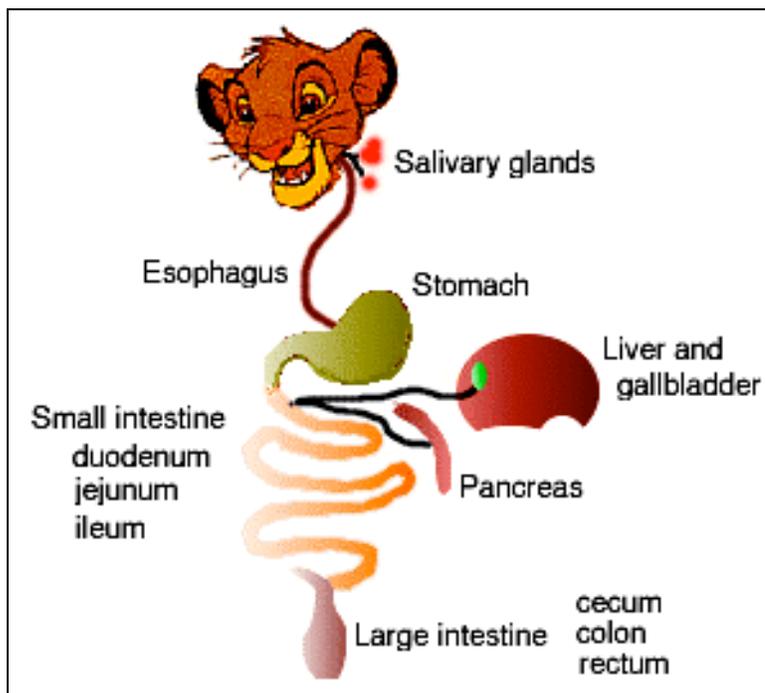


Figure 13.1 Digestive System

Introduction

Food, glorious food! Movement, processing information and responding to the environment, and maintenance of homeostasis all require energy. Ultimately, energy is derived from food. In addition, food provides building material for cells and tissues.

The job of the **digestive system** is to break down food and absorb **nutrients: carbohydrates, proteins, and lipids** and smaller quantities of **vitamins** and **minerals**. Most of the water we need also comes from food. Few foods combine all six nutrients. As primates, we are **omnivores**, adapted to eat a wide variety of foods to obtain a full complement of necessary nutrients. Our digestive system anatomy and physiology reflects the eclectic diet for which we are adapted.

Releasing nutrients from food requires **mechanical digestion** where large pieces are crushed

and ground primarily by teeth, with the aid of tongue and saliva. This increases the surface area for **chemical digestion** in which **digestive enzymes** break down complex large molecules such as proteins and carbohydrates to their basic components (e.g. amino acids and simple sugars).

Chemical digestion is performed by many organs: for example, salivary glands produce amylase, an enzyme that breaks down starches (polysaccharides) to disaccharides; the pancreas and small intestine produce numerous enzymes that complete the breakdown of proteins, lipids, and carbohydrates to forms usable by cells. The nutrients are absorbed through the lining of the small intestine and are then transported throughout the body.

Today we will examine nutrients in food and review the **structures** of the digestive system.

Testing Your Comprehension: Answer the following questions based on your reading of the introduction.

1. List the five nutrients found in food.
2. What is an omnivore? How does the fact that humans are omnivores influence our anatomy and behavior?
3. Where and how does mechanical digestion occur?
4. What molecules are necessary for chemical digestion? Give examples of organs that perform chemical digestion.

Food Chemistry & Nutrition

Carbohydrates, proteins, lipids, and vitamins and minerals are the nutrients in food.

Carbohydrates are either simple sugars (**monosaccharides**) consisting of a single sugar molecule such as glucose, or **disaccharides**, two monosaccharides joined together (e.g. sucrose, or table sugar), or **polysaccharides (complex carbohydrates)**, large chains of monosaccharides. Starch and glycogen are polysaccharides. They are major sources of energy for cellular work. Common sources of carbohydrates in the diet are breads, cereals, fruits and vegetables.

Proteins have numerous functions. They are the basis for tissue and organ structure; some are capable of movement (so-called “motor proteins”) while others act as enzymes. All proteins are chains of **amino acids**. Twenty amino acids combine to form thousands of different proteins. Twelve amino acids can be assembled in the body but eight must be obtained directly from the diet. Dietary sources of proteins include fish, soybeans, meat, and dairy products.

Lipids are hydrophobic (insoluble in water). They include fats, oils, waxes, phospholipids, and steroids. Concentrated sources of energy, each gram of lipid has more calories than a gram of protein or carbohydrate.

of plasma membranes and provide support for joints, tendons, and internal organs. Dietary sources of lipids include nuts, meat, butter and cheese, and vegetable oils.

Although only minute quantities of **vitamins** and **minerals** are required, a deficiency can have devastating effects. Vitamins help control chemical reactions, often facilitating the actions of enzymes. They are necessary for normal growth and metabolism. Thirteen vitamins are essential for health—four of those are fat soluble and are stored for months at a time in adipose tissue; nine are water soluble and must be regularly replaced. Minerals such as calcium and phosphorus are also derived from the diet and perform vital functions.

Vitamins are obtained from a wide variety of foods. For example, vitamin C is obtained from citrus fruits and tomatoes whereas vitamin B is found in nuts, whole grains, and beans. Vitamin pills may supplement the diet. Each vitamin has specific functions in the body, leading to particular symptoms if there is a lack. The first symptom of vitamin C deficiency is fatigue, followed by anemia, back and joint pain, bleeding of the gums, and poor wound healing. With time, death ensues, as was the fate of numerous sailors who succumbed to “scurvy.”

Testing Your Comprehension: Answer the following questions based on your reading.

1. Define monosaccharide, disaccharide, and polysaccharide, and give examples of each.
2. What is the basic building block of proteins? What are dietary sources of proteins?
3. List several functions of lipids.
4. What causes scurvy and what are some of its symptoms?

Activity 1: Testing for the Presence of Nutrients

Simple chemical tests using indicators can be used to determine the presence of nutrients in food. A color change of an indicator is usually a positive test for the presence of a certain nutrient. In this experiment, you will use several indicators to test for the presence of nutrients in solutions. The purpose of this lab is to demonstrate how different foods can contain one, some, or all of the organic compounds that are important to cells.

Summary of Activities

1. Make a hypothesis about the content of food samples you and your lab partners have brought from home.
2. Test each food, along with the appropriate positive and negative controls, for protein, monosaccharide, and complex carbohydrate.

Biology 13A Lab Manual

We will be using three different tests to identify protein, monosaccharide (glucose and/or fructose), and complex carbohydrates (starch) in various foods. Monosaccharides and starch are both carbohydrates. Monosaccharides are the small organic molecules that are the subunits used to build large starch macromolecules. **Bring one food or drink to lab that you think contains one of these compounds as an experimental sample.**

Some examples of what to bring:

- juice or milk
- fruit or vegetables
- flour, or tofu, or bread
- anything that can mix with water

NO:

- oily foods
- uncooked beans or pasta, or other dry unhydrated food
- dark-colored foods or drinks
- acidic, or sour foods like orange juice

These items will not react well with the test chemicals.

Foods will contain at least one type of organic compound. Before beginning, make a prediction about which type of compound or compounds you think your experimental sample contains. Record your prediction on your RESULTS page.

You will perform three different tests on the same four experimental samples (share with your lab partners). Each test will use a different **indicator reagent** that will change color in the presence of the particular organic compound that is being tested for. As part of the experimental method, you must include **control samples** to insure the validity of your results. A control is a test sample with a known result. If your control samples do not give you the expected result, then your experimental results are not valid and you must reevaluate your experimental set-up (maybe your test chemicals are no good).

A **negative control** will result in no change in color. It will either contain no sample at all or it will contain a nonreactive sample like water. For example, if you are testing for the presence of monosaccharides, the test chemical, called Benedict's solution, will remain the original color blue when mixed with water.

A **positive control** will result in a color change indicating the presence of the compound you are testing for. For example, a 5% glucose solution will react with Benedict's solution and change it from blue to rust (brown-red).

You can compare your experimental results to your control results to determine if you obtained a positive reaction.

Testing your comprehension: Define the following terms and give an example of each from today's lab exercise:

1. Macromolecule:
2. Positive experimental control:
3. Negative experimental control:

To Prepare Your Samples:

1. If your experimental sample is **solid**, chop or break it up into the smallest pieces possible using a razor blade or glass rod, whichever is appropriate. Use a pinch of sample small enough so that the material can be easily suspended in 1.5 ml of water and does not fill the bottom of the tube.
 - Add 1.5 ml distilled water to your sample and mix it well.
2. If your sample is a **liquid**, add 1.5 ml of the liquid to the appropriate tube.
3. Each tube should have the same volume of fluid, regardless of the type of sample.

Part I. Identification of Protein

Materials:

- test tube rack
- test tubes
- tape for labeling your tubes
- 0.5% CuSO₄
- 10% NaOH
- albumin protein solution (egg white)
- distilled water
- four different experimental samples (share with the people at your table)

The test chemicals used in this experiment react with the covalent bonds that link amino acids together in protein chains. In the presence of protein, the chemicals will turn varying shades of purple.

NOTE: NaOH (sodium hydroxide) is very caustic and will burn your skin and damage your clothes. Handle it with caution. If you do come into contact with it, notify the instructor and flush the area thoroughly with running water. NaOH is the ingredient in hair removal products like Nair. It works by dissolving protein, which is what hair is made of.

Procedure:

1. Predict which organic compounds your experimental samples might contain. Record your predictions in Table 13.1.
2. Label your tubes 1 through 6.
3. Prepare your sample following the instructions from above.
4. CAUTIOUSLY add 20 drops of 10% NaOH solution to each tube. Agitate the tube gently. See instructor for demonstration.
5. Add 4 drops of 0.5% CuSO₄ to each tube. Agitate the tubes again.
6. Let the tubes sit at room temperature a few minutes, until you see a color change in your positive control.
7. Record the results in Table 13.2.

Part II. Identification of Monosaccharides

Materials:

- hot plate
- 400 ml beaker half filled with boiling water
- test tube clamp for picking hot test tubes
- Benedict's solution
- 5% glucose solution
- 5% fructose solution
- 5% sucrose solution
- distilled water
- 4 experimental samples

Benedict's solution is a blue solution that will change color in the presence of monosaccharides, such as glucose or fructose. Benedict's changes from blue --> green --> orange --> brown, depending on the amount of monosaccharide present. Any change in color indicates the presence of monosaccharides.

Procedure:

1. Set up a boiling water bath using a 400 ml beaker filled with approximately 150 ml of tap water on a hot plate. Add **2 or 3** boiling chips to the water in the beaker. These will prevent boiling water from slashing up when you add your test tubes. Set the hot plate on high to get the water boiling, then reduce the temperature to a setting of "2" to keep the water simmering. The water should be boiling BEFORE you place your tubes in it.
2. Label your tubes 1 through 8. If you are using tape, make sure the tape is high enough on the tube so that it does not get wet in the water bath. Otherwise, the tape will fall off and you will not be able to identify your samples.

Biology 13A Lab Manual

3. Prepare your samples as before.
4. Add 1.5 ml of Benedict's solution to each test tube, for a total of 3 ml.
5. Agitate your tubes so that the sample and Benedict's is well mixed. See instructor for demonstration.
6. Place all the test tubes **at the same time** in the boiling water bath for 5 minutes.
7. Remove the tubes using the test tube clamp and record the resulting color. Do not mix the tubes again once they have been boiled. If your sample was a solid, note the color change in the immediate vicinity of your sample. The rest of the Benedict's may stay blue since a solid cannot mix well.
8. Record your results in Table 13.3.

Part III. Identification of Starch (Complex Carbohydrate)

Materials:

- Iodine solution (IKI)
- Starch suspension
- distilled water
- 4 experimental samples

Iodine will react with starch and turn from a yellow/brown color to a purple/black color. Only the purple/black color is an indication of starch.

Procedure:

1. Number your tubes.
2. Prepare your samples as before. Remember, each tube should have 1.5 ml of liquid.
3. Add 2-3 drops IKI to each tube. Agitate your tubes.
4. Record your results in Table 13.4.

Clean Up!!!

Questions

1. What is the indicator reagent for each of the following organic compounds and what color change will tell you that the organic compound is present?
 - Monosaccharides:
 - Starch
 - Protein
2. What is the purpose of the samples containing albumin, glucose, fructose and boiled starch solution?
3. What is the purpose of using the water only sample in each of the experiments?
4. The sucrose sample in the test for monosaccharides is also a negative control. Why does it not react with the Benedict's reagent?
5. For each food you tested, list the organic compounds it contained.
6. How do your results compare to your original predictions? Explain.
7. Based on what you learned from today's experiment, explain why it is important to eat a variety of foods to nourish your cells.

Table 13.1. Before you begin, predict which organic compounds may be found in each of your samples.

Experimental Samples	Color of Sample	Predicted Organic Compounds
#1:		
#2:		
#3:		
#4:		

Table 13.2. Identification of Protein

Tube #	Solution in Tube:	Color of reaction	Presence of Protein? (yes or no)
1	1.5 ml albumin solution		
2	1.5 ml distilled water		
3	Sample #1:		
4	Sample #2		
5	Sample #3		
6	Sample #4		

Table 13.3. Identification of Monosaccharides

Tube #	Solution in tube:	Color of Reaction		Presence of Monosaccharides ? (yes or no)
		Before Heating	After Heating	
1	1.5 ml 5% glucose solution			
2	1.5 ml fructose solution			
3	1.5 ml 5% sucrose solution			
4	1.5 ml distilled water			
5	Sample #1			
6	Sample #2			
7	Sample #3			
8	Sample #4			

Table 13.4. Identification of Starch

Tube #	Solution in tube:	Color of Reaction	Presence of Starch? (yes or no)
1	1.5 ml boiled starch		
2	1.5 ml distilled water		
3	Sample #1		
4	Sample #2		
5	Sample #3		
6	Sample #4		

Activity 2: The Digestive System and Digestion

Part 1: Parts of the Digestive System

The previous experiment explored some of the nutrients in food. How are nutrients extracted from the food we eat? In this activity, we will follow a bite of food through the digestive system and identify the structures that it passes through.

1. Use the torso model to examine the parts of the system. Beginning at the mouth, follow an imaginary bite of food through the system.
2. On the figure of the human digestive system (Figure 13.2), label the indicated structures:
 - Mouth
 - Pharynx
 - Esophagus
 - Stomach
 - Small intestine
 - Large intestine
 - Rectum
 - Liver
 - Gall bladder
 - Pancreas

Part 2: Mechanical Digestion

On the diagram, draw an arrow to the place where mechanical digestion occurs. What structures are involved in mechanical digestion?

Part 3: Chemical Digestion

1. On the diagram, label the places where the following chemical digestion occurs.
 - Carbohydrate digestion
 - Protein digestion
 - Lipid digestion
2. What structures are involved in chemical digestion?

Part 4: Absorption of Nutrients

1. On the diagram, place an arrow and label the location where absorption of nutrients occurs. What structures are involved?
2. On the diagram, place an arrow and label the location where most water is reabsorbed. Why is reabsorption of water important?

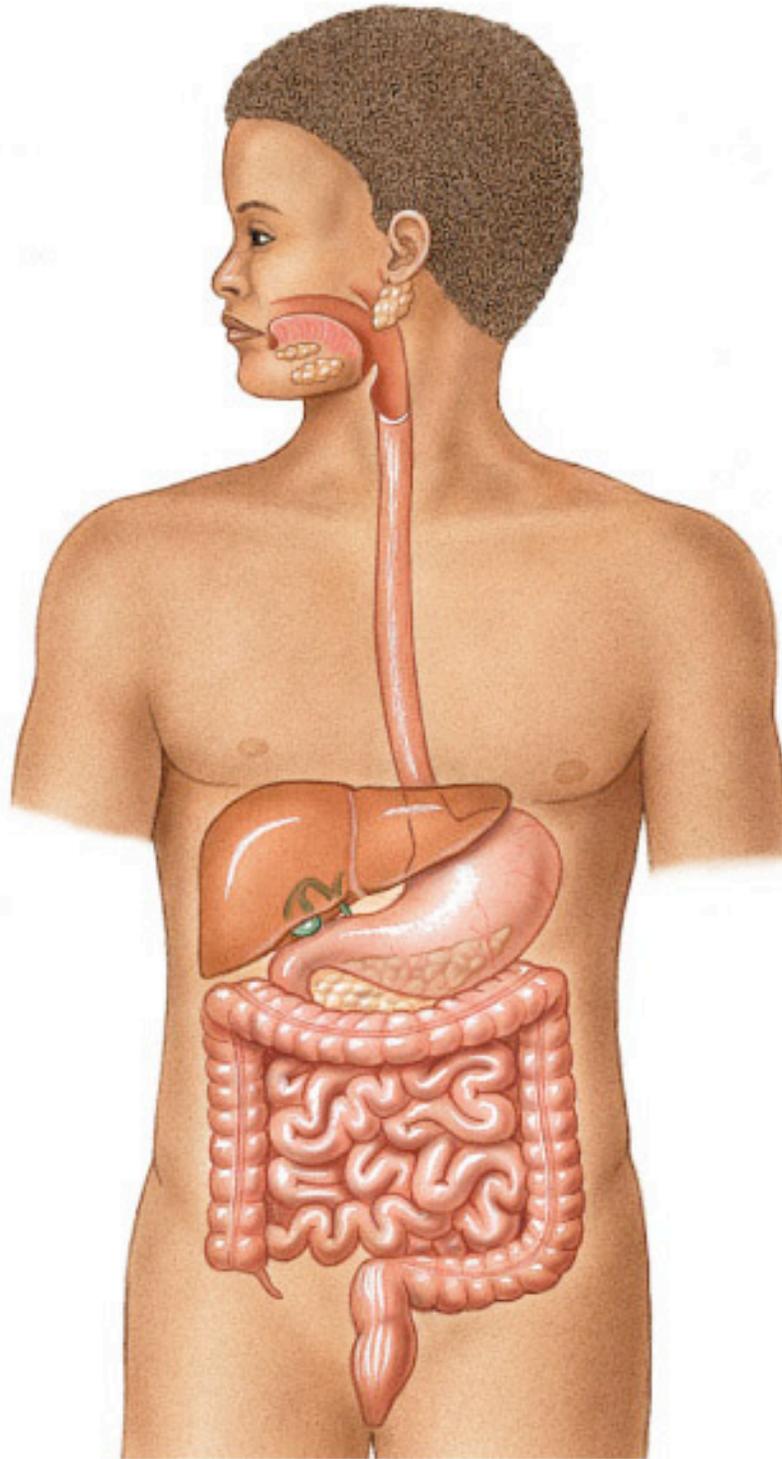


Figure 13.2. Human Digestive System