

Biology 13A Lab #13: Nutrition and Digestion

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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;
- demonstrate how nutrients are broken down in the presence of digestive enzymes; and
- explain functions of major nutrients in the body.

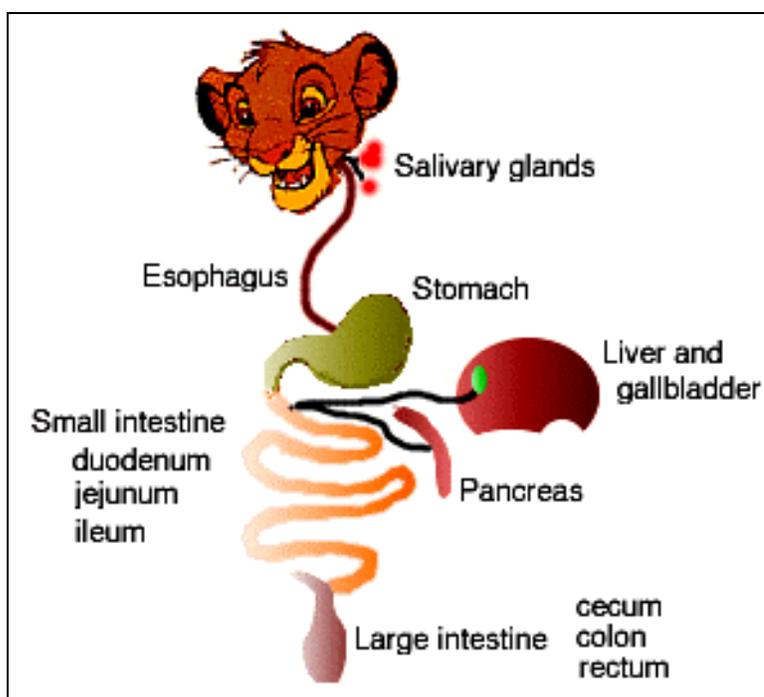


Figure 13.1 Digestive System

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, review the **structures** of the digestive system, and investigate enzymes responsible for chemical digestion.

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.

Activity 1: 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**, 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. In addition to energy storage, lipids form the basic structure

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 monosachharide, 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?

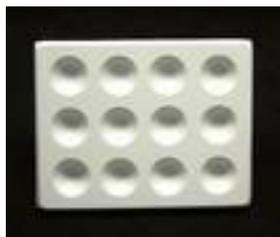
Simple chemical tests using indicators can be used to determine the presence of nutrients in food. A color change of an indicator is usually a positive test for the presence of a certain nutrient. In this experiment, you will use several indicators to test for the presence of nutrients in solutions.

Part 1: Testing Samples Where Nutrient Content is Known

In the first part of the experiment, you will determine the presence of nutrients in prepared samples where the contents are known, **at least to the teacher!** You won't know what's in them until you run the tests, then you can check to determine whether your results are accurate. We will then proceed to testing nutrient contents of a variety of foods.

Procedure

1. Obtain 4 small plastic "medicine" cups. Use a wax pencil to label them from #1 through #4, for the four samples.
2. Pour approximately 5 mL of each of the samples into the corresponding labeled cups. Use the mL marks on the cup to measure the amount.
3. Each group should obtain 1 white spot plate. Each plate has 4 columns with 3 rows (figure 13.2). Use the wax pencil to number the wells 1 through 12 from left to right (e.g. 1, 5, and 9 will be in Col. 1).



Use a plastic pipette to transfer 1 mL of Nutrient Sample #1 to each of the four wells across Row 1 of the spot plate. **Rinse the pipette.** Add 1 mL of Sample #2 to the four wells in Row #2 then **rinse.** Add 1 mL of Sample #3 to Row 3.

Figure 13.2 Spot Plate

4. Use a clean pipette to add 1-2 drops of indophenol solution to Wells #1, 5, and 9 in column 1. Indophenol is an indicator for ascorbic acid (vitamin C). If ascorbic acid is present, it will bleach the indophenol and change the color from blue to colorless. Record observations in Table 13.1. If the color changed, put a + in the appropriate column.

5. Use a clean pipette and add 1-2 drops of iodine solution to Wells #2, 6, and 10 in Column 2. Iodine is an indicator for starch. If starch is present, the mixture will change color from yellow-brown to blue-black. Record observations in Table 13.1.

6. Use a clean pipette to add 1-2 drops of Biuret reagent to Wells # 3, 7, and 11 in Column 3 of the spot plate. In the presence of protein, the mixture will change color from light blue to pinkish or purplish violet. Record observations in Table 13.1.

7. Use a clean pipette to add 1-2 drops of Sudan III to Wells #4, 8, and 12 in Column 4. Sudan III is an indicator for lipids and if they are present, the mixture will stain red. Record observations in Table 13.1.

Table 13.1 Results for Nutrient Sample Tests

	<i>Sample1</i>		<i>Sample2</i>		<i>Sample3</i>		<i>Sample4</i>	
	Color	(+/-)	Color	(+/-)	Color	(+/-)	Color	(+/-)
Indo-phenol								
Iodine Solution								
Biuret Reagent								
Sudan III								

Part 2: Testing Samples Where Nutrient Content is Not Known

Now that you know how to test for carbohydrates, proteins, Vitamin C, and lipids, we can apply the tests to some common foods to determine what nutrients they contain.

1. Thoroughly rinse the spot plate and dry it. Use a clean pipette to transfer 1 mL of Nutrient Sample #4 to each of the four wells across Row 1 of the spot plate.
2. There are food samples prepared for you to test. Each group will be assigned 1 to 2 samples.

Predict what nutrients you will find in:

Potato Chips _____

Orange Juice _____

Strawberries _____

Rice _____

Test the food samples as you did the unknown nutrient samples in steps #3-7 on pages 105-106. Record results in Table 13.2.

3. Clean Up!!!

Table 13.2 Results for Known Food Items

	<i>Potato Chip</i>	(+/-)	<i>Orange Juice</i>	(+/-)	<i>Strawberries</i>	(+/-)	<i>Rice</i>	(+/-)
	Color		Color		Color		Color	
Indo-phenol								
Iodine Solution								
Biuret Reagent								
Sudan III								

Testing Your Comprehension: Answer the following questions based on the experiment.

1. Which nutrients were identified in the unknown nutrient samples? What were the samples? Record answers in the following table.

	Sample 1	Sample 2	Sample 3	Sample 4
Nutrient(s)				
Sample I.D.				

2. Which indicators are used to detect lipids, starch, vitamin C, and proteins?
3. Which of the following do you think might test positive for the presence of all the nutrients: carbohydrates, proteins, fats, minerals, and vitamins? Circle your choice.

Corn, potatoes, olive oil, red meat, dairy products

4. What nutrients did you find when you tested potato chips, orange juice, strawberries, and rice? Did the results match your predictions?
5. Why is it important to eat a variety of foods? In your answer, refer to the results from tests of different food items.

Activity 2: 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. Get a hand-out with the diagram of the digestive system from the instructor.
2. Use the torso model to examine the parts of the system. Beginning at the mouth, follow an imaginary bite of food through the system.
3. On the diagram, place an arrow to the place where mechanical digestion occurs. What structures are involved in mechanical digestion?
4. On the diagram, place an arrow and label the place where absorption of nutrients occurs. What structures are involved?
5. On the diagram, place an arrow and label the location where most water is reabsorbed. Why is reabsorption of water important?

Activity 3: Chemical Digestion

Chemical digestion is due to enzymes that break down large food molecules to their basic components. Several organs produce enzymes that break down specific food molecules. The mouth contains **amylase**, an enzyme from saliva that breaks starches (polysaccharides) into disaccharides. Cells in the lining of the stomach produce **pepsin**, which in the presence of **hydrochloric acid** serves to break proteins into peptide chains. Chemical digestion is completed in the first part of the small intestine. Enzymes such as **lactase**, **maltase**, and **sucrase** break disaccharides into simple sugars. Polypeptide chains are further broken down to single amino acids by **trypsin** and **peptidase**. Lipids are broken into fatty acids and glycerol by **lipases**. The smaller molecules can then be absorbed by the villi of the small intestine.

Procedure

Each group needs the following:

- 1 spot plate
- pH test strips
- toothpicks
- 3 mL Albumin 2% solution
- 3 mL Biuret solution
- plastic pipettes
- Starch solution
- Amylase solution
- Corn oil
- Lipase solution 10%
- Liquid soap

Protein Digestion

1. Label the wells of a spot plate 1 through 12 with #1 to 4 going from left to right across the top row.
2. Place 5 drops of the albumin solution in wells 1 to 4, across the top.
3. To wells #2, #4 and #5, add 5 drops of hydrochloric acid. To wells #3 and #4 add 5 drops of pepsin.
4. Stir the mixture in each well using a clean toothpick. Allow the mixture in each well to remain undisturbed for 5 – 10 minutes.
5. Determine the pH in each of the wells. Dip a separate pH strip in each well and compare the color change to the pH chart provided on the package. Record results in Table 13.3.
6. Test for the presence of protein by adding 2 drops of Biuret reagent to each well. A positive test for protein is indicated by a pinkish color. In the “observations” column, write down whether the sample is a control, whether the protein is completely digested, etc.

Table 13.3 Protein Digestion Test Results

Well #	Contents	PH	Protein Test (+/-)	Observations
1	Albumin			
2	Albumin + HCl			
3	Albumin + Pepsin			
4	Albumin + Pepsin + Hydrochloric Acid			
5	Hydrochloric Acid			

Questions:

1. How could you tell that protein digestion took place?
2. Explain what may have happened in well #2 after the addition of hydrochloric acid.
3. Explain what happened after addition of pepsin in #3.
4. Explain what happened in well #4 after adding pepsin and HCl.
5. Which well showed the greatest degree of protein digestion and why?
6. Does the effect of pepsin depend on pH? Explain your answer with reference to human physiology.

Carbohydrate Digestion

1. Use a clean spot plate. Label wells 1 and 2. Place 15 drops of starch solution in the wells of the spot plate that are numbered 1 and 2.
2. To well #2, add 5 drops of amylase solution. Stir thoroughly with a toothpick and leave the mixture undisturbed for 5 to 10 minutes.
3. Test for the presence of starch (a complex carbohydrate) in the two wells. Using a clean pipette, add 1 drop IKI (potassium iodine) solution to each of the two wells. In the presence of starch, the mixture will change color from yellow-brown to blue-black.
4. Observe any color changes and record results in Table 13.4.

Table 13.4 Carbohydrate Digestion Test Results

Well #	Contents	Starch Test	Observations
1	Starch		
2	Starch & Amylase		

Questions:

1. How do you know that carbohydrate digestion has taken place? Explain the process.
2. Explain what happened in well #2 after the addition of amylase.
3. What is the purpose of well #1?

Fat Digestion

1. Clean and dry the spot plate thoroughly. Use a wax pencil to number the first three wells in the top row #1-3.
2. Place 10 drops of water and 3 drops of corn oil in the wells of the spot plate numbered 1-3.
3. Stir each well thoroughly using a toothpick.

4. Test the pH of each of the wells by dipping a pH strip in the well and comparing the color change to the pH chart provided on the package. Record the pH of each well in data table 13.5.
5. Add 5 drops of lipase solution to well #2, then add 5 drops of lipase solution and 2 drops of soap solution to well #3.
6. Stir the mixture in each well thoroughly with a toothpick and allow the spot plate to remain undisturbed for about 20 minutes.
7. After 20 minutes, test the pH in each well and record results and observations in table 13.5.

Table 13.5 Fat Digestion Test Results

Well #	Contents	pH	Observations
1	Oil and water		
2	Oil, water, and lipase		
3	Oil, water, lipase, and liquid soap		

1. What are the end products of digestion of fats? How does this relate to pH?
2. In this experiment, what data were collected? How were the data used to show that fat digestion occurred?
3. What is the role of the soap in the experiment? What substance in the body performs a similar function?
4. Which well showed the greatest amount of fat digestion? Explain why.