Carbohydrates

Carbohydrates are composed of carbon, hydrogen, and oxygen. Sugars, starches, and fiber are the main forms in which carbohydrates occur in food. Starches and sugars are the major source of body energy. They are the cheapest and most easily used form of fuel for the body. Although most carbohydrates occur in plant foods, a few are of animal origin. Carbohydrates are also good sources of fiber, which is the indigestible part of plant foods. It is nutritionally significant in gastrointestinal functioning.

Food Sources

Cereal grains and their products such as rice, wheat, barley, various bread, pastas, breakfast cereals, rye and oat. Vegetables such as potatoes, beets, peas, lima beans, and corn provide substantial amounts of carbohydrates (in the form of starch). Green leafy vegetables provide dietary fiber. Fruits provide fruit sugar and fiber. Sugars such as table sugar, syrup, and honey and sugar-rich foods such as desserts and candy.

Classification

1- Simple carbohydrates which include:

a- Monosaccharides: These are small molecules, which dissolve in water and are absorbed very quickly in the body. They are sweet, require no digestion, and can be absorbed directly into the bloodstream from the small intestine. They include glucose, fructose, and galactose.

- Glucose, also called dextrose, is the form of carbohydrate to which all other forms are converted for eventual metabolism. It is found naturally in corn syrup and some fruits and vegetables. The central nervous system, the red blood cells, and the brain use only glucose as fuel; therefore, a continuous source is needed.

- Fructose, also called levulose or fruit sugar, is found with glucose in many fruits and in honey. It is the sweetest of all the monosaccharides.

- Galactose is a product of the digestion of milk. It is not found naturally.

b- Disaccharides: These are small molecules, which dissolve in water and are absorbed very quickly in the body. They are sweet and must be changed to simple sugars by hydrolysis before they can be absorbed. Disaccharides include sucrose, maltose, and lactose.

- Sucrose is composed of glucose and fructose. It is the form of carbohydrate present in granulated, powdered, and brown sugar and in molasses. It is one of the sweetest and least expensive sugars. Its sources are sugar cane, sugar beets, and the sap from maple trees.

- Maltose is a disaccharide that is an intermediary product in the hydrolysis of starch. It is produced by enzyme action during the digestion of starch in the body. It also is created during the fermentation process that produces alcohol. It can be found in some infant formulas, malt beverage products, and beer. It is considerably less sweet than glucose or sucrose.

- Lactose is the sugar found in milk. It is distinct from most other sugars because it is not found in plants. It helps the body absorb calcium. Lactose is less sweet than monosaccharides or other disaccharides.

2- Complex carbohydrates which include:

- **Polysaccharides** they are compounds of many monosaccharides (simple sugars). Three polysaccharides are important in nutrition: starch, glycogen, and fiber.

- Starch is a polysaccharide found in grains and vegetables. It is the storage form of glucose in plants. Vegetables contain less starch than grains because vegetables have a higher moisture content. Legumes (dried beans and peas) are another important source of starch as well as of dietary fiber and protein. Starches are

more complex than monosaccharides or disaccharides, and it takes the body longer to digest them. Thus, they supply energy over a longer period of time. The starch in grain is found mainly in the endosperm (center part of the grain). This is the part from which white flour is made. The tough outer covering of grain kernels is called the bran. The bran is used in coarse cereals and whole wheat flour. The germ is the smallest part of the grain and is a rich source of B vitamins, vitamin E, minerals, and protein. Wheat germ is included in products made of whole wheat. Before the starch in grain can be used for food, the bran must be broken down. The heat and moisture of cooking break this outer covering, making the food more flavorful and more easily digested. Although bran itself is indigestible, it is important that some be included in the diet because of the fiber it provides.

- **Glycogen** is sometimes called animal starch because it is the storage form of glucose in the body. In the healthy adult, approximately one-half day's supply of energy is stored as glycogen in the liver and muscles.
- **Fibers** also called roughage, are indigestible because it cannot be broken down by digestive enzymes. It is classified as soluble or insoluble. Insoluble fibers include cellulose and hemicellulose are found in legumes, vegetables, whole grains, fruits, and seeds. Soluble fibers include pectins, gums, mucilages and some hemicellulose are found in vegetables, fruits, oats and oat bran, legumes, rye, and barley.

Table 1: Comparative Sweetness of Sugars

Sugar	Sweetness Value
Fructose	173
Invert sugar	130
Sucrose	100
Glucose	74
Galactose, Maltose	32
Lactose	16

Functions

Carbohydrates have many important functions in the body:

1. The primary function of carbohydrates in the body is to supply energy. Each gram of carbohydrate, as starch or sugar, provides 4 kcal/g. Carbohydrates are a source of readily available energy, which is needed for physical activities as also the work of the body cells. The brain and the central nervous system are dependent on the constant supply of glucose from the blood to meet their energy needs.

2. Carbohydrates act also as reserve fuel supply in the form of glycogen, stored in muscles and liver. The total amount of glycogen in the body is over 300g. But it must be maintained by regular intake of carbohydrates at frequent intervals, so that the breakdown of fat and protein tissue is prevented.

3. Carbohydrates serve other special functions in the body. Carbohydrates provide chemical framework, which combine with the nitrogen to synthesize non-essential amino acids in the body.

4. Carbohydrates and their derivatives work as precursors of important metabolic compounds. These include nucleic acids, the matrix of connective tissue and galactosides of nerve tissue.

5. Lactose, the milk sugar, provides galactose needed for brain development. It aids absorption of calcium and phosphorus, thus helping bone growth and maintenance.

6. Lactose forms lactic acid in the intestinal track due to the action of the bacteria (lactobacilli) present there. These lactobacilli synthesize some of the B-complex vitamins. It aids, bacteria (lactobacilli) present to suppress the activities of putrefactive bacteria and protects us from their undesirable effects.

7. Carbohydrates are an important part of some compounds, which increase our resistance to infection (immunopolysaccharides). Ribose, a five carbon sugar, is an essential part of DNA and RNA. Carbohydrates are a part of important compounds, which are components of nervous tissue (galactolipid), heart valve, cartilage, bone and skin (chondroitin sulfate).

8. Carbohydrates are needed for ensuring complete normal metabolism of fats, thus preventing ketoacidosis.

9. Carbohydrates are needed to prevent dehydration. A low carbohydrate diet causes loss of water from tissues as also electrolytes (especially sodium and potassium) in the urine and can lead to involuntary dehydration.

10. Dietary fiber acts like a sponge and absorbs water. It helps smooth movement of food waste through the digestive tract and the soft, bulky stools are comfortably eliminated.

Digestion and Absorption

Monosaccharides are simple sugars that may be absorbed from the intestine directly into the bloodstream. They are subsequently carried to the liver, where fructose and galactose are changed to glucose, the blood then carries glucose to the cells. Disaccharides are require an additional step of digestion. They must be converted to the simple sugar glucose before they can be absorbed into the bloodstream. This conversion is accomplished by the enzymes amylase, maltase, and lactase. Polysaccharides are more complex, and their digestibility varies. After the cellulose wall is broken down, starch is changed to the intermediate product dextrin; it is then changed to maltose and finally to glucose. Cooking can change starch to dextrin. For example, when bread is toasted, it turns golden brown and tastes sweeter because the starch has been changed to dextrin. The digestion of starch begins in the mouth, where the enzyme salivary amylase begins to change starch to dextrin. The second step occurs in the stomach, where the food is mixed with gastric juices. The final step occurs in the small intestine, where the digestible carbohydrates are changed to simple sugars by the enzyme action of pancreatic amylase and are subsequently absorbed into the blood.

Metabolism and Elimination

All carbohydrates are changed to the simple sugar glucose before metabolism can take place in the cells. After glucose has been carried by the blood to the cells, it can be oxidized. Frequently, the volume of glucose that reaches the

cells exceeds the amount the cells can use. In these cases, glucose is converted to glycogen and is stored in the liver and muscles. (Glycogen is subsequently broken down only from the liver and released as glucose when needed for energy.) When more glucose is ingested than the body can either use immediately or store in the form of glycogen, it is converted to fat and stored as adipose (fatty) tissue. The process of glucose metabolism is controlled mainly by the hormone **insulin,** which is secreted by the **islets of Langerhans** in the pancreas and which maintains normal blood glucose at 70–110 mg/dl. When the secretion of insulin is impaired or absent, the glucose level in the blood becomes excessively high. This condition is called **hyperglycemia** (blood glucose more than 126 mg/dl) and is usually a symptom of diabetes mellitus. When blood glucose levels are unusually low, the condition is called **hypoglycemia** (blood glucose less than 70 mg/dl). A mild form of hypoglycemia may occur if one waits too long between meals or if the pancreas secretes too much insulin. Symptoms include fatigue, shaking, sweating, and headache.

Proteins

The name protein is derived from the Greek term proteos, which means "primary" or "to take place first." Protein was first identified in a laboratory about a century ago at which time scientists described it as a nitrogen-containing part of food that is essential to human life. Protein content reaches in the adult level of about 18% of body weight. Proteins contain carbon, hydrogen, and oxygen, but in different proportions. In addition, and most important, they are the only nutrient group that contains nitrogen, and some contain sulfur.

Amino acids

Proteins are composed of chemical compounds called **amino acids** which are sometimes called the building blocks of protein because they are combined to form the thousands of proteins in the human body. All amino acids have the same basic design, there is both a nitrogen-containing amino portion and carboxylic acid portion attached to a central carbon atom. There are probably hundreds of

different amino acids found in nature, but only **twenty** are incorporated into the proteins found in living things (Table 1).

Table 1. An amino acids

Essential Amino Acids that body cannot synthesize so must be obtained through food	**Nonessential Amino Acids that body can manufacture with enough amount**
Tryptophan	Alanine
Valine	Proline
Threonine	Tyrosine
Isoleucine	Cysteine
Leucine	Serine
Lysine	Glutamine
Phenylalanine	Glutamic acid
Methionine	Glycine
Arginine*	Asparagine
Histidine*	Aspartic acid

*** Essential during childhood.**

Scientists often refer to the links of amino acids in the following manner:

- **Peptides are 2 to 10 amino acids including dipeptides, tripeptides, etc.**
- **Polypeptides are 11 to 100 amino acids.**
- **Proteins are over 100 amino acids.**

Other scientists will describe protein size based on the weight of the protein molecule (molecular weight) and sometimes use the term **Daltons** as a unit of weight.

Food Sources

Proteins are found in both animal and plant foods. The animal food sources provide the highest quality of **complete proteins:** proteins that contain all the essential amino acids such as meats, fish, poultry, eggs, milk, and cheese. Despite the high biologic value of proteins from animal food sources, they also provide

saturated fats and cholesterol. The plant food sources provide the highest quality of **incomplete proteins:** proteins that lack one or more of the essential amino acids such as lentil, peas, soybeans, corn, grains and nuts.

Functions

1- Proteins can provide energy each gram of protein provides 4 calories.

2- Proteins build and repair body tissue, play major roles in regulating various body functions, and provide energy if there is insufficient carbohydrate and fat in the diet.

3- Proteins is build and repair body tissues, this is made possible by the provision of the correct type and number of amino acids in the diet. Also, as cells are broken down during metabolism (catabolism), some amino acids released into the blood are recycled to build new and repair other tissue (anabolism).

4-Proteins are important components of hormones and enzymes that are essential for the regulation of metabolism and digestion. Proteins help maintain fluid and electrolyte balances in the body.

References

- Schiff, W., J. The Nutrition for Healthy Living. 2nd ed., 2011. The McGraw-Hill Companies, Inc.
- Roth, R., A. Nutrition and Diet Therapy. 10th ed., 2011. Cengage Learning com.