Carbohydrates, Proteins, and Lipids

Carbohydrates

Carbohydrates should account for the largest portion of a healthy diet. Their predominant role is providing an efficient source of energy in the form of glucose. Including adequate amounts in the diet is vital for peak performance in cells and tissues, especially red blood cells and the central nervous system. Other tissues can use fat as an energy source, but if carbohydrate intake is very low, body protein will be converted to glucose for these cells to function. This leads to the second function of carbohydrates: protecting body protein from being used as fuel. In fact, even if fat is utilized as the main source of energy, carbohydrates are needed to help the body burn fat efficiently. Carbohydrates are a component in the formation of collagen (the body’s major form of connective tissue), are required for the production of certain hormones and enzymes, and are a part of genetic structure (specifically the helix structure of DNA and RNA).

Categories, Classifications, and Sources

Nutrition professionals stress that everyone should consume more complex carbohydrates and limit consumption of simple carbohydrates. The terms complex and simple are categories that divide carbohydrates into sugars and starches and fiber based on the carbohydrates’ impact on blood sugar levels and nutrient content. Simple carbohydrates include single sugars (monosaccharides) and two-sugar units (disaccharides) that are in high concentrations in fruits and honey. Sugars added to products, such high-fructose corn syrup and brown and white sugars also qualify as simple carbohydrates. Polysaccharides (starches and fibers) fall in the complex category. Good sources of complex carbohydrates include whole grains, vegetables, beans, and legumes.

Monosaccharide

Mono means “one,” and saccharides are sugars. Thus, the monosaccharide’s glucose, fructose, and galactose are single sugars. Chemically, these sugars are comprised of carbon, hydrogen, and oxygen, arranged in differently shaped, five carbon rings. Glucose provides the most efficient source of fuel for the body and is commonly measured in blood sugar. Prevalent in food, glucose can be found as a monosaccharide, or as a part of all three disaccharides. When used as a sweetener or bulking agent in processed food, glucose goes by the name of dextrose. Fructose strikes the highest sweet note with taste buds of all of the monosaccharides. Fruits and honey are raw sources of fructose, but it is also found in many commercially sweetened products in the form of high-
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fructose corn syrup. Galactose is rarely found as a monosaccharide in food or nature. It is a component of lactose, or milk sugar.

Disaccharides

When monosaccharides link up, they form two-sugar molecules known as disaccharides. Commonly thought of as table sugar (but also found in fruits and vegetables) sucrose is the result of glucose joining with fructose. When two glucose units connect, the end product is the disaccharide maltose. The only place maltose is seen in nature is as an energy source for emerging plant sprouts. It is utilized in the fermentation of alcoholic beverages, and traces can be found in corn syrup. But maltose is not encountered in detectable amounts in other foods. Lactose is the product of a glucose and galactose bond, and is considerably less sweet than sucrose and maltose.

Polysaccharides

Poly means many. In the case of carbohydrates, glucose units numbering in the hundreds (or even thousands) can join to form chains known as starches. Amylose and amylopectin, the major types of starch in diets, originate in plants and appear very different. Amylose chains are linear, whereas amylopectin chains split into offshoots that resemble tree branches. Plants store energy as starch, but humans and animals also keep carbohydrates as an energy reserve. Mainly in liver and muscle tissue, carbohydrates are tucked away as glycogen. Like amylopectin, glycogen is highly branched to pack away as much glucose in as compact a space as possible. Even so, carbohydrate energy stores in the body are very limited, providing about the equivalent of one day’s worth of kilocalories.

Although humans don’t produce the enzyme to digest fiber, it still provides a variety of health benefits. Insoluble fiber comes from the woody parts of plants and provides bulk to fecal material, making it easier to move through the colon. This type of fiber helps prevent weaknesses in the colon wall, known as diverticula, which can become inflamed if food gets trapped in them. Insoluble fiber is sticky and is able to bind some of the cholesterol in food, preventing it from being absorbed back into the body. This is one of the mechanisms by which fiber can help lower blood lipid levels. Soluble fiber also encourages the growth of beneficial bacteria that enhances intestinal health and produces vitamin K. Both types of fiber lengthen the amount of time it takes for food to traverse the gastrointestinal (GI) tract, slowing the rise of blood sugar and providing satiety, which helps manage blood glucose levels in diabetics and
promotes weight loss.

**Artificial Sweeteners**

Artificial sweeteners are lab-created molecules that are regulated by the U.S. Food and Drug Administration and used to sweeten foods without the added calories or impact on blood glucose levels of sugar (Drummond & Brefere, 2010). There are currently five products on the market that fall into this category, with the first being saccharine.Introduced in 1879, saccharine is 300 times as sweet as sugar and was a boon to food manufacturers during wars, when sugar was in short supply. Not recognized as carbohydrate by the body, saccharine is packaged up in urine and excreted. Saccharine has a troubled history based on a 1977 animal study in which saccharine consumption in rats was associated with bladder tumors. Immediately pulled from grocery store shelves, saccharine was not reintroduced until 2000 upon recognition of major design flaws in the 1977 study.

Aspartame is the result of two bonded amino acids—aspartic acid and phenylalanine—and is 180 times as sweet as sugar. It is not suitable for use in cooking because heat denatures the amino acids causing a loss in sweetness. Because it contains phenylalanine, it is also mandated to carry a warning label for people with an inborn error of metabolism known as phenylketonuria (PKU). Acesulfame-potassium (K) is usually blended with aspartame in diet soft drinks (Drummond & Brefere, 2010). Sucralose is a tweaked sucrose molecule with 600 times the sweetness of sugar. Sucralose passes through the GI tract undigested.

**Proteins**

Protein is the only nutrient that contains the element nitrogen. Comprised of long chains of amino acids, protein functions as a major component of all tissues in the body. In transportation mode, protein delivers fats, vitamins, and minerals to cells. As a solute in blood, protein helps to keep fluids inside and outside of cells in balance. Its ability to either donate an electron or take one up makes it a perfect buffer to maintain proper blood pH levels. Protein is required to build hormones, enzymes, and antibodies. Protein can even be converted to glucose if the diet does not provide enough in a process called gluconeogenesis.

**Quality**

Protein can be found in foods of both plant and animal origin. However, the
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Amino acids present determine the quality of the source. There are 20 dietary amino acids, of which 9 are essential. A high-quality source, or complete protein, supplies all essential amino acids in the amount required for a serving. Animal protein is a complete protein. Most plant sources are low in at least one essential amino acid. In vegetarian diets, combining foods that have a complimentary amino acid profile is necessary to ensure that needs are met for all essential amino acids.

Lipids

Dietary fats and oils are part of a greater class of compounds known as lipids. Lipids will not dissolve in water but require organic solutions, including other lipids. Energy-rich lipids provide 9 kilocalories per gram, rather than 4 kilocalories per gram like carbohydrates and protein.

Functions

Lipids rival protein when it comes to functions they perform in the body. Lipids, which are stored in adipose or fat cells, provide a source of energy when calories in the diet are not adequate to meet needs, help retain core temperature by insulating and trapping heat, protect organs from damage, and carry fat-soluble vitamins. Lipids are constituents of cell membranes that provide both structure and flexibility, and are required to manufacture several hormones.

Classes

The linkage of three fatty acids with a glycerol molecule forms a triglyceride. Triglycerides are found in both fats and oils. The different physical properties of each are determined by the length and saturation of the fatty acids incorporated. Oils are comprised of mostly long-chained fatty acids that are unsaturated, meaning that there is at least one double bond between carbons in the chain. Olive and canola oils contain a high concentration of monounsaturated fatty acids. Excellent sources of polyunsaturated fatty acids, those containing two or more double bonds between carbons, include other vegetable oils like corn, sunflower, or safflower oils. Polyunsaturated fatty acids promote heart health by lowering blood cholesterol levels.

Because the body can’t produce two polyunsaturated fatty acids, they must be derived from the diet. Omega-3 fatty acids are found in fatty fish like salmon, mackerel, anchovies, and sardines. Plant sources include flax and grape seed
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oils. Omega-6 fatty acids are plentiful in vegetable oils.

Foods of animal origin, like butter or the marbling in meat, supply most of the saturated fatty acids in the American diet. Dense and firm in moderate temperatures, these fatty acids have a short carbon chain and no double bonds. Diets high in saturated fatty acids increase the risk of heart disease by increasing blood lipid levels.

**Phospholipids**

Their unique ability to bring lipids and water together is the reason phospholipids are part of the bilipid layer of cell membranes and aid in fat digestion. The molecule’s phosphate group is highly attracted to water, whereas the fatty acid tails are drawn to lipids. When incorporated in cell membranes, the fatty acid tails come together to make a barrier that keeps intra- and extracellular fluids in balance. As a component in bile, phospholipids break large droplets of fat into small ones to allow enzymes to complete digestion.

**Sterols**

Cholesterol, found only in foods from animal sources, is the main dietary contributor from the sterol group. Synthesis of many hormones, bile acids, and vitamin D requires cholesterol, and it is a structural component for cell membranes. Produced in the liver, cholesterol is not considered an essential nutrient.

**Trans Fatty Acids**

Most dietary trans fatty acids are the result of a process known as *hydrogenation*, which converts oils to semisolids. Like saturated fats, trans fats increase blood lipid levels, particularly LDL, the “bad cholesterol.” However, trans fats go a step farther than saturated fats by lowering HDL, the “good cholesterol.”

**Reference**