SBCH322: UNIT 3

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Important notice

The questions and answers provided in this file are only for students' practice purposes. The intention of providing this information is purely to educate and make students aware of the correct way of answering the questions. All the sources used in the preparation of this material are properly cited at the end of this document. Students are requested not to regard this material as a reference, but as guidance on how to answer questions. However, ultimately the onus rests on the student to work hard and to read the books and other material on the topics listed in the module.

1. What are macronutrients?

Nutrients that are needed in large quantities are known as macronutrients for normal function and good health. These are also energy-yielding nutrients, meaning these nutrients provide calories. Carbohydrates, fats and proteins are macronutrients.

2. Carbohydrates

A carbohydrate is a biomolecule consisting of carbon (C), hydrogen (H) and oxygen (O) atoms, usually with a hydrogen–oxygen atom ratio of 2:1 (as in water); in other words, with the empirical formula $C_m(H_2O)_n$ (where m may be different from n). 1 gram of carbohydrate generates 4 kilocalories of energy.

Carbohydrates are critical to support life's most basic function—the production of energy. Without energy none of the other life processes are performed. Although our bodies can synthesize glucose it comes at the cost of protein destruction. As with all nutrients though, carbohydrates are to be consumed in moderation as having too much or too little in the diet may lead to health problems.

2.1. Types of carbohydrates

There are various types of carbohydrate. They include monosaccharides, disaccharides, and polysaccharides. Monosaccharides and disaccharides are considered as simple carbohydrates whereas polysaccharides considered as complex carbohydrates.

2.1.1. Simple carbohydrates may be single sugar molecules called monosaccharides or two monosaccharides joined together called disaccharides. Glucose, a monosaccharide, is the most abundant sugar molecule and is the preferred energy source for the brain. It is a part of all disaccharides and the only component of polysaccharides. Fructose is another common monosaccharide. Two common disaccharides in food are sucrose, common table sugar, and lactose, the source of frequent gas and bloating that some experience from drinking milk.

2.1.2. Complex carbohydrates are any that contain more than two sugar molecules. Short chains are called oligosaccharides. Chains of more than ten monosaccharides linked together are called polysaccharides. They may be hundreds and even thousands of glucose molecules long. The way glucose molecules link together makes them digestible (starch) or non-digestible (fiber). Polysaccharides include the following.

- Starch is a series of long chains of bound glucose molecules. It's the storage form of glucose for grains, tubers and legumes and is used during the plant's growth and reproduction.

- Fiber is also long chains of glucose molecules, but they are bound in a way we cannot digest.
- Glycogen is the storage form of glucose in humans and other animals. It's not a dietary source of carbohydrate because it is quickly broken down after an animal is slaughtered.

2.2 Five primary functions of carbohydrates in the human body

There are five primary functions of carbohydrates in the human body. They are energy production, energy storage, building macromolecules, sparing protein, and assisting in lipid metabolism.

2.2.1. Energy Production

The primary role of carbohydrates is to supply energy to all cells in the body. Many cells prefer glucose as a source of energy versus other compounds like fatty acids. Some cells, such as red blood cells, are only able to produce cellular energy from glucose. The brain is also highly sensitive to low blood-glucose levels because it uses only glucose to produce energy and function (unless under extreme starvation conditions). About 70 percent of the glucose entering the body from digestion is redistributed (by the liver) back into the blood for use by other tissues. Cells that require energy remove the glucose from the blood with a transport protein in their membranes. The energy from glucose comes from the chemical bonds between the carbon atoms.

2.2.2. Energy Storage

If the body already has enough energy to support its functions, the excess glucose is stored as glycogen (the majority of which is stored in the muscle and liver). A molecule of glycogen may contain in excess of fifty thousand single glucose units and is highly branched, allowing for the rapid dissemination of glucose when it is needed to make cellular energy.

2.2.3. Building Macromolecules

Although most absorbed glucose is used to make energy, some glucose is converted to ribose and deoxyribose, which are essential building blocks of important macromolecules, such as RNA, DNA, and ATP. Glucose is additionally utilized to make the molecule NADPH, which is important for protection against oxidative stress and is used in many other chemical reactions in the body. If all of the energy, glycogen-storing capacity, and building needs of the body are met, excess glucose can be used to make fat. This is why a diet too high in carbohydrates and calories can add on the fat.

2.2.4. Sparing Protein

In a situation where there is not enough glucose to meet the body's needs, glucose is synthesized from amino acids. Because there is no storage molecule of amino acids, this process requires the destruction of proteins, primarily from muscle tissue. The presence of adequate glucose basically spares the breakdown of proteins from being used to make glucose needed by the body.

2.2.5. Fat-sparing effect

As blood-glucose levels rise, the use of lipids as an energy source is inhibited. Thus, glucose additionally has a "fat-sparing" effect. This is because an increase in blood glucose stimulates release of the hormone insulin, which tells cells to use glucose (instead of lipids) to make energy.

2.2.6. Preventing ketosis

Even when fat is used for fuel, the cells need a bit of carbohydrate to completely break it down. Otherwise, the liver produces ketone bodies, which can eventually build up to unsafe levels in the blood causing a condition called ketosis. Ketosis is a metabolic condition resulting from an elevation of ketone bodies in the blood. Ketone bodies are an alternative energy source that cells can use when glucose supply is insufficient, such as during fasting. Ketone bodies are acidic and high elevations in the blood can cause it to become too acidic. Adequate glucose levels in the blood also prevent the development of ketosis.

3. Proteins

Proteins are large biomolecules, or macromolecules, consisting of one or more long chains of amino acid residues. A linear chain of amino acid residues is called a polypeptide. A protein contains at least one long polypeptide. Short polypeptides, containing less than 20–30 residues, are rarely considered to be proteins and are commonly called peptides, or sometimes oligopeptides. 1 gram of protein generates 4 kilocalories of energy. Proteins perform important functions in organisms. In fact, this class of molecules is found in every cell and is essential for life.

There are many different types of proteins in our bodies. They all serve important roles in our growth, development and everyday functioning. Here are some examples:

- **Some proteins are enzymes**. Enzymes speed up chemical actions such as the digestion of carbohydrates or the synthesis of cholesterol by the liver. They increase the rate of chemical reactions so much that not having them because of a genetic defect can be catastrophic.
- **Some proteins are hormones**. Hormones are chemicals that are created in one part of the body and carry messages to another organ or part of the body. For example, both glucagon and insulin are hormones that are made in the pancreas and travel throughout the body to regulate blood glucose.
- **Some proteins provide structure**. The protein collagen gives structure to bones, teeth and skin. Hair and nails depend on keratin.

- **Some proteins are antibodies**. Without adequate protein, your immune system cannot properly defend you against bacteria, viruses and other invaders. Antibodies are the blood proteins that attack and neutralize these invaders.
- **Proteins maintain fluid balance**. Fluid is present in many compartments of your body. It is within the cells (intracellular fluid), in the blood (intravascular fluid) and between the cells (interstitial fluid). Fluids also flow between these spaces. It's the proteins and minerals that keep them in balance. Proteins are too large to pass freely across the membranes separating the compartments, but since proteins attract water, they act to maintain proper fluid balance. If your protein intake is too low to maintain normal blood protein levels, fluid will leak into the surrounding tissues and cause swelling called edema.
- **Proteins transport nutrients and other compounds**. Some proteins sit inside your cell membranes pumping compounds in and out of the cell. Others attach themselves to nutrients or other molecules to transport them to distant parts of the body. Hemoglobin, which carries oxygen, is one such protein.
- **Proteins maintain acid-base balance**. Blood that is too acidic or too alkaline will kill you. Fortunately, the body regulates its acid-base balance very tightly. One mechanism uses proteins as buffers. Proteins have negative charges that pick up positively charged hydrogen ions when conditions are too acidic. Hydrogen ions can then be released when the blood is too alkaline. To illustrate the dire consequences of an acid-base imbalance, think about what happens to proteins in an environment too acid or alkaline. They get denatured which changes their shape and renders them useless. Hemoglobin, for example, would not be able to carry oxygen throughout your body.
- **Protein is a backup source of energy**. With so many jobs, you can see why protein is not used as a primary source of energy. But rather than allowing your brain to go without glucose in times of starvation or low carbohydrate intake, the body sacrifices protein from your muscles and other tissues or takes it from the diet (if available) in order to make new glucose from amino acids in a process called gluconeogenesis.

4. Fats

Fat is one of the three main macronutrients, along with carbohydrate and protein. Fats, also known as triglycerides, are esters of three fatty acid chains and the alcohol glycerol. 1 gram of fat generates 9 kilocalories of energy. Fat is an important foodstuff for many forms of life and fats serve both structural and metabolic functions. They are a necessary part of the diet of most heterotrophs (including humans). Some fatty acids that are set free by the digestion of fats are called essential because they cannot be synthesized in the body from simpler constituents. There are two essential fatty acids (EFAs) in human nutrition: alpha-linolenic acid (an omega-3 fatty acid) and linoleic acid (an omega-6 fatty acid). Other lipids needed by the body can be synthesized from these and other fats.

Role of fats in human body

- **Fats are an energy reserve.** Your body can store just small amounts of glucose as glycogen for energy, but you can put away unlimited amounts of energy as fat tissue. This is a problem in our world of excess calories, but was necessary in earlier times when food was scarce. You'll use this stored energy while you're sleeping, during periods of low energy intake and during physical activity.

- **Fats provide essential fatty acids (EFA).** Fatty acids differ chemically by the length of their carbon chains, the degree of saturation (how many hydrogen atoms are bound to carbon) and the location of carbon-carbon double bonds. These are critical differences that give each fatty acid unique functions. Our bodies are amazing machines capable of producing most of the needed fatty acids. There are two fatty acids that it cannot make at all, however. They are called LA (linoleic acid) and ALA (alpha linolenic acid). This makes LA and ALA "essential", meaning they must be obtained through the diet. In the body, fatty acids are important constituents of cell membranes, and they are converted to chemical regulators that affect inflammation, blood clotting, blood vessel dilation and more. Clinical deficiencies are rare. A deficiency of LA is usually seen in people with severe malabsorption problems. Its symptoms are poor growth in children, decreased immune function, and a dry, scaly rash. In the few cases of ALA deficiency that doctors and researchers are aware of, the symptoms were visual problems and nerve abnormalities.

- **Fats carry fat-soluble nutrients.** Dietary fats dissolve and transport fat-soluble nutrients, such as some vitamins and also disease-fighting phytochemicals like the carotenoids alpha- and beta-carotene and lycopene. To illustrate, researchers were able to detect only negligible amounts of absorbed carotenoids in the blood of individuals who had eaten a tossed salad with fat-free salad dressing. With reduced-fat dressing, the study participants absorbed some carotenoids, but with full-fat dressing, they absorbed even more.

- **Fats add to the texture and flavor of foods.** You already know that fat makes food taste good. That's partly because fats dissolve flavorful, volatile chemicals. They also add a rich, creamy texture, giving food a satisfying mouthfeel. Imagine the texture of fat-free chocolate. Not good, probably. Finally, fats provide a tenderness and moistness to baked goods.

5. Foods contains high amount of carbohydrates, proteins and fats

Simple sugar is the most basic carbohydrate found in fruits, vegetables and dairy products. Starch is made up of more than one sugar unit bound together and is found in whole grains, vegetables and beans. Dietary fiber is the carbohydrate found in plants that passes through the intestines undigested. It is present in fruits, vegetables, legumes, nuts, seeds and whole grains.

Protein is found in varying amounts in meat, poultry, fish, dairy, eggs, legumes, vegetables, tofu, nuts, seeds and some grains. Fats are broken down into three main categories, saturated, unsaturated and trans-fats. Saturated fats include foods such as meat, butter, lard and cream and are known to raise LDL, or bad cholesterol, levels. Unsaturated or healthy fats help to lower blood cholesterol. There are two types of unsaturated fats, mono and poly. Monounsaturated fats are found in olive and canola oil while polyunsaturated fats are found in sunflower, safflower, corn and soybean oils as well as in avocados, nuts and fatty fish such as salmon, herring and trout. Trans-fats are found primarily in fried foods, snack foods and commercial baked goods. These fats have been found to increase your risk of developing heart disease.

Sources:

Video sources

Basic Nutrition and Macro - Nutrients Video Animation by Train With Kane:
https://www.youtube.com/watch?v=cKRf53I737E
Macros: Explained! Mind Over Munch Kickstart 2016
https://www.youtube.com/watch?v=7HXkkanqPKA
What are Macronutrients?
https://www.youtube.com/watch?v=9Jnz-Ix1GPg
Carbohydrates
https://www.youtube.com/watch?v=LeOUIXbFyqk
Proteins
https://www.youtube.com/watch?v=AUMJwjLXh1M
Lipids
https://www.youtube.com/watch?v=5BBYBRWzsLA
Nutrition 1 - Carbohydrates, Proteins and Fats
https://www.youtube.com/watch?v=jqrVl4V5ttQ

Textual source

http://www.innerbody.com/nutrition/macronutrients
https://www.runtastic.com/blog/en/what-are-macronutrients/
https://www.medicalnewstoday.com/articles/161547.php
https://en.wikipedia.org/wiki/Carbohydrate
https://2012books.lardbucket.org/books/an-introduction-to-nutrition/s08-03-the-functions-of-carbohydrates.html
https://www.sciencelearn.org.nz/resources/209-role-of-proteins-in-the-body