COURSE CODE: FSM 201

COURSE TITLE: Introduction to Food and Nutrition

NUMBER OF UNITS: 2 Units

COURSE DURATION: Two hours per week

COURSE DETAILS:

Course Coordinator: **Dr. (Mrs) M.O. Adegunwa** *B.Sc., M.Sc., MBA, PGDE, PhD*
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Other Lecturers:

COURSE CONTENT:

Definition and history of the science of nutrition; carbohydrates, fats, proteins, vitamins, minerals, water, cellulose, their sources, digestion, absorption of products and roles in the body function. Introduction to nutrient requirements and deficiencies.

COURSE REQUIREMENTS:

This is a compulsory course for students in the department of Foodservice and Tourism. In view of this, students are expected to participate in all the course activities and have minimum of 75% attendance to be able to write the final examination.

READING LIST:

1. Carbohydrates. Nutrition Source, Harvard School of Public Health. http://www.hsph.harvard.edu/nutritionsource/what-should-you-eat/carbohydrates-full-story/index.html

2. Food and Nutrition Board, National Academy of Sciences. Recommended Dietary Allowances, revised 1945. National Research Council, Reprint and Circular Series, No. 122, 1945 (Aug), p. 3-18.

3. Present knowledge in Nutrition, 8th edition. Edited b Barbara A. Bowman and Robert M. Rusell.

4. Perspective in Nutrition, 3rd edition by G.M Wardlaw and Paul Insel.

LECTURE NOTES

NUTRITION

The process of nourishing or being nourished, especially the process by which a living organism assimilates food and uses it for growth and for replacement of tissues.
Processes of taking in and utilizing food substances. Food generates energy and supplies materials used in body tissues and processes. Calories are supplied by carbohydrates (sugars and starches), fats, and proteins. Other nutrients include minerals, vitamins, and dietary fibre. Minerals are used in many ways — iron for hemoglobin; calcium for bones, teeth, and cellular processes; sodium and potassium to regulate homeostasis, iodine to produce thyroid hormones. Trace minerals have functions that are less well-understood. Fibre is not broken down chemically in the body but aids digestion, lowers blood cholesterol, and may help prevent some cancers and hypertension. Different amounts of these nutrients exist in different foods; a varied diet ensures an adequate supply. Nutritional supplements, required by some people, do not compensate for an unhealthy diet. Sufficient water is always essential. Inadequate nutrient intake or absorption leads to malnutrition and disease.

Nutrition (also called **nourishment** or **aliment**) is the provision, to cells and organisms, of the materials necessary (in the form of food) to support life. Many common health problems can be prevented or alleviated with a healthy diet.

The diet of an organism is what it eats, which is largely determined by the perceived palatability of foods. Dietitians are health professionals who specialize in human nutrition, meal planning, economics, and preparation. They are trained to provide safe, evidence-based dietary advice and management to individuals (in health and disease), as well as to institutions.

Overview

Nutrition science investigates the metabolic and physiological responses of the body to diet. With advances in the fields of molecular biology, biochemistry, and genetics, the study of nutrition is increasingly concerned with metabolism and metabolic pathways: the sequences of biochemical steps through which substances in living things change from one form to another.

Nitrogen is needed by animals to build proteins. Carnivore and herbivore diets vary in their source of nitrogen, which is a limiting nutrient for both. Herbivores consume plants to get nitrogen and carnivores consume other animals to obtain nitrogen.[1] Nitrogen is a common element in the atmosphere but exists in a state that is not usable by most living organisms. Certain fungi and bacteria are able to convert atmospheric nitrogen into a form plants can adsorb and utilize.

The human body contains chemical compounds, such as water, carbohydrates (sugar, starch, and fiber), amino acids (in proteins), fatty acids (in lipids), and nucleic acids (DNA and RNA). These compounds in turn consist of elements such as carbon, hydrogen, oxygen, nitrogen, phosphorus, calcium, iron, zinc, magnesium, manganese, and so on. All of these chemical compounds and elements occur in various forms and combinations (e.g. hormones, vitamins, phospholipids, hydroxyapatite), both in the human body and in the plant and animal organisms that humans eat.

The human body consists of elements and compounds ingested, digested, absorbed, and circulated through the bloodstream to feed the cells of the body. Except in the unborn fetus, which receives processed nutrients from the mother, the digestive system is the first system involved in breaking down food prior to further digestion. Digestive juices, excreted into the lumen of the gastrointestinal tract, break chemical bonds in ingested molecules, and modulate their conformations and energy states. Though some molecules are absorbed into the bloodstream unchanged, digestive processes release them from the matrix of foods. Unabsorbed matter, along with some waste products of metabolism, is eliminated from the body in the feces.

Studies of nutritional status must take into account the state of the body before and after experiments, as well as the chemical composition of the whole diet and of all material excreted and eliminated from the body (in urine and feces). Comparing the food to the waste can help determine the specific compounds and elements absorbed and metabolized in the body. The effects of nutrients may only be discernible over an extended period, during which all food and waste must be analyzed. The number of variables involved in such experiments is high, making nutritional studies time-consuming and expensive, which explains why the science of human nutrition is still slowly evolving.

In general, eating a wide variety of fresh, whole (unprocessed), foods has proven favorable for one's health compared to monotonous diets based on processed foods.

In particular, the consumption of whole-plant foods slows digestion and allows better absorption, and a more favorable balance of essential nutrients per Calorie, resulting in better management of cell growth, maintenance, and mitosis (cell division), as well as better regulation of appetite and blood sugar.[2] Regularly scheduled meals (every few hours) have also proven more wholesome than infrequent or haphazard ones,[3] although a recent study has also linked more sfrequent meals with a higher risk of colon cancer in men.[4]

Nutrients

There are six major classes of nutrients: carbohydrates, fats, minerals, protein, vitamins, and water.

These nutrient classes can be categorized as either macronutrients (needed in relatively large amounts) or micronutrients (needed in smaller quantities). The macronutrients include carbohydrates, fats, protein, and water. The micronutrients are minerals and vitamins.

The macronutrients (excluding water) provide structural material (amino acids from which proteins are built, and lipids from which cell membranes and some signaling molecules are built), energy. Some of the structural material can be used to generate energy internally, and in either case it is measured in Joules or kilocalories (often called "Calories" and written with a capital *C* to distinguish them from little 'c' calories). Carbohydrates and proteins provide 17 kJ approximately (4 kcal) of energy per gram, while fats provide 37 kJ (9 kcal) per gram.,[5] though the net energy from either depends on such factors as absorption and digestive effort, which vary substantially from instance to instance. Vitamins, minerals, fiber, and water do not provide energy, but are required for other reasons. A third class of dietary material, fiber (i.e., non-digestible material such as cellulose), is also required, for both mechanical and biochemical reasons, although the exact reasons remain unclear.

Molecules of carbohydrates and fats consist of carbon, hydrogen, and oxygen atoms. Carbohydrates range from simple monosaccharides (glucose, fructose, galactose) to complex polysaccharides (starch). Fats are triglycerides, made of assorted fatty acid monomers bound to glycerol backbone. Some fatty acids, but not all, are essential in the diet: they cannot be synthesized in the body. Protein molecules contain nitrogen atoms in addition to carbon, oxygen, and hydrogen. The fundamental components of protein are nitrogen-containing amino acids, some of which are essential in the sense that humans cannot make them internally. Some of the amino acids are convertible (with the expenditure of energy) to glucose and can be used for energy production just as ordinary glucose in a process known as gluconeogenesis. By breaking down existing protein, some glucose can be produced internally; the remaining amino acids are discarded, primarily as urea in urine. This occurs normally only during prolonged starvation.

Other micronutrients include antioxidants and phytochemicals, which are said to influence (or protect) some body systems. Their necessity is not as well established as in the case of, for instance, vitamins.

Most foods contain a mix of some or all of the nutrient classes, together with other substances, such as toxins of various sorts. Some nutrients can be stored internally (e.g., the fat soluble vitamins), while others are required more or less continuously. Poor health can be caused by a lack of required nutrients or, in extreme cases, too much of a required nutrient. For example, both salt and water (both absolutely required) will cause illness or even death in excessive amounts.

Carbohydrates

Carbohydrates include sugars, starches and fiber. They constitute a large part of foods such as rice, noodles, bread, and other grain-based products. Carbohydrates may be classified chemically as monosaccharides, disaccharides, or polysaccharides depending on the number of monomer (saccharide or sugar) units they contain. Monosaccharides, disaccharides, and polysaccharides contain one, two, and three or more sugar units, respectively.

Polysaccharides are often referred to as *complex* carbohydrates because they consist of long, sometimes branched chains of single sugar units. Mono- and disaccharides are called simple carbohydrates. Dietary advice frequently but erroneously suggests that complex carbohydrates are superior to simple because they take longer to digest and absorb. Simple carbohydrates, on the other hand, are said to cause a spike in blood glucose levels rapidly after ingestion. These traditional claims are false.[6] In fact, many digestible polysaccharides are processed as rapidly as simple sugars in the human body. On the other hand some simple carbohydrates (fructose, for example) are processed in a different way and do not spike blood sugar. Thus the distinction between "complex" and "simple" does not predict the nutritional value or impact of carbohydrates. A better way of determining what effect particular foods may have on blood sugar and ultimately on health in general is the glycemic index.[7]

Carbohydrates are not essential nutrients (with the likely exception of fiber), but are typically an important part of the human diet. While it would not be accurate to categorize all carbohydrates as "bad" nutritionally, some carbohydrate sources may well have deleterious effects on health, especially when consumed in large quantities. Highly processed carbohydrates (sugars and starches) as well as fructose consumed in large quantities have been implicated in negative health outcomes.[8][9][10][11]

What Carbohydrates Are

Carbohydrates are naturally occurring compounds that consist of carbon, hydrogen, and oxygen, and are produced by green plants in the process of undergoing photosynthesis. In simple terms, photosynthesis is the biological conversion of light energy (that is, electromagnetic energy) from the Sun to chemical energy in plants. It is an extremely complex process, and a thorough treatment of it involves a great deal of technical terminology. Although we discuss the fundamentals of photosynthesis later in this essay, we do so only in the most cursory fashion.

Photosynthesis involves the conversion of carbon dioxide and water to sugars, which, along with starches and cellulose, are some of the more well known varieties of carbohydrate. Sugars can be defined as any of a number of water-soluble compounds, of varying sweetness. (What we think of as sugar—that is, table sugar—is actually sucrose, discussed later.) Starches are complex carbohydrates without taste or odor, which are granular or powdery in physical form. Cellulose is a polysaccharide, made from units of glucose, that constitutes the principal part of the cell walls of plants and is found naturally in fibrous materials, such as cotton. Commercially, it is a raw material for such manufactured goods as paper, cellophane, and rayon.

Monosaccharides

The preceding definitions contain several words that also must be defined. Carbohydrates are made up of building blocks called monosaccharides, the simplest type of carbohydrate. Found in grapes and other fruits and also in honey, they can be broken down chemically into their constituent elements, but there is no carbohydrate more chemically simple than a monosaccharide. Hence, they are also known as simple sugars or simple carbohydrates.

Examples of simple sugars include glucose, which is sweet, colorless, and water-soluble and appears widely in nature. Glucose, also known as dextrose, grape sugar, and corn sugar, is the principal form in which carbohydrates are assimilated, or taken in, by animals. Other monosaccharides include fructose, or fruit sugar, and galactose, which is less soluble and sweet than glucose and usually appears in combination with other simple sugars rather than by itself. Glucose, fructose, and galactose are isomers, meaning that they have the same chemical formula ($C_6H_{12}O_6$), but different chemical structures and therefore different chemical properties.

Disaccharides

When two monosaccharide molecules chemically bond with each other, the result is one of three general types of complex sugar: a disaccharide, oligosaccharide, or polysaccharide.

Disaccharides, or double sugars, are composed of two monosaccharides. By far the most well known example of a disaccharide is sucrose, or table sugar, which is formed from the bonding of a glucose molecule with a molecule of fructose. Sugar beets and cane sugar provide the principal natural sources of sucrose, which the average American is most likely to encounter in refined form as white, brown, or powdered sugar.

Another disaccharide is lactose, or milk sugar, the only type of sugar that is produced from animal (i.e., mammal) rather than vegetable sources. Maltose, a fermentable sugar typically formed from starch by the action of the enzyme amylase, is also a disaccharide. Sucrose, lactose, and maltose are all isomers, with the formula $C_{12}H_{22}O_{11}$.

Oligosaccharides and Polysaccharides

The definitions of oligosaccharide and polysaccharide are so close as to be confusing. An oligosaccharide is sometimes defined as a carbohydrate containing a known, small number of monosaccharide units, while a polysaccharide is a carbohydrate composed of two or more monosaccharides. In theory, this means practically the same thing, but in practice, an oligosaccharide contains 3-6 monosaccharide units, whereas a polysaccharide is composed of more than six.

Oligosaccharides are found rarely in nature, though a few plant forms have been discovered. Far more common are polysaccharides ("many sugars"), which account for the vast majority of carbohydrate types found in nature. (See Where to Learn More for the Nomenclature of Carbohydrates Web site, operated by the Department of Chemistry at Queen Mary College, University of London. A glance at the site will suggest something about the many, many varieties of carbohydrates.)

Polysaccharides may be very large, consisting of as many as 10,000 monosaccharide units strung together. Given this vast range of sizes, it should not be surprising that there are hundreds of polysaccharide types, which differ from one another in terms of size, complexity, and chemical makeup. Cellulose itself is a polysaccharide, the most common variety known, composed of numerous glucose units joined to one another. Starch and glycogen are also glucose polysaccharides. The first of these polysaccharides is found primarily in the stems, roots, and seeds of plants. As for glycogen, this is the most common form in which carbohydrates are stored in animal tissues, particularly muscle and liver tissues.

Digestion, Absorption, and Transportation

In order for carbohydrates to be absorbed by the intestinal mucosal cells, they must first be converted into monosaccharides. The digestive process begins in the mouth with salivary a-amylase that partially breaks down starch by hydrolyzing some of the a-1,4 bonds. However, the digestion that takes place here is of little significance since food remains in the mouth for only a brief period, although this may differ depending on chewing time. The enzyme continues to work for a short time in the stomach until the pH is lowered due to hydrochloric acid that inhibits the enzyme.

Table 1

Examples of carbohydrate food sources		
Monosaccharides		
Glucose	**Fructose**	**Galactose**
Fruit	High-fructose corn syrup	Milk
Vegetables	Honey	Milk products
Honey	Fruit	
Disaccharides		
Sucrose	**Lactose**	**Maltose**
Table sugar	Milk	Beer
Maple sugar	Milk products	Malt liquor
Fruit		
Vegetables		
Honey		
Polysaccharides		
Starch (rye, oats, wheat, rice, potatoes, legumes, cereals, bread)		
Dietary Fiber		
Soluble		
Pectin	**Gums**	
Fruits (apples, berries)	Oats, barley	
Jams and jellies (additive)	Ice cream (additive) Legumes	
Insoluble		
Cellulose	**Hemicellulose**	**Lignin**

Examples of carbohydrate food sources		
Monosaccharides		
Glucose	**Fructose**	**Galactose**
Whole wheat foods	Whole grains	Fruit
Bran		Seeds
Leafy vegetables		Bran, wheat Vegetables

The bulk of carbohydrate digestion occurs in the small intestine by pancreatic a-amylase. The pH of the small intestines is increased due to the addition of bicarbonate and bile, allowing the enzyme activity to occur. Specific disaccharidases located on the intestinal mucosal cells help to further break down the carbohydrates into the monosaccharides: glucose, fructose, and galactose.

Once the carbohydrates have been broken down, the monosaccharides can be absorbed by the mucosal cells. Glucose and galactose enter by active transport, which requires energy as well as specific receptors and carriers. Fructose is absorbed by facilitated diffusion. Like active transport, facilitated diffusion requires a specific carrier, but instead of needing energy, it relies on the low levels of fructose inside the cell to "pull" the fructose inside. Once transported through the intestinal wall, the monosaccharides enter the blood through the capillaries and are carried to the portal circulation and then to the liver.

Metabolism of Carbohydrates

The liver is the major site of galactose and fructose metabolism, where they are taken up, converted to glucose derivatives, and either stored as liver glycogen or used for energy immediately when needed. Although glucose is metabolized extensively in the liver, unlike galactose and fructose, it is also passed into the blood supply to be used by other tissues. Tissues like skeletal muscle and adipose tissue depend on insulin for glucose uptake, whereas the brain and liver do not. This dependence on insulin becomes a problem for diabetics who either cannot make insulin or are resistent to insulin. For individuals left untreated, dietary carbohydrates cause glucose levels to rise, resulting in hyperglycemia, which will lead to serious consequences if steps are not taken to correct it.

Once in the tissues, the fate of glucose depends on the energy demands of the body. Glucose can be metabolized through the glycolysis pathway to pyruvate where it is either converted to lactate or completely oxidized to CO_2, H_2O, and energy. Liver and skeletal muscle can convert excess glucose to glycogen through a pathway known as glycogenesis. The glycogen is stored after meals to be used as an energy source when energy demands are higher than intake. At this time the glycogen is broken down into individual glucose units, a process known as glycogenolysis, and the glucose can be metabolized further. Excess carbohydrates also can be used as a substrate for fat synthesis.

Carbohydrates are an essential part of a healthy diet. They provide an easily available energy source, are an important vehicle for micronutrients and phytochemicals, help to maintain adequate blood glucose, and are important in maintaining the integrity and function of the gastrointestinal tract. Table 2 contains examples of foods that contain the various types of carbohydrates.

Starch

Starch from plants makes up about half of our dietary carbohydrates. Starch molecules can aggregate to form granules that differ by size and shape depending on the source of the starch, for example, corn, potato, and manioc. Although there is no difference in the nutritional value between the starches since all cooked starches are broken down in the body into glucose molecules, they do differ by characteristics such as solubility, flavor, and thickening power. Because of these characteristics, starch is often removed from the source to use commercially. For example, the starch can be removed from tubers such as potatoes and manioc (also known as cassava) through a wet milling process, or in the case of manioc, through leaching and drying. The potato starch is often used as a thickener or instead of cornstarch in recipes, while manioc is best known as tapioca.

Cellulose

One of the aspects of fruits and vegetables to which we have alluded several times is the high content of inedible material, or cellulose. (Actually, it is edible—just not digestible.) A substance found in the cell walls of plants, cellulose is chemically like starch but even more rigid, and this property makes it an excellent substance for imparting strength to plant bodies. Animals do not have rigid, walled cells, but plants do. The heavy cellulose content in plants' cell walls gives them their erect, rigid form; in other words, without cellulose, plants might be limp and partly formless. Like human bone, plant cell walls are composed of fibrils (small filaments or fibers) that include numerous polysaccharides and proteins. One of these polysaccharides in cell walls is pectin, a substance that, when heated, forms a gel and is used by cooks in making jellies and jams. Some trees have a secondary cell wall over the primary one, containing yet another polysaccharide called *lignin*. Lignin makes the tree even more rigid, penetrable only with sharp axes.

Cellulose in Digestion

As we have noted, cellulose is abundant in fruits and vegetables, yet humans lack the enzyme necessary to digest it. Termites, cows, koalas, and horses all digest cellulose, but even these animals and insect do not have an enzyme that digests this material. Instead, they harbor microbes in their guts that can do the digesting for them. (This is an example of symbiotic mutualism, a mutually beneficial relationship between organisms, discussed in Symbiosis.)

Cows are ruminants, or animals that chew their cud—that is, food regurgitated to be chewed again. Ruminants have several stomachs, or several stomach compartments, that break down plant material with the help of enzymes and bacteria. The partially digested material then is regurgitated into the mouth, where it is chewed to break the material down even further. (If you have ever watched cows in a pasture, you have probably observed them calmly chewing their cud.) The digestion of cellulose by bacteria in the stomachs of ruminants is anaerobic, meaning that the process does not require oxygen. One of the by-products of this anaerobic process is methane gas, which is foul smelling, flammable, and toxic. Ruminants give off large amounts of methane daily, which has some environmentalists alarmed, since cow-borne methane may contribute to the destruction of the ozone high in Earth's stratosphere.

Alhough cellulose is indigestible by humans, it is an important dietary component in that it aids in digestion. Sometimes called fiber or roughage, cellulose helps give food bulk as it moves through the digestive system and aids the body in pushing out foods and wastes. This is particularly important inasmuch as it helps make possible regular bowel movements, thus ridding the body of wastes and lowering the risk of colon cancer.

Fiber

Dietary fiber is a carbohydrate (or a polysaccharide) that is incompletely absorbed in humans and in some animals. Like all carbohydrates, when it is metabolized it can produce four Calories (kilocalories) of energy per gram. However, in most circumstances it accounts for less than that because of its limited absorption and digestibility. Dietary fiber consists mainly of cellulose, a large carbohydrate polymer that is indigestible because humans do not have the required enzymes to disassemble it. There are two subcategories: soluble and insoluble fiber. Whole grains, fruits (especially plums, prunes, and figs), and vegetables are good sources of dietary fiber. There are many health benefits of a high-fiber diet. Dietary fiber helps reduce the chance of gastrointestinal problems such as constipation and diarrhea by increasing the weight and size of stool and softening it. Insoluble fiber, found in whole-wheat flour, nuts and vegetables, especially stimulates peristalsis -- the rhythmic muscular contractions of the intestines which move digesta along the digestive tract. Soluble fiber, found in oats, peas, beans, and many fruits, dissolves in water in the intestinal tract to produce a gel which slows the movement of food through the intestines. This may help lower blood glucose levels because it can slow the absorption of sugar. Additionally, fiber, perhaps especially that from whole grains, is thought to possibly help lessen insulin spikes, and therefore reduce the risk of type 2 diabetes. The link between increased fiber consumption and a decreased risk of colorectal cancer is still uncertain. [12]

Fat

A molecule of dietary fat typically consists of several fatty acids (containing long chains of carbon and hydrogen atoms), bonded to a glycerol. They are typically found as triglycerides (three fatty acids attached to one glycerol backbone). Fats may be classified as saturated or unsaturated depending on the detailed structure of the fatty acids involved. Saturated fats have all of the carbon atoms in their fatty acid chains bonded to hydrogen atoms, whereas unsaturated fats have some of these carbon atoms double-bonded, so their molecules have relatively fewer hydrogen atoms than a saturated fatty acid of the same length. Unsaturated fats may be further classified as monounsaturated (one double-bond) or polyunsaturated (many double-bonds). Furthermore, depending on the location of the double-bond in the fatty acid chain, unsaturated fatty acids are classified as omega-3 or omega-6 fatty acids. Trans fats are a type of unsaturated fat with *trans*-isomer bonds; these are rare in nature and in foods from natural sources; they are typically created in an industrial process called (partial) hydrogenation. There are nine kilocalories in each gram of fat.

Saturated fats (typically from animal sources) have been a staple in many world cultures for millennia. Unsaturated fats (e.g., vegetable oil) are considered healthier (citation needed), while trans fats are to be avoided. Saturated and some trans fats are typically solid at room temperature (such as butter or lard), while unsaturated fats are typically liquids (such as olive oil or flaxseed oil). Trans fats are very rare in nature, and have been shown to be highly detrimental to human health, but have properties useful in the food processing industry, such as rancidity resistance.

Essential fatty acids

Most fatty acids are non-essential, meaning the body can produce them as needed, generally from other fatty acids and always by expending energy to do so. However, in humans, at least two fatty acids are essential and must be included in the diet. An appropriate balance of essential fatty acids—omega-3 and omega-6 fatty acids—seems also important for health, although definitive experimental demonstration has been elusive. Both of these "omega" long-chain polyunsaturated fatty acids are substrates for a class of eicosanoids known as prostaglandins, which have roles throughout the human body. They are hormones, in some respects. The omega-3 eicosapentaenoic acid (EPA), which can be made in the human body from the omega-3 essential fatty acid alpha-linolenic acid (LNA), or taken in through marine food sources, serves as a building block for series 3 prostaglandins (e.g. weakly inflammatory PGE3). The omega-6 dihomo-gamma-linolenic acid (DGLA) serves as a building block for series 1 prostaglandins (e.g. anti-inflammatory PGE1), whereas arachidonic acid (AA) serves as a building block for series 2 prostaglandins (e.g. pro-inflammatory PGE 2). Both DGLA and AA can be made from the omega-6 linoleic acid (LA) in the human body, or can be taken in directly through food. An appropriately balanced intake of omega-3 and omega-6 partly determines the relative production of different prostaglandins, which is one reason why a balance between omega-3 and omega-6 is believed important for cardiovascular health. In industrialized societies, people typically consume large amounts of processed vegetable oils, which have reduced amounts of the essential fatty acids along with too much of omega-6 fatty acids relative to omega-3 fatty acids.

Protein

Proteins are the basis of many animal body structures (e.g. muscles, skin, and hair). They also form the enzymes that control chemical reactions throughout the body. Each molecule is composed of amino acids, which are characterized by inclusion of nitrogen and sometimes sulphur (these components are responsible for the distinctive smell of burning protein, such as the keratin in hair). The body requires amino acids to produce new proteins (protein retention) and to replace damaged proteins (maintenance). As there is no protein or amino acid storage provision, amino acids must be present in the diet. Excess amino acids are discarded, typically in the urine. For all animals, some amino acids are ***essential*** (an animal cannot produce them internally) and some are ***non-essential*** (the animal can produce them from other nitrogen-containing compounds). Twenty-one proteinogenic amino acids are found in the human body, along with non-proteinogenic amino acids (e.g. gamma-aminobutyric acid). Ten of the proteinogenic amino acids are essential and, therefore, must be included in the diet. A diet that contains adequate amounts of amino acids (especially those that are essential) is particularly important in some situations: during early development and maturation, pregnancy, lactation, or injury (a burn, for instance). A ***complete*** protein source contains all the essential amino acids; an ***incomplete*** protein source lacks one or more of the essential amino acids.

Sources of dietary protein include meats, tofu and other soy-products, eggs, legumes, and dairy products such as milk and cheese. Excess amino acids from protein can be converted into glucose and used for fuel through a process called gluconeogenesis. The amino acids remaining after such conversion are discarded.

Different proteins have different levels of biological availability (BA) to the human body. Many methods have been introduced to measure protein utilization and retention rates in humans. They include biological value, net protein utilization, and PDCAAS (Protein Digestibility Corrected Amino Acids Score) which was developed by the FDA as an improvement over the Protein Efficiency Ratio (PER) method. These methods examine which proteins are most efficiently used by the body.

Egg whites have been determined to have the standard biological value of 100 (though some sources may have higher biological values), which means that most of the absorbed nitrogen from egg white protein can be retained and used by the body. Corn has a BA of 70 while peanuts have a relatively low BA of 40.[1]

Digestion

Digestion typically begins in the stomach when pepsinogen is converted to pepsin by the action of hydrochloric acid, and continued by trypsin and chymotrypsin in the intestine. The amino acids and their derivatives into which dietary protein is degraded are then absorbed by the gastrointestinal tract. The absorption rates of individual amino acids are highly dependent on the protein source; for example, the digestibilities of many amino acids in humans differ between soy and milk proteins[2] and between individual milk proteins, beta-lactoglobulin and casein.[3] For milk proteins, about 50% of the ingested protein is absorbed between the stomach and the jejunum and 90% is absorbed by the time the digested food reaches the ileum.[4] Biological value (BV) is a measure of the proportion of absorbed protein from a food which becomes incorporated into the proteins of the organism's body.

Dietary requirements

Considerable debate has taken place regarding issues surrounding protein intake requirements.[5][6] How much protein needed in a person's daily diet is determined in large part by overall energy intake, as well as by the body's need for nitrogen and essential amino acids. Physical activity and exertion as well as enhanced muscular mass increase the need for protein. Requirements are also greater during childhood for growth and development, during pregnancy or when breast-feeding in order to nourish a baby, or when the body needs to recover from malnutrition or trauma or after an operation.[7] It was suggested that protein intake amount should be measured by using three parameters (which should be viewed together): absolute intake (g/d), intake per body weight (g/body kg/d) and intake as energy percent.[5]

If enough energy is not taken in through diet, as in the process of starvation, the body will use protein from the muscle mass to meet its energy needs, leading to muscle wasting over time. If the individual does not consume adequate protein in nutrition, then muscle will also waste as more vital cellular processes (e.g. respiration enzymes, blood cells) recycle muscle protein for their own requirements.

According to US & Canadian Dietary Reference Intake guidelines, women aged 19–70 need to consume 46 grams of protein per day, while men aged 19–70 need to consume 56 grams of protein per day to avoid a deficiency.[8] The US guidelines recommend a daily protein dietary allowance, measured as intake per body weight, is 0.8 g/kg.[5] However, this recommendation is based on structural requirements, but disregards use of protein for energy metabolism.[5] Several studies have concluded that active people and athletes may require elevated protein intake (compared to 0.8 g/kg).[5][6][9] Suggested amounts vary between 1.6 g/kg and 1.8 g/kg,[6] while a proposed *maximum* daily protein intake would be approximately 25% of energy requirements i.e. approximately 2 to 2.5 g/kg.[5] However, many questions still remain to be resolved.[6]

Deficiency

In developing countries

Protein deficiency is a serious cause of ill health and death in developing countries. Protein deficiency plays a part in the disease kwashiorkor. War, famine, overpopulation and other factors can increase rates of malnutrition and protein deficiency. Protein deficiency can lead to reduced intelligence or mental retardation (see nutrition disorder).

In countries that suffer from widespread protein deficiency, food is generally full of plant fibers, which makes adequate energy and protein consumption very difficult. Protein deficiency is generally caused by lack of total food energy, making it an issue of not getting food in total. Symptoms of kwashiorkor include apathy, diarrhea, inactivity, failure to grow, flaky skin, fatty liver, and edema of the belly and legs. This edema is explained by the normal functioning of proteins in fluid balance and lipoprotein transport.[10]

Moringa trees are known to overcome protein deficiency in developing countries as the leaves and other parts of the tree contain comparably to soy bean high amount of crude proteins and amino acids.

Excess consumption

The body is unable to store excess protein. Protein is digested into amino acids which enter the bloodstream. Excess amino acids are converted to other usable molecules by the liver in a process called deamination. Deamination converts nitrogen from the amino acid into ammonia which is converted by the liver into urea in the urea cycle. Excretion of urea is performed by the kidneys. These organs can normally cope with any extra workload but if a kidney disease occurs, a decrease in protein will often be prescribed.[11]

Many researchers think excessive intake of protein forces increased calcium excretion. If there is to be excessive intake of protein, it is thought that a regular intake of calcium would be able to stabilize, or even increase the uptake of calcium by the small intestine, which would be more beneficial in older women.[12]

Specific proteins are often the cause of allergies and allergic reactions to certain foods. This is because the structure of each form of protein is slightly different; some may trigger a response from the immune system while others remain perfectly safe. Many people are allergic to casein, the protein in milk; gluten, the protein in wheat and other grains; the particular proteins found in peanuts; or those in shellfish or other seafoods.

Testing in foods

The classic assays for protein concentration in food are the Kjeldahl method and the Dumas method. These tests determine the total nitrogen in a sample. The only major component of most food which contains nitrogen is protein (fat, carbohydrate and dietary fibre do not contain nitrogen). If the amount of nitrogen is multiplied by a factor depending on the kinds of protein expected in the food the total protein can be determined. This value is known as the "crude protein" content. On food labels the protein is given by the nitrogen multiplied by 6.25, because the average nitrogen content of proteins is about 16%. The Kjeldahl test is typically used because it is the method the AOAC International has adopted and is therefore used by many food standards agencies around the world, though the Dumas method is also approved by some standards organizations.

Accidental contamination and intentional adulteration of protein meals with non-protein nitrogen sources that inflate crude protein content measurements have been known to occur in the food industry for decades. To ensure food quality, purchasers of protein meals routinely conduct quality control tests designed to detect the most common non-protein nitrogen contaminants, such as urea and ammonium nitrate.

In at least one segment of the food industry, the dairy industry, some countries (at least the U.S., Australia, France and Hungary), have adopted "true protein" measurement, as opposed to crude protein measurement, as the standard for payment and testing: "True protein is a measure of only the proteins in milk, whereas crude protein is a measure of all sources of nitrogen and includes nonprotein nitrogen, such as urea, which has no food value to humans. ... Current milk-testing equipment measures peptide bonds, a direct measure of true protein."[15] Measuring peptide bonds in grains has also been put into practice in several countries including Canada, the UK, Australia, Russia and Argentina where near-infrared reflectance (NIR) technology, a type of infrared spectroscopy is used.[16] The Food and Agriculture Organization of the United Nations (FAO) recommends that only amino acid analysis be used to determine protein in, *inter alia*, foods used as the sole source of nourishment, such as infant formula, but also provides: "When data on amino acids analyses are not available, determination of protein based on total N content by Kjeldahl (AOAC, 2000) or similar method ... is considered acceptable."[17]

Minerals

Dietary minerals are the chemical elements required by living organisms, other than the four elements carbon, hydrogen, nitrogen, and oxygen that are present in nearly all organic molecules. The term "mineral" is archaic, since the intent is to describe simply the less common elements in the diet. Some are heavier than the four just mentioned, including several metals, which often occur as ions in the body. Some dietitians recommend that these be supplied from foods in which they occur naturally, or at least as complex compounds, or sometimes even from natural inorganic sources (such as calcium carbonate from ground oyster shells). Some minerals are absorbed much more readily in the ionic forms found in such sources. On the other hand, minerals are often artificially added to the diet as supplements; the most famous is likely iodine in iodized salt which prevents goiter.

Macrominerals

Many elements are essential in relative quantity; they are usually called "bulk minerals". Some are structural, but many play a role as electrolytes.[13] Elements with recommended dietary allowance (RDA) greater than 200 mg/day are, in alphabetical order (with informal or folk-medicine perspectives in parentheses):

- Calcium, a common electrolyte, but also needed structurally (for muscle and digestive system health, bone strength, some forms neutralize acidity, may help clear toxins, provides signaling ions for nerve and membrane functions)
- Chlorine as chloride ions; very common electrolyte; see sodium, below
- Magnesium, required for processing ATP and related reactions (builds bone, causes strong peristalsis, increases flexibility, increases alkalinity)
- Phosphorus, required component of bones; essential for energy processing[14]

- Potassium, a very common electrolyte (heart and nerve health). Sodium (also see salt), a very common electrolyte; not generally found in dietary supplements, despite being needed in large quantities, because the ion is very common in food: typically as sodium chloride, or common salt. Excessive sodium consumption can deplete calcium and magnesium,[*verification needed*] leading to high blood pressure and osteoporosis (Note: Some sources suggest high blood pressure is due to high water retention per osmosis).
- Sulfur, for three essential amino acids and therefore many proteins (skin, hair, nails, liver, and pancreas). Sulfur is not consumed alone, but in the form of sulfur-containing amino acids

Trace minerals

Many elements are required in trace amounts, usually because they play a catalytic role in enzymes.[15] Some trace mineral elements (RDA < 200 mg/day) are, in alphabetical order:

- Cobalt required for biosynthesis of vitamin B_{12} family of coenzymes. Animals cannot biosynthesize B_{12}, and must obtain this cobalt-containing vitamin in the diet
- Copper required component of many redox enzymes, including cytochrome c oxidase
- Chromium required for sugar metabolism
- Iodine required not only for the biosynthesis of thyroxine, but probably, for other important organs as breast, stomach, salivary glands, thymus etc. (see Extrathyroidal iodine); for this reason iodine is needed in larger quantities than others in this list, and sometimes classified with the macrominerals
- Iron required for many enzymes, and for hemoglobin and some other proteins
- Manganese (processing of oxygen)
- Molybdenum required for xanthine oxidase and related oxidases
- Nickel present in urease

- Selenium required for peroxidase (antioxidant proteins)
- Vanadium (Speculative: there is no established RDA for vanadium. No specific biochemical function has been identified for it in humans, although vanadium is required for some lower organisms.)
- Zinc required for several enzymes such as carboxypeptidase, liver alcohol dehydrogenase, and carbonic anhydrase

Vitamins

As with the minerals discussed above, some vitamins are recognized as essential nutrients, necessary in the diet for good health. Vitamin D is the exception: it can be synthesized in the skin, in the presence of UVB radiation. Certain vitamin-like compounds that are recommended in the diet, such as carnitine, are thought useful for survival and health, but these are not "essential" dietary nutrients because the human body has some capacity to produce them from other compounds. Moreover, thousands of different phytochemicals have recently been discovered in food (particularly in fresh vegetables), which may have desirable properties including antioxidant activity (see below); however, experimental demonstration has been suggestive but inconclusive. Other essential nutrients that are not classified as vitamins include essential amino acids (see above), choline, essential fatty acids (see above), and the minerals discussed in the preceding section.

Vitamin deficiencies may result in disease conditions, including goitre, scurvy, osteoporosis, impaired immune system, disorders of cell metabolism, certain forms of cancer, symptoms of premature aging, and poor psychological health (including eating disorders), among many others.[16] Excess levels of some vitamins are also dangerous to health (notably vitamin A), and for at least one vitamin, B6, toxicity begins at levels not far above the required amount. Deficient or excess levels of minerals can also have serious health consequences.

FAT-SOLUBLE VITAMINS

• vitamin A (retinol; carotene is an important precursor of vitamin A)
• vitamin D (ergocalciferol and cholecalciferol)
• vitamin E (tocopherol)
• vitamin K (phylloquinone from plants; menaquinone from gut bacteria)

WATER-SOLUBLE VITAMINS

• vitamin B_1 (thiamin)

• vitamin B_2 (riboflavin)

• vitamin B_6 (pyridoxine)

• vitamin B_{12} (cobalamin)

• niacin (nicotinic acid and nicotinamide)

• pantothenic acid

• biotin

• folic acid

• vitamin C (ascorbic acid)

Each vitamin has a specific function; one vitamin cannot substitute for another. Lack of any one vitamin in the diet leads to ill health and eventually a deficiency disease. In addition, many body functions require the interaction of several vitamins, and the lack of one may undermine the function of others.

The relationship between vitamin requirements and exercise is complex, and the subject of much debate. There is some dispute about whether active people require more of every type of vitamin. However, it is generally agreed that requirements of the B-complex vitamins, which play many diverse roles in energy metabolism, are directly related to calorie expenditures of up to 5000 Calories per day. On this basis, some coaches believe that very active people may need at least twice the recommended daily amounts of these vitamins. Many sports nutritionists maintain that this increased demand for vitamins can be satisfied by eating a well-balanced diet. They argue that, as energy expenditure increases, food intake and therefore vitamin intake will also increase. On the other hand, some coaches advocate the use of vitamin supplements, arguing that increased dietary intake alone cannot guarantee a sufficient vitamin intake. The following vitamins are important in a healthy diet and also may assist in cancer prevention. Their role in maintaining health and the best food sources are listed below.

Vitamin A (retinal, carotene)

- role in growth and repair of body tissues
- important in night vision
- immune function
- Best sources: eggs, dark green and yellow fruits and vegetables, low-fat dairy products, liver

Vitamin B6 (pyridoxine)

- role in formation of antibodies
- important in carbohydrate and protein metabolism
- red blood cells
- nerve function
- Best sources: lean meat, fish, poultry, whole grains, and potatoes

Folic acid (folate)

- assists in red blood cell formation
- important in protein metabolism
- growth and cell division
- Best sources: green leafy vegetables, poultry, dried beans, fortified cereals, nuts, and oranges

Vitamin C (ascorbic acid)

- resistance to infection
- important in collagen maintenance
- contributes to wound healing
- strengthens blood vessels
- assists in maintaining healthy gums
- Best sources: citrus fruits, tomatoes, melons, broccoli, green and red peppers, and berries

Vitamin E (tocopherol)

- may assist in immune function
- important in preventing oxidation of red blood cells and cell membranes
- Best sources: vegetable oils, wheat germ, nuts, dark green vegetables, beans, and whole grains.
-
- The vitamins

vitamin		**functions**	**deficiency disease**

vitamin		functions	deficiency disease
A	retinol β-carotene	visual pigments in the retina; regulation of gene expression and cell differentiation;	night blindness, xerophthalmia; keratinization of skin.
		(β-carotene is an antioxidant)	
D	calciferol	maintenance of calcium balance; enhances intestinal absorption of Ca^{2+} and mobilizes bone mineral; regulation of gene expression and cell differentiation	rickets = poor mineralization of bone; osteomalacia = bone demineralization
E	tocopherols tocotrienols	antioxidant, especially in cell membranes; roles in cell signalling	extremely rare—serious neurological dysfunction
K	phylloquinone menaquinones	coenzyme in formation of γ-carboxy-glutamate in enzymes of blood clotting and bone matrix	impaired blood clotting, haemorrhagic disease
B_1	thiamin	coenzyme in pyruvate and 2-oxo-glutarate dehydrogenases, and transketolase; regulates Cl^- channel in nerve conduction	peripheral nerve damage (beriberi) or central nervous system lesions (Wernicke-Korsakoff syndrome)
B_2	riboflavin	coenzyme in oxidation and reduction reactions; prosthetic group of flavoproteins	lesions of corner of mouth, lips and tongue, sebhorroeic dermatitis
niacin	nicotinic acid nicotinamide	coenzyme in oxidation and reduction reactions, functional part of NAD and NADP; role in intracellular calcium regulation and cell signalling	pellagra—photosensitive dermatitis, depressive psychosis,
B_6	pyridoxine pyridoxal pyridoxamine	coenzyme in transamination and decarboxylation of amino acids and glycogen phosphorylase; modulation of steroid hormone action	disorders of amino acid metabolism, convulsions
	folic acid	coenzyme in transfer of one-carbon	megaloblastic anemia

vitamin		functions	deficiency disease
		fragments	
B_{12}	cobalamin	coenzyme in transfer of one-carbon fragments and metabolism of folic acid	pernicious anemia = megaloblastic anemia with degeneration of the spinal cord.
	pantothenic acid	functional part of CoA and acyl carrier protein: fatty acid synthesis and metabolism	peripheral nerve damage (nutritional melalgia or 'burning foot syndrome')
H	biotin	coenzyme in carboxylation reactions in gluconeogenesis and fatty acid synthesis; role in regulation of cell cycle	impaired fat and carbohydrate metabolism, dermatitis
C	ascorbic acid	coenzyme in hydroxylation of proline and lysine in collagen synthesis; anti-oxidant; enhances absorption of iron	scurvy—impaired wound healing, loss of dental cement, subcutaneous haemorrhage

Vitamin	**What it does for the body**
Vitamin A (Beta Carotene)	Promotes growth and repair of body tissues: reduces susceptibility to infections; aids in bone and teeth formation; maintains smooth skin
Vitamin B-1 (Thiamin)	Promotes growth and muscle tone; aids in the proper functioning of the muscles, heart, and nervous system; assists in digestion of carbohydrates
Vitamin B-2 (Riboflavin)	Maintains good vision and healthy skin, hair, and nails; assists in formation of antibodies and red blood cells; aids in carbohydrate, fat, and protein metabolism
Vitamin B-3 (niacinamide)	Reduces cholesterol levels in the blood; maintains healthy skin, tongue, and digestive system; improves blood circulation; increases energy
Vitamin B-5	Fortifies white blood cells; helps the body's resistance to strees; builds cells
Vitamin B-6 (Pyridoxine)	Aids in the synthesis and breadown of amino acids and the metabilism of fats and carbohydrates; Supports the central nervous system; maintains healthy skin

vitamin		functions	deficiency disease
Vitamin B-12 (Cobalamin)		Promotes growth in children; prevents anemia by regenerating red blood cells; aids in the metabolism of carbohydrates, fats and proteins; maintains healthy nervous system	
Biotin		Aids in the metabolism of proteins and fats; promotes healthy skin	
Choline		Helps the liver eliminate toxins	
Folic Acid (Folate, Folacin)		Promotes the growth and reproduction of body cells; aids in the formation of red blood cells and bone marrow	
Vitamin C (Ascorbic Acid)		One of the major antioxidants; essential for healthy teeth, gums, and bones; helps to heal wounds, fracures, and scar tissue; builds resistance to infections; assists in the prevention and treatment of the common cold; prevents scurvy	
Vitamin D		Improves the absorption of calcium and phosphorous (essential in the formation of healthy bones and teeth) maintains nervous system	
Vitamin E		A major antioxidant; supplies oxygen to blood; provides nourishment to cells; prevents blood clots; slows cellular aging	
Vitamin K		(Menadione) Prevents internal bleeding; reduces heavy menstural flow	

WATER

It is not fully clear how much water intake is needed by healthy people, although some assert that 6–8 glasses of water daily is the minimum to maintain proper hydration.[17] The notion that a person should consume eight glasses of water per day cannot be traced to a credible scientific source.[18] The effect of, greater or lesser, water intake on weight loss and on constipation is also still unclear.[19] The original water intake recommendation in 1945 by the Food and Nutrition Board of the National Research Council read: "An ordinary standard for diverse persons is 1 milliliter for each calorie of food. Most of this quantity is contained in prepared foods."[20] The latest dietary reference intake report by the United States National Research Council recommended, generally, (including food sources): 2.7 liters of water total for women and 3.7 liters for men.[21] Specifically, pregnant and breastfeeding women need additional fluids to stay hydrated. According to the Institute of Medicine—who recommend that, on average, women consume 2.2 litres and men 3.0 litres—this is recommended to be

2.4 litres (approx. 9 cups) for pregnant women and 3 litres (approx. 12.5 cups) for breastfeeding women because an especially large amount of fluid is lost during nursing.[22]

For those who have healthy kidneys, it is somewhat difficult to drink too much water, but (especially in warm humid weather and while exercising) it is dangerous to drink too little. People can drink far more water than necessary while exercising, however, putting them at risk of water intoxication, which can be fatal In particular, large amounts of de-ionized water are dangerous.

Normally, about 20 percent of water intake comes in food, while the rest comes from drinking water and assorted beverages (caffeinated included). Water is excreted from the body in multiple forms; including urine and feces, sweating, and by water vapor in the exhaled breath.

Antioxidants

As cellular metabolism/energy production requires oxygen, potentially damaging (e.g. mutation causing) compounds known as free radicals can form. Most of these are oxidizers (i.e. acceptors of electrons) and some react very strongly. For the continued normal cellular maintenance, growth, and division, these free radicals must be sufficiently neutralized by antioxidant compounds. Some are produced by the human body with adequate precursors (glutathione, Vitamin C), and those the body cannot produce may only be obtained in the diet via direct sources (Vitamin C in humans, Vitamin A, Vitamin K) or produced by the body from other compounds (Beta-carotene converted to Vitamin A by the body, Vitamin D synthesized from cholesterol by sunlight). Phytochemicals and their subgroup, polyphenols, make up the majority of antioxidants; about 4,000 are known. Different antioxidants are now known to function in a cooperative network. For example, Vitamin C can reactivate free radical-containing glutathione or Vitamin E by accepting the free radical itself. Some antioxidants are more effective than others at neutralizing different free radicals. Some cannot neutralize certain free radicals. Some cannot be present in certain areas of free radical development (Vitamin A is fat-soluble and protects fat areas, Vitamin C is water soluble and protects those areas). When interacting with a free radical, some antioxidants produce a different free radical compound that is less dangerous or more dangerous than the previous compound. Having a variety of antioxidants allows any byproducts to be safely dealt with by more efficient antioxidants in neutralizing a free radical's butterfly effect.

Although initial studies suggested that antioxidant supplements might promote health, later large clinical trials did not detect any benefit and suggested instead that excess supplementation may be harmful.[23]

Malnutrition

Malnutrition refers to insufficient, excessive, or imbalanced consumption of nutrients. In developed countries, the diseases of malnutrition are most often associated with nutritional imbalances or excessive consumption. Although there are more people in the world who are malnourished due to excessive consumption, according to the United Nations World Health Organization, the real challenge in developing nations today, more than starvation, is combating insufficient nutrition — the lack of nutrients necessary for the growth and maintenance of vital functions.[*citation needed*]

Illnesses caused by improper nutrient consumption

Nutrients	Deficiency	Excess
Macronutrients		
Calories	Starvation, Marasmus	Obesity, diabetes mellitus, Cardiovascular disease
Simple carbohydrates	Ketoacidosis (in diabetics and some other groups)	diabetes mellitus, Obesity, Cardiovascular disease
Complex carbohydrates	Ketoacidosis (in diabetics and some other groups)	Obesity, Cardiovascular disease (high glycemic index foods)
Protein	kwashiorkor	Rabbit starvation, Ketoacidosis (in diabetics)
Saturated fat	Possible essential fatty acid deficiency	Obesity, Cardiovascular Disease
Trans fat	none	Obesity, Cardiovascular Disease
Unsaturated fat	fat-soluble vitamin deficiency, EFA deficiency	Obesity, Cardiovascular disease
Micronutrients		
Vitamin A	Xerophthalmia and Night Blindness	Hypervitaminosis A (cirrhosis, hair loss)
Vitamin B_1	Beri-Beri	
Vitamin B_2	Skin and Corneal Lesions	

Niacin	Pellagra	dyspepsia, cardiac arrhythmias, birth defects
Vitamin B_{12}	Pernicious Anemia	
Vitamin C	Scurvy	diarrhea causing dehydration
Vitamin D	Rickets	Hypervitaminosis D (dehydration, vomiting, constipation)
Vitamin E	neurological disease	Hypervitaminosis E (anticoagulant: excessive bleeding)
Vitamin K	Hemorrhage	
Omega 3 Fats	Cardiovascular Disease	Bleeding, Hemorrhages, Hemorrhagic stroke, reduced glycemic control among diabetics
Omega 6 Fats	none	Cardiovascular Disease, Cancer
Cholesterol	none	Cardiovascular Disease[citation needed]
Macrominerals		
Calcium	Osteoporosis, tetany, carpopedal spasm, laryngospasm, cardiac arrhythmias	Fatigue, depression, confusion, nausea, vomiting, constipation, pancreatitis, increased urination, kidney stones
Magnesium	Hypertension	Weakness, nausea, vomiting, impaired breathing, and hypotension
Potassium	Hypokalemia, cardiac arrhythmias	Hyperkalemia, palpitations
Sodium	hyponatremia	Hypernatremia, hypertension
Trace minerals		
Iron	Anemia	Cirrhosis, Hepatitis C, heart disease
Iodine	Goiter, hypothyroidism	Iodine Toxicity, Iodism , (goiter, hypothyroidism)