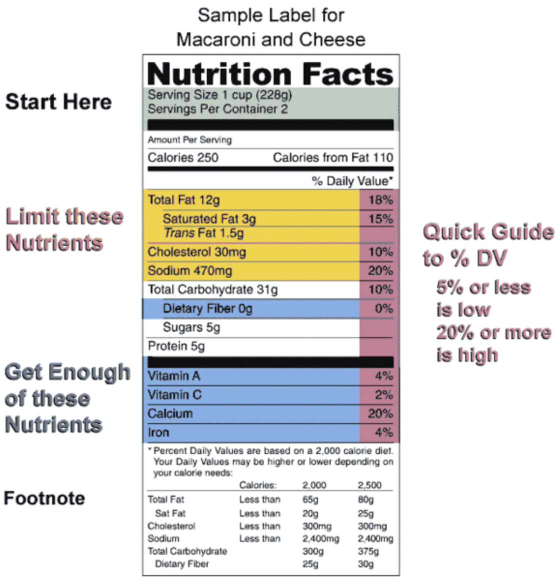
Nutrition

This article is about nutrition in general. For nutrition in humans, see human nutrition. For the medical journal, see Nutrition (journal).



The "Nutrition Facts" table indicates the amounts of nutrients that experts recommend to limit or consume in adequate amounts.

Nutrition is the science that interprets the interaction of nutrients and other substances in food (e.g. phytonutrients, anthocyanins, tannins, etc.) in relation to maintenance, growth, reproduction, health and disease of an organism. It includes food intake, absorption, assimilation, biosynthesis, catabolism and excretion.[1]

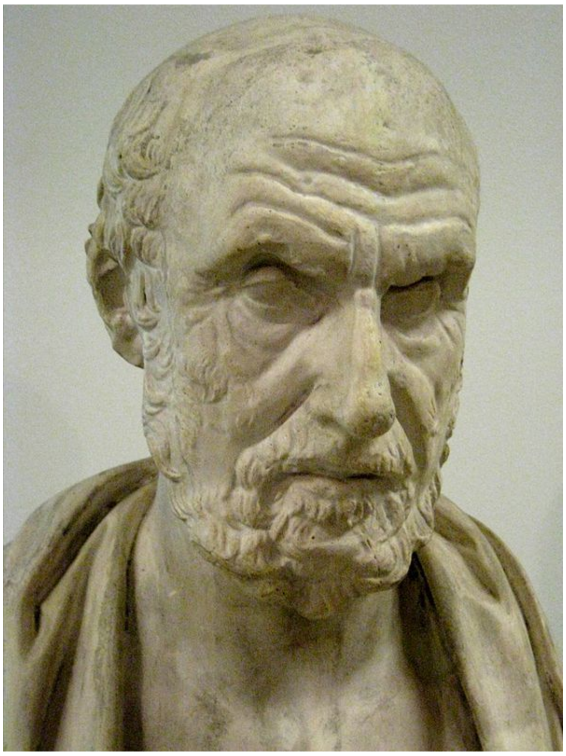
The diet of an organism is what it eats, which is largely determined by the availability, the processing and palatability of foods. A healthy diet includes preparation of food and storage methods that preserve nutrients from oxidation, heat or leaching, and that reduce risk of food-born illnesses.

Registered dietitian nutritionists (RDs or RDNs)[2] are health professionals qualified to provide safe, evidence-based dietary advice which includes a review of what is eaten, a thorough review of nutritional health, and a personalized nutritional treatment plan. They also provide preventive and therapeutic programs at work places, schools and similar institutions. Certified Clinical Nutritionists or CCNs, are trained health professionals who also offer dietary advice on the role of nutrition in chronic disease, including possible prevention or remediation by addressing nutritional deficiencies before resorting to drugs.[3] Government regulation especially in terms of licensing, is currently less universal for the CCN than that of RD or RDN.

A poor diet may have an injurious impact on health, causing deficiency diseases such as blindness, anemia, scurvy, preterm birth, stillbirth and cretinism;[4] health-threatening conditions like obesity[5][6] and metabolic syndrome;[7] and such common chronic systemic diseases as cardiovascular disease,[8] diabetes,[9][10] and osteoporosis.[11][12][13] A poor diet can cause the wasting of kwashiorkor in acute cases, and the stunting of marasmus in chronic cases of malnutrition.[4]

1 History

1.1 Antiquity



Hippocrates lived about 400 BC, and Galen and the understanding of nutrition followed him for centuries.

The first recorded dietary advice, carved into a Babylonian stone tablet in about 2500 BC, cautioned those with pain inside to avoid eating onions for three days. Scurvy, later found to be a vitamin C deficiency, was first described in 1500 BC in the Ebers Papyrus.[14]

According to Walter Gratzer, the study of nutrition probably began during the 6th century BC. In China, the concept of *Qi* developed, a spirit or "wind" similar to what Western Europeans later called *pneuma*.[15] Food was classified into "hot" (for example, meats, blood, ginger, and hot spices) and "cold" (green vegetables) in China, India, Malaya, and Persia.[16] *Humours* developed perhaps first in China alongside *qi*.[15] Ho the Physician concluded that diseases are caused by deficiencies of elements (Wu Xing: fire, water, earth, wood, and metal), and he classified diseases as well as prescribed diets.[16] About the same time in Italy, Alcmaeon of Croton (a Greek) wrote of the importance of equilibrium between what goes in and what goes out, and warned that imbalance would result disease marked by obesity or emaciation.[17]

Around 475 BC, Anaxagoras stated that food is absorbed by the human body and, therefore, contains "homeomerics" (generative components), suggesting the existence of nutrients.[18] Around 400 BC, Hippocrates, who recognized and was concerned with obesity, which may have been common in southern Europe at the time,[17] said, "Let food be your medicine and medicine be your food."[19] The works that are still attributed to him, *Corpus Hippocraticum*, called for moderation and emphasized exercise.[17]

Followed for a millennium and a half, Galen (1st century) created the first coherent theory of nutrition.[20]

Salt, pepper and other spices were prescribed for various ailments in various preparations for example mixed with vinegar. In the 2nd century BC, Cato the Elder believed that cabbage (or the urine of cabbage-eaters) could cure digestive diseases, ulcers, warts, and intoxication. Living about the turn of the millennium, Aulus Celsus, an ancient Roman doctor, believed in "strong" and "weak" foods (bread for example was strong, as were older animals and vegetables).[20]

1.2 Galen to Lind

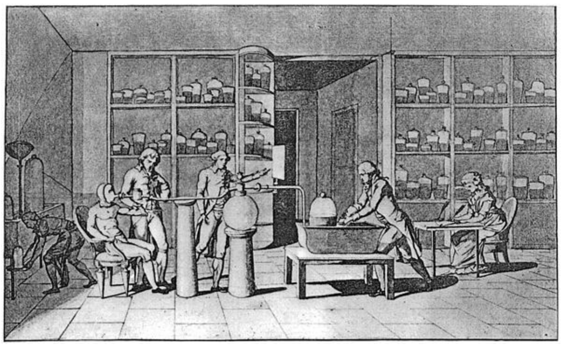
One mustn't overlook the doctrines of Galen: In use from his life in the 1st century AD until the 17th century, it was heresy to disagree with him for 1500 years.[21] Galen was physician to gladiators in Pergamon, and in Rome, physician to Marcus Aurelius and the three emperors who succeeded him.[22] Most of Galen's teachings were gathered and enhanced in the late 11th century by Benedictine monks at the School of Salerno in *Regimen sanitatis Salernitanum*, which still had users in the 17th century.[23] Galen believed in the bodily *humours* of Hippocrates, and he taught that *pneuma* is the source of life. Four elements (earth, air, fire and water) combine into "complexion", which combines into states (the four temperaments: sanguine, phlegmatic, choleric, and melancholic). The states are made up of pairs of attributes (hot and moist, cold and moist, hot and dry, and cold and dry), which are made of four humours: blood, phlegm, green (or yellow) bile, and black bile (the bodily form of the elements). Galen thought that for a person to have gout, kidney stones, or arthritis was scandalous, which Gratzer likens to Samuel Butler's *Erehwon* (1872) where sickness is a crime.[21]

James Lind conducted in 1747 the first controlled clinical trial in modern times, and in 1753 published Treatise on Scurvy.*[24]*

In the 1500s, Paracelsus was probably the first to criticize Galen publicly.[21] Also in the 16th century, scientist and artist Leonardo da Vinci compared metabolism to a burning candle. Leonardo did not publish his works on this subject, but he was not afraid of thinking for himself and he definitely disagreed with Galen.[16] Ultimately, 16th century works of Andreas Vesalius, sometimes called the father of modern medicine, overturned Galen's ideas.[25] He was followed by piercing thought amalgamated with the era's mysticism and religion sometimes fueled by the mechanics of Newton and Galileo. Jan Baptist van Helmont, who discovered several gases such as carbon dioxide, performed the first quantitative experiment. Robert Boyle advanced chemistry. Sanctorius measured body weight. Physician Herman Boerhaave modeled the digestive process. Physiologist Albrecht von Haller worked out the difference between nerves and muscles.[26]

Sometimes overlooked during his life, James Lind, a physician in the British navy, performed the first scientific nutrition experiment in 1747. Lind discovered that lime juice saved sailors that had been at sea for years from scurvy, a deadly and painful bleeding disorder. Between 1500 and 1800, an estimated two million sailors had died of scurvy.[27] The discovery was ignored for forty years, after which British sailors became known as "limeys."[28] The essential vitamin C within citrus fruits would not be identified by scientists until 1932.[27]

1.3 Lavoisier and modern science



By containing his assistant, Armand Seguin, inside a rubber suit fitted with a tube sealed to his mouth with putty, Antoine Lavoisier first measured basal metabolic rate.[29] Drawing by Madame Lavoisier (seated at right).

Around 1770, Antoine Lavoisier discovered the details of metabolism, demonstrating that the oxidation of food is the source of body heat. He discovered the principle of conservation of mass. His ideas made the phlogiston theory of combustion obsolete.[30]

In 1790, George Fordyce recognized calcium as necessary for fowl survival. In the early 19th century, the elements carbon, nitrogen, hydrogen, and oxygen were recognized as the primary components of food, and methods to measure their proportions were developed.[31]

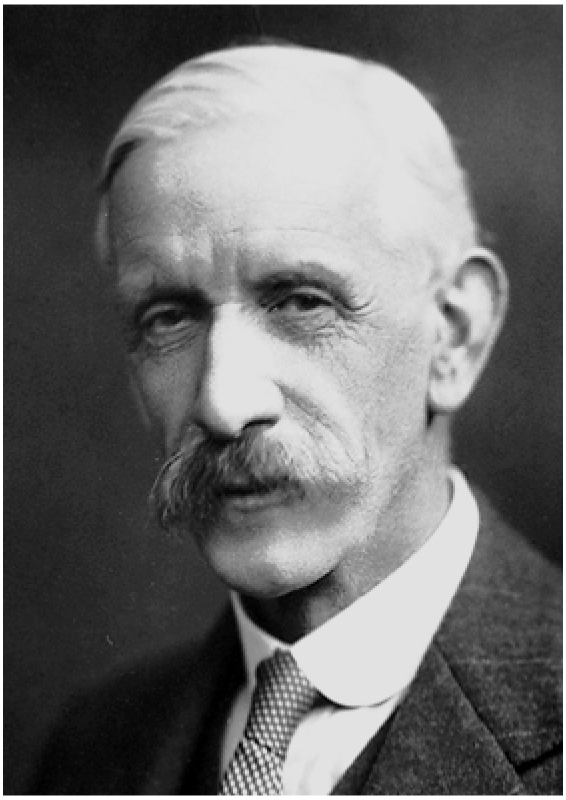
In 1816, François Magendie discovered that dogs fed only carbohydrates (sugar), fat (olive oil), and water died evidently of starvation, but dogs also fed protein survived, identifying protein as an essential dietary component.[32] William Prout in 1827 was the first person to divide foods into carbohydrates, fat, and protein.[33] During the 19th century, Jean-Baptiste Dumas and Justus von Liebig quarrelled over their shared belief that animals get their protein directly from plants (animal and plant protein are the same and that humans do not create organic compounds).[34] With a reputation as the leading organic chemist of his day but with no credentials in animal physiology,[35] Liebig grew rich making food extracts like beef bouillon and infant formula that were later found to be of questionable nutritious value.[36] In the 1860s, Claude Bernard discovered that body fat can be synthesized from carbohydrate and protein, showing that the energy in blood glucose can be stored as fat or as glycogen.[37]

In the early 1880s, Kanehiro Takaki observed that Japanese sailors (whose diets consisted almost entirely of white rice) developed beriberi (or endemic neuritis, a disease causing heart problems and paralysis), but British sailors and Japanese naval officers did not. Adding various types of vegetables and meats to the diets of Japanese sailors prevented the disease, (not because of the increased protein as Takaki supposed but because it introduced a few parts per million of thiamine to the diet, later understood as a cure[38]).

In 1896, Eugen Baumann observed iodine in thyroid glands. In 1897, Christiaan Eijkman worked with natives of Java, who also suffered from beriberi. Eijkman observed that chickens fed the native diet of white rice developed the symptoms of beriberi but remained healthy when fed unprocessed brown rice with the outer bran intact. Eijkman cured the natives by feeding them brown rice, discovering that food can cure disease. Over two decades later, nutritionists learned that the outer rice bran contains vitamin B1, also known as thiamine.

1.4 From 1900 to the present

In the early 20th century, Carl von Voit and Max Rubner independently measured caloric energy expenditure in different species of animals, applying principles of physics in nutrition. In 1906, Wilcock and Hopkins showed that the amino acid tryptophan is necessary for the survival of rats. He fed them a special mixture of food containing all the nutrients he believed to be essential for survival, but the rats died. A second group of rats were fed an amount of milk containing vitamins. Sir Frederick Hopkins recognized that there exist "accessory food factors" other than calories, protein, and minerals, as organic materials essential to health but that the body cannot synthesize. In 1907, Stephen M. Babcock and Edwin B. Hart conducted the single-grain experiment, which took nearly four years to complete.[31]



Frederick Hopkins discovered vitamins, for which he shared a Nobel prize with Eijkman.

Oxford University closed down its nutrition department after World War II because the subject seemed to have been completed between 1912 and 1944.[40]

In 1912, Casimir Funk coined the term vitamin, a vital factor in the diet, from the words "vital" and "amine," because these unknown substances preventing scurvy, beriberi, and pellagra, were thought then to be derived from ammonia. The vitamins were studied in the first half of the 20th century.

In 1913, Elmer McCollum discovered the first vitamins, fat-soluble vitamin A, and water-soluble vitamin B (in 1915; now known to be a complex of several water-soluble vitamins) and named vitamin C as the then-unknown substance preventing scurvy. Lafayette Mendel and Thomas Osborne also performed pioneering work on vitamins A and B. In 1919, Sir Edward Mellanby incorrectly identified rickets as a vitamin A deficiency because he could cure it in dogs with cod liver oil.[41] In 1922, Elmer McCollum destroyed the vitamin A in cod liver oil, but found that it still cured rickets. Also in 1922, H.M. Evans and L.S. Bishop discover vitamin E as essential for rat pregnancy, originally calling it "food factor X" until 1925.

In 1925, Hart discovered that trace amounts of copper are necessary for iron absorption. In 1927, Adolf Otto Reinhold Windaus synthesized vitamin D, for which he won the Nobel Prize in Chemistry in 1928. In 1928, Albert Szent-Györgyi isolated ascorbic acid, and in 1932 proved that it is vitamin C by preventing scurvy. In 1935, he synthesized it, and in 1937, he won a Nobel Prize for his efforts. Szent-Györgyi concurrently elucidated much of the citric acid cycle.

In the 1930s, William Cumming Rose identified essential amino acids, necessary protein components that the body cannot synthesize. In 1935, Underwood and Marston independently discovered the necessity of cobalt. In 1936, Eugene Floyd DuBois showed that work and school performance are related to caloric intake. In 1938, Erhard Fernholz discovered the chemical structure of vitamin E and then he tragically disappeared.[42][43] It was synthesised the same year by Paul Karrer.[42]

In 1940, rationing in the United Kingdom during and after World War II took place according to nutritional principles drawn up by Elsie Widdowson and others. In 1941, the first Recommended Dietary Allowances (RDAs) were established by the National Research Council.

In 1992, The U.S. Department of Agriculture introduced the Food Guide Pyramid.[44] In 2002, a Natural Justice study showed a relation between nutrition and violent behavior.[31] In 2005, one inconclusive study found that obesity could be caused by adenovirus in addition to bad nutrition.[45]

World leaders are looking at alternatives like genetically modified foods to tackle the problem of world hunger and food shortages.[46]

2 Nutrients

Main article: Nutrient

The list of nutrients that people are known to require is, in the words of Marion Nestle, "almost certainly incomplete".[47] As of 2014, nutrients are thought to be of two types: macro-nutrients which are needed in relatively large amounts, and micronutrients which are needed in smaller quantities.[48] A type of carbohydrate, dietary fiber, i.e. non-digestible material such as cellulose, is required,[49] for both mechanical and biochemical reasons, although the exact reasons remain unclear. 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 types, 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.[50][51]

2.1 Macronutrients

The macronutrients are carbohydrates, fats, protein, and water.[48] The macronutrients (excluding fiber and water) provide structural material (amino acids from which proteins are built, and lipids from which cell membranes and some signaling molecules are built) and 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,[52] 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.

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 a 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, the carbon skeleton of the various amino acids can be metabolized to intermediates in cellular respiration; the remaining ammonia is discarded primarily as urea in urine. This occurs normally only during prolonged starvation.

2.1.1 Carbohydrates

Main article: Carbohydrate

Carbohydrates may be classified as monosaccharides, disaccharides, or polysaccharides depending on the number of monomer (sugar) units they contain. They constitute a large part of foods such as rice, noodles, bread, and other grain-based products. Monosaccharides, disaccharides, and polysaccharides contain one, two, and three or more sugar units, respectively. Polysaccharides are often referred to as *complex* carbohydrates because they are typically long, multiple branched chains of sugar units.

Traditionally, simple carbohydrates are believed to be absorbed quickly, and therefore to raise blood-glucose levels more rapidly than complex carbohydrates. This, however, is not accurate.[53][54][55][56] Some simple carbohydrates (e.g., fructose) follow different metabolic pathways (e.g., fructolysis) that result in only a partial catabolism to glucose, while, in essence, many complex carbohydrates may be digested at the same rate as simple carbohydrates.[57] Glucose stimulates the production of insulin through food entering the bloodstream, which is grasped by the beta cells in the pancreas.

Fiber Main article: Dietary fiber

Dietary fiber is a carbohydrate 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 which is indigestible as 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 that 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.

2.1.2 Fat

Main article: 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. Fatty acids such as conjugated linoleic acid, catalpic acid, eleostearic acid and punicic acid, in addition to providing energy, represent potent immune modulatory molecules.

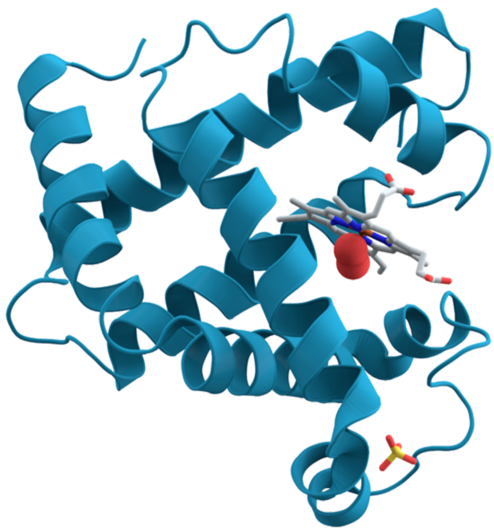
Saturated fats (typically from animal sources) have been a staple in many world cultures for millennia. Unsaturated fats (e. g., vegetable oil) are considered healthier, while trans fats are to be avoided. Saturated and some trans fats are typically solid at room temperature (such as butter or lard), 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 Main article: 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 (ALA), 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.

The conversion rate of omega-6 DGLA to AA largely determines the production of the prostaglandins PGE1 and PGE2. Omega-3 EPA prevents AA from being released from membranes, thereby skewing prostaglandin balance away from pro-inflammatory PGE2 (made from AA) toward anti-inflammatory PGE1 (made from DGLA). Moreover, the conversion (desaturation) of DGLA to AA is controlled by the enzyme delta-5-desaturase, which in turn is controlled by hormones such as insulin (up-regulation) and glucagon (down-regulation). The amount and type of carbohydrates consumed, along with some types of amino acid, can influence processes involving insulin, glucagon, and other hormones; therefore, the ratio of omega-3 versus omega-6 has wide effects on general health, and specific effects on immune function and inflammation, and mitosis (i.e., cell division).

2.1.3 Protein



Proteins are chains of amino acids found in most nutritional foods.

Main article: Protein (nutrient)

Proteins are structural materials in much of the animal body (e.g. muscles, skin, and hair). They also form the enzymes that control chemical reactions throughout the body. Each protein 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). About twenty amino acids are found in the human body, and about ten of these 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.

It is possible with protein combinations of two incomplete protein sources (e.g., rice and beans) to make a complete protein source, and characteristic combinations are the basis of distinct cultural cooking traditions. However, complementary sources of protein do not need to be eaten at the same meal to be used together by the body.[58] 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.

2.1.4 Water

Main article: Drinking water

Water is excreted from the body in multiple forms; including urine and feces, sweating, and by water vapour in the exhaled breath. Therefore, it is necessary to adequately rehydrate to replace lost fluids.

A manual water pump in China

Early recommendations for the quantity of water required for maintenance of good health suggested that 6–8 glasses of water daily is the minimum to maintain proper hydration.[59] However the notion that a person should consume eight glasses of water per day cannot be traced to a credible scientific source.[60] 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."[61] More recent comparisons of well-known recommendations on fluid intake have revealed large discrepancies in the volumes of water we need to consume for good health.[62] Therefore, to help standardize guidelines, recommendations for water consumption are included in two recent European Food Safety Authority (EFSA) documents (2010): (i) Food-based dietary guidelines and (ii) Dietary reference values for water or adequate daily intakes (ADI).[63] These specifications were provided by calculating adequate intakes from measured intakes in populations of individuals with "desirable osmolarity values of urine and desirable water volumes per energy unit consumed."[63] For healthful hydration, the current EFSA guidelines recommend total water intakes of 2.0 L/day for adult females and 2.5 L/day for adult males. These reference values include water from drinking water, other beverages, and from food. About 80% of our daily water requirement comes from the beverages we drink, with the remaining 20% coming from food.[64] Water content varies depending on the type of food consumed, with fruit and vegetables containing more than cereals, for example.[65] These values are estimated using country-specific food balance sheets published by the Food and Agriculture Organisation of the United Nations.[65] Other guidelines for nutrition also have implications for the beverages we consume for healthy hydration- for example, the World Health Organization (WHO) recommend that added sugars should represent no more than 10% of total energy intake.[66]

The EFSA panel also determined intakes for different populations. Recommended intake volumes in the elderly are the same as for adults as despite lower energy consumption, the water requirement of this group is increased due to a reduction in renal concentrating capacity.[63] Pregnant and breastfeeding women require additional fluids to stay hydrated. The EFSA panel proposes that pregnant women should consume the same volume of water as non-pregnant women, plus an increase in proportion to the higher energy requirement, equal to 300 mL/day.[63] To compensate for additional fluid output, breastfeeding women require an additional 700 mL/day above the recommended intake values for non-lactating women.[63]

For those who have healthy kidneys, it is somewhat difficult to drink too much water,[63] but (especially in warm humid weather and while exercising) it is dangerous to drink too little. While overhydration is much less common than dehydration, it is also possible to drink far more water than necessary, which can result in water intoxication, a serious and potentially fatal condition.[67] In particular, large amounts of de-ionized water are dangerous.[63]

2.2 Micronutrients

The micronutrients are minerals, vitamins, and others.[48]

2.2.1 Minerals

Main articles: Dietary mineral and Composition of the human body

Dietary minerals are inorganic chemical elements required by living organisms,[68] 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.[69] Elements with recommended dietary allowance (RDA) greater than 150 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[70]
- Potassium, a very common electrolyte (heart and nerve health)
- Sodium, a very common electrolyte; in general not 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, leading to high blood pressure and osteoporosis.
- 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.[71] Some trace mineral elements (RDA < 200 mg/day) are, in alphabetical order:

- Cobalt required for biosynthesis of vitamin B12 family of coenzymes. Animals cannot biosynthesize B12, and must obtain this cobalt-containing vitamin in the diet
- Copper required component of many redox enzymes, including cytochrome c oxidase
  Main article: Copper in health
- Chromium required for sugar metabolism
- Iodine required not only for the biosynthesis of thyroxine but also — it is presumed — 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

2.2.2 Vitamins

Main article: Vitamin

As with the minerals discussed above, some vitamins are recognized as organic essential nutrients,[68] 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.[72] Excess levels of some vitamins are also dangerous to health (notably vitamin A). Deficient or excess levels of minerals can also have serious health consequences.

2.2.3 Other nutrients

In general, other micronutrients are more recent discoveries that have not yet been recognized as vitamins or as required. Phytochemicals may act as antioxidants, but not all phytochemicals are antioxidants.

Blackberries are a source of polyphenol antioxidants

Phytochemicals Main article: Phytochemical

Phytochemicals are chemical compounds that occur naturally in plants (phyto means “plant” in Greek). In general, the term is used to refer to those chemicals that may have biological significance, for example antioxidants.

There is research interest in the health effects of phytochemicals, but to date there is no conclusive evidence.[73] While many fruits and vegetables that happen to contain phytochemicals are thought to be components of a healthy diet, by comparison dietary supplements based on them have no proven health benefit.[73]

Antioxidants Main article: Antioxidant

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. Recently, some researchers suggested an interesting theory of evolution of dietary antioxidants. 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 (*Section Below*) 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.

Colorful fruits can be components of a healthy diet.

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.[74][75]

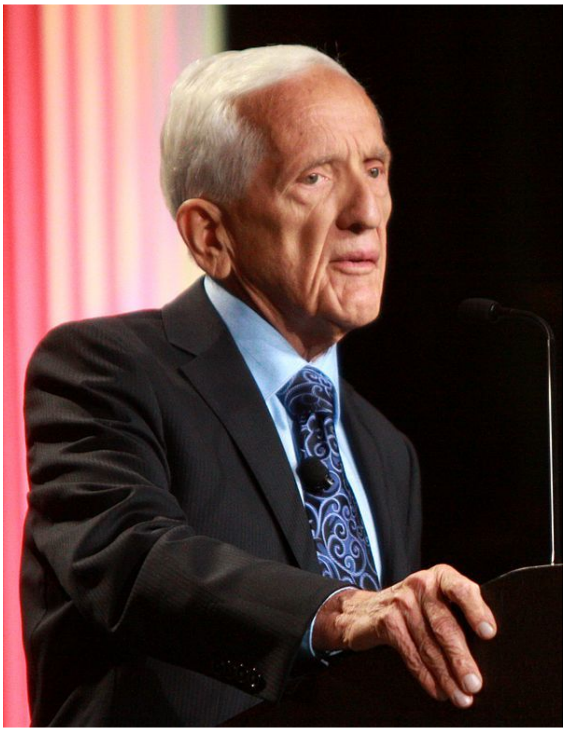
Intestinal bacterial flora Main article: Gut flora

Animal intestines contain a large population of gut flora. In humans, the four dominant phyla are Firmicutes, Bacteroidetes, Actinobacteria, and Proteobacteria.[76] They are essential to digestion and are also affected by food that is consumed. Bacteria in the gut perform many important functions for humans, including breaking down and aiding in the absorption of otherwise indigestible food; stimulating cell growth; repressing the growth of harmful bacteria, training the immune system to respond only to pathogens; producing vitamin B_{12}; and defending against some infectious diseases.[77]

3 Healthy diets

Main article: Healthy diet

3.1 Whole plant food diet



T. Colin Campbell is among the scientists who advocate a plant-based diet

Heart disease, cancer, obesity, and diabetes are commonly called "Western" diseases because these maladies were once rarely seen in developing countries. An international study in China found some regions had virtually no cancer or heart disease, while in other areas they reflected "up to a 100-fold increase" coincident with shifts from diets that were found to be entirely plant-based to heavily animal-based, respectively.[78] In contrast, diseases of affluence like cancer and heart disease are common throughout the developed world, including the United States. Adjusted for age and exercise, large regional clusters of people in China rarely suffered from these "Western" diseases possibly because their diets are rich in vegetables, fruits, and whole grains, and have little dairy and meat products.[78] Some studies show these to be, in high quantities, possible causes of some cancers. There are arguments for and against this controversial issue.

The United Healthcare/Pacificare nutrition guideline recommends a whole plant food diet, and recommends using protein only as a condiment with meals. A *National Geographic* cover article from November 2005, entitled *The Secrets of Living Longer*, also recommends a whole plant food diet. The article is a lifestyle survey of three populations, Sardinians, Okinawans, and Adventists, who generally display longevity and "suffer a fraction of the diseases that commonly kill people in other parts of the developed world, and enjoy more healthy years of life." In sum, they offer three sets of 'best practices' to emulate. The rest is up to you. In common with all three groups is to "Eat fruits, vegetables, and whole grains."

The *National Geographic* article noted that an NIH funded study of 34,000 Seventh-day Adventists between 1976 and 1988 "...found that the Adventists' habit of consuming beans, soy milk, tomatoes, and other fruits lowered their risk of developing certain cancers. It also suggested that eating whole grain bread, drinking five glasses of water a day, and, most surprisingly, consuming four servings of nuts a week reduced their risk of heart disease."

3.2 The French "paradox"

Main article: French paradox

The French paradox is the observation that the French suffer a relatively low incidence of coronary heart disease, despite having a diet relatively rich in saturated fats. A number of explanations have been suggested:

- Saturated fat consumption does not cause heart disease[80]
- Reduced consumption of processed carbohydrate and other junk foods.
- Regular consumption of red wine.
- Higher consumption of artificially produced trans-fats by Americans, which has been shown to have

greater lipoprotein effects per gram than saturated fat.[81]

However, statistics collected by the World Health Organization from 1990–2000 show that the incidence of heart disease in France may have been underestimated and, in fact, may be similar to that of neighboring countries.[82]

4 Animal nutrition

Main articles: Animal nutrition and Human nutrition

Nutritional science investigates the metabolic and physiological responses of the body to diet. With advances in the fields of molecular biology, biochemistry, nutritional immunology, molecular medicine 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.

Carnivore and herbivore diets are contrasting, with basic nitrogen and carbon proportions vary for their particular foods. "The nitrogen content of plant tissues averages about 2%, while in fungi, animals, and bacteria it averages about 5% to 10%."[83] Many herbivores rely on bacterial fermentation to create digestible nutrients from indigestible plant cellulose, while obligate carnivores must eat animal meats to obtain certain vitamins or nutrients their bodies cannot otherwise synthesize. All animals' diets must provide sufficient amounts of the basic building blocks they need, up to the point where their particular biology can synthesize the rest.[84] Animal tissue 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).

Animal tissue 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, the digestive system is the first system involved . Digestive juices break chemical bonds in ingested molecules, and modify 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 animal nutrition is still slowly evolving.

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 . Regularly scheduled meals (every few hours) have also proven more wholesome than infrequent or haphazard ones.[85]

5 Plant nutrition

Main article: Plant nutrition

Plant nutrition is the study of the chemical elements that are necessary for plant growth.[86] There are several principles that apply to plant nutrition. Some elements are directly involved in plant metabolism. However, this principle does not account for the so-called beneficial elements, whose presence, while not required, has clear positive effects on plant growth.

A nutrient that is able to limit plant growth according to Liebig's law of the minimum is considered an essential plant nutrient if the plant cannot complete its full life cycle without it. There are 16 essential plant soil nutrients, besides the three major elemental nutrients carbon and oxygen that are obtained by photosynthetic plants from carbon dioxide in air, and hydrogen, which is obtained from water.

Plants uptake essential elements from the soil through their roots and from the air (consisting of mainly nitrogen and oxygen) through their leaves. Green plants obtain their carbohydrate supply from the carbon dioxide in the air by the process of photosynthesis. Carbon and oxygen are absorbed from the air, while other nutrients are absorbed from the soil. Nutrient uptake in the soil is achieved by cation exchange, wherein root hairs pump hydrogen ions (H^+) into the soil through proton pumps. These hydrogen ions displace cations attached to negatively charged soil particles so that the cations are available for uptake by the root. In the leaves, stomata open to take in carbon dioxide and expel oxygen. The carbon dioxide molecules are used as the carbon source in photosynthesis.

Although nitrogen is plentiful in the Earth's atmosphere, very few plants can use this directly. Most plants, therefore, require nitrogen compounds to be present in the soil in which they grow. This is made possible by the fact that largely inert atmospheric nitrogen is changed in a nitrogen fixation process to biologically usable forms in the soil by bacteria.[87]

Plant nutrition is a difficult subject to understand completely, partially because of the variation between different plants and even between different species or individuals of a given clone. Elements present at low levels may cause deficiency symptoms, and toxicity is possible at levels that are too high. Furthermore, deficiency of one element may present as symptoms of toxicity from another element, and vice versa.

6 Environmental Nutrition

Research in the field of nutrition has greatly contributed in finding out the essential facts about how environmental depletion can lead to crucial nutrition-related health problems like contamination, spread of contagious diseases, malnutrition, etc. Moreover, environmental contamination due to discharge of agricultural as well as industrial chemicals like organocholrines, heavy metal, and radionucleotides may adversely affect the human and the ecosystem as a whole. As far as safety of the human health is concerned, then these environmental contaminants can reduce people's nutritional status and health. This could directly or indirectly cause drastic changes in their diet habits. Hence, food-based remedial as well as preventive strategies are essential to address global issues like hunger and malnutrition and to enable the susceptible people to adapt themselves to all these environmental as well as socio-economic alterations.[88]

7 Advice and guidance

7.1 U.S. Government policies

In the US, dietitians are registered (RD) or licensed (LD) with the Commission for Dietetic Registration and the American Dietetic Association, and are only able to use the title "dietitian," as described by the business and professions codes of each respective state, when they have met specific educational and experiential prerequisites and passed a national registration or licensure examination, respectively. In California, registered dietitians must abide by the "Business and Professions Code of Section 2585-2586.8".Anyone may call themselves a nutritionist, including unqualified dietitians, as this term is unregulated. Some states, such as the State of Florida, have begun to include the title "nutritionist" in state licensure requirements. Most governments provide guidance on nutrition, and some also impose mandatory disclosure/labeling requirements for processed food manufacturers and restaurants to assist consumers in complying with such guidance.

In the US, nutritional standards and recommendations are established jointly by the US Department of Agriculture and US Department of Health and Human Services. Dietary and physical activity guidelines from the USDA are presented in the concept of MyPlate, which superseded the food pyramid, which replaced the Four Food Groups. The Senate committee currently responsible for oversight of the USDA is the *Agriculture, Nutrition and Forestry Committee*. Committee hearings are often televised on C-SPAN.

The U.S. Department of Health and Human Services provides a sample week-long menu that fulfills the nutritional recommendations of the government.[89] Canada's Food Guide is another governmental recommendation.

7.2 Government programs

Federal and state governmental organizations have been working on nutrition literacy interventions in non-primary health care settings to address the nutrition information problem in the U.S. Some programs include:

The Family Nutrition Program (FNP) is a free nutrition education program serving low-income adults around the U.S. This program is funded by the Food Nutrition Service's (FNS) branch of the United States Department of Agriculture (USDA) usually through a local state academic institution that runs the program. The FNP has developed a series of tools to help families participating in the Food Stamp Program stretch their food dollar and form healthful eating habits including nutrition education.

Expanded Food and Nutrition Education Program (ENFEP) is a unique program that currently operates in all 50 states and in American Samoa, Guam, Micronesia, Northern Marianas, Puerto Rico, and the Virgin Islands. It is designed to assist limited-resource audiences in acquiring the knowledge, skills, attitudes, and changed behavior necessary for nutritionally sound diets, and to contribute to their personal development and the improvement of the total family diet and nutritional well-being.

An example of a state initiative to promote nutrition literacy is Smart Bodies, a public-private partnership between the state's largest university system and largest health insurer, Louisiana State Agricultural Center and Blue Cross and Blue Shield of Louisiana Foundation. Launched in 2005, this program promotes lifelong healthful eating patterns and physically active lifestyles for children and their families. It is an interactive educational program designed to help prevent childhood obesity through classroom activities that teach children healthful eating habits and physical exercise.

7.3 Education

Nutrition is taught in schools in many countries. In England and Wales, the Personal and Social Education and Food Technology curricula include nutrition, stressing the importance of a balanced diet and teaching how to read nutrition labels on packaging. In many schools, a Nutrition class will fall within the Family and Consumer Science or Health departments. In some American schools, students are required to take a certain number of FCS or Health related classes. Nutrition is offered at many schools, and, if it is not a class of its own, nutrition is included in other FCS or Health classes such as: Life Skills, Independent Living, Single Survival, Freshmen Connection, Health etc. In many Nutrition classes, students learn about the food groups, the food pyramid, Daily Recommended Allowances, calories, vitamins, minerals, malnutrition, physical activity, healthful food choices, portion sizes, and how to live a healthy life.

A 1985, US National Research Council report entitled *Nutrition Education in US Medical Schools* concluded that nutrition education in medical schools was inadequate.[90] Only 20% of the schools surveyed taught nutrition as a separate, required course. A 2006 survey found that this number had risen to 30%.[91]

8 Nutrition literacy

At the time of this entry, we were not able to identify any specific nutrition literacy studies in the U.S. at a national level. However, the findings of the 2003 National Assessment of Adult Literacy (NAAL) provide a basis upon which to frame the nutrition literacy problem in the U.S. NAAL introduced the first ever measure of “the degree to which individuals have the capacity to obtain, process and understand basic health information and services needed to make appropriate health decisions” – an objective of Healthy People 2010[92] and of which nutrition literacy might be considered an important subset. On a scale of below basic, basic, intermediate and proficient, NAAL found 13 percent of adult Americans have proficient health literacy, 44% have intermediate literacy, 29 percent have basic literacy and 14 percent have below basic health literacy. The study found that health literacy increases with education and people living below the level of poverty have lower health literacy than those above it.

Another study examining the health and nutrition literacy status of residents of the lower Mississippi Delta found that 52 percent of participants had a high likelihood of limited literacy skills.[93] While a precise comparison between the NAAL and Delta studies is difficult, primarily because of methodological differences, Zoellner et al. suggest that health literacy rates in the Mississippi Delta region are different from the U.S. general population and that they help establish the scope of the problem of health literacy among adults in the Delta region. For example, only 12 percent of study participants identified the My Pyramid graphic two years after it had been launched by the USDA. The study also found significant relationships between nutrition literacy and income level and nutrition literacy and educational attainment[93] further delineating priorities for the region.

These statistics point to the complexities surrounding the lack of health/nutrition literacy and reveal the degree to which they are embedded in the social structure and interconnected with other problems. Among these problems are the lack of information about food choices, a lack of understanding of nutritional information and its application to individual circumstances, limited or difficult access to healthful foods, and a range of cultural influences and socioeconomic constraints such as low levels of education and high levels of poverty that decrease opportunities for healthful eating and living.

The links between low health literacy and poor health outcomes has been widely documented[94] and there is evidence that some interventions to improve health literacy have produced successful results in the primary care setting. More must be done to further our understanding of nutrition literacy specific interventions in non-primary care settings[93] in order to achieve better health outcomes.

9 Malnutrition

Main article: Malnutrition

Malnutrition refers to insufficient, excessive, or imbalanced consumption of nutrients by an organism. In developed countries, the diseases of malnutrition are most often associated with nutritional imbalances or excessive consumption. In developing countries, malnutrition is more likely to be caused by poor access to a range of nutritious foods or inadequate knowledge. In Mali the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and the Aga Khan Foundation, trained women’s groups to make *equinut*, a healthy and nutritional version of the traditional recipe *di-dègè* (comprising peanut paste, honey and millet or rice flour). The aim was to boost nutrition and livelihoods by producing a product that women could make and sell, and which would be accepted by the local community because of its local heritage.[95]

Although there are more organisms in the world who are malnourished due to insufficient consumption, increasingly more organisms suffer from excessive overnutrition; a problem caused by an over abundance of sustenance coupled with the instinctual desire (by animals in particular) to consume all that it can.

Nutritionism is the view that excessive reliance on food science and the study of nutrition can lead to poor nutrition and to ill health. It was originally credited to Gyorgy Scrinis,[96] and was popularized by Michael Pollan. Since nutrients are invisible, policy makers rely on nutrition experts to advise on food choices. Because science has an incomplete understanding of how food affects the human body, Pollan argues, nutritionism can be blamed for many of the health problems relating to diet in the Western World today.[97][98]

9.1 Insufficient

In general, *under-consumption* refers to the long-term consumption of insufficient sustenance in relation to the energy that an organism expends or expels, leading to poor health.

9.2 Excessive

In general, *over-consumption* refers to the long-term consumption of excess sustenance in relation to the energy that an organism expends or expels, leading to poor health and, in animals, obesity. It can cause excessive hair loss, brittle nails, and irregular premenstrual cycles for females.

9.3 Unbalanced

When too much of one or more nutrients is present in the diet to the exclusion of the proper amount of other nutrients, the diet is said to be unbalanced.

9.4 Illnesses caused by improper nutrient consumption

9.5 Mental agility

Main article: Nootropic

Research indicates that improving the awareness of nutritious meal choices and establishing long-term habits of healthy eating have a positive effect on cognitive and spatial memory capacity, with potential to increase a student's ability to process and retain academic information.

Some organizations have begun working with teachers, policymakers, and managed foodservice contractors to mandate improved nutritional content and increased nutritional resources in school cafeterias from primary to university level institutions. Health and nutrition have been proven to have close links with overall educational success.[99] Currently, less than 10% of American college students report that they eat the recommended five servings of fruit and vegetables daily.[100] Better nutrition has been shown to have an impact on both cognitive and spatial memory performance; a study showed those with higher blood sugar levels performed better on certain memory tests.[101] In another study, those who consumed yogurt performed better on thinking tasks when compared to those that consumed caffeine-free diet soda or confections.[102] Nutritional deficiencies have been shown to have a negative effect on learning behavior in mice as far back as 1951.[103]

> "Better learning performance is associated with diet-induced effects on learning and memory ability".[104]

> The "nutrition-learning nexus" demonstrates the correlation between diet and learning and has application in a higher education setting.

> "We find that better-nourished children perform significantly better in school, partly because they enter school earlier and thus have more time to learn but mostly because of greater learning productivity per year of schooling."[105]

> 91% of college students feel that they are in good health, whereas only 7% eat their recommended daily allowance of fruits and vegetables.[100]

> Nutritional education is an effective and workable model in a higher education setting.[106][107]

> More "engaged" learning models that encompass nutrition is an idea that is picking up steam at all levels of the learning cycle.[108]

There is limited research available that directly links a student's Grade Point Average (G.P.A.) to their overall nutritional health. Additional substantive data is needed to prove that overall intellectual health is closely linked to a person's diet, rather than just another correlation fallacy.

9.6 Mental disorders

Nutritional supplement treatment may be appropriate for major depression, bipolar disorder, schizophrenia, and obsessive compulsive disorder, the four most common mental disorders in developed countries.[109] Supplements that have been studied most for mood elevation and stabilization include eicosapentaenoic acid and docosahexaenoic acid (each of which an omega-3 fatty acid contained in fish oil but not in flaxseed oil), vitamin B12, folic acid, and inositol.

9.7 Cancer

Cancer is now common in developing countries. According to a study by the International Agency for Research on Cancer, “In the developing world, cancers of the liver, stomach and esophagus were more common, often linked to consumption of carcinogenic preserved foods, such as smoked or salted food, and parasitic infections that attack organs.” Lung cancer rates are rising rapidly in poorer nations because of increased use of tobacco. Developed countries “tended to have cancers linked to affluence or a 'Western lifestyle' — cancers of the colon, rectum, breast and prostate — that can be caused by obesity, lack of exercise, diet and age.”[110]

9.8 Metabolic syndrome

Several lines of evidence indicate lifestyle-induced hyperinsulinemia and reduced insulin function (i.e., insulin resistance) as a decisive factor in many disease states. For example, hyperinsulinemia and insulin resistance are strongly linked to chronic inflammation, which in turn is strongly linked to a variety of adverse developments such as arterial microinjuries and clot formation (i.e., heart disease) and exaggerated cell division (i.e., cancer). Hyperinsulinemia and insulin resistance (the so-called metabolic syndrome) are characterized by a combination of abdominal obesity, elevated blood sugar, elevated blood pressure, elevated blood triglycerides, and reduced HDL cholesterol. The negative impact of hyperinsulinemia on prostaglandin PGE1/PGE2 balance may be significant.

The state of obesity clearly contributes to insulin resistance, which in turn can cause type 2 diabetes. Virtually all obese and most type 2 diabetic individuals have marked insulin resistance. Although the association between overweight and insulin resistance is clear, the exact (likely multifarious) causes of insulin resistance remain less clear. It is important to note that it has been demonstrated that appropriate exercise, more regular food intake, and reducing glycemic load (see below) all can reverse insulin resistance in overweight individuals (and thereby lower blood sugar levels in those with type 2 diabetes).

Obesity can unfavourably alter hormonal and metabolic status via resistance to the hormone leptin, and a vicious cycle may occur in which insulin/leptin resistance and obesity aggravate one another. The vicious cycle is putatively fuelled by continuously high insulin/leptin stimulation and fat storage, as a result of high intake of strongly insulin/leptin stimulating foods and energy. Both insulin and leptin normally function as satiety signals to the hypothalamus in the brain; however, insulin/leptin resistance may reduce this signal and therefore allow continued overfeeding despite large body fat stores. In addition, reduced leptin signalling to the brain may reduce leptin’s normal effect to maintain an appropriately high metabolic rate.

There is a debate about how and to what extent different dietary factors— such as intake of processed carbohydrates, total protein, fat, and carbohydrate intake, intake of saturated and trans fatty acids, and low intake of vitamins/minerals—contribute to the development of insulin and leptin resistance. In any case, analogous to the way modern man-made pollution may possess the potential to overwhelm the environment’s ability to maintain homeostasis, the recent explosive introduction of high glycemic index and processed foods into the human diet may possess the potential to overwhelm the body’s ability to maintain homeostasis and health (as evidenced by the metabolic syndrome epidemic).

9.9 Hyponatremia

Excess water intake, without replenishment of sodium and potassium salts, leads to hyponatremia, which can further lead to water intoxication at more dangerous levels. A well-publicized case occurred in 2007, when Jennifer Strange died while participating in a water-drinking contest.[111] More usually, the condition occurs in long-distance endurance events (such as marathon or triathlon competition and training) and causes gradual mental dulling, headache, drowsiness, weakness, and confusion; extreme cases may result in coma, convulsions, and death. The primary damage comes from swelling of the brain, caused by increased osmosis as blood salinity decreases. Effective fluid replacement techniques include water aid stations during running/cycling races, trainers providing water during team games, such as soccer, and devices such as Camel Baks, which can provide water for a person without making it too hard to drink the water.

9.10 Antinutrient

Main article: Antinutrient

Antinutrients are natural or synthetic compounds that interfere with the absorption of nutrients. Nutrition studies focus on antinutrients commonly found in food sources and beverages.

Sugar consumption in the United States

The relatively recent increased consumption of sugar has been linked to the rise of some afflictions such as diabetes, obesity, and more recently heart disease. Increased consumption of sugar has been tied to these three, among others. Obesity levels have more than doubled in the last 30 years among adults, going from 15% to 35% in the United States.[112] Obesity and diet also happen to be high risk factors for diabetes. In the same time span that obesity doubled, diabetes numbers quadrupled in America. Increased weight, especially in the form of belly fat, and high sugar intake are also high risk factors for heart disease.[113] Both sugar intake and fatty tissue increase the probability of elevated LDL cholesterol in the bloodstream. Elevated amounts of Low-density lipoprotein (LDL) cholesterol, is the primary factor in heart disease. In order to avoid all the dangers of sugar, moderate consumption is paramount.

9.11 Processed foods

Main article: Food processing

Since the Industrial Revolution some two hundred years ago, the food processing industry has invented many technologies that both help keep foods fresh longer and alter the fresh state of food as they appear in nature. Cooling is the primary technology used to maintain freshness, whereas many more technologies have been invented to allow foods to last longer without becoming spoiled. These latter technologies include pasteurisation, autoclavation, drying, salting, and separation of various components, all of which appearing to alter the original nutritional contents of food. Pasteurisation and autoclavation (heating techniques) have no doubt improved the safety of many common foods, preventing epidemics of bacterial infection. But some of the (new) food processing technologies have downfalls as well.

Modern separation techniques such as milling, centrifugation, and pressing have enabled concentration of particular components of food, yielding flour, oils, juices, and so on, and even separate fatty acids, amino acids, vitamins, and minerals. Inevitably, such large-scale concentration changes the nutritional content of food, saving certain nutrients while removing others. Heating techniques may also reduce food's content of many heat-labile nutrients such as certain vitamins and phytochemicals, and possibly other yet-to-be-discovered substances.[114] Because of reduced nutritional value, processed foods are often 'enriched' or 'fortified' with some of the most critical nutrients (usually certain vitamins) that were lost during processing. Nonetheless, processed foods tend to have an inferior nutritional profile compared to whole, fresh foods, regarding content of both sugar and high GI starches, potassium/sodium, vitamins, fiber, and of intact, unoxidized (essential) fatty acids. In addition, processed foods often contain potentially harmful substances such as oxidized fats and trans fatty acids.

A dramatic example of the effect of food processing on a population's health is the history of epidemics of beri-beri in people subsisting on polished rice. Removing the outer layer of rice by polishing it removes with it the essential vitamin thiamine, causing beri-beri. Another example is the development of scurvy among infants in the late 19th century in the United States. It turned out that the vast majority of sufferers were being fed milk that had been heat-treated (as suggested by Pasteur) to control bacterial disease. Pasteurisation was effective against bacteria, but it destroyed the vitamin C.

As mentioned, lifestyle- and obesity-related diseases are becoming increasingly prevalent all around the world. There is little doubt that the increasingly widespread application of some modern food processing technologies has contributed to this development. The food processing industry is a major part of modern economy, and as such it is influential in political decisions (e.g., nutritional recommendations, agricultural subsidising). In any known profit-driven economy, health considerations are hardly a priority; effective production of cheap foods with a long shelf-life is more the trend. In general, whole, fresh foods have a relatively short shelf-life and are less profitable to produce and sell than are more processed foods. Thus, the consumer is left with the choice between more expensive, but nutritionally superior, whole, fresh foods, and cheap, usually nutritionally inferior, processed foods. Because processed foods are often cheaper, more convenient (in both purchasing, storage, and preparation), and more available, the consumption of nutritionally inferior foods has been increasing throughout the world along with many nutrition-related health complications.

10 See also

Main article: Outline of nutrition

Balanced Eating:

- Food Balance Wheel

Biology:

- Bioenergetics
- Digestion
- Enzyme

Dangers of poor nutrition

- Deficiency
  - Avitaminosis is a deficiency of vitamins.
  - Boron deficiency (medicine)
  - Chromium deficiency
  - Iron deficiency (medicine)
  - Iodine deficiency
  - Magnesium deficiency (medicine)
- Diabetes
- Eating disorders
- Illnesses related to poor nutrition

- Malnutrition
- Obesity
    - Childhood obesity
- Starvation

Food:

Food (portal)

- 5 A Day
- Canada's Food Guide
- Fast food
- Food group
- Food guide pyramid
- Food supplement
- Fruits
- Functional food
- Grains
- Junk food
- Meat
- Vegetables

Healthy diet:

- Dieting
- Eating
- Healthy eating pyramid
- Nutritional rating systems
- Physicians Committee for Responsible Medicine (PCRM)
- The China Study

Lists:

- Diets (list)
- List of food additives
- List of illnesses related to poor nutrition
- List of life extension related topics
- List of publications in nutrition
- List of unrefined sweeteners
- List of antioxidants
- List of phytochemicals

Nutrients:

- Carbohydrates
- Dietary minerals
    - Essential minerals
- Dietary supplements
- Evolution of dietary antioxidants
- Essential nutrients
- Fat
    - Essential fatty acids
- Macronutrients
- Micronutrients
- Nootropics
- Nutraceuticals
- Food fortification
- Phytochemicals
- Protein
    - Complete protein
    - Essential amino acids
    - Incomplete protein
    - Protein combining
    - Protein (nutrient)
- Table of food nutrients
- Vitamins
    - Megavitamin therapy
    - Vitamin C megadosage

Profession:

- Dietitian
- Nutritionist
- Food Studies

Tools:

- Nutrition scale

Organizations:

- Academy of Nutrition and Dietetics

- American Society for Nutrition
- British Dietetic Association
- Society for Nutrition Education

Related topics

Main article: Health

- Auxology
- Exercise
- Food preferences in older adults and seniors
- General Fitness Training
- Health (portal)
- Life extension
- Orthomolecular medicine
- Palatability
- Physical fitness

11 Notes and references

[1] http://www.nlm.nih.gov/pubs/cd_hum.nut.html#2 National Institutes of Health, Joint Collection Development Policy: The National Agricultural Library, The National Library of Medicine, The Library of Congress, February 27, 1998, Updated October 14, 2014. Retrieved on 2014-12-13

[2] "What is an RDN and DTR?". Academy of Nutrition and Dietetics. Retrieved May 9, 2015.

[3] http://www.iaacn.org/ The International & American Associations of Clinical Nutritionist, 2014, Retrieved 2014-12-14

[4] Whitney, Ellie and Rolfes, Sharon Rady (2013). *Understanding Nutrition* (13 ed.). Wadsworth, Cengage Learning. pp. 667, 670. ISBN 978-1133587521.

[5] Obesity, Weight Linked to Prostate Cancer Deaths – National Cancer Institute. Cancer.gov. Retrieved on 2011-10-17.

[6] Obesity and Overweight for Professionals: Causes | DNPAO | CDC. Cdc.gov (2011-05-16). Retrieved on 2011-10-17.

[7] Metabolic syndrome – PubMed Health. Ncbi.nlm.nih.gov. Retrieved on 2011-10-17.

[8] Omega-3 fatty acids. Umm.edu (2011-10-05). Retrieved on 2011-10-17.

[9] What I need to know about Eating and Diabetes – National Diabetes Information Clearinghouse. Diabetes.niddk.nih.gov. Retrieved on 2011-10-17.

[10] Diabetes Diet and Food Tips: Eating to Prevent and Control Diabetes. Helpguide.org. Retrieved on 2011-10-17.

[11] Osteoporosis & Vitamin D: Deficiency, How Much, Benefits, and More. Webmd.com (2005-07-07). Retrieved on 2011-10-17.

[12] Dietary Supplement Fact Sheet: Vitamin D. Ods.od.nih.gov. Retrieved on 2011-10-17.

[13] Brody, Jane E. (March 19, 1998). "Osteoporosis Linked to Vitamin D Deficiency". *The New York Times*. Archived from the original on 2008-03-09.

[14] Payne-Palacio, June R. and Canter, Deborah D. (2014). *The Profession of Dietetics*. Jones & Bartlett Learning. pp. 3, 4. ISBN 978-1-284-02608-5.

[15] Gratzer 2005, p. 40.

[16] Gratzer 2005, p. 41.

[17] Gratzer 2005, p. 36.

[18] *History of the Study of Nutrition in Western Culture* (Rai University lecture notes for General Nutrition course, 2004)

[19] Smith, Richard (24 January 2004). "Let food by thy medicine...". *BMJ* **328** (7433): 0–g. doi:10.1136/bmj.328.7433.0-g.

[20] Gratzer 2005, p. 37.

[21] Gratzer 2005, pp. 38, 39, 41.

[22] Gratzer 2005, p. 38.

[23] Gratzer 2005, p. 39.

[24] Bhatt, Dr Arun (January–March 2010). "Evolution of Clinical Research: A History Before and Beyond James Lind". *Perspectives in Clinical Research* (Indian Society for Clinical Research via US National Center for Biotechnology Information) **1** (1): 6–10. ISSN 2229-3485. PMC 3149409. PMID 21829774.

[25] Gratzer 2005, p. 48.

[26] Gratzer 2005, pp. 48, 49, 50, 52, 53, 54.

[27] Willett, Walter C. with Skerrett, Patrick J. (2005) [2001]. *Eat, Drink, and be Healthy: The Harvard Medical School Guide To Healthy Eating*. Free Press (Simon & Schuster). p. 183. ISBN 0-684-86337-5.

[28] Gratzer 2005, pp. 21–24, 32.

[29] Gratzer 2005, p. 60.

[30] Gratzer 2005, p. 56.

[31] Muljadi, Paul. *Health*. Paul Muljadi. p. 42.

[32] Gratzer 2005, pp. 73–74.

[33] Ahrens, Richard (January 1, 1977). "William Prout (1785-1850): A Biographical Sketch" (PDF). *The Journal of Nutrition* **107** (1): 15.

[34] Gratzer 2005, p. 82.

[35] Carpenter 1994, p. 224.

[36] Gratzer 2005, pp. 86, 92, 95, 115.

[37] Gratzer 2005, pp. 98–99.

[38] Carpenter 1994, p. 220.

[39] Carpenter's table gives the year each vitamin was proposed, the year isolated (shown here), the year the structure was determined, and the year that synthesis was achieved. Carpenter, Kenneth J. (October 1, 2003). "A Short History of Nutritional Science: Part 3 (1912–1944)". *The Journal of Nutrition* **133** (10): 3023–3032. from Combs, G. F., Jr (1992). *The Vitamins: Fundamental Aspects in Nutrition and Health*. Academic Press. ISBN 0123819806.

[40] Carpenter, Kenneth J. (November 1, 2003). "A Short History of Nutritional Science: Part 4 (1945–1985)". *The Journal of Nutrition* **133** (11): 3331–3342.

[41] NASEO (12 October 2000). "Unraveling the Enigma of Vitamin D - Text View". *tryphonov.ru*.

[42] Subcommittee on Vitamin Tolerance, Committee on Animal Nutrition, National Research Council (1987). "Vitamin E, in Vitamin Tolerance of Animals". National Academy of Sciences. Retrieved December 22, 2013.

[43] "F.B.I. Joins Hunt for Young German Chemist". San Bernardino Daily Sun. December 18, 1940. Retrieved December 22, 2013.

[44] "USDA's Food Guide Pyramid Booklet, 1992" (PDF). United States Department Of Agriculture. Archived from the original (PDF) on August 24, 2014.

[45] Contagious obesity? Identifying the human adenoviruses that may make us fat. Science Blog

[46] Montouri, Paulo; Triassi, Maria and Sarnacchiaro, Pasquale (2012). "The consumption of genetically modified foods in Italian high school students". *Food Quality and preference* **26** (2): 246–251. doi:10.1016/j.foodqual.2012.05.004.

[47] Nestle, Marion (2013) [2002]. *Food Politics: How the Food Industry Influences Nutrition and Health*. University of California Press. p. 413. ISBN 978-0-520-27596-6.

[48] Fuhrman, Joel (2014). *The End of Dieting*. Harper One (Harper Collins). pp. 101–102. ISBN 978-0-06-224932-6.

[49] "Get the Facts on Fiber". *webmd.com*.

[50] "Strange but True: Drinking Too Much Water Can Kill". *Scientific American*. June 21, 2007.

[51] "Can shipwrecked men survive if they drink sea water?". Natural History Magazine.

[52] Berg J, Tymoczko JL, Stryer L (2002). *Biochemistry* (5th ed.). San Francisco: W.H. Freeman. p. 603. ISBN 0-7167-4684-0.

[53] Otto, H (1973). *Diabetik Bei Diabetus Mellitus*. Bern: Verlag Hans Huber.

[54] Crapo, P; Reaven, Olefsky (1977). "Postprandial plasma-glucose and -insulin responses to different complex carbohydrates". *Diabetes* **26** (12): 1178–1183. doi:10.2337/diabetes.26.12.1178. PMID 590639.

[55] Crapo, P; Kolterman, Waldeck; Reaven, Olefsky (1980). "Postprandial hormonal responses to different types of complex carbohydrate in individuals with impaired glucose tolerance". *Am J Clin Nutr* **33** (8): 1723–1728. PMID 6996472.

[56] Jenkins, David; Jenkins, Alexandra L.; Wolever, Thomas M.S.; Thompson, Lilian H. and Rao, A. Venkat (February 1986). "Simple and complex carbohydrates". *Nutritional Reviews* **44** (2): 44–49. doi:10.1111/j.1753-4887.1986.tb07585.x.

[57] "The Nutrition Source: Carbohydrates". Harvard School of Public Health. Retrieved 2011-07-07.

[58] American Dietetic Association; Dietitians Of, Canada (2003). "Position of the American Dietetic Association and Dietitians of Canada: Vegetarian diets". *JADA* **103** (6): 748–765. doi:10.1053/jada.2003.50142. PMID 12778049.

[59] "Healthy Water Living". BBC. Retrieved 2007-02-01. Archived from the original on 2007-01-01.

[60] ""Drink at least eight glasses of water a day." Really? Is there scientific evidence for "8 × 8"?". *physiology.org*.

[61] Food and Nutrition Board, National Academy of Sciences. Recommended Dietary Allowances, revised 1945. National Research Council, Reprint and Circular Series, No. 122, 1945 (Aug), pp. 3–18.

[62] Le Bellego L, Jean C, Jiménez L, Magnani C, Tang W, Boutrolle I (2010). "Understanding fluid consumption patterns to improve healthy hydration". *Nutr Today* **45** (6): S22–S26. doi:10.1097/NT.0b013e3181fe4314.

[63] EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA) (2010). "Scientific Opinion on Dietary Reference Values for Water". *EFSA Journal* **8** (3): 1459. doi:10.2903/j.efsa.2010.1459.

[64] Armstrong LE, Pumerantz AC, Roti MW, Judelson DA, Watson G, Dias JC, Sokmen B, Casa DJ, Maresh CM et al. (2005). "Fluid, electrolyte, and renal indices of hydration during 11 days of controlled caffeine consumption". *Int J Sport Nutr Exerc Metab* **15** (3): 252–65. PMID 16131696.

[65] "FAO Corporate Document Repository. Food Balance Sheets- A Handbook." Retrieved 2011-03-07

[66] "WHO Technical Report Series. Diet, nutrition and the prevention of chronic diseases." Report of a Joint WHO/FAO Expert Consultation; Geneva 2003. Retrieved 2011-03-07

[67] Farrell DJ, Bower L (October 2003). "Fatal water intoxication". *J. Clin. Pathol.* (Journal of Clinical Pathology) **56** (10): 803–4. doi:10.1136/jcp.56.10.803-a. PMC 1770067. PMID 14514793.

[68] Mitchell, Dakota and Haroun, Lee (2012). *Introduction to Health Care* (3 ed.). Delmar Cengage. p. 279. ISBN 978-1-435-48755-0.

[69] Nelson, D. L.; Cox, M. M. (2000). *Lehninger Principles of Biochemistry* (3rd ed.). New York: Worth Publishing. ISBN 1-57259-153-6.

[70] Corbridge, D. E. C. (1995). *Phosphorus: An Outline of its Chemistry, Biochemistry, and Technology* (5th ed.). Amsterdam: Elsevier. ISBN 0-444-89307-5.

[71] Lippard, S. J. and Berg, J. M. (1994). *Principles of Bioinorganic Chemistry*. Mill Valley, CA: University Science Books. ISBN 0935702725.

[72] Shils, M. S. et al., eds. (2005). *Modern Nutrition in Health and Disease*. Lippincott Williams and Wilkins. ISBN 0-7817-4133-5.

[73] "Phytochemical". American Cancer Society. 17 January 2013. Retrieved 1 October 2013.

[74] Bjelakovic G; Nikolova, D; Gluud, LL; Simonetti, RG; Gluud, C (2007). "Mortality in randomized trials of antioxidant supplements for primary and secondary prevention: systematic review and meta-analysis". *JAMA* **297** (8): 842–57. doi:10.1001/jama.297.8.842. PMID 17327526.

[75] Sepkowitz, Kent (3 August 2011). "The Doctor and the Pomegranate". Slate.

[76] Khanna S, Tosh PK (January 2014). "A clinician's primer on the role of the microbiome in human health and disease". *Mayo Clin. Proc.* **89** (1): 107–14. doi:10.1016/j.mayocp.2013.10.011. PMID 24388028.

[77] Guarner, F; Malagelada, J (2003). "Gut flora in health and disease". *The Lancet* **361** (9356): 512–9. doi:10.1016/S0140-6736(03)12489-0. PMID 12583961.

[78] Campbell T., Campbell T. (2005). *The China Study*. Dallas: Benella Books. ISBN 1-932100-38-5.

[79] "USDA Table of Nutrient Retention Factors, Release 6" (PDF). *USDA*. USDA. Dec 2007.

[80] Andrew Mente; Lawrence de Koning; Harry S. Shannon; Sonia S. Anand (2009). "A Systematic Review of the Evidence Supporting a Causal Link Between Dietary Factors and Coronary Heart Disease". *Arch Intern Med* **169** (7): 659–669. doi:10.1001/archinternmed.2009.38. PMID 19364995.

[81] Eckel RH, Borra S, Lichtenstein AH, Yin-Piazza SY (April 2007). "Understanding the complexity of trans fatty acid reduction in the American diet: American Heart Association Trans Fat Conference 2006: report of the Trans Fat Conference Planning Group". *Circulation* **115** (16): 2231–46. doi:10.1161/CIRCULATIONAHA.106.181947. PMID 17426064.

[82] Ducimetière P, Lang T, Amouyel P, Arveiler D, Ferrières J (January 2000). "Why mortality from heart disease is low in France. Rates of coronary events are similar in France and Southern Europe". *BMJ* **320** (7229): 249–50. doi:10.1136/bmj.320.7229.249/a (inactive 2015-01-01). PMC 1117444. PMID 10642245.

[83] Chapter 6 Energy and Nutrient Relations, Ecology course text at SCNU.edu

[84] Chapter 6 Energy and Nutrient Relations, Ecology course text at SCNU.edu, summarized

[85] Researchers Look at How Frequency of Meals May Affect Health. USDA Agricultural Research Service. Ars.usda.gov (February 15, 2008). Retrieved on 2011-10-17.

[86] Allen V. Barker, David J. Pilbeam. *Handbook of Plant Nutrition*. CRC Press, 2010. p. Preface.

[87] Lindemann, W.C. and Glover C.R. (2003) Nitrogen Fixation by Legumes. New Mexico State University/

[88] Nutrition and the Environment, Retrieved 20 June 2014.

[89] Sample Menus for a 2000 Calorie Food Pattern. mypyramid.gov

[90] Commission on Life Sciences. (1985). *Nutrition Education in US Medical Schools*, p. 4. National Academies Press.

[91] Adams KM, Lindell KC, Kohlmeier M, Zeisel SH (2006). "Status of nutrition education in medical schools". *Am. J. Clin. Nutr.* **83** (4): 941S–4S. PMC 2430660. PMID 16600952.

[92] Baldi, S. (ED.) et al. (2009). Technical Report and Data File User's Manual for the 2003 National Assessment of Adult Literacy (NCES 2009–47). U.S. Department of Education, National Center for Education Statistics. Washington, D.C.: U.S. Government Printing Office.

[93] Zoellner, J., Connell, C., Bounds, W., Crook, L., Yadrick, K. (2009). "Nutrition Literacy Status and Preferred Nutrition Communications Channels Among Adults in the Lower Mississippi Delta". *Preventing Chronic Disease* **6** (4): A128. PMC 2774642. PMID 19755004.

[94] Berkman N. D., Sheridan, S.L., Donahue, K. E., Halpern, D.J., Viera, A., Crotty, K., … Viswanathan, M. (2011). Health and Literacy Intervention Outcomes: an Updated Systematic Review. Evidence Report/Technology Assessment no. 199. Prepared by RTI International – University of North Carolina Evidence-based Practice Center. Publication Number 11-E006. Rockville, MD. Agency for Healthcare Research and Quality.

[95] *Nourishing communities through holistic farming*, Impatient optimists, Bill & Melinda Gates Foundation. April 30th 2013.

[96] "Gyorgy Scrinis' Web Page". Retrieved 2009-01-14.

[97] Pollan, Michael (2007-01-28). "Unhappy Meals". The New York Times.

[98] Pollan, Michael (2008). In Defense of Food: An Eater's Manifesto. New York, USA: Penguin Press. ISBN 978-1594201455.

[99] Jere R. Behrman (1996). “The impact of health and nutrition on education”. *World Bank Research Observer* **11** (1): 23–37. doi:10.1093/wbro/11.1.23.

[100] American College Health Association (2007). “American College Health Association National College Health Assessment Spring 2006 Reference Group data report (abridged)". *J Am Coll Health* **55** (4): 195–206. doi:10.3200/JACH.55.4.195-206. PMID 17319325.

[101] Benton D, Sargent J (July 1992). “Breakfast, blood glucose and memory”. *Biol Psychol* **33** (2–3): 207–10. doi:10.1016/0301-0511(92)90032-P. PMID 1525295.

[102] Kanarek RB, Swinney D (February 1990). “Effects of food snacks on cognitive performance in male college students”. *Appetite* **14** (1): 15–27. doi:10.1016/0195-6663(90)90051-9. PMID 2310175.

[103] Whitley JR, O'Dell BL, Hogan AG (September 1951). “Effect of diet on maze learning in second generation rats; folic acid deficiency”. *J. Nutr.* **45** (1): 153–60. PMID 14880969.

[104] Umezawa M, Kogishi K, Tojo H et al. (February 1999). “High-linoleate and high-alpha-linolenate diets affect learning ability and natural behavior in SAMR1 mice”. *J. Nutr.* **129** (2): 431–7. PMID 10024623.

[105] Glewwe P, Jacoby H, King E (2001). “Early childhood nutrition and academic achievement: A longitudinal analysis”. *Journal of Public Economics* **81** (3): 345–68. doi:10.1016/S0047-2727(00)00118-3.

[106] “Managed food service contractors react quickly to the demands of their clients achievement: A longitudinal analysis”. *Journal of Public Economics* **81** (3): 345–368. doi:10.1016/S0047-2727(00)00118-3.

[107] Guernsey L (1993). “Many colleges clear their tables of steak, substitute fruit and pasta”. *Chronicle of Higher Education* **39** (26): A30.

[108] Duster T, Waters A (2006). “Engaged learning across the curriculum: The vertical integration of food for thought”. *Liberal Education* **92** (2): 42.

[109] Lakhan SE, Vieira KF (2008). “Nutritional therapies for mental disorders”. *Nutr J* **7** (1): 2. doi:10.1186/1475-2891-7-2. PMC 2248201. PMID 18208598.

[110] Coren, Michael (2005-03-10). “Study: Cancer no longer rare in poorer countries”. CNN. Retrieved 2007-01-01.

[111] “Why is too much water dangerous?". BBC News. 2007-01-15. Retrieved 2008-11-09.

[112] Centers for Disease Control and Prevention. 3 Mar 2013. Web. 4 Mar 2015. http://www.cdc.gov/diabetes/statistics/prev/national/figpersons.htm

[113] American Heart Association. Nd. Web. 4 Mar 2015.http://www.heart.org/HEARTORG/HealthcareResearch/Healthcare-Research_UCM_001093_SubHomePage.jsp

[114] Morris, Audrey; Audia Barnett; Olive-Jean Burrows (2004). “Effect of Processing on Nutrient Content of Foods” (PDF). *Cajanus* **37** (3): 160–164. Retrieved 2006-10-26.

12 Bibliography

- Carpenter, Kenneth J. (1994). *Protein and Energy: A Study of Changing Ideas in Nutrition*. Cambridge University Press. ISBN 0521452090.
- Curley, S., and Mark (1990). *The Natural Guide to Good Health*, Lafayette, Louisiana, Supreme Publishing
- Galdston, I. (1960). *Human Nutrition Historic and Scientific*. New York: International Universities Press.
- Gratzer, Walter (2006) [2005]. *Terrors of the Table: The Curious History of Nutrition*. Oxford University Press. ISBN 0199205639.
- Mahan, L.K. and Escott-Stump, S. eds. (2000). *Krause’s Food, Nutrition, and Diet Therapy* (10th ed.). Philadelphia: W.B. Saunders Harcourt Brace. ISBN 0-7216-7904-8.
- Thiollet, J.-P. (2001). *Vitamines & minéraux*. Paris: Anagramme.
- Walter C. Willett and Meir J. Stampfer (January 2003). “Rebuilding the Food Pyramid”. *Scientific American* **288** (1): 64–71. doi:10.1038/scientificamerican0103-64. PMID 12506426.

13 External links

- WHO site on Nutrition
- Diet, Nutrition and the prevention of chronic diseases by a Joint WHO/FAO Expert consultation (2003)
- UN Standing Committee on Nutrition – In English, French and Portuguese
- Health-EU Portal Nutrition
- USDA National Nutrient Database for Standard Reference Search By Food

14 Text and image sources, contributors, and licenses

14.1 Text

- **Nutrition** *Source:* https://en.wikipedia.org/wiki/Nutrition?oldid=681167016 *Contributors:* Kpjas, Peter Winnberg, Ed Poor, Andre Engels, Rmhermen, Toby Bartels, PierreAbbat, William Avery, SimonP, Mbmanie, Heron, Jaknouse, R Lowry, Ewen, Olivier, Ram-Man, Elian, DennisDaniels, Edward, Dwmyers, Patrick, Infrogmation, D, Fred Bauder, Lexor, Gabbe, Tannin, Zanimum, Egil, Mdebets, Haakon, Ronz, Docu, Angela, BigFatBuddha, Julesd, Glenn, Michael Shields, TonyClarke, Ilyanep, TheStick, Lenaic, Emperorbma, Ww, Ike9898, Dysprosia, StAkAr Karnak, Timc, Tpbradbury, John NRW, Tero~enwiki, Omegatron, Samsara, Pakaran, Blt, Finlay McWalter, Pollinator, Owen, Northgrove, Donarreiskoffer, Hankwang, RedWolf, P0lyglut, Flauto Dolce, Rasmus Faber, Borislav, Jy, Anthony, Black Jack~enwiki, Guy Peters, Filemon, Unfree, Alan Liefting, Fabiform, Giftlite, Mintleaf~enwiki, Bork, Zigger, Ratjed, Peruvianllama, Everyking, Curps, Jfdwolff, Guanaco, Yekrats, Enkrates, Mboverload, Bobblewik, Jrdioko, Neilc, Masterhomer, Utcursch, Pgan002, Andycjp, Rhoganjosh, CryptoDerk, Dvavasour, Antandrus, Beland, Rdsmith4, APH, Thincat, Icairns, Sam Hocevar, Tharenthel~enwiki, Popadopolis, Jcw69, World4health, Everlong, Astronouth7303, Poccil, Diagonalfish, Discospinster, Rich Farmbrough, Guanabot, YUL89YYZ, LindsayH, Notinasnaid, Bender235, Terrapin, Techtoucian, Violetriga, Fenice, RJHall, El C, Rgdboer, RoyBoy, Coolcaesar, Rpresser, Bobo192, Johnkarp, Kissall~enwiki, Evolauxia, Geocachernemesis~enwiki, Arcadian, Caia, Tim Smith, Obradovic Goran, Sam Korn, Nsaa, Alansohn, Walter Görlitz, 119, Eric Kvaalen, Mr Adequate, Kurieeto, YDZ, Redfarmer, Rwendland, Velella, Cromwellt, Ahu~enwiki, Bsadowski1, Kusma, MrVibrating, Versageek, Gene Nygaard, Frankg, Tainter, Ceyockey, Mahanga, Mindmatrix, SCEhardt, Eras-mus, Plrk, Noetica, Wayward, GraemeLeggett, Gena Wenli, Dysepsion, Mandarax, Obersachse, Matilda, FreplySpang, Grammarbot, Rjwilmsi, Jake Wartenberg, Vivekdse, Kazrak, Kalogeropoulos, StephanieM, Yamamoto Ichiro, Titoxd, AED, Weel, Musical Linguist, Doc glasgow, A scientist, Crazycomputers, Nivix, Fragglet, Omega025, RexNL, Mancini, Fresheneesz, Nutrinaut, Le Anh-Huy, DVdm, Bgwhite, Elfguy, Jodine Sparks, Wavelength, Jimp, Jtkiefer, Muchness, Anonymous editor, Splash, Epolk, SpuriousQ, Tsch81, Stephenb, Rintrah, Gaius Cornelius, Eleassar, Rsrikanth05, Jimphilos, Sentausa, NawlinWiki, Wiki alf, Nirvana2013, Veledan, Jredwards, NickBush24, Wikikraut, Mccready, Aaron Brenneman, Haoie, Doofsmack, Syrthiss, Mysid, RoussiG, PS2pcGAMER, Psy guy, Elkman, Sandstein, Jvoegele, Deville, 2over0, Zzuuzz, Arthur Rubin, KGasso, JQF, Tsunaminoai, BorgQueen, GraemeL, JoanneB, TBadger, Spliffy, ChipperGuy, Rathfelder, Masonbarge, CIreland, Sardanaphalus, Lordspaz, Veinor, SmackBot, Moeron, Incnis Mrsi, TestPilot, FloNight, NaiPiak, Unyoyega, Pgk, Od Mishehu, WookieInHeat, KVDP, Delldot, Hardyplants, Kslays, Edgar181, HalfShadow, Tocotrienols, Apers0n, Gilliam, Portillo, Phillipbeynon, Ohnoitsjamie, Hmains, ERcheck, Psiphiorg, David.Throop, Tyciol, Atrzcins, Chris the speller, Bluebot, Sgd2z, Ziiv, MikeSy, Quinsareth, RDBrown, NCurse, Carbonrodney, SchfiftyThree, Deli nk, Kaya~enwiki, Sbharris, Darth Panda, A. B., Can't sleep, clown will eat me, RyanEberhart, Onorem, T00h00, Rsm99833, Megamix, Aldaron, Auno3, Radagast83, Cybercobra, RandomP, Usmns, Nrcprm2026, Egres74, Zero Gravity, Jbergquist, Excaliburo, DMacks, Where, Er Komandante, Bezapt, Cast, Lambiam, AThing, Anlace, JzG, Akendall, John, J. Finkelstein, Cat Parade, Euchiasmus, Scientizzle, FredSand, Agencius, Gobonobo, Disavian, Sir Nicholas de Mimsy-Porpington, Accurizer, Majorclanger, MarkSutton, Stwalkerster, Beetstra, Mr Stephen, Waggers, Seth Hall, TastyPoutine, Ryulong, Fluppy, Dcperi, Pere Serafi, Mindbodyfitness, KJS77, Nehrams2020, Alonc, Pipedreambomb, Igoldste, Saturday, SweetNeo85, CapitalR, Blehfu, Esurnir, Majora4, Dunne409, Raetzsch, Courcelles, Linkspamremover, Tawkerbot2, WarrenGuy, MightyWarrior, Google20, Warren Guy, Nirax, Daedalus969, JForget, CmdrObot, Bobtherandomguy, Basawala, Rae-Rae, TipPt, Neelix, AndrewHowse, Cydebot, Ssarjola, Wodepigu, Brillig20, Munckin, Chuck Marean, Gogo Dodo, Chasingsol, Eu.stefan, Wildnox, Dancter, Doug Weller, Christian75, Markus Ramikin, PSv255, Omicronpersei8, UberScienceNerd, FrancoGG, Regentagger, Epbr123, Ucanlookitup, N5iln, Andyjsmith, Mojo Hand, Marek69, Vertium, John254, Tapir Terrific, SGGH, Cool Blue, Superpel2710, Leon7, Miller17CU94, NigelR, Mrsci68, SusanLesch, Transhumanist, Openland, Escarbot, Mentifisto, KrakatoaKatie, Hires an editor, AntiVandalBot, Luna Santin, Mattsilv, Duh Svemira, KP Botany, DrewPrice.co.uk, Alphachimpbot, Wayiran, Jgebis, 1of3, Siukin, Demosthenes716, Canadian-Bacon, JAnDbot, Husond, LossIsNotMore, Aurumsolis, Barek, MER-C, Hydro, Nelas, The Transhumanist, Cleanupman, Ron7684, BenB4, Smith Jones, SiobhanHansa, Magioladitis, Ramurf, Staib, Zakahori, Murgh, Bongwarrior, VoABot II, JamesBWatson, Snaxorb, Faizhaider, BigChicken, Crazytonyi, Condraz23, Murmur74, TheNautilus, Afisher333, WhatamIdoing, Nposs, Allstarecho, Ceribik, Heliac, Glen, DerHexer, Michaelbedar, WLU, Kimjune01, Patstuart, DGG, Scottalter, TravisNygard, J mareeswaran, Hdt83, MartinBot, Axlq, Naohiro19, Phasechange, Nono64, Fconaway, Ooga Booga, J.delanoy, DrKiernan, Trusilver, Jscnet, Angela C, Tikiwont, Listenschöpfer, Idontthinkso, Eliz81, Sharlene Thompson, Bookguy2, Minderbinder~enwiki, Yoongkheong, Jorgensgard, Ncmvocalist, Ehwills, Jsirico, Coppertwig, Arbogop, AntiSpamBot, Plasticup, LittleHow, The Transhumanist (AWB), Belovedfreak, Richard D. LeCour, NewEnglandYankee, S0uperness, Molly-in-md, ARTE, 2help, KylieTastic, Cometstyles, Omegamormegil, Gwen Gale, Lyonessj, Joaquín Martínez Rosado, Bonadea, Sdohrn, RJASE1, Szalzala, Burlywood, Wikieditor06, Lights, VolkovBot, Morenooso, Javance, Mrh30, Jeff G., Nburden, Mmaunder, Philip Trueman, Johnhardy75, Zidonuke, Womenshealth, Alpinebrains, Ezhuks, Darana, JS Bangalore, Lradrama, MackSalmon, Michael H 34, Leafyplant, LeaveSleaves, ^demonBot2, Tonwhy, Pishogue, Eubulides, BigDunc, Andy Dingley, Falcon8765, Brianga, Jcianche, Discussall, Doc James, Quantpole, Quartet, Irongood, EJF, Wikiapg, Pare Mo, Ccfd9, SieBot, Mikemoral, Enam Esru, Tresiden, Sebastiano venturi, Sakkura, Dawn Bard, Caltas, Yintan, Donny417, GlassCobra, Djayjp, Toddst1, Alexbrn, Annjackson, Big ossan, Allmightyduck, Brian R Hunter, Oxymoron83, Hello71, Aykadm, Steven Crossin, Tekavec, Lightmouse, RW Marloe, KathrynLybarger, Amitkumar.india, Svick, C'est moi, Nplonski, Schmidi9, Pinkadelica, Hordaland, Maja123456, Denisarona, Dmannsanco, Escape Orbit, Squash Racket, Faithlessthewonderboy, Ricklaman, PuercoPop, Stefanbusch03, Loren.wilton, Jageshwar, Martarius, ClueBot, GorillaWarfare, Bobathon71, Healthwise, Foxj, The Thing That Should Not Be, HugheZ05, Petorial, ImperfectlyInformed, Matsuiny2004, DanielDeibler, Doseiai2, CounterVandalismBot, OccamzRazor, LizardJr8, Bengalixlust, Nycfoodie, Michaplot, Phenylalanine, Gdevor, Daimanuel, Excirial, Dets03ab, Jusdafax, Explosius, Muhandes, Blueman1878, Tyler, Peter.C, Htfiddler, Achilles.g, DenisePro, MilesAgain, Light show, Thingg, Aitias, Denisefao, Versus22, SoxBot III, Thinking Stone, DumZiBoT, InternetMeme, Onitake, XLinkBot, Spitfire, HuxleyFan, Cozinsky, Gyozaz64, WikHead, SilvonenBot, The Aviv, NellieBly, Kaiwhakahaere, JinJian, Somedianetworks, ZooFari, Lemmey, Addbot, Proofreader77, Ddecadee, Willking1979, Sjkaddu, Some jerk on the Internet, DOI bot, Sd44, Simonridg, CL, Ayapota, Yobmod, MalachiK, CanadianLinuxUser, Leszek Jańczuk, Fluffernutter, Cldaino, Pcapozzi, MrOllie, Download, RTG, Favonian, Tassedethe, Tide rolls, Camlings, Jarble, NutritionEd, Ben Ben, Legobot, TheSuave, Yobot, Legobot II, Jnivekk, Public Health Foundation Of India, ArchonMagnus, Maxí, Mfbz78, Dlogronios, Jordancmu3232, Backslash Forwardslash, AnomieBOT, Delaunay08, Jim1138, Neut Nuttinbutter, Kingpin13, Materialscientist, 90 Auto, Citation bot, E2eamon, Frapple hok, Frankenpuppy, LilHelpa, Lmaolmaolmao, Ztablant, Capricorn42, D2earth, Kerack, GrouchoBot, Ute in DC, H8erade, Mark Schierbecker, RibotBOT, Navalctm, Omicron777, Wiki emma johnson, Sup765, Doulos Christos, Sophus Bie, Mnmngb, Shadowjams, Erik9, Apgevity, Prari, FrescoBot, XXsaradominXx, Tobby72, Unsbridge, Sydney12345, Sky Attacker, Financial Officer, StaticVision, Arlen22, Intubate, Ionutzmovie, MGA73bot, Golfasweetness20, Simpler12, Healthceus, Civilizededucation, HamburgerRadio, Afranky8, Rwt1vj, Pinethicket, I dream of horses, Haresh sharma28, Fresho, LinDrug, Jstraining, Luvaca10, BrianBwiki, Jschnur, Mathiaseu, Sadlala, Eatwell bewell, Sheenagopa, RandomStringOfCharacters, Nedvied-safari, නිශාන්සුගතදාස, Irbisgreif, Jikybebna, Vactivity, Trappist the monk, Wotnow, Kelly2357, Kalaiarasy, MexicanFish, Dinamik-bot, Vrenator, Janedeer, NutrisaurusRex, Ivanvector, Mttcmbs, Suffusion of Yellow, □□□, Tbhotch, RobertMfromLI, DARTH SIDIOUS 2, Senvim, Mean as custard, CordeliaNaismith, RjwilmsiBot, Hajatvrc, Slon02, Dual Use, DASHBot, J36miles, EmausBot, John of Reading, Orphan Wiki, Padurar2009, WikitanvirBot, Immunize, Spainbeach, Wendyschnitzer, Gogomeat3, GoingBatty, RA0808, Je suis la lune, Medimac, Prenigmamann, Vbhubeny, Dishcmds, Kav uk, Solarra, Tommy2010, Shireenwickham, Mktgguest1, Tropicanahouse, Wikipelli, Pinkigreen, Morbb1, Thecheesykid, PhosphateBufferedSaline, Eurith, Josve05a, Shuipzv3, Hogwash eliminator, Lateg, Cshubh, Heathy01, Peter.fit4flirt, Jason.somarelli, Elektrik Shoos, H3llBot, Msmithurst, AManWithNoPlan, Gz33, Mrwiti, Wayne Slam, Tolly4bolly, Jsayre64, L Kensington, Noodleki, NutritionResearcher, Donner60, Dougertman, Walkerville01, Rangoon11, Lisavance, Indy141, Theta1997, Sharonmil, Amlui89, Sandy sakura, Mbuguamuchoki, Cdub42, E. Fokker, Petrb, Will Beback Auto, ClueBot NG, CRJ200flyer, MelbourneStar, This lousy T-shirt, Satellizer, Spearsr, Millermk, Cobalt387, Cntras, GMTrovato, Bmgoose, O.Koslowski, Jpsonit, Angelta89, Widr, Organo435, Dirtydemon39, Kjenks22, Mercbenzfan, Helpful Pixie Bot, Jacob15917, Camik08, Bertieri4, Calabe1992, Lowercase sigmabot, MusikAnimal, Sowsnek, JohnWilliams2011, Inaiyo, Wikih101, CitationCleanerBot, Tomcorsonknowles, YodaRULZ, SodaAnt, MrBill3, NotWith, Adam Simmonds, Smile360, Kjlarsen1644, Babhi, Lancelot2012, Alecblenche, BattyBot, RachelDaeger, Bkalio, Georam89, Pratyya Ghosh, Mavswin, Jennap38, Cyberbot II, 32cllou, Vwalvekar, Webclient101, Jony10045, Hitarthi, NuteWorld, Josepestana1234, Sidelight12, Frosty, Abagoth xo, Ryanwtyler, Faizan, Epicgenius, Robertpattinsons, Camyoung54, Bananasoldier, Jodosma, Kbrittanyleonard, Andyashwood, DavidLeighEllis, Biraalo, Ashleyleia, Bolton123456, Alice853, Parentune19, 00prometheus, Mr RD, WikiMaster1234567, Ugog Nizdast, Edubroski, Binko100, Ginsuloft, Tkyles1009, Biggso, EtymAesthete, Mon3oturf, JoeyWinter, Nikki MJ, 25OHD3, Fewaut001, JaconaFrere, Snehatyrewala, MaximusAlphus, Monkbot, Sreeteja10, Indiamonsoon, Hedieh Taraghi, Dmrwikiprof, Jalecm4, SMiles828, JoeHebda, Biblioworm, Puplemonkey2511, Dianamendez, NQ, Archiloc, Mirkasvirka, D.S. Cordoba-Bahle, Kalthoum1985, Siri4747, Simplegirl56, Ayeletshacar, Jamapeds, Ujimix, Doubledouche, Chandransh Singh, Newt1986 and Anonymous: 1441

14.2 Images

- **File:Blackberry_fruits10.jpg** *Source:* https://upload.wikimedia.org/wikipedia/commons/0/0c/Blackberry_fruits10.jpg *License:* CC-BY-SA-3.0 *Contributors:* ? *Original artist:* ?
- **File:Colorfull.jpg** *Source:* https://upload.wikimedia.org/wikipedia/commons/b/b3/Colorfull.jpg *License:* CC BY 2.0 *Contributors:* Flickr *Original artist:* Jane Fresco from הרצליהHerzlia, ישראלIsrael
- **File:Commons-logo.svg** *Source:* https://upload.wikimedia.org/wikipedia/en/4/4a/Commons-logo.svg *License:* ? *Contributors:* ? *Original artist:* ?
- **File:Folder_Hexagonal_Icon.svg** *Source:* https://upload.wikimedia.org/wikipedia/en/4/48/Folder_Hexagonal_Icon.svg *License:* Cc-by-sa-3.0 *Contributors:* ? *Original artist:* ?
- **File:Foodlogo2.svg** *Source:* https://upload.wikimedia.org/wikipedia/commons/d/d6/Foodlogo2.svg *License:* CC-BY-SA-3.0 *Contributors:* Original *Original artist:* Seahen
- **File:Frederick_Gowland_Hopkins_nobel.jpg** *Source:* https://upload.wikimedia.org/wikipedia/commons/7/75/Frederick_Gowland_Hopkins_nobel.jpg *License:* Public domain *Contributors:* [1] [2] *Original artist:* John Palmer Clarke (active 1890-1909)
- **File:Galen_detail.jpg** *Source:* https://upload.wikimedia.org/wikipedia/commons/f/f5/Galen_detail.jpg *License:* Public domain *Contributors:* [1] [2] [3] [4] *Original artist:* Pierre-Roch Vigneron
- **File:Gersdorff_-_Schädelwunde.jpg** *Source:* https://upload.wikimedia.org/wikipedia/commons/c/cd/Gersdorff_-_Sch%C3%A4delwunde.jpg *License:* Public domain *Contributors:* ? *Original artist:* ?
- **File:Hippocrates_pushkin02.jpg** *Source:* https://upload.wikimedia.org/wikipedia/commons/1/18/Hippocrates_pushkin02.jpg *License:* CC BY-SA 3.0 *Contributors:* Own work *Original artist:* user:shakko
- **File:James_lind.jpg** *Source:* https://upload.wikimedia.org/wikipedia/commons/7/77/James_lind.jpg *License:* Public domain *Contributors:* http://history.amedd.army.mil/booksdocs/misc/evprev/fig2.jpg. Also published in Hudson, A. E. A., and Herbert, A.: James Lind, J. Hist. Med. & Allied Sc. 11: 1-12, January 1956. Courtesy of the National Library of Medicine, photograph negative No. 52-661. *Original artist:* Hudson, A.E.A.
- **File:Lavoisier_humanexp.jpg** *Source:* https://upload.wikimedia.org/wikipedia/commons/b/b1/Lavoisier_humanexp.jpg *License:* Public domain *Contributors:* ? *Original artist:* ?
- **File:Myoglobin.png** *Source:* https://upload.wikimedia.org/wikipedia/commons/6/60/Myoglobin.png *License:* Public domain *Contributors:* self made based on PDB entry *Original artist:* →AzaToth
- **File:Nutrition_label.gif** *Source:* https://upload.wikimedia.org/wikipedia/commons/1/1e/Nutrition_label.gif *License:* Public domain *Contributors:* ? *Original artist:* ?
- **File:Portal-puzzle.svg** *Source:* https://upload.wikimedia.org/wikipedia/en/f/fd/Portal-puzzle.svg *License:* Public domain *Contributors:* ? *Original artist:* ?
- **File:Symbol_book_class2.svg** *Source:* https://upload.wikimedia.org/wikipedia/commons/8/89/Symbol_book_class2.svg *License:* CC BY-SA 2.5 *Contributors:* Mad by Lokal_Profil by combining: *Original artist:* Lokal_Profil
- **File:TColinCampbell-by-GageSkidmore-crop.jpg** *Source:* https://upload.wikimedia.org/wikipedia/commons/f/fb/TColinCampbell-by-GageSkidmore-crop.jpg *License:* CC BY-SA 2.0 *Contributors:* Flickr *Original artist:* Gage Skidmore
- **File:TapWater-china.JPG** *Source:* https://upload.wikimedia.org/wikipedia/commons/e/ef/TapWater-china.JPG *License:* CC-BY-SA-3.0 *Contributors:* ? *Original artist:* Shizhao2005□□□□□□□□
- **File:Wikiquote-logo.svg** *Source:* https://upload.wikimedia.org/wikipedia/commons/f/fa/Wikiquote-logo.svg *License:* Public domain *Contributors:* ? *Original artist:* ?

14.3 Content license

- Creative Commons Attribution-Share Alike 3.0