**Nutrition** (also called **nourishment** or **aliment**) is the provision, to [cells](http://en.wikipedia.org/wiki/Cells_%28biology%29) and [organisms](http://en.wikipedia.org/wiki/Organism), of the materials necessary (in the form of food) to support [life](http://en.wikipedia.org/wiki/Life). Many common health problems can be prevented or alleviated with a [healthy diet](http://en.wikipedia.org/wiki/Healthy_diet).

The [diet](http://en.wikipedia.org/wiki/Diet_%28nutrition%29) of an organism is what it eats, which is largely determined by the perceived [palatability](http://en.wikipedia.org/wiki/Palatability) of foods. [Dietitians](http://en.wikipedia.org/wiki/Dietitian) are [health professionals](http://en.wikipedia.org/wiki/Health_professional) who specialize in human nutrition, meal planning, economics, and preparation. They are trained to provide safe, evidence-based dietary advice and management to individuals (in health and disease), as well as to institutions. Clinical [nutritionists](http://en.wikipedia.org/wiki/Nutritionist) are health professionals who focus more specifically on the role of nutrition in chronic disease, including possible prevention or remediation by addressing nutritional deficiencies before resorting to drugs. While government regulation of the use of this professional title is less universal than for "dietician", the field is supported by many high-level academic programs, up to and including the Doctoral level, and has its own voluntary certification board,[[1]](http://en.wikipedia.org/wiki/Nutrition#cite_note-0) professional associations, and peer-reviewed journals, e.g. the [American Society for Nutrition](http://en.wikipedia.org/wiki/American_Society_for_Nutrition) and the [*American Journal of Clinical Nutrition*](http://en.wikipedia.org/wiki/American_Journal_of_Clinical_Nutrition).

A poor diet can have an injurious impact on health, causing deficiency diseases such as [scurvy](http://en.wikipedia.org/wiki/Scurvy)[[2]](http://en.wikipedia.org/wiki/Nutrition#cite_note-1) and [kwashiorkor](http://en.wikipedia.org/wiki/Kwashiorkor);[[3]](http://en.wikipedia.org/wiki/Nutrition#cite_note-2) health-threatening conditions like [obesity](http://en.wikipedia.org/wiki/Obesity)[[4]](http://en.wikipedia.org/wiki/Nutrition#cite_note-3)[[5]](http://en.wikipedia.org/wiki/Nutrition#cite_note-4) and [metabolic syndrome](http://en.wikipedia.org/wiki/Metabolic_syndrome);[[6]](http://en.wikipedia.org/wiki/Nutrition#cite_note-5) and such common chronic systemic diseases as [cardiovascular disease](http://en.wikipedia.org/wiki/Cardiovascular_disease),[[7]](http://en.wikipedia.org/wiki/Nutrition#cite_note-6)[[8]](http://en.wikipedia.org/wiki/Nutrition#cite_note-7) [diabetes](http://en.wikipedia.org/wiki/Diabetes),[[9]](http://en.wikipedia.org/wiki/Nutrition#cite_note-8)[[10]](http://en.wikipedia.org/wiki/Nutrition#cite_note-9) and [osteoporosis](http://en.wikipedia.org/wiki/Osteoporosis).[[11]](http://en.wikipedia.org/wiki/Nutrition#cite_note-10)[[12]](http://en.wikipedia.org/wiki/Nutrition#cite_note-11)[[13]](http://en.wikipedia.org/wiki/Nutrition#cite_note-12)

|  |
| --- |
| **Contents**[[hide](http://en.wikipedia.org/wiki/Nutrition)]* [1 Animal nutrition](http://en.wikipedia.org/wiki/Nutrition#Animal_nutrition)
	+ [1.1 Overview](http://en.wikipedia.org/wiki/Nutrition#Overview)
	+ [1.2 Nutrients](http://en.wikipedia.org/wiki/Nutrition#Nutrients)
		- [1.2.1 Carbohydrates](http://en.wikipedia.org/wiki/Nutrition#Carbohydrates)
			* [1.2.1.1 Fiber](http://en.wikipedia.org/wiki/Nutrition#Fiber)
		- [1.2.2 Fat](http://en.wikipedia.org/wiki/Nutrition#Fat)
			* [1.2.2.1 Essential fatty acids](http://en.wikipedia.org/wiki/Nutrition#Essential_fatty_acids)
		- [1.2.3 Protein](http://en.wikipedia.org/wiki/Nutrition#Protein)
		- [1.2.4 Minerals](http://en.wikipedia.org/wiki/Nutrition#Minerals)
			* [1.2.4.1 Macrominerals](http://en.wikipedia.org/wiki/Nutrition#Macrominerals)
			* [1.2.4.2 Trace minerals](http://en.wikipedia.org/wiki/Nutrition#Trace_minerals)
		- [1.2.5 Vitamins](http://en.wikipedia.org/wiki/Nutrition#Vitamins)
		- [1.2.6 Water](http://en.wikipedia.org/wiki/Nutrition#Water)
		- [1.2.7 Other nutrients](http://en.wikipedia.org/wiki/Nutrition#Other_nutrients)
			* [1.2.7.1 Antioxidants](http://en.wikipedia.org/wiki/Nutrition#Antioxidants)
			* [1.2.7.2 Phytochemicals](http://en.wikipedia.org/wiki/Nutrition#Phytochemicals)
		- [1.2.8 Intestinal bacterial flora](http://en.wikipedia.org/wiki/Nutrition#Intestinal_bacterial_flora)
	+ [1.3 Advice and guidance](http://en.wikipedia.org/wiki/Nutrition#Advice_and_guidance)
		- [1.3.1 Governmental policies](http://en.wikipedia.org/wiki/Nutrition#Governmental_policies)
		- [1.3.2 Teaching](http://en.wikipedia.org/wiki/Nutrition#Teaching)
	+ [1.4 Healthy diets](http://en.wikipedia.org/wiki/Nutrition#Healthy_diets)
		- [1.4.1 Whole plant food diet](http://en.wikipedia.org/wiki/Nutrition#Whole_plant_food_diet)
		- [1.4.2 The French "paradox"](http://en.wikipedia.org/wiki/Nutrition#The_French_.22paradox.22)
	+ [1.5 Sports nutrition](http://en.wikipedia.org/wiki/Nutrition#Sports_nutrition)
		- [1.5.1 Protein](http://en.wikipedia.org/wiki/Nutrition#Protein_2)
		- [1.5.2 Water and salts](http://en.wikipedia.org/wiki/Nutrition#Water_and_salts)
		- [1.5.3 Carbohydrates](http://en.wikipedia.org/wiki/Nutrition#Carbohydrates_2)
	+ [1.6 Malnutrition](http://en.wikipedia.org/wiki/Nutrition#Malnutrition)
		- [1.6.1 Insufficient](http://en.wikipedia.org/wiki/Nutrition#Insufficient)
		- [1.6.2 Excessive](http://en.wikipedia.org/wiki/Nutrition#Excessive)
		- [1.6.3 Unbalanced](http://en.wikipedia.org/wiki/Nutrition#Unbalanced)
		- [1.6.4 Illnesses caused by improper nutrient consumption](http://en.wikipedia.org/wiki/Nutrition#Illnesses_caused_by_improper_nutrient_consumption)
		- [1.6.5 Mental agility](http://en.wikipedia.org/wiki/Nutrition#Mental_agility)
		- [1.6.6 Mental disorders](http://en.wikipedia.org/wiki/Nutrition#Mental_disorders)
		- [1.6.7 Cancer](http://en.wikipedia.org/wiki/Nutrition#Cancer)
		- [1.6.8 Metabolic syndrome](http://en.wikipedia.org/wiki/Nutrition#Metabolic_syndrome)
		- [1.6.9 Hyponatremia](http://en.wikipedia.org/wiki/Nutrition#Hyponatremia)
		- [1.6.10 Antinutrient](http://en.wikipedia.org/wiki/Nutrition#Antinutrient)
		- [1.6.11 Processed foods](http://en.wikipedia.org/wiki/Nutrition#Processed_foods)
	+ [1.7 History](http://en.wikipedia.org/wiki/Nutrition#History)
		- [1.7.1 From antiquity to 1900](http://en.wikipedia.org/wiki/Nutrition#From_antiquity_to_1900)
		- [1.7.2 From 1900 to the present](http://en.wikipedia.org/wiki/Nutrition#From_1900_to_the_present)
* [2 Plant nutrition](http://en.wikipedia.org/wiki/Nutrition#Plant_nutrition)
	+ [2.1 Macronutrients](http://en.wikipedia.org/wiki/Nutrition#Macronutrients)
	+ [2.2 Micronutrients](http://en.wikipedia.org/wiki/Nutrition#Micronutrients)
	+ [2.3 Processes](http://en.wikipedia.org/wiki/Nutrition#Processes)
* [3 See also](http://en.wikipedia.org/wiki/Nutrition#See_also)
* [4 References](http://en.wikipedia.org/wiki/Nutrition#References)
* [5 Further reading](http://en.wikipedia.org/wiki/Nutrition#Further_reading)
* [6 External links](http://en.wikipedia.org/wiki/Nutrition#External_links)
	+ [6.1 Databases and search engines](http://en.wikipedia.org/wiki/Nutrition#Databases_and_search_engines)
 |

**Animal nutrition**

**Overview**

Nutritional science investigates the [metabolic](http://en.wikipedia.org/wiki/Metabolism) and physiological responses of the body to diet. With advances in the fields of [molecular biology](http://en.wikipedia.org/wiki/Molecular_biology), [biochemistry](http://en.wikipedia.org/wiki/Biochemistry), and [genetics](http://en.wikipedia.org/wiki/Genetics), the study of nutrition is increasingly concerned with metabolism and [metabolic pathways](http://en.wikipedia.org/wiki/Metabolic_pathway): the sequences of biochemical steps through which substances in living things change from one form to another.

[Carnivore](http://en.wikipedia.org/wiki/Carnivore) and [herbivore](http://en.wikipedia.org/wiki/Herbivore) diets are contrasting, with basic [nitrogen](http://en.wikipedia.org/wiki/Nitrogen) and [carbon](http://en.wikipedia.org/wiki/Carbon) proportions being at varying levels in particular foods. Carnivores consume more nitrogen than carbon while herbivores consume less nitrogen than carbon, when an equal quantity is measured.

The [human body](http://en.wikipedia.org/wiki/Human_body) contains [chemical compounds](http://en.wikipedia.org/wiki/Chemical_compounds), such as [water](http://en.wikipedia.org/wiki/Water), [carbohydrates](http://en.wikipedia.org/wiki/Carbohydrate) (sugar, starch, and [fiber](http://en.wikipedia.org/wiki/Fiber)), [amino acids](http://en.wikipedia.org/wiki/Amino_acids) (in [proteins](http://en.wikipedia.org/wiki/Proteins)), [fatty acids](http://en.wikipedia.org/wiki/Fatty_acids) (in [lipids](http://en.wikipedia.org/wiki/Lipids)), and [nucleic acids](http://en.wikipedia.org/wiki/Nucleic_acids) ([DNA](http://en.wikipedia.org/wiki/DNA) and [RNA](http://en.wikipedia.org/wiki/RNA)). These compounds in turn consist of [elements](http://en.wikipedia.org/wiki/Chemical_element) such as [carbon](http://en.wikipedia.org/wiki/Carbon), [hydrogen](http://en.wikipedia.org/wiki/Hydrogen), [oxygen](http://en.wikipedia.org/wiki/Oxygen), [nitrogen](http://en.wikipedia.org/wiki/Nitrogen), [phosphorus](http://en.wikipedia.org/wiki/Phosphorus), [calcium](http://en.wikipedia.org/wiki/Calcium), [iron](http://en.wikipedia.org/wiki/Iron), [zinc](http://en.wikipedia.org/wiki/Zinc), [magnesium](http://en.wikipedia.org/wiki/Magnesium), [manganese](http://en.wikipedia.org/wiki/Manganese), and so on. All of these chemical compounds and elements occur in various forms and combinations (e.g. [hormones](http://en.wikipedia.org/wiki/Hormones), [vitamins](http://en.wikipedia.org/wiki/Vitamins), [phospholipids](http://en.wikipedia.org/wiki/Phospholipids), [hydroxyapatite](http://en.wikipedia.org/wiki/Hydroxyapatite)), both in the [human body](http://en.wikipedia.org/wiki/Human_body) and in the plant and animal organisms that humans eat.

The human body consists of elements and compounds ingested, digested, absorbed, and circulated through the [bloodstream](http://en.wikipedia.org/wiki/Blood) to feed the [cells](http://en.wikipedia.org/wiki/Cell_%28biology%29) of the body. Except in the unborn fetus, the [digestive system](http://en.wikipedia.org/wiki/Digestive_system) is the first system involved[*[vague](http://en.wikipedia.org/wiki/Wikipedia%3AVagueness%22%20%5Co%20%22Wikipedia%3AVagueness)*]. In a typical adult, about seven liters of digestive juices enter the [lumen](http://en.wikipedia.org/wiki/Lumen_%28anatomy%29) of the digestive tract.[[*citation needed*](http://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)][[*clarification needed*](http://en.wikipedia.org/wiki/Wikipedia%3APlease_clarify)] These digestive juices break [chemical bonds](http://en.wikipedia.org/wiki/Chemical_bonds) in ingested molecules, and modulate their [conformations](http://en.wikipedia.org/wiki/Protein_conformation) 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](http://en.wikipedia.org/wiki/Metabolism), is eliminated from the body in the [feces](http://en.wikipedia.org/wiki/Feces).

Studies of nutritional status must take into account the state of the body before and after experiments, as well as the [chemical](http://en.wikipedia.org/wiki/Chemical) composition of the whole diet and of all material [excreted](http://en.wikipedia.org/wiki/Excreted) and eliminated from the body (in [urine](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Variable_%28mathematics%29) involved in such [experiments](http://en.wikipedia.org/wiki/Experiment) is high, making nutritional studies time-consuming and expensive, which explains why the science of human nutrition is still slowly evolving.

In general, eating a wide variety of fresh, whole (unprocessed), foods has proven favorable for one's health compared to monotonous diets based on processed foods.[[14]](http://en.wikipedia.org/wiki/Nutrition#cite_note-13) In particular, the consumption of whole-plant foods slows digestion and allows better absorption, and a more favorable balance of essential nutrients per [Calorie](http://en.wikipedia.org/wiki/Calorie), resulting in better management of cell growth, maintenance, and [mitosis](http://en.wikipedia.org/wiki/Mitosis) (cell division), as well as better regulation of appetite and blood sugar[[*citation needed*](http://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)]. Regularly scheduled meals (every few hours) have also proven more wholesome than infrequent or haphazard ones,[[15]](http://en.wikipedia.org/wiki/Nutrition%22%20%5Cl%20%22cite_note-14) although a recent study has also linked more frequent meals with a higher risk of colon cancer in men.[[16]](http://en.wikipedia.org/wiki/Nutrition#cite_note-15)

**Nutrients**

*Main article:* [*Nutrient*](http://en.wikipedia.org/wiki/Nutrient)

There are six major classes of nutrients: [carbohydrates](http://en.wikipedia.org/wiki/Carbohydrates), [fats](http://en.wikipedia.org/wiki/Fat), [minerals](http://en.wikipedia.org/wiki/Dietary_minerals), [protein](http://en.wikipedia.org/wiki/Protein), [vitamins](http://en.wikipedia.org/wiki/Vitamin), and [water](http://en.wikipedia.org/wiki/Water).

These nutrient classes can be categorized as either [macronutrients](http://en.wikipedia.org/wiki/Macronutrients) (needed in relatively large amounts) or [micronutrients](http://en.wikipedia.org/wiki/Micronutrients) (needed in smaller quantities). The macronutrients include carbohydrates (including [fiber](http://en.wikipedia.org/wiki/Dietary_fiber)), fats, protein, and water. The micronutrients are minerals and vitamins.

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](http://en.wikipedia.org/wiki/Bioenergetics). Some of the structural material can be used to generate energy internally, and in either case it is measured in [Joules](http://en.wikipedia.org/wiki/Joule) or [kilocalories](http://en.wikipedia.org/wiki/Calorie) (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.,[[17]](http://en.wikipedia.org/wiki/Nutrition%22%20%5Cl%20%22cite_note-Stryer-16) though the net energy from either depends on such factors as absorption and digestive effort, which vary substantially from instance to instance. Vitamins, minerals, fiber, and water do not provide energy, but are required for other reasons. A third class of dietary material, fiber (i.e., non-digestible material such as cellulose), is also required,[*[citation needed](http://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed%22%20%5Co%20%22Wikipedia%3ACitation%20needed)*] for both mechanical and biochemical reasons, although the exact reasons remain unclear.

Molecules of carbohydrates and fats consist of carbon, hydrogen, and oxygen atoms. Carbohydrates range from simple [monosaccharides](http://en.wikipedia.org/wiki/Monosaccharides) (glucose, fructose, galactose) to complex [polysaccharides](http://en.wikipedia.org/wiki/Polysaccharides) (starch). Fats are [triglycerides](http://en.wikipedia.org/wiki/Triglyceride), made of assorted [fatty acid](http://en.wikipedia.org/wiki/Fatty_acid) [monomers](http://en.wikipedia.org/wiki/Monomers) bound to [glycerol](http://en.wikipedia.org/wiki/Glycerol) backbone. Some fatty acids, but not all, are [essential](http://en.wikipedia.org/wiki/Essential_fatty_acids) 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](http://en.wikipedia.org/wiki/Amino_acids), some of which are [essential](http://en.wikipedia.org/wiki/Essential_amino_acids) in the sense that humans cannot make them internally. Some of the amino acids are convertible (with the expenditure of energy) to glucose and can be used for energy production just as ordinary glucose in a process known as gluconeogenesis. By breaking down existing protein, some glucose can be produced internally; the remaining amino acids are discarded, primarily as urea in urine. This occurs normally only during prolonged starvation.

Other micronutrients include [antioxidants](http://en.wikipedia.org/wiki/Antioxidants) and [phytochemicals](http://en.wikipedia.org/wiki/Phytochemicals), which are said to influence (or protect) some body systems. Their necessity is not as well established as in the case of, for instance, vitamins.

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

**Carbohydrates**

*Main article:* [*Carbohydrate*](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Rice), [noodles](http://en.wikipedia.org/wiki/Noodles), [bread](http://en.wikipedia.org/wiki/Bread), and other [grain](http://en.wikipedia.org/wiki/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 were believed to be absorbed quickly, and therefore raise blood-sugar levels more rapidly than complex carbohydrates. This, however, is not accurate.[[18]](http://en.wikipedia.org/wiki/Nutrition#cite_note-17)[[19]](http://en.wikipedia.org/wiki/Nutrition#cite_note-18)[[20]](http://en.wikipedia.org/wiki/Nutrition#cite_note-19)[[21]](http://en.wikipedia.org/wiki/Nutrition#cite_note-20) Some simple carbohydrates (e.g. fructose) are digested very slowly, while many complex carbohydrates are digested at essentially the same rate as simple.[[22]](http://en.wikipedia.org/wiki/Nutrition#cite_note-21)

**Fiber**

*Main article:* [*Dietary fiber*](http://en.wikipedia.org/wiki/Dietary_fiber)

Dietary fiber is a [carbohydrate](http://en.wikipedia.org/wiki/Carbohydrate) (or a polysaccharide) that is incompletely absorbed in humans and in some animals. Like all carbohydrates, when it is metabolized it can produce four Calories (kilocalories) of energy per gram. However, in most circumstances it accounts for less than that because of its limited absorption and digestibility. Dietary fiber consists mainly of [cellulose](http://en.wikipedia.org/wiki/Cellulose), a large carbohydrate polymer that is indigestible because humans do not have the required enzymes to disassemble it. There are two subcategories: soluble and insoluble fiber. Whole grains, fruits (especially [plums](http://en.wikipedia.org/wiki/Plum), [prunes](http://en.wikipedia.org/wiki/Prune), and [figs](http://en.wikipedia.org/wiki/Ficus)), 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](http://en.wikipedia.org/wiki/Constipation) and [diarrhea](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Peristalsis) -- the rhythmic muscular contractions of the intestines which move digesta along the digestive tract. Soluble fiber, found in oats, peas, beans, and many fruits, dissolves in water in the intestinal tract to produce a gel which slows the movement of food through the intestines. This may help lower blood glucose levels because it can slow the absorption of sugar. Additionally, fiber, perhaps especially that from whole grains, is thought to possibly help lessen insulin spikes, and therefore reduce the risk of type 2 diabetes. The link between increased fiber consumption and a decreased risk of colorectal cancer is still uncertain. [[23]](http://en.wikipedia.org/wiki/Nutrition#cite_note-22)

**Fat**

*Main article:* [*Fat*](http://en.wikipedia.org/wiki/Fat)

A molecule of dietary fat typically consists of several [fatty acids](http://en.wikipedia.org/wiki/Fatty_acid) (containing long chains of carbon and hydrogen atoms), bonded to a [glycerol](http://en.wikipedia.org/wiki/Glycerol). They are typically found as [triglycerides](http://en.wikipedia.org/wiki/Triglyceride) (three fatty acids attached to one glycerol backbone). Fats may be classified as [saturated](http://en.wikipedia.org/wiki/Saturated_fat) or [unsaturated](http://en.wikipedia.org/wiki/Unsaturated_fat) 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](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Omega-3) or [omega-6](http://en.wikipedia.org/wiki/Omega-6) fatty acids. [Trans fats](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Hydrogenation). There are nine kilocalories in each gram of fat.

Saturated fats (typically from animal sources) have been a staple in many world cultures for millennia. Unsaturated fats (e. g., vegetable oil) are considered healthier, while trans fats are to be avoided. Saturated and some trans fats are typically solid at room temperature (such as [butter](http://en.wikipedia.org/wiki/Butter) or [lard](http://en.wikipedia.org/wiki/Lard)), while unsaturated fats are typically liquids (such as [olive oil](http://en.wikipedia.org/wiki/Olive_oil) or [flaxseed oil](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Food_processing) industry, such as rancidity resistance.[*[citation needed](http://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed%22%20%5Co%20%22Wikipedia%3ACitation%20needed)*]

**Essential fatty acids**

*Main article:* [*Essential fatty acids*](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Essential_fatty_acids) and must be included in the diet. An appropriate balance of essential fatty acids—[omega-3](http://en.wikipedia.org/wiki/Omega-3) and [omega-6 fatty acids](http://en.wikipedia.org/wiki/Omega-6_fatty_acid)—seems also important for health, although definitive experimental demonstration has been elusive. Both of these "omega" long-chain [polyunsaturated fatty acids](http://en.wikipedia.org/wiki/Unsaturated_fat) are [substrates](http://en.wikipedia.org/wiki/Substrate_%28biochemistry%29) for a class of [eicosanoids](http://en.wikipedia.org/wiki/Eicosanoids) known as [prostaglandins](http://en.wikipedia.org/wiki/Prostaglandins), which have roles throughout the human body. They are [hormones](http://en.wikipedia.org/wiki/Hormone), in some respects. The omega-3 [eicosapentaenoic acid](http://en.wikipedia.org/wiki/Eicosapentaenoic_acid) (EPA), which can be made in the human body from the omega-3 essential fatty acid [alpha-linolenic acid](http://en.wikipedia.org/wiki/Alpha-linolenic_acid) (LNA), or taken in through marine food sources, serves as a building block for series 3 prostaglandins (e.g. weakly [inflammatory](http://en.wikipedia.org/wiki/Inflammation) 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](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Desaturase), which in turn is controlled by hormones such as [insulin](http://en.wikipedia.org/wiki/Insulin) (up-regulation) and [glucagon](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Inflammation), and [mitosis](http://en.wikipedia.org/wiki/Mitosis) (i.e. cell division).

**Protein**





Most [meats](http://en.wikipedia.org/wiki/Meats) such as [chicken](http://en.wikipedia.org/wiki/Chicken_%28food%29) contain all the [essential amino acids](http://en.wikipedia.org/wiki/Essential_amino_acids) needed for humans

*Main article:* [*Protein in nutrition*](http://en.wikipedia.org/wiki/Protein_in_nutrition)

Proteins are the basis of many animal body structures (e.g. muscles, skin, and hair). They also form the enzymes that control chemical reactions throughout the body. Each molecule is composed of [amino acids](http://en.wikipedia.org/wiki/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*](http://en.wikipedia.org/wiki/Essential_amino_acid) (an animal cannot produce them internally) and some are [*non-essential*](http://en.wikipedia.org/wiki/Non-essential_amino_acid) (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 to combine 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. Sources of dietary protein include [meats](http://en.wikipedia.org/wiki/Meat), [tofu](http://en.wikipedia.org/wiki/Tofu) and other [soy](http://en.wikipedia.org/wiki/Soy)-products, [eggs](http://en.wikipedia.org/wiki/Egg_%28food%29), [legumes](http://en.wikipedia.org/wiki/Legume), and [dairy products](http://en.wikipedia.org/wiki/Dairy_product) such as [milk](http://en.wikipedia.org/wiki/Milk) and [cheese](http://en.wikipedia.org/wiki/Cheese). Excess amino acids from protein can be converted into glucose and used for fuel through a process called [gluconeogenesis](http://en.wikipedia.org/wiki/Gluconeogenesis). The amino acids remaining after such conversion are discarded.

**Minerals**

*Main article:* [*Dietary mineral*](http://en.wikipedia.org/wiki/Dietary_mineral)

Dietary minerals are the [chemical elements](http://en.wikipedia.org/wiki/Chemical_element) required by living organisms, other than the four elements [carbon](http://en.wikipedia.org/wiki/Carbon), [hydrogen](http://en.wikipedia.org/wiki/Hydrogen), [nitrogen](http://en.wikipedia.org/wiki/Nitrogen), and [oxygen](http://en.wikipedia.org/wiki/Oxygen) that are present in nearly all [organic molecules](http://en.wikipedia.org/wiki/Organic_chemistry). 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](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Calcium_carbonate) from ground [oyster](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Iodized_salt) which prevents [goiter](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Electrolyte).[[24]](http://en.wikipedia.org/wiki/Nutrition#cite_note-23) Elements with recommended dietary allowance ([RDA](http://en.wikipedia.org/wiki/Recommended_Dietary_Allowance)) greater than 200 mg/day are, in alphabetical order (with informal or folk-medicine perspectives in parentheses):

* [Calcium](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Chlorine) as [chloride](http://en.wikipedia.org/wiki/Chloride) ions; very common electrolyte; see sodium, below
* [Magnesium](http://en.wikipedia.org/wiki/Magnesium), required for processing [ATP](http://en.wikipedia.org/wiki/Adenosine_triphosphate) and related reactions (builds bone, causes strong peristalsis, increases flexibility, increases alkalinity)
* [Phosphorus](http://en.wikipedia.org/wiki/Phosphorus), required component of bones; essential for energy processing[[25]](http://en.wikipedia.org/wiki/Nutrition#cite_note-24)
* [Potassium](http://en.wikipedia.org/wiki/Potassium), a very common electrolyte (heart and nerve health)
* [Sodium](http://en.wikipedia.org/wiki/Sodium), a very common electrolyte; not generally found in dietary supplements, despite being needed in large quantities, because the ion is very common in food: typically as [sodium chloride](http://en.wikipedia.org/wiki/Sodium_chloride), or common salt. Excessive sodium consumption can deplete [calcium](http://en.wikipedia.org/wiki/Calcium) and [magnesium](http://en.wikipedia.org/wiki/Magnesium),[*[verification needed](http://en.wikipedia.org/wiki/Wikipedia%3AVerifiability%22%20%5Co%20%22Wikipedia%3AVerifiability)*] leading to high blood pressure and osteoporosis.
* [Sulfur](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Catalytic) role in [enzymes](http://en.wikipedia.org/wiki/Enzymes).[[26]](http://en.wikipedia.org/wiki/Nutrition#cite_note-lipp-25) Some trace mineral elements (RDA < 200 mg/day) are, in alphabetical order:

* [Cobalt](http://en.wikipedia.org/wiki/Cobalt) required for biosynthesis of [vitamin B12](http://en.wikipedia.org/wiki/Vitamin_B12) family of [coenzymes](http://en.wikipedia.org/wiki/Coenzyme). Animals cannot biosynthesize B12, and must obtain this cobalt-containing vitamin in the diet
* [Copper](http://en.wikipedia.org/wiki/Copper) required component of many redox enzymes, including [cytochrome c oxidase](http://en.wikipedia.org/wiki/Cytochrome_c_oxidase)

*Main article:* [*Copper in health*](http://en.wikipedia.org/wiki/Copper_in_health)

* [Chromium](http://en.wikipedia.org/wiki/Chromium) required for sugar metabolism
* [Iodine](http://en.wikipedia.org/wiki/Iodine) required not only for the biosynthesis of [thyroxine](http://en.wikipedia.org/wiki/Thyroxine), but probably, for other important organs as breast, stomach, salivary glands, thymus etc. (see Extrathyroidal [iodine](http://en.wikipedia.org/wiki/Iodine)); for this reason iodine is needed in larger quantities than others in this list, and sometimes classified with the macrominerals
* [Iron](http://en.wikipedia.org/wiki/Iron) required for many enzymes, and for [hemoglobin](http://en.wikipedia.org/wiki/Hemoglobin) and some other proteins
* [Manganese](http://en.wikipedia.org/wiki/Manganese) (processing of oxygen)
* [Molybdenum](http://en.wikipedia.org/wiki/Molybdenum) required for [xanthine oxidase](http://en.wikipedia.org/wiki/Xanthine_oxidase) and related oxidases
* [Nickel](http://en.wikipedia.org/wiki/Nickel) present in [urease](http://en.wikipedia.org/wiki/Urease)
* [Selenium](http://en.wikipedia.org/wiki/Selenium) required for [peroxidase](http://en.wikipedia.org/wiki/Peroxidase) (antioxidant proteins)
* [Vanadium](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Zinc) required for several enzymes such as [carboxypeptidase](http://en.wikipedia.org/wiki/Carboxypeptidase), [liver alcohol dehydrogenase](http://en.wikipedia.org/wiki/Alcohol_dehydrogenase#In_humans), and [carbonic anhydrase](http://en.wikipedia.org/wiki/Carbonic_anhydrase)

**Vitamins**

*Main article:* [*Vitamin*](http://en.wikipedia.org/wiki/Vitamin)

As with the minerals discussed above, some vitamins are recognized as essential nutrients, necessary in the diet for good health. ([Vitamin D](http://en.wikipedia.org/wiki/Vitamin_D) is the exception: it can be synthesized in the skin, in the presence of [UVB radiation](http://en.wikipedia.org/wiki/UVB_radiation).) Certain vitamin-like compounds that are recommended in the diet, such as [carnitine](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Phytochemicals) have recently been discovered in food (particularly in fresh vegetables), which may have desirable properties including [antioxidant](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Essential_amino_acid) (see [above](http://en.wikipedia.org/wiki/Nutrition#Protein)), [choline](http://en.wikipedia.org/wiki/Choline), [essential fatty acids](http://en.wikipedia.org/wiki/Essential_fatty_acid) (see [above](http://en.wikipedia.org/wiki/Nutrition#Essential_fatty_acids)), and the minerals discussed in the preceding section.

Vitamin deficiencies may result in disease conditions, including [goitre](http://en.wikipedia.org/wiki/Goitre), [scurvy](http://en.wikipedia.org/wiki/Scurvy), [osteoporosis](http://en.wikipedia.org/wiki/Osteoporosis), impaired [immune system](http://en.wikipedia.org/wiki/Immune_system), disorders of cell [metabolism](http://en.wikipedia.org/wiki/Metabolism), certain forms of cancer, symptoms of premature [aging](http://en.wikipedia.org/wiki/Aging), and poor [psychological health](http://en.wikipedia.org/wiki/Psychology) (including [eating disorders](http://en.wikipedia.org/wiki/Eating_disorders)), among many others.[[27]](http://en.wikipedia.org/wiki/Nutrition#cite_note-26) Excess levels of some vitamins are also dangerous to health (notably [vitamin A](http://en.wikipedia.org/wiki/Vitamin_A)), and for at least one vitamin, B6, toxicity begins at levels not far above the required amount. Deficient or excess levels of minerals can also have serious health consequences.

**Water**

*Main article:* [*Drinking water*](http://en.wikipedia.org/wiki/Drinking_water)





A manual [water](http://en.wikipedia.org/wiki/Water) [pump](http://en.wikipedia.org/wiki/Pump) in [China](http://en.wikipedia.org/wiki/China)

Water is excreted from the body in multiple forms; including [urine](http://en.wikipedia.org/wiki/Urine) and [feces](http://en.wikipedia.org/wiki/Feces), [sweating](http://en.wikipedia.org/wiki/Sweating), and by [water vapour](http://en.wikipedia.org/wiki/Water_vapour) in the exhaled breath. Therefore it is necessary to adequately rehydrate to replace lost fluids.

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.[[28]](http://en.wikipedia.org/wiki/Nutrition#cite_note-27) However the notion that a person should consume eight glasses of water per day cannot be traced to a credible scientific source.[[29]](http://en.wikipedia.org/wiki/Nutrition#cite_note-28) The original water intake recommendation in 1945 by the Food and Nutrition Board of the [National Research Council](http://en.wikipedia.org/wiki/United_States_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."[[30]](http://en.wikipedia.org/wiki/Nutrition#cite_note-29) 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.[[31]](http://en.wikipedia.org/wiki/Nutrition#cite_note-Le_Bellego-30) Therefore, to help standardize guidelines, recommendations for water consumption are included in two recent [European Food Safety Authority](http://en.wikipedia.org/wiki/European_Food_Safety_Authority) (EFSA) documents (2010): (i) Food-based dietary guidelines and (ii) Dietary reference values for water or adequate daily intakes (ADI).[[32]](http://en.wikipedia.org/wiki/Nutrition#cite_note-Scientific_Opinion_on_Dietary_Reference_Values_for_water-31) 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.”[[32]](http://en.wikipedia.org/wiki/Nutrition#cite_note-Scientific_Opinion_on_Dietary_Reference_Values_for_water-31) For healthy 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.[[33]](http://en.wikipedia.org/wiki/Nutrition#cite_note-32) Water content varies depending on the type of food consumed, with fruit and vegetables containing more than cereals, for example.[[34]](http://en.wikipedia.org/wiki/Nutrition#cite_note-FAO-33) These values are estimated using country-specific food balance sheets published by the Food and Agriculture Organisation of the United Nations.[[34]](http://en.wikipedia.org/wiki/Nutrition#cite_note-FAO-33) 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.[[35]](http://en.wikipedia.org/wiki/Nutrition#cite_note-34)

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.[[32]](http://en.wikipedia.org/wiki/Nutrition#cite_note-Scientific_Opinion_on_Dietary_Reference_Values_for_water-31) [Pregnant](http://en.wikipedia.org/wiki/Pregnant) and [breastfeeding](http://en.wikipedia.org/wiki/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.[[32]](http://en.wikipedia.org/wiki/Nutrition#cite_note-Scientific_Opinion_on_Dietary_Reference_Values_for_water-31) To compensate for additional fluid output, breastfeeding women require an additional 700 mL/day above the recommended intake values for non-lactating women.[[32]](http://en.wikipedia.org/wiki/Nutrition#cite_note-Scientific_Opinion_on_Dietary_Reference_Values_for_water-31)

For those who have healthy kidneys, it is somewhat difficult to drink too much water,[[32]](http://en.wikipedia.org/wiki/Nutrition%22%20%5Cl%20%22cite_note-Scientific_Opinion_on_Dietary_Reference_Values_for_water-31) 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](http://en.wikipedia.org/wiki/Water_intoxication), a serious and potentially fatal condition.[[36]](http://en.wikipedia.org/wiki/Nutrition#cite_note-35) In particular, large amounts of de-ionized water are dangerous.[[32]](http://en.wikipedia.org/wiki/Nutrition#cite_note-Scientific_Opinion_on_Dietary_Reference_Values_for_water-31)

**Other nutrients**

Other micronutrients include antioxidants and phytochemicals. These substances are generally 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.[*[citation needed](http://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed%22%20%5Co%20%22Wikipedia%3ACitation%20needed)*]

**Antioxidants**

*Main article:* [*Antioxidant*](http://en.wikipedia.org/wiki/Antioxidant)

As cellular [metabolism](http://en.wikipedia.org/wiki/Metabolism)/energy production requires oxygen, potentially damaging (e.g. [mutation](http://en.wikipedia.org/wiki/Mutation) causing) compounds known as [free radicals](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Evolution_of_dietary_antioxidants). Some are produced by the human body with adequate [precursors](http://en.wikipedia.org/wiki/Precursor_%28chemistry%29) ([glutathione](http://en.wikipedia.org/wiki/Glutathione), [Vitamin C](http://en.wikipedia.org/wiki/Vitamin_C)), and those the body cannot produce may only be obtained in the diet via direct sources (Vitamin C in humans, [Vitamin A](http://en.wikipedia.org/wiki/Vitamin_A), [Vitamin K](http://en.wikipedia.org/wiki/Vitamin_K)) or produced by the body from other compounds ([Beta-carotene](http://en.wikipedia.org/wiki/Beta-carotene) converted to Vitamin A by the body, [Vitamin D](http://en.wikipedia.org/wiki/Vitamin_D) synthesized from [cholesterol](http://en.wikipedia.org/wiki/Cholesterol) by [sunlight](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Fat-soluble) and protects fat areas, Vitamin C is [water](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Butterfly_effect).

Although initial studies suggested that antioxidant supplements might promote health, later large [clinical trials](http://en.wikipedia.org/wiki/Clinical_trial) did not detect any benefit and suggested instead that excess supplementation may be harmful.[[37]](http://en.wikipedia.org/wiki/Nutrition#cite_note-36)[[38]](http://en.wikipedia.org/wiki/Nutrition#cite_note-37)

**Phytochemicals**





[Blackberries](http://en.wikipedia.org/wiki/Blackberry) are a source of [polyphenol antioxidants](http://en.wikipedia.org/wiki/Polyphenol_antioxidants)

*Main article:* [*Phytochemical*](http://en.wikipedia.org/wiki/Phytochemical)

A growing area of interest is the effect upon human health of trace chemicals, collectively called [phytochemicals](http://en.wikipedia.org/wiki/Phytochemicals). These nutrients are typically found in edible plants, especially colorful fruits and vegetables, but also other organisms including seafood, algae, and fungi. The effects of phytochemicals increasingly survive rigorous testing by prominent health organizations. One of the principal classes of phytochemicals are [polyphenol antioxidants](http://en.wikipedia.org/wiki/Polyphenol_antioxidant), chemicals that are known to provide certain health benefits to the [cardiovascular system](http://en.wikipedia.org/wiki/Cardiovascular_system) and [immune system](http://en.wikipedia.org/wiki/Immune_system). These chemicals are known to down-regulate the formation of [reactive oxygen species](http://en.wikipedia.org/wiki/Reactive_oxygen_species), key chemicals in [cardiovascular disease](http://en.wikipedia.org/wiki/Cardiovascular_disease).

Perhaps the most rigorously tested phytochemical is [zeaxanthin](http://en.wikipedia.org/wiki/Zeaxanthin), a yellow-pigmented carotenoid present in many yellow and orange fruits and vegetables. Repeated studies have shown a strong correlation between ingestion of zeaxanthin and the prevention and treatment of [age-related macular degeneration](http://en.wikipedia.org/wiki/Age-related_macular_degeneration) (AMD).[[39]](http://en.wikipedia.org/wiki/Nutrition#cite_note-38)[[*non-primary*](http://en.wikipedia.org/wiki/Wikipedia%3ANo_original_research#Primary.2C_secondary_and_tertiary_sources) *source*[*needed*](http://en.wikipedia.org/wiki/Wikipedia%3AVerifiability)] Less rigorous studies have proposed a correlation between zeaxanthin intake and [cataracts](http://en.wikipedia.org/wiki/Cataracts).[[40]](http://en.wikipedia.org/wiki/Nutrition#cite_note-39)[[*non-primary*](http://en.wikipedia.org/wiki/Wikipedia%3ANo_original_research#Primary.2C_secondary_and_tertiary_sources) *source*[*needed*](http://en.wikipedia.org/wiki/Wikipedia%3AVerifiability)] A second carotenoid, lutein, has also been shown to lower the risk of contracting AMD. Both compounds have been observed to collect in the retina when ingested orally, and they serve to protect the rods and cones against the destructive effects of light.

Another carotenoid, beta-[cryptoxanthin](http://en.wikipedia.org/wiki/Cryptoxanthin%22%20%5Co%20%22Cryptoxanthin), appears to protect against chronic joint inflammatory diseases, such as [arthritis](http://en.wikipedia.org/wiki/Arthritis). While the association between serum blood levels of beta-cryptoxanthin and substantially decreased joint disease has been established,[[41]](http://en.wikipedia.org/wiki/Nutrition%22%20%5Cl%20%22cite_note-40) neither a convincing mechanism for such protection nor a cause-and-effect have been rigorously studied. Similarly, a red phytochemical, [lycopene](http://en.wikipedia.org/wiki/Lycopene), has substantial credible evidence of negative association with development of prostate cancer.

As indicated above, some of the correlations between the ingestion of certain phytochemicals and the prevention of disease are, in some cases, enormous in magnitude. Yet, even when the evidence is obtained, translating it to practical dietary advice can be difficult and counter-intuitive. Lutein, for example, occurs in many yellow and orange fruits and vegetables and protects the eyes against various diseases. However, it does not protect the eye nearly as well as zeaxanthin, and the presence of lutein in the retina will prevent zeaxanthin uptake. Additionally, evidence has shown that the lutein present in egg yolk is more readily absorbed than the lutein from vegetable sources, possibly because of fat solubility.[[42]](http://en.wikipedia.org/wiki/Nutrition#cite_note-41) At the most basic level, the question "should you eat eggs?" is complex to the point of dismay, including misperceptions about the health effects of cholesterol in egg yolk, and its saturated fat content.

As another example, lycopene is prevalent in tomatoes (and actually is the chemical that gives tomatoes their red color). It is more highly concentrated, however, in processed tomato products such as commercial pasta sauce, or [tomato soup](http://en.wikipedia.org/wiki/Tomato_soup), than in fresh "healthy" tomatoes. Yet, such sauces tend to have high amounts of salt, sugar, other substances a person may wish or even need to avoid.

The following table presents phytochemical groups and common sources, arranged by family:

|  |  |  |
| --- | --- | --- |
| **Family** | **Sources** | **Possible benefits** |
| [Flavonoids](http://en.wikipedia.org/wiki/Flavonoid) | [Berries](http://en.wikipedia.org/wiki/Berry), [herbs](http://en.wikipedia.org/wiki/Herbs), [vegetables](http://en.wikipedia.org/wiki/Vegetables), [wine](http://en.wikipedia.org/wiki/Wine), [grapes](http://en.wikipedia.org/wiki/Grapes), [tea](http://en.wikipedia.org/wiki/Tea) | General [antioxidant](http://en.wikipedia.org/wiki/Antioxidant), oxidation of [LDLs](http://en.wikipedia.org/wiki/LDL), prevention of [arteriosclerosis](http://en.wikipedia.org/wiki/Arteriosclerosis) and [heart disease](http://en.wikipedia.org/wiki/Heart_disease) |
| [Isoflavones](http://en.wikipedia.org/wiki/Isoflavone) ([phytoestrogens](http://en.wikipedia.org/wiki/Phytoestrogens)) | [Soy](http://en.wikipedia.org/wiki/Soy), [red clover](http://en.wikipedia.org/wiki/Red_clover), [kudzu root](http://en.wikipedia.org/wiki/Kudzu_root) | General [antioxidant](http://en.wikipedia.org/wiki/Antioxidant), prevention of [arteriosclerosis](http://en.wikipedia.org/wiki/Arteriosclerosis) and [heart disease](http://en.wikipedia.org/wiki/Heart_disease), easing symptoms of [menopause](http://en.wikipedia.org/wiki/Menopause), [cancer prevention](http://en.wikipedia.org/wiki/Cancer) [[43]](http://en.wikipedia.org/wiki/Nutrition#cite_note-42) |
| [Isothiocyanates](http://en.wikipedia.org/wiki/Isothiocyanate) | [Cruciferous vegetables](http://en.wikipedia.org/wiki/Cruciferous_vegetables) | [cancer prevention](http://en.wikipedia.org/wiki/Cancer) |
| [Monoterpenes](http://en.wikipedia.org/wiki/Monoterpene) | [Citrus](http://en.wikipedia.org/wiki/Citrus) peels, [essential oils](http://en.wikipedia.org/wiki/Essential_oil), [herbs](http://en.wikipedia.org/wiki/Herbs), [spices](http://en.wikipedia.org/wiki/Spices), [green plants](http://en.wikipedia.org/wiki/Green_plants), [atmosphere](http://en.wikipedia.org/wiki/Atmosphere)[[44]](http://en.wikipedia.org/wiki/Nutrition#cite_note-43) | [Cancer prevention](http://en.wikipedia.org/wiki/Cancer), treating [gallstones](http://en.wikipedia.org/wiki/Gallstones) |
| [Organosulfur compounds](http://en.wikipedia.org/wiki/Organosulfur_compounds) | [Chives](http://en.wikipedia.org/wiki/Chives), [garlic](http://en.wikipedia.org/wiki/Garlic), [onions](http://en.wikipedia.org/wiki/Onion) | [cancer prevention](http://en.wikipedia.org/wiki/Cancer), lowered [LDLs](http://en.wikipedia.org/wiki/LDL), assistance to the [immune system](http://en.wikipedia.org/wiki/Immune_system) |
| [Saponins](http://en.wikipedia.org/wiki/Saponin) | [Beans](http://en.wikipedia.org/wiki/Bean), [cereals](http://en.wikipedia.org/wiki/Cereal), [herbs](http://en.wikipedia.org/wiki/Herbs) | [Hypercholesterolemia](http://en.wikipedia.org/wiki/Hypercholesterolemia), [Hyperglycemia](http://en.wikipedia.org/wiki/Hyperglycemia), [Antioxidant](http://en.wikipedia.org/wiki/Antioxidant), [cancer prevention](http://en.wikipedia.org/wiki/Cancer), [Anti-inflammatory](http://en.wikipedia.org/wiki/Anti-inflammatory) |
| [Capsaicinoids](http://en.wikipedia.org/wiki/Capsaicinoid) | [All *capiscum* (chile) peppers](http://en.wikipedia.org/wiki/Chile_pepper) | Topical [pain relief](http://en.wikipedia.org/wiki/Pain_relief), [cancer prevention](http://en.wikipedia.org/wiki/Cancer), cancer cell [apoptosis](http://en.wikipedia.org/wiki/Apoptosis) |

**Intestinal bacterial flora**

*Main article:* [*Gut flora*](http://en.wikipedia.org/wiki/Gut_flora)

It is now also known that animal [intestines](http://en.wikipedia.org/wiki/Intestine) contain a large population of [gut flora](http://en.wikipedia.org/wiki/Gut_flora). In humans, these include species such as [*Bacteroides*](http://en.wikipedia.org/wiki/Bacteroides), [*L. acidophilus*](http://en.wikipedia.org/wiki/L._acidophilus) and [*E. coli*](http://en.wikipedia.org/wiki/E._coli), among many others. They are essential to [digestion](http://en.wikipedia.org/wiki/Digestion), and are also affected by the food we eat. 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 B12](http://en.wikipedia.org/wiki/Vitamin_B12), and defending against some infectious diseases.

**Advice and guidance**

**Governmental policies**





The updated [USDA](http://en.wikipedia.org/wiki/United_States_Department_of_Agriculture) [food pyramid](http://en.wikipedia.org/wiki/MyPyramid), published in 2005, is a general nutrition guide for recommended [food](http://en.wikipedia.org/wiki/Food) consumption for [humans](http://en.wikipedia.org/wiki/Humans).

In the US, [dietitians](http://en.wikipedia.org/wiki/Dietitian) 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"](http://www.leginfo.ca.gov/cgi-bin/displaycode?section=bpc&group=02001-03000&file=2585-2586.8). <http://www.leginfo.ca.gov/cgi-bin/displaycode?section=bpc&group=02001-03000&file=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](http://en.wikipedia.org/wiki/Mandatory_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](http://en.wikipedia.org/wiki/USDA) and [US Department of Health and Human Services](http://en.wikipedia.org/wiki/United_States_Department_of_Health_and_Human_Services). Dietary and physical activity guidelines from the USDA are presented in the concept of a [food pyramid](http://en.wikipedia.org/wiki/MyPyramid), which superseded the [Four Food Groups](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/C-SPAN) as seen here.

The [U.S. Department of Health and Human Services](http://en.wikipedia.org/wiki/U.S._Department_of_Health_and_Human_Services) provides a sample week-long menu which fulfills the nutritional recommendations of the government.[[45]](http://en.wikipedia.org/wiki/Nutrition#cite_note-44) [Canada's Food Guide](http://en.wikipedia.org/wiki/Canada%27s_Food_Guide) is another governmental recommendation.

**Teaching**

Nutrition is [taught](http://en.wikipedia.org/wiki/Teaching) in schools in many countries. In [England and Wales](http://en.wikipedia.org/wiki/England_and_Wales) the [Personal and Social Education](http://en.wikipedia.org/wiki/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, healthy food choices and how to live a healthy life.

A 1985 US [National Research Council](http://en.wikipedia.org/wiki/United_States_National_Research_Council) report entitled *Nutrition Education in US Medical Schools* concluded that nutrition education in medical schools was inadequate.[[46]](http://en.wikipedia.org/wiki/Nutrition#cite_note-45) Only 20% of the schools surveyed taught nutrition as a separate, required course. A 2006 survey found that this number had risen to 30%.[[47]](http://en.wikipedia.org/wiki/Nutrition#cite_note-46)

**Healthy diets**

*Main article:* [*Healthy diet*](http://en.wikipedia.org/wiki/Healthy_diet)

**Whole plant food 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](http://en.wikipedia.org/wiki/The_China_Study) found some regions had essentially 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.[[48]](http://en.wikipedia.org/wiki/Nutrition#cite_note-Campbell-China-47) 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.[[48]](http://en.wikipedia.org/wiki/Nutrition#cite_note-Campbell-China-47) Some studies show these to be, in high quantities, possible causes of some cancers. There are [arguments](http://en.wikipedia.org/wiki/Veganism#Health_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*](http://en.wikipedia.org/wiki/National_Geographic_%28magazine%29) 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](http://en.wikipedia.org/wiki/Sardinia), [Okinawans](http://en.wikipedia.org/wiki/Okinawa), and [Adventists](http://en.wikipedia.org/wiki/Seventh-day_Adventist_Church), 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](http://en.wikipedia.org/wiki/NIH) funded study of 34,000 [Seventh-day Adventists](http://en.wikipedia.org/wiki/Seventh-Day_Adventist_Church) 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."

**The French "paradox"**

*Main article:* [*French paradox*](http://en.wikipedia.org/wiki/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[[49]](http://en.wikipedia.org/wiki/Nutrition#cite_note-48)
* Reduced consumption of processed carbohydrate and other junk foods.[[*citation needed*](http://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)]
* Regular consumption of [red wine](http://en.wikipedia.org/wiki/Red_wine).[[*citation needed*](http://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)]
* More active lifestyles involving plenty of daily exercise, especially walking; the French are much less dependent on cars than Americans are.[[*citation needed*](http://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)]
* Higher consumption of artificially produced trans-fats by Americans, which has been shown to have greater [lipoprotein](http://en.wikipedia.org/wiki/Lipoprotein) effects per gram than saturated fat.[[50]](http://en.wikipedia.org/wiki/Nutrition#cite_note-49)

However, statistics collected by the [World Health Organization](http://en.wikipedia.org/wiki/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.[[51]](http://en.wikipedia.org/wiki/Nutrition#cite_note-50)

**Sports nutrition**

*Main article:* [*Sports nutrition*](http://en.wikipedia.org/wiki/Sports_nutrition)

**Protein**





Protein milkshakes, made from protein powder (center) and milk (left), are a common [bodybuilding supplement](http://en.wikipedia.org/wiki/Bodybuilding_supplement).

Protein is an important component of every cell in the body. Hair and nails are mostly made of protein. The body uses protein to build and repair tissues. In addition, protein is used to make hormones and other chemicals in the body. Protein is also an important building block of bones, muscles, cartilage, skin, and blood.

The protein requirement for each individual differs, as do opinions about whether and to what extent physically active people require more protein. The 2005 [Recommended Dietary Allowances](http://en.wikipedia.org/wiki/Recommended_Dietary_Allowance) (RDA), aimed at the general healthy adult population, provide for an intake of 0.8 - 1 grams of protein per kilogram of body weight (according to the BMI formula), with the review panel stating that "no additional dietary protein is suggested for healthy adults undertaking resistance or endurance exercise".[[52]](http://en.wikipedia.org/wiki/Nutrition#cite_note-51) Conversely, [Di Pasquale](http://en.wikipedia.org/wiki/Mauro_Di_Pasquale) (2008), citing recent studies, recommends a minimum protein intake of 2.2 g/kg "for anyone involved in competitive or intense recreational sports who wants to maximize lean body mass but does not wish to gain weight".[[53]](http://en.wikipedia.org/wiki/Nutrition#cite_note-52)

**Water and salts**

Water is one of the most important nutrients in the sports diet. It helps eliminate food waste products in the body, regulates body temperature during activity and helps with digestion. Maintaining hydration during periods of physical exertion is key to peak performance. While drinking too much water during activities can lead to physical discomfort, dehydration in excess of 2% of body mass (by weight) markedly hinders athletic performance.[[54]](http://en.wikipedia.org/wiki/Nutrition#cite_note-53) Additional carbohydrates and protein before, during, and after exercise increase time to exhaustion as well as speed recovery. The amount of water needed is based on work performed, lean body mass, and environmental factors, especially ambient temperature and humidity. Maintaining the right amount is key.[*[vague](http://en.wikipedia.org/wiki/Wikipedia%3AVagueness%22%20%5Co%20%22Wikipedia%3AVagueness)*]

**Carbohydrates**

The main fuel used by the body during exercise is carbohydrates, which are stored in muscle as glycogen—a form of sugar. During exercise, muscle glycogen reserves can be used up, especially when activities last longer than 90 min.[[*citation needed*](http://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)] Because the amount of glycogen stored in the body is limited, it is important for athletes to replace glycogen by consuming a diet high in carbohydrates. Meeting energy needs can help improve performance during the sport, as well as improve overall strength and endurance.

There are different kinds of carbohydrates—simple or refined, and unrefined. A typical American consumes about 50% of their carbohydrates as simple sugars, which are added to foods as opposed to sugars that come naturally in fruits and vegetables. These simple sugars come in large amounts in sodas and fast food. Over the course of a year, the average American consumes 54 gallons of soft drinks, which contain the highest amount of added sugars.[[55]](http://en.wikipedia.org/wiki/Nutrition#cite_note-54) Even though carbohydrates are necessary for humans to function, they are not all equally healthful. When machinery has been used to remove bits of high fiber, the carbohydrates are refined. These are the carbohydrates found in white bread and fast food.[[56]](http://en.wikipedia.org/wiki/Nutrition#cite_note-55)

**Malnutrition**

*Main article:* [*Malnutrition*](http://en.wikipedia.org/wiki/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.

Although there are more organisms in the world who are malnourished due to insufficient consumption, increasingly more organisms suffer from excessive over-nutrition; 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](http://en.wikipedia.org/wiki/Nutritionism) is the view that excessive reliance on food science and the study of nutrition can, paradoxically, lead to poor nutrition and to ill health. It was originally credited to [Gyorgy Scrinis](http://en.wikipedia.org/w/index.php?title=Gyorgy_Scrinis&action=edit&redlink=1),[[57]](http://en.wikipedia.org/wiki/Nutrition%22%20%5Cl%20%22cite_note-56) and was popularized by [Michael Pollan](http://en.wikipedia.org/wiki/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.[[58]](http://en.wikipedia.org/wiki/Nutrition#cite_note-unhappy-57)[[59]](http://en.wikipedia.org/wiki/Nutrition#cite_note-58)

**Insufficient**

Under consumption generally refers to the long-term consumption of insufficient sustenance in relation to the [energy](http://en.wikipedia.org/wiki/Energy) that an organism expends or expels, leading to poor health.

**Excessive**

Over consumption generally 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](http://en.wikipedia.org/wiki/Obesity). It can cause excessive hair loss, brittle nails, and irregular premenstrual cycles for females

**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.

**Illnesses caused by improper nutrient consumption**

|  |  |  |
| --- | --- | --- |
| **Nutrients** | **Deficiency** | **Excess** |
| [**Macronutrients**](http://en.wikipedia.org/wiki/Macronutrients) |
| [Calories](http://en.wikipedia.org/wiki/Calories) | [Starvation](http://en.wikipedia.org/wiki/Starvation), [Marasmus](http://en.wikipedia.org/wiki/Marasmus) | [Obesity](http://en.wikipedia.org/wiki/Obesity), [diabetes mellitus](http://en.wikipedia.org/wiki/Diabetes_mellitus), [Cardiovascular disease](http://en.wikipedia.org/wiki/Cardiovascular_disease) |
| [Simple carbohydrates](http://en.wikipedia.org/wiki/Simple_carbohydrates) | none | [diabetes mellitus](http://en.wikipedia.org/wiki/Diabetes_mellitus), [Obesity](http://en.wikipedia.org/wiki/Obesity), [Cardiovascular disease](http://en.wikipedia.org/wiki/Cardiovascular_disease) |
| [Complex carbohydrates](http://en.wikipedia.org/wiki/Complex_carbohydrates) | micronutrient deficiency | [Obesity](http://en.wikipedia.org/wiki/Obesity), [Cardiovascular disease](http://en.wikipedia.org/wiki/Cardiovascular_disease) (high glycemic index foods) |
| [Protein](http://en.wikipedia.org/wiki/Protein) | [kwashiorkor](http://en.wikipedia.org/wiki/Kwashiorkor) | [Rabbit starvation](http://en.wikipedia.org/wiki/Rabbit_starvation), [Ketoacidosis](http://en.wikipedia.org/wiki/Ketoacidosis) (in diabetics) |
| [Saturated fat](http://en.wikipedia.org/wiki/Saturated_fat) | none | [Obesity](http://en.wikipedia.org/wiki/Obesity), [Cardiovascular Disease](http://en.wikipedia.org/wiki/Cardiovascular_Disease) |
| [Trans fat](http://en.wikipedia.org/wiki/Trans_fat) | none | [Obesity](http://en.wikipedia.org/wiki/Obesity), [Cardiovascular Disease](http://en.wikipedia.org/wiki/Cardiovascular_Disease) |
| [Unsaturated fat](http://en.wikipedia.org/wiki/Unsaturated_fat) | [fat-soluble](http://en.wikipedia.org/wiki/Fat-soluble) vitamin deficiency | [Obesity](http://en.wikipedia.org/wiki/Obesity), [Cardiovascular disease](http://en.wikipedia.org/wiki/Cardiovascular_disease) |
| [**Micronutrients**](http://en.wikipedia.org/wiki/Micronutrients) |
| [Vitamin A](http://en.wikipedia.org/wiki/Vitamin_A) | [Xerophthalmia](http://en.wikipedia.org/wiki/Xerophthalmia) and Night Blindness | [Hypervitaminosis A](http://en.wikipedia.org/wiki/Hypervitaminosis_A) (cirrhosis, hair loss) |
| [Vitamin B1](http://en.wikipedia.org/wiki/Thiamin) | [Beri-Beri](http://en.wikipedia.org/wiki/Beri-Beri) |  |
| [Vitamin B2](http://en.wikipedia.org/wiki/Riboflavin) | Skin and Corneal Lesions |  |
| [Niacin](http://en.wikipedia.org/wiki/Niacin) | [Pellagra](http://en.wikipedia.org/wiki/Pellagra) | [dyspepsia](http://en.wikipedia.org/wiki/Dyspepsia), [cardiac arrhythmias](http://en.wikipedia.org/wiki/Cardiac_arrhythmias), birth defects |
| [Vitamin B12](http://en.wikipedia.org/wiki/Vitamin_B12) | Pernicious Anemia |  |
| [Vitamin C](http://en.wikipedia.org/wiki/Vitamin_C) | [Scurvy](http://en.wikipedia.org/wiki/Scurvy) | [diarrhea](http://en.wikipedia.org/wiki/Diarrhea) causing [dehydration](http://en.wikipedia.org/wiki/Dehydration) |
| [Vitamin D](http://en.wikipedia.org/wiki/Vitamin_D) | [Rickets](http://en.wikipedia.org/wiki/Rickets) | [Hypervitaminosis D](http://en.wikipedia.org/wiki/Hypervitaminosis_D) (dehydration, vomiting, constipation) |
| [Vitamin E](http://en.wikipedia.org/wiki/Vitamin_E) | neurological disease | [Hypervitaminosis E](http://en.wikipedia.org/wiki/Hypervitaminosis_E) (anticoagulant: excessive bleeding) |
| [Vitamin K](http://en.wikipedia.org/wiki/Vitamin_K) | [Hemorrhage](http://en.wikipedia.org/wiki/Hemorrhage) |  |
| [Omega 3 Fats](http://en.wikipedia.org/wiki/Omega-3_fatty_acid) | [Cardiovascular Disease](http://en.wikipedia.org/wiki/Cardiovascular_Disease) | Bleeding, Hemorrhages, [Hemorrhagic stroke](http://en.wikipedia.org/wiki/Hemorrhagic_stroke), reduced glycemic control among diabetics |
| [Omega 6 Fats](http://en.wikipedia.org/wiki/Omega-6_fatty_acid) | none | [Cardiovascular Disease](http://en.wikipedia.org/wiki/Cardiovascular_Disease), [Cancer](http://en.wikipedia.org/wiki/Cancer) |
| [Cholesterol](http://en.wikipedia.org/wiki/Cholesterol) | none | [Cardiovascular Disease](http://en.wikipedia.org/wiki/Cardiovascular_Disease) |
| [**Macrominerals**](http://en.wikipedia.org/wiki/Macromineral) |
| [Calcium](http://en.wikipedia.org/wiki/Calcium) | [Osteoporosis](http://en.wikipedia.org/wiki/Osteoporosis), [tetany](http://en.wikipedia.org/wiki/Tetany_%28medical_sign%29), [carpopedal spasm](http://en.wikipedia.org/wiki/Carpopedal_spasm), [laryngospasm](http://en.wikipedia.org/wiki/Laryngospasm), [cardiac arrhythmias](http://en.wikipedia.org/wiki/Cardiac_arrhythmia) | [Fatigue](http://en.wikipedia.org/wiki/Fatigue_%28physical%29), [depression](http://en.wikipedia.org/wiki/Clinical_depression), [confusion](http://en.wikipedia.org/wiki/Confusion), [nausea](http://en.wikipedia.org/wiki/Nausea), [vomiting](http://en.wikipedia.org/wiki/Vomiting), [constipation](http://en.wikipedia.org/wiki/Constipation), [pancreatitis](http://en.wikipedia.org/wiki/Pancreatitis), [increased urination](http://en.wikipedia.org/wiki/Polyuria), [kidney stones](http://en.wikipedia.org/wiki/Kidney_stones) |
| [Magnesium](http://en.wikipedia.org/wiki/Magnesium) | [Hypertension](http://en.wikipedia.org/wiki/Hypertension) | Weakness, nausea, vomiting, impaired breathing, and [hypotension](http://en.wikipedia.org/wiki/Hypotension) |
| [Potassium](http://en.wikipedia.org/wiki/Potassium) | [Hypokalemia](http://en.wikipedia.org/wiki/Hypokalemia), [cardiac arrhythmias](http://en.wikipedia.org/wiki/Cardiac_arrhythmia) | [Hyperkalemia](http://en.wikipedia.org/wiki/Hyperkalemia), [palpitations](http://en.wikipedia.org/wiki/Palpitations) |
| [Sodium](http://en.wikipedia.org/wiki/Sodium) | [hyponatremia](http://en.wikipedia.org/wiki/Hyponatremia) | [Hypernatremia](http://en.wikipedia.org/wiki/Hypernatremia), [hypertension](http://en.wikipedia.org/wiki/Hypertension) |
| [**Trace minerals**](http://en.wikipedia.org/wiki/Trace_minerals) |
| [Iron](http://en.wikipedia.org/wiki/Iron) | [Anemia](http://en.wikipedia.org/wiki/Anemia) | [Cirrhosis](http://en.wikipedia.org/wiki/Cirrhosis), [Hepatitis C](http://en.wikipedia.org/wiki/Hepatitis_C), [heart disease](http://en.wikipedia.org/wiki/Heart_disease) |
| [Iodine](http://en.wikipedia.org/wiki/Iodine) | [Goiter](http://en.wikipedia.org/wiki/Goiter), [hypothyroidism](http://en.wikipedia.org/wiki/Hypothyroidism) | [Iodine Toxicity](http://en.wikipedia.org/wiki/Iodine#Toxicity) (goiter, hypothyroidism) |

**Mental agility**

*Main article:* [*Nootropic*](http://en.wikipedia.org/wiki/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, potentially increasing a student's potential 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.[[60]](http://en.wikipedia.org/wiki/Nutrition#cite_note-59) Currently, less than 10% of American college students report that they eat the recommended five servings of fruit and vegetables daily.[[61]](http://en.wikipedia.org/wiki/Nutrition#cite_note-ACHA-p195-60) 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.[[62]](http://en.wikipedia.org/wiki/Nutrition#cite_note-61) In another study, those who consumed yogurt performed better on thinking tasks when compared to those who consumed caffeine free diet soda or confections.[[63]](http://en.wikipedia.org/wiki/Nutrition#cite_note-62) Nutritional deficiencies have been shown to have a negative effect on learning behavior in mice as far back as 1951.[[64]](http://en.wikipedia.org/wiki/Nutrition#cite_note-63)

"Better learning performance is associated with diet induced effects on learning and memory ability".[[65]](http://en.wikipedia.org/wiki/Nutrition#cite_note-64)

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."[[66]](http://en.wikipedia.org/wiki/Nutrition#cite_note-65)

91% of college students feel that they are in good health while only 7% eat their recommended daily allowance of fruits and vegetables.[[61]](http://en.wikipedia.org/wiki/Nutrition#cite_note-ACHA-p195-60)

Nutritional education is an effective and workable model in a higher education setting.[[67]](http://en.wikipedia.org/wiki/Nutrition#cite_note-66)[[68]](http://en.wikipedia.org/wiki/Nutrition#cite_note-67)

More "engaged" learning models that encompass nutrition is an idea that is picking up steam at all levels of the learning cycle.[[69]](http://en.wikipedia.org/wiki/Nutrition#cite_note-68)

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](http://en.wikipedia.org/wiki/Correlation_fallacy).

**Mental disorders**

Nutritional supplement treatment may be appropriate for major [depression](http://en.wikipedia.org/wiki/Clinical_depression), [bipolar disorder](http://en.wikipedia.org/wiki/Bipolar_disorder), [schizophrenia](http://en.wikipedia.org/wiki/Schizophrenia), and [obsessive compulsive disorder](http://en.wikipedia.org/wiki/Obsessive_compulsive_disorder), the four most common mental disorders in developed countries.[[70]](http://en.wikipedia.org/wiki/Nutrition#cite_note-69) Supplements that have been studied most for mood elevation and stabilization include [eicosapentaenoic acid](http://en.wikipedia.org/wiki/Eicosapentaenoic_acid) and [docosahexaenoic acid](http://en.wikipedia.org/wiki/Docosahexaenoic_acid) (each of which are an [omega-3 fatty acid](http://en.wikipedia.org/wiki/Omega-3_fatty_acid) contained in [fish oil](http://en.wikipedia.org/wiki/Fish_oil), but not in [flaxseed oil](http://en.wikipedia.org/wiki/Flaxseed_oil)), [vitamin B12](http://en.wikipedia.org/wiki/Vitamin_B12), [folic acid](http://en.wikipedia.org/wiki/Folic_acid), and [inositol](http://en.wikipedia.org/wiki/Inositol).

**Cancer**

Cancer is now common in developing countries. According to a study by the [International Agency for Research on Cancer](http://en.wikipedia.org/wiki/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."[[71]](http://en.wikipedia.org/wiki/Nutrition%22%20%5Cl%20%22cite_note-70)

**Metabolic syndrome**

Several lines of evidence indicate lifestyle-induced [hyperinsulinemia](http://en.wikipedia.org/wiki/Hyperinsulinemia) and reduced insulin function (i.e. [insulin resistance](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Clot) formation (i.e. heart disease) and exaggerated cell division (i.e. cancer). Hyperinsulinemia and insulin resistance (the so-called [metabolic syndrome](http://en.wikipedia.org/wiki/Metabolic_syndrome)) are characterized by a combination of abdominal [obesity](http://en.wikipedia.org/wiki/Obesity), elevated [blood sugar](http://en.wikipedia.org/wiki/Blood_sugar), elevated [blood pressure](http://en.wikipedia.org/wiki/Blood_pressure), elevated blood [triglycerides](http://en.wikipedia.org/wiki/Triglycerides), and reduced HDL [cholesterol](http://en.wikipedia.org/wiki/Cholesterol). The negative impact of hyperinsulinemia on prostaglandin PGE1/PGE2 balance may be significant.

The state of [obesity](http://en.wikipedia.org/wiki/Obesity) clearly contributes to insulin resistance, which in turn can cause [type 2 diabetes](http://en.wikipedia.org/wiki/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. Importantly, it has been demonstrated that appropriate exercise, more regular food intake and reducing [glycemic load](http://en.wikipedia.org/wiki/Glycemic_load) (see below) all can reverse insulin resistance in overweight individuals (and thereby lower blood sugar levels in those who have type 2 diabetes).

Obesity can unfavourably alter hormonal and metabolic status via resistance to the hormone [leptin](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/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 potentially overwhelm the environment's ability to maintain [homeostasis](http://en.wikipedia.org/wiki/Homeostasis), the recent explosive introduction of high [glycemic index](http://en.wikipedia.org/wiki/Glycemic_index) and processed foods into the human diet may potentially overwhelm the body's ability to maintain homeostasis and health (as evidenced by the metabolic syndrome epidemic).

**Hyponatremia**

Excess water intake, without replenishment of sodium and potassium salts, leads to [hyponatremia](http://en.wikipedia.org/wiki/Hyponatremia), which can further lead to [water intoxication](http://en.wikipedia.org/wiki/Water_intoxication) at more dangerous levels. A well-publicized case occurred in 2007, when [Jennifer Strange](http://en.wikipedia.org/wiki/KDND) died while participating in a water-drinking contest.[[72]](http://en.wikipedia.org/wiki/Nutrition#cite_note-71) More usually, the condition occurs in long-distance endurance events (such as [marathon](http://en.wikipedia.org/wiki/Marathon) or [triathlon](http://en.wikipedia.org/wiki/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.

**Antinutrient**

*Main article:* [*Antinutrient*](http://en.wikipedia.org/wiki/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.

**Processed foods**

*Main article:* [*Food processing*](http://en.wikipedia.org/wiki/Food_processing)

Since the [Industrial Revolution](http://en.wikipedia.org/wiki/Industrial_Revolution) some two hundred years ago, the food processing industry has invented many [technologies](http://en.wikipedia.org/wiki/Technology) 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](http://en.wikipedia.org/wiki/Pasteurisation), [autoclavation](http://en.wikipedia.org/wiki/Autoclavation), [drying](http://en.wikipedia.org/wiki/Drying), [salting](http://en.wikipedia.org/wiki/Salting_%28food%29), and separation of various components, all of which appear 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 undoubtedly have downfalls as well.

Modern separation techniques such as [milling](http://en.wikipedia.org/wiki/Gristmill), [centrifugation](http://en.wikipedia.org/wiki/Centrifugation), and [pressing](http://en.wikipedia.org/wiki/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.[[73]](http://en.wikipedia.org/wiki/Nutrition#cite_note-72) 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](http://en.wikipedia.org/wiki/Potassium)/[sodium](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Beri-beri) in people subsisting on polished rice. Removing the outer layer of rice by polishing it removes with it the essential vitamin [thiamine](http://en.wikipedia.org/wiki/Thiamine), causing beri-beri. Another example is the development of [scurvy](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Louis_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.

**History**

Humans have evolved as [omnivorous](http://en.wikipedia.org/wiki/Omnivore) [hunter-gatherers](http://en.wikipedia.org/wiki/Hunter-gatherer) over the past 250,000 years. The diet of early modern humans varied significantly depending on location and climate. The diet in the tropics tended to be based more heavily on plant foods, while the diet at higher latitudes tended more towards animal products. Analysis of postcranial and cranial remains of humans and animals from the Neolithic, along with detailed bone modification studies have shown that cannibalism was also prevalent among prehistoric humans.[[74]](http://en.wikipedia.org/wiki/Nutrition#cite_note-73)

[Agriculture](http://en.wikipedia.org/wiki/Agriculture) developed about 10,000 years ago in multiple locations throughout the world, providing grains such as [wheat](http://en.wikipedia.org/wiki/Wheat), [rice](http://en.wikipedia.org/wiki/Rice), [potatoes](http://en.wikipedia.org/wiki/Potatoes), and [maize](http://en.wikipedia.org/wiki/Maize), with staples such as [bread](http://en.wikipedia.org/wiki/Bread), [pasta](http://en.wikipedia.org/wiki/Pasta), and [tortillas](http://en.wikipedia.org/wiki/Tortillas). Farming also provided milk and dairy products, and sharply increased the availability of meats and the diversity of vegetables. The importance of food purity was recognized when bulk storage led to infestation and contamination risks. [Cooking](http://en.wikipedia.org/wiki/Cooking) developed as an often ritualistic activity, due to efficiency and reliability concerns requiring adherence to strict recipes and procedures, and in response to demands for food purity and consistency.[[75]](http://en.wikipedia.org/wiki/Nutrition#cite_note-history-74)

**From antiquity to 1900**

The first recorded nutritional experiment is found in the Bible's [Book of Daniel](http://en.wikipedia.org/wiki/Book_of_Daniel). Daniel and his friends were captured by the king of [Babylon](http://en.wikipedia.org/wiki/Babylon) during an invasion of Israel. Selected as court servants, they were to share in the king's fine foods and wine. But they objected, preferring vegetables ([pulses](http://en.wikipedia.org/wiki/Pulse_%28legume%29)) and water in accordance with their [Jewish](http://en.wikipedia.org/wiki/Jewish) dietary restrictions. The king's chief steward reluctantly agreed to a trial. Daniel and his friends received their diet for 10 days and were then compared to the king's men. Appearing healthier, they were allowed to continue with their diet.[[76]](http://en.wikipedia.org/wiki/Nutrition#cite_note-75)





Anaxagoras

Around 475 BC, [Anaxagoras](http://en.wikipedia.org/wiki/Anaxagoras) stated that food is absorbed by the human body and therefore contained "homeomerics" (generative components), suggesting the existence of nutrients.[[75]](http://en.wikipedia.org/wiki/Nutrition#cite_note-history-74) Around 400 BC, [Hippocrates](http://en.wikipedia.org/wiki/Hippocrates) said, "Let food be your medicine and medicine be your food."[[77]](http://en.wikipedia.org/wiki/Nutrition#cite_note-Smith-76)

In the 16th century, scientist and artist [Leonardo da Vinci](http://en.wikipedia.org/wiki/Leonardo_da_Vinci) compared [metabolism](http://en.wikipedia.org/wiki/Metabolism) to a burning candle. In 1747, Dr. [James Lind](http://en.wikipedia.org/wiki/James_Lind), a physician in the British navy, performed the first [scientific](http://en.wikipedia.org/wiki/Science) nutrition experiment, discovering that [lime](http://en.wikipedia.org/wiki/Lime_%28fruit%29) juice saved sailors who had been at sea for years from [scurvy](http://en.wikipedia.org/wiki/Scurvy), a deadly and painful bleeding disorder. The discovery was ignored for forty years, after which British sailors became known as "limeys." The essential [vitamin C](http://en.wikipedia.org/wiki/Vitamin_C) within lime juice would not be identified by scientists until the 1930s.

Around 1770, [Antoine Lavoisier](http://en.wikipedia.org/wiki/Antoine_Lavoisier), the "Father of Nutrition and Chemistry" discovered the details of metabolism, demonstrating that the [oxidation](http://en.wikipedia.org/wiki/Oxidation) of food is the source of body heat. In 1790, [George Fordyce](http://en.wikipedia.org/wiki/George_Fordyce) recognized [calcium](http://en.wikipedia.org/wiki/Calcium) as necessary for fowl survival. In the early 19th century, the elements [carbon](http://en.wikipedia.org/wiki/Carbon), [nitrogen](http://en.wikipedia.org/wiki/Nitrogen), [hydrogen](http://en.wikipedia.org/wiki/Hydrogen) and [oxygen](http://en.wikipedia.org/wiki/Oxygen) were recognized as the primary components of food, and methods to measure their proportions were developed.

In 1816, [François Magendie](http://en.wikipedia.org/wiki/Fran%C3%A7ois_Magendie) discovered that dogs fed only [carbohydrates](http://en.wikipedia.org/wiki/Carbohydrates) and [fat](http://en.wikipedia.org/wiki/Fat) lost their body [protein](http://en.wikipedia.org/wiki/Protein) and died in a few weeks, but dogs also fed protein survived, identifying protein as an essential dietary component. In 1840, [Justus Liebig](http://en.wikipedia.org/wiki/Justus_Liebig) discovered the chemical makeup of carbohydrates ([sugars](http://en.wikipedia.org/wiki/Sugar)), fats ([fatty acids](http://en.wikipedia.org/wiki/Fatty_acid)) and proteins ([amino acids](http://en.wikipedia.org/wiki/Amino_acid).) In the 1860s, [Claude Bernard](http://en.wikipedia.org/wiki/Claude_Bernard) discovered that body fat can be synthesized from carbohydrate and protein, showing that the energy in blood [glucose](http://en.wikipedia.org/wiki/Glucose) can be stored as fat or as [glycogen](http://en.wikipedia.org/wiki/Glycogen).

In the early 1880s, [Kanehiro Takaki](http://en.wikipedia.org/wiki/Kanehiro_Takaki) observed that Japanese sailors (whose diets consisted almost entirely of white rice) developed [beriberi](http://en.wikipedia.org/wiki/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.

In 1896, Eugen Baumann observed [iodine](http://en.wikipedia.org/wiki/Iodine) in thyroid glands. In 1897, [Christiaan Eijkman](http://en.wikipedia.org/wiki/Christiaan_Eijkman) worked with natives of [Java](http://en.wikipedia.org/wiki/Java_%28island%29), 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](http://en.wikipedia.org/wiki/Thiamine).

**From 1900 to the present**

In the early 20th century, [Carl Von Voit](http://en.wikipedia.org/w/index.php?title=Carl_Von_Voit&action=edit&redlink=1) and [Max Rubner](http://en.wikipedia.org/wiki/Max_Rubner) independently measured [caloric](http://en.wikipedia.org/wiki/Calorie) energy expenditure in different species of animals, applying principles of physics in nutrition. In 1906, Wilcock and Hopkins showed that the amino acid [tryptophan](http://en.wikipedia.org/wiki/Tryptophan) was necessary for the survival of rats. He fed them a special mixture of food containing all the nutrients he believed were essential for survival, but the rats died. A second group of rats were fed an amount of milk containing [vitamins](http://en.wikipedia.org/wiki/Vitamins).[[78]](http://en.wikipedia.org/wiki/Nutrition#cite_note-77) [Gowland Hopkins](http://en.wikipedia.org/wiki/Gowland_Hopkins) recognized "accessory food factors" other than calories, protein and [minerals](http://en.wikipedia.org/wiki/Dietary_mineral), as [organic](http://en.wikipedia.org/wiki/Organic_compound) materials essential to health, but which the body cannot synthesize. In 1907, [Stephen M. Babcock](http://en.wikipedia.org/wiki/Stephen_M._Babcock) and [Edwin B. Hart](http://en.wikipedia.org/wiki/Edwin_B._Hart) conducted the [single-grain experiment](http://en.wikipedia.org/wiki/Single-grain_experiment), which took nearly four years to complete.

In 1912, [Casimir Funk](http://en.wikipedia.org/wiki/Casimir_Funk) coined the term [vitamin](http://en.wikipedia.org/wiki/Vitamin), a vital factor in the diet, from the words "vital" and "amine," because these unknown substances preventing scurvy, beriberi, and [pellagra](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Elmer_McCollum) discovered the first vitamins, fat soluble [vitamin A](http://en.wikipedia.org/wiki/Vitamin_A), and water soluble [vitamin B](http://en.wikipedia.org/wiki/Vitamin_B) (in 1915; now known to be a complex of several water-soluble vitamins) and named [vitamin C](http://en.wikipedia.org/wiki/Vitamin_C) as the then-unknown substance preventing scurvy. [Lafayette Mendel](http://en.wikipedia.org/wiki/Lafayette_Mendel) and Thomas Osborne also performed pioneering work on vitamins A and B. In 1919, Sir [Edward Mellanby](http://en.wikipedia.org/wiki/Edward_Mellanby) incorrectly identified [rickets](http://en.wikipedia.org/wiki/Rickets) as a vitamin A deficiency because he could cure it in dogs with cod liver oil.[[79]](http://en.wikipedia.org/wiki/Nutrition#cite_note-78) 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](http://en.wikipedia.org/wiki/Tocopherol) as essential for rat pregnancy, originally calling it "food factor X" until 1925.

In 1925, Hart discovered that trace amounts of [copper](http://en.wikipedia.org/wiki/Copper) are necessary for [iron](http://en.wikipedia.org/wiki/Iron) absorption. In 1927, [Adolf Otto Reinhold Windaus](http://en.wikipedia.org/wiki/Adolf_Otto_Reinhold_Windaus) synthesized vitamin D, for which he won the [Nobel Prize](http://en.wikipedia.org/wiki/Nobel_Prize) in Chemistry in 1928. In 1928, [Albert Szent-Györgyi](http://en.wikipedia.org/wiki/Albert_Szent-Gy%C3%B6rgyi) isolated [ascorbic acid](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Citric_acid_cycle).

In the 1930s, [William Cumming Rose](http://en.wikipedia.org/wiki/William_Cumming_Rose) identified [essential amino acids](http://en.wikipedia.org/wiki/Essential_amino_acid), necessary protein components which the body cannot synthesize. In 1935, Underwood and Marston independently discovered the necessity of [cobalt](http://en.wikipedia.org/wiki/Cobalt). In 1936, [Eugene Floyd Dubois](http://en.wikipedia.org/w/index.php?title=Eugene_Floyd_Dubois&action=edit&redlink=1) showed that work and school performance are related to caloric intake. In 1938, [Erhard Fernholz](http://en.wikipedia.org/w/index.php?title=Erhard_Fernholz&action=edit&redlink=1) discovered the chemical structure of vitamin E. It was synthesised by [Paul Karrer](http://en.wikipedia.org/wiki/Paul_Karrer).

In 1940, [rationing in the United Kingdom during and after World War II](http://en.wikipedia.org/wiki/Rationing_in_the_United_Kingdom_during_and_after_World_War_II) took place according to nutritional principles drawn up by [Elsie Widdowson](http://en.wikipedia.org/wiki/Elsie_Widdowson) and others. In 1941, the first [Recommended Dietary Allowances](http://en.wikipedia.org/wiki/Recommended_Dietary_Allowance) (RDAs) were established by the [National Research Council](http://en.wikipedia.org/wiki/United_States_National_Research_Council).

In 1992, The U.S. Department of Agriculture introduced the [Food Guide Pyramid](http://en.wikipedia.org/wiki/Food_Guide_Pyramid). In 2002, a [Natural Justice](http://en.wikipedia.org/wiki/Natural_Justice) study showed a relation between nutrition and violent behavior. In 2005, a study found that obesity may be caused by [adenovirus](http://en.wikipedia.org/wiki/Adenovirus) in addition to bad nutrition.[[80]](http://en.wikipedia.org/wiki/Nutrition#cite_note-79)

**Plant nutrition**

*Main article:* [*Plant nutrition*](http://en.wikipedia.org/wiki/Plant_nutrition)

Plant nutrition is the study of the [chemical elements](http://en.wikipedia.org/wiki/Chemical_element) that are necessary for plant growth. There are several principles that apply to plant nutrition. Some elements are directly involved in plant [metabolism](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Liebig%27s_law_of_the_minimum), is considered an essential plant nutrient if the plant cannot complete its full life cycle without it. There are 17 essential plant nutrients.

Macronutrients:

* N = [Nitrogen](http://en.wikipedia.org/wiki/Nitrogen)
* P = [Phosphorus](http://en.wikipedia.org/wiki/Phosphorus)
* K = [Potassium](http://en.wikipedia.org/wiki/Potassium)
* Ca = [Calcium](http://en.wikipedia.org/wiki/Calcium)
* Mg = [Magnesium](http://en.wikipedia.org/wiki/Magnesium)
* S = [Sulfur](http://en.wikipedia.org/wiki/Sulfur)
* Si = [Silicon](http://en.wikipedia.org/wiki/Silicon)

Micronutrients (trace levels) include:

* Cl = [Chlorine](http://en.wikipedia.org/wiki/Chlorine)
* Fe = [Iron](http://en.wikipedia.org/wiki/Iron)
* B = [Boron](http://en.wikipedia.org/wiki/Boron)
* Mn = [Manganese](http://en.wikipedia.org/wiki/Manganese)
* Na = [Sodium](http://en.wikipedia.org/wiki/Sodium)
* Zn = [Zinc](http://en.wikipedia.org/wiki/Zinc)
* Cu = [Copper](http://en.wikipedia.org/wiki/Copper)
* Ni= [Nickel](http://en.wikipedia.org/wiki/Nickel)
* Mo = [Molybdenum](http://en.wikipedia.org/wiki/Molybdenum)

**Macronutrients**

**Calcium**

Calcium regulates transport of other nutrients into the plant and is also involved in the activation of certain plant enzymes. [Calcium deficiency](http://en.wikipedia.org/wiki/Calcium_deficiency_%28plant_disorder%29) results in stunting.

**Nitrogen**

Nitrogen is an essential component of all proteins. [Nitrogen deficiency](http://en.wikipedia.org/wiki/Nitrogen_deficiency) most often results in stunted growth.

**Phosphorus**

Phosphorus is important in plant [bioenergetics](http://en.wikipedia.org/wiki/Biological_thermodynamics). As a component of [ATP](http://en.wikipedia.org/wiki/Adenosine_triphosphate), phosphorus is needed for the conversion of light energy to chemical energy (ATP) during photosynthesis. Phosphorus can also be used to modify the activity of various enzymes by [phosphorylation](http://en.wikipedia.org/wiki/Phosphorylation), and can be used for [cell signaling](http://en.wikipedia.org/wiki/Cell_signaling). Since ATP can be used for the [biosynthesis](http://en.wikipedia.org/wiki/Biosynthesis) of many plant [biomolecules](http://en.wikipedia.org/wiki/Biomolecule), phosphorus is important for plant growth and [flower](http://en.wikipedia.org/wiki/Flower)/[seed](http://en.wikipedia.org/wiki/Seed) formation.

**Potassium**

Potassium regulates the opening and closing of the [stoma](http://en.wikipedia.org/wiki/Stomata) by a potassium ion pump. Since stomata are important in water regulation, potassium reduces water loss from the leaves and increases [drought](http://en.wikipedia.org/wiki/Drought) tolerance. [Potassium deficiency](http://en.wikipedia.org/wiki/Potassium_deficiency_%28plants%29) may cause necrosis or interveinal chlorosis.

**Silicon**

Silicon is deposited in [cell walls](http://en.wikipedia.org/wiki/Cell_wall) and contributes to its mechanical properties including [rigidity](http://en.wikipedia.org/wiki/Stiffness) and [elasticity](http://en.wikipedia.org/wiki/Elasticity_%28physics%29)

**Micronutrients**

**Boron**

Boron is important in sugar transport, [cell division](http://en.wikipedia.org/wiki/Cell_division), and synthesizing certain enzymes. [Boron deficiency](http://en.wikipedia.org/wiki/Boron_deficiency_%28plant_disorder%29) causes necrosis in young leaves and stunting.

**Copper**

Copper is important for photosynthesis. Symptoms for copper deficiency include chlorosis. Involved in many enzyme processes. Necessary for proper photosythesis. Involved in the manufacture of lignin (cell walls). Involved in grain production.

**Chlorine**

Chlorine is necessary for [osmosis](http://en.wikipedia.org/wiki/Osmosis) and [ionic balance](http://en.wikipedia.org/w/index.php?title=Ionic_balance&action=edit&redlink=1); it also plays a role in [photosynthesis](http://en.wikipedia.org/wiki/Photosynthesis).

**Iron**

Iron is necessary for photosynthesis and is present as an enzyme cofactor in plants. [Iron deficiency](http://en.wikipedia.org/wiki/Iron_deficiency_%28plant_disorder%29) can result in interveinal [chlorosis](http://en.wikipedia.org/wiki/Chlorosis) and [necrosis](http://en.wikipedia.org/wiki/Necrosis).

**Manganese**

Manganese is necessary for building the [chloroplasts](http://en.wikipedia.org/wiki/Chloroplast). [Manganese deficiency](http://en.wikipedia.org/wiki/Manganese_deficiency_%28plant%29) may result in coloration abnormalities, such as discolored spots on the [foliage](http://en.wikipedia.org/wiki/Foliage).

**Molybdenum**

Molybdenum is a cofactor to enzymes important in building amino acids.

**Nickel**

In [higher plants](http://en.wikipedia.org/wiki/Vascular_plant), Nickel is essential for activation of [urease](http://en.wikipedia.org/wiki/Urease), an enzyme involved with [nitrogen metabolism](http://en.wikipedia.org/wiki/Nitrogen_metabolism) that is required to process urea. Without Nickel, toxic levels of urea accumulate, leading to the formation of necrotic lesions. In [lower plants](http://en.wikipedia.org/wiki/Lower_plants), Nickel activates several enzymes involved in a variety of processes, and can substitute for Zinc and Iron as a cofactor in some enzymes.[*[citation needed](http://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed%22%20%5Co%20%22Wikipedia%3ACitation%20needed)*]

**Sodium**

Sodium is involved in the regeneration of [phosphoenolpyruvate](http://en.wikipedia.org/wiki/Phosphoenolpyruvate) in [CAM](http://en.wikipedia.org/wiki/Crassulacean_acid_metabolism) and [C4](http://en.wikipedia.org/wiki/C4_carbon_fixation) plants. It can also substitute for potassium in some circumstances.

**Zinc**

Zinc is required in a large number of enzymes and plays an essential role in [DNA transcription](http://en.wikipedia.org/wiki/DNA_transcription). A typical symptom of zinc deficiency is the stunted growth of leaves, commonly known as "little leaf" and is caused by the oxidative degradation of the growth hormone [auxin](http://en.wikipedia.org/wiki/Auxin).

**Processes**

Plants uptake essential elements from the [soil](http://en.wikipedia.org/wiki/Soil) through their [roots](http://en.wikipedia.org/wiki/Root) and from the air (mainly consisting of nitrogen and oxygen) through their [leaves](http://en.wikipedia.org/wiki/Leaves). Nutrient uptake in the soil is achieved by [cation exchange](http://en.wikipedia.org/wiki/Cation_exchange), wherein [root hairs](http://en.wikipedia.org/wiki/Root_hairs) pump [hydrogen](http://en.wikipedia.org/wiki/Hydrogen) [ions](http://en.wikipedia.org/wiki/Ions) (H+) into the soil through [proton pumps](http://en.wikipedia.org/wiki/Proton_pumps). These hydrogen ions displace [cations](http://en.wikipedia.org/wiki/Cations) attached to negatively charged soil particles so that the cations are available for uptake by the root. In the leaves, [stomata](http://en.wikipedia.org/wiki/Stomata) open to take in carbon dioxide and expel [oxygen](http://en.wikipedia.org/wiki/Oxygen). The carbon dioxide molecules are used as the carbon source in photosynthesis.

Although [nitrogen](http://en.wikipedia.org/wiki/Nitrogen) is plentiful in the Earth's atmosphere, relatively few plants engage in [nitrogen fixation](http://en.wikipedia.org/wiki/Nitrogen_fixation) (conversion of atmospheric nitrogen to a biologically useful form). Most plants therefore require nitrogen compounds to be present in the soil in which they grow.

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](http://en.wikipedia.org/wiki/Cloning). 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.

Carbon and oxygen are absorbed from the air, while other nutrients are absorbed from the soil. Green plants obtain their carbohydrate supply from the carbon dioxide in the air by the process of [photosynthesis](http://en.wikipedia.org/wiki/Photosynthesis).