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Understanding Nutrition

The National Institute of Health defines nutrition as "the field of study focusing on foods and substances in foods that help animals (and plants) to grow and stay healthy." Nutrition is the science that looks at the components of food and how they affect our bodies. It also defines the quality of food and determines which foods are better for us while at the same time identifying foods or components of food that are harmful to us.

We talk a lot about food, but it is important to understand that a food item is a collection of chemicals and each of these chemicals reacts differently in our bodies. Nutrition is really the study of chemicals found in food and their effect on our bodies.

To simplify discussions, nutritionists have categorized these chemicals into several main groups, including protein, carbohydrates, fiber, fats, minerals, vitamins, and water. Except for water, each group consists of many different compounds and each of these compounds is a nutrient for our bodies. For example, vitamin C is a nutrient in the vitamin group. Sucrose is a nutrient in the carbohydrate group.

These nutrients are not isolated compounds. Many react with each other, forming a complex system. Calcium is an interesting example in this regard. It is an important nutrient for us, but there is a difference between the amount in food and the amount that is available to us, something we call bioavailability.

In plants, calcium combines with other molecules such as phytate, fiber, proteins, fatty acids, and oxalate. You might recognize

oxalate as oxalic acid, the toxic substance in rhubarb leaves. When calcium binds with oxalic acid to form calcium oxalate, the calcium is no longer bioavailable in our gut. Our bodies can't digest it. So even if a plant has high levels of calcium oxalate, our bodies get no nutritional value from it.

Phytate is an antioxidant molecule that is called an "antinutrient" because it binds with calcium and makes it biounavailable to us. Unrefined cereals and legumes contain the highest concentrations of phytate. Eating a lot of these foods will reduce the calcium you absorb during digestion.

When I was growing up spinach was called a "superfood" because it contained high amounts of iron, which is the nutrient that gave Popeye his super-human strength. It turns out that spinach does contain a fair amount of iron, but it is not super high. Iron is another nutrient that binds with oxalic acid, and our bodies can only absorb about 2 percent of the iron found in spinach.

Here are some things you can do to make food more bioavailable:

- chop or mince food that has a rigid structure like leaves and stems
- soak grains in water and discard the water (phytate is water-soluble)
- cook foods like beans to reduce polyphenols
- balance raw and cooked foods to maximize the absorption of micronutrients
- eat citrus foods high in vitamin C along with iron-containing foods

Human Nutrients vs Plant Nutrients

Gardeners routinely talk about plant nutrients, and these include things like nitrate, phosphate, iron, and zinc. These are all small molecules that are able to enter a plant through the root system. Plants are also able to absorb molecules that are slightly larger, including things such as glucose and amino acids.

What happens when a large protein nutrient is given to a plant? Nothing. Proteins are just too big to get through the wall of a root.

Plants have to wait until microbes break up the protein, first into amino acids and finally into small molecules such as nitrate and sulfur. It is only then that plants are able to use the protein as food. Because plants can't use proteins directly, proteins are not plant nutrients. Only nitrate is a plant nutrient.

Humans and other animals process food differently. We can take a big bite out of a chicken leg and chew it up along with saliva, which starts the digestion process. The stomach then adds digestive juices containing hydrochloric acid and the enzyme pepsin, which starts breaking down the protein. The protein molecule is slowly broken down into smaller and smaller pieces. The resulting mixture in the stomach is called chyme.

The digestion of protein in the stomach takes longer than the digestion of carbohydrates, but not as long as the digestion of fats. This explains why a high protein meal makes you feel full longer.

The chyme now passes into the small intestine where the majority of the protein will be digested. The pancreas secretes more enzymes (chymotrypsin and trypsin) into the mix to further break down the protein fragments. The lining of the small intestine adds even more enzymes that finally break the protein down into amino acids, which are then absorbed into the blood. Our bodies can use amino acids as building blocks to make new proteins.

When we are talking about animals, the term nutrient includes many larger molecules that the digestive system can absorb. In terms of human nutrition, all usable food molecules are nutrients.

Nutrients vs Calories

Nutrients are molecules the body needs to survive. Calories is a measure of the amount of energy stored in those molecules. Our bodies need energy to function, stay warm, and carry out all chemical reactions. If you need 2,400 calories a day, you can get this by eating a wide variety of food including candy, chicken, and vegetables. The right amount of each of these foods will give you the right amount of calories, but each food item supplies different types of nutrients.

Counting calories is not a good way to evaluate a diet. It is actually better to eat more calories of healthy food than fewer calories of less healthy food. Eating more calories than you need increases body weight. A gram of fat contains nearly twice as many calories as a gram of carbohydrate or protein.

Nutrients in Food

Proteins

Proteins are large complex molecules that do most of the work in cells. We know them under different names including enzymes, antibodies, transporters, and messengers. Antibodies bind to specific foreign particles such as viruses and bacteria, and protect us from them. Enzymes carry out most of the chemical reactions in a cell. Messenger proteins can function as hormones to coordinate biological functions, thereby controlling things such as growth. Structural proteins are key components of cell walls, and on a larger scale they provide structure to muscles. Transport proteins move specific molecules across cell membranes, allowing our digestive systems—and plant roots—to absorb nutrients.

Each type of protein is made up of a long chain of hundreds or thousands of amino acids. Once the chain is made, it folds up in a 3-D structure that is unique for each protein. That structure is critical in determining the functionality and properties of the protein. Proteins are made out of mostly carbon, hydrogen, nitrogen, oxygen, and sulfur. A few contain phosphorus, iron, copper, or zinc. They affect the flavor and texture of food, and sulfur and nitrogen are important nutrients.

The human body has about 100,000 different proteins, while our DNA codes for only 20,000 proteins. Our cells are able to take the DNA template for one protein and use it to make several different ones by cutting and splicing pieces together. The total number of protein molecules in a single cell is estimated at 42 million. Most exist as a few thousand molecules, but some are plentiful at more than half a million copies.

There are twenty different types of amino acids. Eleven of these are made in our body and the others, called “essential amino acids,”

must be obtained from our food. The nine essential amino acids are histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine. Each protein contains a different amount of each amino acid, so the amount of each amino acid required in our diet is different. For example, the recommended daily amount for every 2.2 pounds of body weight is 42 mg for leucine and only 5 mg for tryptophan.

The three-dimensional structure of proteins is essential for them to carry out their function. The term denaturation is used for a process whereby proteins unfold, and this can be caused by pH, heat, freezing, physical agitation, and high salt concentrations. Heating egg whites denatures protein, producing white solids. Making cottage cheese by adding acid to milk is the result of a denatured protein. Beating the proteins in egg whites forms meringue. Once a protein is denatured, it will not reform properly and its original characteristics are lost.

Percent Protein in Various Foods[1]

Food type	Percent protein	Food type	Percent protein
Beans	7	Nuts	15
Broccoli	2	Pasta	5
Cheese	25	Peas	5
Eggs	14	Potato	3
Fish	24	Rice	11
Fruit	1	Spinach	3
Meat	30	Yogurt	5

Enzymes

All enzymes are proteins, but not all proteins are enzymes. Each enzyme is specific for a particular reaction, although what we think of as a single reaction might actually be a set of reactions. For example, photosynthesis is a complex process that requires several enzymes. The "oxygen evolving complex," consisting of several enzymes, breaks up water molecules to start the photosynthesis process. "ATP Synthase," another enzyme, converts ATP to ADP to release the energy needed for the reaction. "Rubisco" combines carbon from CO_2 to form sugar molecules.

Enzymes carry out reactions that affect molecular structure, flavor, taste, and texture. They can increase or decrease important nutrients, and they are reused over and over again. You can think of them as taxis moving molecules from place to place. It drives around until flagged down by someone. That passenger might go and pick up a second person and then both are dropped off at a new location for a date. The taxi is now free to do it all over again. A big difference between a taxi and enzymes is that enzymes are specific to a particular type of passenger (molecule).

Understanding enzymes can be important in cooking. For example, gelatin is a protein that absorbs water and other small molecules as it sets into a solid gel. Pineapple contains a protein-digesting enzyme called bromelain that reacts with proteins to break them up into small peptide molecules. What happens when you try to make a gelatin salad with pineapple? Bromelain reacts with gelatin and breaks it down so that it can no longer form a gel and your gelatin salad stays runny.

Canned pineapple doesn't have the same effect because heat from the canning process denatures (inactivates) bromelain. Canned pineapple works just fine in a gelatin salad, as does cooked pineapple. Other plants also produce similar enzymes called proteases that prevent gelatin from setting. These include fresh papaya, mango, guava, and kiwi.

Bromelain is also used as a meat tenderizer. In fact, some people are very sensitive to the enzyme and find that it makes their lips and tongue sore. This is because the bromelain is tenderizing your tongue! Why does it not also tenderize your stomach? The acids there denature it.

Complete Proteins

A food is considered to be a complete protein source when it contains all nine essential amino acids in amounts relative to what our bodies need. An incomplete protein source has some of these amino acids but not all of them. Meat, poultry, fish, eggs, and milk are complete protein sources and for this reason many people believe that we need to have some of these in our diet.

Most sources of plant protein are not complete:

- legumes are a good source of lysine, and a poor source of tryptophan and sulfur-containing amino acids.
- nuts and seeds contain tryptophan and sulfur-containing amino acids.
- cereals and grains are a good source of tryptophan and sulfur-containing amino acid, and a poor source of lysine.
- starchy vegetables have lower levels of lysine and methionine.
- green leafy vegetables contain tryptophan, leucine, threonine, and phenylalanine, but are low in the others.

There are some complete plant-based sources, including:

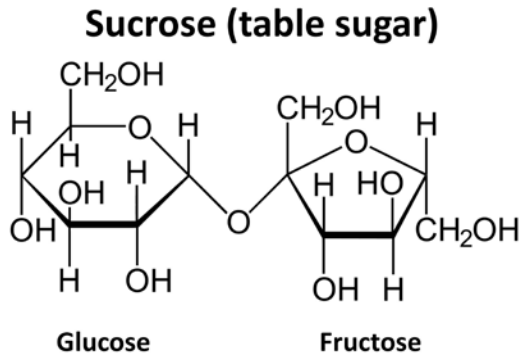
- quinoa
- buckwheat
- hempseed
- blue-green algae
- soybeans

A common belief is that every meal needs to include all of the essential amino acids so that they are consumed at the same time, but that is a myth. It's been shown that an optimal amino acid profile is perfectly obtainable by eating a variety of protein sources over the course of a day. A single serving of meat will provide all of the essential amino acids. Vegetarian or vegan diets should include a variety of different protein sources so that the total amount of amino acids consumed in a day meets the daily requirements.

Carbohydrates

Carbohydrates are organic compounds that contain carbon, oxygen, and hydrogen and include important food constituents such as sugars, dextrins, starches, celluloses, pectins, and gums. These provide both energy and fiber in our diets. Most of the dry weight of plants as well as the pages of this book are made up of carbohydrates.

Table sugar (sucrose) is called a disaccharide because it contains the two simple sugars: glucose and fructose. These three sugars are critical for all life forms, including bacteria, plants, and animals. They are broken down in a process called respiration to produce energy (4 calories/g) and carbon dioxide.



The molecular structure of sucrose (glucose + fructose)

Sugars are sweet, and fructose is the main sugar that gives fruits their sweet taste. In solution they are viscous and provide food with a desirable mouthfeel. Microbes can also use sugar as an energy source, but at high concentrations sugar prevents microbes from growing. That is why jams and jellies keep so well.

Sugar molecules can be joined together to form longer chains called polysaccharides. An example of this is raffinose that contains galactose, glucose, and fructose. It is found in dried beans and peas. Our bodies are unable to digest it, so it travels through the stomach into the large intestine where bacteria break it down, producing gas. You might be familiar with the jingle, "beans, beans, good for the heart. The more you eat the more you…." You get the picture.

Starches, pectins, and gums are more complicated polysaccharides that are found in all living things. There are hundreds of different types and when we eat them, enzymes break the long chains of molecules into smaller and smaller chains. We are then able to use these small molecules to build the new polysaccharides that we need. The take-home message here is that too much sugar is not good for us, but without a steady supply of these carbohydrates, we cannot live.

The term fiber is used for carbohydrates that travel through the digestive tract but are not digested or absorbed. They therefore don't provide energy or nutrients, but they are very important for making our digestive system work properly. Fiber provides bulk for muscles

of the digestive tract to squeeze against, which helps move food through the system. They are found in roots, stems, leaves, nuts, and the outer seed covering of vegetables, fruits, and whole grains.

Fiber also acts like a sponge for unhealthy substances, reducing their absorption into our body. For example, fiber reduces the absorption of cholesterol into the bloodstream, lowering the chance of getting colon cancer.

Food Myth: Brown Sugar Is Healthier

Most table sugar is made from sugar cane and sugar beets. Both are ground up and a liquid is extracted and refined to form white sugar. During the refining process, a brown liquid waste product called molasses is also produced. Brown sugar is made by coating refined white sugar with varying amounts of molasses. The amount of molasses in brown sugar is very small and therefore does not provide much nutrition.

Molasses is 22 percent water, 75 percent sugar, and about 2 percent minerals, including selenium, calcium, magnesium, iron, manganese, potassium, and copper. Sulfur may be added to the molasses to help control bacteria growth during the manufacturing process.

Natural sugar is found in fruits and vegetables and is claimed to be healthier, but it is the exact same sugar, namely sucrose, found in refined white sugar. The fact that it comes from fruits and vegetables does not make it any healthier.

From a nutritional point of view, natural sugar, refined white sugar, and brown sugar are all the same sugar. None is more nutritious than the others.

Fats & Oils

Fats and oils are essentially the same thing and are collectively called triglycerides. Each triglyceride is made up of a molecule of glycerol and three fatty acids. They consist of carbon, hydrogen, and oxygen, which are the same components of carbohydrates. A triglyceride is called a fat if it is a solid at room temperature (77°F, 25°C) and an

oil if it is a liquid at room temperature. Fats come from meat, lard, butter, coconut oil, and palm oil, while oils come from fish and plants.

You have probably heard terms like "saturated fats" or "unsaturated fatty acids." The term saturated refers to the amount of hydrogen atoms in the molecule. A higher number of hydrogen atoms results in a higher "degree of saturation." Saturated fatty acids have more hydrogen and tend to be found in saturated fats. Unsaturated fatty acids have fewer hydrogen atoms and are found in unsaturated fats, which tend to be called oils. In general, unsaturated fats are healthier. The degree of saturation has a significant effect on the properties of food such as flavor, mouthfeel, texture, and aroma. Higher fat levels make doughnuts taste better!

Humans are able to synthesize most of the fatty acids, but there are two that are essential in our diet. They include linoleic acid, an omega-6 fatty acid, and α-linolenic acid, an omega-3 fatty acid. The former is found in soybean oil, corn oil, and safflower oil, and the latter is found in soybean oil, canola oil, walnuts, and flaxseed. Note that meat is not a good source for either of these.

Fats are important in our diet because they provide fat-soluble vitamins and they are an important energy source. Fat has about 9 calories per gram while carbohydrates and protein have about 4 calories per gram. Fat is an important part of cell membranes and is found in high concentrations in brain and nerve tissue. Excess fat is stored in our bodies and too much has a negative health effect.

Fruits and vegetables are a better source of unsaturated triglycerides, but vegetables only contain about 5% fat (dry weight) and fruits are even less at 1%.

Vitamins

Vitamins are organic substances that our bodies need in small amounts. They are essential in our diet because we are either unable to synthesize them or we can't make enough to meet our needs. The list of vitamins is unique to each organism. For example, humans need to get vitamin C from their diets while dogs can produce their own vitamin C.

In some cases we don't need the vitamin in our diet because we can use other similar molecules to make the vitamin. The term used for these other molecules is provitamin or previtamin. For example, beta-carotene is a provitamin A. Our bodies have an enzyme that can convert beta-carotene into vitamin A. Most discussions do not distinguish between a vitamin and a provitamin. The term vitamin A is used for both beta-carotene and vitamin A.

Vitamins are classified as either fat soluble or water soluble. Fat-soluble vitamins (A, D, E, K) dissolve in fat and tend to accumulate in the body. They are more abundant in food that contains fat. Water-soluble vitamins, including C and the B-complex, dissolve in water. They are not stored, and any unused amounts are expelled in the urine. We therefore require a daily dose of these vitamins.

This difference in solubility is important in preserving food. Soaking or boiling food in water tends to remove the water-soluble vitamins more than the fat-soluble ones. Vitamins are also degraded by enzymes. Blanching food prior to freezing destroys enzymes and helps preserve vitamins.

Many people in developed countries take daily vitamin supplements because it's become fashionable, but in most cases they are unnecessary. A good healthy diet provides all the vitamins your body can use. If you are not getting enough vitamins you will get sick. On the other hand, you can also get sick by eating too much of some vitamins. Since fat-soluble vitamins are stored, they can accumulate to toxic levels.

Some of the food available in grocery stores has been fortified with vitamins. This means that the manufacturer has added additional vitamins to the product. Milk usually contains added vitamin D, and bread is fortified with B9.

Vitamin A, also called retinol, is essential for growth and development, healthy vision, immune function, healthy teeth and bones, and reproduction. It helps the heart, lungs, and kidneys function properly. A deficiency of vitamin A causes eye problems and can lead to night blindness. Cataracts are responsible for 50 percent of blindness cases, and vitamin A and C can help prevent them.

Vitamin A is only available from animal sources, and the best sources include organ meats (liver), fatty fish (tuna), milk, cheese, and eggs. Humans are able to make vitamin A from beta-carotene and alpha-carotene, which are collectively known as provitamin A. These are the orange pigments found in carrots, oranges, squash, and red peppers. Provitamin A is also found in mango, broccoli, and spinach.

Vitamin C (ascorbic acid) helps your body fight infection and prevents diseases such as scurvy. It contributes to collagen production (muscles), helps wounds heal, strengthens blood vessels, and helps bone formation. It is important for iron absorption and acts as an antioxidant. Scurvy results in bleeding gums, loss of teeth, and wounds that don't heal. This used to be a common disease with sailors two hundred years ago until the British discovered that citrus fruits prevented it.

Fruits and vegetables are good sources of vitamin C with citrus and berries having the highest level. Cooking destroys it.

The idea of taking a daily dose of vitamin C to ward off a cold is a myth. It might shorten the time you are sick by a small amount, but a cold is an infection and no amount of vitamin C will prevent it. Most people in developed countries get enough vitamin C from the food they eat. The body can't store it, and any excess is expelled through urine.

Vitamin D (cholecalciferol) indirectly helps bones and teeth develop properly by helping intestines absorb calcium and phosphorus into the bloodstream. Human bodies can produce vitamin D, but they are not very efficient at doing so unless skin is exposed to UVB rays from the sun or other source. That can be a problem in cold climates in winter, but even exposing the face to one hour of sunlight is enough to produce the daily requirement of vitamin D.

A vitamin D deficiency can cause rickets and osteomalacia, a softening of the bones. A good source for vitamin D includes fatty fish (salmon, tuna), egg yolks, cheese, beef liver, and mushrooms. Processed foods may be fortified with vitamin D.

Vitamin E (tocopherol) scavenges free radicals (loose electrons) that can damage cells. By doing so it enhances the immune system, prevents clots, decreases inflammation, and may prevent diseases.

Vitamin E is mainly stored in the liver until it is released into the bloodstream. Deficiencies are rare, but they can cause muscle weakness, problems with coordination, and numbness. Vitamin E is found in plant-based oils, nuts, seeds, wheat germ, fruits, and vegetables.

Vitamin K comes in two types. Phylloquinone is found in green leafy vegetables such as collard greens, kale, and spinach, and in oils such as soybean and canola, while menaquinone is found in meat, cheese, eggs, and fermented foods. Vitamin K is important for developing proteins that are used for blood clotting and bone development. It is found throughout the body, including the liver, brain, heart, pancreas, and bones. Excess vitamin K is quickly broken down and excreted in urine and stool.

An important source for this vitamin are the bacteria in our gut. Antibiotics can destroy the bacteria, resulting in deficiencies, especially if the drug is taken for more than a couple of weeks. Since vitamin K is fat-soluble, it is a good idea to consume some fat or oil with meals to help absorb it.

B vitamins include B1 (thiamin), B2 (riboflavin), B3 (niacin), B5 (pantothenic acid), B6 (pyridoxine), B7 (biotin), B9 (folate, folic acid), B12 (cobalamin). These vitamins help a variety of enzymes complete their task, ranging from releasing energy to breaking down amino acids and transporting oxygen around the body. Some of these may also play a role in reducing cancer and heart disease.

The B vitamins are found in a wide variety of foods, both animal and plant based, so the best approach is to eat a varied diet. They are also added as supplements to many processed foods. A deficiency can have a variety of symptoms, including skin rashes, scaly skin on lips, weakness, confusion, depression, nausea, and numbness of hands and feet.

Folate is a natural B vitamin found in many foods. Unfortunately, our digestive system is not efficient at absorbing it and we don't store it for long. A manufactured form of this vitamin called folic acid is used to fortify foods and it has the advantage that our bodies are better at absorbing it. This is a good example of a manufactured chemical that is better than the natural form.

Important Mineral Nutrients for Humans[2]

Mineral	What it does	Where it's found
Macrominerals		
Sodium	controls fluid balance, nerve transmission, muscle contraction	table salt, processed foods, bread, vegetables, unprocessed meats
Calcium	part of bones and teeth, muscle contraction, nerve function, blood clotting, blood pressure	milk products, greens, legumes
Chlorine	proper fluid balance, stomach acid	table salt, processed foods, bread, vegetables, unprocessed meats
Magnesium	important in bones, making proteins, nerve transmission, immune system	nuts, seeds, legumes, leafy vegetables, seafood, hard water
Phosphorus	teeth and bones, acid-base balance, DNA, ATP (our energy source)	meats, fish, poultry, eggs, milk
Potassium	fluid balance, nerve transmission, muscle contraction	meats, milk, fresh fruits and vegetables, whole grains, legumes
Sulfur	found in proteins	meats, poultry, fish, eggs, milk, legumes and nuts
Microminerals		
Iron	hemoglobin found in red blood cells, movement of oxygen, energy metabolism	meats, fish, poultry, shellfish, egg yolks, legumes, dried fruits, dark leafy greens, iron-enriched breads, cereals
Zinc	part of many enzymes, taste perception, wound healing, normal fetal development, production of sperm, normal growth and sexual maturation, immune system health	meats, fish, poultry, leavened whole grains, vegetables
Chromium	works with insulin to regulate blood sugar	liver, brewer's yeast, whole grains, nuts, cheese
Copper	part of many enzymes, iron metabolism	legumes, nuts, seeds, whole grains, organ meats, drinking water
Fluoride	formation of bones and teeth, helps prevent tooth decay	drinking water, fish, most teas
Iodine	thyroid hormone, regulate growth, development, and metabolism	seafood, foods grown in iodine-rich soil, iodized salt, bread, dairy products
Manganese	part of many enzymes	most food, especially plant-based food
Molybdenum	part of enzymes	legumes, bread, grains, leafy green vegetables, milk, liver
Selenium	an antioxidant	meats, seafood, grains

Minerals

Minerals are inorganic elements that are mostly the same as the nutrients used by plants, including calcium, magnesium, potassium, phosphorus, etc. Plants absorb these from the soil and they are in turn eaten by animals. Fruits, vegetables, and meats provide the minerals in our diet. Just like plants, we need some of these minerals in larger amounts and call them macrominerals, and those needed in smaller amounts are called microminerals.

Minerals play many important roles. Sodium and potassium carry charges that make nerves and muscles work. Iron is part of the hemoglobin molecule that carries oxygen in red blood cells. Calcium and phosphorus along with vitamin D are critical for building strong bones and teeth. Several minerals are part of enzymes that carry out a wide range of reactions.

The body usually recycles minerals. For example, when red blood cells are about four months old, they are broken down. Iron is extracted and blood transports it to bone marrow where it is recycled into new hemoglobin molecules.

Minerals can also be tied up by other molecules that we eat. You might know that vegetables such as spinach and rhubarb contain oxalic acid. Seeds, nuts, legumes, and unprocessed bran contain a chemical called phytic acid. Both of these compounds bind with calcium in our gut, preventing its absorption.

Phytonutrients

Many of the compounds that have been discussed so far are essential in our diets, but there are many other compounds in our diet that are beneficial but not essential. One group of these are called phytonutrients or phytochemicals. “Phyto” refers to the Greek word for plant. Most of these chemicals are produced naturally by the plant to ward off pests and diseases, but in our diet they can be very beneficial to our health and help us fight off certain diseases.

We have now identified more than twenty-five thousand phytonutrients, and to be honest we don’t know what most of them do. The science on these compounds is just starting to emerge.

Many claims have been made for these compounds. Some seem to help cancer cells self-destruct. Others react with carcinogens before they can affect cells. They may even block the formation of tumors in blood vessels. Notice that I used the words "seem to" and "may." We have to be very careful about these claims because most of this is very preliminary science.

Quite a few phytochemicals have been shown to work well in the lab, only to find out that they are not even absorbed by the gut. In other cases, helpful bacteria in our gut break them down before they can be absorbed and provide a benefit to us. The side effects of these compounds have not been studied well at all. We still have a lot to learn about this group of compounds, but the general sense is that they are valuable in our diet and the best way to get a lot of different ones is to eat a varied diet.

To help quantify the benefits of such a large number of compounds, scientists have developed the Phytochemical Index (PI), which is defined as the percent of dietary calories derived from foods rich in phytochemicals. These foods include fruits, most vegetables, fruit/vegetable juices, legumes, whole grains, nuts, seeds, soy products, wine, beer, and cider. It excludes refined oils, sugars, grains, potato products, hard liquors, and animal products. There are some apps that let you input your food intake and then calculate the PI.

This is a list of some of the more common groups of phytonutrients:

- carotenoid pigments
- flavonoid pigments
- sulforaphane
- isothiocyanates in the cabbage family
- saponins in legumes
- limonene and phenols in citrus

"Eating the rainbow" has become a popular expression. The idea is that you should eat a lot of different colored fruits and vegetables. This does not include colorful jujubes! Many of the phytonutrients are compounds that have a color, and if you eat the rainbow you are eating a lot of different healthy nutrients.

Colorful food is good for us, but so are white vegetables. Cauliflower, mushrooms, and garlic also have nutritional benefits, including fiber, potassium, and magnesium.

Antioxidants

What are antioxidants? The term has become popular and is associated with nutrition and health, but few actually understand what they are. In simple terms, antioxidants are compounds that neutralize free radicals.

Free radicals are compounds that travel through your body, trying to strip electrons from other compounds. When they are successful, many of these other compounds become harmful to our bodies and cause a variety of chronic diseases. Free radicals can change DNA, cause LDL (the bad cholesterol) to stick to artery walls, and they can alter cell membranes, which changes the movement of molecules into and out of cells.

Our bodies produce antioxidants to keep the quantity of free radicals in check so that they don't do too much harm. We can also get antioxidants from food since every other living organisms is also producing them to control their own free radicals.

It is important to understand that there are many different kinds of free radicals and many different kinds of antioxidants. Free radicals are only neutralized when a matching type of antioxidant is present. What this means is that increasing the wrong antioxidant in your diet won't be of any help. What you really need is lots of different ones so that the right one is available when needed.

There are hundreds if not thousands of different antioxidants. Some familiar ones include vitamin C, vitamin E, beta-carotene, selenium, manganese, flavonoids, phenols, and many more.

Some foods have higher amounts of antioxidants and they have been labeled as "superfoods," including things like cocoa, berries, spices, and legumes. Along with that title came all kinds of health claims and people started promoting higher consumption of superfoods. Blueberries topped the list and were heavily promoted as disease-fighters. The reality is that the science supporting these claims is very weak or nonexistent.

It is clear that excessive free radicals contribute to chronic diseases, including cancer, heart disease, cognitive decline, and vision loss and that natural antioxidants in our bodies help reduce diseases. However, there is little scientific support for the idea that eating more antioxidants or using supplements containing antioxidants will reduce diseases.[3]

Water

You might be surprised that I have included water here, but it is essential for life. Plants are 80–90 percent water, while seeds only have about 10 percent. Our bodies contain about 60 percent water, with the brain and heart having 73 percent, the lungs 83 percent, the skin 64 percent, and bones 31 percent. For comparison, fish are about 78 percent water, which is less than plants.

Water is needed for digestion, carrying waste, making urine, circulating blood, controlling body temperature, and for controlling many chemical reactions taking place in cells. If you lose too much water, cells shrink and may no longer function properly. Keep in mind that we get water from both drinking and eating. All of our food contains some water, and we get about 20 percent of our water from food (such as soup).

Moisture content is also important if you are looking at the cost of food. Which is cheaper: lettuce, apples, or peanuts? The price of nuts has skyrocketed, so they must be more expensive, right? Not really. Water is cheap, so we need to remove it from the food before we compare prices. The table below shows that peanuts are actually cheaper on a dry weight basis. Lettuce is extremely high in cost.

The Real Cost of Food

Food	Cost/500 g	Moisture content	Cost/100g dry weight
Washed, cut iceberg lettuce	$3.00	95%	$12.00
Shelled peanuts	$3.00	10%	$0.66
Honeycrisp apples	$2.00	80%	$2.00

Note: The above prices are from Walmart, in US dollars.

Food Myth: You Should Drink 8 Glasses of Water a Day

Our bodies lose about half a gallon (2 litres) of water per day, mostly through sweating, breathing, and urination. This is higher in hot climates, with extra exercise, and with a fever. This water needs to be replenished, and about 20 percent comes from solid food. Normal consumption of juice, milk, tea, or coffee provides the rest of the requirement. Even the original recommendation of drinking eight glasses a day (1945, US Food and Nutrition Board) stated that most of our water intake could come from food sources.

You do not need to drink eight glasses of water each day. Here are some other myths about drinking water:

- Being thirsty does not mean you are dehydrated. Spicy and salty foods will make you thirsty. If you are thirsty, drink some water but don't worry about being dehydrated.
- You can drink too much water, which leads to hyponatremia where salt levels are too low. At high doses, water is toxic and can kill you.
- Coffee and other caffeinated beverages consumed in moderation provide the same hydration as noncaffeinated drinks. They do not dehydrate you.
- Many people now drag a water bottle along wherever they go because "you need to drink every few minutes." This is a complete myth even during normal exercise.
- Tap water in developed countries is highly regulated and is usually just as good if not better than bottled water. Years ago I saw a chemical analysis of Toronto, Ontario, drinking water compared to bottled water. Although both are safe to drink, the bottled water contained higher levels of toxins, many coming from the plastic in the bottle. Bottled water also costs a lot more.

Factors Affecting Nutrients

Many factors affect the nutrient level in food, starting with the selection of seed, the growing methods, harvesting, storage, and finally the cooking methods used to prepare the food. Food science studies the impact of all of these factors.

Food Myth: Brown Eggs Are More Nutritious

Chicken eggs are available in two common colors: brown and white. Some parts of the country prefer brown eggs because they are reported to be more nutritious. Other regions prefer white eggs. What is the difference?

Shell color depends on the breed of chicken. Brown-eared hens produce brown-shelled eggs. White eggs come from hens with white ears. Yes, chickens have ears; they are hidden under the feathers. There are also bluish eggs and matching colored hens. All of these eggs have the same flavor, quality, and nutrition provided they were raised the same way.

The color and nutrition of the yolk is affected by the feed given to the birds. A deep yellow pigment is due to beta-carotene, xanthophyll, or lycopene, three phytonutrients.

It all starts with the selection of seeds. Not only do you have to decide which food to grow, but you also need to select the cultivar (the variety). Each type of tomato will produce fruit that has different nutrient levels. For example, some tomatoes have a higher sugar level than others and they may taste sweeter. Each type of potato has different levels of solanine, a toxic compound I'll discuss later in the book.

Unfortunately for the gardener, there is very little information about the nutritional qualities of different cultivars. You can find the nutrient levels in peas online, but you are unlikely to find any useful information that compares the nutrient levels between snap peas and snow peas, let alone between Early Frosty and Green Arrow.

Once you have something growing, the next big impact on nutrition is climate and soil. Most of the nutrients in plants are compounds produced by the plant, and the production of these is very dependent on where the plant is grown. You have probably heard about low acid tomatoes, which is mostly a myth, but in the US you can find low acid tomatoes growing in a few locations. Grow the exact same cultivar in any other location and it won't have low acidity.

You have limited control over climate, but you can control the amount of water your plants get, and this can be important for nutrient levels. You also have limited control over soil, but again, you can improve the quality of your soil to grow more nutritious food. I won't discuss the topic of soil very much since it is fully covered in my other book, *Soil Science for Gardeners*.

Harvesting fruits and vegetables at the right time can have a big impact on nutrition. It is also very important to either eat the food right away, or to process and store it correctly to maintain a high level of nutrition. Each of these topics has their own chapter in this book.

Nutrition Myths

Myth #1: Avoid Total Fat and Saturated Fat

Fat provides energy and fat-soluble vitamins. In moderation it is good for you.

Myth #2: Eggs Raise Cholesterol Level

Eggs are high in cholesterol, but eating them does not seem to raise cholesterol levels. They are also full of minerals, vitamins, and antioxidants.

Myth #3: Lose Weight by Eating Less Fat

The cry for using low fat diets to lose weight has backfired. Companies replace fat with carbohydrates such as sugar to replace the good taste of fats. Overeating these "better for you" foods has actually led to more obesity.

Fat from foods such as nuts, vegetable oil, and fish are essential in the diet. Fat also helps you feel full longer, which reduces snacking.

Myth #4: Only People with High Blood Pressure Should Limit Their Sodium

Many healthy people consume more sodium than recommended and it can lead to future stroke, heart disease, and kidney disease. Most of the sodium we eat comes from processed food, but even fresh fruits and vegetables contain some sodium.

Myth #5: Honey Is Better than White Sugar
Table sugar is sucrose, a type of sugar. Most of the sugar in honey, maple syrup, and coconut sugar is also sucrose. Honey does contain twenty-two amino acids, thirty-one different minerals and a wide range of vitamins and enzymes. However, these nutrients are only present in trace amounts and add no real nutritional value. None of these sources are much better than white sugar.

Myth #6: A Detox Diet Will Clean Toxins Out of the Body
The idea of removing toxins by eating special foods has no scientific support. Your existing liver, kidneys, and gastrointestinal tract do a good job of removing toxins without any special help from you.

Myth #7: Red Meat Is Harmful
The right kind of meat in moderation is not harmful. Fresh red meat, steak, and hamburger, do not cause heart disease, but processed meat can. The salts and nitrates in processed meat such as bacon, salami, and lunch meats are related to higher heart disease. A few small servings of these a week are fine, but it is better to reduce these in the diet and to limit the overall amount of meat you eat.

Myth #8: Fresh Fruits and Vegetables Are Always Healthier
This is a very common belief, but studies have shown that canned, frozen, or dried food can be just as nutritious. Preserving these foods properly is important, and I'll discuss details about that in other parts of the book.

Myth #9: Potato Skins Are Much More Nutritious than the Flesh
The skin does have higher levels of fiber, but most of the other nutrients including potassium and vitamin C are found in the flesh. It might also surprise you that a potato has more potassium than a banana and more vitamin C than an orange.