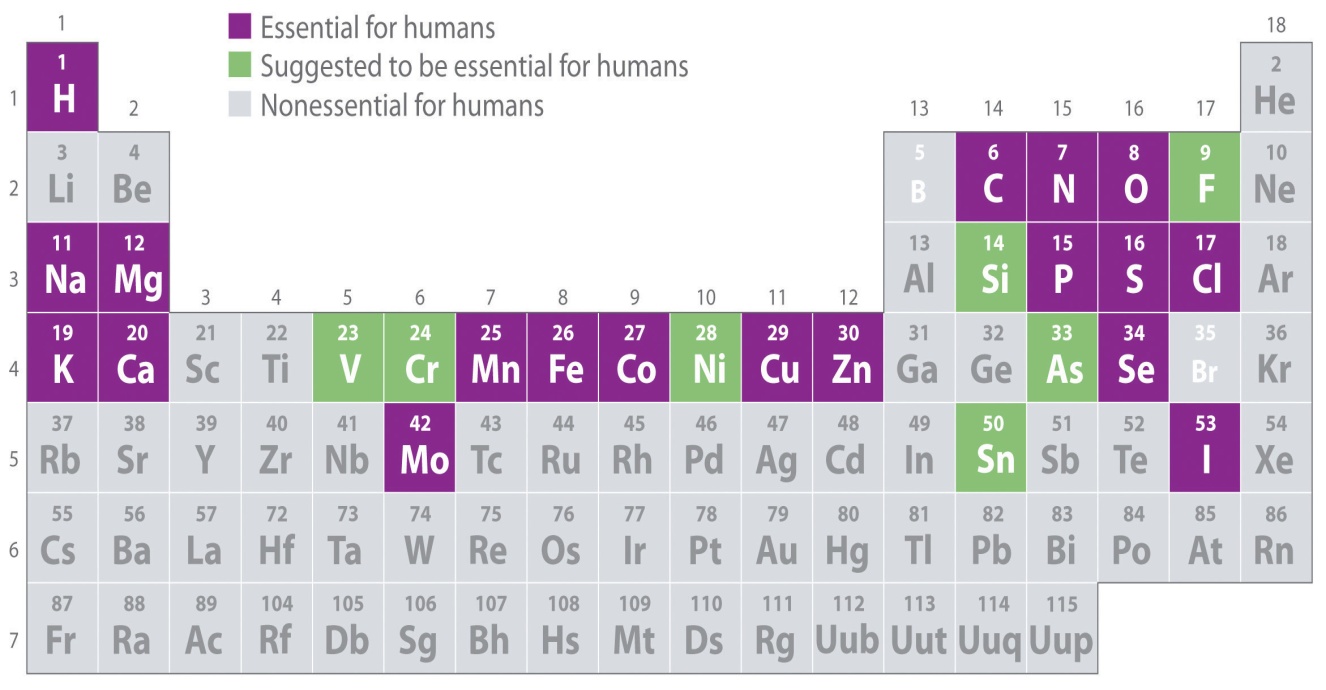
**Essential and non essential Elements for Life or bio systems**

Of the approximately 115 elements known, only the 19 highlighted in purple in [Figure 1.26 "The Essential Elements in the Periodic Table"](http://catalog.flatworldknowledge.com/bookhub/4309?e=averill_1.0-ch01_s08#averill_1.0-ch01_s08_f01) are absolutely required in the human diet. These elements—called essential elements—are restricted to the first four rows of the periodic table with only two or three exceptions (molybdenum, iodine, and possibly tin in the fifth row). Some other elements are essential for specific organisms. For example, boron is required for the growth of certain plants, bromine is widely distributed in marine organisms, and tungsten is necessary for some microorganisms.

*Figure 1.26 The Essential Elements in the Periodic Table*

[](http://images.flatworldknowledge.com/averillfwk/averillfwk-fig01_026.jpg)

*Elements that are known to be essential for human life are shown in purple; elements that are suggested to be essential are shown in green. Elements not known to be essential are shown in gray.*

What makes an element “essential”? By definition, an essential element is one that is required for life and whose absence results in death. Because of the experimental difficulties involved in producing deficiencies severe enough to cause death, especially for elements that are required in very low concentrations in the diet, a somewhat broader definition is generally used. An element is considered to be essential if a deficiency consistently causes abnormal development or functioning and if dietary supplementation of that element—*and only that element*—prevents this adverse effect. Scientists determine whether an element is essential by raising rats, chicks, and other animals on a synthetic diet that has been carefully analyzed and supplemented with acceptable levels of all elements *except* the element of interest (E). Ultraclean environments, in which plastic cages are used and dust from the air is carefully removed, minimize inadvertent contamination. If the animals grow normally on a diet that is as low as possible in E, then either E is not an essential element *or* the diet is not yet below the minimum required concentration. If the animals do not grow normally on a low-E diet, then their diets are supplemented with E until a level is reached at which the animals grow normally. This level is the *minimum required intake* of element E.

**Classification of the Essential Elements**

The approximate elemental composition of a healthy 70.0 kg (154 lb) adult human is listed in [Table 1.6 "Approximate Elemental Composition of a Typical 70 kg Human"](http://catalog.flatworldknowledge.com/bookhub/4309?e=averill_1.0-ch01_s08#averill_1.0-ch01_s08_s01_t01). Note that most living matter consists primarily of the so-called *bulk elements*: oxygen, carbon, hydrogen, nitrogen, and sulfur—the building blocks of the compounds that constitute our organs and muscles. These five elements also constitute the bulk of our diet; tens of grams per day are required for humans. Six other elements—sodium, magnesium, potassium, calcium, chlorine, and phosphorus—are often referred to as *macrominerals* because they provide essential ions in body fluids and form the major structural components of the body. In addition, phosphorus is a key constituent of both DNA and RNA: the genetic building blocks of living organisms. The six macrominerals are present in the body in somewhat smaller amounts than the bulk elements, so correspondingly lower levels are required in the diet. The remaining essential elements—called *trace elements*—are present in very small amounts, ranging from a few grams to a few milligrams in an adult human. Finally, measurable levels of some elements are found in humans but are *not* required for growth or good health. Examples are rubidium and strontium, whose chemistry is similar to that of the elements immediately above them in the periodic table (potassium and calcium, respectively, which are essential elements). Because the body’s mechanisms for extracting potassium and calcium from foods are not 100% selective, small amounts of rubidium and strontium, which have no known biological function, are absorbed.

Table 1.6 Approximate Elemental Composition of a Typical 70 kg Human

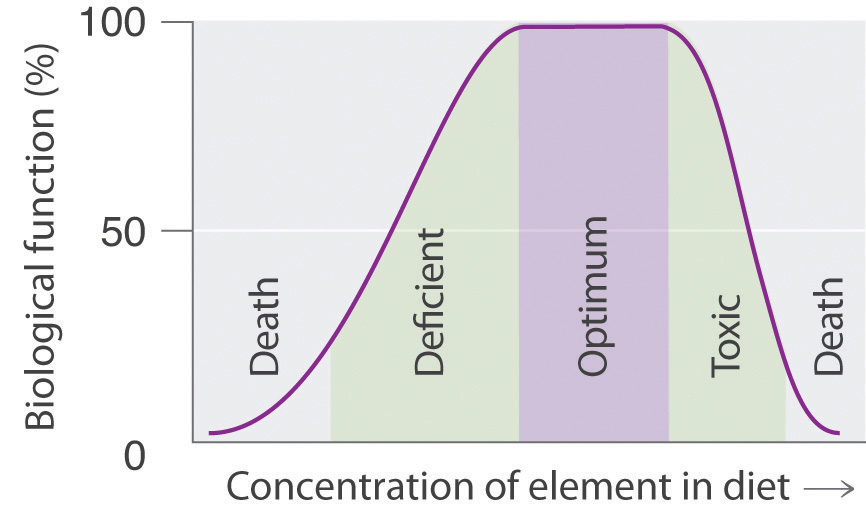
|  |  |  |  |
| --- | --- | --- | --- |
| **Bulk Elements (kg)** | | **Macrominerals (g)** | |
| oxygen | 44 | calcium | 1700 |
| carbon | 12.6 | phosphorus | 680 |
| hydrogen | 6.6 | potassium | 250 |
| nitrogen | 1.8 | chlorine | 115 |
| sulfur | 0.1 | sodium | 70 |
|  |  | magnesium | 42 |
| **Trace Elements (mg)** | | | |
| iron | 5000 | lead | 35 |
| silicon | 3000 | barium | 21 |
| zinc | 1750 | molybdenum | 14 |
| rubidium | 360 | boron | 14 |
| copper | 280 | arsenic | ~3 |
| strontium | 280 | cobalt | ~3 |
| bromine | 140 | chromium | ~3 |
| tin | 140 | nickel | ~3 |
| manganese | 70 | selenium | ~2 |
| iodine | 70 | lithium | ~2 |
| aluminum | 35 | vanadium | ~2 |

**The Trace Elements**

Because it is difficult to detect low levels of some essential elements, the trace elements were relatively slow to be recognized as essential. Iron was the first. In the 17th century, anemia was proved to be caused by an iron deficiency and often was cured by supplementing the diet with extracts of rusty nails. It was not until the 19th century, however, that trace amounts of iodine were found to eliminate goiter (an enlarged thyroid gland). This is why common table salt is “iodized”: a small amount of iodine is added. Copper was shown to be essential for humans in 1928, and manganese, zinc, and cobalt soon after that. Molybdenum was not known to be an essential element until 1953, and the need for chromium, selenium, vanadium, fluorine, and silicon was demonstrated only in the last 50 years. It seems likely that in the future other elements, possibly including tin, will be found to be essential at very low levels.

Many compounds of trace elements, such as arsenic, selenium, and chromium, are toxic and can even cause cancer, yet these elements are identified as essential elements in [Figure 1.26 "The Essential Elements in the Periodic Table"](http://catalog.flatworldknowledge.com/bookhub/4309?e=averill_1.0-ch01_s08#averill_1.0-ch01_s08_f01). In fact, there is some evidence that one bacterium has replaced phosphorus with arsenic, although the finding is controversial. This has opened up the possibility of a “shadow biosphere” on Earth in which life evolved from an as yet undetected common ancestor. How can elements toxic to life be essential? First, the toxicity of an element often depends on its chemical form—for example, only certain compounds of chromium are toxic, whereas others are used in mineral supplements. Second, as shown in [Figure 1.27 "Possible Concentrations of an Essential Element in the Diet"](http://catalog.flatworldknowledge.com/bookhub/4309?e=averill_1.0-ch01_s08#averill_1.0-ch01_s08_s02_f01), every element has three possible levels of dietary intake: *deficient, optimum*, and *toxic* in order of increasing concentration in the diet. Very low intake levels lead to symptoms of deficiency. Over some range of higher intake levels, an organism is able to maintain its tissue concentrations of the element at a level that optimizes biological functions. Finally, at some higher intake level, the normal regulatory mechanisms are overloaded, causing toxic symptoms to appear. Each element has its own characteristic curve. Both the width of the plateau and the specific concentration corresponding to the center of the plateau region differ by as much as several orders of magnitude for different elements. In the adult human, for example, the recommended daily dietary intake is 10–18 mg of iron, 2–3 mg of copper, and less than 0.1 mg of chromium and selenium.

*Figure 1.27 Possible Concentrations of an Essential Element in the Diet*

[](http://images.flatworldknowledge.com/averillfwk/averillfwk-fig01_027.jpg)

*The deficient, optimum, and toxic concentrations are different for different elements.*

**Roles of trace elements**

1. Transport of biological small molecules

O2-transport: hemoglobin (Fe), hemocianin (Cu)

O2-storage: mioglobin (Fe)

2. Activation of molecules: metalloenzymes, enzymes activated by metal ions

a) catalysing of redox processes (Fe, Cu, Mn, Co, Mo, Ni) biological oxidation, reduction of substrate

b) catalysing of acid-base processes (Zn)

3. Secondary conformation of macromolecules

– determination of conformation of enzymes

– determination of conformation of proteins, nucleic acids

4. Metabolism of microelements

– uptaking, transport, storage of trace elements

**Role of Alkali Metals and Alkaline Earth Metal Ions in Biological System –**

Li, Na, K, Rb, Cs, Fr are Alkali metals

Be, Mg, Ca, Sr, Ba, Ra are Alkaline Earth Metals

The ions of some Alkali Metals as well as Alkali Earth Metals play a vital role in the Biological Systems. Both sodium and potassium ions are essential to life. We need around 1 gram of sodium ion per day in our diet. The intake of sodium ions is as much as five times this value in many people because of our addiction to salt on foods. Excessive intake of potassium ion is rarely a problem. In fact potassium deficiency is very common. Thus, it is important to include potassium-rich foods such as bananas and coffee in our diet. In inorganic chemistry, one always considers the similarities between sodium and potassium, but as far as biology is concerned, it is the difference which is more important. Na+ ion is the major ion of extracellular fluids of living organisms which activates certain enzymes in the body. Cells pump sodium ions out of cytoplasm and pump potassium ions in. This ion transport is called a sodium pump which involves both the active expulsion of Na+ and the active take up of K+. The energy required for the transport is obtained by the hydrolysis of adenosine triphosphate, ATP. Like sodium and potassium ions both calcium and magnesium ions serve regulatory functions. Magnesium ions are concentrated in animal cells, whereas calcium ions are concentrated in the body fluids outside the cell. The Mg2+ help in the activation of phosphate transfer enzymes, which participates in the energy releasing biochemical process occurring in animal bodies. Both calcium and magnesium ions are responsible for the transmission of electrical impulses along the nerves and for the contraction of muscles. Calcium ions are important in clotting of blood and these are required to trigger contraction of muscles, such as those that control the beating of the heart.

**Alkali and alkali earth metal ions: biological roles**



**Membrantransport**

**processes**



**Membrantransport processes**

*Transport across the membrane*

**Diffusion**:

Non-selective, in direction of concentration gradient

**Facilated passive transport**:

By means of carriers (ionophors) energy is not required

**Active transport**:

In opposite direction of contentration gradient, energy is required energy source: hydrolysis of ATP

**Membrantransport processes**

*Transport across the membrane*



**Membrantransport processes**

**Passive transport**

Ligands: carrier ionophors: e.g. Valinomicin





Chanel ionophors

e.g. *Gramicidin A*



***Biological roles***

Na+, K+:

• maintaining of osmotic pressure of cells

• take part in acid-base processes

• regulation of membrane potentials

• K+: take part in determination of conformation of biomolecules, in activation of enzymes, in synthesis of acetilcoline

• Na+: take part in activation of enzymes, in secondary active transport

Ca2+:

• Regulation the processes of nerve transmission

• Regulation the muscle contraction

• regulation electrolyte balance

• Blood coagulation

• Building up bones and theeths

Mg2+:

• activation of enzymes, determination of conformation of proteins

• take part in hydrolysis of ATP, universal source of energy→ metabolism of energy

• building up of bones

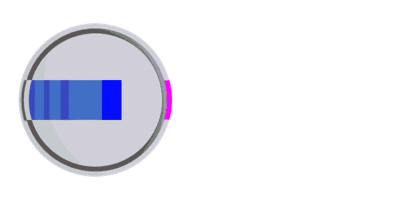
• part of chlorophyll (photosynthesis)

**Role of alkali metals in bio-systems**

Lithium naturally only occurs in traces in biological systems and has no known biological role, but does have effects on the body when ingested. [Lithium carbonate](https://en.wikipedia.org/wiki/Lithium_carbonate) is used as a [mood stabiliser](https://en.wikipedia.org/wiki/Mood_stabiliser) in [psychiatry](https://en.wikipedia.org/wiki/Psychiatry) to treat [bipolar disorder](https://en.wikipedia.org/wiki/Bipolar_disorder) ([manic-depression](https://en.wikipedia.org/wiki/Manic-depression)) in daily doses of about 0.5 to 2 grams, although there are side-effects.[ Excessive ingestion of lithium causes drowsiness, slurred speech and vomiting, among other symptoms, and [poisons](https://en.wikipedia.org/wiki/Poison) the [central nervous system](https://en.wikipedia.org/wiki/Central_nervous_system), which is dangerous as the required dosage of lithium to treat bipolar disorder is only slightly lower than the toxic dosage. Its biochemistry, the way it is handled by the human body and studies using rats and goats suggest that it is an [essential](https://en.wikipedia.org/wiki/Essential_element) [trace element](https://en.wikipedia.org/wiki/Trace_element), although the natural biological function of lithium in humans has yet to be identified.

Sodium and potassium occur in all known biological systems, generally functioning as [electrolytes](https://en.wikipedia.org/wiki/Electrolytes) inside and outside [cells](https://en.wikipedia.org/wiki/Cell_(biology)). Sodium is an essential nutrient that regulates blood volume, blood pressure, osmotic equilibrium and [pH](https://en.wikipedia.org/wiki/PH); the minimum physiological requirement for sodium is 500 milligrams per day. [Sodium chloride](https://en.wikipedia.org/wiki/Sodium_chloride) (also known as common salt) is the principal source of sodium in the diet, and is used as seasoning and preservative, such as for [pickling](https://en.wikipedia.org/wiki/Pickling) and [jerky](https://en.wikipedia.org/wiki/Jerky_(food)); most of it comes from processed foods.The [DRI](https://en.wikipedia.org/wiki/Dietary_Reference_Intake) for sodium is 1.5 grams per day, but most people in the United States consume more than 2.3 grams per day, the minimum amount that promotes hypertension; this in turn causes 7.6 million premature deaths worldwide.

Potassium is the major [cation](https://en.wikipedia.org/wiki/Cation) (positive ion) inside [animal cells](https://en.wikipedia.org/wiki/Cell_(biology)), while sodium is the major cation outside animal cells. The [concentration](https://en.wikipedia.org/wiki/Concentration) differences of these charged particles causes a difference in [electric potential](https://en.wikipedia.org/wiki/Electric_potential) between the inside and outside of cells, known as the [membrane potential](https://en.wikipedia.org/wiki/Membrane_potential). The balance between potassium and sodium is maintained by [ion pumps](https://en.wikipedia.org/wiki/Ion_pumps) in the [cell membrane](https://en.wikipedia.org/wiki/Cell_membrane). The cell membrane potential created by potassium and sodium ions allows the cell to generate an [action potential](https://en.wikipedia.org/wiki/Action_potential)—a "spike" of electrical discharge. The ability of cells to produce electrical discharge is critical for body functions such as [neurotransmission](https://en.wikipedia.org/wiki/Neurotransmission), muscle contraction, and heart function.

[](https://en.wikipedia.org/wiki/File:Goi%C3%A2niaRadiationsource.gif)

A wheel type radiotherapy device which has a long [collimator](https://en.wikipedia.org/wiki/Collimator) to focus the radiation into a narrow beam. The caesium-137 chloride radioactive source is the blue square, and gamma rays are represented by the beam emerging from the aperture. This was the radiation source involved in the Goiânia accident, containing about 93 grams of caesium-137 chloride.

Rubidium has no known biological role, but may help stimulate [metabolism](https://en.wikipedia.org/wiki/Metabolism),and, similarly to caesium,replace potassium in the body causing [potassium deficiency](https://en.wikipedia.org/wiki/Hypokalemia). Caesium compounds are rarely encountered by most people, but most caesium compounds are mildly toxic because of chemical similarity of caesium to potassium, allowing the caesium to replace the potassium in the body, causing potassium deficiency. Exposure to large amounts of caesium compounds can cause [hyperirritability](https://en.wikipedia.org/wiki/Irritability) and [spasms](https://en.wikipedia.org/wiki/Spasm), but as such amounts would not ordinarily be encountered in natural sources, caesium is not a major chemical environmental pollutant. The [median lethal dose](https://en.wikipedia.org/wiki/Median_lethal_dose) (LD50) value for [caesium chloride](https://en.wikipedia.org/wiki/Caesium_chloride) in mice is 2.3 g per kilogram, which is comparable to the LD50 values of [potassium chloride](https://en.wikipedia.org/wiki/Potassium_chloride) and [sodium chloride](https://en.wikipedia.org/wiki/Sodium_chloride). Caesium chloride has been promoted as an alternative cancer therapy,but has been linked to the deaths of over 50 patients, on whom it was used as part of a scientifically unvalidated cancer treatment.[Radioisotopes](https://en.wikipedia.org/wiki/Radioisotope) of caesium require special precautions: the improper handling of caesium-137 [gamma ray](https://en.wikipedia.org/wiki/Gamma_ray) sources can lead to release of this radioisotope and radiation injuries. Perhaps the best-known case is the Goiânia accident of 1987, in which an improperly-disposed-of radiation therapy system from an abandoned clinic in the city of [Goiânia](https://en.wikipedia.org/wiki/Goi%C3%A2nia), [Brazil](https://en.wikipedia.org/wiki/Brazil), was scavenged from a junkyard, and the glowing [caesium salt](https://en.wikipedia.org/wiki/Caesium_chloride) sold to curious, uneducated buyers. This led to four deaths and serious injuries from radiation exposure. Together with [caesium-134](https://en.wikipedia.org/wiki/Caesium-134), [iodine-131](https://en.wikipedia.org/wiki/Iodine-131), and [strontium-90](https://en.wikipedia.org/wiki/Strontium-90), caesium-137 was among the isotopes distributed by the [Chernobyl disaster](https://en.wikipedia.org/wiki/Chernobyl_disaster) which constitute the greatest risk to health.

Francium has no biological roleand is most likely to be toxic due to its extreme radioactivity, causing [radiation poisoning](https://en.wikipedia.org/wiki/Acute_radiation_syndrome), but since the greatest quantity of francium ever assembled to date is about 300,000 neutral atoms, it is unlikely that most people will ever encounter francium.

**Role of alkali earth metals in bio-systems**

Magnesium and calcium are ubiquitous and essential to all known living organisms. They are involved in more than one role, with, for example, magnesium or calcium [ion pumps](https://en.wikipedia.org/wiki/Ion_pumps) playing a role in some cellular processes, magnesium functioning as the active center in some [enzymes](https://en.wikipedia.org/wiki/Enzymes), and calcium salts taking a structural role, most notably in bones.

Strontium plays an important role in marine aquatic life, especially hard corals, which use strontium to build their [exoskeletons](https://en.wikipedia.org/wiki/Exoskeleton). It and barium have some uses in medicine, for example "[barium meals](https://en.wikipedia.org/wiki/Barium_meal)" in radiographic imaging, whilst strontium compounds are employed in some [toothpastes](https://en.wikipedia.org/wiki/Toothpaste). Excessive amounts of strontium-90 are toxic due to its radioactivity and strontium-90 mimics calcium and then can kill.

Beryllium and radium, however, are toxic. Beryllium's low aqueous solubility means it is rarely available to biological systems; it has no known role in living organisms and, when encountered by them, is usually highly toxic. Radium has a low availability and is highly radioactive, making it toxic to life.

**Biological functions of transition metals**

The d-block transition metals have great importance in our lives. They are building blocks for life and are found directly in the center of the periodic table. The d-block simply means that the elements’ d-orbitals are the last to get occupied according to the building-up principle. The transition metals give off electrons from their outer s orbital, but most can lose a multiple number of d orbital electrons. Because of this many of the d-block metals have multiple oxidation numbers. A good example is copper which has two common oxidation states +1 and +2. This causes d-block metals to make great catalysts.

Several transition elements are important to the chemistry of living systems, the most familiar examples being iron, cobalt, copper, and molybdenum. Iron is by far the most widespread and important transition metal that has a function in living systems; proteins containing iron participate in two main processes, oxygen transport and electron transfer (i.e., oxidation–reduction) reactions. There are also a number of substances that act to store and transport iron itself.

Though cobalt is understood to be an essential trace element in animal nutrition, the only detailed chemical knowledge of its biochemical action has to do with vitamin B12 and related co-enzymes. These molecules contain one atom of cobalt bound in a macrocyclic ring (i.e., one consisting of many atoms) called corrin, which is similar to a porphyrin ring. Copper is found in both plants and animals, and numerous copper-containing proteins have been isolated. The blood of many lower animals, such as mollusks, cephalopods, gastropods, and decapods, contains respiratory proteins called hemocyanins, which contain copper atoms (but no heme) and appear to bind one oxygen molecule per two copper atoms. Human serum contains a glycoprotein called ceruloplasmin, the molecule of which contains eight copper atoms; its biological function is still uncertain. Other proteins, called cerebrocuprein, erythrocuprein, and hepatocuprein, that are found in the mammalian brain, erythrocytes, and liver, respectively, contain about 60 percent of the total copper in those tissues; their functions are still unknown. There are a number of copper-containing enzymes; examples are (1) ascorbic acid [oxidase](http://www.britannica.com/science/oxidase) (an oxidase is an oxidizing enzyme), which contains eight atoms of copper per molecule; it is widely distributed in plants and microorganisms; (2) cytochrome oxidase, which contains heme and copper in a 1:1 ratio; (3) [tyrosinases](http://www.britannica.com/science/tyrosinase), which catalyze the formation of melanin (brownish-black pigments occurring in hair, skin, and retina of higher animals) and were the first enzymes in which copper was shown to be essential to function.

Vanadium occurs widely in petroleum, notably that from Venezuela, and can be isolated as porphyrin complexes, the origin of which is not known. Vanadium is present in high concentrations in blood cells (vanadocytes) of certain ascidians (sea squirts), apparently in a curious, complex, and poorly understood protein-containing substance called hemovanadin, thought to serve in oxygen transport. Molybdenum is believed to be a necessary trace element in animal diets, but its function and the minimum levels have not been established. Nitrogen-fixing bacteria utilize enzymes that contain both molybdenum and iron. One such enzyme, or at least a part of it that has been isolated in the crystalline state, contains two atoms of molybdenum and 40 atoms of iron. This protein in association with another, which contains only iron, can catalyze the reduction of nitrogen gas to nitrogen compounds.

Efforts to understand the function of transition metals in biological systems have led to the growth of the field of bioinorganic chemistry.

**Biological role of Zn, Cd, Hg**

The group 12 elements have multiple effects on biological organisms as cadmium and mercury are toxic while zinc is required by most plants and animals in trace amounts.

Zinc is an essential [trace element](https://en.wikipedia.org/wiki/Trace_element), necessary for plants, animals, and [microorganisms](https://en.wikipedia.org/wiki/Microorganism). It is "typically the second most abundant transition metal in organisms" after [iron](https://en.wikipedia.org/wiki/Iron) and it is the only metal which appears in all [enzyme classes](https://en.wikipedia.org/wiki/Enzyme#Naming_conventions). There are 2–4 grams of zincdistributed throughout the human body and it plays "ubiquitous biological roles". A 2006 study estimated that about 10% of human proteins (2800) potentially bind zinc, in addition to hundreds which transport and traffic zinc. In the U.S., the [Recommended Dietary Allowance](https://en.wikipedia.org/wiki/Recommended_Dietary_Allowance) (RDA) is 8 mg/day for women and 11 mg/day for men. Harmful excessive supplementation may be a problem and should probably not exceed 20 mg/day in healthy people, although the U.S. National Research Council set a Tolerable Upper Intake of 40 mg/day.

Mercury and cadmium are toxic and may cause environmental damage if they enter rivers or rain water. This may result in contaminated crops as well as the [bioaccumulation](https://en.wikipedia.org/wiki/Bioaccumulation) of mercury in a food chain leading to an increase in illnesses caused by [mercury](https://en.wikipedia.org/wiki/Mercury_poisoning) and [cadmium poisoning](https://en.wikipedia.org/wiki/Cadmium_poisoning).

**Summary of functions of transition metals**

|  |  |  |
| --- | --- | --- |
| **Element** | **Mass/ mg** | **Biological Roles** |
| Ti |  | biological function not clear. |
| V | 0.11 | found in [Amanita Muscaria (mushroom)](http://wwwchem.uwimona.edu.jm/gifs/amanita.gif)and in [Ascidians (sea squirts)](http://wwwchem.uwimona.edu.jm/gifs/cionaintest.jpg), Enzymes (nitrogenases, haloperoxidases), essential for humans |
| Cr | 14 | essential for higher animals [involved in carbohydrate utilisation](http://www.icdachromium.com/pdf/publications/crfile6sep99.htm) |
| Mn | 12 | Mn accumulates in mitochondria and is essential for their function. Some similarities to Mg2+. metalloenzymes included: arginase, glutamine synthetase, pyruvate carboxylase, SOD |
| Fe | 4200 | Extremely important eg [haem,](http://www.chemistry.wustl.edu/~edudev/LabTutorials/Hemoglobin/MetalComplexinBlood.html)[more on haemoglobin](http://www.umass.edu/microbio/chime/hemoglob/2frmcont.htm) Electron transfer systems, ferredoxins, N2 fixation involves Fe, Mo, S proteins. |
| Co | 3 | [Vitamin B12](http://www.chm.bris.ac.uk/motm/vitaminb12/) coenzyme contains Co3+ in corrin. |
| Ni | 15 | Nickel containing enzymes include, [urease](http://mmbr.asm.org/cgi/content/citation/51/1/22) and some hydrogenases |
| Cu | 72 | Some vertebrates use Cu-O2 carrier,[haemocyanin](http://www.brookscole.com/chemistry_d/templates/student_resources/0030244269_campbell/HotTopics/NonHbOxygenCarriers.html). Cu containing enzymes include: tyrosinase, amine oxidase and cytochrome oxidase |

Mass of the first row transition metal ions present in a 70 kg human and a summary of where they are found and their roles.

**Iron**

Iron is a biologically important transition metal as it is also vital to life - it is one of the few trace elements needed for organisms to sustain life. It has three main biological roles: 1. Transport oxygen from lungs to cells It is used to bind to [enzymes](https://en.wikibooks.org/wiki/Structural_Biochemistry/Enzyme) throughout the body, such as in [Hemoglobin](https://en.wikibooks.org/wiki/Structural_Biochemistry/Hemoglobin) to transport oxygen throughout the human body in blood. 2. Energy Production Iron is used in the conversation of sugar, fats, and proteins into adenosine triphosphate, ATP. 3. Catalase Production Iron is involved with the production of catalase and this is important because catalase protects the body from free radical damage.

Rich sources of iron in food include: red meat, soybean, white flour products, seafood, and sunflower seeds Despite its uses in biological systems, an excess amount of iron can be detrimental to the human body. First, iron can cause enzyme dysfunctions by replacing other vital minerals. All these essential minerals compete for binding sites in enzymes, and when iron replaces the competing mineral, it causes the enzyme to malfunction. Second, when iron replaces other elements in the body, it also causes inflammation. Iron attracts oxygen and when in excess, the free radical oxygen damages the surrounding body tissue. In addition, as a carrier for oxygen, iron promotes bacterial growth by feeding it oxygen, leading to chronic infections. Iron can mostly be found in the pancreas, joints, liver, and intestines.

Transition metals are also found in our bodies. Humans excrete about 1 mg of iron every day and must constantly have approximately three grams of iron in their bodies. The iron is mostly used as hemoglobin, which transports oxygen to the brain and muscles. Iron deficiency, or anemia, occurs when your body doesn’t have enough iron and causes one to become chronically tired. Cobalt is another transition metal our bodies need. It is a component of vitamin B12 which humans need in their diet.

**Physical Illnesses Associated with Iron**

* Diabetes
* Nervous System Diseases: Parkinson’s disease, Alzheimer’s disease and behavioral abnormalities, including violence, anti-social behavior, ADHD, and autistic characteristics.
* Hypertension and Cardiac Conditions
* Kidney Problems

**Copper**

Copper has a diverse role in the human body.

**Connective Tissue and Bones**

Copper repairs the calcium in bones and connective tissue. Insufficiency or excess can lead to conditions like osteoporosis, bone spurs, and scoliosis.

**Immune System**

In the immune system, copper must be in balanced with zinc. When these two elements are not balanced, the body is prone to infection, particularly yeast and fungal infections. Since copper is a critical element in aerobic metabolism, an improper level of copper allows the fungal organisms to flourish.

**Reproductive System**

Copper also plays a role in the reproductive system as it is required for pregnancy and fertility. An imbalance of copper can lead to premenstrual syndrome, ovarian cysts, miscarriages, and sexual dysfunctions. Studies have shown that woman with deficient estrogen and copper have a higher risk of miscarriage. Correcting the copper level by eating more meats, eggs, poultry, nuts, seeds, and grains can help with a normal pregnancy.

**Nervous System**

In the nervous system, copper plays a role in triggering the production of neurotransmitters epinephrine, norepinephrine and dopamine. As a result, copper imbalance can be associated with psychological, neurological, and emotional problems in humans.

Copper is used to bind to enzymes throughout the body. It is used to defend the body against damage from free radicals. Foods that contain copper include shellfish (i.e. crab, lobster, etc.), dried beans, and nuts.

Hemocyanin

[Hemocyanin](http://en.wikipedia.org/wiki/Hemocyanin%7C) is an excellent example of the use in proteins. Hemocyanin is an alternative O2 transport protein that involves the binding of O2 to the two Cu2+, which is then oxidized to Cu3+ after binding. It is different from [Hemoglobin](https://en.wikibooks.org/wiki/Structural_Biochemistry/Hemoglobin) in that in doesn't "tag along" with red blood cells, but is contained in hemolymph.

**Zinc**

Zinc is an inorganic compound that play an active role in biological settings. Its ability to adapt to various coordination geometries and its properties as a Lewis acid and redox inert makes it an important compound in structural and catalytic biochemistry.

Zinc undergoes rapid ligand exchange and is regulated by several proteins in cell signaling. For example, in the central nervous system, zinc is released from the synaptic vesicles at some glutamatergic nerve terminals to trigger signaling pathways which affect physiological functions such as synaptic plasticity, potentiation, and cell death. In addition, diabetes studies have shown that zinc is released along with insulin to control glucose levels.

Besides from being regulated, zinc is also capable of regulating other proteins by shifting its concentration. Zinc can influence the productivity of nitric oxide which changes the immune system. Lack of zinc in the body weakens the immune system and leaves the body prone for infections. In the prostate glandular epithelium, a change in the normal concentration level can lead to complications in the prostate. In the nervous system, a concentration of zinc that is too high can mean mitochondrial dysfunctions.

**Cobalt**

Cobalt is at the core of B12 vitamins.The structure of this is based on the corrin ring. It is used to treat anemia because it stimulates the production of erythropoietin which makes red blood cells. Like any other element, a high concentration of cobalt is harmful to the human body. Excess intake of cobalt can result in vomiting, nausea, vision problems, heart problems, and thyroid damage. We mainly obtain it from the environment by breathing air, drinking water, and eating food that contain cobalt such as meats, dairy, and leafy green vegetables.

Radioactive cobalt can also cause health concerns. This type of radiation is sometimes used to treat cancer patients. Exposure affects include hair loss, diarrhea,and vomiting.

There are several enzymes that contain cobalt and use it as a ligand to bind to methyls and adenosyl. It is thought that cobalt acts by inhibition of enzymes involved in oxidative metabolism and that the response is the result of tissue hypoxia. More specifically, cobalt blocks the conversion of pyruvate to acetyl coenzyme A (coA) and of α-ketoglutarate to succinate.

**Mercury**

Mercury was an important constituent of [drugs](https://en.wikibooks.org/wiki/Structural_Biochemistry/Medicine_%26_Drug_Design) for centuries-as an ingredient in many diuretics, antibacterials, antiseptics, skin ointments, and laxatives. The use of mercury in medicinal preparations has dramatically decreased due to the toxic effects that it has in the human body, such as nausea, vomiting, abdominal pain, bloody diarrhea, kidney damage, and death. Mercury readily forms covalent bonds with sulfur, and it is this property that accounts for most of the biological properties of the metal. When the sulfur is in the form of sulfhydryl groups, divalent mercury replaces the hydrogen atom to form mercaptides, X-Hg-SR and Hg(SR)2, where X is an electronegative radical and R is a protein. Organic mercurials form mercaptides of the type RHg-SR'. Mercurials even in low concentrations are capable of inactivating sulfhydryl enzymes and thus interfering with cellular metabolism and function. Mercury also combines with other ligands of physiological importance, such as [phosphoryl](https://en.wikibooks.org/wiki/Structural_Biochemistry/Organic_Chemistry/Organic_Functional_Group/Phosphate), [carboxyl](https://en.wikibooks.org/wiki/Structural_Biochemistry/Organic_Chemistry/Organic_Functional_Group/Carboxyl), amide, and amine groups.

**Chromium**

In mammals, chromium, a micronutrient, is only required in small quantities in biological systems. While the exact roles that chromium plays in the body is still unknown, research has proposed that chromium helps maintain proper carbohydrate and lipid metabolism. In the late 1950s. Schwarz and Mertz showed the importance of chromium through experiments involving the diets of rats. When the rats were fed with Torula yeast, a diet lacking chromium, the rats were unable to efficiently remove glucose from the bloodstream. Then when the rats were fed with food rich in chromium, the rats were able to maintain a normal glucose level. This experiment became evidence that chromium depends on insulin.

In the 1980s, Wada and Yamamoto were able to isolate the oligopeptide that binds chromium. This peptide is called chromodulin. Chromodulin is a small molecule of about 1500 Da and can bind four equivalents of chromium ions. The most significant characteristic of chromodulin is its ability of effect insulin by conversion of glucose into carbon dioxide or lipid.

In addition, there has also been some studies that suggests chromium and chromodulin play a role in signal transduction. Analysis of how chromodulin activate or inhibit phosphatase and kinase activity in rat adipocytes reveal an effect of small activation of a membrane phosphotyrosin phosphatase and a significant stimulation of insulin receptor tyrosine kinase activity.

**Manganese**

The human body averagely contains about 10 to 20 milligrams of manganese mostly concentrated in the pancreas, bone, liver, and kidneys. Manganese plays a role as a cofactor to important enzymes in the mitochondria and in the synthesis of glycoproteins. It can also act as a catalyst in enzyme processes involved in the synthesis of fatty acids and cholesterol. In skeletal and connective tissue development, manganese is involved in the process of mucopolysaccharide synthesis which is important in skeletal and cartilage structural matrix. Lack of manganese can lead to formation of abnormal cartilage and skeletal tissue, impaired connective tissue, poor muscle coordination,and impaired glucose tolerance and management of blood sugar levels. In the liver, manganese helps enzymes convert arginine to urea. In addition, manganese accompanies the enzyme pyruvate carboxylase which converts various non-carbohydrate substances into glucose for later use.