= Selenium =

Selenium is a chemical element with symbol Se and atomic number 34 . It is a nonmetal with properties that are intermediate between the elements above and below in the periodic table , sulfur and tellurium . It rarely occurs in its elemental state or as pure ore compounds in the Earth 's crust . Selenium (Greek ?????? selene meaning " Moon ") was discovered in 1817 by Jöns Jacob Berzelius , who noted the similarity of the new element to the previously discovered tellurium (named for the Earth) .

Selenium is found in metal sulfide ores , where it partially replaces the sulfur . Commercially , selenium is produced as a byproduct in the refining of these ores , most often during production . Minerals that are pure selenide or selenate compounds are known but rare . The chief commercial uses for selenium today are glassmaking and pigments . Selenium is a semiconductor and is used in photocells . Applications in electronics , once important , have been mostly supplanted by silicon semiconductor devices . Selenium is still used in a few types of DC power surge protectors and one type of fluorescent quantum dot .

Selenium salts are toxic in large amounts , but trace amounts are necessary for cellular function in many organisms , including all animals . Selenium is an ingredient in many multivitamins and other dietary supplements , including infant formula . It is a component of the antioxidant enzymes glutathione peroxidase and thioredoxin reductase (which indirectly reduce certain oxidized molecules in animals and some plants) . It is also found in three deiodinase enzymes , which convert one thyroid hormone to another . Selenium requirements in plants differ by species , with some plants requiring relatively large amounts and others apparently requiring none .

= = Characteristics = =

= = = Physical properties = = =

Selenium forms several allotropes that interconvert with temperature changes , depending somewhat on the rate of temperature change . When prepared in chemical reactions , selenium is usually an amorphous , brick @-@ red powder . When rapidly melted , it forms the black , vitreous form , usually sold commercially as beads . The structure of black selenium is irregular and complex and consists of polymeric rings with up to 1000 atoms per ring . Black Se is a brittle , lustrous solid that is slightly soluble in CS2 . Upon heating , it softens at 50 ° C and converts to gray selenium at 180 ° C ; the transformation temperature is reduced by presence of halogens and amines .

The red ? , ? , and ? forms are produced from solutions of black selenium by varying the evaporation rate of the solvent (usually CS2) . They all have relatively low , monoclinic crystal symmetries and contain nearly identical puckered Se8 rings with different arrangements , as in sulfur . The packing is most dense in the ? form . In the Se8 rings , the Se @-@ Se distance is 233 @.@ 5 pm and Se @-@ Se @-@ Se angle is 105 @.@ 7 ° . Other selenium allotropes may contain Se6 or Se7 rings .

The most stable and dense form of selenium is gray and has a hexagonal crystal lattice consisting of helical polymeric chains , where the Se @-@ Se distance is 237 @.@ 3 pm and Se @-@ Se @-@ Se angle is 130 @.@ 1 ° . The minimum distance between chains is 343 @.@ 6 pm . Gray Se is formed by mild heating of other allotropes , by slow cooling of molten Se , or by condensing Se vapor just below the melting point . Whereas other Se forms are insulators , gray Se is a semiconductor showing appreciable photoconductivity . Unlike the other allotropes , it is insoluble in CS2 . It resists oxidation by air and is not attacked by nonoxidizing acids . With strong reducing agents , it forms polyselenides . Selenium does not exhibit the changes in viscosity that sulfur undergoes when gradually heated .

= = = Isotopes = = =

Selenium has six naturally occurring isotopes . Synthetic isotope 79Se and 23 others have been identified :

82Se is stable , for all practical purposes . See also Selenium @-@ 79 for recent changes in the measured half @-@ life of 79Se , which are important for the dose calculations in the geological disposal of long @-@ lived radioactive waste .

= = Chemical compounds = =

Selenium compounds commonly exist in the oxidation states ? 2 , + 2 , + 4 , and + 6 .

= = = Chalcogen compounds = = =

Selenium forms two oxides : selenium dioxide (SeO2) and selenium trioxide (SeO3) . Selenium dioxide is formed by the reaction of elemental selenium with oxygen :

Se8 + 8 O2 ? 8 SeO2

It is a polymeric solid that forms monomeric SeO2 molecules in the gas phase . It dissolves in water to form selenous acid , H2SeO3 . Selenous acid can also be made directly by oxidizing elemental selenium with nitric acid :

3 Se + 4 HNO3 + H2O ? 3 H2SeO3 + 4 NO

Unlike sulfur , which forms a stable trioxide , selenium trioxide is thermodynamically unstable and decomposes to the dioxide above 185 ° C :

2 SeO3 ? 2 SeO2 + O2 (?H = ? 54 kJ / mol)

Selenium trioxide is produced in the laboratory by the reaction of anhydrous potassium selenate (K2SeO4) and sulfur trioxide (SO3) .

Salts of selenous acid are called selenites . These include silver selenite (Ag2SeO3) and sodium selenite (Na2SeO3) .

Hydrogen sulfide reacts with aqueous selenous acid to produce selenium disulfide :

H2SeO3 + 2 H2S ? SeS2 + 3 H2O

Selenium disulfide consists of 8 @-@ membered rings . It has an approximate composition of SeS2 , with individual rings varying in composition , such as Se4S4 and Se2S6 . Selenium disulfide has been used in shampoo as an antidandruff agent , an inhibitor in polymer chemistry , a glass dye , and a reducing agent in fireworks .

Selenium trioxide may be synthesized by dehydrating selenic acid , H2SeO4 , which is itself produced by the oxidation of selenium dioxide with hydrogen peroxide :

SeO2 + H2O2 ? H2SeO4

Hot , concentrated selenic acid can react with gold to form gold (III) selenate .

= = = Halogen compounds = = =

Iodides of selenium are not well known . The only stable chloride is selenium monochloride (Se2Cl2) , which might be better known as selenium (I) chloride ; the corresponding bromide is also known . These species are structurally analogous to the corresponding disulfur dichloride . Selenium dichloride is an important reagent in the preparation of selenium compounds (e.g. the preparation of Se7) . It is prepared by treating selenium with sulfuryl chloride (SO2Cl2) . Selenium reacts with fluorine to form selenium hexafluoride :

Se8 + 24 F2 ? 8 SeF6

In comparison with its sulfur counterpart (sulfur hexafluoride) , selenium hexafluoride (SeF6) is more reactive and is a toxic pulmonary irritant . Some of the selenium oxyhalides , such as selenium oxyfluoride (SeOF2) and selenium oxychloride (SeOCl2) have been used as specialty solvents .

= = = Selenides = = =

Analogous to the behavior of other chalcogens , selenium forms hydrogen selenide , H2Se . It is a

strongly odiferous , toxic , and colorless gas . It is more acidic than H2S . In solution it ionizes to HSe ? . The selenide dianion Se2 ? forms a variety of compounds , including the minerals from which selenium is obtained commercially . Illustrative selenides include mercury selenide (HgSe) , lead selenide (PbSe) , zinc selenide (ZnSe) , and copper indium gallium diselenide (Cu (Ga , In) Se2) . These materials are semiconductors . With highly electropositive metals , such as aluminium , these selenides are prone to hydrolysis :
Al2Se3 + 6 H2O ? Al2O3 + 6 H2Se
Alkali metal selenides react with selenium to form polyselenides , Se2 ?
n , which exist as chains .

= = = Other compounds = = =

Tetraselenium tetranitride , Se4N4 , is an explosive orange compound analogous to tetrasulfur tetranitride (S4N4) . It can be synthesized by the reaction of selenium tetrachloride (SeCl4) with [((CH
3)
3Si)
2N]
2Se .
Selenium reacts with cyanides to yield selenocyanates :
8 KCN + Se8 ? 8 KSeCN

= = = Organoselenium compounds = = =

Selenium , especially in the II oxidation state , forms stable bonds to carbon , which are structurally analogous to the corresponding organosulfur compounds . Especially common are selenides (R2Se , analogues of thioethers) , diselenides (R2Se2 , analogues of disulfides) , and selenols (RSeH , analogues of thiols) . Representatives of selenides , diselenides , and selenols include respectively selenomethionine , diphenyldiselenide , and benzeneselenol . The sulfoxide in sulfur chemistry is represented in selenium chemistry by the selenoxides (formula RSe (O) R) , which are intermediates in organic synthesis , as illustrated by the selenoxide elimination reaction . Consistent with trends indicated by the double bond rule , selenoketones , R (C = Se) R , and selenaldehydes , R (C = Se) H , are rarely observed .

= = History = =

Selenium (Greek ?????? selene meaning " Moon ") was discovered in 1817 by Jöns Jakob Berzelius and Johan Gottlieb Gahn . Both chemists owned a chemistry plant near Gripsholm , Sweden , producing sulfuric acid by the lead chamber process . The pyrite from the Falun mine created a red precipitate in the lead chambers which was presumed to be an arsenic compound , so the pyrite 's use to make acid was discontinued . Berzelius and Gahn wanted to use the pyrite and they also observed that the red precipitate gave off a smell like horseradish when burned . This smell was not typical of arsenic , but a similar odor was known from tellurium compounds . Hence , Berzelius 's first letter to Alexander Marcet stated that this was a tellurium compound . However , the lack of tellurium compounds in the Falun mine minerals eventually led Berzelius to reanalyze the red precipitate , and in 1818 he wrote a second letter to Marcet describing a newly found element similar to sulfur and tellurium . Because of its similarity to tellurium , named for the Earth , Berzelius named the new element after the Moon .
In 1873 , Willoughby Smith found that the electrical resistance of grey selenium was dependent on the ambient light . This led to its use as a cell for sensing light . The first commercial products using selenium were developed by Werner Siemens in the mid @-@ 1870s . The selenium cell was used in the photophone developed by Alexander Graham Bell in 1879 . Selenium transmits an electric current proportional to the amount of light falling on its surface . This phenomenon was used in the

design of light meters and similar devices . Selenium 's semiconductor properties found numerous other applications in electronics . The development of selenium rectifiers began during the early 1930s , and these replaced copper oxide rectifiers because they were more efficient . These lasted in commercial applications until the 1970s , following which they were replaced with less expensive and even more efficient silicon rectifiers .

Selenium came to medical notice later because of its toxicity to human beings working in industries . Selenium was also recognized as an important veterinary toxin , which is seen in animals that have eaten high @-@ selenium plants . In 1954 , the first hints of specific biological functions of selenium were discovered in microorganisms . It was discovered to be essential for mammalian life 1957 . In the 1970s , it was shown to be present in two independent sets of enzymes . This was followed by the discovery of selenocysteine in proteins . During the 1980s , selenocysteine was shown to be encoded by the codon UGA . The recoding mechanism was worked out first in bacteria and then in mammals (see SECIS element) .

= = Occurrence = =

Native (i.e. , elemental) selenium is a rare mineral , which does not usually form good crystals , but , when it does , they are steep rhombohedra or tiny acicular (hair @-@ like) crystals . Isolation of selenium is often complicated by the presence of other compounds and elements .

Selenium occurs naturally in a number of inorganic forms , including selenide , selenate , and selenite , but these minerals are rare . The common mineral selenite is not a selenium mineral , and contains no selenite ion , but is rather a type of gypsum (calcium sulfate hydrate) named like selenium for the moon well before the discovery of selenium . Selenium is most commonly found as an impurity , replacing a small part of the sulfur in sulfide ores of many metals .

In living systems , selenium is found in the amino acids selenomethionine , selenocysteine , and methylselenocysteine . In these compounds , selenium plays a role analogous to that of sulfur . Another naturally occurring organoselenium compound is dimethyl selenide .

Certain solids are selenium @-@ rich , and selenium can be bioconcentrated by some plants . In soils , selenium most often occurs in soluble forms such as selenate (analogous to sulfate) , which are leached into rivers very easily by runoff . Ocean water contains significant amounts of selenium .

Anthropogenic sources of selenium include coal burning , and the mining and smelting of sulfide ores .

= = Production = =

Selenium is most commonly produced from selenide in many sulfide ores , such as those of copper , nickel , or lead . Electrolytic metal refining is particularly productive of selenium as a byproduct , obtained from the anode mud of copper refineries . Another source was the mud from the lead chambers of sulfuric acid plants , a process that is no longer used . Selenium can be refined from these muds by a number of methods . However , most elemental selenium comes as a byproduct of refining copper or producing sulfuric acid . Since its invention , solvent extraction and electrowinning (SX / EW) production of copper produces an increasing share of the worldwide copper supply . This changes the availability of selenium because only a comparably small part of the selenium in the ore is leached with the copper .

Industrial production of selenium usually involves the extraction of selenium dioxide from residues obtained during the purification of copper . Common production from the residue then begins by oxidation with sodium carbonate to produce selenium dioxide , which is mixed with water and acidified to form selenous acid (oxidation step) . Selenous acid is bubbled with sulfur dioxide (reduction step) to give elemental selenium .

About 2 @,@ 000 tonnes of selenium were produced in 2011 worldwide , mostly in Germany (650 t) , Japan (630 t) , Belgium (200 t) , and Russia (140 t) , and the total reserves were estimated at 93 @,@ 000 tonnes . These data exclude two major producers , the United States and China . A

previous sharp increase was observed in 2004 from 4 ? 5 to $ 27 / lb . The price was relatively stable during 2004 ? 2010 at about US $ 30 per pound (in 100 @-@ pound lots) but increased to $ 65 / lb in 2011 . The consumption in 2010 was divided as follows : metallurgy ? 30 % , glass manufacturing ? 30 % , agriculture ? 10 % , chemicals and pigments ? 10 % , and electronics ? 10 % . China is the dominant consumer of selenium at 1 @,@ 500 ? 2 @,@ 000 tonnes / year .

= = Applications = =

= = = Manganese electrolysis = = =

During the electro winning of manganese , the addition of selenium dioxide decreases the power necessary to operate the electrolysis cells . China is the largest consumer of selenium dioxide for this purpose . For every tonne of manganese , an average 2 kg selenium oxide is used .

= = = Glass production = = =

The largest commercial use of Se , accounting for about 50 % of consumption , is for the production of glass . Se compounds confer a red color to glass . This color cancels out the green or yellow tints that arise from iron impurities typical for most glass . For this purpose , various selenite and selenate salts are added . For other applications , a red color may be desired , produced by mixtures of CdSe and CdS .

= = = Alloys = = =

Selenium is used with bismuth in brasses to replace more toxic lead . The regulation of lead in drinking water applications with the Safe Drinking Water Act of 1974 made a reduction of lead in brass necessary . The new brass is marketed under the name EnviroBrass . Like lead and sulfur , selenium improves the machinability of steel at concentrations around 0 @.@ 15 % . Selenium produces the same machinability improvement in copper alloys .

= = = = Solar cells = = = =

Copper indium gallium selenide is a material used in solar cells .

= = = Other uses = = =

Small amounts of organoselenium compounds are used to modify the vulcanization catalysts for the production of rubber .

The demand for selenium by the electronics industry is declining , despite a number of continuing applications . Its photovoltaic and photoconductive properties are still useful in photocopying , photocells , light meters and solar cells . Its use as a photoconductor in plain @-@ paper copiers once was a leading application , but in the 1980s , the photoconductor application declined (although it was still a large end @-@ use) as more and more copiers switched to organic photoconductors . Though once widely used , selenium rectifiers have mostly been replaced (or are being replaced) by silicon @-@ based devices . The most notable exception is in power DC surge protection , where the superior energy capabilities of selenium suppressors make them more desirable than metal oxide varistors .

Zinc selenide was the first material for blue LEDs , but gallium nitride is dominating the market now . Cadmium selenide was an important component in quantum dots . Sheets of amorphous selenium convert X @-@ ray images to patterns of charge in xeroradiography and in solid @-@ state , flat @-@ panel X @-@ ray cameras .

Selenium is a catalyst in some chemical reactions , but it is not widely used because of issues with

toxicity . In X @-@ ray crystallography , incorporation of one or more selenium atoms in place of sulfur helps with multiple @-@ wavelength anomalous dispersion and single wavelength anomalous dispersion phasing .

Selenium is used in the toning of photographic prints , and it is sold as a toner by numerous photographic manufacturers . Selenium intensifies and extends the tonal range of black @-@ and @-@ white photographic images and improves the permanence of prints .

75Se is used as a gamma source in industrial radiography .

= = Biological role = =

Although it is toxic in large doses , selenium is an essential micronutrient for animals . In plants , it occurs as a bystander mineral , sometimes in toxic proportions in forage (some plants may accumulate selenium as a defense against being eaten by animals , but other plants , such as locoweed , require selenium , and their growth indicates the presence of selenium in soil) . See more on plant nutrition below .

Selenium is a component of the unusual amino acids selenocysteine and selenomethionine . In humans , selenium is a trace element nutrient that functions as cofactor for reduction of antioxidant enzymes , such as glutathione peroxidases and certain forms of thioredoxin reductase found in animals and some plants (this enzyme occurs in all living organisms , but not all forms of it in plants require selenium) .

The glutathione peroxidase family of enzymes (GSH @-@ Px) catalyze certain reactions that remove reactive oxygen species such as hydrogen peroxide and organic hydroperoxides :

2 GSH + H2O2----GSH @-@ Px ? GSSG + 2 H2O

The thyroid gland and every cell that uses thyroid hormone use selenium , which is a cofactor for the three of the four known types of thyroid hormone deiodinases , which activate and then deactivate various thyroid hormones and their metabolites ; the iodothyronine deiodinases are the subfamily of deiodinase enzymes that use selenium as the otherwise rare amino acid selenocysteine . (Only the deiodinase , iodotyrosine deiodinase , which works on the last breakdown products of thyroid hormone , does not use selenium .)

Selenium may inhibit Hashimoto 's disease , in which the body 's own thyroid cells are attacked as alien . A reduction of 21 % on TPO antibodies is reported with the dietary intake of 0 @.@ 2 mg of selenium .

Increased dietary selenium reduces the effects of mercury toxicity , although it is effective only at low to modest doses of mercury . Evidence suggests that the molecular mechanisms of mercury toxicity includes the irreversible inhibition of selenoenzymes that are required to prevent and reverse oxidative damage in brain and endocrine tissues .

= = = Evolution in biology = = =

From about three billion years ago , prokaryotic selenoprotein families drive the evolution of selenocysteine , an amino acid . Selenium is incorporated into several prokaryotic selenoprotein families in bacteria , archaea , and eukaryotes as selenocysteine , where selenoprotein peroxiredoxins protect bacterial and eukaryotic cells against oxidative damage . Selenoprotein families of GSH @-@ Px and the deiodinases of eukaryotic cells seem to have a bacterial phylogenetic origin . The selenocysteine @-@ containing form occurs in species as diverse as green algae , diatoms , sea urchin , fish , and chicken . Selenium enzymes are involved in the small reducing molecules glutathione and thioredoxin . One family of selenium @-@ bearing molecules (the glutathione peroxidases) destroys peroxide and repairs damaged peroxidized cell membranes , using glutathione . Another selenium @-@ bearing enzyme in some plants and in animals (thioredoxin reductase) generates reduced thioredoxin , a dithiol that serves as an electron source for peroxidases and also the important reducing enzyme ribonucleotide reductase that makes DNA precursors from RNA precursors .

Trace elements involved in GSH @-@ Px and superoxide dismutase enzymes activities , i.e.

selenium , vanadium , magnesium , copper , and zinc , may have been lacking in some terrestrial mineral @-@ deficient areas . Marine organisms retained and sometimes expanded their selenoproteomes , whereas the selenoproteomes of some terrestrial organisms were reduced or completely lost . These findings suggest that , with the exception of vertebrates , aquatic life supports selenium use , whereas terrestrial habitats lead to reduced use of this trace element . Marine fishes and vertebrate thyroid glands have the highest concentration of selenium and iodine . From about 500 million years ago , freshwater and terrestrial plants slowly optimized the production of " new " endogenous antioxidants such as ascorbic acid (vitamin C) , polyphenols (including flavonoids) , tocopherols , etc . A few of these appeared more recently , in the last 50 ? 200 million years , in fruits and flowers of angiosperm plants . In fact , the angiosperms (the dominant type of plant today) and most of their antioxidant pigments evolved during the late Jurassic period .

The deiodinase isoenzymes constitute another family of eukaryotic selenoproteins with identified enzyme function . Deiodinases are able to extract electrons from iodides , and iodides from iodothyronines . They are , thus , involved in thyroid @-@ hormone regulation , participating in the protection of thyrocytes from damage by H2O2 produced for thyroid @-@ hormone biosynthesis . About 200 million years ago , new selenoproteins were developed as mammalian GSH @-@ Px enzymes .

= = = Nutritional sources of selenium = = =

Dietary selenium comes from nuts , cereals and mushrooms . Brazil nuts are the richest dietary source (though this is soil @-@ dependent , since the Brazil nut does not require high levels of the element for its own needs) .

Recommended Dietary Allowance ~ 55 µg / day . Selenium as a dietary supplement is available in many forms , including multi @-@ vitamins / mineral supplements - typically 20 µg / day . Selenium @-@ specific supplements may have -200 µg / day .

In June 2015 the U.S. Food and Drug Administration (FDA) published its final rule establishing the requirement of minimum and maximum levels of selenium in infant formula .

The selenium content in the human body is believed to be in the 13 ? 20 milligram range .

= = = Indicator plant species = = =

Certain species of plants are considered indicators of high selenium content of the soil becauses they require high levels of selenium to thrive . The main selenium indicator plants are Astragalus species (including some locoweeds) , prince 's plume (Stanleya sp .) , woody asters (Xylorhiza sp .) , and false goldenweed (Oonopsis sp .)

= = = Medical use = = =

The substance loosely called selenium sulfide (approximate formula , SeS2) is the active ingredient in some anti @-@ dandruff shampoos . The selenium compound kills the scalp fungus Malassezia , which causes shedding of dry skin fragments . The ingredient is also used in body lotions to treat tinea versicolor due to infection by a different species of Malassezia fungus .

= = = Detection in biological fluids = = =

Selenium may be measured in blood , plasma , serum , or urine to monitor excessive environmental or occupational exposure , to confirm a diagnosis of poisoning in hospitalized victims , or investigate a suspected case of fatal overdose . Some analytical techniques are capable of distinguishing organic from inorganic forms of the element . Both organic and inorganic forms of selenium are largely converted to monosaccharide conjugates (selenosugars) in the body prior elimination in the urine . Cancer patients receiving daily oral doses of selenothionine may achieve very high plasma and urine selenium concentrations .

= = = Toxicity = = =

Although selenium is an essential trace element , it is toxic if taken in excess . Exceeding the Tolerable Upper Intake Level of 400 micrograms per day can lead to selenosis . This 400 µg Tolerable Upper Intake Level is based primarily on a 1986 study of five Chinese patients who exhibited overt signs of selenosis and a follow up study on the same five people in 1992 . The 1992 study actually found the maximum safe dietary Se intake to be approximately 800 micrograms per day (15 micrograms per kilogram body weight) , but suggested 400 micrograms per day to avoid creating an imbalance of nutrients in the diet and to accord with data from other countries . In China , people who ingested corn grown in extremely selenium @-@ rich stony coal (carbonaceous shale) have suffered from selenium toxicity . This coal was shown to have selenium content as high as 9 @.@ 1 % , the highest concentration in coal ever recorded .

Signs and symptoms of selenosis include a garlic odor on the breath , gastrointestinal disorders , hair loss , sloughing of nails , fatigue , irritability , and neurological damage . Extreme cases of selenosis can exhibit cirrhosis of the liver , pulmonary edema , or death . Elemental selenium and most metallic selenides have relatively low toxicities because of low bioavailability . By contrast , selenates and selenites have an oxidant mode of action similar to that of arsenic trioxide and are very toxic . The chronic toxic dose of selenite for humans is about 2400 to 3000 micrograms of selenium per day . Hydrogen selenide is an extremely toxic , corrosive gas . Selenium also occurs in organic compounds , such as dimethyl selenide , selenomethionine , selenocysteine and methylselenocysteine , all of which have high bioavailability and are toxic in large doses .

On 19 April 2009 , 21 polo ponies died shortly before a match in the United States Polo Open . Three days later , a pharmacy released a statement explaining that the horses had received an incorrect dose of one of the ingredients used in a vitamin / mineral supplement compound that had been incorrectly compounded by a compounding pharmacy . Analysis of blood levels of inorganic compounds in the supplement indicated the selenium concentrations were ten to fifteen times higher than normal in the blood samples , and 15 to 20 times higher than normal in the liver samples . Selenium was later confirmed to be the toxic factor .

Selenium poisoning of water systems may result whenever new agricultural runoff courses through normally dry , undeveloped lands . This process leaches natural soluble selenium compounds (such as selenates) into the water , which may then be concentrated in new " wetlands " as the water evaporates . Selenium pollution of waterways also occurs when selenium is leached from coal flue ash , mining and metal smelting , crude oil processing , and landfill . The resultant high selenium levels in waterways were found to cause congenital disorders in oviparous species , including wetland birds and fish . Elevated dietary methylmercury levels can amplify the harm of selenium toxicity in oviparous species .

In fish and other wildlife , selenium is necessary for life , but toxic in high doses . For salmon , the optimal concentration of selenium is about 1 microgram selenium per gram of whole body weight . Much below that level , young salmon die from deficiency ; much above , they die from toxic excess .

The Occupational Safety and Health Administration (OSHA) has set the legal limit (Permissible exposure limit) for selenium in the workplace at 0 @.@ 2 mg / m3 over an 8 @-@ hour workday . The National Institute for Occupational Safety and Health (NIOSH) has set a Recommended exposure limit (REL) of 0 @.@ 2 mg / m3 over an 8 @-@ hour workday . At levels of 1 mg / m3 , selenium is immediately dangerous to life and health .

= = = Deficiency = = =

Selenium deficiency is rare in otherwise healthy , well @-@ nourished individuals . It can occur in patients with severely compromised intestinal function , those undergoing total parenteral nutrition , and in those of advanced age (over 90) . Also , people dependent on food grown from selenium @-@ deficient soil are at risk . Although New Zealand soil has low levels of selenium , adverse

health effects have not been detected in the residents .

Selenium deficiency , defined by low (< 60 % of normal) selenoenzyme activity levels in brain and endocrine tissues , occurs only when a low selenium level is linked with an additional stress , such as high exposures to mercury or increased oxidant stress from vitamin E deficiency .

Selenium interacts with other nutrients , such as iodine and vitamin E. The effect of selenium deficiency on health remains uncertain , particularly in relation to Kashin @-@ Beck disease . Also , selenium interacts with other minerals , such as zinc and copper . High doses of Se supplements in pregnant animals might disturb the Zn : Cu ratio and lead to Zn reduction ; in such treatment cases , Zn levels should be monitored . Further studies are needed to con?rm these interactions .

In the regions (e.g. various regions within North America) where low selenium soil levels lead to low concentrations in the plants , some animal species may be deficient unless selenium is supplemented with diet or injection . Ruminants are particularly susceptible . In general , absorption of dietary selenium is lower in ruminants than other animals , and is lower from forages than from grain . Ruminants grazing certain forages , e.g. , some white clover varieties containing cyanogenic glycosides , may have higher selenium requirements , presumably because cyanide is released from the aglycone by glucosidase activity in the rumen and glutathione peroxidases is deactivated by the cyanide acting on the glutathione moiety . Neonate ruminants at risk of WMD (white muscle disease) may be administered both selenium and vitamin E by injection ; some of the WMD myopathies respond only to selenium , some only to vitamin E , and some to either .

= = = Controversial health effects = = =

A number of correlative epidemiological studies have implicated selenium deficiency (measured by blood levels) in a number of serious or chronic diseases , such as cancer , diabetes , HIV / AIDS , and tuberculosis . In addition , selenium supplementation has been found to be a chemopreventive for some types of cancer in some types of rodents . However , in randomized , blinded , controlled prospective trials in humans , selenium supplementation has not succeeded in reducing the incidence of any disease , nor has a meta @-@ analysis of such selenium supplementation studies detected a decrease in overall mortality .