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ROLE OF STRONTIUM IN BIOLOGICAL SYSTEMS

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Strontium in biological systems

Discovery and Naming

Strontium is a soft metal like lead and, when freshly cut, has a silvery lustre. A mineral from a lead mine near the village of Strontian, in Argyll, Scotland, was originally misidentified as a type of barium carbonate, but Adair Crawford and William Cruickshank in 1789 noted that it was likely a different substance (1). The chemist Thomas Charles Hope named the new mineral strontites, after the village, and the corresponding earth (strontium oxide, SrO) was accordingly referred to as strontia. The metal was isolated (1808) by Sir Humphry Davy, who electrolyzed a mixture of the moist hydroxide or chloride with mercuric oxide, using a mercury cathode, and then evaporated the mercury from the resultant amalgam. He used the stem of the word strontia to form the name of the element.[1]

Occurrence in nature

Strontium is a relatively abundant element in the Earth's crust. It ranks about 15th among the elements found in the Earth. That makes it about as abundant as 45 fluorine and its alkaline earth partner, barium. Its cosmic abundance is estimated as 18.9 atoms (on a scale where the abundance of silicon = 10^6 atoms).[2]

The most common minerals containing strontium are celestine and strontianite. Celestine contains primarily strontium sulfate ($SrSO_4$), while strontianite contains mostly strontium carbonate ($SrCO_3$).[3] Celestite occurs frequently in sedimentary deposits of sufficient size, thus the development of mining facilities attractive. The main mining areas are UK, Mexico, Turkey and Spain. World production of strontium ores is about 140.000 tonnes per year from an unassessed total of reserves.[3] Important world sources of strontium are Mexico, Spain, Turkey, and Iran. A small amount of strontium is also obtained from mines in California and Texas.[3] Strontium may be obtained in the form of sticks by the contact cathode method of electrolysis, in which a cooled iron rod, acting as a cathode, just touches the surface of a fused mixture of potassium and strontium chlorides and is raised as the strontium solidifies on it.[4, 5]

Metallic strontium may be also obtained by reduction of the oxide with aluminum. The metal is malleable and ductile and a good conductor of electricity, but there are relatively few uses for elemental strontium. One of them is as an alloying agent for aluminum or magnesium in cast engine blocks and wheels; the strontium improves the machinability and creep resistance of the metal.[6]

In general, the chemistry of strontium is quite similar to that of calcium. In its compounds strontium has an exclusive oxidation state of +2, as the Sr^{2+} ion. The metal 46 is an active reducing agent and readily reacts with halogens, oxygen, and sulfur to yield halides, oxide, and sulfide.[7] Strontium compounds have rather limited commercial value because the corresponding calcium and barium compounds generally serve the same purpose yet are cheaper.

Physical & Chemical properties

Strontium is a soft, silver-yellow, alkaline-earth metal. It has three allotropic crystalline forms and in its physical and chemical properties it is similar to calcium and barium. Strontium reacts vigorously with water and quickly tarnishes in air, so it must be stored out of contact with air and water. It must be stored under kerosene or mineral oil (8). Due to its extreme reactivity to air, this element always naturally occurs combined with other elements and compounds. Finely powdered strontium metal will ignite spontaneously in air to produce both strontium oxide and strontium nitride. Strontium also reacts with cold water and with acids to release hydrogen gas.[8]

Applications

Strontium has uses similar to those of calcium and barium, but it is rarely employed because of its higher cost. Principal uses of strontium compounds are in pyrotechnics, for the brilliant reds in fireworks and warning flares and in greases. A little is used as a getter in vacuum tubes to remove the last traces of air. Most strontium is used as the carbonate in special glass for television screens and visual display units.[9] Although strontium-90 is a dangerously radioactive isotope, it is a useful by-product of nuclear reactors from whose spent fuel is extracted. Its high-energy radiation can be used to generate an electric current, and for this reason it can be used in space vehicles, remote weather stations and navigation buoys. Strontium-90 is used to measure the density of silk and tobacco products. Strontium-90 has medical applications. A recent advance is to use the isotope for the control of pain.[10]

Injecting strontium-90 into a person's body is now an alternative to the use of drugs. The strontium-90 deposits in the bones, just as the calcium does. Within bones, the isotope stops pain signals being sent to the brain. Strontium-90 is used to treat a variety of eye disorders. And strontium-85 and strontium-87m are used to study the condition of bones in a person's body.[11]

Strontium hydroxide, $Sr(OH)_2$, is sometimes used to extract sugar from molasses because it forms a soluble saccharide from which the sugar can be easily regenerated by the action of carbon dioxide. Strontium monosulfide, SrS, is employed as a depilatory and as an ingredient in phosphorus for electroluminescent devices and luminous paints. Permanent ceramic magnets are made from strontium ferrites and find use in applications as diverse as loudspeakers, motors for automobile windshield wipers, and children‘s toys.[12]

Health effects of strontium Strontium compounds that are water-insoluble can become water-soluble, as a result of chemical reactions. The water-soluble compounds are a greater threat to human health than the water-insoluble ones. Therefore, water-soluble forms of strontium have 50 the opportunity to pollute drinking water. Fortunately the concentrations in drinking water are usually quite low.

Few data are available on the occurrence of strontium in natural water. Odum (1951) determined the strontium content of certain Florida waters.[13] Alexander, Nusbaum, and Mac Donald (1954) measured the strontium content of the public water supplies of many of the major cities through the United States.[14] Nichols and McNall (1957) determined strontium in 380 municipal water supplies in Wis-consin, and reported results for about 100 which contained more than 1.0 ppm (parts per million).[15] Blanchard, Leddicotte, and Moeller (1958) have analyzed the drinking water of seven major cities of the United States by a neutron activation method and have reported their strontium content. These four reports contain about all that is known about the general distribution and occurrence of strontium in fresh water of the United States. This is somewhat surprising considering the fact that the concentration of strontium in sea water (13 ppm) exceeds that of any other cation except the four most common cations: sodium, magnesium, calcium, and potassium. The strontium concentration of ground water samples ranged from less than 0.2 ppm to 36ppm.[16]

People can be exposed to small levels of (radioactive) strontium by breathing air or dust, eating food, drinking water, or by contact with soil that contains strontium. We are most likely to come in contact with strontium by eating or drinking. Strontium concentrations in food contribute to the strontium concentrations in the human body. Foodstuffs that contain significantly high concentrations of strontium are grains, leafy vegetables and dairy products. Foods containing strontium range from very low e.g. in 51 corn (0.4 ppm) and ranged to high, e.g. in cabbage (45 ppm), onions (50 ppm) and lattuce (74 ppm).

Isotopes

Naturally occurring strontium is a mixture of four stable isotopes: strontium-88 (82.6 percent), strontium-86 (9.9 percent), strontium-87 (7.0 percent), and strontium-84 (0.56 percent). Depending on the location, it is possible for the ratios of strontium-87 to strontium-86 to differ by more than a factor of 5.[17] This variation is used in dating geological samples and in identifying the provenance of skeletons and clay artifacts. About 16 synthetic radioactive isotopes have been produced by nuclear reactions, of which the longest-lived is strontium-90 (28.9-year half-life). This isotope, formed by nuclear explosions, is considered the most dangerous constituent of fallout. Because of its chemical resemblance to calcium, it is assimilated in bones and teeth, where it continues ejecting electrons that cause radiation injury by damaging bone marrow, impairing the process of forming new blood cells, and possibly inducing cancer.[18] Under controlled conditions, however, it has been used for treatment of some superficial cancers and bone cancer. It is also used as a source in thickness gauges and has been used in radioisotope thermoelectric generators, where the heat of its radioactive decay is converted to electricity for long-lived, lightweight power sources in navigation buoys, remote weather stations, and space vehicles.[19] Strontium-89 is employed in the treatment of bone cancer, as it targets bone tissues, delivers its beta radiation, and then decays in a few months time (half-life 51 days). Strontium is not an essential element for higher 47 life-forms, and its salts are generally nontoxic. The same bone-seeking property that makes strontium-90 dangerous is beneficially employed in strontium supplements to increase bone density and growth.[20]

For most people, strontium uptake will be moderate. The only strontium compound that is considered a danger to human health, even in small quantities, is strontium chromate. The toxic chromium that it contains mainly causes this. Strontium chromate is known to cause lung cancer, but the risks of exposure have been greatly reduced by safety procedures in companies, so that it is no longer an important health risk.[21]

The uptake of high strontium concentrations is generally not known to be a great danger to human health. In one case someone experienced an allergic reaction to strontium, but there have been no similar cases since.[22]

For children exceeded strontium uptake may be a health risk, because it can cause problems with bone growth. Strontium salts are not known to cause skin ashes or other skin problems of any kind. When strontium uptake is extremely high, it can cause disruption of bone development. But this effect can only occur when strontium uptake is in the thousands of ppm range. Strontium levels in food and drinking water are not high enough to be able to cause these effects.[23, 24]

Radioactive strontium is much more of a health risk than stable strontium. When the uptake is very high, it may cause anaemia and oxygen shortages, and at extremely 52 high concentrations it is even known to cause cancer as a result of damage to the genetic materials in cells.[25,26]

Effects of strontium on the Environment

Strontium in its elemental form occurs naturally in many compartments of the environment, including rocks, soil, water, and air.[27] Strontium compounds can move through the environment fairly easily, because many of the compounds are water soluble. Strontium is always present in air as dust, up to a certain level. Strontium concentrations in air are increased by human activities, such as coal and oil combustion. Dust particles that contain strontium will settle to surface water, soils or plant surfaces at some point. When the particles do not settle they will fall back onto earth when rain or snow falls. All strontium will eventually end up in soils or bottoms of surface waters, where they mix with strontium that is already present. Strontium can end up in water through soils and through weathering of rocks.[28 29] Only a small part of the strontium in water comes from dust particles from the air. Most of the strontium in water is dissolved, but some of it is suspended, causing muddy water at some locations. Not much strontium ends up in drinking water.

When strontium concentrations in water exceed regular concentrations, this is usually caused by human activities, mainly by dumping waste directly in the water. Exceeded strontium concentrations can also be caused by settling of dust particles from air that have reacted with strontium particles from industrial processes. Strontium concentrations in soil may also be increased by human activities, such as the disposal of coal ash and incinerator ash, and industrial wastes.[30, 31] Strontium in soil dissolves in water, 53 so that it is likely to move deeper into the ground and enter the groundwater. A part of the strontium that is introduced by humans will not move into groundwater and can stay within the soil for decades. Because of the nature of strontium, some of it can end up in fish, vegetables, livestock and other animals.[32, 33, 34]

Health Benefits of Strontium

Strontium is a non-essential trace mineral that is found in minute amounts in the body. Because strontium can increase the retention of calcium by the body, it is sometimes used to help prevent bone loss due to osteoporosis.[35,36, 37] It is known to contribute to the health of bones and teeth. Strontium‘s actions in the body are similar to those of calcium. Because strontium prevents the re-absorption of bone, it helps reduce bone loss. It also may build stronger teeth, and is being studied as a cavity preventative.[38]

Strontium is found in foods grown in strontium rich soil and in some drinking water. The amount of strontium in plants is directly related to the amount of the strontium in the soil in which it is grown. Strontium is available in a number of different forms, including strontium carbonate, strontium chloride, strontium sulfate, strontium gluconate and strontium citrate. Strontium glucanate seems to be most easily absorbed by the body.[39-42]

Symptoms of Strontium Deficiency

Because strontium is not an essential mineral, there is no defined level of deficiency.

Strontium Toxicity

There are no identified symptoms of strontium toxicity or strontium overdose.

Supplementing with Strontium

Because it is considered a non-essential trace element, many health supplements overlook the benefits of strontium when creating their formulas, despite the fact that strontium can improve the health of bones and teeth, reduce the pain of osteoarthritis and promote overall absorption of other minerals. Xtend-Life Natural Products Total Balance includes six mineral sea salts in a special blend of ingredients that is formulated to work synergistically with the other 70 ingredients. The inclusion of strontium, iodine, molybdenum, indium, rubidium and tungsten help boost the absorption and effectiveness of every other ingredient in Total Balance as well as providing their own unique health benefits.

Strontium ions play important roles in biological systems. The inhalation of strontium can cause severe respiratory difficulties, anaphylactic reaction and extreme tachycardia. Strontium can replace calcium in organisms, inhibit normal calcium absorption and induce strontium "rickets" in childhood.[43, 44] Thus, the development of sensitive and selective methods for the determination of trace amounts of Sr^{2+} in aqueous media is of considerable importance for environmental and human health protection. A number of methodologies, such as X-ray energy dispersive spectrometry, inductively coupled argon plasma atomic emission spectroscopy (ICP-AES), atomic absorption spectrometry (AAS) and instrumental thermal neutron activation analysis, have been reported. However, these methods are somewhat complex, costly, time consuming and, especially, need special instruments. Thus, the design of convenient and inexpensive approaches for the sensitive and selective detection of Sr^{2+} with rapid, easy manipulation is in ever-increasing demand. Thiazole orange (TO) is used as a signal reporter to devise a simple Sr^{2+} detection assay based on $Sr2^{2+}$+ induced human telomeric DNA conformational change in the presence of SWNTs.

The calcium particle is required for the operation of various physiological procedures, for example, bone and tooth arrangement, blood coagulation, nerve motivation transmission, and muscle withdrawal. At the phone biochemical level, the calcium particle takes part in sign transduction and is a critical element in cell 57 replication and cell division [45]. A definitive wellspring of this imperative component is the eating routine, and the best possible ingestion of calcium is required to address body issues. Anomalous or lacking calcium ingestion is a contributing variable in certain ailment states, including osteoporosis, vitamin D-inadequacy rickets, vitamin Dsubordinate rickets sorts I and II, and endless renal disappointment, to give some examples. The proceeded with investigation of calcium retention and calcium digestion system in creatures and people is fundamental for further explanation of essential components, for comprehension of ailment procedures, and for appraisal of the viability of remedial methodologies. Significantly, the utilization of tracer systems in investigations of calcium digestion system has given important data not generally feasible.[45]

The radio-nuclides of calcium that have been broadly utilized with significant point of interest as tracers in the investigation of calcium and bone digestion system are the beta-discharging Ca^{2+} and the gamma-transmitting Ca^{2+}. Be that as it may, the utilization of radioactive substances in fundamental and clinical examination is diminishing as a result of the expenses of radio-nuclides, the expenses of transfer of radioactive squanders, and the legitimate hesitance of giving possibly unsafe radionuclides to human subjects, especially to the youthful and the pregnant. Stable isotopes of calcium are accessible that have been usefully utilized as a part of human and creature concentrates however here the hindrances are the expense of the steady isotopes of calcium (Ca^{45}, Ca^{46}) and the more particular gear required for their examination [28, 29]. For these and different reasons, analysts have swung to the utilization of strontium as a surrogate for calcium.

The strontium and the calcium particles, individuals from the soluble earth arrangement (Group IIB of the Periodic Table), have numerous properties in like manner, both having a valency of 2, comparable ionic radii, and the capacity to shape buildings and chelates of different solubilities and different restricting qualities. The relative restricting liking of Ca^{2+} and Sr^{2+} varies among anionic intensifies, some leaning toward Ca^{2+} and others Sr^{2+}. The authoritative of Sr^{2+} to alginates surpasses that of Ca^{2+} by elements of 1.5 to 4.3, though calcium is favored in different collaborations, e.g., official to G-actin, blocking negative charges on layers, and official to collagen. In most natural frameworks, inclination when all is said in done is given to Ca^{2+} over Sr^{2+}, in spite of the fact that a marine living being, an Acantharia, builds its inward skeleton of strontium sulfate (33). In higher vertebrates, the hard skeleton is for the most part made out of the exceedingly insoluble calcium phosphate complex, hydroxyapatite. Strontium present in bone is normally viewed as a contaminant, with no physiological capacity at the follow values show in that. Be that as it may, the helpfulness of strontium as a potential restorative specialist for osteoporosis has test support. For instance, in late concentrates, low dosages of strontium are accounted for to have gainful impact on bone arrangement in osteoporotic patients and, in some studies, strontium has been given as a salt, assigned S 12911.[33]

The rise in enthusiasm for strontium as a valuable simple of calcium in clinical examination was gone before by the improvement of an expansive collection of data provoked by the arrangement of radionuclides of strontium as side effects of atomic parting and nuclear bomb explosion (19). Sr^{2+} and Sr^{2+} are the noticeable radionuclides of strontium that are shaped, with Sr^{2+} being a standout amongst the most risky in light of its 59 testimony in the skeleton, its long natural half-life (~10 years), and a rot half-existence of ~30 years.[23] A noteworthy motivation behind the prior examinations was to discover strategies for diminishing the body weight of radio strontium in case of sullying of nature and sustenance supply. Despite the fact that the particular development of calcium over strontium between compartments in natural frameworks has for some time been known, an essential goal of numerous studies in the 1950s and 1960s was to evaluate the relative development and the maintenance of these antacid earth cations, and to devise methodology to minimize the body weight of radio strontium (25). Ideas were produced to formalize the connections amongst Ca^{2+} and Sr^{2+} in their advancement along the natural way of life to people.[30, 31]

The level of segregation was characterized by the proportion of Sr/Ca in one compartment concerning a forerunner compartment. For instance, test thinks about demonstrated that the Sr/Ca proportion in milk was 0.1 concerning a definitive antecedent, the eating routine, for which the Sr^{2+}/Ca^{2+} proportion was alloted the estimation of 1.0.[31, 33, 34] This implies calcium is enhanced 10-fold over strontium in the exchange from eating routine to drain—on account of the particular translocation of Ca^{2+} over Sr^{2+} in the procedures of intestinal assimilation, renal tubular reabsorption, and milk emission. Calcium likewise moves more quickly than Sr^{2+} over the placenta from dam to embryo. Little separation happens in the exchange of Ca^{2+} and Sr^{2+} from blood to bone (35). 60 Quantitatively, the separation of calcium over strontium throughout ingestion shifts among vertebrate species and ranges generally from 2.4 to 5.0. Lengemann, in his audit, noticed that expansions in dietary calcium diminished the fragmentary assimilation of both components proportionately, that the relative retention of Ca^{2+} and Sr^{2+} tracers was not considerably diverse in various portions of the small digestive system (duodenum, jejunum, ileum) in spite of contrasts in the level of partial ingestion, and that vitamin D comparably expanded the ingestion of Ca^{2+} and Sr^{2+} (i.e., there is no obvious vitamin D-subordinate change in the particular assimilation of Ca^{2+} over Sr^{2+}). In light of the high level of retention of calcium in newborn children, especially from milk sources, little contrast in the relative ingestion of Ca^{2+} and Sr^{2+} is seen.[37,38]

The component of segregation amongst Ca^{2+} and Sr^{2+} is surely a result of cooperations that happen amid their exchange starting with one compartment or site then onto the next. For intestinal retention, the special assimilation of Ca^{2+} over Sr^{2+} can be clarified, at any rate to some degree, by current perspectives of the way that calcium is retained from the ingesta (3). Two elements in the transcellular way of retention that are included in the tough transport of calcium can be ensnared as a major aspect of the oppressive procedure, these being the high-fondness calcium-restricting protein, calbindin, that probably serves to build the intracellular dispersion of calcium, and the plasma film ATP-subordinate calcium-pump that effectively expels calcium from the enterocyte. Official of Ca^{2+} to each of these proteins is significantly more prominent than that of Sr^{2+}. Notwithstanding dynamic transport, calcium additionally moves over the intestinal layer by a paracellular, diffusional-sort prepare, and that way likewise appears to offer inclination to the development of Ca^{2+} over Sr^{2+}.[38]

Various studies have seemed all the more as of late in which Sr^{2+} was to be sure utilized as a simple of Ca^{2+}, just a couple of which are referenced here on account of space limitations. Huge numbers of these, for example, those refered to, have given an appraisal of the convenience of Sr2+ in clinically related examinations. For instance, Blumshon et al., [46] as an aftereffect of their study, expressed that steady strontium is a helpful substitution of calcium in routine clinical evaluation of the absorbability of dietary calcium. >30 years prior. Milsom et al.[47] in like manner inferred that a Sr^{2+}assimilation test is a helpful technique in the clinical appraisal of Ca^{2+} retention in human patients, and watched a special ingestion of Ca^{2+} over Sr^{2+}, additionally by an element of ∼1.9. An expansion in Sr^{2+} assimilation in hyper parathyroid patients and a decline in patients with celiac sickness were appeared by Milsom et al., results anticipated from earlier studies on calcium digestion system. High connections (r = ∼0.9) between the absorbability of Ca^{2+} and Sr^{2+} in patients who were idiopathic hyper calciuric stone formers and in patients with osteoporosis, hypothyroidism, and development hormone inadequacies were accounted for by Sips et al. (48) and by Reid et al.[49] in patients with different issue of calcium digestion system.

Vezzoli et al.,[50] in this issue, successfully utilized stable strontium as a tracer of calcium assimilation in their investigation of normocalciuric subjects with calcium kidney stones. The urinary discharge of retained Sr was additionally inspected however found not to associate with calcium discharge. This outcome is not very astounding in perspective of the arrangement of occasions that happen between the glomerular filtration of Ca^{2+} and Sr^{2+} and their consequent discharge in pee. Not at all like intestinal 62 ingestion in the grown-up, the vast majority of the sifted Ca^{2+} and almost as a great part of the separated Sr^{2+} is reabsorbed. In this way, little changes in the reabsorption forms as a consequence of forced variables or ailment states will bring about extensive impacts on the relative urinary discharge of these soluble earth cations. Trial concentrates on in creatures have appeared, indeed, that the relative freedom of Ca^{2+} and Sr^{2+} can be broadly adjusted by different controls, for example, encouraging lowcalcium eating regimens or nourishing eating methodologies of various Ca/P proportions.[45] Intravenous mixture of calcium diminished the effectiveness of Ca^{2+} reabsorption yet diminished the productivity of Sr^{2+} reabsorption to a more prominent degree, in this way adjusting the Sr/Ca proportion in the pee regarding the Sr/Ca proportion in plasma.

Walser and Robinson.[51] basically analyzed renal Sr/Ca connections in mutts and people and built up a scientific method for relating the freedom of these cations to one other. Their methodology depended on the physiologically sensible reason that the rate of reabsorption of these soluble earths from tubular liquid in the nephrons is an immediate capacity of their fixation in that liquid. The condition created on the premise of the above reason and data is: (Sru/Srf) = (Cau/Caf) 0.7, where Sru and Cau = strontium and calcium discharged in pee, and Srf and Caf = strontium and calcium sifted, the last requiring information of the centralization of filterable cations in plasma and the glomerular filtration rate. The exponential estimation of 0.7 was observed to be about the same for control mutts and those with metabolic acidosis, with metabolic alkalosis, or given thiazide diuretics. The same quality, 0.7, related to ordinary human subjects and those with either Addison infection, hyper aldosteronism, or 63 hyperparathyroidism. As the condition demonstrates, the rate of reabsorption of Sr^{2+} is 0.7 of that of Ca^{2+}. The standard blunder of assessment of this quality over an extensive variety of variety was 15%.

In outline, the information now accessible unequivocally bolster the perspective that Sr^{2+} is a helpful tracer for calcium in frameworks where a direct precursor–product relationship can be distinguished and examined, for example, intestinal retention, placental exchange, and drain discharge. Conversely, the urinary discharge of tracer Sr does not specifically mirror the urinary discharge of Ca^{2+} on account of the differential tubular reabsorption occasions that go before their appearance in pee. Be that as it may, investigation of renal discharge information by the Walser–Robinson condition provides a method for relating urinary discharge of Sr^{2+} and Ca^{2+} to their separate rates of tubular reabsorption. It appears to be clear that strontium will keep on being utilized, and progressively in this way, as a pseudo-calcium in clinical and physiological experimentation.[51]

The calcium ions are required for the operation of a number of physiological processes such as bone formation, blood coagulation, signal transduction and muscle contraction. The radionuclide's of calcium that have been widely used with considerable advantage as tracks in the study of calcium and bone metabolism are the beta emitting Ca^{45} and the gama-emitting Ca^{47}.[52] However, the use of radioactive substances in basic and clinical research is dwindling because of the costs of radionuclide's, the cost of disposal of radioactive wastes and the justifiable reticence's of giving potentially hazardous radionuclide's to human subjects. Though stable isotopes of calcium are available, the more specialized equipment required for their analysis. Hence, researchers have moved to the use of strontium as a substituent for calcium.[52]

The Sr^{2+} and Ca^{2+} metals are the members of alkaline earth series (group IIB of periodic table), have many properties in common, both having a valence of 2+, similar ionic radii and the ability to form complexes and chelates of various solubilities and binding strengths. In most biological systems, preference in general is given to Ca^{2+} over Sr^{2+}.[53] The marine organism, *Acantharia*, constructs its internal skeleton with strontium sulfate. The usefulness of strontium as a potential therapeutic agent for osteoporosis has experimental support (52). The upswing is in interest in strontium as a useful analogue of calcium made researchers to develop concepts to formalize the relationships between Ca^{2+} and Sr^{2+}. Numerous studies have appeared very recently in which Sr^{2+} has been used as an analogue of calcium of which a few are referenced here; High correlations (r=5; 0.9) between the absorbability of calcium and strontium was reported by patients who are idiopathic hypercalciuric stone formers and in patients with osteoporosis etc.,.[54, 55]

The results described here indicate that the mechanisms involved in strontium uptake process in the model filamentous fungus *Neurospora crassa.* The better binding and uptake of strontium over calcium depends on the biosorptive capacity and also an inherent physiological response to external conditions. There are several calcium binding proteins reported in *N.crassa* and other fungi and these proteins are activated by calcium and have specific binding sites for calcium.[55]

Further studies on isolation and characterization of calcium binding proteins from cell walls of *N.crassa* and the determination of Ca^{2+}/Sr^{2+} binding sites with binding energies using in vitro and bioinformatics approach will provide clear picture about the strontium binding to the cell walls in significant quantities.

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