S-block elements: pharmacological properties and potential medical applications of alkali and alkaline earth metals (#100012)

First submission

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- Clear, unambiguous, professional English language used throughout.
- Intro & background to show context. Literature well referenced & relevant.
- Structure conforms to PeerJ standards, discipline norm, or improved for clarity.
- Is the review of broad and cross-disciplinary interest and within the scope of the journal?
- Has field been reviewed recently. It there a good reason for this review (different viewpoint, audience etc.)?
- Introduction adequately introduces the subject and makes audience and motivation clear.

STUDY DESIGN

- Article content is within the Aims and Scope of the journal.
- Rigorous investigation performed to a high technical & ethical standard.
- Methods described with sufficient detail & information to replicate.
- Is the Survey Methodology consistent with a comprehensive, unbiased coverage of the subject? If not, what is missing?
- Are sources adequately cited? Quoted or paraphrased as appropriate?
- Is the review organized logically into coherent paragraphs/subsections?

VALIDITY OF THE FINDINGS

- **Impact and novelty is not assessed.** Meaningful replication encouraged where rationale & benefit to literature is clearly stated.
- Conclusions are well stated, linked to original research question & limited to supporting results.
- Is there a well developed and supported argument that meets the goals set out in the Introduction?
- Does the Conclusion identify unresolved questions / gaps / future directions?

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Please provide constructive criticism, and avoid personal opinions	*I thank you for providing the raw data, however your supplemental files need more descriptive metadata identifiers to be useful to future readers. Although your results are compelling, the data analysis should be improved in the following ways: AA, BB, CC*
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S-block elements: pharmacological properties and potential medical applications of alkali and alkaline earth metals

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Background: The periodic table contains the s-block elements in groups 1 and 2. In the periodic table, they reside in the first 2 columns. S-block consists of 14 elements that include, hydrogen (H), lithium (Li), helium (He), sodium (Na), beryllium (Be), potassium (K), magnesium (Mg), rubidium (Rb), calcium (Ca), cesium (Cs), strontium (Sr), francium (Fr), barium (Ba), and radium (Ra). Because their valence electrons are in the s-orbital, these elements are known as s-block elements. Alkali and alkaline earth metals are used extensively in synthetic and technical chemistry. Because of its numerous applications, structural chemistry has received a great deal of attention, and a growing number of target molecules have been identified during the last ten years. **Methodology:** Articles were searched using the following search engine: PubMed, Google Scholar, Worldwide Science and Research Gate, etc. **Result:** S-block components are vital to life as they are essential for metabolism, synthesis of proteins and brain development as well. The diverse uses and effects of alkali metals and alkaline earth metals in the field of medicine and research has been discussed in review. **Conclusion:** Lastly, review covers the historical background and pharmacological potential of s-block elements and their properties, uses, and potential medical applications such as mood stabilization, neuroprotection, anti-inflammatory activity, diagnostic imaging, vasodilatory activity, and cardio protective activity.

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Abstract

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1. Introduction

The ancient Greek philosophy of nature is where the idea of components first appeared (1). Empedocles (5th century B.C.) asserted that all matter was composed of the four basic "elements" of fire, air, water, and earth, which were brought together and divided by the two "active forces" of love and conflict (2, 3). Only 13 elements in the contemporary sense of the word were known up to the 17th century, and by known we mean that they had been employed in a relatively pure condition. An avalanche of elemental discoveries began in the second half of the 18th century and has continued to this day. There are now 112 elements (2, 4, 5).

The elements in the periodic table are arranged such that elements with comparable electron configurations are grouped together (6). Blocks can be created from elements in comparable groups or columns according to the electron orbital that the valence electrons of those elements occupy (7). There are four distinct electron orbitals represented by the four blocks: s, d, p, and f (8).

Deep roots may be found in the 18th and 19th centuries in the investigation of s-block constituents (9). The narrative starts in the late 18th century with the publication of Antoine Lavoisier's seminal study on chemical elements and their compounds (10, 11) . Group 1 of the periodic table is occupied by the alkali metals, which include hydrogen, lithium, helium, sodium, potassium, rubidium, cesium, and francium. These are soft, glossy, low melting, extremely reactive metals (apart from hydrogen), that tarnish when exposed to air (12). These elements display a remarkable reactivity, especially with water, and their qualities became increasingly evident via the efforts of pioneers such as Sir Humphry Davy, who separated numerous alkali metals using electrolysis (13).

The alkaline earth metals of Group 2, which include beryllium, magnesium, calcium, strontium, barium, and radium, also attracted interest as the 19th century went on. Chemists such as Antoine Bussy and Sir Humphry Davy were instrumental in identifying and defining these components (14). These elements' compounds dissolve in water to generate basic (pH greater than 7) or alkaline solutions, thus the term "alkaline (15). These substances are effective electrical conductors. When first cut, they have a grey-white brilliance, but they tarnish easily in the air (16).

Synthetic and technical chemistry make significant use of alkali and alkaline earth metals (17, 18). Because of its many uses, structural chemistry has attracted a lot of attention, and throughout the past ten years, a growing number of target molecules have been identified (19, 20). While alkaline earth metals are metals that produce alkaline oxides and hydroxides and are found in the earth's crust, alkali metals are not found in nature in their free state (21).

2. Survey Methodology

A comprehensive search for relevant literature was conducted using multiple databases including PubMed, Google Scholar, Worldwide Science, and ResearchGate. The search strategy involved specific keywords and combinations related to the pharmacological properties and medical applications of alkali and alkaline earth metals. The search terms included: s-block elements, alkali metals, alkaline earth metals, pharmacological properties, medical applications, hydrogen, lithium, sodium, potassium, rubidium, cesium, francium, beryllium, magnesium, calcium, strontium, barium, and radium. Articles that addressed the pharmacological characteristics of alkali and alkaline earth metals and detailed their possible therapeutic uses were considered for inclusion in the review. To ensure the relevance and accessibility of the information, only articles published in English were considered. Additionally, the availability of full-text versions of the articles was a prerequisite for inclusion in the review. On the other hand, articles were excluded from the review if they were not available in full text. Publications in languages other than English were also excluded to maintain consistency in language comprehension and analysis. Furthermore, articles that did not focus on the pharmacological properties or medical applications of the target elements were deemed irrelevant and thus excluded from the review. Relevant data from the included studies were extracted and reviewed, encompassing information on the historical background, pharmacological properties, medical applications, and potential therapeutic benefits of the s-block elements. The review explored the uses of these elements in various areas such as mood stabilization, neuroprotection, anti-inflammatory activity, diagnostic imaging, vasodilatory activity, and cardioprotective activity, among others. The search resulted in numerous publications detailing the various applications and properties of alkali and alkaline earth metals. Key findings from these studies include the role of hydrogen in reducing oxidative stress and inflammation, and the effectiveness of lithium in mood stabilization and neuroprotection. Sodium and potassium were found to have crucial functions in maintaining electrolyte balance, muscle contraction, and cardiovascular health. Additionally, rubidium and cesium were highlighted for their diagnostic and therapeutic uses in medical imaging and cancer treatment. Furthermore, the anti-inflammatory, antioxidant, and neuroprotective properties of helium were also identified. The literature review underscores the significant pharmacological potential and diverse medical applications of s-block elements. These findings advocate for the ongoing research and development of therapies that utilize alkali and alkaline earth metals to treat various health conditions.

3. Pharmacological potential of S-block elements

3.1. Hydrogen

The English chemist Henry Cavendish discovered hydrogen in 1766 (22). Hydrogen is made up of diatomic molecules of H_2. At 75% by weight, or 88% of all atoms in the cosmos, it is the most plentiful element; hydrogen and helium together make up 99% of the universe's "normal" matter (23). It is acknowledged that molecules such as molecular hydrogen are inert and nonfunctional in human bodies. Strong oxidants like hydroxyl radicals in cells react with H_2, which has been shown to have potential uses in both therapeutic and preventative measures (24). Given how quickly H_2

diffuses into tissues and cells, it offers a variety of benefits with wide-ranging impacts (25). H_2 promotes energy metabolism and has anti-inflammatory and anti-apoptotic properties (26). Research on hydrogen has advanced quickly in recent years due to the growing evidence that molecular hydrogen is a particularly effective therapy for numerous illness models, including ischemia-reperfusion damage (27). It has been demonstrated that hydrogen is beneficial whether consumed as a gas as well as when administered orally, intravenously, or topically as a liquid treatment (28, 29).

3.1.1. Antioxidant activity

Given how quickly H_2 diffuses into tissues and cells, it offers a variety of benefits with wide-ranging impacts (30). Reactive oxygen species (ROS) are very reactive oxygen-containing molecules that have the ability to harm tissues and cells (31). Diatomic hydrogen has been suggested as a new type of antioxidant that preferentially lowers harmful reactive oxygen species levels (32). H_2 (orally eaten or breathed; usually as 0.8 mM H_2-saturated water) has been shown in several studies recently to have positive effects in a variety of animal models of neurological, inflammatory, and ischemia-reperfusion damage (24). Oral H_2 saturated water therapy has been shown to enhance glucose and lipid metabolism in individuals with diabetes mellitus or impaired glucose tolerance in the clinic; encouraging outcomes have also been shown in the reduction of inflammation in patients receiving hemodialysis and in the treatment of metabolic syndrome (27). According to research, H_2 may have antiapoptotic, anti-inflammatory, and antiallergenic benefits in addition to its specific antioxidant capabilities (33).

3.1.2. Anti-inflammatory activity

It has been demonstrated that molecular hydrogen lowers pro-inflammatory cytokine levels, which are signaling molecules that contribute to the inflammatory response (34). Hydrogen could reduce inflammation by adjusting the expression of these molecules. Certain inflammatory signaling pathways, such the nuclear factor-kappa B (NF-κB) pathway, may be inhibited by hydrogen (35). One transcription factor that is essential for controlling inflammatory and immunological responses is NF-κB (36).

3.1.3. Neuroprotective activity

Treatment with hydrogen reduces the size of infarcts, enhances cognitive performance following traumatic brain damage, protects against the loss of dopaminergic neurons in Parkinson's disease, has antioxidant benefits in Alzheimer's disease, and lessens oxidative stress in newborn hypoxic-ischemic encephalopathy (37, 38).

3.2. Lithium

The element's name comes from the Greek word “lithos”, which means stone (39). The soft, silvery metal lithium has a very low density, interacts violently with water, and tarnishes easily in air (40). Although it was only produced in small amounts, lithium was one of the three elements created during the Big Bang (41).

3.2.1. Mood Stabilization activity

Since its introduction in psychiatry at the end of the 1940s, the monovalent cation lithium has been the first-choice medication for treating people with bipolar disorder (BD) (42). It lowers the risk of suicide and is useful in the treatment of moderate-to-severe acute mania as well as a preventative measure against repeated manic and depressive episodes. Additionally, it can strengthen the efficacy of antidepressants when used to treat major depressive disorder (43). Bipolar disorder and certain forms of depression are treated with lithium salts (such as lithium carbonate, Li_2CO_3), which are also used to enhance the effects of other antidepressants (44).

3.2.2. Suicidal prevention activity

Most bipolar disorder patients should be offered lithium as their first treatment, especially if they exhibit suicidal thoughts or behaviors, and they should be given enough information regarding the drug's possible long-term advantages as well as negative effects (45). Many people are able to take lithium without the need for antipsychotics or antidepressants, which could have serious long- term negative effects or worsen the illness, respectively (46). Treatment with Li substantially lowers "impulsive-aggressive" behavior, a susceptibility factor linked to bipolar disorder and suicide, by targeting the serotoninergic system specifically (47).

3.2.3. Neuroprotective activity

Lithium modulates neurotransmitters, calcium, potassium, and other neurotrophic and neuroprotective proteins and supports protective signaling pathway in neuronal cells. According to clinical reports, lithium might be a useful supplement to treat Parkinsonism and help regulate the "on-off" phenomena (48). By downregulating tau proteins, lithium at doses of 1.25, 2.5, 5, and 7.5 mM protects neurons from the harmful effects of amyloid beta (Aβ) and apoptosis (49, 50). Lithium prevents apoptosis from occurring, which has neuroprotective properties (49, 51-53). The neuroprotective effects of lithium are mediated through the inhibition of intrinsic and/or extrinsic apoptotic mechanisms (54, 55).

3.2.4. Anti- inflammatory activity

By preventing the synthesis of two important inflammatory cytokines, interleukin (IL)-1 beta and tumor necrosis factor (TNF)-alpha, lithium has the ability to reduce inflammation. The way that lithium prevents neurodegeneration during neuroinflammatory events is reinforced by these processes (56-58).

3.3. Helium

August 18, 1868, saw the discovery of helium in the form of a brilliant yellow line (59). After hydrogen, helium is the second-most plentiful and lightest gas in the universe. Numerous uses for helium exist in biomedicine (60). It is a monoatomic gas that has no color or smell (61). Helium finds several uses in arc welding, cryogenics, MRI scanners, gas pressurizing, and the cooling of superconducting magnets. Deep sea diving decompression sickness has historically been less common when helium is utilized (62).

3.3.1. Diagnostic activity

A medical imaging method called magnetic resonance imaging (MRI) is used in radiology to look into the architecture and physiology of the body in both healthy and sick conditions (63). It has been discovered that liquid helium, which boils at 4.2 K, is helpful for producing superconducting magnets, which are necessary for nuclear magnetic resonance and nuclear resonance imaging (64). Due to the medical profession's ability to employ magnetic resonance imaging (MRI) to diagnose complicated disorders, the usage of liquid helium in MRI is constantly growing (65).

3.3.2. Vasodilatory activity

It has been found that helium increases collateral circulation in the heart (66) and strengthen the pulmonary arteries' natural vasodilatory response to breathed nitric oxide (67). It may be applied to the evaluation of airflow distribution and anatomical alterations in the lung parenchyma, including fibrosis and emphysema. The 2007 recommendations released by the National Heart, Lung, and Blood Institute also acknowledged heliox (a gas combination of helium and oxygen) as a critical adjuvant in the treatment of severe exacerbations of asthma (68). When children with severe asthma exacerbations were treated, pulsus paradoxus, peak flow, and dyspnea were improved with inhalational heliox therapy (69). Helium has therapeutic effects because of its faster flow rate and lower turbulent flow, which enable gases to enter the distal alveoli deeper, produce larger minute quantities, and enhance breathing (70).

3.3.3. Neuroprotective activity

Research on neurological disorders has been done to assess the possibility of low temperature atmospheric pressure plasma based on helium in treating conditions like Parkinson's and Alzheimer's disease, which are linked to amyloid fibrils (71, 72). It has been discovered that in vitro, amyloid fibrils can fragment into smaller units when exposed to low temperature atmospheric pressure plasma (73).

3.3.4. Anticancer activity

There are other consequences of atmospheric pressure helium plasma jet on live cells (74, 75). It has been shown that plasma interactions with several cancer cell types cause cell death, which may be related to the generation of reactive oxygen species (ROS) (76-80). Helium plasma at atmospheric pressure has been used recently to treat human lung cancer cells in vitro (74). It has shown promise in the treatment of cancer cells, blood coagulation, sterilization, and teeth whitening (81-83).

Helium-based non-thermal atmospheric plasma jets have been investigated in depth in a number of cancer types, and in vitro antitumor effects have been noted on carcinogenic cell lines associated with skin (melanoma), brain (glioblastoma), colon, liver, lungs, breast, cervix, bladder, oral and ovarian carcinoma, and leukaemia (73, 84).

3.4. Sodium

The word "soda," which appears in several sodium compounds like washing soda, sodium bicarbonate, and sodium hydroxide, is where the word "sodium" originates (85). The Latin name for the element, natrium, is where the sign "Na" originates. In the crust of the Earth, it ranks as the fourth most plentiful element (86). To transmit nerve impulses, contract and relax muscles, and maintain the ideal balance of water and minerals, the human body needs a tiny quantity of sodium (87). It is estimated that 500 mg of salt every day is required for these essential processes (88).

3.4.1. Electrolyte regulation

The main solute preserving water in the extracellular compartment is sodium. Total body sodium is a prerequisite for both total body water and extracellular volume. Thus, maintaining sodium balance is essential for controlling volume (89). Changes in the sodium balance cause variations in plasma volume, which are mostly detected by changes in the circulatory system (90). The most common form of IV fluid for both replacement and maintenance has historically been normal saline (91).

3.4.2. Blood pressure regulation

Blood pressure management requires the careful maintenance of salt and fluid balance, and changes to this equilibrium can result in the development of hypertension (91). Since sodium is the primary cation in extracellular fluid, any alteration in sodium excretion through the urine would result in an increase in the amount of intravascular fluid, which would raise blood pressure and possibly cause hypertension (92).

3.4.3. Sodium muscularity activity

Sodium makes it easier for calcium ions to enter muscle fibers, which releases ATP, the body's energy storage (93). Proper muscle activity and electrical impulse transmission depend on the sodium and potassium ion balance (94). Moreover, magnesium is necessary for muscular contraction, and sodium promotes the dephosphorylation of ATP and ADP in the presence of magnesium (95). Consequently, sodium is a necessary element for preserving the best possible health, especially during the contraction of muscles (96).

3.5. Potassium

"Potash" is the root word of the term potassium. For a very long time, potassium carbonate and potassium hydroxide have been combined to create potash (97). In earlier ages, ashes in pots were used to make potash. Potassium is a soft, silvery metal that tarnishes quickly in air and interacts quite strongly with water (98).

3.5.1. Electrolyte balance

Potassium is essential for maintaining the body's electrolyte and fluid balance (99). Its participation in a number of physiological processes contributes to the maintenance of appropriate electrolyte concentrations, fluid distribution, and cellular function (100). Intake can be reduced to the point of total loss, often due to famine. The kidneys filter potassium, and the amount expelled in urine is controlled to preserve equilibrium (101). Studies have also looked at electrolyte imbalance changes that occur with mental illnesses; cyclic mood disorders, such manic-depressive illness (102).

3.5.2. Acid-Base balance

Potassium, in conjunction with sodium, control the body's and tissue's acid-base and water balance (103). It acts as a buffer to balance out access basses or acids, assisting in the stabilization of the internal environment of the organism (104).

3.5.3. Cardioprotective activity

In the heart, potassium is essential for the passage of electrical impulses (105). Maintaining a normokalaemia condition is crucial for the prevention of potentially significant consequences and for the preservation of cardiovascular health, particularly in individuals who are at-risk for cardiovascular disease (106). Serum K^+ values kept between 4.0 and 5.0 mmol/L seem to be both safe and likely to offer stability in a variety of cardiovascular processes (107). Increased consumption of potassium-rich foods is linked to a decreased incidence of stroke and may also lessen the risk of congenital cardiac conditions and overall cardiovascular disease (108). These

findings corroborate suggestions to increase intake of foods high in potassium in order to prevent vascular disorders (109).

3.6. Rubidium

An alkali metal in Group 1 of the Periodic Table is rubidium. Its physical and chemical characteristics often fall between those of cerium and potassium (110). Rubidium is not the major metallic element in any minerals. Rubidolite and pollucite are the minerals that contain rubidium (111). In general, rubidium is classified as having a low level of toxicity. There are health dangers related to chemicals called rubidium (112). Rubidium is mostly used in research. Pharmaceuticals and medical procedures both employ rubidium isotopes (113).

3.6.1. Cardiac imaging

In particular, coronary artery disease is one cardiovascular illness for which rubidium is used in diagnostic and treatment (114). A radioactive isotope of rubidium called rubidium-82 is utilized as a positron-emitting radiotracer in cardiac imaging. Rubidium-82 PET (Positron Emission Tomography) imaging is the name of this application (115). It is frequently used to evaluate blood flow to the heart muscle in myocardial perfusion imaging. When evaluating the myocardial perfusion of individuals with known or suspected coronary artery disease, rubidium-82 PET imaging is especially helpful (116).

3.6.2. Neurological research

Rubidium's ability to mirror the behavior of potassium has made it a useful ion in neurological studies (117). Rubidium influx has been utilized by researchers as a measure for neurotransmitter release because rubidium ions may enter neuron terminals and imitate the actions of potassium (118). Rubidium has been used in combination with electrophysiological methods, such as patch-clamp recordings, to investigate the electrical characteristics of neurons (119). Evaluation of rubidium's effects on membrane potential, action potentials, and other electrophysiological parameters may be part of these investigations (120). A few studies have looked at rubidium's possible neuroprotective benefits (121). Alzheimer's disease can be strongly predicted by changes in brain rubidium levels. Rubidium 82/86 PET imaging may be able to detect Alzheimer's disease in its early stages (117). It has been claimed that lithium and rubidium have neuroprotective effects on disorders of the central nervous system, such as mania and depression (122).

3.6.3. Diagnostic marker for brain tumor

Positron emission tomography (PET) has made considerable use of rubidium-82 as a diagnostic marker for brain tumors; greater absorption of the tracer indicates a breakdown in the integrity of the blood-brain barrier (BBB) (123).

3.7. Cesium

In 1860, Gustav Kirchoff and Robert Bunsen made the discovery of cesium (124). The soft alkaline metallic element cesium has a silver-white color and atomic number 55. As the isotope 133Cs, it is the rarest naturally occurring alkali metal. With a cesium oxide content ranging from 5% to 32%, pollucite is the most widely used commercial source of cesium (125). Cesium in radioactive forms (134Cs and 137Cs) is also present in the environment. When cesium was radioactive and had potential for radiation therapy and carcinogenesis, it first attracted interest (126). When cesium metal comes into touch with flesh, it may burn people severely (127). Cesium has limited practical uses in neurology because of its possible toxicity. Serious health concerns, including as cardiovascular, gastrointestinal, and neurological disorders, can result from cesium poisoning (128). As a result, using cesium therapeutically is quite rare in traditional medicine and calls for great caution (129).

3.7.1. Anticancer activity

It has been proposed that using cesium chloride as a cancer treatment, often known as "high pH therapy," will have anticancer effects by increasing intracellular pH and inducing apoptosis (130). Since the 1980s, anticancer efficaciousness for steady cesium treatment has been asserted. Studies conducted in vivo have demonstrated a substantial reduction in tumor volume following the treatment of oral gavage or intraperitoneal injection of calcium chloride (131). Prostate cancer has been treated using 131Cesium brachytherapy (132).

3.8. Francium

Marguerite Perey made the discovery of francium in 1939 (133). It is the lustrous metal in its purest form, existing at room temperature as a liquid as opposed to a solid. It emits a lot of radioactivity. With a maximum half-life of just 22 minutes, it is a radioactive metal that is heavy and unstable (134). The chemical characteristics of francium and cesium are comparable (135). After astatine, it is the second rarest element in the crust of the Earth. It is the most chemically reactive alkali metal since it is the least electronegative element among all of the elements (136). There is no known biological function of francium in human life. Due to its volatility and scarcity, francium has no commercial use. It is exclusively utilized for research. Its use as a potential diagnostic tool for various malignancies has also been examined, although this use has been judged unfeasible. Its only toxicity is from its radioactivity, which can harm nuclear material and cells (137).

3.9. Beryllium

Wohler made the first isolation of beryllium in 1828 (138). It is a lightweight alkaline earth metal with a steel-gray color. It is the only metal with the unusual quality of being almost X-ray transparent (139). It is harmful when breathed or applied topically, and it can cause dermatitis, acute pneumonitis, and chronic lung disease (140). Breathing problems, chest discomfort, or shortness of breath may be the initial symptoms of a severe or potentially fatal acute beryllium exposure (141). In conclusion, beryllium is not used in pharmaceutical applications as any possible therapeutic advantages are outweighed by its hazardous qualities (142).

3.9.1. Chronic beryllium disease (CBD)

Berylliosis, sometimes referred to as chronic beryllium disease (CBD), is a granulomatous illness brought on by beryllium exposure (143). Granulomas, or aberrant inflammatory nodules, are formed in the lungs and other regions of the body as a result of a systemic illness (144). The most frequent symptoms are cough, fever, night sweats, and exhaustion, although the clinical course might vary. The beryllium lymphocyte proliferation test (BeLPT), bronchoalveolar lavage (BAL), and granulomatous inflammation on lung biopsy are the mainstays of a conclusive diagnosis of berylliosis (145).

3.10. Magnesium

Magnesia, a location in Greece, is where magnesium compounds were initially found. In the crust of the earth, magnesium is the seventh most common element (146). It is an alkaline Earth metal that occurs in minerals and rocks in the natural world (147). Just 1% of the magnesium in the body is found in the blood, with the majority of the mineral being in high metabolic tissues such the muscles, brain, heart, kidneys, and liver (148). The human body uses magnesium (Mg^{2+}) for a variety of processes, including blood pressure, neuromuscular transmission, and muscle contraction (149, 150). Furthermore, the creation of nuclear materials, the generation of energy, active transmembrane transport for other ions, and bone growth all depend on magnesium (151). Moreover, a variety of illnesses have been linked to magnesium shortage (152).

3.10.1. Cardiovascular health

Magnesium is essential for preserving heart health (153). Magnesium affects vascular tone, peripheral vascular resistance, and endothelial function in addition to its significant involvement in the control of heart rhythm. An increased risk of cardiac arrhythmia is linked to hypomagnesemia. Additionally, hypomagnesemia raised the risk of postcardiac surgery for atrial fibrillation. Individuals with congestive heart failure are more likely to have low potassium and magnesium levels in their blood (154).

3.10.2. Maintain heart rhythm

Ion channels, such as those that control the electrical activity of the heart, depend on magnesium to operate properly. It contributes to the preservation of a regular heartbeat and aids in the stabilization of cell membranes (155). Sufficient magnesium levels can promote the heart's general electrical stability and help avoid arrhythmias, or irregular heartbeats (156).

3.10.3. Blood pressure regulation

Blood pressure management is aided by magnesium. It facilitates blood channel dilating, which lowers peripheral resistance and increases blood flow (157).

3.10.4. Anti-inflammatory effects

Cardiovascular disorders are linked to chronic inflammation (158). Due to its anti- inflammatory qualities, magnesium may help lower inflammatory processes in the cardiovascular system and promote heart health (159, 160).

3.10.5. Preventing Coronary Artery Spasms

Coronary artery spasms are abrupt contractions of the coronary arteries that might lower cardiac blood flow. Magnesium can help avoid these spasms (161). Magnesium may help to avoid these spasms by encouraging the relaxation of smooth muscles (162).

3.10.6. Protecting Against Ischemia-Reperfusion Injury

The possible preventive benefits of magnesium against ischemia-reperfusion injury, a condition in which blood flow is momentarily obstructed and then restored have been investigated. The heart may be shielded from such damage by magnesium's capacity to lower inflammation and oxidative stress (163, 164).

3.10.7. Laxative effect

It is commonly known that magnesium and sulphate have laxative properties (164). Patients commonly self-treat constipation using over-the-counter medications, such as magnesium hydroxide (Milk of Magnesia) or magnesium citrate (165-167).

3.10.8. Migraine prevention

Magnesium is a cheap, safe, and well-tolerated migraine preventive alternative, according to the NCBI (168). Acute headaches, such as tension-type headaches, migraines, and cluster headaches, may also benefit from its use. One kind of magnesium that is frequently used to stop migraines is magnesium oxide (169, 170).

3.10.9. Pre-eclampsia prevention

A lot of people use magnesium sulphate to avoid eclamptic seizures (171). In preeclamptic women, $MgSO_4$ is more effective than phenytoin, nimodipine, diazepam, and placebo for eclamptic seizure prevention (172). Additionally, magnesium sulphate may function as a central anticonvulsant or preserve the blood-brain barrier while preventing the development of cerebral edema (173-176)

3.10.10. Bone health

Given its importance to bone health, magnesium may be a useful nutrient in the fight against osteoporosis and bone loss (177, 178). A magnesium deficit may impact bone by lowering bone mineral density, boosting osteoclasts and decreasing osteoblasts that interfere with vitamin D, causing oxidative stress and inflammation, and ultimately leading to bone loss (179).

3.11. Calcium

London in 1808, Cornish chemist Sir Humphry Davy made the discovery of calcium. Its name comes from the Latin word "calx," which means "lime" (limestone is a calcium ore) (180). A soft element, calcium is a member of the alkali earth metal family. Of all the metallic components that make up the human body, it is the most prevalent (181). There is no toxicity to calcium. It is a necessary mineral for the growth of strong bones and teeth, as the primary component of bones is calcium phosphate (182-184). Calcium shortage can lead to osteoporosis, osteopenia, hypocalcemia, and other illnesses (185). Although calcium is not a medicine in and of itself, supplements and products containing calcium are utilized for a variety of pharmacological objectives (186). For adults, the recommended daily intake (RDI) of calcium is 1,000 mg daily (187).

3.11.1. Bone health

In addition to being essential for maintaining healthy bones, calcium is frequently used to treat and prevent diseases including osteoporosis and osteopenia (188). In order to increase bone density and lower the risk of fractures, doctors commonly prescribe calcium supplements together with vitamin D, particularly for people who are deficient in these nutrients or who are at risk for bone-related illnesses (189, 190). Early adult peak bone mass is determined by the amount of calcium an individual consumes, which also impacts skeletal calcium retention during growth (191). In later age, calcium also helps to prevent osteoporotic fractures and bone loss (192).

3.11.2. Antacids

An ionic substance called calcium carbonate is used as an antacid or calcium supplement to treat the symptoms of acid reflux, heartburn, and sour stomach. It is a simple substance that works by balancing the acidic effects of hydrochloric acid in stomach secretions (193) .

3.11.3. Cardiovascular health

A family of drugs known as calcium channel blockers is used to treat a number of cardiovascular diseases, such as hypertension (high blood pressure) and certain arrhythmias (194). These drugs function by obstructing the calcium channels in the heart and blood vessels, which causes the smooth muscle to relax and the blood vessels to dilate (195).

3.12. Strontium

First found in a mine in 1790, strontium was separated in 1808. An alkaline earth metal, strontium is a delicate silver-white yellowish metallic element that is very chemically reactive (196). This silvery metal is a non-radioactive element that occurs naturally. Strontium possesses physical and chemical characteristics comparable to those of its two vertical neighbours in the periodic table, calcium and barium (197). The bones contain 99 percent of all the strontium in the human body. Its pharmacological uses are mostly related to the treatment of osteoporosis (198, 199). Because of its radioisotopes, strontium has become more important in nuclear medicine, primarily for the palliative and pain-relieving treatment of bone metastases (200).

3.12.1. Osteoporosis treatment

The most significant cation in bones is strontium, which can fight osteoporosis by promoting the proliferation of osteoblast cells and preventing bone reabsorption (199). In osteoporotic individuals, strontium ranelate lowers the fracture rate and raises bone calcium (201). In the bone structure, strontium-coated halloysite nanotubes (SrHNTs) strengthened the bone and stimulated osteoblasts to produce new bone (202). It has the ability to load drugs, lower bone reabsorption, and exhibit antibacterial action (203).

3.12.2. Dentistry

Strontium has the ability to both strengthen bones and shield teeth against decay (204). It has also been discovered that strontium-substituted hydroxyapatite (SrHAp) nanoparticles enhance the process of tooth remineralization by raising the ALP activity, which is linked to the cloning process in hard tissues (205, 206).

3.12.3. Anticancer activity

Strontium nanoparticles, or SrNPs, find applications in chemosensory medicine, bioimaging, and cancer treatment (207). Chemosensing, medication delivery, cancer treatments, and biomedical imaging all employ strontium-suspended vesicles (208).

2.12.4. Antimicrobial activity

Gram-positive and gram-negative bacteria were both susceptible to the antibacterial properties of strontium cerium oxide (SrO-CeO_2) nanoparticles (209, 210). Gram-negative bacteria are more likely to attach themselves to SrO-CeO_2-combined NPs (211). Strontium oxide nanoparticles (SrONPs) displayed excellent antibacterial activity against gram-negative bacteria such as Proteus vulgaris, Psudomonas aeruginosa, Morganella morganii, and Klebsiella pneumonia than that of the gram-positive bacteria (212, 213).

3.12.4. Analgesic activity

Due to its radioisotopes, strontium has become more important in nuclear medicine, primarily for the palliative and pain-relieving treatment of bone metastases (214, 215).

3.12.5. Barium

One of the alkaline-earth metals in group 2 (IIa) of the periodic table is barium (Ba) (215). It is a prevalent element in the crust of the Earth, occurring naturally in one oxidation state (+II) and at a concentration greater than that of most other trace elements (216). The most prevalent minerals of Barium are hollandite and barite, and they are typically related to potassium in geochemical processes (217). Barium is mostly known for its poisonous qualities, and it is not thought to have any substantial therapeutic effect. When consumed or breathed, barium compounds can cause toxicity by interfering with cellular functions, especially by inhibiting potassium channels (218).

3.12.6. Anti-ulcer activity

Barium oxide (BaBG) is a novel bioactive glass that may be used as an anti-ulcer agent (219).In a number of ulcer models, including ethanol, aspirin, gastric ulcers caused by pyloric ligation, duodenal ulcers caused by cysteamine, and ulcers that heal when exposed to acetic acid, BaBG was found to greatly minimize ulcerative damage (220). BaBG has been shown to neutralize stomach acid, promote cell proliferation, and provide a physical barrier of protection over the gastro-duodenal epithelial cell (221). It also increased the pH of the stomach, exhibiting antacid-like effects (219) .

3.12.7. Diagnostic activity

Since barium sulphate is mostly employed as a contrast agent in medical imaging rather than for therapeutic purposes, it is not usually recognized for its pharmacological properties in the conventional sense (222). Most frequently, barium sulphate is used as a contrast agent in treatments like barium enema and swallow (223). The esophagus, stomach, and intestines are highlighted in these imaging investigations, which aid in the visualization of the gastrointestinal system. Barium sulphate is appropriate for this use since it is insoluble and inert (223). It covers the lining of the gastrointestinal tract during imaging examinations. The organs and tissues under examination are more visible because to this covering (224, 225).

3.12.8. Radium

The heaviest of the Group 2 (IIa) alkaline-earth metals in the periodic table is radium (chemical symbol Ra) (226). The discovery was made by Marie and Pierre Curie in 1898. It is created when uranium decays, releasing gamma, beta, and alpha ionizing radiation (227). In an aqueous solution, it produces the colorless radium cation, which is very basic and does not form complexes. As a result, the majority of radium compounds are basic ionic compounds (228). It exists in trace amounts in rocks, soil, and water in the natural environment. Radon is a radioactive gas that is created when some of the atoms in radium decay and release radiation (229-231). One type of anticancer medication is radon. In terms of radium isotopes, Ra-226 and Ra-228 are the most prevalent (232). The chemistry of radium is comparable to barium, which is widely employed as a substitute due to the high radiation of radium (233).

3.12.9. Anti-cancer activity

The first and only alpha-emitting radiopharmaceutical to be approved for clinical use by the FDA and EMEA for treating metastases linked to metastatic castration-resistant prostate cancer (mCRPC) is [223Ra] radium chloride (Xofigo®; previously alpharadin) (234-236). Six intravenous doses totaling 50 kBq kg-1 and 223 $RaCl_2$ are given, with a four-week interval between each administration. After entering the body, 223Ra^{2+} will work as a Ca^{2+} imitator and form complexes with the mineral hydroxyapatite at locations where bone is actively growing, which happens in metastatic bone tissue at a faster pace. Through a multimodal method, 223radium kills tumor cells as well as osteoblasts and osteoclasts, the effector cells of pathological bone metabolism (237). It may also stimulate local immunological responses against tumors (238).

3.12.10. Ankylosing spondylitis treatment

Radium chloride was first used to treat ankylosing spondylitis in 1948 (239). A course of ten weekly injections, totaling roughly 50 MBq, was administered to most patients. For ankylosing spondylitis patients, positive clinical outcomes were documented, indicating a sustained effect and a decrease in the requirement for analgesic and anti-inflammatory medications (240).

4. Conclusion

In conclusion, the s-block elements, including the alkali metals and alkaline earth metals, exhibit diverse and significant roles in health, disease, and medical research. From neurological research to anticancer activity, these elements have shown potential therapeutic applications, such as lithium's neuroprotective effects and cesium's investigation for anti-cancer properties. Additionally, the pharmacological potential of these elements extends to the applications of helium in human life and medical treatments. Overall, this comprehensive overview highlights the multifaceted potential of s-block elements in medicine and research. These findings would motivate us to carry out additional analysis and testing to show the effectiveness of s-block elements as prospective options in medicine.

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Reference

1. Naden J. The five elements of Ancient Greece. Conjunction. 2011;51:16-8.
2. Siekierski S, Burgess J. Concise chemistry of the elements: Elsevier; 2002.
3. Betti M. The Sophia Mystery in Our Time: The Birth of Imagination: Temple Lodge Publishing; 2013.
4. Armbruster P. On the production of heavy elements by cold fusion: the elements 106 to 109. Annual Review of Nuclear and Particle Science. 1985;35(1):135-94.
5. Ropp RC. Encyclopedia of the alkaline earth compounds: Newnes; 2012.
6. Schwerdtfeger P, Smits OR, Pyykkö P. The periodic table and the physics that drives it. Nature reviews chemistry. 2020;4(7):359-80.
7. Peng Y, Lei T, Zhen H, Yuan Z, Xu H, Wen F, editors. New Periodic Table of Elements: Electron Configuration and Motion, and Formation of Simple Compound. Journal of Physics: Conference Series; 2021: IOP Publishing.

8. Rahm M, Cammi R, Ashcroft N, Hoffmann R. Squeezing all elements in the periodic table: electron configuration and electronegativity of the atoms under compression. Journal of the American Chemical Society. 2019;141(26):10253-71.
9. Tan D, García F. Main group mechanochemistry: from curiosity to established protocols. Chemical Society Reviews. 2019;48(8):2274-92.
10. BOANTZA VD. Practice and Experiment: Operations, Skills, and Experience in Eighteenth-Century Chemistry. A Cultural History of Chemistry in the Eighteenth Century. 2023;4:45.
11. Wilson A. The Great Instauration of the Eighteenth Century. Journal of Early Modern Studies. 2023.
12. Parida L, Patel TN. Systemic impact of heavy metals and their role in cancer development: a review. Environmental Monitoring and Assessment. 2023;195(6):766.
13. Shukla A, Prem Kumar T. Electrochemistry: retrospect and prospects. Israel Journal of Chemistry. 2021;61(1-2):120-51.
14. Thakur P, Ward AL, González-Delgado AM. Optimal methods for preparation, separation, and determination of radium isotopes in environmental and biological samples. Journal of Environmental Radioactivity. 2021;228:106522.
15. Middelburg JJ, Soetaert K, Hagens M. Ocean alkalinity, buffering and biogeochemical processes. Reviews of Geophysics. 2020;58(3):e2019RG000681.
16. Singh D. Dictionary of Mechanical Engineering: Springer Nature; 2023.
17. Xu M, Xing J, Yuan B, He L, Lu L, Chen N, et al. Organic small-molecule fluorescent probe-based detection for alkali and alkaline earth metal ions in biological systems. Journal of Materials Chemistry B. 2023;11(15):3295-306.
18. Zhang F, Dong W, Ma Y, Jiang T, Liu B, Li X, et al. Fluorescent pH probes for alkaline pH range based on perylene tetra-(alkoxycarbonyl) derivatives. Arabian Journal of Chemistry. 2020;13(6):5900-10.
19. Zhou M, Frenking G. Transition-metal chemistry of the heavier alkaline earth atoms Ca, Sr, and Ba. Accounts of Chemical Research. 2021;54(15):3071-82.
20. Robertson SD, Uzelac M, Mulvey RE. Alkali-metal-mediated synergistic effects in polar main group organometallic chemistry. Chemical reviews. 2019;119(14):8332-405.
21. West K. The Basics of Metals and Metalloids: The Rosen Publishing Group, Inc; 2013.
22. Szydło ZA. Hydrogen-some historical highlights. Chemistry-Didactics-Ecology-Metrology. 2020;25(1-2):5-34.
23. Tennyson J. Astronomical Spectroscopy: An Introduction to the Atomic and Molecular Physics of Astronomical Spectroscopy: World Scientific; 2019.
24. LeBaron TW, Kura B, Kalocayova B, Tribulova N, Slezak J. A new approach for the prevention and treatment of cardiovascular disorders. Molecular hydrogen significantly reduces the effects of oxidative stress. Molecules. 2019;24(11):2076.
25. Ahmad A, Baig AA, Hussain M, Saeed MU, Bilal M, Ahmed N, et al. Narrative on Hydrogen Therapy and its Clinical Applications: Safety and Efficacy. Current Pharmaceutical Design. 2022;28(31):2519-37.
26. Xie F, Song Y, Yi Y, Jiang X, Ma S, Ma C, et al. Therapeutic potential of molecular hydrogen in metabolic diseases from bench to bedside. Pharmaceuticals. 2023;16(4):541.
27. Slezak J, Kura B, LeBaron TW, Singal PK, Buday J, Barancik M. Oxidative stress and pathways of molecular hydrogen effects in medicine. Current Pharmaceutical Design. 2021;27(5):610-25.
28. Perveen I, Bukhari B, Najeeb M, Nazir S, Faridi TA, Farooq M, et al. Hydrogen therapy and its future prospects for ameliorating COVID-19: Clinical applications, efficacy, and modality. Biomedicines. 2023;11(7):1892.
29. Ostojic S. Molecular hydrogen in sports medicine: new therapeutic perspectives. International journal of sports medicine. 2015;36(04):273-9.

30. Tian Y, Zhang Y, Wang Y, Chen Y, Fan W, Zhou J, et al. Hydrogen, a novel therapeutic molecule, regulates oxidative stress, inflammation, and apoptosis. Frontiers in physiology. 2021;12:789507.
31. Ahmed OM, Mohammed MT. Oxidative stress: The role of reactive oxygen species (ROS) and antioxidants in human diseases. Plant Arch. 2020;20(2):4089-95.
32. Napolitano G, Fasciolo G, Venditti P. The ambiguous aspects of oxygen. Oxygen. 2022;2(3):382-409.
33. Hirano S-i, Ichikawa Y, Sato B, Yamamoto H, Takefuji Y, Satoh F. Molecular hydrogen as a potential clinically applicable radioprotective agent. International Journal of Molecular Sciences. 2021;22(9):4566.
34. Alwazeer D, Liu FF-C, Wu XY, LeBaron TW. Combating oxidative stress and inflammation in COVID-19 by molecular hydrogen therapy: Mechanisms and perspectives. Oxidative Medicine and Cellular Longevity. 2021;2021.
35. Kura B, Bagchi AK, Singal PK, Barancik M, LeBaron TW, Valachova K, et al. Molecular hydrogen: Potential in mitigating oxidative-stress-induced radiation injury. Canadian journal of physiology and pharmacology. 2019;97(4):287-92.
36. Mitchell JP, Carmody RJ. NF-κB and the transcriptional control of inflammation. International review of cell and molecular biology. 2018;335:41-84.
37. Chen W, Zhang H-T, Qin S-C. Neuroprotective effects of molecular hydrogen: A critical review. Neuroscience Bulletin. 2021;37(3):389-404.
38. Rahman MH, Bajgai J, Fadriquela A, Sharma S, Trinh Thi T, Akter R, et al. Redox effects of molecular hydrogen and its therapeutic efficacy in the treatment of neurodegenerative diseases. Processes. 2021;9(2):308.
39. Jayanthi A, Kistan A, Marcus M, RAJESwARI R. A Linguistic study of chemical terms. Oriental Journal of Chemistry. 2022;38(2):459.
40. Wei C, Zhang Y, Tian Y, Tan L, An Y, Qian Y, et al. Design of safe, long-cycling and high-energy lithium metal anodes in all working conditions: Progress, challenges and perspectives. Energy Storage Materials. 2021;38:157-89.
41. Arcones A, Thielemann F-K. Origin of the elements. The Astronomy and Astrophysics Review. 2023;31(1):1.
42. Baldessarini RJ, Tondo L. Lithium in Psychiatry. Revista de Neuro-Psiquiatría. 2013;76(4):189-203.
43. Albert U, De Cori D, Blengino G, Bogetto F, Maina G. Lithium treatment and potential long-term side effects: a systematic review of the literature. Rivista di Psichiatria. 2014;49(1):12-21.
44. Oruch R, Elderbi MA, Khattab HA, Pryme IF, Lund A. Lithium: a review of pharmacology, clinical uses, and toxicity. European journal of pharmacology. 2014;740:464-73.
45. Tondo L, Baldessarini RJ. Antisuicidal effects in mood disorders: are they unique to lithium? Pharmacopsychiatry. 2018;51(05):177-88.
46. Volkmann C, Bschor T, Köhler S. Lithium treatment over the lifespan in bipolar disorders. Frontiers in Psychiatry. 2020;11:537937.
47. Bénard V, Vaiva G, Masson M, Geoffroy P-A. Lithium and suicide prevention in bipolar disorder. L'encephale. 2016;42(3):234-41.
48. Chiu C-T, Chuang D-M. Molecular actions and therapeutic potential of lithium in preclinical and clinical studies of CNS disorders. Pharmacology & therapeutics. 2010;128(2):281-304.
49. Ghanaatfar F, Ghanaatfar A, Isapour P, Farokhi N, Bozorgniahosseini S, Javadi M, et al. Is lithium neuroprotective? An updated mechanistic illustrated review. Fundamental & clinical pharmacology. 2023;37(1):4-30.
50. Camins A, Verdaguer E, Junyent F, Yeste-Velasco M, Pelegrí C, Vilaplana J, et al. Potential mechanisms involved in the prevention of neurodegenerative diseases by lithium. CNS neuroscience & therapeutics. 2009;15(4):333-44.

51. Lazzara CA, Kim Y-H. Potential application of lithium in Parkinson's and other neurodegenerative diseases. Frontiers in neuroscience. 2015;9:166031.

52. Motaghinejad M, Fatima S, Karimian M, Ganji S. Protective effects of forced exercise against nicotine-induced anxiety, depression and cognition impairment in rat. Journal of basic and clinical physiology and pharmacology. 2016;27(1):19-27.

53. Ciftci E, Karaçay R, Caglayan A, Altunay S, Ates N, Altintas MO, et al. Neuroprotective effect of lithium in cold-induced traumatic brain injury in mice. Behavioural brain research. 2020;392:112719.

54. Puglisi-Allegra S, Ruggieri S, Fornai F. Translational evidence for lithium-induced brain plasticity and neuroprotection in the treatment of neuropsychiatric disorders. Translational psychiatry. 2021;11(1):366.

55. Bojja SL, Singh N, Kolathur KK, Rao CM. What is the Role of Lithium in Epilepsy? Current Neuropharmacology. 2022;20(10):1850.

56. Mehrafza S, Kermanshahi S, Mostafidi S, Motaghinejad M, Motevalian M, Fatima S. Pharmacological evidence for lithium-induced neuroprotection against methamphetamine-induced neurodegeneration via Akt-1/GSK3 and CREB-BDNF signaling pathways. Iranian Journal of Basic Medical Sciences. 2019;22(8):856.

57. Yu F, Wang Z, Tchantchou F, Chiu C-T, Zhang Y, Chuang D-M. Lithium ameliorates neurodegeneration, suppresses neuroinflammation, and improves behavioral performance in a mouse model of traumatic brain injury. Journal of neurotrauma. 2012;29(2):362-74.

58. Khan MS, Ali T, Abid MN, Jo MH, Khan A, Kim MW, et al. Lithium ameliorates lipopolysaccharide-induced neurotoxicity in the cortex and hippocampus of the adult rat brain. Neurochemistry International. 2017;108:343-54.

59. Wheeler M. Helium: The Disappearing Element: Springer; 2015.

60. Dai Z, Deng J, He X, Scholes CA, Jiang X, Wang B, et al. Helium separation using membrane technology: Recent advances and perspectives. Separation and Purification Technology. 2021;274:119044.

61. Tamanna T, Qanungo K, editors. A mini review on the role of helium in human life. AIP Conference Proceedings; 2023: AIP Publishing.

62. Sherrier DM, Gerth WA, Doolette DJ, MURPHY FG. Man-Trial of the Twenty-First Century Surface-Supplied Heliox (He-O2) Decompression Table. 2023.

63. Fatahi M, Speck O. Magnetic resonance imaging (MRI): A review of genetic damage investigations. Mutation Research/Reviews in Mutation Research. 2015;764:51-63.

64. Sharma R, Sharma R. Other Applications of Superconducting Magnets. Superconductivity: Basics and Applications to Magnets. 2021:549-620.

65. Sharma RG. Superconductivity: Basics and applications to magnets: Springer Nature; 2021.

66. Wang Q, Zuurbier CJ, Huhn R, Torregroza C, Hollmann MW, Preckel B, et al. Pharmacological cardioprotection against ischemia reperfusion injury—the search for a clinical effective therapy. Cells. 2023;12(10):1432.

67. Shevade M, Bagade R. Medical Gas: Helium/Oxygen and Nitric Oxide Mixture in Noninvasive Ventilation. Pharmacology in Noninvasive Ventilation: Springer; 2024. p. 37-45.

68. Lew A, Morrison JM, Amankwah E, Sochet AA. Heliox for pediatric critical asthma: A multicenter, retrospective, registry-based descriptive study. Journal of Intensive Care Medicine. 2022;37(6):776-83.

69. Lew A, Morrison JM, Amankwah EK, Sochet AA. Heliox Prescribing Trends for Pediatric Critical Asthma. Respiratory care. 2022;67(5):510-9.

70. Levy SD, Alladina JW, Hibbert KA, Harris RS, Bajwa EK, Hess DR. High-flow oxygen therapy and other inhaled therapies in intensive care units. The Lancet. 2016;387(10030):1867-78.

71. Laroussi M. Low-temperature plasma jet for biomedical applications: a review. IEEE transactions on plasma science. 2015;43(3):703-12.

72. Karakas E. Characterizations of atmospheric pressure low temperature plasma jets and their applications: Old Dominion University; 2011.
73. PANDEY B, SINGH S, SHARMA N, DIXIT S. BIOMEDICAL APPLICATIONS OF HELIUM: AN OVERVIEW.
74. Joh HM, Choi JY, Kim SJ, Chung T, Kang T-H. Effect of additive oxygen gas on cellular response of lung cancer cells induced by atmospheric pressure helium plasma jet. Scientific reports. 2014;4(1):6638.
75. Joh HM, Kim SJ, Chung T, Leem S. Comparison of the characteristics of atmospheric pressure plasma jets using different working gases and applications to plasma-cancer cell interactions. Aip Advances. 2013;3(9).
76. Ishaq M, Evans M, Ostrikov K. Effect of atmospheric gas plasmas on cancer cell signaling. International journal of cancer. 2014;134(7):1517-28.
77. Kim C-H, Bahn JH, Lee S-H, Kim G-Y, Jun S-I, Lee K, et al. Induction of cell growth arrest by atmospheric non-thermal plasma in colorectal cancer cells. Journal of biotechnology. 2010;150(4):530-8.
78. Vandamme M, Robert E, Lerondel S, Sarron V, Ries D, Dozias S, et al. ROS implication in a new antitumor strategy based on non-thermal plasma. International journal of cancer. 2012;130(9):2185-94.
79. Yan X, Xiong Z, Zou F, Zhao S, Lu X, Yang G, et al. Plasma-induced death of HepG2 cancer cells: intracellular effects of reactive species. Plasma Processes and Polymers. 2012;9(1):59-66.
80. Barekzi N, Laroussi M. Effects of low temperature plasmas on cancer cells. Plasma Processes and Polymers. 2013;10(12):1039-50.
81. Pouvesle JM, Robert E, editors. NON THERMAL ATMOSPHERIC PLASMA JETS: A NEW WAY FOR CANCER TREATMENT? 20th International Conference on Gas Discharges and their Applications; 2014.
82. Schlegel J, Köritzer J, Boxhammer V. Plasma in cancer treatment. Clinical Plasma Medicine. 2013;1(2):2-7.
83. Tuhvatulin A, Sysolyatina E, Scheblyakov D, Logunov DY, Vasiliev M, Yurova M, et al. Non-thermal plasma causes p53-dependent apoptosis in human colon carcinoma cells. Acta Naturae (англоязычная версия). 2012;4(3 (14)):82-7.
84. Han X, Kapaldo J, Liu Y, Stack MS, Alizadeh E, Ptasinska S. Large-scale image analysis for investigating spatio-temporal changes in nuclear DNA damage caused by nitrogen atmospheric pressure plasma jets. International Journal of Molecular Sciences. 2020;21(11):4127.
85. Malik D, Narayanasamy N, Pratyusha V, Thakur J, Sinha N. Inorganic Nutrients: Macrominerals. Textbook of Nutritional Biochemistry: Springer; 2023. p. 391-446.
86. Fontani M, Costa M, Orna MV. The lost elements: The periodic table's shadow side: Oxford University Press, USA; 2015.
87. GUPTA P, PUSHKALA K. TWO WHITE ENEMIES: SALT AND SUGAR. Journal of Cell and Tissue Research. 2022;22(2):7203-23.
88. Preuss HG. Sodium, chloride, and potassium. Present knowledge in nutrition: Elsevier; 2020. p. 467-84.
89. Bernal A, Zafra MA, Simón MJ, Mahía J. Sodium homeostasis, a balance necessary for life. Nutrients. 2023;15(2):395.
90. Hoorn EJ, Gritter M, Cuevas CA, Fenton RA. Regulation of the renal NaCl cotransporter and its role in potassium homeostasis. Physiological reviews. 2020;100(1):321-56.
91. Van Regenmortel N, Verbrugghe W, Roelant E, Van den Wyngaert T, Jorens PG. Maintenance fluid therapy and fluid creep impose more significant fluid, sodium, and chloride burdens than resuscitation fluids in critically ill patients: a retrospective study in a tertiary mixed ICU population. Intensive care medicine. 2018;44:409-17.
92. Polychronopoulou E, Braconnier P, Burnier M. New insights on the role of sodium in the physiological regulation of blood pressure and development of hypertension. Frontiers in Cardiovascular Medicine. 2019;6:136.

93. Toigo M. Muscular Energy Bundles. Muscle Revolution: Concepts and Recipes for Building Muscle Mass and Force: Springer; 2024. p. 63-76.
94. Pohl HR, Wheeler JS, Murray HE. Sodium and potassium in health and disease. Interrelations between essential metal ions and human diseases. 2013:29-47.
95. Pirkmajer S, Chibalin AV. Na, K-ATPase regulation in skeletal muscle. American Journal of Physiology-Endocrinology and Metabolism. 2016;311(1):E1-E31.
96. Jomova K, Makova M, Alomar SY, Alwasel SH, Nepovimova E, Kuca K, et al. Essential metals in health and disease. Chemico-biological interactions. 2022;367:110173.
97. Wakeel A, Ishfaq M. Potash use and dynamics in agriculture. 2022.
98. McKinney DB. Potassium: Enslow Publishing, LLC; 2018.
99. Palmer BF, Clegg DJ. Physiology and pathophysiology of potassium homeostasis. Advances in physiology education. 2016;40(4):480-90.
100. Palmer BF. Regulation of potassium homeostasis. Clinical Journal of the American Society of Nephrology. 2015;10(6):1050-60.
101. Unwin RJ, Luft FC, Shirley DG. Pathophysiology and management of hypokalemia: a clinical perspective. Nature Reviews Nephrology. 2011;7(2):75-84.
102. Jalil J, Volle D, Zhu T, Sassounian M. Depression, Anxiety, and Other Mood Disorders. Geriatric Medicine: A Person Centered Evidence Based Approach: Springer; 2024. p. 1111-53.
103. Prabhu S. Imbalances in Fluids and Electrolytes, Acids and Bases: An Overview. Textbook of General Pathology for Dental Students. 2023:111-4.
104. Madhavan Unny N, Zarina A, Beena V. Fluid and Electrolyte Balance. Textbook of Veterinary Physiology: Springer; 2023. p. 193-211.
105. Aliyeva G, Holmirzayeva M, Ikromiddinov A. PHYSIOLOGY OF CARDIAC ACTIVITY. Центральноазиатский журнал образования и инноваций. 2023;2(10 Part 2):91-5.
106. Adamson RT. The burden of hyperkalemia in patients with cardiovascular and renal disease. Am J Manag Care. 2015;21:S307-S15.
107. Sica DA, Struthers AD, Cushman WC, Wood M, Banas Jr JS, Epstein M. Importance of potassium in cardiovascular disease. The Journal of Clinical Hypertension. 2002;4(3):198-206.
108. O'Donnell M, Yusuf S, Vogt L, Mente A, Messerli FH. Potassium intake: the Cinderella electrolyte. European heart journal. 2023;44(47):4925-34.
109. D'Elia L, Barba G, Cappuccio FP, Strazzullo P. Potassium intake, stroke, and cardiovascular disease: a meta-analysis of prospective studies. Journal of the American College of Cardiology. 2011;57(10):1210-9.
110. Mendeleev D. On the atomic volume of simple bodies. Bulletin for the History of Chemistry. 2019;44(2):109-15.
111. Xing P, Wang C, Chen Y, Ma B. Rubidium extraction from mineral and brine resources: A review. Hydrometallurgy. 2021;203:105644.
112. Usuda K, Kono R, Ueno T, Ito Y, Dote T, Yokoyama H, et al. Risk assessment visualization of rubidium compounds: comparison of renal and hepatic toxicities, in vivo. Biological trace element research. 2014;159:263-8.
113. Nasim H, Jamil Y. Recent advancements in spectroscopy using tunable diode lasers. Laser Physics Letters. 2013;10(4):043001.
114. Gopal S, Murphy C. Nuclear Medicine Stress Test. 2020.
115. Chatal J-F, Rouzet F, Haddad F, Bourdeau C, Mathieu C, Le Guludec D. Story of rubidium-82 and advantages for myocardial perfusion PET imaging. Frontiers in medicine. 2015;2:65.
116. Dantas RN, Assuncao AN, Marques IA, Fahel MG, Nomura CH, Avila LFR, et al. Myocardial perfusion in patients with suspected coronary artery disease: comparison between 320-MDCT and rubidium-82 PET. European Radiology. 2018;28:2665-74.

117. Roberts BR, Doecke JD, Rembach A, Yévenes LF, Fowler CJ, McLean CA, et al. Rubidium and potassium levels are altered in Alzheimer's disease brain and blood but not in cerebrospinal fluid. Acta neuropathologica communications. 2016;4:1-8.
118. Reinis S, Goldman JM. The chemistry of behavior: A molecular approach to neuronal plasticity: Springer Science & Business Media; 2012.
119. Bell DC, Fermini B. Use of automated patch clamp in cardiac safety assessment: past, present and future perspectives. Journal of pharmacological and toxicological methods. 2021;110:107072.
120. Chacar S, Catacutan MK, Albakr S, Al Safar H, Babiker S, Ahmed S, et al. Rapid, Label-free, contactless measurement of membrane potential in excitable H9c2 cardiomyoblasts using ζ-potential. Measurement Science and Technology. 2024.
121. Hao M, Zhang Z, Guo Y, Zhou H, Gu Q, Xu J. Rubidium chloride increases life span through an AMPK/FOXO-dependent pathway in Caenorhabditis elegans. The Journals of Gerontology: Series A. 2022;77(8):1517-24.
122. Malhi GS, Tanious M, Das P, Coulston CM, Berk M. Potential mechanisms of action of lithium in bipolar disorder: Current understanding. CNS drugs. 2013;27:135-53.
123. Marques F, Sousa JC, Sousa N, Palha JA. Blood–brain-barriers in aging and in Alzheimer's disease. Molecular neurodegeneration. 2013;8:1-9.
124. Casasanta CV. Pioneers in Optics: Robert Wilhelm Bunsen (1811–1899). Microscopy Today. 2023;31(3):40-1.
125. Shichalin O, Papynov E, Ivanov N, Balanov M, Dran'kov A, Shkuratov A, et al. Study of adsorption and immobilization of Cs+, Sr2+, Co2+, Pb2+, La3+ ions on Na-Faujasite zeolite transformed in solid state matrices. Separation and Purification Technology. 2024;332:125662.
126. Qin Y-C, Tang L-Y, Su Y, Chen L-J, Su F-X, Lin Y, et al. Association of urinary cesium with breast cancer risk. Asian Pacific Journal of Cancer Prevention. 2014;15(22):9785-90.
127. Greenwood NN, Earnshaw A. Chemistry of the Elements: Elsevier; 2012.
128. Yan T-T, Lin G-A, Wang M-J, Lamkowski A, Port M, Rump A. Pharmacological treatment of inhalation injury after nuclear or radiological incidents: The Chinese and German approach. Military Medical Research. 2019;6:1-10.
129. Pathak A. Use of Radiation in Therapy. Tools and Techniques in Radiation Biophysics: Springer; 2023. p. 177-93.
130. Daza EA, Misra SK, Schwartz-Duval AS, Ohoka A, Miller C, Pan D. Nano-cesium for anti-cancer properties: an investigation into cesium induced metabolic interference. ACS applied materials & interfaces. 2016;8(40):26600-12.
131. Wang X, Liang Z, Guo J, Wang M, Zhu R, Li Y, et al. Metal/metalloid levels and variation in lifetime cancer risks among tissues. Human and Ecological Risk Assessment: An International Journal. 2021;27(2):504-16.
132. Wernicke AG, Lazow SP, Taube S, Yondorf MZ, Kovanlikaya I, Nori D, et al. Surgical technique and clinically relevant resection cavity dynamics following implantation of cesium-131 brachytherapy in patients with brain metastases. Operative Neurosurgery. 2016;12(1):49-60.
133. Rayner-Canham M, Rayner-Canham G. Marguerite Perey: the discoverer of francium. Women in their Element: Selected Women's Contributions to the Periodic System: World Scientific; 2019. p. 341-9.
134. Halka M, Nordstrom B. Alkali and Alkaline Earth Metals: Infobase Publishing; 2010.
135. Delmau LH, Moine Jrm, Mirzadeh S, Moyer BA. First experimentally determined thermodynamic values of francium: hydration energy, energy of partitioning, and thermodynamic radius. The Journal of Physical Chemistry B. 2013;117(31):9258-61.
136. Cao C, Vernon RE, Schwarz W, Li J. Understanding periodic and non-periodic chemistry in periodic tables. Frontiers in Chemistry. 2021;8:549296.

137. Yin J, Hu Y, Yoon J. Fluorescent probes and bioimaging: alkali metals, alkaline earth metals and pH. Chemical Society Reviews. 2015;44(14):4619-44.
138. Freeman S. Occurrence and production of beryllium. Science and Technolog y from Lithium to Calcium, The Lightest Metals. 2015:23.
139. Gobato R, Heidari A. Calculations using quantum chemistry for inorganic molecule simulation BeLi2SeSi. American Journal of Quantum Chemistry and Molecular Spectroscopy. 2017;2(3):37-46.
140. Pawlas N, Pałczyński CM. Beryllium. Handbook on the Toxicology of Metals: Elsevier; 2022. p. 101-19.
141. Stearney ER, Jakubowski JA, Regina AC. Beryllium Toxicity. 2022.
142. Sinicropi MS, Amantea D, Caruso A, Saturnino C. Chemical and biological properties of toxic metals and use of chelating agents for the pharmacological treatment of metal poisoning. Archives of toxicology. 2010;84:501-20.
143. Newman LS, Maier LA. Chronic beryllium disease (berylliosis). Waltham (MA): UpToDate. 2021.
144. Weissferdt A, Weissferdt A. Infectious lung disease. Diagnostic Thoracic Pathology. 2020:3-71.
145. Prasse A, Quartucci C, Zissel G, Kayser G, Müller-Quernheim J, Frye BC. Interstitial Lung Diseases of Occupational Origin. Orphan Lung Diseases: A Clinical Guide to Rare Lung Disease: Springer; 2023. p. 641-69.
146. Kielstein JT, David S. Magnesium: the 'earth cure'of AKI? Nephrology Dialysis Transplantation. 2013;28(4):785-7.
147. Teng F-Z. Magnesium isotope geochemistry. Reviews in Mineralogy and Geochemistry. 2017;82(1):219-87.
148. Morris AL, Mohiuddin SS. Biochemistry, nutrients. 2020.
149. Salama MM, Mohammed ZA. Metal ions and their Biological Functions in Human Body. International Journal of New Chemistry. 2023;10(3):151-61.
150. De Baaij JH, Hoenderop JG, Bindels RJ. Regulation of magnesium balance: lessons learned from human genetic disease. Clinical kidney journal. 2012;5(Suppl_1):i15-i24.
151. Huang Y, Zhai X, Ma T, Zhang M, Pan H, Lu WW, et al. Rare earth-based materials for bone regeneration: breakthroughs and advantages. Coordination Chemistry Reviews. 2022;450:214236.
152. Hamada AM. Vitamins, omega-3, magnesium, manganese, and thyme can boost our immunity and protect against COVID-19. European Journal of Biological Research. 2020;10(4):271-95.
153. Barbagallo M, Veronese N, Dominguez LJ. Magnesium in aging, health and diseases. Nutrients. 2021;13(2):463.
154. DiNicolantonio JJ, Liu J, O'Keefe JH. Magnesium for the prevention and treatment of cardiovascular disease. Archives of Disease in childhood; 2018. p. e000775.
155. De Baaij JH, Hoenderop JG, Bindels RJ. Magnesium in man: implications for health and disease. Physiological reviews. 2015.
156. Guarracini F, Bonvicini E, Zanon S, Martin M, Casagranda G, Mochen M, et al. Emergency management of electrical storm: A practical overview. Medicina. 2023;59(2):405.
157. Schutten JC, Joosten MM, de Borst MH, Bakker SJ. Magnesium and blood pressure: a physiology-based approach. Advances in chronic kidney disease. 2018;25(3):244-50.
158. Lopez-Candales A, Burgos PMH, Hernandez-Suarez DF, Harris D. Linking chronic inflammation with cardiovascular disease: from normal aging to the metabolic syndrome. Journal of nature and science. 2017;3(4).
159. Rapa SF, Di Iorio BR, Campiglia P, Heidland A, Marzocco S. Inflammation and oxidative stress in chronic kidney disease—potential therapeutic role of minerals, vitamins and plant-derived metabolites. International journal of molecular sciences. 2019;21(1):263.
160. Mathew AA, Panonnummal R. 'Magnesium'-the master cation-as a drug—possibilities and evidences. Biometals. 2021;34(5):955-86.

161. Franczyk B, Dybiec J, Frąk W, Krzemińska J, Kućmierz J, Młynarska E, et al. Cellular mechanisms of coronary artery spasm. Biomedicines. 2022;10(10):2349.
162. Crisponi G, Nurchi VM, Cappai R, Zoroddu MA, Gerosa C, Piras M, et al. The potential clinical properties of magnesium. Current Medicinal Chemistry. 2021;28(35):7295-311.
163. Weglicki WB. Hypomagnesemia and inflammation: clinical and basic aspects. Annual review of nutrition. 2012;32:55-71.
164. Shahi A, Aslani S, Ataollahi M, Mahmoudi M. The role of magnesium in different inflammatory diseases. Inflammopharmacology. 2019;27:649-61.
165. Abbasalizadeh S, Ebrahimi B, Azizi A, Dargahi R, Tayebali M, Ghadim ST, et al. Review of Constipation Treatment Methods with Emphasis on Laxative Foods. Current Nutrition & Food Science. 2020;16(5):675-88.
166. Tabrizi A, Dargahi R, Ghadim ST, Javadi M, Pirouzian HR, Azizi A, et al. Functional laxative foods: Concepts, trends and health benefits. Studies in natural products chemistry. 2020;66:305-30.
167. Shea LA, Sorauf KJ, Polson KS, Calderon B, Poupard M, Zolnir-Groshong A. One-dollar medications: evaluating the true cost. Advances in Translational Medicine. 2022:17-32.
168. Kang SJ, Cho YS, Lee TH, Kim S-E, Ryu HS, Kim J-W, et al. Medical management of constipation in elderly patients: systematic review. Journal of Neurogastroenterology and Motility. 2021;27(4):495.
169. Karimi N, Razian A, Heidari M. The efficacy of magnesium oxide and sodium valproate in prevention of migraine headache: a randomized, controlled, double-blind, crossover study. Acta Neurologica Belgica. 2021;121:167-73.
170. Dolati S, Rikhtegar R, Mehdizadeh A, Yousefi M. The role of magnesium in pathophysiology and migraine treatment. Biological trace element research. 2020;196:375-83.
171. Parthasarathy A, Gupta A, Borker AS, Dharmapalan D. Partha's Comprehensive Manual for Pediatric and Adolescent Practice: Jaypee Brothers Medical Publishers; 2020.
172. Bilqis H, Noreen H, Bano N, Chaudhri R. Magnesium Sulphate in Eclampsia and Pre-Eclampsia-A Case Series Of 103 Patients Treated with Single Loading Dose of MgSO4 (14 Grams) At Holy Family Hospital, Rawalpindi. Journal of The Society of Obstetricians and Gynaecologists of Pakistan. 2018;8(3):154-8.
173. Darngawn L, Jose R, Regi A, Bansal R, Jeyaseelan L. A shortened postpartum magnesium sulfate prophylaxis regime in pre-eclamptic women at low risk of eclampsia. International Journal of Gynecology & Obstetrics. 2012;116(3):237-9.
174. Lingam I. Magnesium Sulphate Neuroprotection in Neonatal Encephalopathy: UCL (University College London); 2020.
175. Lozada-Martinez ID, Padilla-Durán TJ, González-Monterroza JJ, Aguilar-Espinosa DA, Molina-Perea KN, Camargo-Martinez W, et al. Basic considerations on magnesium in the management of neurocritical patients. Journal of Neurocritical Care. 2021;14(2):78-87.
176. Gupta VK. Eclampsia in the 21st Century: Paradigm Shift from Empirical Therapy with Magnesium Sulfate. Basic Science Synthesis vs. Current Who-Recommended Pharmacotherapeutic Practice. J Brain and Neurological Disorders. 2023;6(2).
177. Sahni S, Mangano KM, McLean RR, Hannan MT, Kiel DP. Dietary approaches for bone health: lessons from the Framingham Osteoporosis Study. Current osteoporosis reports. 2015;13:245-55.
178. Hejazi J, Davoodi A, Khosravi M, Sedaghat M, Abedi V, Hosseinverdi S, et al. Nutrition and osteoporosis prevention and treatment. Biomedical research and Therapy. 2020;7(4):3709-20.
179. Zheng L-Z, Wang J-L, Xu J-K, Zhang X-T, Liu B-Y, Huang L, et al. Magnesium and vitamin C supplementation attenuates steroid-associated osteonecrosis in a rat model. Biomaterials. 2020;238:119828.
180. Miśkowiec P. Name game: the naming history of the chemical elements—part 1—from antiquity till the end of 18th century. Foundations of Chemistry. 2023;25(1):29-51.

181. Aversa R, Petrescu RV, Apicella A, Petrescu FI. The basic elements of life's. American Journal of Engineering and Applied Sciences. 2016;9(4):1189-97.
182. Epple M. Review of potential health risks associated with nanoscopic calcium phosphate. Acta biomaterialia. 2018;77:1-14.
183. Dorozhkin SV. Calcium orthophosphates: occurrence, properties, biomineralization, pathological calcification and biomimetic applications. Biomatter. 2011;1(2):121-64.
184. Dorozhkin SV. Medical application of calcium orthophosphate bioceramics. Bio. 2011;1(1):1-51.
185. Sobh MM, Abdalbary M, Elnagar S, Nagy E, Elshabrawy N, Abdelsalam M, et al. Secondary osteoporosis and metabolic bone diseases. Journal of Clinical Medicine. 2022;11(9):2382.
186. Andrew R, Izzo AA. Principles of pharmacological research of nutraceuticals. British Journal of Pharmacology. 2017;174(11):1177.
187. Adatorwovor R, Roggenkamp K, Anderson JJ. Intakes of calcium and phosphorus and calculated calcium-to-phosphorus ratios of older adults: NHANES 2005–2006 data. Nutrients. 2015;7(11):9633-9.
188. Body J-J, Bergmann P, Boonen S, Devogelaer J-P, Gielen E, Goemaere S, et al. Extraskeletal benefits and risks of calcium, vitamin D and anti-osteoporosis medications. Osteoporosis international. 2012;23:1-23.
189. Lems WF, Raterman HG. Critical issues and current challenges in osteoporosis and fracture prevention. An overview of unmet needs. Therapeutic advances in musculoskeletal disease. 2017;9(12):299-316.
190. Melaku YA, Gill TK, Taylor AW, Adams R, Shi Z. Association between nutrient patterns and bone mineral density among ageing adults. Clinical nutrition ESPEN. 2017;22:97-106.
191. Peacock M. Calcium metabolism in health and disease. Clinical Journal of the American society of nephrology. 2010;5(Supplement_1):S23-S30.
192. Zhu K, Prince RL. Calcium and bone. Clinical biochemistry. 2012;45(12):936-42.
193. Garg V, Narang P, Taneja R. Antacids revisited: review on contemporary facts and relevance for self-management. Journal of International Medical Research. 2022;50(3):03000605221086457.
194. Godfraind T. Discovery and development of calcium channel blockers. Frontiers in pharmacology. 2017;8:259145.
195. Hansen P. Functional and pharmacological consequences of the distribution of voltage-gated calcium channels inthe renal blood vessels. Acta physiologica. 2013;207(4):690-9.
196. Park G. Introducing natural resources: Dunedin Academic Press Ltd; 2015.
197. Bhusal SP. STUDY OF STRUCTURAL AND ELECTRONIC PROPERTIES OF ALKALINE EARTH METAL CALCIUM AND STRONTIUM: Department of Physics Birendra Multiple Campus; 2020.
198. Pilmane M, Salma-Ancane K, Loca D, Locs J, Berzina-Cimdina L. Strontium and strontium ranelate: Historical review of some of their functions. Materials Science and Engineering: C. 2017;78:1222-30.
199. Querido W, Rossi AL, Farina M. The effects of strontium on bone mineral: A review on current knowledge and microanalytical approaches. Micron. 2016;80:122-34.
200. Liberal FDG, Tavares AAS, Tavares JMR. Palliative treatment of metastatic bone pain with radiopharmaceuticals: A perspective beyond Strontium-89 and Samarium-153. Applied Radiation and Isotopes. 2016;110:87-99.
201. Marie P, Felsenberg D, Brandi ML. How strontium ranelate, via opposite effects on bone resorption and formation, prevents osteoporosis. Osteoporosis International. 2011;22:1659-67.
202. Mukherjee S, Mishra M. Application of strontium-based nanoparticles in medicine and environmental sciences. Nanotechnology for Environmental Engineering. 2021;6(2):25.
203. Cheng H, Xiong W, Fang Z, Guan H, Wu W, Li Y, et al. Strontium (Sr) and silver (Ag) loaded nanotubular structures with combined osteoinductive and antimicrobial activities. Acta biomaterialia. 2016;31:388-400.

204. Semenishchev VS, Voronina AV. Isotopes of strontium: Properties and applications. Strontium Contamination in the Environment. 2020:25-42.
205. Ifijen IH, Maliki M, Odiachi IJ, Omoruyi IC, Aigbodion AI, Ikhuoria EU. Performance of metallic-based nanomaterials doped with strontium in biomedical and supercapacitor electrodes: a review. Biomedical Materials & Devices. 2023;1(1):402-18.
206. Krishnan V, Bhatia A, Varma H. Development, characterization and comparison of two strontium doped nano hydroxyapatite molecules for enamel repair/regeneration. Dental Materials. 2016;32(5):646-59.
207. Shrivastava P, Jain V, Nagpal S. Nanoparticle intervention for heavy metal detection: A review. Environmental Nanotechnology, Monitoring & Management. 2022;17:100667.
208. Kanaoujiya R, Saroj SK, Rajput VD, Alimuddin, Srivastava S, Minkina T, et al. Emerging application of nanotechnology for mankind. Emergent Materials. 2023;6(2):439-52.
209. Birhanu R, Afrasa MA, Hone FG. Recent progress of advanced metal-oxide nanocomposites for effective and low-cost antimicrobial activates: A review. Journal of Nanomaterials. 2023;2023:1-25.
210. Kasirajan K, Karunakaran M. Synthesis and characterization of strontium cerium mixed oxide nanoparticles using plant extract. Sensor Letters. 2019;17(12):924-37.
211. Butt A, Ali JS, Sajjad A, Naz S, Zia M. Biogenic synthesis of cerium oxide nanoparticles using petals of Cassia glauca and evaluation of antimicrobial, enzyme inhibition, antioxidant, and nanozyme activities. Biochemical Systematics and Ecology. 2022;104:104462.
212. Kavitha S, Mohan K, Deepika K, Janani P, Kamali B, Bhavadharani S. The Impact of Zn doping on structural and optical behavior of SrO2 NPs and Anti-Microbial activities for Zn@ SrO2 NPs. Materials Today: Proceedings. 2023;94:1-12.
213. Din MI, Rehman S, Hussain Z, Khalid R. Green synthesis of strontium oxide nanoparticles and strontium based nanocomposites prepared by plant extract: a critical review. Reviews in Inorganic Chemistry. 2024;44(1):91-116.
214. Pandit-Taskar N, Mahajan S. Targeted Radionuclide Therapy for Bone Metastasis. Nuclear Oncology: From Pathophysiology to Clinical Applications: Springer; 2022. p. 1481-513.
215. Kuroda I. Effective use of strontium-89 in osseous metastases. Annals of nuclear medicine. 2012;26:197-206.
216. Aziz HA, Ghazali MF, Hung Y-T, Wang LK. Toxicity, source, and control of barium in the environment. Handbook of Advanced Industrial and Hazardous Wastes Management: CRC Press; 2017. p. 463-82.
217. Rezvukhin DI, Alifirova TA, Golovin AV, Korsakov AV. A plethora of epigenetic minerals reveals a multistage metasomatic overprint of a mantle orthopyroxenite from the Udachnaya Kimberlite. Minerals. 2020;10(3):264.
218. Oskarsson A. Barium. Handbook on the Toxicology of Metals: Elsevier; 2022. p. 91-100.
219. Paliwal P, Kumar AS, Tripathi H, Singh S, Patne SC, Krishnamurthy S. Pharmacological application of barium containing bioactive glass in gastro-duodenal ulcers. Materials Science and Engineering: C. 2018;92:424-34.
220. Majumdar S, Gupta S, Krishnamurthy S. Bioactive glass: soft tissue reparative and regenerative applications. Bioactive Glasses and Glass-Ceramics: Fundamentals and Applications. 2022:479-517.
221. Kargozar S, Hamzehlou S, Baino F. Can bioactive glasses be useful to accelerate the healing of epithelial tissues? Materials Science and Engineering: C. 2019;97:1009-20.
222. Hsu JC, Nieves LM, Betzer O, Sadan T, Noël PB, Popovtzer R, et al. Nanoparticle contrast agents for X-ray imaging applications. Wiley Interdisciplinary Reviews: Nanomedicine and Nanobiotechnology. 2020;12(6):e1642.
223. Yang X, Lovell JF, Zhang Y. Ingestible contrast agents for gastrointestinal imaging. ChemBioChem. 2019;20(4):462-73.

224. Stollfuss J, Hellerhoff P. Gastrointestinal System. Diagnostic and Interventional Radiology: Springer; 2016. p. 825-61.

225. Booth A. Introduction to Patient Preparation and Pharmacology for GI Tract Investigation. In: Nightingale J and Law R, editors. Gastrointestinal Tract Imaging. Edinburgh, Elsevier 2009. Gastrointestinal Tract Imaging: Elsevier; 2010.

226. Vernon RE. The location and composition of Group 3 of the periodic table. Foundations of Chemistry. 2021;23(2):155-97.

227. G’anievich MY. History Of Great Discoveries In Physics. The American Journal of Interdisciplinary Innovations and Research. 2021;3(03):64-9.

228. Fromm KM. Chemistry of alkaline earth metals: It is not all ionic and definitely not boring! Coordination Chemistry Reviews. 2020;408:213193.

229. Dobrzynska M, Gajowik A, Wieprzowski K. Radon-occurrence and impact on the health. Roczniki Państwowego Zakładu Higieny. 2023;74(1).

230. Singh P, Khan M. Some Aspects of Radon Radiation. IRE Journals. 2018;1:130-4.

231. Orabi M. Radon release and its simulated effect on radiation doses. Health Physics. 2017;112(3):294-9.

232. Gott M, Steinbach J, Mamat C. The radiochemical and radiopharmaceutical applications of radium. Open Chemistry. 2016;14(1):118-29.

233. Zhang T, Gregory K, Hammack RW, Vidic RD. Co-precipitation of radium with barium and strontium sulfate and its impact on the fate of radium during treatment of produced water from unconventional gas extraction. Environmental science & technology. 2014;48(8):4596-603.

234. Pasquini L, Morris MJ. Case Study# 8: Alpha-Therapy with Radium-223 Dichloride for Metastatic Castration-Resistant Prostate Cancer. Radiopharmaceutical Therapy: Springer; 2023. p. 387-405.

235. Dizdarevic S, McCready R, Vinjamuri S. Radium-223 dichloride in prostate cancer: proof of principle for the use of targeted alpha treatment in clinical practice. European Journal of Nuclear Medicine and Molecular Imaging. 2020;47:192-217.

236. Buroni FE, Persico MG, Pasi F, Lodola L, Nano R, Aprile C. Radium-223: Insight and perspectives in bone-metastatic castration-resistant prostate cancer. Anticancer research. 2016;36(11):5719-30.

237. Clézardin P, Coleman R, Puppo M, Ottewell P, Bonnelye E, Paycha F, et al. Bone metastasis: mechanisms, therapies, and biomarkers. Physiological reviews. 2021;101(3):797-855.

238. Vardaki I, Corn P, Gentile E, Song JH, Madan N, Hoang A, et al. Radium-223 treatment increases immune checkpoint expression in extracellular vesicles from the metastatic prostate cancer bone microenvironment. Clinical Cancer Research. 2021;27(11):3253-64.

239. Lassmann M, Eberlein U. Comparing absorbed doses and radiation risk of the α-emitting bone-seekers [Ra] RaCl and [Ra] RaCl. Targeted alpha particle therapy in oncology. 2023.

240. Tański W, Świątoniowska-Lonc N, Dudek K, Jankowska-Polańska B. Benefit of biological drugs for quality of life in patients with ankylosing spondylitis: a systematic review and meta-analysis of clinical trials. Best Practice in Health Care. 2020:63-78.

Table 1 (on next page)

S-block elements (symbols and letters)

Table 1: S-block elements (symbols and letters)

H Hydrogen	**He** Helium	**Li** Lithium	**Na** Sodium	**K** Potassium	**Rb** Rubidium	**Cs** Cesium
Fr Francium	**Be** Beryllium	**Mg** Magnesium	**Ca** Calcium	**Sr** Strontium	**Ba** Barium	**Ra** Radium