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Biological Significance of Alkalis

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ABSTRACT: Alkali metals, any of the six chemical elements that make up Group 1 (Ia) of the periodic table—namely, lithium (Li), sodium (Na), potassium (K), rubidium (Rb), cesium (Cs), and francium (Fr). The alkali metals are so called because reaction with water forms alkalies (i.e., strong bases capable of neutralizing acids). Sodium and potassium are the sixth and seventh most abundant of the elements, constituting, respectively, 2.6 and 2.4 percent of Earth's crust. The other alkali metals are considerably more rare, with rubidium, lithium, and cesium, respectively, forming 0.03, 0.007, and 0.0007 percent of Earth's crust. Francium, a natural radioactive isotope, is very rare and was not discovered until 1939.

KEYWORDS: alkalis, elements, biological, atom, significance, periodic table

I. INTRODUCTION

The alkali metals are so reactive that they are generally found in nature combined with other elements. Simple minerals, such as halite (sodium chloride, NaCl), sylvite (potassium chloride, KCl), and carnallite (a potassium-magnesium chloride, $KCl \cdot MgCl_2 \cdot 6H_2O$), are soluble in water and therefore are easily extracted and purified. More complex, water-insoluble minerals are, however, far more abundant in Earth's crust. A very dilute gas of atomic sodium (about 1,000 atoms per cubic cm [about 16,000 atoms per cubic inch]) is produced in Earth's mesosphere (altitude about 90 km [60 miles]) by ablation of meteors. Subsequent reaction of sodium with ozone and atomic oxygen produces excited sodium atoms that emit the light we see as the "tail" of a meteor as well as the more diffuse atmospheric nightglow. Smaller amounts of lithium and potassium are also present. The alkali metals have the silver-like lustre, high ductility, and excellent conductivity of electricity and heat generally associated with metals. Lithium is the lightest metallic element. The alkali metals have low melting points, ranging from a high of 179 °C (354 °F) for lithium to a low of 28.5 °C (83.3 °F) for cesium. Alloys of alkali metals exist that melt as low as -78 °C (-109 °F).[1,2]

The alkali metals react readily with atmospheric oxygen and water vapour. (Lithium also reacts with nitrogen.) They react vigorously, and often violently, with water to release hydrogen and form strong caustic solutions. Most common nonmetallic substances such as halogens, halogen acids, sulfur, and phosphorus react with the alkali metals. The alkali metals themselves react with many organic compounds, particularly those containing a halogen or a readily replaceable hydrogen atom.

Their bioinorganic chemistry and analytical determination, the solid state structures of bio-ligand complexes and the properties of alkali metal ions in solution in the context of all kinds of biologically relevant ligands are covered, this includes proteins (enzymes) and nucleic acids (G-quadruplexes). Minerals containing sodium (Na^+) and potassium (K^+) are abundant in the Earth's crust, making Na^+ and K^+ easily available. In contrast, the alkali elements lithium (Li^+), rubidium, and cesium are rare and the radioactive francium occurs only in traces. Since the intra- and extracellular, as well as the compartmental concentrations of Na^+ and K^+ differ significantly, homeostasis and active transport of these ions are important; this involves transporters/carriers and pore-forming ion channel proteins. Systems like Na^+/K^+ -ATPases, H^+/K^+ -ATPases or Na^+/H^+ antiporters are thoroughly discussed. The role of K^+ in photosynthesis and the role of Na^+ in charging the "battery of life" are pointed out. Also, the relationships between alkali metal ions and diseases

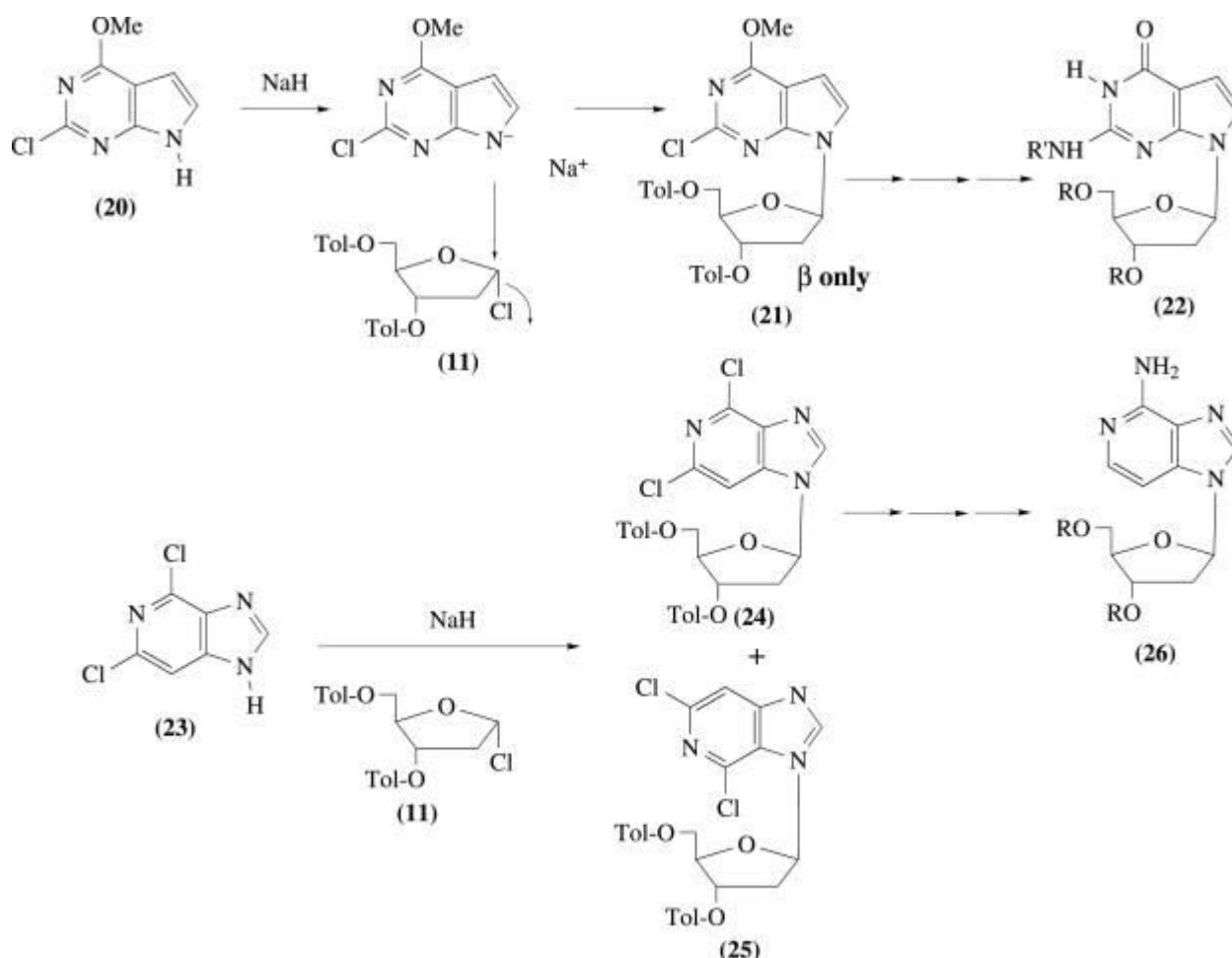
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(e.g., Parkinson or traumatic brain injury) are covered and the relevance of Li⁺ salts in medicine (pharmacology and mechanism) is reviewed. [3,4]



Alkali metal salt

II. OBSERVATIONS

Introduction of Group Ia And Iia Elements: Lithium (Li), Sodium (Na), Potassium (K), Rubidium (Rb) and Cesium (Cs) are all group IA elements, also known as the alkali metals. The seventh member of the group francium (Fr) is radioactive.

BIOLOGICAL IMPORTANCE OF HYDROGEN : To Protect the lung against oxygen toxicity Hydrogen-saturated saline is used. Tritium which is Hydrogen isotope is very radioactive often used as X-rays, to identify tumor markers. Hydrogen makes up two of the three atoms in water and water is absolutely essential of life. Hydrogen is present in all organic compounds. For gastric acidifier diluted hydrochloric acid is used. A form of water in which both hydrogen

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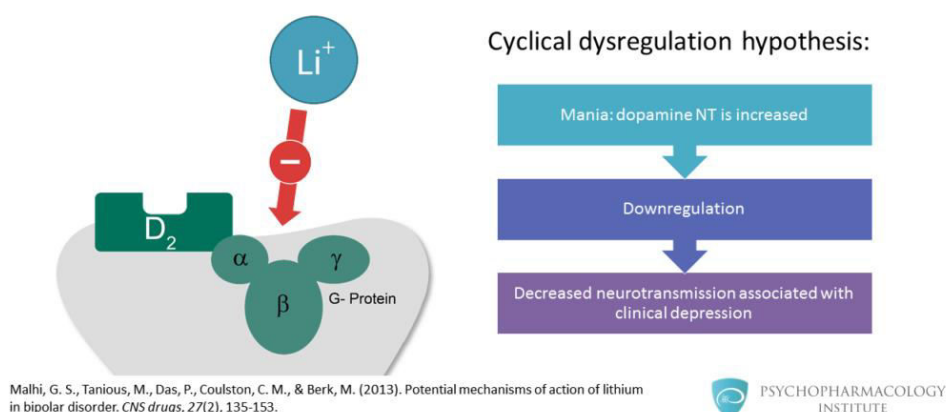
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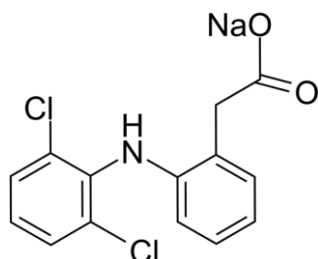
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atoms are replaced by deuterium (2H, or D) is called “heavy water” (D2O) and is toxic to mammals. Some bacteria are known to metabolise molecular hydrogen (H2O). **BIOLOGICAL IMPORTANCE OF LITHIUM** : Lithium has an effect on the body it swallowed. Sometimes lithium based compound such as (Li2CO3) are use as drugs to treat manic depressive disorders. The dose is around 0.5g- 2g daily. For hypertension treatment Lithium chloride can be used. [5,6]

Lithium inhibits dopamine neurotransmission



BIOLOGICAL IMPORTANCE OF SODIUM : Sodium regulates blood volume, blood pressure, neuron function, osmotic equilibrium & PH Higher levels of sodium can prevent kidney failure, loss of fluids, hypothyroidism, heart failure, liver cirrhosis etc. Sodium plays an important role in the body because it deals with maintaining water balance, transmitting nerve impulses and regulating muscle contraction & relaxation Lodized salt is essential for the body as it helps in the production of thyroid hormones which affects growth & metabolic rates. Diclofenac is used to treat pain & reduce inflammation that accompanies rheumatoid arthritis and osteoarthritis. Sodium bromide is used by the medical fraternity to treat headaches & seizures. Naproxen sodium is used to reduce pain associated with muscle injuries. [7,8]



Diclofenac sodium

BIOLOGICAL IMPORTANCE OF POTASSIUM : Potassium cautions are important in neuron function, in fluencing osmotic balance between cells and interstitial fluid and in maintaining the fluid and electrolyte balance. Higher levels of potassium is used to treat hypokalemia, renal damage, muscle contraction, muscle weakness, paralytic ileus, acidosis, inflammatory bowel diseases, ECG abnormalities, respiratory paralysis, alkalosis and cardiac arrhythmia. In taking higher levels of potassium can reduce the risk of hyper tension, stroke and potassium deficiency as well as reduce bone turnover in people. Potassium is used as medicine in conjunction with lops diuretics and thiazides. Potassium bromated is used to improve dough strength and rise height. Potassium helps move nutrients into cells and waste products out of cells. Potassium is needed for muscle growth, nervous system and brain function. Measuring the amount of potassium by blood test can identify the presence of kidney disease, diabetes, and vomiting problem in the

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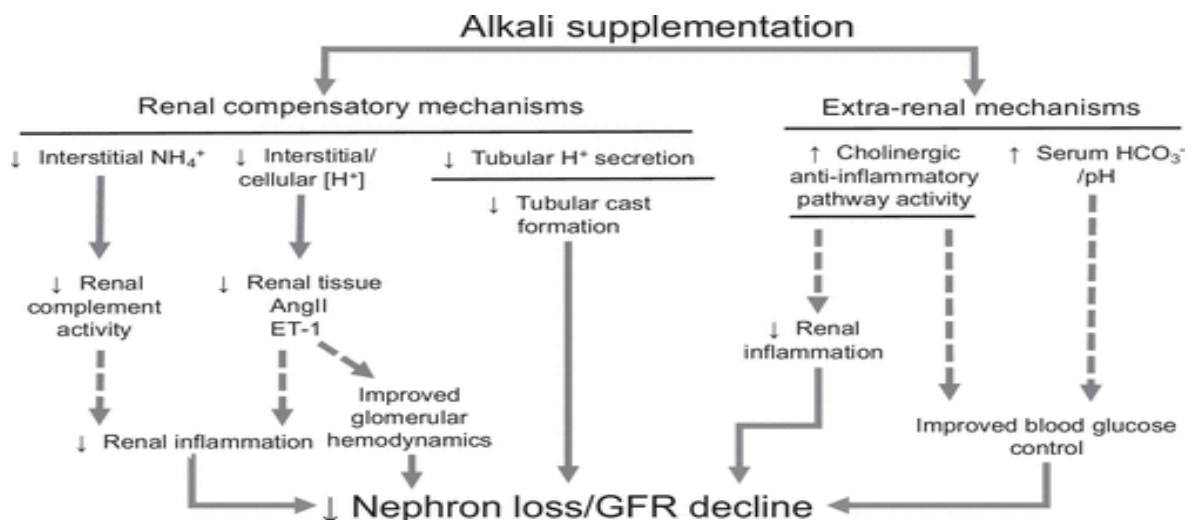
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body. Consumption of foods rich in potassium plays a role to prevent osteoporosis. Potassium chloride is used as the treatment of meniere's syndrome and familiar periodic paralysis. Potassium bicarbonate is used as antacid for those people who are restricted for in taking sodium. [9]

BIOLOGICAL IMPORTANCE OF RUBIDIUM : It stimulate the metabolism. It can accumulate ahead of potassium in muscle. It readily reacts with skin moisture to form rubidium hydroxide. Failure to aggravated by exposure, heart patients, Potassium imbalance. **BIOLOGICAL IMPORTANCE OF CAESIUM :** It is capable of replacing potassium in the body to some extent because of its chemical similarity. Ingestion of any Caesium compounds is therefore to be avoided. Because of this similarity, the isotopes ^{134}Cs and ^{137}Cs (present in the biosphere in small amounts as a result of radiation leaks)are very toxic. Rats fed Caesium in place of potassium in their diet die.[10]

BIOLOGICAL IMPORTANCE OF FRANCIUM : Biological role of francium: Francium has no biological role. Hazards and risks: Francium does not occur to any significant extent in the biosphere and so normally never presents a risk. Francium is studied in a few nuclear research laboratories where its high radioactivity requires special handling techniques and precautions. One could speculate that its chemical hazards would be very similar to those of caesium. **BIOLOGICAL IMPORTANCE OF BERYLLIUM :** Beryllium foil is used for radiation windows in scientific X-ray equipment. Beryllium mammography equipment enables to scan the finer tumor resolution and detect the breast cancer at its early, most treatable stages. Medical lasers made with beryllia ceramic help ophthalmologists to improve or restore eyesight for millions. Beryllium is also used in components of the analytical equipment used to analyze blood for HIV and other diseases.[11,12]



BIOLOGICAL IMPORTANCE OF MAGNESIUM : Magnesium supports the process of protein synthesis, cell growth and energy production. It has played role in nerve function, muscle control and blood pressure, even blood sugar regulation depends on magnesium. Magnesium strengthens bones and teeth as well as prevents clotting of blood. Magnesium seems to be effective for asthma exacerbation, heart attack osteoporosis etc. Inject able magnesium is used for the treatment of preeclampsia. Magnesium hydroxide, suspended in water, is used in milk of magnesia antacids and laxatives. Magnesium salts is injected intramuscularly or intravenously which have a powerful anesthetic action like chloroform. Magnesium oxide is used to treat constipation, IBS, hypomagnesaemia, kidney stones, gastro esophageal reflux disease and gastric ulcer. Magnesium citrate is a hyper osmotic saline laxative which is used to treat constipation, kidney stones, colon and rectal diseases. Oral magnesium supplement has been therapeutic for the patient of restless leg syndrome. Magnesium borate, magnesium salicylate and magnesium sulphate are all used as antiseptics.

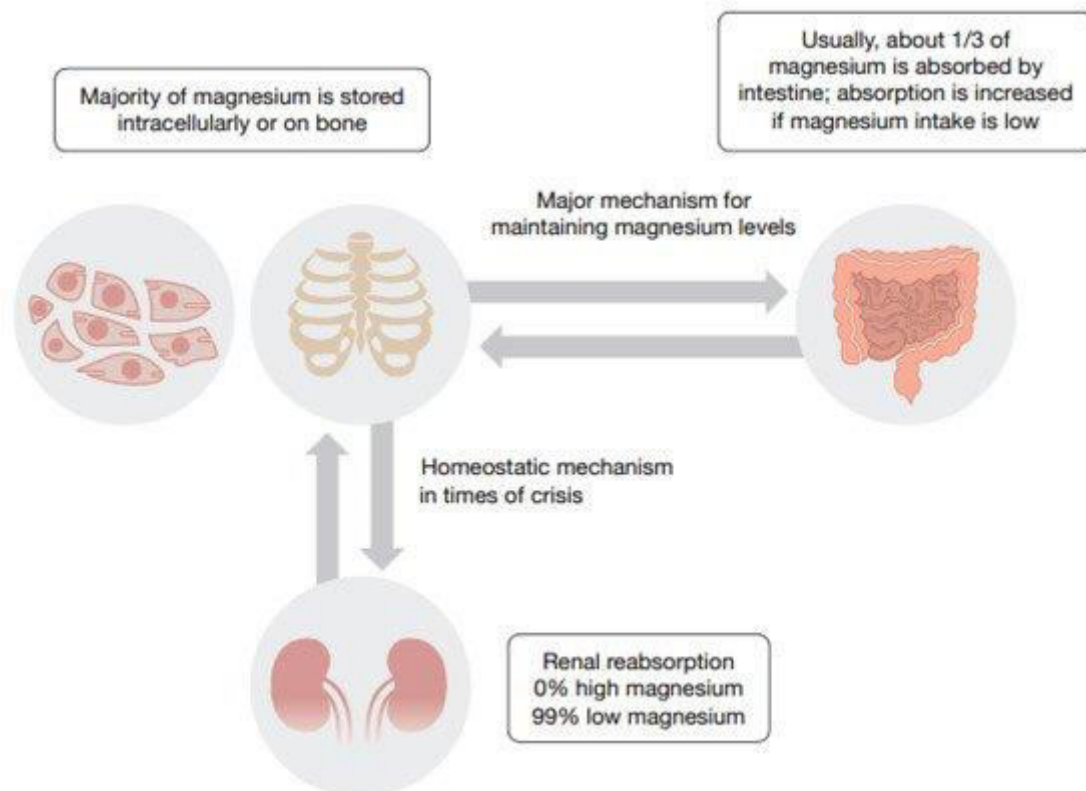
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Some types of migraine and cluster headaches can prevent by magnesium supplements. Magnesium phosphate is used as laxative and antacid. [13]



BIOLOGICAL IMPORTANCE OF CALCIUM : Calcium is important for blood clotting. It forms part of cell walls and bones. The consumption of large amounts of the mineral calcium are necessary to maintain good health in adulthood. It prevents or remedies the thinning and weakening of bones.

BIOLOGICAL IMPORTANCE OF STRONTIUM: This review summaries old and more recent literature on the biological role of the bone – seeking trace metal strontium (Sr). It covers areas of chemistry, nutrition, toxicity, transport across biological membranes, homeostasis, general physiology, calcium-strontium interactions and particularly the role of strontium in bone. The promoting action of strontium of calcium uptake into bone at moderate strontium supplementation. The rachitogenic action of strontium at higher dietary strontium levels are emphasized . The literature of summarized of the novel antiosteoporotic drug strontium ranelate which appears to act by a combination of reduced bone resorption and increased uptake of calcium into bone.

BIOLOGICAL IMPORTANCE OF BARIUM: The British Pharmaceutical Codex from 1907 indicates that barium chloride has a stimulant action on the heart and other muscles. It was said that it "raises blood pressure by constricting the vessels and tends to empty the intestines, bladder, and gall bladder". Its poisonous nature was also pointed out. Barium sulphide (bas) was used as a depilatory agent (removes hair). Barium sulphate (baso₄) is insoluble and used for body imaging (barium meal).[14]

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Barium usage in body imaging

Barium salt may damage the liver. Health effects of barium : The amount of barium that is detected in food and water usually is not high enough to become a health concern. People with the greatest risk to barium exposure with additional health effects are those that work in the barium industry. Most of the health risks that they can undergo are caused by breathing in air that contains barium sulphate or barium carbonate. Many hazardous waste sites contain certain amounts of barium. People that live near them may be exposed to harmful levels. The exposure will then be caused by breathing dust, eating soil or plants, or drinking water that is polluted with barium. Skin contact may also occur. The health effects of barium depend upon the water-solubility of the compounds. Barium compounds that dissolve in water can be harmful to human health. The uptake of very large amounts of barium that are water-soluble may cause paralysis and in some cases even death. Small amounts of water-soluble barium may cause a person to experience breathing difficulties, increased blood pressures, heart rhythm changes, stomach irritation, muscle weakness, changes in nerve reflexes, swelling of brains and liver, kidney and heart damage. Barium has not shown to cause cancer with humans. There is no proof that barium can cause infertility or birth defects. [15]

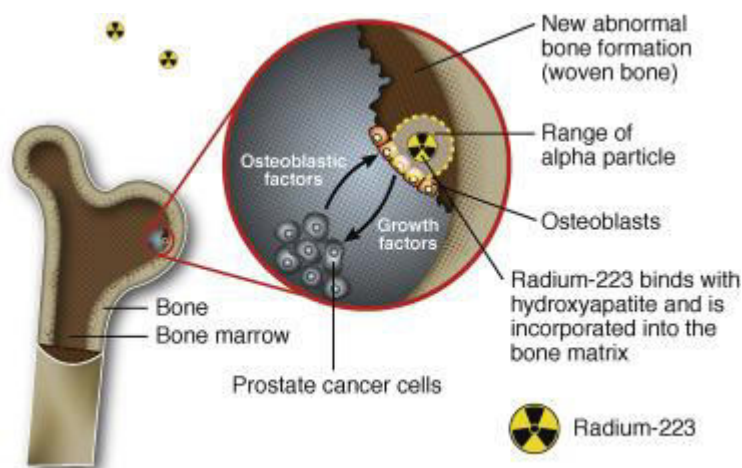
BIOLOGICAL IMPORTANCE OF RADIUM : Radium chloride is used in medicine as a cancer treatment. Radium-223 isotope is currently under investigated to use as a medicine for cancer treatment to use as a medicine for cancer treatment of bone-metastasis. Using preparations of radium salt in bath water can treat arthritis, gaut & neuralgias. Radium therapy is used to prevent lupus, ulcerous growth & keloid. Iodo-radium therapy is used for the treatment of tuberculosis. Radioactive iodine which produces from radium and iodine is used as a treatment of thyrotoxicosis and some types of thyroid cancer that absorb iodine.

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Use of radium in treatment of cancer

IV. DISCUSSION

After intravenous injection of $^{133}\text{Ba}^{2+}$ into beagle dogs, specific activity was highest in the sternum, followed by sacrum and coccyx, vertebrae, ribs, humerus, and femur. In the skull, mandible, radius, ulna, and tibia-fibula, the specific activity was less than whole-body specific activity.

For most soft tissues, barium accumulation after intravenous injection is low and in proportion to their calcium content. Exceptions are the submaxillary gland, which was found to concentrate barium from serum in preference to the other alkaline earth metals

The pigmented parts of the eye (iris, sclera, and especially the choroid) accumulate the highest levels of circulating barium, with concentrations reaching the 0.1 g/kg (wet weight) level. High concentrations of barium were also found in melanoma cells. Strontium ranelate appeared to stimulate bone formation and inhibit bone resorption in rodents, but functioned as a moderately effective antiresorptive agent in humans.[16]

Sodium, Potassium, Magnesium and Calcium are four of the most important constituents of living systems (sodium being the principal extracellular and potassium the major intracellular monovalent cations). Alkaline and Alkaline earth metal cations also participate in the stabilization of cell membrane, enzyme, polynucleotide (DNA, RNA) conformations via electrostatic interactions and Osmotic effects. Nucleic acids are polyanions and as such, require, counter ions to neutralize partially or completely the negative charged phosphate groups, so that electrostatic repulsions do not overwhelm other stabilizing effects. Sodium is a vital element. The human diet must contain a sensible amount of sodium. The sodium cation is the main extracellular (outside cells) cation in animals and is important for nerve function in animals. Potassium salts are essential for both animals and plants.

In order to maintain the cell potential, cells must keep a low concentration of sodium ions and high levels of potassium ions within the cell (intracellular). Outside cells (extracellular), there are high concentrations of sodium and low concentrations of potassium, so diffusion occurs through ion channels in the plasma membrane. In order to keep the appropriate concentrations, the sodium-potassium pump pumps sodium out and potassium in through active transport. The ionic transport conducted by sodium pump creates both an electrical and chemical gradient across the plasma membrane.

First of all the $\text{Na}^+ - \text{K}^+$ pump bound with ATP binds 3 intracellular $\text{Na}^+ + \text{P}$ ions (step a). This starts phosphorylation of an Asp residue leading to a conformational change, which weakens $\text{Na}^+ + \text{P}$ binding and moves $\text{Na}^+ + \text{P}$ out of the cell (step b). A conformational change in the pump exposes the $\text{Na}^+ + \text{P}$ ions to the outside, where they are released.

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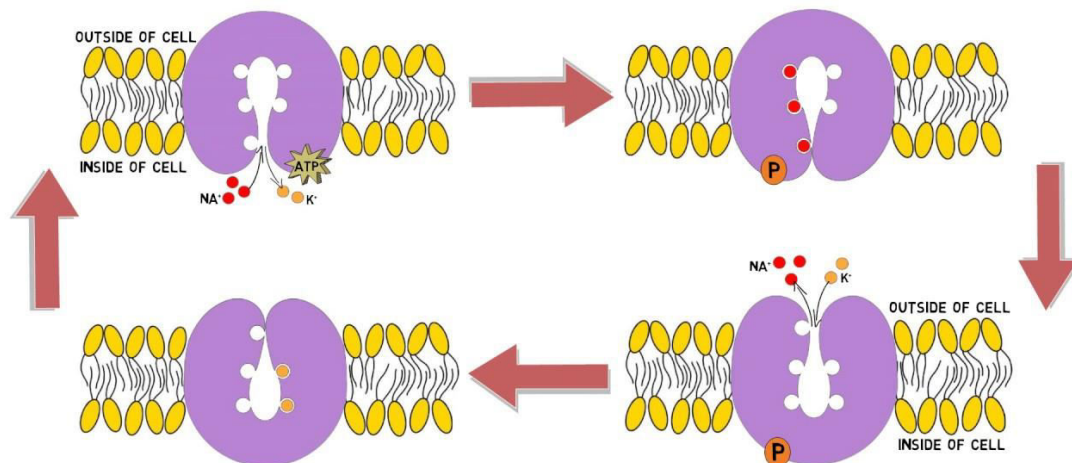
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ATP is hydrolyzed during this process with the release of ADP. Now in the changed conformational state pump binds 2 extracellular K^+ ions (step c). Potassium binding leads to dephosphorylation and return to original conformation (step d). In this conformation ATP binds and the pump reorients to release K^+ ions inside the cell (step e). The pump is ready to go again.[14]

SODIUM-POTASSIUM PUMP CYCLE

-USES ATP TO TRANSPORT SODIUM AND POTASSIUM IONS ACROSS THE CELL MEMBRANE



V. RESULTS

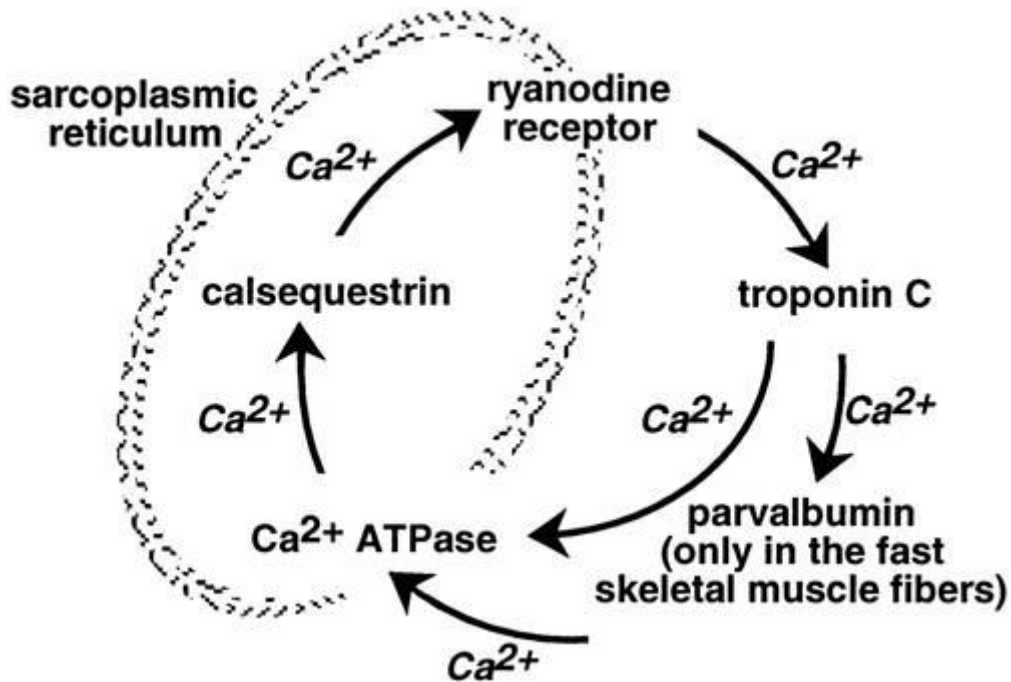
Ca^{2+} has many important roles as an intracellular messenger. The release of a large amount of free Ca^{2+} can trigger a fertilized egg to develop, skeletal muscle cells to contract, secretion by secretory cells and interactions with Ca^{2+} - responsive proteins like calmodulin. To maintain low concentrations of free Ca^{2+} in the cytosol, cells use membrane pumps like calcium ATPase found in the membranes of sarcoplasmic reticulum of skeletal muscle. These pumps are needed to provide the steep electrochemical gradient that allows Ca^{2+} to rush into the cytosol when a stimulus signal opens the Ca^{2+} channels in the membrane. The pumps are also necessary to actively pump the Ca^{2+} back out of the cytoplasm and return the cell to its pre-signal state. Calcium is an important signaling molecule involved in the regulation of many cellular functions. The large free energy in the Ca^{2+} ion membrane gradients make Ca^{2+} signaling inherently sensitive to the available cellular free energy, primarily in the form of ATP. In addition, Ca^{2+} regulates many cellular ATP consuming reactions such as muscle contraction, exocytosis, biosynthesis and neuronal signaling. Thus, Ca^{2+} becomes a logical candidate as a signaling molecule to modulate ATP hydrolysis and synthesis during changes in numerous forms of cellular work. Mitochondria are the primary source of aerobic energy production in mammalian cells and also maintain a large Ca^{2+} gradient across their inner membrane providing a signaling potential for this molecule.[15]

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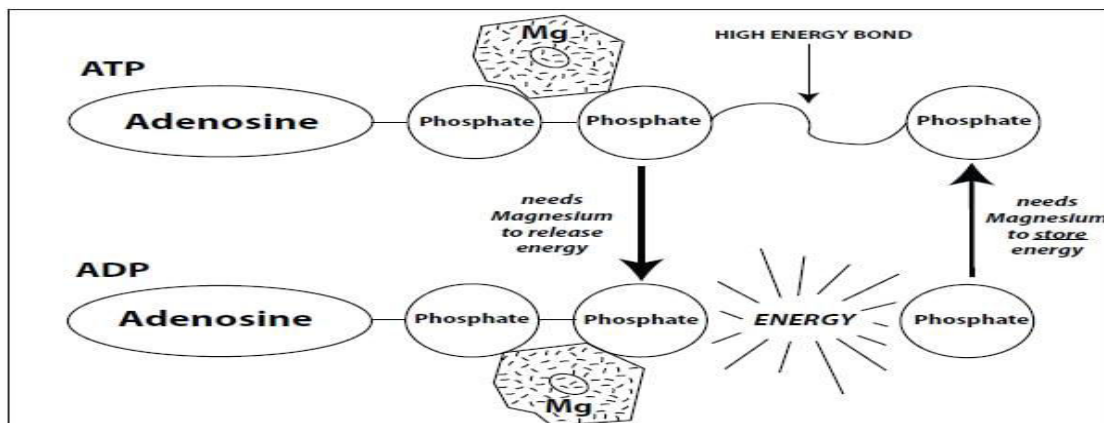
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Calcium ion in muscle

Magnesium is an essential element in biological systems. Magnesium occurs typically as the Mg^{2+} ion. It is an essential mineral nutrient (i.e., element) for life and is present in every cell type in every organism. For example, ATP (adenosine triphosphate), the main source of energy in cells, must bind to a magnesium ion in order to be biologically active. What is called ATP is often actually Mg-ATP. As such, magnesium plays a role in the stability of all polyphosphate compounds in the cells, including those associated with the synthesis of DNA and RNA. Over 300 enzymes require the presence of magnesium ions for their catalytic action, including all enzymes utilizing or synthesizing ATP, or those that use other nucleotides to synthesize DNA and RNA. In plants, magnesium is necessary for synthesis of chlorophyll and photosynthesis.



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Magnesium ATP

Transporters that use ATP convert the energy in ATP into potential energy in the form of a concentration gradient. They use the ATP to transport an ion from a low concentration to a higher concentration. Examples of proteins that use ATP are P-type ATPases that transfer Na⁺, K⁺, and Ca²⁺ ions by phosphorylation, A-type ATPases that transfer anions, and ABC transporters (ATP binding cassette transporters) that transport a broad set of molecules. Examples of the P-type ATPase include Na⁺/K⁺-ATPase that is regulated by Janus Kinase-2 as well as Ca²⁺ ATPase which exhibits sensitivity to ADP and ATP concentrations P-glycoprotein is an example of an ABC transport binding protein in the human body.[16]

V. CONCLUSION

Alkali and alkaline earth metals are useful co-catalysts in many inorganic and organometallic reactions. The interactions of these metals to transition-metal complexes modulate the overall structures. The alkali and alkaline earth metal ions withdraw electron density from transition metal center and tune the reduction potentials. The stabilization of anion intermediates by alkali and alkaline earth metal ions reduces transition-state energy and enhance the reactivity kinetically. In homogeneous catalysis, alkali and alkaline earth metals have been shown to bind to electron-rich anionic ligands that then stabilize the formation of heterobimetallic complexes. This is especially important when key transition states are stabilized by such coordination as this can lead to greatly enhanced catalytic efficiency. These metal ions can also collaboratively bind to crown-ether installed ligands and control metal-ligand cooperativity. In addition, reaction selectivity could also be enhanced by using different sizes of alkali or alkaline earth metal ions. Thus, incorporation of alkali and alkaline earth metals to transition-metal catalysts can modulate or completely change the reactivity

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