

Bio-Inorganic chemistry



It explains the bio-chemical function of inorganic elements (metal and non-metals)

Bioinorganic chemistry deals with role of metal or metal-containing compounds within the biological and biochemical systems. (role of metal in biology)

The metals are important for functioning of biological processes such as, photosynthesis, respiration, metal ion transport, enzymatic actions. etc.

e.g. Iron present in haemoglobin helps in transportation of oxygen,

- Cobalt present in vitamin B₁₂.

- Magnesium present in chlorophyll.

Bioinorganic chemistry helps to

→ the study of naturally occurring inorganic elements in biological systems.

→ the artificial introduction of metals in biological system as a drugs to treat disease.

→ the investigation of inorganic elements in nutritions.

Micronutrients and Macronutrients

Nutrients are chemical substances required for functioning of ~~body~~ body, including growth, repair, protection against disease etc.

Depend on the requirement of nutrients on body they are two types.

(i) Micronutrients:

(ii) Macronutrients

1) Micronutrients:-

Nutrients required in lesser amounts are such as vitamins, minerals and trace elements (elements needed in minute quantity) are called micronutrients.

Importance:-

(i) → Micronutrients helps for functioning the body and maintaining metabolism, cellular function, physical and mental well being.

(ii) Vitamins helps to maintain immune system, energy production, act as antioxidants, etc.

(iii) Minerals helps in growth, and fluid balance.

IV. Antioxidants protect against cell damage associated with certain ~~diseases~~, diseases, cancer, Alzheimer's and heart diseases.

- Micronutrients are found in vegetables, fruits, eggs, green leafy vegetables etc. Their deficiency causes diseases like anemia, scurvy, goitre etc.
- Overconsumption of vitamins leads to liver and nerve damage.

2). Macronutrients:- (e.g.: C, H, N, O, Na, K, Mg etc)

Nutrients required by body in greater amounts; such as, carbohydrates, protein, and fibre ~~and fat~~ are called macronutrients.

Importance of macronutrients.

- I They are also called energy-providing nutrients (except water).
- II It helps to prevent disease and allow the body to function correctly.
- III Carbohydrates are the main source of energy which helps to fuel brain, kidneys, heart muscles, and central nervous system.
- IV Macronutrients found abundantly in cereals, legumes, meat, fish, potatoes etc.

and their deficiency results in malnutrition, kwashiorkor, marasmus, etc and overconsumption causes diabetes, obesity etc.

- (i) Water is essential for body's metabolism in regulation of body temperature and ionic balance of blood.
- (ii) fibre is indigestible which helps easy elimination of waste from body and decrease the risk of obesity, high cholesterol etc
- (iii) Proteins helps to make cell structure and provide energy during starvation.
- (iv) Fats ~~are~~ have highest calorie used in making steroids and hormones, and provides largest amount of energy. Extra fat stored in tissue and ~~is~~ burnt when carbohydrate is run out.

Micro nutrients :- 13 elements required to our body.

C, H, O, N, P, S, Cl, K, Ca, Mg, Fe, Cu, Zn, Mn, Cr, Ni, Co, Mo, W, Se, F, I, and B.

Macro nutrients :- 13 elements.

C, H, O, N, Na, K, Mg, Ca, Si, P, Cl, S, and Fe.

Bulk metals:- Na, K, Mg and Ca

Trace metals:- Zn, Fe, Co, Ni, Cu, Mo,
V etc, used for biocatalyst

Importance of metal ions in a biological system, (Na, K, Mg, Ca, Fe, Cu, Zn, Ni, Co, Cr)

② Biological importance of Na^+ , K^+

→ Helps to balance electrical charges and osmotic pressure in cells. Na & K

Helps in transportation of CO_2 from lungs body tissue to lungs in the form of NaHCO_3 and KHCO_3 in plasma. & RBC.

③ [Function of K^+]

① It helps in heart function, skeleton and muscle contraction.

② It lowers the kidney stone by lowering the amount of calcium in urine.

③ It is important for removal of waste process.

④ It regulates the opening and closing of stomata in plants.

* Functions of Na^+ :-

① It is needed for transport of sugar and amino acids into the cells.

- (ii) It is present inside the nerve cell and regulates the flow of water across the membrane.
- (iii) It maintains osmotic pressure of body.

(b) Biological function of Ca^{2+} and Mg^{2+} .

Mg^{2+} and Ca^{2+} catalyzes the formation of pyrophosphates, which hydrolyses and release energy in the body.

Function of Mg^{2+}

- (i) It is present in chlorophyll helps in photosynthesis, and nitrogen metabolism.
- (ii) It helps in energy production ($ATP \rightarrow ADP$)
- (iii) It helps in activation of enzyme as an enzyme-co factor.
- (iv) It plays important role in breakage of glucose molecule, fat, protein and regulation of ~~etc~~ cholesterol.
- (v) It helps in synthesis and proper functioning of DNA.
- (vi) It controls blood glucose level and blood pressure.

Function of Ca^{+2}

- (i) It is the inorganic part of endoskeletons. (bones, teeth,
- (ii) It helps in neuromuscular (muscle and nerve) functioning and cell signaling.
- (iii) It helps in blood coagulation.
- (iv) It helps in enzyme activation, cell division, and release of hormones.
- (v) It acts as charge carrier and support muscle contraction.

(c) Biological importance of trace metals

Trace element act as catalyst in enzyme system.

(i) Function of ~~Zinc~~ Zinc (Zn^{+2})

- (i) Zinc metalloenzyme catalyze peptide hydrolysis and maintain $\text{HCO}_3^-/\text{CO}_2$ in body.
- (ii) It helps in metal storage.
- (iii) helps in body's metabolism, such as protein synthesis, DNA synthesis.
- (iv) It regulates the function of insulin.
- (v) It maintains the contraction of vitamin A in plasma.
- (vi) It helps in wound healing.

(ii) Copper. Cu (I/II)

- ① It is essential for formation of hemoglobin in the blood & bones.
- ② It helps in transport of electrons and storage of oxygen.
- ③ It is important for pregnant women for developing a fetus.
- ④ It helps in formation of pigment melanin in the skin & for healthy hair.
- ⑤ It is required for normal brain and nervous system function.

(iii) Iron Fe II / II

- ① Helps in oxygen carrier and storage in muscles.
- ② It helps in electron carrier in plants, animals and bacteria.
- ③ Fe (III) acts as iron storage protein (ferritin).

IV. It assists in creation of hormones.

- ④ It helps in conversion of N_2 to ammonia.

(IV) Cobalt (II)

- ① It is the constituent of Vitamin B_{12} (Cobalamin), helps in normal functioning of the brain & nervous system.
- ② It helps in formation of ^{Red} blood cell

(VI) Nickel II / III

- ① It involves electron transfer.
- ② It helps in iron absorption, adrenaline, and glucose metabolism.
- ③ It involves in enzyme activity hydrogenase and hydrolases.

chromium (III)

- ① It helps in fat and protein metabolism.
- ② It helps in glucose metabolism.

Symptoms of elemental deficiency in humans.

Difficulty in digestion of food or absorption of nutrients, ~~can result in~~ or a poor diet can result in deficiency of minerals.

- I). zinc deficiency causes stunted (retarded) growth, skin damage, and retarded maturation.
- II). deficiency of iodine causes ~~goiter~~ goiter.
- III). Deficiency of cobalt on soil adversely affects ~~of~~ the health of grazing animals, and its deficiency causes pernicious anemia (anemia due to lack of Vitamin B₁₂)
- IV). Iron deficiency causes anemia and immune disorders.
- V). Copper deficiency causes heart and circulation problem, bone abnormalities, disorder in lungs, malfunctioning of pancreas and kidney, complication in nervous and immune system.
- VI). calcium deficiency causes osteopenia (decrease in bone mineral density) & rickets, (weak bone in child)

- (v) Magnesium deficiency causes neuromuscular dysfunction, muscle cramps, and deficiency in plants affects the size and number of chloroplasts.
- (vi) Potassium deficiency causes paralysis of muscles and irregular heart beat.
- (vii) Chromium deficiency causes diabetes symptoms.
- (viii) High intake of sodium causes hypertension, but loss of sodium results muscular cramps, of abdomen and headaches.

ION PUMPS (Sodium-potassium and sodium-glucose pump)

The ion pump (ion transporter) is a special protein that moves ions across the membrane. Ion pumps are used to bring some substances into cell and remove other from cell. Ions pumps that hydrolyze adenosine triphosphate (ATP), and stored energy in form (often Na) electrochemical gradient.



17. Sodium potassium pump

Sodium potassium pump in nerve cells that transport sodium ion out of the cell and potassium ion in. The movement of Na^+ and K^+ across the cell membrane is an active transport process involved in the hydrolysis of ATP (adenosine triphosphate) to provide energy.

Sodium is an extracellular ion and potassium is intracellular. 3Na^+ trans port outside and 2K^+ to the inside. ~~and the unbalance~~ and the unbalanced charge transfer contributes to separation of charge across the membrane.

It is an important contributor to action potential produced by nerve cells. The Na^+ and K^+ ions participate in transmission of nerve signals.

18. Sodium glucose pump

Glucose is essential for energy production in the living body. The glucose transporter plays a critical role in various organs.

Glucose transporters are classified into two families ② facilitative glucose

transporters (GLUTs), which ~~is~~ transport,

glucose by diffusion, i.e. glucose is

transported from higher concentration to
lower concentration.

(b) Sodium-dependent Glucose Transporters (SGLTs)

in which Na^+ /glucose are co-transported by pumping electrochemical gradient created by pumping out of ions from cell across the membrane and the sodium gradient was maintained by the Na^+/K^+ pump. Here, the glucose is transported along with sodium ion, from ~~lower~~^{higher} concentration to higher concentration. Thus extra energy is required for the transport of glucose and sodium ion which is provided by hydrolysis of ATP to ADP and phosphate.

Metal toxicity

^{metabolic}

The ~~metabolic~~ defects in biological system which is caused due to the presence of metal is called metal toxicity. When the metal is present in higher concentration than the normal cellular level then there arises toxicity. e.g. cobalt

poisoning causes gastrointestinal distress and heart failure.

Excess metal binds with active site of enzymes and causes failure of enzyme. There are many metals which are carcinogenic in nature and causes several problems in organism some of the metal causing toxicity are as follows:

① Iron,

Iron in the +2 oxidation state are of low acute toxicity when exposure through dermal, oral and inhalation routes, however other forms of iron are of serious health problems. The source of iron in surface water is anthropogenic. The excess iron leads to the formation of gastrointestinal ulcerations. Excess of iron in diet also increases the risk of cancer. Asbestos contain both of iron and the worker who are highly exposed to asbestos are at high risk of asbestos a condition which is known to cause lung cancer.

② Lead Toxicity:-

Toxicity due to lead exposure is called lead poisoning. Lead is released into the atmosphere from industrial processes as well as vehicle exhausts. The main source of lead exposure include drinking water, food and smoking, industrial process and domestic sources.

The industrial source of lead include gasoline (Tetraethyl lead), housepaint, plumbing pipes, storage batteries etc.

→ Lead poisoning ~~causes~~ results a wide range of symptoms, from weakness loss of appetite to ~~coma~~ coma, and death. In very massive exposures.

It also causes high blood pressure and damage to the reproductive organ.

Lead overexposure may cause children to be less playful, irritable sluggish (lethargic & etc.)

It also affects in plants leading to damage of chlorophyll and photosynthesis process. photosynthetic process and suppresses the overall growth of plant.

11) Mercury.

Mercury is very toxic and exceedingly bioaccumulated. Mercury pollution include anthropogenic activities such as agriculture, municipal waste water discharges, mining, incineration and discharge of industrial waste water. Extensively used by electric bulb, mercury lamp, fluorescent lamp, thermometer, barometer etc.

Mercury is highly toxic and affects the lungs, kidney, brain, skin; symptoms of mercury include fatigue, depression, irritability and headache. Respiratory symptoms associated with inhalation to mercury vapours causes, include coughing, breathlessness, chest pain and respiratory distress. It is Neurotoxic as it damages the nervous system and brain.

12)

12) Arsenic.

Arsenic is highly carcinogenic and causes cancer of liver, lungs, and skin. Most of the paints, dyes, soap, metal semiconductor and drugs contain arsenic. certain pesticides, fertilizer and animal

feeding operation also release arsenic to the environment in higher amounts.

Drinking water contaminated with arsenic is one of the major causes for arsenic toxicity. (from, pesticides, paints, herbicides, etc)

Arsenic toxicity can be either acute or chronic. Chronic arsenic toxicity is termed as arsenicosis. Pigmentation and keratoses are specific skin lesions (abnormal growth) are chronic arsenic toxicity. Long-term exposure can lead to, internal cancers, neurological problems, pulmonary diseases, cardiovascular diseases, diabetes and hypertension.

⑤ cadmium:

Cadmium is highly toxic non-essential heavy metal for its adverse influence on the enzymatic systems of cells. Cadmium is used in various industrial production of alloys, pigments., electroplating, storage batteries.etc, over exposure of cadmium may cause fatigue, headache, nausea, vomiting, abdominal cramps, diarrhea, fever etc. In addition, progressive loss of lungs function, abnormal buildup of fluid within lungs and breathlessness. Cadmium can also cause damage of skeletal system.

skeletal