Copper [Cu]

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1 Overview

- Copper(Cu) is the 26th element in abundance in the crust of the earth[1].
- 29th periodic element
- 2 stable and 9 radioactive isotopes[1]

2 Macro clinical perspective

- Cu is only needed in only trace amounts in humans. Total Cu in the body is >100 mg[1]. The skeleton and muscles account for 1/2 of the Cu in the body[1].
- Most Cu in the body exists copper almost always exists in biological systems bound to proteins[1]. Free copper in cells and in the body is extremely low[1]
- High [Cu] is related to metabolic activity of organs[1]. Kidney and liver have the highest [Cu], followed by the brain (~5 µg/g), then the heart[1].

3 Copper metabolism

3.1 Copper absorption

- Copper absorption is considerably higher than for that of other trace elements (~55-75%)[1]
- Relative amount of copper in the diet seems to be inversely correlated with percent intestinal absorption[1]. Percent absorption increases during states of deficiency[1].
- Copper absorption occurs mainly in the upper small intestine[1]

3.2 Copper Bioavailability

- Dietary factors (i.e. iron, vitamin C, and Zinc) have been reported to exert adverse effects on the bioavailability of copper[1]
- Other factors impact Copper's bioavailability, such as lead poisoning, hemochromatosis, and excessive ingestion of soft drinks[1]

4 Function

Through copper's enzymes (Multi-copper oxidases) copper has the unique ability to convert O_2 into H_2O without producing oxidative "exhaust"[2]. This allows our bodies to manage O_2 without being negatively affected by its toxic and highly reactive nature[2]

4.1 Metabolic Functions

Copper plays a crucial role in energy transformation in the body[1]. Copper impacts this process by acting as a cofactor for cytochrome c oxidase (Terminal enzyme in the electron transport chain)[1]

4.2 Iron utilization

Copper is important in the normal utilization of iron in the body[1]. From Intestinal iron absorption, iron release from stores (e.g. in macrophages of liver and spleen), iron incorporation into hemoglobin, and even preventing anemia[1].

4.3 Vascular function

- Blood coagulation is assisted by copper[1].
- Blood pressure control[1]
- Cross-linking of connective tissues in arteries[1]

4.4 Cardiac function

- Cross-linking of CT in heart[1]

4.5 Skeleton

- Cross-linking of CT in bones[1]

4.6 Oxidative damage defense

- Defense against oxidative damage[1]

4.7 Myelination

- Myelination of brain and spinal cord[1]

4.8 Reproduction

- Copper has a function in reproduction[1]

4.9 Hormone synthesis

- Copper plays a role in hormone synthesis[1]

5 Multi-Copper Oxidases (MCOs)

3 Multi-Copper oxidases have been detected in humans:[2]

1. Ceruloplasmin[2]
2. Hephaestin[2]
3. Zyklopen[2]

All 3 of these enzymes have a high specificity towards iron with the resulting ferroxidase activity being associated with ferroportin (the only known iron exporter protein in humans.)[2]

Ferroportin exports iron as Fe2+, but transferrin, the major iron transporter protein of blood, can bind only Fe3+ effectively. Iron oxidation in enterocytes is mediated mainly by hephaestin thus allowing dietary iron to enter the bloodstream[2]

5.1 Ceruloplasmin

Function: Release of iron from the liver relies on ferroportin and the ferroxidase activity of ceruloplasmin which is found in blood in a soluble form[2]

5.2 Hephaestin

Iron oxidation in enterocytes is mediated mainly by hephaestin thus allowing dietary iron to enter the bloodstream[2]

5.3 Zyklopen

Zyklopen is involved in iron efflux from placental trophoblasts during iron transfer from mother to fetus[2]

References

1. Collins JF, Klevay LM. Copper. *Advances in Nutrition (Bethesda, Md)*. 2011;2(6):520-522. doi:10.3945/an.111.001222
2. Vashchenko G, MacGillivray RTA. Multi-copper oxidases and human iron metabolism. *Nutrients*. 2013;5(7):2289-2313. doi:10.3390/nu5072289