

Copper [Cu]

Nathaniel Giovanni Yomogida, SPT

Chloë Kerstein, SPT

Overview

- Copper(Cu) is the 26th element in abundance in the crust of the earth¹.
- 29th periodic element
- 2 stable and 9 radioactive isotopes¹

Macro clinical perspective

- Cu is only needed in only trace amounts in humans. Total Cu in the body is >100 mg¹. The skeleton and muscles account for 1/2 of the Cu in the body¹.
- Most Cu in the body exists copper almost always exists in biological systems bound to proteins¹. Free copper in cells and in the body is extremely low¹
- High [Cu] is related to metabolic activity of organs¹. Kidney and liver have the highest [Cu], followed by the brain (~5 µg/g), then the heart¹.

Copper metabolism

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 absorption¹. Percent absorption increases during states of deficiency¹.
- Copper absorption occurs mainly in the upper small intestine¹

Copper Bioavailability

- Dietary factors (i.e. iron, vitamin C, and Zinc) have been reported to exert adverse effects on the bioavailability of copper¹
- Other factors impact Copper's bioavailability, such as lead poisoning, hemochromatosis, and excessive ingestion of soft drinks¹

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 nature²

Metabolic Functions

Copper plays a crucial role in energy transformation in the body¹. Copper impacts this process by acting as a cofactor for cytochrome c oxidase (Terminal enzyme in the electron transport chain)¹

Iron utilization

Copper is important in the normal utilization of iron in the body¹. From Intestinal iron absorption, iron release from stores (e.g. in macrophages of liver and spleen), iron incorporation into hemoglobin, and even preventing anemia¹.

Vascular function

- Blood coagulation is assisted by copper¹.
- Blood pressure control¹
- Cross-linking of connective tissues in arteries¹

Cardiac function

- Cross-linking of CT in heart¹

Skeleton

- Cross-linking of CT in bones¹

Oxidative damage defense

- Defense against oxidative damage¹

Myelination

- Myelination of brain and spinal cord¹

Reproduction

- Copper has a function in reproduction¹

Hormone synthesis

- Copper plays a role in hormone synthesis¹

Multi-Copper Oxidases (MCOs)

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

1. Ceruloplasmin²
2. Hephaestin²
3. Zyklopen²

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 bloodstream²

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 form²

Hephaestin

Iron oxidation in enterocytes is mediated mainly by hephaestin thus allowing dietary iron to enter the bloodstream²

Zyklopen

Zyklopen is involved in iron efflux from placental trophoblasts during iron transfer from mother to fetus²

References

1. Collins JF, Klevay LM. Copper. *Advances in Nutrition (Bethesda, Md)*. 2011;2(6):520-522. doi:[10.3945/an.111.001222](https://doi.org/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](https://doi.org/10.3390/nu5072289)