

# Copper [Cu]

Nathaniel Giovanni Yomogida, SPT

Chloë Kerstein, SPT

## Overview

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

## Macro clinical perspective

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

## Copper metabolism

### Copper absorption

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

## Copper Bioavailability

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

## Function

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

## Metabolic Functions

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

## Iron utilization

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

## Vascular function

- Blood coagulation is assisted by copper<sup>1</sup>.
- Blood pressure control<sup>1</sup>
- Cross-linking of connective tissues in arteries<sup>1</sup>

## Cardiac function

- Cross-linking of CT in heart<sup>1</sup>

## **Skeleton**

- Cross-linking of CT in bones<sup>1</sup>

## **Oxidative damage defense**

- Defense against oxidative damage<sup>1</sup>

## **Myelination**

- Myelination of brain and spinal cord<sup>1</sup>

## **Reproduction**

- Copper has a function in reproduction<sup>1</sup>

## **Hormone synthesis**

- Copper plays a role in hormone synthesis<sup>1</sup>

## **Multi-Copper Oxidases (MCOs)**

3 Multi-Copper oxidases have been detected in humans:<sup>2</sup>

1. Ceruloplasmin<sup>2</sup>
2. Hephaestin<sup>2</sup>
3. Zyklopen<sup>2</sup>

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.)<sup>2</sup>

Ferroportin exports iron as Fe<sup>2+</sup>, but transferrin, the major iron transporter protein of blood, can bind only Fe<sup>3+</sup> effectively. Iron oxidation in enterocytes is mediated mainly by hephaestin thus allowing dietary iron to enter the bloodstream<sup>2</sup>

## **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<sup>2</sup>

## Hephaestin

Iron oxidation in enterocytes is mediated mainly by hephaestin thus allowing dietary iron to enter the bloodstream<sup>2</sup>

## Zyklopen

Zyklopen is involved in iron efflux from placental trophoblasts during iron transfer from mother to fetus<sup>2</sup>

## 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)