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THE IMPORTANCE OF COPPER AS A MICROELEMENT IN THE BODY AND THE USE OF ITS COMPOUNDS IN MEDICINE

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ABSTRACT:

Copper (Latin name: cuprum, Cu) is a chemical element located in Group I of the periodic table. Copper has been known to humans since ancient times. It is one of the essential trace elements in the body. Copper is a necessary nutrient for all vertebrates and some lower species. This thesis explores the amount and role of copper in the human body, its applications in medicine and radiobiology, and the consequences of copper deficiency.

Instroduction. **Literature Review:** Scientific literature reveals the important biological role of copper in the body, especially its participation in metalloproteins and hemopoiesis. Sources like the Dietary Reference Intakes (DRI) provide detailed information on daily copper requirements, absorption, and toxic levels. Copper's antibiotic properties and synergistic effects in combating resistant microbes are emphasized. Its use in radiobiology is a promising field, particularly in cancer diagnosis and treatment. Animal studies have shown that copper deficiency leads to several pathologies.

Role of Copper in the Body:

Copper is a component of several metalloenzymes that act as oxidases in oxygen reduction reactions. Key copper-containing enzymes include:

- **Diamine oxidase:** Inactivates histamine during allergic reactions.

- **Monoamine oxidase (MAO):** Breaks down serotonin and metabolizes adrenaline, noradrenaline, and dopamine. MAO inhibitors are used as antidepressants.
- **Ferroxidases:** Convert Fe^{2+} to Fe^{3+}, enabling iron to bind to transferrin.
- **Dopamine beta-monooxygenase:** Produces noradrenaline from dopamine using copper, oxygen, and ascorbic acid.
- **Copper/zinc superoxide dismutase (Cu/Zn SOD):** Protects against oxidative damage. Mutations in the gene encoding this enzyme can lead to amyotrophic lateral sclerosis (Lou Gehrig's disease). (Source: DRI)

Copper and Hemopoiesis: Copper and copper-binding proteins are vital for hemoglobin formation, iron utilization by developing red blood cells, and erythrocyte membrane function. Ceruloplasmin, a copper-containing protein, is crucial for releasing stored iron. In copper deficiency, iron cannot be mobilized from stores, leading to low hemoglobin despite adequate iron levels. Copper accelerates hemopoiesis through stimulation or catalysis of hemoglobin synthesis. Although not part of hemoglobin itself, copper is a natural component of blood and supports its metabolism. (Nutritional Anemia)

Copper Absorption in the Body:

Absorption depends on intake:

- <1 mg/day: >50% absorbed
- 5 mg/day: <20% absorbed
- At 2 mg/day: ~35% absorbed

Copper travels to the liver via the venous blood, bound to albumin. Excess copper is excreted in bile. Around 95% of body copper is bound to ceruloplasmin in plasma. Needs vary by life stage:

- 0–6 months: based on breast milk
- 7–12 months: breast milk + supplementary foods
- 1–18 years: same reference range as adults
- Pregnancy: considers fetal copper needs
- Lactation: accounts for copper in breast milk

Tolerable Upper Intake Level (UL):

- UL is the safe daily maximum to avoid toxicity, mainly liver damage. For lactating women, 4,700 mg/day is considered the 99th percentile of maximum intake. For most people, the risk of excess copper intake is low. (DRI pp. 304–310)

Antimicrobial Properties of Copper:

Copper is known for its antimicrobial qualities. Copper surfaces kill bacteria on contact (contact killing) by producing reactive oxygen species (ROS) that damage bacterial membranes. Copper ions interact with antibiotics in two ways:

1. **Synergistic effect:** Enhances antibiotic activity, including against resistant strains.
2. **Antagonistic effect:** May degrade or reduce antibiotic efficacy, requiring caution in clinical use.

(Source: International Journal of Science and Research)

Role in Radiobiology:

Copper-64 (Cu-64) has excellent biodistribution properties, making it useful in cancer treatment. Copper-67 (Cu-67), a beta-emitting radionuclide, is used in tumor therapy. Copper-based tracers are also used in positron emission tomography (PET) to detect hypoxia in tumors (e.g., Cu-ATSM).
(Sources: *Drug Discovery Today*; *Basic Clinical Radiobiology*, *4th ed. by M. Joiner*)

Effects of Copper Deficiency:

In animals, copper deficiency leads to anemia, skeletal abnormalities, demyelination and nerve degeneration, changes in hair pigmentation and structure, reproductive issues, heart muscle degeneration, and reduced arterial elasticity. Copper is essential for iron and cobalt metabolism and enzymes like cytochrome oxidase. A copper deficiency can reduce cytochrome oxidase activity by up to 8-fold.
(Sources: Davis & Mertz, 1987; *Recommended Dietary Allowances*, 10th ed.)

Conclusion:

Copper is a vital trace element for numerous physiological functions including iron metabolism, antioxidant defense, nervous and cardiac systems, hemopoiesis, and enzyme function. Copper deficiency can result in anemia, neurological and skeletal problems, and immune suppression. Its medical and radiobiological applications are promising areas for future research, highlighting the need for a deeper understanding of copper's biological significance.

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