Available online at www.sciencedirect.com
SCIENCE DIRECT®
Molecular Aspects of Medicine 26 (2005) 235–244
MOLECULAR ASPECTS OF MEDICINE
www.elsevier.com/locate/mam

Review

Relevance, essentiality and toxicity of trace elements in human health

Cesar G. Fraga *

Department of Nutrition, University of California, Davis, CA 95616, USA
Physical Chemistry-PRALIB, University of Buenos Aires-CONICET, Buenos Aires, Argentina

Abstract

The metals Mn, Fe, Cu, and Zn, and the non-metal Se are considered "trace elements" (TE) because of their essentiality and very limited quantity in humans. The biological activities of Cu, Fe, Mn, and Se are strongly associated with the presence of unpaired electrons that allow their participation in redox reactions. In biological systems these metals are mostly bound to proteins, forming metalloproteins. Many of the metals in metalloproteins are part of enzymatic systems, have structural and storage functions, or use the protein to be transported to their target site in the organism. In humans Mn, Fe, Cu, Zn, and Se accomplish decisive functions to maintain human health. Deficiency in any of these TE leads to undesirable pathological conditions that can be prevented or reversed by adequate supplementation. In sufficiently nourished persons, supplementation should be carefully controlled, given the toxic effects ascribed to TE when present in quantities exceeding those required for accomplishing their biological functions. The dietary reference intakes provided by national regulatory agencies are guides to define intake, supplementation and toxicity of Mn, Fe, Cu, Zn, and Se, as well other elements considered micronutrients for humans.

Abbreviations: TE, Trace elements; DRI, Dietary reference intakes

Keywords: Micronutrients; Manganese; Iron; Copper; Zinc; Selenium; Oxidative stress

* Tel.: +1 530 7546667; fax: +1 530 7528966.
E-mail address: cgfraga@ucdavis.edu

0098-2997/$ - see front matter
doi:10.1016/j.mam.2005.07.013

Contents

1. Elements, trace elements and micronutrients

Four elements (oxygen, carbon, hydrogen, and nitrogen) account for 96% of living matter. About 50 of the known elements occur in measurable concentrations in the living systems. In humans and other mammals, 23 elements have known physiological activities. From these elements, 11 can be classified as "trace elements" (TE) because of their essentiality and very limited quantity in humans. Out of these 11 TE, eight are in the period 4 of the Periodic Table (Fig. 1), suggesting an optimal relationship of nuclei size/electron availability of the elements in this period to interact with organic molecules present in biological systems. TE include, at least, the transition metals vanadium, chromium, manganese (Mn), iron (Fe), cobalt, copper (Cu), zinc (Zn), and molybdenum; and the non-metals selenium (Se), fluorine, and iodine. All of these belong to the category of micronutrients, which are needed by the human body in very small quantities (generally less than 100 mg/day), as opposed to elements considered macronutrients, such as sodium, calcium, magnesium, potassium, chlorine, etc., which are required in larger quantities.

TE are essential components of biological structures, but at the same time they can be toxic at concentrations beyond those necessary for their biological functions.

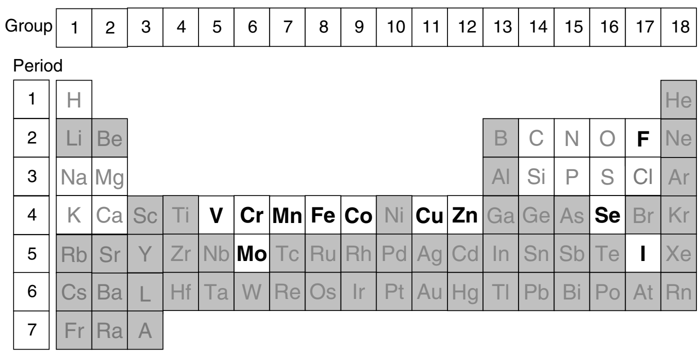

Fig. 1. Periodic Table indicating elements essential for humans (white background) and the trace elements (black characters).