

## Thematic Minireview Series: Metals in Biology\*

Published, JBC Papers in Press, April 10, 2009, DOI 10.1074/jbc.M109.003863

F. Peter Guengerich<sup>1</sup>

From the Department of Biochemistry and the Center in Molecular Toxicology, Vanderbilt University School of Medicine, Nashville, Tennessee 37232-0146

Metals have important roles in biochemistry ranging from essential to toxic. This prologue introduces the second of the Thematic Minireview Series on Metals in Biology, which includes minireviews on five metals: iron, zinc, nickel, vanadium, and arsenic. Three of the minireviews are focused on the roles of the metals in enzymes (iron, nickel, and vanadium). Zinc deficiency is discussed in another, and the arsenic minireview deals with the toxic and some potentially useful applications of the biological effects.

As mentioned in the prologue to the previous Thematic Minireview Series on Metals in Biology (Guengerich, F. P. (2009) *J. Biol. Chem.* **284**, 709), biochemistry is often presented as a collection of amino acids and proteins, carbohydrates, lipids, and nucleic acids. Information about metals is not generally presented in biochemistry courses until later. Metals are used in biology in many ways, and many metals are essential to life for lower organisms as well as eukaryotes. Thus, it is important to help readers be aware of advances in the biochemistry of metals.

This Thematic Minireview Series on Metals in Biology follows an earlier series this year, which had three articles dealing with iron, copper, and selenium. In the current series, there are five minireviews dealing with two metals essential in all life (iron and zinc), two that have interesting roles in prokaryotes (nickel and vanadium), and one that has no physiological function but is toxic (arsenic).

The first minireview in the series deals with iron, specifically the desaturases (Shanklin *et al.*). These enzymes are functionally related to other diiron proteins. Structure-function relationships have been established and have helped to delineate the bifurcation between desaturation and hydroxylation reac-

tions. Some desaturases have unusual features, *e.g.* the ability to form acetylenes.

The second minireview (Eide) deals with zinc, an essential metal, in a yeast model. The focus of this article is transcriptional responses to zinc deficiency. Homeostatic responses include zinc uptake, vacuolar zinc storage, zinc shock tolerance, and zinc conservation. Adaptive responses to zinc deficiency include oxidative stress tolerance, phospholipid synthesis, and sulfate assimilation. The transcriptional activator protein Zap1 has a central role in these processes.

The third minireview (Ragsdale) involves nickel. Nickel enzymes were first discovered in 1975, and although depletion studies have suggested a role in higher mammals, no role has been defined. Of the eight known bacterial examples, seven utilize gases central to carbon, nitrogen, and oxygen cycles. The one exception is glyoxylase I, where nickel has a catalytic role as a Lewis acid.

The fourth minireview (Winter and Moore) is about vanadium, specifically its role in haloperoxidases. These enzymes are found in fungi and marine plants (*e.g.* algae) and use vanadium in the process of synthesizing halogenated compounds.

The fifth and final minireview in this series (Platanias) is about the metal arsenic, which has no known biological function but has been used as a drug. In the environment, it is recognized as a carcinogen in several parts of the world. Under some conditions, it also suppresses tumors. Both inorganic arsenic and its methylated metabolites can be toxic. In this minireview, Platanias discusses mechanisms of arsenic-induced cell death, cellular targets of arsenic, and cellular pathways that negatively regulate responses to arsenic.

Overall, this is an interesting series of minireviews covering common essential metals, less commonly encountered metals with roles in selected organisms, and a toxic metal of considerable interest in health. Readers should know more about the biochemistry of metals after reading these minireviews. Additional series in this area will feature other interesting metals.

\* This minireview will be reprinted in the 2009 Minireview Compendium, which will be available in January, 2010.

<sup>1</sup> To whom correspondence should be addressed. E-mail: [f.guengerich@vanderbilt.edu](mailto:f.guengerich@vanderbilt.edu).