

1: Transition-Metal Storage, Transport, and Biomineralization

Living organisms store and transport transition metals both to provide appropriate concentrations of them for use in metalloproteins or cofactors and to protect themselves against the toxic effects of metal excesses; metalloproteins and metal cofactors are found in plants, animals, and microorganisms. The normal concentration range for each metal in biological systems is narrow, with both deficiencies and excesses causing pathological changes. In multicellular organisms, composed of a variety of specialized cell types, the storage of transition metals and the synthesis of the transporter molecules are not carried out by all types of cells, but rather by specific cells that specialize in these tasks. The form of the metals is always ionic, but the oxidation state can vary, depending on biological needs. Transition metals for which biological storage and transport are significant are, in order of decreasing abundance in living organisms: iron, zinc, copper, molybdenum, cobalt, chromium, vanadium, and nickel. Although zinc is not strictly a transition metal, it shares many bioinorganic properties with transition metals and is considered with them in this chapter. Knowledge of iron storage and transport is more complete than for any other metal in the group.

I. General Principles

- A. [Biological Significance of Iron, Zinc, Copper, Molybdenum, Cobalt, Chromium, Vanadium, and Nickel](#)
- B. [Chemical Properties Relative to Storage and Transport](#)
 - 1. [Iron](#)
 - 2. [Zinc, Copper, Vanadium, Chromium, Molybdenum, and Cobalt](#)

II. Biological Systems of Metal Storage, Transport, and Mineralization

- A. [Storage](#)
 - 1. [Iron](#)
 - 2. [Zinc, Copper, Vanadium, Chromium, Molybdenum, Cobalt, Nickel, and Manganese](#)
- B. [Transport](#)
 - 1. [Iron](#)
 - 2. [Zinc, Copper, Vanadium, Chromium, Molybdenum, and Cobalt](#)
- C. [Iron Biomineralization](#)

III. Summary

Transition metals (Fe, Cu, Mo, Cr, Co, Mn, V) play key roles in such biological processes as cell division (Fe, Co), respiration (Fe, Cu), nitrogen fixation (Fe, Mo, V), and photosynthesis (Mn, Fe). Zn participates in many hydrolytic reactions and in the control of gene activity by proteins with "zinc fingers." Among transition metals, Fe predominates in terrestrial abundance; since Fe is involved in a vast number of biologically important reactions, its storage and transport have been studied extensively. Two types of Fe carriers are known: specific proteins and low-molecular-weight complexes. In higher animals, the transport protein transferrin binds two Fe atoms with high affinity; in microorganisms, iron is transported into cells complexed with catecholates or hydroxamates called siderophores; and in plants, small molecules such as citrate, and possibly plant siderophores, carry Fe. Iron complexes enter cells through complicated paths involving specific membrane sites (receptor proteins). A problem yet to be solved is the form of iron transported in the cell after release from transferrin or siderophores but before incorporation into Fe-proteins.

Iron is stored in the protein ferritin. The protein coat of ferritin is a hollow sphere of 24 polypeptide chains through which Fe^{2+} passes, is oxidized, and mineralizes inside in various forms of hydrated Fe_2O_3 . Control of the formation and dissolution of the mineral core by the protein and control of protein synthesis by Fe are subjects of current study.

Biomineralization occurs in the ocean (e.g., Ca in shells, Si in coral reefs) and on land in both plants (e.g., Si in grasses) and animals (e.g., Ca in bone, Fe in ferritin, Fe in magnetic particles). Specific organic surfaces or matrices of protein and/or lipid allow living organisms to produce minerals of defined shape and composition, often in thermodynamically unstable states.

IV. References

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