In the last few years, considerable evidence has been obtained regarding the importance of zinc in human nutrition. Zinc is an important component of many metalloenzymes and is also required for metabolism of nucleic acids and synthesis of protein. Human requirements for zinc vary at different times in development, but appear to be particularly high during embryonic life, during periods of rapid growth, and during pregnancy. Although zinc is widely distributed in foods, a number of types of diets appear to be deficient or marginal in terms of available zinc. In addition, there is physiological loss of zinc in bleeding and sweating which may lead to low levels of body zinc. A syndrome characterized by markedly retarded growth and sexual development that occurs in the Middle East has been shown to be due to zinc deficiency. This syndrome is reviewed. It is thought that the zinc deficiency syndrome is only one end of a continuum of growth-related problems associated with low levels of physiologically available zinc. In rats, zinc deficiency during pregnancy has been shown to lead to congenital malformations in a large percentage of the offspring. A number of these malformations involve the central nervous system. We have suggested that epidemiological data support the possible importance of maternal zinc deficiency as an etiological factor in human CNS malformations. These data are discussed.

KEY WORDS: zinc; nutrition; growth; central nervous system malformations.
INTRODUCTION

In the last few years, considerable evidence has been obtained regarding the important role of zinc in human nutrition. Although it was traditionally believed that, since zinc is so widely distributed in nature, human populations would not be deficient in this element, this is not the case. Frank zinc deficiency has been demonstrated in several populations, and the possibility of marginal deficiency affecting large segments of other populations is a very real one. The topic of zinc and human development is now being investigated on many fronts, and some of the more important aspects of this topic are addressed in this paper.

BIOLOGICAL ROLE OF ZINC IN MAN

Although many questions remain unanswered regarding the biological role of zinc in man, it is quite clear that this element is necessary for a number of metabolic activities. There is a family of metalloenzymes that require zinc in order to function, approximately 20 of which have been identified so far (Sandstead, 1968). These metalloenzymes include carbonic anhydrase, alkaline phosphatase, lactic dehydrogenase, and carboxypeptidase (Hambidge et al., 1972). Zinc functions by binding to molecules to establish and maintain spatial and configurational relationships which are necessary for enzymatic action (Fox, 1970). In this role it helps to bind enzymes to substrates and may modify the molecular shape of enzymes by simultaneously combining with amino acids at different places on the protein (Sandstead, 1968), thus affecting secondary, tertiary, and quaternary protein structure (Fox, 1970). A number of the zinc metalloenzymes are involved in the regulation of cellular growth (Anon., 1973).

In addition to its functions in enzymes, zinc participates in the metabolism of nucleic acids and synthesis of proteins (Hambidge et al., 1972). Although its role is not completely understood, zinc appears to be an integral part of the RNA molecule of a number of species and is thought to help maintain stable molecular configuration (Sandstead, 1968). Studies by Sandstead and Rinaldi (1969) suggest that zinc has an important role in cell division. They found adverse effects of zinc deficiency on the incorporation of thymidine into the DNA of rats.

Zinc absorption occurs mainly in the small intestine, predominantly in the duodenum, although the exact mechanism is not known (Underwood, 1971). In terms of intermediary metabolism, absorbed or injected zinc is incorporated at different rates in different tissues, with various rates of turnover (Underwood, 1971). Uptake by the bones and central nervous system is relatively slow and the zinc remains firmly bound for long periods. The most rapid rates of uptake and turnover of retained zinc occur in the pancreas, liver, kidney, and spleen (Under-