3.1 Introduction

McCance and Widdowson (1937) proposed the theory that the amount of iron in the body must be regulated by controlled absorption with excretion by the bowel practically nil and with very little excretion via the kidney. Subsequent data reinforced this view, and research focused on absorption. Despite the volume of research conducted since that time, there are still considerable gaps in our understanding of the mechanism of iron absorption and its control. Discrepancies in the data on which present concepts are based complicate interpretation.

Historically, the study of iron absorption has gone through a number of phases coinciding with changes in technology. Before 1930, methods were poor, and although there were a few balance studies, the results obtained are questionable. Between 1930 and 1940, the methods were sufficiently developed to permit better clinical studies using the chemical balance technique. After 1940, there was more widespread use of radio-isotopes, and the total number of studies and the number of subjects per study increased. With changes in technique, studies concentrated not only on absorption in whole animals but also on intestinal absorption by intestinal segments, isolated mucosa, and fractions of the mucosal cells. Studies of iron absorption can be categorized as those investigating the mechanism and regulation of absorption, those investigating absorption from food and interactions between dietary components, and those comparing different iron salts for use in fortification. Practical applications are the diagnosis of prelatent iron deficiency and prevention of iron deficiency by appropriate fortification.

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Absorption of minerals, such as iron, appears to involve several steps: reduction and release from conjugation, uptake by the epithelial cells of the intestine, and serosal transfer. Iron is sequestered by the epithelial cell in variable amounts and may or may not reach the plasma. There appears to be a separate control mechanism for the uptake by the cell and by the plasma. Epithelial cells monitor the body's requirements by a mechanism not yet completely understood.

In this chapter, the amount of iron absorbed means the amount which passes from the lumen of the intestine into the bloodstream. The process of absorption includes mucosal uptake, mucosal transfer, and serosal transfer of a proportion of the iron present in the cell to the plasma. Important factors in total food iron absorption are the form of the iron, heme, or nonheme; total iron in the diet; conditions within the gastrointestinal tract; amounts and proportions of various other components in the diet; and the physiological state of the individual.

Partial and complete reviews of iron absorption have appeared with regularity (Josephs, 1958; Crosby, 1968; Pinkerton, 1969; Bothwell and Charlton, 1970; Conrad, 1970; Heinrich, 1970; Fairbanks et al., 1971; Turnbull, 1974; Forth and Rummel, 1973; Jacobs, 1973; Cook, 1977; and Cook and Lipschitz, 1977). In this chapter we attempt to cover recent work without neglecting the historical development of studies of iron absorption.

3.1.1 Quantitative Significance of Iron in the Body

Sixty to seventy percent of the body iron is functional iron incorporated in hemoglobin, myoglobin, and certain respiratory enzymes. The remainder is storage iron. In the healthy adult there are 3–5 g of iron, the male adult has 40–50 mg of iron per kg of body weight, and the female 35–50 mg/kg of body weight. In the newborn there is approximately 250 mg total or 70 mg/kg of body weight. Premature infants are born with lower iron stores. Growing children must absorb approximately 0.5 mg in excess of body losses to meet the needs of growth and build up storage. Adult males lose 1 mg of iron daily, two-thirds as desquamated epithelium and secretions from the gut and most of the remainder from the skin and urine. Losses are reduced to half normal in patients with iron deficiency and increased in patients with iron overload (Bothwell and Charlton, 1970). Stores in the male are approximately 900–1000 mg of iron. During the childbearing years adult females lose, on the average, an additional 30 mg/month (ranges, 3–80 mg) from menstrual bleeding and about 800 mg with each pregnancy. In the adult female, approximately 300 mg are