The effect of differences in dietary iron intake on ^{59}Fe absorption and duodenal morphology in pregnant rats

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The effect of iron intake on ^{59}Fe absorption throughout pregnancy, and on maternal and fetal Fe status towards the end of pregnancy, was investigated in rats. The influence of pregnancy and dietary Fe on duodenal morphology was also studied. Female rats were fed on a diet containing 17 or 100 mg Fe/kg for 2 weeks before and throughout pregnancy. ^{59}Fe absorption was measured on days 1 or 2, 8 or 9 and 17 or 18 of pregnancy, and maternal and fetal Fe status was determined on days 18 or 19. Pregnancy resulted in a fall in haemoglobin (Hb) concentration. Compared with non-pregnant counterparts, total liver Fe was reduced in the low-Fe group, but not in the high-Fe group, indicating that the fall in Hb in the high-Fe rats was not associated with an Fe-deficient state. ^{59}Fe absorption in rats fed on both diets increased throughout pregnancy, demonstrating that Fe supplementation of the diet, to a level that prevented the development of Fe-deficiency, failed to suppress an increase in absorption. Fetal weight appeared to be an important determinant of the efficiency of Fe absorption in late pregnancy. Poor maternal Fe status was accompanied by a reduction in fetal Fe concentration but results also suggested that fetuses were partly protected from maternal Fe-deficiency. Pregnancy resulted in increased duodenal circumference and villus dimensions, whilst high dietary Fe reduced duodenal growth in both pregnant and non-pregnant animals. The relevance of this finding is discussed. It was concluded that, in rats, pregnancy *per se* causes an enhancement in Fe absorption and that the degree of enhancement is in part related to fetal mass.

Duodenal morphology: Iron absorption: Pregnancy: Rat

The efficiency of iron absorption by the small intestine has been shown to improve in pregnancy (Hahn *et al.* 1951; Heinrich *et al.* 1968; Apte & Iyengar, 1970). The increase is greatest during the latter stages of pregnancy when materno-fetal transfer of Fe reaches a maximum (Glasser *et al.* 1968). There is some debate as to whether this increase is a consequence of Fe depletion, since it has been demonstrated that a reduction in body Fe stores leads to an enhancement of Fe absorption (Bothwell *et al.* 1958; Bezwoda *et al.* 1979), or whether it is a normal physiological adjustment that takes place even in the absence of maternal Fe depletion. If absorption is entirely linked to status any increase in absorption would be eliminated by raising body Fe stores sufficiently before conception. Murray *et al.* (1970) tested this suggestion and concluded that the injection of an amount of Fe calculated to counteract fetal drain and extra haemoglobin (Hb) synthesis in pregnant rats 'turned off' absorption to an amount greater than that injected. In the study both Fe-supplemented and non-supplemented rats were fed on laboratory chow containing 144–244 mg Fe/kg for 5 weeks before and during pregnancy, so that even the non-supplemented rats would have had good liver Fe stores and high mucosal cell Fe content, both of which are known to reduce the proportion of Fe absorbed from a meal or test dose (Bothwell *et al.* 1979; Fairweather-Tait *et al.* 1985). Consequently, percentage ^{59}Fe absorption from an intragastric dose given on days 5 and 16 of pregnancy was extremely low in both groups of animals and differences in absorptive efficiency between the two time points, and between groups of rats, would have been difficult to detect.

In the present study Fe absorption was determined in pregnant rats given levels of dietary Fe more closely related to physiological requirements. Rats were maintained, for a period before and throughout pregnancy, on a semi-synthetic diet containing approximately half or three times the American Institute of Nutrition (1977) recommended concentration for growth, pregnancy and lactation in the rat. Thus, it was assumed that animals fed on the lower level of Fe were likely to develop a degree of Fe depletion during pregnancy, whilst those fed on the supplemented diet should be protected from maternal Fe deficiency. The effect of the different Fe intakes on ^{59}Fe absorption in early, mid- and late pregnancy, and on maternal and fetal Fe status towards the end of pregnancy, was determined. In addition, the influence of pregnancy and dietary Fe intake on the morphology of the duodenum, the region of maximal Fe absorption, was investigated.

MATERIALS AND METHODS

Virgin, female Wistar rats weighing approximately 200 g were randomly allocated to one of two groups and caged individually in polypropylene cages with stainless steel grids. The first group was fed on a powdered semi-synthetic diet containing 17 mg Fe/kg, which is approximately half the dietary concentration (35 mg/kg) recommended by the American Institute of Nutrition (1977); this was designated the low-Fe group. The second group received a similar diet containing 100 mg Fe/kg, which is approximately three times the American Institute of Nutrition (1977) recommended level; this was designated the high-Fe group. The general composition of the diet was as previously described (Fairweather-Tait & Wright, 1984) with the addition of 2 g methionine/kg and the replacement of 32 g carbohydrate/kg with an equivalent amount of protein. Food and distilled water were provided *ad lib*. Rats were maintained on these diets for 2 weeks before a 48 h mating period and then for a further 17 d. Food intake and body-weight gain were measured from time of mating until the end of the experiment.

On days 0 or 1 of pregnancy (day 0 being the day on which a mating plug was found) rats were fasted overnight and on the following morning given a meal of 3 g cooked starch–sucrose (1:1, w/w) paste containing 120 μg Fe as ferrous sulphate in 0.1 M-hydrochloric acid, labelled with 74 kBq [59]Fe (FeCl$_3$; 110–740 MBq/mg Fe, Amersham International, Amersham, Bucks). Immediately after consuming the meal, each rat was counted in a NE8112 small-animal whole-body counter (NE Technology Ltd, Beenham, Berks) and, not less than 5 h after this initial count, they were offered the appropriate diet *ad lib*. Rats were counted again 7 d later when all the unabsorbed isotope from the test meal had been excreted. The amount of ^{59}Fe remaining at this time was taken as an estimate of Fe absorption from the meal (Fairweather-Tait & Wright, 1984). Rats that consumed less than two-thirds of the test meal were excluded from the final results because of the possibility of a dose-related response.

This procedure was repeated in the same animals on days 8 or 9 of pregnancy, due allowance being made for the amount of radioisotope remaining in each animal at the time of redosing.

On days 17 or 18 of pregnancy rats were given a final test meal and killed 24 h later by an intraperitoneal injection of sodium pentobarbital (1 ml, 160 mg/ml, Euthatal; May & Baker, Dagenham, Essex). It was necessary to kill the animals before parturition for accurate measurement of carcass ^{59}Fe retention. A small sample of whole blood was obtained from the tip of the tail for Hb analysis, after which the entire intestine was removed and the carcass was counted in a small-animal counter. After counting, fetuses and liver were removed, weighed, freeze-dried and ground to an homogenous powder. Subsamples were ashed for 48 h at 480° and the ash was taken up in hot hydrochloric acid

(11·7 M) for Fe analysis by atomic absorption spectroscopy (PU 9000; Pye Unicam, Cambridge).

Rats that failed to mate successfully were used as non-pregnant controls. After the final test meal, several non-pregnant rats from each group were counted immediately after dosing and again 7 d later, while the remainder were killed 24 h after the meal as described for the pregnant animals. Measurement of [59] Fe absorption obtained by both techniques were then compared.

The numbers of observations made for each measurement are given in the figures and tables of results.

Morphological study

Samples (10 mm) of duodenum, taken 20 mm below the phyloric sphincter, were fixed by immersion in absolute ethanol–glacial acetic acid (75:25, v/v), followed by storage in ethanol–water (75:25, v/v). Each sample was slit open, placed mucosal side uppermost and examined under a dissecting microscope fitted with a graduated eyepiece for measurement of intestinal width. A total of ten villi were then removed from each sample by microdissection with sharpened needles for estimates of maximum height and basal width.

Statistical analysis

Regression analysis and analysis of variance were performed. Two-way analysis of variance was used for comparisons between pregnant and non-pregnant low- and high-Fe groups, with variables diet and pregnancy. One-way analysis of variance was used for comparisons of percentage ^{59}Fe absorption within each pregnant group at three time-points. Where the variance ratio (F) showed a treatment effect ($P < 0.05$), approximate t tests between means ($\bar{x}_1$ and $\bar{x}_2$) having n replicates (n_1 and n_2) were performed using the standard error of the differences of means (SED) calculated from the residual mean square (RMS) as follows: SED $= \sqrt{(RMS.(1/n_1 + 1/n_2))}$; $t = (\bar{x}_1 - \bar{x}_2)/$SED. The residual degrees of freedom were used to estimate the level of significance of t. The standard error for any mean can be calculated as follows: SEM $= \sqrt{(RMS/n)}$. Fetal values were compared using Student's unpaired t test.

RESULTS

Body-weight gain, food intake, number of fetuses and total fetal dry weight were unaffected by dietary Fe concentration (Table 1).

Fe status

Maternal liver Fe concentration and total liver Fe were significantly reduced in both pregnant and non-pregnant rats fed on the low-Fe diet, compared with the high-Fe groups (Table 1). Pregnancy resulted in a significant fall in total liver Fe in the low-Fe group, despite a 33 % increase in liver weight in the pregnant animals, whilst the high-Fe pregnant rats had a similar total liver Fe content to their non-pregnant counterparts. Liver weight increased in both groups of pregnant rats, but the increase was significantly less in the high-Fe animals (Table 1).

Hb concentration in blood was unaffected by dietary Fe intake in non-pregnant rats. There was a characteristic fall in Hb concentration during pregnancy; however, Hb concentration for the low-Fe pregnant group was significantly lower than that for the high-Fe group (Table 1).

The Fe concentration of fetuses from rats fed on the low-Fe diet was significantly lower than that in the high-Fe group but, because the dry litter weight was slightly lower in the high-Fe group, mean values for total litter Fe were not significantly different (Table 1).

Table 1. *Body-weight gain, food intake, liver weight, liver iron content, whole-blood haemoglobin (Hb) concentration, number of fetuses and fetal Fe content for pregnant rats fed on 17 (low-Fe) or 100 (high-Fe) mg Fe/kg diet compared, where appropriate, with non-pregnant female rats*

(Maternal values are means for no. of observations given. Fetal values are means with their standard errors for no. of observations given)

Group...	Pregnant				Non-pregnant				Statistical significance of variance† ratio (F), effect of:				
Diet...	Low-Fe		High-Fe		Low-Fe		High-Fe						
	Mean	n	Mean	n	Mean	n	Mean	n	Diet	Pregnancy	Diet × pregnancy	RMS	Residual df
Body-wt gain (g)*	79	14	70	15	16	21	16	21	—	$P < 0.01$	—	164·1	67
Total food intake (g)*	325	14	313	15	260	21	260	21	—	$P < 0.01$	—	1033	67
Liver dry wt (g)	5·20	14	4·72	15	3·92	14	3·92	13	$P < 0.05$	$P < 0.01$	—	0·2561	52
Liver Fe													
µg/g dry wt	214	14	494	15	431	14	702	13	$P < 0.01$	$P < 0.01$	—	14264	52
mg total	1·11	14	2·29	15	1·7	14	2·48	13	$P < 0.01$	$P < 0.01$	$P < 0.01$	0·1951	52
Hb (g/l)	123	12	136	12	147	12	157	12	$P < 0.01$	$P < 0.01$	—	211·8	44
No. of fetuses													
Mean	12·8	14	10·3	15									
SE	1·2		1·4										
Total fetal dry wt (g)													
Mean	2·99	14	2·34	15									
SE	0·45		0·37										
Fetal Fe: µg/g dry wt													
Mean	315ᵃ	14	498ᵇ	15									
SE	19		14										
mg total													
Mean	0·93	14	1·17	15									
SE	0·10		0·18										

RMS, residual mean square.

a, b Values with unlike superscript letters, within a horizontal row, were significantly different: $P < 0.001$.

* Measured from days 0 or 1 of pregnancy.

† Values for pregnant and non-pregnant groups compared by two-way analysis of variance. Fetal data compared by Student's unpaired t test.
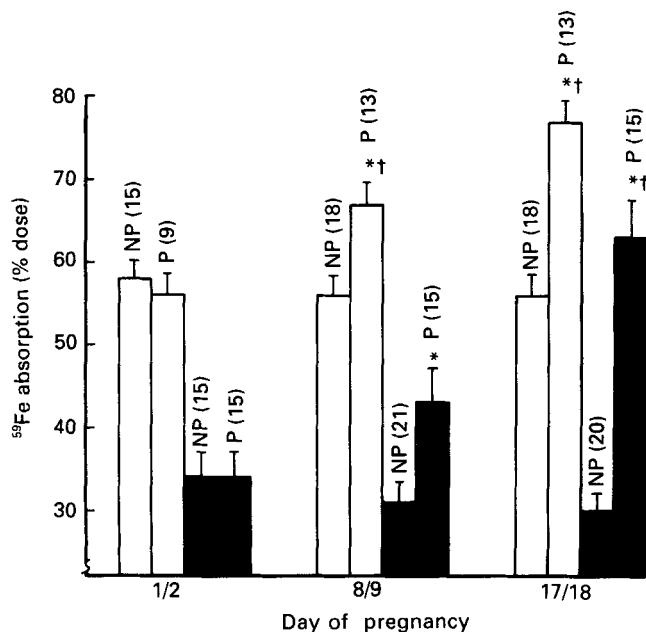
Fig. 1. ^{59}Fe absorption (% dose) by pregnant (P) rats fed on a test meal of 3 g starch–sucrose paste containing 120 μg Fe and 74 kBq ^{59}Fe on days 1 or 2, 8 or 9 and 17 or 18 of pregnancy. Rats were fed on low-Fe (□; 17 mg/kg) or high-Fe (■; 100 mg/kg) diets for 2 weeks before and throughout pregnancy. Values are compared with those for non-pregnant (NP) female rats. Values are means with their standard errors, represented by vertical bars, for the no. of observations indicated in parentheses. Values for high-Fe groups were all significantly lower ($P < 0.001$) than for their low-Fe counterparts. * Mean values within a time-point were significantly different ($P < 0.001$) from those for the appropriate non-pregnant group. † Mean value was significantly different ($P < 0.05$) from that obtained for the same animals at the preceding time-point.

^{59}Fe absorption

There was no difference in mean percentage ^{59}Fe absorption in the non-pregnant rats when estimated by measuring radioactivity for the carcass minus the intestine 24 h after dosing or by measuring the whole animal radioactivity 7 d after dosing. Values obtained were as follows: low-Fe group 59·7 (SE 3·5; n 11) and 51·2 (SE 3·3; n 7), high-Fe group 31·6 (SE 3·1; n 8) and 27·0 (SE 1·8; n 8) for 24 h and 7 d respectively. Measurements of ^{59}Fe absorption obtained for pregnant rats killed 24 h after a test dose on days 17 or 18 of pregnancy were, therefore, assumed to represent the 7 d values.

^{59}Fe absorption from the radiolabelled test meal was significantly lower in all rats fed on the high-Fe diet compared with the appropriate low-Fe group (Fig. 1). Percentage ^{59}Fe absorption remained constant throughout the experiment within each of the non-pregnant groups, mean values being approximately 56 and 30% for the low- and high-Fe groups respectively.

Absorption values for the pregnant rats, however, showed an increase at mid-pregnancy (days 8 or 9) and rose further towards term (days 17 or 18) (Fig. 1). In the low-Fe group, absorption increased from 56% at days 1 or 2 of pregnancy to 67% at days 8 or 9, and finally to 77% at days 17 or 18, each increase being statistically significant. For the high-Fe group, although the mean absorption value also increased at each time point (34, 43 and 63%, respectively), the increase became significant only for the days 17 or 18 measurement. However, percentage ^{59}Fe absorption in the high-Fe pregnant group was significantly
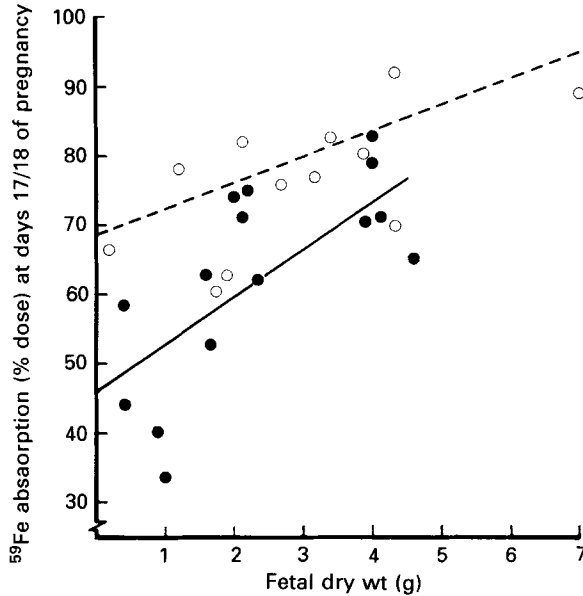
Fig. 2. Correlation between ^{59}Fe absorption at day 17 or 18 of pregnancy and total fetal dry weight for rats fed on low-Fe (○‑‑‑○; 17 mg/kg) or high-Fe (●——●, 100 mg/kg) diets. Low Fe: r 0·59, $P < 0·05$. High Fe: r 0·70, $P < 0·01$.

greater than in non-pregnant controls for both days 8 or 9 and 17 or 18, and the increase in absorption between early and late pregnancy was much greater in the high-Fe animals (87 %) than in those fed on the low-Fe diet (37 %) (Fig. 1).

Regression analysis was performed on individual values within each of the pregnant groups to test for an association between the efficiency of ^{59}Fe absorption in late pregancy and the following measurements: maternal Fe status, number of fetuses in a litter and total fetal dry weight. In both the high- and low-Fe groups the only significant correlation found was between ^{59}Fe absorption on days 17 or 18 of pregnancy and the dry weight of the litter (Fig. 2).

Duodenal morphology

There was a significant effect of both pregnancy and diet on duodenal morphology (Table 2). Pregnancy resulted in a significant increase in circumference and villus height and width, whilst both pregnant and non-pregnant rats consuming the higher-Fe diet had a lower duodenal circumference and smaller villi compared with low-Fe counterparts (Table 2). The effect of diet was much more marked in the pregnant rats where values for circumference, villus height and villus width in the high-Fe group were approximately 12, 12 and 16 % lower respectively than for rats fed on the lower-Fe diet (Table 2).

DISCUSSION

Investigations of Fe transfer from maternal to fetal tissues in man and laboratory animals have shown that the major accumulation of fetal Fe occurs in late gestation, maternal plasma Fe being the source of fetal Fe, and that there is an increased maternal capacity for Fe absorption and depletion of maternal Fe stores during gestation (Svanberg et al. 1975). The increase in Fe absorption during pregnancy has often been interpreted as evidence that pregnancy invariably induces an Fe-deficient state (Heinrich et al. 1968), a conclusion

Table 2. *Duodenal circumference, villus height and villus width for pregnant (days 18 or 19 of pregnancy) rats fed on 17 (low-Fe) or 100 (high-Fe) mg Fe/kg diets compared with non-pregnant female rats*

(Values are means for no. of observations given in parentheses)

Group...	Pregnant		Non-pregnant		Significance of variance* ratio (F), effect of:				
Diet...	Low Fe mean (14)	High Fe mean (15)	Low Fe mean (13)	High Fe mean (13)	Diet	Pregnancy	Diet × pregnancy	RMS	Residual df
Duodenal									
Circumference (mm)	11·3	9·9	8·9	8·0	P < 0·01	P < 0·01		0·832	51
Villus height (μm)	804	708	623	596	P < 0·05	P < 0·01		11 160	51
Villus width (μm)	715	598	528	506	P < 0·01	P < 0·01	P < 0·05	8257	51

RMS, residual mean square.
* Values compared by two-way analysis of variance.

supported by a single study in rats which showed that increased Fe absorption did not occur in pregnant animals injected intramuscularly with 2·8 mg Fe and fed on a diet containing 144–244 mg Fe/kg (Murray *et al.* 1970). However, possibly because of the high concentration of dietary Fe used in the study, values for percentage ^{59}Fe absorption from an intragastric dose given to both supplemented and unsupplemented rats were extremely low (4–5 % on day 5, and 7–9 % on day 16 of pregnancy), making interpretation of the results difficult.

In the present study rats were fed on a semi-synthetic diet containing lower levels of Fe, either half (low-Fe group) or three times (high-Fe group) the American Institute of Nutrition (1977) recommended concentration of 35 mg/kg, for 2 weeks before and throughout pregnancy. Both the low- and high-Fe pregnant groups of rats had lower whole-blood Hb and liver Fe concentrations than non-pregnant controls fed on similar diets, but those receiving the higher-Fe diet maintained total liver Fe content at a similar level to their non-pregnant counterparts. The liver is one of the most important storage sites for readily mobilized Fe. In view of the fact that depletion of storage Fe occurs before a reduction in Hb concentration, or changes in any indicators of latent Fe deficiency (Heinrich, 1975), the fall in Hb concentration in the high-Fe pregnant group must have been primarily due to haemodilution and did not indicate an Fe-deficient state. It also appears that the suggestion that liver Fe stores decline rapidly in pregnancy, independently of previous intake or oral Fe supplementation (Howells *et al.* 1986), may not necessarily be true. The increase in liver weight in pregnant rats was affected by diet, although the difference was small, the liver weight of rats fed on the higher-Fe diet being 10 % less than that for the low-Fe group. No such difference in liver growth was observed in non-pregnant animals. The metabolic significance of this finding is as yet unknown.

Despite the fact that liver Fe stores were unaffected by pregnancy in animals fed on the high-Fe diet, percentage ^{59}Fe absorption increased significantly toward the end of pregnancy. This conflicts with the argument that enhanced Fe absorption in pregnancy is mainly related to the depletion of storage Fe (Svanberg *et al.* 1975). The results of the present study support the work of Batey & Gallagher (1977) who demonstrated that Fe loading failed to suppress an increase in Fe uptake and transport from isolated duodenal loops in pregnant rats, and the observation of Apte & Iyengar (1970) that pregnancy *per se* appears to influence beneficially the absorption of Fe in pregnant women. In the study performed by Batey & Gallagher (1977) increased uptake and transfer of Fe by rats were found to occur from day 16 of pregnancy, with maximum levels reached immediately before delivery. In the present study a significant increase in absorption was observed as early as days 8 or 9 of pregnancy in the low-Fe group. The difference in absorption between early and mid-pregnancy for the high-Fe group was not statistically significant but absorption at days 8 or 9 was significantly higher than that for the non-pregnant control group, indicating the onset of an increased efficiency of absorption at this time. In both studies Fe absorption increased during pregnancy irrespective of Fe supplementation, but it is likely that the timing of this event is strongly influenced by dietary Fe intake and body status. Thus, the difference in dietary regimen between the present study, where the dietary Fe concentration was 17 or 100 mg/kg, and that performed by Batey & Gallagher (1977), where the Fe concentration was 280 mg/kg, may have been responsible for the difference in time of onset of increased absorption. The lower percentage ^{59}Fe absorption observed in pregnant and non-pregnant rats fed on the higher level of Fe was to be expected since studies have clearly demonstrated that the proportion of Fe absorbed is directly related to both whole-body and mucosal cell Fe status (Bezwoda *et al.* 1979; Fairweather-Tait *et al.* 1985). Such factors would also have accounted for the larger relative increase in absorption between early and late pregnancy in the high-Fe group, compared with low-Fe rats. Absorption by the low-

Fe animals at the beginning of pregnancy was almost double that of their high-Fe counterparts, making the scope for further enhancement more limited.

The nature of the control of Fe absorption in pregnancy is unclear but in rats has been related to an increased rate of ^{59}Fe clearance from maternal serum (Batey & Gallagher, 1977). Materno-fetal transfer in the rat proceeds at an increasing rate in late gestation so that by day 21 the fetal tissues are accumulating 50 % of injected ^{59}Fe (Kaufmann & Wyllie, 1970). Thus, it has been postulated that enhanced fetal uptake of plasma Fe is the primary event resulting in increased plasma Fe turnover, which in turn facilitates the absorption of Fe from the gut (Hershko *et al.* 1976). It has been shown that extraction of Fe from the maternal circulation of the rat is a primary function of the placenta dissociable from and not dependent on a fetal acceptor (Glasser *et al.* 1968; Batey & Gallather, 1977), but it is likely that the rate of materno-fetal transfer is also influenced by fetal demand. It is possible, therefore, that the significant positive correlation between total fetal weight and percentage ^{59}Fe absorption, observed in the present study, was associated with differences in maternal plasma Fe turnover as a consequence of variation in the amount of fetal tissue to be supplied. Within the high- or low-Fe groups, fetal weight appeared to be a more important determinant of the efficiency of Fe absorption in late pregnancy than maternal status, since no relationship was found between Hb concentration, liver Fe concentration or total liver Fe and ^{59}Fe retention.

The relationship between increased Fe absorption in pregnancy and erythropoietic activity is uncertain. Fowler & Nash (1968) found erythropoiesis in the mouse to be maximal at day 12 of gestation whereas increased Fe absorption was not established until the third (final) week, thereby indicating that the level of maternal erythropoiesis and maximum Fe absorption are not related. On the other hand, findings from the present study demonstrated enhanced ^{59}Fe absorption at days 8 or 9 of pregnancy, which could not have been due to any significant materno-fetal transfer of Fe. The higher Fe absorption observed at this time in pregnant rats may, therefore, have been directly associated with an increased rate of erythropoiesis, as has been demonstrated in non-pregnant animals (Bothwell *et al.* 1958).

A controversy exists concerning the relationship between maternal Fe nutrition and Fe status of the fetus. It has been suggested that in rats the fetus is supplied with Fe, from storage Fe and from absorption, after the maternal requirements have been met (Fenton *et al.* 1977; Matoth & Zaizov, 1977). Several other studies in pregnant women show that the amount of Fe received by the developing fetus is independent of the mother's status (Lanzkowky, 1976; Murray *et al.* 1978). In the present study, liver Fe concentration and total liver Fe were reduced by 57 and 52 %, respectively, in low-Fe pregnant rats compared with the high-Fe group and this was accompanied by a 10 % fall in Hb concentration. The difference in fetal Fe concentration was less, 37 % lower in the low-Fe group, and mean values for total fetal Fe were not significantly different. This indicates that, although there was clearly an effect of maternal Fe status on the status of the individual fetus, there also appeared to be some degree of protection from maternal Fe deficiency.

In late pregnancy and in lactation there is hypertrophy of all layers of the small intestinal wall in rats (Craft, 1970; Cripps & Williams, 1975), which has been suggested to be linked to increased food intake, hormonal changes or functional adaptation of the mucosa to increased bodily demands (Fell *et al.* 1963). The influence of maternal nutrition on small intestinal hypertrophy, however, is largely unknown. Fe is absorbed mainly in the duodenum, hence the present study concentrated on morphological changes occurring in this region of the gut. Increased duodenal circumference, villus height and villus width were observed in all pregnant animals on days 18 or 19 of pregnancy but the degree of hypertrophy was dependent on dietary Fe intake, in that values for each of these

measurements were significantly lower for high-Fe pregnant rats than for rats fed at the lower Fe concentration. A similar response was seen in the non-pregnant animals, although differences were less marked. This suggests that mucosal growth, in the proximal intestine at least, was sensitive to lumen Fe concentration, the Fe content of mucosal cells or body Fe status. It is tempting to speculate that the greater mucosal growth in low-Fe groups reflected a higher demand for Fe and was, thus, the result of a direct adaptational response to reduced dietary Fe intake. Although it has been suggested that a relationship exists between intestinal hypertrophy and absorptive capacity, this is not invariably the case. In pregnant rats, reduced, increased and unchanged absorption of glucose and amino acids have all been reported (Craft, 1970). Interpretation of absorptive capacity is often dependent on the term of expression (for example per unit small intestinal length, weight, surface area) especially when there are significant changes in intestinal morphology, and differences in choice of expression could well be responsible for these conflicting findings. However, at present there is little evidence that greater absolute absorption is associated with mucosal hypertrophy in pregnancy (Craft, 1970). The relationship between duodenal mucosal growth and Fe absorption, however, is unknown and requires further investigation, particularly in relation to the efficiency of Fe absorption in late pregnancy when the fetal demand for Fe is high.

In conclusion, findings from the present investigation support the hypothesis that the physiological state of pregnancy results in an enhancement of Fe absorption. The increase in absorption appeared to be unrelated to the depletion of liver Fe stores and in late pregnancy was found to be positively correlated with total fetal weight within each group of rats.

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