examined (fig. 3). It is of interest that heterozygous individuals showing asymmetric puffs in the same chromosome region (i.e. 7B–C of IIIL) on day 7 are also found in the congeneric species *P. misera* (fig. 5), where one also finds individuals in which both homologues puff but to a different degree (fig. 6).

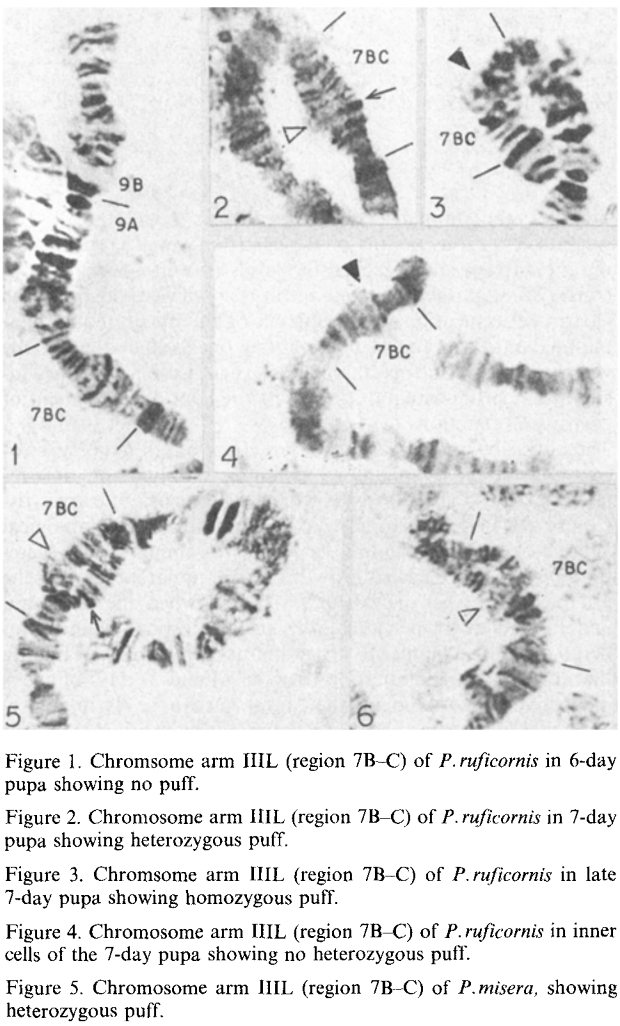

Figure 1. Chromsome arm IIIL (region 7B–C) of *P. ruficornis* in 6-day pupa showing no puff.

Figure 2. Chromosome arm IIIL (region 7B–C) of *P. ruficornis* in 7-day pupa showing heterozygous puff.

Figure 3. Chromsome arm IIIL (region 7B–C) of *P. ruficornis* in late 7-day pupa showing homozygous puff.

Figure 4. Chromosome arm IIIL (region 7B–C) of *P. ruficornis* in inner cells of the 7-day pupa showing no heterozygous puff.

Figure 5. Chromosome arm IIIL (region 7B–C) of *P. misera*, showing heterozygous puff.

Figure 6. Chromsome arm IIIL (region 7B–C) of *P. misera*, showing different degrees of puffing in both the homologues.

By contrast, the 2 inner cells of the same foot pad do not show puff heterozygosity on day 7 (compare figures 2 and 4, which show the outer and inner cells of the same foot pad). This is not surprising in view of the fact that in *Sarcophaga bullata* the puffing patterns in the 24-foot pad cells of the 3 pairs of legs have been found to be identical but not synchronous – the cells of the hind legs lag behind the cells of the fore legs, and the 2 outer cells of each foot pad lag behind the 2 inner cells[13].
The present results also demonstrate that the puff activity is not identical in both the cells. Since the outer cells lag behind the inner cells it is obvious that the same activity level of a certain puff is reached at a later stage in the outer cells than in the inner cells. Thus, it appears that in the heterozygotes one of the homologues becomes active a little later and as a result a puff heterozygosity appears on day 7 in the outer cells only. By late day 7 an identical activity level is reached in both the homologues in the outer cells.
The puff heterozygosity could be due to a submicroscopical change in one of the 2 strands, such that it delays the onset of puffing. The recent report of Staiber[14], demonstrating that transposition of a gene to a new location on the genome can affect its expression, opens the way for many interesting possibilities for speculation on the cause of the asynchronous activation of the 2 alleles; it could be envisaged that transposition of an element from or to the region in question might alter the time of onset of puffing in that homologue.

1 Acknowledgments. Thanks are due to Prof. U. S. Srivastava, Head, Dept. of Zoology, University of Allahabad for providing the laboratory facilities.

2 Amabis, J. M., and Simoes, L. C. G., Caryologia *25* (1972) 199.
3 Ashburner, M., Nature *214* (1967) 1159.
4 Beerman, W., Chromosoma *12* (1961) 1.
5 Gabrusewycz-Garcia, N., Chromosoma *33* (1971) 421.
6 Hsu, T. C., and Liu, T. T., Evolution *2* (1948) 49.
7 Panitz, R., Naturwissenschaften *47* (1960) 359,
8 Panitz, R., Chromosoma *17* (1965) 199.
9 Pavan, C., and Perondini, A. L. P., Expl Cell Res. *48* (1967) 202.
10 Perondini, A. L. P., and Dessen, M., Genetics *61* Suppl. 1 (1969) 251.
11 Troiano, G., Caryologia *28* (1975) 321.
12 Kaul, D., Agrawal, U. R., and Tewari, R. R., Kromosomo *II-32* (1983).
13 Bultman, H., and Clever, U., Chromosoma *28* (1969) 120.
14 Staiber, W., Experientia *38* (1982) 1490.

0014-4754/84/070750-02$1.50 + 0.20/0

Postnatal undernutrition: effect on antral gastrin levels at a later age

A. P. N. Majumdar[1]

Institute of Medical Biochemistry, University of Aarhus, DK-8000 Aarhus C (Denmark), 6 September 1983

Summary. In rats undernutrition from birth to 14 days of age resulted in retardation of growth and diminution of antral gastrin concentration. When the 14-day-old undernourished rats were nutritionally rehabilitated, they grew at a faster rate, and at 27 days of age their body weight and the weight of various tissues of the gastrointestinal tract including the antrum reached the levels of the well-nourished littermate controls. In spite of this, antral gastrin concentration was found to be about one-half of that of the well-nourished littermates.

It is hardly necessary to emphasize that infants are most vulnerable to nutritional inadequacies. Infancy is a period of rapid growth of the body and of various organs. At this time the immature organs grow at an accelerating rate[2] and the metabolic processes acquire homeostatic control presumably through the development of many endocrine systems. The gastrointestinal tract is the largest endocrine organ in the body. Endocrine cells are scattered throughout the gastrointestinal mucosa[3] and secrete a variety of hormones[4]. Although pre- or postnatal undernutrition has been shown to retard the growth of a number of organs including the gastrointestinal tracts[5], little is known about whether at nearly stages of life undernutrition affects the development and function of the endocrine system(s) of the digestive tract. In the present communi-

Effects of postnatal undernutrition and subsequent nutritional rehabilitation on antral gastrin levels

Treatment	Final age (days)	Final body weight (g)	Antral weight (mg)	Gastrin (ng SHG equiv.) per mg protein	per g tissue
Well-nourished	14	29.2 ± 0.4	22.7 ± 3.0	23.0 ± 2.2	2880 ± 282
undernourished	14	21.0 ± 0.5[c]	16.6 ± 2.2	14.1 ± 2.5[b]	1887 ± 250[a]
Well-nourished	27	66.0 ± 0.8	81.7 ± 5.0	134.2 ± 11.0	10497 ± 564
Nutritional rehabilitation of undernourished rats	27	67.4 ± 2.0	75.0 ± 7.1	68.9 ± 14.0[e]	6450 ± 614[d]

Values represent the mean ± SEM (N = 6). Experiments were statistically evaluated using Student's t-test for non-paired values, taking $p < 0.05$ as the level of significance. [a] $p < 0.05$, [b] $p < 0.025$, [c] $p < 0.001$, when compared with the 14-day-old well-nourished control. [d] $p < 0.05$, [e] $p < 0.01$, when compared with the 27-day-old well-nourished control.

cation we report that postnatal undernutrition, which results in diminution of antral gastrin levels, could not be normalized by nutritional rehabilitation even though the weight of the body and gastrointestinal tract could be corrected.

Materials and methods. 12–14 h after birth (day 1) the newborn Wistar rats were divided into 2 groups. One group consisted of 6 newborn pups to a mother (well-nourished) whereas the other had 18 pups to a mother (undernourished). They were allowed to suckle ad. libitum for 14 days when 6 from each group were killed. The rest of the 14-day-old undernourished animals were then nutritionally rehabilitated by placing 6 rats to a lactating mother with whom they remained for the next 13 days. During this period they were allowed to suckle and eat Chow pellets ad libitum. Well-nourished controls (6 pups/mother) also had access to Chow pellets from 14 days of age. On sacrifice various tissues of the digestive tract inlcuding the antrum were dissected out, washed, blotted dry, frozen on solid CO_2 and kept at −20°C. The antrum was weighed accurately while frozen. The tissue was cut into small pieces and dropped into boiling water, boiled for 20 min and homogenized. After centrifugation at 3000 × g for 10 min, the volume of the supernatant was made to 1 ml and gastrin immunoreactivity was determined (6) using antisera 2604, raised against human synthetic gastrin (G-17 I). The precipitates recovered from centrifugation were dissolved in 1 N NaOH and protein content was determined[7]. The results were expressed as nanogram equivalents of human synthetic gastrin (HSG) per gram tissue (wet wt) and per milligram protein.

Results and discussion. Immunocytochemical studies on the ontogeny of antral gastrin cells (G cells) in rats have demonstrated that they appear 1 day after birth and then increase steadily during the next 3–4 weeks of postnatal life[8]. These observations have also been supported by the demonstration of a parallel change in gastrin immunoreactivity in antral extracts[9,10]. The mechanisms regulating the development of G cells are, however, unknown. In the present investigation, when the rats were undernourished from birth to 14 days of age, we observed a significant 35–40% reduction in antral gastrin concentration when compared with their well-nourished littermate controls (table). Undernutrition for 14 days of postnatal life also significantly decreased the b.wt and antral weight by 27–28% compared to the well-nourished controls (table). The weights of the oxyntic gland area and the small intestine were also similarly reduced (data not shown). Thus, the above observation of a decreased antral gastrin level in undernourished suckling rats could be the consequence of an overall growth retardation caused by undernutrition.

It is well known that growth retardation resulting from malnutrition or illness could be normalized by nutritional rehabilitation, which results in acceleration of growth[11]. In the present investigation, when the 14-day-old undernourished pups were nutritionally rehabilitated by placing them in groups of 6 to a mother and were allowed to suckle and eat solid food for the next 13 days, they grew at a faster rate gaining an average of 3.57 g/day compared to the 2.83 g/day of the well-nourished controls during the same period. At 27 days of age the nutritionally rehabilitated rats regained their b.wt (table). The weights of various organs of the gastrointestinal tract, including the antrum, also reached the levels of well-nourished controls. Although the body and antral weights were regained, the gastrin concentration in the antrum of the nutritionally rehabilitated rats was found to be about one half of that of the well-nourished controls (table). This suggests that a dietary insult at an early postnatal age affects the later developmnent of gastrin cell function.

The antral hormone gastrin has an effect on all major gastrointestinal activities inlcuding secretion, motility and absorption[12,13]. It also stimulates growth of the mucosa in certain tissues of the gastrointestinal tract[14]. A number of physiological actions of gastrin including its ability to stimulate acid secretion and gastric mucosal growth become apparent around the 3rd postnatal week in rats[15,16], a period when the structural and functional properties of the gastrointestinal mucosa undergo dramatic changes to attain maturity. The present finding that nutritional rehabilitation between 14 and 27 days of age is ineffective in normalizing the antral gastrin levels in undernourished rats suggests that postnatal undernutrition causes an impairment of G cell development. Whether the diminution in antral gastrin level during this critical period of growth affects the structural and functional integrity of the digestive tract remains to be evaluated.

1 Acknowledgments. I am indebted to Professor J.F. Rehfeld of Rigshospitalet, Copenhagen, for his generous supply of gastrin antisera. I whish to thank Mr S. Frandsen for his skilful technical assistance. The work was supported by grants from the Danish Medical Research Council, NOVO Research Fund and Christian den Tiendes Fond, Denmark.
2 Winick, M., and Noble, A., Dev. Biol. *12* (1965) 451.
3 Larsson, L.-I., Scand. J. Gastroent. *14* (1979) 1.
4 Rehfeld, J.F., in: Gastrointestinal Physiology III, vol. 19, p. 291. University Park Press, Baltimore 1979.
5 Younoszai, M.K., and Ranshaw, J., J. Nutr. *103* (1973).
6 Rehfeld, J.F., Stadil, F., and Rubin, B., Scand. J. clin. Lab. Invest. *30* (1972) 221.
7 Lowry, D.H., Rosebrough, N.J., Farr, A.L., and Randall, R.J., J. biol. Chem. *193* (1951) 265.
8 Larsson, L.-I., Histochemistry *54* (1977) 133.
9 Larsson, L.-I., Håkanson, R., Rehfeld, J.F., Stadil, F., and Sundler, F., Cell Tiss. Res. *149* (1974) 275.
10 Majumdar, A.P.N., and Rehfeld, J.F., Digestion *27* (1983) 165.
11 Prader, A., Tanner, J.M., and Van Harnack, G.A., J. Pediat. *62* (1963) 646.
12 Grossman, M.I., Nature *228* (1970) 1147.
13 Grossman, M.I., Lancet *1* (1970) 1088.
14 Johnson, L.R., in: Physiology of the Gastrointestinal Tract, vol. 1, p. 169. Raven Press, New York 1981.
15 Takeuchi, K., Peitsch, W., and Johnson, L.R., Am. J. Physiol. *240* (1981) G163.
16 Majumdar, A.P.N., and Johnson, L.R., Am. J. Physiol. *242* (1982) G135.

0014-4754/84/070751-02$1.50 + 0.20/0