essential to give also a complete vitamin supplement and supplements of the elements which are deficient in galactomin if it is to be used for more than a few weeks. Although disaccharide intolerance causes severe diarrhoea it may not last long and cow's milk feeds can be cautiously resumed. The control of infection in the bowel is often difficult because the causal organism is not susceptible to available chemotherapy and may even be encouraged by it.

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Feeding the newborn baby

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A steady decline in breast-feeding and increasing sophistication of artificial feeding is to some extent a consequence of the emancipation of women. Approximately 80% of the nation's babies are now bottle-fed, their mothers influenced, subconsciously no doubt, in their choice of food and even method by the large-scale advertizing of the commercial baby food caucuses. Striking differences in mortality between breast- and bottle-fed no longer exist in this country but we should remind ourselves of other aspects of this trend, of importance alike to the well-grown mature infant and the baby of low birth weight. Discussion will be confined to the physical properties of human milk vis-a-vis cow's milk, and will not include the psychological advantage to mother and child, real though it may be, of the act of breast feeding.

Widdowson (1963) has stressed the successful integration of growth with renal function occurring for each species when maternal milk is available. This fine adjustment of mineral balance and kidney function is of particular importance in the first weeks of life, when the fits, thought to be hypocalcaemic, of 'neonatal tetany' may occur in the artificially fed. This complex metabolic upset may be initiated in part by the higher phosphate load of cow's milk which is excreted with difficulty by the infant kidney (Bakwin, 1939). Lactose is known to increase the retention of dietary calcium (Duncan, 1955), and the higher content of lactose in

human milk may be another factor in maintaining protective calcium levels in the breast-fed. Though of uncertain relevance in terms of potential radiation exposure, cow's milk contains about six times as much strontium as human milk, and the artificially fed infant may double the strontium content of his body in 1 month, while the breast-fed baby quickly develops a negative strontium balance (Widdowson, Slater, Harrison & Sutton, 1960). The much higher salt content of cow's milk (Mellander, Vahlquist & Mellbin, 1959) may lead to serious hypertonic dehydration in excessive heat or with diarrhoea. We do not know the significance to the baby of pesticide, weed-killer and antibiotic residues which may be higher in cow's milk in certain circumstances.

The finer protein curd of human milk leaves the stomach sooner than that of cow's milk (Silverio, 1964) and the concentration of protein is lower. Platt (1954) has pointed out that the ratio of the time taken to reach puberty to the length of the normal life span is uniquely high in man compared with that for other animals, and that long-term consequences of mineral and protein overfeeding with cow's milk are unknown. The possible relationship to obesity in later life should be borne in mind. Nitrogen retention on equivalent calorie diets is larger in infants fed cow's milk (Stearns, 1956), and blood urea levels are higher (Fomon, 1967).

Galactose, formed from the intestinal hydrolysis of lactose, is necessary for the synthesis of cerebrosides (Duncan, 1955), which in turn are the principal lipids of myelin, most of which is laid down after birth (Johnson, McNabb & Rossiter, 1949). Lactose, and thus indirectly galactose, is in shorter supply in cow's milk than in human milk; other sugars such as sucrose may be added to the infant's artificial feed, and we have no answer to Platt's (1955) provocative question as to whether myelin composition differs in the artificially fed infant, and if so whether or not this could have any part to play in the later development of demyelinating disease. Osborn (1968) has reported that coronary artery lesions seen at autopsy in young adults were less common in those who had been breast-fed for over 2 months in infancy. Dental caries is less common in the breast-fed (Mellander *et al.* 1959). The essential fatty acid content of human milk is about three times greater than that of cow's milk (Mellander *et al.* 1959), and there is evidence to suggest that infants fed cow's milk have less than is required for normal fat metabolism (Holman, Hayes, Rinne & Söderhjelm, 1965).

If the significance of some of the differences between human and cow's milk mentioned so far is hypothetical, we are on more certain ground when dealing with infective illness. Though there are no striking differences in mortality now in the more prosperous parts of the world, there is still an increased incidence of infection among bottle-fed infants (Robinson, 1951; Mellander *et al.* 1959; Hooper, 1965), which includes illness of the upper and lower respiratory tract, in addition to gastro-intestinal infection. Placental transfer of immune globulins largely protects the infant from measles in the first 6 months, but Douglas (1950) has reported a longer period of protection in the breast-fed. This has not been confirmed by Atkins (1958). Immune globulins present in human milk probably inhibit viral and bacterial multiplication when they reach the gastro-intestinal tract (Kenny, Boesman &

Michaels, 1967). The stools of the breast-fed infant have a mixed bacterial flora in contrast to the mainly Gram-negative one of the artificially fed, and are acid, because of the predominance of *Lactobacillus bifidus*, with its property of breaking down lactose into acetic acid and lactic acid (György, 1961). A specific *bifidus* growth factor may have an inhibitory effect on the growth of *Escherichia coli* (György, 1953), and the presence of large amounts of lysozyme may add to the antibacterial effect (Glynn, 1968).

Sudden unexpected death, or 'cot death', has been found to occur more often among infants who were bottle-fed in the first 2 weeks of life (Ministry of Health, 1965). Cow's milk protein may be absorbed from the gut during its increased permeability in the first days of life (Vahlquist, 1958), and regurgitation and aspiration into the lungs of even a small amount of milk at a later date might cause a severe anaphylactic reaction leading to pulmonary oedema, and death in a sensitized infant (Parish, Barrett, Coombs, Gunther & Camps, 1960). The serum levels of antibodies to cow's milk proteins have not, though, been found higher in these children than in controls (Gold & Godek, 1961). Gastro-intestinal bleeding has been reported in artificially fed infants with biopsy and sigmoidoscopic evidence of colitis, which has reverted to normal after the elimination of cow's milk from the diet (Gryboski, 1967); and cow's milk induced malabsorption which acted as a precursor of gluten intolerance is described (Fällström, Winberg & Andersen, 1965), and also upper and lower respiratory tract symptoms as a manifestation of cow's milk allergy (Gerrard, 1966).

We may fairly say that the undoubted physical advantages of breast milk are these: its mineral composition is perfectly suited to the newborn kidney and has an important homoeostatic effect in the first weeks of life; its role in combating certain infections is definite and important; well over a thousand cot deaths in this country each year might not occur if breast feeding were carried out even in the first weeks of life only. Less certain is the possibility that differences in tissue composition resulting from the different chemical constitution of cow's milk may be associated with disease much later in adult life, but it is a possibility which has received little critical attention from paediatricians who have to ask themselves whether the increasing size and earlier maturity of their charges are necessarily associated with longevity. Of greater concern in human terms however is the fact that this rejection of breast feeding by our society has now been imitated by immigrants to this country (Aykroyd & Hossain, 1967), and much more seriously by the women of lower socio-economic groups in the towns and urban communities of certain underdeveloped areas of the world where unhygienic conditions are still rife. Jelliffe (1968) has emphasized the increase in infant mortality that this will mean and the tremendous cost in economic terms of replacing breast milk by cow's milk.

The low birth weight infant

Low birth weight infants may be truly immature, or small for the period of gestation. This distinction has only recently been made, and has not always been drawn in previous comprehensive reviews of later growth and development, which

in general describe increasing neurological handicap with declining birth weight (Drillien, 1964; McDonald, 1967). There is evidence, some of it tentative and indirect, to suggest that starvation—which in the past has been enforced for 48 h or more—may be one of the causative factors of such handicap in both groups. In the very immature infant an increased time taken to regain birth weight has been associated with an increased incidence of spastic diplegia, though whether this is a cause and effect relationship is uncertain (Churchill, 1963). High bilirubin levels, known to cause brain damage in certain circumstances, are enhanced by a low food intake in the first days of life (Wennberg, Schwartz & Sweet, 1966). In her follow-up studies Drillien (1964) found the incidence of handicaps highest in those children subjected at birth to the most rigorous starvation. Kansas children, weighing 1500–2500 g at birth, whose later IQ scores were below 90, had their first feed at a mean age of 37 h, while the corresponding figure was 28 h for those with IQ 90 or above (Bacola, Behrle, de Schweinitz, Miller & Mira, 1966). The relevance of animal work must be even more tentative, but we know that restricted food intake before weaning leads to inferior physical growth and performance later (Lát, Widdowson & McCance, 1961), and that the uptake by the brain of non-lipid solids, cholesterol, phospholipids and cerebrosides may be reduced (Culley & Mertz, 1965). Dobbing (1968) has found in rats, using the measurement of deoxyribose nucleic acid and cholesterol as estimates respectively of cell number and myelin, that a period of very early though mild undernutrition leads to deficits in both, not recovered by later *ad lib.* feeding. This has led him to hypothesize that there may be a vulnerable period during the last weeks of human gestation and the first of postnatal life when quite minor food restrictions could affect both rate and ultimate extent of brain growth. This of course is just the time when the immaturely delivered infant has his continuous food supply abruptly cut off.

It may not be unreasonable therefore to hope that some of the neurological handicap of these very small infants might be prevented if the period of interruption of growth following birth was as short as possible. The introduction of liberal feeding for such babies with expressed breast milk starting within a few hours of delivery has lessened the time taken to regain birth weight (Smallpeice & Davies, 1964); and the incidence of neurological defect among survivors is low by comparison with recent surveys (Davies & Russell, 1968).

Figs. 1 and 2 show, for some infants weighing 1500 g and below at birth, and cared for at Hammersmith Hospital between 1964 and 1967, their postnatal growth expressed as an arbitrary line drawn between birth weight and that attained on or near the expected date of delivery. The initial weight loss and regain to birth weight are not shown. Fig. 1 shows normal birth weights for gestation, and Fig. 2 those below the 10th percentile, and small for gestation. In both groups some infants are capable of maintaining intrauterine growth rates while others are not, and though many factors other than food supply may influence postnatal growth in these early weeks, food requirements might appropriately be calculated according to expected weight on these percentile curves. The tendency of the small for dates infants to hypoglycaemia can be largely prevented if liberal amounts of breast milk are given

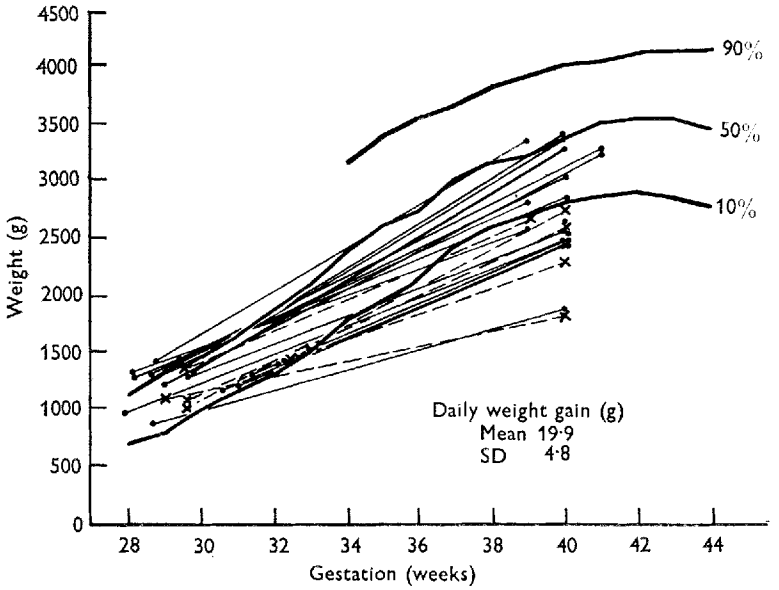

Fig. 1. Early postnatal growth of infants 1500 g and less at birth: normal weight for gestation. Percentile curves are those for singletons derived from the National Birthday Trust's 1958 Perinatal Mortality Survey, supplemented by data from Gruenwald (1966) at the lowest birth weights. ×, twin; ●, singleton.

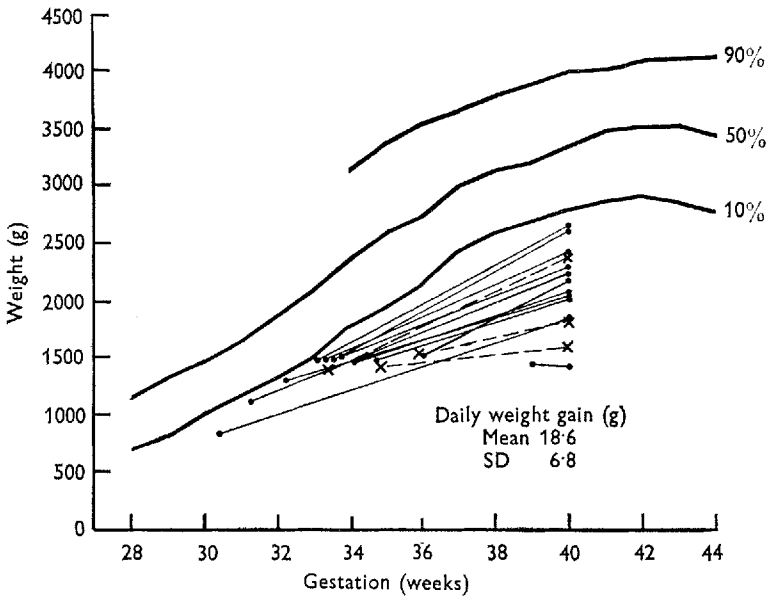

Fig. 2. Early postnatal growth of infants 1500 g and less at birth: small for gestation. ×, twin; ●, singleton.

https://doi.org/10.1079/PNS19690013 Published online by Cambridge University Press

in the first few days of life (Ditchburn, Wilkinson, Davies & Ainsworth, 1967). Although their brain has grown preferentially *in utero*, it is still smaller than that of the well-grown baby of the same gestation, and follow-up studies of twins of discrepant birth weight have shown the smaller twin to have a significantly lower IQ (Churchill, 1965). Thus in these infants we can only hope to prevent further deficit occurring after delivery.

In conclusion, there are good reasons for trying to reverse the trend away from breast feeding. By example, we may also help to re-establish it in those areas of the world where only disaster could follow its widespread rejection. There is gathering evidence in favour of early and liberal feeding of low birth weight babies, whether they are born prematurely or small for their gestation, preferably with breast milk, in order to reduce the interruption of brain growth at a vital period for as short a time as possible.

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The Symposium concluded with a general discussion, opened as follows by Professor J. P. M. Tizard, MA, BM, BCh, FRCP, Institute of Child Health, Hammersmith Hospital, London, W12

The other guests and I are most grateful for being invited to this meeting of the Nutrition Society. We have been very impressed not only with the papers but by the standard of discussion; just because the discussion of individual papers has been so good, my task is all the harder, and I imagine that what is really wanted now are some provocative and speculative remarks.

Although our knowledge of the nutrition of the foetus and newborn could be so rich that we could afford to look at the subject from, shall I say, oblique angles, I suspect that it would be nearer the truth to say that we know so little directly about the subject that we are forced to glean what information we can from studies designed originally for another purpose. Perhaps we should consider what direct observations are possible and practical in the human and other species, and which one would like made soon; and we should consider the ultimate purpose of such studies. Of course, the truth in itself is part of the ultimate purpose, but is there a more utilitarian part? In the case of the human being great stress has, I think rightly, been laid on ultimate intelligence, and as Dr Davies has pointed out, quantity in the shape of a human infant, may not necessarily mean quality. Clearly one wants a good many different kinds of human being, but the Aldous Huxleyan view of the future, in which there would be some point in breeding a race of morons, has become less credible; he could hardly have been expected to have anticipated that to dig a hole in the ground would in the year 1968 demand a considerable technical knowledge of how to manipulate a large and complicated machine—a technical knowledge that could not be acquired by people with IQ's of less than, perhaps, 100. As the problem of how to employ those of low IQ will surely be one of the major world problems in the future, anything directed towards increasing the total level of intelligence in a population is well worth considering. With animals of course one is looking for quite simple attributes, like milk yield; but is it important for a race-horse, for example, to have a high IQ?—and is this looked for when it comes to breeding and to questions of early environment?

Turning now to the individual papers, I am prompted by Dr Widdowson's fascinating remarks about trace elements to wonder about lead. Studies of lead