assumption is that the results within any given class interval (for example, the 7 results in the interval 0·4 up to 0·8) are distributed evenly along the interval. The midway point represents that interval better than points nearer its top or bottom. Thus $7 \times 0{\cdot}6$ will, on the average, give a better estimate of the sum of those 7 results than $7 \times 0{\cdot}4$ or $7 \times 0{\cdot}79$ or $7 \times$ any other number in between. For this reason the midway points of the class intervals are set out in col (3). In col (4) the value of each midway point is multiplied by the number of children in the class. The sum of the lead concentrations is then put at the bottom of col (4)—namely, 305·6. To find the mean lead concentration in the 140 specimens, this sum is divided by 140, giving 2·18 μm/24 h.

If this procedure is carried out on a calculator with a memory, the figures in col (4) need not be written out. The multiplication of each value of lead concentration is done, the result added into the memory, and the sum extracted from the memory at the end. Further, if the class intervals in col (1) are carefully chosen, as recommended in Part I last week, it may be possible (as it is here) to see the midway point by inspection. Col (3) is then superfluous, and the calculation can be done with the aid of the calculator straight from table 1·2 without the need for additional columns.

Adding like and unlike

At the end of Part I the question was raised whether it was correct to make calculations on the total group of 140 children. In so far as they are children, the sources of these observations clearly belong to the same class of creatures and have much in common. But as parents have often had occasion to remark, children differ greatly among themselves. Some are boys, some are girls, some (in this group) were near the age of 1 and others nearly 16. Disparities of this kind often lie hidden but need to be thought of.

For example, according to the Registrar General's estimate for mid-1973, the population of the Birmingham hospital region was 5 163 200 and that for the South-western hospital region 3 246 200. But women constituted 50·49% of the Birmingham region and 51·80% of the South-western, a difference of 1·31%. This might be large enough to invalidate a comparison between the incidence of a disease in the two regions if women were particularly susceptible or relatively immune to it. Furthermore, while 35% of people in the Birmingham region were aged 45 or over, the figure for the South-western region was 41%. Susceptibility to many diseases varies with age, so that this difference too must be taken account of in any comparison between the regions. The figures for the total populations of these two regions conceal important dissimilarities between them.

Likewise when studying the urinary lead concentrations it would be advisable to analyse them according to the age and sex of the children. It is possible, for instance, that the younger children, having less judgment of what is safe to put in their mouths, might have higher lead concentrations than the older children; and boys, being more exploratory than girls, might have got more lead-contaminated material from a forbidden site.

Exercise 2. From the 140 children whose urinary concentration of lead he had investigated Dr Green selected the 40 who were aged at least 1 year but under 5. He found in the urine the following concentrations of copper in μmol/24 h:

0·70,	0·45,	0·72,	0·30,	1·16,	0·69,	0·83,	0·74,
1·24,	0·77,	0·65,	0·76,	0·42,	0·94,	0·36,	0·98,
0·64,	0·90,	0·63,	0·55,	0·78,	0·10,	0·52,	0·42,
0·58,	0·62,	1·12,	0·86,	0·74,	1·04,	0·65,	0·66,
0·81,	0·48,	0·85,	0·75,	0·73,	0·50,	0·34,	0 88.

What is the mean when calculated (1) from the individual observations, (2) from a frequency distribution of the observations arranged at intervals of 0·1 μmol/24 h? *Answer:* (1) 0·6965, (2) 0·705 μmol/24 h.

Problems of Childhood

Bottle-feeding

BRIAN A WHARTON, HOWARD M BERGER

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Whenever possible mothers should be encouraged to breast-feed their babies—even as little as two weeks is valuable, but preferably it should continue for the first four to six months of life. If, however, the mother is unable or unwilling to do so the baby is bottle-fed. This article is concerned with "Which baby?" "When?" "How much?" "How?" "What?" and "What else?" of bottle-feeding. We have paid particular attention to "What?" —that is, What substitutes for breast milk are available?—because it is in this area that the most substantial changes have occurred recently.

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TABLE I—*Rule-of-thumb feeding categories*

Feeding category	Birth weight (g) at gestational ages (completed weeks)				
	Preterm		Term		Post-term
	<36	36-37	38-39	40-41	>41
Group 1, special care	All below 36 weeks require special care	<2300	<2400	<2500	All above 41 weeks require special care
Group 2, extra care	—	2300-2500	2400-2800	2500-2900	—
Group 3, normal	—	>2500	>2800	>2900	—

In group 1 the lower limit of weights for babies of 38-41 weeks are well below the 5th centile for gestational age—that is, they are very light-for-dates babies. Group 2 consists mainly of term babies who are moderately small for dates—from below the 5th centile up to the 10th centile. If born at home the individual circumstances will indicate whether extra care with feeding can be achieved or whether admission to hospital is necessary. The mother must have reasonable diligence and ability; a feeding record is necessary; three or four visits by the midwife or doctor during the first 48 hours are desirable, particularly if the baby is below 2500 g or of only 36 weeks' gestation. Group 3 consists of babies born at term or only just preterm and whose birth weight is above the 10th centile for gestational age. If the birth weight is more than 1400 g above the limits given in group 1 he is probably large for dates (>95th centile) and the possibilities of complications requiring special care should be borne in mind—for instance, infant of diabetic mother.

Which baby?

Table I gives some indication of babies who if otherwise well we consider: (1) require special care with feeding, usually found only in a hospital unit because they are preterm, post-term, or very small for dates; (2) require extra care with feeding because they are small for dates; and (3) may be bottle-fed normally. Like all rules of thumb they may need alteration for particular circumstances and clearly should not be slavishly applied. We think, however, that it is useful to give some specific guidelines. A very rough summary is that babies below 2500 g will probably require special care with feeding (group 1), those between 2500 and 3000 g will require extra care (group 2), and those above 3000 g may be fed normally (group 3). It is better, however, if the gestational age is also considered, as in table I.

We have limited our discussion to babies in groups 2 and 3—that is, those who if otherwise well could be fed during the first week of life on a postnatal ward or in a good home, and thereafter at home. This article applies only to Britain, and no attempt has been made to cover conditions in developing countries.

When?

FIRST FEED

Most normal babies will take their first feed within eight hours of birth. If the baby shows no interest in feeding by the age of 24 hours he should be carefully examined again, even if otherwise apparently well, to ensure that the lack of interest is not an indication of illness such as cerebral birth injury, hypothermia, etc.

If there has been polyhydramnios or the baby after birth has been very frothy then special care with feeding is necessary; in particular a tracheo-oesophageal fistula must be excluded. Extra-care babies should receive their first feed within four hours of birth (preferably within two) and be given at least three-hourly feeds for the first 48 hours.

SUBSEQUENT FEEDS

Demand or schedule feeding is largely a matter of personal choice for the parents, but light-for-dates babies should be fed at least every three hours during the first 48 hours. Most bottle-fed babies will adopt a three- to four-hourly feeding interval throughout the 24 hours during the first month of life.

How much?

FIRST WEEK

A virtue of using one of the formulae recommended below is that the baby may take as much as he wants without the fear of metabolic complications which used to occur in babies receiving unmodified cows' milk. Generally, then, detailed attention to volumes of formula taken is unnecessary. Nevertheless, some broad rules of thumb concerning intake may be worth while even for the completely normal baby—for instance, in assessing the cause of excessive weight loss or poor weight gain. During the first 24 hours almost all term babies will take at least 15 ml/kg birth weight/day, working up to at least 120 ml/kg by the end of the first week. To take less than this is very unusual and careful consideration should be given to the possibility of illness in the baby. Most take more—40 ml/kg, working up to 150 ml/kg—and some far more—60 ml/kg, working up to 200 ml/kg. The small-for-dates baby (group 2) should receive not less than 60 ml/kg during the first 24 hours and not less than 90 ml/kg during the next 24 hours; if these volumes are not achieved tube-feeding should be seriously considered, probably in a special care unit. A good fluid intake helps to reduce the concentration of plasma bilirubin, so that every effort should be made to persuade the more than mildly jaundiced baby to take more formula or water, or both.

We think the baby's weight is, despite criticisms, a useful monitor. A healthy baby who is feeding adequately (either breast or bottle) rarely loses more than 8% of his birth weight; we find that several babies have not regained their birth weight by seven days but all should be gaining by then. Babies who are not meeting these weight criteria even though they appear reasonably well need special attention: Are they taking sufficient food? Do they have a urinary tract infection? Are they acidosed? Do they have the adrenogenital syndrome?

SUBSEQUENT WEEKS

The baby usually settles into a pattern of taking 120-200 ml/kg/day, the upper limit usually reducing to about 150 ml/kg by the fourth month. The babies should be weighed and measured regularly so that growth may be assessed by comparison with standard centile charts; attention may then be paid at an early stage to inadequate or excessive weight gain. Table II summarises when and how much for normal (group 3) and light-for-dates (group 2) babies.

TABLE II—*When and how much for normal and light-for-dates babies*

Feeding category	When		How much (ml/kg)		
	First feed*	How often	1st day	7 days	4 months
Normal	Usually in first 8 hours, sometimes 8–24 hours	Variable	15–60	120–200	120–150
Extra care light-for-dates	Within 2–4 hours†	At least 3-hourly during first 48 hours†	60†	200†	120–150

*If polyhydramnios has been present or baby is very frothy, special care with feeding is necessary.
†These timings and volumes should be achieved in light-for-dates babies; if they are not the child requires special attention, probably in a special care baby unit. Other figures give an indication of what the normal baby will do and are not target figures; he should be largely left to his own appetite.

How?

STERILISATION OF BOTTLES AND TEATS

Bottles and teats may be effectively sterilised by chemical agents, acting via the release of chlorine (Milton and Simpla), or by boiling. Unfortunately this result is often not achieved by mothers because of errors in their technique.

With both methods the bottle and teat must first be thoroughly cleaned. Immediately after use, before the film of milk hardens, they must be rinsed under cold water, and then, when convenient, bottle and teat must be thoroughly cleaned with detergent and warm water using a bottle brush. The teat is difficult to clean properly and should be turned inside-out for cleaning and also sprinkled inside and out with salt and rubbed between the fingers. The bottle brush should not be used for any other purpose and must be regularly washed and boiled. After rinsing, the bottle and teat are ready for sterilisation. If boiling is used the bottle and teat must be completely submerged under the water in a closed container and kept at boiling point for 10 minutes. With a chemical agent (usually sodium hypochlorite) the mother should make up a fresh solution every 24 hours and again ensure that the bottle and teat are totally submerged and contain no air bubbles (quite difficult). The shortest length of time recommended for sterilisation by these chemicals varies and a minimum of three hours is safest.

After sterilisation the bottles and teats should be left in the boiled water or sterilising solution covered with a lid until needed. If chemical sterilisation has been used the excess fluid should be drained from bottle and teat but there is no need to rinse off the remaining drops of chemical.

MAKING UP THE FEED

Most formulae can now be prepared either in the bottle itself or in a jug and then poured into the bottle. Preparation in the bottle may be difficult when it is almost full, and the graduation marks on many bottles are very approximate.

Water in a few areas contains appreciable amounts of sodium but this amount can be tolerated if one of the recommended low-solute formulae is used. Some types of domestic water softener and some used in hospitals add sodium to the water and should not be used when preparing a feed. The water should be brought to the boil (prolonged boiling will increase the content of minerals and nitrate by evaporation), and then allowed to cool a little (a temperature of about 60°C allows easy mixing without clumping and does not destroy the water-soluble vitamins). The kettle used for boiling the water should always be emptied completely after use so as to avoid building up a concentrated residue of water.

Care is needed with scoops used for measuring out powdered formulae. They should be level, not heaped, scoopfuls of powder, and since scoops from different packs hold different amounts of powder, scoops from other packs must not be used.

Reconstitution instructions vary. With some formulae (Cow and Gate variety) it is necessary to make up the feed to a final volume, while with others a stated amount of water (usually 1 oz; 30 ml) is added to a stated amount of powder (usually one scoop); the final volume is not given. "Frothing" may make accurate make-up to a final volume difficult. The instructions for each brand must, therefore, be followed carefully. Generally a too concentrated feed is more dangerous than a too dilute one. After reconstitution the feed should be given within 10-15 minutes or, alternatively, placed in a refrigerator until shortly before use.

FEEDING

Feeds straight from the refrigerator seem to be well accepted by babies, but most mothers will prefer to warm them first. The milk should not be kept warming for more than a few minutes, so that if any bacterial contamination has occurred it will not be incubated. To put the night feed to warm on going to bed so that it is immediately ready for use some hours later or to mix a feed and leave it warm in a vacuum flask for some hours is potentially dangerous. The way the feed is handled after reconstitution, particularly the length of time it is kept warm before feeding, probably gives as great an opportunity for infection as the use of imperfectly sterilised bottles.

A teat hole which is too small or is partially blocked may lead to aerophagia as the baby sucks vigorously and sucks in air around the side of the teat, leading to gastric distension, regurgitation, and sometimes underfeeding. When inverted, the milk should drip steadily (about one drop per second) from the teat. It is unusual for the teat hole to be so large as to cause any problem. Some teats ("anti-colic") have a separate air inlet so that air enters the bottle while the baby is sucking, whereas in normal teats the air enters through the feed hole when the baby stops feeding for a moment. Some brands of bottles are made of polyethylene and gradually collapse as the baby feeds, so that air does not have to enter the bottle. Most babies, however, manage well with normal teats and bottles.

What?

A breast milk substitute is usually based on cows' milk. Some babies, particularly in America, receive a soya-based formula, but in Britain this is usually given only when there are specific indications and usually under medical supervision.

COWS' MILK

Figure 1 shows the composition of cows' milk and breast milk as regards major nutrients. In comparison with breast milk, cows' milk contains more protein and more minerals, about the same amount of fat but of different quality, and less lactose. The formulae received by most babies in Britain (Cow and Gate Baby Milk 2, National Dried Milk, and Ostermilk No 2) consist essentially of dried cows' milk to which iron and vitamins have been added. Similarly, the canned evaporated milks (Carnation and Cow and Gate) consist of partially evaporated cows' milk plus vitamin D.

Cows' milk has been modified in three major ways to bring its composition closer to that of breast milk. To understand these modifications various products of the dairy industry (fig 2) must be considered—whole milk, skim milk (a byproduct of butter manufacture), whey (whey protein plus lactose plus minerals and water—a byproduct of cheese manufacture), and demineralised whey. The modifications of cows' milk may be described as "added carbohydrate," "substituted fat," and "demineralised whey" formulae. Figure 3 shows the composition of these formulae.

ADDED CARBOHYDRATE FORMULAE

The higher content of protein and minerals may, in the baby receiving cows' milk, lead to (*a*) high concentrations of phosphate in the blood, and thence low concentrations of calcium with risk of convulsions; and (*b*) a high renal solute load—that is, a large amount

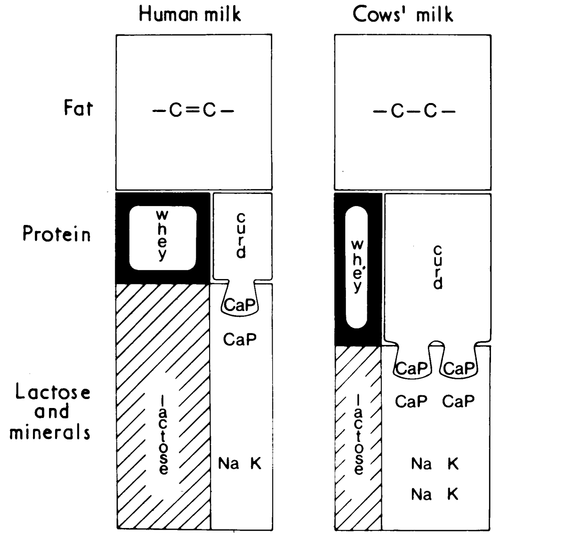

FIG 1—Composition of human and cows' milk. Cows' milk contains more protein (mainly curd protein), more minerals (some of which form micellar complexes with protein), less lactose, and about the same quantity of fat (but of different quality) when compared with breast milk.

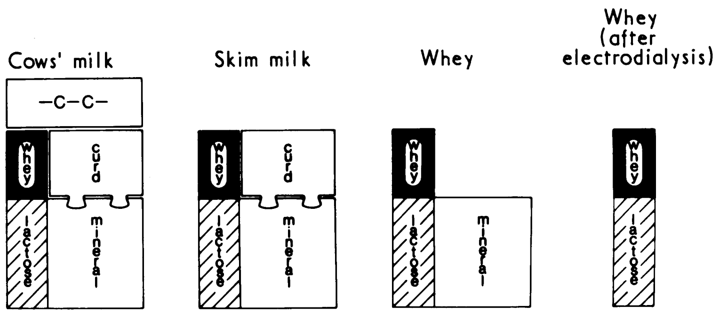

FIG 2—Products of dairy industry which are used in manufacture of infant formulae: whole cows' milk; skim milk (a byproduct of butter manufacture); whey, consisting of whey protein, lactose, minerals, and water (a byproduct of cheese manufacture) and whey demineralised by electrodialysis.

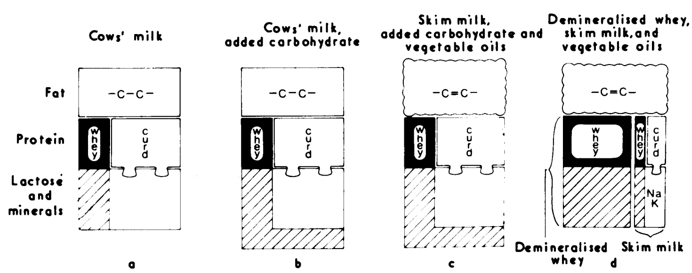

FIG 3—Modifications of whole cows' milk (a) in manufacture of infant formulae; (b) added carbohydrate; (c) substituted fat; and (d) demineralised whey.

of urea and various minerals requiring excretion—with embarrassment of the concentrating ability of the kidney, which contributes to hyperosmolality of the body fluids and development of hyperosmolar dehydration (this type of dehydration is more serious than the iso-osmolar variety; most people find it has a higher mortality rate and a greater risk of neurological sequelae).

Figure 3 (b) shows the simplest modification of cows' milk designed to deal with some of these problems—addition of carbohydrate. The added carbohydrate not only increases the overall concentration of carbohydrate but also reduces (dilutes) the concentration of protein, fat, and minerals per unit energy intake. Added carbohydrate formulae are in wide use in Europe.

There are some problems in deciding which carbohydrate to use for dilution. The total carbohydrate concentration in such a formula must be 500-555 mmol/l (9-10 g/100 ml) of feed (compared with 222 mmol (4 g) in cows' milk and 389 mmol (7 g) in breast milk) to achieve the desirable reduction in protein and mineral concentration. Should all of this carbohydrate be lactose the gut of some babies would be unable to handle this amount, which would result in lactose malabsorption and fermentative diarrhoea. Therefore, instead of adding lactose the following may be added: (*a*) a small amount of fat as well as lactose (Cow and Gate Plus; and all substituted fat formulae) or (*b*) a different carbohydrate (such as maltodextrins (Ostermilk Complete Formula); sucrose and maltodextrins are commonly used in Europe).

Lactose may have, apart from its teleological position, certain physiological functions not shared by other sugars, so perhaps all formulae for normal infants should contain some lactose; arguments against using sucrose have included an increased risk of obesity, development of a sweet tooth, and abnormalities of plasma lipids, but none of these possibilities have actually been demonstrated in infants.

It is, of course, possible to reduce the concentration of phosphate, sodium, and protein in cows' milk merely by adding more water to it; indeed the instructions given with National Dried Milk recommend this during the early weeks of life, and this could be applied to any dried cows' milk, evaporated milk, or doorstep milk. The added water will, however, also reduce the concentration of every other nutrient, including energy. If a satisfactory reduction in renal solute load is achieved by adding extra water then a considerable amount of extra carbohydrate must be added to bring the energy concentration back to the levels normally found in milk (although instructions on packets of Cow and Gate Baby Milk 2, National Dried Milk, and Ostermilk No 2 advise adding small amounts of sucrose, the reduction in renal solute load per unit of energy is small). If large amounts of sugar are to be added then this probably is better done accurately by the manufacturer rather than by the mother—that is, an added carbohydrate formula as described above should be used. If carbohydrate is not added the energy content of the overdiluted milk will be much below that in breast milk, and, although the baby will drink more to satisfy his appetite, it is unlikely that during the first six weeks of life the extra volume of formula taken will make up for the reduced energy content. Although, therefore, the addition by the mother of extra water to cows' milk with or without added sugar might be useful in an emergency and is certainly cheap, it is not now usually advised.

SUBSTITUTED FAT FORMULAE (FILLED MILKS)

Although breast milk and cows' milk contain the same amount of fat (fig 1), it is of very different quality. Cows' milk fat is much less well absorbed. Furthermore, it contains only small amounts of the polyunsaturated fatty acids which are probably essential for man. Figure 3 (c) shows the composition of a substituted fat formula—that is, replacement of the cows' milk fat with a mixture of vegetable and animal fats whose fatty acid compositions more closely approximate to that of breast milk; examples in Britain include Cow and Gate V Formula, SMA, and the demineralised whey formulae (see below).

The use of formulae rich in polyunsaturated fatty acids, however, increases the infant's requirements for vitamin E; vitamin E deficiency in babies receiving such formulae was described before the importance of the vitamin E content was realised. Some fats used for substitution, although well absorbed, are very different in fatty acid composition from those of breast milk, and consequently the fatty acid composition of the adipose tissue may differ appreciably from that seen in babies receiving breast milk or cows' milk. The biological significance of these differences in adipose tissue composition is not known.

DEMINERALISED WHEY FORMULAE

Figure 1 shows that not only does cows' milk contain more protein than breast milk but it is predominantly curd protein (casein), whereas breast milk protein is about equal parts of casein and whey protein (mainly lactalbumin). Some animals thrive better on a curd and whey formula than on a curd one alone, probably because of the greater cysteine content of whey protein, and there may be a marginal advantage for human infants in the early weeks of life. To deal with this difference between cows' milk and breast milk, formulae based on demineralised whey have been introduced (fig 3 (d)). Demineralised whey, containing whey protein and a low concentration of minerals, is used as the base; to this is added a small amount of skim milk, so introducing curd protein, further lactose, and some minerals in their naturally occurring form, while other minerals such as copper, iron, zinc, and sometimes manganese may be added individually. A fat mixture and vitamins are added to complete the formula.

Overall, protein in the formula is about equal curd and whey in quality as in human milk, while the concentrations of major electrolytes, calcium and phosphorus, are reduced and are much nearer to those of breast milk than can be achieved by adding carbohydrate alone. Examples of such formulae in Britain are Cow and Gate Premium and Gold Cap SMA S26. There are four possible problems with such formulae. Firstly, they are more expensive than other formulae. Secondly, they depart substantially from a naturally occurring food product, and so the potential for error in manufacture (either accidental or because of inadequate knowledge) is greater and could lead to a "feeding accident," such as the outbreaks of pyridoxine deficiency and vitamin E deficiency which occurred in early attempts to modify cows' milk. The demineralisation process is perhaps the most worrying aspect: Are minerals about which we know little removed in the process? When part of the minerals are replaced are they in a biologically suitable form? In skim milk they are, presumably, but not necessarily if they are added as individual compounds. Such formulae have, however, been used in the USA for many years, so far without apparent trouble, though it should be remembered that infant formulae based on unmodified cows' milk with added vitamins and iron were used for 30 years or more before the dangers of too much vitamin D or too much sodium were fully realised. Thirdly, minerals, particularly copper and iron, are often added to these formulae, and to the other varieties too, to give a concentration much greater than that found in breast milk (to prevent iron deficiency and the rarely described copper deficiency); these concentrations may catalyse the oxidation of polyunsaturated fatty acids in the formula, while high plasma iron levels may interfere with antimicrobial defence mechanisms; extra iron is usually added to the other types of formulae too and the same problems may occur. Finally, cows' milk protein is a foreign one and so may cause an immunological reaction in the baby; whey proteins—particularly the lactoglobulin present in cows' milk whey but not in breast milk—may be more immunogenic than casein.

ANTI-INFECTIVE PROPERTIES: A SPECULATION

Breast milk has certain anti-infective properties when compared with cows' milk. Partly these are related to maintaining a low pH in the intestine and depend on the higher lactose, lower phosphate, and lower casein content of breast milk. Therefore, they can be at least partially copied by the formulae described above. The anti-infective properties of breast milk also depend on its content of lactoferrin (a fraction of whey protein present in only small amounts in cows' milk) and immunoglobulins (secreted by the mothers). Possibly by genetic selection a cows' milk containing larger amounts of lactoferrin might be developed. Experiments are already being made to produce cows' milk rich in immunoglobulins by immunising cows with appropriate organisms. The anti-infective properties may also be related to other constituents of breast milk, such as lysozyme, complement, and white cells. It would seem difficult to incorporate all of these properties, but perhaps these anti-infective considerations will be the basis of the next generation of infant formulae.

CHOICE OF FORMULA

We endorse the view that (*a*) "milk feeds should contain a concentration of phosphate, sodium, and protein which is lower than that of cows' milk and nearer to that of breast milk"; (*b*) "that artificial feeds should be so manufactured that they are either liquids which are ready to feed, or liquids or powders that require the addition only of water and no other substance"; (*c*) "that artificial feeds should be so manufactured that the dilution required to reconstitute the milk should be independent of the age of the baby and thus instructions about dilution can apply to feeds for a baby from birth onwards."[1] The added carbohydrate, substituted fat, and demineralised whey formulae discussed above all achieve this. Although the substituted fat and the demineralised whey formulae carry some extra advantages, we do not regard these as so paramount as to exclude the added carbohydrate formulae from use.

We therefore regard the following formulae as suitable: Cow and Gate Plus, Cow and Gate Premium, Cow and Gate V Formula, Ostermilk Complete Formula, SMA, and Gold Cap SMA S26. Details of these formulae are given in table III. The

TABLE III—*Details of recommended formulae*

Brand	Type	Constituents per 100 ml reconstituted feed*											Consumer details				Reconstitution	
				Carbohydrate														
		Protein (g)	Fat (g)	Lactose (g)	Other (g)	Energy (kJ)	Sodium (mmol)	Calcium (mg)	Phosphorus (mg)	Vit D (µg)	Vit C (mg)	Renal solute load (mmol)‡	Size of pack (g)	Price (pence)§	Approx volume reconstituted formula for cost of 1p (ml)**	Approx energy for cost of 1p (kJ)	(a) Make up with water to final volume, (b) add stated volume of water to powder or liquid	Concentration (g solid/100 ml)
Cow and Gate Baby Milk Plus	Added carbohydrate	1·8	3·3	6·6		263	1·3	62	50	1·1	5·3	12·2	454	66	57	150	(a)	12
Cow and Gate Premium	Demineralised whey	1·8	3·3	6·9		263	1·0	55	40	1·1	5·0	11·3	454	78	49	130	(a)	12
Cow and Gate V Formula	Substituted fat	1·8	3·0	7·0		259	1·4	63	50	1·1	5·3	13·7	454	63	60	155	(a)	12
Ostermilk Complete Formula	Added carbohydrate	1·7	2·7	2·8	5·8	271	1·3	56	46	1·0	6·4	12·0	500	62	62	168	(b)	13
SMA	Substituted fat	1·5	3·5	7·0		271	1·1	53	43	1·1	5·3	10·3	450	62	60	163	(b)	12
SMA Concentrated Liquid	Substituted fat	1·5	3·5	7·0		271	1·1	53	43	1·1	5·3	10·3	370 ml	19″	39	104	(b) 1/1 with water	12
Gold Cap SMA S26	Demineralised whey	1·5	3·6	7·2		280	0·6	42	33	1·1	5·3	9·1	450	67	56	154	(b)	12
Breast milk		1·2	3·8	7·0		280	0·6	33	15	0·01†	4·3	8·0						12
Pasteurised cows' milk		3·3	3·7	4·8		275	2·5	125	96	0·06	1·6	22·1	568 ml	(8½)	67	184		12

*From DHSS[1] except Ostermilk Complete, for which recent figures are given after changes in reconstitution.
†New methods of analysis suggest that concentrations in breast milk are much higher than this figure.
‡Method of Zielger *et al*[2]; this method probably overestimates a little the renal solute load of these lower protein formulae.
§As available mid-January in a Birmingham chain chemist (note these are *not* recommended retail prices; prices vary from shop to shop).
″Not available, but quoted price given on inquiry.
**For powdered formulae calculated as pack size ÷ concentration of reconstituted formula ÷ price × 100 with appropriate modification for liquid formula and pasteurised milk.
Conversion: SI to traditional units—Energy: 1 kJ ≈ 0·24 kcal.

final choice within these for normal babies will depend as much on their availability and price as on their nutritional features. In practice there is a much greater variation in price between shops than between brands, as with many other foods. The hitherto traditional (and cheaper) formulae, such as Cow and Gate Baby Milk 2, National Dried Milk (as currently formulated), Ostermilk No 2, and various evaporated milks, do not fulfil the criteria set out above and are, therefore, not recommended before weaning.

What else?

SOLID FOODS

If solid foods are introduced too early, three problems may occur: (*a*) the renal solute load may be greatly increased, particularly if some of the higher protein or higher salt weaning foods are used; (*b*) if the child is destined to have coeliac disease then very early introduction to dietary gluten (from wheat cereals) may lead to symptoms developing earlier in infancy, often leading to a prolonged period of malnutrition and a stay of some weeks in hospital; and (*c*) there may be an increased energy intake contributing to the development of obesity, although there is little epidemiological evidence on this point.

On the other hand, if other foods are introduced too late then three other problems may arise: (*a*) theoretically deficiencies of some trace elements might occur (in practice, since many of the formulae have trace elements added (see What? above) this risk may apply more to the breast-fed baby); (*b*) if the baby is receiving cows' milk fat only then the intake of polyunsaturated fatty acids will be low (see What? above; introducing other foods, particularly cereals, will boost the intake of these substances); and (*c*) normal chewing movements may be slower in developing if the baby receives only fluid for too long. Generally, other foods should be introduced from 4 to 6 months.[1] Naturally it is possible to quibble over the exact numerical choice of 4 to 6; it is, however, a reasonable one because the range allows for biological variation, and in the interests of giving mothers consistent advice it would be useful if it were adopted by all members of the health care team.

As more solids are included in the diet the amount of formula required diminishes but it is difficult to give any rules of thumb on this other than the unwieldy one that the energy intake usually remains around 420 kJ/kg (100 kcal/kg). The volume of water required, however, does not reduce. It is important, therefore, that the baby is offered plenty of "free" water (in practice often flavoured with a little fruit juice) at this time, otherwise he may satisfy his thirst by drinking more milk and hence receive much more energy than he requires.

DOORSTEP MILK

When solids have been introduced the mother may continue to use one of the recommended formulae, and indeed their low renal solute load and vitamin content are good reasons for continued use. When the infant is receiving a mixed diet, however, the advantages of using a formula scrupulously manufactured to resemble breast milk are much less, and it is to some extent unnecessarily expensive. Doorstep milk may, therefore, be used instead of an infant formula once mixed feeding has become established, but if so it is *essential* that (*a*) liberal amounts of free water (see above) are offered, since the renal solute load of a diet consisting of doorstep milk, together with high protein, high sodium weaning foods, is very high, and (*b*) supplements of vitamins C and D are given (see below).

Pasteurised or sterilised doorstep milk may be used without prior boiling so long as reasonable precautions are taken. The bottle should be taken in from the doorstep shortly after delivery and stored in a refrigerator. After opening it should be kept covered in the refrigerator and the milk used completely that day. If the mother does not have a refrigerator the bottle should be kept in a cool dark place and the milk for each feed brought to the boil for a second or so, even though this will slightly reduce its nutritive quality.

VITAMIN SUPPLEMENTS

The formulae recommended all have added vitamins—mainly A, B, C, and D, and if vegetable oils are used, extra vitamin E too. Is it necessary, therefore, to give babies receiving these formulae any extra vitamin preparations? In Britain deficiencies of vitamin D, and rarely of vitamin C, may occur during infancy. Current recommended daily intakes (RDI) in Britain during infancy are 10 µg (400 units) of vitamin D and 15 mg of vitamin C. These are average figures relating to the first year of life for a baby of average weight (7·3 kg), and from table III it may be calculated that a baby of this weight drinking about one litre of formula would achieve the RDI for both vitamins. Supplementation is, therefore, not essential for the formula-fed baby. It is essential, however, for babies receiving doorstep milk in later infancy, and in view of this the DHSS recommends a small amount of vitamin supplement even for formula-fed babies to establish the habit with the mother. Using the DHSS supplement, which contains (per ml; 35 drops) vitamin A 1500 μg as retinol (5000 IU), vitamin C 150 mg, and vitamin D 50 μg cholecalciferol (2000 IU), the recommended doses for a baby receiving a fortified formula are: 2 drops at 1 month, working up to 4 drops by 2 to 3 months. The cost of these drops is subsidised and they are available free of charge to certain mothers. In the interests of giving the mother consistent advice we endorse the DHSS recommendation that drops be routinely given to *all* children. If, after weaning, doorstep milk is used instead of formula then the full dose of 7 drops (0·2 ml) daily is essential, supplying vitamin A 300 μg, vitamin C 30 mg, and vitamin D 10 μg.

FLUORIDE

The fluoride situation is complex. Even in areas where the amount of fluoride in drinking water is low the baby receiving a powdered formula probably receives more fluoride than a breast-fed one. An American recommendation is to give 0·5 mg of fluoride daily to a formula-fed baby only when he lives in an area where the fluoride content of the water used for reconstitution is below 0·3 ppm (where fluoride is added to drinking water the level is around 1 ppm). We are unaware of a preparation containing 0·5 mg of fluoride which is freely available in Britain.

When considering the dental health of the bottle-feeding baby other dietary factors, apart from fluoride, are important: (*a*) high-phosphate cows' milk resulting in hypocalcaemia should be avoided (see What ?); (*b*) formulae requiring sucrose to be added for reconstitution (none of those recommended) may be more cariogenic than others; and (*c*) high concentrations of sweet syrups, such as undiluted fruit drinks in pacifiers, should be avoided since they lead to severe caries of the incisors.

Colleagues in midwifery, nursing, health administration, and the food manufacturing industry gave valued advice during the preparation of this article; the figures were prepared by the department of medical illustration, Birmingham Children's Hospital. We are grateful to all of them and to Mrs P Cox for secretarial help.

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Further reading

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Letter from . . . Chicago

Poikilodokia simplex: a paramarmaladosis

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Our faults and failures constitute a more amusing and perhaps instructive topic than our virtues and achievements. Their exposition, however, is best accomplished not "by grave and serious declamation" but in the spirit of the young James Boswell—who in the introduction to his 1762 *London Journal* promised to relate the various stories or conversations that he had heard, and to put down the whims that may seize him, the sallies of his luxuriant imagination, and the various adventures that he may have. One such adventure might well have led him into the crowd of white-coated individuals attending the teaching rounds at the Miniscience University College of Medicine:

"And why didn't you order the magnesium, the chromium, the pseudocholinesterase, the protein bound iodine, and the blood marmalade, Smith ?," asks the professor, surrounded by his retinue, as he peers from the end of the bed at an obvious case of poikilodokia simplex.

"I didn't think of it, Sir," answers the cowed houseman.

"Well, don't you think you should have ?"

"Yes Sir," says Smith in a strangled and barely audible voice.

There is no cure for poikilodokia simplex. There is indeed not even much that symptomatic treatment can achieve. In fact, no patient with poikilodokia has ever left the professorial unit alive. Yet the above scene, regularly enacted on the wards at Miniscience, will not only give Smith an inferiority complex and hasten his metamorphosis from an idealistic freshman to a cynical young graduate; it will also make sure he will never again forget to order marmalade levels on any suspected case of poikilodokia, whether latent or overt, whether in remission or terminal, since the professor makes it a point of honour to come to every necropsy, and since the above scene may repeat itself in the pathology amphitheatre. Moreover, in view of the professor's interest in the paramarmaladoses, Smith will henceforth regard marmalade determinations as a routine investigation, since one can never tell when poikilodokia may turn up, and since one can never tell when the professor may turn up.

Besides, measuring marmalade levels is harmless. It requires only one additional test-tube of blood, the AutoAnalyzer is set up anyway, and the result could even be useful. It serves as a screening test, as a baseline. It is of interest; you never know what it may show, it may help the patient, it may help someone else in the future. And Smith will leave the teaching hospital convinced of the value of marmalade determinations. On entering private practice, worried about all the poikilodokias he may be missing, he will go to considerable lengths to send specimens to the professor's laboratory and not rest satisfied until serum marmalades are included in the commercially available multichannel automated routine screen. And when he returns to the university to teach the weekly physical diagnosis class, he will make sure to indoctrinate *his* students and pass on all the pearls he has picked up from his old teacher.

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