# MILK CONSUMPTION AND THE GROWTH OF SCHOOL CHILDREN.

## SECOND PRELIMINARY REPORT ON TESTS TO THE SCOTTISH BOARD OF HEALTH

BY

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THE preliminary report, by Dr. J. B. Orr, on the result of the 1926–27 investigation into the feeding of a large number of school children was published in the *British Medical Journal*, January 28th, 1928 (p. 140).

The conclusions which might be drawn from that work appeared to the committee in charge of the test to be so interesting and important that it was decided to continue the investigation over a further period of equal length. That has been done, and the present report* deals with this period of the repeated test—namely, November, 1927, to June, 1928.

The seven centres at which the investigation was carried out were Peterhead, Aberdeen, Dundee, Edinburgh, Glasgow, Greenock, and Belfast. The number of children involved was 1,425. At each place four groups of children were selected, and each group treated differently. One group received whole milk, another separated milk, a third a biscuit ration of the caloric value of the separated milk, while a fourth acted as controls, receiving nothing.

> The children of 13 to 14 years received 1 pint of milk daily.
> The children of 9 to 10 years received 1 pint of milk daily.
> The children of 6 to 7 years received three-quarters of a pint of milk daily.

All the milk was given at the schools under supervision. The whole milk was pasteurized, except at Peterhead and Aberdeen, where it was "certified." The separated milk was machine-skimmed.

Samples of all the milk given were taken monthly and sent to the Rowett Research Institute, where they were analysed. These analyses show that the average fat percentage of the whole milk was 3.85, and that of the separated milk 0.33.

### *Measurements.*

The measurements were all done by one of us (M. L. C.), and were done four times everywhere, except at Belfast, where they were done three times. As in the 1927 test the children were all weighed and measured in indoor garments and without shoes. This year the heights were recorded to the nearest eighth of an inch and the weights to the nearest quarter of a pound. To obtain a fairly accurate *average* increase in weight a careful record was made at each weighing of every article of clothing worn by the child, and from these records the average weight of clothing for boy or girl was calculated. The difference between the initial (winter) and final (summer) weight of clothing was then added to the final gross weight. In Belfast, in three schools, the children were weighed in one garment only, and the difference between winter and summer weights was, therefore, the exact increase made by the child.

To obviate fluctuations as far as possible the weights and heights were taken at the same hour of the day on each occasion, this being in the case of children receiving milk before the milk was drunk. As far as possible the schools were visited in the same rotation in order that the period between initial and final weights and heights might be identical. On each visit an accurate record was obtained for each child of all absences and illnesses. Thus the exact amount of supplementary feeding was known. Any child who had missed 25 per cent. of feeds, or showed other abnormality, was excluded when calculating the results. The number so excluded was 268.

### *Special Conditions of the Investigation.*

In considering the results of this investigation the following points should be borne in mind. The number of children involved was very large, no fewer than 1,157 being available for the measurements from which the tables are compiled. These children were divided among seven centres of population, in which the test was conducted simultaneously. Their ages ranged from 5 to 13 years, including the beginning, the middle, and the end of their ordinary school life. All the children in the six Scottish centres were living in the ordinary conditions of Scottish working-class homes, and received the ordinary diet of such homes. The milk and biscuit given to them at the schools were therefore in the nature of a *supplementary ration to their home food.* The results, consequently, must be regarded as the effect of the addition of definite quantities of milk to the average home diet of children of school age living in ordinary working-class conditions in industrial centres. It would appear to be justifiable to infer that the same results, whatever they may be, would apply to the whole school population living their ordinary life. Those conditions, from the standpoint of a nutritional investigation, are, of course, very complicated, but this test was so devised as to bring out any *significant* differences which might arise within the limits laid down.

The following three tables show the total results of the investigation.

TABLE I.—*1928—Increases: Milk versus Non-milk Groups and Percentages.*

| | No. of Children. | Height Increase. | Weight Increase. |
|---|---|---|---|
| 13-year Groups: | | | |
| Milk ... ... ... ... | 137 | 1.4699 in. | 5.6387 lb. |
| Non-milk ... ... ... | 133 | 1.1908 ,, | 4.2368 ,, |
| | | = +0.2791 ins. | = +1.4019 lb. |
| | | or 23.44% | or 33.09% |
| 9-year Groups: | | | |
| Milk ... ... ... ... | 188 | 1.3943 in. | 3.4202 lb. |
| Non-milk ... ... ... | 212 | 1.1068 ,, | 2.0495 ,, |
| | | = +0.2875 in. | = +1.3707 lb. |
| | | or 25.98% | or 66.88% |
| 6-year Groups: | | | |
| Milk ... ... ... ... | 242 | 1.5021 in. | 2.5331 lb. |
| Non-milk ... ... ... | 245 | 1.2398 ,, | 1.8531 ,, |
| | | = +0.2623 in. | = +0.6800 lb. |
| | | or 21.16% | or 36.70% |
| All Age Groups: | | | |
| Milk ... ... ... ... | 567 | 1.4585 in. | 3.5776 lb. |
| Non-milk ... ... ... | 590 | 1.1810 ,, | 2.4610 ,, |
| | | = +0.2775 in. | = +1.1166 lb. |
| | | or 23.50% | or 45.37% |
| 1927 increases (Scotland—all ages): | | | |
| Milk ... ... ... ... | 551 | 1.470 in. | 3.617 lb. |
| Non-milk ... ... ... | 731 | 1.212 ,, | 2.974 ,, |
| | | = +0.258 in. | = +0.643 lb. |
| | | or 21.29% | or 21.62% |

From this table it is seen that, taking all the ages combined of the 1,157 children and dividing them into milk-fed groups and non-milk-fed groups, there is an average increase in height of 23.5 per cent., and in weight of 45.37 per cent., in favour of the milk-fed groups over the non-milk-fed groups.

It is also seen that these increases are greater in this second and repeated test than they were in the first (1927) test.

* Owing to the death of Dr. L. Cruickshank and to the absence of Dr. J. B. Orr abroad, it was decided to place the organization of the second investigation in the hands of Dr. Gerald Leighton, Medical Officer of Foods, Scottish Board of Health. This also enabled the Board's wide knowledge of the nutrition of school children and the implications of such in connexion with public health to be more readily utilized.

TABLE II.—*1928—Increases in Age Groups.*

| | No. of Children. | Height Increase. | Weight Increase. |
|---|---|---|---|
| **13-year Groups:** | | | |
| Whole milk ... ... | 68 | 1.4540 in. | 5.5662 lb. |
| Separated milk ... ... | 69 | 1.4855 ,, | 5.7101 ,, |
| Biscuits ... ... | 67 | 1.1194 ,, | 4.4179 ,, |
| Controls ... ... ... | 66 | 1.2633 ,, | 4.0530 ,, |
| | 270 | | |
| **9-year Groups:** | | | |
| Whole milk ... ... | 105 | 1.4238 in. | 3.5333 lb. |
| Separated milk ... ... | 83 | 1.3569 ,, | 3.2771 ,, |
| Biscuits ... ... | 101 | 1.1077 ,, | 2.0396 ,, |
| Controls ... ... ... | 111 | 1.1059 ,, | 2.0586 ,, |
| | 400 | | |
| **6-year Groups:** | | | |
| Whole milk ... ... | 121 | 1.5589 in. | 2.7107 lb. |
| Separated milk ... ... | 121 | 1.4452 ,, | 2.3554 ,, |
| Biscuits ... ... | 115 | 1.2424 ,, | 2.1609 ,, |
| Controls ... ... ... | 130 | 1.2375 ,, | 1.5808 ,, |
| | 487 | | |
| **Total number** ... | 1157 | | |

This table shows the increase in height and weight in all the age groups, with the number of children in each group. In every case the milk-fed children are ahead of the "biscuit" and "control" groups. The greatest increase in height is in the 6-year-old milk-fed group. The greatest increase in weight is in the 13-year-old separated milk group. The difference between the "biscuit" group and the "controls" is but slight, except that the 13-year-old controls did better in height but not so well in weight. In the 6-year-old group the "biscuit" group is better in weight than the "controls."

Those familiar with the manner in which statistics of this kind are worked out will be aware that, in order that the difference between two groups and figures may be regarded as "significant," that difference must be at least three times as great as the "probable error." The results in this table are calculated on that basis.

In Table III there is set forth the mean increase in pounds and inches (that is, for weight and height) in each group at each age, together with the probable error involved and the significance or otherwise of the differences.

*Other Observations.*

In addition to the foregoing statistical observations, two other lines were adopted which cannot be stated in figures.

Dr. C. A. Douglas examined all the children clinically when they were measured. Her report states that "in practically every case it was noted that the children receiving milk showed, even where there was obviously poor maternal care, that sleekness peculiar to a well-nourished animal. Their hair had a glossy and bright appearance. Their nails were smooth, resilient, and looked as if polished. General alertness was common to all the children fed on milk. No difference could be detected with regard to these points between the children receiving milk irrespective of the kind of milk. It was gathered from teachers and janitors that the children receiving milk were much more alert and very much more boisterous and difficult to control than the others. This latter fact was only too evident when they were waiting in small groups to be weighed."

TABLE III.—*1928 Nutrition Test.*

A.—13 Years: Weights (Increases in Pounds).

| | Increase I. | Increase II. | Difference. | Probable Error. | Result. | Remarks. |
|---|---|---|---|---|---|---|
| Whole milk (68) v. Separated milk (69) ... | 5.5662 | 5.7101 | −0.1439 | 0.2979 | −0.483 | Insignificant. |
| v. Biscuits (67) ... | " | 4.4179 | +1.1483 | 0.3080 | +3.728 | Significantly better. |
| v. Controls (66) ... | " | 4.0530 | +1.5132 | 0.2816 | +5.374 | " " |
| Separated milk (69) v. Biscuits (67) ... | 5.7101 | 4.4179 | +1.2922 | 0.3400 | +3.801 | " " |
| v. Controls (66) ... | " | 4.0530 | +1.6571 | 0.3163 | +5.239 | " " |
| Biscuits (67) v. Controls (66) ... | 4.4179 | " | +0.3649 | 0.3258 | +1.120 | Insignificant. |

B.—Heights (Increases in Inches).

| | Increase I. | Increase II. | Difference. | Probable Error. | Result. | Remarks. |
|---|---|---|---|---|---|---|
| Whole milk (68) v. Separated milk (69) ... | 1.4540 | 1.4855 | −0.0315 | 0.0424 | −0.743 | Insignificant. |
| v. Biscuits (67) ... | " | 1.1194 | +0.3346 | 0.0431 | +7.763 | Significantly better. |
| v. Controls (66) ... | " | 1.2633 | +0.1907 | 0.0444 | +4.295 | " " |
| Separated milk (69) v. Biscuits (67) | 1.4855 | 1.1194 | +0.3661 | 0.0453 | +8.081 | " " |
| v. Controls (66) ... | " | 1.2633 | +0.2222 | 0.0[illegible]66 | +4.768 | " " |
| Biscuits (67) v. Controls (66) ... | 1.1194 | " | −0.1439 | 0.0472 | −3.049 | Significantly worse. |

C.—9 Years: Weights (Increases in Pounds).

| | Increase I. | Increase II. | Difference. | Probable Error. | Result. | Remarks. |
|---|---|---|---|---|---|---|
| Whole milk (105) v. Separated milk (83) ... | 3.5333 | 3.2771 | +0.2562 | 0.1468 | +1.745 | Insignificant. |
| v. Biscuits (101) ... | " | 2.0396 | +1.4937 | 0.1344 | +11.114 | Significantly better. |
| v. Controls (111) ... | " | 2.0586 | +1.4747 | 0.1360 | +1[illegible].843 | " " |
| Separated milk (83) v. Biscuits (101) ... | 3.2771 | 2.0396 | +1.2375 | 0.1403 | +8.820 | " " |
| v. Controls (111) ... | " | 2.0586 | +1.2185 | 0.1419 | +8.587 | " " |
| Biscuits (101) v. Controls (111) .. | 2.0396 | " | −0.0190 | 0.1290 | −0.147 | Insignificant. |

D.—Heights (Increases in Inches).

| | Increase I. | Increase II. | Difference. | Probable Error. | Result. | Remarks. |
|---|---|---|---|---|---|---|
| Whole milk (105) v. Separated milk (83) ... | 1.4238 | 1.3569 | +0.0669 | 0.0261 | +2.563 | Not quite significant. |
| v. Biscuits (101) ... | " | 1.1077 | +0.3161 | 0.0281 | +1[illegible].249 | Significantly better. |
| v. Controls (111) ... | " | 1.1059 | +0.3179 | 0.0263 | +12.087 | " " |
| Separated milk (83) v. Biscuits (101) ... | 1.3569 | 1.1077 | +0.2492 | 0.0237 | +10.515 | " " |
| v. Controls (111) ... | " | 1.1059 | +0.2510 | 0.0215 | +11.674 | " " |
| Biscuits (101) v. Controls (111) ... | 1.1077 | " | +0.0018 | 0.0239 | +0.075 | Insignificant. |

E.—6 Years: Weights (Increases in Pounds).

| | Increase I. | Increase II. | Difference. | Probable Error. | Result. | Remarks. |
|---|---|---|---|---|---|---|
| Whole milk (121) v. Separated milk (121) .. | 2.7107 | 2.3554 | +0.3553 | 0.1112 | +3.195 | Significantly better. |
| v. Biscuits (115) ... | " | 2.1609 | +0.5498 | 0.1020 | +5.390 | " " |
| v. Controls (130) ... | " | 1.5808 | +1.1[illegible]99 | 0.[illegible]031 | +10.959 | " " |
| Separated milk (121) v. Biscuits (115) ... | 2.3554 | 2.1609 | +0.1945 | 0.1055 | +1.844 | Insignificant. |
| v. Controls (130) ... | " | 1.5808 | +0.7746 | 0.1066 | +7.266 | Significantly better. |
| Biscuits (115) v. Controls (130) ... | 2.1609 | " | +0.5801 | 0.0969 | +5.987 | " " |

F.—Heights (Increases in Inches).

| | Increase I. | Increase II. | Difference. | Probable Error. | Result. | Remarks. |
|---|---|---|---|---|---|---|
| Whole milk (121) v. Separated milk (121) ... | 1.5589 | 1.4452 | +0.1137 | 0.0250 | +4.548 | Significantly better. |
| v. Biscuits (115) ... | " | 1.2424 | +0.3165 | 0.0243 | +13.025 | " " |
| v. Controls (130) ... | " | 1.2375 | +0.3214 | 0.0250 | +12.856 | " " |
| Separated milk (121) v. Biscuits (115) ... | 1.4452 | 1.2424 | +0.2028 | 0.0221 | +9.[illegible]76 | " " |
| v. Controls (130) ... | " | 1.2375 | +0.2077 | 0.02[illegible]8 | +9.110 | " " |
| Biscuits (115) v. Controls. (130) ... | 1.2424 | " | +0.0049 | 0.0221 | +0.222 | Insignificant. |

Dr. G. W. Simpson made a different observation. He asked the headmasters to parade the children in their respective groups, he himself being unaware which group was milk-fed or otherwise. From this general survey he placed the groups in order of apparent standard of nutrition. Of five examinations thus made he found that first places of nutritional standard were accorded to three whole milk and two separated milk groups. Second places were accorded to two whole milk and three separated milk groups. Third places were accorded to all five biscuit groups, and fourth places to all five control groups. "The difference in nutrition between groups receiving milk and not receiving milk was plainly evident. No great difference was noticed between the whole milk and separated milk groups." A sixth examination did not correspond with the other five, but in this case the best nourished children had been selected as controls, while those apparently needing the milk most were put into the milk groups. The desired conditions for observation were thus not fulfilled.

### *A Test Reversed.*

One very interesting result came out in this repeated investigation. In order to ascertain what would occur two of the previous feeding groups were reversed. A group which in the first investigation received separated milk now received biscuit. Another group which in the first investigation were "controls" now received whole milk. The general result in both cases was that they changed places, the former milk group now receiving biscuit fell to biscuit standard, while the former "control" group now receiving milk rose to the milk standard. Table IV shows the detailed results of this reversed test.

TABLE IV.—*Groups Reversed.*

| | Average Increase in Height (inches). | | Average Increase in Weight (lb.). | |
|---|---|---|---|---|
| | 1927. | 1928. | 1927. | 1928. |
| GLASGOW. | | | | |
| 5-year-old children: | | | | |
| Separated milk 1927; biscuits, 1928 | 1.500 | 1.351 | 2.407 | 2.212 |
| Biscuits, 1927; separated milk, 1928 | 1.101 | 1.454 | 2.234 | 2.237 |
| 8-year-old children: | | | | |
| Separated milk, 1927; biscuits, 1928 | 1.297 | 1.213 | 3.471 | 2.063 |
| Biscuits, 1927; separated milk, 1928 | 1.089 | 1.336 | 2.266 | 3.207 |
| GREENOCK. | | | | |
| 5-year-old children: | | | | |
| Whole milk, 1927; controls, 1928 | 1.543 | 1.163 | 1.994 | 1.875 |
| Controls, 1927; whole milk, 1928 | 1.470 | 1.479 | 1.595 | 2.639 |

The following table shows similar details for the other areas (groups not reversed).

TABLE IVA.—*Groups Continued.*

| | Average Increase in Height (inches). | | Average Increase in Weight (lb.). | |
|---|---|---|---|---|
| | 1927. | 1928. | 1927. | 1928. |
| PETERHEAD. | | | | |
| 5-year-old children: | | | | |
| Whole milk ... ... ... | 1.550 | 1.384 | 2.741 | 2.569 |
| Separated milk ... ... ... | 1.568 | 1.356 | 2.983 | 2.576 |
| Biscuits ... ... ... ... | 1.392 | 1.270 | 1.973 | 2.188 |
| Controls ... ... ... ... | 1.425 | 1.311 | 1.773 | 2.048 |
| DUNDEE. | | | | |
| 8-year-old children: | | | | |
| Whole milk ... ... ... ... | 1.105 | 1.197 | 2.556 | 3.205 |
| Separated milk ... ... ... | 1.209 | 1.347 | 2.659 | [illegible] |
| Biscuits ... ... ... ... | 0.931 | 1.054 | 2.404 | 2.738 |
| Controls ... ... ... ... | 0.972 | 1.156 | 2.433 | 1.911 |
| EDINBURGH. | | | | |
| 8-year-old children: | | | | |
| Whole milk ... ... ... ... | 1.483 | 1.429 | 3.330 | 4.057 |
| Separated milk ... ... ... | 1.457 | 1.383 | 3.238 | 3.531 |
| Biscuits ... ... ... ... | 1.286 | 1.031 | 2.972 | 1.650 |
| Controls ... ... ... ... | 1.224 | 1.100 | 2.132 | 2.438 |
| GREENOCK. | | | | |
| 5-year-old children: | | | | |
| Separated milk ... ... ... | 1.625 | 1.443 | 1.969 | 2.243 |
| Biscuits ... ... ... ... | 1.455 | 1.131 | 1.200 | 2.050 |

### *Conclusions.*

As the result of this repeated investigation (1927-28), it may be said at once that the tentative conclusions drawn by Dr. J. B. Orr from the first investigation were more than justified.

The great value of an additional milk ration to that already taken at home is clearly demonstrated for all ages of school children.

In the repeated test the average increase in height in the milk-fed groups in all ages combined is actually *1.21 per cent. more than in the first test.* The average increase in weight in the milk-fed groups in all ages combined is no less than *3.75 per cent. more than in the first test.* Not only have the same milk-fed children benefited again, but they have done so to a greater extent than before. Their initial improvement has *continued over the second year.*

Once more the value of separated milk for children of school age is shown. In most groups the difference in height and weight between the whole milk and separated milk groups is not "significant," but in the six-year-old group whole milk is "significantly" better than separated for both weight and height. In every case the whole milk and separated milk groups are better than the "biscuit" or the "controls." In this repeated test the difference between the "biscuit" and the "controls" is usually "insignificant"; the effect of the extra biscuit appears almost negligible. The improvement of the milk-fed groups in general health and appearance is clearly brought out in the reports of Dr. C. A. Douglas and Dr. G. W. Simpson. Many of the teachers have recorded similar opinions.

When these results are considered, along with those published by Dr. Corry Mann in this country and those of observers in other countries, the only conclusion possible is that they have a wide public health significance, especially with the nutrition of school children.

"In 1903, when the Royal Commission on Physical Training (Scotland) issued their report, two things became clear: first, that medical examination and superintendence were essential conditions of any system of physical education; second, that in the end *the fundamental problem is one of nutrition. . . .* When every preventable ailment is prevented, and every serious disease treated to its finish, the new battalions of children coming forward have to be superintended from the nutritional standpoint." (Sir Leslie Mackenzie.) The two reports of this investigation fully substantiate these views.

### *Committee of Investigation.*

The investigation was conducted under the direction of a committee appointed by the Scottish Board of Health with Sir Leslie Mackenzie as chairman. The members consisted of the school medical officers for the cities and towns where the work was carried out.

We desire to thank Dr. J. F. Tocher, Aberdeen, and Mr. J. S. Thomson, Rowett Research Institute, for advice and help on the statistical side of this investigation.

The results of the investigation have also been submitted from time to time to Professor A. P. Cathcart, chairman of the Nutrition Committee of the Medical Research Council.

The cost of the investigation was defrayed by a grant made by the Empire Marketing Board to the Rowett Research Institute, Aberdeen.

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THE seventh issue of the *Medical and Scientific Archives of the Adelaide Hospital* contains records of various cases of general interest, and a tabulation of certain lesions found during the course of 1,000 necropsies performed between 1920 and 1925. In this survey the conditions dealt with include diseases of the vascular system, the digestive system, the female generative tract, and the ductless glands; in the *Archives* of the previous year data were given for all neoplasms. The hope is expressed that the material thus tabulated will prove of value to those engaged in research work who require references to the occurrence of peculiar lesions. Any particular case can be followed up, fuller details being obtainable on application to the registrars at the Adelaide Hospital. It is suggested that unexpected associations between various lesions may be brought out in this way, and that if similar statistics were to be made at large hospitals throughout the world, a very important mass of information would be made available.

## Milk Tests in Lanarkshire Schools.*

THE Department of Health for Scotland has recently issued a report on the investigation into the effect of the addition of milk to the diet of school children. The data have been compiled and annotated by Dr. Gerald Leighton, Medical Officer (Foods), and Dr. Peter L. McKinlay, Medical Officer (Statistics).

Twenty thousand children were concerned in the experiment, 10,000 being given a daily ration of milk and a like number being used as control subjects. All the milk used was Grade *A* (Tuberculin Tested). Half of the milk was given in the raw state and half was pasteurised.

The schools selected for the tests were all situated in the densely populated industrial part of the county. While no account was taken of the distress prevalent in these localities in the selection, it has been estimated that one-third of the children came from homes in which there was unemployment, complete or partial. The ages of the subjects ranged from five years to twelve years. The sexes were balanced in each age group.

The teachers showed great interest in the experiment, and their "remarks" on the various subjects are often enlightening. One teacher noticed that "in the playground buoyancy and pugnacity developed to an alarming extent". Another states that a little girl increased in vitality to such an extent that she boasted to her teacher of her ability to fight her big brother.

While the physical benefits of the experiment made themselves fairly obvious, it was not easy to estimate the mental improvement. However, many teachers have reported great improvements in mental alertness, especially among the younger children. Others say that some of the children became drowsy. One boy, who hitherto was very backward in reading, improved greatly and became very smart in reading, arithmetic, and history. Another child, formerly very morose and sullen, has become bright and talkative.

There are complete records of the progress of 17,159 children. These records are in three parts—(*a*) Controls, (*b*) children fed with raw milk, (*c*) children fed with pasteurised milk. These are further subdivided according to age and sex.

Tables were prepared in such a way that not only the average increase in height or weight for the whole group, but also the average increase in height or weight for children of a given initial height or weight could be calculated. In view of the fact that there were definite differences of weights and heights in the controls compared with 'feeders' at the beginning of the experiment, it was considered advisable to inquire whether the amount of growth within this period was affected to any appreciable extent by original physique: that is, whether the heavier or taller child added more or less to its height or weight than the lighter or shorter child. For this purpose coefficients of correlation between original weight and original height and change in height were calculated for the control group. From these results it was inferred that there was no uniform tendency for gain in weight or height to be influenced by original weight or height.

The conclusions may be summarised as follows:

(1) The addition of milk to the diet of school children is reflected in a definite increase in the rate of growth, both in weight and height.

(2) There is no obvious or constant difference in this respect between the sexes. There is little evidence of definite relation between the age of the children and the amount of improvement. The results do not support the popular belief that the younger children derived more benefit than the older children. As manifested merely by growth in weight or height, the increase found in younger children through the addition of milk to the usual diet is certainly not greater than, and is probably not even so great as, that found in older children.

INCREASE IN WEIGHTS (IN OUNCES) IN THE THREE GROUPS.

| Age. | Boys. | | | Girls. | | |
|---|---|---|---|---|---|---|
| | Control. | Raw Milk. | Pasteurised Milk. | Control. | Raw Milk. | Pasteurised Milk. |
| 5 | 11·64 | 14·88 | 15·65 | 7·00 | 14·50 | 6·62 |
| 6 | 13·75 | 13·51 | 9·96 | 11·21 | 10·61 | 10·05 |
| 7 | 11·17 | 14·85 | 15·55 | 8·90 | 11·22 | 12·94 |
| 8 | 11·38 | 14·21 | 15·21 | 9·77 | 13·40 | 13·37 |
| 9 | 9·53 | 13·43 | 11·83 | 7·87 | 13·81 | 12·52 |
| 10 | 7·10 | 13·53 | 10·39 | 9·51 | 15·08 | 18·96 |
| 11 | 6·14 | 12·74 | 11·05 | 12·62 | 24·92 | 17·08 |

INCREASE IN HEIGHTS (IN INCHES) IN THE THREE GROUPS.

| Age. | Boys. | | | Girls. | | |
|---|---|---|---|---|---|---|
| | Control. | Raw Milk. | Pasteurised Milk. | Control. | Raw Milk. | Pasteurised Milk. |
| 5 | 0·75 | 0·95 | 0·94 | 0·86 | 0·64 | 0·87 |
| 6 | 0·80 | 0·87 | 0·87 | 0·80 | 0·86 | 0·84 |
| 7 | 0·76 | 0·87 | 0·82 | 0·75 | 0·84 | 0·81 |
| 8 | 0·74 | 0·82 | 0·79 | 0·71 | 0·81 | 0·78 |
| 9 | 0·69 | 0·80 | 0·74 | 0·66 | 0·76 | 0·78 |
| 10 | 0·68 | 0·76 | 0·68 | 0·71 | 0·79 | 0·72 |
| 11 | 0·69 | 0·74 | 0·70 | 0·77 | 0·86 | 0·81 |

(3) In so far as the conditions of this investigation are concerned, the effects of raw and pasteurised milk on growth in weight and height are, so far as can be judged from this experiment, equal.

Dr. J. P. Kinloch, Chief Medical Officer of the Department of Health for Scotland, says, in a prefatory note, that the scheme was made possible by a grant of £5000 from the Empire Marketing Board, which approved its purpose and the selection of Lanarkshire for the experiment. The Distress in Mining Areas (Scotland) Fund financed the experiment also, by a grant of £2000. Individuals and firms interested in the dairying industry contributed £477. The results, states Dr. Kinloch, demonstrate that the addition of milk to the children's diet results in improved physique and mental alertness. They also suggest that, apart from its own food value, milk enables the other constituents of the ordinary diet to be fully utilised as growth factors.

It is significant that, by powers conferred by the Education (Scotland) Act, 1930, local authorities may make a ration of milk available for school children. The exercise of these powers would, Dr. Kinloch states, affect 800,000 children in Scotland, and, by improving their physical and mental well-being, would have a powerful influence in improving the quality of the Scottish race.

JOHN TAYLOR.

* Department of Health for Scotland. Milk Consumption and the Growth of Schoolchildren. By Dr. Gerald Leighton and Dr. Peter L. McKinlay. (Edinburgh and London: H.M. Stationery Office, 1930.) 3*d*. net.

alloy content of the copper and the comparative mildness of the cold working, it is not so high as to lend support to the view that the Egyptians possessed a method of hardening copper with which we are unacquainted. The hardness of the axe-head was produced partly by alloying and partly by cold working. By a suitable choice of alloying elements and more effective mechanical treatment, much greater hardness can be produced to-day.

One further conclusion may be drawn. This investigation has made it possible to answer the question whether hardening by cold work is permanent in an alloy of this type at the ordinary temperatures. According to Mr. Brunton's view, the axe-head is more than 3700 years old. When I discussed this question with him and the extent to which this date might be in doubt, he was willing to advance it 200 years but no more. Accepting this, its age is at least 3500 years. No one, of course, can say whether it has lost any of its original hardness, but it is quite clear that it has retained a considerable amount of work hardness throughout this long period.

I wish to acknowledge the assistance of two members of my staff, Mr. C. W. Dannatt and Dr. M. S. Fisher, in the above investigation.

H. C. H. CARPENTER.

Royal School of Mines, South Kensington,
London, S.W.7, March 9.

## Constitution of Rhenium.

OWING to the kindness of Dr. Noddack, who provided me with a sample of the heptoxide of his recently discovered element rhenium, I have been able to obtain its mass spectrum. $Re_2O_7$ is a slightly volatile greenish crystalline solid. Its vapour was first admitted to the discharge like that of osmium tetroxide, but with no success. The solid was then introduced into the discharge tube and heated in the cathode ray beam, but although the volatilisation was ultimately such as to cause a visible dark layer on the surrounding walls, not the slightest sign of its mass spectrum could be obtained. The substance seemed hopeless, so I proceeded to my next investigation, which was an attempt to get the mass spectrum of gold by volatilising its chloride. This compound is unstable and, as the presence of halogens had on some previous occasions brought out the lines of other bodies in a remarkable way, it seemed just worth while to volatilise it in the discharge tube before the rhenium oxide deposit had been removed from the walls. This procedure was successful beyond all expectation. Although no lines of gold were visible, the doublet lines of rhenium appeared in great intensity and in addition were repeated 16, 32, and 48 units higher as ReO, $ReO_2$, and $ReO_3$, so giving unusually convincing evidence of its constitution.

Rhenium consists of two isotopes, 185, 187, as was expected from the general rule that complex elements of odd atomic number (above 9) consist of two odd mass numbers two units apart, but it is the first element analysed in which the heavier isotope is the more abundant. The ratio of this abundance was estimated photometrically by analogy with the mercury lines to be 1·62 : 1. The position of the line 203 due to $Re^{187}O$ in the mercury group was used to determine its packing fraction, which is $-1 \pm 2$, the same as that of osmium. From these provisional values the atomic weight on the chemical scale works out at $186{\cdot}22 \pm 0{\cdot}07$, in good agreement with Hönigschmid's latest value of 186·31. The strongest isotope of rhenium is isobaric with the weakest of osmium.

F. W. ASTON.

Cavendish Laboratory, Cambridge, Mar. 31.

## The Behaviour of Antiknocks.

IT is generally agreed that it is the metallic radicle of an organometallic antiknock compound that is mainly responsible for the delaying of the oxidation of a combustible mixture. That the metal atom is in an oxidised state before it becomes effective, was an inference made on the basis of many different experimental facts, for example, the behaviour of potassium vapour,[1] but it has not been proved directly. We have recently been able to show that a small quantity of lead tetraethyl vapour, when let into an evacuated vessel heated to 265° C. into which a charge of pentane vapour and oxygen is afterwards introduced, will not affect the course of the combustion to any great extent, and may even accelerate it, but that if some oxygen is let into the vessel before the lead tetraethyl vapour, and then this followed by the bulk of the charge, the combustion is invariably strongly inhibited. These experiments provide direct evidence that the lead must first be oxidised before it is effective as an inhibitor. It is possible that the accelerating effect is due to the $C_2H_5$ radicles which help to start reaction chains, but that has yet to be proven.

A. EGERTON.
L. M. PIDGEON.

Clarendon Laboratory, Oxford.

[1] See Egerton and Gates, *J. Inst. Petm. Tech.*, **13**, 244; 1927.

## Pasteurised and Raw Milk.

IN NATURE of Mar. 21, p. 466, an abstract appears of a report issued by the Department of Health for Scotland on "Milk Tests in Lanarkshire Schools", by G. Leighton and P. L. McKinlay. In this experiment, nearly ten thousand school-children received a supplementary ration of three-quarters pint of milk daily for about four months. Two important tables from the report, showing the average increases in height and weight of the children, divided into 14 groups by age and sex, are reproduced.

The special point to which we wish to direct attention concerns the apparent contrast in the effects of pasteurised with that of raw milk. About half the children receiving milk consumed it raw, while the other half were supplied with milk from the same source which had been pasteurised. It is somewhat unfortunate, however, that the recipients in the same school were never so divided, the whole of the milk supplied to any one school being either raw or pasteurised. In the absence of the records from the separate schools, it is impossible altogether to eliminate the doubt which this choice of method introduces; nevertheless, the report concludes with the statement (p. 20):

"In so far as the conditions of this investigation are concerned the effects of raw and pasteurised milk on growth in weight and height are, so far as we can judge, equal."

The importance of such a conclusion, if well established, is manifest. It is, however, open to some question, for Table 12, printed on the same page, shows that of the 14 groups (by age and sex), pasteurised milk gave a greater increase in height in only 2 groups, the increases were equal in 1 group, while in 11 groups the raw milk gave the greater increase. If we may regard these as 14 independent experiments, the difference from expectation on the hypothesis that raw and pasteurised milk have the same effects, is such as would only occur once in about ninety trials, and it seems evident that the conclusion should have been that the *growth response in height to raw milk is significantly greater than that to pasteurised milk.*

In order to examine the magnitude of the difference, we have calculated from Tables 6 and 7 of the Report the average increments in the control, raw milk and pasteurised milk groups, weighting the averages given according to the total numbers of boys and girls in each group. In this way we find an average increase in height and weight, standardised for age, for the whole group of children observed. From the average increase, the excess ascribable to milk feeding is obtained by subtraction, and the relative value of pasteurised as a percentage of the value of raw milk, as measured by increase in growth, is calculated from the two differences.

AVERAGE INCREASES IN WEIGHT IN OUNCES.

| | Boys. | | |
|---|---|---|---|
| | Control. | Raw Milk. | Pasteurised. |
| Increase | 10·041 | 13·780 | 12·507 |
| Excess over control | .. | 3·739 | 2·466 |
| Value per cent | .. | 100·0 | 66·0 |

| | Girls. | | |
|---|---|---|---|
| | Control. | Raw Milk. | Pasteurised. |
| Increase | 9·755 | 14·315 | 13·907 |
| Excess over control | .. | 4·560 | 4·152 |
| Value per cent | .. | 100·0 | 91·1 |

In weight the average increment ascribable to the consumption of about 10 gallons of milk is a little more than 4 ounces, being a little more for girls than for boys. In both sexes the pasteurised milk gives a lower return, the increment ratios being 66·0 per cent in the case of boys, and 91·1 per cent in the case of girls. In respect of growth in height the contrast is even more striking:

AVERAGE INCREASES IN HEIGHT IN INCHES.

| | Boys. | | |
|---|---|---|---|
| | Control. | Raw Milk. | Pasteurised. |
| Increase | 0·7274 | 0·8145 | 0·7707 |
| Excess over control | .. | 0·0871 | 0·0433 |
| Value per cent | .. | 100·0 | 49·8 |

| | Girls. | | |
|---|---|---|---|
| | Control. | Raw Milk. | Pasteurised. |
| Increase | 0·7300 | 0·8140 | 0·7889 |
| Excess over control | .. | 0·0840 | 0·0589 |
| Value per cent | .. | 100·0 | 70·1 |

Measured by its effect in increasing growth in height, pasteurised milk appears from these data to have only half the value of raw milk in the case of boys, and about 70 per cent of the value in the case of girls.

These results are put on record to avoid the danger that, from a superficial examination of the report, the conclusion should be drawn that this extensive experiment demonstrates the equivalence of pasteurised and raw milk. In reality the reverse is the case; and the very marked difference in response to two materials, which in their gross nutritional contents are so closely equivalent, raises a problem of very great interest, which can probably only be cleared up by more deliberate experimentation. The contrast between the response to pasteurised milk and that to raw milk is of value also in interpreting the difference between the milk-fed and the control children, for it would evidently be extremely rash to draw from the experimental results the 'natural' conclusion, that the increases induced by milk feeding indicate that the Lanarkshire children are, in their normal diet, inadequately supplied with such nutrients as fat, protein, or sugar, which are contained equally by the raw and by the pasteurised milk.

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S. BARTLETT.
National Institute for Research in Dairying,
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### Capture of Electrons from Mercury Atoms by Positive Ions of Helium.

IN a recent paper [1] we gave an account of some experiments on the determination of the mobility of ions in helium gas at a pressure of 360 mm. of mercury. We found that the mobility of the positive ions decreased when small traces of other impurities were introduced into the apparatus, and we interpreted the results as due to an 'exchange' phenomenon similar to that observed by Kallmann and Rosen in the case of high-speed positive ions. On this view, when a helium ion 'collides' with an

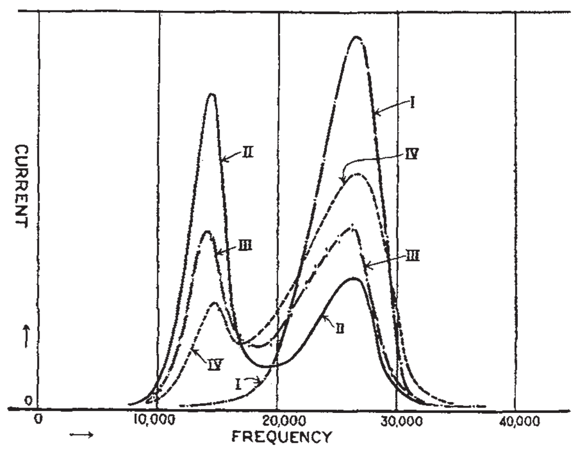



FIG. 1.

impurity molecule there is a certain probability that an electron will be captured from the impurity by the ion. The impurity ion so formed will not lose its charge in collisions with other helium atoms, because the ionisation potential of helium is greater than that of any impurity and the speed of the ions in our experiment is much too small to supply the energy required for the transition. For this reason, a very small concentration of impurity is sufficient to change completely the rate at which the positive charge is carried through the gas.

In our first experiments we had not sufficient control of the purity of the gas to identify the impurities which gave rise to ions of smaller mobility. We have now made experiments in a new apparatus in helium at 20 mm. pressure and have obtained a definite example of the exchange phenomenon from helium to mercury.

In our method of measuring the mobility of ions in gases, a peak is obtained in a current-frequency curve for each type of ion present (Fig. 1). Curve I shows the curve which we obtained for positive ions in pure helium in a baked-out apparatus, mercury vapour being excluded by liquid air traps. On

# THE LANARKSHIRE MILK EXPERIMENT.

By "STUDENT."

In the spring of 1930* a nutritional experiment on a very large scale was carried out in the schools of Lanarkshire.

For four months 10,000 school children received ¾ pint of milk per day, 5000 of these got raw milk and 5,000 pasteurised milk, in both cases Grade A (Tuberculin tested); another 10,000 children were selected as controls and the whole 20,000 children were weighed and their height was measured at the beginning and end of the experiment.

It need hardly be said that to carry out an experiment of this magnitude successfully requires organisation of no mean order and the whole business of distribution of milk and of measurement of growth reflects great credit on all those concerned.

It may therefore seem ungracious to be wise after the event and to suggest that had the arrangement of the experiment been slightly different the results would have carried greater weight, but what follows is written not so much in criticism of what was done in 1930 as in the hope that in any further work full advantage may be taken of the light which may be thrown on the best methods of arrangement by the defects as well as by the merits of the Lanarkshire experiment.

The 20,000 children were chosen in 67 schools, not more than 400 nor less than 200 being chosen in any one school, and of these half were assigned as "feeders" and half as "controls," some schools were provided with raw milk and the others with pasteurised milk, no school getting both.

This was probably necessary for administrative reasons, owing to the difficulty of being sure that each of as many as 200 children gets the right kind of milk every day if there were a possibility of their getting either of the two. Nevertheless, as I shall point out later, this does introduce the possibility that the raw and pasteurised milks were tested on groups of children which were not strictly comparable.

Secondly, the selection of the children was left to the Head Teacher of the school and was made on the principle that both "controls" and "feeders" should be representative of the average children between 5 and 12 years of age: the actual method of selection being important I quote from Drs Leighton and McKinlay's* Report: "The teachers selected the two classes of pupils, those getting milk and those acting as "controls," in two different ways. In certain cases they selected them by ballot and in others on an alphabetical system." So far so good, but after invoking

* Department of Health for Scotland. *Milk Consumption and the Growth of Schoolchildren.* By Dr Gerald Leighton and Dr Peter L. McKinlay. (Edinburgh and London: H.M. Stationery Office, 1930.)

the goddess of chance they unfortunately wavered in their adherence to her for we read: "In any particular school where there was any group to which these methods had given an undue proportion of well fed or ill nourished children, others were substituted in order to obtain a more level selection." This is just the sort of afterthought that most of us have now and again and which is apt to spoil the best laid plans. In this case it was a fatal mistake, for in consequence the controls were, as pointed out in the Report*, definitely superior both in weight and height to the "feeders" by an amount equivalent to about 3 months' growth in weight and 4 months' growth in height.

Presumably this discrimination in height and weight was not made deliberately, but it would seem probable that the teachers, swayed by the very human feeling that the poorer children needed the milk more than the comparatively well to do, must have unconsciously made too large a substitution of the ill-nourished among the "feeders" and too few among the "controls" and that this unconscious selection affected, secondarily, both measurements.

Thirdly, it was clearly impossible to weigh such large numbers of children without impedimenta. They were weighed in their indoor clothes, with certain obvious precautions, and the difference in weight between their February garb and their somewhat lighter clothing in June is thus necessarily subtracted from their actual increase in weight between the beginning and end of the experiment. Had the selection of "controls" and "feeders" been a random one, this fact, as pointed out in the Report*, would have mattered little, both classes would have been affected equally, but since the selection was probably affected by poverty it is reasonable to suppose that the "feeders" would lose less weight from this case than the "controls." It is therefore not surprising to find that the gain in weight of "feeders" over "controls," which includes this constant error, was more marked, relatively to their growth rate, than was their gain in height, which was fortunately not similarly affected.

Fourthly, the "controls" from those schools which took raw milk were bulked with those from the schools which took pasteurised milk.

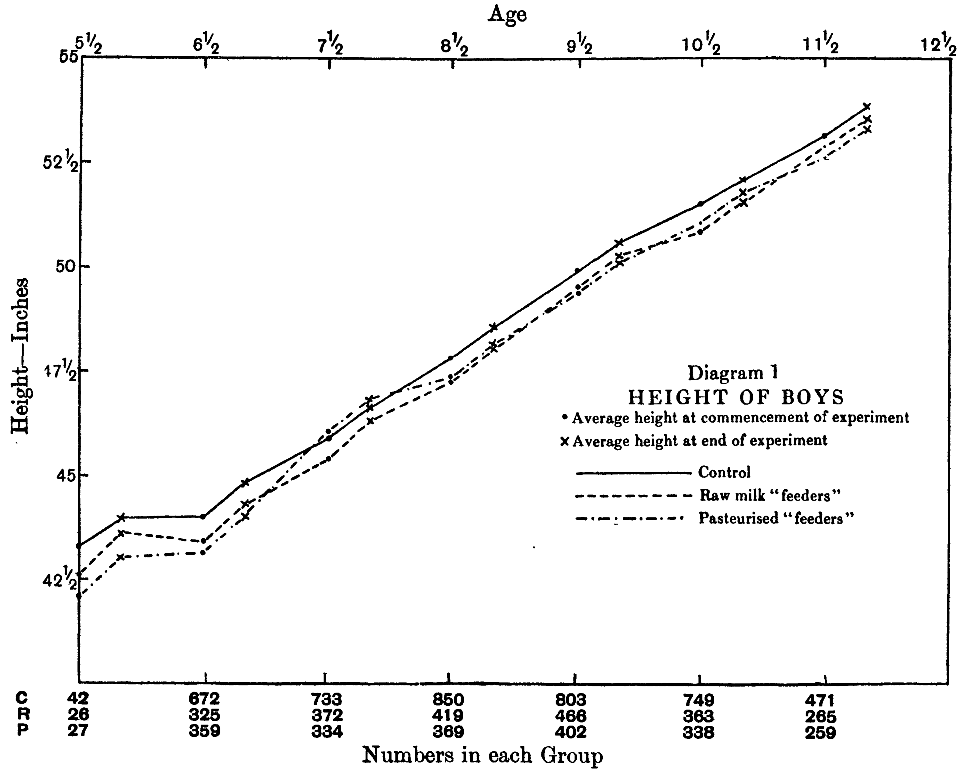
Now with only 67 schools, at best 33 against 34, in a district so heterogeneous both racially and socially, it is quite possible that there was a difference between the averages of the pupils at 33 schools and those of the pupils at another 34 schools both in the original measurements and in the rate of growth during the experiment.

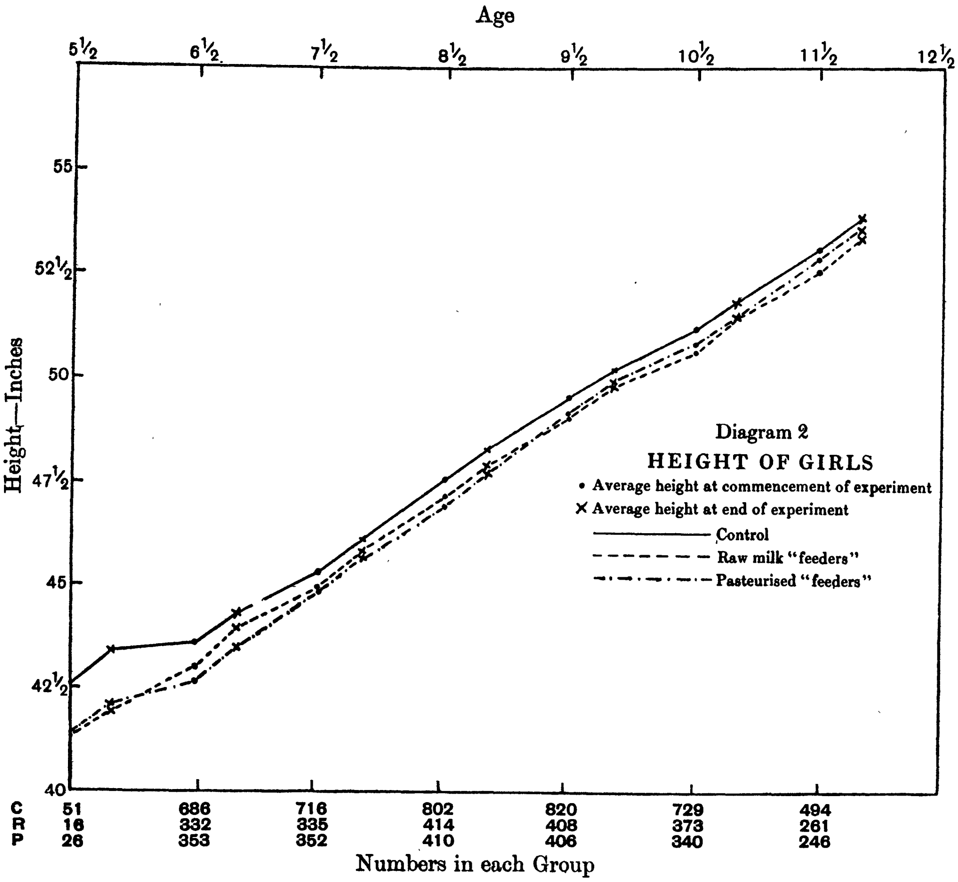
In that case the average "control" could not be used appropriately to compare with either the "raw" group or the "pasteurised" group.

This possibility is enhanced by the aforementioned selection of "controls" which can hardly have been carried out in a uniform manner in different schools.

Fortunately it would still be possible to correct this, for the figures for the different schools must still be available in the archives.

* See footnote on p. 398.


Age
5½
6½
7½
8½
9½
10½
11½
12½
55
52½
50
47½
45
42½
Height—Inches
Diagram 1
HEIGHT OF BOYS
• Average height at commencement of experiment
× Average height at end of experiment
Control
Raw milk "feeders"
Pasteurised "feeders"
C 42 672 733 850 803 749 471
R 26 325 372 419 466 363 265
P 27 359 334 369 402 338 259
Numbers in each Group


Age
5½
6½
7½
8½
9½
10½
11½
12½
55
52½
50
47½
45
42½
40
Height—Inches
Diagram 2
HEIGHT OF GIRLS
• Average height at commencement of experiment
× Average height at end of experiment
Control
Raw milk "feeders"
Pasteurised "feeders"
C 51 686 716 802 820 729 494
R 16 332 335 414 408 373 261
P 26 353 352 410 406 340 246
Numbers in each Group

Diagrams 1 and 2 give the average heights of "controls," raw milk "feeders" and pasteurised milk "feeders" for boys and girls respectively. The heights at the beginning of the experiments are set out against a uniform age scale centring each group at the half year above the whole number. This is doubtless accurate enough except for the first group aged "5 and less than 6," which was very much smaller in numbers than the other groups, either because only the older (or larger) children are sent to school between 5 and 6 or because the teachers did not think that the smaller children would be able to play their part. For this reason they should probably be centred more to the right compared to the others. A similar argument might lead us to centre the "11 and over" group a little more to the left.

The average heights at the end of the experiment are of course set out four months to the right of those at the beginning and it will be noticed that except for the first group, which is clearly out of place, not any of the points diverge very much from their appropriate line of growth whether "controls," "raws" or "pasteuriseds."

The case is very different in Diagrams 3 and 4 which show the corresponding average weights. Here there is, after the first two ages, a very decided dip, especially in the later ages. The weights at the end of the experiment are too low. This might be accounted for by a tendency in older children to grow normally in height and subnormally in weight during the spring, but I think it much more likely that older children wear about 1 lb. more clothes in February than they do in June, while in the case of younger children a more limited wardrobe permits of fewer discards.

The authors have tried to show that the selection of the "controls" has not affected the validity of the comparison, by computing the correlation coefficients between the original heights (and weights) and the growth during the experiment for each of the 42 age groups into which the measurements were divided. These they find to be quite small even though they are here and there significant, and they argue that the additional height and weight of the "controls" was without effect on the comparison of subsequent growth.

Now this might have been a perfectly good argument had the height and weight been selected directly, but if, as I have indicated was very likely the case, the selection was made according to some unconscious scale of well being, then it is surely natural to suppose that the relatively ill nourished "feeders" would benefit more than their more fortunate school mates, the "controls," would have done by the extra $\frac{3}{4}$ pint of milk per day.

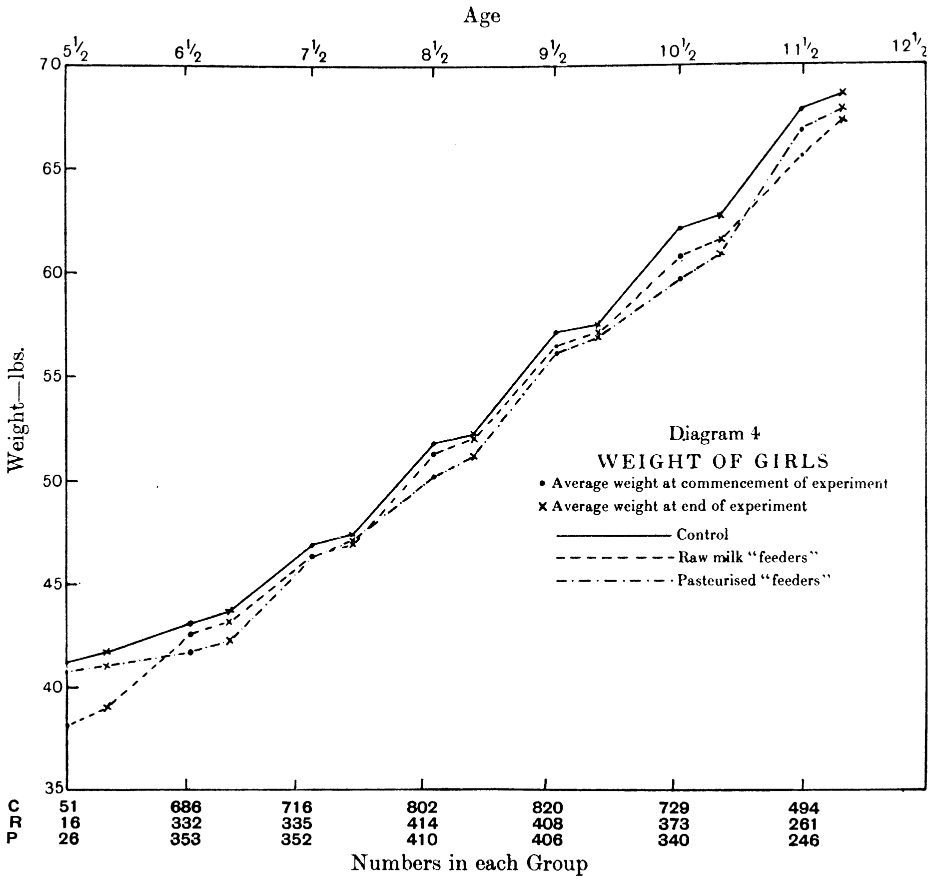
That being so how are we to regard the conclusions of the Report*:

(1) "The influence of the addition of milk to the diet of school children is reflected in a definite increase in the rate of growth both in height and weight."

This conclusion was probably true; the average increase for boys' and girls' heights was 8 per cent. and 10 per cent. over "controls" and for boys' and girls' weights was 30 per cent. and 45 per cent., respectively, and though, as pointed out,

* See footnote on p. 398.


Age
5½ 6½ 7½ 8½ 9½ 10½ 11½ 12½
Weight—lbs.
70 65 60 55 50 45 40 35
Diagram 3
WEIGHT OF BOYS
• Average weight at commencement of experiment
× Average weight at end of experiment
Control
Raw milk "feeders"
Pasteurised "feeders"
C 42 672 733 850 803 749 471
R 26 325 372 419 466 363 265
P 27 359 334 369 402 338 259
Numbers in each Group


Age
5½ 6½ 7½ 8½ 9½ 10½ 11½ 12½
Weight—lbs.
70 65 60 55 50 45 40 35
Diagram 4
WEIGHT OF GIRLS
• Average weight at commencement of experiment
× Average weight at end of experiment
Control
Raw milk "feeders"
Pasteurised "feeders"
C 51 686 716 802 820 729 494
R 16 332 335 414 408 373 261
P 26 353 352 410 406 340 246
Numbers in each Group

the figures for weights were wholly unreliable it is likely enough that a substantial part of the difference in height and a small part of that in weight were really due to the good effect of the milk. The conclusion is, however, shifted from the sure ground of scientific inference to the less satisfactory foundation of mere authority and guesswork by the fact that the "controls" and "feeders" were not randomly selected.

(2) "There is no obvious or constant difference in this respect between boys and girls and there is little evidence of definite relation between the age of the children and the amount of improvement. The results do not support the belief that the younger derived more benefit than the older children. As manifested merely by growth in weight and height the increase found in younger children through the addition of milk to the usual diet is certainly not greater than, and is probably not even as great as, that found in older children."

Now from the authors' point of view, believing in the validity of their comparisons in weight, this is much understating the case, as the following table derived from Capt. Bartlett's condensed tables shows:

| Age in years | Gain in weight in ozs. by Feeders over Controls | | Gain in height in inches by Feeders over Controls | | As °/$_\circ$ of control | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Weight | | Height | |
| | Boys | Girls | Boys | Girls | Boys | Girls | Boys | Girls |
| 5, 6 and 7 | 1·13 ± ·73 | 1·24 ± ·72 | ·083 ± ·011 | ·059 ± ·011 | 9 | 13 | 11 | 8 |
| 8 and 9 | 3·15 ± ·68 | 4·47 ± ·67 | ·071 ± ·011 | ·098 ± ·010 | 30 | 51 | 10 | 14 |
| 10 and 11 | 5·21 ± ·85 | 7·88 ± ·79 | ·037 ± ·012 | ·055 ± ·012 | 78 | 73 | 5 | 8 |

Note that the P.E.'s are calculated from Capt. Bartlett's tables and are subject, as his are, to his having interpreted the methods of the original Report correctly.

From this they might have concluded:

(*a*) That in the matter of weight older children, both boys and girls, derived more benefit than younger, while

(*b*) In height the younger boys did better than the older, though the difference is not quite significant, but that there was no regular tendency in the matter of girls' height.

In the light of previous criticism, however, we must be content to say that apparently the differential shedding of clothes between the "feeders" and the more fortunate "controls" is more marked with older children (and possibly with girls than with boys), and that there is some probability that younger boys gain in height more than older.

Finally, conclusion (3) runs: "In so far as the conditions of this investigation are concerned the effects of raw and pasteurised milk on growth in weight and height are, so far as we can judge, equal."

This conclusion has been challenged by Capt. Bartlett*, and by Dr Fisher and Capt. Bartlett†, who conclude that there is definite evidence of the superiority of raw over pasteurised milk in both height and weight.

Even they however point out that the raw and pasteurised milk were not supplied to the same schools, and their conclusion amounts to saying: "If the groups of children taking raw and pasteurised milk respectively were random samples from the same population, the observed differences would be decisively in favour of the raw milk."

Unfortunately they were not random samples from the same population: they were selected samples from populations which may have been different, and moreover the "controls" with which they were compared were not appropriate to either group; and so—again it is a matter of guess and authority—I would be very chary of drawing any conclusion from these small biased differences.

That is not to say that there is no difference between the effect of raw and pasteurised milk—personally I believe that there is and that it is in favour of raw milk—but that this experiment, in spite of all the good work which was put into it, just lacked the essential condition of randomness which would have enabled us to prove the fact.

This note would be incomplete without some constructive proposals in case it should be considered necessary to do further work upon the subject, and accordingly I suggest the following:

(1) If it should be proposed to repeat the experiment on the same spectacular scale,

(*a*) The "controls" and "feeders" should be chosen by the teachers in pairs of the same age group and sex, and as similar in height, weight and especially physical condition (i.e. well or ill nourished) as possible, and divided into "controls" and "feeders" by tossing a coin for each pair. Then each pair should be considered to be a unit and the gain in weight and height by the "feeder" over his own "control" should also be considered as a unit for the purpose of determining the error of the gain in weight or height.

In this way the error will almost certainly be smaller, perhaps very much smaller, than if calculated from the means of "feeders" and "controls."

If in addition the social status of each pair be noted (well to do, medium, poorly nourished or some such scale) further useful information will be available for comparing pasteurised and raw "feeders."

If this is found to be too difficult a perfectly good comparison can be made by adhering to the original plan of the 1930 experiment and drawing lots to decide which should be "controls" and which "feeders" (this is better than an alphabetical arrangement), but the error of the comparison is likely to be larger than in the plan outlined above.

* "Nutritional Value of Raw and Pasteurised Milk," by Stephen Bartlett, M.C., B.Sc. (*Journal of the Ministry of Agriculture*, April, 1931).

† *Nature*, April 18th, 1931, p. 591, "Pasteurised and Raw Milk."

(*b*) If it is at all possible each school should supply an equal number of raw and pasteurised "feeders," again by selection of similar children followed by coin tossing, but I fear that this is a counsel of perfection.

(*c*) Some effort should be made to estimate the weight of clothes worn by the children at the beginning and end of the experiment: possibly the time of year could be chosen so that there would be little change in this respect.

(2) If it be agreed that milk is an advantageous addition to children's diet—and I doubt whether any one will combat that view—and that the difference between raw and pasteurised milk is the matter to be investigated, it would be possible to obtain much greater certainty at an expenditure of perhaps 1—2 per cent. of the money* and less than 5 per cent. of the trouble.

For among 20,000 children there will be numerous pairs of twins; exactly how many it is not easy to say owing to the differential death rate, but, since there is about one pair of twins in 90 births, one might hope to get at least 160 pairs in 20,000 children. But as a matter of fact the 20,000 children were not all the Lanarkshire schools population, and I feel pretty certain that some 200—300 pairs of twins would be available for the purpose of the experiment.

Of 200 pairs some 50 would be "identicals" and of course of the same sex, while half the remainder would be non-identical twins of the same sex.

Now identical twins are probably better experimental material than is available for feeding experiments carried out on any other mammals, and the error of the comparison between them may be relied upon to be so small that 50 pairs of these would give more reliable results than the 20,000 with which we have been dealing.

The proposal is then to experiment on all pairs of twins of the same sex available, noting whether each pair is so similar that they are probably "identicals" or whether they are dissimilar.

"Feed" one of each pair on raw and the other on pasteurised milk, deciding in each case which is to take raw milk by the toss of a coin.

Take weekly measurements and weigh without clothes.

Some way of distinguishing the children from each other is necessary or the mischievous ones will play tricks. The obvious method is to take finger-prints, but as this is identified with crime in some people's minds, it may be necessary to make a different indelible mark on a fingernail of each, which will grow off after the experiment is over.

With such comparatively small numbers further information about the dietetic habits and social position of the children could be collected and would doubtless prove invaluable.

The comparative variation in the effect in "identical" twins and in "unlike" twins should furnish useful information on the relative importance of "Nature and Nurture."

* This is a serious consideration: the Lanarkshire experiment cost about £7500.

To sum up: The Lanarkshire experiment devised to find out the value of giving a regular supply of milk to children, though planned on the grand scale, organised in a thoroughly business-like manner and carried through with the devoted assistance of a large team of teachers, nurses and doctors, failed to produce a valid estimate of the advantage of giving milk to children and of the difference between raw and pasteurised milk.

This was due to an attempt to improve on a random selection of the controls which in fact selected as controls children who were on the average taller and heavier than those who were given milk.

The hypothesis is advanced that this was due not to a selection of the shorter, lighter children as such to take the milk, but to an unconscious bias leading the teachers to pick out for this purpose the needier children whom the milk would be most likely to benefit.

This hypothesis is supported by the fact that while the advantage derived from the milk was only 8—10 per cent. of the gain in height, without much variation for age, it was 30—45 per cent. of the gain in weight, varying from 9—13 per cent. in the younger children (who do not seem to have shed much clothing in the summer) up to 73—78 per cent. in the older children—who obviously did.

Suggestions are made for the arrangement:

(1) Of a similar large scale experiment on random lines, and

(2) Of a much smaller and cheaper experiment carried out on pairs of twins of like sex.

The second is likely to provide a much more accurate determination of the point at issue, owing to the possibility of balancing both nature and nurture in the material of the experiment.