letters are written in a racy literary style, effervesce with good spirits, and are stamped by a broad humanity. These extracts have been chosen with a fine discrimination, and show the writer to have been a man of varied attainments, who combined a strong sense of his duty to his fellow men with a healthy determination to get the very best out of life. By remaining anonymous D. F. has artistically contrived that all the light is shed upon the one central arresting figure of this admirable memoir. Copies (price 3s. 6d., postage 5d.) may be obtained from Messrs. Douglas and Foulis, 9, Castle Street, Edinburgh, or from Messrs. Macniven and Wallace, 138, Princes Street, Edinburgh.

INFLUENCE OF AMOUNT OF MILK CONSUMPTION ON THE RATE OF GROWTH OF SCHOOL CHILDREN.

PRELIMINARY REPORT BY

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DURING the past few years a number of tests have been carried out in America[1 2 3] to determine the nutritive value of milk for children. More recently a test under exact conditions in a labour colony for boys, where the whole diet was controlled, was carried out by Dr. Corry Mann[4] for the Medical Research Council. The results of all these tests, which are in general agreement, have demonstrated the high nutritive value of milk for growth.

In 1926-27 a large-scale test was carried out in schools in seven cities and towns in Scotland and in Belfast to determine whether the results obtained by Corry Mann under the rather special conditions of an institutional school would be obtained in children attending elementary schools and receiving the varied and changing diet of the ordinary working class household.

The tests were conducted under the auspices of a committee appointed by the Scottish Board of Health, with Sir Leslie Mackenzie as chairman. The committee consisted of the school medical officers for the cities and towns where the work was carried out. The collection of data was undertaken by four women medical officers. The clinical examination of the children was made by the late Dr. Cruickshank of the Scottish Board of Health and the school medical officers. A repeat test is at present being undertaken under the supervision of Dr. Gerald Leighton, Scottish Board of Health, and a full report will be issued when the new test is completed. The results obtained to date, however, so strongly confirm those of Corry Mann and previous workers, which are of such importance in public health, that it has been thought advisable to issue the present interim report.

Method.

At each centre four groups of children were taken, each numbering from forty to fifty, according to the size of the classes in the school. One group received whole milk, a second separated milk, and a third a biscuit of the same energy-yielding value as the separated milk. The fourth group, which acted as control, received no supplementary feeding. The test began at the end of November and finished at the end of June. The Belfast test did not begin till the end of January; it is, therefore, not included in the results of the seven months' experiment.

At Peterhead and Greenock the children were between 5 and 6 years of age, at Dundee and Edinburgh between 8 and 9 years, and at Aberdeen and Paisley between 13 and 14 years. Glasgow and Belfast had a series of groups of each of the three ages. There were thus under test children at the beginning, the middle, and the end of school life.

The 5- to 6-year-old children received three-quarters of a pint of milk per school day, the 8 to 9 one pint, and the 13 to 14 one and a quarter pints. The milk was given at school.

Owing to unforeseen difficulties the tests in Glasgow had to be rearranged about three months after they had been begun, and the whole milk group was dropped. The Glasgow data, therefore, are limited to the control, biscuit, and separated milk groups.

Weights and Heights.

It was intended to weigh the children with only one layer of underclothing. This was found to be impracticable. The children were therefore weighed in indoor clothing, without shoes, and there are considerable fluctuations in the weight figures, even those taken on successive days. The average weight of clothing was ascertained month by month and the necessary addition or deduction made in the final weight figure. Owing to these circumstances the records of individual weights are not so reliable an indication of the influence of milk as the figures showing the increase in height.

The weights were recorded to the nearest quarter-pound. The heights were recorded to the nearest quarter-inch, the children being measured without shoes. The measurements were taken on three consecutive days at the beginning and end of the test, and at intervals of about one month during its progress.

Before the results were calculated such cards were rejected as showed absence due to serious illness, about 25 per cent. of missed feeds, doubtful increases in weight or height, etc. This accounts for the decreased number of children available for the final analysis.

The *average* increase in height and weight has been worked out per group at each age and in each centre, giving the following results.

TABLE I.—*Average Increase in Height (Inches).*

	Controls.	Biscuit.	Separated Milk.	Whole Milk.
Age 5–6:				
Peterhead	1.425	1.392	1.568	1.550
Greenock	1.470	1.455	1.625	1.543
Glasgow	1.267	1.101	1.500	—
Age 8–9:				
Edinburgh	1.224	1.286	1.457	1.483
Dundee	0.972	0.931	1.209	1.105
Glasgow	1.125	1.089	1.297	—
Age 13–14:				
Aberdeen	1.395	1.263	1.602	1.622
Paisley	0.889	0.841	1.292	1.365
Glasgow	1.143	1.265	1.734	—

TABLE II.—*Average Increase in Weight (lb.).*

	Controls.	Biscuit.	Separated Milk.	Whole Milk.
Age 5–6:				
Peterhead	1.773	1.973	2.983	2.741
Greenock	1.595	1.200	1.969	1.994
Glasgow	2.784	2.234	2.407	—
Age 8–9:				
Edinburgh	2.132	2.972	3.238	3.330
Dundee	2.433	2.404	2.659	2.556
Glasgow	2.292	2.266	3.471	—
Age 13–14:				
Aberdeen	5.212	4.939	4.790	5.837
Paisley	3.986	3.934	5.242	4.821
Glasgow	3.855	4.809	5.959	—

The height increases when all the groups at one age, irrespective of locality, are combined, show very strikingly the influence of the milk supplement in aiding growth, and the failure of the biscuit supplement.

At every age the increase in height of the whole milk or the separated milk groups is significantly greater than that of the biscuit or control groups, while the difference in increase in height between the two milk groups is insignificant. The supplementary biscuit, on the other hand, fails to exercise any significant stimulus in the 8-year-old group, and in the 13- and 5-year-old groups has an almost significantly retarding effect.

As the milk groups (whether separated or whole) showed a distinct improvement in growth over the non-milk (that is, biscuit and control) groups, the figures of

* The Chairman of the Investigation Committee is Sir Leslie Mackenzie, M.D., LL.D., of the Scottish Board of Health to whom we are indebted for the report.

TABLE III.—*Showing the Mean Increase (in Inches) in Each Group at Each Age, with the Probable Error.*

Group I.	Group II.	Mean I.	Mean II.	M. I – M. II.		Probable Error.	Remarks.
Age 13.							
Biscuits	Controls	1.1279	1.2175	– 0.0896	=	0.0401	Biscuits almost significantly worse.
Whole milk	Controls	1.5122	1.2175	– 0.2947	=	0.0469	Whole milk significantly better.
Separated milk	Controls	1.5524	1.2175	– 0.3349	=	0.0417	Separated milk significantly better.
Separated milk	Biscuits	1.5524	1.1279	– 0.4245	=	0.0444	Separated milk significantly better.
Whole milk	Biscuits	1.5122	1.1279	– 0.3843	=	0.0493	Whole milk significantly better.
Whole milk	Separated milk	1.5122	1.5524	– 0.0402	=	0.0507	No significant difference.
Age 8.							
Biscuits	Controls	1.1160	1.1000	– 0.0160	=	0.0278	No significant difference.
Whole milk	Controls	1.3233	1.1000	– 0.2233	=	0.0318	Whole milk significantly better.
Separated milk	Controls	1.3355	1.1000	– 0.2355	=	0.0254	Separated milk significantly better.
Separated milk	Biscuits	1.3355	1.1160	– 0.2195	=	0.0281	Separated milk significantly better.
Whole milk	Biscuits	1.3233	1.1160	– 0.2073	=	0.0340	Whole milk significantly better.
Whole milk	Separated milk	1.3233	1.3355	– 0.0122	=	0.0321	No significant difference.
Age 5.							
Biscuits	Controls	1.3443	1.4026	– 0.0583	=	0.0291	Biscuits almost significantly worse.
Whole milk	Controls	1.5458	1.4026	– 0.1432	=	0.0298	Whole milk significantly better.
Separated milk	Controls	1.5697	1.4026	– 0.1671	=	0.0295	Separated milk significantly better.
Separated milk	Biscuits	1.5697	1.3443	– 0.2254	=	0.0303	Separated milk significantly better.
Whole milk	Biscuits	1.5458	1.3443	– 0.2015	=	0.0305	Whole milk significantly better.
Whole milk	Separated milk	1.5458	1.5697	– 0.0239	=	0.0309	No significant difference.

the average increase at all ages were arranged into two groups, with the following results.

TABLE IV.—*Average Increase (All Ages).*

	Milk Groups.		Non-Milk Groups.
Average increase in height ...	1.470 in.	......	1.212 in.
Average increase in weight ...	3.617 lb.	......	2.974 lb.

This seven months' experiment thus shows an average monthly increase of 0.17 in. and 0.42 lb. in the non-milk groups, and of 0.21 in. and 0.52 lb. in the milk groups. In the much lengthier experiment by Corry Mann the corresponding figures were 0.15 in. and 0.32 lb. for all boys on the basal diet, and 0.22 in. and 0.58 lb. for all boys receiving the supplement of one pint of pasteurized milk every day; the milk group increases in height in both experiments, thus approximating very closely in spite of the Scottish children receiving the supplement only five days a week.

The children in the different groups at the various centres were examined at the end of the experiment and clinical observations made. Independent reports were also handed in by the headmasters of the schools. These clinical reports, which cannot be expressed in figures, show that at most of the centres the children who had received milk appeared to be in better condition than those receiving no milk. It was noted that, on the whole, they had glossier hair and clearer complexions, and held themselves more erect. At other centres this difference was less marked, and in Glasgow no distinct difference could be detected. The most marked improvement in the children in the milk groups was shown in children who had been in poor condition at the beginning of the test.

From the particulars gathered as to the home dietary of 626 households, it would seem that the average milk consumption in the home was 2.5 pints per head per week. The total milk consumption of the children under test in these homes was then calculated on the assumption that the average consumption per head in the household to which the child belonged was the home consumption of that child, to which was added the amount received at school. The rate of growth of children receiving more than the average of the total milk consumption (home *plus* school) was compared with that of children receiving less than the average.

TABLE V.—*Showing the Average Rate of Increase in Height in the "Over Average" and "Under Average" Milk Consumption Groups.*

	Age 5–6.	Age 8–9.	Age 13–14.
Increase in height of "over average" group	1.58 in.	1.37 in.	1.51 in.
Increase in height of "under average" group	1.44 in.	1.19 in.	1.21 in.
Percentage increase of "over average" to "under average" group	9.4	15.5	24.2

Conclusions.

From this survey of the data it seems probable that, in the final report, it will be possible to draw the following conclusions:

1. The addition of the milk to the diet of school children during the seven months' experimental period has been accompanied by a rate of growth as indicated by an increase in both height and weight 20 per cent. greater than that in children not receiving the extra milk.

2. This increase in rate of growth has been accompanied by an improvement in the general condition of many of the children receiving milk.

3. Separated milk is of great value for promoting growth. Its nutritive value for children would appear to be underestimated.

The writer wishes to record his indebtedness to Miss M. L. Clark, who has prepared the above tables, for valuable services in connexion with the supervision of the tests during their progress. Dr. Lewis D. Cruickshank, who superintended the investigation from the administrative side on behalf of the committee, died towards the end of the test period, and we can only record our profound regret that we have not had the continued advantage of his intimate knowledge of school and social conditions.

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

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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 in.	= +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 ,,	2.9[illegible]4 ,,
		= +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.*

	Increase I.	Increase II.	Difference.	Probable Error.	Result.	Remarks.
A.—13 Years: Weights (Increases in Pounds).						
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).						
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	0.0466	+4.768	,, ,,
Biscuits (67) *v.* Controls (66) ...	1.1194	,,	−0.1439	0.0472	−3.049	Significantly worse.
C.—9 Years: Weights (Increases in Pounds).						
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).						
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).						
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	0.1031	+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).						
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	3.000
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.

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 ± 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.

R. A. Fisher.
Rothamsted Experimental Station.
S. Bartlett.
National Institute for Research in Dairying,
University of Reading.

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 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.

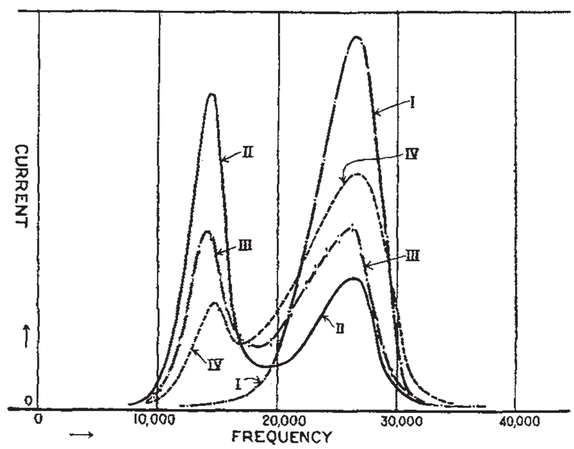


Fig. 1.

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 $\frac{3}{4}$ 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.

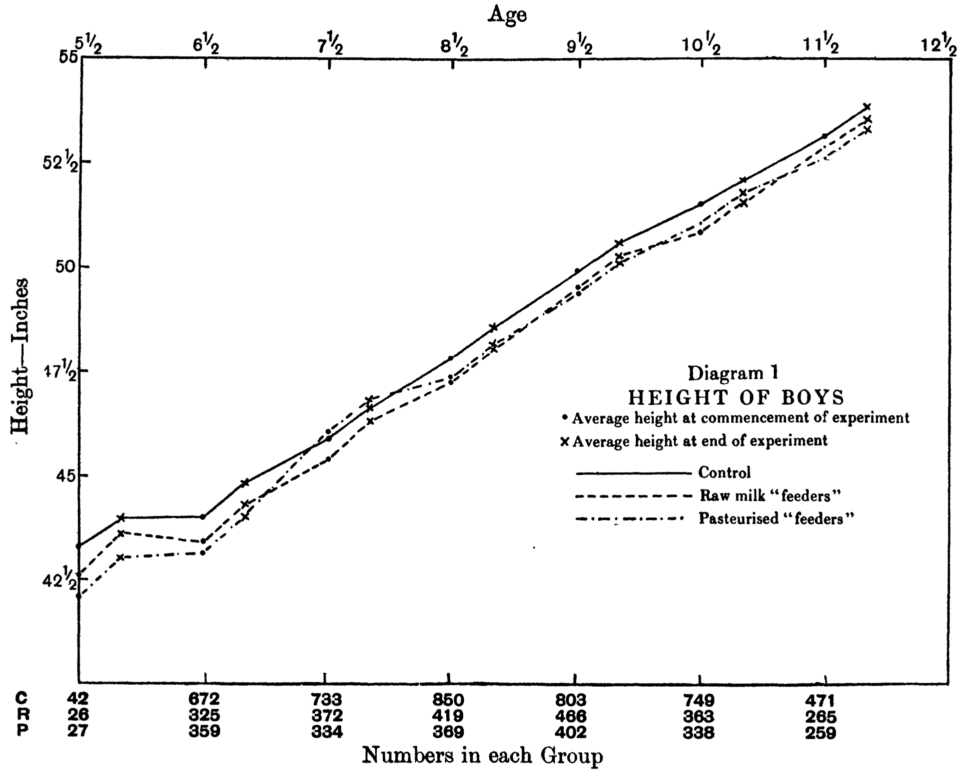
Now with only 67 schools, at best 33 against 34, in a district so heterogeneous both racially and socially, it is quite possible that there was a difference between the averages of the pupils at 33 schools and those of the pupils at another 34 schools both in the original measurements and in the rate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

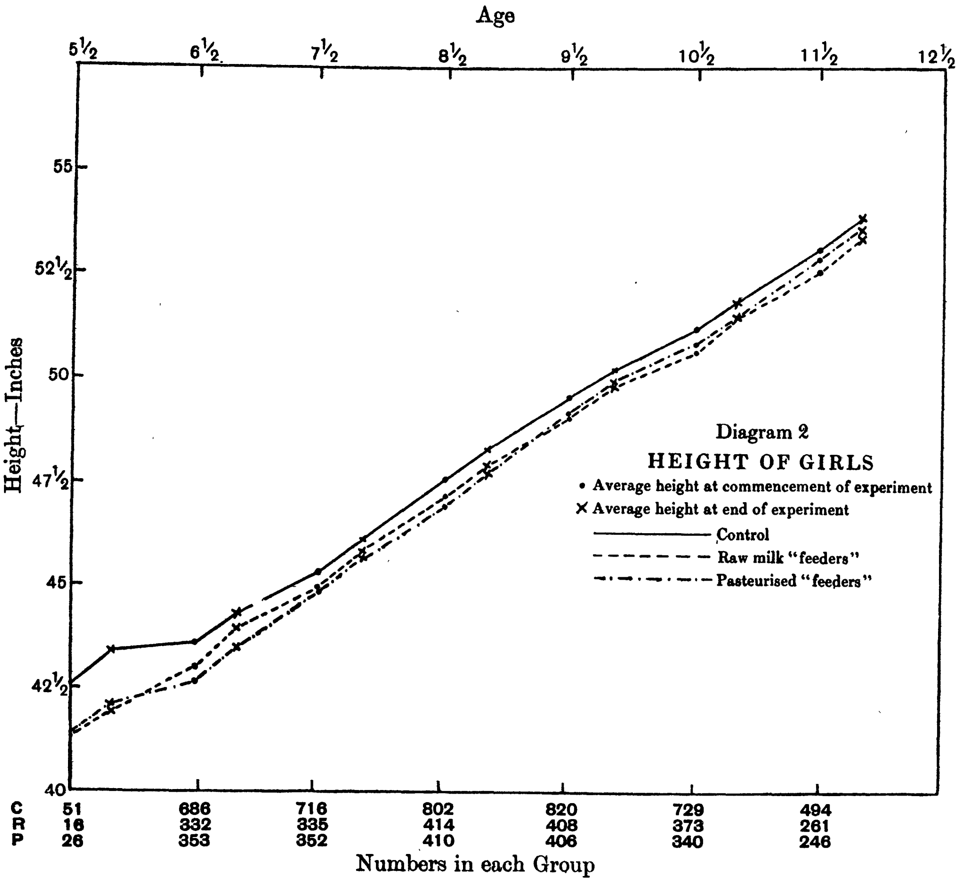
In that case the average "control" could not be used appropriately to compare with either the "raw" group or the "pasteurised" group.

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.

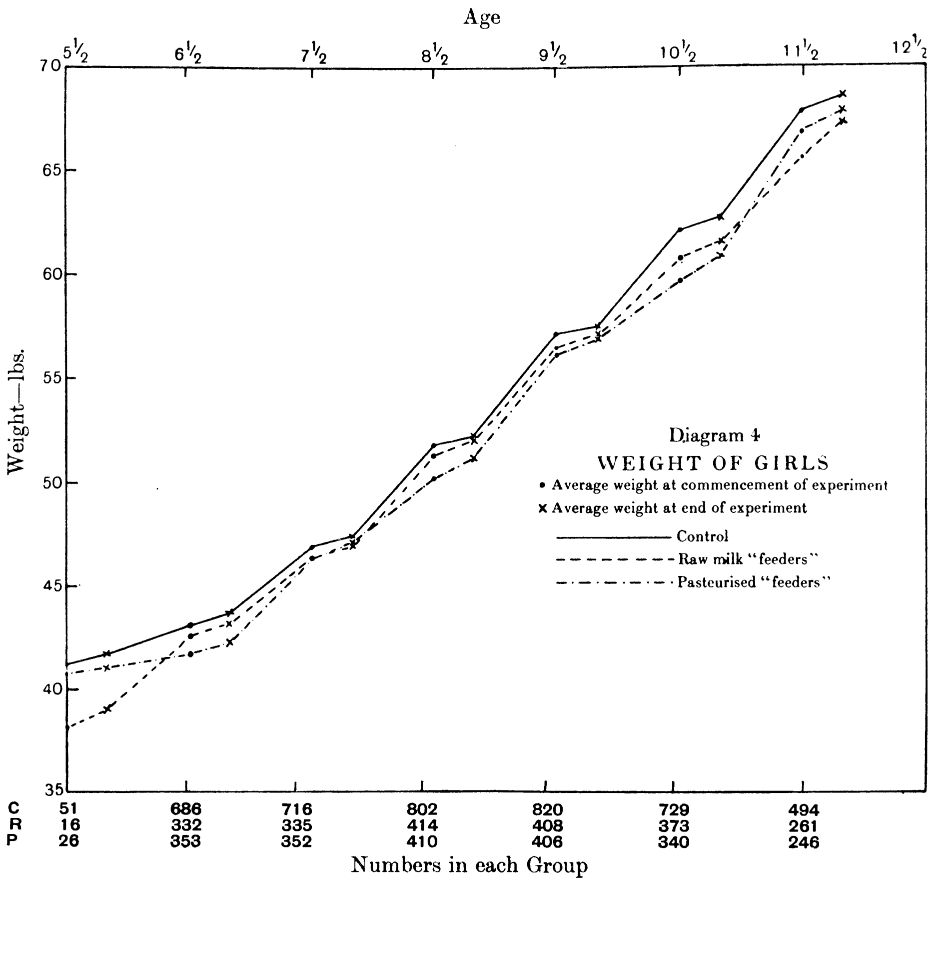
That being so how are we to regard the conclusions of the Report*:

(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 °/₀ 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.

Annals of Human Genetics

October 1933

Volume 5, Issue 3-4

THE LANARKSHIRE MILK EXPERIMENT.

By ETHEL M. ELDERTON, D.Sc.

This experiment was carried out in 1930 and a paper was published in that same year by Dr Leighton and Dr McKinlay*.

For four months in Lanarkshire in certain schools 5000 children were given $\frac{3}{4}$ pint of raw milk a day and 5000 children in these same schools were selected to act as a control series; in another set of schools, 5000 children were given $\frac{3}{4}$ pint of pasteurised milk and another 5000 children in these same schools were selected to act as a control; the children were measured and weighed at the beginning and end of the experiment.

"Student" in a paper "The Lanarkshire Milk Experiment" published in 1931 in *Biometrika*, Vol. XXIII, pp. 398–406, dealt with the difficulties of comparison which may be restated briefly from his paper:

(1) Raw milk and pasteurised milk were never given in the same schools.

(2) The initial heights and weights of the children in the control series were greater than those of the children who were milk fed.

(3) The children were weighed in their clothes and the first weighing was in February and the second in June; had there been no selection of cases this would not have mattered but it seems possible that the slightly poorer children who were given milk would lose less weight from change of clothes than the children in the control series who are assumed from their greater height and weight to be slightly more prosperous.

"Student" suggested that the experiment should be carried out on identical twins and if identical twins were more numerous and could with ease and certainty be discriminated from other twins they would be ideal subjects for such an experiment. In the absence of such data Professor Pearson suggested that, from the original cards, enough children of each class—controls, raw milk feeders, pasteurised milk feeders—could be found and paired who would have the same initial height and weight within reasonable limits.

The original cards were most willingly and courteously lent to Professor Pearson by the Department of Health for Scotland and were sorted for each sex into the year of birth; children had been measured to the nearest eighth of an inch in height and to the nearest ounce in weight. Having sorted the cards into heights for each year of birth a selection was made of a child from the control series who was of the same initial height, the same weight within 4 ounces and the same age within a month as one who had been given milk. In practically no cases were the initial conditions the same for the controls, raw milk feeders and pasteurised milk feeders, and therefore a comparison must be made of the three groups individually: controls with those who had raw milk; controls with those who had pasteurised milk; those who had raw milk with those who had pasteurised. The numbers were too few to be satisfactory and I decided to allow a variation of as much as 8 ounces in initial weight. This seemed justifiable since Dr Stocks in his

* 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.) See also Stephen Bartlett: "Nutritional Value of Raw and Pasteurised Milk," *Journal of the Ministry of Agriculture*, April 1931, pp. 60–64. Also R. A. Fisher and S. Bartlett, *Nature*, Vol. CXXVII, p. 591, 1931.

study of twins* found differences in weight as great as 28 hectograms (10 ounces) in those twins he regarded as monozygotic whose ages corresponded to the children in the milk experiment. The standard deviation of weight in pounds is roughly twice that of the standard deviation of height in inches, so that if 8 ounces difference in initial weight be permitted $\frac{1}{4}$ inch difference in height could be allowed. Judging also by Dr Stocks' material in which monozygotic twins showed a modal difference of 1 cm. in height it would have been justifiable to allow children to be paired who differed by two-eighths of an inch, but the labour of pairing would have been much heavier if a greater variation than that entered on the cards had been allowed for height as well as for weight. As it was the work of sorting and pairing took much time and the writer is greatly indebted to Miss Margaret Beer for her very ready help in this preliminary work.

The first thing to be noted is that in selecting two children, one treated with milk and one not treated, who have the same height and the same weight within 8 ounces we can only find *average* children; the shortest and lightest and tallest and heaviest will not appear in this selected data. In Table I the standard deviations and coefficients of variation of the initial height and weight for each year of birth are given, and if these be compared with those for Glasgow boys and girls† it will be seen that they are distinctly less. The Glasgow figures were obtained by linear interpolation and are given in brackets after those for the selected Lanarkshire data. At a later stage of the work the children differed in age by as much as two months and the constants in this table are found from the larger group in order to diminish the errors. The central age given is an approximate value only; children born in any one year were paired, but those born in the first two months of any year were also paired with those born in November and December of the previous year.

Table I. *Variability in Initial Height and Weight.*

	Central Age (approximate)	No. of Cases	Standard Deviations		Coefficients of Variation	
			Height	Weight	Height	Weight
Boys	6 years 9 months	382	1·483 (2·58)	3·143 (5·19)	3·41 (6·0)	7·15 (11·7)
	7 years 9 months	337	1·648 (2·82)	3·973 (5·75)	3·61 (6·2)	8·20 (11·9)
	8 years 9 months	360	1·556 (2·83)	4·018 (6·28)	3·29 (6·0)	7·63 (11·9)
	9 years 9 months	323	1·627 (2·82)	4·550 (6·88)	3·32 (5·8)	7·72 (12·0)
	10 years 9 months	243	1·731 (2·84)	5·288 (7·56)	3·37 (5·6)	8·41 (12·2)
Girls	6 years 9 months	356	1·560 (2·59)	3·280 (5·06)	3·62 (6·0)	7·75 (11·7)
	7 years 9 months	307	1·545 (2·65)	3·732 (5·62)	3·42 (5·9)	8·11 (12·1)
	8 years 9 months	375	1·523 (2·77)	4·117 (6·32)	3·22 (5·9)	8·10 (12·5)
	9 years 9 months	344	1·681 (2·85)	5·596 (7·10)	3·38 (5·8)	9·93 (12·9)
	10 years 9 months	274	2·094 (2·95)	6·288 (8·03)	4·08 (5·8)	10·24 (13·4)

If the difference in the standard deviations be expressed as a percentage of the standard deviations found for Glasgow children the variability in height in this selected material is roughly 40 % less except when the year of birth is 1919 when the difference is less, and in weight roughly 30 % less except for girls born in 1919 and 1920 when it is about 20 % less. This difference in variability shows that conclusions reached apply only to very average children and not to those much below or above the mean in height and weight.

The point we have to consider is whether the average child given extra milk gains in height and

* Percy Stocks, assisted by Mary N. Karn: "A Biometric Investigation of Twins and their Brothers and Sisters," *Annals of Eugenics*, Vol. v, pp. 46–50. Francis Galton Laboratory for National Eugenics.

† E. M. Elderton: "Note on Variability in Girls and Boys (Glasgow) for Height and Weight," *Biometrika*, Vol. xxi, Miscellanea, p. 429.

weight over the child not receiving extra milk and whether children fed on raw milk gain more than children fed on pasteurised when their initial heights and weights are the same. In Table II the children included were of the same initial height within $\frac{1}{8}$ in., of the same initial weight within 8 ounces and did not differ by more than a month in age; the numbers of pairs are given in brackets. The change in weight from year to year at the age groups with which we are dealing is about 4 lb. and we should therefore expect over a period of four months an average gain of something over a pound in weight*, but owing to the fact that the children were weighed at the end of June and were in many cases wearing lighter clothes we find only a small average increase of 11·6 ounces in weight for the boys and 8·5 ounces for the girls in the control series, and an extraordinary amount of variation in the amount of increase in weight during the four months. The tables on p. 335 show this very clearly and it will be seen that 19 % of the boys and 25 % of the girls in the control series lost weight while the standard deviation was 20 ounces for both series; it is interesting to note that the standard deviation is no greater for the controls than for those fed on milk.

Standard Deviation in Ounces.

	Controls	Raw Milk Feeders	Controls	Pasteurised Milk Feeders	Raw Milk Feeders	Pasteurised Milk Feeders
Males	20·44 ± ·38	21·10 ± ·40	20·32 ± ·38	19·76 ± ·37	20·20 ± ·51	20·26 ± ·51
Females	21·19 ± ·40	21·37 ± ·40	19·86 ± ·36	21·57 ± ·40	22·48 ± ·59	21·70 ± ·57

In height boys gained ·72 in. and girls ·70 in. in the control series which is an amount of growth to be expected. Owing to the variability in gain in weight the probable errors are large and in Table II A the children of all ages have been combined to see the general effect of giving raw or pasteurised milk to school children. The gain in height and weight of milk feeders over controls and of raw milk feeders over pasteurised milk feeders is given in each case, and a negative sign means that the controls have done better than the children given milk and that those who have had pasteurised milk have done better than children given raw milk.

At all ages children who are given milk gain in height more than the children in the control series though several individual differences are not significant and in some cases are so small that it is not surprising to find them becoming negative though still insignificant when children who differ by from one to two months in age are added to the children included in Table II. Both boys and girls given raw milk gain more in height than those fed on pasteurised, but the differences in this case are never significant. In weight also the children having extra milk generally gain more though exceptions occur; girls benefit more than boys and there is some indication that the older children of both sexes gain more weight over the controls than the younger ones when they take raw milk, but when pasteurised milk is given the differences are more erratic. On the whole children receiving pasteurised milk gained more weight than the children receiving raw milk though they gained less in height, but again no individual difference is significant. An examination of Table II A shows that boys and girls profit equally in height by taking raw milk but that girls gain more in weight than the boys; girls gain more in height than the boys by taking pasteurised milk and more in weight though the difference is not significant. Though raw milk feeders have a slightly greater gain in height than pasteurised milk feeders they have the disadvantage in weight though none of the differences is significant except possibly for height of girls.

* The rate of growth may vary according to the time of year, but probably not greatly or it would have been a subject studied.

Table II. *Gain in Height and Weight of Milk Feeders over Controls and of Raw Milk Feeders over Pasteurised Milk Feeders for five age groups.*

Central Age (Approximate)	Raw Milk Feeders over Controls		Pasteurised Milk Feeders over Controls		Raw Milk Feeders over Pasteurised Milk Feeders	
	Boys	Girls	Boys	Girls	Boys	Girls
	Gain in Height in Inches					
$6\frac{3}{4}$	(74) ·061 ± ·037	(71) ·100 ± ·039	(85) ·062 ± ·032	(62) ·022 ± ·033	(39) ·016 ± ·051	(31) ·101 ± ·052
$7\frac{3}{4}$	(66) ·114 ± ·038	(59) ·004 ± ·036	(64) ·004 ± ·037	(61) ·131 ± ·036	(41) ·021 ± ·045	(28) ·179 ± ·074
$8\frac{3}{4}$	(71) ·097 ± ·044	(70) ·177 ± ·041	(83) ·042 ± ·032	(84) ·147 ± ·030	(30) ·033 ± ·053	(31) ·097 ± ·052
$9\frac{3}{4}$	(65) ·073 ± ·047	(75) ·152 ± ·035	(69) ·087 ± ·036	(69) ·178 ± ·048	(39) ·090 ± ·052	(31) − ·036 ± ·057
$10\frac{3}{4}$	(61) ·227 ± ·039	(61) ·082 ± ·048	(41) ·098 ± ·052	(49) ·151 ± ·052	(39) ·035 ± ·049	(28) ·125 ± ·072
	Gain in Weight in Ounces					
$6\frac{3}{4}$	(74) − 4·26 ± 2·08	(71) 1·14 ± 1·92	(85) − ·53 ± 1·85	(62) 4·06 ± 1·83	(39) − 5·54 ± 2·85	(31) − 1·45 ± 2·87
$7\frac{3}{4}$	(66) 1·50 ± 2·22	(59) 3·05 ± 2·47	(64) 4·78 ± 2·12	(61) ·74 ± 2·14	(41) − 8·12 ± 3·42	(28) − 1·29 ± 2·99
$8\frac{3}{4}$	(71) 1·39 ± 2·41	(70) 10·03 ± 2·51	(83) 4·66 ± 2·27	(84) 7·07 ± 2·25	(30) 1·80 ± 3·34	(31) − 1·45 ± 3·60
$9\frac{3}{4}$	(65) 2·77 ± 2·30	(75) 7·08 ± 2·66	(69) 3·52 ± 2·31	(69) 9·39 ± 2·60	(39) − 2·08 ± 2·89	(31) 4·06 ± 4·28
$10\frac{3}{4}$	(61) 2·21 ± 3·09	(61) 10·33 ± 2·79	(41) 1·98 ± 3·50	(49) − 3·12 ± 3·60	(39) 2·31 ± 3·26	(28) − 4·50 ± 5·50

Table II A. *Gain in Height and Weight of Milk Feeders over Controls and of Raw Milk Feeders over Pasteurised Milk Feeders, all ages combined.*

	Gain in Height		Gain in Weight		No. of Cases	
	Boys	Girls	Boys	Girls	Boys	Girls
Raw Milk Feeders over Controls	·111 ± ·019	·108 ± ·018	·59 ± 1·08	6·32 ± 1·13	337	336
Pasteurised Milk Feeders over Controls ...	·056 ± ·017	·127 ± ·017	2·84 ± 1·16	4·26 ± 1·11	342	325
Raw Milk Feeders over Pasteurised Milk Feeders	·039 ± ·023	·091 ± ·028	− 2·58 ± 1·43	− ·85 ± 1·77	188	149

To try to discover whether the differences in the effect of milk at the different ages were significant or not I decided to add to the data those children who differed by one to two months in age; including these children may introduce a slight error for one might be pairing children of a slightly different class and the weight of one member of the pair might be more influenced by change of clothing; on the average one would expect the differences to cancel one another out, but if the means of the original heights and weights differ the frequencies in any group will be different and therefore the bias may be always in one direction, but it is not likely that by making the range of difference in age two months instead of one month that any appreciable error will be introduced, and there is a distinct gain since the number of cases is nearly doubled. There are still many irregularities as can be seen from Table III, and it is impossible to deduce much as to the effect of extra milk on children at different ages; on the whole the older the children the greater the gain in weight when raw milk is taken, but this is not the case when pasteurised milk is given. Again girls profit from the extra milk more than the boys, though the difference does not exceed three times the probable error. The gain in weight of raw milk feeders over pasteurised milk feeders is still negative though insignificant for girls, but is positive though insignificant for boys. Combining the first two age groups and the last three we obtain Table IV.

This table adds little to our information; comparing raw milk feeders with their controls the elder girls profit more than the younger in weight but there is no difference in height, while the elder boys also gain more than the younger in both height and weight, but the differences are not significant compared with their probable errors. Comparing pasteurised milk feeders with the controls age makes no difference to the boys, but the older girls who take the milk gain significantly more over the controls in height than the younger and they gain more in weight, but on the number of cases the difference is not significant. Noticing that the greater difference in weight among the older girls is due to less gain by the controls one wishes more than ever that the children had been weighed without clothes.

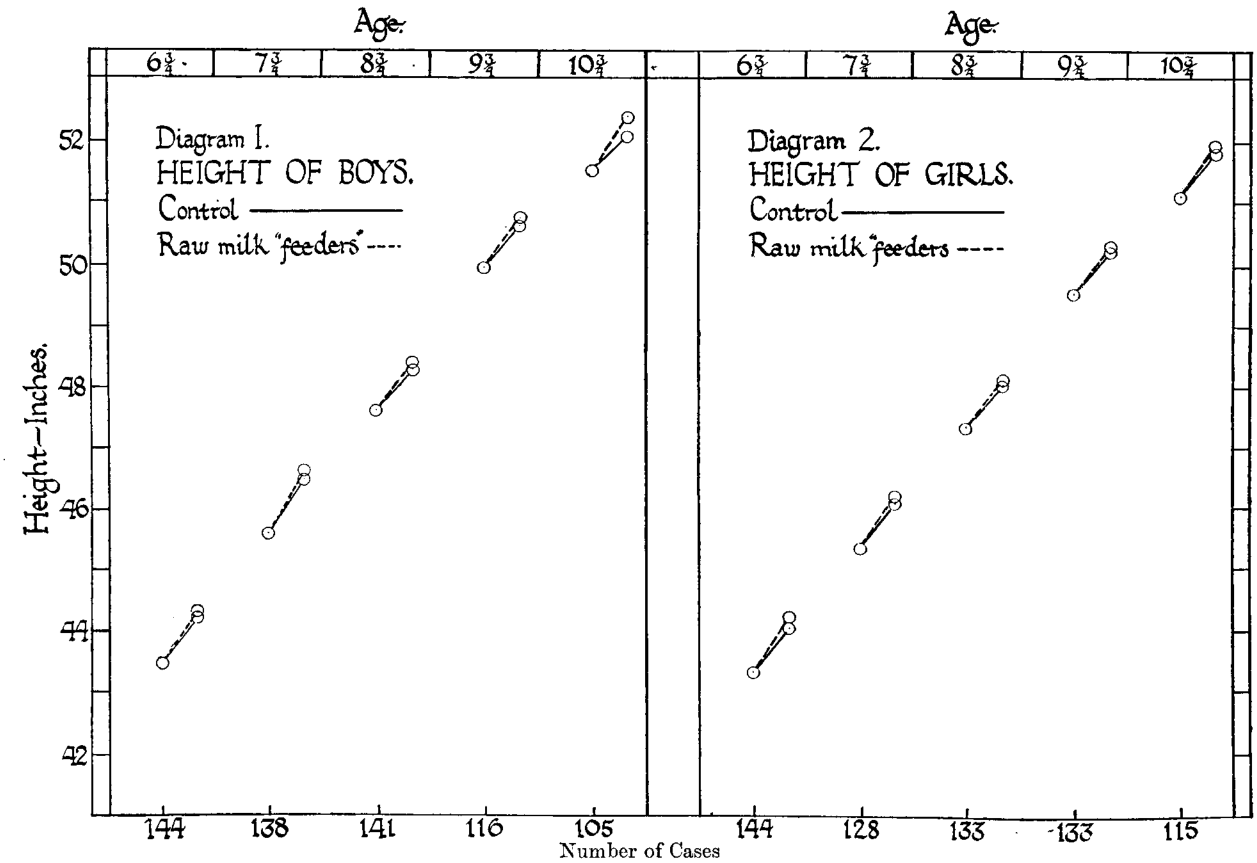
Table III. *Gain in Height and Weight of Milk Feeders over Controls and of Raw Milk Feeders over Pasteurised Milk Feeders when differences in age may be as much as two months.*

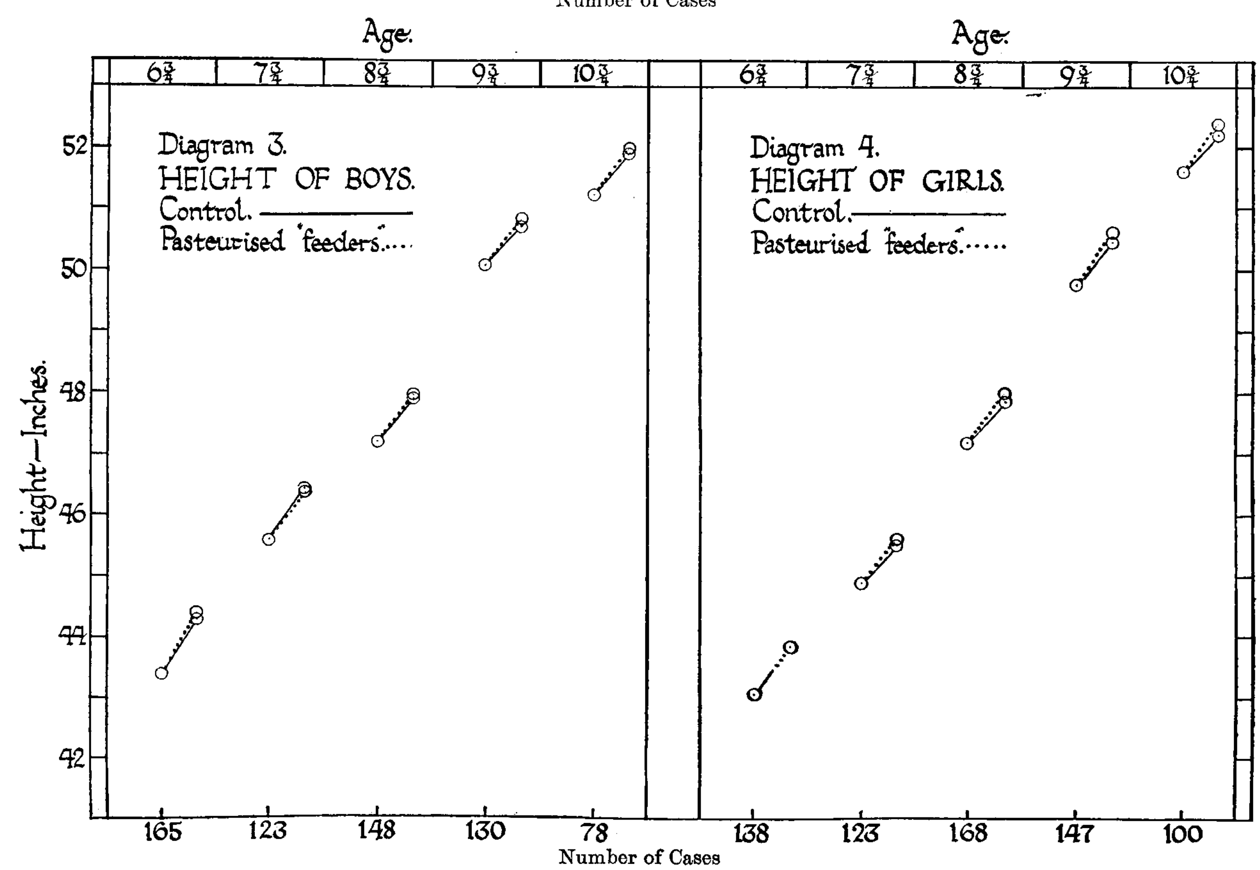
Central Age (Approximate)	Gain in Height in Inches					
	Raw Milk Feeders over Controls		Pasteurised Milk Feeders over Controls		Raw Milk Feeders over Pasteurised Milk Feeders	
	Boys	Girls	Boys	Girls	Boys	Girls
$6\frac{3}{4}$	(144) ·083 ± ·026	(144) ·167 ± ·028	(165) ·094 ± ·024	(138) − ·004 ± ·028	(73) − ·066 ± ·036	(74) ·110 ± ·040
$7\frac{3}{4}$	(138) ·106 ± ·026	(128) ·023 ± ·027	(123) − ·027 ± ·026	(123) ·105 ± ·026	(76) ·022 ± ·036	(56) ·167 ± ·051
$8\frac{3}{4}$	(141) ·098 ± ·030	(133) ·107 ± ·029	(148) ·046 ± ·025	(168) ·129 ± ·023	(71) − ·003 ± ·035	(74) ·017 ± ·034
$9\frac{3}{4}$	(116) ·112 ± ·034	(133) ·087 ± ·027	(130) ·068 ± ·025	(147) ·134 ± ·028	(77) ·011 ± ·037	(64) ·021 ± ·043
$10\frac{3}{4}$	(105) ·208 ± ·031	(115) ·084 ± ·034	(78) ·057 ± ·036	(100) ·128 ± ·034	(60) ·002 ± ·038	(59) ·080 ± ·045
	Gain in Weight in Ounces					
$6\frac{3}{4}$	(144) − ·88 ± 1·44	(144) ·13 ± 1·36	(165) ·00 ± 1·33	(138) 1·25 ± 1·28	(73) − 3·46 ± 2·02	(74) − ·13 ± 1·89
$7\frac{3}{4}$	(138) 1·36 ± 1·52	(128) 1·12 ± 1·62	(123) 3·54 ± 1·68	(123) 3·36 ± 1·53	(76) − 2·85 ± 2·46	(56) − 4·50 ± 2·23
$8\frac{3}{4}$	(141) 2·50 ± 1·72	(133) 7·98 ± 1·79	(148) 5·28 ± 1·64	(168) 3·96 ± 1·46	(71) − 3·06 ± 2·15	(74) 5·23 ± 2·46
$9\frac{3}{4}$	(116) 4·27 ± 1·77	(133) 5·62 ± 1·87	(130) ·35 ± 1·71	(147) 9·86 ± 1·88	(77) 3·06 ± 2·09	(64) − 1·55 ± 2·90
$10\frac{3}{4}$	(105) 4·80 ± 2·41	(115) 11·66 ± 2·20	(78) − 2·77 ± 2·36	(100) ·36 ± 2·44	(60) 3·15 ± 2·65	(59) − 2·45 ± 3·36

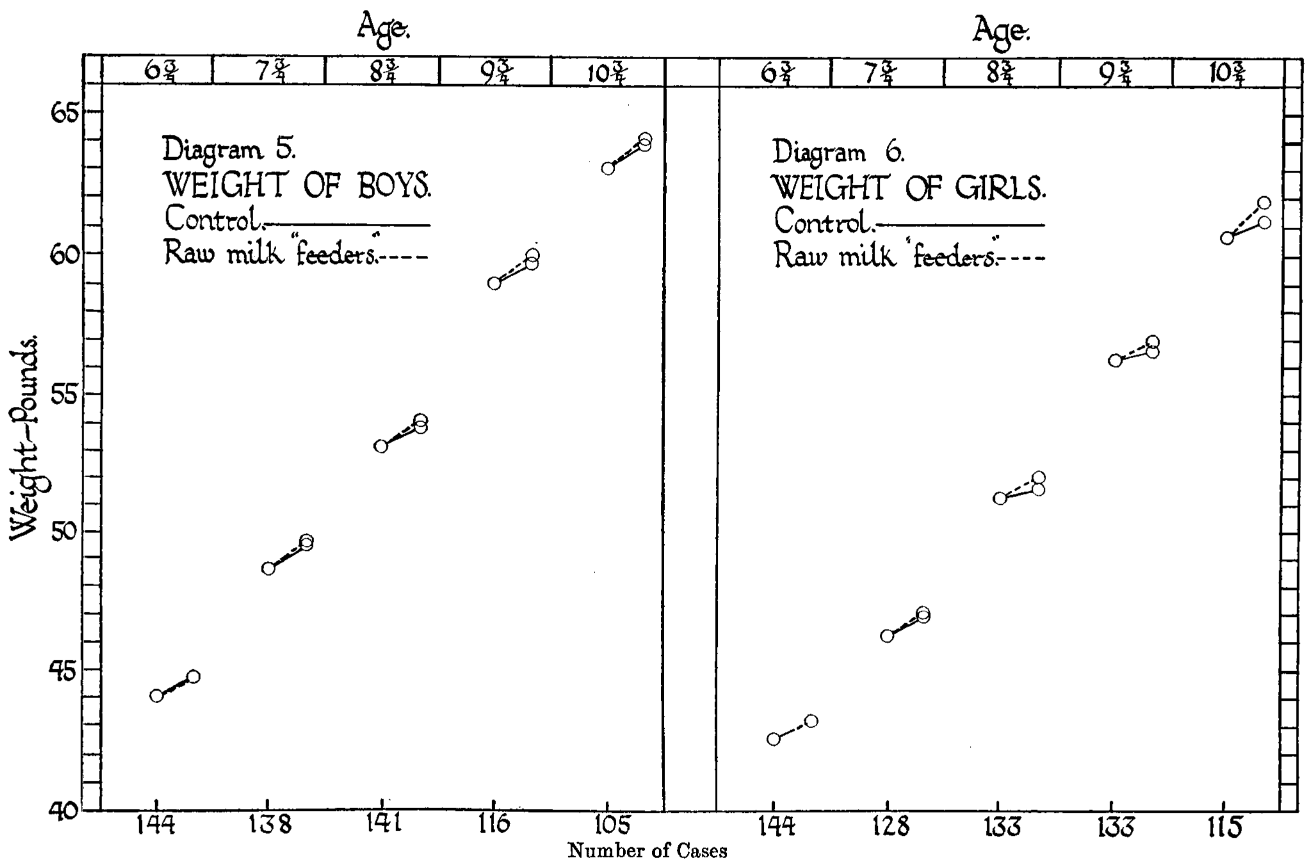
Table IV. *Gain in Height and Weight of Milk Feeders over Controls and of Raw Milk Feeders over Pasteurised Milk Feeders in two age groups.*

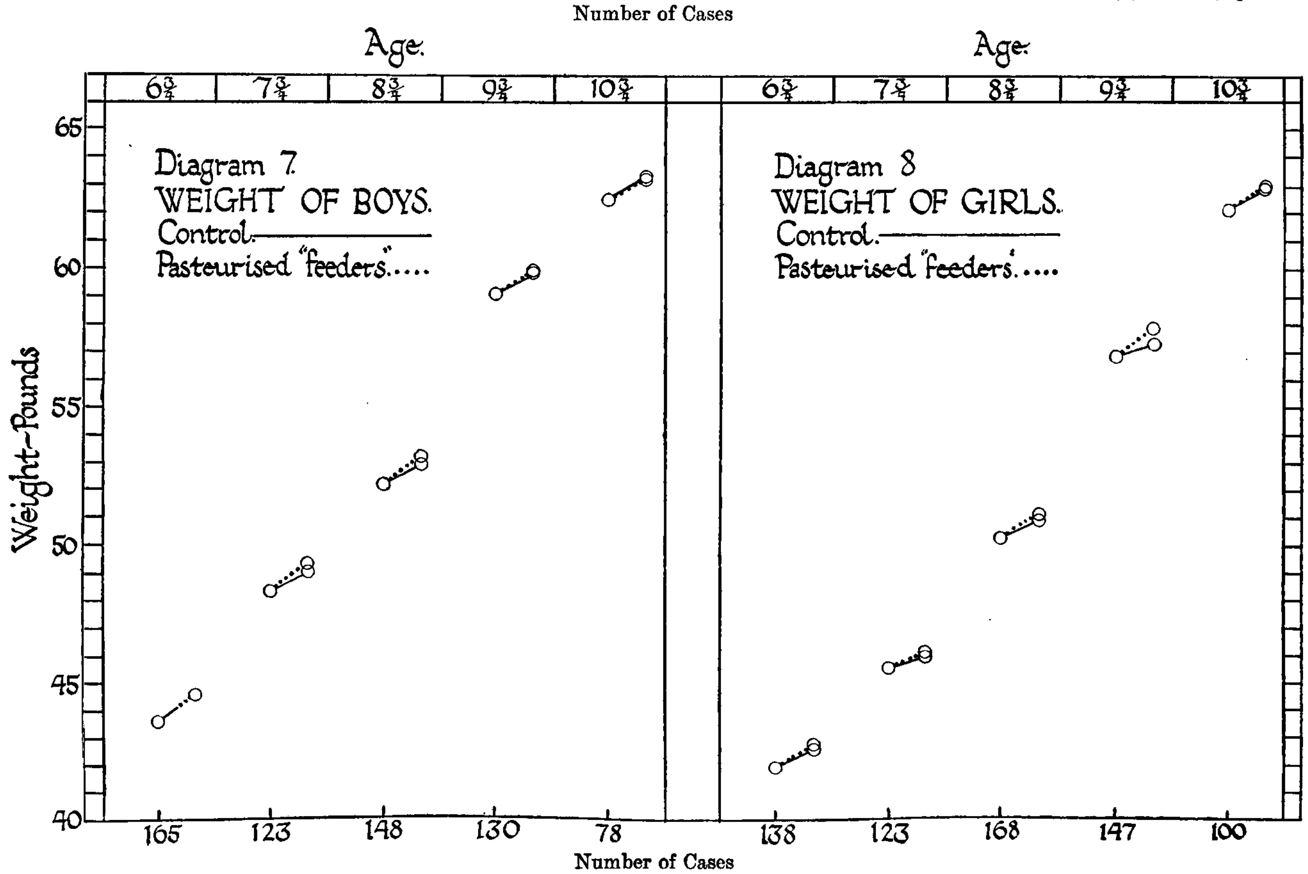
Age Group[1]		Gain in Height in Inches					
		Boys			Girls		
		No. of Cases	Means	Differences	No. of Cases	Means	Differences
$6\frac{2}{12}$–$8\frac{4}{12}$	C.[2]	282	·739	·094 ± ·019	272	·741	·099 ± ·020
	R.[2]		·834			·840	
$8\frac{2}{12}$–$11\frac{4}{12}$	C.	362	·685	·134 ± ·019	381	·678	·093 ± ·018
	R.		·819			·771	
$6\frac{2}{12}$–$8\frac{4}{12}$	C.	288	·782	·043 ± ·017	261	·740	·047 ± ·019
	P.[2]		·825			·787	
$8\frac{2}{12}$–$11\frac{4}{12}$	C.	356	·684	·057 ± ·016	415	·655	·130 ± ·016
	P.		·741			·785	
$6\frac{2}{12}$–$8\frac{4}{12}$	R.	149	·823	− ·021 ± ·025	130	·929	·135 ± ·032
	P.		·844			·794	
$8\frac{2}{12}$–$11\frac{4}{12}$	R.	208	·720	·004 ± ·022	197	·801	·037 ± ·024
	P.		·716			·764	
		Gain in Weight in Ounces					
$6\frac{2}{12}$–$8\frac{4}{12}$	C.	282	12·22	·23 ± 1·05	272	10·12	·60 ± 1·05
	R.		12·45			10·72	
$8\frac{2}{12}$–$11\frac{4}{12}$	C.	362	9·89	3·73 ± 1·12	381	6·00	8·27 ± 1·13
	R.		13·62			14·27	
$6\frac{2}{12}$–$8\frac{4}{12}$	C.	288	14·06	1·50 ± 1·05	261	10·38	2·24 ± ·99
	P.		15·56			12·62	
$8\frac{2}{12}$–$11\frac{4}{12}$	C.	356	10·90	1·72 ± 1·06	415	8·39	5·25 ± 1·07
	P.		12·62			13·64	
$6\frac{2}{12}$–$8\frac{4}{12}$	R.	149	10·57	− 3·14 ± 1·61	130	9·14	− 2·01 ± 1·45
	P.		13·71			11·15	
$8\frac{2}{12}$–$11\frac{4}{12}$	R.	208	11·77	1·00 ± 1·32	197	14·71	·73 ± 1·67
	P.		10·77			13·98	

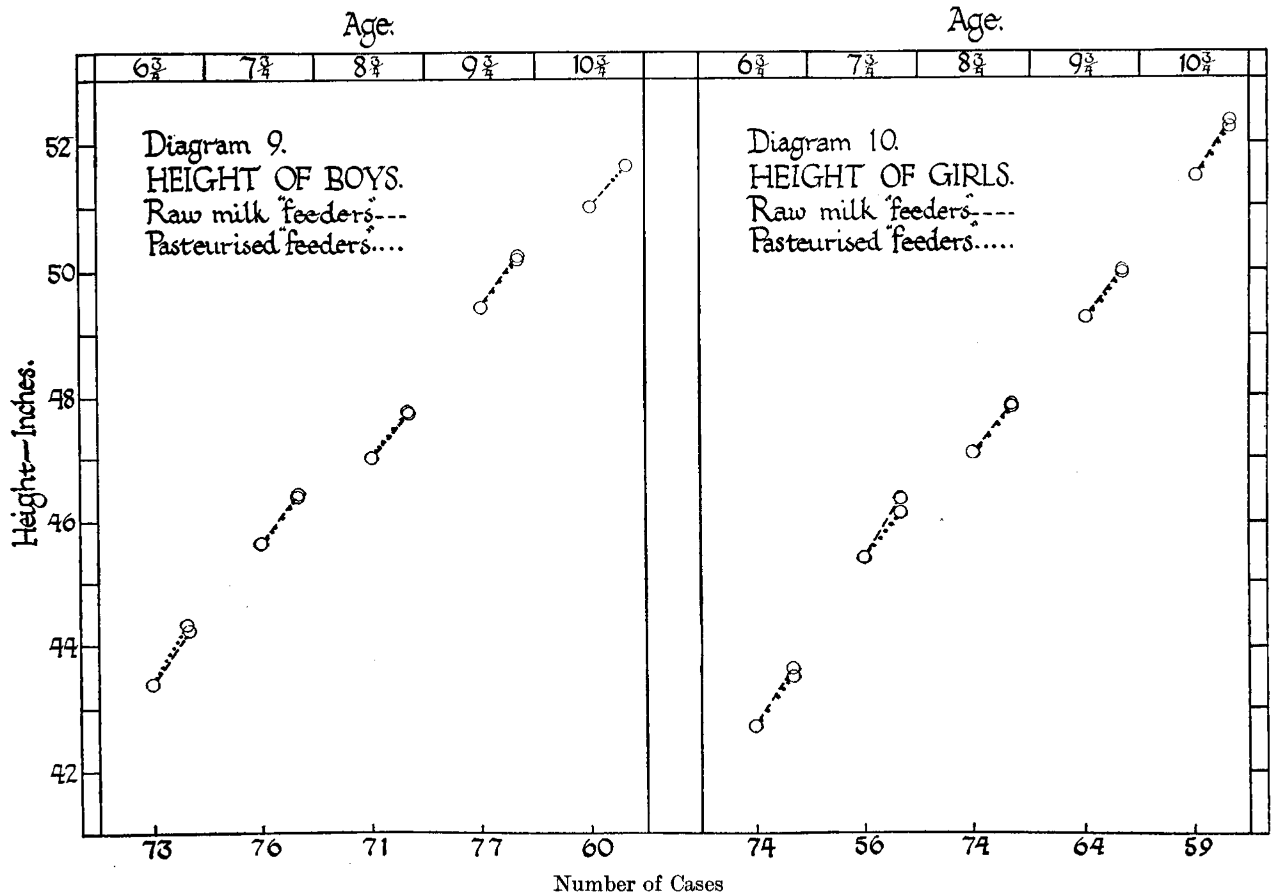
[1] The overlap in ages of the two groups arises from the two months' difference in age in any pair.
[2] C. = Controls. R. = Raw Milk Feeders. P. = Pasteurised Milk Feeders.


Age.
6¾
7¾
8¾
9¾
10¾
Diagram 1.
HEIGHT OF BOYS.
Control
Raw milk "feeders" ----
Diagram 2.
HEIGHT OF GIRLS.
Control
Raw milk "feeders" ----
Height—Inches.
52
50
48
46
44
42
144
138
141
116
105
144
128
133
133
115
Number of Cases


Age.
6¾
7¾
8¾
9¾
10¾
Diagram 3.
HEIGHT OF BOYS.
Control.
Pasteurised "feeders"....
Diagram 4.
HEIGHT OF GIRLS.
Control.
Pasteurised "feeders".....
Height—Inches.
52
50
48
46
44
42
165
123
148
130
78
138
123
168
147
100
Number of Cases


Age.
6¾ 7¾ 8¾ 9¾ 10¾
Diagram 5.
WEIGHT OF BOYS.
Control.
Raw milk "feeders."----
Diagram 6.
WEIGHT OF GIRLS.
Control.
Raw milk "feeders."----
Weight-Pounds.
65 60 55 50 45 40
144 138 141 116 105
144 128 133 133 115
Number of Cases


Age.
6¾ 7¾ 8¾ 9¾ 10¾
Diagram 7.
WEIGHT OF BOYS.
Control.
Pasteurised "feeders."....
Diagram 8
WEIGHT OF GIRLS.
Control.
Pasteurised "feeders."....
Weight-Pounds
65 60 55 50 45 40
165 123 148 130 78
138 123 168 147 100
Number of Cases


Age.
Age.
6¾
7¾
8¾
9¾
10¾
Diagram 9.
HEIGHT OF BOYS.
Raw milk "feeders" - - -
Pasteurised "feeders" . . . .
Diagram 10.
HEIGHT OF GIRLS.
Raw milk "feeders" - - - -
Pasteurised "feeders" . . . . .
Height—Inches.
52
50
48
46
44
42
73
76
71
77
60
74
56
74
64
59
Number of Cases

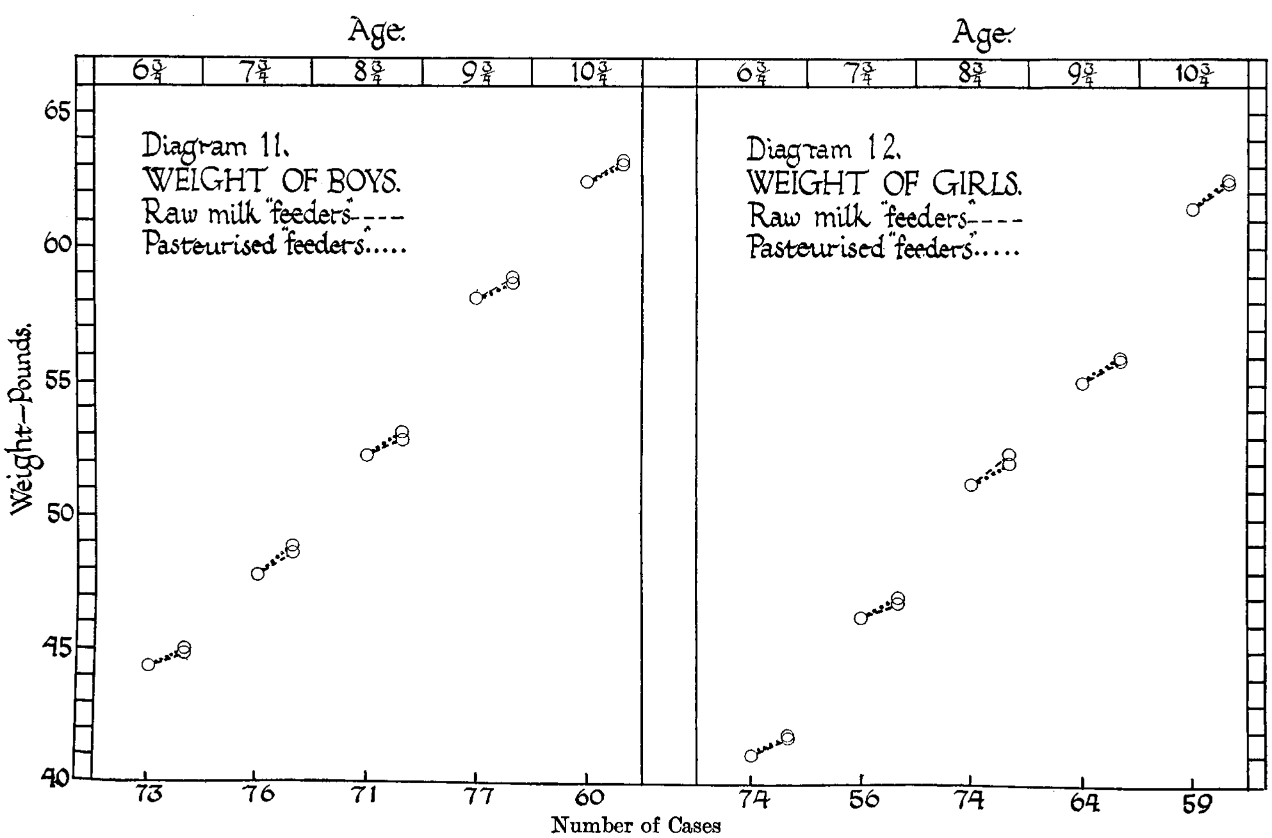

Age.
Age.
6¾
7¾
8¾
9¾
10¾
Diagram 11.
WEIGHT OF BOYS.
Raw milk "feeders" - - - -
Pasteurised "feeders" . . . . .
Diagram 12.
WEIGHT OF GIRLS.
Raw milk "feeders" - - - -
Pasteurised "feeders" . . . . .
Weight—Pounds.
65
60
55
50
45
40
73
76
71
77
60
74
56
74
64
59
Number of Cases

Table V. *Change in Height (in eighths of an inch). Males.*

Change in Height in eighths of an inch	Controls and Raw Milk Feeders											
	Controls						Raw Milk Feeders					
	Central Ages[1]						Central Ages[1]					
	$6\frac{3}{4}$	$7\frac{3}{4}$	$8\frac{3}{4}$	$9\frac{3}{4}$	$10\frac{3}{4}$	Totals	$6\frac{3}{4}$	$7\frac{3}{4}$	$8\frac{3}{4}$	$9\frac{3}{4}$	$10\frac{3}{4}$	Totals
0	4	2	1	1	3	11	2	.	2	.	.	4
1	4	4	10	6	4	28	1	2	3	.	.	6
2	6	7	8	10	12	43	5	4	10	7	5	31
3	10	17	15	8	13	63	10	10	9	9	8	46
4	12	13	17	19	19	80	14	11	11	16	9	61
5	20	20	21	13	18	92	9	22	21	8	19	79
6	23	22	20	24	10	99	27	25	18	20	9	99
7	18	17	15	8	9	67	26	18	24	13	18	99
8	27	17	13	9	7	73	22	11	14	16	17	80
9	13	5	10	5	3	36	12	11	13	9	8	53
10	1	9	4	4	4	22	8	13	4	3	4	32
11	5	3	1	1	1	11	.	6	1	7	4	18
12	1	2	1	3	.	7	1	2	7	4	2	16
13	.	.	3	1	1	5	2	1	.	1	1	5
14	.	.	1	3	1	5	2	2	1	2	.	7
15	.	.	1	.	.	1	1	.	1	1	.	3
16	.	.	.	.	.	.	2	.	.	.	.	2
17	.	.	.	.	.	.	.	.	1	.	1	2
18	.	.	.	.	.	.	.	.	.	.	.	.
19	.	.	.	.	.	.	.	.	.	.	.	.
20	.	.	.	.	.	.	.	.	1	.	.	1
21	.	.	.	.	.	.	.	.	.	.	.	.
22	.	.	.	1	.	1	.	.	.	.	.	.
Totals	144	138	141	116	105	644	144	138	141	116	105	644

Change in Height in eighths of an inch	Controls and Pasteurised Milk Feeders											
	Controls						Pasteurised Milk Feeders					
	Central Ages[1]						Central Ages[1]					
	$6\frac{3}{4}$	$7\frac{3}{4}$	$8\frac{3}{4}$	$9\frac{3}{4}$	$10\frac{3}{4}$	Totals	$6\frac{3}{4}$	$7\frac{3}{4}$	$8\frac{3}{4}$	$9\frac{3}{4}$	$10\frac{3}{4}$	Totals
0	1	2	1	.	2	6	1	.	4	.	.	5
1	5	3	8	7	2	25	1	.	.	1	2	4
2	4	3	6	8	5	26	1	5	5	4	5	20
3	14	6	14	12	6	52	7	7	11	10	5	40
4	19	9	24	23	16	91	17	14	14	22	15	82
5	24	28	22	25	19	118	19	21	25	26	17	108
6	24	17	26	16	8	91	26	21	32	19	9	107
7	26	17	15	18	6	82	23	26	22	16	12	99
8	20	15	15	11	3	64	38	17	13	11	4	83
9	14	7	3	2	7	33	12	5	11	11	1	40
10	6	7	3	2	1	19	12	4	6	7	3	32
11	4	4	7	.	2	17	3	2	3	3	3	14
12	2	4	.	3	.	9	1	.	2	.	.	3
13	2	.	3	1	1	7	.	.	.	.	.	.
14	.	.	1	1	.	2	2	1	.	.	1	4
15	.	1	.	1	.	2	.	.	.	.	.	.
16	.	.	.	.	.	.	.	.	.	.	.	.
17	.	.	.	.	.	.	2	.	.	.	.	2
18	.	.	.	.	.	.	.	.	.	.	.	.
19	.	.	.	.	.	.	.	.	.	.	1	1
20	.	.	.	.	.	.	.	.	.	.	.	.
21	.	.	.	.	.	.	.	.	.	.	.	.
22	.	.	.	.	.	.	.	.	.	.	.	.
Totals	165	123	148	130	78	644	165	123	148	130	78	644

Change in Height in eighths of an inch	Raw Milk Feeders and Pasteurised Milk F									
	Raw Milk Feeders						Pasteurised Mi			
	Central Ages[1]						Central A			
	$6\frac{3}{4}$	$7\frac{3}{4}$	$8\frac{3}{4}$	$9\frac{3}{4}$	$10\frac{3}{4}$	Totals	$6\frac{3}{4}$	$7\frac{3}{4}$	$8\frac{3}{4}$	$9\frac{3}{4}$
0	1	.	1	3	2	7	.	.	.	1
1	.	2	3	3	.	8	1	1	.	1
2	4	7	11	3	4	29	2	5	5	5
3	6	2	5	4	4	21	3	1	8	3
4	4	4	4	10	10	32	3	6	11	10
5	8	12	7	6	12	45	7	11	12	10
6	12	9	11	11	17	60	15	10	13	16
7	11	14	13	10	2	50	11	15	7	11
8	11	7	9	11	1	39	17	17	9	7
9	13	9	3	7	2	34	7	4	4	3
10	.	2	2	5	1	10	1	5	1	5
11	1	4	.	2	5	12	1	.	.	5
12	.	1	1	1	.	3	4	1	1	.
13	.	2	.	.	.	2	.	.	.	.
14	1	.	1	.	.	2	.	.	.	.
15	1	.	.	.	.	1	.	.	.	.
16	.	1	.	1	.	2	.	.	.	.
17	.	.	.	.	.	.	.	.	.	.
18	.	.	.	.	.	.	1	.	.	.
19	.	.	.	.	.	.	.	.	.	.
20	.	.	.	.	.	.	.	.	.	.
21	.	.	.	.	.	.	.	.	.	.
22	.	.	.	.	.	.	.	.	.	.
Totals	73	76	71	77	60	357	73	76	71	77

[1] Approximately.

Table VI. *Change in Height (in eighths of an inch). Females.*

Change in Height in eighths of an inch	Controls and Raw Milk Feeders											
	Controls						Raw Milk Feeders					
	Central Ages						Central Ages					
	$6\frac{3}{4}$	$7\frac{3}{4}$	$8\frac{3}{4}$	$9\frac{3}{4}$	$10\frac{3}{4}$	Totals	$6\frac{3}{4}$	$7\frac{3}{4}$	$8\frac{3}{4}$	$9\frac{3}{4}$	$10\frac{3}{4}$	Totals
0	2	.	2	3	1	8	1	3	2	3	1	10
1	5	4	9	3	6	27	1	4	8	5	5	23
2	7	4	7	16	8	42	2	3	4	5	8	22
3	10	6	22	8	11	57	8	6	5	17	12	48
4	11	23	17	17	14	82	10	17	22	15	9	73
5	23	18	16	27	19	103	15	14	12	9	13	63
6	30	24	26	22	18	120	20	22	24	18	10	94
7	24	18	7	16	7	72	29	18	13	23	11	94
8	12	16	11	9	10	58	28	17	15	13	25	98
9	13	7	7	5	10	42	11	17	14	9	6	57
10	5	2	3	2	2	14	8	6	7	8	6	35
11	1	2	2	2	7	14	2	.	4	3	2	11
12	.	1	1	1	.	3	2	.	2	2	2	8
13	1	1	1	.	2	5	.	.	.	2	1	3
14	.	1	1	.	.	2	.	.	.	1	.	1
15	.	1	.	1	.	2	2	.	.	.	1	3
16	.	.	.	.	.	.	1	.	.	.	1	2
17	.	.	.	.	.	.	.	.	.	.	2	2
18	.	.	1	1	.	2	3	.	1	.	.	4
19	.	.	.	.	.	.	1	.	.	.	.	1
20	.	.	.	.	.	.	.	1	.	.	.	1
21	.	.	.	.	.	.	.	.	.	.	.	.
22	.	.	.	.	.	.	.	.	.	.	.	.
23	.	.	.	.	.	.	.	.	.	.	.	.
24	.	.	.	.	.	.	.	.	.	.	.	.
25	.	.	.	.	.	.	.	.	.	.	.	.
Totals	144	128	133	133	115	653	144	128	133	133	115	653

Change in Height in eighths of an inch	Controls and Pasteurised Milk Feeders											
	Controls						Pasteurised Milk Feeders					
	Central Ages						Central Ages					
	$6\frac{3}{4}$	$7\frac{3}{4}$	$8\frac{3}{4}$	$9\frac{3}{4}$	$10\frac{3}{4}$	Totals	$6\frac{3}{4}$	$7\frac{3}{4}$	$8\frac{3}{4}$	$9\frac{3}{4}$	$10\frac{3}{4}$	Totals
0	.	3	3	5	1	12	2	.	1	2	1	6
1	1	4	9	8	2	24	1	1	3	3	2	10
2	3	9	14	15	9	50	6	7	5	3	4	25
3	16	11	13	17	9	66	6	15	9	11	6	47
4	13	13	29	14	16	85	22	7	19	16	19	83
5	17	18	24	20	19	98	11	13	35	24	19	102
6	35	28	29	30	15	137	23	22	24	23	11	103
7	21	14	23	12	12	82	19	18	21	16	6	80
8	12	11	10	9	8	50	27	15	22	28	9	101
9	7	8	6	9	6	36	8	18	13	8	8	55
10	4	1	5	1	1	12	7	2	6	3	6	24
11	2	1	1	2	1	7	4	2	6	3	3	18
12	2	.	.	1	.	3	2	2	4	5	1	14
13	2	2	.	3	1	8	.	.	.	.	.	.
14	.	.	.	.	.	.	.	1	.	2	2	5
15	2	.	.	.	.	2	.	.	.	.	.	.
16	.	.	.	.	.	.	.	.	.	.	1	1
17	.	.	2	.	.	2	.	.	.	.	2	2
18	.	.	.	.	.	.	.	.	.	.	.	.
19	.	.	.	.	.	.	.	.	.	.	.	.
20	.	.	.	1	.	1	.	.	.	.	.	.
21	.	.	.	.	.	.	.	.	.	.	.	.
22	.	.	.	.	.	.	.	.	.	.	.	.
23	.	.	.	.	.	.	.	.	.	.	.	.
24	.	.	.	.	.	.	.	.	.	.	.	.
25	1	.	.	.	.	1	.	.	.	.	.	.
Totals	138	123	168	147	100	676	138	123	168	147	100	676

Change in Height in eighths of an inch	Raw Milk Feeders and Pasteurised Milk F									
	Raw Milk Feeders						Pasteurised Mi			
	Central Ages						Central A			
	$6\frac{3}{4}$	$7\frac{3}{4}$	$8\frac{3}{4}$	$9\frac{3}{4}$	$10\frac{3}{4}$	Totals	$6\frac{3}{4}$	$7\frac{3}{4}$	$8\frac{3}{4}$	$9\frac{3}{4}$
0	2	.	.	.	.	2	1	.	2	2
1	2	2	.	1	1	6	2	.	1	3
2	1	1	4	5	.	11	2	2	3	1
3	1	4	3	4	1	13	5	4	4	4
4	2	2	11	11	16	42	6	5	5	10
5	10	3	14	6	7	40	8	10	14	8
6	16	9	13	14	2	54	13	10	17	10
7	14	4	6	7	9	40	14	9	5	6
8	11	10	10	7	9	47	13	3	8	10
9	5	10	4	2	5	26	2	9	6	3
10	3	3	4	3	2	15	6	1	5	5
11	.	4	.	1	3	8	2	2	3	.
12	1	1	3	.	1	6	.	.	1	2
13	1	.	2	1	.	4	.	.	.	.
14	1	.	.	1	2	4	.	.	.	.
15	.	.	.	.	1	1	.	1	.	.
16	.	.	.	.	.	.	.	.	.	.
17	3	1	.	.	.	4	.	.	.	.
18	1	.	.	.	.	1	.	.	.	.
19	.	.	.	1	.	1	.	.	.	.
20	.	.	.	.	.	.	.	.	.	.
21	.	2	.	.	.	2	.	.	.	.
22	.	.	.	.	.	.	.	.	.	.
23	.	.	.	.	.	.	.	.	.	.
24	.	.	.	.	.	.	.	.	.	.
25	.	.	.	.	.	.	.	.	.	.
Totals	74	56	74	64	59	327	74	56	74	64

Table VII. *Change in Weight (in ounces). Males.*

Change in Weight in ounces	Controls and Raw Milk Feeders											
	Controls						Raw Milk Feeders					
	Central Ages						Central Ages					
	6¾	7¾	8¾	9¾	10¾	Totals	6¾	7¾	8¾	9¾	10¾	Totals
−59 to −67	.	.	.	1	.	1	.	.	.	.	.	.
−50 to −58	.	.	.	.	1	1	.	.	1	.	2	3
−41 to −49	1	.	.	.	.	1	.	1	.	.	.	1
−32 to −40	1	1	4	2	3	11	1	3	2	4	3	13
−23 to −31	4	3	4	1	4	16	.	2	2	1	5	10
−14 to −22	4	5	16	8	12	45	6	5	11	4	6	32
− 5 to −13	13	14	8	15	4	54	22	14	7	13	14	70
− 4 to + 4	23	24	18	17	14	96	20	14	27	17	5	83
5 to 13	32	29	31	20	21	133	30	25	26	13	9	103
14 to 22	25	31	26	24	23	129	26	33	24	22	25	130
23 to 31	19	14	18	14	9	74	24	16	20	19	6	85
32 to 40	12	9	6	6	4	37	10	17	10	14	11	62
41 to 49	6	3	5	7	6	27	3	5	2	5	12	27
50 to 58	2	3	1	1	1	8	1	3	4	3	2	13
59 to 67	2	1	1	.	2	6	.	.	3	.	.	3
68 to 76	.	.	1	.	.	1	.	.	2	1	2	5
77 to 85	.	.	2	.	.	2	.	.	.	.	3	3
86 to 94	.	1	.	.	.	1	1	.	.	.	.	1
95 to 103	.	.	.	.	.	.	.	.	.	.	.	.
104 to 112	.	.	.	.	.	.	.	.	.	.	.	.
113 to 121	.	.	.	.	1	1	.	.	.	.	.	.
Totals	144	138	141	116	105	644	144	138	141	116	105	644

Change in Weight in ounces	Controls and Pasteurised Milk Feeders											
	Controls						Pasteurised Milk Feeders					
	Central Ages						Central Ages					
	6¾	7¾	8¾	9¾	10¾	Totals	6¾	7¾	8¾	9¾	10¾	Totals
−59 to −67	.	.	1	.	.	1	.	.	1	.	.	1
−50 to −58	.	1	.	.	.	1	.	.	.	.	.	.
−41 to −49	1	1	.	1	1	4	.	.	.	.	.	.
−32 to −40	.	.	6	2	1	9	1	1	3	4	1	10
−23 to −31	2	3	2	3	1	11	.	2	2	2	3	9
−14 to −22	4	5	4	14	4	31	5	5	2	7	13	32
− 5 to −13	11	9	19	9	10	58	11	10	11	12	6	50
− 4 to + 4	29	23	29	23	11	115	27	11	19	24	8	89
5 to 13	40	18	22	17	12	109	30	28	35	20	6	119
14 to 22	29	25	32	23	11	120	42	28	28	28	19	145
23 to 31	19	20	10	16	6	71	24	15	18	14	13	84
32 to 40	13	12	14	10	17	66	12	9	13	10	4	48
41 to 49	6	3	5	8	3	25	10	8	8	4	2	32
50 to 58	6	2	2	4	.	14	1	1	5	4	1	12
59 to 67	4	1	.	.	1	6	2	2	2	1	.	7
68 to 76	1	.	.	.	.	1	.	3	.	.	.	3
77 to 85	.	.	2	.	.	2	.	.	1	.	2	3
86 to 94	.	.	.	.	.	.	.	.	.	.	.	.
95 to 103	.	.	.	.	.	.	.	.	.	.	.	.
104 to 112	.	.	.	.	.	.	.	.	.	.	.	.
113 to 121	.	.	.	.	.	.	.	.	.	.	.	.
Totals	165	123	148	130	78	644	165	123	148	130	78	644

Change in Weight in ounces	Raw Milk Feeders and Pasteurised Milk									
	Raw Milk Feeders						Pasteurised M			
	Central Ages						Central			
	6¾	7¾	8¾	9¾	10¾	Totals	6¾	7¾	8¾	9¾
−59 to −67	.	.	.	.	.	.	.	.	.	.
−50 to −58	.	.	.	.	1	1	.	.	.	.
−41 to −49	.	.	2	.	.	2	.	.	.	.
−32 to −40	1	.	1	.	.	2	.	1	.	1
−23 to −31	2	3	.	2	.	7	2	2	2	6
−14 to −22	6	5	7	6	1	25	5	7	1	2
− 5 to −13	9	8	3	8	7	35	7	7	5	7
− 4 to + 4	17	6	17	12	12	64	7	8	16	11
5 to 13	10	17	13	8	10	58	16	11	14	16
14 to 22	11	15	14	23	14	77	17	11	17	17
23 to 31	7	9	6	5	4	31	13	10	8	7
32 to 40	7	6	4	6	5	28	3	10	6	7
41 to 49	2	5	.	5	1	13	2	6	1	3
50 to 58	.	2	1	.	3	6	.	.	.	.
59 to 67	1	.	2	1	1	5	1	1	.	.
68 to 76	.	.	1	1	1	3	.	.	1	.
77 to 85	.	.	.	.	.	.	.	.	.	.
86 to 94	.	.	.	.	.	.	.	1	.	.
95 to 103	.	.	.	.	.	.	.	.	.	.
104 to 112	.	.	.	.	.	.	.	.	.	.
113 to 121	.	.	.	.	.	.	.	1	.	.
Totals	73	76	71	77	60	357	73	76	71	77

Table VIII. *Change in Weight (in ounces). Females.*

Change in Weight in ounces	Controls and Raw Milk Feeders											
	Controls						Raw Milk Feeders					
	Central Ages						Central Ages					
	6¾	7¾	8¾	9¾	10¾	Totals	6¾	7¾	8¾	9¾	10¾	Totals
−59 to −67	.	.	1	.	.	1	.	.	.	.	.	.
−50 to −58	.	.	.	1	.	1	.	.	1	.	1	2
−41 to −49	.	.	2	.	2	4	.	.	.	.	.	.
−32 to −40	2	2	1	9	1	15	1	2	2	1	1	7
−23 to −31	4	1	8	6	6	25	6	5	5	3	3	22
−14 to −22	6	6	12	14	14	52	6	6	3	13	2	30
− 5 to −13	14	17	26	10	12	79	11	18	16	9	11	65
− 4 to + 4	26	23	20	26	15	110	24	22	21	22	14	103
5 to 13	26	31	22	16	27	122	32	20	20	27	20	119
14 to 22	27	22	17	20	12	98	25	24	25	23	13	110
23 to 31	27	9	10	16	8	70	26	10	14	14	18	82
32 to 40	8	12	6	3	9	38	8	7	15	14	14	58
41 to 49	3	4	4	6	1	18	5	10	5	1	5	26
50 to 58	.	1	2	1	4	8	.	2	5	3	3	13
59 to 67	.	.	.	4	2	6	.	1	1	.	3	5
68 to 76	1	.	.	1	1	3	.	.	.	1	3	4
77 to 85	.	.	2	.	1	3	.	.	.	1	2	3
86 to 94	.	.	.	.	.	.	.	1	.	1	2	4
95 to 103	.	.	.	.	.	.	.	.	.	.	.	.
104 to 112	.	.	.	.	.	.	.	.	.	.	.	.
113 to 121	.	.	.	.	.	.	.	.	.	.	.	.
Totals	144	128	133	133	115	653	144	128	133	133	115	653

Change in Weight in ounces	Controls and Pasteurised Milk Feeders											
	Controls						Pasteurised Milk Feeders					
	Central Ages						Central Ages					
	6¾	7¾	8¾	9¾	10¾	Totals	6¾	7¾	8¾	9¾	10¾	Totals
−59 to −67	.	.	.	1	.	1	.	.	1	.	.	1
−50 to −58	1	.	.	.	1	2	.	.	.	.	.	.
−41 to −49	.	.	1	.	2	3	.	.	.	2	2	4
−32 to −40	.	1	1	6	.	8	1	.	.	2	2	5
−23 to −31	.	.	10	6	5	21	2	1	3	5	4	15
−14 to −22	6	8	7	14	5	40	6	4	16	13	4	43
− 5 to −13	17	16	22	8	12	75	9	12	12	14	11	58
− 4 to + 4	20	27	37	35	10	129	29	21	28	14	15	107
5 to 13	36	20	26	26	18	126	12	27	28	23	16	106
14 to 22	25	22	28	26	14	115	48	32	35	17	9	141
23 to 31	21	16	20	13	12	82	21	14	19	14	12	80
32 to 40	9	8	8	3	7	35	6	6	14	15	9	50
41 to 49	2	4	2	6	5	19	3	3	7	13	8	34
50 to 58	.	1	4	2	5	12	.	.	3	7	4	14
59 to 67	1	.	1	1	1	4	1	.	.	3	3	7
68 to 76	.	.	1	.	2	3	.	.	1	3	1	5
77 to 85	.	.	.	.	.	.	.	.	.	1	.	1
86 to 94	.	.	.	.	.	.	.	2	1	1	.	4
95 to 103	.	.	.	.	1	1	.	1	.	.	.	1
104 to 112	.	.	.	.	.	.	.	.	.	.	.	.
113 to 121	.	.	.	.	.	.	.	.	.	.	.	.
Totals	138	123	168	147	100	676	138	123	168	147	100	676

Change in Weight in ounces	Raw Milk Feeders and Pasteurised Milk									
	Raw Milk Feeders						Pasteurised M			
	Central Ages						Central			
	6¾	7¾	8¾	9¾	10¾	Totals	6¾	7¾	8¾	9¾
−59 to −67	.	.	.	.	.	.	.	.	1	.
−50 to −58	.	.	.	1	.	1	.	.	.	.
−41 to −49	.	.	.	1	1	2	.	.	.	.
−32 to −40	.	1	.	.	1	2	.	.	.	.
−23 to −31	3	1	.	4	3	11	3	.	.	4
−14 to −22	5	5	5	7	5	27	2	2	5	4
− 5 to −13	9	8	5	2	7	31	11	4	8	9
− 4 to + 4	10	7	8	9	8	42	11	11	13	13
5 to 13	19	13	9	11	8	60	15	13	16	8
14 to 22	9	6	17	7	5	44	19	12	9	6
23 to 31	11	6	5	10	7	39	10	6	6	3
32 to 40	6	7	16	8	5	42	1	6	6	9
41 to 49	2	2	3	1	3	11	.	.	5	3
50 to 58	.	.	5	2	.	7	1	1	1	4
59 to 67	.	.	1	.	2	3	.	1	.	.
68 to 76	.	.	.	.	2	2	1	.	2	.
77 to 85	.	.	.	1	.	1	.	.	2	.
86 to 94	.	.	.	.	2	2	.	.	.	1
95 to 103	.	.	.	.	.	.	.	.	.	.
104 to 112	.	.	.	.	.	.	.	.	.	.
113 to 121	.	.	.	.	.	.	.	.	.	.
Totals	74	56	74	64	59	327	74	56	74	64

An attempt was made to discover whether the smaller children gained more over the controls from the extra milk than the other children but within the range of heights and weights available the η's were insignificant; if the pairing were done at the beginning of the experiment in the schools the question could have been answered, and it is one of importance as the undergrown child might profit more by extra milk than the child of normal size.

Six diagrams have been constructed from the data in Table III (for which I am indebted to Miss N. T. Pridham) which attempt to indicate the growth of the children in the different groups. The initial height and weight is shown for each age group, the centres being at $6\frac{3}{4}$, $7\frac{3}{4}$, etc. approximately, and the height and weight of the children four months later has been plotted; one cannot assume that the children at the earlier ages who have milk will have the initial height and weight of the selected children of the next age group and consequently no continuous growth curve can be drawn. Nor can we assume that if the children receiving milk for four months had received it from six to eleven years of age their gain over the controls would be the sum of the gains of children at different ages, for it is not only possible, but not improbable that the effect of the additional milk would slacken as the child attained a size, which for want of a better expression, we may term natural to its constitution.

Conclusions.

From this selected material in which the children have the same initial height and weight within fixed limits but in which all undergrown and overgrown children are omitted we conclude:

(1) That those who have extra milk generally gain in height over those who do not and that the older girls gain more than the younger when pasteurised milk is taken, but that otherwise younger and older gain equally in height by having extra milk.

(2) That those who have extra milk generally gain in weight over those who do not; that girls gain more than boys, and the older girls than the younger, and that this difference associated with age is greater when raw milk is taken than when pasteurised is added to the diet. In the poorer classes milk is largely reserved for the younger children, and accordingly there might be less difference between extra-milk feeders and control when the children are young than when they are older. Further the elder girls are nearer pubescence, a period during which girls put on weight from any available source and too often lack a diet with enough fats.

(3) There is no evidence that raw milk has an advantage over pasteurised or pasteurised over raw in increasing growth when the two are directly compared on this selected material. Thus the question of the value of pasteurisation turns practically on the elimination of possible sources of disease, or on determining whether cases of certain diseases are less frequent when pasteurised rather than raw milk is taken*.

(4) I heartily endorse the suggestion made by "Student" in his paper in *Biometrika*, Vol. XXIII, to which reference has been made before, that "controls" and "feeders" should be chosen in pairs of the same age and sex and as similar in height and weight and physical condition as possible, and that the one to be given milk be decided by tossing a coin; it is the method I have tried in this paper, but the weakness in my work is that the undergrown and overgrown children have been omitted, and that no knowledge of the general physical condition of the children was available.

* A certain number of children in both series of milk receivers fell out for causes not stated. A knowledge of these causes might be of the greatest importance in judging between the relative value of raw and pasteurised milk feeding.

APPENDIX TO DR ELDERTON'S PAPER ON "THE LANARKSHIRE MILK EXPERIMENT"

By KARL PEARSON.

It may not be without interest to indicate by a single probability value the result of each of the twelve sets of experiences illustrated graphically in Dr Elderton's diagrams. The method I shall apply will be that of the (P, λ_n) test. If $x_1, x_2, \ldots, x_s, \ldots, x_n$ be n quantities which follow a supposed law $\phi(x)$ of distribution, then let the probability integrals of these n quantities, i.e. $p_s = \int_{x_s}^{a} \phi(x)\,dx$, be computed, where a is the end of the range of x. Let λ_n = the continuous product of $p_1, p_2, \ldots, p_s, \ldots, p_n$, be ascertained. Then the probability of a sample differing more from randomness than $x_1, x_2, x_s, \ldots, x_n$ does, is given by $P_{\lambda_n} = 1 - I\,(n-1, -\log_{10}\lambda_n/(\sqrt{n}\log_{10}e)$, where I is the incomplete Γ-function ratio usually represented by $I, (p, u)$ which can be found at once from the *Tables of the Incomplete Γ-Function**.

In Dr Elderton's case we have the difference of two means which we may suppose to be due to two random samples from the same population. If we divide such a difference by the standard deviation of the difference as computed from the samples, we have a quantity which should be a random sample from the "z" distribution of "Student." The published tables of "z" do not go far enough to provide the requisite probability integrals. This is not, however, serious, as for the size of samples in Dr Elderton's cases, no error of importance for our present purposes will arise, if we use the normal curve to represent the "z" curve.

We may take one illustration of the method, namely Boys' Height in the case of pasteurised milk feeders and control.

Centre of Age Group	Number	$m_p - m_c$	S.D.	z	Probability Integral p	$\log_{10} p$
$6\frac{3}{4}$	165	·094	·035	2·69	·003,5726	$\bar{3}$·552,9844
$7\frac{3}{4}$	123	− ·027	·038	−·71	·761,1479	$\bar{1}$·881,4690
$8\frac{3}{4}$	148	·046	·037	1·24	·107,4877	$\bar{1}$·031,3602
$9\frac{3}{4}$	130	·068	·037	1·84	·032,8841	$\bar{2}$·516,9859
$10\frac{3}{4}$	78	·057	·054	1·06	·144,5723	$\bar{1}$·160,0845
					Sum=	$\bar{6}$·142,8840

$\sqrt{n}\log_{10}e = \sqrt{5} \times 434{,}2945 = \cdot971{,}1120,\qquad -\log_{10}\lambda n = \quad 5\cdot857{,}1160$

Accordingly $u = -\dfrac{\log_{10}\lambda_n}{\sqrt{n}\log_{10}e} = 6\cdot03145$, and $P_{\lambda_n} = 1 - I\,(n-1,\, u) = 1 - I\,(4,\, 6\cdot03145)$. Interpolating linearly from the *Incomplete Γ-Function Tables*, we have $P_{\lambda_n} = 1 - \cdot9974 = \cdot0026$. This signifies that, if the control and pasteurised milk feeders were random samples from "z" populations, only 26 times in 10,000 trials would on the average a pair of samples occur differing so much from one another as these two do. We therefore conclude that as far as the stature of boys is concerned the effect of the additional pasteurised milk does differentiate the feeders from the control boys.

Proceeding in this manner I computed from Dr Elderton's data the value of $\log_{10}\lambda_n$ for her

* H.M. Stationery Office, 1922.

twelve cases and thence determined the probability P_{λ_n} that the observed differences could arise from random sampling, and accordingly were independent of the extra milk-feeding, or of its nature. I reached the following system of values:

Table of P_{λ_n}. *Measuring the Probability of Randomness.*

Difference of Means	Boys		Girls	
	Stature	Weight	Stature	Weight
Raw Milk—Control	< ·000,00005	·0588	·000,00055	·00011
Pasteurised Milk—Control	·0026	·1130	< ·000,00005	·00022
Raw—Pasteurised Milk	·7381	·6461	·0088	·6032

Now let us consider these values individually.

(i) *Stature.* In the case of both boys and girls we must discard the hypothesis of randomness. Raw milk undoubtedly accelerated the growth of stature.

In the case of girls certainly, and in the case of boys it is highly probable, although less so than for girls, that pasteurised milk accelerated the growth of stature.

(ii) *Weight.* In the case of boys it cannot be predicated definitely that either raw or pasteurised milk accelerated the growth in weight. In the case of girls it can be asserted that the use of both raw and pasteurised milk accelerated the growth in weight. The probabilities of randomness are of a totally different order from those for the boys.

Can we find any explanation of this sex-difference in the case of weight between boys and girls, while for stature the growth acceleration of both is marked? Is it possible that the milk giving greater growth to the boys, also gives them greater energy, and exercising it, the milk administration does not lead to greater weight than in the control series? In the case of the girls the administration of the milk may lead to a storage of this additional nutrition, and it may not be spent in greater activity in games, etc. This view might be supported by the fact that it is the elder girls, not the younger, which show the superiority of the milk-feeders' growth in weight. This divergence between boys and girls might possibly be taken as an instance of that katabolism of the male and anabolism of the female on which some writers, perhaps too emphatically, have insisted.

(iii) *Difference of the two Types of Milk.* In the case of the boys both for stature and weight there appears to be no evidence whatever that one type of milk more than the other accelerates the growth. This is also true of weight in the girls. But we have the remarkable result that in girls the two types of milk are not indifferent with regard to the acceleration of growth in stature, randomness here is highly improbable, and raw milk seems more advantageous than pasteurised; but why should raw milk have a constituent which accelerates stature growth in girls but not in boys, while the factors for the production of weight acceleration appear to be the same for both types of milk? If this result be true—and it is difficult on the data to disregard it—it would appear that there is some sexual difference in the constituents required for bone growth in the young male and female; or possibly there is a constituent of some form in raw milk, which form preserves it from immediate conversion into fat, so that it may serve better for bone creation. This point deserves fuller physiological investigation.

Of course there is nothing in these results which touches on the question of whether pasteurisation is of value as a preventive of possible disease. But they do seem to indicate that while milk in either form accelerates the growth of both boys and girls in stature, and of girls in weight, yet raw milk has a greater influence than pasteurised in accelerating the growth of stature in girls.