THE DIAMETERS OF RED CELLS IN PERNICIOUS ANÆMIA AND IN ANÆMIA FOLLOWING HÆMORRHAGE.*

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By the method already described (1920[1]), dried blood films were prepared and the diameters of 500 red cells in each were measured to 0·25 μ. The mean diameter of 500 cells was taken to represent the mean diameter of the red cells for any specimen of blood.

Blood films were made from twenty healthy persons, twenty cases of pernicious anæmia, and ten cases of anæmia following hæmorrhage. Of the healthy persons sixteen were in ordinary occupation at the hospital, and four being older were living sedentary lives. It was shown (1921[2]) that there is no correlation between the sizes of red cells and the age of the individual. The specimens were all obtained as nearly as possible at the same time of the forenoon. The pernicious anæmia cases were all clinically diagnosed as such. They were in various stages of the disease and in some cases the diagnosis was confirmed post-mortem. The hæmorrhage anæmia cases were all suffering from varying degrees of anæmia, at varying periods after hæmorrhage from different sources—gastric and uterine—and of varying amounts.

The details of the measurements are given in Tables I., II., III., and IV., and are summarised in Tables V. and VI. (pp. 500-504).

From Table V. it appears:—

(*a*) That the mean diameter of the red cells in pernicious anæmia is greater than the mean diameter of the red cells in healthy persons. The smallest mean diameter of the pernicious anæmia cases is equal to the largest mean diameter of the healthy persons, but otherwise they do not overlap, or, in other words, all the mean diameters of the pernicious anæmia cases are greater than those of the healthy persons excepting one.

(*b*) That the mean diameter of the red cells in the cases of anæmia following hæmorrhage is smaller than the mean diameter of the red cells in healthy persons. The biggest mean diameter is less than the average mean diameter of the healthy persons. In seven out of ten

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of the cases the mean diameter is less than the smallest mean diameter of the healthy persons.

(*c*) The mean coefficient of variation of the red cells of the pernicious anæmia cases is more than twice the mean coefficient of variation of the healthy persons, and the smallest coefficient of variation of these cases is greater than the biggest coefficient of variation of the healthy persons.

(*d*) The mean coefficient of variation of the red cells of the hæmorrhage anæmia cases is half as much again greater than the mean

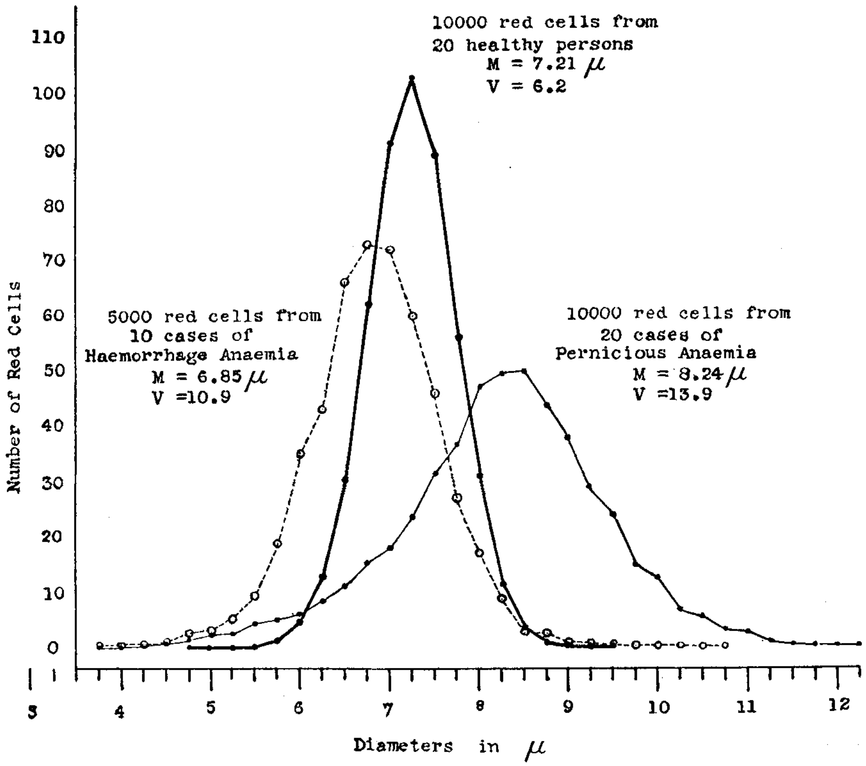

Fig. 1.*

coefficient of variation of the red cells of the healthy persons, and the smallest coefficient of variation is equal to the biggest coefficient of variation of the healthy persons.

If all the red cells in each class are brought together into three groups, a procedure which is obviously not altogether legitimate on account of the heterogeneous nature of the material, we obtain the results given in Table VI.

Both in pernicious anæmia and hæmorrhage anæmia there are some cells which are larger than the largest cells of the healthy persons, and others which are smaller than the smallest. This is demonstrated in

* The Curves (figs. 1 to 11) are reduced to the size of a curve of 500 cells.

Fig. 1. In Figs. 2 and 3 sets of distribution curves of the red cells of individual cases are shown. It is between these that comparison is more properly made. Similar graphical representations have been drawn of all the fifty cases. The most marked feature of these curves is the similarity amongst themselves of the healthy cases and the wide dissimilarity among the pernicious anæmia cases, and to a rather less extent among the hæmorrhage anæmia cases.

Generally speaking, the curves of the healthy cells have a more or less symmetrical form. The curves of pernicious anæmia lie to the

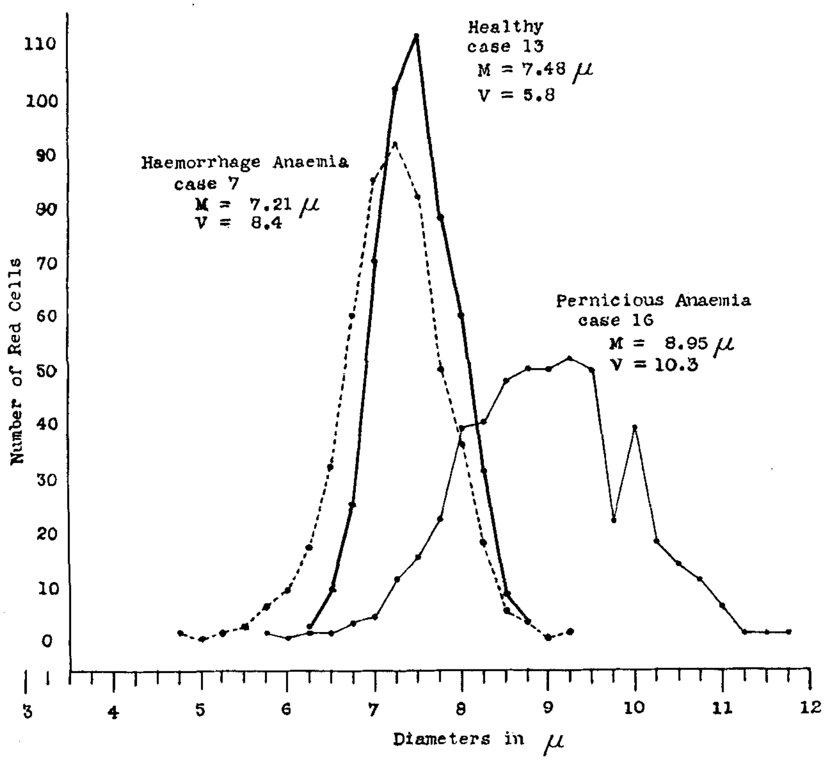

Fig. 2.

right of the healthy curve and are more or less, often extremely, asymmetrical. The curves of the hæmorrhage anæmia lie to the left of the healthy curve and are asymmetrical in type, though to a much less degree than the curves of pernicious anæmia.

The coefficient of variation of the mean diameters of the twenty healthy persons is 16, of the ten cases of hæmorrhage anæmia 42, and of the twenty cases of pernicious anæmia 48. The figure for the healthy cases seems high for a linear dimension, but the number of cases is small and it is known that the size of the red cells in any individual is liable to very considerable variation with exercise, time of day, etc. (1920 [1]) so that the material is likely to be exceptionally variable. But the difference in comparison with the abnormal cases is clear enough.

In Tables II. and III. the cases are arranged in order of their hæmoglobin percentages. From these it appears that there is no correlation between the hæmoglobin percentages and the mean red cell diameters, nor between the hæmoglobin percentages and the variability. It is possible that the want of correlation is due to a variable amount of hæmoglobin in the individual red cells, and that whereas in health the amount of hæmoglobin is proportional to the

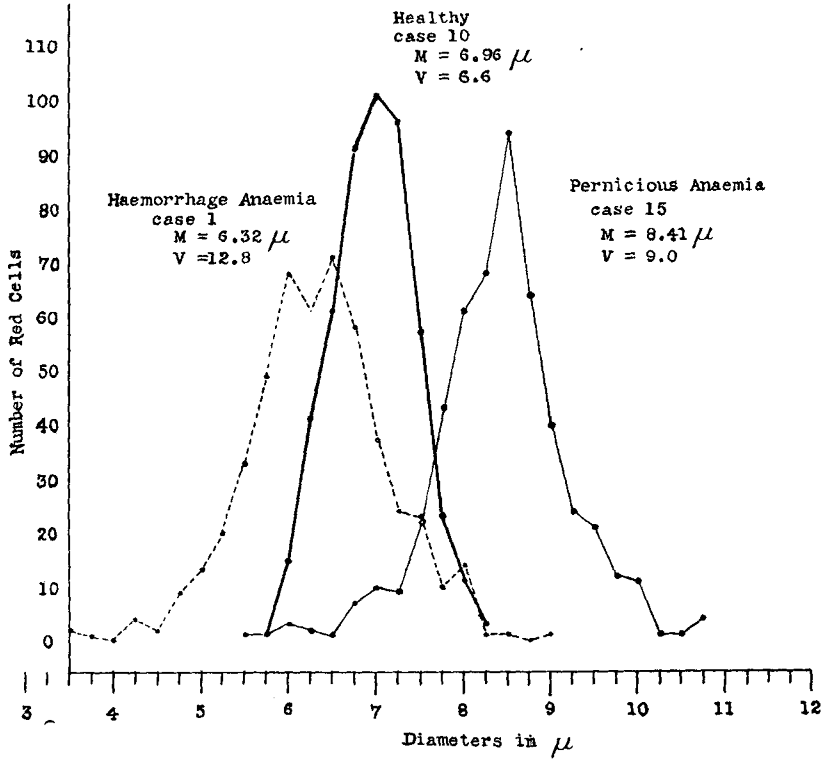

FIG. 3.

size of the cell, in unhealthy cells this relation does not hold. It is common knowledge that the red cells of anæmic blood stain unequally with eosin, and polychromasic red cells, which are constantly present in these cases, very probably contain less hæmoglobin than the normal cells of the same size.

All the measurable properties and products of living things are arranged according to the normal curve of variation, and it may be presumed that the red cells of the blood are no exception. In other words, the majority of the cells will have a diameter near to the mean diameter, and at increasing distances on either side of the mean the number of cells will be progressively fewer. Thus in a case where the mean diameter is 7·28 μ, two-thirds of the cells are found to lie between 6·50 μ and 8·0 μ, and only about 6 per thousand are smaller than 6 μ or greater than 8·50 μ.

More precisely, the "normal" Gaussian curve is a symmetrical binomial curve, the nature and properties of which are described in

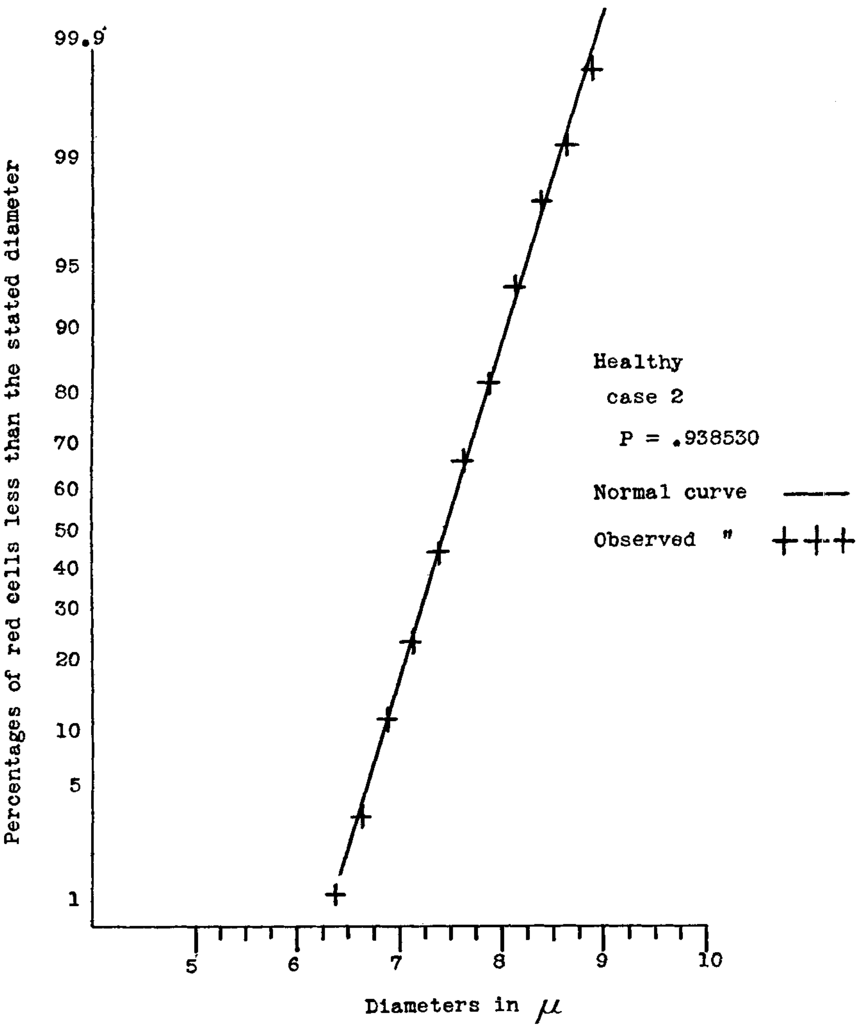

Fig. 4.

books on statistics (Yule, 1919[3], chap. xv.; Bowley, 1920[4], Bk. II., chaps. ii. and iii.). An ideal symmetrical curve with its base line bounds an area or polygon which is divided into two equal parts by the mean ordinate, the mode, median and mean being identical. Given the number of observations (frequencies), the mean value and the standard deviation, it is possible to construct a corresponding normal curve for any sample of a population or collection of variables from a calculation of the values of the ordinates at different distances from the mean ordinate. Since the mean ordinate divides the polygon into two equal parts, each portion is 50 per cent. or 0·5. With an ordinate at a distance of 0·1 times the standard deviation from the mean, there will

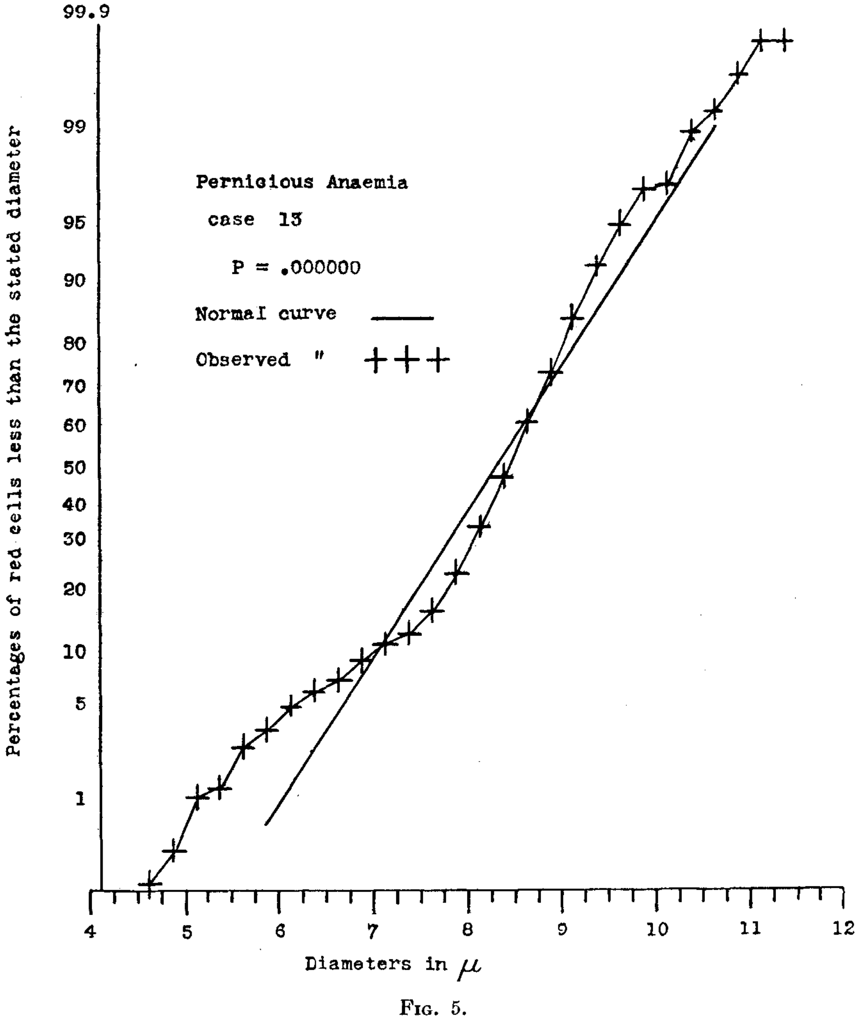

FIG. 5.

be 0·53983 of the whole area on one side and 0·46017 on the other. With an ordinate at a distance from the mean equal to the standard deviation, about 16 per cent. of the area will be cut off and the greater fraction will be 0·84134. With an ordinate at a distance from the mean equal to twice the standard deviation, only 2·3 per cent. will be cut off and therefore the greater fraction will be 0·97725. Tables have been constructed giving the calculated values for the areas at any distance from the mean (Yule, *loc. cit.*, p. 310). The symmetrical curve formed by these ordinates is the "normal" curve.

The theoretical curve which is calculated in this way could be expected always to correspond exactly with the curve of the observed data only if the whole of a large population (in this case all the red cells in the whole blood) had been measured. In practice it is possible to examine only a sample, and 500 cells is a convenient number, bearing in mind that the precision of the result varies as the square

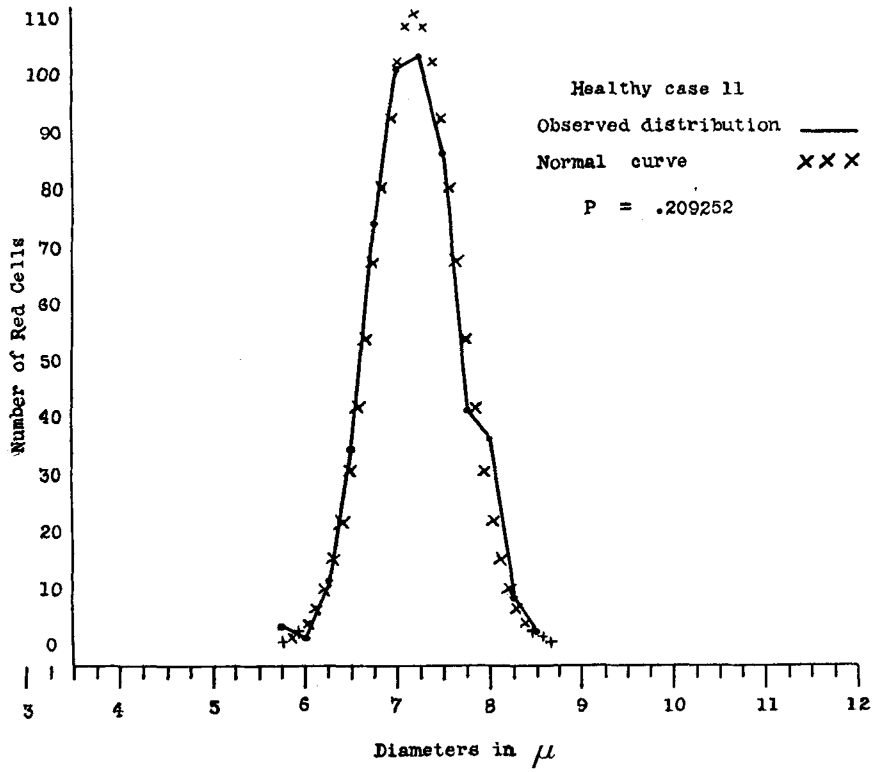

FIG. 6.

root of the number measured (1920 [1]). Owing to the error of random sampling, the correspondence between the actual and calculated curves of distribution will in the great majority of these samples be more or less imperfect. When the correspondence is so slight that it would seem unlikely or impossible that the measured sample could belong to a population of cells distributed according to size exactly on the normal curve, there is a strong presumption that the population is not homogeneous but is composed of a mixture of two or more groups of individuals, each group varying according to the normal curve. If, on the other hand, the correspondence between the two curves is good there is no *primâ facie*

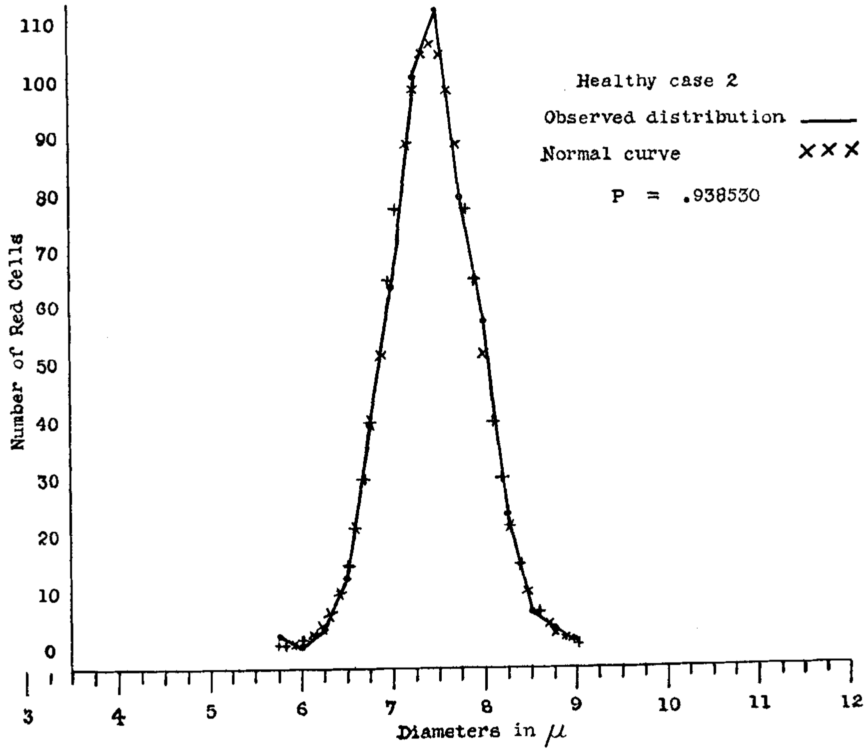
Healthy case 2
Observed distribution
Normal curve
P = .938530
Number of Red Cells
Diameters in μ

FIG. 7.

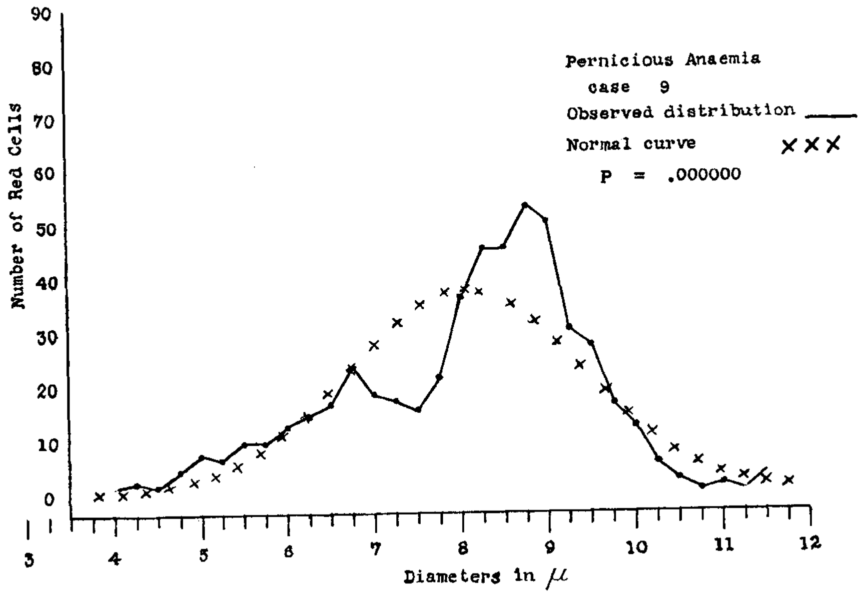
Pernicious Anaemia
case 9
Observed distribution
Normal curve
P = .000000
Number of Red Cells
Diameters in μ

FIG. 8.

reason to suspect heterogeneity, though it does not necessarily follow that it is certainly absent.

Two ways were taken to demonstrate the differences between the observed figures and their respective calculated normal curves.

1. By the use of "Probability Paper." This variety of ruled paper was invented by Dr Allen Hazen and is described by G. C. Whipple (1919 [5]). When the percentage values of the mean ordinate and the ordinates at distances of one, two, and three times the standard deviation on either side of the mean (0·003, 2·3, 15·9, 84·1, 97·7, and 99·99 per cent.) of the normal curve are plotted on this paper the result is a straight line. If on the same diagram the percentages of the progressively summed frequencies (summed ordinates) of the

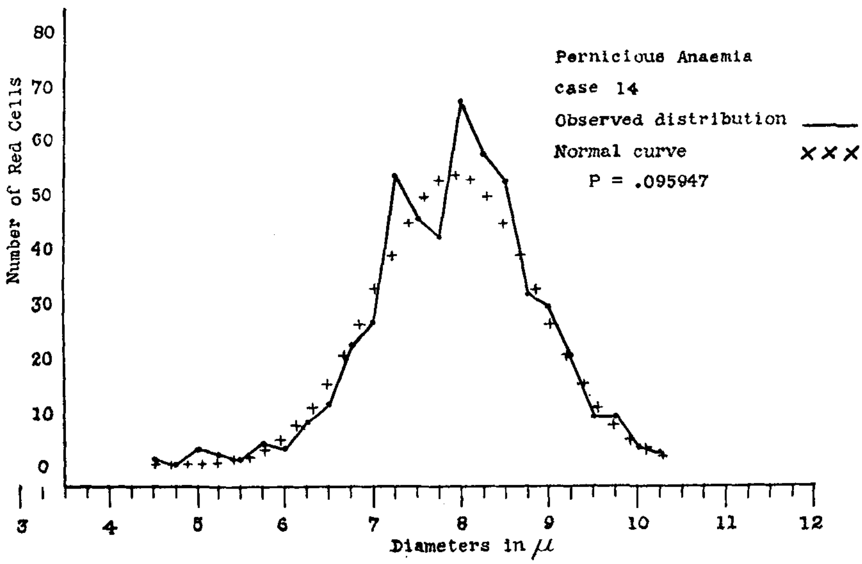

Fig. 9.

corresponding observed distribution are plotted, the degree of departure from the straight line is a measure of the want of correspondence. This seems to be a quick and convenient plan. At present unfortunately, to the best of my belief, this special form of ruled paper cannot be obtained in this country, and I have to thank Prof. Whipple for a supply of it.

Examples of this method are given in Figs. 4 and 5, which show the close correspondence in a healthy case and the marked divergence in a case of pernicious anæmia.

It is, however, well to emphasise the fact that the comparison of curves by the mere ocular inspection of graphs is apt to be extremely misleading, and excepting in cases of wide and obvious divergence such comparisons would be of small value.

2. I have found it more satisfying but certainly much more

laborious to calculate the normal curves by the method given by Yule[3] (p. 307). Examples are given in Figs. 6 to 11 showing the observed curves of distribution of the red cell diameters from healthy persons, cases of pernicious anæmia and hæmorrhage anæmia, superposed on their respective normal curves.

The quantitative measure of the goodness or badness of correspondence or "fit" was carried out by Karl Pearson's χ^2 method (1914[6,7]). There finally emerges from this procedure a figure "P" which is a measure of the goodness of fit. When P = 0·50 it means that 50 out of 100 samples from a population varying according to the normal curve would diverge more from the normal distribution

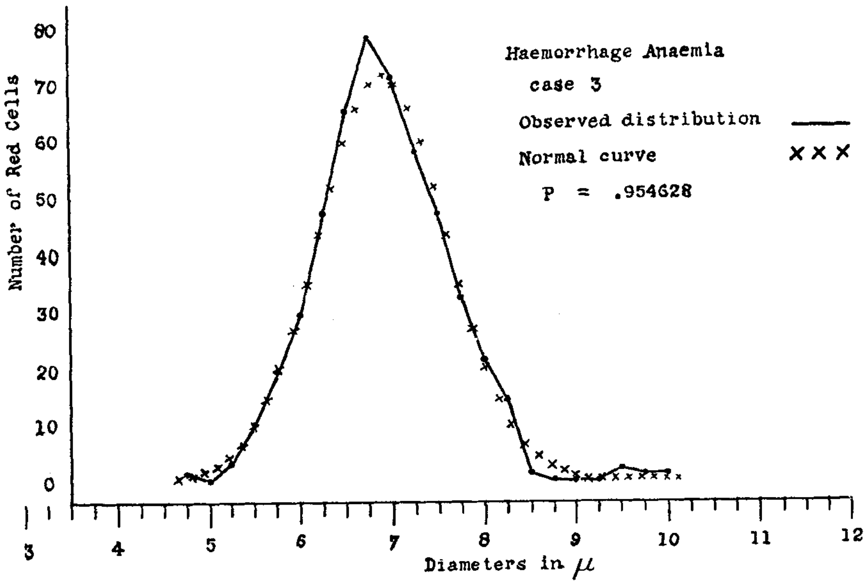

Fig. 10.

than the sample under consideration, in other words, the fit is fairly good. When P = 0·999999 it means that with 999,999 out of 1,000,000 samples there would be a worse fit, or the sample under consideration is practically a perfect fit. When P = 0·001 it means that only once in 1000 samples would a worse fit be met with, and the divergence is so great that it is impossible to imagine that the sample belongs to a normal population. The value of P depends to some extent upon the judgment used in forming the groups of figures for the calculation. Inasmuch as "good" and "bad" are relative terms, the interpretation of P is dependent on the stringency of the criteria which are chosen for dealing with the question of chances. It seems reasonable to regard P = 0·5 and over as a good fit, and when P is less than 0·1 it is a bad fit.

Table VII. gives the values of P for all the fifty samples examined.

From this it appears that of the twenty healthy cases three have P = 0·9 or over, fifteen have P = 0·5 or over, and the worst fit is P = 0·12. This last value means that a greater divergence would be expected twelve times in a hundred samples, which though not a good correspondence must not be regarded as a very bad one. On the whole, the goodness of fit of the observed curves of the red cell diameters of the healthy persons with their respective normal curves is satisfactory.

I am here reminded that in the early stages of my enquiry into the sizes of red cells by the dried film method, there was evidence that the data are subject to some error or errors apart from the error

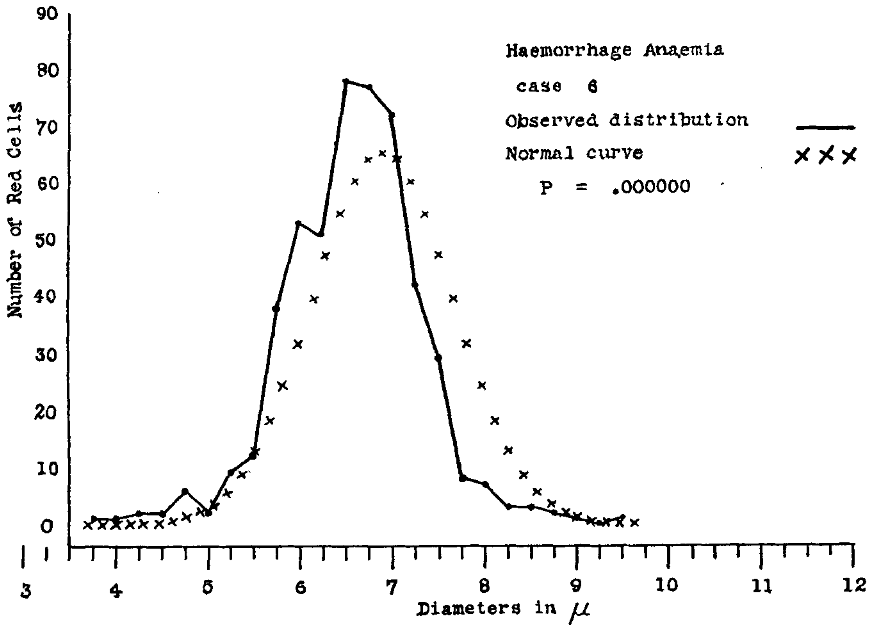

Fig. 11.

of sampling (1920[1]). It was found when searching for a valid criterion of "real difference," that instead of the usual three times it was necessary to take at least five times the standard error of the means. Making some allowance for this, there is nothing in the samples from the healthy persons incompatible with the red cells being derived from homogeneous populations. Among the twenty cases of pernicious anæmia only two gave P = 0·5 or over. The best fit is P = 0·597, and nine cases gave P = 0·000000, or generally the correspondence of the observed curves to their respective normal curves was bad, and the populations of red cells in the individual cases was more or less heterogeneous and abnormal.

Among the ten cases of hæmorrhage anæmia five gave P = 0·5 or over, the best fit being P = 0·954, and two cases gave P = 0·000000.

On the whole, the red cell populations of these cases appear to have a greater heterogeneity than those of the healthy persons, but not so great as that found among the cases of pernicious anæmia.

Mention has been made of the similarity of the distribution curves of the red cell diameters in the healthy persons and the dissimilarity among the abnormal cases. The curves from the healthy persons are of symmetrical type, which is confirmed by their good agreement with their respective normal curves. The curves obtained from the hæmorrhage anæmia cases have a tendency to a symmetrical type and only a fair agreement with their respective normal curves. But the pernicious anæmia cells give mostly asymmetrical, often grotesque, curves which agree very badly with their respective normal curves, many being polymodal and suggesting the probability that they are composite curves formed by two or more sets of cells in a heterogeneous population.

It would be of much interest to analyse the components of these curves after the manner adopted by Karl Pearson in his study of trypanosome strains (1914 [6]); unfortunately, however, apart from the labour this would entail, the method presupposes a more intimate acquaintance with statistical procedures than is usually at the disposal of pathologists, and I have been obliged most regretfully to postpone the analyses of these curves.

The suggestion of the composite nature of the curves from the pernicious anæmia cases is compatible with the legitimate assumption that the blood of pernicious anæmia contains three classes of red cells:—(1) Abnormally large cells arising from some abnormal excitation of the bone marrow, and probably only of some portions, even quite small portions of the bone marrow; this may be considered as the "pernicious" element; (2) some normal sized cells resulting from the normal stimulation of the healthy portions of the bone marrow; (3) small cells resulting from the extra stimulation of the remaining portions of the bone marrow, as a result of the anæmia caused by the abnormal destruction of red cells. This is the "anæmia" element. These three classes of cells are combined as a heterogeneous population, each group possessing its own curve of distribution and varying according to its respective normal curve. It would be of great interest to know if the cells of malignant tumours (of which pernicious anæmia may possibly be an example) are similarly diverse; impressions made without measurement strongly suggest that this is the case.

All these cases were only examined on one occasion. By repeated examinations it would be possible to observe what changes take place in the distribution curves of the cell diameters during the course of the disease, and by consideration of the component curves some conception might be formed of the relative activities of these three groups of cells at any particular period or clinical condition.

Regarding the hæmorrhage anæmia curves, it has been suggested that the small cells are all newly produced as a result of extra stimulation of the bone marrow, and that the normal sized cells have been removed during the hæmorrhage. This is a possible explanation of the cases with symmetrical type of curve, but in some of the cases there is evidence of heterogeneity and the suggestion of composite curves. It seems here to be a legitimate assumption that there are two classes of cells: (1) small cells newly formed by overstimulation of the bone marrow on account of the anæmia caused by the loss of blood; (2) normal sized cells. The dominance of one kind of cell would be expressed by a more or less symmetrical type of curve, A low mean diameter with such a curve type would represent the production of small cells by extra stimulation and would conceivably occur after a severe hæmorrhage. A symmetrical curve with only slightly or not at all diminished mean would indicate the continued production of normal sized cells, and might be expected after slight hæmorrhage. Asymmetrical curves would suggest intermediate conditions and might be expected during the convalescence of the patient. In other words, the relative share taken by these two classes of cells would depend on the amount of the hæmorrhage, on the period after the cessation of the hæmorrhage at which the examination was made, and also on the specific rate at which the individual was able to return to health. Here, again, repeated examinations and measurements during the progress of the anæmia towards recovery would probably show changes in the distribution curves of the red cell diameters, which might indicate the relative activities of these two groups of cells.

SUMMARY.

The mean diameter of the red cells in pernicious anæmia is larger and in anæmia following hæmorrhage is smaller than in health. In both of these conditions the range of size and variability of the red cell diameters is greater than in health, and this is due to the blood containing mixtures of different kinds of cells.

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7. „ . . . . Tables for Statisticians and Biometricians, 1914.

[TABLES

TABLE I.

Healthy persons.

μ.	Number. 1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	Total.
4·75	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	2
5·00	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
5·25	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
5·50	...	...	...	...	...	...	...	1	...	...	...	1	...	...	...	...	...	...	1	...	3
5·75	...	2	...	1	...	...	2	3	3	1	3	5	...	...	...	...	...	...	3	2	25
6·00	2	...	7	3	5	3	14	5	6	15	1	4	...	1	3	2	6	2	9	4	92
6·25	10	3	10	14	24	15	14	22	25	41	11	12	2	5	3	6	15	9	14	4	259
6·50	19	12	25	31	50	28	35	47	36	61	34	29	9	20	18	28	41	16	43	31	613
6·75	54	39	56	61	81	70	68	72	72	91	74	57	25	55	53	51	77	64	63	59	1,242
7·00	64	63	88	77	97	96	91	121	106	101	101	76	70	96	98	92	106	99	94	96	1,832
7·25	119	100	106	93	82	119	94	93	114	96	103	102	102	110	103	106	92	107	105	114	2,060
7·50	100	112	84	96	84	76	95	73	79	57	86	89	112	118	105	88	73	84	87	86	1,784
7·75	68	79	50	66	47	52	43	40	36	23	41	68	78	59	73	66	51	79	48	68	1,135
8·00	39	57	45	37	21	31	25	19	13	11	36	34	60	24	32	42	22	27	23	22	620
8·25	20	23	16	16	7	6	12	3	6	3	8	15	31	10	8	12	15	7	7	11	236
8·50	5	6	11	3	2	4	4	1	4	...	2	6	8	2	3	3	2	5	2	1	74
8·75	...	3	...	2	...	...	3	...	...	...	...	1	3	...	1	3	...	1	1	...	18
9·00	...	1	1	...	...	...	...	...	...	...	...	1	...	...	...	1	...	...	...	...	4
9·25	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
9·50	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1
Total . .	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	10,000
Mean diameter .	7·339	7·443	7·302	7·280	7·124	7·211	7·186	7·091	7·114	6·968	7·200	7·274	7·487	7·283	7·307	7·311	7·169	7·280	7·160	7·231	7·210
Stand. deviation	0·47	0·47	0·52	0·50	0·48	0·46	0·52	0·46	0·47	0·46	0·45	0·52	0·44	0·41	0·43	0·47	0·48	0·44	0·49	0·47	0·45
Variability .	6·4	6·3	7·1	6·9	6·7	6·3	7·2	6·4	6·6	6·6	6·2	7·1	5·8	5·6	5·8	6·4	6·6	6·0	6·8	6·5	6·2

Average of 20 cases: diameter, 7·239; standard deviation, 0·470; coefficient of variation, 6·46.

TABLE II.

Distribution of red cells in 20 cases of pernicious anœmia.

	Case.																				
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	Total.
3·75	...	..	...	...	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	2
4·00	...	...	...	1	1	...	...	0	1	...	...	...	...	...	...	...	...	...	2	1	6
4·25	...	...	...	0	1	2	...	3	2	2	...	...	...	...	...	...	...	...	0	1	11
4·50	1	...	...	1	3	0	...	1	1	2	1	...	1	1	...	...	...	1	2	1	16
4·75	0	1	...	3	2	0	...	9	4	0	1	2	1	0	...	...	...	0	2	1	26
5·00	0	1	1	5	2	5	...	7	7	0	3	0	4	3	...	...	...	1	6	3	48
5·25	0	1	1	3	3	7	2	4	6	5	1	2	1	2	...	...	...	2	7	4	51
5·50	0	2	0	3	8	13	0	13	9	4	9	4	6	1	1	...	6	1	4	5	89
5·75	1	1	5	9	6	13	3	11	9	4	4	3	4	4	1	1	1	5	11	3	99
6·00	1	4	3	9	3	9	4	17	12	6	7	2	7	3	3	0	1	5	9	13	118
6·25	4	6	3	11	4	11	1	28	14	9	23	1	5	8	2	1	3	8	12	12	166
6·50	3	4	10	9	15	12	7	36	16	8	23	3	6	11	1	1	4	11	16	22	218
6·75	4	19	9	15	11	22	11	29	23	8	37	14	9	22	7	3	11	11	16	31	312
7·00	20	24	13	15	21	14	9	27	18	7	49	8	10	26	10	4	12	15	27	31	360
7·25	21	48	13	12	19	12	11	34	17	28	50	8	8	53	9	11	39	10	23	47	473
7·50	41	55	24	16	26	17	10	32	15	21	65	16	17	45	22	15	52	42	30	71	632
7·75	35	64	33	24	19	15	22	20	21	42	63	16	33	42	43	22	71	34	46	64	729
8·00	35	66	54	36	33	24	39	23	36	49	64	21	57	67	61	39	77	65	55	48	948
8·25	52	71	63	32	35	33	47	27	45	63	33	26	64	57	68	40	80	68	46	48	998
8·50	40	55	63	34	44	35	68	27	45	60	27	28	75	52	94	48	56	88	42	22	1003
8·75	28	29	52	62	46	39	62	44	53	68	17	42	60	31	64	50	41	43	29	18	878
9·00	28	21	56	55	34	43	49	38	50	53	12	59	52	29	40	50	18	28	30	15	760
9·25	26	10	29	46	30	42	54	29	30	24	5	58	37	20	24	52	13	18	19	7	573
9·50	24	11	25	46	26	44	44	11	27	16	3	66	18	9	21	50	5	10	23	6	485
9·75	22	1	12	24	17	24	20	6	16	11	1	57	10	9	12	22	5	13	13	5	300
10·00	18	3	18	18	24	31	12	11	12	7	1	24	1	3	11	39	1	8	10	3	255
10·25	18	1	4	3	19	10	5	2	5	2	0	17	8	2	1	18	3	2	11	4	135
10·50	23	2	3	5	15	10	6	4	2	1	1	14	2	...	1	14	1	4	6	5	119
10·75	20	...	1	1	8	5	6	3	0	..	...	3	2	...	4	11	...	2	2	1	69
11·00	16	...	1	2	6	7	6	1	1	...	...	4	1	...	...	6	...	2	1	6	60
11·25	8	...	2	...	9	0	1	1	0	...	...	0	0	...	...	1	...	1	...	2	25
11·50	4	...	0	...	5	1	1	0	3	...	...	1	1	...	...	1	...	1	...	0	18
11·75	3	...	0	...	2	...	...	1	...	...	...	1	...	...	...	1	...	1	...	1	10
12·00	2	...	1	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5
12·25	2	...	1	...	...	...	...	...	...	...	..	...	...	...	...	...	...	...	...	...	3

TABLE III.

Pernicious anæmia.

	Number.																			
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
Hæmoglobin .	18	20	22	26	28	28	30	31	32	35	40	45	48	50	58	70	98	...	...	...
Red cells, mill. .	0·74	1·00	1·05	1·02	1·27	1·37	1·56	1·37	1·07	1·63	1·80	1·70	2·15	2·20	3·25	2·50	4·40	...	...	...
Colour index .	1·28	1·00	1·00	1·27	1·17	1·03	0·97	1·15	1·49	1·07	1·11	1·32	1·11	1·13	0·89	1·40	1·11	...	...	...
Mean diameter .	8·809	7·928	8·425	8·366	8·512	8·369	8·654	7·650	8·060	8·196	7·487	8·897	8·314	7·930	8·418	8·956	8·022	8·204	7·972	7·693
Stand. deviation	1·28	0·79	0·96	1·23	1·45	1·43	0·97	1·39	1·32	0·99	0·85	1·09	0·99	0·90	0·76	0·93	0·72	0·97	1·25	1·10
Variability .	14·6	9·9	11·3	14·7	17·0	17·0	11·2	18·2	16·3	12·0	11·3	12·2	11·9	11·3	9·0	10·3	8·9	11·8	15·6	14·1

Average of 20 Cases.	Mean Diameter.	Standard Deviation.	Coefficient of Variation.
Average of 10,000 cells . .	8·243	1·15	13·9
Average of 20 cases . .	8·243	1·07	12·9

TABLE IV.

Anæmia after hæmorrhage.

	Number.										
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	
Hæmoglobin .	20	20	26	30	38	40	40	42	44	60	...
Red cells, mill. .	1·80	2·50	3·45	2·80	3·60	3·30	2·64	2·13	3·97	3·07	...
Colour index .	0·55	0·40	0·37	0·53	0·53	0·60	0·75	0·98	0·56	0·99	...
Mean diameter .	6·319	7·225	6·900	6·611	7·179	6·891	7·215	6·943	6·702	6·813	6·850
Stand. deviation .	0·79	0·69	0·70	0·57	0·92	0·76	0·61	0·51	0·66	0·65	0·75
Variability . .	12·5	9·5	10·1	8·6	12·8	11·0	8·4	7·4	9·8	9·5	10·9
											Total
3·50	2	...	...	...	...	...	...	...	...	...	2
3·75	1	...	...	...	...	1	...	...	...	...	2
4·00	...	...	...	1	...	1	...	...	...	1	3
4·25	4	...	...	...	...	2	...	...	1	2	9
4·50	2	...	...	...	...	2	...	3	...	...	7
4·75	9	1	1	...	...	6	1	1	2	3	24
5·00	13	1	...	1	1	2	...	1	2	2	23
5·25	20	1	3	3	3	9	1	...	5	4	49
5·50	33	1	10	12	5	12	2	1	15	6	97
5·75	49	7	19	29	5	38	6	1	21	14	189
6·00	68	19	29	58	25	53	9	15	48	26	350
6·25	61	25	47	61	44	51	17	30	58	41	435
6·50	71	40	65	97	54	78	32	58	83	83	661
6·75	58	52	78	78	61	77	60	102	79	86	731
7·00	37	64	71	69	77	72	85	104	55	87	721
7·25	24	75	58	45	61	42	92	90	50	64	601
7·50	23	85	47	26	47	29	82	54	35	34	462
7·75	10	46	32	13	33	8	50	26	26	25	269
8·00	12	40	21	5	22	7	36	10	13	11	177
8·25	1	26	14	1	16	3	18	3	3	3	88
8·50	1	6	1	1	4	3	5	...	2	5	28
8·75	...	5	...	...	12	2	3	1	2	3	28
9·00	1	3	...	...	7	1	...	...	...	...	12
9·25	...	2	...	...	8	...	1	...	...	...	11
9·50	...	1	2	...	3	1	...	...	...	...	7
9·75	...	...	1	...	4	...	...	...	...	...	5
10·00	...	...	1	...	3	...	...	...	...	...	4
10·25	...	...	...	...	1	...	...	...	...	...	1
10·50	...	...	...	...	...	...	...	...	...	...	0
10·75	...	...	...	...	2	...	...	...	...	...	2
11·00	...	...	...	...	2	...	...	...	...	...	2
Total . .	500	500	500	500	500	500	500	500	500	500	5000

Averages: diameter, 6·879; standard deviation, 0·686; coefficient of variation, 9·98.

TABLE V.

	Cases.	Mean Diameters in μ.			Coefficients of Variation.		
		Min.	Max.	Mean	Min.	Max.	Mean
Healthy	20	6·968	7·487	7·239	5·4	7·4	6·4
Pernicious anæmia .	20	7·487	8·955	8·240	8·9	18·2	12·9
Hæmorrhage anæmia .	10	6·319	7·225	6·879	7·4	12·8	9·9

TABLE VI.

	Number of Cells.	Diameters in μ.			Coefficients of Variation.
		Min.	Max.	Mean	
Healthy	10,000	4·75	9·50	7·21	6·2
Pernicious anæmia . . .	10,000	3·75	12·25	8·24	13·9
Hæmorrhage anæmia . . .	5,000	3·50	11·00	6·85	10·9

TABLE VII.

20 Healthy Persons.		20 Cases of Pernicious Anæmia.		10 Cases of Hæmorrhage Anæmia.	
No.	P.	No.	P.	No.	P.
1	·642362	1	·000000	1	·448860
2	·938530	2	·184192	2	·197762
3	·346007	3	·000794	3	·954628
4	·986495	4	·000000	4	·910259
5	·766456	5	·583125	5	·000000
6	·875660	6	·000000	6	·000000
7	·275236	7	·000017	7	·546328
8	·796553	8	·000083	8	·771246
9	·774200	9	·000000	9	·737455
10	·835080	10	·000000	10	·038519
11	·209252	11	·080451		
12	·772150	12	·000000		
13	·595948	13	·000000		
14	·822281	14	·095947		
15	·957299	15	·000916		
16	·577395	16	·597407		
17	·671508	17	·024078		
18	·254894	18	·000000		
19	·791552	19	·056055		
20	·119721	20	·000000		