THESIS FOR DEGREE OF M.D.

INDIVIDUAL GROWTH

A Physiological Study

by

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June, 1909

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INTRODUCTION

The subject of this Thesis, Individual Growth, requires some little explanation. Although much work has been done on the growth of children, and numerous observers have published their results, still, with the exception of Manouvrier's and a few by Buffon, all these records were obtained by taking the averages of the heights and weights of children at the various ages between infancy and maturity.

The published Tables, therefore, shew very conclusively the changes which take place in the rate of growth during the different years of childhood and adolescence, but as they are made up from isolated observations on large numbers of different children they have a great want of information about the laws which regulate the growth of the individual.

In order to investigate these laws, it was necessary to have a separate series of observations, taken at more or less regular and frequent intervals, of the height and weight of each individual. Such records were obtained from the Anthropometric Register of Bootham School, York.

Then to elucidate certain phenomena which appeared in the growth of healthy boys, a number of experiments on the growth of animals and plants were performed. There were several points in the mode of growth of an animal with an exo-skeleton which required investigation, and although several papers have been written on the growth of the crab, these only deal with the change in size at the times of moulting, and no systematic weighing of the specimens had been done, so that there was no information as to what changes might occur during the periods between the moults.

Such regular and systematic weighing of fourteen specimens of the common shore crab (carcinus maenas) has been done, and the full results of the experiments will be found in the First Section.

Systematic weighing of young rabbits and guineapigs has also been performed, and complete details are given in Section Two.

Section Three deals with the growth of 250 healthy boys over a period of approximately four years in each instance; the data for these observations having been obtained from the Anthropometric Register of Bootham School, York.

In Section Four the growth exhibited by children

suffering from acute illnesses is considered, the remarks in this Section being based on observations of over 1390 patients at the City of Glasgow Fever Hospital, Belvidere.

The growth of internodes in plants has also been investigated and the experiments are fully described in Section Five.

It is proposed to discuss each class of experiments, with a preliminary precis of the literature of the special subject, in separate sections, and then, in a final summary, to gather the results together and consider their meaning in the light of general biological principles.

Appended to this will be found a note of the Bibliography on the subject of Growth.

SECTION ONE

EXPERIMENTS ON THE GROWTH

of

THE COMMON SHORE CRAB (CARCINUS MAENAS)

A considerable series of observations on the rate of growth of Crabs has been recorded by various authors. Their experiments were conducted under most favourable circumstances, and with the object of determining the size of Crabs in relation to age, the increase in size, and frequency of moults.

This gave no information regarding any phenomena occurring during the intervals between the moults, and the following observations were carried out with that end in view.

Fourteen young specimens of the Common Shore Crab (Carcinus maenas) were obtained from the Marine Biological Station, Millport. To prevent injury, to insure a regular supply of food and to facilitate the recognition of the various specimens, each Crab was kept in a separate glass

dish. The water in the dishes was renewed frequently from a large storage tank, and as an aid to oxygenation, pieces of the weed Cladophora were placed in each dish. Feeding was with fresh fish, and occasionally mussel. The experiments were carried out in a cool room, with a reasonable amount of light, and a free air supply.

The Crabs were perhaps not kept under the most favourable conditions, and the observations may be of little practical value with regard to increase in size and the frequency of casting, but several interesting points have emerged.

Every second day each Crab was weighed, the method adopted being to remove all excess of water by gently drying it between two folds of a towel, and then place it on a Sartorius Short arm Balance. After a little practice a fair degree of accuracy was reached by this procedure.

The growth of a Crab is essentially cyclic, a more or less regular alternation of outbursts of rapid growth, and periods of arrest. Growth takes place during a moult, when the whole test is thrown off, and while the new shell is still soft, increase in size is rapid. From the results published by Williamson and Brook,[1] the ratio of increase in size is evidently very variable; it may be as high as 2/3rds or as low as 1/15th, but in the large majority of

cases it is about 1/4th.[1] These observers took the greatest breadth of the carapace for measurement, and the ratios are found in the second column in Tables 1, 3 and 4, and the fourth in Table 2.

In my own series the area of the carapace is recorded, and the ratio, varying from 2/7ths to 3/4ths is found in column two of Table 5.

For obvious reasons it is impossible to take accurate measurements of the size of a crab after a moult, as the shell is soft and also the animal is unusually active at that period, so these measurements were taken from the cast shells.

It seems probable, however, that increase in size, although occurring for the most part immediately after the old shell is cast, continues slowly for two or three days during the process of hardening. In Table 2, which gives the ratio of increase on moulting of various specimens of the Edible Crab, (Cancer pagurus) this was commonly 1/3rd to 1/4th of the original size, but in Crabs Nos. 3 and 4 (ratios only 1/5th.5 and 1/6th) the measurements were taken immediately after casting and while the shell was still soft, and to some extent at least these low figures may be explained by their being taken before the process of hardening was complete.[2]

T A B L E 1.

WADDINGTON'S SERIES of CANCER PAGURUS (Published by CHAS. H. WILLIAMSON, M.A., D.Sc. in the XXII ANNUAL REPORT of the FISHERY BOARD for SCOTLAND, Part III. p. 135.

No.	Date	Size MM.	Ratio of Increase	Interval (Days)
		A.		
1.	4 Aug 1899	3.25		
2.	15 " "	4.75	1/2	
3.	7 Sep "	5.75	1/4.7	23
4.	6 Oct "	8.5	1/2	29
5.	3 Nov. "	10.75	1/3.7	28
6.	12 Dec "	14.5	1/2.8	39
7.	27 Jan 1900	19.5	1/2.9	46
8.	3 Apr. "	24.5	1/3.9	66
9	4 June "	30.75	1/3.9	63
10.	30 Sep "	36.5	1/5	118
11.	19 Mar 1901	45.75	1/3.9	170
12.	5 Nov "	56.5	1/5	231
		B.		
		9.25		
1.	30 Apr 1900	13	1/3.4	
2.	25 Aug "	15.5	1/5.2	117
3.	30 Oct "	18.75	1/4.7	66
4.	9 Feb 1901	20.75	1/6.5	102
		C.		
1.	7 Sep 1896	12		
2.	25 Nov "	16	1/3	
3.	20 Mar 1897	19	1/5.3	115
4.	26 May "	24	1/3.8	67
5.	21 Aug "	30	1/4	87
6.	4 Nov.	37	1/4.2	75
7.	31 Dec.	46	1/4.1	57

TABLE 2

From "Contributions to the life & history of the Edibh Crab (CANCER PAGURUS) Chas H. Williamson, M.A. B.Sc. XVIII Annual Report of the Fishery Board for Scotland. Part III p.110

Crab No.	Original Size in inches	Size of Soft Crab	Increase (Inch)	Ratio of Increase	Authority
1.	4/5	1	1/5	1/4	Marine Lab. Dunbar
2.	1 3/8	1 3/4	3/8	1/3.6	"
3.	2 1/16	2 7/16	3/8	1/5.5	"
4.	2 5/8	3 1/16	7/16	1/6	"
5.	2 3/4	3 5/8	7/8	1/3.1	J. Couch
6.	2 8/10	3 7/10	9/10	1/3.1	"
7.	3 7/8	5	1 1/8	1/3.4	Buckland
8.	4	5 1/16	1 1/16	1/3.7	Gatty Lab. St Andrews.
9.	4 3/8	5 1/2	1 1/8	1/3.9	Wilson
10.	5 1/4	6 3/8	1 3/8	1/3.7	Meek
11.	6 3/4	7 1/2	3/4	1/9	J. Couch
12.	7 1/4	8 3/4	1 1/2	1/4.8	Cunningham.

T A B L E 5.

Shewing Ratios of increase in SIZE and WEIGHT at MOULTS of FOURTEEN SPECIMENS of CARCINUS MAENAS (Own Series)

Date	Size (in Sq.MM)	Ratio of Increase in Size	Weight (in Grammes)	Ratio of Increase in Weight	Interval between Moults (Days)
1908			CRAB No.1		
Capture	49	-	.2	-	-
July 17	82.1	3/5	.31	1/2	-
Aug 17	110.8	3/8	.54	2/3	31
Sept 18	(died in Moult)		-	-	32
			CRAB No.2		
Capture	62.5	-	.26	-	-
Sept 20	(died in Moult)		-	-	-
			CRAB No.3		
Capture	84.2	-	.43	-	-
July 23	141.6	5/8	.86	1	-
Sept 8	199.2	3/7	1.36	5/8	47
			CRAB No.4		
Capture	39.4	-	.15	-	-
July 25	77.8	1/2	.25	2/3	
Aug 31	(died in Moult)		-	-	37
			CRAB No.5		
Capture	54.4	-	.21	-	-
Aug 3	89.9	3/5	.41	1	-
Sept 30	123.5	1/3	.59	1/2	58
			CRAB No.6		
Capture	80.4	-	.38	-	-
July 30	125.3	1/2	.69	3/4	-
Sept 18	161.8	1/3	.93	1/3	50
			CRAB No.7		
Capture	47.7	-	-	-	-
July 14	77	3/5	.34	-	-
Augt 3	125.4	3/5	.66	1	20

Date	Size (in Sq.MM)	Ratio of Increase in Size	Weight (in Grammes)	Ratio of Increase in Weight	Interval between Moults (Days)
			CRAB No.8		
Capture	68.1	-	.33	-	-
			CRAB No.9		
Capture	36.3	-	.11	-	-
July 28	46.3	2/7	.14	1/4	-
Sept 20	(died in Moult)		-	-	54
			CRAB No.10		
Capture	35	-	.11	-	-
Aug 3	47.9	1/3	.17	1/2	-
Oct 2	66.1	2/5	.25	1/2	60
			CRAB No.11		
Capture	62.5	-	.27	-	-
Aug 7	97.2	3/5	.48	3/4	-
Oct 1	131.2	1/3	.76	4/7	55
			CRAB No.12		
Capture	77	-	.36	-	-
Aug 5	120.6	4/7	.62	2/3	-
Oct 1	166.8	1/3	1.01	2/3	57
			CRAB No.13		
Capture	54.9	-	.22	-	-
Aug 3	90.1	3/5	.40	1	-
			CRAB No.14		
Capture	44.6	-	.15	-	-
July 31	75.3	3/4	.30	1	-
Sept 27	98	1/3	.42	1/3	58

Herrick[3] also has demonstrated increase in size taking place during the hardening of the shell, having observed an addition of half an inch being made during the calcification in the test of a lobster twelve inches long.

On taking the weight of crabs it is found to accord almost identically with the size: there is the same sudden accession at the time of moulting with a subsequent period of arrest when the increase is very small indeed.

The great rapidity of this increase is well shewn in the case of Crab No. 11. On September 30th, its weight was .52 gramme. On October 1st it was noticed to be casting. The weight was taken before it had escaped from the old shell, .61 gramme: six hours later it had increased to .71 gramme, and within twenty-four hours of the commencement of the moult the weight was .76 gramme, and the new test was hard. The ratio of increase in this instance was almost $\frac{1}{2}$, and that in a matter of twenty-four hours.

In most cases there is a slight increase in weight for a few days following the moult, then the gain becomes even less till the cycle is complete and a new moult determines another rapid advance.

The ratio of increase in weight varies from 1/3rd to 1, and in the same specimen at different moults the ratios shew considerable diversity; thus in Crab No. 3 the ratio

at the first moult was 1 and at the next only 5/9ths; in Crab No. 6 it was 3/4ths and then 3/7ths, while in No. 12 it fell from 5/6ths to 3/7ths. It will be observed that the lower register in each case is the latter, a possible explanation being that the crabs had been longer in captivity and the altered conditions were beginning to shew effect before the second moult occurred.

During a moult, therefore, there is sudden and rapid increase both in size and weight, and this continues to a minor degree for a short time afterwards till sufficient quantities of lime-salts have been deposited in the shell to at least limit, if not cause, total cessation of growth.

In the intervals between the moults, once the shell has become hard, it is probable that there is no increase in size. Increase in weight, on the other hand, does take place throughout the whole period of arrest. This increase is trifling, from 1/32nd to 1/9th of the total body weight, but it is present in every instance. With the occurrence of this gradual gain in weight without increase in size the question arose as to whether it was due to actual cellular proliferation and storage of glycogen, or if it might be accounted for by mere accretion of lime in the shell. To settle this point the cast shells were calcined and the amount of lime-salt found in each was carefully estimated and compared with the increase in weight which had occurred

during the respective inter-moult periods.

An analysis of these observations is found in Table 6. The first column gives the number of the crab, the second the increase in weight which took place during the interval between the moults and the third the weight of lime-salts deposited in the shell during the same period. Columns four and five shew respectively the increase or decrease in the actual weight of the crab's body during the period between the moults.

TABLE 6

Shewing the relation of the accretion of salts in the shell to the increase in weight of the crab during the period between moults.

No. of Crab	Increase in weight during interval between moults (gramme)	Weight of lime-salts deposited in shell (gramme)	Increase in actual weight of body (minus shell) during interval between moults (gramme)	Decrease in actual weight of body (minus shell) during interval between moults (gramme)
	(.01	.04	-	.03
1	(.07	.06	.01	-
3	.06	.06	-	-
5	.04	.04	-	-
6	.07	.06	.01	-
7	.03	.03	-	-
9	.02	.01	.01	-
10	.02	.02	-	-
11	.04	.04	-	-
12	.08	.07	.01	-
14	.03	.03	-	-

The striking feature of this Table is the frequency with which the increase in weight shewn by the crab in the inter-moult period accords with the amount of calcareous material which has been deposited in the shell.

In six out of the ten specimens; in Crabs Nos. 3, 5, 7, 10, 11 and 14 these two weights tally precisely, so that the actual weight of the body, irrespective of the shell, was constant from the termination of one moult to the commencement of the next. In three specimens, Nos. 6, 9 and 12, a slight increase in the body-weight, .01 gramme in each case, is recorded, while in Crab No. 1 during the first period under observation there is a decrease of .03 gramme in the actual weight of the body, but in the second period an increase of .01 gramme is noted.

On consideration of these facts relating to the periods between the moults it would seem to be clearly indicated that growth takes place during a moult, and then only: that the intervals were more a time of rearrangement and recuperation than of storage of material or cellular activity.

Further comment regarding the growth of crabs will be made later.

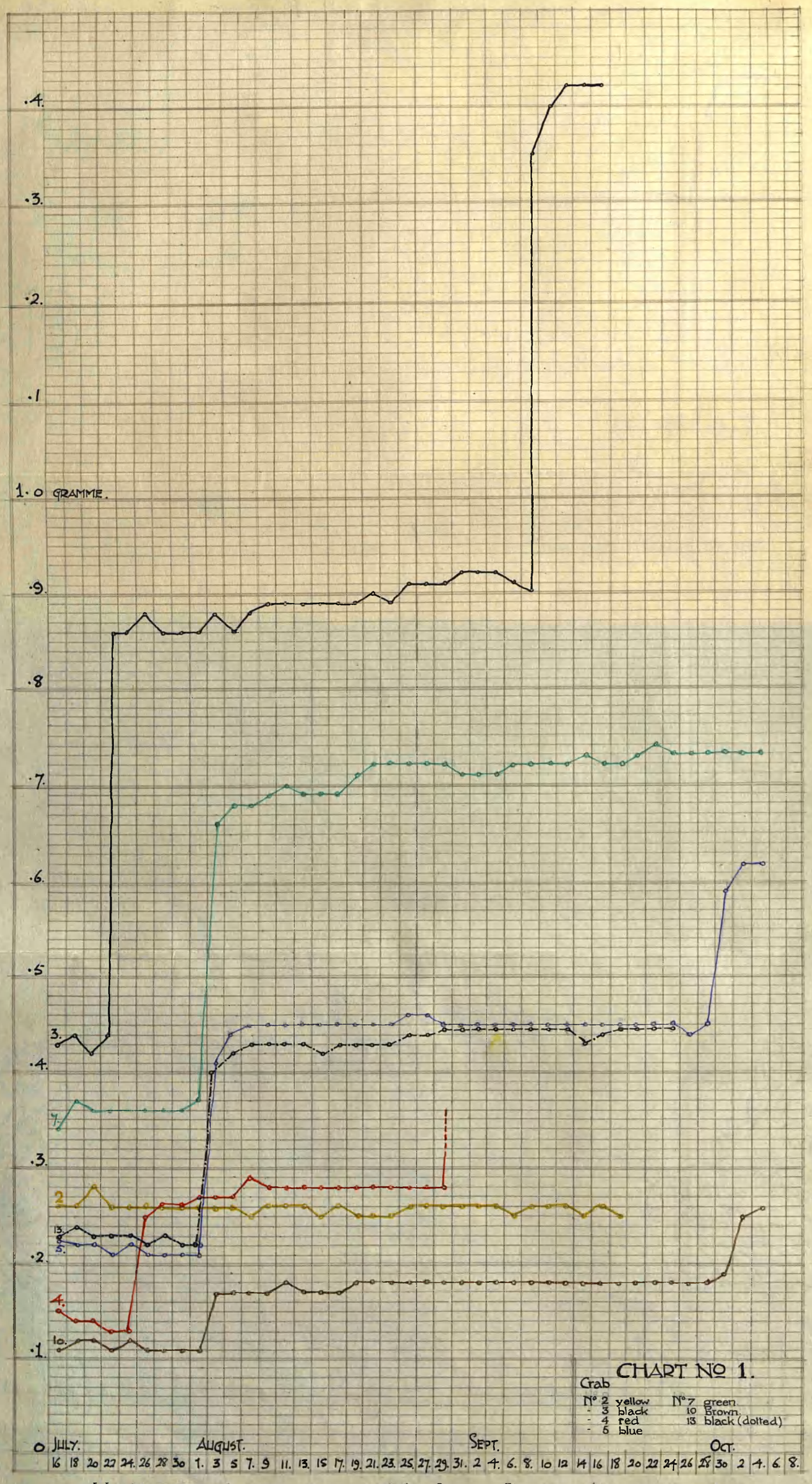
Full records of the observations on the weights of these fourteen specimens of Carcinus maenas are given in the following Table and Charts (Table 7 and Charts Nos. 1 and 2.)

TABLE 7

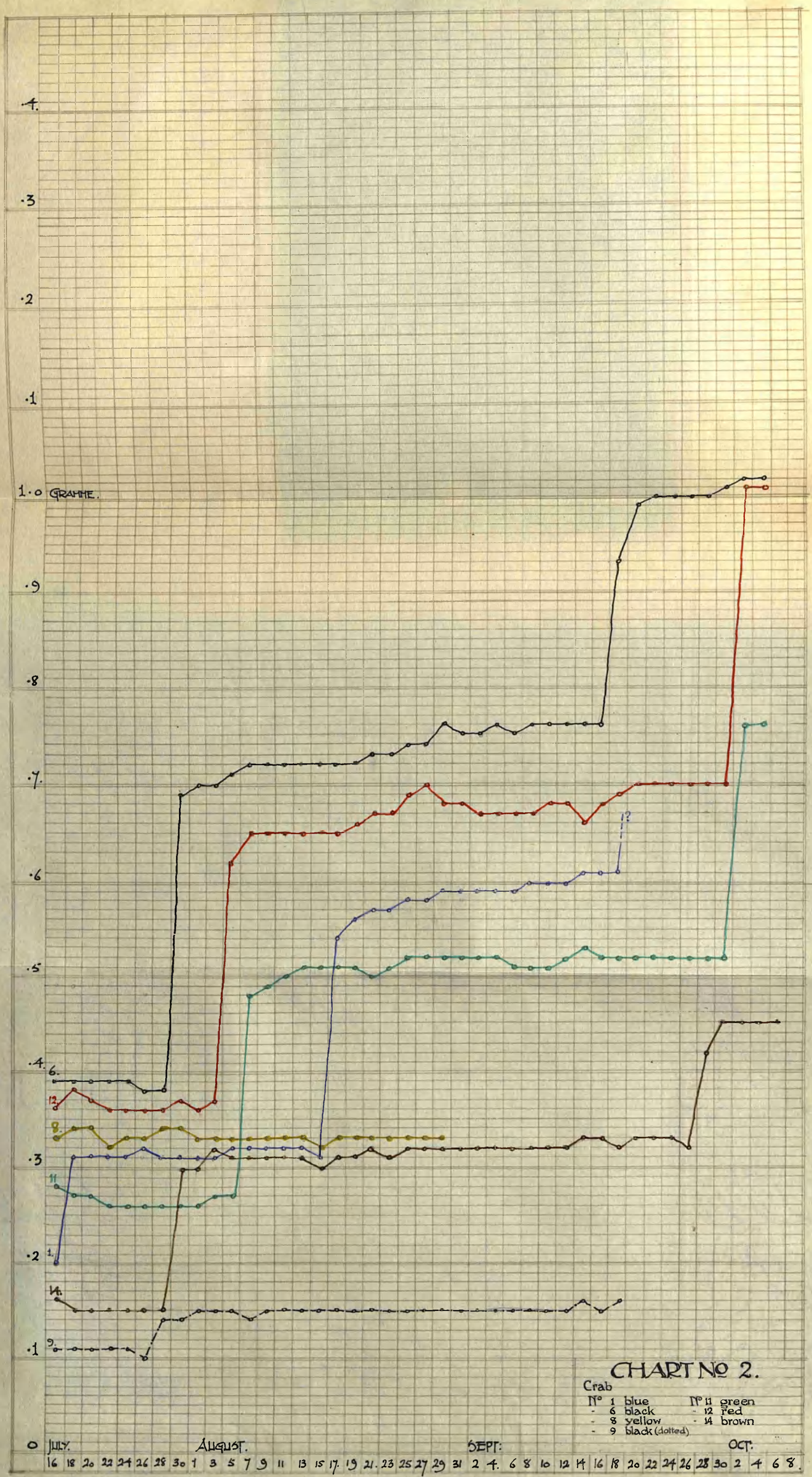
GIVING the WEIGHT (in GRAMMES) of FOURTEEN SPECIMENS of CARCINUS MAENAS

1908

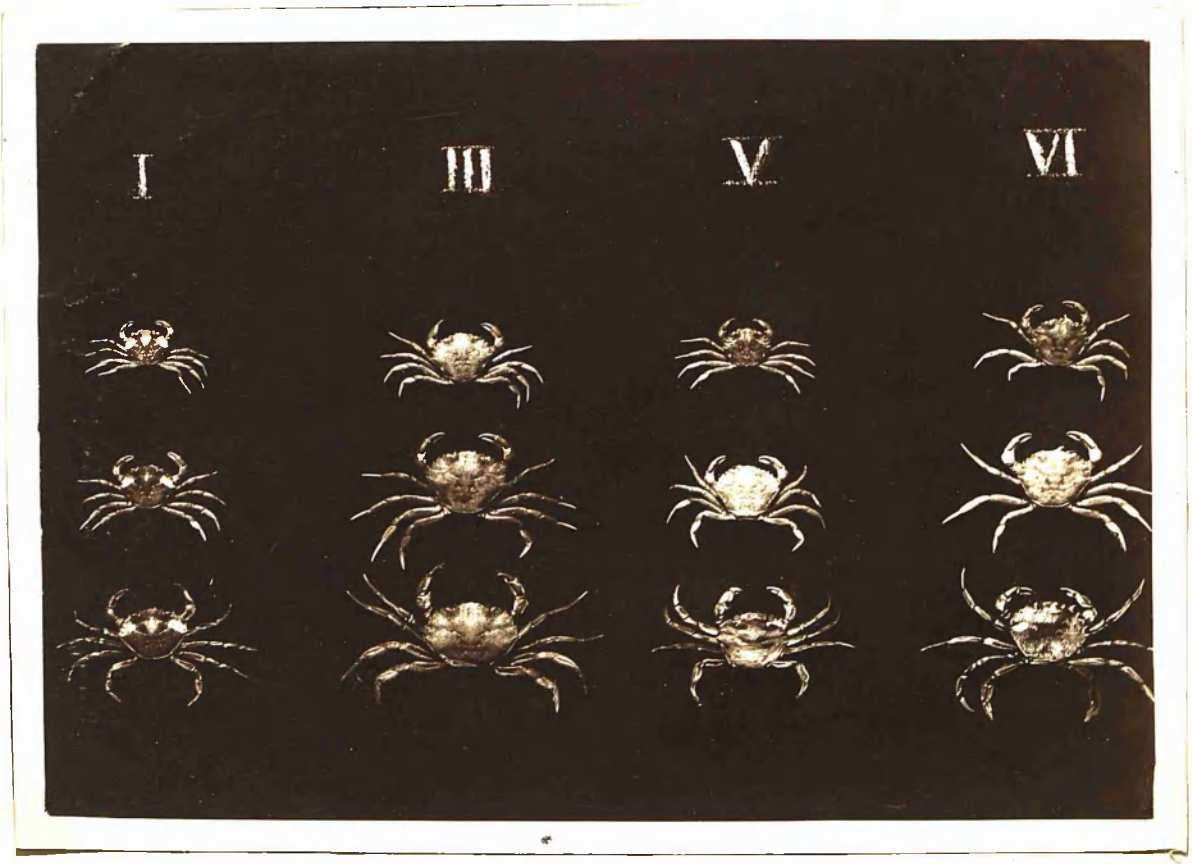
Crab No.	July								August																						September									October	
	16	18	20	22	24	26	28	30	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	2	4
1	.20	.31	.31	.31	.31	.32	.31	.31	.31	.31	.32	.32	.32	.32	.32	.31	.54	.56	.57	.57	.58	.58	.59	.59	.59	.59	.59	.60	.60	.60	.61	.61									
2	.26	.26	.28	.26	.26	.26	.26	.26	.26	.26	.26	.25	.26	.26	.26	.25	.26	.25	.25	.25	.26	.26	.26	.26	.26	.26	.25	.26	.26	.26	.25	.26	.25								
3	.43	.44	.42	.44	.86	.88	.86	.86	.86	.88	.86	.88	.89	.89	.89	.88	.88	.89	.90	.89	.91	.91	.91	.92	.92	.92	.91	.90	140	1.42	1.42	1.42									
4	.15	.14	.14	.13	.13	.25	.26	.26	.27	.27	.27	.29	.28	.28	.28	.28	.28	.28	.28	.28	.28	.28	.28	.28																	
5	.23	.22	.22	.21	.22	.21	.21	.21	.21	.41	.44	.45	.45	.45	.45	.45	.45	.45	.45	.45	.46	.46	.45	.46	.46	.46	.46	.46	.46	.46	.46	.46	.46	.46	.46	.46	.45	.46	.59	.62	.62
6	.39	.39	.38	.38	.39	.38	.38	.69	.70	.70	.71	.72	.72	.72	.72	.72	.72	.72	.73	.73	.75	.74	.76	.76	.76	.76	.75	.76	.76	.76	.76	.76	.93	.99	1.00	1.00	1.00	1.00	1.01	1.02	1.02
7	.34	.37	.36	.36	.36	.36	.36	.36	.37	.66	.68	.68	.69	.70	.69	.69	.69	.71	.72	.72	.72	.72	.72	.71	.71	.71	.72	.72	.72	.73	.74	.73	.73	.73	.74	.73	.73	.73	.73	.73	.73
8	.33	.34	.34	.32	.33	.33	.34	.34	.33	.33	.33	.33	.33	.33	.33	.32	.33	.33	.33	.33	.33	.33	.33																		
9	.11	.11	.11	.11	.11	.10	.14	.14	.15	.15	.15	.14	.15	.15	.15	.15	.15	.15	.15	.15	.15	.15	.15	.15	.15	.15	.15	.15	.15	.15	.16	.15	.16								
10	.11	.12	.12	.11	.12	.11	.11	.11	.11	.17	.17	.17	.17	.18	.17	.17	.17	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.19	.25	.26
11	.28	.27	.27	.26	.26	.26	.26	.26	.26	.27	.27	.48	.49	.50	.51	.51	.51	.51	.50	.51	.52	.52	.52	.52	.52	.52	.51	.51	.51	.52	.53	.52	.52	.52	.52	.52	.52	.52	.52	.76	.76
12	.36	.38	.37	.36	.36	.36	.36	.37	.36	.37	.62	.65	.65	.65	.65	.65	.65	.66	.67	.67	.69	.70	.68	.68	.67	.67	.67	.67	.68	.68	.66	.68	.69	.70	.70	.70	.70	.70	.70	1.01	1.01
13	.23	.24	.23	.23	.23	.22	.23	.22	.22	.40	.42	.43	.43	.43	.43	.42	.43	.43	.43	.43	.44	.44	.45	.45	.45	.45	.45	.45	.45	.45	.44	.45	.46	.46	.46	.46	.46				
14	.16	.15	.15	.15	.15	.15	.15	.15	.30	.22	.31	.31	.31	.31	.31	.30	.31	.31	.32	.31	.32	.32	.32	.32	.32	.32	.32	.32	.32	.32	.33	.33	.32	.33	.33	.33	.32	.45	.45	.45	.45



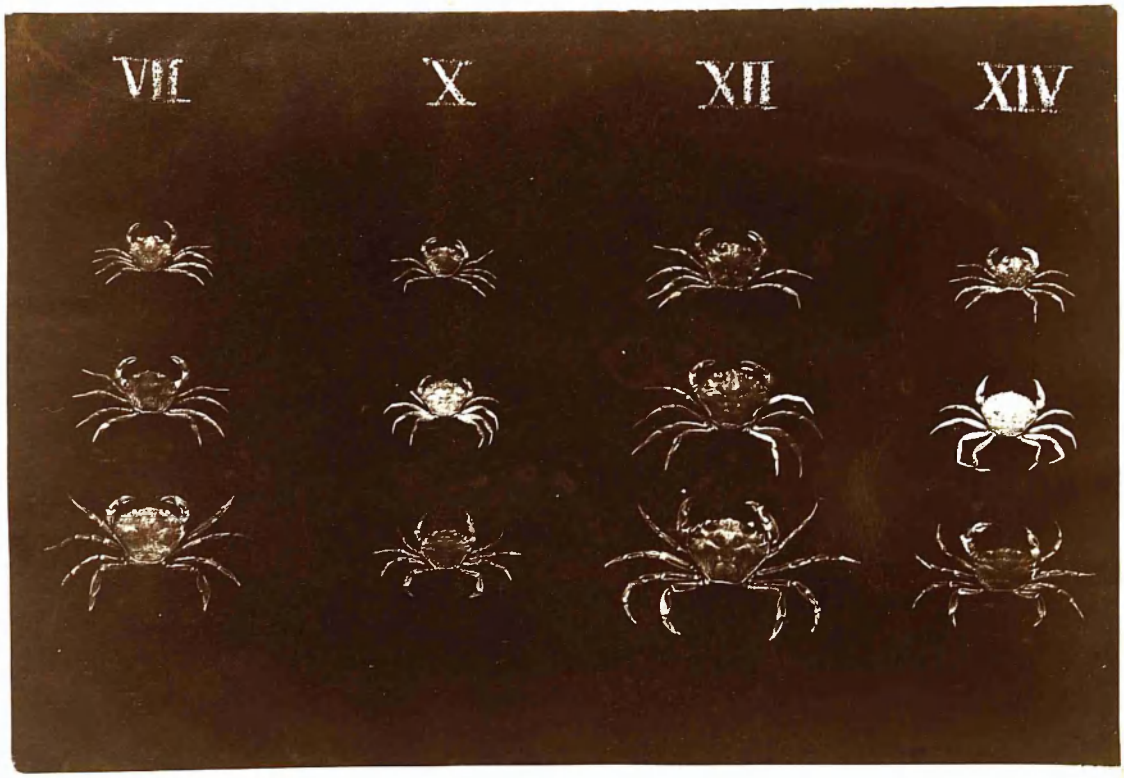
Weight-curves of seven specimens of the Common Shore-crab (Carcinus mænas)



Weight curves of seven specimens of the Common Shore-crab (Carcinus mænas)



Shells from three successive moults of Crabs Nos I, III, V, VI.



Shells from three successive moults of Crabs Nos. VII, X, XII, XIV.

SECTION TWO

OBSERVATIONS

on the

GROWTH OF RABBITS AND GUINEA-PIGS

The following records of the weights of young rabbits and guinea-pigs were obtained at Belvidere Fever Hospital. The animals there are kept in large wire cages in a special house, and the fact that they have been uniformly healthy over a considerable period of years indicates that the conditions are entirely favourable. Feeding and bedding were carried out with great regularity, and with a few exceptions, all the animals observed thrived from the commencement to the close of the experiments.

The weights were taken every other day, and to minimise, as far as possible, any fallacies from daily variation the observations were always made at the same time, four o'clock in the afternoon.

Originally it was intended to record the increase in size as well as weight, but this was very soon found to be impracticable.

With regard to the rabbits, those of Series A, Nos. 1, 2, 3, and 4 were thirty days old when the weighings were commenced, while in Series B, Nos. 5,6,7, and 8, were fifty days old. In Series C. Nos. 11, 12, 13, 14 and 15 records were taken from the earliest time at which the rabbits could be safely handled, that is from the tenth day onwards.

It may be well, therefore, to consider Series C first. The weights are given in Table No. 8 and Charts Nos. 3 and 4. This litter originally consisted of five, but the youngest, No. 15, as is commonly the case, was a weakly individual from the beginning, and, only surviving until its fortieth day, can be dismissed in a word. As will be seen from Chart No. 3, the increase in weight was remarkably steady until the thirty-sixth day, and relatively as great as in the stronger individuals. For four days before death a loss in weight took place.

Unfortunately it was impossible to weigh these animals immediately after birth and on the succeeding days, so that it cannot be said whether a loss of weight at that time does or does not occur. The first records were taken on the tenth day, and from that time onwards increase was the rule.

In the four other animals, Nos 11, 12, 13 and 14, growth is on the whole regular, but cyclic variations in the rapidity are shewn to a greater or less extent in all. The most marked case of this is seen in No. 11, where,

after a period of rapid increase during which the first observation was made on the tenth day and which lasted till the fourteenth, there follows a lapse of twelve days when growth is slow. On the twenty-sixth day another wave of increase starts, and continues for ten days, to be followed by a period of six days during which the weight remains almost stationary. Again, from the forty-second to the fifty-sixth days, growth is rapid, then followed, as before, by a practically quiescent interval of fourteen days before a fresh increase of weight takes place.

Rabbit No. 13 also shews a tendency to the same cyclic form of growth, and as will be seen from Chart 3 there are in its curve three quite definite subsidiary ones occurring between the twentieth and fortieth, fortieth and sixtieth, and sixtieth and seventy-sixth days.

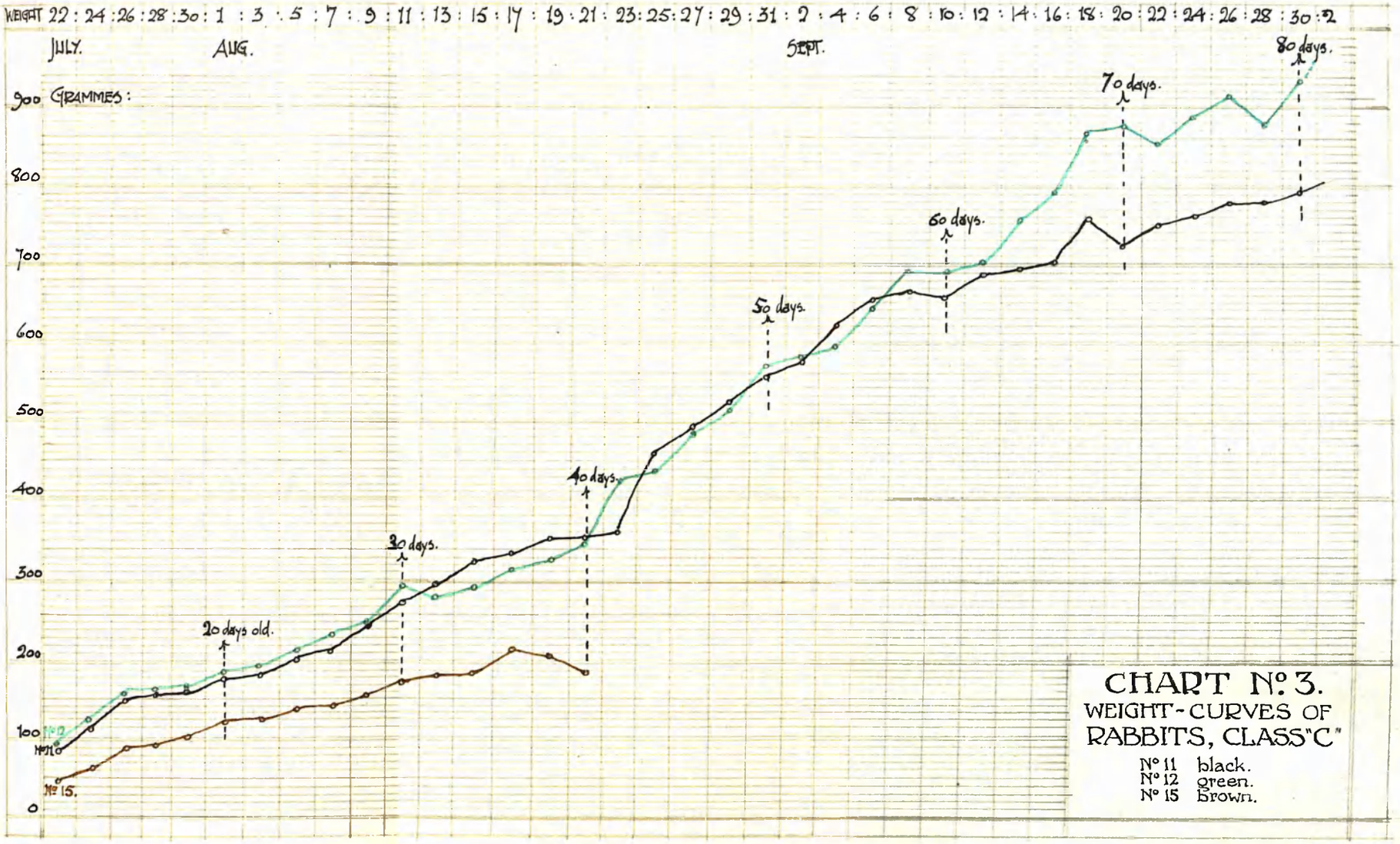
The growth of Rabbits Nos. 12 and 14, on the other hand, though shewing small variations in the rate of increase, is more suggestive of regularity, in fact this is their most striking feature. In each there is an almost uninterrupted rise during the whole of the time the animals were under observation. Doubtless short periods of rest do occur: in No. 12 from the thirty-sixth to the fortieth day, and again from the fifty-eighth to the sixty-second: in No. 14 from the twenty-sixth to the thirty-

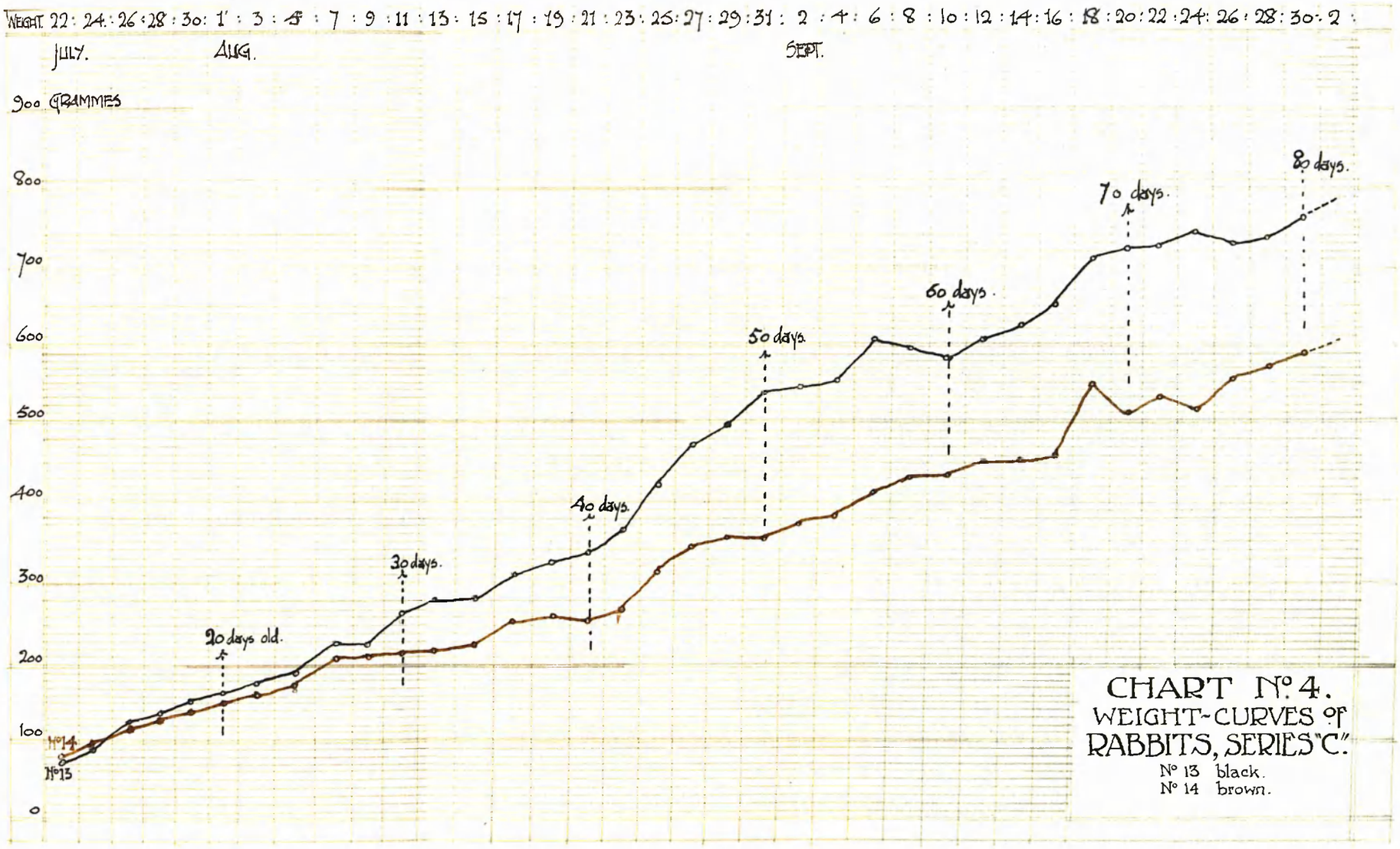
fourth, between the sixty-second and sixty-sixth and immediately following that from the sixty-eighth to the seventy fourth, but these quiescent periods are hardly sufficient to break the gradual line of ascent.

In Chart 3, Rabbits Nos. 11 and 12 are shewn, and in Chart 4 Nos. 13 and 14 so that the contrast between the two types of growth, cyclic and regular, may be evident, an example of each form being present in both charts.

On consideration of Series A and B in which the rabbits were thirty and fifty days old respectively at the time of the first observation, it is more difficult to draw any conclusion than in the case of Series C. At first sight the rate of growth would appear to be markedly irregular, but on more critical inquiry this impression is modified.

With regard to Series A, it will be seen from Table No. 8, or better from Charts 5 and 6, that all the rabbits in this group, Nos. 1, 2, 3 and 4, gained steadily in weight until the eightieth day. In that period there are three irregularities where the weight suddenly shoots up (in some instances more than 100 grammes or 1/7th of the total body weight) and then falls as rapidly before the time of the next observation. These irregularities occur at fairly regular intervals, and originally, in view of


WEIGHT 22 : 24 : 26 : 28 : 30 : 1 : 3 : 5 : 7 : 9 : 11 : 13 : 15 : 17 : 19 : 21 : 23 : 25 : 27 : 29 : 31 : 2 : 4 : 6 : 8 : 10 : 12 : 14 : 16 : 18 : 20 : 22 : 24 : 26 : 28 : 30 : 2
JULY.
AUG.
SEPT.
900 GRAMMES :
800
700
600
500
400
300
200
100
0
20 days old.
30 days.
40 days.
50 days.
60 days.
70 days.
80 days.
№ 12
№ 11
№ 15.
CHART № 3.
WEIGHT-CURVES OF RABBITS, CLASS "C"
№ 11 black.
№ 12 green.
№ 15 brown.


WEIGHT. 22 : 24 : 26 : 28 : 30 : 1 : 3 : 5 : 7 : 9 : 11 : 13 : 15 : 17 : 19 : 21 : 23 : 25 : 27 : 29 : 31 : 2 : 4 : 6 : 8 : 10 : 12 : 14 : 16 : 18 : 20 : 22 : 24 : 26 : 28 : 30 : 2 :
JULY.
AUG.
SEPT.
900 GRAMMES
800
700
600
500
400
300
200
100
0
20 days old.
30 days.
40 days.
50 days.
60 days.
70 days.
80 days.
№14.
№13
CHART № 4.
WEIGHT-CURVES OF
RABBITS, SERIES "C."
№ 13 black.
№ 14 brown.

the fact that the rabbits were all of one litter, it seemed possible that it was an expression of periodic growth, but this idea had to be abandoned.

When Series A is compared with Series B it is found that these fluctuations occur in both, and synchronously, and therefore the explanation was to be sought in some external influence affecting two different litters of rabbits in separate cages.

Changes of temperature and weather are thrown out of court, as in some instances the irregularity occurred in the middle of a week of soft rainy weather with comparatively low readings on the thermometer, and in others during a spell of sunshine and warmth.

In spite of the regular feeding of the animals, and the endeavour to have always an excess of food in the cages, one is forced to consider the irregularity as due to the condition of the alimentary tract, and it is probable that more green food was given on the days in which the rapid increase in weight took place. These sudden and unsustained fluctuations in weight are therefore to be neglected; they must be considered as unavoidable inaccuracies, and their more or less periodic recurrence as mere coincidence.

After the eightieth day, that is in the second half of the records, growth becomes very definitely cyclic, and

in the charted tracing of each specimen there appears a succession of alternating periods of active growth followed by times of rest which, in many instances, is accompanied by loss of weight. (See Charts 5 and 6) These irregularities may be regarded as giving evidence of variation in the rate of growth as they differ widely from those already described occurring before the eightieth day. In the earlier ones the irregularity was extremely short-lived, and the same phenomena were shewn simultaneously in the Chart of every rabbit, whereas in these later ones the rapid increase in weight is sustained over a period of several days before arrest or loss occurs, which again occupy a fair amount of time. Further, the curves are not simultaneous in the tracings of the different rabbits, and while the weight of one animal is stationary or even falling, that of another may be increasing rapidly.

From these facts one can hardly doubt that the curves are actually expressive of the periodic nature of the growth, an idea which seems to be borne out by the regular succession of times of activity and intervals of quiescence which are shown best in the tracings of Rabbits Nos. 1 and 2. In No. 1 a period of rapid increase starts on the ninety-fourth day, and continues for eight days with a resulting total gain of over 200 grammes, then follows

another period of eight days in which 60 grammes are lost before the next cycle begins. In No. 2 the curves are even more regular in their arrangement, occurring between the ninety-second and one hundred and sixth, and one hundred and sixth and one hundred and twenty-second days, and following that the larger part of another curve is shewn.

Rabbit No. 4 also gives fair evidence of cyclic growth but in this instance the cycles are less regular. Thus there is a long steady increase of almost 500 grammes between the seventy-eighth and one hundred and second day. following that a period of arrest when 100 grammes are lost before the weight begins to rise again on the hundred and eighth day. The record of Rabbit No. 3 is difficult to decipher. It is extremely irregular and is further obscured by pregnancy, but it is possible that the three small curves which take place between the eighty-fourth and one hundred and fourteenth days are due to a type of cyclic growth in which the periods of activity and arrest are of short duration.

It seems hardly necessary to describe in detail the charts from the rabbits of Series B, Nos. 5, 6, 7 and 8. (Charts Nos. 7 and 8) What has been said of those in Series A applies to and covers all the points which emerge

WEIGHT 18 : 20 : 22 : 24 : 26 : 28 : 30 : 2 : 4 : 6 : 8 : 10 : 12 : 14 : 16 : 18 : 20 : 22 : 24 : 26 : 28 : 30 : 1 : 3 : 5 : 7 : 9 : 11 : 13 : 15 : 17 : 19 : 21 : 23 : 25 : 27 : 29 : 31 : 2 : 4 : 6 : 8 : 10 : 12 : 14 : 16 : 18 : 20 : 22 : 24 : 26 : 28 : 30 :

JUNE. JULY. AUG. SEPT.

GRAMMES.

1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300

60 days.
70 days
80 days.
90 days.
100 days.
110 days.
120 days.
130 days.
50 days.
70 days old

No 1
Grammes.
No 4

CHART No. 5.

WEIGHT-CURVES OF RABBITS, SERIES "A"

No 1 black.
No 4 red.

WEIGHT 18 : 20 : 22 : 24 : 26 : 28 : 30 : 2 : 4 : 6 : 8 : 10 : 12 : 14 : 16 : 18 : 20 : 22 : 24 : 26 : 28 : 30 : 1 : 3 : 5 : 7 : 9 : 11 : 13 : 15 : 17 : 19 : 21 : 23 : 25 : 27 : 29 : 31 : 2 : 4 : 6 : 8 : 10 : 12 : 14 : 16 : 18 : 20 : 22 : 24 : 26 : 28 : 30

JUNE JULY. AUG. SEPT.

GRAMMES:

1600 1500 1400 1300 1200 1100 1000 900 800 700 600 500 400 300 200

40 days old. 50 days. 60 days. 70 days. 80 days. 90 days. 100 days. 110 days. 120 days. 130 days.

No 3. No 2.

CHART No. 6.

WEIGHT-CURVES OF RABBITS, SERIES "A"

No 2 red.
No 3 black.

in Series B.

It is sufficient to say that growth in Nos. 5, 7 and 8 was steady during the first half of the time under observation, and that in No. 5 it continued so until the end, while in Nos. 7 and 8 it became cyclic. Rabbit No. 6 thrived with the others for a time, but between the ninetieth and one hundredth days it was noticed to be lethargic, the fur staring, and there was profuse and persistent diarrhea. At this time, and for some days subsequently, growth was arrested, and though the symptoms of illness passed off in about ten days, the rabbit never thoroughly regained its previous condition. It will be observed that growth, when it did return, was of cyclic type.

Table No. 8 giving full details of the weights of these rabbits throughout the course of the experiment is appended.

With reference to the Guinea-pigs, the same mode of procedure and precautions were taken in obtaining their growth records, as were observed in the case of the rabbits.

In the guinea-pigs the observations are perhaps more valuable than those of the rabbits,as they extend from the time of birth to full maturity, whereas with rabbits such free handling in the early stages is quite impossible.

TABLE NO. 8

WEIGHTS of RABBITS (Grammes)

OBSERVATIONS on the

SERIES	Number of Rabbit	June 18	20	22	24	26	28	30	July 2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	August 1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	Sept. 2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
A.	1.	318	362	383	413	453	500	542	622	606	650	660	694	710	729	802	780	794	774	857	858	869	909	912	965	900	947	955	1024	1070	1102	1180	1126	1124	1213	1215	1291	1336	1310	1295	1290	1276	1327	1340	1341	1345	1340	1351	1410	1397	1432	1440	1431	1435
	2.	240	272	295	315	363	393	444	485	481	521	546	569	580	577	652	627	637	686	755	748	779	818	829	894	848	872	880	965	975	987	1119	1072	1089	1110	1200	1231	1252	1250	1209	1255	1290	1300	1329	1334	1330	1337	1346	1331	1372	1399	1440	1459	1451
	3.	272	313	341	383	434	463	502	585	561	616	621	642	692	686	779	765	778	791	853	842	880	922	946	1045	948	999	1020	1024	1179	1207	1265	1210	1244	1273	1366	1421	1458	1401	1354	1472	1540	1491	1424	1431	1437	1451	1594	1627	1610	1653	1684	1666	1689
	4.	302	353	357	398	450	490	539	604	598	644	629	658	669	663	763	733	754	788	882	883	891	951	959	1039	960	1005	1020	1106	1163	1192	1264	1213	1235	1281	1300	1385	1432	1317	1293	1320	1436	1453	1463	1471	1489	1473	1465	1461	1483	1497	1495	1510	1491
B.	5.		566	607	611	617	718	716	730	744	794	774	817	818	928	901	912	942	990	1076	1037	1107	1119	1070	1190	1134	1130	1138	1178	1192	1205	1304	1316	1392	1300	1450	1437	1410	1460	1465	1520	1545	1550	1572	1567	1539	1555	1559						
	6.		485	500	505	515	581	607	634	611	693	655	687	673	783	745	747	796	844	914	906	977	979	928	1029	952	937	922	950	1001	1032	1080	1114	1069	1129	1240	1240	1229	1241	1237	1270	1376	1375	1381	1390	1345	1373	1374						
	7.		509	503	538	555	638	639	693	688	747	707	742	757	806	856	844	892	939	1004	984	1064	1060	1035	1043	1072	1100	1140	1197	1212	1222	1296	1312	1305	1470	1488	1480	1485	1483	1484	1560	1593	1621	1646	1601	1586	1611	1640						
	8.		560	610	611	620	695	695	749	756	806	798	828	819	872	890	889	948	1016	1073	1041	1016	1140	1084	1211	1126	1143	1174	1231	1290	1300	1311	1366	1354	1472	1525	1512	1490	1485	1487	1582	1654	1612	1652	1652	1590	1634	1640						
C.	11.																		86	110	149	158	162	178	186	202	212	247	279	297	325	339	352	355	360	460	497	521	557	575	620	663	667	654	689	695	701	760	721	749	763	778	780	799
	12.																		96	120	147	157	166	186	198	216	237	247	295	286	294	316	330	349	425	440	493	513	570	578	599	650	693	691	701	757	793	868	873	852	888	912	879	934
	13.																		71	89	127	136	151	167	176	191	230	228	265	280	283	310	327	337	361	422	475	498	537	544	552	609	599	584	607	625	661	711	725	729	743	730	737	765
	14.																		74	89	124	127	139	151	162	176	210	212	216	219	225	257	262	256	271	317	343	357	355	372	385	414	430	432	457	456	460	547	512	529	513	555	572	591
	15.																		49	65	90	93	101	115	121	135	140	157	174	185	186	214	204	187																						

WEIGHT. 20 : 22 : 24 : 26 : 28 : 30 : 2 : 4 : 6 : 8 : 10 : 12 : 14 : 16 : 18 : 20 : 22 : 24 : 26 : 28 : 30 : 1 : 3 : 5 : 7 : 9 : 11 : 13 : 15 : 17 : 19 : 21 : 23 : 25 : 27 : 29 : 31 : 2 : 4 : 6 : 8 : 10 : 12 : 14 : 16 : 18

1500 GRAMMES.

1400

1300

1200

1100

1000

900

800

700

600

500

400

60 days old

70 days

80 days

90 days

100 days.

110 days

120 days.

130 days.

No 5

No 6

CHART No 7.

WEIGHT-CURVES OF RABBITS, SERIES "B"

No 5 black.
No 6 green.

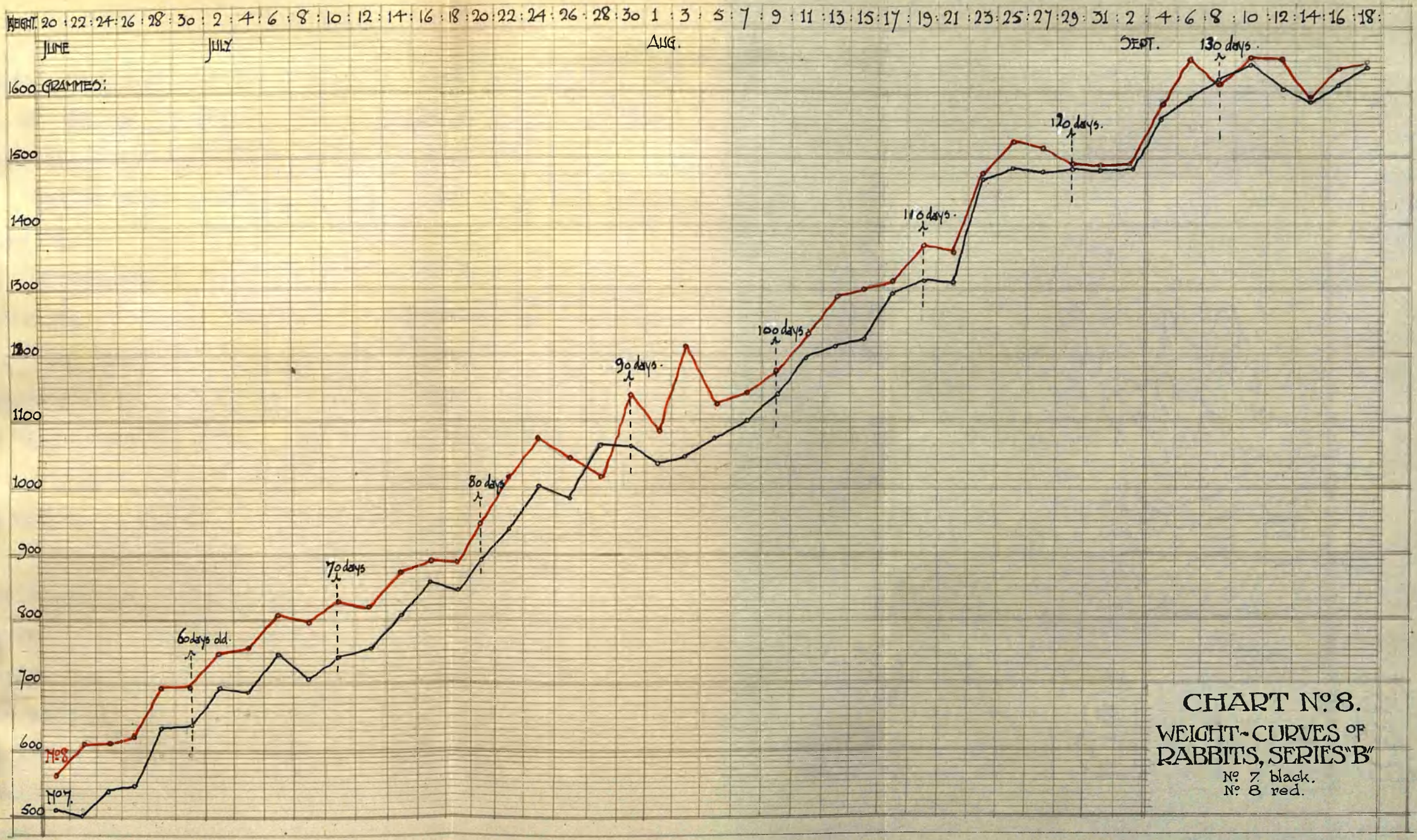


CHART No. 8.

WEIGHT-CURVES OF RABBITS, SERIES "B"

No 7 black.
No 8 red.

Records were taken of the weights of seven animals, Nos. 20, 21, 22, 23, 24, 25 and 26, and in every instance the first observation was made within a few hours of birth.

The weights are given in Table 9, and in Charts Nos. 9 and 10.

Guinea-pigs Nos. 20 and 21 were of the same litter, (Chart No. 9) as also Nos. 23, 24, 25 and 26 (Chart No. 10) while No. 22 was a single specimen (Chart No. 10). It is unnecessary to consider the growth records of the animals in the different litters separately, as the essential features are common to all, and when discrepancies do occur they will be noted.

From the Table and Charts it will be seen that weight may or may not be lost during the first few days after birth. Thus all the specimens of one litter, Nos. 23, 24, 25 and 26, lost weight to the extent of 1/5th to $\frac{1}{8}$th of the original body weight, while in the other two litters, guinea-pigs Nos. 20, 21 and 22, an unbroken line of increase from the time of birth is shewn. During the first week the weights of all the young guinea-pigs were taken daily, and not one of these three animals gave any sign of decrease. In Nos. 23, 24, 25 and 26, the loss of weight continued for variable periods: No. 24 had regained its original weight by the fifth day, while No. 23 took eleven

days to regain what it had lost.

Once increase in weight commenced, its course was remarkably similar in all the animals under observation, and the salient feature in the growth curves of these guinea-pigs is the uniformity of the rate of increase from the time of birth to maturity.

Small irregularities do occur, and in each Chart one can pick out periods of more rapid growth followed by slowing or complete arrest: for example, in Guinea-pig No. 20, between its fortieth and sixtieth days, or in No. 23 from the fortieth to the seventieth day, so that it would appear as if periodic growth does occur, though not to any marked extent.

As already stated, the main characteristic of these Charts is their regularity, and it would be difficult to find a more evenly continuous increase in weight than is shewn by No. 22 from the time of birth to the thirtieth day.

Guinea-pigs Nos. 21, 22 and 26, were females, and in all of them pregnancy supervened before the close of the experiment, so that the records are spoilt as observations on individual growth. The sudden loss of weight in No. 21 on the eighty-fifth day is explained by the occurrence of parturition on that date.

One hesitates, from such a small number of observations

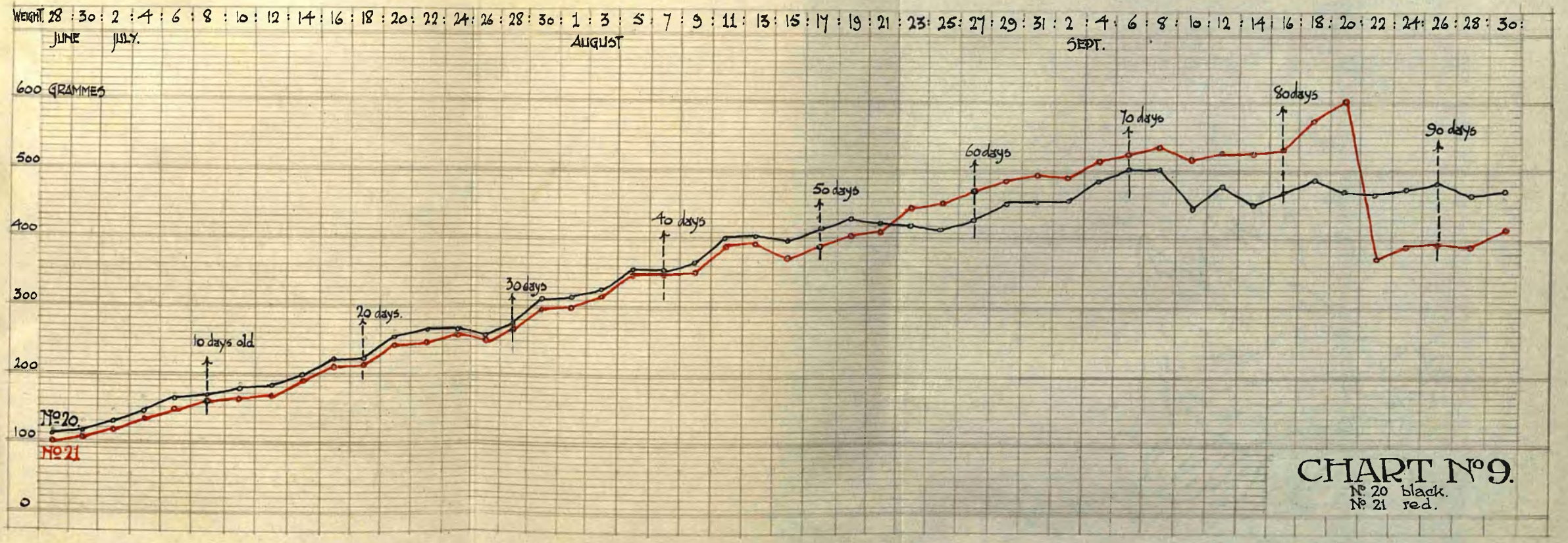
to generalise or draw any inferences regarding the phenomena of growth as shewn in rabbits and guinea-pigs, but such as seem obvious will be discussed later.

TABLE NO. 9

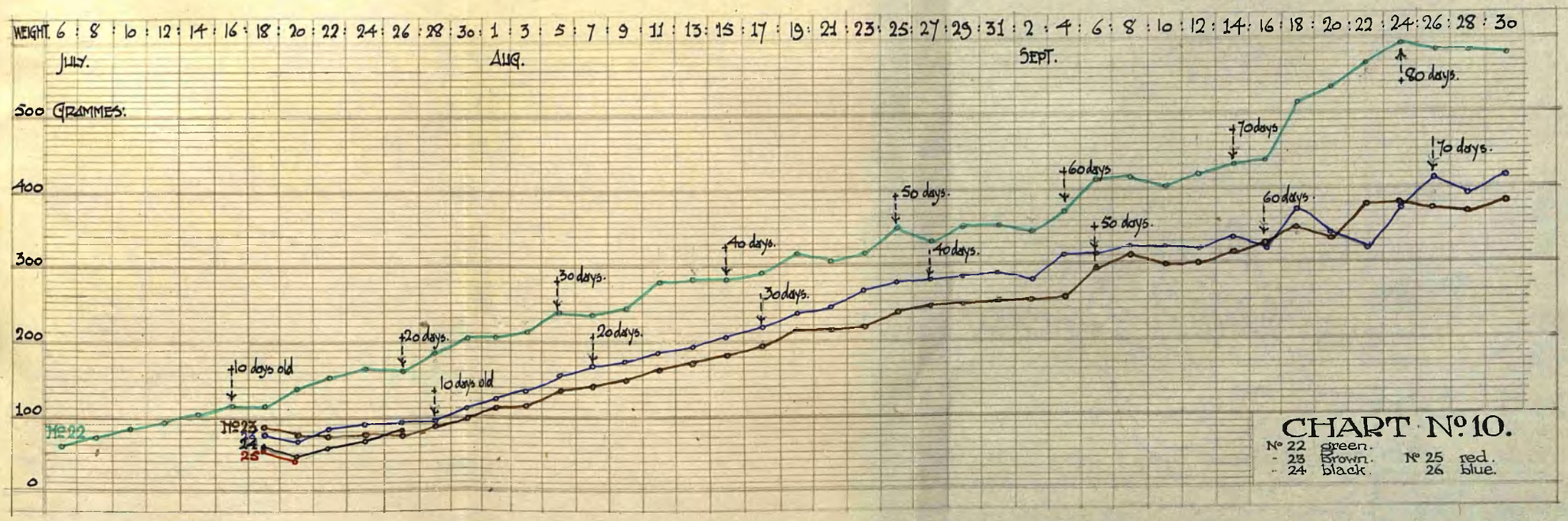
OBSERVATIONS on the WEIGHT of GUINEA - PIGS (Grammes)

Number of Guinea-Pig																				
20	110	117	130	145	163	168	179	184	200	224	224	252	263	267	258	275	306	309	327	358
21	98	106	119	133	149	162	162	169	194	213	215	244	249	262	252	277	297	300	318	349
22					59	71	82	97	103	117	117	140	152	164	161	185	204	207	211	240
23											86	75	73	75	76	88	99	112	116	138
24											56	47	58	68	78					
25											55	43								
26											79	69	84	91	91	97	110	123	133	155

Number of Guinea-Pig																												
20	352	362	400	402	389	417	429	423	420	415	430	454	453	459	489	504	500	447	481	452	470	490	472	459	475	485	468	472
21	350	351	391	395	372	392	404	412	449	453	473	488	495	492	519	528	533	520	529	528	534	586	601	373	391	397	392	417
22	236	242	280	282	282	291	315	306	315	349	331	349	352	343	371	410	415	402	420	431	437	511	532	567	591	583	581	579
23	140	148	163	174	183	196	213	214	219	238	245	248	250	251	253	295	310	299	300	315	329	349	331	379	381	372	369	381
24																												
25																												
26	169	176	189	194	202	219	237	242	269	277	280	284	289	279	312	313	320	322	319	334	327	374	333	319	377	412	391	417



Weight-curves of Guinea-pigs.



Weight-curves of Guinea-pigs.

SECTION THREE

OBSERVATIONS ON THE GROWTH

of

HEALTHY BOYS BETWEEN THE AGES OF TEN AND NINETEEN YEARS

The following inquiry was undertaken for the purpose of observing the phenomena of growth in young healthy adolescents during the school age. For the data on which these observations are based I am indebted to the Headmaster of Bootham School, York.

At that School a record is taken at the beginning and end of each term of the physical condition of every boy. Height, weight, chest measurements and capacity, besides various tests for the fitness of several groups of muscles are all systematicly gone through and noted down in the Anthropometric Register.

Physical exercise of all kinds enters largely into the curriculum, so that the boys are continuously in hard condition, the sick-rate is practically nil, and therefore one can accept these records as those of normal, healthy individuals.

The school year is divided into three terms of approximately thirteen weeks each, with breaks at Christmas, Easter and late summer for vacation, and as the records are taken at the time of dismissal for holidays, and again on returning, a series of six observations per year is the result. The intervals between the observations are not equal in length, but from the method which one has adopted in charting them, it is possible to tell at a glance the rate of growth of a boy in any given month of the year.

For the objects of the present work, a study of individual growth, it was considered sufficient to take out the heights and weights and neglect the muscle and chest measurements as having no very definite bearing on the matter in hand.

Records of the growth of 250 boys as evidenced by height and weight were taken from the Register. Those which did not extend over a period of at least eighteen months were neglected, but in order that the results might be as far as possible representative of the incidence of the various forms of growth, and the relative frequency with which they occur, the records are consecutive, taken in the order in which they appear in the Register, i.e. in the order of the boys' entrance to the School.

Some of the records, therefore, only cover periods

of eighteen months, but the large majority extend over a matter of four years, while a few are seven or even eight years in length. The ages of the boys observed range between ten and nineteen.

To make it possible to sort out the Charts into different groups a separate one was made for each individual and the series of observations of height and weight plotted out on it. The records in the Register are given in feet, inches and eighths of an inch, and the weights in pounds; and the method of charting these was as follows.

Ruled paper divided into eighths was used so that it was a simple matter recording the height. It was found that, on the average, for every ten pounds gained in weight there was an addition of two inches in stature, and to keep the height and weight curves within reasonable limits this ratio was maintained.

The Charts were further subdivided by vertical lines into regular spaces representing months, thus allowing the rate of growth to be gauged.

As the exact dates of all the records are given in the register, it was possible by the above means to plot out the curves of growth, both in height and weight with great accuracy.

In the first place growth as represented by increase

in height will be considered.

On inspection of the 250 Charts, considerable difficulty was experienced in reducing them to any sort of arrangement, according to the type of growth displayed. While hardly two of them were alike certain others presented such diverse and definite characteristics as to suggest of themselves a method of classification.

Charts shewing regular growth with continuous and steady increase sustained over the whole period of observation form the first group, while at the other extreme, those giving examples of typically cyclic growth make up the third group. Between these two comes a large series comprising the great proportion of the Charts, in which growth is irregular in type, and yet not regular in its irregularity as in the cyclic form. This second group was so large that for purposes of description it was necessary to sub-divide it into two classes; the first in which the irregularities are only slight, and the second where marked variation is the prominent feature of the Charts.

Of course this classification is purely arbitrary, and as one group merges imperceptibly into another, there are necessarily outlying charts which come just on the borderland and which required repeated rearrangement before their positions were finally determined. Lastly, those

charts were classed by themselves in which the ages ranged between the seventeenth and nineteenth years, and which therefore demonstrated the slowing of growth which occurs at that time, and in considering this series one had to include charts from other groups which continued into that period.

It is now proposed to describe severally the features of these groups.

With reference to Group 1, composed of charts shewing the regular form of growth, little need be said by way of description. It may be well, however, to mention that as the average length of a chart in this Group represents over three and a half years, and that from commencement to close each one gives evidence of steady increase, the continuous or regular nature of the mode of growth is amply proved. The time under observation in every instance was sufficiently long to exclude the possibility of only the period of active growth in one of the irregular or cyclic types being recorded and then causing inaccuracy by its inclusion in this series.

The group is a small one, comprising as it does only 29 Charts out of the total 250. Every Chart presents the same feature, an unbroken line of ascent, the growth of one year being almost identically repeated in the next, and apparently quite uninfluenced by seasonal change or

other external agency.

The most interesting chart in the series is one which extends from the eleventh to the nineteenth year, and in which growth is perfectly regular, with an increase of approximately two and a quarter inches yearly until the age of seventeen, when growth suddenly stops, and in the eighteenth and nineteenth years no further addition is made to the stature. This chart continues into the later stage, when growth stops, but all the others in the Group are identical with it in its earlier phase of marked uniformity in the rate of growth.

Charts Nos. 11 and 12 are typical examples of this first Group, and require no further description.

Appended is Table No. 10, indicating the ages over which the charts in Group 1 extend.

TABLE 10

CHARTS OF GROUP 1

Age from	Years 10	11	12	13	14	15	16
to 15 years	-	-	2	-	-	-	-
16	-	1	4	1	-	-	-
17	-	-	1	2	6	1	-
18	-	-	1	2	3	2	2
19	1	-	-	-	-	-	-

Total - 29 Charts

HEIGHT FT. INS. | JAN. FEB. MAR APR MAY JUNE JULY AUG SEPT. OCT. NOV. DEC. | JAN. FEB. MAR APR MAY. JUNE JULY AUG SEPT OCT NOV. DEC. | JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC | JAN FEB MAR APR MAY JUNE JULY. AUG. SEPT OCT NOV. DEC. | JAN FEB | WEIGHT LBS.

AGE 12 YEARS — AGE 13 YEARS — AGE 14 YEARS — AGE 15 YEARS — AGE 16.

6 : 0
5 : 11
5 : 10"
5 : 9"
5 : 8"
5 : 7"
5 : 6"
5 : 5"
5 : 4"
5 : 3"
5 : 2"
5 : 1"
5 : 0

140
130
120
110
100
90

CHART No 11.

SHEWING REGULAR TYPE OF GROWTH. (GROUP I.)

black line ------- height
blue Do. --------- weight.

HEIGHT FT INS. | JAN FEB. MAR. APR. MAY. JUNE JULY. AUG SEPT. OCT. NOV. DEC. JAN FEB. MAR. APR. MAY JUNE JULY. AUG SEPT. OCT. NOV. DEC. JAN. FEB. MAR. APR. MAY. JUNE JULY. AUG SEPT. OCT. NOV. DEC. JAN FEB MAR. APR. MAY. JUNE JULY. AUG. SEPT. OCT. NOV. DEC. JAN. FEB. | WEIGHT. LBS.

age 13 years. age 14 years age 15 years.

5' 7"
5' 6"
5' 5"
5' 4"
5' 3"
5' 2"
5' 1"
5' 0
4' 11
4' 10"
4' 9"
4' 8"

130
120
110
100
90
80

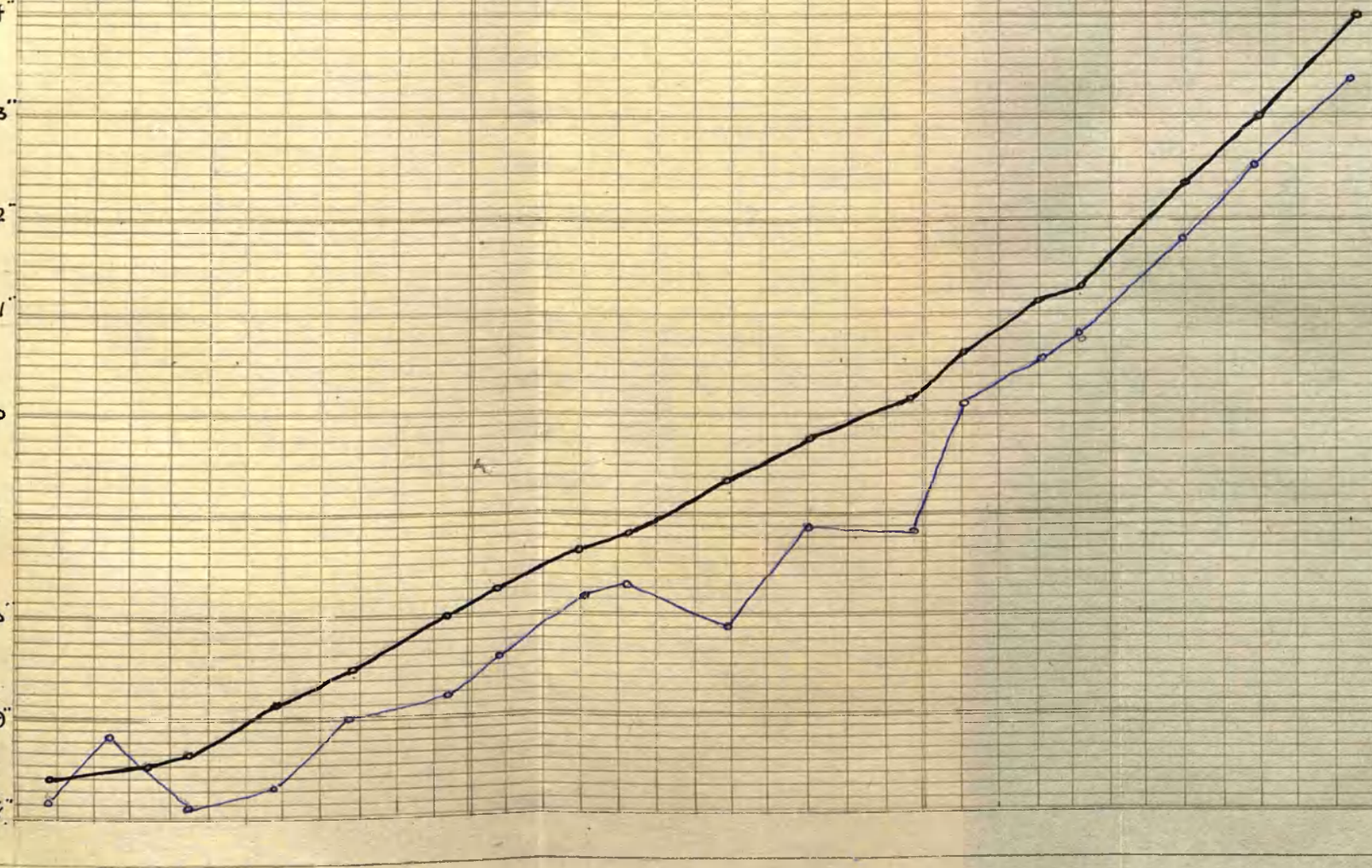


CHART No 12.

SHEWING REGULAR TYPE OF GROWTH. (GROUP I.)

black line ------ height:
blue do. ------- weight:

Group 2

In Group 2, irregularity in the curve of growth is the essential feature of the charts.

The series is a large one, made up of 194 charts, all of which shew variation in the rate of increase to a greater or less extent. According to the degree of irregularity the Group has been divided into two classes, A and B, the former composed of 174 charts, the latter 20.

With regard to Class A the charts in this series have been selected as shewing a small degree of irregularity in the rate of growth. In the 174 charts in the class there naturally is considerable difference in the amount of variation displayed: at one extreme are those in which growth is almost uniform enough for their inclusion in Group 1, but which, on more detailed examination, shew a trifling but unequivocal irregularity, while at the other extreme irregularity is quite a prominent feature of the charts.

Considering the series, therefore, as starting with charts of almost regular growth, and then followed by others becoming gradually more and more irregular,purposes of description of the class as a whole will be most easily met by picking out a typical specimen from either extreme of the class and commenting upon it individually. Such

Charts are found in Nos. 13 and 14.

In Chart No. 13, which perhaps shews the most regular growth of any in the Class, it will be observed that although taken as a whole, increase is fairly uniform, irregularities in the rate of growth are also evident. Thus, from October 1899, till July 1900, there is slow steady increase, then more rapid during August and September, and slower again in October and November. At the beginning of 1901 there is a short period of rapid growth, followed by a lapse of fully three months, till the middle of May, when increase is slow, but at the end of which there appears another time of more active growth fairly uniformly sustained for eight months, that is till February 1902.

In the spring of 1902, and again in the autumn, growth is slow, while from June to September it is more rapid. 1903 begins with a short period of rapid growth, but this is only of short duration, and from February to July the increase is uniformly slow.

This chart is representative of a fairly large number in the Class, charts which shew a slight but quite definite amount of variation in the rate of growth.

Chart No. 14 marks the limit of the greatest irregularity displayed by the charts in Class A of the second group. As will be seen the rate of growth is markedly variable. The curve is composed of successive periods,

HEIGHT FT. INS.

'99 Oct. Nov. Dec. 1900 Jan Feb Mar Apr May June July Aug Sept Oct. Nov. Dec. 1901 Jan Feb Mar Apr May June July Aug Sept. Oct Nov Dec 1902 Jan Feb. Mar Apr. May June July Aug Sept Oct. Nov Dec. 1903 Jan Feb Mar Apr May June July Aug. Sept. Oct. Nov.

Aged 13 years

Aged 14

Aged 15

Aged. 16

8
7.
6.
5.
4.
3.
2.
1.
5.0
11
10
4:9

LBS.
130
120
110
100
90
80.

CHART No 13.

SHEWING SLIGHT VARIATIONS IN RATE OF GROWTH.

GROUP II

CLASS A.

(black=height, red=weight)

of unequal duration, when increase is either rapid, slow, or even in entire abeyance.

There are thus definite periods of accelerated and retarded growth, but these periods are irregular in the time and frequency of their recurrence, and do not comform to any cyclic arrangement, as will be found to be the case with the irregularities in Group 3.

Chart No. 14 commences with an absolutely quiescent period of fully three months, from January to April 1902, when no increase in height is recorded, then follows fairly rapid growth in May and June, with another period of arrest during July, August, and September. For the remainder of that year growth is rapid, but in the first three months of 1903 it is only slow, becoming more rapid again in April, May and June, while in July, August and September complete arrest is shewn. In October, November and December, rapid increase again takes place, followed by a short quiescent period after which growth is again rapid and sustained, on this occasion, over a matter of seven months, that is until September 1904. A resting stage of three months ensues, from early in September till the middle of December, but after this, rapid growth recommences and is continued to the end of the period of observation - July 1905.

The description of these two Charts, Nos. 13 and 14, coming as they do from the extremes of the series, covers all that might be said in discussion of the class as a whole.

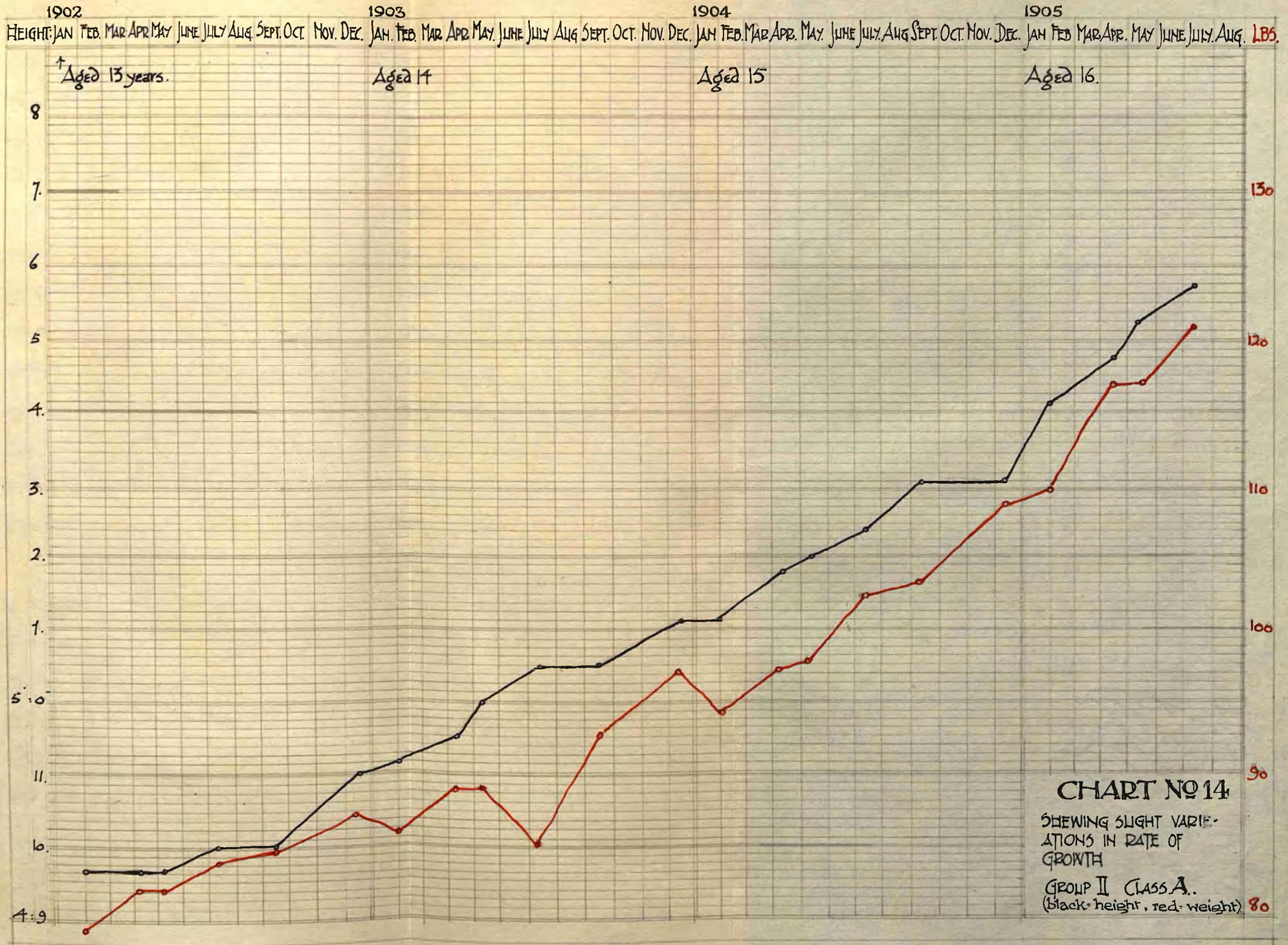
Essentially all the charts present the same feature - irregularity - the only point in which they differ from one another being in the degree of variation displayed, and as Class A is limited to those which shew only a slight amount of irregularity, the differences between the individual charts are small.

Class B of Group 2 comprises only 20 charts but each one shews great irregularity in the curve of growth. The Class is a small one, but in every case the features of the charts are sufficiently distinctive to warrant their being classed by themselves.

In the earlier charts in Class B the irregularities in the rate of growth are only slightly greater than those shewn in Chart No. 14 belonging to the latter series in Class A, but towards the end of Class B an extreme amount of variation is displayed.

Charts Nos. 15 and 16 are examples of the most pronounced form of this irregular type of growth.

Chart No. 15, at the outset, shews a resting stage of fully two month's duration, from October to December 1901,


1902
1903
1904
1905
HEIGHT: JAN FEB MAR APR MAY JUNE JULY AUG SEPT. OCT NOV. DEC. JAN. FEB. MAR APR. MAY. JUNE JULY AUG SEPT. OCT. NOV. DEC. JAN FEB. MAR APR. MAY. JUNE JULY. AUG SEPT. OCT. NOV. DEC. JAN FEB MAR. APR. MAY JUNE JULY. AUG. LBS.
Aged 13 years.
Aged 14
Aged 15
Aged 16.
8
7.
6
5
4.
3.
2.
1.
5'.0"
11.
10.
4'.9
130
120
110
100
90
80
CHART No 14
SHEWING SLIGHT VARIATIONS IN RATE OF GROWTH
GROUP II CLASS A.
(black- height, red- weight)

when the height remains stationary. In the middle of December there is a sudden accession of growth which continues at a uniform rate throughout the year 1902, and results in an addition of over four inches in the twelve months. During January, February and March, 1903, the rate of growth gradually becomes slower, then ceases altogether, while in April and May there is a loss of a quarter of an inch before a fresh outburst of rapid increase takes place in the summer months. This period of active growth is only short, and from September until the following July, there is a long quiescent stage, in the early part of which there is another decrease in height to the extent of a quarter of an inch as there had been previously in spring.

It may be well to note here, in reference to these periods in which there is decrease in height, that probably this phase of retrogression does actually occur. It can hardly be accounted for by inaccuracy in observation as in some of the charts a gradual descent in stature can be traced through several observations; and also on inquiry one learns that it has long been recognised and remarked by the Bootham School authorities.

The loss in height is shewn in several charts in this class, and also in some in Groups 3 and 4, so that it would appear to be of fairly common occurrence. Its significance

will be discussed later.

Chart No. 16, during the first eighteen months, from October 1897 to April 1899 presents an even line of uniformly regular growth. Following this, however, there is a period of arrest lasting for six months, till the end of September, and in which a decrease of three eighths of an inch is shewn. On the return of active growth in October increase is extremely rapid, and in the succeeding seven months an addition of four and three eighths inches is made. From May 1900 until the close of the observations in December the increase is slower and comparatively uniform in rate.

This Chart, No. 16, reaches the extreme limit of the irregularities in rate of growth as shewn in Group 2.

The most noteworthy feature of these irregular charts is the occurrence of periods of rest in the curves of growth, periods in which increase may be only retarded or may cease altogether, while occasionally an actual loss in height is recorded.

Table No. 11 shews ages to which the charts in Group 2 refer.

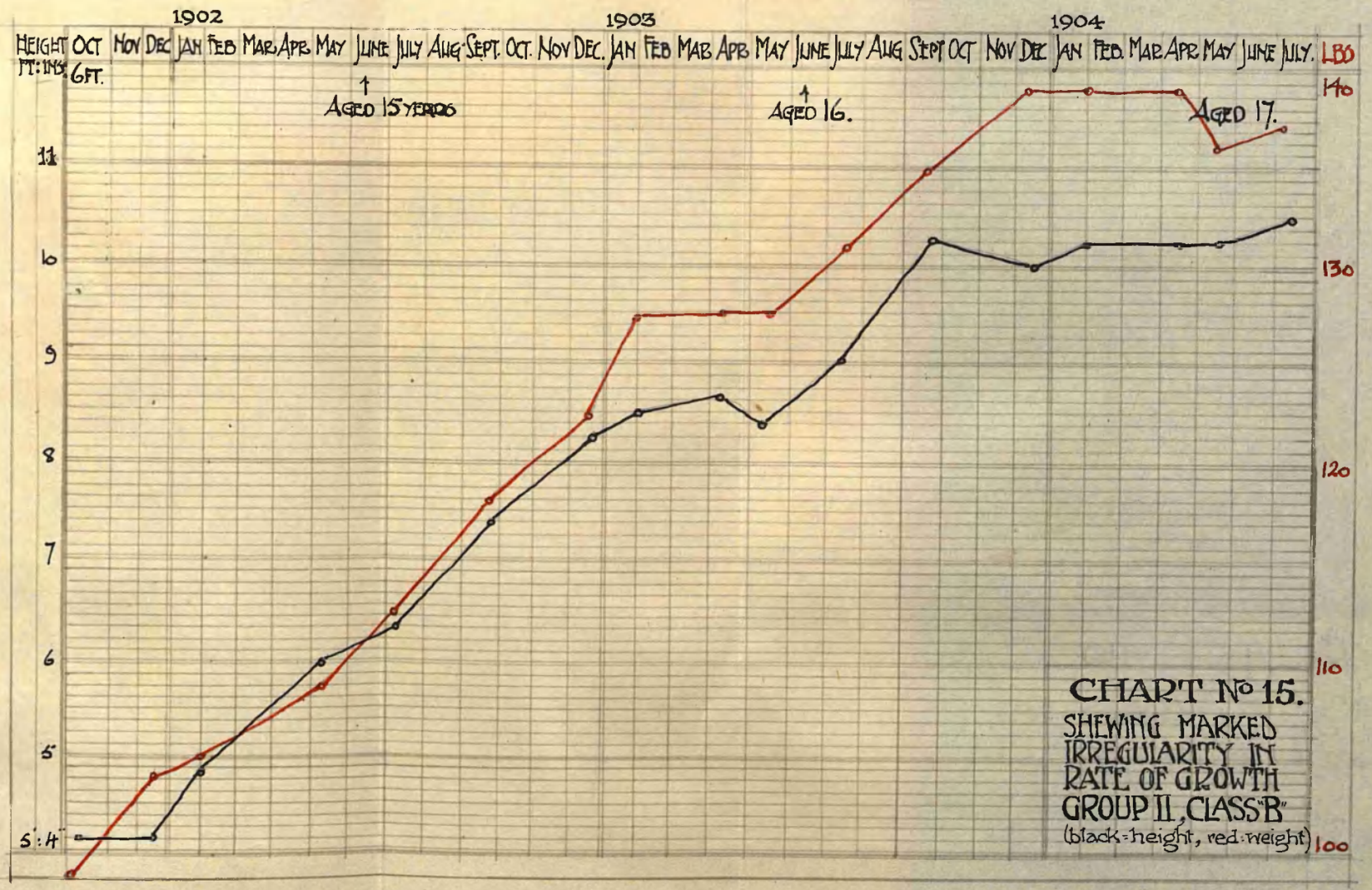

1902
1903
1904
HEIGHT FT: INS.
OCT NOV DEC JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC JAN FEB MAR APR MAY JUNE JULY.
LBS
6 FT.
AGED 15 YEARS
AGED 16.
AGED 17.
11
10
9
8
7
6
5
5' 4"
140
130
120
110
100
CHART No 15.
SHEWING MARKED IRREGULARITY IN RATE OF GROWTH GROUP II, CLASS "B"
(black = height, red = weight)

TABLE No. 11

Charts of Group 2 (Classes A and B)

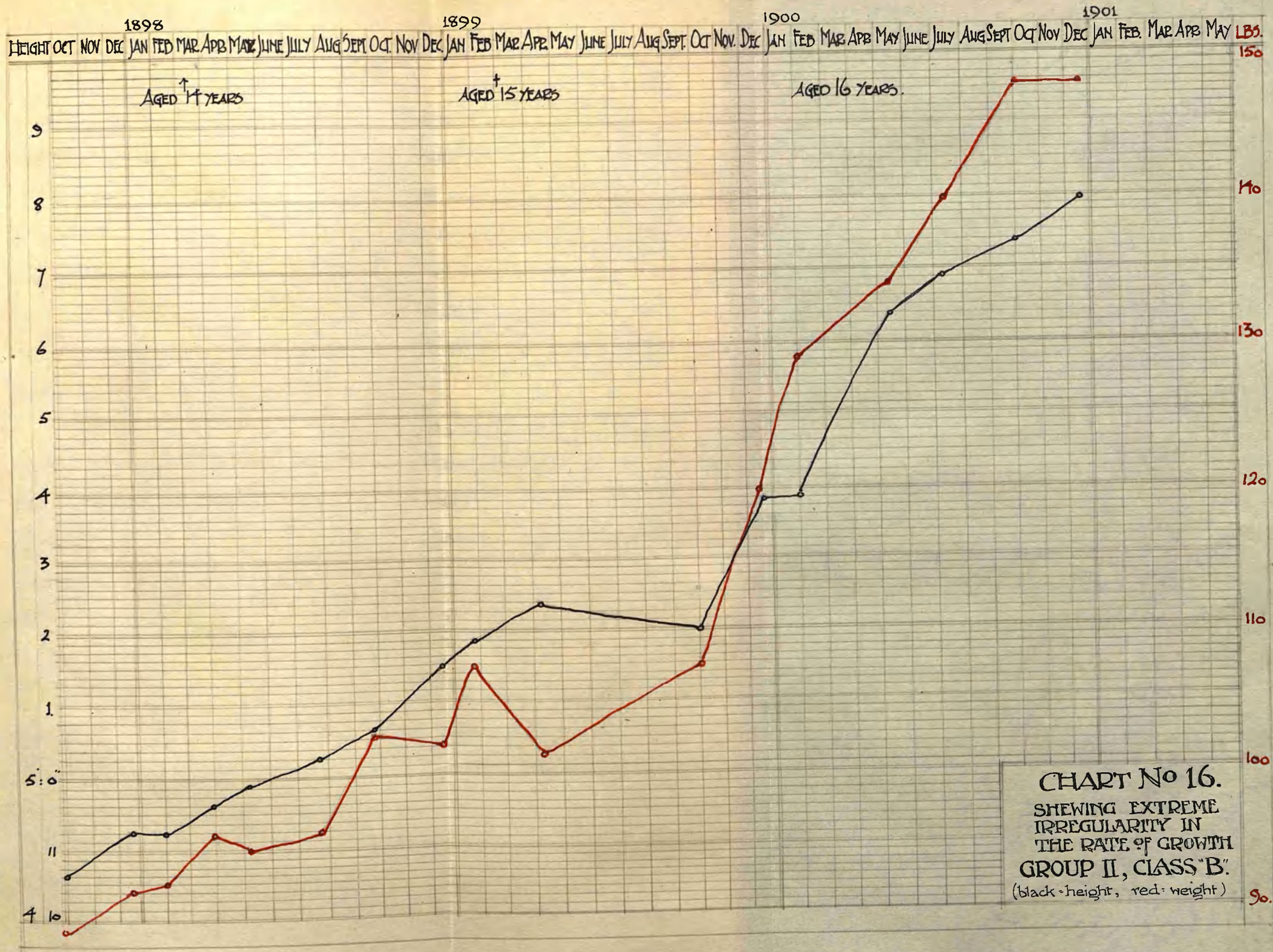
Age from	Years 11	12	13	14	15	16
13 to 13 years	1	-	-	-	-	-
14	-	2	-	-	-	-
15	-	-	4	-	-	-
16	1	5	11	12	-	-
17	1	8	20	33	43	-
18	-	2	5	18	11	15
19	-	-	-	-	-	1

Total number of Charts 194

Group 3

On inspection of the eleven charts which form Group 3 there is ample evidence of the existence of a cyclic type of growth in healthy adolescents.

The term "cyclic" implies a succession of variations in the rate of growth which occur in a definite order and with perfect regularity, so that when one cycle is completed it is followed by a second presenting precisely the same features as the first, and which, in its turn, is succeeded by a third and so on.


1898
1899
1900
1901
HEIGHT OCT NOV DEC JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC JAN FEB MAR APR MAY LBS.
AGED 14 YEARS
AGED 15 YEARS
AGED 16 YEARS.
9
8
7
6
5
4
3
2
1
5:0"
11
4 10
150
140
130
120
110
100
90.
CHART No 16.
SHEWING EXTREME IRREGULARITY IN THE RATE of GROWTH
GROUP II, CLASS "B".
(black - height, red - weight)

The curve of growth, therefore, is in the cyclic type, made up of a series of subsidiary curves formed by the changes in the rate of growth, and marking off the separate cycles, any one of which would almost exactly coincide with either of its neighbours, so regular are they in time and degree of variation displayed.

As Group 3 is a small one, containing only 11 Charts, it is evident that the cyclic variety is a comparatively rare form of growth in Man.

The period of time occupied by a single cycle varies in the different charts. In two of them, from four to six months pass between the commencement of one cycle and that of the next, two shew an eight months swing, three ten months, in other three the cycles occupy twelve months, while in one the swing is even longer, extending over fifteen months.

With regard to the first two charts which present the rapidly changing phases, the cycles though perfectly definite, are not quite regular in point of time. In one of these charts which extends over nearly three years, seven cycles are shewn, but one is completed in four months, while another occupies six, the remainder being fairly regular.

The period of active growth in these cycles is of relatively short duration as compared with the time of rest,

in most cases the increase takes place in one month, but occasionally it lasts for two or two and a half months. The period of rest is therefore of variable duration also and although in it the height usually remains stationary a decrease is occasionally seen.

Of the two charts shewing the eight month cycles it need only be said that in each case the times are more regular than in either two charts already described. The characters of the cycles are similar, the period of active growth being short in comparison with the intervals of slow increase and rest.

In each of the three charts which present a cyclic change occurring every ten months the time and degree of variation displayed in successive cycles are remarkably regular.

One of these charts is given in No. 17, and in spite of extending over only two years, has been selected as an example of the cyclic charts of Group 3, as it presents such great variation in the rate of growth.

Commencing with two months of rapid increase in May and June 1900, this gradually slows during July, August and September, and from September till the middle of December there is a stationary period of rest. In the second half of December, growth begins again and continues for five

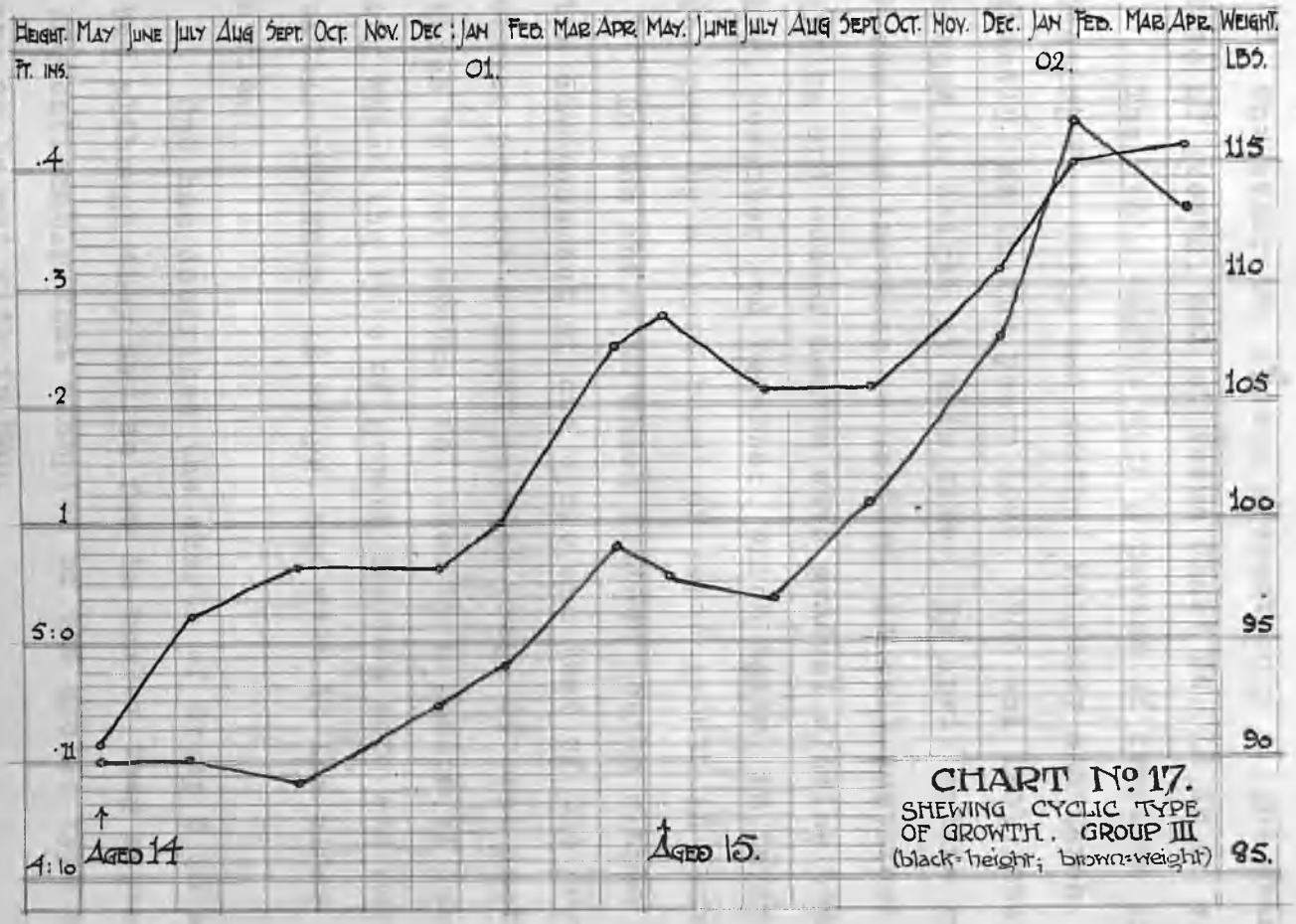
months till the middle of May 1901, being extremely rapid during February and March, while in the initial stage in December and January, and again at the close in April and May the rate increases and diminishes respectively. From the middle of May till well on into September there is a period of rest, in the early part of which a considerable decrease in height occurs: a matter of five eighths of an inch being lost in two months.

At the end of this quiescent period, active growth recommences, and continues to shew rapid increase for fully four months, from September to the end of January 1902, after which another period of rest begins.

The other two charts shewing a ten months swing are similar to this one, except that in them there is not such a wide range in the rate of growth, and therefore the curves representing the cycles are less prominent.

With reference to the three charts in which periods of twelve months are occupied by the cycles, little description is necessary. These charts, however, shewing the same phenomena occurring year after year, raise the question of seasonal influence on growth: a point which will be considered later.

In one of these charts the twelve month cycles are divided into two periods of four and eight months each, in the former, from June to September growth is rapid, while


HEIGHT.
MAY
JUNE
JULY
AUG
SEPT.
OCT.
NOV.
DEC
JAN
FEB.
MAR
APR.
MAY.
JUNE
JULY
AUG
SEPT
OCT.
NOV.
DEC.
JAN
FEB.
MAR
APR.
WEIGHT.
FT. INS.
01.
02.
LBS.
4
3
2
1
5:0
11
4:10
115
110
105
100
95
90
85.
AGED 14
AGED 15.
CHART Nº 17.
SHEWING CYCLIC TYPE
OF GROWTH. GROUP III
(black=height; brown=weight)

the latter is a time of comparative quiescence.

The other two charts present only slight changes in the rate of growth, and of these Chart No. 18 is an example.

The cycle begins with a period of complete arrest, lasting for fully two months: February and March, and frequently, as in the years 1899, 1900 and 1901, there is decrease in height at this time. In April active growth returns, and increase is uniform and well sustained over the spring and summer months with gradual slowing towards October, November and December, which again, is invariably followed by a short burst of rapid growth in January.

In the chart in which fifteen months elapse between the commencement of one cycle and that of the next, the curves present a short initial stage of rest lasting from three to four months, followed by a period of increase during which the rate of growth becomes more and more rapid until, suddenly, it stops, and with it the close of the cycle.

One has described the charts of Group 3 in some detail, but although they are so few in number they appear to prove unquestionably that examples of the cyclic type of growth are to be met with in Man.

1898 1899 1900 1901 1902

HEIGHT JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC JAN FEB MAR APR MAY JUN JULY AUG SEPT OCT NOV DEC JAN FEB MAR APR MAY JUN JULY WEIGHT

FT. INS.

Aged 12 years

Aged 13 years:

Aged 14 years

Aged. 15 years.

Aged. 16 years:

5

2

1

5 : 0

11

10

9.

8

7.

4:6.

LBS.

110

100

90

80

70

CHART №18.

SHEWING CYCLIC TYPE OF GROWTH

GROUP III

(black: height, red: weight)

TABLE 12

Shewing the ages covered by the Charts in Group 3.

Age from	Years 12	13	14	15
to 14 years	-	-	-	-
15	-	1	-	-
16	-	2	2	-
17	2	1	2	1

Total - 11 Charts

Group 4

All the charts reaching to the age of eighteen or over, and which therefore shew the slowing of growth which commonly occurs during the seventeenth and eighteenth years, have been placed in Group 4. There are in all 54 Charts in this Group.

Of the original 250 charts, 16 were put straight into Group 4, as, representing only the sixteenth, seventeenth and eighteenth years, the number of observations made during the period of active growth before the commencement of slowing was too small to allow of the type of growth being determined, and therefore the charts could not be included in Groups 1, 2 or 3.

The remaining 38 charts extend over several years, and in their earlier stages the curves of growth have already been considered and grouped according to the regular, irregular or cyclic nature of the increase shewn, but as their later records extend into the period now under-noted they must also be included in Group 4.

It has been found necessary to divide the Group into four classes: firstly those charts which shew only a slight change in the rate of growth: secondly, charts in which growth is definitely retarded: thirdly, where it stops entirely, and fourthly, a set of charts in which, immediately after the cessation of growth, a sudden decrease in height occurs before the stature becomes stationary.

Before describing these classes in detail, it may be well to say of the Group as a whole, that the age at which the change in the rate of growth takes place is remarkably constant; the average of the 44 charts falling at the end of the seventeenth year, while a period of six months on either side of that includes every chart except four. In two of these four charts growth had stopped at the age of fifteen, and in the other two at sixteen, but it is noteworthy that in each case considerable stature had been attained before growth ceased, the height registered being five feet ten inches in every instance: a matter of fully

six and four inches above the average heights at those ages as taken over the whole series of 250 charts.

With regard to the 10 charts forming Class A, and which shew little or no change in the rate of growth during the seventeenth and eighteenth years, one need only say that in these charts the heights are in most instances far below the average. They therefore present the converse to the four charts already mentioned in which growth ceased early, and it would seem as if wide extremes of stature were avoided to some extent at least, by the early or late occurrence of the period at which the growth of the individual slows and ceases.

Chart No. 19 is given as an example of those in Class A. It is from a chart beginning at the age of fourteen, but the curve of growth during the seventeenth and eighteenth years only is given, and needs no explanation. It will be seen that the rate of growth during the eighteenth year does not differ much from that during the seventeenth, and that stature at the age of eighteen is only five feet five inches.

From Class B, composed of 18 charts shewing a definite slowing in the rate of growth at the period under consideration, a typical example will be found in Chart No. 20. Here the increase is fairly regular and sustained throughout the seventeenth year, but at the commencement of the eighteenth

there is obvious slowing, as an increase of only one half inch takes place during that year as compared with one inch and a half in the previous one.

In Class C are 20 charts, all shewing complete arrest of growth; Chart No. 21 is a specimen of this Class. In each of these charts growth becomes slower and slower, until at some point, usually about the age of seventeen, it ceases altogether. This is seen in Chart No. 21; steady increase in the seventeenth year, and continuing into the first half of the eighteenth, after which it stops, the height remaining stationary during the remainder of the time of observation.

Class D, though it contains only 6 Charts, is the most interesting one in the Group.

They are all long charts, previously included in Group 1 or Class A of Group 2. In each the curve of growth shews a more or less regular rate of increase, until the end of the seventeenth or the beginning of the eighteenth year, when it suddenly stops, and is immediately followed by a period of decrease with loss in height before the stature becomes stationary. The amount of height lost, though always quite appreciable, is variable, as in one chart it is only a quarter of an inch, in another three eighths, in two it is a half, while in other two it reaches to three

quarters of an inch. One of the latter charts, No. 22, is given as an example of Class D.

In this chart increase is seen during the first eighteen months, and then, without any warning, in the middle of the eighteenth year growth stops, and in the following five months a loss in height to the extent of three quarters of an inch takes place, after which the records become practically stationary.

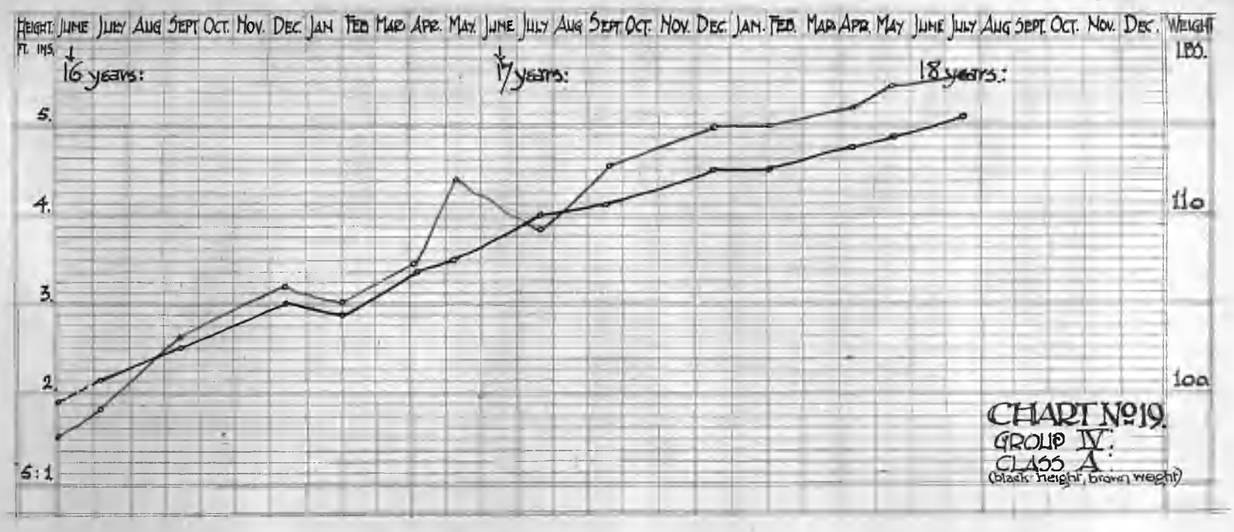
This chart is a typical example of Class D: the loss in height is greater than in most of the others, but apart from this the main features are precisely similar.

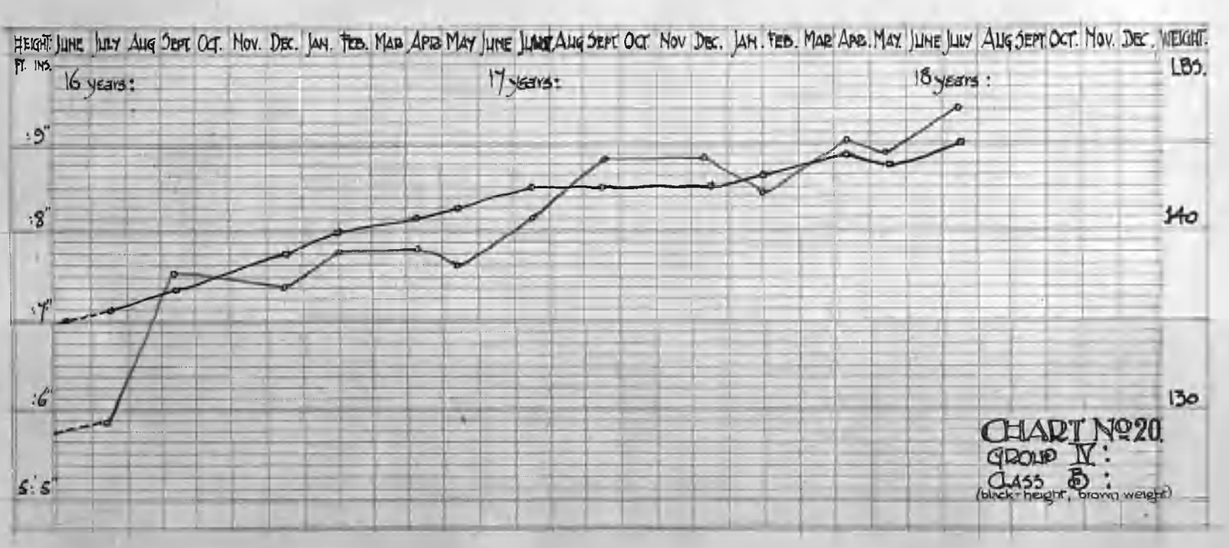
TABLE No. 13

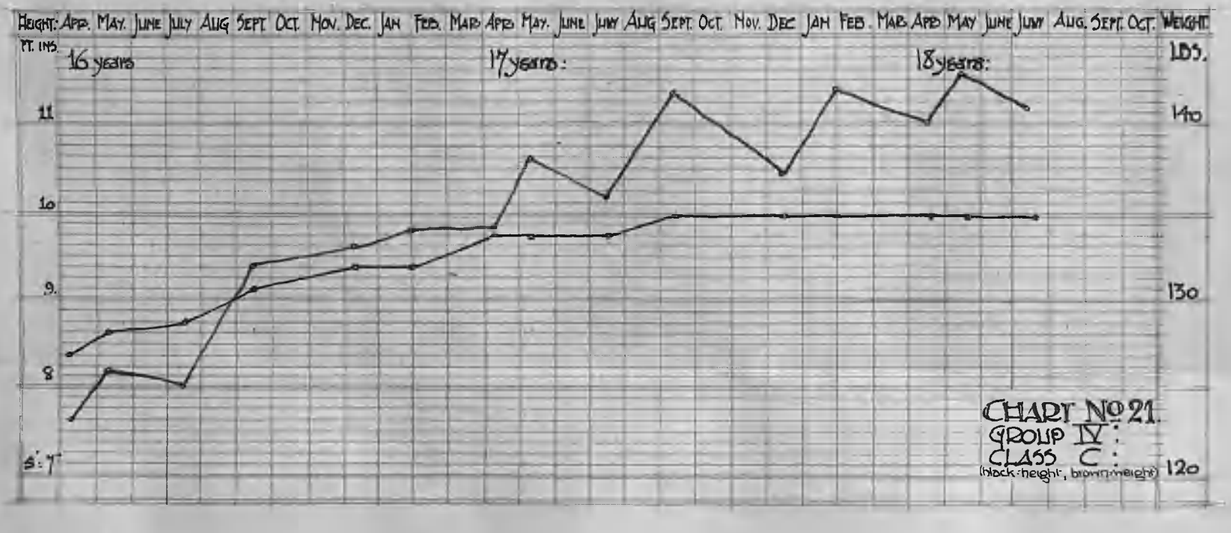
Ages covered by the Charts of Group 4

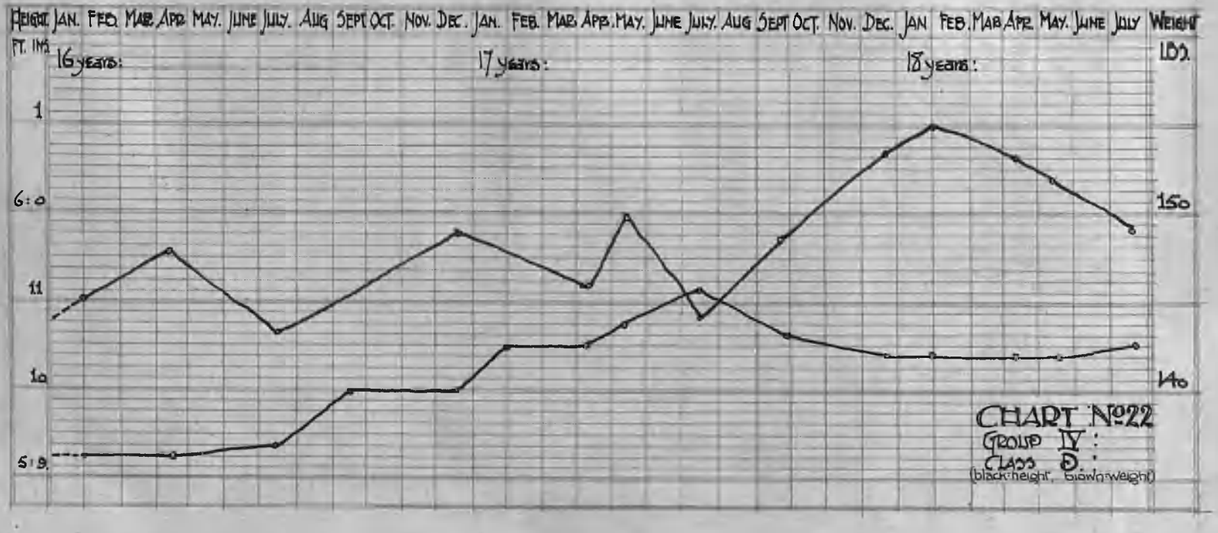
Ages from	Years 10	11	12	13	14	15	16
18 to 19 years	-	-	-	7	13	14	16
	1	-	-	1	-	1	1

Total - 54 Charts


HEIGHT
FT. INS.
JUNE JULY AUG SEPT OCT. NOV. DEC. JAN FEB MAR APR. MAY JUNE JULY AUG SEPT OCT. NOV. DEC. JAN. FEB. MAR APR. MAY JUNE JULY AUG SEPT. OCT. NOV. DEC.
WEIGHT
LBS.
16 years:
17 years:
18 years:
5.
4.
3.
2.
5:1
110
100
CHART No 19.
GROUP IV:
CLASS A:
(black: height, brown: weight)


HEIGHT
FT. INS.
JUNE JULY AUG SEPT OCT. NOV. DEC. JAN. FEB. MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC. JAN. FEB. MAR APR. MAY JUNE JULY AUG SEPT OCT. NOV. DEC.
WEIGHT
LBS.
16 years:
17 years:
18 years:
5'5"
:6"
:7"
:8"
:9"
140
130
CHART No 20.
GROUP IV:
CLASS B:
(black: height, brown: weight)


HEIGHT
FT. INS.
APR. MAY. JUNE JULY AUG SEPT OCT. NOV. DEC. JAN FEB. MAR APR. MAY. JUNE JULY AUG SEPT OCT. NOV. DEC JAN FEB. MAR. APR MAY JUNE JULY AUG. SEPT. OCT.
WEIGHT
LBS.
16 years
17 years:
18 years:
5'7"
8
9.
10
11
140
130
120
CHART No 21.
GROUP IV:
CLASS C:
(black: height, brown: weight)


HEIGHT
FT. INS.
JAN. FEB. MAR. APR. MAY. JUNE JULY. AUG SEPT OCT. NOV. DEC. JAN. FEB. MAR. APR. MAY. JUNE JULY. AUG SEPT OCT. NOV. DEC. JAN FEB. MAR. APR. MAY. JUNE JULY
WEIGHT
LBS.
16 years:
17 years:
18 years:
5:9
10
11
6:0
1
140
150
CHART No 22.
GROUP IV:
CLASS D.
(black: height, brown: weight)

Weight-curves

It is unnecessary to do more than mention the evidences of growth as furnished by the curves of weight. The measurement of height is the more accurate test of growth, the different types as shewn by the height records have been described in some detail, and apparently no new points emerge on studying the progress of growth from the point of view of the weight curves.

As a rule there is a fairly close accordance between the rates of increase in height and weight, but this is not always so, for occasionally rapid increase in weight is observed while the height remains stationary, or, more rarely, the converse, the weight records shewing no increase while rapid additions to the height are in progress.

Although these discrepancies are by no means of rare occurrence, and several instances will be found in the Specimen charts, still the main features of the curves of weight and height are remarkably similar in the individual charts.

One need hardly point out the comparatively steady increase in weight in the charts of Group 1: the irregular weight-curves in Group 2, the degree of irregularity bearing some proportion to the amount of variation in the height curves: or the cyclic swings in the weight as well as in

height shewn by the Charts belonging to Group 3.

There is naturally a certain amount of irregularity in all the tracings of the weight records, even in the most regular ones, but in spite of this, had the division into Groups been made according to the features of the weight curves instead of the simpler and probably more accurate plan of classification by the height curves, the result would have been practically the same: three main types of growth, regular, irregular and cyclic, and in the proportions of 3, 20, 1 respectively.

Having outlined the several Groups into which the growth-charts of healthy adolescents were divided, only two points remain for consideration in this section.

The first of these is with reference to the rate of growth during the periods of active increase in the irregular and cyclic types. On looking over the 221 charts belonging to Groups 2, 3 and 4, one finds that in the phases of activity the rate of increase is extremely variable.

The most rapid growth observed is one inch per month which occurs in three instances, while seven-eighths and three quarters of an inch per month are comparatively frequent. An increase of three eighths to five eighths of an inch is common, and rates below these were not considered

as rapid.

The duration of the periods of activity also varies; most commonly it is between three and six months, but occasionally lasts only one month, while examples shewing active growth over a period of nine months or even a year are not infrequent.

The second point has regard to the relative incidence of periods of active growth, and periods of arrest in the different months of the year, or in other words, the possibility of seasonal influence on growth. In connection with this an analysis has been made of the 221 charts from Groups 2, 3 and 4, that is all charts which shew variations in the rate of growth.

The number of times that rapid increase took place during the several months of the year was noted, and the same procedure followed out with the periods of arrest.

The totals are somewhat significant, and are given in Table No. 14.

TABLE No. 14

Month	Number of Times Rapid Growth (Total of 221 Charts)	Month	Number of Times Periods of Arrest (Total of 221 Charts)
Jan.	48	Jan.	73
Feb.	40	Feb.	65
Mar.	38	Mar.	62
Apl	60	Apl	62
May	76	May	45
June	69	June	33
July	68	July	33
Aug.	53	Aug.	37
Sept.	50	Sept.	48
Oct.	47	Oct.	50
Nov.	45	Nov.	53
Dec.	60	Dec.	73

From this Table it will be seen that, though either rapid increase or arrest of growth may occur in any month of the year, the incidence of active growth is mainly in the spring and summer months, while with the periods of arrest the converse obtains, the highest registers being in winter.

The figures are more striking when presented graphically in Charts Nos. 23 and 24.

Chart No. 23 refers to the active growth, and shews

well how, in the majority of cases it is in the months of April, May, June and July that rapid increase takes place. Also it is not uncommon for active growth to appear in December and January though the excess observed in these two months is much less than that seen in the earlier ones. The actual number of instances in which it has occurred is sufficiently great, however, to make it probable that rapid growth is more common in the months of December and January than in those immediately preceding or following them.

Chart No. 24 depicts the incidence of periods of rest in the various months of the year, and gives undoubted evidence of the relative frequency of retardation of growth in the winter months as compared with the low registers during summer.

It is proposed only to note these facts in this section, and they will be further considered in their relation to the seasons in a later sub-section, where the influence of temperature on growth will be discussed.

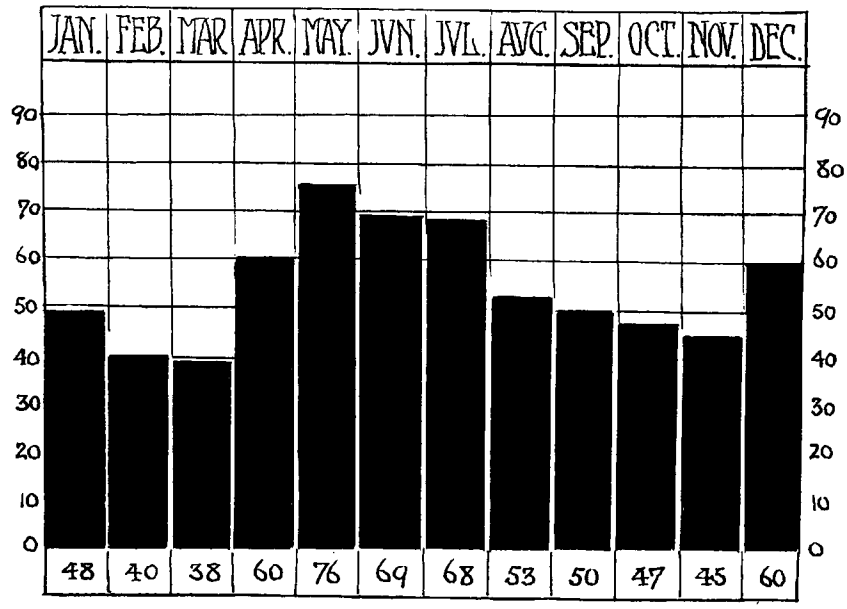


CHART Nº23. Shewing the incidence of heriods of rapid growth in the several months of the year.

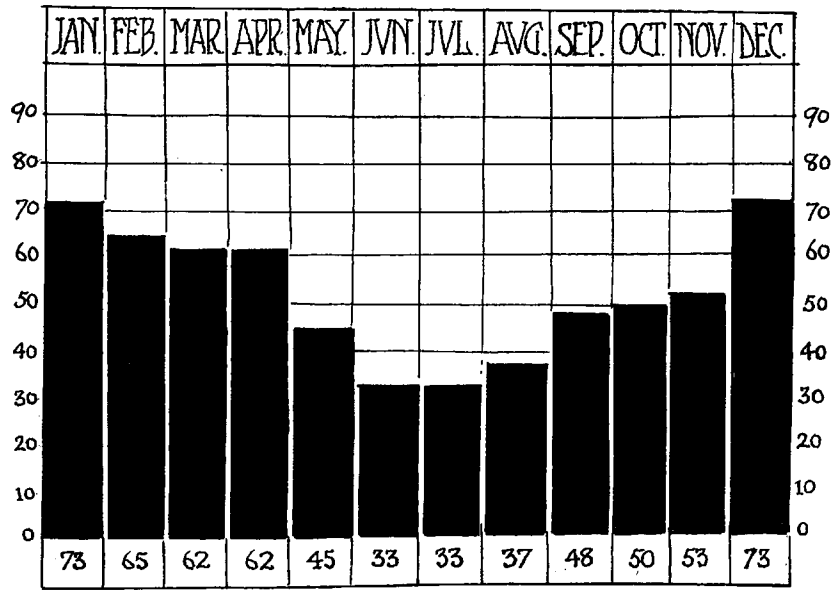


CHART Nº24 Shewing the incidence of heriods of arrested growth in the several months of the year.

SECTION FOUR

INQUIRY INTO THE GROWTH

of

CHILDREN SUFFERING FROM ACUTE FEVERS

Growth during convalescence from prolonged illnesses, and more especially the acute fevers, has at different times received a considerable amount of attention from various authors.

Unfortunately one has not been able to see some of the fullest and most interesting publications on this subject, such as the Thèse de Paris, 1881, in which Auboyer[4] collected from medical literature a number of facts regarding exaggerated growth following acute illnesses, or M. Bouchard's[5] paper in the Soc. Clinique de Paris, Jan. 1879, in which he discusses the rapid increase in stature which occasionally takes place during typhoid fever, giving details of the condition of the bony epiphysis and, in addition, describing certain strial which appear in the skin: "vergetures de croissance".

The above information is taken from a chapter on

"Croissance" by M. Comby in the first volume of "Traite des Maladies de l'Enfance".

That author also gives details of his personal observations, and states that he has seen growth of 10, 15 or 20 centimeters after illnesses which have necessitated confinement to bed for a few weeks or months, and remarks that he has observed "vergetures de croissance".

Going on to discuss the etiology and appearance of these striae he says that they usually occur over the epiphyseal lines of the long bones, but are sometimes to be found in the lumbar region, on the back, or on the sides of the chest.

He speaks of them as being precisely similar in appearance to the striae gravidarum, and explains their occurrence as due to the skin, unable to follow the rapid elongation of the bones, becoming over-stretched.

As this point is subsidiary to the present purpose, and as the above explanation seems to misinterpret certain facts, implying, as it does, a rapid and very considerable increase in stature, the following case of a patient of my own in the practice of Belvidere Fever Hospital may be cited.

The patient, A. M. aet. 19 years, a labourer, was admitted to Hospital on Feb. 23rd, 1908, with a history of

having been ill for three weeks. He was suffering from a sharp attack of enteric fever, and it was not until the end of the sixth week of the disease that lysis was complete. The temperature remained normal for ten days and then, at the beginning of April, became hectic, and four abscesses appeared, one in either arm, one in the left leg and one under the pectoral muscles on the left side. This was the commencement of a general pyaemic condition of staphylococcal origin, and for five and a half months, until the middle of September, the hectic character of the temperature was maintained. During that time twenty-eight large intra-muscular abscesses were opened in the limbs, trunk and neck. Though convalescence was slow there was ultimately a complete recovery and the patient was dismissed well on December 19th 1908.

During the whole course of this illness in which confinement to bed lasted for nine and a half months the increase in stature amounted to only one half inch; from five feet seven and a half inches to five feet eight inches.

In spite of this small addition to the height "vergetures de croissance" were present, the first one being observed on the left arm during the fourteenth week of illness. As will be seen from Chart No. 25 there were, in all, nine striae in this case: one on the left arm immediately above

the insertion of the triceps muscle, one in either groin at the level of the great trochanter and three on the dorsum of each foot. The striae were spindle shaped patches, pink or violet in colour, with the skin surface of a shiny glistening appearance. The long axes of the spindles measured from one to two and a half inches, and lay parallel to the "planes of cleavage" of the skin described by Langer.(6)

The "vergetures de croissance" therefore look more like a pathological condition due to impaired nutrition rather than to mechanical stretching of the skin.

The main part of the observations recorded in this Section refers to the amount of increase in stature which accompanies an attack of acute disease.

On looking over the literature it would seem as if only those cases had been recorded in which exceptional growth followed an illness. There is no mention of any systematic measuring of children having been done before and after an illness: and as only the instances of extremely rapid growth are cited, an exaggerated idea of the frequency of its occurrence is conveyed.

At Belvidere Fever Hospital, for a period of eighteen months almost every child under the age of ten years was weighed and measured at the time of admission, and again on dismissal.

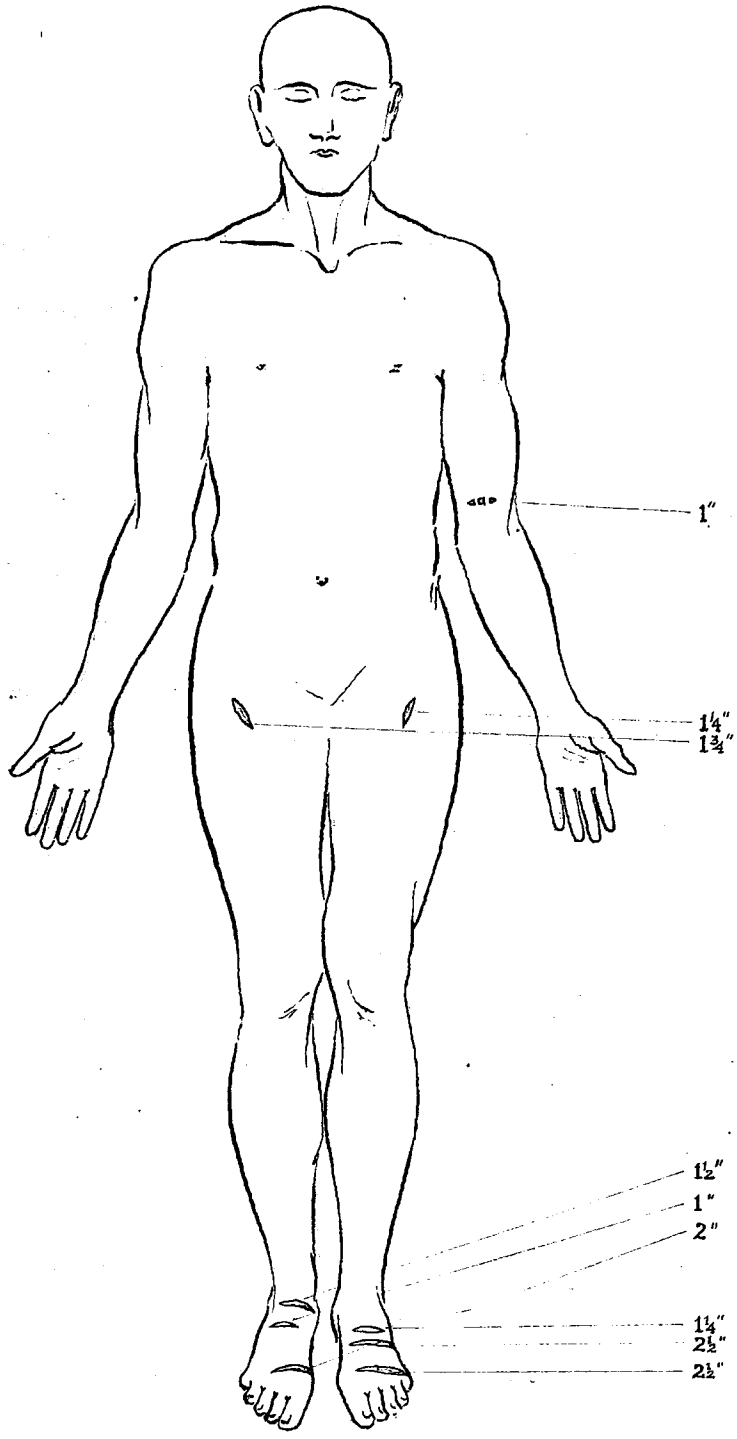


CHART Nº 25. Shewing size and position of 'vergetures de croissance' in the case of A.M.

Unfortunately the records of Enteric Fever, which according to the French authors, is one of the diseases most frequently followed by rapid growth, are too few to be of any value so they have not been included.

Records have been obtained, however, of 1395 cases of Scarlet Fever, Measles, Whooping-Cough and Diphtheria. For the objects of the present work only the heights have been considered, as unquestionably a child's nutrition suffers during the stage of incubation, and therefore a large increase in the weight between the times of admission and dismissal could not be taken as an index of the activity of growth during the course of the disease and subsequent convalescence.

The complete results of these observations on the growth of children as evidenced by increase in height during the course of the above named Fevers are given in Tables 15, A and B, 16 A and B, 17 A and B, and 18 A and B.

These Tables have been arranged to give full details of the results of this inquiry, and separate Tables are given for the two sexes.

The first column shews the age in years. Following this, in a series of columns for the various amounts of increase which took place between admission and dismissal are the total numbers of children at the different ages shewing such

increase

In a corresponding series of columns the duration of residence of each child is given, the figures indicating the number of weeks the child was a patient in Hospital.

From the observations on the growth of children published by various authors it would seem unnecessary to include either the age or the sex in Tables of this kind. There is very little variation in the mean annual increase in height between the ages of two and ten years, the curve of average growth being practically a straight line during that period. With regard to sex, so far as stature is concerned the curves of growth in the male and female run a parallel course during the first decade, and therefore one feels justified in neglecting age and sex and reducing the records to cross-tables as in Nos. 19, 20, 21, and 22.

In working out the average annual rate of growth of children suffering from the four acute fevers under notice, it has been thought advisable to neglect all records referring to infants under two years of age.

Normally the increase in stature during the first two years of extra-uterine life is twice as rapid as that between the ages of two and ten. The number of children under two years included in these observations is too small in comparison with the relatively large numbers of higher

age to allow of the average rate of growth being taken over the whole series. For this reason the records of children below the age of two years have been neglected.

Considering, then, only children between the ages of two and ten years, from the Tables of Scarlet Fever one finds the average duration of a child's residence in Hospital 8.04 weeks, an average growth of .349 inch, giving an increase of 2.25 inches in the year. In the same way with Measles the average residence works out at 3.74 weeks with an increase of .15 inch, or a mean annual growth of 2.08 inches. The Diphtheria averages work out to a growth of .37 inch in 9.42 weeks, a yearly increase of 2.04 inches: while in Whooping-Cough an average increase of .52 inch in 8.38 weeks gives a yearly addition to the stature of 3.22 inches.

Comparing these average annual growths during fevers; 2.25 inches in Scarlet, 2.08 inches in Measles, 3.22 inches in Whooping-Cough, and 2.04 inches in Diphtheria with the normal mean yearly increase between the ages of two and ten the result is striking.

The average annual increase in normal, healthy children between the ages of two and ten years, from the statistics published by Cruchet[7] is 2.5 inches; from Roberts'[8] figures 2.57 inches, and from those of Comby[9] 2.66 inches.

It will be observed that instead of being more rapid the

average rate of growth during Scarlet Fever, Measles and Diphtheria is slower than in health, and that Whooping-Cough with its 3.22 inches is the only one of the diseases observed in which the rate of increase is accelerated.

The reason for the average rate of growth in Whooping-Cough being so much higher than in the three other fevers is not evident. As a class the children admitted to Hospital suffering from Whooping Cough are drawn from a lower social grade than is the rule in the other infectious diseases, and it is possible that they shew a greater reaction to the improved hygienic conditions of hospital life.

Another possible explanation may be that the bony epiphysis are stimulated by a raised blood tension due to back pressure from the increased resistance in the pulmonary circulation. This idea has,to some extent, been borne out by estimation of the blood pressure by the Riva-Rocci sphygmomanometer.

It is found that in Whooping Cough the average pressure is higher throughout than the normal average, and that during and for a short time after a paroxysm of coughing the pressure is considerably in advance of this. (Unpublished results by MacDonald)

Considering the growth of the individual rather than the average growth, one finds that 65 children out of the

total 1395 observed, or 4.6%, shewed extremely rapid increase in stature during their time in hospital.

In the 462 cases of Scarlet Fever rapid growth occurred in 23, the most marked instance being that of a girl of six growing four and a half inches in eight weeks, in fact this is the most rapid increase recorded in the whole series of observations. Following this come a boy and a girl each putting on three inches in seven weeks; another boy with two inches in five weeks; next four girls shewing an addition of three inches in eight weeks; another girl increasing two and a half inches in six weeks, while two more shew the same amount of increase for a period of eight weeks.

These children, a boy and two girls, added two inches in six weeks; another boy, growing at the same rate, three inches in nine weeks; a girl with two inches in seven weeks; and lastly two boys and two girls with an increase of two inches in eight weeks; a boy growing three inches in twelve weeks, and two girls each shewing an increase of one inch and a half in six weeks.

The total number of Measles cases measured was 465 and in this disease also there are 23 instances of rapid growth. The quickest increase occurred in a boy four years old, one inch in two weeks, and a girl of three, one inch and a half in three weeks; next three girls growing one inch and a half

in four weeks, and then eleven children, nine boys and two girls who in three weeks added one inch; next two girls adding one inch and a half in five weeks, and lastly three boys and two girls each of whom grew one inch in four weeks.

Out of the 88 cases of Diphtheria there are only three instances of rapid growth, two of them boys three years old, one adding two inches in six weeks, the other two and a half inches in eight weeks, while in the third, a boy of four, one inch is added in four weeks.

Though the average increase is so much higher in Whooping Cough than in Scarlet, Measles or Diphtheria, only 16 of the 380 children observed during that disease shewed any very active growth. The most rapid instance is seen in a boy one year old, four inches in nine weeks; next a girl of five growing three and a half inches in eight weeks; then two more girls with two inches in six weeks, and a boy one inch in three weeks. Another girl in eight weeks shews an increase of two and a half inches, and then four children, a girl and three boys in whom there is an addition of two inches in eight weeks; and at the same rate, a boy and a girl, one inch and a half in six weeks, and another boy and three girls, one inch in four weeks.

It is difficult to compare the incidence of sudden spurts of rapid growth in health and in disease. One has

shewn in Section Three that outbursts of rapid increase do occur in normal health without any apparent cause, but it would seem as if one of these sudden spurts might be precipitated by an attack of illness.

If one may compare the growth during the second decade with that of the first, and setting the standard of "rapid growth" at a minimum of one half inch per month, in the observations of healthy boys already detailed it is found that in the total of almost one thousand years of growth investigated there are five hundred and fourteen instances of rapid increase, whereas, in the inquiry into growth during an acute illness it occurs two hundred and thirty-five times in a matter of one hundred and fifty eight years; in other words, rapid increase occurs almost three times more frequently during the course of an illness than it does in health.

The figures for these observations are somewhat limited however, and comparison of the growth of children between the ages of two and ten with that of boys between ten and twenty is perhaps hardly justifiable.

The above ratio of 3 to 1 is further modified by the fact that the children measured before and after the fevers were, during their residence in hospital, living under immensely improved hygienic conditions. The salutary effect

of healthful surroundings and an adequate and wholesome dietary upon the growth of children has been amply proved. (Unpublished results by Macgregor).

It is thus almost impossible to estimate the influence of an attack of fever, per se, in bringing about a spurt of rapid growth, and probably the ratio of 3 to 1 is considerably higher than is really the case. Whether this is so or not it is a significant fact that the average rate of growth during the three fevers, Scarlet, Measles and Diphtheria is slower than in health.

TABLE NO. 15 A.

SCARLET FEVER (Males)

Shewing the numbers of Cases at each age-period with the corresponding Alteration in Stature observed during residence in Hospital.

Age (in years)	Alteration in Stature													Number of weeks in Hospital								
	-½"	-¼"	Same height	½"	1"	1½"	2"	2½"	3"	3½"	4"	4½"	½"	¼"	Same height	½"	1"	1½"	2"	2½"	3"	3½"	4"	4½"
0- 1			4	1	1		1								8.9.8.7	12	7		8					
1- 2			3		1										13.11.7		7							
2- 3	2		4	3	5		2		1				8.7		6.8.11.8	8.15.7	7.8.7.8.10		8.5		9			
3- 4			19	7	3										10.4.9.8.5.8.10.8.11.8.7 7.6.8.8.8.8.8.7.	8.6.19.17.8.8.8	8.9.9							
4- 5			23	3	4	2	1								8.8.9.6.17.5.7.8.8.7.6.8 8.9.8.14.8.12.14.7.8.12.7	8.8.10	9.9.10.8.	8.9	6					
5- 6		1	19	5	2	1			1					10	7.8.8.2.5.7.7.10.8.7.8.7. 7.8.6.5.7.6.7.	9.9.5.11.8	8.7	8			7			
6- 7			29	5	3	2									12.8.4.8.11.7.7.7.8.7.7. 5.9.5.8.9.7.8.8.7.8.8.7. 7.2.7.13.8.7.	6.8.6.6.4.	8.6.8	8.8.						
7- 8			20	3	3										7.8.6.7.8.7.7.8.8.7.7.8. 7.7.8.7.7.8.7.7.	4.7.8.	8.8.11.							
8- 9			16	1	1										9.11.8.8.8.7.8.8.8.8.8.8. 6.7.8.8.	7.	6.							
9-10			11	2	1										8.7.8.6.7.7.11.8.5.7.10.	8.4.	8.							

TABLE NO. 15 B.

SCARLET FEVER (Females)

Shewing the numbers of cases at each age-period with the corresponding Alteration in Stature observed during residence in Hospital.

Age (in years)	Alteration in Stature: -½"	½"	Same height	½"	1"	1½"	2"	2½"	3"	3½"	4"	4½"	½"	½"	Number of weeks in Hospital: Same height	½"	1"	1½"	2"	2½"	3"	3½"	4"	4½"
0- 1			3	1	2	1	1								6.11.8.	7.	7.13	6	9					
1- 2			3	1	2	1	1								6.11.8.	7	7.13	6	9					
2- 3			7	2	2										8.8.6.8.7.8.6.	14.7	9.8							
3- 4			14	7	6	1									7.6.8.12.8.8.13.7.16.5.8. 9.10.8.	7.9.9.8.5.8.8.	8.8.7.10.8.6.	8						
4- 5			27	4	2	1	2	1							8.5.6.6.7.9.9.11.9.7.8.8. 9.8.13.12.10.7.8.7.8.8.7. 8.6.4.8.	9.8.8.6.	8.8.	8	7.10.	8				
5- 6			21	7	1	2	2		2						8.6.9.8.9.11.9.6.8.7.13. 8.9.6.5.8.10.9.6.9.8.	6.9.8.8.8.8.6.	8	8.20	6.8.		8.8.			
6- 7	1		30	5	2	1			1			1		8	11.8.8.10.8.8.8.8.10.8.8. 6.8.8.8.13.8.8.7.10.9.9. 8.6.9.10.7.8.9.6.	14.15.8.9.6.	8.9.	8.			12			8
7- 8			13	5	3	1		1	2						8.8.7.10.7.7.9.7.8.8.8.7.7.	9.8.8.8.8.	8.8.9.	8.		6	8.8.			
8- 9			19	6	6	1		1	1						5.8.8.8.9.9.8.8.7.8.8.4.8. 12.8.9.9.8.9.	8.8.9.8.5.8.	9.8.11.5.8.10.	10.		8	7.			
9-10			14	2	1		2								8.7.8.5.8.9.5.8.7.10.8.9. 10.10.	6.8.	8.		6.8.					

TABLE NO. 16 A.

MEASLES (Males)

Shewing the numbers of cases at each age-period with the corresponding Alteration in Stature observed during residence in Hospital

Age (in years)	Alteration in Stature									Number of weeks in Hospital					
	$-\frac{1}{2}$"	$-\frac{1}{4}$"	Same height	$\frac{1}{2}$"	1"	$1\frac{1}{2}$"	2"	$2\frac{1}{2}$"	3"	$-\frac{1}{2}$" $-\frac{1}{4}$"	Same height	$\frac{1}{2}$"	1"	$1\frac{1}{2}$"	2"	$2\frac{1}{2}$"	3"
0- 1			6	1	1						5.10.5.2.4.5.	3.	5.				
1- 2			12	1	1						4.2.3.4.3.3.6.8.4.7.3.2.	3.	10.				
2- 3			31	5							2.3.2.2.3.2.3.3.4.3.3.4.3.3.8.4.5.9.4.3.7.3.5.4.3.3.3.3.2.3.2.	2.4.4.3.3.					
3- 4			35	1	8						3.2.4.2.4.4.6.7.2.5.4.7.3.4.2.3.4.5.4.4.3.2.3.11.5.3.6.4.4.6.3.4.7.3.3.	2.	7.3.3.4.3.3.7.13.				
4- 5		2	31	5	4	1				2.5.	3.4.3.4.5.3.4.4.4.5.3.3.4.2.3.5.3.7.4.5.9.2.2.4.4.3.3.3.3.4.5.	4.3.4.3.4.	2.3.4.3.	13			
5- 6			32	7	1						4.3.3.2.4.4.3.2.4.3.3.3.2.3.4.7.4.4.3.2.4.2.4.4.4.3.7.3.3.2.5.2.	5.3.4.4.3.4.2.	4.				
6- 7			29	7	3						4.3.2.4.3.3.4.3.3.3.2.3.4.2.4.3.3.6.2.5.4.2.3.4.3.7.3.4.2.	4.3.9.3.3.3.4.	3.3.9.				
7- 8			20	3	1						3.5.9.3.3.3.4.3.3.3.4.9.3.3.3.3.3.5.4.3.	4.5.3.	10.				
8- 9			11								3.3.3.3.3.5.3.2.3.4.3.						
9-10			2		1						3.3.		3.				

TABLE NO. 16 B.

MEASLES (Females)

Shewing the numbers of cases at each age-period with the corresponding Alteration in Stature observed during residence in Hospital.

Age (in years)	Alteration in Stature											Number of weeks in Hospital					
	-½"	-¼"	Same height	½"	1"	1½"	2"	2½"	3"	-½"	-¼"	Same height	½"	1"	1½"	2"	2½"	3"
0- 1			7	2								3.4.3.3.2.3.2.	5.3.					
1- 2		1	16		1						3	4.8.4.6.6.4.5.6.4.2.5.5.13.6. 2.5.		5.				
2- 3			27	2	1							8.3.5.2.6.3.7.7.3.4.5.4.3.2. 4.3.3.3.2.3.3.3.4.2.6.3.5.	7.4.	6.				
3- 4	1		31	5	2	1				4		3.2.3.2.3.2.3.2.2.2.4.3.7.6.4. 3.3.3.2.4.4.4.3.7.3.2.2.3.4.3.3.	3.3.4.5.3.	4.4.	3.			
4- 5		1	18	4	2	2					2	2.4.5.2.2.3.3.3.5.2.2.3.3.3.7. 4.5.3.	8.2.2.6.	6.5.	4.4.			
5- 6		2	23	5		1					3.3	2.5.2.4.3.2.3.4.2.3.4.5.4.4.2. 3.3.2.4.2.3.2.3.	8.3.3.4.3.		5			
6- 7			16	3	1	1						4.17.3.4.2.3.5.3.3.4.4.2.4.4. 3.3.	3.3.3.	6.	10			
7- 8			10	2	1	1						2.3.3.3.3.3.3.3.3.2.	9.3.	3	4			
8- 9			6		1	1						2.3.3.4.2.5.		3	5			
9-10			4	1								4.2.2.3.	3.					

TABLE NO. 17 A.

WHOOPING COUGH (Males)

Shewing the numbers of cases at each age-period with the corresponding Alteration in Stature observed during residence in hospital.

Age (in years)	Alteration in Stature: 1"	½"	¼"	Same height	½"	1"	1½"	2"	2½"	3"	3½"	4"	4½"	1" ½"	¼"	Same height	Number of weeks in Hospital: ½"	1"	1½"	2"	2½"	3"	3½"	4"	4½"
0- 1				4	4	3		2								9.16.9.4.	7.10.4.4.	11.9.20		8.20.					
1- 2				6	4	4	1	1		1		1				11.7.23.19.9.12	11.9.9.10.	15.9.13.6.	21	9		15		9	
2- 3		1		8	11	8	1	1						9		8.10.8.12.6.5.8.6.	4.3.11.10.5.8. 12.15.12.7.8.	7.4.12.7.8.11. 7.3.	13	16					
3- 4				12	2	2	1	3								7.7.6.9.7.6.7.13.4. 6.7.6.	7.5.	8.20.	15.	9.11.12.					
4- 5	1			19	4	5	3	1	1					7		3.6.6.4.8.4.8.6.6.8. 6.7.9.4.15.5.9.4.7.	10.11.5.13	5.7.11.8.12	12.12.10.	9	22				
5- 6				12	4	2		2	1							23.14.6.9.7.3.12.12. 4.8.6.3.	6.7.9.4.	11.14		16.8.	16				
6- 7				12	3	3	2	1								3.3.17.3.6.15.7.12. 4.4.8.6.	6.6.5.	12.11.9.	8.6.	8.					
7- 8				6	1	2										13.8.4.6.6.7.	7.	14.5.							
8- 9				1		1										3.		6.							
9-10				4	1	1										9.7.12.4.	18.	13.							

TABLE NO. 17. B.

WHOOPING COUGH (Females)

Shewing the Numbers of Cases at each age-period with the corresponding Alteration in Stature observed during residence in Hospital

Age (in years)	Alteration in Stature: 1"	½"	¼"	Same height	Number of weeks in Hospital: ½"	1"	1½"	2"	2½"	3"	3½"	4"	4½"	1" ½" ¼"	Same height
0. 1				5	1	3	2	3		1					8.10.9.7.4.
1- 2		1		9	8	2	2	3						34	7.4.8.8.7.9.10.9.8.
2- 3				19	3	6	1	1	2				1		10.6.7.9.10.10.14. 17.13.5.8.3.7.6.12. 9.16.24.16.
3- 4				15	8	10	2			1					9.3.9.2.8.9.9.4.13. 8.4.14.4.8.9.
4- 5				14	7	6		1							8.5.6.13.6.7.10.5.9. 6.6.4.7.9.
5- 6			1	14	3	2	2	1	1		1			10	2.5.10.10.8.6.9.6. 7.9.8.6.7.8.
6- 7		1		8	3	3	2	2						11	7.8.8.6.4.6.5.6.
7- 8				7.	3.	4	2	1							3.7.4.4.7.4.7.
8- 9				3	1	2									6.7.3.
9-10		1		1										3	7.

Age (in years)	Number of weeks in Hospital: ½"	1"	1½"	2"	2½"	3"	3½"	4"	4½"
0. 1	14	8.7.12	9.12.	20.16.14		11			
1- 2	14.23.9.9.6.9.19.5.	4.12.	12.12.	12.10.25					
2- 3	5.9.8.	9.4.9.12.9. 19.	8	16	17.20.				20
3- 4	6.6.30.8.6.8.12.12.	6.7.8.8.8.8. 8.8.10.10.	9.7.			16			
4- 5	9.7.7.8.11.6.9.	8.12.8.9.4.11		8					
5- 6	8.8.6.	6.7.	9.12	6	8		8		
6- 7	7.9.7.	5.7.5.	9.6.	6.10					
7- 8	8.5.8.	16.9.8.7.	7.7.	11					
8- 9	8.	8.10.							
9-10									

T A B L E 18 A.

DIPHTHERIA (Males)

Shewing the numbers of cases at each age-period with the corresponding alteration in Stature observed during residence in Hospital.

Age (in years)	Alteration in Stature							Number of weeks in Hospital						
	$-\frac{1}{2}$"	$-\frac{1}{4}$"	Same height	$\frac{1}{2}$"	1"	$1\frac{1}{2}$"	2"	$2\frac{1}{2}$"	$-\frac{1}{2}$"	$-\frac{1}{4}$"	Same height	$\frac{1}{2}$"	1"	$1\frac{1}{2}$"	2"	$2\frac{1}{2}$"
1- 2			5	1							30.7.16.5.6	8				
2- 3			2	3	1						6.8	7.12.7	8			
3 -4			3		1	1	1	1			11.9.11		17	8	6	8
4- 5			2	4	1						7.8	6.22.12.11	4			
5- 6			5		2						19.12.6.6.9		8.11			
6- 7			3	3	1						9.19.12	13.6.7	11			
7- 8				1								6				
8- 9			2	2							8.6	6.7				
9-10			3		1	1					9.13.6		15	14		

T A B L E 18 B.

DIPHTHERIA (Females)

Shewing the numbers of cases at each age-period with the corresponding alteration in stature observed during residence in Hospital.

Age (in years)	Alteration in Stature								Number of weeks in Hospital							
	-½"	-¼"	Same height	½"	1"	1½"	2"	2½"	-½"	-¼"	Same height	½"	1"	1½"	2"	2½"
1- 2			2	4	2						5.6	6.6.9.9	6.10			
2- 3			10	1	1						5.6.16.7.10.6.7.7.6.7	6	7			
3- 4			4	3	1						6.6.9.6	6.12.6	9			
4- 5			2	2							6.14	26.11				
5- 6			1								6					
6- 7			1	1							12	9				
7- 8																
8- 9			2		1						4.5		28			
9-10																

TABLE 19

SCARLET FEVER

Alteration in Stature

Number of weeks in Hospital	-½"	-¼"	Same height	½"	1"	1½"	2"	2½"	3"	3½"	4"	4½"
2			2									
3												
4			4	3								
5			13	3	1		1					
6			24	9	3	2	3	1				
7	1		66	7	8		1		2			
8	2		118	30	23	9	4	2	4			1
9			30	9	8	1	2		1			
10		1	15	1	4	1	1					
11			11	1	2							
12			6	1					1			
13			6		2							
14			2	2								
15				2								
16			1									
17			1	1								
19				1								
20						1						

TABLE 20

MEASLES

Alteration in Stature

Number of weeks in Hospital	$-\frac{1}{2}$"	$-\frac{1}{4}$"	Same height	$\frac{1}{2}$"	1"	$1\frac{1}{2}$"
2		2	69	5	1	
3		3	144	25	11	1
4	1		84	14	5	3
5		1	32	4	3	2
6			12	1	3	
7			14	1	2	
8			4	2		
9			4	2	1	
10			1		2	1
11			1			
13			1		1	1
17			1			

TABLE 21

WHOOPING COUGH

Alteration in Stature

Number of weeks in Hospital	-1"	-½"	-¼"	Same height	½"	1"	1½"	2"	2½"	3"	3½"	4"	4½"
(2				2									
) 3		1		11	1	1							
(4				21	4	4							
(5				7	7	4							
(6				30	9	4	2	2					
(7	1			27	9	9	3						
) 8				23	11	14	2	4	1		1		
(9		1		22	10	8	4	3				1	
(10			1	9	4	3	1	2					
)11		1		1	4	6		2		1			
(12				7	4	7	6	2					
)13				5	1	2	1						
(14				3	2	2		1					
)15				2	1	1	1			1			
(16				3		1		4	1	1			
)17				2					1				
(18					1								
)19				1	1	1							
(20						2		2	1				1
(21							1						
)22									1				
(23				2	1								
)24				1									
(25								1					
)30					1								
(34		1											

TABLE 22

DIPHTHERIA

Alteration in Stature

Number of weeks in Hospital	-½"	-¼"	Same height	½"	1"	1½"	2"	2½"
4			1		1			
5			4					
6			15	9	1		1	
7			6	4	1			
8			3	1	2	1		1
9			5	3	1			
10			1		1			
11			2	2	2			
12			3	3				
13			1	1				
14			1			1		
15					1			
16			2					
17					1			
19			2					
22				1				
26				1				
28					1			
30			1					

SECTION FIVE

OBSERVATIONS

on

THE GROWTH OF INTERNODES IN PLANTS

During the months of July, August and September, 1908, some observations were made on the growth of plants.

The object of the experiments was to record the growth of the internode rather than that of the plant as a whole, and thus one was enabled to follow out the development of a large number of practically separate individuals, all of which were influenced by precisely the same external conditions.

In the choice of a plant it was necessary to consider two points, firstly, one which would shew an appreciable increase in a comparatively short time, and secondly, one in which the internodes would be very definitely marked so that there might be only the minimum chance of inaccuracy in measurement.

These combined characters were present in the specimens finally selected, viz. Peas, Beans, Oats, Maize, Musk and

Eucalyptus.

Observations were made on all the internodes of thirty plants, six each of the Peas, Beans, Oats and Maize and three of Musk and Eucalyptus.

The Peas, Beans, Oats and Maize were grown from seed, and the records extend from the fourteenth day until the time of cessation of growth in the two former, while in the Oats and Maize increase continued longer.

The records of the Musk and Eucalyptus were obtained from growing plants after all the off-shoots had been removed except those directly under observation.

With regard to the technique of the experiment it need only be said that the plants were kept under most favourable conditions, being placed in a large room with abundance of air and light, with a regular water supply, and in a practically constant temperature, night and day, of 54°F. or thereby.

Measurements of the internodes were taken with compasses and a m.m. scale every second day and at the same hour on each occasion.

The complete results are given in Tables Nos. 23, 24, 25, 26, 27, 28, 29 and 30, and specimen charts from each set of plants are found in Charts Nos. 26, 27, 28, 29, 30 and 31.

The records of Pea "F", Bean "E", and Musk "A" have not been included, as those plants died before the series of observations on their internodes were sufficiently long to be of any value.

On looking over the Tables, or perhaps better, the Charts, the most obvious feature is the great similarity in the curves of increase, not only of different internodes of the same plant but even of different plants.

The typical curve of internodal growth might be described as having a primary phase of extreme but short-lived energy during which increase is continuous and very rapid. When this first outburst of growth is spent, there is, as a rule, no further addition to the length of the internode, and the future observations shew neither increase nor decrease.

This general description covers the large majority of the records, but more detailed remark is necessary in a few cases.

While it is the rule that an internode shews uninterrupted increase at a fairly uniform rate from the time of its first appearance until growth is complete, a few examples are found of temporary arrest, or at least retardation, of increase during the stage of rapid growth. Out of the total number of internodes observed, 254, there are 8 instances of this period of rest occurring in the middle of the time when

increase, in the majority of cases, is rapid and continuous.

In the fifth internode of Pea "A", after growing at the rate of 3 m.ms. per day between July 18th and 20th there follows a couple of days in which an increase of only 1m.m. is registered, after which growth again becomes rapid and in the next two days additions of $5\frac{1}{2}$ m.ms. are recorded.

In the same way the sixth internode of Pea "C", after growing at $2\frac{1}{2}$ m.m. per day, shews a period of retardation lasting for two days when the rate of increase is only $\frac{1}{2}$ m.m. each day followed by a return of the active growth with daily additions of 3 m.m.

The seventh and twelfth internodes of Pea "E" presents a similar slowing of growth during the third, fourth and fifth days, after which rapid growth reappears.

With regard to the Musk the ninth internode of plant "B" shews a period of definitely retarded growth between the eighth and twelfth days, and the same thing occurs in the tenth internode of plant "C".

In the whole series of observations there are only two examples of growth being, for a time, completely arrested. These are found in the Oats, plants "A" and "C" in the first internode in both cases and for a period of four days in each instance, from July 20th to 24th, no increase was recorded.

As there was no similar variation at the same time in

the other internodes these periods of retardation and arrest can hardly be explained by the interference of some external agency.

It would seem that, though the curve of growth of an internode usually presents a regular course of continuous increase, one may on occasion find that the rate of growth has been irregular, that periods have occurred when it was quite definitely retarded, or more rarely, that it has been in entire abeyance for a time.

Another interesting point which emerged during these observations on the growth of internodes in plants, is the comparative frequence of decrease in the length of an internode after growth has ceased. Shrinkage took place in 55 of the internodes examined, or over 21%, so that it would appear to be of fairly common occurrence, and several examples will be found in the appended Charts.

The instances are scattered fairly evenly throughout the Peas, Beans, Oats and Eucalyptus, but in the Maize plants it occurs only once and in the Musk there is not a single example present. As a rule the decrease commences almost immediately after the growth of the internode is complete, as for example, in the fourth internode of Pea "D" (see Chart No. 26) but in some cases the shrinkage is a slow process, and is not apparent until several days, or it may

even be weeks after growth has stopped, as in the first internode of Oat "E" (see Chart No. 28).

Naturally there is a considerable amount of variation in the degree to which this decrease takes place in different internodes. In many instances it amounts to only one or two m.ms., but in a few cases the decrease is greater than this; e.g., the first internode of Oat "D" losing 10 m.ms.; from 49 m.m. to 39 m.m. or 1/5th of its original length. Further, there does not appear to be any definite relation between the amount of decrease and the original length of the internode. The above mentioned instance, that of the first internode of Oat "D" falling from 49 m.ms. to 39 m.ms. is the greatest amount of decrease in the whole series, and there are all stages between that and the loss of 1 m.m. in 132 m.ms. shewn by the fourth internode of Bean "C".

It is difficult to suggest any explanation for the occurrence of shrinkage in some internodes, while it does not take place in others. An internode which later decreases in size does not grow more rapidly than its neighbour in which no such shrinkage is observed, and as they are both sections of the same plant they are presumably subjected to precisely the same external influences.

One can only account for the loss in length of an internode by its cells becoming smaller. It is not clear

whether this is a normal phenomenon, the mature cell being smaller than the embryonal, or whether the cells in getting rid of an undue amount of moisture absorbed during their rapid growth become less bulky later with the diminishing succulence.

As shrinkage was only observed in some of the internodes and not in others, the latter explanation sounds the more probable, and therefore one must regard a decrease in length as due to an inherent peculiarity of the individual internode.

It is possible of course, that in placing these plants in what seemed ideal conditions they were to some extent "forced", and perhaps the irregularities in their growth owe their origin, at least partially, to the influence of environment, but on the other hand the external conditions were the same for each internode and yet only a few presented individual peculiarities.

For the objects of the present work it seems unnecessary to go into details of the different rates of growth shewn by the various kinds of plants under observation. A Specimen Chart is given of each, and from these the slow but prolonged growth of an internode of Eucalyptus stands out in marked contrast to the extremely rapid and short-lived phase of growth in that of the Pea or Bean.

Evidently the usual type of growth of an internode is

one of regularity. The cells start with a certain amount of reproductive energy and until this is exhausted the growth of the internode is steady and uninterrupted. Internodal growth might therefore be taken as representative of the regular form of increase, although a few examples are met with in which short periods of retardation or arrest produce irregularities in the curves.

The decrease in size of an internode which is sometimes seen after the cessation of growth will be further dealt with later.

The Tables and Charts giving the full results of these observations on the growth of internodes in plants are appended.

TABLE NO. 23.

GROWTH of INTERNODES in PEAS MEASUREMENTS in M.Ms.

	Internode	July 18	20	22	24	26	28	30	August 1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	Sept 2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
PLANT A	No.1	7	7	7	7	7	8	8	9	9	9	9	9	9	9	9	9	9	9																			
	2	27	28	29	29	28	28	28	28	28	28	28	28	27	27	27	27	27	27																			
	3	36	37	38	39	39	39	39	38	39	39	39	39	39	39	39	39	39	39																			
	4	17	31	36	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38																			
	5	8	14	16	27	34	36	36	37	39	39	39	39	39	39	39	39	39	39																			
	6								2	5	8	9	9	10	10	10	10	10	10																			
PLANT B	No.1	25	25	25	25	24	25	25	24	25	25	25	25	25	25	25	25	25	24	24	24	24	24				24											
	2	59	59	60	59	59	59	59	59	59	59	59	59	59	59	59	59	59	59	59	59	59	59				59											
	3	69	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70				70											
	4	65	74	76	77	77	77	77	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78				78											
	5	28	38	62	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66				66											
	6		4	14	35	50	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55				55											
	7					43	49	58	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66				66											
	8								26	47	51	59	65	66	66	66	66	66	66	66	66	66	66	66	66	66	66											
	9											9	34	48	53	57	57	58	58	58	58	58	58	58	58	58	58											
	10																25	42	50	54	54	54	54	54	54	54	54											
	11																			11	29	37	40	41	42	41	41											
	12																							8	8	8	8											
PLANT C	No.1	22	23	23	24	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23															
	2	47	48	48	48	49	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48															
	3	29	44	45	45	46	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45															
	4		3	46	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49															
	5			8	21	24	30	37	38	40	40	40	40	40	40	40	40	40	40	40	40	40	40															
	6								4	14	19	20	26	30	30	30	31	31	31	31	31	31	31															

TABLE NO. 24.

GROWTH of INTERNODES in PEAS

MEASUREMENTS in M.Ms.

	Internode	July 18	20	22	24	26	28	30	August 1	3	5	7	9	11	13	15	17
PLANT D	No. 1	20	20	20	20	21	21	21	21	21	21	21	21	21	21	21	21
	2	50	51	51	50	50	49	49	48	48	48	48	48	48	48	48	48
	3	61	62	62	61	62	62	61	61	62	62	62	62	62	62	62	62
	4	42	78	79	78	76	76	75	75	74	74	74	74	74	74	74	73
	5	25	25	50	56	56	57	57	57	57	57	57	57	57	57	57	57
	6		7	9	30	52	54	55	56	56	56	56	56	56	56	56	56
	7					15	34	56	68	70	70	70	70	70	69	69	69
	8							12	33	72	74	74	75	76	75	74	73
	9									14	48	80	82	84	84	85	85
	10											12	46	79	82	84	86
	11													11	48	69	77
	12														2	10	39
	13																
	14																
	15																
	16																

	Internode	19	21	23	25	27	29	31	Sept. 2	4	6	8	10	12	14	16	18	20
PLANT D	No. 1	21	21	21	21	21	21		20		20			20				20
	2	48	48	48	48	48	48		48		48			48				48
	3	62	62	62	62	62	62		62		62			62				62
	4	73	73	73	73	73	73		73		73			73				73
	5	57	57	57	57	57	57		57		57			57				57
	6	56	56	56	56	56	56		56		56			56				56
	7	69	69	69	69	69	69		69		69			69				69
	8	73	73	73	73	73	73		73		73			73				73
	9	85	86	86	86	86	86		86		86			86				86
	10	87	87	87	87	87	87	87	87	86	87	87	87	87	87	87	87	87
	11	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81
	12	80	85	87	87	87	87	87	87	87	87	87	87	87	87	87	87	87
	13	23	64	75	78	79	79	79	79	79	79	80	80	80	79	79	79	79
	14				17	41	79	97	97	97	103	110	106	109	110	110	110	110
	15							20	40	65	77	85	94	95	95	95	95	95
	16									7	62	81	94	97	101	101	101	101

	Internode	July 18	20	22	24	26	28	30	August 1	3	5	7	9	11	13	15	17
PLANT E	No. 1	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
	2	59	59	59	59	59	58	58	57	58	58	58	58	58	58	58	58
	3	39	57	57	57	58	58	58	58	57	57	57	57	57	57	57	57
	4	20	36	56	61	61	61	61	62	62	62	62	62	62	62	62	62
	5		2	13	44	64	64	64	64	65	64	64	64	64	64	64	64
	6					18	52	70	71	72	73	73	73	73	73	73	73
	7							18	20	21	51	77	77	78	78	78	78
	8											19	65	79	83	86	88
	9													19	69	84	86
	10															18	62
	11																
	12																
	13																
	14																

	Internode	19	21	23	25	27	29	31	Sept. 2	4	6	8	10	12	14	16	18	20
PLANT E	No. 1	35	35	35	35	35	35		35		35			35		35		
	2	58	58	58	58	58	58		58		58			58		58		
	3	57	57	57	57	57	57		57		57			57		57		
	4	62	62	62	62	62	62		62		62			62		62		
	5	64	64	64	64	64	64		64		64			64		64		
	6	73	73	73	73	73	73		73		73			73		73		
	7	78	78	78	78	78	78		78		78			78		78		
	8	88	88	88	88	88	88	88	88	88	88			88		88		
	9	87	88	88	88	88	88	88	88	88	88	88	88	88	88	88		
	10	89	91	92	92	92	95	96	96	96	96	96	96	96	96	96		
	11	18	73	90	96	98	107	111	111	111	111	111	111	111	111	111		
	12				32	49	49	58	70	83	99	109	111	111	111	111		
	13								13	45	62	85	89	91	91	91		
	14									7	49	81	87	89	89	89		

TABLE NO. 25.

GROWTH of INTERNODES in BEANS MEASUREMENTS in M.Ms.

	Inter-node	July 18	20	22	24	26	28	30	August 1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	Sept 2	4	6	8	10	12	14	16	18
PLANT A	(No.1	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26			26			26					26
	) 2	49	49	49	50	48	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49			49			49					49
	(3	58	95	97	97	97	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98			98			98					98
	) 4		45	87	130	136	137	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138			138			138					138
	(5			14	46	96	128	131	131	131	131	131	131	128	128	128	128	128	128	128	128	128			128			128					128
	) 6				6	16	40	71	96	108	109	109	109	108	108	108	108	108	108	108	108	108			108			108					108
	(7							9	20	46	64	77	78	79	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78
	) 8									7	12	24	40	62	77	83	86	84	84	84	84	82	84	84	84	84	84	84	84	84	84	84	84
	(9													6	19	28	47	60	63	64	65	65	65	65	65	65	65	65	65	65	65	65	65
	) 10															4	7	19	48	56	63	66	67	67	67	67	67	67	67	67	67	67	67
	(11																					2	4	5	6	7	8	9	9	9	9	9	9
PLANT B	(No.1	35	36	36	36	35	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36			36			36					36
	) 2	47	51	51	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52			52			52					52
	(3	34	70	88	87	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88			88			88					88
	) 4		22	54	106	153	160	161	163	163	161	161	161	161	161	161	161	161	161	161	161	161			161			161					161
	(5		7	23	59	96	108	110	110	110	110	109	108	108	108	108	108	108	108	108	108	108			108			108					108
	) 6				15	37	61	82	89	89	89	89	89	89	89	89	89	89	89	89	89	89			89			89					89
	(7					16	29	35	58	72	81	81	81	81	81	81	81	81	81	81	81	81			81			81					81
	) 8								16	29	53	60	61	61	61	61	61	61	61	61	61	61			61			61					61
	(9								5	18	22	41	50	58	59	59	59	59	59	59	59	59	59	59	59	60	60	60	59	60	60	60	60
	) 10										10	16	23	33	52	65	65	65	65	65	65	66	66	66	66	66	66	66	66	66	66	66	66
	(11													5	18	41	67	85	85	85	85	85	85	85	86	86	86	86	86	86	86	86	86
	) 12															2	6	24	36	51	74	74	75	75	75	75	75	75	75	75	75	75	75
	(13																				37	59	62	64	65	65	65	66	66	66	66	66	66
	) 14																						13	17	20	24	26	27	29	31	32	33	
PLANT C	(No.1	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36			36			36					36
	) 2	65	71	71	72	69	69	69	70	70	70	70	70	70	70	70	70	70	70	70	70	70			70			70					70
	(3	45	84	95	98	98	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97			97			97					97
	) 4		33	72	117	132	130	131	130	130	131	131	131	131	131	131	131	131	131	131	131	131			131			131					131
	(5			11	33	69	103	107	108	109	109	109	109	109	109	109	109	109	109	109	109	109			109			109					109
	) 6				4	14	35	63	84	93	93	94	94	94	94	94	94	94	93	93	93	93			93			93					93
	(7							14	28	56	62	68	69	69	69	69	69	69	69	68	68	68			68			68					68
	) 8								6	15	25	38	46	48	48	48	48	48	48	48	48	48			48			48					48
	(9										3	12	22	34	49	62	63	63	63	63	63	63			63			63					63
	) 10													7	24	35	56	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64
	(11															7	21	43	70	72	72	72	72	72	72	72	72	72	72	72	72	72	72
	) 12																4	14	45	54	56	58	59	59	59	59	59	59	59	59	59	59	59
	(13																			15	36	42	46	49	49	49	49	49	49	49	49	49	49
	) 14																					7	13	17	22	26	29	30	30	32	32	32	32

TABLE NO. 26.

GROWTH of INTERNODES in BEANS

MEASUREMENTS in M.Ms.

	Inter-node	July 18	20	22	24	26	28	30	August 1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	Sept 2	4	6	8	10	12	14	16	18
PLANT D	(No.1	36	36	37	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35			35			35					35
	) 2	76	76	76	76	77	77	78	77	76	76	76	76	76	76	76	76	76	76	76	76	76			76			76					76
	(3	59	107	121	123	123	123	123	124	124	124	124	124	124	124	124	124	124	124	124	124	124			124			124					124
	) 4		3	63	93	119	123	123	123	123	123	123	123	123	123	123	123	123	123	123	123	123			123			122					122
	(5			6	17	42	80	94	100	100	100	100	100	100	100	100	100	100	100	100	100	100			100			100					100
	) 6					3	10	23	40	61	68	71	71	71	71	71	71	71	71	71	71	71			71			71					71
	(7								6	21	40	63	72	73	73	73	73	73	73	73	73	73			73			73					73
	) 8									6	10	22	40	54	58	62	62	62	62	62	62	62			62			62					62
	(9												11	23	47	69	75	76	76	76	76	76			76			76					76
	) 10													4	18	29	48	63	67	69	69	69	69	69	69	69	69	69	69	69	69	69	69
	(11															5	13	34	59	76	77	77	77	77	77	77	77	77	77	77	77	77	77
	) 12																	5	27	33	51	66	67	67	67	67	67	67	67	67	67	67	67
	(13																			4	17	28	40	47	49	50	50	50	50	50	50	50	50
	) 14																					3	13	19	19	19	19	19	19	19	19	19	19
	(15																										2	6	8	9	9	9	9
PLANT F	(No.1	15	15	15	14	13	13	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14			14			14					14
	) 2	28	50	51	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50			50			50					50
	(3	48	49	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55			55			55					55
	) 4	28	40	87	129	138	139	139	139	140	140	140	139	139	139	139	139	139	139	139	139	139			139			139					139
	(5		8	15	46	87	99	114	114	114	114	114	115	115	115	115	115	115	115	115	115	115			115			115					115
	) 6				6	15	47	68	90	102	102	102	102	102	102	102	102	102	102	102	102	102			102			102					102
	(7							6	17	45	68	82	83	83	83	83	83	83	83	83	83	83			83			83					83
	(8									6	18	39	59	66	66	66	66	66	66	66	66	66			66			66					66
	) 9											6	16	33	51	59	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
	(10													7	27	39	57	63	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64
	) 11															5	17	37	59	69	70	70	70	70	70	70	70	70	70	70	70	70	70
	(12																		6	15	29	37	43	46	46	46	46	46	46	46	46	46	46
	(13																							6	10	13	14	15	15	15	15	15	15

TABLE NO. 27.

GROWTH of INTERNODES in OATS

MEASUREMENTS in M.Ms.

	Internode	July 18	20	22	24	26	28	30	August 1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	Sept 2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
PLANT A	No. 1	25	30	30	30	31	31	33	34	34	41	41	41	41	39	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37						
	2					24	35	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39						
	3									4	20	21	29	40	39	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36						
	4															17	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21						
	5																16	18	18	18	18	18	18	18	18	18	18	81	81	18	18	18						
	6																	19	28	38	38	38	38	38	38	38	38	38	38	38	38	38						
	7																					31	45	48	48	48	48	48	48	48	48	48						
	8																									47	47	47	47	47	47	47						
	9																														11	31						
PLANT B	No. 1	15	19	20	21	23	23	23	23	24	25	25	25	25	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23						
	2					13	29	35	35	35	35	35	35	35	33	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32						
	3										7	13	14	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15						
	4															10	13	14	14	14	14	15	15	15	15	15	15	15	15	15	15	15						
	5																	3	17	30	33	35	37	38	38	38	38	38	38	38	38	38						
	6																								17	40	41	41	41	41	41	41						
	7																														3	19						
PLANT C	No. 1	23	32	32	32	33	35	35	35	40	44	42	42	40	40	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39						
	2					16	25	27	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28						
	3								3	15	30	34	35	35	35	34	34	34	34	34	33	33	33	33	33	33	33	33	33	33	33	33						
	4														10	24	25	25	25	25	24	25	25	25	25	25	25	25	25	25	25	25						
	5																	30	36	38	38	38	38	38	38	38	38	38	38	38	38	38						
	6																				33	41	48	50	50	50	50	50	50	50	50	50						
	7																								30	39	42	51	51	51	52	51						
PLANT D	No. 1	30	33	37	41	42	44	46	48	49	49	49	45	42	42	42	42	42	42	41	41	41	39	39	39	39	39	39	39	39	39	39						
	2				2	25	33	33	34	34	34	34	33	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32						
	3								24	38	39	40	40	39	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40						
	4													40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40						
	5														12	32	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45						
	6																			18	27	31	49	69	84	85	85	85	85	85	85	85						
PLANT E	No. 1	31	34	35	34	35	35	35	35	35	35	35	35	35	35	35	35	34	35	34	35	34	34	33	33	33	33	33	33	33	33	33						
	2					21	32	32	32	32	32	33	32	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31						
	3								17	25	32	33	31	31	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30						
	4												7	16	16	15	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16						
	5															11	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27						
	6																				11	43	49	54	54	54	54	54	54	54	54	54						
	7																									29	39	41	43	43	43	43	43						
	8																											2	34	34	34	34	34						
PLANT F	No. 1	13	18	20	22	23	25	28	33	33	33	33	32	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30						
	2					19	28	28	28	28	28	28	27	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25						
	3									31	39	39	39	39	39	37	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36						
	4												2	12	13	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16						
	5																24	32	32	32	32	33	33	33	33	33	33	33	33	33	33	33						
	6																				21	48	49	49	49	49	49	49	49	49	49	49						
	7																									40	49	55	58	59	59	59	59						

TABLE NO. 28.

GROWTH of INTERNODES in MAIZE MEASUREMENTS in M.Ms.

Internode	July 18	20	22	24	26	28	30	August 1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	Sept 2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
PLANT A (No.1		3	11	14	16	20	32	32	32	32	32	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33						
) 2							6	10	16	17	18	18	18	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19						
(3												4	11	15	19	24	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25						
) 4																		1	5	19	23	25	27	28	28	28	28	28	28	28	28						
(5																											3	10	16	18	19	20						
PLANT B (No.1	26	35	52	62	63	64	64	64	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65						
) 2				15	22	25	26	27	27	27	27	27	27	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28						
(3										4	7	8	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9						
) 4															7	13	16	17	19	20	21	21	21	21	21	21	21	21	21	21	21	21						
(5																					9	17	22	27	29	29	29	30	31	31	31						
) 6																												11	26	31	33						
PLANT C (No.1	25	41	44	46	47	47	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48						
) 2			17	30	34	36	37	37	39	39	39	39	38	38	38	38	38	38	37	38	38	38	38	38	38	38	38	38	38	38	38	38						
(3							8	17	25	27	28	28	29	29	29	29	29	29	29	29	29	30	29	29	29	29	29	29	29	29	29	29						
) 4												14	23	28	30	30	30	31	32	32	32	32	32	32	32	32	32	32	32	32	32	32						
(5																	11	19	23	29	32	35	36	36	36	36	36	36	37	36	36	36						
) 6																							8	15	20	26	28	30	31	31	31	31						
(7																													6	17	26	30						
PLANT D (No.1	25	40	49	64	66	66	66	66	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67						
) 2			4	24	29	33	33	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34						
(3							12	17	22	22	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23						
) 4										7	15	24	26	28	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29						
(5																10	16	18	19	23	24	24	25	25	25	25	25	25	25	25	25	25						
) 6																					6	13	19	21	22	22	22	22	22	23	22						
(7																									14	22	26	29	34	36	37	37						
PLANT E (No.1	26	54	71	73	76	77	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78						
) 2					14	21	26	28	29	30	31	31	31	31	31	31	31	31	31	3o	31	31	31	31	31	31	31	31	31	31	31	31						
(3											4	18	25	27	28	28	28	28	29	29	29	29	29	29	29	29	29	29	29	29	29	29						
) 4																9	15	17	18	22	24	25	25	25	25	25	25	25	25	25	25	25						
(5																							8	12	15	17	18	19	20	20	21	21						
PLANT F (No.1	27	36	37	50	55	57	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61						
) 2			10	38	45	51	52	52	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53						
(3									12	17	20	22	22	22	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23						
) 4														16	31	36	38	38	42	42	42	42	42	42	42	42	42	42	42	42	42	42						
(5																							9	13	16	17	17	17	17	17	17	17						
) 6																											4	10	25	33	41	47						

T A B L E

NO. 29

GROWTH of INTERNODES in EUCALYPTUS

MEASUREMENTS in M.Ms

Internode	July 18	20	22	24	26	28	30	August 1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	Sept. 2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
PLANT A (No.1.	66	67	68	66	66	66	65	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64		64															
(2.	52	52	52	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51		51				64				64							64
) 3.	53	53	53	54	54	54	54	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53		53				51				51							51
(4.	34	36	36	36	35	35	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36		36				53				53							53
(5.	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22		22				36				36							36
(6.	23	23	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24		24				22				22							22
) 7.	9	9	11	12	13	15	15	16	17	17	17	17	17	17	17	17	17	17	17	17	17	17		17				24				24							24
(8.	3	3	3	3	3	3	4	5	5	5	5	5	5	6	6	6	6	6	6	6	6	7	8	8	8			17				17							17
) 9.																2	2	2	2	2	2	2	2	2	2	8	8	8	8	8	9	9	9	9	9	9	9	9
																										2	2	2	2	3	3	3	3	3	3	3	3	3
PLANT B (No.1.	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104		104															
) 2.	32	32	32	32	32	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33		33				104				104							104
(3.	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32		32				33				33							33
) 4.	22	23	23	23	23	23	23	23	23	23	23	23	23	22	22	22	22	22	22	22	22	22		22				32				32							32
(5.	17	19	20	22	22	23	24	25	25	25	25	25	25	24	24	24	24	24	24	24	24	24		24				22				22							22
(6.	3	4	6	8	8	10	12	14	18	21	24	25	26	26	26	26	26	26	26	26	26	26		26				24				24							24
(7.			3	3	3	3	6	6	9	9	12	12	14	16	17	20	22	23	23	24	25	25	25	25	25			26				26							26
) 8.										4	6	7	8	8	9	10	10	11	11	13	14	16	17	17	17	25	25	25	25	25	25	25	25	25	25	25	25	25
(9.															3	3	3	3	4	4	4	4	4	4	4	17	17	17	18	18	18	19	19	20	20	20	20	20
) 10.																										4	4	5	5	5	5	6	7	8	8	8	8	8
(																																2	2	2	2	2	2	2
PLANT C. (No.1.	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74		74															
) 2.	28	28	28	28	28	29	29	29	29	29	29	29	29	28	28	28	28	28	27	27	27	27		27				74				74							74
(3.	26	26	26	26	26	26	26	26	26	26	26	26	26	26	25	25	25	25	25	25	25	25		25				27				27							27
) 4.	17	19	19	21	22	23	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24		24				25				25							25
(5.	5	5	6	8	9	10	12	12	14	14	17	17	17	18	18	19	19	19	19	19	19	19		19				24				24							24
(6.												6	8	9	10	11	11	12	14	15	15	16	18	18	18			19				19							19
(7.														1	3	3	4	5	6	8	9	10	10	10	10	18	18	18	18	19	19	19	19	19	19	19	19	19
) 8.																	2	4	5	5	5	5	7	8	8	10	10	10	10	11	14	14	16	16	16	16	17	17
(9.																							4	4	4	8	8	8	9	11	13	14	16	18	20	21	21	21
) 10.																										4	4	4	4	4	5	9	11	11	11	11	11	11
(11.																																3	3	5	5	6	7	7
																																				3	3	3

TABLE NO. 30

GROWTH of INTERNODES in MUSK MEASUREMENTS in M.Ms

	Internode	July 18	20	22	24	26	28	30	August 1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	Sept. 2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
PLANT B	No.1	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	2	10	10	10	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
	3	11	14	14	15	15	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
	4	3	4	7	10	14	15	16	16	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17
	5				2	3	5	8	11	14	19	22	24	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
	6									3	3	9	15	20	26	33	37	39	39	40	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41
	7													2	4	8	14	21	30	34	37	38	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39
	8																			6	14	17	21	23	27	30	32	32	32	32	32	32	32	32	32	32	32	32	32	32
	9																							4	7	10	13	14	15	21	27	34	36	38	38	38	38	38	38	38
	10																														3	10	16	22	27	33	37	40	41
	11																																		2	11	19	23	27
PLANT C	No.1	5	5	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	2	15	15	15	15	15	15	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17
	3	14	14	16	17	18	18	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19
	4	2	5	6	10	16	22	26	28	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
	5					4	7	12	18	25	32	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
	6								2	4	9	17	26	33	39	43	44	46	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47
	7												2	6	9	18	25	33	39	42	43	43	43	43	43	43	43	43	43	42	43	43	43	43	43	43	43	43	43	43
	8															2	4	7	13	16	27	31	35	37	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38
	9																					7	9	15	23	28	30	31	31	32	35	36	36	36	36	36	36	36	36	36
	10																							2	3	3	6	8	9	19	26	33	36	38	39	39	39	39	39	39
	11																														3	7	10	16	19	24	28	31	33
	12																																			3	9	13	17

CHART No. 26.

INTERNODES OF PEA "D"

- 16th Internode
- 15th "
- 14th "
- 13th "
- 12th "
- 11th "
- 10th "
- 9th "
- 8th "
- 7th "
- 6th "
- 5th "
- 4th "
- 3rd "
- 2nd "
- 1st Internode

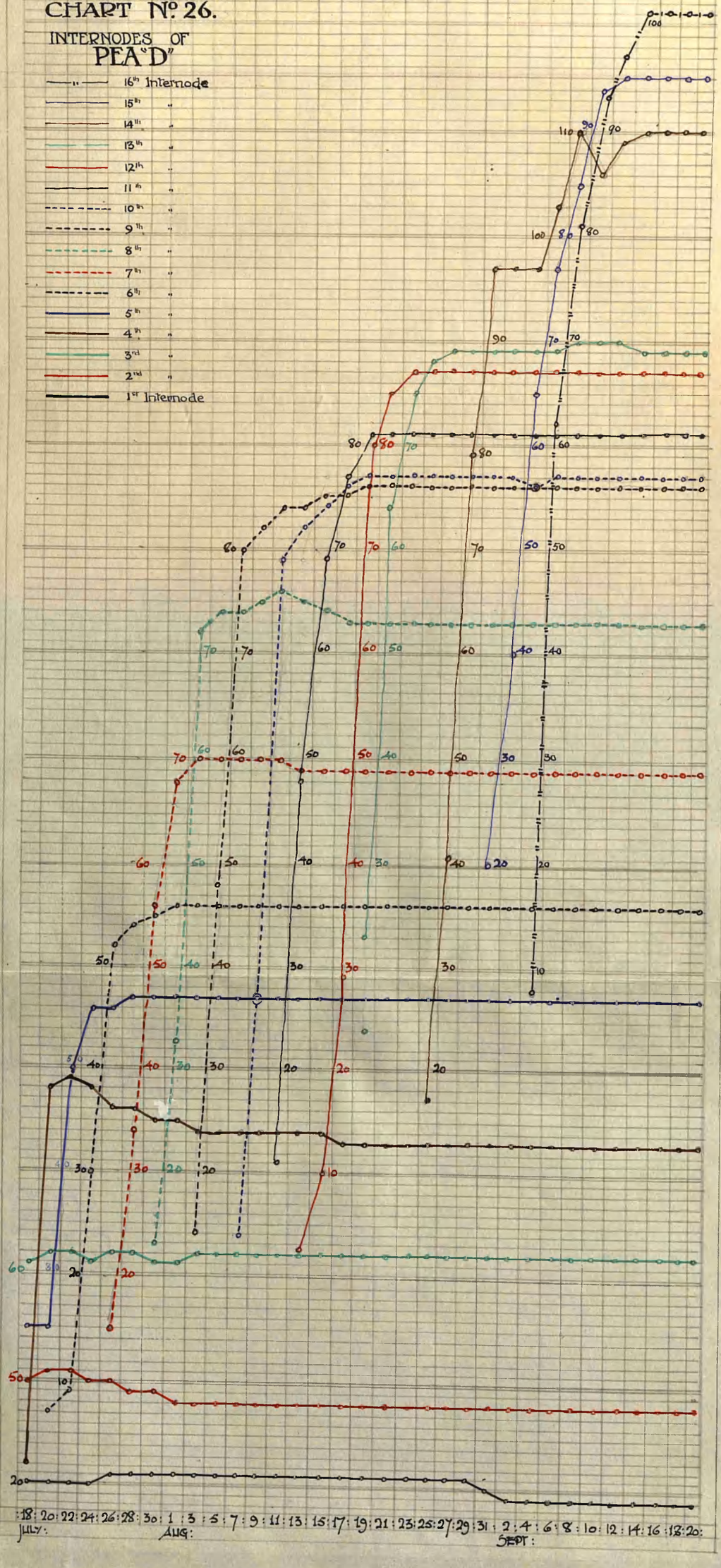


CHART No. 27.

INTERNODES OF BEAN "C"

- 14th Internode.
- 13th "
- 12th "
- 11th "
- 10th "
- 9th "
- 8th "
- 7th "
- 6th "
- 5th "
- 4th "
- 3rd "
- 2nd "
- 1st Internode

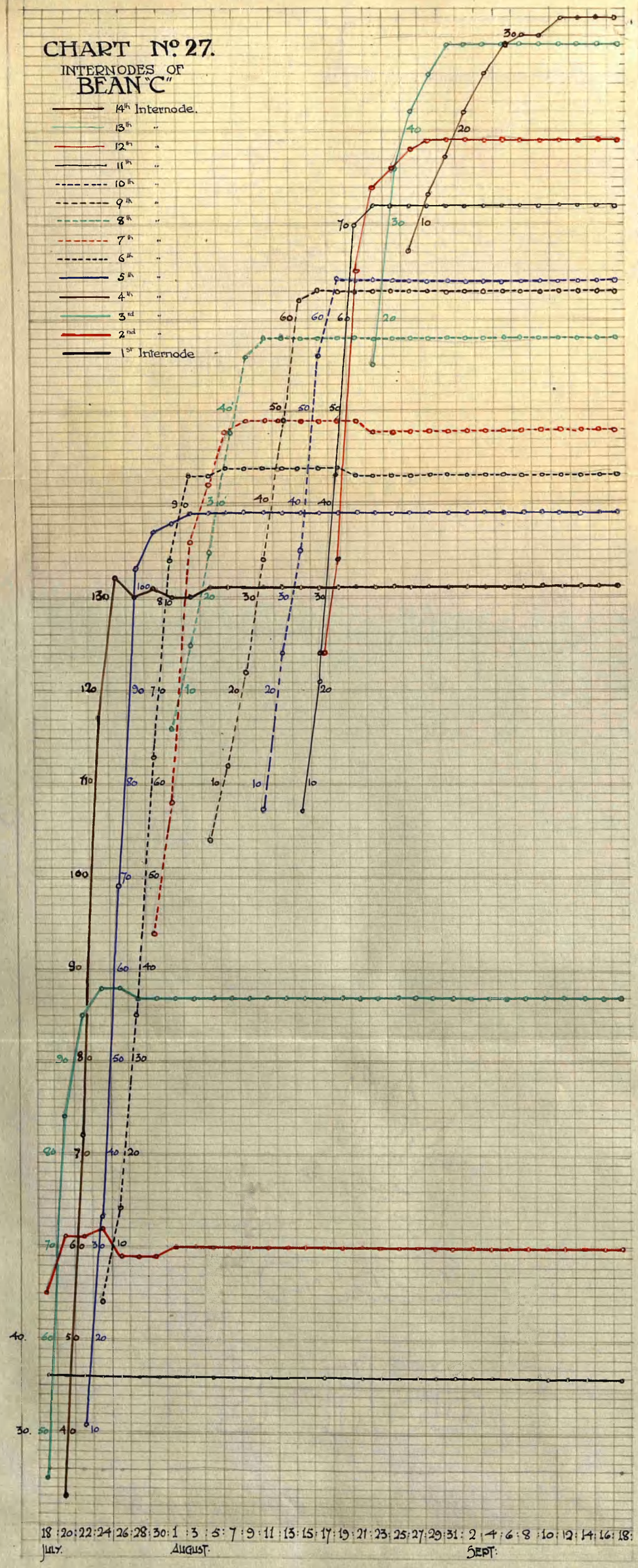


CHART No. 28.

INTERNODES OF

OAT "E"

8th Internode.

7th "

6th "

5th "

4th "

3rd "

2nd "

1st Internode.

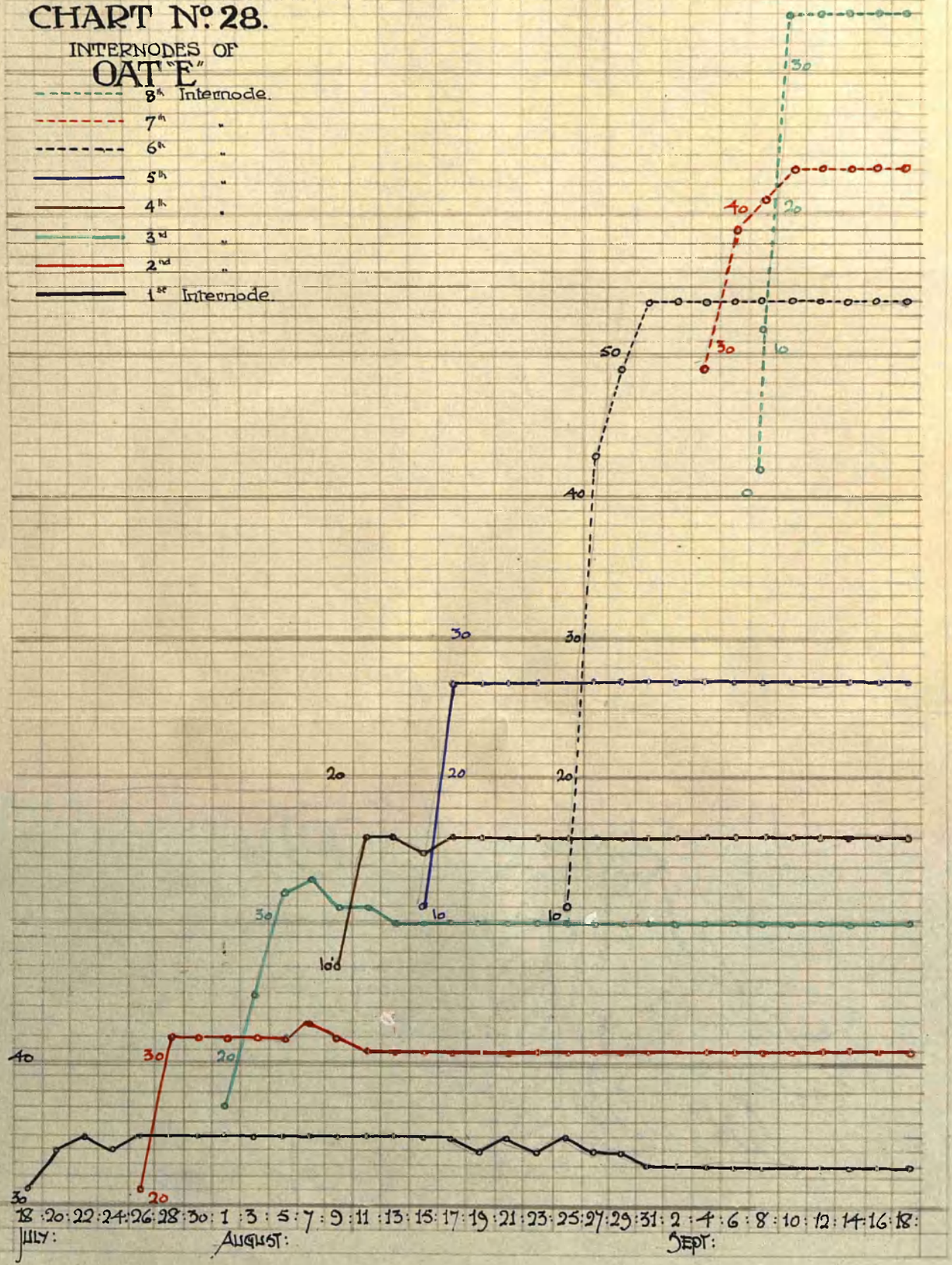
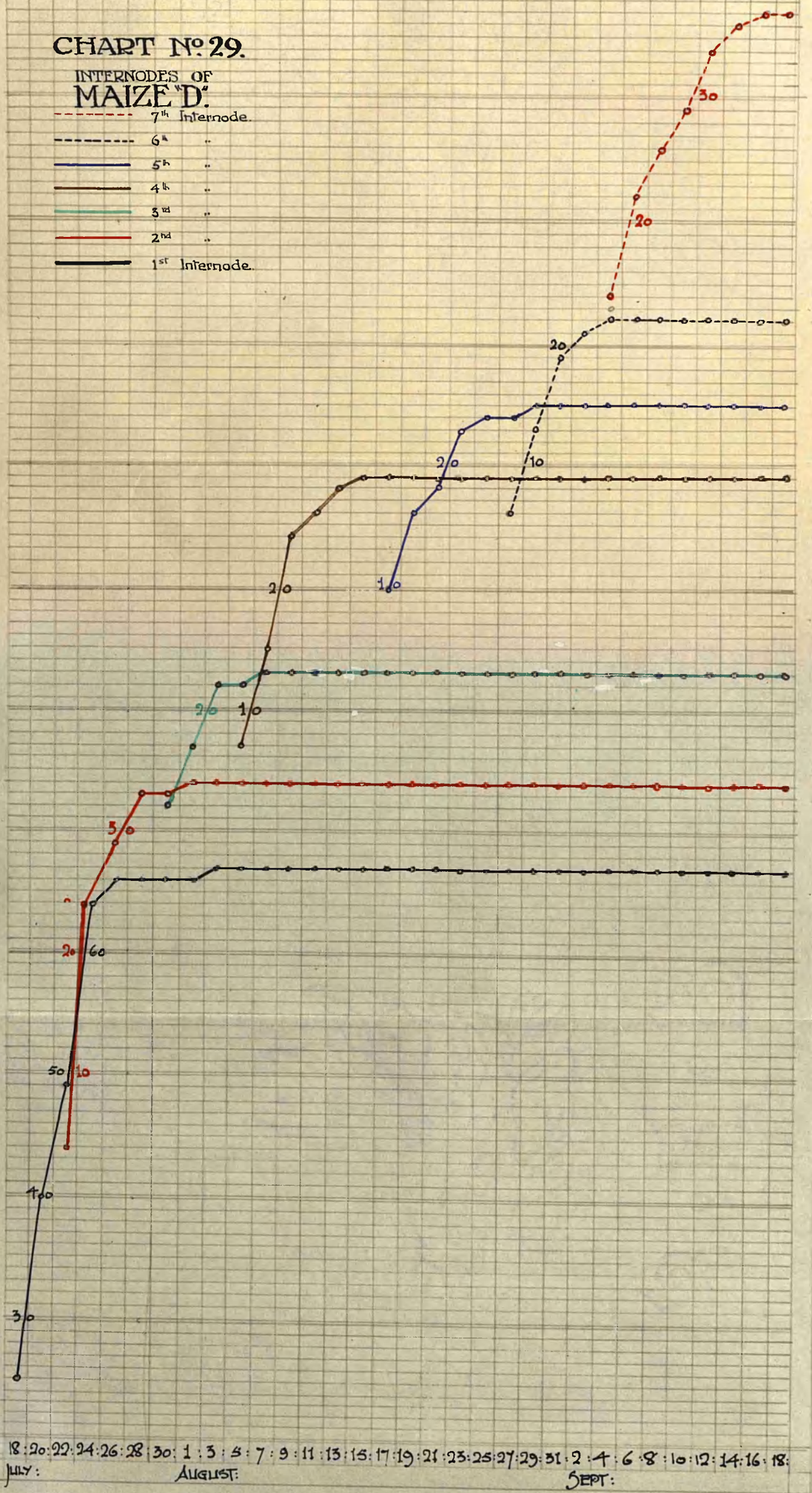


CHART No. 29.

INTERNODES OF MAIZE "D".

- 7th Internode.
- 6th ..
- 5th ..
- 4th ..
- 3rd ..
- 2nd ..
- 1st Internode.



18 : 20 : 22 : 24 : 26 : 28 | 30 : 1 : 3 : 5 : 7 : 9 : 11 : 13 : 15 : 17 : 19 : 21 : 23 : 25 : 27 : 29 : 31 : 2 : 4 : 6 : 8 : 10 : 12 : 14 : 16 : 18 :

JULY : AUGUST : SEPT :

CHART No. 30.

INTERNODES OF MUSK "B"

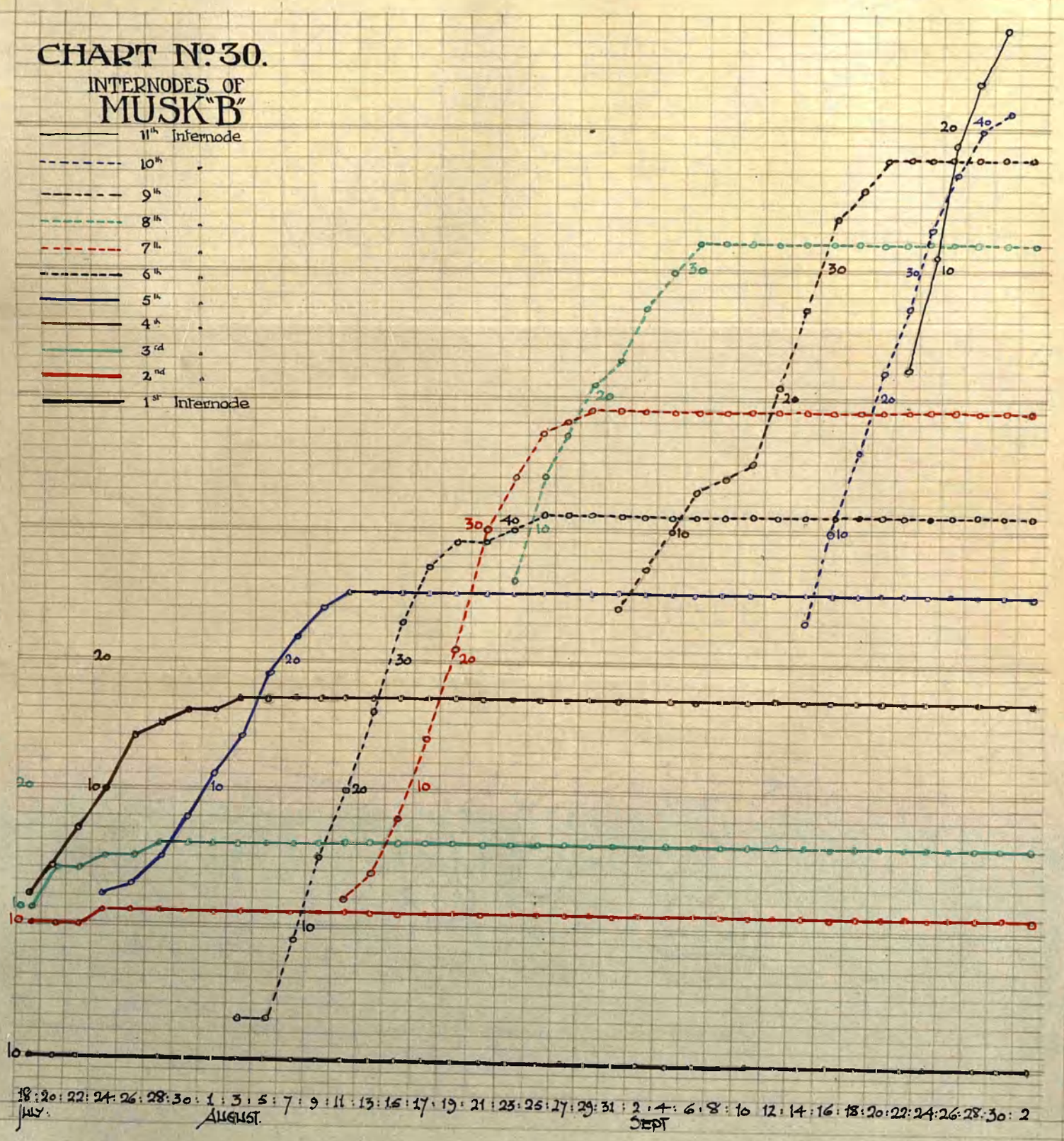
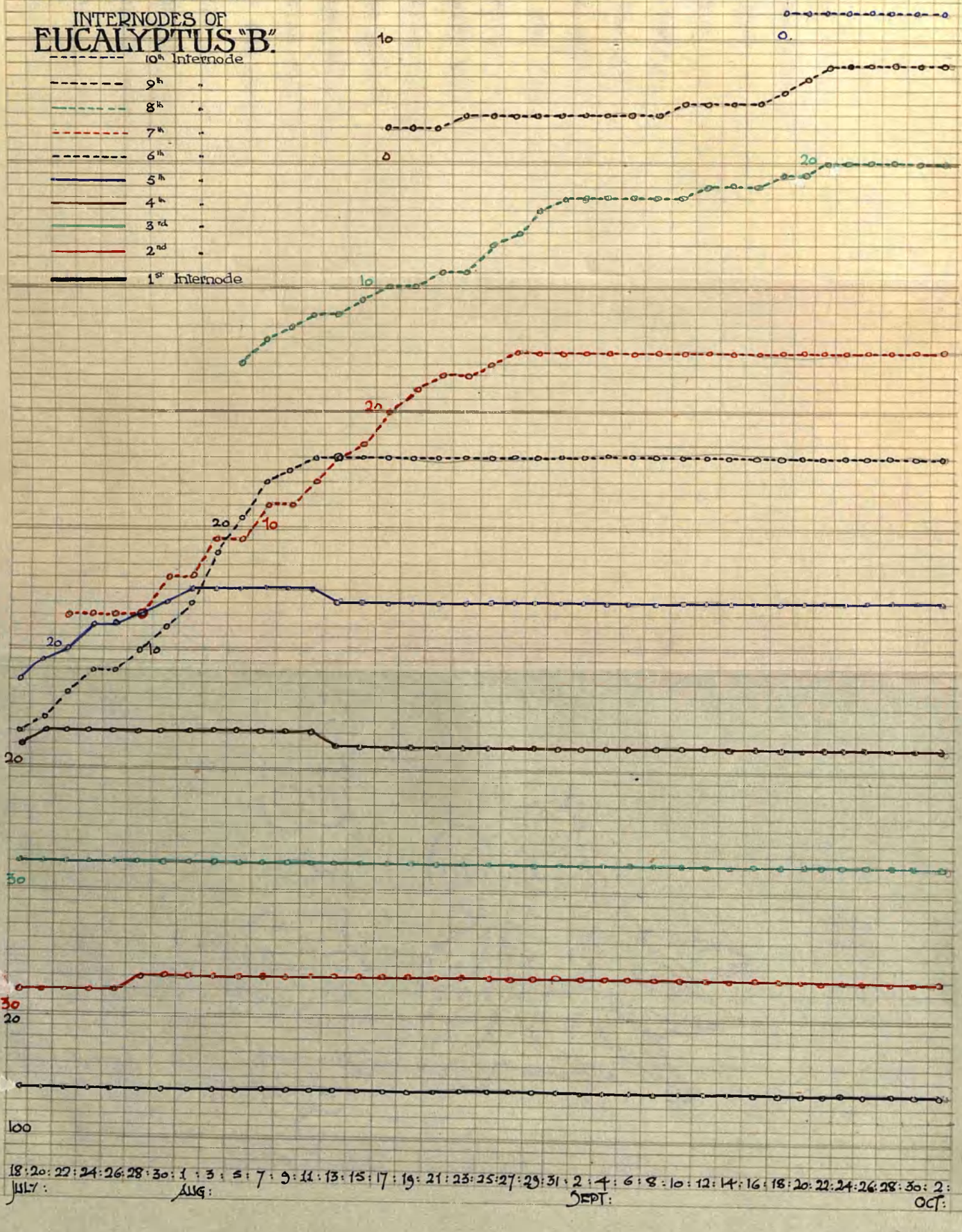


CHART Nº 31.

INTERNODES OF EUCALYPTUS "B."



SECTION SIX

Having now given in detail all the observations made, and outlined their chief points in the various Sections under which they are grouped it is proposed to discuss briefly their meaning. As the main object of this inquiry was to study the growth of the individual in Man, and the experiments on Animals and Plants were entirely subsidiary, and to see if any light could be thrown on certain phenomena which appeared in the growth of the human being, these few comments will deal chiefly with the observations recorded in Section 3, and the points made in the other Sections on the growth of animals and plants will only be used as examples and for reference.

This Section will deal with (A) the different types of growth, (B) the avoidance of wide extremes of stature, and some remarks will be made on the relationship of (C) temperature and (D) environment to the growth of the individual and their possible influence in determining the type of growth.

A. DIFFERENT TYPES OF GROWTH

With regard to the various forms of growth there are apparently three main types, Regular, Irregular and Cyclic.

Regular Growth

Growth of the Regular type is not commonly found in Man, and was observed in only 12.3% of the charts detailed in Section 3. A uniform and continuous increase in height and weight is thus occasionally seen in the human subject, and in the series of 250 charts such examples of this type as were present were very perfect, an even line of ascent being maintained throughout the whole period the boys were under observation.

In the records of the growth of rabbits the regular type was rare, while in the guinea-pigs uniformity in the rate of increase was the marked feature of the charts, and in the internodes of plants, regularity of growth was observed as the rule and not the exception.

From these observations the existence of a type of growth in which increase progresses at a uniform and regular rate would seem to be fully proved, and although only a few examples were seen in Man there were several instances

in the records of guinea-pigs, and in plants it appeared to be the usual mode of growth.

Irregular Growth

Irregularity in the rate of growth, on the other hand, is the form most frequently met with in Man, and in the series of records of the growth of boys taken from the Bootham School Register it was found to the extent of 83%. As a rule the variation in the rate of increase was slight, and merely amounted to alternating periods, of indefinite length, when growth was either slower or more rapid as the case might be, There were however, examples of all grades of irregularity, from the faintest undulation in the ascending line of increase to Charts shewing periods of exceedingly rapid growth followed by a term of some weeks or months duration in which no increase whatever took place and in which there might be actual decrease in stature. Marked irregularity in the rate of growth was shewn by many of the rabbits, and in some of the guinea-pigs a slight degree was found. The growth of the chickens recorded by Professor Minot (17) was probably of this irregular type also. Of the ten chickens under observation two were males, eight females, and although he only gives in his Tables the average daily increase of a male chick and a female, the average increments are so irregular that the rate of growth of the in-

dividual chicks must have been very variable.

With reference to the periods which have been noted as occasionally seen in growing boys in which temporary decrease in stature occurs.

In most instances the diminution takes place immediately after an outburst of very rapid growth, but this is not invariably the case, and occasionally the phase of retrogression precedes the period of active increase.

The explanation of decrease in stature is not clear. Presumably it is due to loss in bulk of the fibrous intervertebral discs. As the measurements were always taken at the same period, the forenoon, it cannot be explained by daily variation. Whether it is to be accounted for by withdrawal of moisture, or whether there is absorption of fat, both from the tissues under the heel and from the nucleus pulposus of each intervertebral disc, but as quite commonly the weight is rising while the decrease in height is taking place, the latter explanation seems hardly probable. A third suggestion is that perhaps, during active growth, the proliferating cells in the discs are of the large embryonal form, and, contracting on becoming mature, produce a minute shrinkage of the disc as a whole. This idea is strengthened to some extent by the comparatively frequent occurrence in this series of observations of

gradual and prolonged decrease in stature of boys between the ages of sixteen and eighteen and in whom the stage of active growth is almost spent.

An analogous decrease was often observed following the cessation of growth in the internodes of plants, and in the records of the growth of rabbits periods of arrest accompanied by loss in weight were common. Diminution in the length and weight of fish has also been noted by Dr. Fulton[10] as occurring when growth is completely arrested during the winter months.

Cyclic Growth

The cyclic type of growth was present in only 4.7% of the records of the growth of boys. The line of increase in this type is composed of a succession of distinct curves which follow each other with perfect regularity and precision. Phases of active growth lasting over a definite period of time alternate with phases of retardation or arrest which also have a constant duration, and thus the curve of growth is made up of a series of waves, each one identical with its neighbours in every respect.

In the investigation of the growth of boys those cases which presented the cyclic form were very typical, and it would be difficult to find a more evident example of cyclic growth than that shewn in Chart No. 17.

The observations on the growth of crabs furnish examples of cyclic growth in its purest form, and it has been shewn how, in these exoskeletal animals, active growth is confined to a short period of a few hours, or at most three or four days, and after that there is a lapse of some weeks of complete arrest before the commencement of a new cycle determines another spurt of rapid increase in size and weight.

Cyclic variations were of fairly common occurrence in the records of the growth of rabbits and, although to a much less extent, those of the guinea-pigs, but in the observations of the growth of plant internodes there was no suggestion of the cyclic type being present.

B. AVOIDANCE OF EXTREMES OF STATURE

An interesting point which emerged in the investigation of the growth of boys was the apparent tendency to avoid wide extremes of size before maturity was reached.

As has been noted in Section 3, Group 4, in those boys who, at the age of seventeen or thereby were considerably below the average height, active growth continued when in the majority of cases it was either slowing or had ceased

altogether, and conversely, how soon growth ceased in those individuals who had attained large size comparatively early on in adolescence.

Thus the differences were to some extent eliminated, growth persisting till a later period than usual in backward individuals, or stopping at an early age if considerable stature had been reached, so that the various individuals were, in a way, brought on to a level with each other and a fairly constant standard maintained in the adult.

Williamson (11) has noted and pointed out this fact in his investigations of the growth of the crab. In Table No. 3 an example is furnished by Crabs Nos. 5 and 11. Crab No. 5 at the end of its first year, (April, 1901) measured 8 m.m. while No. 11 at the same age (Feb. 1902) measured 22 m.m. During their second years, however, No. 5 moulted eight times to No. 11's four, so that, at the end of the year their respective measurements were 53 m.m. and 52 m.m. This presents a very marked case of the avoidance of extremes of size.

In the observations of the growth of rabbits and guinea-pigs there was no instance of an animal which had increased more rapidly ceasing to grow earlier than its neighbours, nor of the stage of growth being prolonged in one in which increase had been unusually slow, but it is

remarkable how little difference there was in the weights of the various specimens at the end of the period of observation.

The number of examples of this tendency towards the maintenance of a common standard of size are too few for any stress to be laid upon the point; but there is certainly a suggestion of its existence.

C. TEMPERATURE AND GROWTH

Before discussing the relation of temperature to growth in Man the results of some experiments on lower animals should be noted. A large amount of work has been done on the influence of temperature on the growth of tadpoles and fishes, and the unanimous opinion is that a close connection exists between the rate of growth and the temperature of the surroundings. It is proposed to consider first the case for and then against such a view, and include a few remarks on the relationship of temperature to the growth of boys as it appeared from the observations detailed in Section 3.

That the temperature of the water plays an important part in determining the rate of growth of young tadpoles has been shewn by Oskar Hertwig.[18] A young tadpole kept at

a temperature of 11.5°C. was no further advanced at the end of three days than the egg stage, while another individual from the same batch of spawn had, in the same period but at a temperature of 24°C. developed into a tadpole, in length more than four times the diameter of its brother in the colder water.

Fishes have been largely chosen as the subjects for experiment, and during the last few years several papers dealing with this subject have appeared in the Annual Reports of the Fishery Board for Scotland.

Dr. Fulton (12) states that "The growth of fishes is closely related to the temperature of the water in which they live, the maximum increment taking place when the water is warm and the minimum when it is cold: and the greatest variations occur where the range of temperature is greatest.". . . "The influence of the temperature of the water is two-fold, directly affecting it by accelerating and retarding metabolism and indirectly by increasing and diminishing the abundance of the lower organisms which form a large part of the food of fishes. The direct effect is probably much the more important of the two."

It appears that temperature modifies the rate of growth by acting directly upon the metabolism and also by affecting the rapidity of digestion. "In very cold water fishes

give up feeding altogether, because the ferments upon which digestion depends do not act, or act very slowly, at low temperatures, therefore appetite is lost," and Knanthe and Zuntz[13] have shewn that metabolism is more active in higher temperatures by the increased excretion of CO_2 and other products.

Dr. Fulton[13] has reported a series of experiments on the growth of fishes kept in tanks at various temperatures during the winter months, and his results seem to prove fairly conclusively that temperature does influence the rate of growth to a certain extent.

Tables Nos. 31 and 32 are adapted from some in his paper; the former shews the rate of growth of five codling kept in Tank "No. 1" in which the water was at the ordinary temperature of the season, (winter) Table No. 32 the growth of three codling in artificially warmed water in Tank "No. 4". The experiment lasted over a period of one hundred and fifty-five days, and in the last column but one of both Tables is given in M.Ms. the total increase in length of the fishes during that period. It will be seen that the codling in the warmer tank grew more rapidly than those in the unheated one, the respective rates of growth being approximately as 5 to 4.

TABLE No. 31 - TANK "No. 1"

Fish Codling	Length	Mean Temp. 4.5°C. (40.1°F.) 100 days later			Mean Temp. 9.3°C. (48.7°F.) 55 days later			Mean Temp. 6.5°C. (43.7°F.) Increase in the 155 days	
		Length	Increase		Length	Increase			
			Total	Mean per 10 days		Total	Mean per 10 days	Total	Mean per 10 days
No.1	147	185	38	3.8	226	41	7.45	79	5.1
2	143	184	41	4.1	200	16	2.9	57	3.7
3	132	169	37	3.7	208	39	7.09	79	4.9
4	129	163	34	3.4	200	37	6.73	71	4.58
5	123	160	37	3.7	194	34	6.18	71	4.58

TABLE No. 32 - TANK "No. 4"

Fish Codling	Length	Mean Temp. 12.3°C. (54.1°F.) 100 days later			Mean Temp. 12.9°C. (55.2°F.) 55 days later			Mean Temp. 12.5°C. (54.5°F.) Increase in 155 days	
		Length	Increase		Length	Increase			
			Total	Mean per 10 days		Total	Mean per 10 days	Total	Mean per 10 days
No. 1	173	225	52	5.2	278	53	9.64	105	6.77
2	126	167	41	4.1	221	54	9.82	95	6.13
3	120	166	46	4.6	220	54	9.82	100	6.45

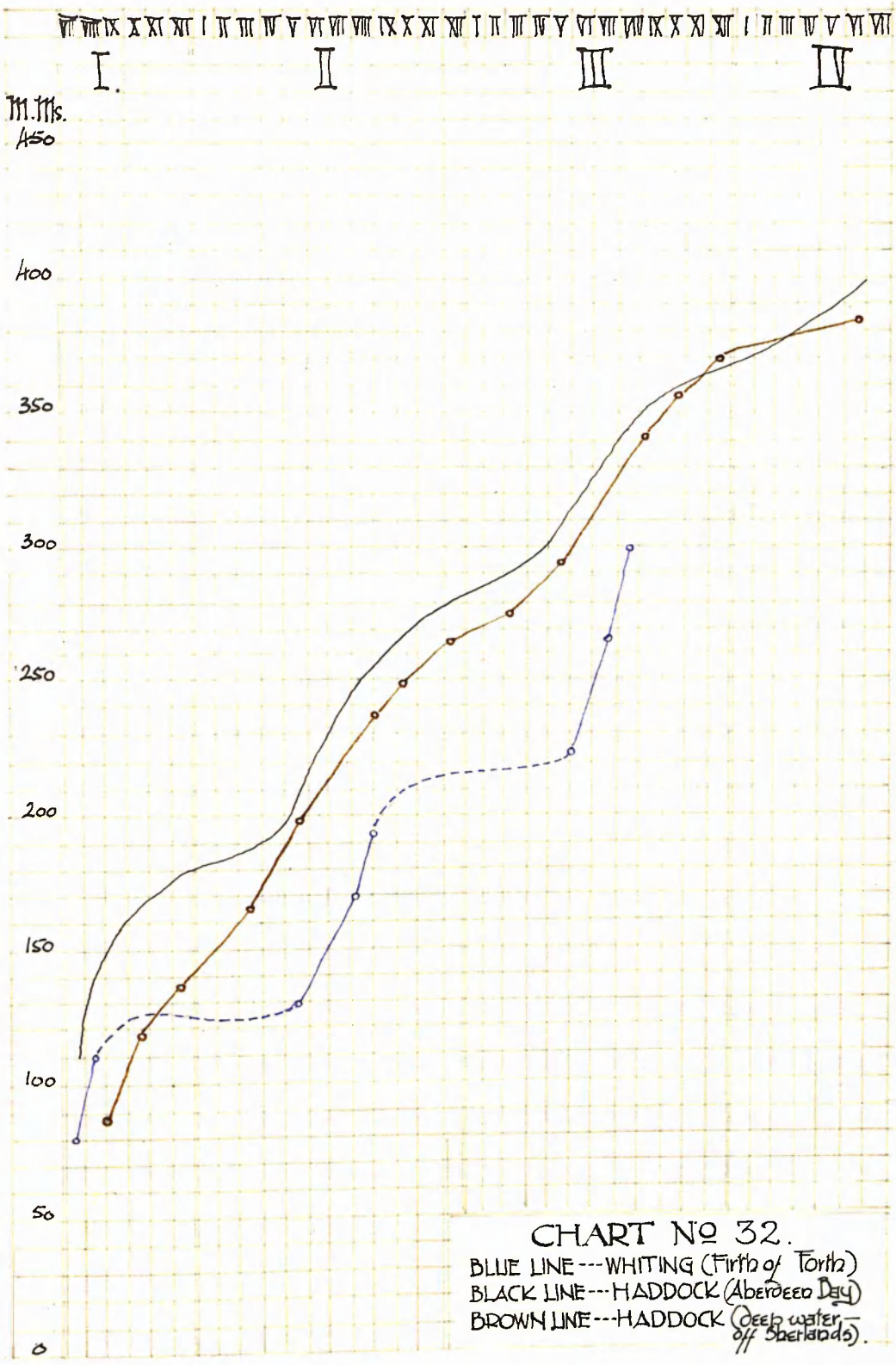
Chart No. 32 is copied from a Plate in the same article and gives the curves of growth of fishes in waters of varying ranges of temperature at the different seasons of the year.

The blue line represents the growth of Whiting in the Firth of Forth, where there is a marked change in the temperature of the water in summer and winter, the black line the growth of Haddock in Aberdeen Bay where the range of temperature is not so great, and the brown line the growth of Haddock in deep water off the Shetlands where the alteration between summer and winter temperature is comparatively slight.

The degree of variation in the rate of growth of the fish is very striking as it decreases pari passu with the diminution of the range between the summer and winter temperatures of the water.

From these observations it is evident that fishes do not grow continuously throughout the year, but shew a definite periodicity bearing some relation to the changes in the temperature of the water during the different seasons, growth as a rule being rapid in spring and retarded throughout the colder months.

Another Plate is given by Dr. Fulton in the same paper shewing the relation of the temperature of the water to the rate of growth of young Plaice, but as it appears to


I.
II
III
IV
M.Ms.
450
400
350
300
250
200
150
100
50
0
CHART No 32.
BLUE LINE --- WHITING (Firth of Forth)
BLACK LINE --- HADDOCK (Aberdeen Bay)
BROWN LINE --- HADDOCK (Deep water off Shetlands).

contain certain points contra-indicating this close connection between temperature and growth it will be discussed later.

With regard to the effect of temperature on the rate of growth of Crabs, a glance at Table 3 is sufficient to shew the relative frequency of moults in the summer months as compared with the winter, but although moulting takes place more commonly in the summer it is by no means confined to the warmer months. There are plentiful examples of moults occurring at all seasons of the year, but the large majority are found between April and September.

It is quite unnecessary to remark on the influence of season on plant life, and the common practice of "forcing" furnishes unquestionable proof of the salutary effect of warmth on vegetable growth.

The relation of temperature to growth in Man is more difficult of investigation than in the lower orders, as the types of growth in the human subject are various and complex. An attempt has been made, however, by charting the incidence of periods of rapid growth and periods of arrest in the several months of the year and comparing these with the Mean Temperature Curve. Such Charts are found in Nos. 33 and 34.

The red line represents the averages of the mean tem-

perature for each month taken at York over a period of forty years.(14) In Chart No. 33 it will be observed that the incidence of spurts of rapid growth, apart from being highest in the months between April and July accords but little with the temperature curve. The maximum temperature is reached in July, while May is the month in which rapid growth was most frequently observed, and again, in December, one of the coldest months, with a mean temperature of 39°F. active growth was more common than in August, with its mean temperature of 59°F.

The short period comprising the months of December and January in which there is a sudden rise in the incidence of active growth, coming as it does right in the middle of winter when the thermometer is at its lowest is a point in disfavour of the direct influence of temperature on growth.

Chart No. 34 combines the incidence of periods of arrest with the temperature curve and is more suggestive of some connection between temperature and growth. In it the number of instances of arrested growth in the several months varies inversely with the mean temperature curve for the different periods of the year. As a general rule the colder the month the more commonly did periods of arrest occur; but it must also be noted that the incidence of these periods of arrest is only roughly in inverse proportion to the

temperature. For example, the thermometer stands at practically the same point in March and November, and yet in the former month retarded growth is considerably more common than in the latter.

It is evident from Charts 33 and 34 that either great activity or complete arrest of growth may occur in any month of the year, and therefore low and high temperatures by no means prohibit rapidity or retardation of increase, although perhaps the higher temperatures predispose to activity of growth and vice versa.

With reference to the arguments against the influence of temperature on growth.

As has already been pointed out there is considerable discrepancy between the times of greatest frequency of active growth and the times of high readings on the thermometer, that May is the month in which rapid increase is most commonly found, while it is not until July that the maximum temperature of the year is reached. Further, that in December and January active growth is more frequent than in the months immediately preceeding and succeeding them although the temperature curve is then at it lowest.

It must also be borne in mind that in the series of growth-charts of boys, there was a certain percentage shewing the regular form of increase and which therefore

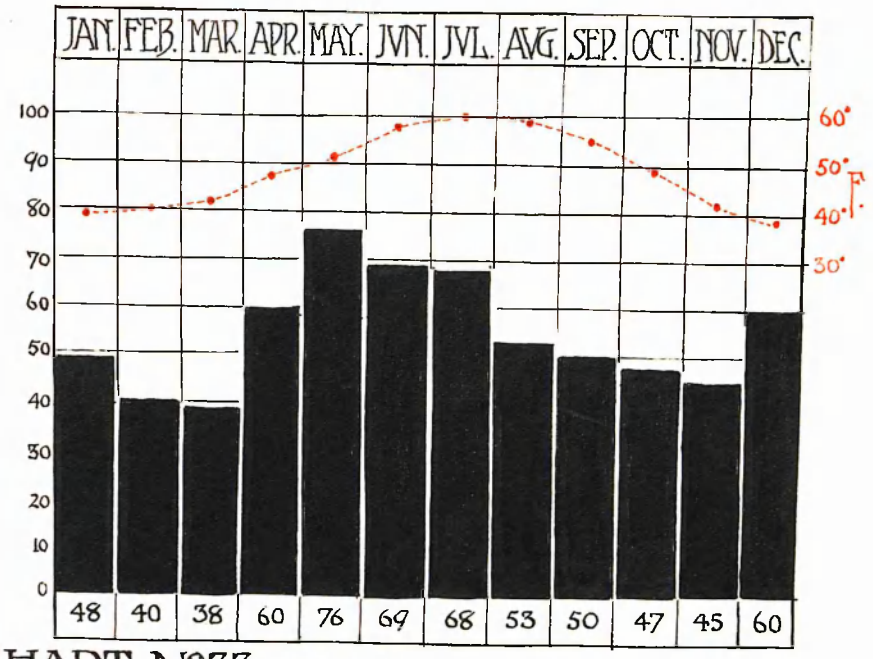


CHART No.33. Shewing the relation of the Mean Temperature Curve to periods of rapid growth.

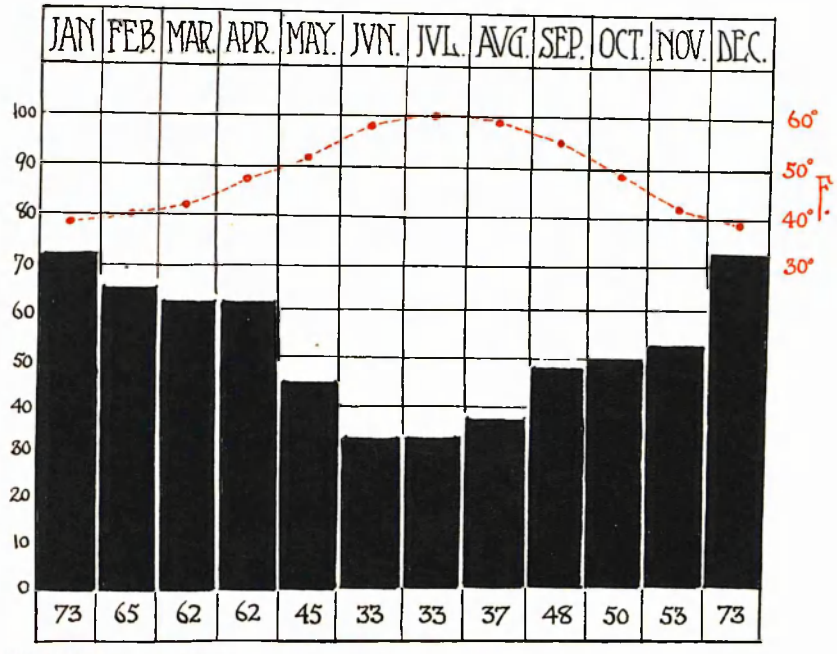


CHART No.34. Shewing the relation of the Mean Temperature Curve to periods of arrested growth.

presented a type of growth absolutely uninfluenced by seasonal changes, and the same might be said of all the cyclic charts except those shewing twelve-month swings, where there is some question of the influence of temperature in determining the rate of growth. The types of growth, therefore, are unaffected by changes of temperature.

Chart No. 35 is copied from a Plate given by Dr. Fulton[12] to illustrate the influence of temperature on the growth of young Plaice.

It was intentionally left over when the direct relation of temperature to the growth of fish was being considered as it seems to contain some points against rather than in support of the idea that there is a close connection between these two.

The black line represents the growth of the fish, the dotted brown one the temperature of the water. Growth is seen to be extremely active during the months of May, June and July; and in August, when the maximum temperature is recorded, the rate of increase is comparatively slow. In August, with the temperature of the water over 56°F. the rate of growth is less than one half what it had been in May when the thermometer registered only 48°F.

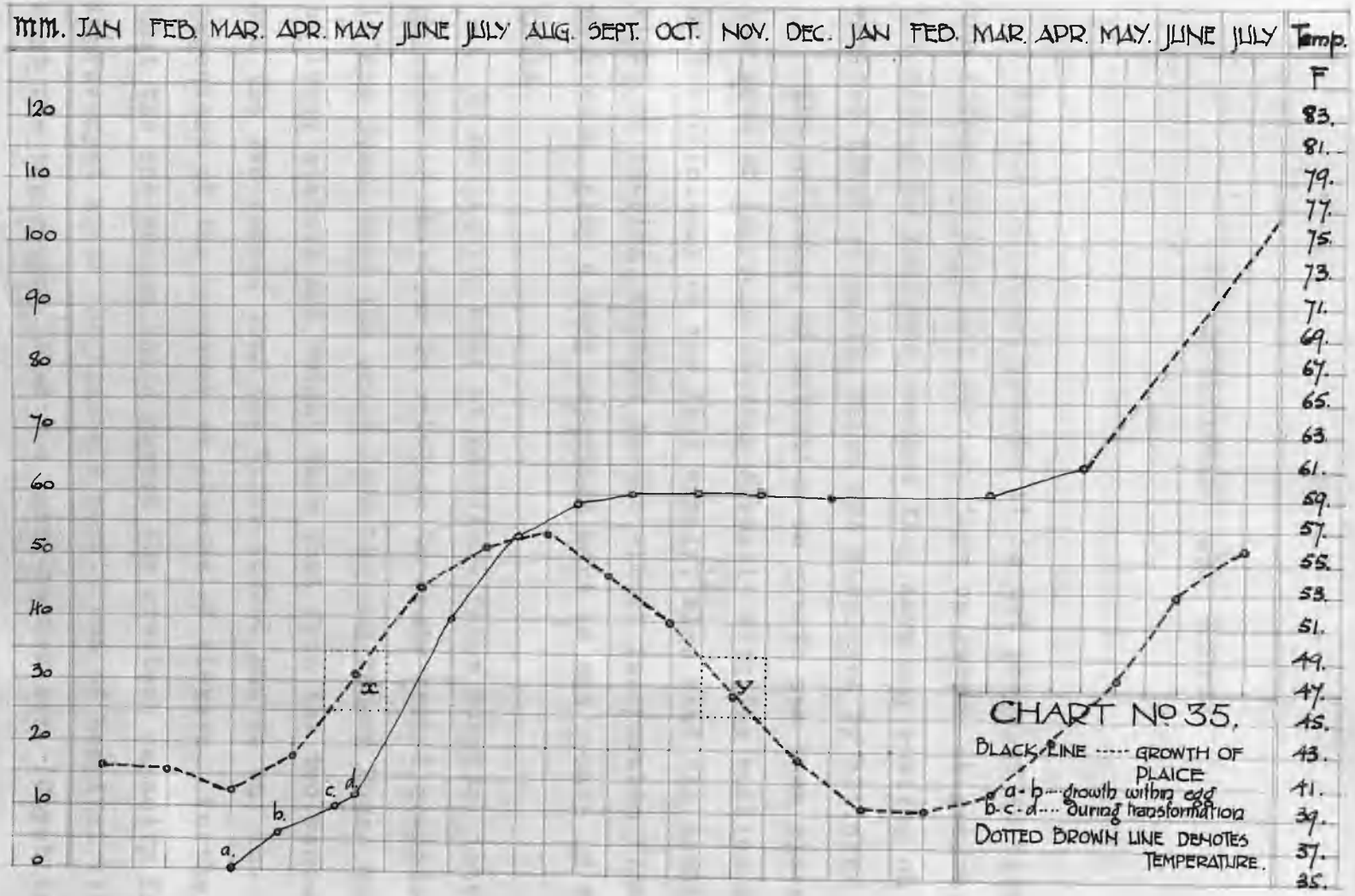
Also, that the temperature is the same during the months of May and November (where the letters "X" and "Y"

have been placed) but it is only in the former that active growth is shewn, there being literally no increase in November.

On the strength of these facts, when the curves of temperature and growth are studied together, it is suggested that the growth of the fish is essentially cyclic, and that the temperature of the water is not such a potent factor in producing acceleration or retardation of growth as it would appear to be in, for example, Chart No. 32.

From the above arguments the variations in the rate of growth of fishes seem to be practically independent of changes of temperature, but Dr Fulton's Tank experiments leave no question but that warmth and cold stimulate or impede growth to a certain extent.

In Man, however, the points in favour of and against the influence of temperature on growth are not so equally divided, the mass of evidence indicating that the rate of increase is independent of the temperature. This is probably explained by the fact that Man is a warm-blooded animal, and therefore external temperature does not sufficiently interfere with the various metabolic processes to accelerate or retard growth.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59.
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53.
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49.
47.
45.
43.
41.
39.
37.
35.
a.
b.
c.
d.
x
y
CHART No 35.
BLACK LINE ----- GROWTH OF PLAICE
a-b--- growth within egg
b-c-d--- during transformation
DOTTED BROWN LINE DENOTES TEMPERATURE.

D. ENVIRONMENT AND GROWTH

In the following remarks it is not proposed to discuss the effect of physical surroundings on growth in general, but merely to consider whether they have any bearing on the various types of growth which are displayed by children.

The influence of nutrition on growth has been proved, the rate of increase varying directly with the sufficiency or insufficiency of the food supply,(15) also that the conditions of housing, another factor almost inseparable from nutrition, play a very important part in the growth of the child.

In an inquiry made at Belvidere Fever Hospital into the physique of children in relation to their social conditions it was found that the child from the one-roomed house was of lower stature and weight than that from the two-roomed, and the two-roomed than the three-roomed and so on; independent of the presence or absence of rickets. Further, that the one-roomed child shewed the greatest capacity for improvement under the hygienic conditions of hospital life, next the two-roomed, then the three-roomed etc. (Unpublished

results by Macgregor)

This close connection between the growth and development of children and their position in the social scale was strikingly demonstrated in the extensive investigations made among the children attending the Primary and Higher Grade Schools of the School Board for Glasgow.(16)

The superior physique of the children belonging to the non-labouring classes as compared with those of the labouring classes was recorded by Bowditch(17) and is well shewn in his Tables of the average heights and weights of Boston school-boys.

Although it has thus been proved beyond question that the different conditions of the social grades favour or impede growth, it is no argument that they have any influence on the type of growth which the child will present.

Unfortunately the series of records of the growth of boys obtained from Bootham School gives little scope for observing the possible effects of altered surroundings.

The only opportunities offered are at the times of holidays, and although these brought about a multitude of small changes in locality, habit, etc., the hygienic conditions of school and home life were equally favourable, so that any very apparent interference with the types of growth could hardly be expected to result from them.

April, August and September, December and January were the months in which holidays took place.

In the Regular and Cyclic charts of Groups 1 and 3, the types are apparently quite independent of external conditions, so that it is only in the Irregular charts of Group 2 that evidences of the influence of surroundings on the type of growth may be looked for.

Charts Nos. 33 and 34 shew that the incidence of rapidity or arrest of growth during the easter holidays in April, or the summer ones in August and September, is not out of proportion to that for the months immediately preceeding and following them.

In December and January there is a rise in the frequency of rapid growth in comparison with November and February, but as it is also in December and January that arrested growth is most commonly recorded, the occurrence of the Christmas holidays cannot be said to have had any more effect than the Easter and Summer ones on the growth shewn by these charts of the Irregular Type.

In describing some experiments on the migration and rate of growth of fishes Dr. Fulton[10] states that Plaice which were kept in a tank (as a control) did not grow so rapidly as those which, after being measured and labelled, had been returned to the sea, recaptured some months later,

and remeasured.

This may be taken as an instance of growth being impeded by comparatively unfavourable surroundings, but the type of growth was unaffected; there was the usual period of rapid increase in the spring months and the period of arrest throughout the autumn and winter, so that the curve of growth presented its normal features.

Such evidence, therefore, as is available, points to the types of growth being independent of and unaffected by the conditions of the surroundings, in spite of the fact that environment plays such an important part in increasing or diminishing the rate of increase and possibly the ultimate limit of growth.

It would seem as if all growth might be classified under the three headings, Regular, Irregular and Cyclic, and whilst, in various organisms growth is confined to one type, as, for example, the cyclic form in animals with an exoskeleton such as the crab, or the regular form in the growth of a plant-internode, in others, as for instance Man, examples representing all three types are found.

It is suggested that the mode of growth pursued is due to some inherent property of the individual, and that environment and all other external influences play little, if any, part in determining the type of growth.

It is significant that in the series of 250 charts of the growth of healthy boys, and in which the three different types were represented, there were nineteen instances of two or more members of the same family having been under observation. In this total of forty-three charts, four in Group 1, thirty-nine in Group 2, the growth of brothers was remarkably similar, pointing to the child being born with a tendency, possibly hereditary, towards one form of growth or another, and against the casual influence of extrinsic agencies producing Regularity, Irregularity or Cyclic variations in the rate of growth.

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