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# FIRST RESULTS FROM THE OXFORD ANTHROPOMETRIC LABORATORY.

[*A paper read before the British Association (Section D) at Sheffield, 1910.*]

By E. SCHUSTER, D.Sc.

THIS Laboratory was instituted in the Department of Comparative Anatomy in January 1908 by Professor G. C. Bourne. Its objects are defined in its circulars as follows :

(1) To obtain a statistical survey of the physical development of undergraduates, which would in itself have a permanent value as a record which might be compared with similar records obtained in other places and possibly in future ages.

(2) To ascertain whether any degree of interconnection or correlation exists between mental and physical characters.

(3) To ascertain what bodily changes or development take place during a man's residence in Oxford as an undergraduate, and whether such changes depend at all on what games he plays, what school he reads for, and so on.

(4) To obtain data by which exact measures can be made of the resemblance between brothers and between first cousins.

As will be shown some progress has already been made with regard to Nos. 1 and 3, but in the present paper no attempt will be made to deal with Nos. 2 and 4.

In order to attain the objects here detailed it was proposed that each undergraduate should be measured twice, once near the beginning and once near the end of his career. The number of men who have actually been measured twice is at present only 89 so that the changes in individuals cannot be satisfactorily dealt with, but the material has been used in this way:—it has been divided into groups according to the age of the subject at the time of measurement, and all those measured twice are included twice, once in the group corresponding to their age at first measurement and once in the group corresponding to their age at second

measurement. Thus reckoned there are 959 men included in my tables. 29 of 18 years of age, 330 of 19, 209 of 20, 137 of 21, 95 of 22, and 59 of 23 and over. The average values for each measurement employed have been determined for each of these six groups and their standard deviations as a measure of variability. In addition a large number of correlation coefficients between pairs of measurements have been calculated for the five largest groups.

*Measurements and Test Applied.*

(1) *Spot Pattern Test.* This test was devised by Dr McDougall and included in our schedule at his suggestion; he considers that it forms a measure of the power of concentration. Its object is to find how soon a simple pattern may be correctly reproduced. The pattern, of which a sample is shown below, is made by pricking holes in a square of cardboard. The holes lie in equidistant rows and columns, the distances between them being obtained by first plotting them at the

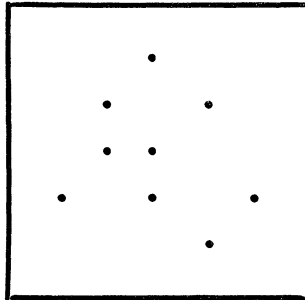


Figure showing one of the patterns employed in the test.

It can be used any way up.

points of intersection of the lines on sectional paper. The number of rows and columns is limited to five so that the number of possible places for the spots is 25. The first pattern attempted has nine spots placed irregularly in these positions. The cardboard square is placed in a wooden frame which brings it to the level of the eyes of the subject who sits before it, behind is placed a large instantaneous self-setting photographic shutter and behind that again a carefully shaded electric light. When the shutter is worked, the subject sees the pattern for a small fraction of a second as a number of bright spots arranged like a constellation. The procedure is for the operator to show the pattern once and then to read the simple directions. After this the pattern is shown again five times at intervals of about two seconds; the subject is then required to attempt to map the spots on sectional paper with the same sized squares as that used in making the pattern. Areas are ruled off on the paper of the right size for the purpose. The first attempt is generally a failure, though one or two successes are recorded; the pattern is then shown again five times and a fresh attempt is made, if this is also unsuccessful the procedure is again repeated, and so on till the map is correctly drawn, except that in order to save time no one was allowed more than ten attempts.

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The actual record of how many people succeeded at the first attempt, how many at the second attempt and so on is not of much interest, but what is of interest are the correlations found to exist between success at this test and intellectual eminence as measured by examination. The fourfold table method was employed for measuring these correlations, but it is only claimed that the coefficients so found give a rough idea of the degree of correlation.

As a specimen table the following may be taken :

*Spot Pattern Test and Class in final Schools.*

	Classes I and II	Classes III and IV and Pass	Totals
5 tries or less ...	27	26	53
6 tries or more ...	18	29	47
Totals ...	45	55	100

$r = \cdot 2.$

This table includes all those who had taken their final Schools by the end of 1909, the following year's results having appeared too late to be included. It will be seen that the first and second class men are distinctly better than those included in Classes III or IV or who obtained pass degrees, since 60 per cent. of the former and only 46 per cent. of the latter mapped the pattern correctly in five attempts or less. The correlation coefficient calculated from this table is  $\cdot 2$  which indicates a low degree of correlation. It should perhaps be explained that when the correlation is perfect, i.e. when a variation of any particular degree of the one variable is always associated with a variation of the same degree of the other variable, then the coefficient is equal to unity; when no correlation exists it is equal to 0.

Since the numbers are small and the correlation is low, the conclusion drawn from this one table could not be regarded as safe if considered independently, but as it receives corroboration from the study of the results of scholarship examinations it may be accepted with fair confidence.

The correlation between the possession of a scholarship or exhibition and success at the test under consideration is positive for each age group, though as the numbers in each such group are small it has a considerable variation. The average value for all age groups taken together is  $\cdot 22$ . Here again the correlation coefficients are not high, nor, since they are based on small numbers, are they particularly constant; but some degree of positive correlation is exhibited by every age group, so that the probability of the result being partly a chance one is so small as to be negligible.

Further, an investigation was made of the relation between an undergraduate subject of study and his success at this test, with the result that those reading science or mathematics were found to be superior to those reading other subjects,

The correlations were in this case :

Age 18	$r = \cdot 19$	Age 21	$r = \cdot 24$
Age 19	$r = \cdot 08$	Age 22	$r = \cdot 02$
Age 20	$r = \cdot 19$	Average	$r = \cdot 14$

Here the correlation is lower than in the case previously considered, but again is positive in every group.

As it had been suggested to me that the test might be effected by eyesight, the correlations with acuity of vision were determined and are here shown :

Age 18	$r = - \cdot 06$	Age 21	$r = + \cdot 11$
Age 19	$r = - \cdot 04$	Age 22	$r = - \cdot 01$
Age 20	$r = - \cdot 12$	Average	$r = - \cdot 02$

The minus signs indicate a negative correlation, i.e. that bad eyesight shows to slight advantage, but since the numerical values are very small and the sign is not constant throughout, it may be concluded that eyesight does not appreciably affect the results of this test.

(2) *Acuity of Vision* is tested by means of a card on which are printed ten lines of type of heights ranging from rather over  $4\frac{1}{2}$  inches in the top line to  $\frac{1}{8}$ th inch in the bottom line. The height of the type is so adjusted that it subtends an angle of five minutes in the eye at the following distances :

Top line	.....	80 metres	6th line	.....	9 metres
2nd "	.....	36 "	7th "	.....	6 "
3rd "	.....	24 "	8th "	.....	4 "
4th "	.....	18 "	9th "	.....	3 "
5th "	.....	12 "	10th "	.....	2 "

A person with normal sight should be able to read each line at the distances named with each eye separately. Since the card is shown to the subject at a distance of six metres, he should be able to read down to the seventh line. As a matter of fact, a considerable number of men can read accurately with either eye as far as the ninth line ; but we have not as yet found anyone who can get as far as the tenth.

In recording the results of this test, the smallest type which can be read is noted and the distance at which it should be read by a person of normal sight is entered in the schedule. For example, if the entry stands "Right Eye 80, Left Eye 36," it means that the subject, standing at a distance of six metres from the card, can read the top line only with his right eye and the second line also with his left. A person of normal sight could have read these at distances of 80 and 36 metres respectively. ( $\frac{1}{2}$ ) entered against the number signifies that only a certain proportion of the letters in the line referred to were read correctly.

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This test is that usually employed as a preliminary by oculists, in making an examination of a patient's eyesight. Short sight and astigmatism are detected by it but not distinguished from one another as different defects of vision; long sight may pass unnoticed.

I give a table in which the men tested are classed in four grades according to the sight of the right eye; a similar table for the left eye would be practically the same, since the correlation between the two eyes is very high.

		4 or better	4½ and 6	6½—24	24½ or worse	Totals
Age 18	Number	52	28	30	19	129
	Percentage	40 %.	22 %.	23 %.	15 %.	
Age 19	Number	113	79	70	64	326
	Percentage	35 %.	24 %.	21 %.	20 %.	
Age 20	Number	87	50	39	32	208
	Percentage	42 %.	24 %.	19 %.	15 %.	
Age 21	Number	50	37	34	12	133
	Percentage	38 %.	28 %.	26 %.	9 %.	
Age 22	Number	37	19	20	19	95
	Percentage	39 %.	20 %.	21 %.	20 %.	
Average percentages		39 %.	24 %.	22 %.	18 %.	

This table shows that about a quarter of the whole number have eyesight of what oculists consider to be of the normal keenness, while the remainder are almost equally distributed above and below. Of those below the normal 18 % have distinctly bad eyesight. The fact that this test is made is of advantage to some, at any rate, of the men who come to the laboratory, for many of those with faulty vision are quite unaware of it till it is thus pointed out, although possibly suffering considerable inconvenience therefrom. The visit to an oculist which is recommended may in consequence conduce to their greater comfort and to the preservation of their sight.

### (3) *Measurements of Physical Development.*

*Lung Capacity* is measured by means of a spirometer. This instrument was copied with slight modifications from that used by Sir Francis Galton in his anthropometric laboratory. It consists of an outer cylinder filled with water, in which there rests an inverted inner cylinder. The subject is asked to take a deep breath and then to blow down a flexible tube which is connected in such a way with the inner cylinder that all the air passes into the latter. The inner cylinder is counterpoised so that the air passing into it causes it to rise, the amount of the rise being proportional to the volume of the air. A pointer is attached to its top, which as the cylinder rises passes up a vertical scale divided into millimetres. The diameter of the cylinder was so arranged that a rise of one mm. corresponds with entrance of 20 c.c. of air. The measurement of volume in this way is not quite accurate, as it is not possible without somewhat elaborate arrangements to

get the inner cylinder counterpoised correctly for all positions, since the more it rises the less it is supported by the water in the outer cylinder. Thus when it rises above a certain level the air contained in it becomes compressed to an extent slightly greater than the atmospheric pressure, and the more it rises the greater this additional pressure becomes. Thus in the case of men with good chest development the lung capacities are slightly understated.

In applying this test three blows are allowed and the mean of them is taken. Sometimes the first blow is a failure, owing to the subject not quite understanding what he has to do, and in this case it is not recorded but a fourth attempt is made instead.

*Stature* is measured by means of a special instrument in which there are two platforms, a lower fixed one, and an upper hinged seat which may be brought down on to fixed brackets at such a height that its top surface is exactly 500 mm. above the lower platform or put out of the way when it is not wanted. The subject first removes his boots and is asked to stand on the lower platform, a sliding block, massive in its proportions but counterpoised, is brought down on to the top of his head and his stature read off a millimetre scale in the usual way. The upper platform is then brought into position, he is asked to sit on it and the height of the top of his head in this position is measured. By deducting the height of the seat (500 mm.) the length of his body without the legs is obtained. He then kneels on the lower platform and another record is taken; in this case his whole length except that part below the knees is measured; by a little subtraction the length of the leg and the length of the thigh are arrived at. Two ratios are then calculated, namely the ratio of length of leg to the whole stature, expressed in the tables in  $\frac{1}{100}$ ths of the stature, and the ratio of the thigh length to the leg length expressed in  $\frac{1}{100}$ ths of the leg length.

*Weight* is measured on an Avery weighing machine in stones, pounds and ounces. The subject is fully dressed but without his boots.

*Strength of Pull* is measured by means of a spring balance, working up to 500 lbs., suspended by a staple driven into the wall. To the free end of the balance a wire rope is attached, which passes under two pulleys fastened to the floor and ends in a cross-piece resting close to the ground. The subject is required to stand over this handle, stooping so as to reach it, and to pull it steadily upwards as far as he can; then to hold it in this position for five seconds.

It is not proposed to give a detailed account of all the means, standard deviations and correlation coefficients which have been calculated. These are recorded more clearly and satisfactorily in a tabular form. But an attempt will be made to point out the more interesting facts which the tables show.

*Strength of Pull.* The average pull for the 18 year old group is 185.2 lbs., this rises fairly steadily with age; at 21 years 216.4 lbs. is reached, then it drops slightly to 211.4 at 22 and 212.9 at 23. As the probable errors of the means for



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the last three ages range from about 3 to  $4\frac{1}{2}$  lbs. no significance need be attached to this slight falling off.

The lung capacity starting at its lowest in the 18 year old group with an average of 4184 c.c. also rises to its highest at 21 years where 4438 c.c. is reached, then follows a slight drop succeeded again by another rise.

The weight is also at its lowest at 18 years of age when the average is 10 st. 7 lbs. 9 ozs., this rises to 10 st. 12 lbs. at 19, and to 11 st. 2 lbs. at 21, then as in the case of the pull there is a drop of the average. Professor Bourne tells me that his experience with rowing men is something of the same kind, after 18 years there is a sudden rise of  $\frac{1}{2}$  stone followed subsequently by a slight drop.

These three measurements are fairly closely correlated one with another, the average correlation coefficients being: strength of pull and weight .46, strength of pull and lung capacity .37, lung capacity and weight .59.

Knowing the correlation between each pair of three variables it is possible to find by means of a formula the correlation between any pair for a constant value of the third variable. In this case for instance it might perhaps be said that there is no independent correlation between strength of pull and lung capacity and that the apparent correlation is due to the fact that people with large lung capacities are also heavy and that their weight gives them an advantage at the pull test. That they do derive some advantage from their weight is perfectly true, but the application of the formula teaches us that for people of equal weight, the correlation between lung capacity and strength of pull is .14.

To take for purposes of comparison the relations of weight, pull and stature.

Here we have the correlation between stature and pull .21, between pull and weight .46 and between stature and weight .66. With a positive correlation between stature and pull it looks as if tall men had an advantage, but again applying the formula we find that for men of equal weight the correlation between stature and pull is actually negative, namely  $-.13$ , and that the tall men are at a distinct disadvantage. If we took from them besides the advantage of extra weight which their extra stature provides them with, the increased lung capacity which also goes with it, we would find that this disadvantage was greater still. The disadvantage itself may be either due to the fact that our apparatus is more difficult for a tall man properly to apply his strength at, or it may be that the tall men are more apt to be weedy and weak in the back than the short, at any rate during the early part of their lives. A certain amount of evidence in favour of the latter supposition is given by a comparison of the correlation coefficients of the different age groups, in the 18 year old group we find the correlation between stature and weight, lung capacity and strength of pull severally smaller than in the succeeding ages. The correlation between stature and weight is .50 for the 18 year olds, .63 for the 19 year olds and goes up to .76 for those aged 21. As the P.E. in the latter case is .02 and in the former .04, this difference is probably significant.



The average stature is 1751.6 mm. for the 18 year old group and goes up to 1767.2 mm. for the 19 year old men, while 1778.6 is recorded for those of 21 years of age. The latter figure is probably an accidentally high one since the succeeding years show lower averages. The numbers are really too small to give a satisfactory curve of growth.

The mean ratio of length of leg to stature is fairly constant through all the ages considered, the lowest average recorded being 47.01 and the highest 47.46. The mean ratio of thigh to leg is even more constant, ranging between 46.44 and 46.65.

The correlation between leg ratio in stature is well marked, its average value being .44, which means that for any particular age group increase in stature is due to a great extent to increased length of leg. On the other hand it must be pointed out that although the mean stature appears to increase with the age the mean length of leg does not, thus it may be argued that growth after the age of 18 concerns the body rather than the legs.

As thigh ratio is sensibly correlated with leg ratio it would appear that people with disproportionately long legs also are apt to have disproportionately long thighs.

#### (4) *Head Measurements.*

(1) *Greatest Length.* Taken from the most prominent point of the glabella or prominence in the mid line between the two eyebrows to the most distant point in the middle line on the back of the head, known as the occipital point.

(2) *Greatest Breadth.* Measured wherever it can be found above the plane of the ear-holes. The calipers must be held in such a way that the two points lie in the same vertical and horizontal planes.

(3) *Auricular Height.* Two points are placed firmly in the ear-holes, and a third point lying in the same vertical plane is brought down on to the top of the head. The distance between this point and the line joining the other two is read off by means of a scale.

(4) *Maximum Circumference.* Measured by passing a steel tape over the glabella in front and the occipital point behind.

(5) *Sagittal Arc.* Measured by passing the tape from the glabella in front, over the top of the head in the middle line to the inion behind. The inion is a bony projection, developed to very varying extent in different people, which lies in the middle line, just above the area of the skull, to which the fleshy muscles at the back of the neck are attached.

(6) *Transverse Arc.* Measured by passing the tape over the top of the head in a vertical plane from one preauricular point to the other. The preauricular point is the point immediately in front of the tragus, or little projection of ear which lies in front of the ear-hole.

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Two cranial indices are deduced from these measurements, namely, the ratio of the greatest breadth to the greatest length, and of the auricular height to the greatest length.

A Flower's Cranimeter was used for measuring the greatest length and the greatest breadth, while the auricular height was taken with a special instrument not hitherto described.

This instrument consists essentially of a long brass box with open ends which forms a bearing for two flat bars. The bars can slide in or out of the box in the direction of its longitudinal axis, but they are constrained to move inwards or outwards to an equal extent as they each carry, where they face one another in the box, a rack which is in mesh with one and the same pinion. Running downwards from the outer ends of the bars and at right angles to them are long arms, to the lower ends of which are attached the ear points. Sliding through bearings in the top and bottom of the box is a round rod, which is brought down on to the top of the subject's head, on it is engraved a scale by which the distance from the top of the head to the line joining the ear points may be arrived at. The object of the two racks and the pinion is to ensure that the end of the rod comes down on to the middle line of the head. This instrument is too heavy to be held in the hand of the operator in the usual way and therefore is suspended from a sort of double gallows and counterpoised.

The numbers available are not sufficient to enable me to make any very definite statement about the changes in head measurements with age, but there is some indication that the length increases during the period dealt with. The mean head length at 18 is 195.2 mm., at 21 196.05, and at 27 197.4 mm. The breadth for these ages 152.9, 152.7, 153.1, respectively, while the highest mean head breadth recorded is, at 22, namely 153.66, so that this measurement shows little if any increase. Consequently the cranial index (breadth to length) drops slightly, being 78.40 for the youngest group, at 77.59 for the oldest. The auricular height shows a very slight tendency to rise, while its index falls slightly. The correlation between stature and head length is .31, which is more than twice as great as that between stature and head breadth (.14). Consequently there is a slight negative correlation between this and the cranial index  $B/L$ . ( $-.13$ .)

The correlation between stature and auricular height is about the same as that between stature and head length, and therefore the auricular height index shows itself as practically independent of stature.

TABLE OF MEANS AND OF STANDARD DEVIATIONS WITH GENERAL AVERAGES OF AGES 18 TO 22; 23 YEARS AND OVER.

TABLE I. *Table of Means\**.

Character	Age 18, No. 129	Age 19, No. 330	Age 20, No. 209
Strength of Pull ...	185.2 ± 2.7 lbs.	200.9 ± 1.7 lbs.	204.8 ± 2.2 lbs.
Lung Capacity ...	4184 ± 34 c.c.	4278 ± 22 c.c.	4268 ± 29 c.c.
Weight ...	10 st. 7 lbs. 9 oz. ± 14 oz.	10 st. 12 lbs. 1 oz. ± 10 oz.	10 st. 11 lbs. 9 oz. ± 12 oz.
Stature ...	1751.6 ± 3.4 mm.	1767.2 ± 2.5 mm.	1766.2 ± 3.2 mm.
Length of Leg ...	840.2 ± 2.6 mm.	835.0 ± 1.6 mm.	835.2 ± 2.2 mm.
Length of Thigh ...	392.9 ± 1.6 mm.	388.6 ± .9 mm.	389.2 ± 1.2 mm.
Ratio of Leg to Stature	47.46 ± .08	47.23 ± .05	47.27 ± .06
Ratio of Thigh to Leg	46.65 ± .06	46.50 ± .04	46.56 ± .05
Head Length <i>L</i> ...	195.23 ± .37 mm.	195.66 ± .22 mm.	195.15 ± .31 mm.
Head Breadth <i>B</i> ...	152.90 ± .27 mm.	152.63 ± .18 mm.	152.04 ± .25 mm.
Auricular Height <i>H</i> ...	136.48 ± .36 mm.	136.52 ± .21 mm.	135.97 ± .28 mm.
Cranial Index <i>B/L</i> ...	78.40 ± .18	78.06 ± .11	77.97 ± .14
Cranial Index <i>H/L</i> ...	69.95 ± .20	69.80 ± .12	69.77 ± .14
Horizontal Circumference of Head	560.76 ± .79 mm.	562.29 ± .51 mm.	560.90 ± .73 mm.
Sagittal Arc ...	345.93 ± .81 mm.	347.35 ± .48 mm.	346.67 ± .66 mm.
Transverse Arc ...	361.77 ± .69 mm.	361.23 ± .41 mm.	360.35 ± .62 mm.

Character	Age 21, No. 137	Age 22, No. 95	Age 23 and over, No. 59	General Average
Strength of Pull ...	216.4 ± 2.9 lbs.	211.4 ± 3.6 lbs.	212.9 ± 4.4 lbs.	205.3 lbs.
Lung Capacity ...	4438 ± 39 c.c.	4301 ± 37 c.c.	4418 ± 59 c.c.	4315 c.c.
Weight ...	11 st. 2 lbs. ± 1 lb.	10 st. 12 lbs. 10 oz. ± 1 lb. 3 oz.	10 st. 11 lbs. 12 oz. ± 1 lb. 6 oz.	10 st. 11 lbs. 15 oz.
Stature ...	1778.6 ± 4.1 mm.	1757.5 ± 4.6 mm.	1769.2 ± 6.2 mm.	1765.0 mm.
Length of Leg ...	840.3 ± 2.9 mm.	826.7 ± 3.0 mm.	838.1 ± 4.4 mm.	836 mm.
Length of Thigh ...	391.1 ± 1.5 mm.	385.6 ± 1.6 mm.	391.1 ± 2.3 mm.	389.8 mm.
Ratio of Leg to Stature	47.23 ± .08	47.01 ± .08	47.38 ± .11	47.26
Ratio of Thigh to Leg	46.44 ± .06	46.58 ± .07	46.63 ± .10	46.56
Head Length <i>L</i> ...	196.05 ± .38 mm.	196.82 ± .43 mm.	197.41 ± .49 mm.	196.05 mm.
Head Breadth <i>B</i> ...	152.69 ± .28 mm.	153.66 ± .38 mm.	153.11 ± .38 mm.	152.84 mm.
Auricular Height <i>H</i> ...	136.90 ± .30 mm.	136.86 ± .41 mm.	137.01 ± .51 mm.	136.62 mm.
Cranial Index <i>B/L</i> ...	78.00 ± .17	78.08 ± .20	77.59 ± .22	78.02
Cranial Index <i>H/L</i> ...	69.94 ± .17	69.58 ± .21	69.35 ± .21	69.73
Horizontal Circumference of Head	563.64 ± .89 mm.	565.53 ± 1.06 mm.	565.47 ± 1.02 mm.	563.10 mm.
Sagittal Arc ...	349.67 ± .74 mm.	348.57 ± .95 mm.	350.17 ± 1.10 mm.	348.06 mm.
Transverse Arc ...	361.45 ± .67 mm.	364.90 ± .87 mm.	364.12 ± 1.01 mm.	362.30 mm.

\* [The following comparative data for 1000 Cambridge and 493 Scottish Undergraduates may be of interest:

	CAMBRIDGE		ABERDEEN	
	Mean	Standard Deviation	Mean	Standard Deviation
Strength of Pull	84.0 ± .27 lbs.	12.7 ± .2 lbs.	—	—
Weight ...	10 st. 12.8 lbs. ± .35 lbs.	16.55 ± .25 lbs.	—	—
Stature ...	1749 ± 1.4 mm.	64.6 ± 1.0 mm.	1717 ± 1.8 mm.	59.4 ± 1.3 mm.
Head Length ...	193.5 ± .13 mm.	6.16 ± .09 mm.	194.8 ± .17 mm.	5.73 ± .12 mm.
Head Breadth...	154.0 ± .11 mm.	5.06 ± .08 mm.	153.4 ± .14 mm.	4.69 ± .10 mm.
Head Index ...	79.6 ± .06	2.999 ± 0.044	78.8 ± .09	2.79 ± .06

See *R. Soc. Proc.* Vol. 66, p. 26, *Biometrika*, Vol. 1. pp. 188 et seq., and *Proc. Anat. and Anthropol. Soc. University of Aberdeen* (Macdonell), 1906-8.

It will be seen at once that the measurement of pull at Oxford and Cambridge are made by different methods and are wholly incomparable. Cambridge appears in weight and breadth of head to exceed *Biometrika* VIII

TABLE II. *Table of Standard Deviations.*

Character	Age 18, No. 129	Age 19, No. 330	Age 20, No. 209
Strength of Pull ...	44·66 ± 1·88 lbs.	45·99 ± 1·20 lbs.	46·17 ± 1·52 lbs.
Lung Capacity ...	566·2 ± 23·8 c.c.	602·5 ± 15·8 c.c.	611·6 ± 20·2 c.c.
Weight ...	1 st. 1 lb. 1 oz. ± 10 oz.	1 st. 2 lbs. 12 oz. ± 7 oz.	1 st. 2 lbs. 12 oz. ± 9 oz.
Stature ...	57·92 ± 2·43 mm.	62·22 ± 1·63 mm.	68·09 ± 2·25 mm.
Length of Leg ...	43·40 ± 1·82 mm.	43·84 ± 1·15 mm.	46·24 ± 1·52 mm.
Length of Thigh ...	26·83 ± 1·13 mm.	24·45 ± ·64 mm.	24·98 ± ·82 mm.
Ratio of Leg to Stature	1·300 ± ·055	1·335 ± ·035	1·287 ± ·043
Ratio of Thigh to Leg	1·076 ± ·045	1·123 ± ·029	1·017 ± ·034
Head Length <i>L</i> ...	6·30 ± ·26 mm.	5·98 ± ·16 mm.	6·73 ± ·22 mm.
Head Breadth <i>B</i> ...	4·62 ± ·19 mm.	4·88 ± ·13 mm.	5·25 ± ·17 mm.
Auricular Height <i>H</i> ...	6·08 ± ·25 mm.	5·73 ± ·15 mm.	5·93 ± ·20 mm.
Cranial Index <i>B/L</i> ...	3·08 ± ·13	2·99 ± ·08	3·00 ± ·10
Cranial Index <i>H/L</i> ...	3·38 ± ·14	3·16 ± ·08	3·02 ± ·10
Horizontal Circumference of Head	13·38 ± ·56 mm.	13·73 ± ·36 mm.	15·65 ± ·52 mm.
Sagittal Arc ...	13·65 ± ·57 mm.	12·85 ± ·34 mm.	14·12 ± ·46 mm.
Transverse Arc ...	11·71 ± ·49 mm.	11·16 ± ·29 mm.	13·19 ± ·44 mm.

Character	Age 21, No. 137	Age 22, No. 95	Age 23 and over, No. 59	General Average
Strength of Pull ...	50·25 ± 2·04 lbs.	51·73 ± 2·53 lbs.	50·31 ± 3·12 lbs.	48·18 lbs.
Lung Capacity ...	683·1 ± 27·8 c.c.	540·9 ± 26·5 c.c.	674·8 ± 41·9 c.c.	613·2 c.c.
Weight ...	1 st. 3 lbs. 3 oz. ± 11 oz.	1 st. 2 lbs. 13 oz. ± 13 oz.	1 st. 1 lb. 15 oz. ± 1 lb.	1 st. 2 lbs. 6 oz.
Stature ...	71·44 ± 2·91 mm.	66·20 ± 3·24 mm.	70·59 ± 4·38 mm.	66·08 mm.
Length of Leg ...	49·53 ± 2·02 mm.	42·78 ± 2·09 mm.	49·63 ± 3·08 mm.	45·90 mm.
Length of Thigh ...	25·73 ± 1·05 mm.	23·15 ± 1·13 mm.	26·66 ± 1·66 mm.	25·30 mm.
Ratio of Leg to Stature	1·311 ± ·053	1·141 ± ·056	1·261 ± ·078	1·273
Ratio of Thigh to Leg	1·021 ± ·042	1·030 ± ·050	1·085 ± ·067	1·059
Head Length <i>L</i> ...	6·59 ± ·27 mm.	6·20 ± ·30 mm.	5·55 ± ·34 mm.	6·23 mm.
Head Breadth <i>B</i> ...	4·84 ± ·20 mm.	5·51 ± ·27 mm.	4·39 ± ·27 mm.	4·92 mm.
Auricular Height <i>H</i> ...	5·27 ± ·21 mm.	5·97 ± ·29 mm.	5·79 ± ·36 mm.	5·80 mm.
Cranial Index <i>B/L</i> ...	2·98 ± ·12	2·94 ± ·14	2·55 ± ·16	2·92
Cranial Index <i>H/L</i> ...	3·00 ± ·12	3·08 ± ·15	2·42 ± ·15	3·01
Horizontal Circumference of Head	15·51 ± ·63 mm.	15·23 ± ·75 mm.	11·65 ± ·72 mm.	14·19 mm.
Sagittal Arc ...	12·87 ± ·52 mm.	13·84 ± ·68 mm.	12·48 ± ·77 mm.	13·30 mm.
Transverse Arc ...	11·74 ± ·47 mm.	12·49 ± ·61 mm.	11·46 ± ·71 mm.	11·96 mm.

Oxford, but Oxford men are taller and longer headed. Thus they are more dolico-cephalic than the Cambridge men, 78·0 as against 79·6. Macdonell's 3000 criminals gave a cephalic index of 78·5. The average head length of 196 mm. agrees fairly well with Pearson's measurements at University College, as the table below will indicate (*Phil. Trans.* Vol. 196 A, p. 251), *U*=Horizontal Circumference.

	<i>L</i>	<i>B</i>	<i>H</i>	<i>U</i>	<i>B/L</i>
British Association Measurements	198·8	155·0	130·9	—	78·0
University College, London Staff	196·4	153·5	134·8	—	78·2
Oxford Undergraduates ...	196·0	152·8	136·6	563·6	78·0
Scottish Undergraduates ...	194·8	153·4	132·3	562·6	78·8
Cambridge Undergraduates ...	193·5	154·0	?	—	79·6
English Criminals ...	191·4	150·3	?	—	78·5

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TABLE III.

*Table of Correlation Coefficients\*.*

Correlation Coefficient	Age 18, No. 129	Age 19, No. 330	Age 20, No. 209	Age 21, No. 137	Age 22, No. 95	General Average
Stature and Length of Leg ...	+·87 ± ·01	+·86 ± ·01	+·89 ± ·01	+·91 ± ·01	+·91 ± ·01	+·89
" and ratio of Leg to Stature	+·44 ± ·05	+·37 ± ·03	+·42 ± ·04	+·50 ± ·04	+·45 ± ·06	+·44
" and Length of Thigh ...	+·80 ± ·02	+·74 ± ·02	+·82 ± ·02	+·82 ± ·02	+·83 ± ·02	+·80
" and ratio of Thigh to Leg	+·31 ± ·05	+·08 ± ·04	+·16 ± ·05	-·06 ± ·06	+·06 ± ·07	+·11
" and Weight ...	+·50 ± ·04	+·63 ± ·02	+·68 ± ·03	+·76 ± ·02	+·72 ± ·03	+·66
" and Lung Capacity ...	+·44 ± ·05	+·65 ± ·02	+·55 ± ·03	+·64 ± ·03	+·59 ± ·04	+·57
" and Strength of Pull ...	+·01 ± ·06	+·25 ± ·03	+·22 ± ·04	+·27 ± ·05	+·28 ± ·06	+·21
" and Head Length <i>L</i> ...	+·22 ± ·06	+·31 ± ·03	+·35 ± ·04	+·36 ± ·05	+·33 ± ·06	+·31
" and Head Breadth <i>B</i> ...	+·05 ± ·06	+·17 ± ·04	+·19 ± ·05	+·10 ± ·06	+·17 ± ·07	+·14
" and Auricular Height <i>H</i> ...	+·09 ± ·06	+·28 ± ·03	+·31 ± ·04	+·32 ± ·05	+·42 ± ·06	+·28
" and Cranial Index <i>B/L</i> ...	-·06 ± ·06	-·10 ± ·04	-·15 ± ·05	-·23 ± ·05	-·10 ± ·07	-·13
" and Cranial Index <i>H/L</i> ...	+·01 ± ·06	+·05 ± ·04	+·03 ± ·05	+·02 ± ·06	+·21 ± ·07	+·06
Head Length and Sagittal Arc of Head	+·65 ± ·03	+·64 ± ·02	+·67 ± ·03	+·64 ± ·03	+·65 ± ·04	+·65
Head Length and Transverse Arc of Head	+·32 ± ·05	+·33 ± ·03	+·54 ± ·03	+·42 ± ·04	+·53 ± ·05	+·43
Head Length and Horizontal Circumference of Head	+·83 ± ·02	+·80 ± ·01	+·86 ± ·01	+·86 ± ·01	+·80 ± ·03	+·83
Strength of Pull and Weight ...	+·37 ± ·05	+·52 ± ·03	+·45 ± ·04	+·47 ± ·04	+·48 ± ·05	+·46
" and Lung Capacity	+·44 ± ·05	+·40 ± ·03	+·37 ± ·04	+·32 ± ·05	+·31 ± ·06	+·37
" and ratio of Leg to Stature	-·19 ± ·06	-·05 ± ·04	-·07 ± ·05	+·00 ± ·06	+·27 ± ·06	-·01
Ratio of Thigh to Leg and ratio of Leg to Stature	+·27 ± ·06	+·43 ± ·03	+·29 ± ·04	+·30 ± ·05	+·18 ± ·07	+·29
Lung Capacity and Weight ...	+·55 ± ·04	+·62 ± ·02	+·52 ± ·03	+·66 ± ·03	+·62 ± ·04	+·59

\* [The following results for 1000 Cambridge Undergraduates may be of interest for purposes of comparison. See Pearson, *R. Soc. Proc.* Vol. 66, p. 26, Dec. 1899, Macdonell, *Biometrika*, Vol. 1. pp. 188, 202.

Stature and Weight ...	+·49 ± ·02	Stature and Head Length ...	+·28 ± ·02
Stature and Pull ...	+·30 ± ·02	Stature and Head Breadth ...	+·15 ± ·02
Weight and Pull ...	+·56 ± ·02		
Stature and Head Index ...	-·08 ± ·02	3000 Criminals	
Weight and Head Index ...	+·01 ± ·02	Stature and Head Length ...	+·34 ± ·02
Pull and Head Index ...	+·04 ± ·02	Stature and Head Breadth ...	+·18 ± ·02

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