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ANTHROPOMETRIC LABORATORY.

NOTES AND MEMOIRS.

BY
FRANCIS GALTON F.R.S.

1890.

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CHAPTER I.

WHY DO WE MEASURE MANKIND?[1]

WHY should you, the reader, put yourself to the trouble of being measured, weighed, and otherwise tested? Why should I, the writer, and why should others, take the trouble of persuading you to go through the process? Are the objects to be gained sufficient to deserve this fuss? The reader may be supposed to say, "I do not care for science, and do not intend to go out of my way to advance it. The so-called scientific men may, and probably have, reasons satisfactory to themselves for asking me to go and be tested, but their motives do not influence me a jot. If anybody can show me that all this measuring will be useful to myself, I will undergo it with pleasure; otherwise not."

It is to this very cynical and not quite imaginary speaker that the first answer must be given. It will make it easier to do so satisfactorily if we confine ourselves to showing that there will be at least a fair proportion between his expenditure and what he will gain by it. So we must begin by showing what the cost of measurement is likely to be.

At the laboratory at Cambridge the charge of threepence per head suffices to defray the working expenses of a short but important series of tests, and of registering the results for future reference. But the use of the part of the room where the testing is carried on is given free of cost, the operator has other sources of remuneration, and the instruments were presented. At the International Health Exhibition the charge was the same, and fully defrayed the working expenses. Here also the necessary space and protection were gratuitously given and the instruments were lent. The little laboratory I have started and carry on, that is attached to the Western Gallery of the South Kensington Scientific Collection, hardly serves as a guide towards expense. There the measurements are

[1] Reprinted from *Lippincott's Magazine*, February, 1890.

at present gratuitous. I think we may say, roundly, that a laboratory that was much and regularly frequented could be wholly and well maintained by a charge of a shilling per head. Accepting this as a basis to reason from, the question that the cynical reader is supposed to have asked may be changed into this:

"Is it worth while for myself, or for my boys and girls, to pay a shilling, a sixpence, or other small sum, in order to be measured and tested in many ways, to have the results registered for future reference, and their meaning explained?" I do not say anything about the trouble of going to the laboratory, because there may be an equivalent for it in the instruction to be found in the books and diagrams that are kept there, and in the amusement of seeing the process. I have always noticed that people seem much interested in looking on.

First, as regards boys and girls, in what way would the measurements be worth the expenditure on them? The answer is briefly this: They will show how the boy or girl ranks among other children of the same sex, age, and of similar social position, in respect to physical efficiency in various specified respects, which are able to give a fair indication of physical efficiency generally. A comparison of the measures made from time to time will show whether the child maintains his former rank, or whether he is gaining or losing it. It must be confessed that at the present moment the necessary tables for giving this information are very imperfect. They exist as yet only for some faculties, ages, and broad subdivisions of social position. But there is nothing to hinder the indefinite extension of tables of this kind. Their construction is steadily going on. Before long, the required information may be given with perfect distinctness for many measurable qualities.

As an example of what can easily be done, let us consider the measurement of eyesight. Its degree of keenness, in persons whose power of accommodating the focal length is normal, is most easily ascertained by noting the greatest distance at which printed numerals of a specified size can be freely read. Measurement would give an indication of the eyesight becoming less good, long before the child would find it out for himself, or before its impairment could attract the observation of others. It is frightful to think of the frequent mischief to eyesight that has been caused by the neglect at schools of the most elementary requisites to protect it from unnecessary strain, such as an abundance of light coming from the proper direction, and desks and chairs so shaped as to discourage a lolling or sidelong attitude, by supporting the book or paper squarely before the reader. The stupid want of care in providing these essentials to eye-comfort has gone far towards converting the educated classes of Germany and the cultured girls of England into short-sighted sections of society. When measurement shows that the sight is beginning to be slightly impaired, there is probably time to hunt out and abolish the cause of mischief before serious harm is done, and an occasional small fee would be little grudged by most persons to insure so timely a warning of danger.

The unobserved existence of colour-blindness is another possibility well worth being inquired into at an early age, as it materially limits the choice of occupation. It is curious how late it may be in life before this remarkable defect is found out either by the person or his friends; and, as it affects about one male in twenty-five, the risk of being subject to it is considerable. I have myself witnessed painful scenes at my own laboratory when the discovery was first made by grown-up persons who came there for general measurement. One case occurs vividly to me as I write, which will serve as an example of what might often happen. A young widow brought her only son, a youth of about eighteen, to the laboratory. When he was put to the colour test he blundered hopelessly among the reds and greens. I privately drew his mother's attention to his indecision and blunders, while he was in the midst of them, but she could not or would not believe that he really had not the power of distinguishing colours. At first she thought he was joking, then she expressed her vexation at his silliness, and at last grew quite angry with the lad. Poor boy! It was easy to realize from that brief experience all the accusations of stupidity and of negligence and all the humiliations that must be endured by every colour-blind person, until the true cause of his failures is ascertained to be due neither to stupidity nor to negligence, but to a natural incapacity in a single particular. Not a few persons have entered upon their occupations without the least conception that this irremediable defect must cause them to fail. In some pursuits colour-blindness is no hindrance to success: in others it is an absolute bar. Therefore before preparing plans for a start in life the efficiency of the colour sense ought to be tested.

The rest of my remarks will refer to adults as wells as to youths, though after adult life has been reached the value of yearly measurement decreases. Perhaps the best general test of bodily efficiency is the breathing capacity, taken not by itself, but with reference either to the stature or the weight. Lungs that are amply large enough for a small man would be wholly inefficient for a large one, as the tables of averages and of "rank" show very distinctly. The next test in importance is that of strength, and preferably the strength of grip. It serves as a fair sample of the general strength, and it can be measured very easily and accurately, without any risk of bodily strain. Like the breathing capacity, the strength also has to be considered in reference to the stature. The possession of a considerable amount of breathing capacity and of muscular strength is an important element of success in an active life, and the rank that a youth holds among his fellows in these respects is a valuable guide to the selection of the occupation for which he is naturally fitted, whether it should be an active or a sedentary one. As life proceeds, the strength declines somewhat, and the breathing capacity fication. I now always cause the thumb-prints to be taken at my laboratory, partly for that reason, and partly because they bear, to myself, a present interest of their own, that lies wholly outside the subject we are talking about, and of which I hope before long to give some account.

The stage at which we have thus far arrived is that a man who occasionally takes a child, or who goes for his own sake, to a well-equipped laboratory where numerous measurements are made, where their meaning is explained and the results are preserved, will obtain what is worth much more to himself than the small fee which is sufficient to defray the cost of the process.

Now let us endeavour to justify those who, like the writer of these remarks, are taking much trouble to persuade persons to be measured and afterwards to discuss the results. Is it more than a harmless hobby on their part, or have they substantial reasons for what they do? My reply is that these measurements afford apparently the only way of obtaining information upon a variety of important topics on which we are at present in deplorable ignorance.

For example, we have no knowledge of the degree in which the promises of youth are fulfilled in after-life. How far may the vigour, strength, keenness of senses, and efficiency in other respects at the various ages of childhood and boyhood be accepted as true indications of the future efficiency of the man? The answer to this question has a direct bearing on the value of examinations at different ages as a means of selecting capable candidates for employment. To the best of my knowledge, this problem has never been adequately discussed, mainly, I presume, owing to the want of a sufficient collection of trustworthy data. It is a question that admits of a perfectly precise and complete answer, as those who are familiar with the modern developments of statistical analysis are well able to appreciate.

Another problem is to ascertain with precision the influences of special education as distinguished from natural capacity. Suppose there are two youths who have been reared in a similar and ordinary way, and who are alike in their physical performances, but that one of them afterwards becomes an artizan in a trade that greatly exercises some particular set of muscles, while there is nothing peculiar in the occupation followed by the other. The years go by, and the performances of the same persons are again compared. What is the difference between them now, in respect to the set of muscles in question? By taking many such pairs, the entire history of the effects of that sort of education ought to be clearly made out. We should learn and be able to express in a very compendious way, the frequency with which education produces each of the various gradations of effect. We should, for example, know in what proportion of cases the strength of those muscles is materially reduced. It is well that a man should have the advantage which occasional measurement affords, to be warned of any premature decay in his powers. If it should take place, and if it is due to mere indolence and disuse, he may exert himself with advantage before it is too late. A register of measures resembles a well-kept account-book. It shows from time to time the exact state of a man's powers, as the account-book shows that of his fortune.

Whatever may be whispered by the inner voices of vanity or of envy, no sane and experienced person can doubt the enormous difference between the natural gifts of different men, whether in moral power, in taste, in intellect, or in physical endowments. Those who have frequently pitted themselves fairly against others, doing their very best to succeed, must have often known what it is to be utterly beaten by their natural superiors. It is only those who have kept aloof from contest who can possibly flatter themselves with the belief that their failures are wholly due to circumstance and in no degree to natural incapacity. Such persons will quickly be awakened from their self-conceit by submitting themselves to physical measurement and thereby ascertaining their exact rank among others in each several respect. They will be pretty sure to receive a good moral lesson from the results.

Employers of labour might often find it helpful to require a list of laboratory measurements when selecting between many candidates who otherwise seem to be equal in merit. Certainly a man who was thereby shown to be measurably much more highly endowed than the generality of his class with physical efficiency, would have a corresponding chance of being selected for any post in which physical efficiency of the kind tested was of advantage. I have great hope of seeing a system of moderate marks for physical efficiency introduced into the competitive examinations of candidates for the Army, Navy, and Indian Civil Services. (*See* Chapter III.)

In this brief notice I will allude to only one other advantage in going to a laboratory—namely, the help that the registration of the measures might hereafter give to identification. Rogues had better avoid such places, but respectable people who may possibly at some future time desire to have their identity proved, or at least their presumed identity with some other undesirable personage disproved, might reasonably go to a laboratory to secure the necessary evidence. Differences that hardly strike the eye or are retained in the memory, whether of the breadth or of the length of the head, or of the cubit, or of the length of foot, and so forth, exceed the greatest errors of measurement that need be feared, added to the utmost change of which the human body is capable between the ages of twenty-one and sixty. They are relied upon as guides to identification in the criminal administration of France, according to the method of M. Alphonse Bertillon. The prints of the thumbs or fingers also afford a singularly exact means of identiwas increased by a quarter, by a half, or in any other ratio. No measurements of persons engaged in different occupations, without a knowledge of their previous history can tell us this. It would be absurd to compare the strength of the arms of blacksmiths with that of the arms of tailors, for the very obvious reason that strong men rarely become tailors, or weak men blacksmiths. The results of such comparisons as these would confuse natural gifts with acquired ones, and would probably be more influenced by the former than by the latter.

It would be most instructive to analyze the measures after a sufficient number had accumulated, in order to find out the rate at which the education of a muscle or a faculty proceeds. At a gymnasium the hitherto imperfectly exercised muscles of new-comers become rapidly strengthened, but the rate of their daily improvement steadily lessens, and at last it stands still. Then the limit of perfectibility has been reached. Experiences of this kind on a large enough scale to give trustworthy results would have a direct bearing on the science of education.

The effect of environment is another obvious line of investigation. As we should have *precise measures* to deal with, we might fairly hope to obtain *precise* results. This, in the most general sense and in the briefest form, is the true justification of those who spend their time in measuring mankind.

The educational effect of a habit of human measurement may be of much value in promoting accuracy of ideas and language. The present vague way in which men mostly estimate and describe the performances of themselves or others, testifies to much muddleheadedness and to a sad lack of power of expression. There is no measure in their epithets; their phraseology readily flies off into hyperbole; superlatives abound but precision is wanting. The generality of mankind would be astonished to learn first, that it is possible to apply a precise measure to the general performance of a man, although his performances vary in value from time to time, and secondly that a measure of his most successful performance is of very little importance. They never dream of using the simple scientific expression, say in reference to a marksman, that such a *proportion* of his shots, at such and such a range, lie within such and such a distance either to the right or to the left of the bull's-eye. They have no conception of *the completeness* with which a brief statement like that defines the varying accuracy of his aim; how it enables us to foretell the distance within which one-quarter of his shots, one-half, or any other specified proportion of them, will fall. There is a world of interest hidden from the minds of the great majority of educated men, to whom the conceptions and laws of the higher statistics are unknown. A familiarity with these conceptions would soon be gained by the habit of dealing with human measurements, as by the assignment of rank in a class, or by making other deductions that I have not space to refer to here, such as the numerical values by which the nearness of different degrees of kinship may be expressed, or the closeness of correlation between different parts of the body. There is no intrinsic difficulty in grasping the conceptions of which I speak, but they are foreign to present usage, and look strange at first sight. They are, consequently very difficult to express briefly and intelligibly to those to whom they are are wholly new.

It is reasonable to expect that if intelligent interest should be taken by many persons in the methods of human measurement, the number of the faculties that we shall be able to deal with, will steadily increase. It is only a few months since the ingenuity of one of the masters at Eton College devised a test of muscular endurance. It is made with an *ordinary grip dynamometer, that measures the strength of squeeze* or grasp. The utmost strength of squeeze is first noted; then a second trial is made to test the length of time during which the experimentee can maintain his previous grip, so far as not to permit the index hand of the instrument to fall back more than ten pounds below its previous maximum. This precise limit of ten pounds is of small importance, as when the muscles fail they give way rapidly. Experience has not yet adequately confirmed the value of this simple and novel measure of an important quality. It is alluded to merely as an example of one of the steps by which the art of human measurement may become indefinitely extended.

CHAPTER II.

HUMAN VARIETY.[1]

It would have been a pleasure to me in this address, given at the conclusion of my office as your President, to have cast a retrospect over the proceedings of our Institute during the four years that I have had the honour to hold it. But the subjects that have come before us are so varied that it seemed difficult to briefly summarize them in a manner that should not be too desultory.

On the whole, I thought it might be more useful if I kept to a branch of anthropometry with which many inquiries have made me familiar, and took the opportunity of urging certain views that seem to be worthy the attention of anthropologists.

Before entering upon these more solid topics, let me mention that my laboratory at South Kensington has been in work during the past year, and that about 1,200 persons have been already measured at it in many ways, some more than once. I lay on the table a duplicate of one of the forms of application to be measured, and of one of the filled-up schedules. It will be observed that I now have the impressions made in printer's ink of the two thumbs of each person who is measured, being desirous of investigating at leisure the possibilities of employing that method for the purpose of identification, not forgetting the success that attended Sir W. Herschel's use of it in India, but conscious at the same time of practical difficulties. There is no doubt that the thumb or finger marks vary so much that a glance suffices to distinguish half a dozen varieties, while a minute investigation shows an extraordinary difference in small, though perfectly distinct, peculiarities. Neither is there any room for doubt that these peculiarities are persistent throughout life; nor, again, that so satisfactory a method of raising a very strong presumption of identity would be valuable in many cases. It will suffice to quote the following. A newspaper was lately sent me from the distant British settlement of North Borneo, where, owing to the wide and rapid spread of information nowadays, attention had been drawn to an account of a lecture I gave on one of the Friday evenings last spring, at the Royal Institution. It was on "Personal Description and Identification," and a writer in the *British North Borneo Herald* commented upon the remarks there made on finger imprints. He spoke of the great difficulty of identifying coolies either by their photographs or measurements, and that the question how this could best be done would probably become

[1] Presidential Address delivered at the anniversary meeting of the Anthropological Institute, on Tuesday, Jan. 22, 1889.

important in the early future of that country. I also am assured that the difficulty of identifying pensioners and annuitants has led to frequent fraud from personation, involving in the aggregate a very large sum of money annually, as there is good reason to believe. If finger imprints could be practically brought into use, such frauds would be extremely difficult. The plan adopted at the laboratory of making them is as follows: A copper plate is smoothly covered with a very thin layer of printers' ink, a printers' roller being used, and the plate being cleaned every day. When the layer is thin, no ink penetrates into the delicate furrows of the skin, but the ridges only are inked, and these leave their impression when the inked thumb is pressed on paper. In this way a permanent mark is registered. A little turpentine cleans the fingers effectually afterwards. But for purposes of identification a simple process is necessary, one by which a person suspected of personation could furnish an imprint for comparison with the registered mark without having recourse to the troublesome paraphernalia of the printer. I am still unable to speak positively as to the best way of making these, but good impressions are easily made by slightly smoking a piece of smooth metal or glass over the candle, pressing the finger on it, and then making the imprint on a bit of gummed paper that is slightly damped. The impression is sufficiently durable for the purpose. The iron used for the ironing of clothes is excellent for condensing the smoke; even a smooth penny will serve the purpose. As for the gummed paper, luggage labels can be used; or the fringe to sheets of postage stamps, which is broad enough to include as much of the impression as is especially wanted—namely, where the whorl of ridges takes its origin.

I hope at some future time to recur to this subject.

Correlation.—The measurements made at the laboratory have already afforded data for determining the general form of the relation that connects the measures of the different bodily parts of the same person. We know in a general way that a long arm or a long foot implies on the whole a tall stature—*ex pede Herculem*; and conversely that a tall stature implies a long foot. But the question was as to whether that reciprocal relation, or correlation as it is commonly called, admitted of being precisely expressed. Correlation is a very wide subject indeed. It exists wherever the variations of two objects are in part due to common causes; but on this occasion I must only speak of such correlations as have an anthropological interest. The particular problem I first had in view was to ascertain the practical limitations of the ingenious method of anthropometric identification due to M. Alphonse Bertillon, and now in habitual use in the criminal administration of France. As the lengths of the various limbs in the same person are to some degree related together, it was of interest to ascertain the extent to which they still admit of being treated as independent. The first results of the inquiry, which is not yet completed, have been to myself a grateful surprise. Not only did it turn out that the expression and the measure of correlation between any two variables are exceedingly simple and definite, but it became evident almost from the first that I had unconciously explored the very same ground before. No sooner had I begun to tabulate the data than I saw that they ran in just the same form as those that referred to family likeness in stature, and which were submitted to you two years ago. A very little reflection made it clear that family likeness was nothing more than a particular case of the wide subject of correlation, and that the whole of the reasoning already bestowed upon the special case of family likeness was equally applicable to correlation in its most general aspect.

It may be recollected that family likeness in any given degree of kinship—say that between father and son—was expressed by the fact that any peculiarity in the father appears in the son, reduced on the average to just one-third of its amount. Conversely, however paradoxical it might at first sight appear, any peculiarity in a son appears in the father, also reduced on the average to one-third of its amount. The regression, as I called it, from the stature of the known father to the average son, or from the known son to the average father, was here from 1 to $\frac{1}{3}$; from the known brother to the unknown brother it was $\frac{2}{3}$; from uncle to nephew, or from nephew to uncle, it was $\frac{2}{9}$; and in kinship so distant as to have insensible influence, it was from 1 to 0. Whether the peculiarity was large or small, these ratios remained unaltered. The reason of all this has been thoroughly explained,[1] and need not be repeated here. Now the relation of head-length to head-breadth, whose variations are on much the same scale, is of the same kind as the above. They are akin to each other in the same sense as kinsmen are. So it would be in the closer relation between the lengths of the corresponding limbs, as left arm to right arm, left leg to right leg. The regression would be strictly reciprocal in these cases. When, however, we compare limbs whose variations are on different scales, their differences of scale have to be allowed for before the regression can assume a reciprocal form. The plan of making the requisite allowance is perfectly simple, but I cannot explain it without using technical terms. In some cases this allowance is large; thus the length of the middle finger varies at so very different a rate from that of the stature that 1 inch of difference of middle-finger length is associated on the average with 8·4 inches of stature. On the other hand, 10 inches of stature is associated on the average with 0·6 inch of middle-finger length. There is no reciprocity in these numerals; yet, for all that, when the scale of their respective variabilities is taken into account as abovementioned, the values at once become strictly reciprocal.

In every pair of correlated variables the conditions that were shown to characterize kinship will necessarily be present—namely, that any given variation in one of the pair is on the average associated with a proportionate variation in the other, the proportion being the same whatever may

[1] See *Natural Inheritance*, by F. Galton, Macmillan & Co., 1889.

be the amount of the variation. Again, when allowance is made for their respective scales of variability, the proportion is strictly reciprocal, and it is always from 1 to something less than 1. In other words, there is always regression.

Variety.—The principal topic of my further remarks will be the claims of variety to more consideration from anthropologists than it has hitherto received. They commonly devote their inquiries to the mean values of different groups, while the variety of the individuals who constitute those groups is too often passed over with contented neglect. It seems to be a great loss of opportunity when, after observations have been laboriously collected, and been subsequently discussed in order to obtain mean values from them, that the small amount of extra trouble is not taken, which would determine other values whereby to express the variety of all the individuals in those groups. Much experience some years back, and much new experience during the past year, has proved to me the ease with which variety may be adequately expressed, and the high importance of taking it into account. There are numerous problems of especial interest to anthropologists that deal solely with variety.

There can be little doubt that most persons fail to have an adequate conception of the orderliness of variability, and think it useless to pay scientific attention to variety, as being, in their view, a subject wholly beyond the powers of definition. They forget that what is confessedly undefined in the individual may be definite in the group, and that uncertainty as regards the one is in no way incompatible with statistical assurance as regards the other. Almost everybody is familiar nowadays with the constancy of the average in different samples of the same large group, but they do not often realize the completeness with which a similar statistical constancy permeates the whole of the group. The Mean or the Average is practically nothing more than the middlemost value in a marshaled series. A constancy analogous to that of the Mean characterizes the values that occupy any other fractional position that we please to name, such as the 10th per cent.; or the 20th per cent.; it is not peculiar to the 50th per cent., or middlemost. Still less do they realize the fact that all Variety has a strong family likeness, by approximating more or less closely to the normal type, which is that which mathematicians prove must be the consequence of Variety being due to the aggregate effect of a very large number of small and independent influences.

Greater interest is attached to individuals who occupy positions towards either of the ends of a marshaled series, than to those who stand about its middle. An average man is morally and intellectually an uninteresting being. The class to which he belongs is bulky, and no doubt serves to keep the course of social life in action. It also affords, by its inertia, a regulator that, like the fly-wheel to the steam-engine, resists sudden and irregular changes. But the average man is of no direct help towards evolution, which appears to our dim vision to be the goal of all living existence. Evolution is an unresting progression; the nature of the average individual is essentially unprogressive. Consider the interest attached to the Hebrew race, whose average value is little worthy of note, but which is of especial importance on account of its variety. Its variability in ancient and modern times seems to have been extraordinarily great. It has been able to supply men, time after time, who have towered high above their fellows, and left enduring marks on the history of the world.

Some thoroughgoing democrats may look with complacency on a mob of mediocrities, but to most other persons they are the reverse of attractive. The absence of heroic gifts among them would be a heavy set-off against the freedom from a corresponding number of very degraded forms. The general standard of thought and morals in a mob of mediocrities must necessarily be mediocre, and, what is worse, contentedly so. The lack of living men to afford lofty examples, and to educate the virtue of reverence, leaves an irremediable blank. All men would find themselves at nearly the same dead average level, each being as meanly endowed as his neighbour.

These remarks apply with obvious modifications to variety in the physical faculties. Peculiar gifts, moreover, afford an especial justification for division of labour, each man doing that which he can do best.

The Measurement of Variety.—The method I have myself usually adopted for expressing and dealing with the variety of the individuals in a group, has been already explained on more than one occasion. I should not have again alluded to it had I not had much occasion of late to test and develop it, also to devise an unpretentious little table of figures that I call a "table of normal distribution," which has been of singular assistance to myself. I trust it may be equally useful to other anthropologists. It is appended to these remarks, and I should like after a short necessary preface to say something about it. The table and its origin, and several uses to which it has been applied, will be found in *Natural Inheritance*. All the data to which I shall refer will be found in that book also, except such as concern correlation. These are contained in a memoir read by me before the Royal Society (*Proc. Roy. Soc.* Vol. xlv. p. 135), in which I regret to say I have since found an undue number of numerical *errata*.

It has already been said that the first step in the problem of expressing variety among the individual members of any sample, is to marshal their measures in order, into a class. We begin with the smallest measure and end with the greatest. The object of the next step is to free ourselves from the embarrassment due to the different numbers of individuals in different classes. This is effected by dividing the class, whatever its size may be, into 100 equal portions, calling the lines that divide the portions by the name of grades. The first of these portions will therefore lie between grades 0° and 1°, and the hundredth and last portion between grades 99°

and 100°. We have next to find by interpolation the values that correspond to as many of these grades as we care to deal with. It is of no consequence whether or no the number in the class is evenly divisible by 100, because we can interpolate and get the values we want, all the same. This having been done, the value that corresponds with the 50th grade will be the middlemost. It is practically the same for ordinary purposes as the Mean value or the Average value; but as it may not be strictly the same it is right to call it by a distinctive name, and none simpler or more convenient occurs than the letter M. So I will henceforth use *M to* denote the middlemost or median value, or, in other words, that which corresponds to the 50th (centesimal) grade.

The difference between the extreme ends of a marshaled series is no proper measure of the variety of the individuals who compose it. However few in number the objects in the series may be, it is always possible that a giant or a dwarf, so to speak, may be among them. The presence of either would mislead as to the range of variety likely to be found in another series or sample taken from the same large group. The values in a marshaled series run with regularity only about its broad and middle part; they never do so near to either of its extremities. In a series that consists of a few hundreds of individuals, the regularity usually begins at about grade 5°, and continues up to about grade 95°. Therefore it is out of this middle part, between 5° and 95°, or better, out of a still more central portion of it, that points should be adopted between which variety may be measured. Such points are conveniently found at the 25th and the 75th grades. Just as the grade 50° divides the class into two equal parts, so the grades 25° and 75° subdivide it into quarters, and the difference between those values affords an irreproachable basis for the unit of variety. The most convenient unit is *half* the value of that difference, partly because the value at 25° tends to be just as much below that at 50°, as the value at 75° is above it. Briefly, if we distinguish the measure at 25° by the letter Q_1, and that at 75° by Q_3, then the unit of variety is $\frac{1}{2}(Q_3 - Q_1)$, and this unit we will henceforth call Q. As M measures the average, so Q measures the variety, and they are independent of one another. In the case of Strength, for example, the relation of Q to M in the particular group of adult males on which I worked was as 1 to 10; in the statures of the same group it was as 1 to 40; in breathing capacity as 1 to 9; in weight as 1 to 14.

The arithmetic Mean or Average is a muddle of all the values in the series, it conveys by no means so clear an idea as the middlemost value M. Therefore, although the peculiarities of an individual are commonly considered in the light of deviations from the average value, I prefer to reckon them as deviations from M. Practically the two methods are identical, but I find the latter more convenient to work with, and believe it to be the better of the two in every way.

Deviation is identical with variation, and the well-known law of frequency of error gives data whence the *relative* values of the deviations at the several grades may be calculated for any normal series. If we know the deviation at any one grade, then the *absolute* value of those at every other grade can be calculated; consequently the variety of the whole series is thereby expressed.

Use of the Table of Distribution.—The small table of distribution, of which I spoke, and which is printed at the end of these remarks gives the normal deviation at each grade when Q is equal to 1. Then the value at 25° is − 1, and that at 75° is + 1. If we desire to determine Q in any given series, the only required datum is the deviation at some one known grade, since, by dividing that deviation by the tabular value, we get Q at once. Or conversely, if we know the Q of the series, and wish to calculate the deviation at any given grade, we multiply Q by the tabular deviation. Thus, in stature, which varies in an approximately normal manner, the value of Q is about 1·7 inch, therefore to find the deviation in stature at any grade, we multiply 1·7 inch by the tabular value.

If we know the *measures* at any two grades, of a normal series, we are easily able to calculate both Q and M, and can thence derive the measures of any other desired grades. I have long since pointed out the possibility of a traveller availing himself of this method; but, for the want of a table of distribution, the calculation would probably puzzle him.

With the aid of this table the calculation is made most readily. Let us suppose that the traveller is among savages who use the bow, and that he desires to learn as much as he can about their strengths. He selects two bows; the one somewhat easy to draw, and the other somewhat difficult, and at leisure, either before or after the experiment, he ascertains exactly how many pounds weight they severally require to draw them to the full. Then by exciting emulation, and by offering small prizes, he induces a great many of the natives to try their strengths upon them. He notes how many make the attempt, and how many of them fail in either test. This is all the observation requisite, though common-sense would suggest the use of three and not two bows, in order that the data from the third bow might correct or confirm the results derived from the other two. Let us work out a case, not an imaginary one, but derived from tables I have already published, and of which I will speak directly. Let the problem be as follows:—

30 per cent. of the men failed to exert a pulling strength 68 pounds; 60 per cent. failed to pull 77 pounds. What is the Q and the M of the group?

Consider this 30 per cent. to be the exact equivalent of grade 30°, and the 60 per cent. of grade 60°. The reason why the percentage of failure, and the number of the grade are always equivalent, will be found in a foot-note to the table and I need not stop to speak of it. Now, the Tabular value at grade 30° is − 0·78; that at 60° is + 0·38; the difference between them being 1·16. On the other hand, the difference between the two test values of 68 pounds and 77 pounds is 9 pounds. Therefore Q is equal to existence. Evolution is an unresting progression; the nature of the average individual is essentially unprogressive. Consider the interest attached to the Hebrew race, whose average value is little worthy of note, but which is of especial importance on account of its variety. Its variability in ancient and modern times seems to have been extraordinarily great. It has been able to supply men, time after time, who have towered high above their fellows, and left enduring marks on the history of the world.

Some thoroughgoing democrats may look with complacency on a mob of mediocrities, but to most other persons they are the reverse of attractive. The absence of heroic gifts among them would be a heavy set-off against the freedom from a corresponding number of very degraded forms. The general standard of thought and morals in a mob of mediocrities must necessarily be mediocre, and, what is worse, contentedly so. The lack of living men to afford lofty examples, and to educate the virtue of reverence, leaves an irremediable blank. All men would find themselves at nearly the same dead average level, each being as meanly endowed as his neighbour.

These remarks apply with obvious modifications to variety in the physical faculties. Peculiar gifts, moreover, afford an especial justification for division of labour, each man doing that which he can do best.

The Measurement of Variety.—The method I have myself usually adopted for expressing and dealing with the variety of the individuals in a group, has been already explained on more than one occasion. I should not have again alluded to it had I not had much occasion of late to test and develop it, also to devise an unpretentious little table of figures that I call a "table of normal distribution," which has been of singular assistance to myself. I trust it may be equally useful to other anthropologists. It is appended to these remarks, and I should like after a short necessary preface to say something about it. The table and its origin, and several uses to which it has been applied, will be found in *Natural Inheritance*. All the data to which I shall refer will be found in that book also, except such as concern correlation. These are contained in a memoir read by me before the Royal Society (*Proc. Roy. Soc.* Vol. xlv. p. 135), in which I regret to say I have since found an undue number of numerical *errata*.

It has already been said that the first step in the problem of expressing variety among the individual members of any sample, is to marshal their measures in order, into a class. We begin with the smallest measure and end with the greatest. The object of the next step is to free ourselves from the embarrassment due to the different numbers of individuals in different classes. This is effected by dividing the class, whatever its size may be, into 100 equal portions, calling the lines that divide the portions by the name of grades. The first of these portions will therefore lie between grades 0° and 1°, and the hundredth and last portion between grades 99°

and 100°. We have next to find by interpolation the values that correspond to as many of these grades as we care to deal with. It is of no consequence whether or no the number in the class is evenly divisible by 100, because we can interpolate and get the values we want, all the same. This having been done, the value that corresponds with the 50th grade will be the middlemost. It is practically the same for ordinary purposes as the Mean value or the Average value; but as it may not be strictly the same it is right to call it by a distinctive name, and none simpler or more convenient occurs than the letter M. So I will henceforth use M to denote the middlemost or median value, or, in other words, that which corresponds to the 50th (centesimal) grade.

The difference between the extreme ends of a marshaled series is no proper measure of the variety of the individuals who compose it. However few in number the objects in the series may be, it is always possible that a giant or a dwarf, so to speak, may be among them. The presence of either would mislead as to the range of variety likely to be found in another series or sample taken from the same large group. The values in a marshaled series run with regularity only about its broad and middle part; they never do so near to either of its extremities. In a series that consists of a few hundreds of individuals, the regularity usually begins at about grade 5°, and continues up to about grade 95°. Therefore it is out of this middle part, between 5° and 95°, or better, out of a still more central portion of it, that points should be adopted between which variety may be measured. Such points are conveniently found at the 25th and the 75th grades. Just as the grade 50° divides the class into two equal parts, so the grades 25° and 75° subdivide it into quarters, and the difference between those values affords an irreproachable basis for the unit of variety. The most convenient unit is *half* the value of that difference, partly because the value at 25° tends to be just as much below that at 50°, as the value at 75° is above it. Briefly, if we distinguish the measure at 25° by the letter Q_1, and that at 75° by Q_3, then the unit of variety is $\frac{1}{2}(Q_3 - Q_1)$, and this unit we will henceforth call Q. As M measures the average, so Q measures the variety, and they are independent of one another. In the case of Strength, for example, the relation of Q to M in the particular group of adult males on which I worked was as 1 to 10; in the statures of the same group it was as 1 to 40; in breathing capacity as 1 to 9; in weight as 1 to 14.

The arithmetic Mean or Average is a muddle of all the values in the series, it conveys by no means so clear an idea as the middlemost value M. Therefore, although the peculiarities of an individual are commonly considered in the light of deviations from the average value, I prefer to reckon them as deviations from M. Practically the two methods are identical, but I find the latter more convenient to work with, and believe it to be the better of the two in every way.

Deviation is identical with variation, and the well-known law of frequency of error gives data whence the *relative* values of the deviations at the several grades may be calculated for any normal series. If we know the deviation at any one grade, then the *absolute* value of those at every other grade can be calculated; consequently the variety of the whole series is thereby expressed.

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9 pounds divided by 1·16; that is, to 7·8 pounds. M may be obtained by either of two ways, which will always give the same answer. We may subtract 0·38 × 7·8 pounds from 77 pounds, or we may add 0·78 × 7·8 pounds to 68 pounds. Each gives 74 pounds. Observation gave precisely these values both for Q and for M.

Table of Percentiles.—The data have been published as a table of "percentiles," and are reprinted at the end of these remarks. They were derived from measures made at the International Health Exhibition.

The value of M is given directly in the table, but that of Q happens not to be given there; it may easily be found by interpolation. That table affords excellent material for experimental calculations on the principle of this test, and for estimating its trustworthiness in practice. It contains a variety of measures referring to eighteen different series, all corresponding to the same grades—namely, to 5°, 10°, 20° and onwards for every tenth grade up to 90° and ending with 95°. The measures refer to stature, height sitting above seat of chair, span, weight, breathing-capacity, strength of pull, strength of squeeze, swiftness of blow, keenness of eyesight, in each case of adult males and of adult females separately.

I have since found when the deviations are all reduced in terms of their respective Q values, that by dividing each of them by its Q, the average value of all the deviations at each of the grades in the eighteen series closely corresponds to the normal series, though individually they differ more or less from it, some in one way some in another. On the whole, the error of treating an unknown series as if it were a normal one can rarely be very large, always supposing that we do not meddle with grades lower than 5° or higher than 95°

It will be of interest to put the comparison on record. It is as follows:—

Grades	5°	10°	20°	30°	40°	50°
Observed	−2·44	−1·87	−1·24	−0·77	−0·40	0
Normal −below 50° +above 50° ...	2·44	1·90	1·25	0·78	0·38	0
Observed	+2·47	+1·92	+1·21	+0·75	+0·38	0
Grades	95°	90°	80°	70°	60°	50°

The "observed" are the mean values, made as above described, of the eighteen series; the "normal" are taken from the table of distribution given further on.

An ingenious traveller might obtain a great number of approximate and interesting data by the method just described, measuring various faculties of the natives, such as their delicacy of eyesight and hearing, their swiftness in running, their accuracy of aim with spear, arrow, boomerang, sling, gun, and so forth, either laterally or else vertically, distance of throw, stature, and much else. But he should certainly use three test objects as a check upon his conclusions, and not two only.

Measure of Precision.—The use of Q is by no means limited to the objects just named. It is a necessary datum wherever the law of frequency of error has to be applied, and the properties of this law are applicable to a very large number of anthropological problems, with more accuracy of result than might have been anticipated when the series are only approximatively normal. One great use of Q is to enable us to estimate the trustworthiness of our average results. We require to know both Q and the number of observations, before we can estimate the degree of dependence to be placed on M. If there was only one observation, then the degree of dependence would be equal to Q ; in other words, the error of M would be just as likely as not to exceed Q. If there were two, two hundred, two thousand, or any other number of observations, the error of M would then be reduced, but not in simple proportion. It would be as likely as not to exceed a value equal to Q divided by the square roots of those numbers. When we desire to ascertain the trustworthiness of the difference between the M values of two series, as between the Mean statures of the professional and artizan class as derived from certain observations, the properties of the law of frequency of error must again be appealed to. Anthropologists are much engaged in studying such differences as these ; but from their disregard of the simple datum Q, and from not being familiar with its employment, there is usually a lamentable and quite unnecessary vagueness in the value to be attached to their results. This is especially the case in comparisons between the average dimensions of the skulls of various races, which often depend upon the measurement of only a few specimens. An almost solitary exception to this needless laxity will be found in a brief but admirably-expressed memoir by Dr. Venn, the well-known author of the *Logic of Chance.* It is upon Cambridge anthropometry, and was published in the last number of the Journal of the Anthropological Institute. It deserves to be a model to those who are engaged in similar inquiries.

Conclusion.—Enough has now been said to justify the claims with which I started, and which take this final form. First, wherever it is likely to be of use, that, in series of which the M is calculated, the measures at a certain number of selected grades should also be calculated and given, sufficient to enable the rest of the series to be found with adequate accuracy by interpolation. Secondly, that the value of Q should always be given, as well as that for M, for two reasons. The one is, that they suffice between them to give an approximate determination of the whole series, more closely approximate as the series is more closely of the normal type; and, secondly, because Q is an essential datum before any application can be made of the law of frequency of error. The properties of this law are, as we have seen, largely available in anthropological inquiry. They enable us to define the trustworthiness of our results, and to deal with such interesting problems as those of correlation and family resemblance, which cannot be solved without its help. Anthropologists seem to have little idea of the wide fields of inquiry open to them as soon as they are prepared to deal with individual variety and cease to narrow their view to the consideration of the Average.

APPENDIX

TABLE I

Table of Ordinates to normal curve of distribution, in which the unit = the probable error, and the grades, which are the abscissæ, run from 0° to 100°.

Grades	0	1	2	3	4	5	6	7	8	9
0	∞	−3·45	−3·05	−2·79	−2·60	−2·44	−2·31	−2·19	−2·08	−1·99
10	−1·90	−1·82	−1·74	−1·67	−1·60	−1·54	−1·47	−1·42	−1·36	−1·30
20	−1·25	−1·20	−1·15	−1·10	−1·05	−1·00	−0·95	−0·91	−0·86	−0·82
30	−0·78	−0·74	−0·69	−0·65	−0·61	−0·57	−0·53	−0·49	−0·45	−0·41
40	−0·38	−0·34	−0·30	−0·26	−0·22	−0·19	−0·15	−0·11	−0·07	−0·04
50	0·00	+0·04	+0·07	+0·11	+0·15	+0·19	+0·22	+0·26	+0·30	+0·34
60	+0·38	+0·41	+0·45	+0·49	+0·53	+0·57	+0·61	+0·65	+0·69	+0·74
70	+0·78	+0·82	+0·86	+0·91	+0·95	+1·00	+1·05	+1·10	+1·15	+1·20
80	+1·25	+1·30	+1·36	+1·42	+1·47	+1·54	+1·60	+1·67	+1·74	+1·82
90	+1·90	+1·99	+2·08	+2·19	+2·31	+2·44	+2·60	+2·79	+3·05	+3·45
	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
99	+3·45	+3·52	+3·58	+3·65	+3·73	+3·30	+3·94	+4·08	+4·28	+4·59

This table is an inverse rendering of the values derived by interpolation from the ordinary table of the probability integral, but its unit is changed from that of the modulus to that of the probable error, Q, and the (centesimal) grades are reckoned from 0° to 100°. In the usual way of reckoning, the 50th grade should have been reckoned as 0°, and the deviations should have run on the one side down to − 50° and on the other up to + 50°.

Referring to what was said some way back, that if 30 per cent. fail to pull 60 pounds, then 60 pounds must be taken as the measure corresponding to grade 30°, the reason is as follows: The 30th grade separates the man who ranks 30th in a class of 100 men from his neighbour who ranks 31st. It does so for the same reason that grade 1° separates the man who ranks 1st from the man who ranks 2nd. Now, the 30th man failed in the test, and the 31st succeeded. Therefore the grade corresponding to bare success lies between them, and is the same as grade 30°.

II.—ANTHROPOMETRIC PER-CENTILES.

Values surpassed, and Values unreached, by various percentages of the adults, mostly aged 23-26, measured at the Anthropometric Laboratory in the International Health Exhibition, 1884.

(*The value that is just unreached by n per cent. of any large group of measurements, and is just surpassed by* 100 – *n of them is called its* nth *per-centile.*)

Subject of measurement.	Age.	Unit of measurement.	Sex.	No. of persons in the group.	Values surpassed by per-cents. as below. 95	90	80	70	60	50	40	30	20	10	5
					Values unreached by per-cents. as below. 5	10	20	30	40	50	60	70	80	90	95
Height, standing, without shoes	23—51	Inches	M.	811	63·2	64·5	65·8	66·5	67·3	67·9	68·5	69·2	70·0	71·3	72·4
			F.	770	58·9	59·9	61·3	62·1	62·7	63·3	63·9	64·6	65·3	66·4	67·3
Height, sitting, from seat of chair	23—51	Inches	M.	1013	33·6	34·2	34·9	35·3	35·4	36·0	36·3	36·7	37·1	37·7	38·2
			F.	775	31·8	32·3	32·9	33·3	33·6	33·9	34·2	34·6	34·9	35·6	36·0
Span of arms...	23—51	Inches	M.	811	65·0	66·1	67·2	68·2	69·0	69·9	70·6	71·4	72·3	73·6	74·8
			F.	770	58·6	59·5	60·7	61·7	62·4	63·0	63·7	64·5	65·4	66·7	68·0
Weight in ordinary indoor clothes	23—26	Pounds	M.	520	121	125	131	135	139	143	147	150	156	165	172
			F.	276	102	105	110	114	118	122	129	132	136	142	149
Breathing capacity ...	23—26	Cubic inches	M.	212	161	177	187	199	211	219	226	236	248	277	290
			F.	277	92	102	115	124	131	138	144	151	164	177	186
Strength of pull as archer with bow ...	23—26	Pounds	M.	519	56	60	64	68	71	74	77	80	82	89	96
			F.	276	30	32	34	36	38	40	42	44	47	51	54
Strength of squeeze with strongest hand.	23—26	Pounds	M.	519	67	71	76	79	82	85	88	91	95	100	104
			F.	276	36	39	43	47	49	52	55	58	62	67	72
Swiftness of blow... ...	23—26	Feet per second	M.	516	13·2	14·1	15·2	16·2	17·3	18·1	19·1	20·0	20·9	22·3	23·6
			F.	271	9·2	10·1	11·3	12·1	12·8	13·4	14·0	14·5	15·1	16·3	16·9
Sight, keenness of—by distance of reading diamond test-type ...	23—26	Inches	M.	398	13	17	20	22	23	25	26	28	30	32	34
			F.	433	10	12	16	19	22	24	26	27	29	31	32

CHAPTER III.

ON THE ADVISABILITY OF ASSIGNING MARKS FOR BODILY EFFICIENCY IN THE EXAMINATION OF CANDIDATES FOR THOSE PUBLIC SERVICE IN WHICH BODILY EFFICIENCY IS OF IMPORTANCE.[1]

AN important paragraph occurs in the recently issued report of H.M. Civil Service Commissioners (xxxiii. p. 15). It runs as follows :—

"It was thought advisable, some years ago, to consider the possibility of making physical qualifications an element in the competitions for entrance into Woolwich and Sandhurst, and a joint Committee of this Department and the War Office drew up a scheme of competition which seemed easy of application. Circumstances caused it to be laid aside at the time, but on our recently bringing it again under the notice of the War Office we were informed that the military authorities did not think it necessary to introduce such a competition, being completely satisfied with the physique of the young men who came to them through our examinations. At the same time we may state that should any department in the public services be desirous of testing the physical qualifications of its officers more severely than at present, we anticipate that there would be no more difficulty in determining the relative capacities of the individual candidates in this respect than is experienced in the literary examination. Moreover, encouragement would be given generally to candidates to maintain a good state of health while preparing for the literary examinations, and any tendency to over-pressure would thereby be diminished."

It is not easy to imagine a topic more suitable for the notice of the Anthropological Section than that which is suggested by these remarks. Anthropologists peculiarly concern themselves with the practice of human measurements, and with determining the most appropriate ways of discussing them. They occupy themselves with defining the bodily efficiency of individuals and of races, and in devising tests that shall give warning whenever growth and development are not proceeding normally. The curious and hardly accountable disregard of bodily efficiency in those examinations through which youths are selected to fill posts in which

[1] From a Memoir read before the British Association in 1889.

exceptional bodily gifts happen to be peculiarly desirable, must strike the attention of anthropologists with especial force, and they of all persons are best able to appreciate how much is sacrified by its neglect.

What has just been said has no reference whatever to the pass-examinations now made by medical men in order to eliminate candidates who are absolutely unfit. The necessity for such pass-examinations is obvious. The reform asked for is to give additional marks to those youths who, being fit for service, are at the same time exceptionally well fit, so far as bodily efficiency is concerned.

If the opinion of the military authorities quoted above be interpreted to mean that literary examinations are indirect tests of bodily efficiency, that view can be now shown to be erroneous. There has been a vast amount of lax assertion in reference to this matter, some having said that high intellect is often associated with a stunted and weakly frame, and others having pointed to instances in which high mental and high physical powers were connected; but it is only very recently that we have secured a firm and sufficiently large basis of facts for trustworthy conclusions. These are the various measures of Cambridge students made during the last two or three years, and discussed by Dr. Venn, F.R.S., in an excellent memoir recently published in the *Journal of the Anthropological Institute*. The number of those who were measured is 1,905, and they were divided into three classes—(1) high honour men, (2) low honour men, and (3) poll men (that is to say, those who did not compete for honours but took an ordinary pass degree). The result was that the physical efficiency of the three classes proved to be almost exactly the same, except that there appeared to be a slight deficiency in eyesight among the high honour men. Otherwise they were alike throughout; alike in their average bodily efficiency, and alike in the frequency with which different degrees of bodily efficiency were distributed among them. Therefore the fact that a man had succeeded in a literary examination does not give the slightest clue to the character of his physical powers, and an opinion that the present literary examinations are indirect tests of bodily efficiency must be considered erroneous.

The intellectual differences are usually small between the candidates who are placed, according to the present literary examinations, near to the dividing line between success and failure. But their physical differences are, as we have just seen, as great as among an equal number of the other candidates taken at random. It seems then to be most reasonable whenever two candidates are almost on a par intellectually, though one is far superior physically, that the latter should be preferred. This is practically all I propose. I advocate no more at present than the introduction of new marks on a very moderate scale, sufficient to save from failure a few very vigorous candidates for the Army, Navy, Indian Civil Service, and certain other Government appointments, in which high bodily powers are of service. I would give the places to them that would be occupied under the present system by men who are far their inferiors physically, and very little their superiors intellectually. I am sure that every successful employer of men would assign at least as much weight as this to bodily efficiency, even among the highest class of those whom he employs, and that Government appointments would be still better adjudged than they now are, if considerations of high bodily efficiency were taken into some account.

It is scarcely necessary to press my own views in detail as to the particular tests most easily available, several of which I actually employ at my own laboratory at South Kensington. They would include the well-known measures of strength, breathing capacity, agility or promptness, keenness of eyesight, and of hearing. In a subsequent short paper I propose briefly to discuss certain general principles that appear to me to underlie the construction of consistent scales of marks. It is sufficient now to say that I have not the least doubt as to the feasibility of constructing off-hand a valuable system of examination for immediate use, though it would be open to great improvement through experience. I would refer to the statement already quoted from the Report of the Civil Service Commissioners, in which they themselves, being experts in the general art of examination, also foresee no difficulty. The higher education of the country is now so pervaded by the spirit of athleticism, that it is not to be feared for a moment that any system of examination for bodily efficiency would become pedantic or fanciful. Many of the examiners in the present literary subjects are themselves past athletes. If the principle of considering physical merit in competitive examinations for Government appointments be once conceded, I am sure that we may safely trust the authorities to frame appropriate tests and methods. It is but reasonable to assume that they would proceed very cautiously at first, and gradually extend the system to its legitimate limit, whatever that may be, with increasing thoroughness.

My motive for bringing this topic before the British Association is the hope of obtaining a public recognition of its importance. Judging from the results of numerous private inquiries, I entertain no doubt that if the reasonableness and feasibility of the proposed reform were widely understood, a loud demand would arise from many sides, without arousing any opposition worth regarding, for the introduction of so salutary a measure. It would certainly be grateful to many parents who now lament the exclusively bookish character of the examinations, and are wont to protest against a system that gives no better chance to their own vigorous children of entering professions where bodily vigour is of high importance than if they had been physically only *just not unfit* to receive an appointment.

CHAPTER IV.

ON THE PRINCIPLE AND METHODS OF ASSIGNING MARKS FOR BODILY EFFICIENCY.[1]

THE question to be solved is of this kind. Suppose that one man can just distinguish a minute test object at the distance of 25 inches, another at that of 35, and again another at 45 inches, how should we mark them? We should be very rash if we marked them in the proportion of 25, 35, and 45, or even if, for some good reason, we had selected 25 as the lowest limit from which marks should begin to count, we should mark them as 0, 10, and 20.

Two separate considerations are concerned in the just determination of a scale of marks—namely, absolute performance and relative rank, which are apt to be confused in unknown and varying proportions.

Absolute performance is such as is expressed by the 25, 35, and 45 inches just spoken of. It is perfectly correct in some cases to mark, or let us say to pay, for this, and this alone, upon the principle of piece-work—namely, that the pay ought to be proportionate to the work accomplished, or to the expected output in after life.

Relative rank is, however, on the whole, a more important consideration than the absolute amount of performance by which that rank is obtained. It has an importance of its own, because the conditions of life are those of continual competition, in which the man who is relatively strong will always achieve success, while the relatively weak will fail. The absolute difference between their powers matters little. The strongest even by a trifle will win the prize as completely as if he had been strongest by a large excess. Undertakings where many have failed, are accomplished at last by one who usually is very little superior to his predecessors, but it is to just that small increment of absolute superiority that his success is due. Therefore it is clear that relative rank has at least as strong a claim for recognition as absolute performance, if not a much stronger one. They have each to be taken into separate consideration, and each to be

[1] *From a Memoir read at the British Association. The diagrams are reprinted from Nature, Oct. 31, 1889.*

separately marked. The precise meaning intended to be conveyed by the phrase "relative rank" will be better understood further on.

Recurring to the example of keenness of eyesight, let the test object be words printed in diamond type, and the persons tested be Englishmen of the middle classes, between the ages of 23 and 26, then the performance of reading diamond type at 25 inches happens to be strictly mediocre. Fifty per cent. of the many persons who were tested performed better than this, and 50 per cent. performed worse. The 35-inch performance was exceeded by only 2½ per cent. of the persons tested; and as to the 45-inch performance, it has not in my experience been reached at all. I have had altogether 12,000 persons tested in this way, of both sexes and of various ages, but not one of them has succeeded in reading diamond type at the distance of 45 inches. It is very rare to find one who can do so at 40 inches. Whenever superiority in eyesight is eminently desirable, it would be absurd to make the marks for the three supposed cases to run proportionately either to 25, 35, and 45, or to 0, 10, and 20. The achievement of 45 inches would deserve much higher recognition. Relative rank and absolute performance should not be confused together.

I use the term relative rank in a large sense, with reference to all persons who have been, or are likely to become, candidates, and not to the small number of them who may happen to be present at a particular examination. Statistical tables concerning the class of persons in question have to be compiled from past examinations, and the rank of the individual has to be determined amidst these. I have often described how this is to be done (*Natural Inheritance*, p. 38, Macmillan and Co., 1889), but the diagram (Fig. 1) is, I think, the simplest of all forms for the use of an examiner. It tells at a glance the rank held by a man among his fellows in respect to any single and separate faculty. The class from which it is constructed might consist of any large number of persons subject only to the condition that the distance between the limits *within which* it extends shall be always divided into centesimal grades; that is to say, running from 0° to 100°. The grades are printed along both the top and the bottom of the diagram, and refer alike to every line. As a specimen of the way to read it, let us take the line of keenness of eyesight among the males. Here we see that the performance of reading diamond type at the distance of 25 inches is appropriate to grade 50°; or, as already stated, 50 per cent. of all the persons tried did worse, and 50 per cent. did better. Therefore the performance in question is exactly mediocre. Again, 30 inches corresponds to grade 80°; in other words, 80 per cent. did worse and the remaining 20 per cent. did better. The method on which this diagram is constructed is of universal application Calling the particular class of persons to which it refers, for brevity, by the letters I.H.E. (International Health Exhibition), then the rank of any individual among the I.H.E. males, aged 23-26, in respect to any of the

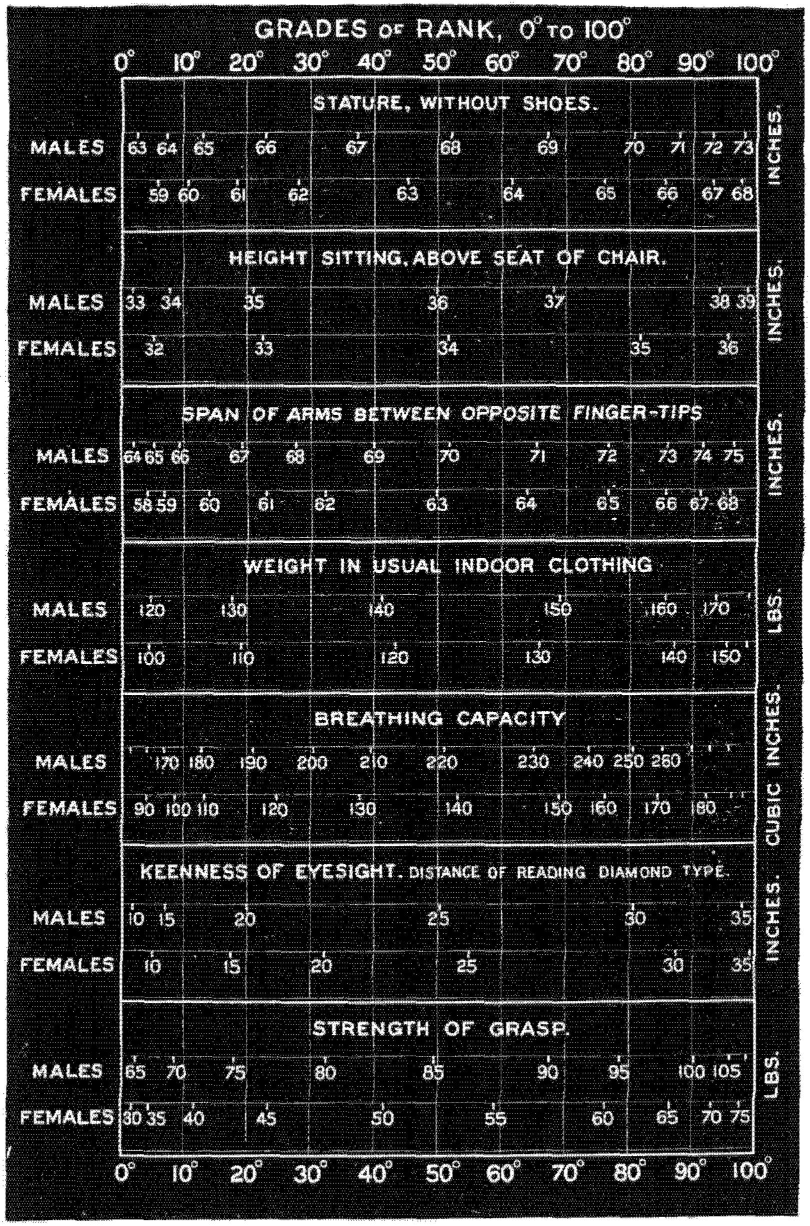
GRADES OF RANK, 0° TO 100°
0° 10° 20° 30° 40° 50° 60° 70° 80° 90° 100°
STATURE, WITHOUT SHOES.
MALES 63 64 65 66 67 68 69 70 71 72 73
FEMALES 59 60 61 62 63 64 65 66 67 68
INCHES.
HEIGHT SITTING, ABOVE SEAT OF CHAIR.
MALES 33 34 35 36 37 38 39
FEMALES 32 33 34 35 36
INCHES.
SPAN OF ARMS BETWEEN OPPOSITE FINGER-TIPS
MALES 64 65 66 67 68 69 70 71 72 73 74 75
FEMALES 58 59 60 61 62 63 64 65 66 67 68
INCHES.
WEIGHT IN USUAL INDOOR CLOTHING
MALES 120 130 140 150 160 170
FEMALES 100 110 120 130 140 150
LBS.
BREATHING CAPACITY
MALES 170 180 190 200 210 220 230 240 250 260
FEMALES 90 100 110 120 130 140 150 160 170 180
CUBIC INCHES.
KEENNESS OF EYESIGHT. DISTANCE OF READING DIAMOND TYPE.
MALES 10 15 20 25 30 35
FEMALES 10 15 20 25 30 35
INCHES.
STRENGTH OF GRASP.
MALES 65 70 75 80 85 90 95 100 105
FEMALES 30 35 40 45 50 55 60 65 70 75
LBS.
0° 10° 20° 30° 40° 50° 60° 70° 80° 90° 100°

Fig. 1.

qualities therein named, can be most easily ascertained; also among the I.H.E. females of the same ages.

This method admits of being extended in more than one way. That for which there is most call is where the rank of the quality immediately in question, has to be considered in reference to some other quality. Thus it is of little use to know the breathing capacity of the man unless we also know his stature or his weight. Lungs capacious enough to enable a small man to labour violently without panting would be wholly insufficient for the ordinary purposes of a giant, just as an excellent little boiler for a small steam-engine would be ineffective with a large one. The diagram appropriate to the case we are considering could not be compressed into a single line, but requires many (see Fig. 2). Successive

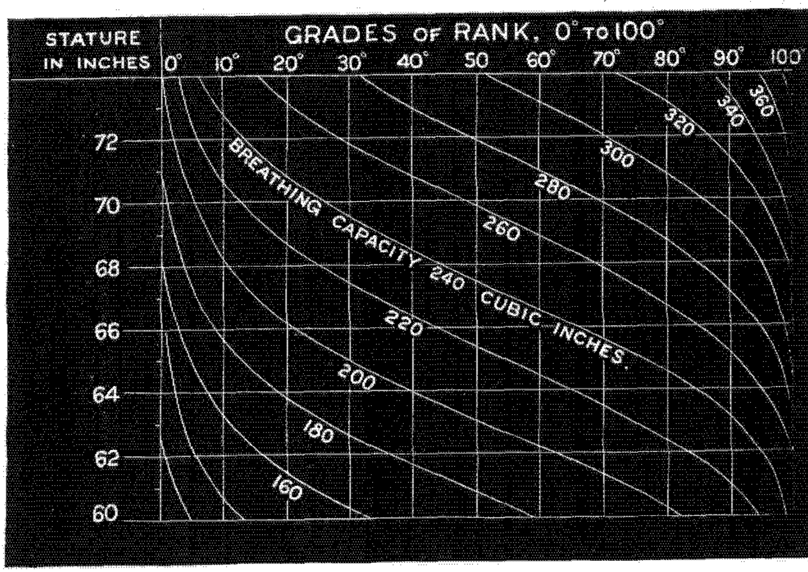

FIG. 2.

lines in that figure refer to the successive statures of 60 inches, 61 inches, and so on up to 72 inches. A diagram of breathing capacities for each of these statures was constructed in pencil, on the principle of one of the lines in Fig. 1; then bold lines were drawn from above downward to connect all the pencilled entries of the same value, just as isobars, isotherms, and other contour lines are drawn (to which the general name of *isograms* might well be given). This completed the figure, which hardly needs further description, either how to make or to use it. The importance of taking stature into account now becomes very evident. A breathing capacity of 220 cubic inches in a man of 72 inches stature has the rank of only 6°, but in a man of 60 inches it has the rank of 94°.

Fig. 3 shows in a similar way the grade of any given strength of grasp, when the weight of the person is taken into account.

When the quality that has to be marked depends upon more than one other quality—as it may be desired to mark breathing capacity with reference *both* to weight and to stature—the simplest plan is to make a separate diagram for each inch or second inch of stature, which is quite near enough. I have, however, contrived to make a single page serve

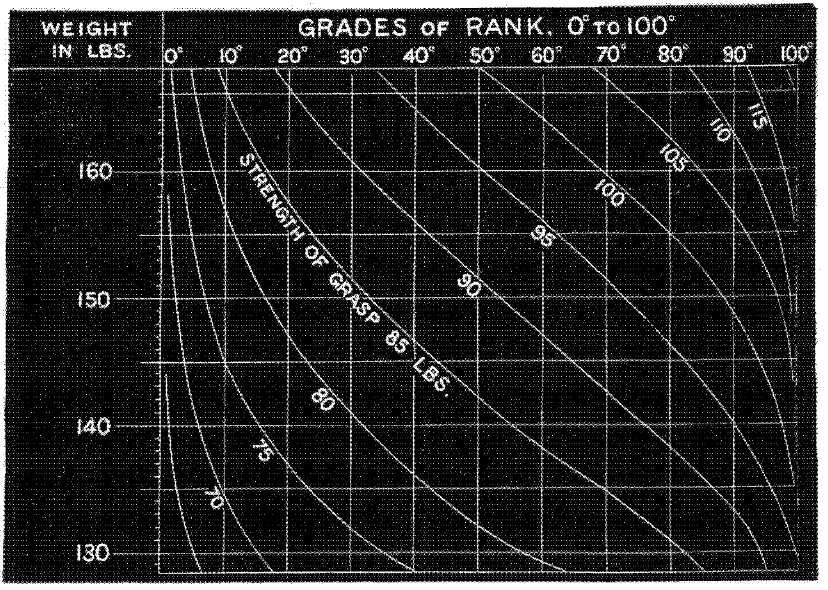

FIG. 3.

for the whole process by using a sliding strip of paper. I have submitted it for inspection, but do not care to describe it.

A strong reason for giving prominence to relative rank is that it affords the only feasible way of measuring many qualities; inasmuch as differences in absolute performance may be inferred from rank, according to a principle now familiar to most anthropologists, by using the well-known table of the probability integral. Table II, in the appendix to the last memoir, is very convenient for this sort of work. The following is a brief extract from it:—

The general conclusion to which these remarks lead is, that before arranging scales of marks, the first step is to measure a large number of persons who are of the same class as the expected candidates. Thence to make tables, and to deduce diagrams from them like Fig. 1 in some cases, and like Figs. 2 and 3 in others. These will exactly determine the qualities of the men to be dealt with, in a statistical sense. It is now the part of those who have to fix the scales of marks to determine the weight to be given respectively to relative rank and to absolute performance in examinations for each different kind of service.