IV. *Mathematical Contributions to the Theory of Evolution.—V. On the Reconstruction of the Stature of Prehistoric Races.*

By KARL PEARSON, *F.R.S., University College, London.**

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[PLATES 3 AND 4]

CONTENTS.

* I have received constant aid and assistance in the laborious arithmetical work of this paper from Mr. LESLIE BRAMLEY-MOORE. To Miss ALICE LEE I owe the fundamental table on p. 180, and the preparation of the test tables on pp. 188 and 189. Mr. G. U. YULE has prepared the diagrams and repeatedly assisted me with suggestion and criticism.

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(1.) THE object of this paper is to show, by the use of a special case as illustration, the true limits within which it is possible to reconstruct the parts of an extinct race from a knowledge of the size of a few organs or bones, when complete measurements have been or can be made for an allied and still extant race. The illustration I have taken is one of considerable interest in itself, and has been considered from a variety of standpoints by a long series of investigators. But I wish it to be considered purely as an illustration of a general method. What is here done for stature from long bones is equally applicable to other organs in Man. We might reconstruct in the same manner the dimensions of the hand from a knowledge of any of the finger bones, or the bones of the upper limbs from a knowledge of the bones of the lower limbs. Further, we need not confine our attention to Man, but can predict, with what often amounts to a remarkable degree of accuracy, the dimensions of the organs of one local race of any species from a knowledge of a considerable number of organs in a second local race, and of only one or two organs of the first. The importance of this result for the reconstruction of fossil or prehistoric races will be obvious.

What we need for any such reconstruction are the following data :—

(*a.*) The mean sizes, the variabilities (standard-deviations), and the correlations of as many organs in an extant allied race as it is possible conveniently to measure. When the correlations of the organs under consideration are high (*e.g.*, the long bones in Man), fifty to a hundred individuals may be sufficient; in other cases it is desirable that several hundred at least should be measured.

(*b.*) The like sizes or characters for as many individual organs or bones of the extinct race should then be measured as it is possible to collect. It will be found always possible to reconstruct the *mean* racial type with greater accuracy than to reconstruct a single individual.

(*c.*) An appreciation must be made of the effect of time and climate in producing changes in the dimensions of the organs which have survived from the extinct race.

(2.) Supposing the above data to exist in any particular instance, we have next to ask what is theoretically the best method of dealing with them. There cannot be a doubt about the answer to be given. If we know an organ A, then the most probable value of an organ B is that given by the regression formula for the two organs. Let m_a, m_b be the mean sizes of A and B, σ_a, σ_b their standard deviations, r_{ab} their coefficient of correlation, then the most probable value of B for a given value of A is,

$$B - m_b = \frac{\sigma_b}{\sigma_a} r_{ab} (A - m_a)$$

or

$$B = \left(m_b - \frac{\sigma_b}{\sigma_a} r_{ab} m_a\right) + \frac{\sigma_b}{\sigma_a} r_{ab} A$$
$$= c_1 + c_2 A \quad \text{(i.)}$$

where c_1 and c_2 are constants for the pair of organs under consideration. The probable error of such a determination is $\cdot 67449\ \sigma_b \times \sqrt{(1 - r_{ab}^2)}$.

Now there are several points to be noticed here.

(i.) If r_{ab} be small, the probable error of reconstruction will be large, if the organ B is to be reconstructed for a single individual. No ingenuity in constructing other formulæ can in the least get over this difficulty; it is simply an expression of the fact that races are variable. Any formula which professes to reconstruct individuals with extreme accuracy may at once be put aside as unscientific. On the other hand, if A be known for p individuals, the corresponding *mean* value of the unknown organ B may be found with a probable error of $\cdot 67449\ \sigma_b \times \sqrt{(1 - r_{ab}^2)}/\sqrt{p}$, and thus with increasing accuracy as p increases.

(ii.) Anthropologists and anatomists have frequently assumed that the ratio of two organs, B/A, is the measure to be ascertained in a reconstruction problem. They were soon compelled to admit, however, that this varies with A, and accordingly have tabulated the ratio B/A for three or four ranges of the organ A. Such a table, for example is given by M. MANOUVRIER* for the ratio of stature to the length of the six long bones. He gives the ratio for three values of each long bone. He also in a second table gives values of the ratios which are to be taken when the long bones exceed or fall short of certain values, *i.e.*, in cases of what he terms *macroskely* and *microskely*. The regression formula shows us that:

$$B/A = c_2 + c_1/A,$$

and since c_1 is never small as compared with A, this ratio can never be treated as constant. Accordingly, while a table can be constructed which will give quite good reconstruction values, by determining the mean value of B/A for each value of A, we see that it is theoretically an erroneous principle to start from; no constancy of the ratio B/A ought to be expected. The theory of regression shows us that the most probable value of B is expressible, so long as the correlation is normal (or at least "linear"), as a *linear* function of A.†

* 'Mémoires de la Société d'Anthropologie de Paris,' vol. 4, pp. 347–402.

† Sir GEORGE HUMPHRY gives a table of the ratio B/A for stature in his "Treatise on the Human

(3.) So far we have dealt only with the reconstruction of the most probable value of B from one organ A, but we may propose to find the most probable value of B from n organs $A_1, A_2, A_3 \ldots A_n$. Let r_{0q} represent the correlation coefficient of B and the organ A_q, $r_{qq'}$ the correlation coefficient of A_q and $A_{q'}$; σ_0 the S.D. of B, and σ_q of the organ A_q, m_0 the mean of B, and m_q of A_q; let R be the determinant

$$\begin{vmatrix} 1 & r_{01} & r_{02} & r_{03} & \cdot & \cdot & \cdot & r_{0n} \\ r_{10} & 1 & r_{12} & r_{13} & \cdot & \cdot & \cdot & r_{1n} \\ r_{20} & r_{21} & 1 & r_{23} & \cdot & \cdot & \cdot & r_{2n} \\ r_{30} & r_{31} & r_{32} & 1 & \cdot & \cdot & \cdot & r_{3n} \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ r_{n0} & r_{n1} & r_{n2} & r_{n3} & \cdot & \cdot & \cdot & 1 \end{vmatrix}$$

and R_{pq}, the minor corresponding to r_{pq}. Then the general theory of correlation shows us that

$$B - m_0 = -\frac{R_{01}}{R_{00}}\frac{\sigma_0}{\sigma_1}(A_1 - m_1) - \frac{R_{02}}{R_{00}}\frac{\sigma_0}{\sigma_2}(A_2 - m_2) \ldots - \frac{R_{0n}}{R_{00}}\frac{\sigma_0}{\sigma_n}(A_n - m_n). \quad \text{(ii.)}$$

is the most probable value of B, and that there is a probable error $= \cdot 67449\, \sigma_b \sqrt{(R/R_{00})}$ in this determination.

Thus we reach again a formula of the character

$$B = c_0 + c_1A_1 + c_2A_2 + c_3A_3 + \ldots + c_nA_n,$$

or, B is expressible as a *linear* function of the organs from which its value is to be predicted. This again supposes normal, or at least "linear" correlation. Now there are several points to be noticed here.

(i.) The linear function which will give the best value for B is unique. For example, some anthropologists have attempted to reconstruct stature by adding together the lengths of femur and tibia. The proportions in which femur and tibia are to be combined are given once for all by the regression formula, and they are not those of equality. I have succeeded in proving the following general theorem, which settles this point conclusively. Given any linear function of the n organs $A_1, A_2, A_3 \ldots A_n$, say

$$b_0 + b_1A_1 + b_2A_2 + b_3A_3 + \ldots + b_nA_n,$$

Skeleton," Cambridge, 1858, p. 108. Many others have been given by French writers, in some cases with several values of B/A for three ranges of stature or of long bone (Topinard, Rollet, etc.). Dr. Beddoe has given a rule which really amounts to making B a linear function of A, but his values for c_1 and c_2 are widely divergent from what I have obtained by applying the theory of correlation. 'Journal of the Anthropological Institute,' vol. 17, 1888, p. 205.

and let ρ be the correlation of this expression with B, then ρ will be greatest or the probable error of the determination of B by means of its correlation with such an expression will be least, *i.e.*, $\cdot 67449\, \sigma_0 \sqrt{(1-\rho^2)}$ will be least, when the b's are proportional to the corresponding c's of the regression formula.

Let Σ be the standard-deviation of the quantity

$$Q = b_0 + b_1 A_1 + b_2 A_2 + \ldots + b_n A_n.$$

Then

$$\Sigma^2 = S_1^n (b_1^2 \sigma_1^2) + 2S\,(b_1 b_2 \sigma_1 \sigma_2 r_{12})$$

and

$$\rho = S_1^n (b_1 r_{01} \sigma_1)/\Sigma.$$

The best value of B as determined from Q is

$$B = m_0 + \frac{\sigma_0 \rho}{\Sigma} \{b_1 (A_1 - m_1) + b_2 (A_2 - m_2) + \ldots + b_n (A_n - m_n)\} \quad . \quad \text{(iii.)},$$

with a probable error $\cdot 67449\, \sigma_0 \sqrt{(1 - \rho^2)}$.

This may be taken to be any linear function of the A's, since so far $b_1, b_2 \ldots b_n$ are n quite arbitrary constants, and the constant b_0 has to satisfy the condition that B takes its mean value when the A's take their mean values.

Now select such a value of the b's as to give the greatest value to ρ. By differentiating ρ with regard to the b's in succession we find the system of equations

$$\begin{aligned}
r_{01}\Sigma/\rho &= b_1\sigma_1 + b_2\sigma_2 r_{12} + b_3\sigma_3 r_{13} + \ldots + b_n\sigma_n r_{1n} \\
r_{02}\Sigma/\rho &= b_1\sigma_1 r_{12} + b_2\sigma_2 + b_3\sigma_3 r_{23} + \ldots + b_n\sigma_n r_{2n} \\
r_{03}\Sigma/\rho &= b_1\sigma_1 r_{13} + b_2\sigma_2 r_{23} + b_3\sigma_3 + \ldots + b_n\sigma_n r_{3n} \\
&\ldots\ldots\ldots\ldots\ldots \\
&\ldots\ldots\ldots\ldots\ldots \\
r_{0n}\Sigma/\rho &= b_1\sigma_1 r_{1n} + b_2\sigma_2 r_{2n} + b_3\sigma_n r_{3n} + \ldots + b_n\sigma_n.
\end{aligned}$$

The solutions of these equations are

$$b_1\sigma_1 = -\frac{R_{01}}{R_{00}}\frac{\Sigma}{\rho}, \qquad b_2\sigma_2 = -\frac{R_{02}}{R_{00}}\frac{\Sigma}{\rho}\ldots \qquad b_n\sigma_n = -\frac{R_{0n}}{R_{00}}\frac{\Sigma}{\rho};$$

or, the equation to the best value of B, (iii.) above, reduces to the regression formula (ii.). In other words, no attempt to reconstruct the organ B from a linear relation to the organs $A_1, A_2 \ldots A_n$ will give such a good result as the ordinary regression formula.* This, of course, excludes all attempts to form type ratios of

* I note that what is here demonstrated is only a special case of Mr. YULE's general theorem. See 'Roy. Soc. Proc.,' vol. 60, p. 477.

A/B or B/A as a method of prediction. We may, in fact, at once dismiss all reconstruction formulæ as insufficient which are not based on the theory of correlation. The theory as here applied, be it noted, depends on the *linearity* of the proposed formula and not on any special form of the distribution of variations.

(ii.) The accuracy of a prediction will not be indefinitely increased by increasing the number of organs upon which the prediction is based. This fundamental fact of the application of the theory of correlation to prediction has already been noticed by Miss ALICE LEE and myself in the case of barometric prediction.* The choice of organs upon which to base the prediction is far more important. Thus, to illustrate this from stature I may remark that the probable error of a prediction of male stature from radius is to a prediction from femur in the ratio of 2·723 to 2·174; that if one takes both femur and tibia for the prediction, the probable error is only reduced to 2·030, and further, if one takes femur, tibia, humerus, and radius, we only reach 1·961. This latter reduction is so small as to be well within the errors of the determination of our means, variations, and correlations, and accordingly scarcely worth making. To pass from the radius to the femur is a real gain; to pass from femur and humerus, say, to femur, humerus, tibia, and radius, is no sensible gain. Hence, one or two organs well selected are worth much more for prediction than a much larger number selected less carefully.

(iii.) It is the custom of French writers, when determining stature, to predict it from several single types of bones, say from femur, tibia, humerus, and radius, and then to take the mean of these results for the true stature. This is not the best *theoretical* procedure. Suppose the regression formulæ for the prediction of B from A_1, A_2, A_3, A_4 separately to be

$$\begin{aligned} B &= c_0' + c_1'A_1, \\ B &= c_0'' + c_1''A_2, \\ B &= c_0''' + c_1'''A_3, \\ B &= c_0'''' + c_1''''A_4. \end{aligned}$$

Then the mean of all these results would give

$$B = \tfrac{1}{4}(c_0' + c_0'' + c_0''' + c_0'''') + \tfrac{1}{4}c_1'A_1 + \tfrac{1}{4}c_1''A_2 + \tfrac{1}{4}c_1'''A_3 + \tfrac{1}{4}c_1''''A_4,$$

that is to say, B has been really found from a linear relationship between B and the four organs in question. But the best linear relationship for the four organs is

$$B = c_0 + c_1A_1 + c_2A_2 + c_3A_3 + c_4A_4,$$

where the c's are the true regression coefficients. But the slightest acquaintance with the theory of regression shows that the *partial* regression coefficient c_1 is as a

* "On the Distribution of Frequency (Variation and Correlation) of the Barometric Height at Divers Stations," 'Phil. Trans.,' A, vol. 190, p. 456 *et seq.*

rule not just $\frac{1}{4}$ of the value of the total regression coefficient c_1'. For example, if A_4 were the radius and B stature, $c_1'''' = 3 \cdot 271$, while c_4 is a *negative* quantity $-\cdot 187$. This process of taking means may accordingly screen some most important element, like the negative value of the partial regression coefficient of the radius. *Theoretically*, therefore, as well as from the standpoint of discovery, the regression formula for n organs will give more valuable results than the mean of the results of the n regression formulæ for the n organs. A *practical* modification of this principle will be referred to below (p. 178).

(4.) The theory of regression will thus enable us to determine the best value to be assigned to an unknown organ, when the values of any other n organs are known, *supposing the individual to which these organs belong is a member of a race or group for which the regression coefficients have been ascertained.*

On what principle, however, can we extend the regression formulæ for one race to a second? The regression coefficients depend upon two things, the variability of the organs under consideration and their correlation. Now the change in variability as we pass from one race to a second has never been questioned. It has been suggested that the correlations were racial characters, but the divergences in correlations between local races are far beyond the probable errors of the observations.* Mr. FILON and I have shown that every *random* selection from a race changes both variation and correlation.† I have shown in a memoir not yet published that all natural and all artificial selection also changes these quantities. How then can we hope that a regression formula as applied from one local race to another will give accurate results? Why should the stature formula obtained from measurements on modern Frenchmen apply to palæolithic man?

I think M. MANOUVRIER somewhat lightly skips this difficulty in the following sentences:—"Enfin les *variations ethniques* des proportions du corps seront dans le même cas que les précédentes [les variations individuelles]. Il y a des races macroskèles et des races microskèles, comme il y des individus de ces deux sortes, et les variations individuelles sont bien plus grandes que les variations ethniques les plus accusées. Or les coefficients moyens des os de grande longueur tendant à abaisser la taille et ceux des os de faible longueur tendant à l'élever, il s'ensuit qu'il sera tenu compte dans une certaine mesure de la macroskélie des races comme de celle des individus dont les os seront absolument longs et de la microskélie des races comme de celle des individus ayant des os absolument courts."‡ If we admit for the moment, which I should not be prepared to do generally,|| that the individual variations in a local race are greater than the "ethnic variations" or divergences between the means of local races, M. MANOUVRIER's conclusion by no means follows.

* See 'Phil. Trans," A, vol. 187, pp. 266, 280, and 'Roy. Soc. Proc.,' vol. 61, p. 350.

† "On Random Selection," see 'Phil. Trans,' A, vol. 191, p. 229, and 'Roy. Soc. Proc.,' vol. 62, p. 173.

‡ *Loc. cit.*, on my page 171.

|| See the results as to the radius referred to on p. 176 below.

The formulæ for stature reconstruction, whether obtained with a consciousness of the theory of regression, as in the present paper, or indirectly by taking the means of small groups, as by M. MANOUVRIER, are based upon averages, and involve the standard-deviations, the variabilities of distribution of each organ. Hence, the fact that individual variations may be greater than ethnic variations does not touch the real point at issue, for the formulæ depend on the proportions of macroskely and microskely in each race, and these undoubtedly change. The individual variation being greater than the ethnic, is not a valid argument for applying a formula based on the observation of one local race straight away to a second.

The validity of applying the formula for one local race to a second depends, I think, upon very different considerations. In the first place, the validity is not general. If we endeavoured to reconstruct the radius, for example, of Aino or Naqada races from the femur or tibia by a regression formula obtained from measurements on the French, the results would, we might *à priori* expect, not be so satisfactory as for stature.*

The validity depends on our conceptions as to "local races." While the problem of local races is dealt with at length in my memoir on artificial and natural selection, and I do not want to anticipate the results there stated, it is still needful to cite here a theorem reached in that memoir. When a sub-race is established by the selection out of a primary race of a group having p organs distributed with given variabilities and given correlations about given means, we shall speak of its establishment as due to a *direct* selection of these p organs. But this direct selection is shown to alter also the sizes of all the remaining organs of the organism, the variabilities of all those organs, and the correlations among themselves of the non-directly selected as well as their correlations with the selected organs. We shall speak of this result as

* Allowing, as in my page 193, for cartilage and shrinking, I find the following formulæ from the French measurements for the reconstruction of radius in centimetres :

$$R = 7{\cdot}839 + {\cdot}367F,$$
$$R = 5{\cdot}715 + {\cdot}508T.$$

	Aino race.		Naqada race.	
	Calculated.	Observed.	Calculated.	Observed.
Reconstruction of R from F .	22·799	22·913	24·692	25·697
Reconstruction of R from T .	22·934	22·913	25·494	25·697

In the case of the Ainos, the prediction is within ·5 per cent. of the observed value. In the case of the Naqada race, the prediction from the femur differs by 1 centim., or 4 per cent. from its true value. An error of 6 to 7 centims. in the prediction of stature of a local race which would correspond in magnitude is hardly likely to occur. The explanation is that the radius is a much differentiated bone.

indirect selection. The changes due to indirect selection are shown in the memoir referred to to be in many cases of considerable importance; every mean, every standard deviation, every correlation may be altered; but the following theorems govern the changes in the regression formulæ :—

(i.) The regression formula of a directly selected organ on any number of other organs, whether directly or indirectly selected, will change.

(ii.) The regression formula of an indirectly selected organ on *all* the directly selected organs, and any number of the indirectly selected organs, does *not* change.

(iii.) The regression formula of an indirectly selected organ on some, but *not all* the directly selected organs, will change, unless the selection happens to be one of size only, and not of variability and correlation at the same time, in which case the formula remains unchanged.

(iv.) Most local races show sensible but small differences in both variability and correlation; if we call these differences quantities of the first order of small quantities, then the changes in the regression formulæ between two or more indirectly selected organs will be of this order of small quantities × the squares and products of correlations, quantities which are themselves less than unity, or what we may term a quantity of the third order; further, the changes in the regression formulæ between an indirectly selected organ and some but *not all* the directly selected organs will be of the first order of small quantities × the correlation, or what we may term a quantity of the second order.

To sum up, then, it would appear that the regression formulæ in general will change from local race to local race, but that a particular set (see (ii.) above) exist which would not be changed at all, while many others, supposing *size** to be the chief character selected, would only be changed by quantities of the second or third order. It will be obvious then that a knowledge of a considerable series of regression formulæ of two local races will enable us to ascertain to some extent the nature and amount of differentiation which has gone on from a common ancestral stock. Further, if we have not sufficient data for one local race to find the variabilities and correlations of its organs, but if we can find fairly closely the mean size of its organs, then the degree of consistency of the results obtained when these means are inserted in the regression formulæ for the second local race is an indication of the amount of differentiation which has taken place. The larger the number of organs we include in a regression formula the more likely we are to embrace *all* the directly selected organs, and so to obtain a formula which remains unchanged for the two races.

Thus we see that the extension of the stature regression formulæ from one local race—say, modern French—to other races—say, palæolithic man—must be made with very great caution. The extension assumes (i.) that stature itself has not been

* A selection of the mean sizes of two organs, which would alter their relative proportions, does not of course involve a selection of correlation; in other words, selection of mean relationship does not necessarily connote a selection of differential relationship.

directly selected, however widely changed by indirect selection, (ii.) that the formulæ involve *all* the directly selected organs closely correlated with stature, or that the selection has been principally one of size, and not of variability of, or correlation between, these organs. The real test of the applicability of the formulæ is whether or not they give for another local race of which we know *à priori* the stature, results in agreement with themselves and with the known stature. I take it that the justification required for applying our formulæ to palæolithic man is not the statement that ethnic are less than individual intra-racial variations, but is to be drawn from the fact that our formulæ, based upon measurements on the French, give results very fairly consistent among themselves and with observation for such a divergent race as the Aino. Such results seem to indicate that racial differences in stature are not the result of direct selection of stature, and that the selection of the long bones has been rather a selection of their absolute and relative sizes than a selection, in the first place, of their degrees of variation and correlation, although these have to some extent undoubtedly changed.

Our general theorems will to some degree indicate the manner in which differentiation has taken place. Suppose there has been a selection of femur and tibia, but not of humerus and radius. Then the regression formulæ for stature on femur and tibia, and for stature on femur and tibia together with one or both of the other two, humerus and radius, ought to give identical results; but these results ought to differ from those given by the formulæ for stature on humerus or on radius, or on both together. Practically, however, we have in many cases so few bones to obtain our means from (and these bones themselves parts of different skeletons), that the probable errors of these means quite obscure the deviations in stature as obtained from various formulæ and due to the influence of selection. From this standpoint a partial practical justification can be found for taking the mean of the divergent reconstructions of stature given by a series of regression formulæ, at any rate for the case when the divergences are not very large.

These divergences may be due to errors in the mean lengths of the long bones, or to selection directly of one or more of the long bones, or even to some small direct selection of stature. But as in our ignorance of these sources of errors we can only suppose some positive and some negative, the mean of all the formulæ may to some extent eliminate these quite unknown and unascertainable divergences (see p. 175). Generally, however, I should expect the stature in which two or more formulæ agree, to be more probable than the mean of several divergent formulæ.

(5.) *On the Data available for Stature Regression Formulæ.*—The only data available for the calculation of the correlation between stature and long bones occur in the measurements made by Dr. ROLLET on 100 corpses in the dissecting room at Lyons.* This material has already been made use of by Miss ALICE LEE and myself in our memoir, "On the Relative Correlation of Civilised and Uncivilised Races,"† so that

* 'De la Mensuration des Os Longs des Membres,' par Dr. ETIENNE ROLLET, Lyons, 1889.

† 'Roy. Soc. Proc.,' vol. 61, p. 343.

all the coefficients of correlation and all the variations of the long bones have already been calculated.

I owe to Miss ALICE LEE the knowledge of the additional constants required for this further investigation, and embodied in Tables I. and II. below, which embrace all that is needed to fully determine the correlation of stature and long bones.

The treatment of Dr. ROLLET's material was not to be briefly settled. He had measured only 50 bodies of each sex, and this number included a great variety of ages. M. MANOUVRIER in determining his table of statures has at once excluded from his calculations all the males but 24 as senile, and all the females but 25. Now, although the correlations between stature and long bones are high, it would be quite hopeless to attempt to calculate them from 25 cases; 50 cases are hardly sufficient, 25 impossible. It seemed, therefore, necessary to include all Dr. ROLLET's cases, and the question now arises how far the inclusion of the senile ones will affect our results. Taking 50 as the age at which stature begins to decrease, we notice that of the 25 lowest statures recorded by ROLLET, 18 are of men over 50, and of the 25 highest statures, 17 are of men over 50. In other words, there appear sensibly as many senile statures above as below the median stature. Of women there are 16 over 50 years old with a stature greater than the median, and only 14 women over 50 under the median stature. Turning to means, we notice that 24 males under 60 years had for mean stature 167·17 centims., and 26 males over 59 years had 165·4 centims., 25 females under 60 had for mean stature 154·04 centims., and 25 females over 59 had 154·00 centims. 37 females under 70 had a stature 153·94 centims., and 13 over 70 gave 154·23 centims., an absolutely greater stature. 24 years was the minimum age. From this it would appear that whatever shrinkage may be due to old age, it is not of a very marked character in these data, or largely disappears when a body is measured after death on a flat table; the senile stoop may then be largely eliminated.

But there is another point to be noted: we shall not directly make use of the mean stature as obtained from ROLLET's data, except to test how far our formulæ will reproduce ROLLET's results. What we shall make use of from ROLLET's data are the standard-deviations and coefficients of correlation, and these will hardly have their values sensibly influenced by such comparatively small senile changes as are to be found indicated in ROLLET's measurements.* Accordingly our constants are calculated by including all ROLLET's measurements, namely, on 50 of each sex.

The following results were found:—

* If the bones shrink with old age, like the stature, the correlation would not be altered. The length of a bone varies with the amount of moisture in it (see below), and such shrinkage is itself a possibility. The bones of the aged will of course be included among those of extinct races, and cannot easily be eliminated.

TABLE I.—Correlation between Stature and Long Bones.

Pairs of organs.	Male.	Female.
Stature and tibia	·7769 ± ·0378	·7963 ± ·0349
Stature and radius	·6956 ± ·0492	·6717 ± ·0523
Stature and humerus *.	·8091 ± ·0329	·7706 ± ·0387
Stature and femur	·8105 ± ·0327	·8048 ± ·0336
Stature and humerus + radius . . .	·7973 ± ·0347	·7547 ± ·0411
Stature and femur + tibia	·8384 ± ·0283	·8268 ± ·0302

The means, standard deviations, and correlations of femur, tibia, humerus, and radius, for ROLLET's measurements, are given in the 'Roy. Soc. Proc.,' vol. 61, pp. 347–350. The means and variability of the remaining organs not there recorded were found to be as follows :—

TABLE II.

	Mean.		Standard deviation.	
	Male.	Female.	Male.	Female.
Stature	166·260 ± ·525	154·020 ± ·520	5·502 ± ·371	5·450 ± ·368
Humerus + radius . . .	57·368 ± ·242	51·240 ± ·241	2·536 ± ·171	2·526 ± ·170
Femur + tibia	82·028 ± ·380	75·024 ± ·382	3·979 ± ·268	4·001 ± ·270

Without reproducing the full tables of the memoir referred to, it is of value to form the correlation tables, which serve as the determinants from which the regression formulæ have been calculated. It is only in the case of stature in terms of the four long bones that the numerical work proved lengthy.

The general formula used is (ii.) on p. 172. S, F, H, T, R stand for Stature, Femur, Humerus, Tibia, Radius, all measured in ROLLET's manner, which will be discussed at length below.

* The somewhat low value of the correlation for female stature and humerus was tested by means of the formula

$$r_{zu} = \frac{\sigma_x}{\sigma_z} r_{xu} + \frac{\sigma_y}{\sigma_z} r_{yu},$$

where $z = x + y$, x, y, and u are organs, σ_x, σ_y, σ_u their standard deviations, and r a coefficient of correlation. Hence putting x = humerus, y = radius, and u = stature, I found the correlation between stature and humerus + radius indirectly; it was ·7564. The table shows that the directly-calculated value was ·7547, a difference well within the errors of observation. Thus the correlations as given for female humerus and stature and female radius and stature must be correct, *i.e.*, the somewhat lengthy arithmetic involved is not at fault.

TABLE III.

MALES.—Stature and Long Bones Correlation.

	S.	F.	H.	T.	R.
S.	1	·8105	·8091	·7769	·6956
F.	·8105	1	·8421	·8058	·7439
H.	·8091	·8421	1	·8601	·8451
T.	·7769	·8058	·8601	1	·7804
R.	·6956	·7439	·8451	·7804	1

TABLE IV.

FEMALES.—Stature and Long Bones Correlation.

	S.	F.	H.	T.	R.
S.	1	·8048	·7706	·7963	·6717
F.	·8048	1	·8718	·8904	·7786
H.	·7706	·8718	1	·8180	·8515
T.	·7963	·8904	·8180	1	·8053
R.	·6717	·7786	·8515	·8053	1

The following cases of reconstruction were then dealt with :—

(*a*) Reconstruction of mean stature from a knowledge of the femur of p individuals.
(*b*) ,, ,, ,, ,, ,, humerus ,, ,,
(*c*) ,, ,, ,, ,, ,, tibia ,, ,,
(*d*) ,, ,, ,, ,, ,, radius ,, ,,
(*e*) ,, ,, ,, ,, ,, femur + tibia ,, ,,
(*f*) ,, ,, ,, ,, ,, femur and tibia ,, ,,
(*g*) ,, ,, ,, ,, ,, humerus + radius ,, ,,
(*h*) ,, ,, ,, ,, ,, humerus and radius ,, ,,
(*i*) ,, ,, ,, ,, ,, femur and humerus ,, ,,
(*k*) ,, ,, ,, ,, ,, {femur, humerus, tibia, and radius} ,, ,,

In the formulæ M denotes a mean, and e the probable error of the estimate.

TABLE V.—Male.

(*a*) $S - M_S = 1{\cdot}880\,(F - M_F)$, $e = 2{\cdot}174/\sqrt{p}$.

(*b*) $S - M_S = 2{\cdot}894\,(H - M_H)$, $e = 2{\cdot}181/\sqrt{p}$.

(*c*) $S - M_S = 2{\cdot}376\,(T - M_T)$, $e = 2{\cdot}337/\sqrt{p}$.

(*d*) $S - M_S = 3{\cdot}271\,(R - M_R)$, $e = 2{\cdot}666/\sqrt{p}$.

(*e*) $S - M_S = 1{\cdot}159\,(F + T - M_{F+T})$, $e = 2{\cdot}023/\sqrt{p}$.*

(*f*) $S - M_S = 1{\cdot}220\,(F - M_F) + 1{\cdot}080\,(T - M_T)$, $e = 2{\cdot}030/\sqrt{p}$.

(*g*) $S - M_S = 1{\cdot}730\,(H + R - M_{H+R})$, $e = 2{\cdot}240/\sqrt{p}$.

(*h*) $S - M_S = 2{\cdot}769\,(H - M_H) + {\cdot}195\,(R - M_R)$, $e = 2{\cdot}179/\sqrt{p}$.

(*i*) $S - M_S = 1{\cdot}030\,(F - M_F) + 1{\cdot}557\,(H - M_H)$, $e = 1{\cdot}962/\sqrt{p}$.

(*k*) $\left.\begin{array}{l} S - M_S - {\cdot}913\,(F - M_F) + {\cdot}600\,(T - M_T) \\ \quad + 1{\cdot}225\,(H - M_H) - {\cdot}187\,(R - M_R) \end{array}\right\}$, $e = 1{\cdot}961/\sqrt{p}$.

TABLE VI.—Female.

(*a*) $S - M_S = 1{\cdot}945\,(F - M_F)$, $e = 2{\cdot}182/\sqrt{p}$.

(*b*) $S - M_S = 2{\cdot}754\,(H - M_H)$, $e = 2{\cdot}343/\sqrt{p}$.

(*c*) $S - M_S = 2{\cdot}352\,(T - M_T)$, $e = 2{\cdot}245/\sqrt{p}$.

(*d*) $S - M_S = 3{\cdot}343\,(R - M_R)$, $e = 2{\cdot}723/\sqrt{p}$.

(*e*) $S - M_S = 1{\cdot}126\,(F + T - M_{F+T})$, $e = 2{\cdot}068/\sqrt{p}$.

(*f*) $S - M_S = 1{\cdot}117\,(F - M_F) + 1{\cdot}125\,(T - M_T)$, $e = 2{\cdot}085/\sqrt{p}$.

(*g*) $S - M_S = 1{\cdot}628\,(H + R - M_{H+R})$, $e = 2{\cdot}412/\sqrt{p}$.

(*h*) $S - M_S = 2{\cdot}582\,(H - M_H) + {\cdot}281\,(R - M_R)$, $e = 2{\cdot}340/\sqrt{p}$.

(*i*) $S - M_S = 1{\cdot}339\,(F - M_F) + 1{\cdot}027\,(H - M_H)$, $e = 2{\cdot}120/\sqrt{p}$.

(*k*) $\left.\begin{array}{l} S - M_S = {\cdot}782\,(F - M_F) + 1{\cdot}120\,(T - M_T) \\ \quad + 1{\cdot}059\,(H - M_H) - {\cdot}711\,(R - M_R) \end{array}\right\}$, $e = 2{\cdot}024/\sqrt{p}$.

(6.) Now these tables require a good deal of comment. In the first place they must not be considered as extending beyond the range of data on which they are based, thus R, F and H are the maximum lengths of bones measured with the cartilage attached, and in a humid state, T is the tibia length excluding spine. All the constants were worked out for the *right* members, except in one or two cases in which they were missing. The stature is the stature measured on the corpse. Further the measurements are made on the French race.

We shall now proceed to generalise these formulæ. In the first place, the

* It may appear strange that the probable error of (*e*) is less than (*f*), but the difference is really less than the probable error of the observations. If $r_{S,\,F+T}$ be calculated from the known values of σ_F, σ_T and r_{FT}, &c., we find it equals ·8369 instead of ·8384 the directly calculated value, while σ_{F+T} thus calculated $= 3{\cdot}967$ instead of $3{\cdot}979$, whence $e = 2{\cdot}031/\sqrt{p}$ instead of $2{\cdot}023/\sqrt{p}$, which is in agreement with the general theorem on p. 173.

numerical factors are functions only of the standard deviations and the correlation coefficients, and will accordingly be unchanged if these be unchanged.

Let O_1 and O_2 be any organs and M_1 and M_2 their means, n_1 and n_2 their numbers, and r_{12} their coefficient of correlation. Suppose that any hygrometric changes, different method of measurement, amount of animal matter in the organs at time of measurement, etc., cause us to measure $\beta_1 O_1 + \beta_2 = O'_1$ and $\gamma_1 O_2 + \gamma_2 = O'_2$ instead of O_1 and O_2, and let σ'_1, σ'_2, M'_1, M'_2, and r'_{12} be the resulting characters, then clearly, S standing for summation :—

$$M'_1 = \beta_1 M_1 + \beta_2, \qquad M'_2 = \gamma_1 M_2 + \gamma_2,$$

$$\sigma'^2_1 = S(O'_1 - M'_1)^2 = \beta_1^2 S(O_1 - M_1)^2 = \beta_1^2 \sigma_1^2, \text{ or } \sigma'_1 = \beta_1 \sigma_1,$$

$$\sigma'^2_2 = S(O'_2 - M'_2)^2 = \gamma_1^2 S(O_2 - M_2)^2 = \gamma_1^2 \sigma_2^2, \text{ or } \sigma'_2 = \gamma_1 \sigma_2,$$

$$r'_{12} = \frac{S(O'_1 - M'_1)(O'_2 - M'_2)}{\sigma'_1 \sigma'_2} = \beta_1 \gamma_1 \frac{S(O_1 - M_1)(O_2 - M_2)}{\sigma'_1 \sigma'_2} = r_{12}.$$

Thus a correlation coefficient will be quite unchanged. A regression coefficient will be changed or not according as the ratio of two standard deviations is changed or not, or according as to whether β_1/γ_1 sensibly differs from unity. Now in stature or any of the long bones with which we have to deal quantities corresponding to β_2, γ_2 may amount to 1 per cent. of the value of O_1 or O_2, but the multipliers like β_1 and γ_1 are not only quantities differing in the second order from unity, but probably very nearly equal to each other. Hence it is reasonable to suppose that changes in the condition of the bones, and stature measured on the living or on the corpse, while sensibly affecting M_S, M_F, M_H, M_T, and M_R will produce little or no effect on the numerical constants of the regression formulæ (a) to (k). We shall find that this *à priori* conclusion is borne out by actual measurements. Hence we conclude that Tables V. and VI. may be applied to stature measured on the living or the corpse, to bones measured humid or dry, with or without the cartilage, provided proper modifications are made in the values of the five means. We might even go so far as to predict that provided M_T be properly altered, the stature from tibia reconstruction formulæ will not be much modified, even if the tibia be measured with instead of without the spine. The change, however, in the regression formulæ when the femur is measured in the oblique position is more likely to be of importance, and the correlation between stature and oblique femur has accordingly been worked out. If F′ denote oblique femur we have :—

Male	$M_{SF'} = 44{\cdot}938$,	$\sigma_{F'} = 2{\cdot}331$,	$r_{SF'} = {\cdot}8025$,
Female	$M_{SF'} = 41{\cdot}240$,	$\sigma_{F'} = 2{\cdot}205$,	$r_{SF'} = {\cdot}8007$,

whence for (a) we find :

Male $\quad S - M_S = 1{\cdot}894\,(F' - M_{F'})$,

Female $\quad S - M_S = 1{\cdot}979\,(F' - M_{F'})$.

Thus the regression coefficient is not changed more than ·55 per cent. for males and 1·7 per cent. for females, even in this case where the difference between the maximum and oblique lengths of the femur has been much insisted upon as very significant with regard to stature. Putting in the lengths of the means as found on the corpse, we have:

$$\left.\begin{array}{ll}\text{Male} & S = 81{\cdot}147 + 1{\cdot}894\,F' \\ \text{Female} & S = 72{\cdot}406 + 1{\cdot}979\,F'\end{array}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad \text{(i.)}.$$

The corresponding formulæ for the stature in terms of the maximum length of femur are, as we shall see later:

$$\left.\begin{array}{ll}\text{Male} & S = 81{\cdot}231 + 1{\cdot}880\,F \\ \text{Female} & S = 73{\cdot}163 + 1{\cdot}945\,F\end{array}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad \text{(ii.)}.$$

The extreme oblique femur lengths are for males 39·6 and 49·8, and for females 37·4 and 48·0. Let us calculate the stature of these individuals directly from (i.) and indirectly from (ii.), by putting $F = F' + {\cdot}32$ for males and $F' + {\cdot}33$ for females. We find

	(i.)	(ii.)
Male min.	156·15	156·21
Female min.	146·42	146·53
Male max.	175·47	175·46
Female max.	167·40	167·17

The differences here in these extreme cases are absolutely unimportant for the determination of stature. In other words, the changes in the regression equation are insignificant, when we even make such a change as from oblique to maximum femur length. Accordingly we have the rule, if the oblique length of femur be given, the equations for the maximum length can always be safely used if we add ·32 for the male and ·33 for female to the oblique length in centimetres before using equations of type (ii.).

So far we have generalised Tables V. and VI., having regard to the nature and condition of the organs when measured. We see that the regression coefficients will remain sensibly constant. Our general considerations on pp. 177 and 178 indicate the limits under which these regression coefficients may be considered constant for different local races. But the constancy of the regression coefficients is not sufficient to preserve the constancy of the linear reconstruction formulæ for stature. It would be of no service if M_S, M_F, M_H, M_T, M_R varied from local race to local race absolutely independently. Now if m_0 be the mean of a not directly selected organ, and m_1, m_2, m_3 . . . the means of any other organs, the constant part in a reconstruction formula will with the notation of p. 172, be:

$$m_0 + \frac{R_{01}}{R_{00}}\frac{\sigma_0}{\sigma_1}m_1 + \frac{R_{02}}{R_{00}}\frac{\sigma_0}{\sigma_2}m_2 + \ldots + \frac{R_{0n}}{R_{00}}\frac{\sigma_0}{\sigma_n}m_n.$$

It is shown in the memoir on selection to which I have previously referred, that this expression remains the same for all local races, and equal to its value in the original stock under precisely the same conditions (stated on p. 177) as the regression coefficients themselves remain constant. Hence we have the same degree of justification in applying our whole stature reconstruction formula from one race to a second, as in applying the regression coefficients.

(7.) Re-examining Tables V. and VI. with a view to drawing one or two general conclusions before we proceed further, we notice :

(i.) The probable error of the reconstruction of the stature of a single individual is never sensibly less than two centimetres, and if we have only the radius to predict from may amount to $2\frac{2}{3}$ centims.

Hence no attempt to reconstruct the stature of an individual from the four chief long bones can possibly exceed this degree of accuracy on the average, at any rate no *linear* formula.* No other linear formulæ will give a better, or indeed as good a result as the above.

The reconstruction of racial stature is naturally more accurate, since if we reconstruct the mean from p bones of one type, the probable error is reduced by the multiplier $1/\sqrt{p}$. At the same time we must bear in mind that possibly a definite, if small amount of direct, selection by stature has actually taken place in the differentiation of human races, and accordingly the values of e given in Tables V. and VI. are not absolutely true measures of the probable error of racial reconstruction, even when one or more of the long bones have not been directly selected. A direct selection of the long bones is usually evidenced by one or more of the formulæ giving discordant results. When, as will be seen later to be usually the case, several of the formulæ give results well in accordance with each other, then we may assume that $2/\sqrt{p}$ centims. is an approximate† measure of the probable error of the reconstructed stature.

(ii.) The four long bones give for males the least probable error, but with sensibly equal accuracy and less arithmetic we may use F & H, F + T or F & T ; then follow fairly close together H & R, F or H alone ; T alone is sensibly worse, and R is worst of all. It is noteworthy that H is better than T, and the H & R is sensibly as good as F alone.

Turning to female stature reconstruction, we notice that the order of probable errors is considerably altered. Tibia and radius now play a more important part in the determination of stature. The four long bones still give the best result ; F & T, and F + T follow closely ; then come F & H, and F alone ; followed at some distance by H & R, and H alone, but both these are now worse than T alone ; last of

* I shall return to the question of the linearity of the formula, when dealing later with the stature of giants and dwarfs, see p. 222.

† It must be remembered that we have, as a rule, a number of long bones which in part do not even belong to the same skeletons. This result accordingly is the probable error of a group to whom one kind of long bones belonged, rather than the probable error of the racial stature as reconstructed.

all comes R, as before. Thus while in the case of men the humerus, in the case of women the tibia is the better bone of the two to predict stature from. A simple examination shows the emphasising of the tibia coefficients in the case of woman. The same holds for the radius coefficients, but in a still more marked degree.

Both male and female show in the regression formula for the four long bones a remarkable feature which they have in common with the anthropomorphous apes, namely, the *negative* character of the partial regression coefficient. *The longer the radius for the same value of femur, humerus, and tibia, the shorter will be the stature.* In this point women are more akin to the anthropomorphous apes than man, for the negative radius coefficient in formula (k) is nearly four times as large. The tibia also has a coefficient almost double that of the male, and pointing in the same direction.

(iii.) A comparison of Table V. with Table VI. shows us that man and woman are in all probability not only differentiated from a common stock directly with regard to stature, but also directly with regard to all other long bones. If we use female to construct male stature, or male to reconstruct female, we get surprisingly bad results. The fact that the formula (k) for female diverges in a direction from that of man, which approximates to that of at least one species of anthropomorphous ape, is only of course a round-about quantitative manner of indicating, what is obvious on other grounds, that a substantial part of the differentiation of male and female took place in that part of the history of man's evolution which preceded his differentiation from the stock common to him and certain of the anthropomorphous apes.

(8.) Before we modify our formulæ in Tables V. and VI. to suit the reconstruction of stature by measurements on prehistoric and other bones, we will put the numerical values for M_S, M_F, M_T, M_H, M_R into these formulæ. This will serve a double purpose (i.), it will enable us to verify our formulæ on ROLLET's material, and (ii.) it will place at the disposal of the criminal authorities the best formulæ yet available for the reconstruction of the stature of an adult of whom one or more members have been found under suspicious circumstances.

FORMULÆ for the Reconstruction of the Stature as Corpse, the Maximum Lengths of F, H, R, and of T without Spine being measured with the Cartilage on and in a Humid State.*

TABLE VII.—Male.

(a) $S = 81{\cdot}231 + 1{\cdot}880\,F.$

(b) $S = 70{\cdot}714 + 2{\cdot}894\,H.$

(c) $S = 78{\cdot}807 + 2{\cdot}376\,T.$

(d) $S = 86{\cdot}465 + 3{\cdot}271\,R.$

(e) $S = 71{\cdot}164 + 1{\cdot}159\,(F + T).$

(f) $S = 71{\cdot}329 + 1{\cdot}220\,F + 1{\cdot}080\,T.$

* The probable error in these and later tables are not reproduced; they may be considered to be substantially the same as in V. and VI.

TABLE VII.—Male (continued).

(*g*) $S = 67{\cdot}025 + 1{\cdot}730\,(H + R)$.
(*h*) $S = 69{\cdot}870 + 2{\cdot}769\,H + {\cdot}195\,R$.
(*i*) $S = 68{\cdot}287 + 1{\cdot}030\,F + 1{\cdot}557\,H$.
(*k*) $S = 66{\cdot}918 + {\cdot}913\,F + {\cdot}600\,T + 1{\cdot}225\,H - {\cdot}187\,R$.

TABLE VIII.—Female.

(*a*) $S = 73{\cdot}163 + 1{\cdot}945\,F$.
(*b*) $S = 72{\cdot}046 + 2{\cdot}754\,H$.
(*c*) $S = 75{\cdot}369 + 2{\cdot}352\,T$.
(*d*) $S = 82{\cdot}189 + 3{\cdot}343\,R$.
(*e*) $S = 69{\cdot}525 + 1{\cdot}126\,(F + T)$.
(*f*) $S = 69{\cdot}939 + 1{\cdot}117\,F + 1{\cdot}125\,T$.
(*g*) $S = 70{\cdot}585 + 1{\cdot}628\,(H + R)$.
(*h*) $S = 71{\cdot}122 + 2{\cdot}582\,H + {\cdot}281\,R$.
(*i*) $S = 67{\cdot}763 + 1{\cdot}339\,F + 1{\cdot}027\,H$.
(*k*) $S = 67{\cdot}810 + {\cdot}782\,F + 1{\cdot}120\,T + 1{\cdot}059\,H - {\cdot}711\,R$.

Should the stature of the living be required from the corpse stature, then 1·26 centim. should be subtracted for the male and 2 centims. for the woman.* If a *left* member has been measured instead of a right, a small allowance might be made for this on the basis of ROLLET's means for the left side, but such refinement is hardly of service when we look at the probable error of an individual reconstruction, *i.e.*, about 2 centims. We shall return to the point later as a second order error in racial reconstruction.

In order to indicate to the reader the degree of confidence he may place in the above formulæ of reconstruction, and also their relative value, I give below a table of observed and reconstructed statures in the case of 20 out of ROLLET's 100 cases. The individuals, in order to avoid any bias, were taken at random as the 5th, 10th, 15th, &c. entries through ROLLET's Tables. The observed statures are recorded and the differences as obtained by the formulæ (*a*)–(*k*). Under the heading M, I give the differences which would be yielded by M. MANOUVRIER's Table. It is formulæ (*f*), (*h*), (*i*), and (*k*) on which I should lay most weight, and which should be used whenever the material is available.

* For the reasons for these numbers, see p. 191 below.

TABLE IX.—Table of Differences of Actual and Reconstructed Male Stature.

No.	5		10		15		20		25		30		35		40		45		50		Mean error.	
	P.	M.	P.	M.	P.	M.	P.	M.	P.	M.	P.	M.	P.	M.	P.	M.	P.	M.	P.	M.	P.	M.
(*a*)	+5	+6	−1	0	+7	+7	−1	0	+1	+1	−2	−1	−5	−5	−8	−7	−1	−1	−2	0	3·3	2·8
(*b*)	+6	+6	−2	−3	0	+1	0	+1	+3	+4	−3	−2	0	+2	−7	−6	−1	+1	−1	+5	2·3	3·1
(*c*)	+2	+4	0	+2	0	+1	−1	0	+3	+3	0	0	−1	−1	−8	−7	+1	+3	0	+4	1·6	2·5
(*d*)	+4	+5	−2	−3	0	+1	0	+1	+3	+4	−3	−2	−2	−2	−6	−5	−5	−5	0	+7	2·5	3·5
(*e*)	+3	..	−1	..	+4	..	−1	..	+2	..	−1	..	−3	..	−9	..	0	..	0	..	2·4	..
(*f*)	+4	..	−1	..	+5	..	−1	..	+2	..	−1	..	−3	..	−9	..	0	..	0	..	2·6	..
(*g*)	+5	..	−3	..	0	..	0	..	+4	..	−3	..	−1	..	−7	..	−2	..	−1	..	2·6	..
(*h*)	+5	..	−3	..	0	..	0	..	+3	..	−3	..	0	..	−7	..	−1	..	−1	..	2·3	..
(*i*)	+5	..	−2	..	+4	..	0	..	+2	..	−2	..	−2	..	−8	..	−1	..	0	..	2·6	..
(*k*)	+4	+5	−2	−1	+3	+3	−1	+1	+2	+3	−2	−1	−2	−2	−8	−6	0	0	0	+4	2·4	2·6
M.D.	−4·3	..	−1·7	..	+2·1	..	− ·5	..	+2·5	..	−2·0	..	−1·9	..	−7·7	..	−1	..	− ·5	..	2·46	2·975
Actual stature	159		161		163		165		166		167		170		171		173		177			

TABLE X.—Table of Differences of Actual and Reconstructed Female Stature.

No.	5		10		15		20		25		30		35		40		45		50		Mean error.	
	P.	M.	P.	M.	P.	M.	P.	M.	P.	M.	P.	M.	P.	M.	P.	M.	P.	M.	P.	M.	P.	M.
(*a*)	+2	+2	−1	+2	+2	+3	+3	+4	+3	+4	−2	−2	+5	+7	0	+1	−1	0	− 3	+1	2·2	2·6
(*b*)	0	−2	−1	−2	+1	+3	+3	+5	+1	+3	+1	+3	+3	+5	0	+1	+1	+3	− 7	−4	1·8	3·1
(*c*)	0	+1	+3	+4	+1	+3	+3	+5	+2	+3	−2	0	+5	+7	+4	+6	−2	−1	− 5	−1	2·7	3·1
(*d*)	+2	+1	+3	+3	+1	+3	+2	+5	+2	+3	+2	+4	+3	+5	−3	+1	0	+3	−10	−7	2·8	3·5
(*e*)	+1	..	0	..	+2	..	+3	..	+3	..	−2	..	+6	..	+2	..	−1	..	− 3	..	2·3	..
(*f*)	+1	..	0	..	+2	..	+3	..	+3	..	−2	..	+6	..	+2	..	−1	..	− 4	..	2·4	..
(*g*)	+1	..	+1	..	+1	..	+3	..	+1	..	+2	..	+3	..	−1	..	+1	..	− 7	..	2·1	..
(*h*)	0	..	0	..	+1	..	+3	..	+1	..	+1	..	+3	..	0	..	+1	..	− 7	..	1·7	..
(*i*)	+1	..	−1	..	+2	..	+3	..	+3	..	−1	..	+5	..	0	..	0	..	− 4	..	2·0	..
(*k*)	0	0	0	+1	+1	+3	+3	+5	+2	+3	−2	+1	+5	+6	+3	+2	−1	+1	− 3	−3	2·0	2·4
M.D.	+ ·8	..	− ·4	..	+1·4	..	+2·9	..	+2·1	..	− ·5	..	+4·4	..	+ ·7	..	− ·3	..	−5·3	..	2·20	3·075
Actual stature	148		149		152		152		153		155		156		158		160		171			

The first point with regard to these tables is to note how, even with only ten cases, the mean errors accord closely with their theoretical values. For example, the mean error of k is 2·31 centims. for male and 2·35 centims. for female when deduced from the probable errors in Tables V. and VI.; the observed mean errors in the two cases are 2·4 centims. for male and 2·0 centims. for female. The mean of the mean errors is for male 2·57 centims., and for females 2·66 centims.; the observed values are 2·46 centims. and 2·2 centims. for the two sets of ten cases respectively. We conclude at once that our formulæ, and therefore certainly any other linear formulæ, will not give results with a probable error of less than 2 centims. for the individual stature. In our case the worst error is one of 8 centims. (about 3 inches) in the stature of a man of 47 years of age, who must have had a remarkably long trunk in proportion to his leg and arm-lengths. It would be impossible to have predicted his stature any closer without taking into account the correlation between stature and trunk. The preservation of the vertebral column is comparatively rare, and at present there are absolutely no statistics on the relationship between the dimensions of any part of it and living stature. We must therefore content ourselves with a probable error of 2 centims., and expect, but rarely, to make an error of as much as 8 centims. in the reconstructing of the stature of an individual.

We have placed in the above tables M. MANOUVRIER's results as calculated from his 'Table-barême.' They give somewhat larger mean errors than our formulæ, which would have been probably reduced somewhat if we had excluded, as he has done, the aged. We have seen, however (p. 179), that there seems no reason to exclude the aged women, and in the case of the seven men over 60, he actually in three cases under-estimates their stature. In other words, while in four cases his table might have given better results for adult stature, in three it would have given worse results. If we allow a mean old-age shrinkage of 3 centims.*—an amount hardly justified by averaging the adult and old-age portions of ROLLET's returns—we should find that MANOUVRIER's method would have made a total error of 17 centims. in estimating the stature of these seven old men in youth, whereas it gives a total error of 16 centims. in estimating their old-age stature. Thus there might, perhaps, be a small, but it would not be a very sensible, reduction of the mean errors of the results given by MANOUVRIER's 'Table-barême' had we excluded the old age cases.

What deserves special notice is that our formula (k) gives a better result than the mean of all the formulæ (a)-(k), and a better result than the mean of the values obtained by MANOUVRIER's method for the four long bones.

(9.) The next stage in our work is to so modify Tables IX. and X. that they will serve for the reconstruction of the *living* stature from bones *out of which all the animal matter has disappeared, and which are dry and free of all cartilage.* This

* This value is that given by M. MANOUVRIER himself, 'Mémoires de la Société d'Anthropologie de Paris,' vol. 4, p. 356, 1892.

is either the condition in which we find the bones of a prehistoric or early race, or it is one to which they are soon reduced on being preserved in museum or laboratory.

The first question which arises is the difference between the *mean* stature of the living and the mean stature of the corpse for both sexes. It is impossible to measure this difference satisfactorily on a sufficiently large number of individuals, and then take the mean difference. If we suppose ROLLET's individuals to be an average sample of the French race, then we must place in Tables V. and VI. for M_S on the left the mean heights of French men and French women.

Now there is a considerable amount of evidence to show that the mean height of Frenchmen is 165 centims. almost exactly. The anthropometric service of M. BERTILLON gives 164·8 centims., and this is the stature furnished by the measurements for military recruiting.* M. MANOUVRIER takes 165 centims. as the mean height, and as by selecting only twenty of ROLLET's cases he gets a mean height of about 167 centims. for the corpse, he concludes that 2 centims. must be deducted from the corpse length to get the living stature. In our case all we have to do is then to put $M_S = 165$ centims. At the same time, BERTILLON's numbers probably include many men over 50, and the recruiting service many men not yet fully grown; hence it seems to me doubtful whether 2 centims. really represents the difference between living and dead stature. 165 centims. is probably a good mean height for the whole adult population,† and should accordingly be compared with ROLLET's whole adult population, which has a mean of 166·26 centims. I accordingly conclude that 1·26 centims. is on the average a more reasonable deduction to make in order to pass from the dead to the living stature of the general population. In the course of my investigations, however, no use is made of this difference, but M_S given its observed living value.

The value for women is far less easy to obtain, as a good series of French statistics entirely fails. The mean given in the footnote below is clearly only that of a special class. MANOUVRIER has found from 130 women, between 20 and 40 years of age, inscribed in BERTILLON's registers the mean height 154·5 centims., and RAHON holds that this is the best result yet obtained.‡ But the mean height of ROLLET's material is 154·02 centims. (see my p. 180), and, as we have seen, this is not sensibly increased by taking only the women in the prime of life (see p. 179, above). If 154·5 centims. were the mean living stature of ROLLET's women, we should have to suppose a shrinkage of stature in women when the corpse is measured, whereas in the case of men the corpse length is greater than the living stature. RAHON, disregarding his own statement as to 154·5 centims. being the best value, follows MANOUVRIER in deducting 2 centims. from the stature as corpse to get the living stature. MANOUVRIER's

* 'Mémoires de la Société d'Anthropologie de Paris,' vol. 4, p. 413, 1893.

† For special classes the stature is considerably greater. See the values 166·8 centims. for male and 156·1 centims. for female given in the 'Mém. Soc. d'Anthrop.,' vol. 3, 1888.

‡ *Loc. cit.*, p. 413.

rule for deducting 2 centims. seems based partly on a comparison of BERTILLON'S measurements for men, with his own selection from ROLLET'S material, which give mean heights 165 centims. and 167 centims. respectively, and partly on the measurement standing and reclining of six men and four women.* Now the reader should notice that in our method of reaching the reconstruction equations, we are not concerned with the amount to be subtracted from an individual stature, but with the mean living stature of the population which ROLLET has sampled. Now there is a quantity which has very remarkable constancy, namely, the sexual ratio for stature. The mean male is to the mean female stature in a great variety of races and classes as 13 to 12.† If, therefore, ROLLET'S women are the same class as his men, we should expect their living stature to have had a mean $= \frac{12}{13}$, that of the men $= \frac{12}{13}(165) = 152 \cdot 3$ centims. We have seen that from the registers of BERTILLON the mean stature of women between 20 and 40 was 154·5 centims.; these probably include a considerable number of stout tramps or vagabonds, not a fair sample of those who would find their way into the Lyons Hospital. TENON measured in 1783 60 women of the village of Mussey, and obtained a mean stature of 150·6 centims.‡ If we take the mean of these groups we find 152·55 centims. as the mean stature for French women of the lower classes; this differs by less than 3 millims. from the result already suggested by using the sex ratio. I am, accordingly, inclined to hold that the best that can be done at present is to take 152·3 centims. as the mean stature of Frenchwomen of the class sampled by ROLLET.

The next stage in our work is to consider the difference in length of the long bones, as measured in the dissecting room by ROLLET and his assistants, and as they would be measured in the case of a primitive race whose bones had been exhumed, and then been preserved and dried before measuring. ROLLET merely observes that he kept several of his bones for some months, and, the cartilage being then dry, they measured on the average 2 millims. less.§ On the strength of this, MANOUVRIER,‖ and he is followed by RAHON, add 2 millims. to the length of each prehistoric bone when reconstructing the stature. Now I am doubtful whether this gives a really close enough result. ROLLET measured the bones in the dissecting room, the cartilages were still on, and the animal matter in the bones, but in the case of prehistoric and ancient bones this does not at all represent the state of affairs. Nor are they merely such bones with the cartilage dry; the cartilage, together with the animal matter, has entirely gone. There are accordingly two allowances to be made (a) for the cartilage, and (b) for the disappearance of the animal matter and drying of the bone.

* 'Mémoires de la Société d'Anthropologie de Paris,' vol. 4, p. 384, 1892.

† ROLLET'S corpse statures give a sexual ratio = 1·079.

‡ "Notes manuscrites relatives à la stature de l'homme, recueillies par VILLERME," 'Annales d'Hygiène,' 1833.

§ ROLLET, *loc. cit.*, p. 24.

‖ MANOUVRIER, *loc. cit.*, p. 386.

(a.) *Allowance for the Cartilage.**

The thicknesses of the cartilages here cited are taken from HEINRICH WERNER'S Inaugural Dissertation, 'Die Dicke der menschlichen Gelenkknorpel,' Berlin, 1897. They are only discussed for the cases required for the long bones as measured by ROLLET and used in my reconstruction formulæ.†

Femur.—(i.) Maximum length ("straight") from top of head to bottom of internal condyle (F).

(ii.) "Oblique" length from top of head to plane in contact with both condyles (F′).

For both we have for articular cartilage at upper end 2 millims., at lower end 2·5 millims., or the total together of 4·5 millims. This is more than double MANOUVRIER'S allowance.

Humerus.—Length from top of head to lowest point of internal margin of trochlea (H). At upper end we must allow 1·5 millims., and at lower 1·3 millims., altogether 2·8 millims. for articular cartilage.

Tibia.—The spine is excluded by ROLLET. The length is from plane of upper surfaces (margins) to tip of internal malleolus (T). In this case the articular cartilage has only to be allowed for at the upper end, and is here 3 millims.

Radius.—The length is measured from top of head to tip of styloid process (R). The allowance must be for articular cartilage at upper end only, and is 1·5 millims.

(b.) *Allowance for Animal Matter in Bones.*

Here unfortunately I had not the same amount of data to guide me. The best hypothesis to go upon seemed to be that a thoroughly dry bone, free from all animal matter, would, if it were thoroughly soaked, approximate to the condition of the bones measured by ROLLET. BROCA, who has written a very elaborate memoir on the effect of humidity in altering the capacity and dimensions of skulls, has referred incidentally to the extension of the femur by humidity.‡ He took three femurs, one macerated in 1873, one of the 15th century, and one of the polished stone age. After soaking for seven days, he found an increase of 1·5 millims. in the first, 1·5 millims. in the second, and 1 millim. in the third. These results, he says, compare very well with WELCKER'S,§ who gives 1·2 millims. for increase of length of femur with humidity.

It was somewhat difficult to make fresh experiments on a considerable number of

* The details of this section I owe entirely to my colleague, Professor GEORGE THANE, who in this matter, as in many others, has given me most ready and generous assistance.

† On another occasion I may take into consideration the ulna and fibula, but they have nothing like the importance for stature of the bones here dealt with.

‡ 'Mémoires d'Anthropologie de PAUL BROCA,' vol. 4, pp. 163 *et. seq.*; p. 195.

§ 'Ueber Wachstum und Bau des menschlichen Schädels,' p. 30, 1862. WELCKER only dealt with one male femur, and soaked it for three days.

long bones of each kind, but it seemed worth while to measure dry and thoroughly humid a bone of each type. A bone of each type was placed at my disposal by Professor THANE, and they were measured independently on each occasion by Mr. BRAMLEY-MOORE and myself. In the one or two instances in which we did not agree within ·02 millim., the bone was again independently measured. Our results were as follows :—

TABLE XI.—Lengths of Long Bones, Dry and Wet, in Centimetres.

	Dry as received.	24 hours in water.	120 hours in water.	72 hours drying.
F.	42·58	42·79	42·84	42·50
T.	37·41	37·52	37·58	37·37
H.	34·52	34·62	34·65	34·48
R.	23·11	23·20	23·19	23·00

The bones themselves were between 200 and 300 years old.* They were only allowed to stand two hours for the water to run off before they were measured after soaking. In the case of the final 72 hours' drying, it concluded with six hours in the neighbourhood of a stove. The first column may be considered to represent the average humidity of bones preserved in a museum ; the last column complete dryness. It seems to me that the difference between the first and third column is what we in general have to deal with. In this case we have a difference of

F.	T.	H.	R.
2·6 millims.	1·7 millims.	1·3 millims.	·7 millim.

between dry and humid bones.

The difference between this result for the femur and BROCA's is very considerable. I think it is due to the fact that he allowed his bones to dry for 24 hours in a room before measuring them. I was much impressed by the rapidity with which the bones dried, and their conditions, of course, are very unlike what they would be if containing or surrounded by animal matter. It is clear that the extensions due to humidity are not by any means proportional to the length of the bone, and it would be quite futile to attempt any percentage allowance for the extension due to this cause, the effect of which clearly differs with the different structure of different parts of the same bone. I have accordingly thought it best to subtract the above quantities from ROLLET's means, M_F, M_T, M_H, and M_R, and to consider the results so derived as giving the means of ROLLET's material on the supposition that the bones were dry and free from animal matter. Even so I do not think we shall err in over-estimating the difference between the lengths of living and dead bone. Making allowances (a) and (b) we have finally to subtract from ROLLET's results for

* See additional note, p. 244.

M_F.	M_H.	M_T.	M_R.
7·1 millims.	4·1 millims.	4·7 millims.	2·2 millims., respectively.

Making these subtractions (which are sensibly different from MANOUVRIER's allowance of 2 millims. for each bone), we are in a position to find the reconstruction formulæ connecting living stature with dry bone entirely free of animal matter. We have for the French population, if $M_{S''}$ denotes living mean stature, and $M_{F''}$, $M_{H'}$, $M_{T''}$, $M_{R''}$, the mean lengths of the corresponding dry bones in centimetres :

TABLE XII.

	$M_{S''}$.	$M_{F''}$.	$M_{H''}$.	$M_{T''}$.	$M_{R''}$.
Male	165·0	44·52	32·60	36·34	24·17
Female	152·3	40·86	29·36	32·97	21·27

If we want the mean oblique length of the femur $M_{F'}$, we must follow the rule given on p. 184, and we find $M_{F'} = 44·20$ for male and $= 40·53$ for female. M. RAHON has measured the lengths of a large collection of long bones in the Faculty of Medicine of Paris,* and he finds :—

Femur, oblique length, 62 males, mean 44·1 (44·2).
,, ,, ,, 38 females, ,, 39·6 (40·5).
Humerus, maximum length, 44 males, ,, 32·3 (32·6).
,, ,, ,, 39 females, ,, 29·2 (29·4).

My results are placed in brackets, and it is clear that for these bones the allowances for cartilage and animal matter have been very satisfactory ; there has certainly been no over-correction, although in the case of the femur our allowance is more than thrice, and in that of the humerus more than twice M. MANOUVRIER's.

M. RAHON does not give the measurement of the radius, but he does of the tibia, and in this case there is undoubtedly some source of error in his result, or in the collection. He gives :—T for 53 males, mean = 37·7 ; for 26 female = 35·7. Now ROLLET's material for 50 of either sex gives, male mean = 36·8, and female = 33·4, without allowance for the cartilage or presence of animal matter. Allowing for these, RAHON's measurements are, male, 1·4 centims., and female, 2·7 centims. *too large.* These are errors much beyond those of the determinations, which have probable errors of about ·17 to ·18 centim. RAHON, since he is using MANOUVRIER's method must be supposed to be measuring the tibia in the same manner as ROLLET, *i.e.*, with the malleolus and without the spine. But even supposing he had included the spine,

* *Loc. cit.*, p. 413.

it could not make this great difference.* That there is some substantial error is evidenced by the fact that tibias of these dimensions would give a reconstructed stature for French males of 168·2 centims. instead of 165 centims., and for French females of 158·9 centims. instead of 152·3 centims. RAHON himself, on the basis of MANOUVRIER's method, forms the estimates of 166·8 centims. and 159·5 centims. respectively,—the latter, at any rate, a quite impossible height for the French female population.

(10.) We are now in a position to write down the reconstruction formulæ for living stature from dry long bones; they are the following:—

TABLE XIV.—Male. Living Stature from Dead† Long Bones.

(*a*) $S = 81{\cdot}306 + 1{\cdot}880\ F.$
(*b*) $S = 70{\cdot}641 + 2{\cdot}894\ H.$
(*c*) $S = 78{\cdot}664 + 2{\cdot}376\ T.$
(*d*) $S = 85{\cdot}925 + 3{\cdot}271\ R.$
(*e*) $S = 71{\cdot}272 + 1{\cdot}159\ (F + T).$
(*f*) $S = 71{\cdot}443 + 1{\cdot}220\ F + 1{\cdot}080\ T.$
(*g*) $S = 66{\cdot}855 + 1{\cdot}730\ (H + R).$
(*h*) $S = 69{\cdot}788 + 2{\cdot}769\ H + {\cdot}195\ R.$
(*i*) $S = 68{\cdot}397 + 1{\cdot}030\ F + 1{\cdot}557\ H.$
(*k*) $S = 67{\cdot}049 + {\cdot}913\ F + {\cdot}600\ T + 1{\cdot}225\ H - {\cdot}187\ R.$

TABLE XV.—Female. Living Stature from Dead† Long Bones.

(*a*) $S = 72{\cdot}844 + 1{\cdot}945\ F.$
(*b*) $S = 71{\cdot}475 + 2{\cdot}754\ H.$
(*c*) $S = 74{\cdot}774 + 2{\cdot}352\ T.$
(*d*) $S = 81{\cdot}224 + 3{\cdot}343\ R.$
(*e*) $S = 69{\cdot}154 + 1{\cdot}126\ (F + T).$
(*f*) $S = 69{\cdot}561 + 1{\cdot}117\ F + 1{\cdot}125\ T.$
(*g*) $S = 69{\cdot}911 + 1{\cdot}628\ (H + R).$
(*h*) $S = 70{\cdot}542 + 2{\cdot}582\ H + {\cdot}281\ R.$
(*i*) $S = 67{\cdot}435 + 1{\cdot}339\ F + 1{\cdot}027\ H.$
(*k*) $S = 67{\cdot}469 + {\cdot}782\ F + 1{\cdot}120\ T + 1{\cdot}059\ H - {\cdot}711\ R.$

Remarks.—(i.) If the femur has been measured in the oblique position and not

* Dr. WARREN found for the New Race from Egypt the mean length of spine for 85 males = ·96 centim., and for 115 females = ·87 centim. These numbers should be introduced as an addition to M_T in Tables V. and VI., when the tibia has been measured including spine.

† The word "dead" is here used to denote a bone from which all the animal matter has disappeared, and which is in a dry state.

straight, add ·32 centim. for male and ·33 centim. for female to the length before using the above formulæ.

(ii.) If the tibia has been measured with, and not without, the spine, subtract ·96 centim. for male and ·87 centim. for female from the length before using the above formulæ.

(iii.) The above formulæ have been determined from the *right* members; a small error, of the second order as a rule, arises when the left is used. The following numbers are determined from ROLLET's measurements; they give the amount to be added to a left bone when it is used in the formulæ:—

	Femur.	Humerus.	Tibia.	Radius.
Male	−·04	+·42	+·18	+·28
Female	+·03	+·51	+·09	+·19

The femur change is insignificant. In most statements of lengths the rightness or leftness of the bone is not given, and hence, no correction can generally be made for an individual. The error will, however, be hardly sensible except in the case of the humerus and radius. If a considerable number of bones have been averaged, probably half may be looked upon as right and half left, and in this case half the above corrections may be added to the average. In any case, it is probably only the estimate based on the humerus and radius which need to be corrected in this manner.

Even here it is a problem how far there is a racial character in this right and left-sideness. Results due to CALLENDER, ROBERTS, GARSON, HARTING, and RAYMONDAUD are cited by ROLLET (*loc. cit.*, pp. 53–60), but being based either on very few cases, on measurements on the living, or on unsexed material, they are not of much service for our present purpose. Results of much greater value for racial comparison have been given by Dr. WARREN for the Naqada race ('Phil. Trans.,' B, vol. 189, p. 135 *et seq.*). He finds:—

	Femur.	Humerus.	Tibia.	Radius.
Male	−·11	+·34	−·08	+·20
Female	−·16	+·57	−·105	+·305

Dr. WARREN's results are for the oblique femur, and from centre to centre of the articulate surfaces in the case of tibia and radius. Thus they are not directly comparable with the results for the French. On the whole, if the bone is stated to be left, we may add ·45 for the humerus and ·25 for the radius, leaving the femur and tibia unaltered. These additions are approximately the same for both sexes.

(11.) Before we proceed to apply the formulæ in Tables XIV. and XV. to the general reconstruction of stature, it is desirable to obtain some measure of confidence in the application of the formulæ. We require to test them by finding what sort of results they give for a second race.* That race ought to be as widely divergent from the French as possible, but one in which the stature as well as the measurement of the long bones is known. There are, I believe, no other measurements than those of ROLLET, in which both the stature and long bones have been measured on the same individuals. A fairly complete series of measurements of the long bones of the Aino have, however, been made by KOGANEI, and he has also determined the mean living

* There is very little detail for verification of our results even in the same race. M. MANOUVRIER gives the dimensions of seven men, six of whom were assassins (see p. 387 of *loc. cit.* in footnote, p. 171 above). I have reconstructed the statures of these seven individuals from our ten formulæ with the following results:—

	Assassins.						A.B. Name unknown.
	MATHELIN.	SELLIER.	KAPS.	RIVIÈRE.	GAMAHUT.	ALORTO.	
Long bones:—							
F.	50·12	45·22	44·52	44·72	42·72	44·82	39·52
H.	35·4	32·6	31·9	32·8	30·5	33·3	29·8
T.	43·3	36·4	37·7	35·3	37·6	36·3	33·4
R.	27·6	24·1	24·4	23·8	24·7	24·5	22·1
Stature:—							
(*a*)	175·5	166·3	165·0	165·4	161·6	165·6	155·6
(*b*)	173·1	165·0	163·6	165·6	158·9	167·0	156·9
(*c*)	181·6	165·2	168·2	162·5	168·0	164·9	158·0
(*d*)	176·2	164·8	165·7	163·8	166·7	166·1	158·2
(*e*)	179·6	165·9	166·6	164·0	164·4	165·3	155·8
(*f*)	179·3	165·9	166·5	164·1	164·2	165·3	155·7
(*g*)	175·9	165·0	164·3	164·8	162·4	166·8	156·6
(*h*)	173·2	164·8	162·9	165·3	159·1	166·8	156·6
(*i*)	175·1	165·7	163·9	165·5	159·9	166·4	154·9
(*k*)	177·0	165·6	164·8	164·8	161·4	166·2	155·5
Mean . . .	176·7	165·4	165·2	164·6	162·7	166·0	156·4
Actual . . .	180·0	173·4	171·7	168·3	165·2	160·9	156·6
Difference . .	−3·3	−8·0	−6·5	−3·7	−2·5	+5·1	−0·2

While the means of the whole series of formulæ agree very closely with the results of (*k*), they differ very markedly from the actual statures. I do not know under what conditions the long bones or the statures were measured. A suggestive but somewhat hasty conclusion (failing more data) would be that the average assassin is tall (170 centims. against the general French population of 165 centims.), but his limbs are relatively short, *i.e.*, he is long of trunk. Anyhow, the divergence is noteworthy.

stature from a fairly large series of living individuals.* Now the Aino are a race widely divergent from the French, and therefore, although the stature and long bones are not measured on the same group, we are likely to get a very good test of the safety with which we can apply our stature results from one local race to a second. The stature, as measured by KOGANEI on 95 living males, was 156·70 centims., and on 71 living females, 147·10 centims. The long bone measurements were made on 20 to 25 female and 40 to 45 male skeletons, not quite from the same districts as the living groups. The maximum length of the long bones is given in the paper by Miss LEE and myself, 'Roy. Soc. Proc.,' vol. 61, pp. 347–8, and accordingly allowance must be made for the spine in the case of the tibia. We then have the following values for insertion in Tables XIV. and XV. :—

	Femur.	Humerus.	Tibia.	Radius.
Male.	40·77	29·50	32·93	22·91
Female	38·20	27·72	30·99	21·08

TABLE XVI.—Reconstruction of Aino Stature.

Formula.	Male.		Female.	
	Calculated value.	Difference.	Calculated value.	Difference.
(*a*) Male	157·95	+1·25	153·12	+6·02
(*b*) ,, ...	156·01	−0·69	150·86	+3·76
(*c*) ,, ...	156·90	+0·20	152·30	+5·20
(*d*) ,, ...	160·90	+4·20	154·88	+7·78
(*e*) ,, ...	156·69	−0·01	151·46	+4·36
(*f*) ,, ...	156·75	+0·05	151·34	+4·24
(*g*) ,, ...	157·52	+0·82	151·28	+4·18
(*h*) ,, ...	155·94	−0·76	150·65	+3·55
(*i*) ,, ...	156·32	−0·38	150·90	+3·80
(*k*) ,, ...	155·90	−0·80	150·53	+3·43
Observed	156·70	0	147·10	0
(*a*) Female . . .	152·14	−4·56	147·14	+0·04
(*b*) ,, . . .	152·72	−3·98	147·82	+0·72
(*c*) ,, . . .	152·33	−4·37	147·66	+0·56
(*d*) ,, . . .	157·82	+1·12	151·69	+4·59
(*e*) ,, . . .	152·14	−4·56	147·06	−0·04
(*f*) ,, . . .	152·14	−4·56	147·18	+0·08
(*g*) ,, . . .	155·23	−1·47	149·36	+2·26
(*h*) ,, . . .	153·15	−3·55	148·04	+0·94
(*i*) ,, . . .	152·32	−4·38	147·05	−0·05
(*k*) ,, . . .	151·14	−5·56	146·48	−0·62

* "Mittheilungen aus der Medicinischen Facultät der k. Japanischen Universität," vol. 2, I. and II., Tokio, 1893 and 1894.

Several results may be noted with regard to this table: (i.) In the first place let us compare our results with those which would be given by M. MANOUVRIER'S Tableau II.* Corresponding to our cases (*a*), (*b*), (*c*), (*d*) he would obtain:—

	Male.		Female.	
	Calculated value.	Difference.	Calculated value.	Difference.
(*a*)	156·80	+0·10	145·36	−1·74
(*b*)	152·47	−4·23	146 86	−0·24
(*c*)	155·59	−1·11	147·32	+0·22
(*d*)	161·13	+4·43	153·08	+5·98
(*f*)	156·19	−0·51	146·34	−0·76
(*h*)	156·80	+0·10	149·92	+2·82
(*i*)	154·63	−2·07	146·11	−0·99
(*k*)	156·50	−0·20	148·15	+1·05
Observed	156·70	0	147·10	0

Here (*f*), (*h*), (*i*), and (*k*) are obtained by taking means of the results for the single bones. Comparing the first four formulæ with my first four, M. MANOUVRIER has for male a mean error of 2·47 centims. against my 1·58 centims., and for the last four a mean error of ·72 centim. as against my ·50 centim. His error in stature, as deduced from the male humerus, is greater than my error from the radius even. In the male measurements M. MANOUVRIER has a mean error of 2·04 centims. against my 1·48 centims. in the first four results, and one of 1·40 centims. against my ·42 centim. in the last four results.

But these results by no means represent the full advantage of the present theory. An examination of the results shows us the formulæ give good, *i.e.*, consistent results except in the case of the radius. Here it is that the greatest differentiation has taken place, very possibly owing to the direct selection of other long bones. Our general principles (p. 177) accordingly suggest that we should omit the results for this bone from our consideration. The best formulæ then to use will be (*e*), (*f*), and (*i*); we shall then have a mean error of ·15 centim. for male and ·06 centim. for female—a better approximation to the true stature could not possibly be reached. M. MANOUVRIER, by the process of means, would have deduced from the same three bones a male stature with an error of 1·75 centims. and a female stature with one of ·59 centim.

Dr. BEDDOE'S rule† would give for male Aino 155·3 centims., and female Aino 146·6 centims., or errors of 1·4 centims. and ·5 centim.; in this case not as great as those of M. MANOUVRIER, but still sensibly greater than our (*e*), (*f*), or (*i*).

The accordance obtained between the formulæ for reconstruction which I have given,

* *Loc. cit.*, tables at end of Memoir.

† 'Journal of the Anthropological Institute,' vol. 17, 1887, p. 205.

and the actually observed stature in the case of such a diverse race as the Aino ought, I think, to give considerable confidence in their use.

(ii.) I have also included in the table the results for the male Aino, calculated from female formulæ, and for the female Aino, calculated from the male formulæ. The reader will perceive at once that sexual differences are immensely greater than racial differences—that it would be perfectly idle to attempt to reconstruct female stature from male formulæ, or *vice versâ*. Exactly the same order of divergences are obtained if we endeavour to reconstruct French female from male formulæ, or *vice versâ*, and we concluded that French men and French women are more differentiated from each other than French of either sex and Aino of the same sex, at any rate, in the relations between stature and the long bones. It is noteworthy that the only instance in which the formula for one sex gives even approximately the stature of the other, is in the case of the female formula applied to find the male stature by means of the length of the radius. In this case we get a better result than from the male formula itself. Now this is peculiarly significant, for it is in the radius that the most marked differentiation between French and Aino has taken place; and in this respect the Aino male approaches nearer to the French female than to the French male. We must therefore conclude that while the sexes are widely differentiated from a common stock, still in respect of radius the females of a highly civilised race like the French, and the males of a primitive race like the Aino, are even closer together than the males or the females of these two races for this special bone. The agreement between the same sex in two different races, however, is generally far closer than between different sexes in highly civilised and primitive races.

(12.) Having taken an extreme case of divergence in man and tested the confidence that may be put in our reconstruction formulæ, it will not be without interest to see the amount of divergence in the formulæ when we apply them to allied species. Stature is, of course, a very difficult character to deal with when we are considering the anthropomorphous apes, and it would be idle to think of going beyond a round number of centimetres. But even here the agreements and disagreements are so remarkable that they appear to furnish material on which certain quantitative statements with regard to the general lines of evolution can be based, and further they suggest that the regression formulæ for the long bones among themselves* open up quite a new method of attacking the problem of the descent of man. Like the rest of the material in this paper, the considerations of the present paragraph must be looked upon as suggestions for new methods of research. I have taken what material was at hand and not endeavoured to form comprehensive statistics. The methods are illustrated on stature, but they are equally applicable to the regression formulæ connecting any characters or organs whatever.

* I hope later to deal at length with the regression formulæ for the long bones of man and apply them to the anthropomorphous apes, placing stature entirely on one side as a quantity very difficult to measure.

The following table, here given in centimetres, is taken from HUMPHRY's work.*

TABLE XVIII.—Stature and Long Bones of Anthropomorphous Apes.

	No.	Stature.	Femur.	Humerus.	Tibia.	Radius.
Chimpanzee . .	4	127	31·52	31·01	25·40	27·90
Orang	2	112	26·92	35·60	23·41	35·60
Gorilla	3	147	35·33	42·12	28·70	32·79

The sexes are not stated, and the results are all mean results for the numbers given. The stature is probably exaggerated rather than understated, and must have been difficult to estimate. It might seem at first sight idle to apply the stature reconstruction formulæ for man, to such data, but as we shall soon see it is a question of coming within 10 or 20 centims. of the true values in all but a few cases. I have calculated the following table from the reconstruction formulæ for both sexes in man :—

TABLE XIX.—Reconstructed Stature of Anthropomorphous Apes.

Formula.	Chimpanzee.		Orang.		Gorilla.	
(*a*) Male .	141	+14	132	+20	148	+ 1
(*b*) ,, .	160	+33	174	+62	193	+46
(*c*) ,, .	139	+12	134	+22	147	0
(*d*) ,, .	177	+50	203	+91	193	+46
(*e*) ,, .	137	+10	130	+18	145	− 2
(*f*) ,, .	137	+10	130	+18	146	− 1
(*g*) ,, .	169	+42	190	+78	196	+49
(*h*) ,, .	161	+34	175	+63	193	+46
(*i*) ,, .	149	+22	152	+40	170	+23
(*k*) ,, .	144	+17	143	+31	162	+15
Observed .	127	0	112	0	147	0
(*a*) Female	134	+ 7	125	+13	142	− 5
(*b*) ,,	157	+30	169	+57	188	+41
(*c*) ,,	135	+ 8	130	+18	142	− 5
(*d*) ,,	174	+47	200	+88	191	+44
(*e*) ,,	133	+ 6	126	+14	141	− 6
(*f*) ,,	133	+ 6	126	+14	141	− 6
(*g*) ,,	166	+39	186	+74	192	+45
(*h*) ,,	158	+31	172	+60	189	+42
(*i*) ,,	141	+14	140	+28	158	+11
(*k*) ,,	134	+ 7	127	+15	148	+ 1

* 'A Treatise on the Human Skeleton,' Cambridge, 1851, p. 106. It is, perhaps, needless to remark that the gibbon gives stature results quite incomparable with those for man.

Now we see that, if the gorilla be put on one side, there is no approach to accordance between the calculated and observed statures* in the case either of the chimpanze or orang for any of the ten formulæ. We conclude therefore, that if man and the chimpanze and orang have been derived from a common stock, they must have been directly selected with regard to stature and with regard to the lengths of the four chief long bones. In the case of the gorilla we notice, however, a remarkable accordance between the observed stature, and that calculated from the male reconstruction formulæ in the case of man, when we use only formulæ involving the femur and tibia. It would thus appear that if man and the gorilla have been differentiated from a common stock, they have been directly selected in the same manner so far as femur and tibia are concerned, but in different directions when we consider humerus and radius—we are here referring only to the lengths of these bones. Re-examining the results for the male formulæ from the standpoint of correspondence in the femur and tibia between the gorilla and man, we see that the chimpanze comes nearer to man than the orang; the lengths of the femur and tibia have been modified in the former, but not to such a marked degree as in the case of the latter. Turning to the female reconstruction formulæ we notice in (*a*) to (*k*) for the chimpanze and orang an accordance between the observed and calculated statures which is some 3 centims. to 6 centims. better, although still very poor. The reason for this is obvious, the stature of the woman for the same length of long bone is 3 centims. to 6 centims. shorter than that of man, and accordingly the female formulæ must give slightly better results than the male formulæ when applied to the anthropomorphous apes, which have for the same length of bone a markedly shorter stature than man. In the gorilla we have over-corrected the stature so far as femur and tibia are concerned by using the female formulæ. One point, however, is of very great interest: while the female formulæ for humerus, radius, or for humerus and radius give very bad results, even worse for the gorilla than they do for the chimpanze, yet the female formula for femur and humerus gives a sensibly better, and that for all the long bones a markedly better result for the stature than the corresponding male formulæ. The difference here is not the 3 centims. to 6 centims. due to sex. The improvement in the result when we apply the female formulæ for all four long bones to the estimate of the stature of the gorilla is noticeable also, if to a lesser degree, in the cases of the chimpanze and orang. We may sum up our results as follows:—

(*a*.) Man is apparently differentiated from the chimpanze and orang by direct selection of stature, but this direct selection appears to be small in the case of the gorilla.

* If the chimpanze and orang be treated as "dwarf men," and their statures estimated in the manner indicated on p. 224 below, the femur and tibia give statures, F, 115·5, 105·0; T, 118·0, 112·5 respectively, nearer the actual values, in fact too small, but the radius and humerus still give values far too great. The stature of the gorilla as estimated from femur and tibia in this manner now becomes far too small.

(*b.*) Man and the gorilla appear to have followed common lines of differentiation from a common stock in the case of the femur and tibia, but the differentiation on which they have not followed common lines has not been that of radius and humerus alone, or (k) would have given good results.

(*c.*) Other organs closely correlated with stature beside the four long bones must have been differentially modified in the case of the chimpanze and orang, or (k) would still have given good results.

(*d.*) The accordance between the result given by female (k) and the observed stature of the gorilla, and the want of accordance in all other formulæ, seems to show that woman has been principally differentiated by these four long bones from the common stock, while man has been differentiated in other organs highly correlated with stature. For example, the differentiation in pelvis may be much greater.

So far as I am able to draw a conclusion from the few data at my command, the correlation of radius and humerus with stature appears to be negative for the chimpanze and orang, while it is positive for the gorilla and man. The negative character of the partial correlation coefficient for the radius in (k) seems to be a relic of this stage of evolution, and it is much more marked in woman than in man.

The above statements must not be taken as dogmatic conclusions; they are only *suggestions* of the manner in which the regression formulæ can possibly be applied to the problems of evolution. They are no more weighty than the very slender material* on which they are based. But they may suffice to indicate how a method of quantitative inquiry might be applied to ascertain more about the relationship of man to the anthropomorphous apes, so soon as a sufficient amount of data concerning the dimensions of the organs of adult apes has been collected, and reduced to numerical expression.

* In order to verify Sir G. HUMPHRY's measurements, I have gone through the catalogues, so far as published, of the German anthropological collections, and extracted the measurements of all *adult* anthropomorphous apes. Unfortunately I could only find one adult chimpanze; the sex was as often as not not given. I find:

	No.	Stature.	Femur.	Humerus.	Tibia.	Radius.
Gorilla	7	144·2	35·51	41·83	28·19	33·91
Orang	9	119·9	26·52	34·34	22·57	34·10

A better agreement with the results cited, p. 202, could not have been expected, or wanted. Thus our data give racial and not random characters.

(13.) *Palæolithic Man.*

I am indebted to the memoir of M. RAHON* for the details of all the individuals that are classed under this heading. I presume that in measuring the tibia he has not included the spine, as his formulæ are, like mine, based on its exclusion. I have further allowed for the fact that he used the oblique length of femur, while I require the maximum length. Unfortunately we have only five cases to base our estimate upon.

Neanderthal Man.

$$F = 44{\cdot}52, \qquad H = 31{\cdot}2, \qquad R = 24{\cdot}0.$$

We find for stature from :

(*a.*)	(*b.*)	(*d.*)	(*h.*)	(*i.*)	Mean
165·01	160·94	163·46	162·83	161·59	162·96

RAHON gives 161·3 centims. (but I think he ought to have given 165·2 centims., as his femur estimate is incorrect) and SCHAAFFHAUSEN† 160·1 centims., so that our estimate diverges by 2 centims. to 3 centims.

Man from Spy.

$$F = 43{\cdot}32, \qquad T = 33{\cdot}0.$$

We find for stature from :

(*a.*)	(*c.*)	(*f.*)	Mean
162·75	157·07	160·26	160·33

RAHON gives 159·0 centims.

Man from Clay at Lahr.

The length of the femur here is doubtful, but it is said to have been between 45·0 centims. and 46·0 centims. If we take the mean value, the probable stature was 166·85 centims., and the maximum value would only be 167·79 centims. RAHON gives 170 centims., using ulna as well as femur. I have not worked out the stature-ulna correlation, but, if this bone is at all akin to the radius, it will give very exaggerated results for primitive man.

Man of Chancelade.

$$F = 40{\cdot}8, \qquad H = 30{\cdot}0, \qquad R = 23{\cdot}6.$$

(*a.*)	(*b.*)	(*d.*)	(*h.*)	(*i.*)
158·095	157·46	163·125	157·46	157·13.

Here again the radius gives clearly an exaggerated result. The mean is

* 'Mémoires de la Société d'Anthropologie de Paris,' 1893, p. 414 *et seq.*

† "Der Neanderthaler Fund," 'Deutsche Anthropologische Gesellschaft,' 1888.

158·7 centims., but, neglecting (*d.*), I am inclined to take the best value as 157·5 centims. RAHON gives 159·2 centims. MANOUVRIER (*loc. cit.*, p. 391) is inclined from the general character of the bones to consider the stature as determined from the ulna and radius to be the better estimate, and even thinks this troglodyte may have been 165 centims. Judging, however, from other primitive races, I should expect the arm bone estimate to exaggerate the stature, and prefer my estimate of 157·5 centims.

Man of Laugerie.—All we know here is the length of the femur = 45·1 centims. The probable stature is accordingly 166·1 centims. TOPINARD gives it as 168·5 centims., and RAHON at 164·9 centims.

Taking the mean of the best values for the above five cases we have :—

Probable stature of palæolithic man = 162·7 centims. All the above cases are supposed to be males. Considering that it is more probably the massive bones which have survived, we must hold that palæolithic man was shorter than the modern French population, but was taller than the men of Southern Italy (156 centims. to 158 centims.), and about the mean height of the modern Italian male population, *i.e.*, 162·4 centims.

(14.) *Neolithic Man.*

(*a.*) *Great Britain.*

We have not very much data to build upon here. Dr. BEDDOE* gives the length of twenty-five male and five female femora. Converted into centimetres, we have

Male F (25), 45·72 centims.	hence probable stature	male,	167·3 centims.
Female F (5), 41·53 ,,	from (*a*)	female,	153·6 ,,

Dr. BEDDOE'S estimates, male 170·2 centims., and female 156·3 centims., are, I think, much too high. The sex-ratio is 1·089.

(*b.*) *France and Belgium.*

The following data have been drawn from RAHON (*loc. cit.*, pp. 418 *et seq.*), the numbers in brackets in the left-hand corners denoting the numbers upon which the average lengths of the bones are based.

	F.	H.	T.	R.
Male	(127) 43·99	(127) 31·085	(133) 35·87	(49) 23·54
Female	(53) 40·105	(79) 28·58	(45) 33·11	(18) 21·76

* 'Journal of the Anthropological Institute,' vol. 17, 1887, p. 209.

We find:

STATURE of Neolithic Man.

Formula.	Male.	Female.
(*a*)	164·01	150·85
(*b*)	160·60	150·18
(*c*)	163·89	152·65
(*d*)	162·92	153·97
(*e*)	163·83	151·59
(*f*)	163·85	151·61
(*g*)	161·36	151·86
(*h*)	160·45	150·45
(*i*)	162·11	150·49
(*k*)	162·41	150·71
Mean . .	162·54	151·44

Sexual ratio ♂/♀ = 1·073.

So far, then, as we have material to judge by, there appears to be no sensible difference between Continental palæolithic and neolithic man; they corresponded very closely to the modern Italian in stature.

On the other hand, if we compare British with Continental neolithic man, we find, judging even from femora only, a very sensible difference in stature. Neolithic man in Britain was taller probably than the modern Frenchman, and markedly taller than neolithic man in France.

(*c*.) This leads us to consider one or two special classes of neolithic bones, for it must be remembered that probably as many neolithic races existed in Europe as we find races existing in historic times. In the first place, we have the big bones of the Cro-Magnon man,* F = 48·32 centims., T = 39·5 centims. These give for the stature:

(*a*.)	(*c*.)	(*e*.)	(*f*.)	Mean.
172·15	172·52	173·06	173·05	172·70

which is a centimetre greater than RAHON's estimate, seven less than ROLLET's, and seventeen less than TOPINARD's. This man was undoubtedly tall, but cannot be taken as a type of his race. The second Cro-Magnon skeleton gives us H = 32·1 centims., T = 37·5 centims. from which we find from:

(*b*.)	(*c*.)	Mean.
163·54	167·76	165·68.

This is also taller than the average neolithic man, but much below the other skeleton.

* As carefully determined by RAHON (*loc. cit.*, p. 421).

Two homogeneous series of neolithic bones are given by M. MANOUVRIER in a paper entitled: "Étude des Crânes et Ossements humains recueillis dans la Sépulture Néolithique dite la Cave aux Fées, à Brueil,"* and deserve separate consideration. We find:

	F.	H.	T.	R.
Brueil male	(10) 41·77	(19) 30·86	(4) 35·20	(5) 24·19
,, female	(7) 38·63	(8) 28·51	. .	(5) 22·08
Mureaux male	(16) 44·51	(10) 31·46	(10) 35·08	(6) 24·63
,, female . . .	(2) 40·38	(5) 29·26	(7) 33·84	(3) 21·57

I have deduced the following results:

Formula.	Male.		Female.	
	Brueil.	Mureaux.	Brueil.	Mureaux.
(*a*)	159·83	164·98	147·98	151·38
(*b*)	159·95	161·69	149·99	152·06
(*c*)	162·30	162·01	. .	154·37
(*d*)	165·05	166·59	155·04	153·33
(*e*)	160·48	163·52	. .	152·73
(*f*)	160·42	163·63	. .	152·74
(*g*)	162·09	163·89	152·27	152·66
(*h*)	159·96	161·70	150·36	152·15
(*i*)	159·47	163·23	148·44	151 55
(*k*)	159·58	162·67	. .	152·60
Mean . .	160·91	163·39	150·68	152·56

The corresponding mean values given by M. MANOUVRIER are: 161·2, 163·8, 150·2 and 154·3, of which only the last diverges sensibly from mine.† I should be inclined to omit the results obtained from (*d*) as excessive, only the larger radii surviving. To do so would not much alter my means, based on ten results, although it would more sensibly modify M. MANOUVRIER's.

The sexual ratios for the two groups are:—

* "Memoires de la Société des Sciences naturelles . . . de la Creuse," 2e Série, vol. 3, 1894 (2e Bulletin).

† The agreement is surprising, considering that M. MANOUVRIER worked only from half my data, and allowed very differently for the drying of the bones.

Brueil ♂/♀ = 1·068. Mureaux ♂/♀ = 1·071,

both less than the result we have obtained for the general averages of neolithic man. Probably we have here to do with local races, but M. MANOUVRIER considers it just possible that the very different environmont at Brueil and Mureaux may account for the differences.

Neither of these groups has a stature equal to that of the modern French commonalty, although the Mureaux group approaches it somewhat closely. The modern British far exceed in stature their neolithic landsmen, and we have thus no evidence at all in favour of a giant stature for prehistoric man. He seems to have been markedly shorter than the taller races (English-Scandinavian) of to-day. Slightly taller than the Aino, he can be compared with the Italians, who appear, as we go southward, to closely represent him in stature.

(15.) *Other Early Races.*

In this group I propose to include a number of prehistoric or protohistoric races of whom we know very little. Their stature is considerably greater than that which we have determined for Continental neolithic man, though sensibly below that of British neolithic man. The data are extracted from RAHON's memoir, and modified to suit the formulæ of this investigation (see his pp. 431, 438 *et. seq.*).

Race.	F.	H.	T.	R.
Dolmen-builders, India, male . . .	(3) 45·81	(1) 32·5	(3) 35·3	(1) 24·5
,, ,, ,, female . .	(1) 42·93	..	(1) 33·3	..
,, ,, Algeria, male . .	(16) 45·32	(16) 31 9	(12) 38·0	(15) 23·8
,, ,, ,, female . .	(8) 40·83	(5) 28.8	(9) 33·8	..
,, ,, Caucasus, male . .	(7) 44·92	(6) 32·4	(3) 34·6	(4) 24·6
,, ,, ,, female . .	(1) 41·3	(1) 29·1	..	..
Guanches, Group I., male	(87) 45·52	(60) 32·8	(79) 37·7	(30) 24·7
,, ,, female. . . .	(90) 41·33	(92) 30·1	(58) 34·7	(32) 22·1
,, Group II., male	(76) 45·22	(81) 32·5	(75) 37·6	(56) 24·6
,, ,, female . . .	(33) 41·03	(34) 29·6	(20) 34·4	(10) 22·1

While the dolmens of India and Algeria appear to belong to the Stone Age, those of the Caucasus belong to the first Iron Age.

The series from these dolmens is very small. On the other hand the Guanch series are both very complete. The first are drawn from the Musée Broca, and the second from the Muséum d'Histoire Naturelle (see RAHON, *loc. cit.*, p. 446), both at Paris. Although the first series comes from a single locality, and the second from several localities, the results are in good agreement. The following statures have been found from our formulæ :—

Formula used.	Dolmens, India.		Dolmens, Algeria.		Dolmens, Caucasus.		Guanches, Group I.		Guanches, Group II.	
	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.
(*a*)	167·43	156·34	166·51	152·26	165·76	153·17	166·88	153·23	166·32	152·65
(*b*)	164·70	..	162·96	150·79	164·41	151·62	165·56	154·37	164·70	152·99
(*c*)	162·54	153·10	168·95	154·27	160·87	..	168·24	156·39	168·00	155·68
(*d*)	166·06	..	163·77	..	166·39	..	166·72	155·10	166·39	155·10
(*e*)	165·28	154·99	167·84	153·19	163·44	..	167·72	154·76	167·26	154·09
(*f*)	164·86	155·01	168·37	153·19	163·61	..	167·69	154·76	167·22	154·09
(*g*)	165·46	..	163·22	..	165·46	..	166·33	154·92	165·64	154·08
(*h*)	164·56	..	162·76	..	164·30	..	165·43	154·47	164·58	153·18
(*i*)	166·18	..	164·75	151·68	165·11	152·62	166·35	153·69	165·58	152·77
(*k*)	165·29	..	165·85	..	163·91	..	166·79	154·82	166·11	153·72
Mean . .	165·24	154·86	165·50	152·56	164·33	152·47	166·77	154·65	166·18	153·83
Sexual ratio .	1·067		1·085		1·078		1·078		1·081	

The first point to be noticed about this table is the confidence it inspires in formula (*k*). Whenever the series is in the least extended, formula (*k*) gives a result sensibly identical with the mean of all ten formulæ.

M. RAHON's means for the eight groups are not very divergent from mine, he gives :—

166·0, 154·8 ; 165·7, 153·2 ; 165·3, 154·4 ; 166·0, 155·4 ; and 165·9, 154·3.

He thus does not make quite such a sensible distinction between the Guanches and the Dolmen-builders as my numbers seem to indicate. It is curious that these three groups of Dolmen-builders should stand so close together, and also comparatively close to the Guanches. The Dolmen-builders must have been as tall as the modern French, while the Guanches were probably slightly taller. Both were of greater stature than neolithic man in France, approaching more nearly the neolithic man of Britain.

The sexual ratio in the first and third cases cannot be considered of any weight, as the female data contain only single individuals.

(16.) *Stature of the Naqada Race from Upper Egypt.*

This race dates from about 4000 B.C. Its orgin and locus have been discussed by Professor FLINDERS PETRIE in "Naqada and Ballus," 1895, and an elaborate series of measurements made on the long bones by Dr. WARREN; see 'Phil. Trans.,' B, Vol. 189, pp. 135–227, 1897.

The measurements suited to our reconstruction Tables XIV. and XV. are :*

	F.	H.	T.	R.
Male	(80) 45·93	(62) 32·62	(85) 37·97	(47) 25·70
Female . . .	(113) 42·63	(97) 29·87	(115) 34·96	(66) 23·33

Whence we deduce for the stature :

Male.	Bones used.	Female.
165·04	H	153·74
165·13	H & R	154·23
166·61	H & F	155·19
166·93	H, F, R & T	155·02
167·66	F	155·76
167·79	H + R	156·53
168·49	F & T	156·51
168·5	F + T	156·93
168·88	T	156·99
169·99	R	159·21
167·5	Mean	156·0

Had we used M. MANOUVRIER'S "Tableau-barême," we should have found :†

Male.	Bone.	Female.
166·4	F	155·4
167·0	T	156·0
164·7	H	154·5
171·5	R	161·7
167·4	Mean	156·9

* The numbers in brackets to the left indicate the number of bones used to form the average.

† Here, as in other cases, the reader must remember before entering the "Tableau-barême," to correct from the maximum to oblique femur length.

While M. MANOUVRIER's male mean does not differ widely from ours, his female mean is ·9 centim. greater. His range for male stature covers 6·8 centims., and for female stature 7·2 centims., as compared with our 4·9 and 5·5 centims. respectively. But the amount of this range in both cases is very significant considering the large number of bones averaged. While our formulæ applied to the Aino gave very self-accordant results except in the case of the radius, we notice here considerable divergences. In particular, the order of the bones arranged in order of increasing stature, which is nearly the same in both sexes, is very different for the corresponding order for the Aino. The Naqada people for their stature have a remarkably small humerus, and although the Aino could hardly be separated more from the French by civilisation and locality, yet they could be derived from a common stock with the French by far less direct selection of the long bones, than would be possible in the case of the French and the Naqada races. This Egyptian race was a tall race—not as tall as the English commonalty—but taller than the better French classes and 2·5 centims. taller than the mean of the French army. The sexual ratio, 1·074, was less than that of the modern European (about 1·080), and this is in keeping with the greater equality in size observable in primitive and early races. On the whole it may be questioned whether any two *modern* races would give such divergence in character as the Naqada and French. We see not only the radius, as in the case of the Aino, but the humerus as a source of divergence, and so far as the lengths of those long bones are concerned, it would be easier to look upon the Ainos and French than upon the Naqada people and French as local races deduced from a common stock. If they have sprung ultimately from such a stock, there has been a very significant amount of direct selection. There is, however, an interesting point which the Naqada people share with the Ainos —the judgment of stature from the radius is excessive. This peculiarity of early and primitive races is one which the table on p. 202 shows that they share, of course in a much less marked manner, with the anthropomorphous apes. It will later be seen to be a feature of other primitive and early peoples.

(17.) *Protohistoric Races.*

My next group covers to some extent the ground which precedes 1000 A.D.—roughly, the beginning of the Middle Ages.

(*a*.) Dr. BEDDOE gives femur measurements for the Round Barrow population of Britain,* as follows:

Male $F = 47{\cdot}75$ centims., mean for 27,
Female $F = 44{\cdot}91$,, ,, 2.

We find at once from (*a*):

$$\text{Stature Male} = 171{\cdot}1 \text{ centims.,} \qquad \text{Female} = 160{\cdot}2 \text{ centims.}$$
$$\text{Sexual ratio } ♂/♀ = 1{\cdot}068.$$

* 'Journal of the Anthropological Institute,' vol. 17, 1887, p. 209.

These values are immense reductions on Dr. BEDDOE'S 176·2 for males and 166·5 for females. Even with this reduction, the Round Barrow population must still be considered a tall one, as tall as the modern English. It will be remembered that it was also brachycephalic,* a curious and infrequent combination in Europe.

(*b*.) We may next consider the Romano-British, for whom we obtain from Dr. BEDDOE the data:

Male F = 45·42 centims., mean for 10,
Female F = 40·82 ,, ,, 4.

Formula (*a*) gives:

Stature Male = 166·7 centims., Female = 152·2 centims.
Sexual ratio ♂/♀ = 1·090.

Here again we have very sensible reductions on Dr. BEDDOE'S estimates of 169·3 and 154·2.

(*c*.) We may compare these results for the Romano-British with those for the Romano-Gauls, based on data provided by RAHON.† These give:

	F.	H.	T.	R.
Male	(40) 45·52	(18) 32·0	(22) 35·9	(9) 24·1
Female	(5) 40·43	(5) 29·7	(1) 30·7	..

Whence we deduce:

STATURE of Romano-Gauls.

	Male.	Female.
(*a*)	166·88	151·48
(*b*)	163·25	153·27
(*c*)	163·96	146·98
(*d*)	164·76	..
(*e*)	165·64	149·25
(*f*)	165·75	149·26
(*g*)	163·91	..
(*h*)	163·10	..
(*i*)	165·11	152·07
(*k*)	165·84	..
Mean	164·82	150·37 (152·27)

* PEARSON, 'The Chances of Death,' vol. 1, "Variation in Man and Woman," p. 363.
† *Loc. cit.*, p. 441.

The second mean estimate for females is determined by neglecting the *single* tibia measurement, and is probably the best obtainable; it agrees closely with (*i.*):

$$\text{Sexual Ratio } ♂/♀ = 1{\cdot}082.$$

A series of 12 femora dug up in Boulogne Harbour* have also been attributed to the Romano-Gauls. They give male F = 45·22 centims., or for the stature 166·32.

My estimate here is about a centimetre larger than RAHON'S. We sensibly agree for the males in the larger series above, while for the females I should take the most probable stature to be a centimetre less than that (153·5) given by RAHON.

We cannot compare the Romano-British with the Romano-Gauls on the basis of all bones, for we have only the results for the femur in the former case. But if we compare the femur estimates for the two cases we see that they are sensibly the same (male 166·9 against 166·7, and female 152·3 against 152·2). It is, therefore, probable that the estimate of the Romano-British male is sensibly too high, and that it would have been nearer 165 centims. had we had other bones than femora to base our estimates upon. The sexual ratio is clearly abnormally high.

(*d.*) *Row-Grave Population of South Germany.*

Dr. R. LEHMANN NITSCHE has published a most interesting series of measurements on the long bones found in the Row-graves of Bavaria.† These interments date from the beginning of the 5th to the end of the 7th century. He divides his material into two groups, "Bajuvars," from the Row-graves of Allach in Upper Bavaria,‡ and Suabians and Alemanns from those of Dillingen, Gundelfingen, Schwetzheim, Memmingen and Fischen.§ The mean lengths of the long bones for these two groups are, however, in such complete accordance, that we are quite justified in following Dr. NITSCHE and combining the two groups.|| We have then the following results after the proper change in the femur :—

	F.	T.	H.	R.
Male	(41) 46·99	(25) 38·05	(17) 33·71	(11) 25·41
Female	(16) 41·07	(7) 33·71	(9) 30·28	(4) 23·10

The following table gives the reconstructed stature on the basis of the ten formulæ of Tables XIV. and XV. :—

* *Loc cit.*, p. 439.

† "Neue Beiträge zur physischen Anthropologie der Bayern," vol. 11, pp. 205–296, München, 1895.

‡ *Ibid.*, p. 207.

§ *Ibid.*, p. 239.

|| pp. 260, *et seq.*

Male.	Bones used.	Female.
168·1	H & R	155·2
168·2	H	154·9
169·0	R	158·4
169·1	T	154·1
169·2	H + R	156·8
169·3	F & H	153·5
169·4	F, H, T & R	153·0
169·6	F	152·6
169·8	F + T	153·4
169·9	F & T	153·4
169·2	Mean	154·5

MANOUVRIER'S "Tableau-barême" gives us—

Male.	Bone.	Female.
168·1	F	152·6
167·6	T	154·6
167·5	H	155·6
170·1	R	160·5
168·3	Mean	155·6

Clearly MANOUVRIER'S method gives results in this case differing almost 1 centim. from mine for both sexes. They have ranges 2·6 centims. and 7·9 centims. for male and female as compared with my 1·8 centim. and 4·2 centims. respectively. Our method of taking the means of the results is not, however, very good. There are very few radii, and the results for that bone have little weight. To properly weight, however, the formulæ involving two or more bones is troublesome, and the increased exactness is so small as to be hardly worth the labour. If we treat F and T, F and H, and F, T, H, and R as likely, *à priori*, to give the best result, we have male stature, 169·5 and female stature 153·3. I doubt whether this is as good as the previous result; it would connote a very high sexual ratio, 1·106, which is contrary to what we generally find with primitive peoples. The sexual ratio of the above results is very high, 1·095, and it seems to me probably that in the difficult matter of sexing rather too large a proportion of large bones have been given to the male and too few to the female group. Further, the smaller radii may probably have disappeared, which accounts for something of the irregularity here—as in other cases—of the estimates from the radius. Allowing, however, for these irregularities we find the Row-grave population by no means so widely differentiated from the French as the Naqada race. They were, however, a tall race, taller than the present French commonalty, almost, but not quite, as tall as the present English commonalty in their men, but sensibly below it as regards their women. The men were *at least* 1 to 3 centims. taller than the present Munich population, which gives 168 centims. as mean of *accepted* recruits, and 166 centims. as a mean based on corpse measurement. (See RANKE, "Zur Statistik der Körpergrösse . . .," in 'Anthropologie der Bayern,' vol. 1, and PEARSON, 'The Chances of Death,' vol. 1, p. 295.)

(18.) *Anglo-Saxons.*

Here my data are extracted from Dr. BEDDOE's paper.*

	Number.	F.	T.
Anglo-Saxons in general, male . .	65	47·17	(12) 39·05
,, ,, female .	26	42·77	..
Wittenham, peasantry, male . .	23	46·69	..
,, ,, female . .	17	42·24	..
,, with tibia, male . .	7	48·34	39·43
Ely, bishops, male	5	46·74	38·51

Allowance has been made (see p. 197) for the length of the spine.

STATURE of Anglo-Saxons.

	(*a*.)	(*c*.)	(*e*.)	(*f*).	Mean.
Anglo-Saxons in general, male . .	170·0	171·4	171·2	171·2	170·9
,, ,, female .	156·0	..	..	..	..
Wittenham, peasantry, male . .	169·1	..	..	..	..
,, ,, female . .	155·0	..	..	..	..
,, with tibia, male . .	172·2	172·3	173·0	173·0	172·6
Ely, bishops, male	169·2	170·1	170·1	170·1	169·9

Dr. BEDDOE's results diverge again immensely from mine.† For the Anglo-Saxons in general he finds, for example: male, 174·7 centims., and female, 160·2 centims.; while his estimate, using the tibia for the Wittenham second male group, is 70·86 inches, or 180 centims.!

If his conclusions were correct, the modern English would have degenerated very much from the Anglo-Saxons in stature.

* *Loc. cit.* p. 209.

† I make Earl BRITHNOTH (F = 52·07, T = 41·58) about 180 centims., while Dr. BEDDOE's estimate is 192.

For modern English we have the following results :—

	GALTON, Commonalty. I.	PEARSON, Middle classes. II.	PEARSON, Middle classes. III.
Male . . .	(811) 172·55	(1000) 172·8	(1077) 175·15
Female . .	(770) 160·85	(1000) 159·9	(135) 162·17

Mr. GALTON's results were measured at his South Kensington Laboratory during the Exhibition of 1884. My first group are from my family data cards, and without boots ; my second group are from the measurement cards of the Cambridge Anthropometrical Committee. Subtracting 2·54 centims. for boots from I. and II., we find :—

Male	170·0	172·8	172·6
Female . . .	158·3	159·9	159·6

Thus there is a sensible agreement between the results II. and III., while I. shows just the class distinction we might expect to find. Comparing these results with the Anglo-Saxon statures, we notice an increase of about 2 centims. in the female stature, while the present English commonalty is about 1 centim. less than the mean male stature, and the English male middle classes about 2 centims. more. If the Wittenham skeletons with tibia belong to a class apart, then they were quite equal in stature to the modern English classes, while the Anglo-Saxon bishops were distinctly inferior. Probably the bishops were men unsuited for fighting, and showing a lower degree of physical development. The Anglo-Saxon women are not very many in number, and we have only the femora to base an estimate upon, which in all these cases gives a less stature than the tibia. We may therefore conclude that the average Englishman of to-day is certainly not behind his Anglo-Saxon ancestors ; he may be very slightly taller. The average Englishwoman is probably somewhat taller, but the paucity of data for Anglo-Saxon women hardly allows an estimate of how much. The sexual ratio, 1·096, is so high that I am compelled to consider the Anglo-Saxon women under-estimated, or possibly mixed with a Romano-British element. The modern value is about 1·080.

(19.) *Franks.*

I have put into one group the Frankish remains belonging to both the Merovingian and Carolingian periods, to be found in RAHON's memoir,* the separate smaller groups giving results in close accordance. We have then :—

* *Loc. cit.*, p. 440, *et seq.*

FRANKS 500–800 A.D.

	F.	H.	T.	R.
Male	(47) 45·18	(23) 33·23	(31) 36·81	(7) 25·31
Female	(16) 40·87	(8) 29·39	(7) 32·77	(3) 22·80

This gives us :—

FRANKISH STATURE.

Formula.	Male.	Female.
(*a*)	166·24	152·34
(*b*)	166·81	152·41
(*c*)	166·12	151·85
(*d*)	168·71	157·44
(*e*)	166·30	152·07
(*f*)	166·32	152·08
(*g*)	168·13	154·88
(*h*)	166·74	152·83
(*i*)	166·67	152·34
(*k*)	166·36	151·03
Mean	166·84 (166·42)	152·93 (152·12)

Sexual ratio ♂/♀ = 1·091.

The means in brackets are obtained by omitting the results of formulæ (*d*) and (*g*), which are clearly exaggerated, owing to only the larger radii having survived.

It is clear, accordingly, that the Frankish conquerors of Romano-Gaul were not a tall race—nothing like as tall as the Anglo-Saxons who conquered Romano-Britain.* Further, while the English commonalty have, if anything, slightly progressed on the stature of their Teutonic invaders, the French commonalty have, if anything, regressed.

* Of course, occasionally we find tall Franks, as those buried at Harmignies (Hainaut), RAHON *loc. cit.*, p. 440. These give :—

	F.	H.	T.	R.	(*a.*)	(*b.*)	(*c.*)	(*d.*)	(*e.*)	(*f.*)	(*g.*)	(*h.*)	(*i.*)	(*k.*)	Mean.
Male . .	50·52	34·9	41·0	27·3	176·28	171·64	176·08	175·22	177·34	177·36	174·46	171·75	174·77	170·03	174·5
Female .	45·83	30·5	34·1	23·5	161·98	155·47	154·98	159·78	159·16	159·12	157·82	155·90	160·12	157·09	158·1

These are tall as compared with the average French of to-day, but not specially tall from the English standpoint, and certainly not comparable with Earl BRITHNOTH.

(20.) *French of the Middle Ages.*

Two groups are classed under this head by RAHON. The first comes from the cemetery of Saint-Marcel, and is said to belong to the 4th to the 7th century. The second comes from the cemetery of Saint-Germain-des-Prés, and probably belongs to the 10th to the 11th century. If these dates be correct, the former group belongs to the protohistoric rather than the mediæval period, and is directly comparable with the above results for the Merovingian and Carolingian periods. The latter group belongs to the early middle ages. We have:

	F.	H.	T.	R.
Saint-Marcel, male	(71) 45·32	(81) 34·2	(96) 37·8	(21) 24·4
,, female	(19) 41·63	(26) 30·3	(40) 34·0	(9) 22·5
Saint-Germain-des-Prés, male . .	(44) 45·32	(37) 33·1	(37) 37·3	(6) 23·7
,, female .	(10) 41·32	(18) 30·9	(18) 34·0	..

These give us for stature of mediæval French:

Formula.	Saint-Marcel. 4th to 7th century.		Saint-Germain-des-Prés. 10th to 11th century.	
	Male.	Female.	Male.	Female.
(*a*)	166·51	153·81	166·51	153·21
(*b*)	169·62	154·92	166·43	156·57
(*c*)	168·48	154·74	167·29	154·74
(*d*)	165·74	156·44	163·45	..
(*e*)	167·61	154·31	167·03	153·96
(*f*)	167·56	154·31	167·02	153·96
(*g*)	168·23	155·87	165·12	..
(*h*)	169·25	155·10	166·06	..
(*i*)	168·33	154·30	166·61	154·50
(*k*)	168·44	154·12	166·92	..
Mean . .	167·98	154·79	166·24	154·49

RAHON obtains the values:

165·7 155·5 165·6 155·5.

The first of these differs very considerably from my estimate, but RAHON has made a slip in using MANOUVRIER's table, and thus much underestimated the Saint-Marcel male stature.

I think it impossible to accept RAHON's view that the modern French are sensibly of the same stature as the mediæval French, because the slight apparent difference may be accounted for by a process of selection preserving for us only the larger bones. It is not, as RAHON supposed, a difference of ·7 centim. which has to be accounted for, but one of nearly 3 centims. We have the following series for France, male and female :—

Neolithic man	162·5	151·4
Romano-Gauls	164·8	152·3
Franks	166·4	152·9
French, 4th to 7th century	168·0	154·8
,, 10th to 11th century	166·2	154·5
,, modern	165·0	152·3

These results would seem to indicate that the Gauls were taller than the races they superseded in France, that their Frankish conquerors were taller again than they; but that the stature has been sinking during the last 800 years, and that the French commonalty of to-day is very close in stature to the Romano-Gauls.

This may denote a selection of stature, or it may mean that the Celtic element of the population has superseded the Teutonic element—an explanation in accordance with the recognised greater fertility of the Breton element in France. We should then have an interesting illustration of the manner in which reproductive selection may reverse the results of natural selection. While it might be rash to attribute the decrease in stature which has taken place in France to any one definite cause, it is interesting to note that we do not trace the like decrease in stature in England, yet we should certainly expect to do so, if the result were due simply to a selective process by which the larger bones were preserved. There does appear to be a like decrease in the stature of the Bavarian population, where we have compared (p. 215) the Row-grave population with that of Munich town recruits, which appears to be considerably above the average of recruits from other near districts,* and considerably above the corpse length (166 centims.)—itself greater than the stature of the living—which I have found from BISCHOFF's data.

(21.) *On Giants and Dwarfs.*

If we pass from the consideration of races with mean statures varying from about 157 centims. to 170 centims. to the consideration of individual giants and dwarfs, we very soon discover that our formulæ give statures hopelessly too small in the case of

* The average of the conscripts for the 1*st Infanterie Brigade*, which includes Munich, was only 166 centims. The average of the Baden conscripts was 163 centims.

giants, and too large in the case of dwarfs. This defect of the theory is the more serious in that while no prehistoric bones at present discovered give us indications of a race with giant proportions, there are such bones which indicate the existence of dwarf races in neolithic Europe. The reconstruction of individual giants from the skeletons preserved is also of some interest, although, from the standpoint of evolution, it, so far, has nothing like the importance of the reconstruction of the dwarf races.

If our formulæ do not apply to giants and dwarfs, we are forced to one or other of the following conclusions :—

(*a.*) Dwarf and giant races must have been differentiated from normal races by a selection which has partially or totally changed the regression formulæ.

(*b.*) The regression formulæ are not really linear ; they are only apparently linear, because, in dealing with the normal range of stature, we have only to consider a small portion of the regression curve which is sensibly straight.

Both these conclusions may of course be partially true.

In order to consider the validity of one or both of these hypotheses, it might seem that all we have to do is to investigate the relation between the long bones and stature in the case of a sufficient number of giants and dwarfs. But alas! the total material is small, and the quality of it is exceptionally bad. The majority of giants and dwarfs probably prefer a quiet life and a normal burial, so that their bones do not reach the anatomical museum.* Of the dwarfs and giants whose skeletons are to be found in museums, the majority earned their livelihood by exhibition, and accordingly their living stature was a character likely to be under- or over-estimated for the purposes of advertisement. If we put aside all records of the living stature, we are thrown back on the measurement of the length as corpse, or on estimates formed by anatomists of the stature from the articulated skeleton. Unfortunately, authorities differ very widely as to (*a*) the difference between the skeleton (after mounting) and the corpse length—ORFILA makes a difference of 7·5 centims., BRIANT and CHAUDÉ of 8 centims., and TOPINARD of 3·5 centims.—and (*b*) on the difference between the living stature and the corpse length (see p. 191). Even if TOPINARD's estimate, based upon 23 *normal* subjects measured as corpse and skeleton, be correct, it could hardly be safely extended to the cases of giants and dwarfs. Professor CUNNINGHAM, in attempting to reconstruct the stature of the Irish Giant, MAGRATH, goes so far as to discard all records of living stature, and all attempts to reconstruct stature from the articulated skeleton, and would estimate only from the length of the femur.† But this method seems to me fatal, at any rate for our present purpose, the very object of which is to find the relation between stature and femur (or any other long bone) in the case of giants. It cannot too

* In the investigation for conscripts in Bavaria, in 1875, 43 dwarfs were found, and among the 35 measured we have a range of 115 centims. to 139 centims. There were also four giants, or men with statures of 190 centims. and over.

† 'Royal Irish Academy Transactions,' vol. 29, 1891, pp. 553–612.

often be repeated that the idea that there is in any sense a constant proportion between stature and any long bone is misleading. MANOUVRIER makes this ratio decrease from dwarf to giant, and this is correct so long as we suppose the regression formula linear, for example, $S/F = a + b/F$. But this ratio really begins to decrease again as we go from short people to actual dwarfs, and to increase again as we go from tall people to actual giants.

For example, we have the following results for the ratios of long bones and stature :—

Data.	S/F.	S/T.	S/H.	S/R.
50 normal Frenchmen	3·71	4·54	5·06	6·83
MANOUVRIER, {" Coefficients moyens ultimes," stature > 181 . . . . }	3·53	4·32	4·93	6·70
TOPINARD, 22 cases, stature > 175	3·61	4·46	5·05	6·94
PEARSON, 12 cases, stature > 200	3·73	4·41	5·01	7·07

It will be at once obvious that MANOUVRIER's "Coefficients moyens ultimes" are by no means ultimate, but that in the case of giants the coefficients actually tend to return to their values for the mean population. This will be sufficient to show that it is quite impossible to consider any method of determining stature from a presumed constant ratio to femur as satisfactory.

But this table shows an important principle, namely, that as the ratio of stature to long bone first decreases as the bone increases and then begins to increase, it is impossible to consider the regression curve as a straight line when we extend it so far as the region of dwarfs and giants.

Now this is, *à priori*, what might have been expected, for all distributions of zoometric frequency that I have come across seem to possess sensible skewness, and in skew correlation the regression curve is not a straight line. Its actual form is of a somewhat complicated nature,* and it would be purely idle to attempt to determine the constants of it from the data for dwarfs and giants which are at present available. Accordingly it seemed to me desirable to select some empirical curve which would, so far as possible, represent the available material and give results in harmony with certain general principles. The considerations which led me to the choice of this curve were of the following character :—

(*a*.) It must sensibly coincide with the line of regression already found between statures of 155 centims. to 175 centims. It must accordingly have a point of inflexion at the mean stature, at which the tangent should be the already determined line of regression. Referred to this tangent and its perpendicular, the form of the curve in the neighbourhood of the origin must be $y = cx^3$. Away from the origin, c may become a sensible function of x and y, one or both.

* I hope to return to this point in a paper on skew correlation.

(*b*.) So far as the data at my command went, the dwarfs and giants appeared to deviate from the regression line in a remarkably symmetrical manner on opposite sides of it. In other words, the branches of the curve on opposite sides of the axis of y appeared to be centrally symmetrical or congruent. Thus the form of the curve was reduced to $y = x^3\phi(x^2, y^2)$.

(*c*.) It follows from this that the asymptotes of the curve, besides $x = 0$, will be given by $\phi(x^2, y^2) = 0$. The problem then turns on what are the probable asymptotes. Now if we examine the regression formula for an organ A on an organ B, it is of the form:

$$A = \left(A_m - \frac{r_{ab}\sigma_a}{\sigma_b} B_m\right) + \left(\frac{r_{ab}\sigma_a}{\sigma_b}\right) B,$$

where A_m and B_m are the mean organs, σ_a and σ_b the standard deviations, and r_{ab} the coefficient of correlation. Now no amount of selection of either A or B, or any other organs, as to *size* only, would influence in the case of normal correlation $r_{ab}\sigma_a/\sigma_b$, but it would change the constant term $A_m - \frac{r_{ab}\sigma_a}{\sigma_b} B_m$. Hence, if we were to take the line of regression for an extreme population of dwarfs alone, or of giants alone, it would seem quite possible that $r_{ab}\sigma_a/\sigma_b$ might have remained constant, while the term $A_m - \frac{r_{ab}\sigma_a}{\sigma_b} B_m$ changed. But these lines of regression would be the asymptotes of the required curve. It was thus suggested to me that the asymptotes might be parallel to the line of regression of the normal population. On examining the points corresponding to giant and dwarf statures plotted to long bones, this hypothesis seemed to be highly probable. Accordingly the form of the curve finally selected to represent the extended curve of regression was

$$y = cx^3 (b^2 - y^2),$$

where the axis of x is the linear line of regression for normal stature, and the axis of y is the perpendicular to it through the mean normal stature of the French.*

(*d*.) A diagram was now formed by plotting to half life-size ($\frac{1}{2}$ centim. for 1 centim.) the points representing giants and dwarfs, and the lines of regression for the normal population were drawn. The y and x for the point for each giant for each bone were then read off, and these formed the data from which the constants of the four curves of the above type were then determined. For this determination only giants over 200 centims. were selected. The class of what may be termed sub-giants, with statures from 180–200 centims., were put on oneside. Such individuals, termed giants, appear in both the Bonn and Munich anthropological catalogues, but the "Körperlänge" there given can hardly represent the living stature; it is very probably only a skeleton

* Some shifting of the origin would probably have improved my results, but the data were not sufficient to justify such extra labour.

length, and considerably under the real stature. A height, for example, of 185 centims., 6 feet 2 inches, say, would hardly entitle a man, in England at any rate, to rank as a giant.

In the next place, no notice whatever was taken of the dwarfs. I felt that, if the curves were determined from the giant data only, the test that they gave good results for dwarfs would be the most satisfactory one conceivable. As it is, I have been able, on the basis of the long-bone stature relations for giants, to predict the stature of dwarfs to within 2·5 centims. average error. MANOUVRIER's "coefficients moyens ultimes" give a mean error for these dwarfs of 7·25 centims., or 2·9 times as great.

The actual fitting of the curves was conducted in the following manner. Remembering that the curve gives the value of the mean stature for the whole series of long-bones of one size, *i.e.*, the mean of the array of statures for a long bone of given type or size, I recognised that the curve, and accordingly its asymptote, must pass fairly centrally through the group of plotted points. An approximate value of the asymptote constant b was accordingly selected, and the value of c calculated from the mean of the observational values of y and x. If this form of the curve gave, as it generally did, not very satisfactory results, b was modified, and the new c calculated. In this manner, for example, three approximations were made in the case of the radius. The method of least squares was not readily applicable to the data (which were at best not very trustworthy), for it involves the calculation of such expressions as $S(x^6y^2)$ and $S(x^6y^4)$, which, owing to the large values of x involved, give far too great importance to the largest giants.

The curves ultimately determined were the following :—*

For the femur :

$$y = \tfrac{1}{37436}\, x^3 (49 - y^2).$$

For the tibia :

$$y = \tfrac{1}{17170}\, x^3 (22{\cdot}5625 - y^2).$$

For the humerus :

$$y = \tfrac{1}{22196}\, x^3 (20{\cdot}25 - y^2).$$

For the radius :

$$y = \tfrac{1}{16981}\, x^3 (20{\cdot}25 - y^2).$$

Here the unit for both y and x is equal to two centims. of stature, or of long-bone. Thus the distances 7, 4·75, 4·5 and 4·5 centims. of the asymptotes from the lines of regression of the normal population are really distances of 14, 9·5, 9 and 9 centims. in actual stature or long-bone length.

* The mathematical reader will bear in mind that it is only the "snake" and not the other two branches of the quintic curve which we require.

I do not suggest for a moment that these curves give a final solution of the problem of determining the stature of any individual in the range of 90 to 250 centims. from the lengths of his long bones, but they seem to me to give the best results obtainable with the data at present available.

Reduced to a formula a curve of this type would be of little service, for both x and y are linear functions of the probable stature and the observed length of the long bone. Hence we should have a quintic equation to find the probable stature from the long bone. But if these curves be plotted once for all, we have a graphical means of at once determining, by simply running the eye along a line, the probable stature corresponding to any given length of long bone. With care we can find the probable stature to ·5 centim., but as a rule to the nearest centimetre is sufficient. As the lines of regression for the normal population are given as part of our curves, it is clear that the diagrams attached to this memoir (Plates 3, 4) will also serve for the determination to a like degree of exactitude of the probable stature of individuals or races falling within the ordinary range of statures. In view of the fact that the diagrams serve all practical purposes, I have not considered it needful to deduce from the above quintics numerical approximations for the value of the stature in terms of the lengths of the various long bones.

(22.) If the reader will examine the diagrams, he will see the twelve giants A, B, C, . . . K, L marked by small dots; from these the curves were determined, and he will notice that they strike fairly well through the groups. The triplet O, M, N contains three pseudo-giants, or sub-giants; these as well as the dwarfs, S, U, V, T, were not used in the determination of the curves. One remarkable feature of the curves must be noted, namely, that in the region of what may be termed sub-giants and super-dwarfs, namely, from about 180 to 200 centims. and 150 to 130 centims., a very small change in the long bone makes a remarkable change in stature. This is specially noteworthy in the case of the radius. Thus between normal individuals on the one hand and giants or dwarfs on the other, there appears to be what may be termed a region of instability, in which an insignificant change in long bone may throw the individual across a considerable range of stature. The points of inflexion of our curves—other than those at the origin—may accordingly have a biological as well as a purely mathematical interest.

The following are all the data which I have been able to collect for giants and dwarfs having any degree of probable truth.

TABLE of Giants.

Letter.	Name.	Locus.	Stature.	F.	T.	H.	R.
A	JOACHIM	Musée Broca	210·0	56·72	47·0	40·4	30·5
B	Berlin Giant I . . .	Berlin Museum	223·0	64·0	53·0	45·5	30·5
C	Berlin Giant II . . .	" "	216·0	55·0	48·0	38·5	29·8
D	O'BYRNE	Royal College of Surgeons	231·0	62·5	54·1	45·0	33·4
E	American Giant . . .	" "	213·0	58·5	47·8	41·3	30·0
F	MAGRATH	R. C. S., Dublin	226·0	62·4	50·6	43·3	33·8
G	"Krainer"	Josephinum Vienna . .	203·3	53·4	43·5	39·5	27·5
H	"Grenadier"	" " . .	208·7	55·5	45·6	40·5	29·0
I	Innsbruck Giant . .	Innsbruck	222·6	61·5	52·0	44·6	34·3
J	St. Petersburg Giant .	St. Petersburg	219·5	56·5	50·0	46·0	33·5
K	"Wichsmacher" . . .	Vienna	202·3	52·4	44·9	39·4	27·8
L	Paris Giant	Musée Orfila	236·2	60·96	55·9		
		Sub-Giants.					
M	Bonn Giant	Bonn	188·7	51·0	41·8	35·8	26·0
N	"Gendarme"	Vienna	186·9	51·4	44·0	38·6	26·4
O	Munich Giant . . .	Munich	185·0	50·2	40·8	35·0	25·3
		Dwarfs.					
S	MIKOLAJIK	Anat. Instit., Vienna . .	112·5	31·0	22·8	20·5	15·1
T	SCHAAFHAUSEN'S Dwarf	Bonn	94·0	22·0	16·0		
U	HIS'S Dwarf	. . . .	120·0	31·0	25·0	21·5	16·5
V	BÉBÉ	Jardin des Plantes . . .	100·0	24·52	17·61	20·38	12·17

Remarks.—A. The measurements of this giant are given by MANOUVRIER, 'Mémoires de la Société d'Anthropologie de Paris,' vol. 4, p. 387. The femur has been given its maximum instead of oblique length. See also TOPINARD, 'Anthropologie Générale,' p. 1101.

B and C. Details extracted from 'Die Anthropologischen Sammlungen Deutschlands,' V. Berlin.

D and E. Data from the Royal College of Surgeons' Catalogue.

F. I have taken the length of the long bones from Professor CUNNINGHAM'S paper, "Royal Irish Academy Transactions," vol. 29, 1891, pp. 553–612. CUNNINGHAM uses the femur and TOPINARD'S ratio to get the stature. TOPINARD himself gives MAGRATH'S stature as 223 centims. I do not see why Dr. BIANCHI'S measurement of 226 centims. should be rejected. There is no reason to suppose the doctor would have any cause to exaggerate MAGRATH'S stature, and he measured him alive. I have accordingly adopted BIANCHI'S value as the best available. It is in very good accordance with the stature of the Innsbruck giant, and both were probably shorter than O'BYRNE.

G, H, I, J, K and N are all taken from the very valuable memoir by K. LANGER: "Wachstum des menschlichen Skeletes mit Bezug auf den Riesen," 'Denkschriften der k. Akademie der Wissenschaften, Math. Naturwiss. Classe,' vol. 31, Wien, 1872, pp. 1–105. F, H and R are here distinctly stated to be the maximum lengths, and T appears to be measured without spine.* The heights are apparently those of the articulated skeletons.

L. This is the only giant I have ventured to retain out of Sir GEORGE HUMPHRY'S list in "The Human Skeleton," Cambridge, 1858, p. 107, for he indicates that he measured it himself (p. 105). I have not been able to identify his "Russian Giant" at Bonn. His Berlin giants differ considerably from those in the Berlin Catalogue, while his estimates of O'BYRNE and of the Irish giant seem hopelessly too large. As he gives the Musée Orfila giant 17 centims. less stature than TOPINARD (*loc. cit.*, p. 436), I think his estimate on this occasion more probable. M and O are taken from the Anthropological Catalogues of the Museums at Bonn and Munich. I am not clear as to what is meant by *Körperlänge* in these cases. The statures are curiously small as compared with the long bones, if *Körperlänge* is to be thus interpreted. Possibly it is the length of the mounted skeleton without disks.

S, T and U. The details of these dwarfs I have taken from PALTAUF'S work: 'Ueber den Zwergwuchs in anatomischer und gerichtsärztlicher Beziehung,' Wien, 1891.† This book compares unfavourably with the careful memoir of LANGER. The measurements of the long bones of MIKOLAJIK are given several times over, on each occasion with different values; the exact nature of the measurements made is not stated, and results such as those on the author's p. 92, depending on the most elementary arithmetic, are erroneously given. I have taken the values which seem to give the most self-consistent results, but it is impossible to feel sure of their absolute accuracy. SCHAAFFHAUSEN'S account of his dwarf appears in the 'Berichte der Niederrhein. Gesellschaft für Naturkunde in Bonn,' vols. 25 and 39, and HIS'S account of his dwarf in 'Virchow's Archiv,' vol. 22, p. 104.

All the giants and dwarfs in the above list were adults; the ages of the four dwarfs at death were S, 49 years; T, 61 years; U, 58 years; and V, 23 years.

The following table gives the reconstructed statures of these giants and dwarfs as obtained from my diagram and from MANOUVRIER'S "Coefficients moyens ultimes." I have not thought it necessary to publish in the latter case the estimate from each individual bone, but have simply printed the mean of the four results and the differences from the supposed actual stature. It will be noticed that MANOUVRIER'S estimate is in every case too small. Of my differences, 2 are zero, 6 are positive, and 11 negative, but the negative differences are sensibly larger than the positive, so that my curves have rather under than over corrected for giant and dwarf stature.

* "Aus der Mitte der lateralen Condylusfläche in die Incisura fibularis."

† I have verified the dimensions given for HIS'S dwarf from 'Virchow's Archiv für Pathologie u. Anatomie,' vol. 22, 1861, p. 104, *et seq.*

My mean error is only 3·7 centims., however, as against MANOUVRIER'S 9·3. Allowing for the doubtful character of some of these measurements, I consider this result fairly satisfactory, and believe my estimate may in several cases be better than the supposed stature.

STATURE of Giants and Dwarfs.

	Estimated stature.						Actual stature.	MANOUVRIER.	
	F.	T.	H.	R.	Mean.	Δ.		Mean.	Δ.
A	213	212	210	213	212	+ 2	210	200	−10
B	229	228	228	215	225	+ 2	223	219	− 4
C	207	215	203	211	209	− 7	216	195	−21
D	226	231	227	224	227	− 4	231	223	− 8
E	218	213	213	211	214	+ 1	213	203	−10
F	226	222	221	226	224	− 2	226	218	− 8
G	200	200	205	182	197	− 6	203	187	−16
H	209	207	210	206	208	− 1	209	195	−14
I	224	225	225	227	225	+ 2	223	221	− 2
J	212	220	229	224	221	+ 2	219	214	− 5
K	193	205	205	197	200	− 2	202	188	−14
L	223	235	..	..	229	− 7	236	226	−10
M	180	184	176	171	178	−11	189	178	−11
N	182	202	200	173	189	+ 2	187	183	− 4
O	178	178	173	170	175	−10	185	174	−11
S	114	111	105	107	109	− 3	112·5	109	− 3
T	95	93	..	..	94	0	94	79	−15
U	114	117	108	112	113	− 7	120	116	− 4
V	100	97	104	97	100	0	100	93	− 7

(23.) *Dwarf Races.*

(*a*) Concerning the curves I have given, much diversity of opinion must naturally exist. For we have made use of giants from a great variety of races in order to produce across a considerable range of stature the regression curves based upon the data for one local race, the French. The justification for this can only be *post-facto*, namely, the capacity of the curves to predict the stature of giants and dwarfs satisfactorily. But it will be seen that in doing this we have proceeded rather on mathematical than anatomical grounds. We have supposed a continuity between the normal population and between giants on the one hand and dwarfs on the other. We have treated these beings as rare variations in a normal population, and not as pathological abnormalities. It is true our curves show a region of marked instability, within which any slight change of long bone is accompanied by a great change in probable stature; but nevertheless we have supposed a mathematical continuity, which in itself is hardly consistent with the theory of "pathological abnormality."

The truth of this theory can only be discussed by anatomists, and many anatomists like Professor CUNNINGHAM and Dr. PALTAUF hold that giants and dwarfs are pathological creations—they are the results of abnormal conditions to which they would give the name of a disease. Such a view would exclude any conception—especially in the case of dwarfs among the normal population—of an atavistic influence. The existence even to-day of dwarf races in both Africa and Asia ought, however, to give ground for pause. When we add to this that Professor SERGI actually considers that he has good evidence of a dwarf racial type still extant in Italy, and that Professor KOLLMANN, after examining SERGI's cranial and other evidence, has been converted from strong disbelief to belief,* when we note the forty-three dwarfs (stature $<$ 140 centims.) actually brought to light by *one* annual conscription in Bavaria alone, and finally when we consider the neolithic dwarf skeletons discovered by NUESCH,† we must undoubtedly hesitate to attribute to pathological causes *all* cases of dwarfs which come under notice. The African, Indian, and Italian dwarfs appear as a distinct racial type as little pathological variations of normal man, as a monkey of the anthropomorphous apes. It is thus possible that the pathological characters found in so many dwarfs may be the result of a conflict between atavistic and normal tendencies, rather than themselves the source of dwarfdom. At any rate, while admitting that our curves are largely based on admittedly pathological instances of both giants and dwarfs, it seems well worth while to consider to what results they lead us when we endeavour to reconstruct the stature of dwarf races.

In making this application we have to bear two points in mind (i.) we must expect a wide range in our prediction of statures lying between 130 and 150 centims., for this is the range for which our curves give very unstable results. We can only hope for a fair degree of approximation in the means. (ii.) Our curves are constructed solely from male data, because female data are practically non-extant. We must accordingly endeavour to find some means of passing from male to female stature. To this we must first devote our attention.

(*b*) I take the following data for sexual ratios for the French and Aino from the material of ROLLET and KOGANEI ; for the Naqada race from Dr. WARREN's memoir, and for the Andamanese from Sir W. H. FLOWER's memoir, which is discussed below.

SEXUAL ratio, ♂/♀.

Race.	Stature.	Femur.	Tibia.	Humerus.	Radius.
French	1·083	1·090	1·102	1·110	1·137
Naqada	1·074	1·080	1·088	1·088	1·100
Aino	1·065	1·067	1·064	1·064	1·087
Andamanese	?	1·034	1·034	1·049	1·071

* KOLLMANN in NUESCH, *loc. cit. infra*, p. 238.

† *Ibid.*

Now, there appears from this table to be a very clear rule, namely, that the sexual ratio for stature is certainly not sensibly larger than the least sexual ratio for the long bones. It would seem accordingly improbable that the sexual ratio for the Andamanese can exceed 1·034. If we compare this result with MAN's measurements on 48 male and 41 female Andamanese of which the statures were: male, mean 149·2 centims.; female, mean 140·3 centims., we find ♂/♀ = 1·063, a value much nearer that of the Aino. Sir W. H. FLOWER's own estimated statures* give a sexual ratio of 1·034; the fundamental formulæ for a normal population (p. 196 of this paper) give 1·048; MANOUVRIER's "Coefficients moyens ultimes" give 1·030, and by applying the ratios of stature to long bones as obtained from the average French population we find 1·023. The mean of all these results is 1·038. For the Laps MANTEGAZZA found male = 152·3 and female = 145·0, or the sexual ratio = 1·050. For the Negritos del Monte, or the Aigtas of Luzon in the Philippines, MARCHE and MONTANO give male = 144·1 centims. and female = 138·4 centims., from which we find the sexual ratio of 1·041. TOPINARD gives for races under 150 centims. a mean difference of 4 per cent. between male and female which corresponds to a sexual ratio of 1·042. FRITSCH found a mean difference between male and female Bushmen of 4 centims. which gives (male = 144·4 centims.) a sexual ratio of 1·028; while PARRY's observations on the Esquimaux appear to give a sexual ratio of 1·025, SUTHERLAND's 1·036. From all this it is clear that the dwarfs have a very small sexual ratio for stature as compared with the normal population. At first sight it might seem best to assume this sexual ratio for dwarf races to be TOPINARD's average of 1·042, but as we are going to apply our chart in connection with the sexual ratios found for the long bones of the Andamanese in the table above, I doubt whether it ought to be taken greater than 1·035, say 1·034 in agreement with the value obtained from FLOWER's estimates. Accordingly I formulate the following rule for ascertaining from the chart the probable stature of a female of dwarf race :—

Reduce the female long bones to male long bones by multiplying their lengths by 1·034 in the case of femur and tibia, by 1·049 in the case of the humerus and 1·071 in the case of the radius. Find the corresponding male statures from the chart and multiply it by ·9662 (*i.e.*, the reciprocal of 1·035); these are the probable values of the female stature as estimated from the several long bones, and their mean may be taken as the best result available.

(*c*) It seems very desirable to compare the results thus obtained for male and female of dwarf races with their statures otherwise estimated. If we form a table similar to that on p. 222, but for the case of dwarfs, we have—

* Using the values given, 'Journal of Anthropological Institute,' vol. 14, p. 117.

Data—Male.	S/F.	S/T.	S/H.	S/R.
50 normal French	3·71	4·54	5·06	6·83
MANOUVRIER { "Coefficients moyens ultimes," stature < 153 . . . . . }	3·92	4·80	5·25	7·11
Aino stature = 156·7	3·84	4·76	5·31	6·84
TOPINARD, 21 men from 143 to 160	3·68	4·59	5·00	6·70
PEARSON, 4 dwarfs under 120	3·93	5·24	5·33	7·59

Now the tendency here is clearly for the ratios to increase with decrease of stature, if we consider only French, Aino and the group of four dwarfs. TOPINARD's measurements show, however, rather a tendency in the ratios to return to their values for the mean of the normal French population, and as this was closely akin to what we found in the case of giants, we cannot afford to disregard it in the case of dwarfs. Sir W. H. FLOWER has reconstructed the Andamese from their femora on this supposition, and it does not give by any means improbable values of the stature. We have only to look, however, at the line of regression for the normal population to see that for statures between 155 and 175 this hypothesis will give bad results, but it is conceivable that for statures above and below these limits the ratios of stature to the long bones obtained for the means of a normal population give results which are closer to the truth than those found from the lines of regression. Accordingly, on Plates 1, 2, dotted lines give these ratios of stature to long bones, and the statures of giants and dwarfs can be at once read off on this hypothesis. It will be seen that these lines do not give such good results for the four dwarfs under 120 centims. as our curves, but possibly they may give better results for normal dwarf races from 140 to 150 centims. At any rate they do not on the surface exhibit the difficulty as to "instability" to which I have previously referred. Sir W. H. FLOWER writes of the Akka skeletons that:

"They conform in the relative proportions of the head, trunk, and limb, not to dwarfs, but to full-sized people of other races."*

The chief and great difficulty, however, of adopting these lines of normal stature ratios to determine the stature of dwarf races is to fix a limit to their application. At what point are we to fall back on the normal line of regression? There must be such a point, for that line gives excellent results for statures from 155 to 175 centims. Wherever we do fall back upon it there will arise the very sort of instability which we find in our curves, only it will be a far more arbitrary and sudden change. For this reason I cannot consider it satisfactory to obtain the stature of races of less than 155 centims. by a process which is not in any sense continuous with that used

* 'Journal of the Anthropological Institute,' vol. 18, p. 90. By "dwarf" in the sentence cited I think we are to understand "pathological" dwarf.

for races of more than 155 centims. stature. The position and character of the instability is undefined and appears to be quite arbitrary. At the same time, I give the stature of the dwarf races with which I have dealt below on this hypothesis. In order to apply it, I add the additional data for the female stature and long bone ratios required for this and MANOUVRIER's method, putting in the Aino for comparison :—

Data—Female.	S/F.	S/T.	S/H.	S/R.
50 normal French	3·73	4·62	5·19	7·16
MANOUVRIER { "Coefficients moyens ultimes," stature < 140 . . . . }	3·87	4·85	5·41	7·44
Aino,* stature = 147·1	3·85	4·75	5·31	6·98

The reader must remember that MANOUVRIER's coefficients are for corpse stature and length of bones when the latter contain animal matter. Hence he first adds 2 millims. to the length of the dead bone to get the bone with animal matter, and then 2 centims. are subtracted by him from the corpse length to get the living stature. In the case of the femur, however, he works with the bone in oblique position, or with a length about 3·2 millims. less in the normal individual than the maximum length. This probably does not amount to more than 2 millims. in the case of dwarf races. Hence, when the femur of the dwarf is given by its maximum length, we need not add or subtract anything before multiplying by the stature-femur coefficient. We have accordingly the following methods of estimating the stature of dwarf races from their long bones :—

(i.) The lines of regression for a normal population, *i.e.*, the formulæ of p. 196 of this paper, or the heavy straight lines of our charts. As we have already seen, this over-estimates the stature of dwarfs as it underestimates that of giants.

(ii.) The curves of regression given by the empirical formulæ of p. 224, or by the heavy curves of our charts. In the case of female dwarfs the lengths of their long bones must first be reduced to male equivalents by the rule on p. 230, and the statures found again reconverted to their female equivalents.

(iii.) The "Coefficients moyens ultimes" of MANOUVRIER may be used. These are given on pp. 231 and 232. Special attention must be paid to the reductions (discussed above) of bones and corpse length.

(iv.) The stature and long bone ratios for the normal population may be used. The values of these ratios are given on pp. 231 and 232, but for most practical purposes it suffices to use the dotted lines of the chart.

I shall refer to these methods as P_I, P_{II}, M, and Fl. In the latter case, not

* It will be noticed how close these are to the male coefficients on p. 231, except in the case of the radius, a bone very irregular in primitive and dwarf races.

because Sir W. H. FLOWER was the first* to use a ratio of stature and long bone for the mean population for the reconstruction of stature, but because he has emphasised the fact that, for dwarf races, it does appear to give fairly good results.

(24.) *Bushmen.*

My material is very sparse. Sir GEORGE HUMPHRY, in his work on "The Human Skeleton," gives (p. 106) the mean long-bone lengths for three presumably male Bushmen.

$$F = 38{\cdot}10, \quad H = 27{\cdot}43, \quad T = 32{\cdot}77, \quad R = 21{\cdot}08.$$

I find :—

ESTIMATED Stature of Bushmen.

Bone.	P_I.	P_{II}.	M.	Fl.
F	152·9	150·0	147·4	141·4
H	150·0	141·0	143·1	138·8
T	156·5	156·5	156·2	148·8
R	154·9	153·0	149·3	144·0
F + T	152·4	..	..	..
F & T	152·3	..	..	..
H + R	150·8	..	..	..
H & R	149·8	..	..	..
F & H	150·3	..	..	..
F, T, H & R	150·6	..	..	..
Means . . .	152·05	149·9	149·0	143·25

Now it is clear that neither the chart (P_{II}), nor MANOUVRIER'S "Coefficients moyens ultimes" (M), make in this case much alteration on the estimate given by my normal regression formula (k) for all four long bones. But the value given by Fl is 6 centims. less. Sir GEORGE HUMPHRY gives the average stature of these three Bushmen as 137·1 centims. He does not, however, state where his data are taken from. Curiously enough, his value for stature coincides exactly with the value TOPINARD says BARROW has assigned to the Bushmen. I cannot think that this was the stature in life of the individuals whose bones are averaged by HUMPHRY. FRITSCH gives the average stature of six Bushmen he measured as 144 centims.,† and I should hesitate to place the mean stature of the above three below 145 centims. to 150 centims. At

* It has been used by ORFILA, Sir GEORGE HUMPHRY, and others, and, as we have seen, gives quite incorrect results for races from 155 to 175 centims. in stature.

† See TOPINARD, 'Anthropologie générale,' p. 461.

the same time it must be remembered that the stature falls within the range within which our chart shows that a very slight change in the long bones makes a great difference in stature. In case the reader should be inclined to put too great faith in Fl, I would draw attention to the fact that it underestimates by slightly over 5 centims. the known stature of the fairly short Aino race, while P_I or P_{II} give it almost accurately and M fairly closely.

The only other Bushmen I have been able to find are a male and two females in the Royal College of Surgeon's Catalogue. Selecting the right members as those for which our formulæ and curves are deduced, we have:

Male,	F = 35·6 centims.,	H = 25·5 centims.,	T = 29·9 centims.,	R = 20·8 centims.
Female 1,	F = 38·0 „	H = 27·0 „	T = 33·2 „	R = 21·0 „
„ 2,	F = 37·6 „	H = 25·7 „	T = 28·8 „	R = 18·6 „

The following table gives the estimated statures:—

Bone.	Male.				Female 1.				Female 2.			
Key letter.	P_I.	P_{II}.	M.	Fl.	P_I.	P_{II}.	M.	Fl.	P_I.	P_{II}.	M.	Fl.
(*a*)	148·2	130	137·6	131·9	146·7	148·8	145·1	141·6	146·0	146·9	143·5	140·1
(*b*)	144·4	124	132·9	129·1	145·8	140·6	145·1	140·1	142·2	131·4	138·1	133·3
(*c*)	149·7	136	142·5	135·7	152·9	154·6	160·0	153·3	142·5	129·4	143·5	133·0
(*d*)	154·0	152	147·3	142·0	151·4	154·3	155·7	150·4	143·4	125·1	137·9	133·2
(*e*)	147·2	..	..	..	149·3	..	..	..	143·9	..	..	..
(*f*)	147·2	..	..	..	149·4	..	..	..	144·0	..	..	..
(*g*)	146·9	..	..	..	148·1	..	..	..	142·0	..	..	..
(*h*)	144·4	..	..	..	146·2	..	..	..	142·1	..	..	..
(*i*)	144·8	..	..	..	146·0	..	..	..	144·2	..	..	..
(*k*)	144·8	..	..	..	148·0	..	..	..	143·1	..	..	..
Mean .	147·2	135·5	140·1	134·9	148·4	149·6	151·5	146·3	143·3	133·2	140·75	134·9

The estimates based on the skeleton height of these three Bushmen are: Male = 133·3, female 1 = 140·0, and female 2 = 139·0 centims. The mean error made by P_{II} is 5·9, by M 6·7, and by Fl 4·1 centims. But it must be noticed that the last gives in one instance *less* than the height estimated from the skeleton—a result which is in itself very improbable. A consideration of the values here given seems to show that with the mean length of bones given by HUMPHRY the mean stature could not possibly have been the 137·1 centims. he states. For whatever estimate we take of the Female 1, she must have been with bones no longer, at least 10 centims. taller than HUMPHRY'S mean male. Taking our four males and two females we get from P_{II} estimated statures for male and female Bushmen of about 146 and 142 centims., which I expect are not very far from the truth.

(25.) *Akka Stature.*

In a paper by Sir W. H. FLOWER in the 'Journal of the Anthropological Institute,' vol. 18, 1889, entitled: "Description of two Skeletons of Akkas, a Pygmy Race from Central Africa," the following data are given (p. 14):

	F.	H.	T.	R.
Male . . .	32·6 centims.	23·8 centims.	27·0 centims.	18·2 centims.
Female . .	33·4 ,,	24·4 ,,	27·0 ,,	19·4 ,,

In the following table the reconstructed statures are given on the same four hypotheses as we have considered in the case of Bushmen.

Bone.	Male.				Female.			
Key letter.	P_{I}.	P_{II}.	M.	Fl.	P_{I}.	P_{II}.	M.	Fl.
(*a*)	142·6	118·5	125·8	121·0	137·8	120·3	127·3	124·6
(*b*)	139·5	117·5	124·0	120·4	138·7	119·8	131·1	126·6
(*c*)	140·7	122·5	128·6	122·6	136·4	121·2	129·9	124·7
(*d*)	145·5	119·5	128·8	124·3	146·1	135·3	143·8	138·9
(*e*)	139·3	..	..	..	136·3	..	..	..
(*f*)	139·4	..	..	..	136·3	..	..	..
(*g*)	139·5	..	..	..	141·2	..	..	..
(*h*)	139·2	..	..	..	139·0	..	..	..
(*i*)	139·0	..	..	..	137·2	..	..	..
(*k*)	138·2	..	..	..	135·0	..	..	..
Mean .	140·3	119·6	126·8	122·1	138·4	124·1	133·0	128·7

Sir W. H. FLOWER estimates the height of both individuals at about 4 feet, or 122 centims. He gives 121·8 as the estimate of stature from the female skeleton. We could hardly want better results than are given by P_{II}. Fl gives also good results, while M appears to err in excess.*

* EMIN PASHA refers to an Akka woman of 136 centims. stature, who must therefore have been considerably taller than the above woman.

(26.) *Andamanese Stature.*

The stature of the Andamanese is a peculiarly difficult one to estimate. They are taller than Bushmen and Akkas, and fall more markedly into the unstable range of our chart curves. The measurements of a very considerable number of long bones have been given by Sir W. H. FLOWER in two papers in the 'Journal of the Anthropological Institute,' vol. 9, 1879, and vol. 14, 1885. I take the following mean values from the latter paper (p. 116) :—

	No.	F.	H.	T.	R.
Male . . .	25	39·34	27·65	33·21	22·52
Female . .	26	38·04	26·35	32·10	21·01

Constructing as in the previous cases a table of stature as estimated by all four methods we find :—

Bone.	Male.				Female.			
Letter.	P_I.	P_{II}.	M.	Fl.	P_I.	P_{II}.	M.	Fl.
(*a*)	155·3	154	152·2	145·8	146·8	148·8	145·2	141·8
(*b*)	150·7	144	144·2	139·9	144·0	138·1	141·6	136·7
(*c*)	157·6	157	158·4	150·8	150·3	151·7	153·7	148·3
(*d*)	159·6	160	159·5	153·7	151·5	154·3	155·8	150·4
(*e*)	155·4	..	..	..	148·1	..	..	..
(*f*)	155·3	..	..	..	148·2	..	..	..
(*g*)	153·6	..	..	..	147·0	..	..	..
(*h*)	150·7	..	..	..	144·5	..	..	..
(*i*)	152·0	..	..	..	145·4	..	..	..
(*k*)	152·6	..	..	..	146·1	..	..	..
Mean .	154·3	153·7	153·6	147·6	147·2	148·2	149·1	144·3

Now it will be observed that P_I, P_{II}, and M give sensibly the same result : 154 centims. for the male; that for the female, P_{II}, owing to our having first to increase the female bones to reduce them to male lengths, gives a higher result than P_I, for we have got into the unstable range of the curves, and the stature-reducing factor afterwards applied does not undo the excess. There is not much, therefore, to choose between P_I, P_{II}, and M for the Andamanese. They give results 4 centims. greater than Fl in the case of males, and 3 centims. greater in the case of females. From them we should conclude that the stature of Andamanese was given by male = 154 centims., female = 148 centims. MAN,* who measured 48 male and 41 female living Andamanese, gives the stature as, male = 149·2 centims., and female = 140·3 centims.

Sir W. H. FLOWER estimates the stature from his skeletons at male = 143·1 centims., and female = 138·3 centims. This is very much less even than MAN's determination of the living stature. MANTEGAZZA, who possesses a skeleton of an Andamanese, gives its skeleton height at 148·5 centims., and KOLLMANN considers its living stature to have been 150 centims.† The femur in this case is 42·4 centims. long, which would correspond in a normal Frenchman to a stature of 161 centims. I must state that I feel inclined to put entirely on one side estimates of stature based on the height of the articulated or unarticulated skeleton, they appear invariably to underrate the living stature, and often by very large amounts. Even if we suppose the Andamanese to have the relative proportions of full-sized people (*e.g.*, use Fl), we obtain statures considerably above Sir W. H. FLOWER's estimates. On the other hand MAN's measurements, which give results much in excess of the latter, fall considerably short of the results we obtain from P_I, P_{II}, or M. They even fall short of Fl, and in the case of females markedly short of it. If we consider that FLOWER's skeletons and MAN's individuals belong to the same group, then it must be confessed that our estimates are unsatisfactory. The hypothesis Fl gives the least divergent result, but it cannot be considered a particularly good one. It will be seen at once that it is the inferior members in each limb which give the exaggerated stature estimates. If we confined our attention to femur and humerus, then P_{II} (*a*) and (*b*) would give 149·0 for males and 143·4 for females, results better in accordance with MAN's measurements than Fl for all four bones, or than Fl for male femur and humerus only.

When we consider the immense importance of these dwarf races for the problem of evolution, the main result of our investigation is obvious; there ought to be an elaborate investigation—such as KOGANEI has made for the Aino—on the long bones of skeletons and the stature of living individuals, of some extant dwarf race. These races are rapidly becoming extinct, and the possibility of making such an investigation is yearly diminishing. Yet it is only by a careful comparison of the regression formulæ for dwarf and normal races that it seems to me possible that we shall be able quantitatively, and therefore definitively, to fix the relationship of dwarf and normal races in the course of evolution.‡

* See Sir W. H. FLOWER on "Pygmy Races," 'Journ. of Anthropological Institute,' vol. 18, 1889, p. 73.

† NUESCH, *loc. cit.*, *infra*, p. 129.

‡ The reader must bear in mind that nearly all the vagueness involved in our attempts to recon-

(27.) *European Neolithic Dwarfs.*

In the recently published work by NUESCH, 'Die prähistorische Niederlassung beim Schweizersbild,' 1896, is a memoir by KOLLMANN, entitled, "Die menschlichen Skelete, besonders über die fossilen menschlichen Zwerge." This publication for the first time showed us that there existed in neolithic Europe, alongside a normal race, with a stature of about 163 centims., a dwarf race, very similar to the pygmy races, of which we still find traces extant in Africa and Asia. At any rate the discovery in the same group of graves of four skeletons, or rather fragments of skeletons, which must have belonged to individuals who were pygmies, and not "pathological" dwarfs, points very strongly in this direction.

KOLLMANN, who gives a most interesting discussion of these neolithic pygmies, provides the following measurements :—

	F.	H.	T.	R.
1. Female . . .	36·9 centims.	..	..	..
2. ,, or male.	31·3 ,,	..	..	..
3. ,, . . .	35·52 ,,	25·15 centims.	29·90 centims.	..
4. ,, or male.	39·40 ,,	28·20 ,,	32·70 ,,	22·60 centims.

Of these: 1, female, is an adult; 2, female or male, is that of a young person 16 to 18 years old, and, according to KOLLMANN, probably, but not certainly, female; 3, female, and 4, female or male, are adults, but as we see the sex of the latter appears doubtful. Proceeding, as in the earlier cases, we find :—

struct stature, arises from the fact that the regression coefficients for long bones and stature are known for *one* local race only, and that we have nothing else to go upon. Had we endeavoured to reconstruct one long bone from a second, we should have had far more exact material to determine the differential evolution of local races.

Bone.	1, female.				2, as female.				2, as male.				3, female.				4, as female.				4, as male.			
Key letter.	P_I.	P_{II}.	M.	Fl.	P_I.	P_{II}.	M.	Fl.	P_I.	P_{II}.	M.	Fl.	P_I.	P_{II}.	M.	Fl.	P_I.	P_{II}.	M.	Fl.	P_I.	P_{II}.	M.	Fl.
(*a*)	144·6	145·4	140·8	137·5	133·7	114·0	119·1	116·7	140·1	115·0	120·7	116·0	141·9	135·7	135·5	132·4	149·5	152·1	150·5	146·8	155·4	154·5	152·5	146·0
(*b*)	..	..	..	..	..	..	..	..	..	..	..	..	140·7	124·1	135·1	130·4	149·1	150·2	151·6	146·3	152·2	149·0	147·1	142·7
(*c*)	..	..	..	..	..	..	..	..	..	..	..	..	145·1	141·5	144·0	138·1	151·7	153·6	157·6	151·0	156·4	155·0	155·9	148·5
(*d*)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	156·8	159·4	167·8	161·8	159·9	159·5	160·1	154·3
(*e*)	..	..	..	..	..	..	..	..	..	..	..	..	142·8	..	..	..	150·3	..	..	..	154·8	..	..	..
(*f*)	..	..	..	..	..	..	..	..	..	..	..	..	142·9	..	..	..	150·4	..	..	..	154·8	..	..	..
(*g*)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	152·6	..	..	..	154·7	..	..	..
(*h*)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	149·7	..	..	..	152·3	..	..	..
(*i*)	..	..	..	..	..	..	..	..	..	..	..	..	140·8	..	..	..	149·1	..	..	..	152·9	..	..	..
(*k*)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	148·7	..	..	..	153·0	..	..	..
Mean	144·6	145·4	140·8	137·5	133·7	114·0	119·1	116·7	140·1	115·0	120·7	116·0	142·4	133·8	138·2	133·6	150·8	153·8	156·8	151·5	154·6	154·5	153·9	147·9

If we include the non-adult and suppose the whole series female, we have:

P_I.	P_{II}.	M.	Fl.
142·9 centims.	136·7 centims.	138·7 centims.	134·8 centims.

Without the non-adult, we have:

P_I.	P_{II}.	M.	Fl.
145·9 centims.	144·3 centims.	145·3 centims.	140·9 centims.

The two possible males give:

P_I.	P_{II}.	M.	Fl.
144·2 centims.	134·2 centims.	136·5 centims.	132·3 centims.

The adult male gives:

P_I.	P_{II}.	M.	Fl.
154·6 centims.	154·5 centims.	153·9 centims.	147·9 centims.

The single male here is about identical with the means obtained by the different methods on p. 236 for the male Andamanese, and the adult females give a result somewhat less than that of the female Andamanese as reconstructed from their long bones, but in close accordance with MAN's measurements of living Andamanese stature. The dimensions are somewhat larger than those of Bushmen, or Akkas, or Negritos. We seem, therefore, justified in assuming a neolithic pygmy race in Europe having a stature about the same as that of the Andamanese. Whether the actual stature of this race was for the female nearer to 144 centims. (P_{II}) or 141 centims. (Fl) it seems to me impossible to ascertain definitely until we have more trustworthy and extensive measurements than yet exist of the living stature of extant pygmy races.

(28.) *Conclusion.*

The formulæ and curves for the reconstruction of stature which are given in this memoir, must by no means be taken as final. No scientific investigation can be final; it merely represents the most probable conclusions which can be drawn from the data at the disposal of the writer. A wider range of facts, or more refined analysis, experiment, and observation will always lead to new formulæ and new theories. This is the essence of scientific progress. All, therefore, which is claimed for this paper is (i.) that it exhibits a better theory of the reconstruction of stature than any which has so far existed—it might not be too much to say that nothing which can be called a theory has hitherto existed; (ii.) that it determines the constants of the formulæ given by that theory as well as the existing data allow of; (iii.) that it gives values for the probable statures of prehistoric races, which have far less divergence among themselves, whatever be the bone or combination of bones used, than those suggested by previous investigators; and lastly (iv.) that it indicates what additional data ought to be sought for, and to some extent what is the inner meaning of divergent results, for the great problem of racial differentiation by natural selection.*

Of the general conclusions reached by the author, perhaps two deserve restating and emphasising here. In the first place, although there were individual tall men among the neolithic populations, whose bones have so far been unearthed, yet neolithic man as a whole was short. Of course, it is possible that a tall neolithic type, *i.e.*, one with a stature greater than 168 centims. say, may yet be discovered—witness the discovery within the last two years of a neolithic dwarf. But failing its appearance, the question arises, where and how did the tall Anglo-Saxon and Scandinavian develop? To what extent is this tallness racial, to what extent due to environment? The apparently greater stature of British over Continental neolithic man deserves special consideration from anthropologists.

Secondly, granting that the modern populations in the same district are taller than the neolithic populations, there still appears in both France and Southern Germany some regression of the modern stature on that of the ancient Franks, Bajuvars, and Allemans. I differ from both RAHON and LEHMANN-NITSCHE in considering that the difference is too great to be accounted for as a process of natural selection applied to the long bones. RAHON has made a slip in his arithmetic, and LEHMANN-NITSCHE compares the Row Grave population with the *most* favourable element of Munich town recruits. If the divergence could be accounted for by selection applied to the bones, why is not a similar divergence to be found in the case of Anglo-Saxons and modern English? I think an explanation must be sought elsewhere. One suggestion is, that as the physical struggle for existence has been lessened, reproductive selection has had more play, and the greater fertility of an older pre-Germanic element in the populations of both Southern Germany and France has led to a return of stature to its more ancient value. In the case of Anglo-Saxons and Scandinavians in England there was very probably a more complete destruction of the earlier populations. Whatever may be the real reason for this apparent degeneration, it seems most desirable that there should be a systematic measurement of all long bones dug up anywhere in our own country, and this whether they belong to prehistoric or historic times. Stature is quite as marked a racial character as cephalic index, or any other skull measurement, and its high correlation with the long bones admits even in the present state of our data of its reconstruction with very considerable accuracy, if only a sufficient representation, say twenty to forty long bones, of an ancient population has been measured. It is only by the gradual accumulation of such data that we can

* The influence of *directed* as distinguished from random selection on size, variation, correlation, and regression has been theoretically developed in a memoir not yet published. Having been fully discussed in my college lectures of this Session, much of the recent work of my department, like the present memoir, touches on it.

hope for light on the manner in which our own population has developed and is developing.*

(29.) The following table restates some of the numerical results reached, and further includes, for the purposes of comparison, the stature of certain modern races as given by various authorities. No stress whatever is laid on the latter values, which have often been determined by doubtful observers from very small series.† They are merely given here in order to show the *general* position of the reconstructed races in the order of racial statures.

TABLE of Stature and Sexual Ratio for Divers Races.

Race.	Authority.	Male.	Female.	Ratio ♂/♀.
12 giants > 200	Memoir, p. 226	217·6	..	..
4 sub-giants, Bavarian recruits	RANKE	190·5	..	..
3 sub-giants in Museums	Memoir, p. 226	186·9	..	..
Samoans	TOPINARD	188·3	..	..
Patagonians	MOVENO and LISTER	185·0	..	..
Caribeans	HUMBOLDT	184·0	..	..
Red Indians	TOPINARD	175–180	..	..
Polynesians	,,	170–180	..	..
Flamboro' Head English	PITT RIVERS	175·2	162·5	1·078
Livonians	TOPINARD	173·6	..	..
Americans (born)	GOULD	173·5	..	..
Fellahs (Egypt)	WOLNEY	173·0	..	..
English (Middle classes)	PEARSON	172·8	159·9	1·080
Todas of Nilgherry	MARSHALL	172·7	..	..
Norwegians	HUNT	172·0	..	..
American Scottish	GOULD	171·6	..	..
Bantu	FRITSCH	171·8	..	..
Finns	BONSDORFF	171·4	..	..
American Norse	BAXTER	171·3	..	..
Round Barrow British	Memoir, p. 213	171·1	160·2	1·090
Anglo-Saxons	,, p. 216	170·9	156·0	1·096
American Irish	GOULD	170·5	..	..
Lithuanians	TOPINARD	170·4	..	..
American English	GOULD	170·1	..	..
English Commonalty	GALTON	170·0	158·3	1·074
Sikhs	TOPINARD	170·0	..	..
Bajuvars from Row Graves.	Memoir, p. 214	169·2	154·5	1·095
American Germans	BAXTER	169·5	..	..
American Danes	,,	169·2	..	..
American Swedes	GOULD	169·2	..	..
Nubians	TOPINARD	169·0	..	..
Bechuanas	FRITSCH	168·4	..	..
American negroes (pure)	GOULD	168·0	..	..

* For example, no one can say at present what was the stature of Englishmen from A.D. 1000 to 1700, and yet large collections of bones exist, which would suffice to answer this problem.

† TOPINARD, for example, considers the sex ratio for 73 series in "Étude sur la taille considérée suivant . . le sexe . . . et les races," 'Revue d'Anthropolgie,' 1876, p. 34, but he merely gives means for grouped results and does not tell us the details for the individual series.

TABLE of Stature and Sexual Ratio for Divers Races—(continued).

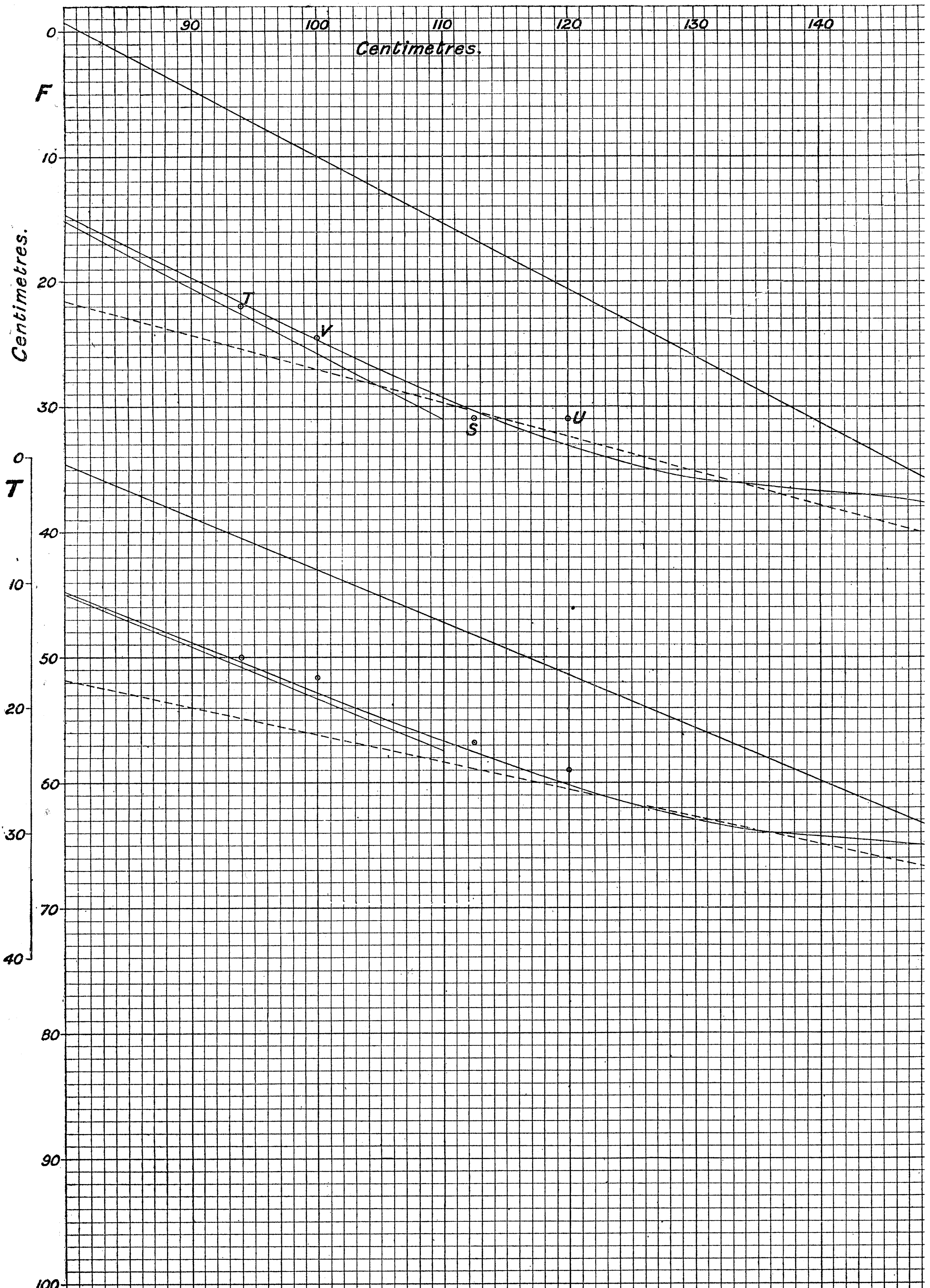
Race.	Authority.	Male.	Female.	Ratio ♂/♀.
4th to 7th cent. mediæval French	Memoir, p. 219	167·98	154·79	1·085
Naqada Race	„ p. 211	167·5	156·0	1·074
Neolithic man in Britain	„ p. 206	167·3	153·6	1·089
Kabyles	PRENGRÜBER	167·3	..	..
Guanches I.	Memoir, p. 210	166·77	154·65	1·078
Romano-British	„ p. 213	166·7	152·2	1·090
Franks	„ p. 218	166·42	152·12	1·091
French (as corpse)	„ p. 180	166·26	154·02	1·079
10th to 11th cent. mediæval French	„ p. 219	166·24	154·49	1·077
Guanches II.	„ p. 210	166·18	153·83	1·081
Mordevins	TOPINARD	166·0	..	..
Munich District conscripts	RANKE	166·0	..	..
Bavarians (as corpse)	BISCHOFF	165·93	153·85	1·078
Russian soldiers (Great Russia)	TOPINARD	165·5	..	..
Dolmens (Algeria)	Memoir, p. 210	165·5	152·56	1·085
French conscripts	MANOUVRIER	165·0	..	..
Italians (Tuscany)	TOPINARD	165·0	..	..
Dolmens (India)	Memoir, p. 210	165·24	154·86	1·067
Romano-Gauls	„ p. 213	164·82	152·27	1·082
Chinese	BRIGHAM	164·5	..	..
Esthonians	TOPINARD	164·2	..	..
Ruthenians	„	164·0	..	..
Dolmens (Caucasus)	Memoir, p. 210	164·33	152·47	1·078
Neolithic man (Mureaux)	„ p. 208	163·39	152·56	1·071
Baden conscripts	ECKER	163·0	..	..
Palæolithic man	Memoir, p. 205	162·7	..	..
Neolithic man, France and Belgium	„ p. 207	162·54	151·44	1·073
Poles	TOPINARD	162·0	..	..
Italians (Piedmont)	„	162·0	..	..
Sicilians	„	161·0	..	..
Neolithic man (Brueil)	Memoir, p. 208	160·91	150·68	1·068
Hottentots	FRITSCH	160·4	..	..
Samoyedes	TOPINARD	159·0	..	..
Annamites	„	158·9	..	..
Esquimaux	SUTHERLAND	158·5	152·8	1·036
Sardinians	TOPINARD	158·0	..	..
Aino	Memoir, p. 199	156·7	147·1	1·065
Juags of Oriva	SHORT	156·0	..	..
Veddahs	BAILEY	153·0	143·3 (?)	1·068
Ostiaks	TOPINARD	153·0	..	..
Siamese	„	152·5	..	..
Laps	MANTEGAZZA	152·3	145·0	1·050
Andamanese I.	MAN	149·2	140·3	1·063
Andamanese II.	Memoir, p. 236	147·6	144·3	1·023
Bushmen I.	FRITSCH	144·4	140·4	1·028
Bushmen II.	Memoir, p. 233	146·0	142·0	..
Aigtas of Luzon	MARCHE and MONTANO	144·1	138·4	1·041
Neolithic dwarfs	Memoir, p. 240	148·0 (?)	141·0 (?)	..
35 Bavarian super-dwarfs	RANKE	133·9	..	..
Akkas	Memoir, p. 235	120·0	124·0	..
4 dwarfs < 125 centims.	„ p. 226	106·6	..	..
Gorilla	Memoir, p. 202	147·0	..	..
Chimpanze	„ „	127·0	..	..
Orang	„ „	112·0	..	..

[Note added November 29, 1898.—Dr. WARREN has made an experiment on two Naqada femora and kindly sent me the following results :—

Femur I. *Oblique Length.*		
Wednesday,	1 P.M. . . .	40·82
Put into water at 1 P.M.		
Wednesday,	7 P.M. . . .	40·97
Thursday,	10 A.M. . .	41·00
,,	7 P.M. . . .	41·00
Friday,	10 A.M. . . .	41·01
,,	6 P.M. . . .	41·02
Saturday,	10 A.M. . . .	41·03
Monday,	10 A.M. . . .	41·04
Removed from water at 10 A.M.		
Monday,	7 P.M. . . .	41·04
Tuesday,	10 A.M. . . .	41·02
,,	7.30 P.M. . . .	41·02
Wednesday,	10 A.M. . . .	40·96
Thursday,	10 A.M. . . .	40·89
Friday,	10 A.M. . . .	40·87
Saturday,	10 A.M. . . .	40·82
Monday,	10 A.M. . . .	40·81
Tuesday,	10 A.M. . . .	40·80
Wednesday,	10 A.M. . . .	40·80
Friday,	10 A.M. . . .	40·80

Femur II. *Oblique Length.*		
Tuesday,	10 A.M. . . .	44·31
Put into water at 10 A.M.		
Tuesday,	12 A.M. . . .	44·38
,,	7.30 P.M. . . .	44·42
Wednesday,	1 P.M. . . .	44·47
,,	7 P.M. . . .	44·48
Thursday,	10 A.M. . . .	44·50
Saturday,	10 A.M. . . .	44·53
Monday,	10 A.M. . . .	44·53
Removed from water at 11 A.M.		
Monday,	7 P.M. . . .	44·53
Tuesday,	10 A.M. . . .	44·43
Wednesday,	10 A.M. . . .	44·34
Thursday,	10 A.M. . . .	44·32
Friday,	7 P.M. . . .	44·32

Thus there was a difference in the dry and wet states of 2·4 and 2·2 millims. respectively. Considering that the bones were some 3500 years older than those I experimented on, the agreement in result must be considered good. The maximum rate of expansion is reached in the first hour or two, and then gradually diminishes; the maximum rate of contraction is not reached before about the second or third day, without artificial drying as in my case.]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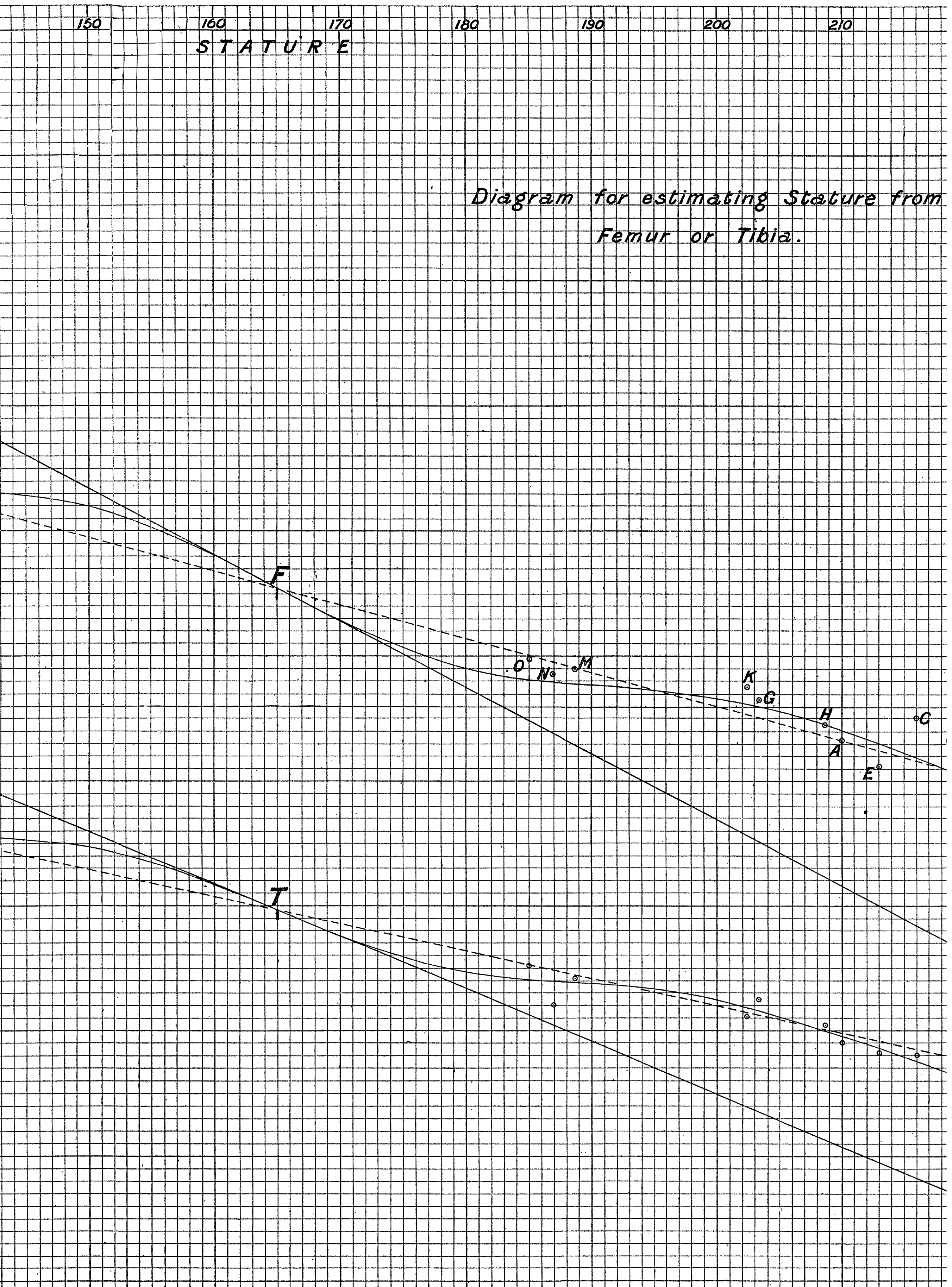
150
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210
STATURE
Diagram for estimating Stature from
Femur or Tibia.
F
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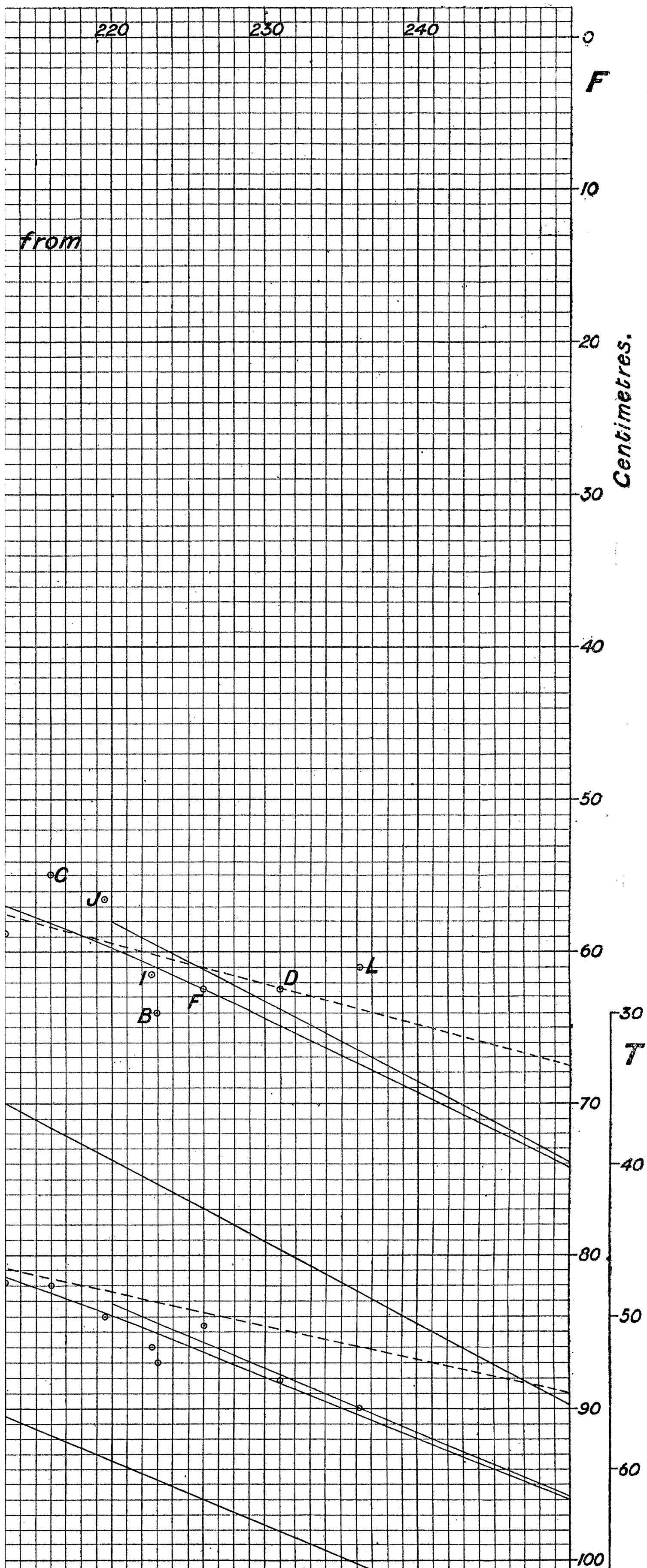
220
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Centimetres.
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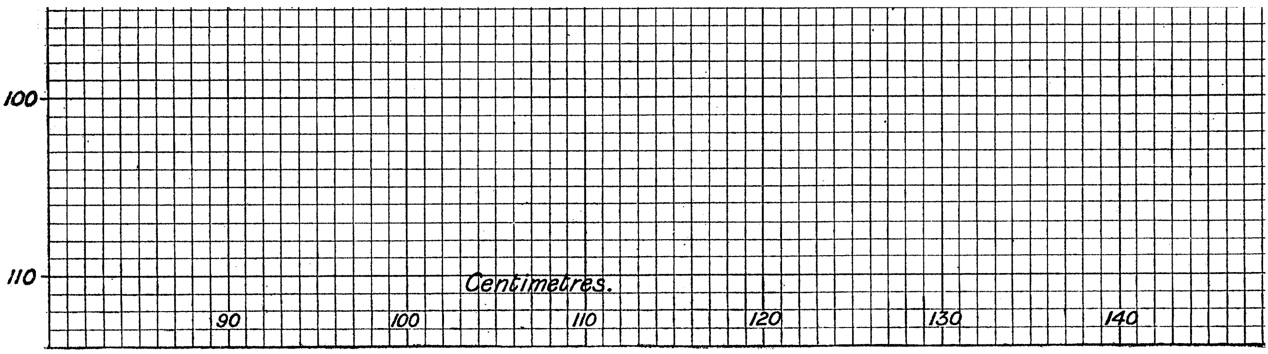
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Centimetres.
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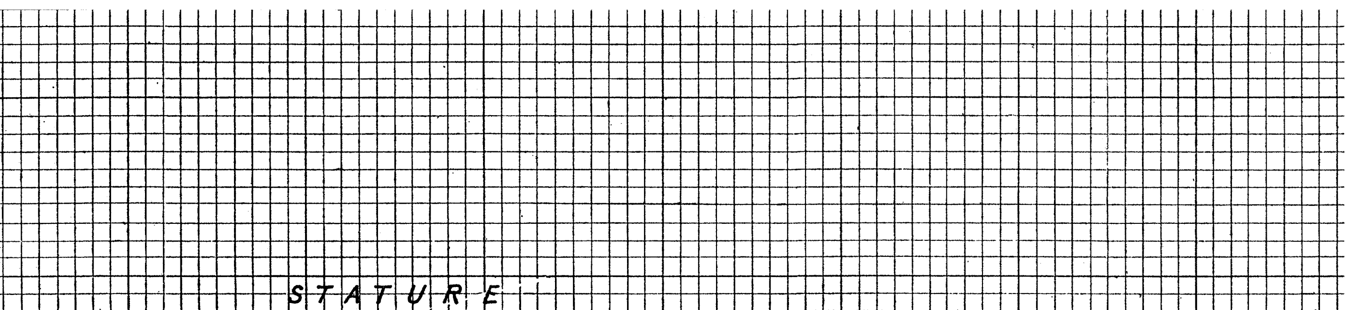
STATURE
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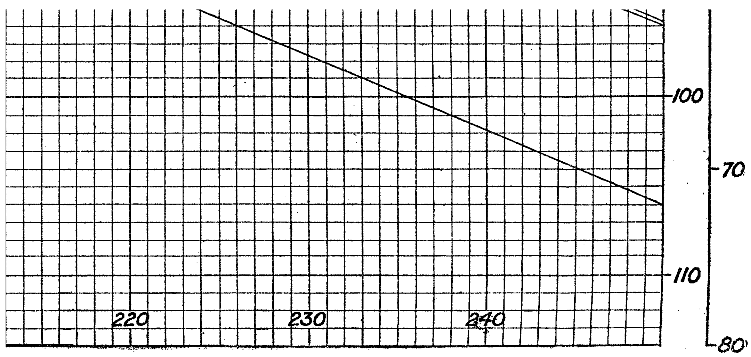

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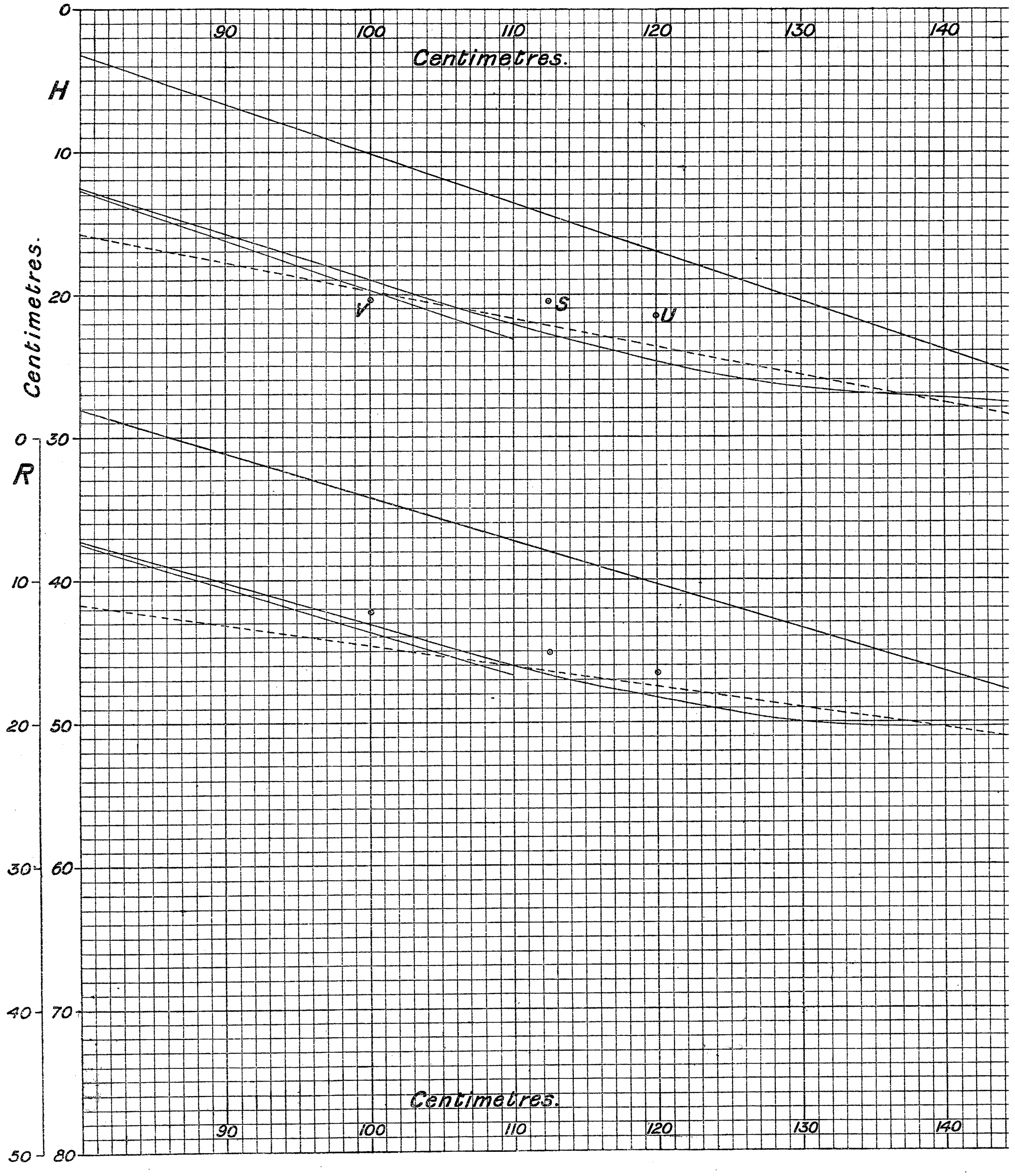
Pearson.



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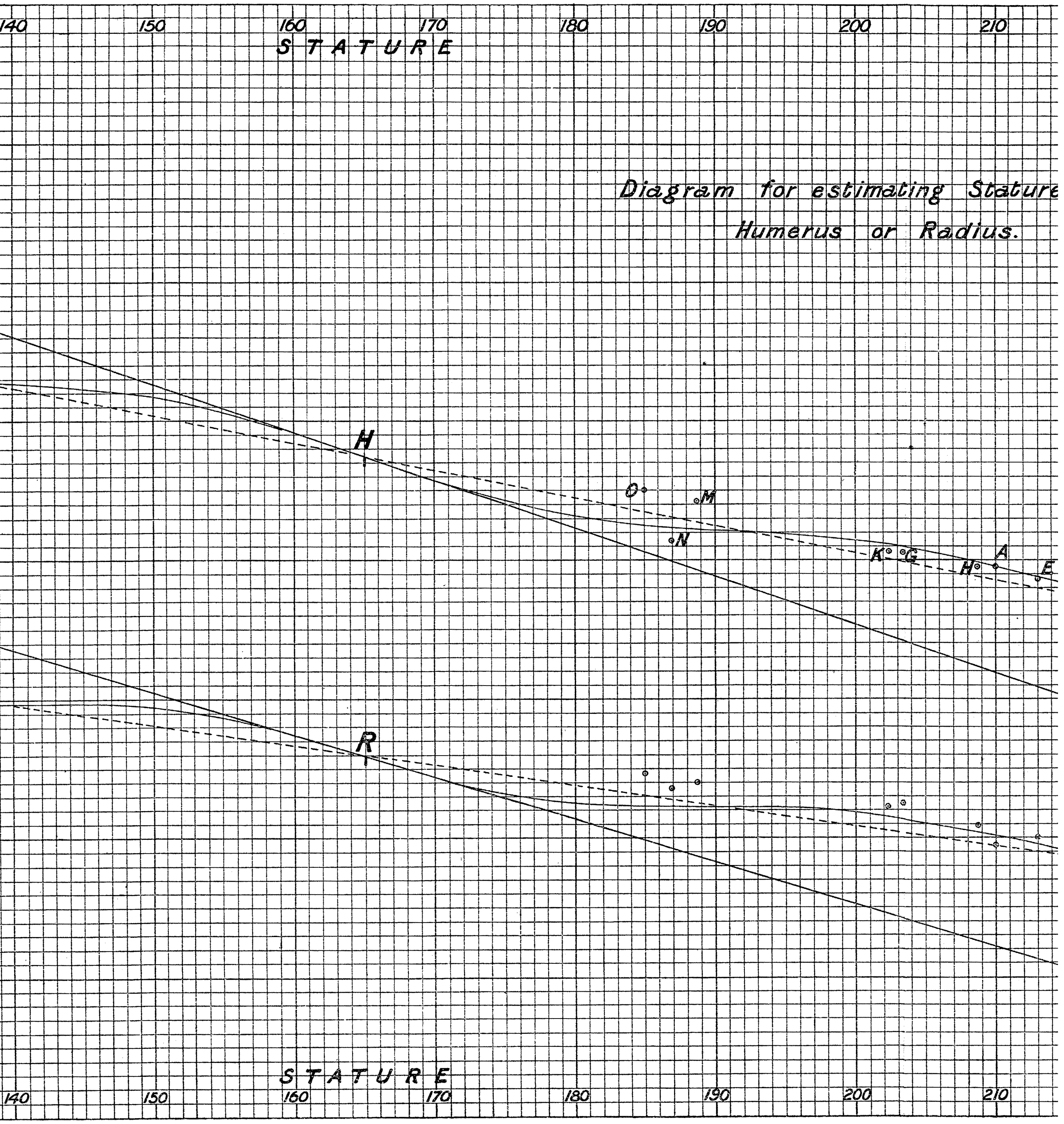

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STATURE
Diagram for estimating Stature
Humerus or Radius.
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STATURE
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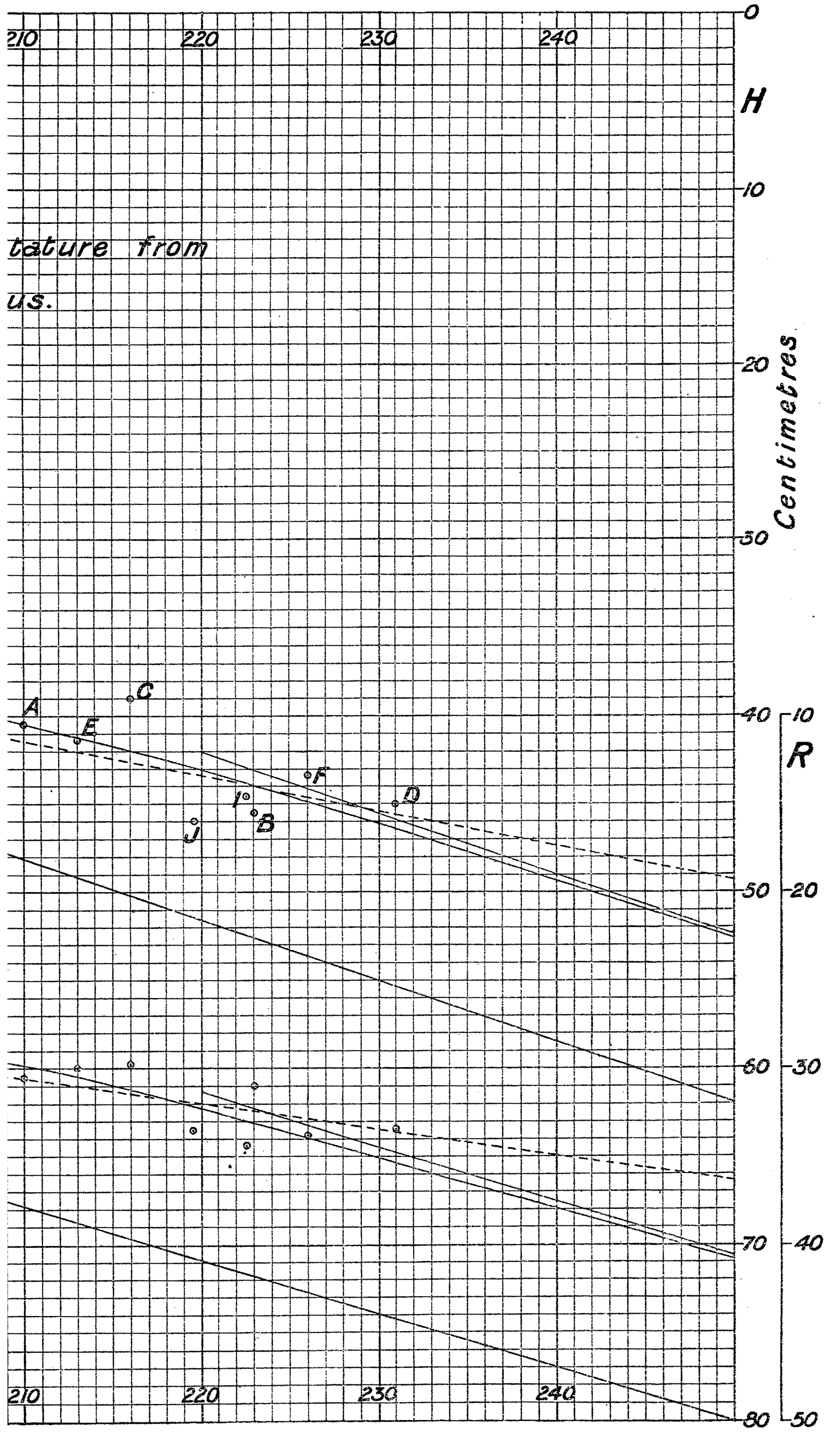
tature from
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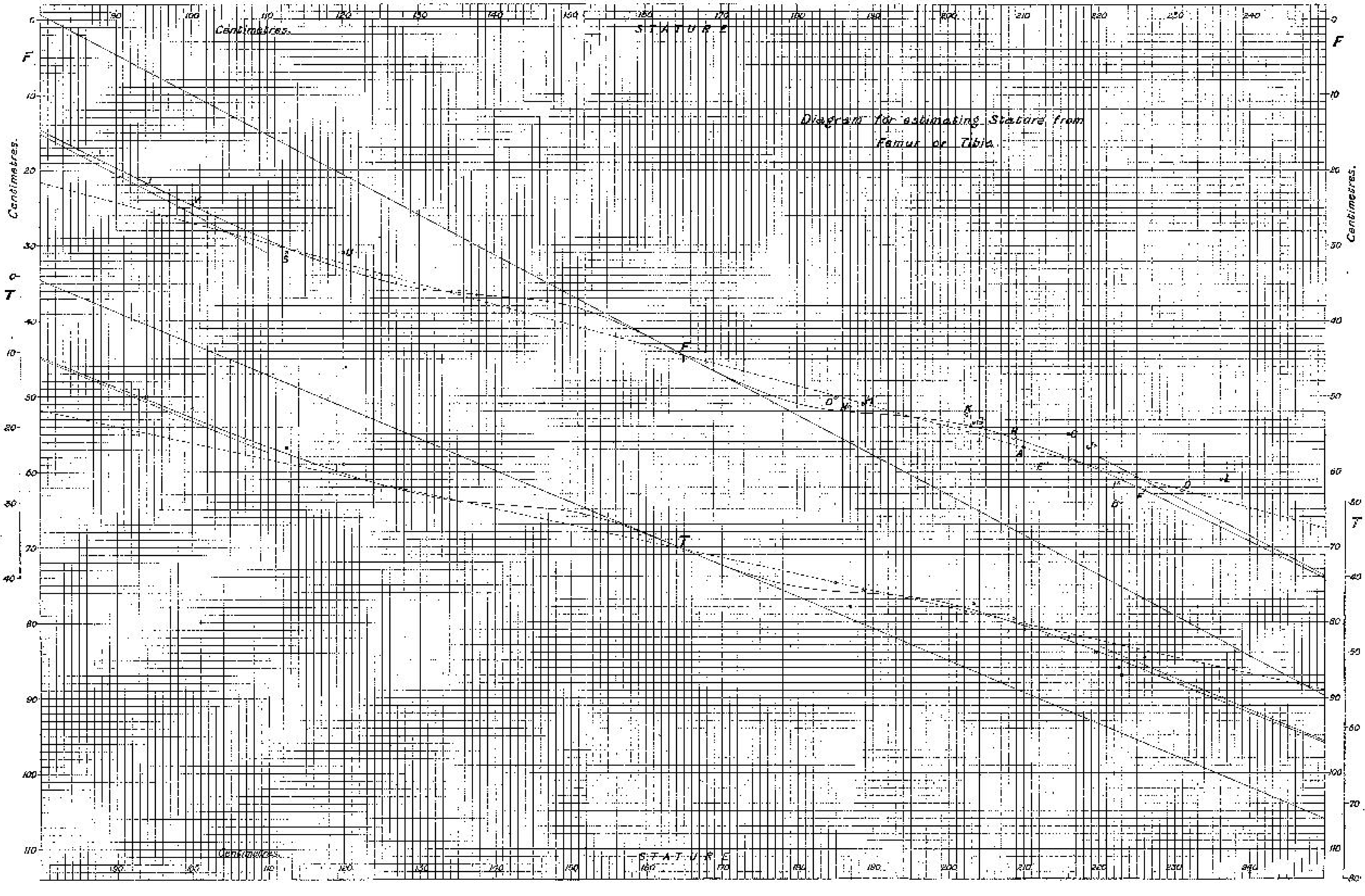
Diagram for estimating Stature from
Femur or Tibia.
STATURE
Centimetres.
F
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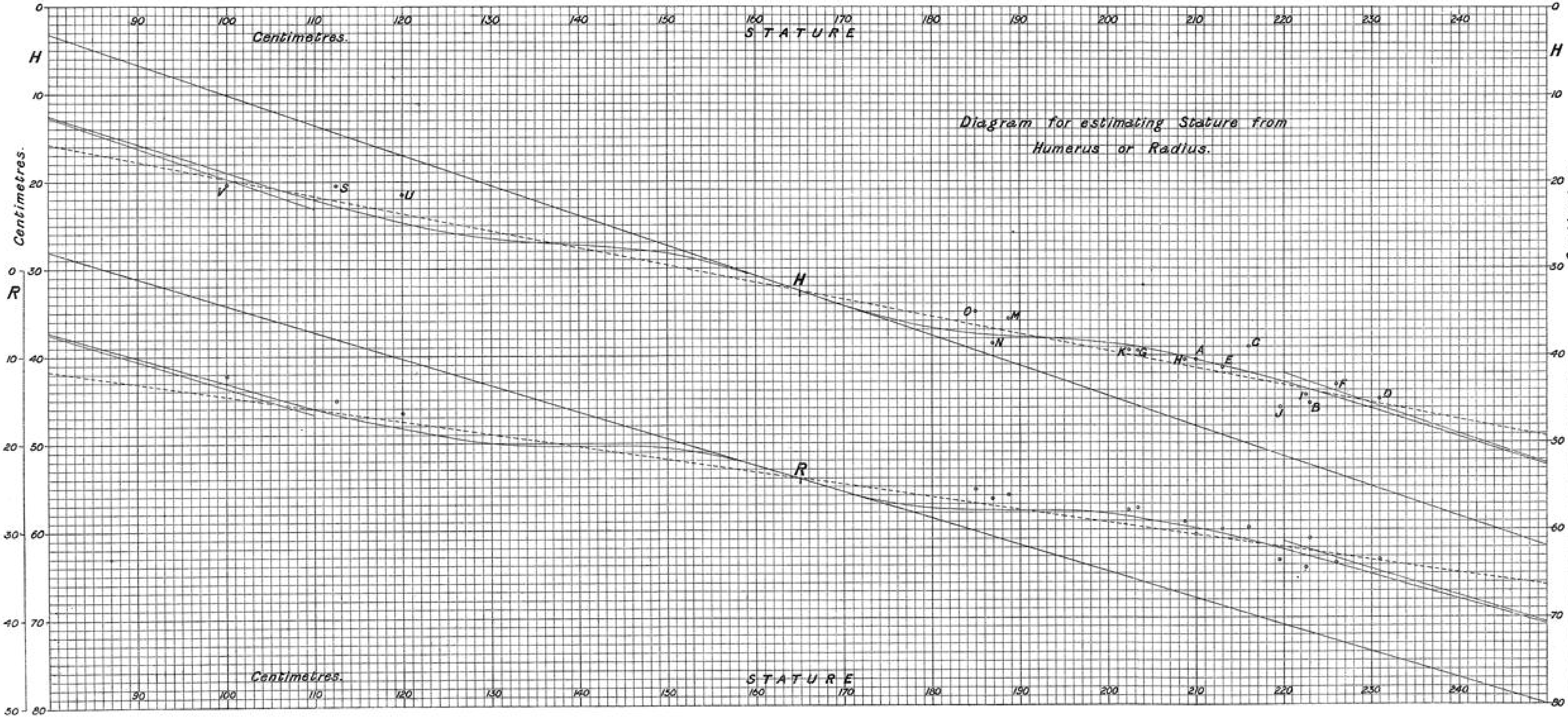
Diagram for estimating Stature from
Humerus or Radius.
STATURE
Centimetres.
Centimetres
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