

- (3) These elements exhibit gradations in properties such as refractive index, atomic volume, melting-point, and boiling-point, which find a fitting place on diagrams showing such periodic relations. Some of these diagrams are reproduced in the original paper. Thus the refractive equivalents are found at the lower apices of the descending curves; the atomic volumes, on the ascending branches, in appropriate positions; and the melting- and boiling-points, like the refractivities, occupy positions at the lower apices.

Although, however, such regularity is to be noticed, similar to that which is found with other elements, we had entertained hopes that the simple nature of the molecules of the inactive gases might have thrown light on the puzzling incongruities of the periodic table. That hope has been disappointed. We have not been able to predict accurately any one of the properties of one of these gases from a knowledge of those of the others; an approximate guess is all that can be made. The conundrum of the periodic table has yet to be solved.

‘Data for the Problem of Evolution in Man. VI.—A First Study of the Correlation of the Human Skull.’ By ALICE LEE, D.Sc., with some assistance from KARL PEARSON, F.R.S., University College, London. Received July 13,—Read November 15, 1900.

(Abstract.)

The substance of this paper was a thesis for the London D.Sc. degree; it was shown to Professor Pearson, at whose suggestion considerable modifications were made, and a revision undertaken with a view to publication.

In order to deal exactly with the problem of evolution in man it is necessary to obtain in the first place a quantitative appreciation of the size, variation, and correlation of the chief characters in man for a number of local races. Several studies of this kind have been already undertaken at University College. These fall into two classes, (i) those that deal with a variety of characters in one local race, and (ii) those which study the comparative value of the constants from a variety of races. Thus Dr. E. Warren has dealt with the long bones of the Naqada race,* Mr. Leslie Bramley-Moore has compared the regression equations for the long bones from a considerable number of races in a memoir not

* ‘Phil. Trans.,’ B, vol. 189, p. 135.

yet published, Professor Pearson has dealt with the regression equations for stature and long bones as applied to a variety of races;* Miss A. Whiteley has studied the correlation of certain joints of the hand,† and is investigating the correlation of the bones of the hand in a second local race; Miss C. D. Fawcett has made a long series of measurements on the Naqada skulls, and correlated their chief characters; the present memoir, on the other hand, deals with only a few characters in the skull, comparing, however, the results obtained from a variety of local races.

It is thus related to Miss Fawcett's work much as Mr. Bramley-Moore's to Dr. Warren's, *i.e.*, it endeavours, by selecting a few characters and testing them, to ascertain how far results obtained for one local race are valid for a second. In Professor Pearson's memoir on the reconstruction of the stature of prehistoric races, results obtained from one local race were then extended to a great variety of other races. The degree of accuracy in this procedure can only be fully ascertained when the data now being collected in both English and German anatomical institutes are available for calculation.

The skull, however, differs very widely from the stature and long bones; for, while these have a very high degree of correlation in all local races, the chief characters of the skull are very loosely correlated, and such correlation as they possess varies in a remarkable manner with sex and race. This was first indicated by Professor Pearson;‡ it has been amply illustrated in the measurements of Miss Fawcett, and is confirmed in a recently published memoir by Dr. Franz Boas. It may be said that this want of correlation in the parts of the skull is the origin of its great importance for the anthropologist; it is the source of its personal and racial individuality. But this anthropological advantage is, from the standpoint of organic evolution, a great disadvantage. Cuvier introduced the conception of correlation with the idea of reconstructing from a single bone the whole skeleton and even the outward form of an extinct animal, but the great want of correlation between the parts of the skull, and between the skull and other parts of the human skeleton, renders quantitative reconstruction—and this is the really scientific reconstruction—of one character of the skull from a second, or of the skull and parts of the skeleton from each other extremely difficult, if not impossible, for all but a very few characters.

Among these characters one of the most feasible to deal with, and one of the most useful, is the capacity of the skull. This is correlated to a fairly high degree (although to nothing like the same extent as the long bones among themselves) with the maximum length and breadth, with the total and auricular heights, and with the horizontal and

* 'Phil. Trans.,' A, vol. 192, p. 169.

† 'Roy. Soc. Proc.,' vol. 65, p. 126.

‡ 'Phil. Trans.,' A, vol. 187, p. 279, and 'Roy. Soc. Proc.,' vol. 60, p. 495.

vertical circumferences of the skull. The present memoir deals in the main with the problem of the reconstruction of the capacity from these characters.

Three fundamental problems arise in the theory of reconstruction, *i.e.*, the determination of the probable value of an unknown character from a known and measurable one, or from several such. Namely:—

- I. The reconstruction of the individual from data for his own race.
- II. The reconstruction of the average value of a character in one local race from data determined for a second local race.
- III. The determination of the probable value in an individual of characters not measurable during life from characters which are measurable.

These three problems are all dealt with for the special character capacity of the skull in the present paper. Their importance may be indicated by the following considerations:—

(a.) Many, especially of the more ancient and accordingly more interesting skulls, are too fragile or too fragmentary to allow of their capacity being directly determined.

(b.) The methods for directly determining capacity are still not only very diverse, but divergent in result, and from the physical standpoint crude and inexact. In the concordat of the German craniologists—the *Frankfurter Verständigung*—the point was left for future consideration, and so it has remained for many years. The capacities of series of skulls determined during the past forty years in France, England, and Germany are, we are convinced, not comparable, at least if the argument from the comparison is to depend on a difference of 30 to 40 cm.³ While the same observer using different methods may be trained to get results within 4 to 6 cm.³ for the same skull, different observers, equally careful, using the same method, will easily get results for the same series diverging by 20 to 30 and even more cubic centimetres. Shortly, the personal equation—involved in the packing in the skull and in the measuring vessel—is very large.

Accordingly a regression equation for the capacity as based on external measurements may, if deduced from a sufficiently large range of series measured by careful independent observers, give results fairly free from the error of personal equation and this sensibly as correct as, or more correct than, direct measurement when we require the mean capacity of a series.

(c.) It is impossible to obtain a large series of skulls belonging to known individuals with a classified measure of intellectual ability. Actually we have only a few skulls of men of great intellectual power, sometimes preserved because they were large, and to compare with these the skulls of the unknown and often the ill-nourished, which reach the

anatomical institutes.* Accordingly it is an investigation of considerable interest to compare the *probable* capacity of the skulls of living persons with their roughly appreciable intellectual grade. It is only by such a comparison that we can hope to discover whether the size and shape of the skull is to any extent correlated with brain power.

In the course of the memoir it is shown that the auricular height of the skull is a better measurement for determining skull capacity than the total height; that the circumferences of the skull, while highly correlated with its capacity, give regression equations which vary widely from one to another closely-allied race; that linear regression equations involving length, breadth, and auricular height, while giving fairly good results for individuals within the local race, have very divergent coefficients as we pass from local race to local race; that the cephalic index has very little correlation with capacity at all (as a rule what there is may be summed up in the words: In a brachycephalic race the rounder the skull the greater the capacity, in a dolichocephalic race the narrower the skull the greater the capacity—the greater capacity following the emphasis of the racial character); finally, that the correlation of capacity with the triple product of length, breadth, and height gives a regression equation which is fairly constant from local race to local race, and is accordingly the best available.

From this and other equations individual and racial reconstructions are made, and the deviations between the actual and predicted capacities in randomly chosen series of skulls are tabulated. The mean error made in the reconstruction of the individual capacity by the best formulæ is 3 to 4 per cent., the maximum error, although of course infrequent, may even be 10 per cent. For the reconstruction of the mean capacity of a race, the mean error is about 1·2 per cent., with a maximum error of 2·5 per cent. If these errors appear large to the craniologist, we would remind him that his search for an absolutely correct formula giving cranial capacity from external measurements is the pursuit of a Will-o'-the-wisp. The theory of probability shows us exactly the sort of errors such formulæ are liable to, and teaches us how to select the best. The whole basis of the theory of evolution, the variability of one character, even with fixed values for a number of others, would be upset if any such absolute formula were forthcoming. What we have to do is to select a few organs as highly correlated as possible, but, having done this, it has been shown elsewhere that we shall not sensibly decrease the error of our prediction by increasing the number of organs upon which the estimate is based.† Accordingly we do not believe that sensibly better reconstruction formulæ than those

* This argument applies also, in even an intensified degree, to the determinations of brain weight.

† 'Phil. Trans.,' A., vol. 190, p. 466.

found will ever be forthcoming, for, as we have already observed, we know from Miss Fawcett's wide series of skull correlations that we have practically chosen the organs of the highest correlation. Better data for determining the equations will undoubtedly be available as further craniological measurements are made, or as the great mass already made are quantitatively reduced.

In the last place we turn to the third problem: the reconstruction of the capacity of the living head. The memoir contains tables of the skull capacity of some sixty men, and also of some thirty women, whose relative intellectual ability can be more or less roughly appreciated. It would be impossible to assert any marked degree of correlation between the skull capacities of these individuals and the current appreciation of their intellectual capacities. One of the most distinguished of Continental anthropologists has less skull capacity than 50 per cent. of the women students of Bedford College; one of our leading English anatomists than 25 per cent. of the same students. There will, of course, be errors in our *probable* determinations, but different methods of appreciation lead to sensibly like results, and although we are dealing with skull *capacity*, and not brain weight, there is, we hold, in our data material enough to cause those to pause who associate relative brain weight either in the individual or the sex with relative intellectual power. The correlation, if it exists, can hardly be large, and the true source of intellectual ability will, we are convinced, have to be sought elsewhere, in the complexity of the convolutions, in the variety and efficiency of the commissures, rather than in mere size or weight.

“Total Eclipse of the Sun, May 28, 1900. Preliminary Account of the Observations made by the Solar Physics Observatory Eclipse Expedition and the Officers and Men of H.M.S. ‘Theseus,’ at Santa Pola.” By Sir NORMAN LOCKYER, K.C.B., F.R.S. Received June 22, 1900.—Read at Joint Meeting of the Royal and Royal Astronomical Societies, June 28, 1900.

The observing station selected for my party was determined upon from information supplied by the Hydrographer, Rear-Admiral Sir W. J. L. Wharton, R.N., K.C.B., F.R.S. Santa Pola appeared likely to meet the requirements of a man-of-war, and without such assistance as a man-of-war can render, the manipulation of long focus prismatic cameras in eclipse observations in a strange country is impracticable.

Santa Pola lies very near the central line of the eclipse, and good anchorage was available, protected from some winds.