

scribed. The southward direction of peninsulas is attributed to folding of the earth's crust, and to depression of the ocean floor, which has caused the water to predominate towards the south, so that they are always in relation to areas of depression. It will thus be seen that, in simplicity of conception, largeness and continuity of the ideas dealt with, amplitude and detail of the knowledge and inductions brought together and correlated, this work promises to be one of the most valuable contributions to the history of the earth which we possess. From the time when Godwin-Austen planned his work on the ancient physical history of Europe which geology supplies, data have been accumulating with a rapidity which has made the task almost hopeless, of writing a history of the earth's surface which should be at once exact in details and large in ideas. But Prof. Suess does not so much trench on geological history, which can only be told intelligibly when supported by masses of technical facts; for his aim is to impart vitality to learning and teaching of those phenomena with which the geographer is concerned. It may be too much to say that he attempts to do for the surface of the earth what Darwin did for the distribution and classification of life, because so much had been previously contributed with which his own work is in perfect harmony; but we may say that henceforth no geographical teacher can neglect to place before his pupils the methods and results which the author's work brings to his hand. And we may anticipate that much as Lyell's treatise, the "Principles of Geology," has laid the firm foundations of geological thought and of scientific observation in geographical science, so this treatise appears likely to mark a similar epoch in the history of geography, becoming a guide to its principles for students and readers.

It is significant that it is the outcome of long experience, first as Professor of Palæontology, then as Professor of Geology, on the part of one who has given many of the best years of his life to the endeavour to make practical application of geological knowledge in improving water-supply and navigation of the earth's surface which surrounds Vienna. The same thoroughness and devotedness with which these earliest of his public works were done are seen in this latest contribution to education; and we cannot but see that geography, as Prof. Suess teaches it, is a science based upon the sciences which he has himself professed, though expanding in its ultimate developments to include that knowledge which the naturalist and the observer of Nature record. Every chapter is followed by a long bibliography, in which the reader finds the more important original sources of information with which the writer has refreshed his memory; and the beautiful drawings and engravings scattered through the volumes will be not less welcome to the earnest student as presenting typical examples of the geological foundations of geographical truths seen on the earth's surface.

H. G. SEELEY.

NATURAL INHERITANCE.

Natural Inheritance. By Francis Galton, F.R.S. (London: Macmillan and Co., 1889.)

IT is related that, when some boastful patriot was once describing the trees in his country as so high that a man could hardly see their tops, a stranger retorted.

"That is nothing to the trees in my country, which are so high that two men are required to see the top of them; one man looks as far as he can, and the other begins where the first stops." A similar division of labour would be required in order to survey adequately the imposing scientific edifice which Mr. Galton has constructed; based as it is on a foundation of geometrical reasoning, and culminating in the clouds of biological hypothesis. The parts which are nearest to *terra firma* are most within our ken. The mathematical foundation and the structure which rests immediately thereupon appear to us solid and elegant. The author has restated the law of error in a form adapted to sociological investigations. He says truly and happily:—

"This part of the inquiry may be said to run along a road on a high level, that affords wide views in unexpected directions, and from which easy descents may be made to totally different goals to those we have now to reach."

Mr. Galton reads a useful lesson to statistical practitioners, when he complains that they limit their inquiries to averages, without taking account of those deviations from the average which are the subject of the theory of errors.

"Their souls seem as dull to the charm of variety as that of the native of one of our flat English counties, whose retrospect of Switzerland was that, if its mountains could be thrown into its lakes, two nuisances would be got rid of at once."

Mr. Galton is not dead to the charms of "normal variability." Statistical theory illustrated by him becomes in a high degree fascinating:

"Not harsh and crabbed as dull fools suppose."

He may well say:

"Some people hate the very name of statistics, but I find them full of beauty and interest."

Some of his riders on the law of error may be interesting even to physicists. The following problem is not so familiar to astronomers, but that Mr. Galton's solution of it may deserve attention. Given three or four observations relative to an unknown quantity; and again another small group of observations made on some other quantity by the same instrument or method of observation; and so on, each of the different little groups not in general comprising the same number of observations: find from the residuals, or apparent errors, presented by the respective groups, the true "probable error" incident to the method of observation. Mr. Galton gives four solutions of this problem, of which two involve data which are special to his subject; two may be described as general. Neither of the latter coincides with the theoretically best possible method; but the consilience of their results with each other and with the other two methods is interesting.

We have worded the problems in terms of *errors*. The form in which it presents itself to Mr. Galton relates rather to the deviations of individuals from their common type. He is determining the "probable error" or dispersion of the heights of brothers compared with their mean. It proves to be much less than the corresponding constant for the adult population generally. The question arises in the course of an inquiry whether the mean height of brothers and sisters deviates from the general average of adults less than the height of their parents. There is a little difficulty in stating the question

owing to the difference in the mean stature of the sexes. Mr. Galton gets over this difficulty by multiplying all his female data by a proper constant—pushing them up, so to speak, to the male standard. Upon this understanding, suppose that the mean height of the father and the “transmuted” mother—the stature of the “mid-parent” in Mr. Galton’s phraseology—differs from the mean height of the general population by say three inches. Then the mean height of the sons and “transmuted,” or pushed up, daughters, is most likely to be not three inches, but two inches. The constant of “regression” is determined with equal precision for other relationships. A general idea is obtained of the extent to which the peculiarities of an individual are likely to be shared by his kith and kin.

It is not easy in a few words, or perhaps in any number of words unaccompanied by symbols, to do justice to the cogency and precision of this anthropometrical reasoning. The manipulation to which Mr. Galton’s materials have been subjected by one of his mathematical coadjutors, Mr. Hamilton Dickson, fully attests their consistency and strength. Some additional corroboration may be afforded by the following considerations. The probable error or dispersion for the statures of adult men, which Mr. Galton has extracted from the family records submitted to him, is identical with, or differs only by a fraction of an inch from, the constant furnished by many other sets of measurements. The value here obtained for this constant is 1·7 inch. The same value is obtainable from the measurements made by Mr. Galton for the British Association. The same value has been obtained by Signor Perozzo for the whole of Italy, and for each of its provinces. The agreement of observations made under such different circumstances is calculated to give us confidence in the higher theory of anthropometry. The result which has been thus verified may be used to confirm Mr. Galton’s reasoning at several points. Any scruples which he may suggest as to the discrepancy in the values of mean stature determined from his different records are removed by a consideration of the error or diversity to be expected among these results. Again, consider those tables in which Mr. Galton compares the heights of a number of persons with the mean height of their children or brothers, in which it is shown, for instance, that men of the height 71·5 inches have brothers averaging 70·2. That all the entries point in the same direction—namely, that of “regression”—is in itself adequate evidence of that fact. But not only are the faggots strong in their union, but also each individually is possessed of considerable strength. Thus, the discrepancy which we have just noticed between the height of a man and the mean height of his brethren, namely, 1·3 inch, is founded on eighty-eight instances. The chances against this degree of divergence occurring by accident are some hundreds to one. The odds that the appearance of law which the tables present is not accidental are immensely increased by this consideration. We should be curious to know whether Mr. Galton’s experiments on the “regression” of sweet peas would admit of this sort of corroboration.

The human stature is a subject particularly well adapted to Mr. Galton’s exact methods of measurement. Length admits of more exact gradation than

the so-called secondary qualities. To arrange in a regular scale the colours of eyes which are variously described as dark blue, blue-green, hazel, and so forth, is a delicate task. How far Mr. Galton has triumphed over this imperfection of his data, it must be for specialists to decide. The student of probabilities cannot doubt that the correspondences between his observations and his calculations are indicative of a real law. The coherence of the table in which he compares fact and theory as to the number of light-eye-coloured children born to parents of various eye-colours cannot possibly be accidental. Ill-adapted as eye-colour may be to exact measurement, it is a more satisfactory quality to deal with than “the artistic faculty.” Can we suppose that the compilers of the different family records which Mr. Galton has analyzed have employed at all similar standards, when they applied the epithets “artistic” and “non-artistic” to their relations? Our misgivings increase when we go on to apply the calculus to the returns as to disease which are obtained from the family records. To arrange parents and children in a graduated scale of “consumptivity,” upon the testimony of unprofessional relatives, seems precarious. The author himself abandons the use of the more delicate methods when he goes on to consider “good and bad temper.” He has not, however, shrunk from dividing into five degrees or classes some sixty shades of temper ranging from “amiable” and “buoyant” to “surly,” “uncertain,” “vicious,” and “vindictive.”

We ascend into a region of hypothesis when we speculate on the causes of the phenomena which have been evidenced. The attention of biologists should be called to Mr. Galton’s views on “particulate inheritance,” “latent characteristics,” and the stability of organic forms. The conceptions which he has formed as to the processes of heredity are placed by him in a variety of lights, and illustrated by many happy analogies. “Appropriate and clear conceptions,” it has been well said, are essential conditions of science. Mr. Galton has done much to make his abstract ideas clear, but are they also appropriate? This is a question upon which, perhaps, only a few specialists are competent to advance an important opinion; and their authority is liable to be impaired by the prejudices incident to an exclusive line of research. We shall be slow to accept adverse criticism from any whose studies may not have qualified them to appreciate the support which Mr. Galton’s theories receive from his masterly use of the calculus of probabilities.

F. Y. E.

NATURE’S HYGIENE.

Nature’s Hygiene: A Systematic Manual of Natural Hygiene, containing a Detailed Account of the Chemistry and Hygiene of Eucalyptus, Pine, and Camphor Forests, and Industries connected therewith. By C. T. Kingsett, F.I.C., F.C.S. Third Edition. (London: Baillière, Tindall, and Cox, 1888.)

THIS book aims at being a systematic manual of natural hygiene. The introductory chapters deal in a popular manner with chemical principles and chemical changes, leading up eventually to questions affecting the chemistry and hygiene of the atmosphere, of water, of sewage, and of