Section a portion of the wide subject of "Hereditary Stature." My inquiries were at that time advanced only to a certain stage, but they have since been completed up to a well-defined resting-place, and it is to their principal net results that I shall ask your attention to-night.

I am, happily, released from any necessity of fatiguing you with details, or of imposing on myself the almost impossible task of explaining a great deal of technical work in popular language, because all these details have just been laid before the Royal Society, and will in due course appear in their Proceedings. They deal with ideas that are perfectly simple in themselves, but many of which are new and most are unfamiliar, and therefore difficult to apprehend at once. My work also required to be tested and cross-tested by mathematical processes of a very technical kind, dependent in part on new problems, for the solution of which I have been greatly indebted to the friendly aid of Mr. J. D. Hamilton Dickson, Fellow and Tutor of St. Peter's College, Cambridge. I shall therefore freely disencumber myself on the present occasion from the sense of any necessity of going far into explanations, referring those who wish thoroughly to understand the grounds upon which my results are based, to the forthcoming memoir in the Proceedings of the Royal Society, and to that amplified and illustrated extract from my Address at Aberdeen, accompanied by tabular data, which appeared among the "Miscellanea" of the Journal of this Institute last November.

The main problem I had in view was to solve the following question. Given a group of men, all of the same stature, whatever that stature may be,—it is required to be able to predict two facts regarding their brothers, nephews, their sons, their grandchildren, respectively, namely, firstly, what will be their average height; secondly, what will be the percentage of those kinsmen whose statures will range between any two heights we may please to specify:—as between 6 feet and 6 feet 1 inch, 6 feet 1 inch and 6 feet 2 inches, &c.?

The same problem admits of another rendering, because whatever is statistically certain in a large number is the most probable occurrence in a small one, so we may phrase it thus: Given a man of known stature, and ignoring every other fact, what will be the most probable average height of his brothers, sons, nephews, grandchildren, &c., respectively, and what proportion of them will most probably range between any two heights we may please to specify?

I have solved this problem with completeness in a practical sense. No doubt my formula admits of extension to include influences of a minor kind, which I am content to disregard, and that more exact and copious observations may slightly correct the values of the constants I use; but I believe that for the general purposes of understanding the nearness of kinship in stature that subsists between relations in different degrees, the problem is solved.

It is needless to say that I look upon this inquiry into stature as a representative one. The peculiarities of stature are that the paternal and maternal contributions blend freely, and that selection, whether under the aspect of marriage selection or of the survival of the fittest, takes little account of it. My results are presumably true, with a few further reservations, of all qualities or faculties that possess these characteristics.

HEREDITARY STATURE

It will perhaps be recollected that, at the meeting last autumn of the British Association in Aberdeen, I chose for my Presidential Address to the Anthropological Institute, January 26.

Extracts from Mr. F. Galton's Presidential Address to the Anthropological Institute, January 26.
the back of the card is passed through the hole; when it is stretched it serves as a pointer, moving in a circle with the pin-hole as a centre. Five vertical lines are drawn down the card at the following distances, measured horizontally from the pin-hole: 1 inch, 2 inches, 3 inches, 6 inches, and 9 inches. For brevity I will call these lines I, II, III, VI, and IX respectively. This completes the instrument. To use it: Hold the stretched thread so that it cuts IX at the point where the reading of the horizontal lines corresponds to the stature of the given group. Then the point where the string cuts VI will show the average height of all their brothers; where it cuts III will be the average height of the sons; where it cuts II will be the average height of the nephews; and where it cuts I will be the average height of the grandchildren. These same divisions will serve for the converse kinship; VI, obviously so; III, son to a parent; II, nephew to an uncle; I, grandson to a grandfather. Another kinship can be got from VI, namely, that between "mid-parent" and son. By "mid-parent" I mean the average of the two statures: (a) the height of the father, (b) the transmitted height of the mother. This process, I may say, is fully justified by the tables already printed in our Journal, to which I have referred. It is a rather curious fact that the kinship between a given mid-parent and a son should appear from my statistics to be exactly the same degree of nearness as that between a given man and his brother. Lastly, if we transpose the stature of kinswomen to their male equivalents by multiplying them after they are reduced to inches, by 708, or say, very roughly, by adding at the rate of 1 inch for every foot, the instrument will deal with them also.

You will notice that the construction of this instrument is based on the existence of what I call "regression" towards the level of mediocrity (which is 7 feet 8 inches), not only in the particular relationship of mid-parent to son, and which was the topic of my Address at Aberdeen, but in every other degree of kinship as well. For every unit that the stature of any group of men of the same height deviates upwards or downwards from the level of mediocrity as above, their brothers will on the average deviate only two-thirds of a unit, their sons one-third, their nephews two-ninths, and their grandsons one-ninth. In remote degrees of kinship, the deviation will become zero; in other words, the distant kinsmen of the group will bear no closer likeness to them than is borne by any group of the general population taken at random.

The rationale of the regression from father to son is due (as was fully explained in the Address) to the double source of the child's heredity. It comes partly from a remote and numerous ancestry, who are on the whole like any other sample of the past population, and therefore mediocre, and it comes partly only from the person of the parent. Hence the parental peculiarities are transmitted in a diluted form, and the child tends to resemble, not his parents, but an ideal ancestor who is always more mediocre than they. The rationale of the regression from a known man to his unknown brother is due to a compromise between two conflicting probabilities: the one that the unknown brother should differ little from the known man, the other that he should differ little from the mean of his race. The result can be mathematically shown to be a ratio of regression that is constant for all statures. The results of observation accord with, and are therefore confirmed by, this calculation.

Variability above and below the Mean Stature.—Here the net result of a great deal of laborious work proves, as in the previous case, to be extremely simple, and to be very easily expressed by a working model. A set of five scales can be constructed, such as I exhibit, one appropriate to each of the lines I, II, III, I., and VI, and suitable for any position on these lines. They are so divided that when the centres of the scales are brought opposite to the points crossed by the thread, in the way already explained, we shall see from the divisions on the scales what are the limits of stature between which successive batches of the kinsmen, each batch containing 10 per cent of their whole number, will be included. Smaller divisions indicate the 5 per cent limits. The extreme upper and extreme lower limits are perfectly indefinite. Each of the scales I give deals completely with ninetenths of the observations, but the upper and lower 5 per cent of the group, or the remaining one-tenth, have only their inner limits defined.

The divisions on the movable scales that are appropriate to the several lines VI, III, II, and I, are given in the table, where they are carried one long step further than I care to recommend in use.

<table>
<thead>
<tr>
<th>Per-cent. of included statures</th>
<th>Divisions, upwards and downwards, from centres of the scales, in inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>0'5  0'6  0'6  0'6</td>
</tr>
<tr>
<td>20</td>
<td>1'0  1'3  1'3  1'3</td>
</tr>
<tr>
<td>30</td>
<td>1'6  2'0  2'1  2'1</td>
</tr>
<tr>
<td>40</td>
<td>2'4  3'0  3'1  3'1</td>
</tr>
<tr>
<td>50</td>
<td>3'1  3'9  4'0  4'0</td>
</tr>
<tr>
<td>60</td>
<td>4'1  4'8  5'1  5'1</td>
</tr>
</tbody>
</table>

The divisions are supposed to be drawn at the distances there given, both upwards and downwards from the centres of the several scales, which have to be adjusted, by the help of the thread, to the average height of the kinsmen indicated in the several lines. The percentage of statures that will then fall between the centre of each scale and the several divisions in it is given in the first column of the table. Example:—In line VI 40 per cent. will fall between the centre and a point 2·4 inches above it, and 40 per cent. will fall between the centre and a point 2·4 inches below it; in other words 80 per cent. will fall within a distance of 2·4 inches from the centre. Similarly we see that 2·4 475, or 90 per cent. will fall within 4·8 inches of the centre.

In respect to the principle on which these scales are constructed, observation has proved that every one of the many series with which I have dealt in my inquiry conforms with satisfactory closeness to the "law of error." I have been able to avail myself of the peculiar properties of that law and of the well-known "probability integral" table, in making my calculations. A very large amount of cross-testing has been gone through, by comparing secondary data obtained through calculation with those given by direct observation, and the results have fully confirmed this course. It is impossible for me to explain what I allude to more minutely now, but much of this work is given, and more is indicated, in the forthcoming memoir to which I have referred.

I know of scarcely anything so apt to impress the imagination with the wonderful form of cosmic order expressed by the "law of error." A savage, if he could understand it, would worship it as a god. It reigns with serenity in complete self-eclipsement amidst the wildest confusion. The huger the mob and the greater the apparent

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1 The following will be of help to those who desire a somewhat closer idea of the reasoning than I can give in a popular Address.

m = mean height of race = 6'0 inches.
m ± s = height of a known individual.
m ± k = the probable height of an unknown kinsman in any given degree.

x (which I designate by s) = ratio of mean regression; it is shown by direct observation to be 2 in the case of mid-parent to son, and of man to brother; it is inferred to be 1 in the case of parent to son. It is upon these primary kinships that the rest depend.

The "probable" deviations ("err. re".) from the mean values of their respective parents are:

s = of the general population = 2'75 inches.
k = of any large family of brothers = 2 inches.

Take a group of kinship in any degree may be considered as statistically identical with a sample of the general population, we get the identical equation that connects s with k; namely, p+n-k = p-k.

The ratio of regression in respect to brothers can be shown to depend on the equation m = s x p/n almost nearly.

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anarchy the more perfect is its sway. Let a large sample of chaotic elements be taken and marshaled in order of their magnitudes, and then, however wildly irregular they appeared, an unsuspected and most beautiful form of regularity proves to have been present all along. Arrange the statures side by side in order of magnitude, and the tops of the marshaled row will form a beautifully flowing curve of invariable proportions; each man will find, as it were, a preordained niche, just at the right height to fit him, and if the class-places and statures of any two men in the row are known, the stature that will be found at every other class-place, except towards the extreme ends, can be predicted with much precision.

It will be seen from the large values of the ratios of regression how speedily all peculiarities that are possessed by any single individual to an exceptional extent, and which blend freely together with those of his or her spouse, tend to disappear. A breed of exceptional animals, rigorously selected and carefully isolated from admixture with others of the same race would become shatted by even a brief period of opportunity to marry freely. It is only those breeds that blend imperfectly with others, and especially such of these as are at the same time prepotent, in the sense of being more frequently transmitted than their competitors, that have a chance of maintaining themselves when marriages are not rigorously controlled—as indeed they never are, except by professional breeders. It is on these grounds that I hail the appearance of every new and valuable type as a fortunate and most necessary occurrence in the forward progress of evolution. The precise way in which a new type comes into existence is untraced, but we may well suppose that the different possibilities in the groupings of some such elements as those to which the term "sports" or variability in its entirety would be as one to nine, and, therefore presumably without teleological intent. They are of various degrees of heritable stability. These form fresh centres, towards which some at least of the offspring have an evident tendency to revert. By refusing to blend freely with other forms, the most peculiar "sports" admit of being transmitted almost in entirety, with no less frequency than if they were not exceptional. Thus a grandchild, as we have seen, regresses on the average one-ninth. Suppose the grandfather's peculiarity refused to blend with those of the other grandparents, then the chance of his grandson inheriting that peculiarity in its entirety would be as one to nine; and, so far as the new type might be prepotent over the other possible heritages, so far would be the chance of its reappearance be increased. On the other hand, if the peculiarity did not refuse to blend, and if it was exceptional in magnitude, the chance of inheriting it to its full extent would be extremely small. The probability (easily to be calculated for any given instance by the "probability integral" tables) might even be a thousand times smaller. I will give for an example a by no means extreme case. Suppose a large group of men all have a height 5 inches in height, the statures of whose wives are happiness, then it can be shown that put of every thousand of the sons not more than one on an average will rival or surpass the height of his father. It is extremely important in its bearing on the origin of species, I feel the greatest difficulty in accounting for the establishment of a new breed in a state of freedom by slight selective influences, unless there has been one or more abrupt changes of type, leading step by step to the new form.

It will be of interest to trace the connection between what has been said about hereditary stature and its application to hereditary ability. Considerable differences have to be taken into account and allowed for. First, after making large allowances for the occasional glaring cases of inferiority on the part of the wife to her eminent husband, I adhere to the view I expressed long since as the result of much inquiry, historical and otherwise, that able men select those women for their wives who on the average are not mediocre women, and still less inferior women, but those who are decidedly above mediocrity. Therefore, so far as this point is concerned, the average regression in the son of an able man would be less than one-third. Secondly, very gifted men are usually of marked individuality, and consequently of a special type. Whenever this type is a stable one, it does not blend easily, but is transmitted almost unchanged, so that specimens of very distinct intellectual heredity frequently occur. Thirdly, there is the fact that men who leave their mark on the world are very often those who, being gifted and full of nervous power, are at the same time haunted and driven by a dominant idea, and are therefore placed in a measurable distance of lunacy. This weakness will probably betray itself in disadvantageous forms among their descendants. Some will be eccentric, others feeble-minded, others nervous, and some may be downright mad.

It will clear our views about hereditary ability if we apply the knowledge gained by our inquiry to solve some hypothetical problem. It is on that ground that I offer the following one. Suppose that in some new country it is desired to institute an Upper House of Legislation consisting of life-peers, in which the hereditary principle shall be largely represented. The principle of insuring this being that two-thirds of the members shall be elected out of a class who possess specified hereditary qualifications, the question is, What reasonable plan can be suggested of determining what those qualifications should be?

In framing an answer, we have to keep the following principles steadily in view: (1) The hereditary qualifications derived from a single ancestor should not be transmitted to an indefinite succession of generations, but should lapse after, say, the grandchildren. (2) All sons and daughters should be considered as standing on an equal footing as regards the transmission of hereditary qualifications. (3) It is not only the sons and grandsons of ennobled persons who should be deemed to have hereditary qualifications, but also their brothers and sisters, and the children of these. (4) Men who earn distinction of a high but subordinate rank to that of the nobility, whose wives had hereditary qualifications, should transmit those qualifications to their children. I calculate roughly and very doubtfully, because many things have to be considered, that there would be about twelve times as many persons hereditarily qualified to be candidates for election as there would be seats to fill. A considerable proportion of these would be nuncios, whom I should be very sorry to omit, as they are twice as near in kinship as grandsons. One in twelve seems a reasonably severe election, quite enough to draft off the eccentric and incompetent, and not too severe to discourage the ambition of the rest. I have not the slightest doubt that such a selection out of a class of men who would be so rich in hereditary gifts of ability, would produce a body of men at least as highly gifted by nature as could be derived by ordinary parliamentary election from the whole of the rest of the nation. They would be reared in families of tradition public services. Their ambitions, shaped by the conditions under which hereditary qualifications could be secured, would be such as to encourage alliances with the gifted classes. They
DEPOSITS OF THE NILE DELTA

A previous communication I referred to the probability that the lower portion of the Delta borings belongs to the Pleistocene and Isthmian deposit which underlies the modern Nile mud, and which has been recognised as an important formation by nearly all geologists who have studied the Nile Valley. I now propose to state shortly some objections to the generalisations of the Report on the Nile borings with reference to the causes assigned for the comparative purity of the waters of the Nile, and the character of its sediment, viz. that the former is due to its flowing through a rainless country, and that the latter is derived from the decay of rocks in this rainless area, and this decay produced not by "chemical agencies," but by "mechanical forces," namely, the "unequal expansion" of the constituent minerals under the influence of heat and cold, aided by "the force of the wind."

It is scarcely necessary to premise that neither the water nor the mud of the Nile can be derived from the rainless district through which the river flows, but from the well-watered regions of interior Africa. The White Nile, which carries scarcely any sediment, is a somewhat constant stream, draining a country of lakes, swamps, and forests. The Blue or Dark Nile and the Atbara drain the mountainous country of Abyssinia, deluged with rain in the wet season, and it is these streams, swollen by violent inundations, that supply the Nile with its sediment, the quantity of fresh material carried into the river below the confluence of the Atbara being very small, as the results of the microscopic study of the sediment sufficiently proves, and I can testify from my own examinations of the Nile mud, that its composition, as stated by Prof. Judd, is essentially the same along the course of the Nile as in the upper layers of the Delta borings, though with some local differences in the fineness of the sand and the proportion of argillaceous matter. Thus the water of the inundations and the material of the alluvial deposit come from a region of copious rains, and where decay of rocks may be supposed to proceed under the ordinary conditions.

What then is the cause of the freedom of the Nile water from saline matter? Simply its derivation from a country of siliceous and crystalline rocks. If, instead of comparing it with the water of the Thames and other streams draining sedimentary districts, it had been compared with that of the lakes and streams of the Scottish Highlands (by no means rainless districts) this would have been apparent. Dr. Sterry Hunt has described and referred to its true cause a fact of the same kind in the case of the Ottawa and St. Lawrence. The former, rising in a region of crystalline rocks, has little more than one-third of the saline matter in solution that is found in the latter, which drains principally a sedimentary country. The proportions in 10,000 parts are, for the Ottawa, only 0.616, and for the St. Lawrence, 1.625. But it may be asked, Why in that case is the Nile mud so deficient in kaolin? The answer is, that the current of the river is sufficiently strong to wash out all the more finely comminuted argillaceous matter and to carry it in its turbid waters to the sea. In connection with this, every voyager on the falling Nile must have observed how the mud-banks are constantly falling as they are undermined by the river, and their material carried down to be redeposited. This work goes on even more energetically in the time of the inundations. Thus any given quantity of sediment on its way from Abyssinia to the Delta is lixiviated thousands of times, and necessarily deprived of its lighter and finer constituents. But the quantity of kaolin need not originally have been large. The older gneisses and schists do not kaolinise after the manner of Cornish granites, but, when decomposed so as readily to crumble into sand, they still contain much of their more refracting felspars in a perfect state.

These facts are further illustrated by the agricultural qualities of the Nile alluvium, as they have been explained by Schweinfurth and others. If the alluvial soil was a stiff clay, it would be practically incapable of cultivation in the circumstances of Egypt. If it were mere quartzose sand, it would be hopelessly barren. It is, in fact, an impalpable sand, highly absorbent of water, crumbling readily when moistened, and containing mere quartz but particles of various silicates and of apatite and dolomite, which, though unalterable when under water, are gradually dissolved by the carbonic acid present in the cultivated soil, yielding alkalies, phosphates, &c., to the crops. In connection with this, recent microscopic examinations by Dr. Bonney of the old crystalline rocks of Assouan, which are probably similar to those farther north, show that, like those of Canada and Norway, they contain numerous crystals of apatite.

Referring to the mechanism of the sea, it is a well-known fact that upon crystalline rocks, any one who examines the polished surfaces still retained by monuments which are in Upper Egypt have been exposed to this influence for thousands of years, must be convinced that no disintegration of this kind occurs. The only evidence of such actions that I have been able to find is the chipping of little circular disks from the exposed sides of nodules of flint on the surface of the desert. Granite rocks decay, however, in Egypt, as elsewhere, when they are exposed to moisture on crystalline rocks, any one who examines the polished surfaces still retained by monuments which in Upper Egypt have been exposed to this influence for thousands of years, must be convinced that no disintegration of this kind occurs. The only evidence of such actions that I have been able to find is the chipping of little circular disks from the exposed sides of nodules of flint on the surface of the desert. Granite rocks decay, however, in Egypt, as elsewhere, when they are exposed to moisture carried from the sea. In this connection I may add that Hague, in a paper in Science on the decay of the New York obelisk, shows that it had probably suffered (as, according to Wigner, that in London has also done) from atmospheric action before its removal from Alexandria, and that this decay has been greatly increased by the alternations of moisture and frost to which it is subjected in New York. At Assouan, in a climate at present rainless, or nearly so, I was surprised to find that the surface of the gneiss and crystalline schists was in many places decayed to the depth of several feet, so that it was impossible to obtain fresh specimens except from the railway cuttings. This may be due to the action of water and carbon dioxide passing through the ground, but is more probably a result of more humid climatal conditions in former ages.

I hope at a future date to pursue these interesting questions farther; but in the meantime I shall be content if it has been shown that Egypt owes the advantage of pure, sweet water to the fact that it drinks of mountain streams which the rains have naturally preserved from pollution by the drainage of the Cretaceous and Tertiary beds, and that its rich alluvial soil has not been produced by any mechanical action of an exceptional nature, but by the ordinary atmospheric agencies of deposition.

These conclusions, as well as those stated in my previous letter, respecting the depth of the modern alluvium and its relation to the well-known Pleistocene formation which underlies it, could be confirmed by the testimony of most geologists who have studied the valley of the Nile, and more especially of Larret, Fraas, and Schweinfurth. I hope that as now stated, however imperfectly, they may suffice to induce the Committee to modify its Report, or to postpone its publication.


1 The freezing of water in the pores of rocks is undoubtedly an important cause of destructive tion in the colder climates.