

ON THE CAUSES WHICH OPERATE TO CREATE SCIENTIFIC MEN.

ON more than one occasion I have maintained that intellectual ability is transmitted by inheritance; and in a memoir published last year in the "Proceedings of the Royal Society," I endeavoured to explain what ought to be understood by that word "inheritance." Two points were especially urged—the first, that each personality originates in a small selection out of a large batch of wonderfully varied elements, which were all latent and competing; and secondly, that these batches, and not the persons derived from them, form the principal successive stages in the line of direct descent. Hence follows the paradoxical conclusion, that the child must not be looked upon as directly descended from his own parents. His true relation to them is both circuitous and complicated, but admits of being easily expressed by an illustration. Suppose an independent nation, A, to have been formed by colonists from two other similarly constituted nations, B and C; then the relation borne by the *representative government* of A to that of B and of C is approximately similar to what I suppose to be the relation of a child to each of his parents. But the existence of a slender strain of direct descent is shown by the fact of acquired habits being occasionally transmitted. We must therefore amend our simile by supposing the members of the governments of B and C to have the privilege of making emigration easy and profitable to their constituents, and also, perhaps, the governments themselves to have the power of nominating a few individuals to seats in the Legislative Council of A.

It appears to me of the highest importance, in discussing heredity, to bear the character of this devious and imperfect connection distinctly in mind. It shows what results we may and may not expect. For instance, if B and C contain a large variety of social elements, it would be impossible, without a very accurate knowledge of them and of the conditions of selection, to predict the characters of their future governments. Still less would it be possible to predict that of A. But if the social elements of B and C were alike, and in each case simple, such as might be found in pastoral tribes, then the character of their governments and that of A could be predicted with some certainty. The former supposition illustrates what must occur when the breed of the parents is mongrel; the latter, when it is pure. Now, no wild or domestic animal is so mongrel as man, especially as regards his mental faculties; therefore, we cannot expect to find an invariable resemblance between the faculties of children

and those of their parents. All that could be expected on the hypothesis of strict inheritance we do find; that is, occasional startling resemblances, and much more frequently partial ones. From this we have a right to argue that if the breed of men were more pure, the intellectual resemblance of child to parent would be as strict as in the forms of the equally pure breeds of our domestic animals.

I propose to refer in this article to a volume written by M. de Candolle,¹ son of the late famous botanist, and himself a botanist and scientific man of high reputation, in which my name is frequently referred to and used as a foil to set off his own conclusions. The author maintains that minute intellectual peculiarities do not go by descent, and that I have overstated the influence of heredity, since social causes, which he analyses in a most instructive manner, are much more important. This may or may not be the case; but I am anxious to point out that the author contradicts himself, and that expressions continually escape from his pen at variance with his general conclusions. Thus he allows (p. 195) that in the production of men of the highest scientific rank, the influence of race is superior to all others ("prime les autres en importance"); that (p. 268) there is a yet greater difference between families of the same race than between the races themselves; and that (p. 326) since most, and probably all, mental qualities are connected with structure, and as the latter is certainly inherited, the former must be so as well. Consequently, I propose to consider M. de Candolle as having been my ally against his will, notwithstanding all he may have said to the contrary.

The most valuable part of his investigation is this: What are the social conditions most likely to produce scientific investigators, irrespective of natural ability; and, *à fortiori*, irrespective of theories of heredity? This is, necessarily, a one-sided inquiry, just as an inquiry would be that treated of natural gifts alone. But for all that, it admits of being complete in itself, because it is based on statistics which afford well-known means of disentangling the effect of one out of many groups of contemporaneous influences. The author, however, continually trespasses on hereditary questions, without, as it appears to me, any adequate basis of fact, since he has collected next to nothing about the relatives of the people upon whom all his statistics are founded. The book is also so unfortunately deficient in method, that the author's views on any point have to be sought for in passages variously scattered; but it is full of original and suggestive ideas, which deserve to have been somewhat more precisely thought out and much more compendiously stated.

Its scheme is to analyse the conditions of social and political life

(1) HISTOIRE DES SCIENCES ET DES SAVANTS DEPUIS DEUX SIÈCLES. PAR ALPHONSE DE CANDOLLE (Membre Corr. de l'Acad. Sciences, Paris; Foreign Member, Royal Soc., etc.). GENOVA, 1873.

under which the principal men of science were severally living at the four epochs 1750, 1789, 1829, and 1869. The list of names upon which he depends is that of the foreign members of the three great scientific societies of Europe—namely, the French Academy, the Royal Society, and the Academy of Berlin—in each case about fifty in number. There is a yet stricter selection on the part of the foreign associates of the French Academy, who number only eight at a time, and of whom there have been only ninety-two¹ in the last two hundred years. It is remarkable that we find in this very select list four cases of father and son—namely, a Bernoulli and two of his sons, the two Eulers, and the two Herschels.

From an examination of these lists the author draws a large variety of interesting deductions. He traces the nationalities and the geographical distribution of the distinguished men of science, and compares the social conditions under which they lived. He finds them to be confined to a triangular slice of Europe, of which middle Italy forms the blunt apex, and a line connecting Sweden and Scotland forms the base; and then he shows that out of a list of eighteen different influences favourable to science, such as liberty of publication, tolerant church and temperate climate, a large majority were found in the triangular space in question, and there alone. The different nations vary at the different epochs in their scientific productiveness;² and he elaborately shows how closely the variation

(1) List of the ninety-two foreign associates of the French Academy (three names of no scientific importance having been omitted, who were elected in early days—these are: Lord Pembroke, 1710; Duc d'Escalonne, 1715; and Prince Lœwenstein-Wertheim, 1766). The names are arranged in the order of their election, and a hyphen (—) divides those elected before and after the year 1800:—

Denmark:—None.—Ersted.

England:—Newton, Sloane (Sir Hans), Halley, Folkes, Bradley, Hales, Macclesfield (Earl), Morton (Earl), Fringle, Hunter, Priestley, Banks, Black.—Maskelyne, Cavendish, Jenner, Watt, Davy, Wollaston, Young, Dalton, Brown (Robert), Faraday, Brewster, Herschel (Sir John), Owen, Murchison.

Germany (Ancient Confederation):—Roemer, Leibnitz, Tschirnhausen (de), Wolff, Margraff, Herschel (Sir Wm.).—Pallas, Klaproth, Humboldt (de), Werner, Gauss, Olbers, Blumenbach, Buch (de), Bessel, Jacobi, Tiedemann, Mitscherlik, Lejeune-Dirichlet, Ehrenberg, Liebig, Wöhler, Kummer.

Holland:—Huyghens, Hartsoeker, Ruysch, Boerhaave, Van Swieten, Camper.—None.

Italy:—Guglielmini, Cassini (Dom), Viviani, Poli, Bianchini, Marsigli, Manfredi, Morgagni, Cervi, Poleni, La Grange (de).—Volta, Scarpa, Piassi, Piana.

[*Poland*:—Jablomowski.—None.

Russia:—Euler (the son).—None.

Sweden:—Linnaeus, Bergmann, Wargentin.—Berzelius.

Switzerland:—Bernoulli (Jacques), Bernoulli (Jean), De Crousas, Bernoulli (Daniel), Haller (de), Euler (Léonard), Tronchin, Bernoulli (Jean II.), Bonnet (Charles), Sausure (Hor. Ben. de).—Candolle (Aug. Pyr. de), Rive (de la).

United States:—Franklin.—Rumford.

(2) The author's tables of the scientific productiveness per million, of different nations at different times, are affected by a serious statistical error. He should have reckoned per million of men above fifty, instead of the population generally. In a rapidly in-

depends on some or other of the eighteen influences becoming favourable or unfavourable. The author, himself descended from the Huguenots, lays just stress on the influence of religious refugees, whose traditions were to work in a disinterested way for the public good, and at the same time to avoid politics. The refugees rarely had their property in land, of which the oversight occupies time, but in moveable securities; thus they had leisure for work. Then, again, as they were debarred from local politics, the ambition, especially of those who had taken refuge in small countries, was to earn the approval of the enlightened men all over Europe, and this could most easily be effected by doing good work in science. Out of the ninety-two foreign associates of the French Academy, no less than ten were descended from religious refugees, usually in the third or fourth generation. Switzerland had eight out of the ten, and we may thence easily gather how enormously she is indebted to the infusion of immigrant blood. Similarly, the only two American associates—Franklin and Rumford—were descended from Puritans.

The blighting effect of dogmatism upon scientific investigation is shown both in Catholic and Protestant countries. The Catholics are the more dogmatic of the two, and they supply, in proportion to their population, less than one quarter as many of the foremost scientific men as the Protestants. There is not a single English or Irish Catholic among the ninety-two French foreign associates. Austria contributes no name, and the rest of Catholic Germany is almost barren. In Switzerland, the scientific productiveness of the Catholics is only 1-26th that of the Protestants. Again, the Catholic missionaries have done nothing for science, notwithstanding their splendid opportunities. In past days, when they were absolute masters of vast countries, as Paraguay and the Philippines, the smallest encouragement and instruction given at the college of the Propaganda to young and apt missionaries would have enriched Rome with collections of natural history. If any city more than others deserved to have the finest botanical garden and richest herbarium, it is Rome; but she has almost nothing to show.

The most notable instance of the repressive force of Protestant dogmatism is to be found in the history of the republic of Geneva. During nearly 200 years (1535 to 1725) its laity as well as clergy were absolutely subject to the principles of the early Reformers. Instruction was imposed on them; nearly every citizen was made to pass through the college, and many attended special courses at the Academy, yet during the whole of that period not a single Genevese distinguished himself in science. Then occurred the wane of the

creasing country like England, the proportion of the youthful population to those of an age sufficient to enable them to become distinguished, is double what it is in France, where population is stationary; and injustice may be done by these tables to England in something like that proportion. They require entire reconstruction.

Calvinist authority, between 1720 and 1735. Social life and education became penetrated with liberal ideas;¹ and since 1739, the date of the first election of a Genevese to an important foreign scientific society—our own Royal Society—Geneva has never ceased to produce mathematicians, physicists, and naturalists, in a number wholly out of proportion to her small population.

The author argues from these and similar cases that it is not so much the character of the dogma taught that is blighting to science as the dogmatic habit in education. It is the evil custom of continually telling young people that it is improper to occupy their minds about such and such things, and to be curious, that makes them timid and indifferent. Curiosity about realities, not about fictions of the imagination, is the motive power of scientific discovery, and it must be backed up by a frank and fearless spirit. M. de Candolle, in spite of his anti-heredity declarations, enunciates an advanced pro-heredity opinion well worthy of note. He says it is known that birds originally tame, when found on a desolate island, soon acquire a fear of man, and transmit that fear as an instinctive habit to their descendants. Hence we might expect a population reared for many generations under a dogmatic creed to become congenitally indisposed to look truth in the face, and to be timid in intellectual inquiry.

Can, then, religion and science march in harmony? It is true that their methods are very different; the religious man is attached by his heart to his religion, and cannot endure to hear its truth discussed, and he fears scientific discoveries which might in some slight way discredit what he holds more important than all the rest. The scientific man seeks truth regardless of consequences; he balances probabilities, and inclines temporarily to that opinion which has most probabilities in its favour, ready to abandon it the moment the balance shifts, and the evidence in favour of a new hypothesis may prevail. These, indeed, are radical differences, but the two characters have one powerful element in common. Neither the religious nor the scientific man will consent to sacrifice his opinions to material gain, to political ends, nor to pleasure. Both agree in the love of intellectual pursuits, and in the practice of a simple, regular, and laborious life, and both work in a disinterested way for the public good. A strong evidence of this fundamental agreement is found in the number of sons of clergymen who have distinguished themselves as scientific investigators; it is so large that we must deplore the void in the ranks of science caused by the celibacy of the Catholic clergy. If Protestant ministers, like them, had never

(1) In 1735, public opinion had become so tolerant that it was enacted that candidates for the ministry should no longer be required to make a declaration of faith, but simply to promise to teach and preach conformably to the Bible and to the light of their own consciences (p. 204).

married, Berzelius, Euler, Linnæus, and Wollaston would never have been born. But to revert to what we were speaking about. There are some six different objects in the pursuit of which most men spend their energies; three of them refer to self—namely, property, pleasure, and political advancement; the other three imply devotion to ideas—namely, religion, science, and art. Without a doubt, as M. de Candolle says, the former three occupy one-half of the moral sphere of the human character, and the latter three the other.

It appears that the men distinguished in science have usually been born in small towns, and educated by imperfect teachers, who made the boys think for themselves. Nothing is brought out more clearly in the work than that the first desideratum in scientific education is to stimulate curiosity and the observation of real things, and that too much encouragement of the receptive faculty is a serious error. The author justly laments that the art of observation is not only untaught, but is actually discouraged by modern education. Children are apt and eager to observe, but, instead of encouraging and regulating their instinct, the schoolmasters keep them occupied solely on internal ideas, such as grammar, the vocabularies of different languages, arithmetic, history, and poetry. They learn about the living world which surrounds them out of books, and not through their own eyes. One of the reformations he proposes is to make much more use of drawing as a means of careful observation, compelling the pupils to draw quickly the object they have to describe, from memory, after a short period allowed for its examination. He is a strong advocate for the encouragement of a class of scientific sinecurists like the non-working fellows of our colleges, who should have leisure to investigate, and not be pestered by the petty mechanical work of continual teaching and examining. Science has lost much by the suppression of the ecclesiastical sinecures at the time of the French Revolution, for there used to be many abbés on the lists of foreign scientific members, but they have now almost wholly disappeared. The modern ideas of democracy are adverse to places to which definite work is not attached, and from which definite results do not regularly flow. This principle is a wise one for the mass of mankind; but how utterly misplaced when applied to those who have the zeal for investigation, and who work best when left quite alone.

There is a curious chapter on the probability of English becoming the dominant language of the world in fifty or a hundred years, and being the one into which the more important scientific publications of all nations will, as a matter of course, be translated. It is not only that the English-speaking population will outnumber the German and the French, as these now outnumber the Dutch and the Swedish, but that the language has peculiar merits, through its relationship with both the Latin and the Teutonic tongues. It also

seems that in families where German and French are originally spoken, French always drives out the German on account of its superior brevity. When people are in a hurry, and want to say something quickly, it is more easily said in French than in German. Precisely in the same way English beats French. Our sentences don't even require to be finished in order to be understood, because the leading ideas come out first; but as for old-fashioned tongues, their roundabout construction would be perfectly intolerable. Fancy languages like Latin and Greek, in which people did not say "yes" or "no." M. de Candolle is very disrespectful to classical Latin. He says that one must have gone through the schools not to be impressed by its ridiculous construction. Translate an ode of Horace literally to an unlettered artisan, keeping each word in its place, and it will produce the effect upon him of a building in which the hall-door was up in the third storey. It is no longer a possible language, even in poetry.

I have only space for one more of the many subjects touched upon in his book—that of acquired habits being transmitted hereditarily—and which has also formed the subject of a recent essay by Dr. Carpenter. That some acquired habits in dogs are transmitted appears certain, but the number is very small, and we have no idea of the cause of their limitation. With man they are fewer still; indeed it is difficult to point out any one to the acceptance of which some objection may not be offered. Both M. de Candolle and Dr. Carpenter have spoken of the idiocy and other forms of nervous disorder which beyond all doubt afflict the children of drunkards. Here, then, appears an instance based on thousands of observations at lunatic asylums and elsewhere, in which an acquired habit of drunkenness, which ruins the will and nerves of the parent, appears to be transmitted hereditarily to the child. For my own part, I hesitate in drawing this conclusion, because there is a simpler reason. The fluids in an habitual drunkard's body, and all the secretions, are tainted with alcohol; consequently the unborn child of such a woman must be an habitual drunkard also. The unfortunate infant takes its dram by diffusion, and is compulsorily intoxicated from its earliest existence. What wonder that its constitution is ruined, and that it is born with unstrung nerves, or idiotic or insane? And just the same influence might be expected to poison the reproductive elements of either sex. I am also informed, but have not yet such data as I could wish, that the children of recent teetotallers who were formerly drunkards are born healthy. If this be really the case, it seems to settle the question, and to show that we must not rely upon the above-mentioned facts as evidence of a once acquired habit being hereditarily transmitted.

FRANCIS GALTON.