WEEKLY EVENING MEETING,

Friday, February 27, 1874.

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On Men of Science, their Nature and their Nurture.

THE purport of this discourse is to specify the chief qualities by which the English men of science of the present day are characterized, to show the possibility of defining and roughly measuring the amount of any of those qualities, and to conclude by summarizing the opinions of the scientific men on the merits and demerits of their own education, giving an interpretation of what, according to their own showing, they would have preferred. My data are obtained from a large collection of autobiographical notes, most obligingly communicated to me by a large part of the leading members of the scientific world. Applications were addressed to 180 Fellows of the Royal Society, who, in addition to their "F.R.S.," had gained medals or filled posts of recognized scientific position; 115 answers have already been received, of which 80 or 9 are full and minute replies to my long and varied series of questions. But I can deal with only a few deductions from this valuable material, and must refer to a forthcoming work for the rest.

It is of interest to know the ratio which the numbers of the leading scientific men bear to the population of England generally. I obtain it in this way. Although 180 persons only were on my list, I reckon that it would have been possible to have included 300 of the same ages, without descending in the scale of scientific position; also it appears that the ages of half of the number on my list lie between 50 and 65, and that about three-quarters of these may be considered English. I combine these numbers, and compare them with that of the male population of England and Wales, between the same limits of age, and find the required ratio to be about one in 10,000. What then are the conditions of nature, and the various circumstances and conditions of life,—which I include under the general name of nurture,—which have selected that one and left the remainder? Some may feel surprise that so many as 300 persons are to be found in the United Kingdom who deserve the title of scientific men; probably they have been accustomed to concentrate their attention upon a few

notabilities, and to ignore their colleagues. It must, however, be recollected that all biographies, even of the greatest men, reveal numerous associates and competitors whose merit and influence were far greater than had been suspected by the outside world. Great discoveries have often been made simultaneously by workers ignorant of each other's labours. This shows that they had derived their inspiration from a common but hidden source, as no mere chance would account for simultaneous discovery. It would appear that few discoveries are wholly due to a single man, but rather that vague and imperfect ideas, which float in conversation and literature, must grow, gather, and develop, until some more perspicuous and prompt mind than the rest, clearly sees them. The first discoverers beat their contemporaries in point of time, and it is therefore due to them, not that science progresses, but that her progress is as rapid as it is. We must neither underrate nor overrate their achievements. I would compare the small band of men who have achieved a conspicuous scientific position, to islands, which are not the detached phenomena they appear, but only the uppermost portions of hills, whose bulk is unseen. To pursue this metaphor; the range of my inquiry dips a few fathoms below the level at which popular reputation begins.

I proceed to speak of the qualities which the returns specify as most conspicuous in scientific men, and I shall endeavour to make them tell their own tale by quoting anonymous extracts from their communications.

The first in order of importance is energy, both of body and of mind. It appears to be possessed in an unusual degree by three-fourths of the men in my list. I should mention that the list contains a very few names of travellers of extraordinary endurance, such as the late Dr. Livingstone; but that I do not speak of these in the following extracts:—1. "Have rowed myself in a skiff 105 miles in 21 hours whilst undergraduate at Cambridge." (This is, I believe, a feat that not one undergraduate in 500 could do.) "Rowed in every race during my stay at the University; rowed two years in the University crews." 2. "Walked many a time 50 miles a day without fatigue, and kept up five miles an hour for three or four hours." 3. "Excelled at school and college in athletic sports, especially in jumping (18 feet). Almost incapable of mental fatigue up to the age of 38. Usually engaged in literary work until long after midnight." 4. "As a boy of 17, I worked for three months all day and all night with not more than four or five hours' sleep. When full of a subject and interested in it, I have written for seven or eight hours without interruption."

Severe scientific work is often done during the night by men engaged all day in anxious business; thus:—"In early life as a boy, I was engaged in business from twelve to fourteen hours a day, yet always found time to study and make my own instruments. Later on, my studies and scientific work were always accomplished after business hours, and it was generally my habit to commence after

dinner, and to work at science until 2, 3, or 4 A.M., and to begin business again at 9 A.M. I never thought of rest if I had anything in hand of interest."

I may mention that energy appears to be correlated with smallness of head, a fact which comes out conspicuously here, although the average circumference of head among the scientific men is great. Energy is also, as we have seen, strongly marked among them; but it is much the more strongly marked among those who have small heads. I have ninety-nine returns, many of which I have verified myself, using the hat-maker's whalebone-hoop and measuring inside the hats. It appears that the average circumference of an English gentleman's head is $22\frac{1}{4}$ to $22\frac{1}{2}$ inches. Now, I have only thirteen cases under 22 inches and eight cases of 24 inches or upwards. The general scientific position of the small-headed and large-headed men seems equally good; but the fact is conspicuous that, out of the thirteen of the former, there are only two or three who have not remarkable energy; and out of eight of the latter there is only one who has. A combination of great energy and great intellectual capacity is the most effective of all conditions; but, like the combination of swiftness and strength in muscular powers, it is very rare.

The excellence of the health of the men in my list is remarkable, considering that the majority are of middle and many of advanced ages. One quarter of the whole have excellent or very good health, a second quarter have good or fair, a third have had good health since they attained manhood, and only one quarter make complaints or reservations. Here are two examples of excellent health:—1. "Only absent from professional duties two days in thirty years; only two headaches in my life." The next is from a correspondent who is between 70 and 80 years of age. 2. "Never ill for more than two or three days except with neuralgia; no surgical operations except inoculation, drawing of one tooth, and cutting of corns." It is positively startling to observe in these returns the strongly hereditary character of good and indifferent constitutions. I have classified the entries, each entry giving the health of the scientific man, of his father and of his mother respectively, and find as follows:—First, a long row of such terms as these: "Excellent; excellent; excellent;" or "Good; good; good;" then comes another row in which some ailment is specified by the scientific man as affecting himself, and as having also affected one or other of his parents. Examples:—1. "Excellent, but hay fever; father, excellent, but severe hay fever." 2. "Good in early life, subject to headache; father, good, subject to headache." 3. "Delicate in early life, one lung seriously affected; mother delicate and phthisical." I can find only two cases, neither very strongly marked, in which both parents were described as unhealthy, although marriages between such persons are not infrequent. These returns seem to show that the issue of such marriages are barely capable of pushing their way to the front ranks of life. All statistical data concur in proving that healthy persons

are far more likely than others to have healthy progeny; and this truth cannot be too often illustrated, until it has taken such hold of the popular mind, that considerations of health and energy shall be of recognized importance in questions of marriage, as much so as the more immediately obvious ones of rank and fortune.

Steady perseverance is a third quality on which much stress is laid, but this might have been anticipated, and it is unnecessary to quote instances.

Some prevalence of practical business habits might also have been anticipated, but it proves much more common than I had expected. Among those who have sent me returns, I count no less than seventeen who are active heads of great commercial undertakings. There are also ten medical men in the highest rank of practice, and eighteen others who fill or have filled important official posts. A most eminent biologist wrote as follows, in reply to the inquiry whether he had any special tastes bearing on scientific success, in addition to those for his own line of investigation:—"I have no special talent except for business, as evinced by keeping accounts, being regular in correspondence, and investing money very well." It is clear that method and order are essential to the man who hopes to deal successfully with masses of details.

Next, as regards the more special qualities; those already mentioned, of energy, health, steadiness of pursuit, and business habits being of general application. The first of these is independence of character. Fifty of my correspondents show that they possess it in excess, and in only two is it below par. Here are a few examples:—1. "Left æt. 12" [that is, ran away from] "a school where I had received injustice from the master." 2. "Opinions in almost all respects opposed to those in which I was educated." 3. "I have always taken my own independent line. My heresy prevented my advancement." 4. "Preference for whatever is not the fashion, not popular, not rich, not very able to help itself, yet with qualities unworthily overlooked or unjustly oppressed." The home atmosphere which the scientific men breathed in their youth was generally saturated with the spirit of independence. Examples:—1. "My father was extremely independent, in some respects more so than I am. He never took off his hat to anyone in his life, and never addressed anyone as Esq." 2. "My father was a Liberal when Liberalism (then styled Jacobinism) was highly obnoxious, an early denouncer of slavery and advocate of religious liberty, a free trader when the world was protectionist, and an opponent of unrighteous war when war was most popular. He was for mitigating our criminal code when hanging was regarded as the sheet-anchor, and, in a word, was politically and socially a very independent spirit." In confirmation of the assertion that the scientific men were usually brought up in families characterized by independence of disposition, I would refer to the strange variety of small and unfashionable religious sects to which they or their parents belonged. We all know that Dalton, the discoverer of the atomic theory, and Dr. Young,

of the undulatory theory of light, were both Quakers, and that Faraday was a Sandemanian. So I find in these returns numerous cases of Quaker pedigree; and I know of one man, not as yet technically on my list, who was born a Sandemanian. There are also representatives of several other small sects, as Moravians and Bible Christians, and the Unitarians are numerous. It will be understood that the object of saying this is not to throw light on the religious tendencies of the scientific men (concerning which I have much material), because so off-hand a statement would mislead, but to prove that they and their parents had the habit of doing what they preferred, without considering the fashion of the day. The man of science is thoroughly independent in character.

We now come to what I look upon as the salt of the character of most scientific men, namely, strong innate taste for science or for some special branch of it. It is not universal even among those who have had the highest success, but it is very common, and it sometimes attains to the height of a passion which is not transient, but abides. Though decidedly hereditary in numerous cases, its appearance is more capricious than health or energy, and it often happens that the scientific man is the only member of his family in whom the taste has shown itself. The following are a few examples of innate taste:—1. "Thoroughly innate; I had no regular instruction, and can think of no event which especially helped to develop it. Bones and shells were attractive to me before I could consider them with apparent profit, and I had a fair zoological collection by the time I was 15." 2. "If any tastes be innate, mine were. They date from beyond my recollection. They were not determined by events occurring after manhood, but I think the reverse; they were discouraged in every way." 3. "I should say innate. As to whether they were largely determined by events occurring after manhood, I think not. All I can say is, that neither profession, nor marriage, nor sickness, have been able to affect them." 4. "As far back as I can remember, I loved nature and desired to learn her secrets, and I have spent my whole life in searching for them. While a schoolboy I taught myself . . . under great difficulties."

Let us now put these results together. We have seen that energy, health, steady pursuit of purpose, business habits, independence of character, and a strong innate taste for science, are characteristics of scientific men. Probably one half of the men on my list possess every one of them in a considerable and some of them in a very high degree. If one or more of these qualities be deficient, success becomes impossible, unless its absence is supplemented by other and as yet unclassified conditions. The want of time prevents me from entering into these, and I must postpone further results to a future publication. However, two groups of cases may be specified in which only a few of the above-mentioned qualities are present, and which end in an abortive career. The one is the possession of energy, health, and independence of character in excess, and little else to control them.

These are dangerous gifts. Those who have them are apt to renounce guidances by which the great body of mankind move safely, and to follow out a career in which they are almost certain to blunder and fail egregiously. Probably every large emigrant ship takes out many such men, full of unjustifiable self-confidence, who, to use a current phrase, "knock about in the world," waste their health, youth, and opportunities, and end broken down. Another common group of cases are those where a strong innate taste for science is accompanied by independence of character and steadiness of pursuit, but with no other quality helpful to success, and who therefore fail. There is hardly a village where some ingenious man may not be found who has ideas and much shrewdness, but is crotchety and impracticable. He wants energy and business habits, and so he never rises. There are many who brood over subjects like perpetual motion, whose peculiarities are well illustrated in De Morgan's book of paradoxes. We also frequently meet persons of the stamp that justifies the old-fashioned caricature of scientific men, being absorbed in some petty investigation, utterly deficient in business habits, and noted for absence of mind. I may add that even idiots have often strongly quasi-scientific tastes, as love for simple mechanism, or objects of natural history, and they have a pleasure in collecting. Also, we all know that madmen have often persistency, as shown by their brooding on a single topic.

Lastly, I wish to give some idea of the very general prevalence of mechanical tastes among the scientific men generally. One would have expected to find it among mechanicians and physicists, but it is just as strong among the biologists and others. One chemist made a 12-inch reflecting telescope; two eminent surgeons have an extraordinary aptitude for and love of mechanical manipulation; two very eminent biologists had a passion for it, and both, if they had followed the bent of their own minds, would have been engineers by profession.

All tends to show that the scientific mind is directed to facts and abstract theories, and not to persons or human interests. The man of science is deficient in the purely emotional element, and in the desire to influence the beliefs of others. Thus I find that two out of every ten do not care for politics at all; they are devoid of partisanship. They school a naturally equable and independent mind to a still more complete subordination to their judgment. In many respects their character is strongly anti-feminine. It is a curious proof of this, that in the very numerous answers which have reference to parental influence, that of the father is quoted three times as often as that of the mother. It would not have been the case, judging from inquiries I elsewhere made, if I had been discussing literary men, commanders, or statesmen, or, still more, divines.

I regret much that time makes it impossible for me now to dive deeper into the rich mine of facts contained in my returns. It becomes necessary for me to leave this branch of the subject and to pass on to some interesting considerations regarding the measurement of qualities such as those we have been engaged upon. These considerations are

of the most general application, and are as applicable to magnitude as they are to intellect and morals, and to every form of animal or vegetable life as they are to men. I shall therefore speak about the size of nuts, and peas, and acorns, as being easily experimented on, and deduce from these the results which I would fain apply to the moral and intellectual qualities of mankind.

The law of statistical constancy may be taken for granted. It is evidenced by the experience of insurance offices against fire, death, shipwreck, and other contingencies, always with the proviso that the facts are gathered with discretion, on well-known general principles. Hence we may say with assurance, that although two common nuts may differ, yet the contents of different packets, each containing 1000 nuts, will be scarcely distinguishable, for the same number of nuts of different sizes will be found in each. Let the contents of the several packets be each arranged in a long row, in order of size, beginning with the biggest nut and ending with the smallest, and place the rows rank behind rank; then by the law of statistical constancy the nuts in the same *files* will in all cases be closely alike (except the outside ones, where more irregularity prevails). Again, if we incorporate two rows into one of double length, still preserving the arrangement as to regular gradation in size, the centre nuts of the two original series will still be found at or near the centre of the compound series, the nuts in quarter positions will still be in quarter positions, and so on. Hence, whatever be the length of the series the *relative* position in it of the nut will be a *strict criterion* of its size. This is of course equally true of all groups of qualities or characters whatever, in which the law of statistical constancy prevails, the series, in each case, being arranged according to gradations of the quality in question. Each individual is measured against his neighbour, and it is quite unnecessary to have recourse to any external standard. As regards a scale of equal parts, I make use of a converse application of the law of "frequency of error" [this was illustrated by many experiments], which shwos that in a row (say as before) of nuts, if we take those which occupy the three quarterly divisions (1st quarter, centre, 3rd quarter) as three elementary graduations of size, a continuous scale of graduations will be determined by the following series, in which the places of the nuts are supposed to be reckoned from the end of the row where the large nuts are situated, and to be given in per-thousandths of the entire length of the row. It might be called the "Common Statistical Scale" (S. S.). The place of + 4° would be at 4 thousandths from large end; + 3° at 21 thousandths; + 2° at 89; + 1° at 250; 0° at 500; − 1° at 750; − 2° at 911; − 3° at 979; and − 4° at 996, or 4 thousandths from the small end of the row. Thus if we say that the size of a nut is + 2° S. S., we absolutely define, or rather identify, what we are speaking about. Anybody can procure such a nut independently by getting a quart of nuts and arranging them. Also we know that the difference between a nut of + 4° S. S. and + 1° S. S. is 3°, and therefore three times as

great as between one of + 2° S. S. and the latter. It cannot be affirmed that this is a precise scale of equal parts for all qualities, but it is found to hold surprisingly well in a great variety of vital statistics; perhaps, too, the mere thickness of tissues may be a chief element in the physical basis of life. This scale appears, at all events, more likely to be nearly approximative to one of equal parts, for qualities generally, than any other that can be specified, and it certainly affords definite standards subject to the law of statistical constancy. The habit should therefore be encouraged in biographies, of ranking a man among his contemporaries, in respect to every quality that is discussed, and to give ample data in justification of the rank assigned to him. By the general use of a system like the above, which is universally applicable, social and political science would be greatly raised in precision.

I now pass on to the education which the scientific men had in their youth, in the hope that my results may give assistance to those who are endeavouring to frame systems of education suitable to the wants of the day. What I have to say, is very partial; it refers solely to the opinions the scientific men entertain of the merits and faults of their own several educations. Their views are remarkably unanimous, considering the very different branches of inquiry they are interested in, and the great dissimilarities in their education. I should mention, that one-third have been educated at Oxford or Cambridge, one-third at Scotch, Irish, or London Universities, and the remaining third have been at no University at all. I am totally unable to decide which of the three groups occupies the highest scientific positions, they seem to me very much alike in this respect. The merits they all ascribe to variety of education are to be gathered from the following examples:—1. "Not tied down to old courses of classics and mathematics." 2. "Sufficient groundwork in many subjects to avoid error." 3. "Early introduced to many subjects of interest." 4. "A well-balanced education, including chemistry, botany, logic, and political economy." 5. "A variety of subjects, and attention to details." 6. "Coming in contact with persons of every rank and sitting in the same form" [in a Scotch school] "with the sons of tradesmen, and ploughmen, as well as gentlemen." In contrast to this, here are some examples as to the faults of their education:—1. "No mathematics, nor modern languages, nor any habits of observation or reasoning." 2. "Enormous time devoted to Latin and Greek, with which languages I am not conversant." 3. "Omission of almost everything useful and good, except being taught to read; Latin, Latin, Latin!" 4. "In an otherwise well-balanced education, three years were spent on Latin and Greek grammar, a blank waste of time." 5. "Neglect of many subjects for the attainment of one or two; not pushing mathematics to a useful end." Evidence such as this, which could be largely added to, establishes the advantage of variety of study. One group of men speak gratefully because they had it, and another group speak regretfully because they had it not. I find none

who had a reasonable variety who disapproved of it, none who had a purely old-fashioned education who were satisfied with it. The scientific men who came from the large public schools usually did nothing when there; they could not assimilate the subjects taught, and have abused the old system heartily. There are several serious complaints about superficial and bad teaching which I need not quote. Overteaching is thoroughly objected to; thus, in speaking of merits of education, I find:—1. "Freedom to follow my own inclinations, and to choose my own subjects of study, or the reverse." 2. "The great proportion of time left free to do as I liked, unwatched and uncontrolled." 3. "Unusual degree of freedom." I should add, that there are many touching evidences of the strong effect of home encouragement and teaching. As regards the subjects specially asked for, even by biologists, mathematics take a prominent place. Two of my correspondents speak strongly of the advantages derived from logic, and the weighty judgment of the late John S. Mill powerfully corroborates their opinions. Accuracy of delineation is also spoken of, and, owing to the extraordinary prevalence of mechanical aptitudes, I believe that the teaching of mechanical manipulation would be greatly prized. The interpretation that I put on the answers as a whole, is as follows: To teach a few congenial and useful things very thoroughly, to encourage curiosity concerning as wide a range of subjects as possible, and not to overteach. As regards the precise subjects for rigorous instruction, the following seem to me in strict accordance with what would have best pleased those of the scientific men who have sent me returns:—1. Mathematics, pushed as far as the capacity of the learner admits, and its processes utilized as far as possible for interesting ends and practical application. 2. Logic (on the grounds already stated, but on those only). 3. Observation, theory, and experiment, in at least one branch of science; some boys taking one branch and some another, to ensure variety of interests in the school. 4. Accurate drawing of objects connected with the branch of science pursued. 5. Mechanical manipulation, for the reasons already given, and also because mechanical skill is occasionally of great use to nearly all scientific men in their investigations. These five subjects should be *rigorously* taught. They are anything but an excessive programme, and there would remain plenty of time for that variety of work which is so highly prized, as: ready access to books; much reading of interesting literature, history and poetry; languages learnt, probably best during the vacation, in the easiest and swiftest manner, with the sole object of enabling the learners to read ordinary books in them. This seems sufficient, because my returns show that men of science are not made by much teaching, but rather by awakening their interests, encouraging their pursuits when at home, and leaving them to teach themselves continuously throughout life. Much teaching fills a youth with knowledge, but tends prematurely to satiate his appetite for more. I am surprised at the mediocre degrees which the leading scientific men, who were at the Universities, have usually

taken, always excepting the mathematicians. They prefer to fix of their own accord on certain subjects, and seem averse to learn what is put before them as a task. Their independence of spirit and coldness of disposition are not conducive to success in competition, they doggedly go their own way and refuse to run races.

Science has hitherto been at a disadvantage compared with other competing pursuits, in enlisting the attention of the best intellects of the nation, for reasons that are partly inherent and partly artificial. To these I will briefly refer in conclusion, with especial reference to the very important question, as to how far the progress of events tends to counterbalance or remove them.

If we class energy, intellect, and the like, under the general name of ability, it follows that, other circumstances being the same, those able men who have vigour to spare for extra professional pursuits, will be mainly governed in the choice of them by the instinctive tastes of their manhood. The majority will address themselves to topics nearly connected with human interests, a few only will turn to science. This tendency to abandon the colder attractions of science for those of political and social life, must always be powerfully reinforced by the very general inclination of women to exert their influence in the latter direction. Again, those who select some branch of science as a profession, must do so in spite of the fact that it is more unremunerative than any other pursuit. A great and salutary change has undoubtedly come over the feeling of the nation since the time when the present leading men of science were boys, for the state of education was then such as an enemy might have invented on purpose to exterminate science. It crushed the inquiring spirit, the love of observation, the pursuit of inductive studies, the habit of independent thought, and it protected classics and mathematics by giving them the monopoly of all prizes for intellectual work, such as scholarships, fellowships, church livings, canonries, bishoprics, and the rest. This gigantic monopoly is yielding, but obstinately and slowly, and it is unlikely that the friends of science will be able, for many years to come, to relax their efforts in educational reform. As regards the future provision for successful followers of science, it is to be hoped that, in addition to the many new openings in industrial pursuits, the gradual but sure development of sanitary administration and statistical inquiry may in time afford the needed profession. These may, as I sincerely hope they will, even in our days, give rise to the establishment of a sort of scientific priesthood throughout the kingdom, whose high duties would have reference to the health and well-being of the nation in its broadest sense, and whose emoluments and social position would be made commensurate with the importance and variety of their functions.

[F. G.]