

A Diagram of Heredity

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Reproduce this diagram for step 3 of Galton's life f.l.r

LETTERS TO THE EDITOR

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A Diagram of Heredity.

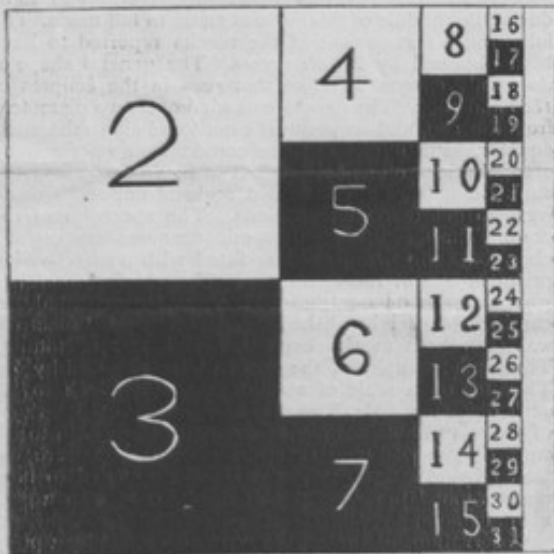
THE law of heredity which was formulated by myself in a memoir entitled "The average Contribution of each several Ancestor to the total Heritage of the Offspring" (*Roy. Soc.*, June 3, 1897, and *NATURE*, July 8, 1897), and which, as I am exceedingly gratified to learn, is now strongly corroborated by an independent investigation, has recently been illustrated by a useful diagram. This was devised by Mr. A. J. Meston, of Allen Farm, Pittsburg, Mass., U.S.A., and communicated by him to the *Horseman* (Chicago, December 28), the leading American newspaper on horsebreeding, together with a popular explanation of the law in question. Believing, as I do, and I am not now alone in the opinion, that the law is a real advance in hereditary science, I think that Mr. Meston's diagram deserves a place in your columns, as conveying in a very intelligible form the chief features of the law.

These are that the total *heritage* of the offspring is derived as follows. The two parents between them contribute *on the average* one half of each inherited faculty, each of them contributing one quarter of it. The four grandparents contribute between them one quarter, or each of them one sixteenth; and

of any particular form or faculty that is bequeathed to any particular individual. It is divided into subsidiary squares, each bearing distinctive numbers, which severally refer to different ancestors. The size of these subsidiary squares shows the average proportion of the total heritage derived from the corresponding ancestors. The distinctive numbers are the same as those which I employed many years ago in connection with the "Family Records" with which I was at that time engaged: they were found both then and subsequently to be very convenient. The Subject of the pedigree is numbered 1. Thenceforward whatever be the distinctive number of an ancestor, which we will call *n*, the number of its sire is *2n*, and that of its dam is *2n + 1*. All male numbers in the pedigree are therefore even, and all female numbers are odd. To take an example—2 is the sire of 1, and 3 is the dam of 1; 6 is the sire of 3, and 7 is the dam of 3. Or, working backwards, 14 is a male who is mated to 15; their offspring is 7, a female, who is mated to 6; their offspring is 3, a female, who is mated to 2, and their offspring is 1, the Subject. The connection of all this with the binary system of notation is obvious, and need not be further alluded to. [In Mr. Meston's own diagram, the number 1 is assigned to the sire, and 2 to the dam, and so on. This detracts from the simplicity of the nomenclature, and therefore I do not adopt that part of his diagram.] The distinction between the male and the female squares is made still more conspicuous by colouring the latter; but, yielding to the exigencies of printing, I have replaced colour by printers' ink. So all male squares in my version of Mr. Meston's diagram have white grounds and black numerals, and all female squares have black grounds and white numerals.

The numbered squares could be continued indefinitely: in this small diagram they cease with the fourth generation, which contributes a 16th part of the total heritage, therefore the whole of the more distant ancestry, comprised in the blank column, contribute 1/16th also.

FRANCIS GALTON.



"Some Unrecognised Laws of Nature."

PRESSURE of important business has prevented me from writing ere this to claim space in your columns to enter a protest against the misrepresentations, as well as the whole tone, of the review—which appeared in your columns of the 9th ult.—of the above work, in which I have had the privilege of assisting during the past six years. Heretics have long learned not to expect mercy, or even to look for justice, at the hands of the orthodox. But from a reviewer who, oblivious of the proverb *Qui s'excuse s'accuse*, warned his readers that he at least was "not one to regard lightly the danger of summarily rejecting a germ of new discovery because it happens to conflict with orthodox opinions," we have a right to expect something very different from the venomous outpourings and direful warnings and threats that might flow quite naturally from an irate theologian when reviewing a work which strikes a blow at the very foundations of his dogmas and doxies. And this is the very head and front of our offending, that, heedless of authority, we regard "the whole doctrine of 'energy,' with all its astounding and contradictory corollaries," as absurd; as the product of the infantile, and necessarily anthropomorphic, imagination of primitive man; and that we have attempted to show how phenomena may be accounted for without having recourse to such figments of the imagination. In this we may have succeeded or not; the immediate verdict will largely, if not entirely, depend on the mental attitude of the judge, and for the ultimate verdict we must be content to wait. But your reviewer may find some comfort in the assurance that the facts of science, slowly accumulated through long ages, would not be affected, nor need the human race necessarily be plunged "once more into pre-Galilean ignorance," even if all the assumptions, the metaphysical conceptions—of ethers, "dead" matter, "animating" energy, &c.—on which current explanations of these same facts are based, were summarily consigned to the limbo of similar long-forgotten "working hypotheses." And it is these hypotheses we assail, not the facts.

Of his criticisms of the fundamental principles, or rather principle, on which all our explanations are based, I need say nothing, for I can safely leave them to the judgment of all who take the trouble to read our work. I may mention, however, that his review is itself a strong *a posteriori* verification of the law of persistence in its application to psychological phenomena. But I must protest against the, conscious or un-

so on, the sum of the series $\frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16} + \dots$ being equal to 1, as it should be. It is a property of this infinite series that each term is equal to the sum of all those that follow: thus $\frac{1}{2} = \frac{1}{4} + \frac{1}{8} + \frac{1}{16} + \dots$; $\frac{1}{4} = \frac{1}{8} + \frac{1}{16} + \dots$, and so on. The prepotencies or subpotencies of particular ancestors, in any given pedigree, are eliminated by a law that deals only with *average* contributions, and the varying prepotencies of sex in respect to different qualities, are also presumably eliminated. Corrections for these can of course be made in any particular pedigree, taking care that the corrected series still amounts to 1 exactly.

It should be borne in mind that the word "Heritage" has a more limited meaning than "Nature," or the sum of the inborn qualities. Heritage is confined to that which is inherited, while Nature also includes those individual variations that are due to other causes than heredity, and which act before birth. Now individual variation in a race that is stable, must have a destructive as often as a constructive effect. Consequently its effects balance one another in *average* results, and disappear from a law which deals only with these.

The area of the square diagram represents the total heritage

conscious, misrepresentation involved in taking certain speculative conclusions—which in the light of current conceptions we know and point out must appear absurd—away from their context, and holding them up to ridicule as if they had been advanced as well-ascertained facts; and all these from a chapter the first words of which read—"This chapter will be mainly speculative."

In conclusion I would thank your reviewer for one useful piece of criticism in his eight-column notice—a notice, by the way, to say that the book is not worth noticing—in which he points out a loosely and badly worded paragraph on page 77, the real purport of which, however, is quite clear from what immediately precedes it.

LEWIS H. BERENS.

Ilkley, January 15.

YOUR reviewer regrets an appearance of antagonism between himself and any one who has been genuinely endeavouring to improve natural knowledge, but he must point out that a great deal more study is necessary before a busy man like Mr. Berens can adequately inform himself what the present condition of scientific knowledge really is.

O. J. L.

THE TOTAL ECLIPSE OF THE SUN.

IT will be some time before the complete results of the observations of last Saturday's eclipse can be made known, but it is extremely satisfactory that all the expeditions to India from this and other countries were favoured with perfect weather for the work. In places where the eclipse could only be partial the weather was not so favourable, for a telegram from Odessa (to the *Standard*) states that the observations of the solar eclipse in Southern Russia were not very successful owing to unfavourable weather. Only a few good photographs were obtained.

From a telegram received at Greenwich from Sohagpoor we learn that one of the official parties sent out by a joint Committee of the Royal Society and Royal Astronomical Society, consisting of the Astronomer Royal, Mr. W. H. M. Christie, and Prof. Turner, of Oxford, who were stationed at that place, were favoured with a perfectly clear sky, and were thus able to carry out completely the programme they had arranged; the same may be said of another official party, under the charge of Mr. Newall, of Cambridge, and Captain Hills, R.E., who were at Palgaon, near Wardha. The plates had not been developed, so it is impossible to say as yet how good the results are. Of Dr. Copeland, of Edinburgh, there is at present no news. As his station lay between those of the observers previously mentioned, it may be presumed that he also experienced a clear sky, and was, doubtless, equally successful.

A later telegram from Sir Norman Lockyer, who was at Vizadurg, on the West Coast, gives the results after developing the plates. It states "Weather excellent, and all instruments satisfactorily employed with very good results except the integrating spectroscope. The temperature fell about 3° C. during the eclipse. It was not a dark eclipse, and very few stars were seen."

This news is expressed in fuller detail in the subjoined cablegram from Sir Norman Lockyer to the *Morning Post* :—

"The total eclipse of the sun was successfully observed at our Vizadurg station in the most perfect weather yesterday.

"At our station we had the invaluable assistance of one hundred and twenty-five officers, petty officers, and men from her Majesty's ship *Melpomene*, the observers being divided into twenty-one parties.

"As many as sixty photographs of the spectrum were taken, including four sets of ten instantaneous exposures at the beginning and at the end of the total phase.

"Some of these have been already developed, and are

found to exhibit changes in the aspect of the chromosphere second by second at each of the four contacts.

"The corona was a very majestic spectacle, and it resembled that of 1896.

"As had been expected with so many sun-spots, there was no equatorial extension of the luminosity.

"A few stars were seen, but the darkness was not of sufficient intensity to necessitate the use of lamps.

"The longest streamer was a polar one, and had a length equal to four apparent diameters of the moon.

"This streamer was altogether a most exquisite structure.

"Mr. Eliot, the Meteorological Reporter to the Indian Government, and Mr. Pedler, of the Calcutta University, were members of our party.

"Mr. Pedler observed arc lines of iron in the lower corona.

"Lord Graham's cinematograph work has proved quite successful.

"The shadow of the moon on the earth was hardly seen in consequence of our atmosphere being too pure.

"The Collector at Ratnagiri and the officials of the Public Works Department attended, and rendered us every possible assistance."

The observations made at Talni by Mr. E. W. Maunder and Mr. C. Thwaites appear to have been very successful. The sky was beautifully clear. The light during the middle of totality was equal to full moon. The following is a statement of the results reported to have been obtained by the observers. The general shape of the sun's corona was like that seen in the eclipses of 1886 and 1896. The corona extended over two diameters from the sun, and its greatest extent was along the sun's equator. Photographs of the corona were obtained by Mrs. Maunder on a scale of four-fifths of an inch to the sun's diameter, and also on a scale of one-tenth of an inch, to get coronal extensions. The spectrum of the corona, chromosphere and prominences was successfully observed with an opera-glass fitted with a direct-vision prism in one of the eye-pieces. The chief coronal line was not seen on one limb of the sun, but extended to a considerable height at the other. The "flash" spectrum was seen both at the beginning and end of totality. Three photographs of the corona were obtained by Mr. Thwaites on a scale of seven-tenths of an inch to the sun's diameter. Mr. Thwaites also secured photographs of the corona on a scale of one-tenth of an inch to the sun's diameter. Good spectrum photographs were obtained by Mr. Evershed, who is also reported to have photographed the spectrum of the "flash" with a prismatic camera.

Observations of the eclipse were also made by a party from the College of Science, Poona, under the direction of Prof. K. D. Naegamvala, and by a party at Jeur, from the Lick Observatory, Mount Hamilton, U.S.A., under the direction of Prof. W. D. Campbell. It is reported that the sky was extremely clear, and that the observations were very successful. The light during the middle of totality is said to have been greater than that of full moon. The general shape of the corona was similar to that observed in 1886 and 1896. The corona extended to a distance of nearly two diameters from the sun, and its greatest extension was observed along the sun's equator.

A telegram from Dumroon states that the photographic observations made by the survey party there were entirely successful.

Seven good pictures of the corona were obtained during totality.

The following telegram was received from the Rev. J. M. Bacon, who was in charge of the British Astronomical Association party at Buxar :—

"On the Ganges weather perfect; observations satis-