§ 7. Similar experiments were made with higher voltages measured by the vertical electrostatic voltmeter, and we found that when the flame was three or four centimetres above the point, there was very rapid discharge; but when the flame was 60 centimetres or more above the point, the leakage from 3500 volts was practically the same as if the flame was not lit.

In place of the metal point, a round disc of zinc, 8 centimetres in diameter, was fixed, as shown in Fig. 3, to the end of another steel wire of the same length; and leakage from it to the flame above it, observed. For the same distance between the flame and either the point or the metal disc, the rate of leakage through the same difference of potential, was *less for the point than for the disc*. Thus with the flame 25 centimetres above the point the time of drop from 3000 volts to 2000 volts was 1 min. 53 secs., and with the flame the same distance above the horizontal plane of the disc the time of drop from 3000 volts to 2000 volts was 1 min. 14 secs. *This is a very important result.*

§ 8. Experiments were next made to find if, and if so, how much, the leakage is diminished by putting non-conducting plates of glass, paraffin, mica, between the point or disc and the flame. At a corner of each plate was pasted a little square of tinfoil, so

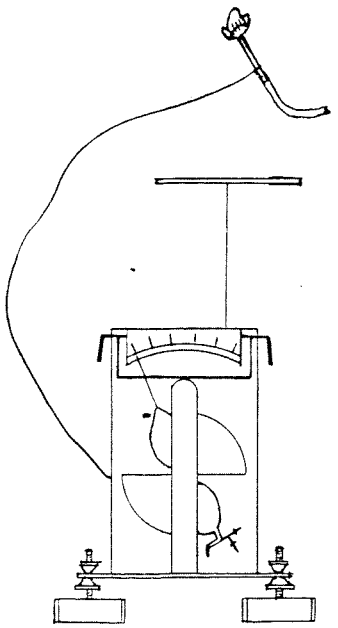

FIG. 3.

as to prevent any electrification of the non-conducting substance by handling. These pieces of tinfoil were always kept metallically connected with the sheath of the electrometer. Each plate was fixed with its under surface 1 cm. above the steel point. In preliminary experiments (of which a continuation is deferred until the insulation of the electrometer is made practically perfect by coating its vulcanite insulators with paraffin) the following numbers were obtained:—

I. *Glass Plate* 18 *cms. by* 19 *cms. by* 0·3 *cm.*

Distance of flame above point	Time of fall from 3000 to 2000 volts		Remarks
Cms.	Min.	Sec.	
—	5	30	Insulation test, with no flame.
12	2	5	Flame lit: no intervening plate.
,,	4	7	,, ,, glass plate between.

II. *Mica Sheet* 18 *cms. by* 9 *cms. by* 0·1 *cm.*

—	6	46	Insulation test, with no flame.
12	1	56	Flame lit: no intervening plate.
,,	3	50	,, ,, mica sheet between.

III. *Paraffin Plate* 11 *cms. by* 11 *cms. and* 0·75 *cm. thick.*

—	6	40	No flame. Insulation test.
12	1	53	Flame lit: no intervening plate.
,,	2	20	,, ,, paraffin plate between.

We hope to return to the investigation with the insulation of the electrometer perfected; and to determine by special experiment, how much of the fall of potential in the electrometer in each case is due to the electricity of opposite kind induced on the uppermost surface of the non-conducting plate, and how much, if any, is due to leakage through the air to the metal disc or point below.

§ 9. To test the quality of the electrification of both sides of the non-conducting plates of glass and paraffin, a thin copper sheet was fixed to one of the terminals of a quadrant electrometer, as represented in Fig. 4, where A is the plan of plate C attached to the electrometer, and B is the plate of paraffin or glass under test.

In the primary experiment (Fig. 3) the non-conducting plate was fixed in a horizontal position one centimetre above the electrified metal (point or disc), and eleven centimetres below the flame. A charge was given to the metal, to raise its potential to about 3500 volts. After some minutes, generally till the potential of the metal fell to 2000 volts, the non-con-

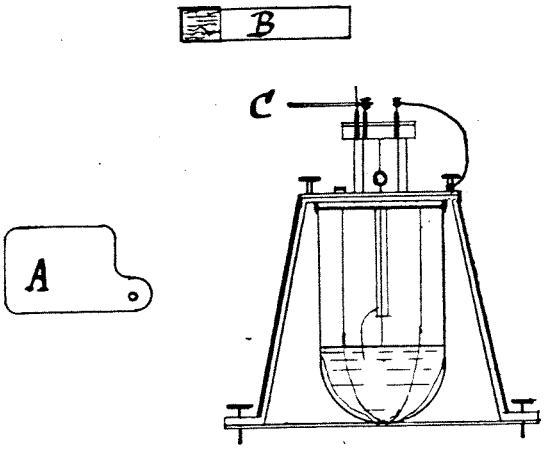

FIG. 4.

ducting plate was removed and placed, as shown in Fig. 4, above the metal plate C attached to the quadrant electrometer, and the deflection was observed. For a thin piece of glass (0·3 cm. thick) the whole effect of the two sides was negative when the electrified metal point or disc had been charged positively and *vice versâ*. But on putting two plates of glass above the electrified metal, we found the top plate to be oppositely charged and the under plate to be charged similarly to the point or disc, but not so highly. We found corresponding results with a plate of paraffin 0·75 cm. thick, and with two plates of paraffin 0·5 cm. and 0·75 cm. thick. When a plate of paraffin 3·25 cms. thick was used, we always found the top face charged oppositely to the charge of the metal, whether disc or needle-point, and the under face charged similarly to the metal below. Thus the apparent total charge of the two faces of a thin non-conducting plate is due to the fact that the face of the plate away from the electrified metal is more highly charged oppositely than the face next the metal is charged similarly.

A NEW LAW OF HEREDITY.

THE truth of a law of heredity proposed by Mr. Francis Galton, has been verified in particular instances, in a memoir[1] read by him before the Royal Society on June 3.

He first put forward the law, with hesitation, in his book "Natural Inheritance" (Macmillan and Co., 1889), page 134, because it was founded at that time almost wholly upon *à priori* grounds. Now, being found to hold good in a large group of

1 "The average Contribution of each several Ancestor to the total Heritage of the Offspring," by Francis Galton, D.C.L., Sc.D., F.R.S.

cases, there is strong reason for its acceptance, as applicable generally to all qualities in all the higher (bisexual) animals. When it is applied to individual cases, minor corrections should of course be made in respect to sexual limitations, prepotencies of particular ancestors, and the like.

The law shows the proportion of the heritage that is contributed on the average by each parent, grandparent, great-grandparent, and so on. There *must* be an *average* contribution, drawn from each ancestral place *independently* of all the rest, because cases are familiar to observers in which a peculiarity found in some single ancestor has appeared in one or more of the offspring; the present law expresses its amount.

The general considerations upon which the law was originally founded, are four in number but not equally cogent; there is only one solution that satisfies them all. (1) The consequence of limitation in space on *particulate* germinal matter, which necessitates the loss of one-half of the total germinal material contributed by the two parents. This is confirmed by the commonly (though not universally) accepted fact of observation in the life-history of the germ. (2) The remark already made, that any ancestor however remote *may* contribute his peculiarity independently of the rest. (3) The contribution of the two parents to the child, being analogous to that of the 4 grandparents to the 2 parents, of the 8 great-grandparents to the 4 grandparents, and so on, make it probable that the latent links of the chain of ancestral contributions form a geometric series of terms, diminishing as we proceed from the ancestor downwards. (4) The sum of the contributed heritages must be equal to 1.

These four conditions are satisfied by the series $\frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16}$ + &c. In other words by the supposition that the two parents contribute between them $\frac{1}{2}$ of the total heritage of the child; the four grandparents, $\frac{1}{4}$: the eight great-grandparents, $\frac{1}{8}$, &c. Or again, that a single parent contributes $\frac{1}{4}$; a single grandparent, $\frac{1}{16}$; and a single ancestor in the nth generation, $1/2^{2n}$. A noteworthy consequence of this is that all the 16 great-great-grandparents taken together, are no more efficient than a single grandparent, and only one quarter as efficient as a single parent.

This supposition does not run counter to the commonly accepted view that the true line of descent stretches from germ to germ, and not (except in, perhaps, a small degree) from person to person; the person must on the average be a fair average representative of the germ, consequently statistical averages which are true of the one, would be true of the other, also.

The verification of the above theory is the object of Mr. Galton's memoir. Appropriate materials for the purpose were at last found in the registered colours of the pedigree stock of Basset hounds. This stock was started some twenty years ago by Sir Everett Millais, who purchased on the continent 93 selected hounds for the purpose, and has subsequently interbred their most valuable descendants. A Basset Club has long been established, which publishes an occasional stud-book (the latest was in 1896) containing the registered name, parentage, date of birth, and breeder of each hound. The colours are not printed in it, but they are always entered on the form sent by the breeders to the Club, and Sir E. Millais kindly had them copied for his use. Now there are two, and only two, recognised varieties of these colours: the one technically known as *lemon and white* (the word "lemon" standing for any shade between yellow and reddish-brown), and the other known as *tricolour*, from its containing black as well. So there are only two alternative conditions to be considered: "with black" and "without black"; or "Tricolour," and "Non-tricolour"—say for brevity, T. or N. It is asserted that intermediate and doubtful cases between T. and N. hardly exist.

The result is a collection (1) of 817 hounds of registered colours, T. or N., descended from parents whose colours are also known. (2) Of these, in 567 cases, the colours of all four grandparents are known; again (3) of these, in 188 cases, the colours of all eight great-grandparents are known. These three sets form the material that is tabulated and discussed, and supplies the requisite means for comparing calculated results with observed ones.

There are numerous points dealt with in the memoir, and explained away, to which there is not space to speak of here; one only need be mentioned, namely the question whether either the sire or the dam is so prepotent in transmitting colour, as to make it necessary to treat the sexes apart. It proves that the dam is prepotent over the sire in this respect, but only in the proportion of 6 to 5; also that the neglect of sex made no sensible difference in a test case. Consequently all ancestral places in the same generation are treated as of equal average efficiency. In short, if n be the order of any given generation (counting $n = 1$ for parents, $= 2$ for grandparents, &c.), there are 2^n ancestral places in the nth order, and these contribute between them $1/2^n$ of the total heritage; consequently each ancestral place contributes $1/2^{2n}$ of it. If the same hound fills more than one ancestral place, he has to be rated separately for each of them.

The contributions from the unknown ancestry are reckoned as follows. It was found that 79 per cent. of the parents of T. hounds are T. also, and that 56 per cent of the parents of N. hounds are T.; consequently the unknown grandparents, great-grandparents, &c., of the T. hounds would have probably $(\cdot79)^2$, $(\cdot79)^3$, &c., of T., and those of the N. hounds would have $(\cdot56)^2$, $(\cdot56)^3$, &c., of T. A simple calculation shows that the sum of the T. contributions to the offspring of the unknown ancestry of each T. grandparent would be 0·0408, and that of each N. grandparent would be 0·0243; these values are used in discussing the set (2). In set (3) the great-grandparents are known, ignorance beginning above that stage; in this case, the pre-ancestral contribution of T. through each T. great-grandparent, is found to be 0·0102, and that through each N. great-grandparent is 0·0061. There is no need here to allude to minor corrections, noticed in the memoir, whose effect is too small to be worth regarding.

It thus becomes a very simple matter to determine the contribution from each several known ancestor as well as that from the unknown ancestry of each of them, and, by adding these together, to obtain a coefficient appropriate to any given group of similar cases, such as when multiplied into the total number of offspring, shall give the "calculated" number that are T.

The test of the truth of the theory lies in the accordance between these calculated numbers and the observed number.

Owing to the large proportion of T. hounds and to selective breeding in favour of T., the different possible matings are by no means equally common, those in which the known ancestry are all (or nearly all) N. being non-existent. The results for such as occurred, are summarised below (excluding seven cases, falling into three groups, that lay outside the limits of the Table for set 3). The coefficients are added to show the degree of variety in the test conditions. Fuller information is to be found in the Tables published in the memoir, out of which these figures are extracted.

CALCULATED AND OBSERVED VALUES COMPARED.

Set 2.

Coefficient...	·91	·83	·76	·68	·66	·58	·51	·43	·26	·18	—	Total
T. calculated	108	99	21	8	24	92	30	3	5	1	—	391
T. observed	106	101	24	8	20	79	36	4	7	2	—	387

Set 3.

Coefficient...	·96	·94	·92	·90	·87	·85	·83	·81	·81	·79	·77	
T. calculated	2	24	13	14	16	18	13	5	2	3	2	(continued)
T. observed	2	25	14	15	17	19	14	6	2	2	3	

Set 3 (continued).

Coefficient...	·75	·69	·67	·65	·64	·62	·60	·58	·56	·54	·52	Total
T. calculated	2	1	1	6	1	17	8	18	5	2	7	180
T. observed	2	1	0	5	1	16	12	8	9	1	7	181

Comparing the totals of each of the two sets, we see that the calculated results are practically identical with the observed ones, 391 with 387; 180 with 181; grand total, 571 with 568. There is therefore no *constant* error, the errors in individual

cases balancing one another. When we examine the several groups, 32 in number, which contribute towards the above totals, a remarkable amount of agreement is shown throughout between calculation and observation, such as would raise the art of breeding to a science of considerable precision. The most notable exception is in the sixth column of set 2, where the numbers are 92 and 79, but, as is shown in the memoir, the observed values run there so irregularly with their neighbours, that they cannot be accepted as true representatives. The causes of heterogeneity undoubtedly include the disturbing effects of close interbreeding, because particular hounds of good shape that have also considerable prepotency, are largely bred from.

The author mentions that he had made experiments with the coefficients, altering them slightly and recalculating, and that he found in every case a notable diminution in the accordance between calculation and observation; the test that the law has successfully undergone thus appears to be even more severe and searching than might have been anticipated.

It is hardly necessary to insist on the value to breeders of a trustworthy law of heredity. Vast sums are spent annually in rearing pedigree stock of the most varied kinds, such as horses, cattle, sheep, pigs, dogs, and other animals, besides flowers and fruits. Certainly no popular view at all resembles that which is put forward and justified in Mr. Galton's memoir, which is epitomised here so far as space admits.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

THE Maine State College at Orono will in future be known as the University of Maine.

MR. MUIR, of Halifax University, has been appointed to the chair of Psychology in Mount Holyoke College.

THE Victoria University on Saturday last conferred on Sir George Gabriel Stokes, Bart., the honorary degree of D.Sc.

THE Rev. D. J. Thomas has been appointed Principal of the Home and Colonial Training College, Gray's Inn Road, and of the Highbury Training College for Secondary Teachers.

THE establishment of a fresh-water biological station at Hemlock Lake, under the direction of Prof. Charles W. Dodge, has been sanctioned by the Board of Trustees of the University of Rochester, U.S.A.

THE library building of the University of Iowa was on June 19 struck by lightning, and destroyed by fire. The physical laboratory was on the first floor of the building. The total loss is estimated at about £20,000.

AMONG recent appointments may be mentioned:—Dr. Brault, to be Professor of Tropical Diseases at Algiers; Prof. W. Th. Engelmann, of Utrecht, to be Professor of Physiology at Berlin, in place of the late Prof. du Bois-Reymond.

THE following resignations are announced:—Dr. James Woodrow from the presidency of South Carolina College; President Craighead and Profs. Tompkins and Wright from Clemson College; Dr. W. H. Hervey from the presidency of the Teachers' College, New York.

ACCORDING to *Science*, Prof. Edward L. Nichols, the President of the New York State Science Teachers' Association, has appointed a committee of nine to consider and report at the next annual meeting of the Association on the following topics:—"Science as an Entrance Requirement to Colleges," "Science Teaching in the Secondary Schools," "Nature Study in Primary Schools."

THE June issue of the *London Technical Education Gazette* contains particulars of various courses of science lectures which are to be given in the autumn and winter of this year at University and King's Colleges, and at the Battersea and South-West London Polytechnics. Many of the courses are quite free of charge, and as only a limited number of persons can be accommodated at some of them, early application is desirable.

UNDER the auspices of the American Society for the Extension of University Teaching, a summer meeting is being held at the University of Pennsylvania from July 6 to 30. *Science* announces that two lectures on "Mediæval Science" will be given by Prof. W. F. Magie, and lectures on "Forestry" and "Museums" will be delivered by Prof. J. T. Rothrock and Prof. W. P. Wilson respectively. In Psychology courses of lectures are announced by Prof. L. Witmer, Prof. J. M. Baldwin and Prof. E. B. Titchener. Conferences on the teaching of geography will be led by Profs. W. M. Davis and R. E. Dodge.

SCIENTIFIC SERIALS.

Symons's Monthly Meteorological Magazine, June.—Hail-storm at Seaford, Sussex, May 30, 1897. It can be very rarely proved that a shower of hailstones as large as a hen's egg has fallen over a considerable area in England, but from letters received from various observers this is shown to have been the case during thunderstorms which occurred over the east of England on that day between the Isle of Wight and Lincoln. At Seaford several hailstones were picked up measuring 4½ inches round, and at Maidstone the stones were as large as walnuts; the noise there was so great that the services in nearly all the churches were interrupted.—Heavy rain at Port Elizabeth, Cape Colony, May 5, 1897. The amount measured between 8 a.m. and 1.30 p.m. was over 5 inches, and in three days 7·29 inches were measured.

Bulletin de la Société des Naturalistes de Moscou, 1896, No. 2.—New tertiary mammals found in Russia, by Mme. Marie Pavloff, with one plate (in French). The most important find is that of a bone which was identified as the lower end of the third metacarpus of *Anchitherium aurelianense*, Cuvier; thus being the first *Anchitherium* rest found in Russia. It comes from the neighbourhood of Nikolaieff, where it was found in a layer containing remains of *Mastodon borsoni*. The other remains belong to the Pliocene yellow "Balta Sands," and are: *Rhinoceros Schleiermacheri* (Kaup), *Capreolus cusanus* (Crois. and Job., *teste* Boyd Dawkins), and *Mastodon turicensis* (Schintz). They throw a new light on that interesting formation.—The reptiles of Europe, by Dr. J. Bedriaga, Part ii. *Urodela*. A most elaborate work (in German), containing full indexes of literature, synoptic tables for determination, and full detailed descriptions of the species (to be continued).—On the structure, &c., of the Nematocysts of Cœlenterata, by N. Iwanzoff, with two plates (in German, concluded).—Polar Land and Tropical Flora, by H. Trautschold (in German). Deichmüller having shown that the invariability of the rotation-period of the earth is not probable, and a variation in the position of the earth-axis having been proved, Prof. Trautschold enumerates the geological data, which render very probable that the position of the axis has been slowly displaced in geological times, and which could not be explained otherwise.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, May 13.—"Further Note on the Influence of a Magnetic Field on Radiation Frequency." By Prof. Oliver Lodge, F.R.S., assisted by Mr. Benjamin Davies.

Referring to a former communication of mine, on the subject of Zeeman's discovery, printed on page 513 of the *Proceedings* of the Royal Society for February 11 this year, vol. lx. No. 367, I wish to add an observation to those previously recorded, as I have recently acquired a concave Rowland grating (3½ × 1½-inch ruled surface, 14,438 lines to inch, being the one used by Mr. George Higgs), of which the spectra of the first and third orders on one side are very satisfactory.

It is said on page 513, "If the focussing is sharp enough to show a narrow, dark reversal line down the middle of each sodium line, that dark line completely disappears when the magnet is excited." With the greater optical power now available the dark reversal line is often by no means narrow, and though in some positions of the flame it does still tend to disappear or become less manifest when the flame is subjected to a concentrated magnetic field, the reason of its partial disappearance is that it is partially reversed again—*i.e.* that a third bright line, as it were, makes its appearance in the midst of the dark line, giving a triple appearance to each sodium line.

The following is a summary of the different appearances that may be seen according to the state of the flame and the strength of the field:—

At low temperature, and with the flame forward in the field, when each sodium line is sharp and single, magnetism widens it,