they began late, and they had not yet caught up some other nations, and much had still to be done in this country in order to provide the facilities that were needed to furnish their sons with the knowledge that was necessary to enable them to carry on the commercial business of the country. The City and Guilds Institute had in the most munificent manner spent on its technical colleges in the course of the past eighteen years about half a million out of the funds over which it had control: but could they go on relying upon private munificence so much as they had done for the purposes of technical education? He ventured to think that the time had come when there should be some system supported by funds, if necessary, of some public nature by which colleges should be founded in the great centres where they were needed, and branch colleges of a similar description in smaller places where they were wanted. The whole scheme of technical education seemed to him to have come to the point at which it required some further consideration. In connection with this subject one had often to speak of Germany and Switzerland, but he was quite sure that they did not speak of them in any spirit of jealousy, but, on the contrary, in a spirit of admiring emulation of their work. They must take what they could that was best from those countries and adopt it, and leave the latter to act in a similar manner towards this country.

SCIENTIFIC SERIALS.

American Journal of Science, January.—A new harmonic analyser, by A. A. Michelson and S. W. Stroud. This is an instrument designed to sum up as many as eighty terms of a Fourier series, or to analyse a given curve into its original series. The pen which traces the curve is worked up and down by a lever controlled by a spring. This spring is stretched by an excentric, which imparts a "simple harmonic" variation to the force. The stretching is resisted by another spring. Eighty such elements are connected together, with one resisting spring to counterbaiance the sum of the elementary springs. The pen therefore moves in accordance with the sum of the elementary periodic motions. The authors obtain by this machine the mathematical series representing the profile of a human face.—A new form of physical pendulum, by J. S. Stevens. The error introduced into the ordinary physical pendulum by the fact that the knife-edges and clamp affect the moment of inertia may be eliminated by boring a hole into the rod and screwing the knife edges a little way in, so that they offset the mass of brass bored out.—The Protostegan plastron, by G. R. Wieland. This is a restoration of the plastron of two specimens of the turtle described before as *Archelon ischyros*.—Phosphorescence produced by electrification, by J. Trowbridge and J. E. Burbank. When a piece of fluorspar is first exposed to the action of X-rays, and subsequently heated, it shows a bright phosphorescence. The same phenomenon may be produced by exposing the mineral to an electric brush discharge, and subsequently heating it. It is probable, therefore, that the X-rays produce an electrification of the fluorspar.—On iron meteorites, as nodular structures in stony meteorites, by H. L. Preston. It is an important fact that of over 100 falls and finds of siderites or iron meteorites but nine have been seen to fall, while of the aerolites or stony meteorites of over 400 falls and finds, more than one-half have been seen to fall. The author gives several reasons in support of the view that the siderites are merely the crystallised metallic nodules contained in the larger and more conspicuous stony meteorites.

SOCIETIES AND ACADEMIES.

LONDON.

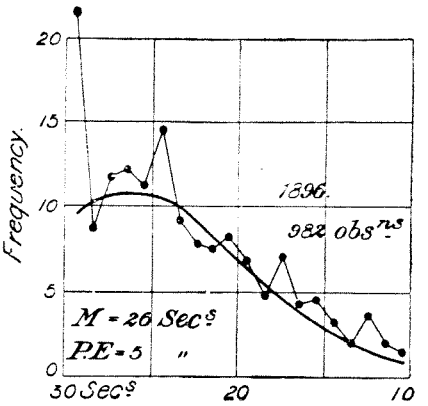
Royal Society, December 13, 1897.—"An Examination into the Registered Speeds of American Trotting Horses, with Remarks on their Value as Hereditary Data." By Francis Galton, D.C.L., F.R.S.

It is strange that the huge sums spent on the breeding of pedigree stock, whether of horses, cattle, or other animals, should not give rise to systematic publications of authentic records in a form suitable for scientific inquiry into the laws of heredity. An almost solitary exception to the disregard shown by breeders and owners, of exact measurements for publication in stud books, exists in the United States with respect to the measured speed of "trotters" and "pacers" under defined conditions. The performance of one mile by a trotter, harnessed to a two-wheeled vehicle, carrying a weight of not less than 150 lbs. inclusive of the driver, in 2 minutes 30 seconds qualifies him for entry in the "Trotting Register," giving him, as it were, a pass-degree into a class of horses whose several utmost speeds or "records" are there published.

The system of timing was first put into practice more than fifty years ago, and has since been developed and improved. In 1892 a considerable change was made in the conditions by the introduction of bicycle wheels with pneumatic tyres, which produced a gain of speed, the amount of which is much discussed, but which a prevalent opinion rates at 5 seconds in the mile. Thenceforward the records are comparable on nearly equal terms. All trotting performances up to the 2′ 30″ standard are registered in the large and closely printed volumes of "Wallace's Year Book," published under the authority of the American Trotting Association. Vols. viii.–xii. refer to the years 1892–6, and it is from the entries in these that the following remarks are based.

The object of my inquiry was to test the suitability of these trotting (and pacing) records for investigations into the laws of heredity. I had to determine whether the observations fell into a tolerably smooth curve; and, if so, whether that curve was a tolerable approach to the normal curve of frequency. In the latter event the observations would fall into line with numerous anthropometric and other measures which have been often discussed, and which, when treated by methods in which the arithmetic mean is employed, yield results that accord with observed facts.

I had 5705 extracts made from the entries published in the Year Books for the five years 1892–6. It was tedious work, and I thought it unnecessary to repeat it to check the results, being satisfied after some examination that they were quite accurate enough for general conclusions. They were arranged in columns; the first to the left contained entries of all observations recorded as 2′ 29·0″, 29¼″, 29½″, or 29¾″; that is of all under 2′ 30″ down to 2′ 29″ inclusive. The second column referred to 2′ 28″ 0, 28″¼, 28″½, and 28″¾, and so on with the rest. These were then reduced to percentages and diagrams were drawn from them, of which the following, for the year 1896, is one; it will serve as a fair sample of the other four.



If divided by the eye into imaginary columns corresponding to those in the tables, the point representing the sum of the observations of 2′ 29″·0, 29″¼, 29″½ and 29″¾ will be found in the middle of the first imaginary column, that is to say it stands vertically above the point that lies half way between 29 and 30 on the scale along the base. The dots are connected by thin lines to show the trace or curve of the observations. The smooth curves are those of normal frequency, calculated from the values of the mean (M) and of the probable error (P.E.), which are given in the diagrams.

Leaving aside for the moment the strange pinnacle that rises on the extreme left of every diagram, we see that the traces of the rest of the observations run very roughly, but not intolerably so. In each diagram they seem to be disposed about a fundamentally smooth curve. Considering the smallness of the interval, namely, only one second, that separates the observations assigned to each pair of successive columns, together with the experience derived from other kinds of statistical curves, it seems to me that the run of the observations is good enough to certify their general trustworthiness. As regards the pinnacle it is different matter, and is one which when beginning work, as

did, on the 1892 entries only, was very perplexing. However, by persevering with the other years, it became increasingly plain that the pinnacle was a false maximum; in 1896 it was certain that the true maximum lay well within the portion of the curve included in the diagram. The explanation of the pinnacle then became obvious[1]; it was that the tolerance granted to those horses who failed by only a little to qualify themselves, was extended considerably beyond the quarter second for which I was prepared. The cases of 2′ 30·0″ were few; they do not appear in the diagram, but their addition would be quite insufficient to remove the difficulty. If the pinnacle were distributed among *two* adjacent columns outside and to the left of the diagram it would smooth away the incongruity, so I suspect that cases of "under 2′ 32″ and down to 2′ 30″" are habitually rated at a trifle less than 2′ 30″. Consequently I had no hesitation in wholly disregarding the entries that helped to make the pinnacle, namely, the whole of those contained in the first column to the left in every one of the diagrams. The course thereupon became clear and straightforward. I estimated the position of the mean value for each year, from inspection of the curve of that year, allowing myself to be somewhat biassed in estimating its point of culmination by the curves of the adjacent years; similarly as to the probable error. Now that the curves are drawn, I see that somewhat better fits might have been made, but they are close enough to show the existence of a fair amount of correspondence between the observed values and those calculated according to the law of normal frequency. It is near enough to remove hesitation in working with the arithmetic mean.

I now come to the fundamental purpose of this memoir, which is to point out the existence in the registers of the American Trotting Association, of a store of material most valuable to inquirers into the laws of heredity, which accumulates and increases in value year by year. But it seems to me hardly worth while to discuss hereditary influence on speed in horses, unless the records of at least their sires and of their dams, and those of each of their four grandparents, as well as their own record, are all known. Even in this case (according, at least, to my own theory) one quarter of the hereditary influences are unknown and have to be inferred. It is practically impossible to make an adequate collection of the names of horses who fulfil the above conditions out of the entries in the "Trotting Register," each search requiring many cross references and occupying a long time, while the number of futile searches before attaining a success is great. On the other hand, the breeders and possessors of these notably bred horses must be familiar with the required facts, and would assuredly be delighted to have them known. There need, therefore, be little difficulty in obtaining materials for the much desired table. In the meantime I am sending circulars to the chief breeders in America, in hopes of making a start.

The great need for genealogical data of an exact numerical kind, by those who prosecute inquiries into the laws of heredity, is the justification that I offer for submitting these remarks to the Royal Society.

Physical Society, January 21.—Mr. Shelford Bidwell, President, in the chair.—Prof. Fitzgerald exhibited some photographs by Mr. Preston in illustration of the Zeeman effect, for various cases, including those of iron, cadmium, zinc, and sodium. These photographs and the method of obtaining them have already been described. The cause of doubling is now attributed by Prof. Fitzgerald to absorption by the surrounding vapour. In a particular case he examined a double line that exists in one of the photographs. Under the polariser the two lines are at first distinctly seen; but when the polariser is turned, a thin line appears in the middle, and this central line is, therefore, circularly polarised in a direction opposite to that of the outer pair of lines. The reason for the appearance of doubling in the first position of the polariser is that the central line is there completely absorbed out by the surrounding vapour.—Prof. Oliver Lodge then gave a communication concerning his work on "Electric Signalling without Connecting-wires." From the nature of the oscillatory disturbances emanating from any of the customary forms of Hertz vibrator, syntony has hitherto been only very partially available as a means for discriminating between receivers. There is in fact so rapid a decrease in the amplitude of the vibrations that almost any receiver can respond to some extent. Discrimination by syntony is possible with magnetic systems of space telegraphy where the magnetic energy much exceeds the electric, *i.e.* as between two separated inductive coils; and by the use of such coils, appropriately applied, the author has been able to attain fair syntony even with true Hertz waves, *i.e.* he has constructed spark-gap oscillators, with sufficient persistence of vibration, and syntonised resonators. The "coherer" principle can be applied to either a purely magnetic or to the Hertzian system. It was first used by Prof. Lodge in devising lightning-guards, and afterwards in his magnetic system of telegraphy by inductive circuits, each in series with a Leyden-jar; a pair of knobs in near contact, or other over-flow gap, being provided in the receiving apparatus. This was the first meaning of a "coherer" in the electrical sense as used by Prof. Lodge. It referred to a *single* contact between two metal knobs. The term has since been extended by others to the filings-tube of M. Branly, and some confusion has arisen, for M. Branly does not consider that simple coherence and break explains fully the behaviour of his instrument. Prof. Lodge is disposed to agree, for he finds that the resistance of almost any form of coherer varies in rough proportion to the received impulses, and that there are other peculiarities (to be mentioned later). He is, therefore, inclined to think that the action cannot after all be entirely explained as due to mere "welding," but that there is something more to be learnt about it. The sensitiveness of a coherer depends upon the number of loose contacts; it is a maximum for a single contact, *i.e.* for a needle-point lightly touching a steel spring. With this sensitive coherer, hardly any "tapping-back" is required for decoherence, but it wants delicate treatment when properly adjusted, and the greatest current through it should not approach a milliampere. On the other hand, a Branly tube rather improves under rough treatment; in such a tube the author prefers to use iron filings in the best possible vacuum; brass, too, is very good, but rather less easy to manage. Aluminium is thoroughly bad, and gold, for an opposite reason, will not work—its surface is too clean. Points, or small surfaces for making contact with the filings, are better than large surfaces. The usual method of connecting the coherer across the gap of an ordinary Hertz receiver, in parallel with the telegraph instrument and battery, has the unavoidable objection that they shunt away part of the received oscillations. With the syntonic receiver of Prof. Lodge, which contains no gap, but a closed wire coil instead, this difficulty no longer exists; for the coherer can now be in series with the detecting instrument, and in so far as these obstruct the oscillations they may be shunted out in various ways, as the author describes. The main feature of his new syntonised vibrators is this self-inductance coil, whose function it is to prolong the duration of the oscillations, and thereby to render syntony possible. Although such a coil acts disadvantageously in so far as it possesses resistance, the resistance does not increase so fast as the self-induction. The coil should consist of thick copper of highest conductivity, and it should have maximum inductance for given resistance. For similar reasons, the capacity-areas should also be of highest conductivity, their dimensions should increase outwards from the spark-gap, as triangles. The receiver must have no gap, it should be accurately bridged over when a transmitter is used as receiver. The limit of speed of response depends upon the telegraphic instrument. Dr. Muirhead adapted a siphon-recorder to the purpose, because it is one of the quickest responders; he arranged it so that it could be used with intermittent currents direct. Under these intermittent impulses the siphon trembles; and instead of the ordinary siphon signals, the slip is marked with dots and dashes. Constant mechanical tremor is usually employed for decoherence, but the author finds that decoherence can be brought about by electrical means, without any mechanical tremor, by connecting the coherer momentarily to a circuit less effective as a collector than that of the proper capacity-areas of the syntonised receiver. The battery and galvanometer detector-circuit may be used for this purpose, the coherer being momentarily connected to it, and while so connected letting it experience an impulse from a distance. Prof. Lodge has designed a revolving commutator by means of which the coherer can be rapidly changed over from the resonating circuit to the instru-

[1] I should like to take the opportunity afforded by the appearance of an abstract of my memoir in NATURE to correct a questionable suspicion, namely, that the pinnacles in the diagrams are due to tolerance shown towards horses who failed by a very little to qualify for the much-coveted rank of standard trotters. I am assured on excellent authority that the strict conditions of timing make this impossible (among other reasons there are three timers). On the other hand, there is a vast competition *just* to pass the 2′ 30″ limit; and when a horse has done so, his owner often does not care to train him for racing, but rather to utilise him at once for breeding or other purposes. The question is too complicated to discuss here at length. Suffice it that the 2′ 29″ to 2′ 30″ records are not homogeneous with the rest, and should be discarded as I proposed.—F. G.